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Benchmark Program for the Evaluation of Methods to Analyze Non-Classically Damped Coupled Systems

Final Report

Brookhaven National Laboratory

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ABSTRACT

Under the auspices of the US Nuclear Regulatory Commission (NRC), Office of Nuclear Regulatory Research, Brookhaven National Laboratory (BNL) developed a two-phase benchmark program to evaluate state-of-the-art methods for performing seismic analysis of coupled nuclear power plant (NPP) structures with non-classical damping. A Preliminary Report was issued for Phase I of the program, in which a series of benchmark problems were established and "exact" solutions were developed by BNL. The Preliminary Report, which included the detailed descriptions of the benchmark problems, the BNL analysis method, and the necessary inputs, was distributed to the program participants who applied alternate state-of-the-art analysis methods for their independent analyses.

In Phase II, the analysis results that were submitted to BNL by the participating organizations and individuals were compared to and evaluated against the BNL "exact" solutions. This report describes the results and evaluations of the participant analyses of the benchmark problems.

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EXECUTIVE SUMMARY

In recent years, new state-of-the-art analytical methods for performing seismic analysis of coupled structures have been developed using complex modes in place of the traditional classical response spectrum methods. These newly developed methods claim to bring benefits to the design process by reducing the conservatisms embedded in classical approaches, thereby reducing design and construction costs. However, from the regulatory standpoint, it is imperative that these state-of-the-art methods and their applicability, as well as their limitations be understood to assure that they produce reasonable results with acceptable safety margins. To this end, this benchmark program was established to evaluate state-of-the-art methods for performing seismic analysis of coupled nuclear power plants (NPP) structures with non-classical damping. The program was focused on the analysis of a coupled primary-secondary system consisting of two subsystems with different modal damping ratios. This program was developed by Brookhaven National Laboratory (BNL) under contract to the US Nuclear Regulatory Commission (NRC), Office of Nuclear Regulatory Research. Eleven organizations worldwide initially accepted the BNL invitation and four organizations completed the program. They are:

- Dr. C. Chen of Apollo Consulting, Inc. (Apollo),
- Professor A. K. Gupta, Professor A. Gupta and Mr. M. K. Bose of North Carolina State University (NCSU),
- Professor T. Igusa of Johns Hopkins University and Professor A. Der Kiureghian of University of California at Berkeley,
- Drs. A. Berkovski, O. Kireev, V. Kostarev and J. Stevenson of Stevenson and Associates, Russian Office (S&A).

In addition, Dr. R. P. Kennedy and Professor A. S. Veletsos provided independent review of the benchmark process.

The benchmark program was executed in two phases. During Phase I, a series of benchmark problems that cover various aspects of application and complexity of typical coupled nuclear power plant (NPP) structures with non-classical damping were first developed. These benchmark problems were subsequently analyzed by BNL using the direct integration time history analysis method with a rigorous formulation for the explicit damping matrices. A preliminary report, which included the detailed descriptions of the benchmark problems, the BNL analysis method, and the necessary inputs, was distributed to the program participants for their independent analyses. Necessary ground rules were also established in the preliminary report.

In Phase II of the benchmark program, the analysis results were submitted to BNL by the participants. These results were then compared to and evaluated against the BNL "exact" solutions. The resulting comparisons and evaluations of the participant analysis results of the benchmark problems and their comparisons to the BNL solutions are provided in this report, including more than 100 tables and figures. In addition, this report provides the evaluation of the analysis methods applied by the participants, and the findings with respect to the applicability and limitations of various alternate state-of-the-art analysis methods to coupled NPP structures with non-classical damping. As a result of the comparisons and evaluations of the finalized benchmark analysis results, the following significant observations were made:

1. For the smaller benchmark problems nos. 1, 2, and 3, the complex-mode time history analysis results provided by S&A, Igusa, & Gupta were in excellent agreement with the BNL direct integration time history results. Based on these results, it is concluded that for these problems, the participants' complex-mode time history analysis methods provide results comparable to those generated by the benchmark direct integration time history analysis methods.

2. For the larger benchmark problems no. 4a and no. 4b, which represent realistic coupled NPP building-piping systems, the complex-mode time history analysis results provided by S&A, Igusa & Gupta were in good agreement with the BNL direct integration time history results. Based on the overall results for both the small and large benchmark problems, it is concluded that the participants' complex-mode time history analysis methods provide results comparable to those generated by the benchmark direct integration time history analysis methods and are acceptable.

3. For the smaller benchmark problems nos. 1, 2, and 3, the complex-mode response spectrum analysis results provided by S&A, Igusa, & Gupta showed larger deviations when individual load case results were compared against the corresponding BNL direct integration time history analysis results. However, due to inherent differences between response spectrum and time history analysis methods, exact one-to-one correspondence of solutions is not expected for a specific load case. In comparing response spectrum to time history analysis results, one should expect that the average responses using a suite of input ground motions should be close to the responses from the corresponding response spectrum analysis. For this benchmark program, using a suite of seven earthquake input motions, it was shown that the mean ratios of participants' to BNL responses were in reasonably good agreement with the BNL results. All methods predicted conservative displacements and forces. Based on these results, it is concluded that for these problems, the participants' complex-mode response spectrum analysis methods provide reasonably accurate and generally conservative results.

4. For the larger benchmark problems nos. 4a and 4b, the comparisons of complex-mode response spectrum analysis results provided by S&A, Igusa, & Gupta to BNL time history results were generally consistent with the smaller problem comparisons. Based on the overall results for both the small and large benchmark problems, it is concluded that the participants' complex-mode response spectrum analysis methods provide reasonably accurate and generally conservative results.

5. For the smaller benchmark problems, parametric studies were performed by varying model properties to investigate potential limitations of alternate analysis methods in predicting the response of coupled systems with: (a) tuned, near-tuned and untuned

subsystems; (b) low to high subsystem mass ratios; and (c) low to high secondary system damping. The complex-mode time history analysis methods provided very good agreement with the benchmark results over the entire range of parameter variations. The response spectrum analysis methods showed larger deviations but since the comparisons were based on single earthquake input motions, it is not possible to determine whether the deviations are due to the parametric variations or to the normal differences in results due to the different analysis methods. It is reasonable, however, to assume that the findings and conclusions from the modal time history analysis parametric studies can be extended to response spectrum analysis. On that basis, no significant limitations were identified within the range of frequency and mass ratios investigated. Based on limited trends in the data and currently accepted practice, it would be prudent to limit the damping ratio to 20%.

6. The solutions provided by Chen using the classical response spectrum method with composite modal damping provided interesting comparisons with the non-classical complex mode method solutions. For the small benchmark problems nos. 1, 2, and 3, Chen's results were comparable and in several cases slightly better than the responses generated using the complex-mode based response spectrum methods. However, for the larger, more complicated coupled models of benchmark problems 4a and 4b, the results showed much larger deviations with significant over-prediction of responses in many locations. The reason for these inconsistent findings is not clear and warrants further investigation.

Based on the results of this benchmark program, the following principal conclusions and recommendations are made with respect to the acceptability and application of the complex-mode and normal-mode solution methods to non-classically damped coupled systems:

1. The complex-mode time history analysis methods applied by Stevenson and Associates, Igusa and Der Kiureghian, and Gupta, Gupta and Bose are acceptable methods for predicting the seismic response of non-classically damped coupled nuclear power plant (NPP) structures, systems and components when the ground input motion is defined as an acceleration time history. The complex-mode methodology is based on well-established theoretical principles and the close agreement between the participants' solutions and the BNL direct integration time history analysis solutions has validated each participant's implementation and application of the basic methodology.

2. The complex-mode response spectrum analysis methods applied by Stevenson and Associates, Igusa and Der Kiureghian, and Gupta, Gupta and Bose are acceptable methods for predicting the seismic response of non-classically damped coupled NPP structures, systems and components when the input motion is defined as an acceleration response spectrum. By comparing individual participant response spectrum solutions to corresponding BNL time history solutions for a suite of earthquakes and averaging the ratios of results, it was shown that the participant methods provided reasonably accurate and generally conservative results consistent

with the accuracy of classical normal mode response spectrum analysis methods. The S&A RSM-I, Igusa, and Gupta methods provided generally closer agreement than the S&A RSM-II method.

3. The classical normal-mode response spectrum analysis method with composite modal damping as applied by Chen has been considered an acceptable method and has been previously applied in seismic design analysis of non-classically damped coupled NPP structures, systems and components for coupled subsystems with different modal damping ratios. In this program, the smaller problem solutions were in good agreement with the BNL benchmark solutions, and the larger problem solutions were generally very conservative.

4. For both the complex-mode and normal-mode methods, the modal damping values of either the primary or secondary system of the coupled model should be in accordance with regulatory requirements and should not exceed 20%.

5. For NPP structures, systems and components, both the complex-mode and normal mode analysis methods must be implemented in accordance with the requirements of the USNRC Standard Review Plan and Regulatory Guides for seismic analysis. For complex-mode methods, care must be applied in properly formulating the coupled system damping matrix, estimating the relative velocity-based response spectrum, and using appropriate modal combination procedures. In addition, since coupled analyses do not require the generation of floor response spectra, the effects of variations in seismic response due to modeling uncertainties normally addressed by the floor spectrum broadening requirements, need to be appropriately considered.

The primary goal of this benchmark program was to evaluate the acceptability of state-of-the-art complex-mode analytical methods for predicting the seismic response of coupled NPP structures with non-classical damping. The program goal was achieved by demonstrating that the methods provide results which are comparable to those obtained using the direct integration time history analysis method which has been long been considered an acceptable "exact" method of seismic analysis in the nuclear industry. In addition, during the course of this program, a significant amount of analytical data was generated using a variety of state-of-the-art analysis methods and computer programs. Additional studies to systematically investigate and evaluate the key elements of each method against the results could provide valuable insights and identify critical areas for improvement of seismic analysis methods. Suggestions for additional studies are presented and discussed in Section 5.0 of this report.

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- Professors T. Igusa of Johns Hopkins University and Professor A. Der Kiureghian of University of California at Berkeley,
- Drs. A. Berkovski, O. Kireev, V. Kostarev and J. Stevenson of Stevenson and Associates, Russian Office (S&A)

for volunteering their own resources to participate in this benchmark program. Their efforts, cooperation and invaluable contributions to this program are gratefully appreciated.

Last but not the least, the authors wish to express their sincere appreciation to Dr. R. P. Kennedy and Professor A. S. Veletsos who provided independent review of the benchmark process, and guided this benchmark program to a successful conclusion.

1.0 INTRODUCTION

This report describes the benchmark program for the evaluation and verification of state-of-the-art analysis methods and computer programs for performing seismic analyses of coupled structures with non-classical damping. The program was developed by Brookhaven National Laboratory (BNL) under contract to the US Nuclear Regulatory Commission (NRC), Office of Nuclear Regulatory Research. The benchmark program was developed in two phases. Under Phase I, a series of benchmark problems that cover various aspects of application and complexity of typical coupled nuclear power plant (NPP) structures with non-classical damping were first developed. These benchmark problems were subsequently analyzed by BNL using the direct integration time history analysis method with a rigorous formulation for the explicit damping matrices. A preliminary report, which included the detailed descriptions of the benchmark problems, the BNL analysis method, and the necessary inputs, was distributed to the program participants of alternate state-of-the-art analysis methods for their independent analyses. In Phase II of the program, the analysis results were submitted to BNL by the participants. These results were then compared to and evaluated against the BNL "exact" solutions. This report provides the participants' analysis results of the benchmark problems and their comparisons to the BNL solutions. The report also provides the evaluation of the analysis methods applied by the participants, and the findings with respect to the applicability and limitations of various alternate state-of-the-art analysis methods to coupled NPP structures with non-classical damping.

1.1 Background

Conventional nuclear industry practice for analyzing and evaluating the seismic response of equipment or piping systems contained within NPP building structures generally involves a two-step process. In the first step, a mathematical model of the building structure (or primary system) is developed and analyzed to the seismic ground motion to obtain the floor level responses. In the second step, a separate mathematical model of the secondary system (equipment or piping) is developed and analyzed using the floor level support point responses from the building analysis as seismic input motion. This uncoupled analysis approach provides acceptable results as long as interaction effects between the primary and secondary system are insignificant. This has generally been assumed to be the case for secondary systems in which the mass is small compared to that of the primary system. However, in recent years, researchers (Refs. 1, 2, 3 and 4) have demonstrated that under certain conditions, interaction effects can be significant, even for very light secondary systems. For these systems, a coupled analysis would be desirable and may provide more accurate results.

While a coupled analysis may be performed by developing a mathematical model of the combined primary/secondary system and applying the same conventional finite element analysis techniques, a complication is encountered when the subsystems have different damping characteristics. In conventional analysis of NPP structures, it is generally assumed that damping may be defined in terms of modal damping ratios for different types of structures. These damping ratios are based on experimental data and prescribed in regulatory guidelines (e.g., 7% damping for reinforced concrete structures, 4% for welded steel structures, etc.). Systems in which damping can be defined in this manner are classically damped. The equations of motion of a classically damped system can be transformed into a set of independent modal equations by using their undamped frequencies and mode shapes, and traditional modal superposition methods can be applied to obtain their solution. However, when two or more subsystems with different modal damping ratios are coupled, the combined system is no longer classically damped. For these non-classically damped systems the transformed modal equations are not independent because they are coupled by the off-diagonal terms in the damping matrix. These equations cannot be solved by the traditional modal superposition methods.

In the nuclear industry, coupled seismic analysis of major subsystems with different damping (such as the NSSS system and Reactor Building) has been performed by applying approximate schemes (Refs 5, 6, 7 and 8) to estimate equivalent modal damping ratios of the coupled system as weighted sums of the component damping ratios based on some weighting functions using the component mass or stiffness or combination of both. While these methods may provide reasonable approximations of the diagonal terms of the damping matrix, they ignore the effects of the off-diagonal terms. In more recent years, more rigorous approaches have been developed based on a method first proposed by Foss (Ref. 9) in which the equations of motion of the non-classically damped systems are uncoupled by a transformation to the damped modal coordinate system. Unlike the traditional methods, the solution involves complex valued eigenvalues and eigenvectors (Ref. 10). In contrast to classical response spectrum methods, in addition to a displacement spectrum input, the response spectrum methods for non-classically damped systems require a velocity spectrum input, which is not explicitly provided in design practice. These newly evolved methods appear more powerful, but are mathematically more complicated, and require greater computational effort than the traditional methods, and to date have not been widely applied or accepted for general use in the nuclear industry. While current regulatory requirements do not prohibit the use of coupled analysis, there is no guidance on the implementation of these new methods. From the regulatory standpoint, it is important to understand the applicability and limitations of these methods to assure that they produce reasonable results with acceptable safety margins.

1.2 Scope and Objectives

The objective of this program is to evaluate state-of-the-art methods for performing seismic analysis of coupled NPP structures with non-classical damping. The program is focused on the analysis of a coupled primary-secondary system consisting of two subsystems with different modal damping ratios. A typical NPP application is the seismic analysis of a coupled model of a piping system with 2% damping supported by a reinforced concrete building with 7% damping. In order to evaluate the methods, BNL developed a series of benchmark problems designed to cover various aspects of application and complexity during Phase I of the program. BNL generated a series of "exact" solutions to these problems using the direct integration time history analysis method. Developers of alternate analysis methods were invited to apply their methods to analyze the benchmark problems and provide solutions for comparison to the BNL solutions. Eleven organizations originally accepted the BNL invitation and a preliminary report that contained a series of benchmark problems, necessary input data and the reporting formats for the analysis results were distributed to these participants. Four participants have returned their analysis results in the required format to BNL. They include: C. Chen of Apollo Consulting, Inc. (Apollo), A. K. Gupta, A. Gupta and M. K. Bose of North Carolina State University (NCSU), T. Igusa of Johns Hopkins University and A. Der Kiureghian of University of California at Berkeley, and A. Berkovski, O. Kireev, V. Kostarev and J. Stevenson of Stevenson and Associates, Russian Office (S&A). In Phase II of the program, the analysis results were then compared to and evaluated against the BNL "exact" solutions. This report provides the participants' analysis results of the benchmark problems and their comparisons to the BNL solutions. The report also provides an evaluation of the analysis methods applied by the participants, and the findings with respect to the applicability and limitations of various alternate state-of-the-art analysis methods to coupled NPP structures with non-classical damping. It is expected that the findings and recommendations from this program will be used to develop new acceptance criteria to provide NRC staff guidance for evaluation of future licensing submittals involving the application of these alternate analysis methods.

1.3 Benchmark Program Process and Report Organization

BNL selected the direct integration time history analysis method to develop the "exact" benchmark problem solutions for this program. This methodology has been widely used and accepted in the nuclear industry for applications requiring dynamic analysis of linear and nonlinear systems. In order to apply this method to non-classically damped coupled systems, BNL developed a formulation for generating the fully populated damping matrix of the coupled system from the damping ratios of its subsystems. This formulation, which is described in detail in Appendix B, was programmed into a series of preprocessor codes. BNL then modified the SAP V program to accept and apply the fully populated damping matrix in a direct integration time history analysis of the coupled model. Finally, the methodology and programs were tested and verified by comparison to other published solutions.

Four benchmark problem configurations were developed for this program. The problems were designed to investigate various aspects of problem complexity and application. They include three simple models and one complex model. For the simple models, a number of load cases were considered to test the applicability of various analysis methods to problems with different dynamic characteristics and input motions. The load cases cover variations in key parameters including secondary to primary system frequency ratio, mass ratio, different modal damping ratios and different earthquake input motions. The complex problem was designed to represent a typical NPP coupled building-piping system model with multiple support connections at different floor elevations. Complex model load cases involve mass variations to test the response of a flexible versus stiffer coupled system, and application of different earthquake input motions.

In order to capture the true dynamic characterization for the earthquake response of structures, the seismic ground inputs to the benchmark models were defined in terms of a series of recorded earthquake ground motion time histories. In this context, the BNL direct integration time history analysis method is, therefore, considered an appropriate approach for generating the "exact" solution to the benchmark problems. However, in design practice, seismic loads are commonly defined by response spectra and the response spectrum methods are utilized for the structural response. To this end, in addition to providing the earthquake ground motion time history inputs (in terms of acceleration, velocity and displacement), the corresponding acceleration response spectra for damping ratios ranging between 2% to 20% were also generated and provided to the participants. Although these response spectra were presented in terms of the true maximum acceleration of the mass of the system instead of the pseudo-acceleration as is typically used in the response spectrum methods, it is believed that the pseudo and true acceleration spectra would be considered the same for practical purposes and, as indicated in the Preliminary Report, the difference occurs only in highly damped, low frequency (less than 2.0 Hz) spectral values. Such differences should not affect the benchmark analysis since the fundamental frequency of the BNL benchmark models is at least 2.5 Hz or higher. Furthermore, the participants were allowed to generate their own response spectra based on the time history inputs that BNL provided. In addition to the set of recorded earthquake ground motion time histories, based on a recommendation of several experts, an artificial time history compatible to the Regulatory Guide 1.60 spectrum was added to the set of earthquake ground inputs to the benchmark models.

All necessary input information needed by participants to develop their own identical or equivalent benchmark problem models and apply their own methods and programs to perform the seismic analyses and generate solutions for comparison to the BNL solutions were provided in the preliminary report. To facilitate the process, BNL also provided the model and earthquake input information to participants on floppy disks. Participants were requested to apply their own methods and computer programs to perform the analyses and provide the results to BNL in the format specified in the preliminary report. BNL compared the participants' responses to the corresponding BNL responses for all problems. In order to streamline the comparison process, BNL requested participants to tabulate the results in a spreadsheet program format (MS Excel or equivalent) and provide the tables on floppy disks in addition to a hard copy.

It was anticipated that participants would be primarily interested in benchmarking design analysis methods based on the response spectrum analysis method. Since the BNL "exact" solutions were generated by time history analysis, multiple load cases were generated to allow for parametric studies of effects such as frequency ratios, mass ratios and damping. The comparisons were made in terms of the ratios of participant response to the corresponding BNL response at each location for each problem. In addition, BNL recognizes that for any single earthquake input motion, a response spectrum analysis and a time history analysis would generally not give identical results. Therefore, additional sets of load cases were defined using a suite of ground motions as inputs to the same baseline structural model, and for each load case, the participants' solutions were compared to the "exact" solutions. The mean and standard deviation of the response comparisons over the suite of ground motions were then calculated for each benchmark problem, as well as maximum ratios and minimum ratios of the response comparisons.

Participants interested in benchmarking time history analysis methods instead of or in addition to response spectrum analysis methods were requested to provide either or both sets of results to BNL for comparison. Three participants (Gupta, Igusa and S&A) provided both response spectrum analyses and modal superposition time history solutions.

This report is organized in five sections: Introduction, The description of benchmark problems and the BNL solution method, Description of methods by participants to produce their independent solutions, Comparisons and Evaluations of the benchmark analysis results, and Conclusions and Recommendations. Section 2 provides a description of the BNL method to produce the "exact" solutions for the benchmark problems. It also provides the benchmark models including both structural and material data, the load cases defined to account for various parametric effects (e.g. frequencies, masses, and damping) and different ground motion effects for benchmark problems. Finally, the ground rules defined for the benchmark process are provided.

Section 3 provides brief descriptions of methods utilized by participants to obtain their independent solutions to the benchmark problems. The aspects of formulation in each method that affect the dynamic response of non-classically damped systems such as complex modes, non-classical damping, approximation of velocity spectrum input, and modal combinations are discussed. However, since the participants have described and documented, in their reports to BNL, the methodologies including formulations and the response results for all benchmark problems in thorough detail, the formulations themselves are not reiterated in this section. Nonetheless, the participant's reports are included as attachments to this report.

Section 4 provides comparisons and discussions of results, which include nodal displacements and element forces. In addition to comparisons for single ground motion, statistical estimates such as mean and coefficient of variation (COV) are provided for a suite of ground motions inputs, as well as maximum ratios and minimum ratios of the responses. The result comparisons are presented in both graphical and tabular formats. Due to the tremendous amount of data generated for the problems 4a and 4b, only selective response parameters were compared and included in this section, However, for completeness and future use, the entire response results produced by BNL for all benchmark problems are included in an appendix to this report.

Finally, conclusions drawn and insights gained from the benchmark comparisons, as well as recommendations are provided in Section 5.

2.0 DESCRIPTION OF BENCHMARK PROBLEMS AND THE BNL SOLUTION METHOD

This section provides a description of the benchmark models including both structural and material data, the load cases considered to account for various parametric effects (e.g. frequencies, masses, and damping) and a suite of ground motions to be applied for benchmark problems. It briefly discusses the BNL method to produce the "exact" solutions for the benchmark problems. The detailed formulation of the BNL solution including the theoretical basis for the explicit damping matrix of coupled non-classical systems is included in Appendix B. This section also provides the ground rules defined and exercised for the benchmark process.

2.1 Description of BNL Benchmark Problems

This section describes the structural models of the benchmark problems and analysis load cases. Since the primary objective of this program is to evaluate state-of-the-art analysis methods for seismic evaluation of coupled structures with non-classical damping typically encountered in nuclear power plant facilities, the emphasis of the structural modeling for the benchmark problems is focused on coupled two-component P-S systems.

Four benchmark problem configurations have been developed for this program. They include three simple models and one complex model, each representing a coupled two-component P-S system. The dynamic properties of the models are representative of NPP structures, systems and components. As described in the previous section, a modified version of the SAP V program was used to generate the models and perform the direct integration time history analysis utilizing the fully populated damping matrix generated by the synthesis formulation using the BNL preprocessor program. For each simple model, a number of load cases covering variations in model properties were analyzed. In addition, for all configurations, multiple load cases were analyzed for different earthquake loads corresponding to both real and artificial earthquake records.

2.1.1 Benchmark Problem No. 1

This problem is representative of a simple model of an NPP building and base-supported equipment as illustrated in Figure 1. The primary component (building) model consists of weightless shear beam elements and lumped masses and is fixed at the ground. The model has five degrees of freedom with each node free to translate in one horizontal direction. The secondary component model consists of four weightless shear beam elements and four lumped masses. The model has four degrees of freedom with each node free to translate in one horizontal direction. The base of the secondary component is coupled to a mid-elevation primary component node. Therefore, there is no effect of constraint modes on the secondary component damping. For simplicity, each model has equally spaced nodes with equal nodal masses and equal element stiffness properties. The shear beam elements are modeled using a standard 3-D beam element in SAP V by prescribing shear modulus G and shear area A_{shear} of the element so that the shear stiffness K_{shear} of the beam is determined by the relation: $K_{shear} = A_{shear} x G/L_e$, where L_e is the length of the beam. Other properties associated with flexural deformations of the beam element, such as bending and torsional moments of inertia, are preset to significantly large values so that those flexural deformations would be effectively removed. All degrees of freedom associated with rotation and with translation in the other two directions were constrained. For the baseline model, properties were selected to provide fundamental frequencies of 5 Hz for both the uncoupled primary component and the uncoupled fixed-base secondary component. Natural frequencies for the primary component and for all secondary component load cases are tabulated in Tables 3 and 4. The ratio of secondary/primary (S/P) component mass was selected as .005 (on an individual mass basis) for the baseline model. Modal damping ratios of 7% for the uncoupled P-component and 2% for the uncoupled fixed-base S-component were assigned to the baseline model. The El Centro (1940) earthquake record was selected as input to the baseline analysis load case.

In order to investigate the applicability of various analysis methods to problems with different dynamic characteristics and input motion, additional load cases were analyzed to cover a range of parameter variations including secondary to primary system frequency ratio, mass ratio, different modal damping ratios, and different earthquake input motions. A total of sixteen load cases were selected to account for different parametric variations, and six real earthquake records plus one artificial acceleration time history compatible to the Regulatory Guide 1.60 spectrum were used as ground motion inputs. Table 1 provides the matrix of load cases covering the parametric variations that were analyzed for the benchmark problem.

2.1.2 Benchmark Problem No. 2

This problem is representative of a simple model of an NPP building and multiply supported piping system as shown in Figure 2. This model is also composed of weightless shear beam elements and lumped masses. The primary component has five degrees of freedom and is identical to the primary component defined in Problem No. 1. The secondary component consists of eight shear beam elements and six lumped masses. It has six degrees of freedom with each node free to translate in one horizontal direction. The secondary component model is connected to the primary system building model at three different nodal elevations. Therefore, two redundant constraints due to the P-component exist in this system. As in the first problem, each model has equally spaced nodes with equal masses and equal element stiffness properties and the modeling considerations are the same as for the first problem. The baseline model primary and multiply supported secondary uncoupled components have fundamental frequencies of 5 Hz. Natural frequencies for the baseline and other load cases are tabulated in Tables 3 and 5. The ratio of secondary to primary system mass (on an individual mass basis) is .005 for the baseline model. Modal damping ratios are 7% for the uncoupled primary system and 2% for the uncoupled multiply supported secondary component. The El Centro (1940) earthquake record was selected as input to the baseline analysis load case.

In addition to the baseline model analysis, the same number of parametric variation load cases as for Problem No. 1, as shown in Table 1, were analyzed.

2.1.3 Benchmark Problem No. 3

The third benchmark problem is shown in Figure 3. This problem also represents a simple coupled model of a building and multiply supported piping system. However, in this case, the secondary component is attached to the building at two elevations and to the ground. Both the building and piping system are subjected to the same ground motion at their ground support points. As in the first two problems, this model is composed of weightless shear beam elements and lumped masses. The primary component has five degrees of freedom and is identical to the primary component defined in the first two problems. The secondary component is identical to that of the second problem except for the support points. As in the previous problems, the baseline model primary and multiply supported secondary uncoupled components have fundamental frequencies of 5 Hz. Natural frequencies for all load cases are tabulated in Tables 3 and 6. The ratio of secondary to primary component mass (on an individual mass basis) is .005 for the baseline model. Modal damping ratios are 7% for the uncoupled primary component and 2% for the uncoupled multiply supported secondary component. The El Centro (1940) earthquake record was applied as input to the baseline analysis load case. In addition to the baseline model analysis, the same number of parametric variations load cases as for Problems No. 1 and No. 2, as shown in Table 1, were analyzed.

2.1.4 Benchmark Problem No. 4a and 4b

The fourth benchmark problem is shown in Figure 4. This model is representative of a realistic complex model of a coupled NPP building and piping system which utilizes the same type of elements that would be used in a design analysis. In this problem, the primary system (building model) consists of eight weightless 3-D flexural beam elements and eight lumped masses. Each node has six degrees of freedom and the bottom node is fixed. The secondary component (the piping model) consists of twenty-three straight and curved SAP V piping elements. Each node also has six degrees of freedom. The pipe is supported by anchors at its end points (nodes 9 and 32) and by two-directional guides at intermediate points (nodes 12, 16, 21, 25 and 28). Rigid weightless beam elements are used to support and couple the piping system to the building as shown in Figure 4. To model the guide constraints, the SAP beam element end release option is used at the piping connection points to provide translational restraint in two directions perpendicular to the axis of the pipe. At the anchor points (nodes 9 and 32), the rigid beams provide full six-degree of freedom constraint. The model uses realistic piping and building material and cross-sectional properties. The properties and support configuration were selected to provide equal fundamental frequencies for the uncoupled building and the uncoupled piping system. Two configurations were selected, which provide uncoupled fundamental natural frequencies of 8.24 Hz (No. 4a) and 4.60 Hz (No. 4b), respectively. Tabulation of natural frequencies for the uncoupled building and the uncoupled piping system is provided in Tables 7 and 8 for the No. 4a, and Tables 9 and

10 for the No. 4b. The pertinent material properties used for the benchmark problem No. 4a are given below:

- For the building: Young's modulus E = 3000 ksi
  Poisson ratio = 0.2
  Nodal mass = 10.0 kips-sec^2/in;

- For the piping: 12-inch schedule 40S
  D = 12.75 inches
  t = 0.375 inches
  Young's modulus E = 30000 ksi
  Poisson ratio = 0.3
  Weight density: $w = w_m + w_w$
  =49.6 lb/ft + 49.0 lb/ft
  = 98.6 lb/ft
  = 0.00822 kips/in
  Piping elbow R = 18.0 inches.

And for the benchmark problem No. 4b:

- For the building: Young's modulus E = 3000 ksi
  Poisson ratio = 0.2
  Nodal mass = 32.1 kips-sec^2/in;

- For the piping: 12-inch schedule 40S
  D = 12.75 inches
  t = 0.375 inches
  Young's modulus E = 30000 ksi
  Poisson ratio = 0.3
  Weight density: w = 0.02644 kips/in
  Piping elbow R = 18.0 inches.

Modal damping ratios of 7% for the uncoupled building and 2% for the uncoupled multiply supported piping system were assigned.

The input ground motion is applied at the base of the primary component (node 1 in Figure 4), in the **global Y direction for the benchmark problem No. 4a**, and in the **global X direction for the benchmark problem No. 4b**. The El Centro (1940) earthquake record was used as input to the baseline analysis load cases. In addition to the baseline model analysis, six other load cases using another six different ground motion inputs and the same baseline structural and damping properties were analyzed as shown in Table 2.

In addition, the forces and moments of the 3-D beam elements are defined following the sign convention depicted in Figure 5. Piping elements of tangent and bend types have their forces and moments defined in accordance to the sign convention shown in Figure 6 for the tangent type, and Figure 7 for the bend type.

2.2 Ground Motion Inputs

In order to adequately evaluate the performance of the state-of-the art methods in predicting the structural response induced by real earthquakes, six recorded earthquake ground motion acceleration time histories plus one artificial acceleration time history compatible to Regulatory Guide 1.60 response spectrum were selected based on the expert recommendation as ground inputs to the BNL benchmark problems. The Reg. Guide 1.60 compatible time history was generated using an in-house program CARES (Ref.11). For each input, the corresponding response spectrum (absolute acceleration vs. frequency) is provided in plot and tabular format. The tabular forms of the response spectra are provided in this section. The plots of input response spectra, together with the corresponding acceleration time histories are included in APPENDIX A.

The six recorded earthquake ground motions and one artificial acceleration time history compatible to the 5.0% damped Regulatory Guide 1.60 response spectrum were selected for the BNL benchmark problems. The recorded earthquakes are numbered sequentially as follows:

Input ground motion No. #1: EL CENTRO, SOOE (1940)
Input ground motion No. #2: TAFT COMP. S69E (1952)
Input ground motion No. #3: OLYMPIA COMP. N86E (1949)
Input ground motion No. #4: EL CENTRO COMP. S40E (1979)
Input ground motion No. #5: LOMA PRIETA, FOSTER CITY (1989)
Input ground motion No. #6: NORTHRIDGE COMP. N30W (1994)

and one artificial acceleration time history:

Input ground motion No. #7: ARTIFICIAL ACCELERATION TIME HISTORY

All seven input ground motion time histories were baseline corrected, and their response spectra for 2.0, 5.0, 7.0 and 20.0 percentage damping were generated and provided to the participants.

2.3 BNL Method for "Exact" Solutions to Benchmark Problems

To obtain the exact solutions to the benchmark problems, BNL selected the step-by-step direct integration time history analysis method. This methodology has been widely used and accepted in the nuclear industry for applications requiring dynamic analysis of linear and nonlinear systems, and is considered to produce exact solutions as long as the appropriate convergence criteria are enforced. In order to apply this method to non-classically damped coupled systems, BNL developed a formulation for generating the fully populated damping matrix of the coupled system from the damping ratios of its subsystems. This formulation, which is described in detail in Appendix B, was programmed into a series of preprocessor codes. BNL then modified the SAP V program to accept and apply the fully populated damping matrix in a direct integration time history analysis in the same manner as the mass and stiffness matrices of the coupled system. For the BNL benchmark problems, the Wilson-Θ method (Refs. 12, 13) via SAP-V program is used to perform the numerical integration. The advantage of this method is that it is unconditionally stable. As a matter a good practice, the time step should not exceed 1/10 the shortest period of interest to correctly account for the missing mass effects and $\Theta = 1.4$ is used.

The formulation for the generation of system level damping matrix for non-classically damped systems is based on a synthesis technique that has been used extensively in the literature. The concept of synthesis was first applied to structural dynamics by Hurty (Ref. 14) to compute the properties of a structural system comprised of multiply connected components by synthesizing the properties of its components. The BNL formulation for the system damping of a coupled structure includes: 1) establishment of component kinematic transformation to physically distinctive structural modes for which damping can be clearly identified, 2) synthesis process for the component damping using the component kinematic transformation to automatically integrate all damping associated with the physically distinctive structural modes into the component damping, and 3) transformation of component damping to the global system damping. The BNL formulation for damping matrix and associated programs were tested and verified by comparison to other published solutions for non-classically damped structures.

2.4 Benchmark Program Ground Rules

In order to succeed in all phases of benchmarking effort, certain ground rules had to be established for all participating organizations to ensure that the benchmark process would move in an orderly fashion. A preliminary report (Ref. 15), which documented all benchmarking models and the BNL formulation for the exact solutions, was provided to all individuals and organizations interested in benchmarking their methods and computer programs for performing seismic analysis of nonclassically damped coupled systems against the NRC sponsored BNL benchmark problem solutions. All of the necessary input information needed by participants to develop their own identical or equivalent benchmark problem models and perform the seismic analyses was contained in this report. To facilitate the process, BNL also provided the model and earthquake load information to participants on floppy disks. Participants were asked to apply their own methods and computer programs in their entirety to perform the analyses. This includes the formulation of the coupled system damping matrix from the given modal damping ratios of the subsystems. Participants were requested to provide their results for both primary and secondary components (maximum nodal displacements, element forces and moments) to BNL in the format given in the Preliminary report. Pipe support forces for problems No. 4a and No. 4b were also requested as maximum joint element forces and moments. In order to streamline the comparisons, participants were requested to tabulate their results in a spreadsheet format (**MS Excel** or equivalent) and provide them on floppy disks in addition to a hard copy.

It was anticipated that most participants would apply complex eigenvalue response spectrum analysis techniques based on the method originally proposed by Foss. However, this benchmark program was not limited to those methods. Participants were allowed to apply any exact or approximate method that is appropriate for solving this type of problem. Participants, who were interested in benchmarking their complex eigenvalue response spectrum methods, could also perform the corresponding modal superposition time history analysis in support of their methodology, and provide the analysis results to BNL.

A suite of earthquake input motions for each problem as acceleration time histories and the corresponding unbroadened response spectra calculated by BNL from the time histories were provided to the participants. The response spectra were computed for four different damping ratios at frequency increments based on the guidelines given in NRC Regulatory Guide 1.122. This input could be used directly to perform time history or response spectrum analyses. Participants could also use the time history information to generate their own ground response spectra but the spectra should not be broadened or smoothed. However, if a response spectrum method was applied, participants were required to base the analysis on the ground response spectrum input and should not use the specific earthquake time history in the analysis. For example, participants who apply complex eigenvalue response spectrum methods may need two sets of spectra based on relative velocity and relative displacement. The relative velocity spectra should be estimated from the input ground spectra in accordance with their analysis method rather than calculated from the time history input motion. At their option (but not as an alternative), participants could perform additional analyses to calculate and apply the relative velocity spectra from the time histories, and provide those results to demonstrate the accuracy of their method for estimating the spectra.

In addition to providing the solutions, participants were requested to provide a detailed description of their analysis method and computer program suitable for inclusion in the final report (**MS Word format**). The description should clearly explain the analytical formulation and should identify and explain the basis for the key assumptions and approximations incorporated in the methodology. It should describe the method for developing the coupled system damping matrix from the modal damping ratios of the subsystems. It would be desirable for participants to illustrate their method by providing examples of the governing equations of motion (specifically, the stiffness and damping matrices) for the three simple models (load cases 1a, 2a, and 3a). For complex eigenvalue response spectrum analysis, participants were asked to describe the method for estimating the relative velocity-based response spectrum from the relative displacement-based ground spectrum, the modal combination method, and the method for treating high frequency modes (missing mass effects).

Upon receipt of the participants' results, BNL compared all results by calculating the response ratios (participant response/BNL response) for all load cases. The mean and COV of each response ratio was determined for each benchmark problem. An acceptable method was expected to provide a mean ratio close to one and a small COV. The results of the comparisons were provided to the participants for their review and comment. When significant differences in solutions were found, BNL requested additional information to explain the differences. Participants were given the opportunity to correct any obvious errors and resubmit their results. They also had the option of withdrawing their solutions and participation in the program at any time.

3.0 DESCRIPTION OF METHODS APPLIED BY PARTICIPANTS TO OBTAIN BENCHMARK SOLUTIONS

Since the objective of the benchmark program is to evaluate methods that were used by participants to produce solutions to the benchmark problems and to gain understanding regarding applicability and limitations of these methods, it is essential that these methods and the associated theoretical bases and assumptions used or implicitly applied be examined and clearly understood. This section provides a brief description of the methods utilized by participants to obtain their independent solutions to the benchmark problems. The aspects of formulation in each method that affect the dynamic response of non-classically damped systems such as complex modes, non-classical damping, approximation of velocity spectrum input, and modal combinations are discussed. However, since the participants have described and documented in their reports to BNL in thorough detail the methodologies, including formulations and the response results for all benchmark problems, the formulations themselves are not reiterated in this section. Nonetheless, the participants' reports are included as attachments to this report.

3.1 Chen's Method

To produce solutions to the benchmark problems, Chen performed coupled analyses based on the classical normal mode method, which he has discussed in numerous conferences (Refs. 16, 17 and 18). The calculation of damping for the coupled structure is based on energy principle, either with strain energy using stiffness matrix or with kinetic energy using mass matrix based on ASCE standard (Ref. 19). Although both methods are expected to produce similar results, strain energy method was applied for the damping calculation.

Many methods for modal combination in coupled analysis have been proposed in literature such as the Square Root Sum Squares (SRSS) method (Ref. 20 and 21) and modal combinations with cross coupling terms which can have positive or negative signs (Ref. 22 and 23). Chen applied Complete Quadratic Combination (CQC) method with cross coupling terms for the benchmark analyses. Chen also discussed the above methods in a 1972 symposium and pointed out that realistic modal responses for systems with close modes can be less than the straight root sum squares method due to negative cross coupling terms (Ref. 18). However, at that time the observation was based on a single time history. The current BNL benchmark program provides the opportunity to test multiple time histories.

In some seismic models, structural modal frequencies far exceed the frequency content of the input time histories. For these cases, the root sum squares combination breaks down because those high frequency modes behave more like rigid oscillators. Under this condition, rigid modes need be considered and the method described in the Appendix A of USNRC Standard Review Plan Section 3.7.2 is applied.

The specific program applied in the benchmark program is the PC version of STARDYNE-3.5, Version May0189. It calculates weighted modal damping values based on strain energy, and it applies cross coupling terms in the modal combination method. The responses are sensitive to the damping value assumed for the cross coupling term calculations for systems with close modes. The rigid mode contribution was handled by a user supplied MATHCAD post processor.

3.2 Gupta's Method

Gupta and colleagues (Refs. 24, 25 and 26) at NCSU developed a method to obtain the coupled frequencies, damping ratios and mode shapes of the nonclassically damped systems using the modal properties of the uncoupled primary and secondary systems. They simplified the Foss formulation (Ref. 9) by algebraically replacing the complex mode shape by two real modal vectors and further extended their formulation to the response spectrum method. Computer programs CREST and CREST-TH implement this method. CREST evaluates the coupled response by response spectrum method and CREST-TH by a time-history analysis. For benchmark problems 4a and 4b, CREST and CREST-TH were interfaced with the piping program PIPESTRESS (Ref. 27) for computing the response of the secondary component.

The Gupta method does not require formulation of the system damping matrix in time domain, since the equations of motion are first transformed in the modal coordinate system and only the modal damping of the coupled system need be computed. The system modal damping is obtained based on the fixed-constraint modal damping of its components, which are assumed to be classically damped. The component damping and system modal damping are related through a transformation that is obtained through a set of static constraints which provide kinematic dependencies relating the motion of the component to other components that constrain it via the constraints. It was shown by Xu (Ref. 28) that the system damping derived by Gupta's method, if transformed to time domain, assumes the same form reduced from the BNL method.

The complex eigenvalue solution is obtained in the modal coordinate system defined using the uncoupled mode shapes of the primary and the secondary systems. This results in a transformed eigenvalue problem which gives accurate eigenvalues and eigenvectors when all the modes of the primary and secondary systems are included in the analysis (Ref. 24). It also gives accurate results when the effect of the high frequency rigid modes of the two uncoupled systems is incorporated through residual modal vectors which are defined using constraints to the secondary system and treated as pseudo-static modal response (Ref. 25).

The modal response of the coupled system can then be represented by superposing the responses of a series of single-degree-of-freedom (SDOF) oscillators. The responses of a SDOF oscillator are calculated using the complex eigenvalue solutions. In contrast to classical normal mode methods which use the relative modal displacements to compute the system response, response of coupled systems is calculated requiring both the relative modal displacements and the relative modal velocities. This would pose some problems if response spectrum methods were used. For a given earthquake motion history, the procedure for obtaining the velocity response spectrum is straightforward. However, for design purposes, the displacement spectrum is specified, the velocity spectrum is not. Gupta had investigated the relationship between velocity spectrum and displacement spectrum for a suite of real earthquakes (Ref. 29), and established a procedure that enables one to estimate velocity spectrum from a given displacement spectrum. This procedure has been implemented in CREST program. It should be noted that the Gupta's procedure was based on a study of a given suite of earthquakes.

For the benchmark problems, Gupta and coworkers have performed both modal superposition time history and response spectrum analyses. For the time history analysis, the number of modes are included up to the cut-off frequency. The residual response in high frequency modes beyond the cut-off frequency (miss mass effect) is considered to be pseudo-static and computed straightforwardly from the system modal equations of motion by dropping the acceleration and velocity terms. The residual response is then combined algebraically with the time history response. This process for performing modal time history analysis is programmed into CREST-TH, which uses "piecewise exact" linear integration method developed by Nigam and Jennings (Ref. 30).

For the response spectrum method, in addition to the procedure for estimating velocity spectrum, a procedure for combining maximum modal responses is also required. The mode combination procedure developed by Megahed and Gupta (Ref. 31) is applied. The basic assumptions for the combination procedure are that the earthquake motions are ergodic and stationary process, and the formulations for the modal correlation coefficients were developed based upon improvements over others (Refs. 32, 33 and 34) and experimentation using actual earthquake motion data at NCSU. Residual response was incorporated into the modal combination procedure similar to the time history analysis (using frequency domain and maxima of the response). This modal combination procedure was implemented into CREST program, which was used to produce solutions for the benchmark problems.

3.3 Igusa and Der Kiureghian Method

The method used by Igusa and Der Kiureghian for the benchmark analysis is based on random vibrations of non-classically damped systems and reflects improvements on formulations for the correlation coefficients developed in their past research efforts (Refs. 35 – 41). The major improvement in the current method is that filtered white noise is used instead of white noise to determine the correlation coefficients. Therefore, seismic events can be modeled with non-stationary properties and maximum response, which is computed separately for each seismic event, can be compared directly with time history analysis.

The BNL formulation for the coupled system damping matrix was used by Igusa and Der Kiureghian in their analysis without modification. The formulation for complex-valued eigenvalue problem as proposed by Foss (Ref. 9) was employed by Igusa and Der Kiureghian and was solved using standard FORTRAN or MATLAB libraries. Therefore, the modal responses of the coupled system can be established in terms of a series of SDOF oscillators in a manner similar to Gupta.

For modal time history analysis, residual response after the cut-off frequency needs be addressed, and it is unclear how the residual response is treated in Igusa and Der Kiureghian method; a similar problem also exists for response spectrum analysis.

When the response spectrum method is applied, treatment of velocity response spectrum input and modal correlation coefficients require careful consideration in addition to residual response. Igusa and Der Kiureghian developed an approximation for the velocity response spectrum in terms of the displacement response spectrum and an equivalent natural frequency. The equivalent frequency is determined based on random vibration theory using a filtered white noise model for non-stationary seismic events. Details of the derivation for the equivalent natural frequency are provided in the Igusa and Der Kiureghian report to BNL (enclosed as Attachment to this report).

One of main differences between Igusa/Der Kiureghian method and others using standard random vibration theory for the determination of correlation coefficients is that Igusa/Der Kiureghian treated the seismic events as non-stationary processes. In the standard random vibration approach to modeling seismic motion, it is assumed that the ground accelerogram can be approximated by a stationary stochastic process. This approach is valid if the displacement response spectrum is averaged over many seismic motions with similar "frequency content." This is the approach used to determine the Kanai-Tajimi values for the two parameters, ω_g, and ζ_g (Refs. 42 and 43). With this approach, the two parameters of the filtered white noise would be obtained by fitting the square root of the spectral moment to the averaged displacement response spectrum. The expression for the maximum response, R, would be accurate under the following conditions: R is the average of maximum responses for many seismic motions with similar frequency content and the displacement response spectrum input is the average of response spectra for the same set of seismic motions. In the NRC/BNL Benchmark Program, the intent was not to consider averages for many seismic events with similar frequency content. Instead, the maximum response, R, was computed separately for each seismic event. Since the seismic events of interest had widely differing frequency contents, averaging would not be appropriate.

Random vibration theory could still be used for analysis of single seismic events. Implicit in such applications of random vibrations is the ergodic property of random processes (Ref. 44). The only difficulty is that single seismic events are non-stationary because the amplitude and frequency content vary with time. Time-dependent, "evolutionary" power spectral density functions can be used to model such seismic events (Refs. 45 - 47). However, it is necessary to perform time-series analysis of the seismic accelerogram. It is not possible to determine the time-dependent power spectral density function directly from the response spectrum. An alternate, simplified method was developed by Igusa and Der Kiureghian, which models single seismic events with non-stationary properties using the filtered white noise power spectral density. The model is determined using information only from the displacement response spectrum. The detailed description of the model is given in Igusa/Der Kiureghian report to BNL.

3.4 Stevenson & Associates Method

The method and analysis of the benchmark problem, which were prepared and carried out by the Stevenson & Associates (S&A), were contributed by Drs. A. Berkovski, O. Kireev, V. Kostarev and J. Stevenson. The basic formulation follows closely to that of Gupta (Ref. 29), such as the system damping and complex-valued eigen problem solution. The analysis for the coupled system was performed using in-house computer codes (Refs.48, 49). Three sets of analyses were performed: 1) modal time history integration, 2) response spectrum method with the exact correlation coefficients and maximum modal responses directly computed from the modal time history analysis (RSM-I), and 3) response spectrum method with approximation for correlation coefficients and the velocity response spectrum input (RSM-II). However, S&A report to BNL did not address the treatment of residual response for three sets of analyses.

The RSM-I analysis, which used the exact correlation coefficients and maximum modal responses directly computed from the modal time history analysis, is not a practical approach since it is generally assumed that when performing a response spectrum analysis, the corresponding modal time history responses are not available. However, the technique may be used for verification and validation of the computer codes.

The RSM-II analysis was performed based on approximations for correlation coefficients and the velocity response spectrum input. The formulation for correlation coefficients proposed by Igusa (Ref. 50) was applied. The pseudo velocity response spectrum was used in place of the velocity response spectrum. The detailed description of the S&A method is provided in their report to BNL (See Attachments).

4.0 BENCHMARK RESULTS AND COMPARISONS

This section of the report provides comparisons and evaluations of the benchmark results. Sixteen load cases were analyzed for each of benchmark problems Nos. 1, 2, 3, and seven load cases for each of benchmark problems No. 4a, No. 4b. Results from the first three benchmark problems include maximum nodal displacements and maximum element forces. Results from benchmark problems No. 4a and No. 4b, which were intended to represent realistic NPP building-piping systems, include nodal displacements in both translations and rotations, element forces and moments, and support forces in the coupling elements. The participants' analysis solutions were compared to the BNL's "exact" solutions by computing ratio of the participant maximum response to the BNL maximum response for each load case, except for moments in the piping elements for problems No. 4a and No. 4b. In conventional piping analysis, Square-Root-of-Sum-of-Squares (SRSS) of all three components of the maximum element moment are used to calculate stresses which are compared against code requirements. Therefore, for the secondary component of the benchmark problems No. 4a and No. 4b, the ratios are computed for the participant SRSS maximum moments to the corresponding BNL SRSS maximum moments. In addition to comparisons for single ground motion, statistical estimates such as mean and COV are also computed and evaluated for a suite of ground motion inputs, as well as the corresponding maxima and minima of the response ratios.

Before proceeding with the discussions of the benchmark results, which are included in Sections 4.2 – 4.5, a brief discussion on the structural modeling of the benchmark problems by participants is provided in the following section (Section 4.1). It should be made clear that the objective of the benchmark program is to provide a systematic benchmark evaluation of analysis methods for non-classically damped systems, not solicitation for the best structural models for the benchmark problems. Therefore, participants were expected to construct the structural models for the benchmark problems as close as possible to the BNL models.

4.1 Evaluation of Participant's Structural Models

To ensure that participants modeled the four benchmark problems in a manner that is consistent with the BNL structural models, the preliminary report (Ref. 14) issued during Phase I of the benchmark program provided the input information that BNL used to construct the benchmarking models. In addition, the preliminary report also included the fixed-base frequencies for all modes of both primary and secondary components for all benchmark problems. Review of the participants' reports to BNL indicates that for the first three benchmark problems, all participants achieved virtually identical structural models to BNL's.

For benchmark problems No. 4a and No. 4b, however, participants achieved identical structural models to the BNL's for the primary component. The secondary component, which is piping that is supported by the primary component, includes both straight sections and curved sections (elbows). Igusa/Der Kuireghian used the stiffness matrices that were supplied by BNL for their analyses. Therefore, no difference in structural modes between Igusa/Der Kuireghian and BNL is expected. Models of the piping elbows used by other participants could be different from that of BNL, due to the fact that different piping programs were applied. BNL modeled the piping elbows with SAP-V, which is based on the work by Poley (Ref. 51) and Hall et al. (Ref. 52). Other participants have used different programs such as PIPESTRESS, STARDYNE and dPIPE, etc. Since the stiffness formulation of bend elements is different from that of SAP-V and the other programs, the piping models developed with these programs are expected to show some differences. Chen and S&A modeled the piping with STARDYNE and dPIPE, respectively. Comparing the fixed-base frequencies of the secondary component, it indicates that the maximum difference between their models and the BNL models was about 7% in the fixed-base frequency of a particular mode. Gupta initially used PIPESTRESS for modeling the pipe elbows, which resulted in differences in the fixed-base frequency of up to 6%. Gupta later avoided the use of the bend element in PIPESTRESS and used the SAP-V elbow stiffness matrix directly, therefore achieving identical piping models to that of BNL. Past studies by Gupta (See Attachment) have shown that an error of 2% in the piping frequencies can result in much larger error in the piping forces and support reactions. This is consistent with the widely published observation that the error in frequencies is usually much smaller than the error in the corresponding mode shapes. It should also be pointed out that although the formulations are essentially the same between BNL and others for the benchmark problems, differences in mode shapes and frequencies of the piping could produce some unwanted numerical difference in the coupled damping matrix.

4.2 Benchmark Problem No. 1

The benchmark problem No. 1 was intended to assess the performance of different methods for seismic response of a P-S system with a single connection (NPP building and base-supported equipment). Sixteen load cases were analyzed, representing typical frequency ratios, different mass ratios, damping effects and different earthquake environments. Figures 8 through 29 provide graphical comparisons of nodal displacements, while the element shear forces are compared in Figures 30 through 51. The comparisons of nodal displacements and element shear forces are also provided in tabular forms: Tables 10 through 22 for nodal displacements and Tables 23 through 35 for element shear forces.

4.2.1 Modal Superposition Time History Methods

Three participants: S&A, Igusa/Der Kiureghian and Gupta et al, performed modal superposition time history analyses using complex modes. The nodal displacement results for load case a, which is the baseline model, were compared to the BNL results as shown in Figure 8. Comparison of the corresponding element shear forces is provided in Figure 30. As seen in these figures, both displacements and shear forces as predicted by the participants were in excellent agreement with the corresponding BNL "exact" solutions. For all three sets of results, the maximum deviation at all locations was within 0.5%.

Load cases b through j investigated variations of the baseline Problem 1 model with different dynamic characteristics. Load cases b though e varied the secondary system stiffness properties to evaluate responses in untuned and nearly-tuned coupled systems. These load cases included secondary to primary system frequency ratios of 0.5, 0.9, 1.1, and 2.0. The displacement comparisons are presented in Tables 10 through 12, and the shear force comparisons are presented in Tables 23 through 25. For these load cases, all participant solutions were in as good agreement with the benchmark solutions as the baseline tuned load case. Load cases f through h varied the secondary system masses to achieve secondary to primary system mass ratios of .0001, 0.1, and 0.5. A review of the load case ratios given in the same tables again shows excellent agreement through the wide range of mass ratios. In load cases i and j, the secondary system modal damping ratio was increased to 5% and to 20%. For both cases, all three participant solutions were in as good agreement as the baseline 2% case.

Load cases k through p subjected the baseline Problem 1 model to a series of six different earthquake input motions including five recorded earthquake time histories and one artificial time history corresponding to the Regulatory Guide 1.60 response spectrum. Ratios of participant to BNL solutions are presented in Tables 10 through 12 for displacements and in Tables 23 through 25 for shear forces. These load cases show all participant results to be in excellent agreement with the BNL displacement and shear force results.

In summary, for benchmark problem No. 1, three participants provided solutions based on modal superposition time history analysis methods using complex modes. Each participant applied a different computer program. By comparing these results to the BNL results which were generated by the direct integration time history analysis method, it was observed that all participants achieved nearly identical solutions. This observation was consistent over the sixteen load cases which covered significant variations in frequency ratios, mass ratios, damping ratios as well as different earthquake input motions.

4.2.2 Response Spectrum Analysis Methods

All four participants provided solutions for the sixteen Benchmark Problem No. 1 load cases using response spectrum analysis methods. Chen applied the classical normal mode method with composite modal damping based on the strain energy method as described in Section 3.1. S&A, Igusa, and Gupta applied their own variations of the complex mode method as described in Sections 3.2, 3.3 and 3.4. S&A provided two sets of solutions (RSM-I and RSM-II) using different correlation coefficients. The comparisons of participant to BNL results for all loads cases are given in Tables 13 through 17 for displacements and Tables 26 through 30 for shear forces. Figures 9 and 10 show comparisons of nodal displacement responses from load cases a and m, which correspond to the baseline structural model subjected to El Centro 1940 and 1979 earthquake ground motions, respectively. The corresponding element shear forces are given in Figures 31 and 32. These comparisons were designed to show how different methods perform when different ground motions are applied. As seen from these figures, for load case a, all participants predicted the displacement response within 10% compared to the BNL solutions, except for S&A RSM-II, which predicted responses as much as about 20% higher. Similar trends to the displacement results but of slightly higher magnitude are seen in the comparison of element shear forces.

For load case m, however, larger differences were observed. All methods underestimated both displacement and shear force responses of the primary component by about 10% to 20%, and overestimated the responses of the secondary component by 40% to 100% compared to the BNL solution, except for S&A RSM-II, which slightly overestimated the responses of the primary component. It was noted that Chen's classical mode method produced results that were comparable and in some cases slightly better than others.

The larger differences between the BNL time history results and the participant response spectrum results are not surprising. Due to inherent differences in the methodologies, exact one-to-one correspondence between a specific time history solution and the corresponding response spectrum solution should not be expected. One should expect that if several time histories and their corresponding response spectra were considered, the average of the time history responses should be in reasonable agreement with the response spectrum responses. This is not believed to be a concern associated with complex mode analysis. Gupta's report to BNL included a detailed study of load case m, and provided an insight into why this behavior occurred across all response spectrum methods. Since the system's response receives significant contribution from only the displacement part of response in the first two modes with closely spaced frequencies (5.4% apart), Gupta showed that that maximum responses in these two modes have opposite signs and occur at almost the same times. In a time history analysis such as the BNL's, the two maximum modal responses cancel each other. In the response spectrum analysis, the maximum responses in two modes are combined using calculated correlation coefficients. For this case, Gupta calculated the correlation coefficient equal to 0.7798. However, to obtain the same response as the time history analysis, the correlation coefficient should equal 0.9356. Gupta concluded that on a one-to-one basis, response spectrum methods can give responses that are significantly different from those of the time history analysis; however, the average responses using a suite of input ground motions should be close to each other for response spectrum methods and time history analysis.

To provide a more meaningful average comparison of the response spectrum versus time history results, load cases k through p provided solutions to the Problem 1 baseline model (load case a) subjected to six additional earthquake input time histories (load cases k through p). The ratios of participant to BNL responses were determined for each load case. The mean ratios of the results from the suite of seven input motions were then calculated. These are presented in Tables 18 through 22 for displacements and Tables 31 through 35 for shear forces. The tables also present additional statistical properties including coefficient of variation (COV), maxima and minima. These results are also presented in graphical form in Figures 11 through 14 for nodal displacements and Figures 33 through 36 for element shear forces. The figures illustrate that for this problem, all five different participant methods predicted conservative mean displacements and shear forces when compared with the BNL solution. The S&A RSM-II method consistently provided the most conservative results. Chen's classical mode method produced results that were comparable to those predicted by the complex mode methods. COVs were similar for all methods, with secondary system COVs consistently higher than those of the primary system. The response ranges were indicated by maxima and minima, which showed that on the high side, the participants' responses could be twice the BNL solution, and on the low side the responses could be 15% below the BNL solution.

In addition to comparisons and evaluation of the methods in the analyses using multiple earthquake ground motions, effects of parametric variations such as frequency, mass, and damping with a single ground input motion (El Centro 1940 earthquake) were also examined. Comparisons and evaluation of the participants' results with these parametric variations are presented below. First, the resulting comparison of the participants' responses due to frequency variations is discussed. Figures 15 through 19 represent nodal displacements and Figures 37 through 41 depict element shear forces. Five frequency ratios (secondary/primary) were analyzed and were grouped and compared to the BNL solution according to a particular analysis method. The frequency range of 0.5 to 2.0 used in the analysis represents flexible, tuned and near tuned, to stiff secondary components. Other parameters such as mass and damping remain unchanged as in the baseline load case. As seen in these figures for frequency variation, in general, the displacement predictions as compared to the BNL solution tend to be poorer in tuned or near tuned frequencies. However, the predictions for element shear forces tend to be better in the tuned frequency. There appears to be consistent under-prediction of about 20% in element shear forces in the secondary component for frequency ratio equal to 2.0 (heavy secondary component) by S&A RSM-I, Gupta and Igusa/Der Kiureghian. It is noted that Chen's results (using classical response method) are comparable to others (using complex-modes response spectrum methods).

Second, when the effect of mass ratio (secondary/primary) variations were examined, the frequency ratio and damping remain the same as in the baseline load case. Similar to the presentation for frequency ratio variation, the results for mass ratio variation in a range of 0.0001 to 0.5 are grouped together according to analysis method. Figures 20 through 24 provide comparisons of nodal displacement responses and Figures 42 through 46 give the corresponding element shear force responses. As compared to the BNL solution, all participant methods responded well to the mass ratio variations (about 10 to 20% difference from BNL solution).

Finally, the damping effects were evaluated by fixing the primary component damping to 7% and varying the secondary component damping from 2% to 20%, while other parameters such as frequency and mass ratios remain the same as the baseline load case. Similar grouping of response comparisons according to analysis method was applied. The comparisons of nodal displacement responses are established in Figures 25 through 29 and the corresponding element shear force comparisons are depicted in Figures 47 through 51. As observed in the displacement comparisons, all methods appear to predict well when the secondary component damping is low. When the secondary component damping is 20%, all methods predicted poorly in the response of the secondary component (under-prediction near 10%) except the Chen's result, which over-predicted the response of the secondary component by about 10 to 14% (however, Chen under-predicted the primary component response by 14% in this case). In element shear forces, however, the observation made for the displacement response with high damping in the secondary component was not seen here across all methods. Gupta's results appear comparable for all damping variations. Igusa's results show a similar trend but slight under-prediction for 20% damping in the secondary component. Chen and S&A RSM-I produced results consistent with the observations for the displacement responses. S&A RSM-II, however, made closer prediction for the 20% damping in the secondary component, compared to responses with lower damping values.

In summary, for benchmark problem No. 1, three participants provided solutions based on response spectrum analysis methods using complex modes, and one participant provided solutions based on classical normal mode response spectrum analysis. The comparisons of specific load case results showed larger differences between participant results and BNL results than were seen in the comparisons of modal superposition time history results. However, due to inherent differences in the methodologies, exact one-to-one correspondence between a specific time history solution and the corresponding response spectrum solution was not expected. A more meaningful comparison of the average ratios of results of the baseline Problem No. 1 using a suite of seven input ground motions showed good agreement, with all five different participant methods predicting conservative mean displacements and shear forces when compared with the BNL solution. The S&A RSM-II method consistently provided the most conservative results. Chen's classical mode method produced results that were comparable to those predicted by the complex mode methods. Comparisons of additional load cases that studied the effects of parametric variations in secondary to primary system frequencies, mass ratios and damping provided mixed results. However, since these comparisons were based on comparing single time history solutions against their corresponding response spectrum solutions, it is impossible to determine whether the deviations were due to the variations in parameters or to the inherent differences in analysis methodologies.

4.3 Benchmark Problem No. 2

The benchmark problem No. 2 was designed to evaluate the performance of different methods for seismic response of a P-S system with multiple connections (NPP building and multiply supported piping). The same number of load cases as the benchmark problem No. 1 was analyzed. The participants' results were compared to the BNL solutions, and the resulting comparisons are presented both graphically and in tabular form. Figures 52 through 73 provide graphical comparisons of nodal displacements, while the element shear forces were compared in Figures 74 through 95. The comparisons of nodal displacements and element shear forces are also provided in tabular form: Tables 36 through 48 for nodal displacements and Tables 49 through 61 for element shear forces.

4.3.1 Modal Superposition Time History Methods

Three participants: S&A, Igusa/Der Kuireghian and Gupta et al, performed modal superposition time history analyses using complex modes. The nodal displacement results for load case a, which is the baseline model, were compared to the BNL results as shown in Figure 52. Comparison of the corresponding element shear forces is provided in Figure 74. As observed in these figures, both displacements and shear forces as predicted by the participants are consistently close to the corresponding BNL "exact" solutions. For all three sets of results at nearly every locations, the maximum deviation was within 0.5%.

As in Problem 1, load cases b through j investigated variations of the baseline Problem 2 model with different dynamic characteristics. Load cases b though e varied the secondary system stiffness properties to evaluate responses in untuned and nearly-tuned coupled systems. These load cases included secondary to primary system frequency ratios of 0.5, 0.9, 1.1, and 2.0. The displacement comparisons are presented in Tables 36 through 38, and the shear force comparisons are presented in Tables 49 through 51. For these load cases, all participant solutions were in as good agreement with the benchmark solutions as the baseline tuned load case. Load cases f through h varied the secondary system masses to achieve secondary to primary system mass ratios of .0001, 0.1, and 0.5. A review of the load case ratios given in the same tables again shows excellent agreement through the wide range of mass ratios. In load cases i and j, the secondary system modal damping ratio was increased to 5% and to 20%. For both cases, all three participant solutions were in as good agreement as the baseline 2% case.

As in Problem 1, load cases k through p subjected the baseline Problem 2 model to a series of six different earthquake input motions including five recorded earthquake time histories and one artificial time history corresponding to the Regulatory Guide 1.60 response spectrum. Ratios of participant to BNL solutions are presented in Tables 36 through 38 for displacements and in Tables 49 through 51 for shear forces. These load cases show all participant results to be in excellent agreement with the BNL displacement and shear force results.

In summary, for benchmark problem No. 2, three participants provided solutions based on modal superposition time history analysis methods using complex modes. Each participant applied a different computer program. By comparing these results to the BNL results which were generated by the direct integration time history analysis method, it was observed that all participants achieved nearly identical solutions. This observation was consistent over the sixteen load cases which covered significant variations in frequency ratios, mass ratios, damping ratios as well as different earthquake input motions.

4.3.2 Response Spectrum Analysis Methods

All four participants provided solutions for the sixteen Benchmark Problem No. 2 load cases using their own response spectrum analysis methods. The comparisons of participant to BNL results for all loads cases are given in Tables 39 through 43 for displacements and Tables 52 through 56 for shear forces. As shown in Figures 53 and 54, which represent the nodal displacement responses from load cases a and m (the baseline structural model subjected to El Centro 1940 and 1979 earthquake ground motions, respectively), the observations similar to the benchmark problem #1 can be made for the benchmark problem No. 2. The corresponding element shear forces, as given in Figures 75 and 76 for load case a and m, also show similar comparisons with the BNL solution as in the benchmark problem No. 1. For load case a, all participants predicted the displacement response within 10% compared to the BNL solutions, except for S&A RSM-II, which over-predicted the response as high as about 20%. Trends similar to the displacement results but of slightly higher magnitude are seen in the comparison of element shear forces.

For load case m, as was observed for the benchmark problem #1, all methods under-estimated both displacement and shear force responses of the primary component by 10% to 20% (except for S&A-II), and over-estimated the responses of the secondary component by 40% to 100%. As was observed in Problem 1, Chen's classical mode method produced results that were comparable and in some cases slightly better than others. The reason for the larger differences between the participant response spectrum results and the BNL time history results is due the inherent differences in the methodologies and is not believed to be a concern associated with complex mode analysis as discussed in Section 4.2.2.

The more meaningful statistical comparisons of the Problem 2 model subjected to a suite of seven earthquakes (load cases a, and k through p) are presented in Tables 44 through 48 and Figures 55 through 58 for displacements, and in Tables 57 through 61 and Figures 77 through 80 for shear forces. Similar to the benchmark problem #1, the figures indicate that for this problem, all five different participant methods predicted conservative mean displacements and shear forces when compared with the BNL solution. The S&A RSM-II method consistently provided the most conservative results. Chen's classical mode method produced results that were comparable to those predicted by the complex mode methods. COVs were similar for all methods, with secondary system COVs consistently higher than those of the primary system. The response ranges indicated by maxima and minima show that on the high side, the participants' responses could be twice the BNL solution, and on the low side the responses could be 15% below the BNL solution.

As was done for benchmark problem No. 1, the effects of parametric variations such as frequency, mass, and damping with a single ground input motion (El Centro 1940 earthquake), were also examined for benchmark problem No. 2. Comparisons and evaluation of participants' results with these parametric variations are presented below. First, the resulting comparison of participants' responses due to frequency variations is discussed. Figures 59 through 63 represent nodal displacement response and Figures 81 through 85 depict element shear forces. Five frequency ratios (secondary/primary) were analyzed and were grouped and compared to the BNL solution according to a particular analysis method. The frequency range of 0.5 to 2.0 used in the analysis represents flexible, tuned and near tuned, to stiff secondary components. Other parameters such as mass and damping remain unchanged as in the baseline load case. As observed in these figures for frequency variation, in general, the displacement predictions as compared to the BNL solution tend to be poorer in tuned or near tuned frequencies. However, the comparisons for element shear forces in the secondary component are much better in the tuned frequency. There appears to be consistent under-prediction of about 20% in element shear forces in the secondary component for frequency ratio equal to 2.0 (heavy secondary component) by S&A RSM-I, Gupta and Igusa/Der Kiureghian. It is also noted that Chen's results are comparable to others for this benchmark problem.

The effect of mass ratio (secondary/primary) variations were examined by specifying a range of mass ratios of 0.0001 to 0.5 while leaving the frequency ratio and damping same as in the baseline load case. The results for mass ratio variation are grouped together according to analysis method. Figures 64 through 68 provide comparisons of nodal displacement responses and Figures 86 through 90 give the corresponding element shear force responses. As observed in these figures, all participant methods responded to the mass ratio variations in similar fashion to the benchmark problem #1, except that the results show greater deviations from the BNL solution, as compared to the benchmark problem No. 1. This is especially true for the mass ratio equal to 0.5 in element shear force response, which were under-predicted by as much as 23%. For the smallest mass ratio studied (0.0001), all methods appear to respond better than for the other mass ratios.

Finally, the damping effects were evaluated by fixing the primary component damping to 7% and varying the secondary component damping from 2% to 20%, while other parameters such as frequency and mass ratios remain the same as for the baseline load case. Similar grouping of response comparisons according to analysis method was applied. The comparisons of nodal displacement responses are given in Figures 69 through 73 and the corresponding element shear force comparisons are depicted in Figures 91 through 95. As seen in the displacement comparisons, all methods appear to predict well when the secondary component damping is low. For the secondary component damping equal to 20%, all methods predicted poorly in the response of the secondary component (under-prediction near 10%) except the Chen's result, which over-predicted the response of the secondary component by about 10% (however, Chen under-predicted the primary component response by 14% in this case). In element shear forces, however, the observation made for the displacement response with high damping in the secondary component was not seen here across all methods. Gupta's results appear comparable for all damping variation. Igusa's results show a similar trend but slight under-prediction for 20% damping in the secondary component. Chen and S&A RSM-I produced results consistent with the observations for the displacement responses. S&A RSM-II, however, made closer prediction for the 20% damping in the secondary component, compared to responses with lower damping values.

In summary, for benchmark problem No. 2, three participants provided solutions based on response spectrum analysis methods using complex modes, and one participant provided solutions based on classical normal mode response spectrum analysis. The comparisons of participant results to BNL results were extremely similar to the comparisons made in Problem 1. Specific load case results showed larger differences between participant results and BNL results than were seen in the comparisons of modal superposition time history results. However, due to inherent differences in the methodologies, exact one-to-one correspondence between a specific time history solution and the corresponding response spectrum solution was not expected. A more meaningful comparison of the average ratios of results of the baseline Problem No. 2 using a suite of seven input ground motions showed good agreement, with all five different participant methods predicting conservative mean displacements and shear forces when compared with the BNL solution. The S&A RSM-II method consistently provided the most conservative results. Chen's classical mode method produced results that were comparable to those predicted by the complex mode methods. Comparisons of additional load cases that studied the effects of parametric variations in secondary to primary system frequencies, mass ratios and damping provided mixed results. However, since these comparisons were based on single time history solutions versus their corresponding response spectrum solutions, the deviations are not necessarily due to the parametric variations but may simply be due to the inherent differences in methods.

4.4 Benchmark Problem No. 3

The benchmark problem No. 3 is similar to the benchmark problem No. 2 as a NPP building supporting a piping system. However, in benchmark problem No. 3, the secondary component is attached to the building at two elevations and to the ground. The same number of load cases was analyzed as for the first two problems. The participants' results were compared to the BNL solutions, and the resulting comparisons are presented both graphically and in tabular form. Figures 96 through 117 provide graphical comparisons of nodal displacements, while the element shear forces were compared in Figures 118 through 139. The comparisons of nodal displacements and element shear forces are also provided in tabular form: Tables 62 through 74 for nodal displacements and Tables 75 through 87 for element shear forces.

4.4.1 Modal Superposition Time History Methods

Three participants: S&A, Igusa/Der Kuireghian and Gupta et al, performed modal superposition time history analyses using complex modes. The nodal displacement results for load case a, which is the baseline model, were compared to the BNL results as shown in Figure 96. Comparison of the corresponding element shear forces is provided in Figure 118. As observed in these figures, the displacement comparisons are within 1.5% as compared to the BNL solution and element shear forces were predicted as well as the displacement prediction. These results, although not as close to the BNL solutions as seen in the first two benchmark problems, are still in excellent agreement.

As in Problems 1 and 2, load cases b through j investigated variations of the baseline Problem 2 model with different dynamic characteristics. Load cases b though e varied the secondary system stiffness properties to evaluate responses in untuned and nearly-tuned coupled systems. These load cases included secondary to primary system frequency ratios of 0.5, 0.9, 1.1, and 2.0. The displacement comparisons are presented in Tables 62 through 64, and the shear force comparisons are presented in Tables 75 through 77. For these load cases, all participant solutions were in as good agreement with the benchmark solutions as the baseline tuned load case. Load cases f through h varied the secondary system masses to achieve secondary to primary system mass ratios of .0001, 0.1, and 0.5. A review of the load case ratios given in the same tables shows excellent agreement for the load case with mass ratio of .0001. Very good agreement is seen for the load cases with larger mass ratios although a tendency to overestimate the displacements and shear forces for the load case with the highest mass ratio of 0.5 by as much as 5% was observed. In load cases i and j, the secondary system modal damping ratio was increased to 5% and to 20%. For both cases, all three participant solutions were in very good agreement, although for the case with 20% damping, at a few locations, the participant results were as much as 12% higher than the BNL results.

As in Problems 1 and 2, load cases k through p subjected the baseline Problem 2 model to a series of six different earthquake input motions including five recorded earthquake time histories and one artificial time history corresponding to the Regulatory Guide 1.60 response spectrum. Ratios of participant to BNL solutions are presented in Tables 62 through 64 for displacements and in Tables 75 through 77 for shear forces. These load cases show participant results to be in excellent agreement with the BNL displacement and shear force results and consistent with the baseline model comparisons.

In summary, for benchmark problem No. 3, three participants provided solutions based on modal superposition time history analysis methods using complex modes. Each participant applied a different computer program. By comparing these results to the BNL results which were generated by the direct integration time history analysis method, it was observed that for nearly all variations investigated, all participant results were in excellent agreement with the BNL results. Slightly higher deviations (in the order of 10%) were seen in load cases with highest secondary to primary system mass ratio (0.5) and highest secondary system damping (20%). These deviations were mostly on the conservative side.

4.4.2 Response Spectrum Analysis Methods

All four participants provided solutions for the sixteen Benchmark Problem No. 3 load cases using their own response spectrum analysis methods. The comparisons of participant to BNL results for all loads cases are given in Tables 65 through 69 for displacements and Tables 78 through 82 for shear forces. Figures 97 and 98 show the displacement responses due to different earthquake input motions, designated as load cases a and m (the baseline structural model subjected to El Centro 1940 and 1979 earthquake ground motions, respectively). The corresponding element shear forces are compared in Figure 119 for load case a and Figure 120 for load case m. For load case a, all participants predicted the displacement response within 10% compared to the BNL solutions, except for S&A RSM-II, which over-predicted the response as high as about 20%. Trends similar to the displacement results but of slightly higher magnitude are seen in the comparison of element shear forces. Overall, the comparisons for benchmark problem No. 3 appear similar to those for the first two benchmark problems.

For load case m, as was observed for the first two benchmark problems, all methods under-estimated both displacement and shear force responses of the primary component by as much as 15%, and over-estimated the responses of the secondary component by 40% to 100%, except for S&A RSM-II, which slightly over-estimated the responses of the primary component. Overall, Chen's classical mode method again produced results that were comparable and, at most locations, slightly better than others. The reason for the larger differences between the participant response spectrum results and the BNL time history results is due the inherent differences in the methodologies and is not believed to be a concern associated with complex mode analysis as discussed in Section 4.2.2.

The more meaningful statistical comparisons of the Problem 3 model subjected to a suite of seven earthquakes (load cases a, and k through p) are presented in Tables 70 through 74 and Figures 99 through 102 for displacements, and in Tables 83 through 87 and Figures 121 through 124 for shear forces. Similar to the first two benchmark problems, the figures indicate that for this problem, all five different participant methods predicted conservative mean displacements and shear forces when compared with the BNL solution. The S&A RSM-II method again consistently provided the most conservative results. Chen's classical mode method produced results that were comparable to those predicted by the complex mode methods. COVs were similar for all methods, with secondary system COVs consistently higher than those of the primary system. The response ranges indicated by maxima and minima show that on the high side, the participants responses could be twice the BNL solution, and on the low side the responses could be 15% below the BNL solution.

As was done for the first two benchmark problems, the effects of parametric variations such as frequency, mass, and damping with a single ground input motion (El Centro 1940 earthquake) were also examined for benchmark problem No. 3. Comparisons and evaluation of participants' results with these parametric variations are presented below. First, the comparison of the participants' responses due to frequency variations is discussed. Figures 103 through 107 represent nodal displacements and Figures 125 through 129 depict element shear forces. Five frequency ratios (secondary/primary) were analyzed and were grouped and compared to the BNL solution according to a particular analysis method. The frequency range of 0.5 to 2.0 used in the analysis represents flexible, tuned and near tuned, to stiff secondary components. Other parameters such as mass and damping remain unchanged as in the baseline load case. As observed in these figures for frequency variation, in general, the displacement predictions as compared to the BNL solution tend to be poorer in tuned or near tuned frequencies. However, the comparisons for element shear forces in the secondary component are much better in the tuned frequency. There appears to be consistent under-prediction of about 20% in element shear forces in the secondary component for frequency ratio equal to 2.0 (stiff secondary component) by S&A RSM-I, Gupta and Igusa/Der Kiureghian. It is also noted that Chen's results appear comparable to others for this benchmark problem.

The effect of mass ratio (secondary/primary) variations were examined by specifying a range of mass ratios of 0.0001 to 0.5 while leaving the frequency ratio and damping the same as in the baseline load case. The results for mass ratio variation are grouped together according to analysis method. Figures 108 through 112 provide comparisons of nodal displacement responses and Figures 130 through 134 give the corresponding element shear force responses. As observed in these figures, all participants' methods responded to the mass ratio variations in similar fashion to the first two benchmark problems, although somewhat larger deviations were observed for the mass ratio equal to 0.5. All methods appear to predict better for the smallest mass ratio (0.0001).

Finally, the damping effects were evaluated by fixing the primary component damping to 7% and varying the secondary component damping from 2% to 20%, while other parameters such as frequency and mass ratios remain the same as the baseline load case. Similar grouping of response comparisons according to analysis method was applied. The comparisons of nodal displacement responses are given in Figures 113 through 117 and the corresponding element shear force comparisons are depicted in Figures 135 through 139. Unlike the first two benchmark problems, the displacement comparisons for benchmark problem No. 3 show that all methods appear to predict well even for high damping in the secondary component damping (20%), except the Chen's result, which under-predicted the response of the primary component by about 14%. In element shear forces, Gupta's results appear comparable for all damping variations. Igusa's results show a similar trend but slight under-prediction for 20% damping in the secondary component. Chen and S&A RSM-I produced results consistent with the observations for the displacement responses. S&A RSM-II, however, made closer prediction for the 20% damping in the secondary component, compared to responses with lower damping values.

In summary, for benchmark problem No. 3, three participants provided solutions based on response spectrum analysis methods using complex modes, and one participant provided solutions based on classical normal mode response spectrum analysis. The comparisons of participant results to BNL results were similar to the comparisons made in Problems 1 and 2. Specific load case results showed larger differences between participant results and BNL results than were seen in the comparisons of modal superposition time history results. However, due to inherent differences in the methodologies, exact one-to-one correspondence between a specific time history solution and the corresponding response spectrum solution was not expected. A more meaningful comparison of the average ratios of results of the baseline Problem No. 3 using a suite of seven input ground motions showed good agreement, with all five different participant methods predicting conservative mean displacements and shear forces when compared with the BNL solution. The S&A RSM-II method consistently provided the most conservative results. Chen's classical mode method produced results that were comparable to those predicted by the complex mode methods. Comparisons of additional load cases that studied the effects of parametric variations in secondary to primary system frequencies, mass ratios and damping provided mixed results. However, since these comparisons were based on single time history solutions versus their corresponding response spectrum solutions, the deviations are not necessarily due to the parametric variations but may simply be due to the inherent differences in methods.

4.5 Benchmark Problem No. 4

The benchmark problem No. 4 is representative of a realistic complex model of a coupled NPP building and piping system, which was modeled with 3-D finite elements. This benchmark problem was designed to investigate the capability and performance of various analysis methods when applied to a real-life coupled system in a design analysis. The piping system was designed with a sufficient number of rigid modes such that it is impractical for participants to consider all modes of the piping system. Therefore, the situation provides a good opportunity for participants to apply their own procedures to account for the effect of high frequency modes (in terms of missing mass effect). However, since the BNL formulation of the coupled damping matrix only requires fixed-supports component modes (not the modes of coupled model), no truncation of rigid modes was made in the BNL "exact" solution. Due to the relatively complex nature of this benchmark model, only two configurations were analyzed, which were designated as No. 4a and No. 4b. No. 4b is more massive than No. 4a, and consequently, No. 4b has lower fundamental frequency than No. 4a. The detailed description of 4a and 4b models is provided in Section 2.1.4. No parametric study was performed for this benchmark problem but seven load cases were considered in which the baseline structural models were analyzed with a suite of seven earthquake input motions. The participants' results were compared to the BNL solutions for selected response components, and the resulting comparisons are presented both graphically and in tabular form. Section 4.5.1 provides comparison results for problem No. 4a, while Section 4.5.2 discusses the comparisons for problem No. 4b.

4.5.1 Benchmark Problem No. 4a

Figures 140 through 145 provide graphical comparisons of the maximum nodal traslational displacement responses of the coupled model in the direction of the input motion (U_y), while the maximum element SRSS moment responses of the piping system (secondary component) are compared in Figures 146 through 151 and comparisons of the maximum axial component of the reaction forces of the link elements are provided in Figures 152 through 157. The comparisons of the corresponding responses are also provided in tabular forms, in which the responses are grouped together in terms of analysis methods. Tables 88 through 95 provide nodal translational displacement responses U_y for seven load cases (representing seven ground-input motions), and the statistics (mean, COV, max ratios and min ratios) computed from the seven load cases. The element SRSS moment responses of the piping system for the seven load cases are tabulated in Tables 96 through 103, which also include the statistics computed in the same fashion as the displacement response. Finally, the maximum axial components of the reaction forces of the link elements are provided in Tables 104 through 109.

4.5.1.1 Modal Superposition Time History Methods

Three participants: S&A, Igusa/Der Kuireghian and Gupta et al, performed modal superposition time history analyses using complex modes. The results of nodal translational displacements for load case a, which applies the El Centro 1940 earthquake as input motion, were compared to the corresponding BNL solution as shown in Figure 140. Comparisons of the element SRSS moments of the piping system and the axial components of reaction forces of the link elements for load case a using modal superposition time history analyses are provided in Figures 146 and 152, respectively. As observed in the figures, the displacements U_y of the primary component were matched very well with the BNL solution, with the S&A results slightly higher than others (still within 4% difference compared to the BNL solution). Both Gupta and Igusa predicted the displacements U_y of the primary component nearly identical to the BNL solution. The prediction of the displacement U_y for the secondary component overall went very well, except for locations near the bottom elbow and the two links for the vertical section of the piping system. S&A matched the BNL solution mostly within 5% except for the locations as noted above, for which S&A over-predicted the displacement U_y by about 10%. On the other hand, Gupta and Igusa over-predicted the displacement near the bottom elbow on the vertical section of the piping system by nearly 25%, while for node 15 on the piping near the link in the mid section of the vertical piece of the piping, Gupta and Igusa over-predicted by nearly 15%. However, it is noted that the displacement components U_y at nodes 14, 15 and 22, where the larger differences were observed, are associated with much smaller magnitude as compared to the maximum system displacement as depicted in Figure 158. Therefore, they have no practical significance. Furthermore, if the structure were analyzed subjected to three directional seismic inputs as is in a real earthquake environment, the response comparison between the participants and the BNL solution could likely be further improved. In addition to the graphical comparisons, tabular forms of the comparisons for all load cases can be found in Tables 89, 90 and 91 for the displacement, Tables 96, 97 and 98 for the SRSS moment, and Tables 104 and 105 for the reaction forces.

For the SRSS moments in the piping system, however, much larger differences between the participant results and the BNL solution were observed in the load case a using the modal superposition time history analyses. Compared to the BNL solution, Gupta over-predicted the SRSS moment of the piping by as much as 40%, and Igusa appears to predict the SRSS moment of the piping relatively better than Gupta. S&A, however, under-predicted the SRSS moment by as much as 40% in the two elbows located in the lower part of the piping. For the rest of the piping elements, the S&A predictions were mostly comparable to those of Gupta and Igusa with a few slight under-predictions of 10 to 15%. In addition, an argument could be made in light of the discussion on the displacement comparisons that the moment comparisons could also be substantially improved if the three directional seismic inputs were considered.

With respect to the comparison of reaction forces of the link elements, only S&A and Gupta provided their time history results. As shown in Figure 152, excellent match was obtained for load case a by S&A in the axial reaction forces of the links. Gupta's prediction of the axial reaction force in the link No. 2 is about 20% below the BNL solution, but in link No. 6, nearly 35% over-prediction and in link No. 7, about 20% over-prediction, are observed. In other links, Gupta obtained results comparable to those of S&A. The large difference in the link No.6 could be explained by the fact that link No.6 connects node 25 of the S-component to the P-component at node 3 in the x-direction as shown in Figure 4, and was not intended to resist earthquake motion applied in the Y-direction. Therefore, link No.6 is only important for x-directional seismic input as in benchmark problem 4b. As indicated in Figure 171, Gupta's result for the link No.6 axial reaction force in problem 4b indeed matches very well to the BNL solution.

4.5.1.2 Response Spectrum Analysis Methods

All four participants provided solutions for the seven load cases using the same response spectrum analysis methods that they applied in their analyses of Problems 1 through 3. The comparisons of the maximum translational displacement U_y for load case a are given in Figure 141, which shows good match for the primary component, and mostly over-predictions for the vertical section and under estimates for the lower section of the piping system. The piping responses are mostly within 20% difference to the BNL solution as predicted by S&A RSM-I, Gupta and Igusa. Much greater differences were observed between the BNL solution and the piping responses computed by S&A RSM-II and Chen.

However, the comparisons could be substantially improved if the responses at nodes 14, 15 and 22 were excluded. For instance, at node 22, which is adjacent to the link No. 5 that connects the vertical section of the piping to the building, over-predictions were made by all participants, especially Chen whose prediction was more than twice the BNL solution. Nevertheless, the displacement at node 22 represents only a small fraction of the maximum displacement of the system as indicated in Figure 158, and has no practical significance. For other load cases, which are tabulated in Tables 91 through 95, comparisons vary among the participants. The best comparison of Gupta's results to the BNL solution was obtained for load case e (within 5%), which is subject to Loma Prieta (1989) earthquake input. For the same load case, Igusa and S&A RSM-I were within 10 to 16% difference to the BNL solution, and Chen and S&A RSM-I were about 50% higher than the BNL solution. In addition, for nodes located between links No. 4 and No. 5 (middle of the vertical section of the piping), all methods tend to over-predict the displacement response by as much as 60 to 90% for the load cases c and d, which correspond to Olympia 1949 and El Centro 1979 earthquakes, respectively. However, when the mean response is computed from the seven earthquakes and compared to the BNL solution, as shown in Figure 142, all methods perform fairly well, especially for the response of the primary component for which the predictions were well within 10% of the BNL solution. For the secondary component, the mean responses computed from Gupta, Igusa and S&A RSM-I are mostly within 10% of the BNL solution and about 20-30% higher for nodes 17 to 20,which are located between links No. 4 and No. 5. As noted above, similar results were also observed for these nodes in comparisons of the individual earthquakes. On the other hand, the mean responses calculated for Chen's results do not appear to be as good as seen in the first three benchmark problems. Compared to other methods, Chen's mean response is much higher in the vertical section (60-90%) and about 14% lower near the bottom end of the piping. Other statistical properties such as coefficient of variation (COV), maxima and minima were computed and shown in Figures143 through 145. COV for all participants are very similar and much less than that computed for the first three benchmark problems. Maxima and minima calculated from the seven earthquakes provide lower and upper bounds. As seen in the above figures, the responses for Gupta, Igusa and S&A RSM-I are bounded within a much smaller range than Chen and S&A RSM-II.

To further evaluate the performance of different response spectrum methods, element stresses were compared for the SRSS moments in the piping and the axial components of the reaction forces in link elements. The result comparisons of SRSS moments for the seven load cases and the associated statistical properties are provided in Tables 99 through 103 grouped in terms of analysis method. The SRSS moment comparisons were plotted for load case a and the statistical properties such as mean, COV, maxima and minima of responses for the seven earthquakes and shown in Figures 147 through 151. For load case a, the SRSS moment results are mostly higher (40 to over 200%) than the BNL solution, except for the lower section of the piping, which Gupta, Chen and S&A RSM-I and -II tend to under-predict the SRSS moments by about 25 to 40% (Chen's report indicates that the SRSS moment ratio at element 22 was improved from 0.4 to 0.66, which is not reflected in Figure 147). Chen's results again deviate from the BNL solution much more than others'. Overall, Igusa's results are either higher or comparable to the BNL solution and appear better than those predicted by other methods. For other load cases, the results vary and the largest over-prediction was observed in Igusa's results for load case e (over three times the BNL solution at element 17). Other methods also mostly over-predicted the SRSS moments by more than 50%, especially for the middle section of the piping. However, for the mean responses, Gupta's results appear slightly better than Igusa's, but both results are either higher or comparable to the BNL solution. The mean responses from Chen's results deviate from the BNL solution more than others', but are mostly over-predictions except at elements 15 and 22 for which Chen under-predicted by 25 to 40%. S&A RSM-I also under-predicted quite significantly at elements 15 and 17 through 19 (15 to 35%), S&A RSM-II shows a trend similar to Chen's but of smaller magnitude. The COVs, as indicated in Figure 149, show similar response variations mostly less than 0.3. The bounding analysis, as shown in Figures 150 and 151 for the maximum and minimum ratios of the result comparisons, indicates that Gupta's results appear more stable than others', Igusa's results are off in the maximum ratios for elements 17 and 18 attributed to the over-prediction in load case e.

Finally, the axial components of the reaction forces in the link elements were compared for the response spectrum methods. Except for Igusa, all methods provided results for the reaction forces in the links. Complete comparisons for the axial components are tabulated in Tables 106 through 109, including seven load cases and the associated statistical properties. Graphical comparisons are provided in Figures 153 through 157 for load case a, along with the statistical properties such as mean, COV, maximum and minimum ratios. As seen in these figures, for load case a, predictions appear comparable among all methods. Significant under-predictions were observed in link No. 6 (more than 60%) for all methods. Except for link No. 6, S&A RSM-I results appear better than others'. Chen also under-predicted significantly the response (60%) in link No. 2. However, the comparisons for the mean response indicate that Gupta and S&A RSM-II obtained excellent matches to the BNL solution in link No. 6. This indicates significant variation in responses for link No.6 resulted from different earthquake input motions. This observation is also substantiated by the COVs (Figure 155), which shows the COVs are in a range between 0.42 to 0.53 for link No. 6. Furthermore, consistent under-predictions for link No.2 and over-predictions for links No. 4 and No. 5 were observed in the comparisons of the maximum and minimum ratios (Figures 156 and 157) for all methods.

4.5.2 Benchmark Problem No. 4b

Figures 159 through 164 provide graphical comparisons of the maximum nodal translational displacement responses U_X of the coupled model in the direction of the input motion, which is the x direction. The maximum element SRSS moment responses of the piping system (secondary component) were compared in Figures 165 through 170 and comparisons of the maximum axial component of the reaction forces of the link elements are provided in Figures 171 through 176. The comparisons of the corresponding responses are also provided in tabular form, in which the responses are grouped together in terms of analysis methods. Tables 110 through 117 provide nodal translational displacement responses U_X for seven load cases (representing seven ground-input motions), and the statistics (mean, COV, max ratios and min ratios) computed for the seven load cases. The element SRSS moment responses of the piping system for the seven load cases are tabulated in Tables 118 through 125, which also include the statistics computed in the same fashion as for the displacement responses. Finally, the maximum axial components of the reaction forces in the link elements are provided in Tables 126 through 131.

4.5.2.1 Modal Superposition Time History Methods

Similar to the treatment for the benchmark problem No. 4a, three participants: S&A, Igusa/Der Kuireghian and Gupta et al, performed modal superposition time history analyses using complex modes for the problem No. 4b. The results of nodal translational displacements for load case a, which applies El Centro 1940 earthquake as input motion, were compared to the corresponding BNL solution as shown in Figure 159. Comparisons of the element SRSS moments of the piping system and the axial components of reaction forces of the link elements for load case a using modal superposition time history analyses are provided in Figures 165 and 171, respectively. As observed in the figures, excellent matches to the BNL solution were obtained by both Gupta and Igusa for the displacement responses U_X (within 2%). S&A results also compare well to the BNL solution (mostly within 5%). Therefore, much better predictions were made by the participants in the displacement responses for the problem No. 4b than the problem No. 4a. Similar comparisons were also found for other load cases, as given in Tables 113 through 115.

In the comparison for the SRSS moments in the piping system, Gupta scored the best, matching the BNL solution within 2%. S&A mostly under-predicted the SRSS moments by a maximum of 25% in the top and bottom end segments of the piping that run in the direction of the seismic input, and matched the BNL solution within 5% for the rest of the piping that runs in the direction normal to the seismic input. Igusa's results compared well to the BNL solution, except for the elbow at the bottom end of the vertical segment, where Igusa under-predicted by about 7%. With respect to the comparison of reaction forces in the link elements, only S&A and Gupta provided time history results. As shown in Figure 171, good predictions were observed in the axial component of reaction forces of the link elements by Gupta, except for link No. 1, in which Gupta under-predicted by about 10%. S&A also predicted well the axial component of reaction forces of the link elements, except for links No. 3 and 7, in which S&A under-predicted by about 20%. However, links No.3 and 7 were not intended to resist the seismic motion in the x-direction, therefore, the forces induced in these links are so small that they have no practical significance. Nonetheless, if the above comparisons were made in the context of three directional seismic inputs, the agreement between the BNL solution and the participants analyses could conceivably be even closer.

4.5.2.2 Response Spectrum Analysis Methods

As with Problem 4a, four participants provided solutions for the seven load cases using their same response spectrum analysis methods. The comparisons of the maximum translational displacement U_X for load case a are given in Figure 160, which again shows that good comparisons were obtained by all participants except for Chen, who over-predicted the displacement response in the middle section of the piping by more than 60%. Gupta, Igusa and S&A all predicted the displacement response close to the BNL solution within 10% margin, except for nodes 14 and 26. However, compared to the maximum displacement of the system, as shown in Figure 176, the displacement responses at nodes 14 and 26 are too small to be of practical significance. Comparisons of mean responses, as shown in Figure 161, were similar, with some of Chen's mean responses being as high as twice those of BNL. COVs calculated for the seven earthquakes are mostly less than 0.2, which indicates that similar results were obtained for all earthquake-input motions. This observation is also substantiated by the comparisons of maximum and minimum ratios, as depicted in Figures 163 and 164.

To further evaluate the performance of different response spectrum methods for the benchmark problem No. 4b, element stresses were compared for the SRSS moments in the piping and the axial components of the reaction forces in link elements. The result comparisons of SRSS moments for the seven load cases and the associated statistical properties are provided in Tables 121 through 125 grouped in terms of analysis method. The SRSS moment comparisons were plotted for load case a and the statistical properties such as mean, COV, maximum and minimum ratios of responses for the seven earthquakes and shown in Figures 166 through 170. In contrast to the benchmark problem No. 4a, the SRSS moment results for the load case a of the benchmark problem No. 4b are mostly under-predicted compared to the BNL solution by all participants except for Chen, who over-predicted the SRSS moments throughout the piping system. The maximum under-prediction is more than 40% for the Gupta and S&A RSM-I results, and more than 20% for the Igusa and S&A RSM-II results. For other load cases, however, the participant's responses vary from load case to load case. Gupta and Igusa mostly over-predicted the SRSS moment responses for load cases b – g. S&A RSM-I results were improved significantly for load cases b – g., while S&A RSM-II results for load cases b - g remain similar to those of load case a. For other load cases, Chen over-predicted the SRSS moments much more than for load case a. However, when the mean responses are computed for the seven load cases, the Igusa and Gupta results become closer to but slightly higher than the BNL solution (the differences mostly remain below 20%), except for elements 19 and 22 where Igusa's results are much higher (more than 30%), and element 2 where Gupta under-predicted by more than 10%. Both S&A RSM-I and –II results appear similar and are within 20% difference from the BNL solution. The mean responses computed from Chen's results are 60 to 200% higher than the BNL solution. The COVs, as depicted in Figure 167, show that the response variations are mostly less than 0.2, except for element 22 where a sharp rise (0.3 to 0.6) in COV is observed for the Gupta, Igusa and Chen results. This sharp rise of COV is attributed to SRSS moment response in element 22 of the load case e for Igusa and Chen, and the load case a for Gupta, which is further substantiated by the comparisons of the maximum and minimum ratios (Figures 169 and 170). In addition, as pointed out by Dr. Chen of Apollo Consulting, the SRSS moment was calculated at the two ends for each element, and for practical purposes, the comparison should be based on the larger of the two sets. Since the BNL comparisons were made based on the maximum moment response calculated at the end I of each element, and for certain elements which are supported by rigid links, the maximum moment response could occur at the end J. As indicated in Chen's report, the ratios for Chen at elements 2 and 23 are 2.2 and 1.7, respectively. When the end j is used for the maximum moment calculation, the ratios dropped down to 1.2 and 1.21. He also suggested that if the benchmark problems No. 4a and 4b were combined for the SRSS moment comparisons, Chen's comparisons with the BNL solution could be substantially improved. However, the structural models used for the No. 4a and 4b were not exactly the same. To support this observation, further studies are required to develop the response due to three directional seismic inputs for comparison.

Finally, the axial components of the reaction forces in the link elements were compared for the response spectrum methods. Except for Igusa, all methods provided results for the reaction forces in the links. Complete comparisons for the axial components are tabulated in Tables 128 through 131, including seven load cases and the associated statistical properties. Graphical comparisons are provided in Figures 172 through 176 for load case a, and the statistical properties such as mean, COV, maximum minimum ratios. As seen in these figures, for load case a, Gupta obtained good prediction compared to the BNL solution, except for the link No. 7, which as noted previously, was not intended to resist the seismic input in the x- direction, and is therefore of little practical significance. Chen's results are higher than the BNL solution (up to 175%). S&A RSM-I and –II results are closer to the BNL solution (within 25%). The comparisons for the mean response indicate that Gupta and S&A RSM-II move closer to the BNL solution, while Chen's results appear to move further away from the BNL solution. The comparisons of the maximum and minimum ratios (Figures 175 and 176) are also provided for all methods.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Program Summary

Under the sponsorship of the U.S. Nuclear Regulatory Commission (NRC), the BNL-NRC benchmark program for the evaluation of analytical methods to calculate the seismic responses of non-classically damped coupled systems was established and successfully executed with participation and cooperation of the following organizations:

- Dr. C. Chen of Apollo Consulting, Inc. (Apollo),
- Professor A. K. Gupta, Professor A. Gupta and Mr. M. K. Bose of North Carolina State University (NCSU),
- Professor T. Igusa of Johns Hopkins University and Professor A. Der Kiureghian of University of California at Berkeley,
- Drs. A. Berkovski, O. Kireev, V. Kostarev and J. Stevenson of Stevenson and Associates, Russian Office (S&A).

In addition, Dr. R. P. Kennedy and Professor A. S. Veletsos provided independent reviews of the benchmark process.

This benchmark program was established and carried out in two phases. Under Phase I, a series of benchmark problems that covers various aspects of application and complexity of typical coupled NPP structures with non-classical damping were first developed by BNL. These benchmark problems were subsequently analyzed by BNL using the direct integration time history analysis method with a rigorous formulation for the explicit damping matrices. A preliminary report, which included the detailed descriptions of the benchmark problems, the BNL analysis method, and the necessary inputs, was distributed to the program participants of alternate state-of-the-art analysis methods for their independent analyses. In Phase II of the program, the analysis results were submitted to BNL by the participants. These results were then compared to and evaluated against the BNL "exact" solutions. The following is a summary of the significant findings, conclusions, recommendations and suggested areas for future study.

5.2 Summary of Significant Findings

Based on the comparisons and evaluations of the final benchmark analysis results discussed in Section 4.0, a number of significant observations were made. These findings are summarized and discussed below:

1. For the smaller benchmark problems Nos. 1, 2, and 3, the complex-mode time history analysis results provided by S&A, Igusa, & Gupta were in excellent agreement with the BNL direct integration time history results. For problem 1 which represented a single-connection coupled system, and problem 2 which represented

a multi-connection coupled system, agreement was generally within 0.5% for displacements and forces. This finding was consistent for the sixteen load cases which considered variations in: secondary to primary system frequency ratio (0.5, 0.9, 1.0, 1.1 and 2.0); secondary to primary system mass ratio (.0001, .005, 0.1, and 0.5); secondary system damping ratio (2%, 5%, and 20%); and for seven different earthquake input time histories. For problem no. 3, in which the secondary system had multiple connections to the primary system and a connection to ground, agreement was within 1.5% for all load cases except those with highest mass ratio (0.5) and highest secondary system damping (20%). For those cases, deviations as high as 5% for high mass and 10% for high damping were seen at a few locations. However, the deviations were mostly on the high side. Based on these results, it is concluded that for these problems, the participants' complex-mode time history analysis methods provide results comparable to those generated by the benchmark direct integration time history analysis methods.

2. For the larger benchmark problems no. 4a and no. 4b, which represent realistic coupled NPP building-piping systems, the complex-mode time history analysis results provided by S&A, Igusa & Gupta were in good agreement with the BNL direct integration time history results. These two problems were identical in configuration but differed in fundamental frequency. In problem 4a, the building and piping system each had an uncoupled fundamental frequency of 8.24 Hz. In problem 4b, each had an uncoupled fundamental frequency of 4.60 Hz. The comparisons to the BNL results were not in as close agreement as for the smaller benchmark problems. Comparisons of displacement results for problem 4a were mostly within 5%. Larger deviations were seen at some locations but the largest deviations were generally associated with the less significant displacements. For problem 4b, however, much better agreement of displacement results was achieved. The Igusa and Gupta results agreed within 2%, and the S&A results were within 5%. Comparisons of pipe moments and support forces (which are quantities derived from the displacements) showed somewhat larger deviations as may be expected. The reasons for the larger differences in the comparisons of the problem 4a and 4b time history analysis results are difficult to ascertain without further study. Since the deviations appear to increase with the size and complexity of the problem, it is likely that they are due to differences in computer program algorithms for numerical integration and eigenvalue extraction, as well as differences in numerical precision of the programs. The differences in the stiffness formulation of the piping bend element between the BNL SAP-V program and other programs (used by S&A and Chen, see Section 4.1) is another contributing factor that would affect the S&A time history result comparisons. Based on the overall results for both the small and large benchmark problems, it is concluded that the participants' complex-mode time history analysis methods provide results comparable to those generated by the benchmark direct integration time history analysis methods and are acceptable.

3. For the smaller benchmark problems nos. 1, 2, and 3, the complex-mode response spectrum analysis results provided by S&A, Igusa, & Gupta showed larger deviations when individual load case results were compared against the

corresponding BNL direct integration time history analysis results. The extent of deviation varied from one load case to the next depending on the particular ground motion applied. However, as discussed in Section 4.2.2, due to inherent differences between response spectrum and time history analysis methods, exact one-to-one correspondence of solutions is not expected for a specific load case. This is true for classical normal mode response spectrum analysis as well as for non-classical complex-mode analysis. In comparing response spectrum to time history analysis results, one should expect that the average responses using a suite of input ground motions should be close to the responses from the corresponding response spectrum analysis. For this benchmark program, the baseline benchmark problem (load case a) was analyzed using a suite of seven earthquake input motions. The average ratios of participants' to BNL responses for the seven load cases were calculated at each location. For all three problems, the average ratios for the four participants' complex mode response spectrum solutions showed reasonably good agreement with the BNL results. All methods predicted conservative displacements and forces. The S&A RSM-II method consistently provided the most conservative results. Based on these results, it is concluded that for these problems, the participants' complex-mode response spectrum analysis methods provide reasonably accurate and generally conservative results.

4. For the larger benchmark problems nos. 4a and 4b, the comparisons of complex-mode response spectrum analysis results provided by S&A, Igusa, & Gupta to BNL time history results were generally consistent with the smaller problem comparisons. For problem 4a, the S&A RSM-I, Igusa and Gupta average displacement predictions are within a few percent of the BNL displacements at most locations, although at a few locations, over-prediction of about 30% was noted. The S&A RSM-II shows somewhat higher average displacement deviations. Comparisons of pipe moments and support forces show larger deviations as may be expected, although most are on the conservative side. For problem 4b, the mean displacement predictions are in very good agreement. All methods show agreement within a few percent except at a few locations where displacements are over-predicted by 10-20%. Again, comparisons of pipe moments and support forces show larger deviations as expected, although mostly on the conservative side. Based on the overall results for both the small and large benchmark problems, it is concluded that the participants' complex-mode response spectrum analysis methods provide reasonably accurate and generally conservative results.

5. For the smaller benchmark problems, parametric studies were performed by varying model properties to investigate potential limitations of alternate analysis methods in predicting the response of coupled systems with: (a) tuned, near-tuned and untuned subsystems; (b) low to high subsystem mass ratios; and (c) low to high secondary system damping. As noted above, the complex-mode time history analysis methods provided very good agreement with the benchmark results over the entire range of parameter variations. On the other hand, both the complex-mode and the normal mode response spectrum analysis methods showed larger deviations in results among different load cases. However, these studies compared participant response spectrum

solutions to the benchmark time history solutions for a single earthquake input motion. As discussed in Item 3 above, exact one-to-one correspondence of solutions is not expected for any specific load case. Therefore, unless further studies using a suite of earthquake motions are performed, it is not possible to determine whether the larger deviations are due to the parametric variations or due to the inherent differences between methods. However, it is reasonable to assume that the findings and conclusions from the modal time history analysis parametric studies can be extended to response spectrum analysis. On that basis, no significant limitations were identified within the range of frequency and mass ratios investigated. Based on limited trends in the data and currently accepted practice, it would be prudent to limit the damping ratio to 20%.

6. The solutions provided by Chen using the classical response spectrum method with composite modal damping provided interesting comparisons with the non-classical complex mode method solutions. For the small benchmark problem Nos. 1, 2, and 3, Chen's results were comparable and in several cases slightly better than the responses generated using the complex-mode based response spectrum methods. However, for the larger, more complicated coupled models of benchmark problems 4a and 4b, the results showed much larger deviations with significant over-prediction of responses in many locations. The reason for these inconsistent findings is not clear and warrants further investigation. If the complex mode methods produce consistently superior results, it would be reasonable to expect that these differences would have been seen in the simple problem solutions as well. A comparison of modal superposition time history analysis results using Chen's classical method against the complex mode results could have provided valuable insights into the sources of differences in results (due to finite element modeling, and classical and non-classical damping). The differences in the stiffness formulation of the piping bend element between the BNL SAP-V program and the program used by Chen (see Section 4.1) may be a contributing factor, but is not likely the primary reason. In addition, as Dr. Chen suggested, the result comparisons might be improved if three directional seismic inputs were considered in the analysis. This can be substantiated through additional studies.

5.3 Principal Conclusions and Recommendations

Based on the results of this benchmark program, the following principal conclusions and recommendations are made with respect to the acceptability and application of the complex-mode and normal-mode solution methods to non-classically damped coupled systems:

1. The complex-mode time history analysis methods applied by Stevenson and Associates, Igusa and Der Kiureghian, and Gupta, Gupta and Bose are acceptable methods for predicting the seismic response of non-classically damped coupled nuclear power plant (NPP) structures, systems and components when the ground input motion is defined as an acceleration time history. The complex-mode methodology is based on well-established theoretical principles and the close

agreement between the participants' solutions and the BNL direct integration time history analysis solutions has validated each participant's implementation and application of the basic methodology.

2. The complex-mode response spectrum analysis methods applied by Stevenson and Associates, Igusa and Der Kiureghian, and Gupta, Gupta and Bose are acceptable methods for predicting the seismic response of non-classically damped coupled NPP structures, systems and components when the input motion is defined as an acceleration response spectrum. By comparing individual participant response spectrum solutions to corresponding BNL time history solutions for a suite of earthquakes and averaging the ratios of results, it was shown that the participants' methods provided reasonably accurate and generally conservative results. The S&A RSM-I, Igusa, and Gupta methods provided generally closer agreement than the S&A RSM-II method.

3. The classical normal-mode response spectrum analysis method with composite modal damping as applied by Chen has been considered an acceptable method and has been previously applied in seismic design analysis of non-classically damped coupled NPP structures, systems and components for coupled subsystems with different modal damping ratios. In this program, the smaller problem solutions were in good agreement with the BNL benchmark solutions, and the larger problem solutions were generally very conservative.

4. For both the complex-mode and normal-mode methods, the modal damping values of either the primary or secondary system of the coupled model should be in accordance with regulatory requirements and should not exceed 20%.

5. For NPP structures, systems and components, both the complex-mode and normal mode analysis methods must be implemented in accordance with the requirements of the USNRC Standard Review Plan and Regulatory Guides for seismic analysis. For complex-mode methods, care must be applied in properly formulating the coupled system damping matrix, estimating the relative velocity-based response spectrum, and using appropriate modal combination procedures. In addition, since coupled analyses do not require the generation of floor response spectra, the effects of variations in seismic response due to modeling uncertainties normally addressed by the floor spectrum broadening requirements, need to be appropriately considered.

5.4 Areas for Future Study

The primary goal of this benchmark program was to evaluate the acceptability of state-of-the-art complex-mode analytical methods for predicting the seismic response of coupled NPP structures with non-classical damping. The program goal was achieved by demonstrating that the methods provide results which are comparable to those obtained using the direct integration time history analysis method which has been long been considered an acceptable "exact" method of seismic analysis in the nuclear industry. All methods were shown to provide results that were reasonably close or generally conservative compared to the BNL benchmark problem results. Modal superposition time history analysis results were in better agreement than response spectrum results as would be expected. The response spectrum results were found be within a level of agreement that would be expected between classical normal-mode response spectrum and time history results.

It was observed that the S&A RSM-I, Igusa, and Gupta response spectrum methods provided generally better results than the S&A RSM-II method. Chen's classical normal mode analyses results were also in very good agreement for small problems but not for larger problems. To better understand the reasons behind the findings, additional studies could be performed. Under this program, participants were invited the use their own methods and computer programs in their entirety, and so there were numerous differences in analytical techniques that may affect the accuracy of their results. Because of the differences, it is difficult to pinpoint the reasons for the variations in participants' results. Some additional studies to systematically investigate the different techniques between methods could provide valuable insights to better understand the differences and identify critical areas for improvement. Suggested areas for additional study are discussed below.

1. Within the range of parameters considered in this study, the small problem results did not demonstrate that the non-classically damped complex-mode methods provide more accurate results than the normal mode methods. However, the larger problem results suggest that the complex-mode methods give better results. The reasons for these inconsistent findings may be due to factors unrelated to normal-mode versus complex-mode methodology (such as modal combination methods). To further investigate this issue, it would be useful to compare modal time history results. Additional studies can be performed using Chen's modal properties to produce modal superposition time history results for comparison with the complex mode results. These studies could provide clearer insight into the improvements that can be achieved with the application of complex-mode methods.

2. One of the most critical elements of a response spectrum analysis method is the modal combination procedure. In the analysis of coupled systems in which a light secondary system model is combined with a primary structure model, closely spaced modes with scaled eigenvector values which are nearly equal and opposite in sign will often occur. For these problems, the highest quality rules are necessary for estimating the modal correlation coefficients. A number of different techniques have been formulated in recent years to develop more accurate modal combination rules for closely spaced modes and high frequency modes. In this benchmark study, it appears that the modal combination rules used in the Gupta and Igusa analyses may have provided better results than the S&A RSM-II and Chen analyses for the larger problems. If the Chen and S&A analyses were repeated using the Gupta or Igusa modal combination rules, the importance of high quality modal combinations rules could be evaluated.

3. The modal time history parametric studies with respect to variations of frequency ratios, mass ratios and damping demonstrated that good agreement can be expected for the entire range of parameters investigated. It is reasonable to believe that the same conclusion should extend to response spectrum methods. However, since the response spectrum analyses were carried out for only a single earthquake ground motion, normal variations associated with single time history to response spectrum solution comparisons made it difficult to identify deviations that are solely attributed to the parametric variations. Additional parametric studies using a suite of earthquake ground motions, with comparisons based on mean ratios of results, could provide more conclusive evidence to validate this conclusion.

4. Although the coupled versus uncoupled analyses were studied in the past (Refs. 53, 54), the results of this study undoubtedly provide an excellent database for further investigation into the benefits of coupled versus uncoupled response spectrum analyses for either complex or normal-mode methods. For each of the benchmark problems, the uncoupled results may be obtained by using the time history analysis of the primary system to obtain the input "floor" spectrum for the secondary system model. Results from these uncoupled secondary system analyses can then be compared against both the BNL coupled time history results and the participants' coupled response spectrum results to evaluate the benefits of coupled analysis.

5. As discussed in Section 4.1, piping programs different from SAP-V were employed by the participants for the benchmark problem no. 4a and no. 4b. Due to different algorithms used in these piping programs, some differences (maximum of 7%) in frequencies of the secondary system for both benchmark problems were exhibited between the BNL solutions and others. This difference in frequencies may translate into larger differences in the response calculations. This was an unanticipated modeling difference that affected the comparisons for the larger problems. In order to focus on coupled analysis issues, any future studies should eliminate this modeling difference.

6. As discussed in Section 4.5 and suggested by several participants, comparison of time history analyses of the benchmark problems 4a and 4b would be most useful in identifying the sources of differences in results; due to finite element modeling, classical composite damping and non-classical damping. Furthermore, the effects of the three components of seismic input, as opposed to a single directional input analyzed in this benchmark problem should also be investigated for the benchmark problems 4a and 4b.

6.0 REFERENCES

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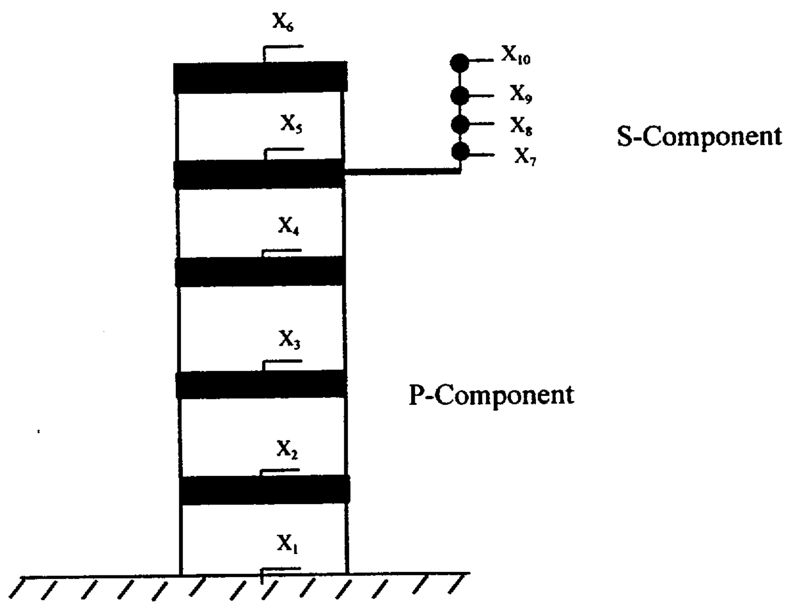

Figure 1. Schematic Diagram of BNL Benchmark Problem No. 1

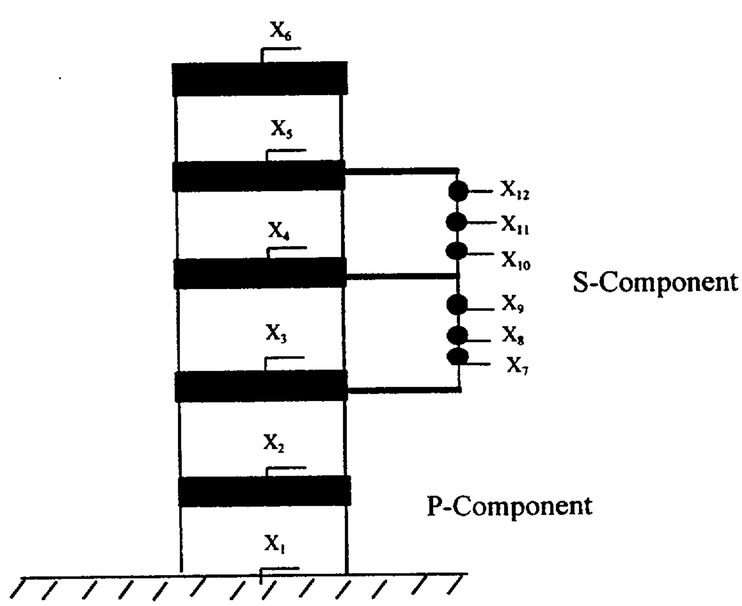

Figure 2. Schematic Diagram of BNL Benchmark Problem No. 2

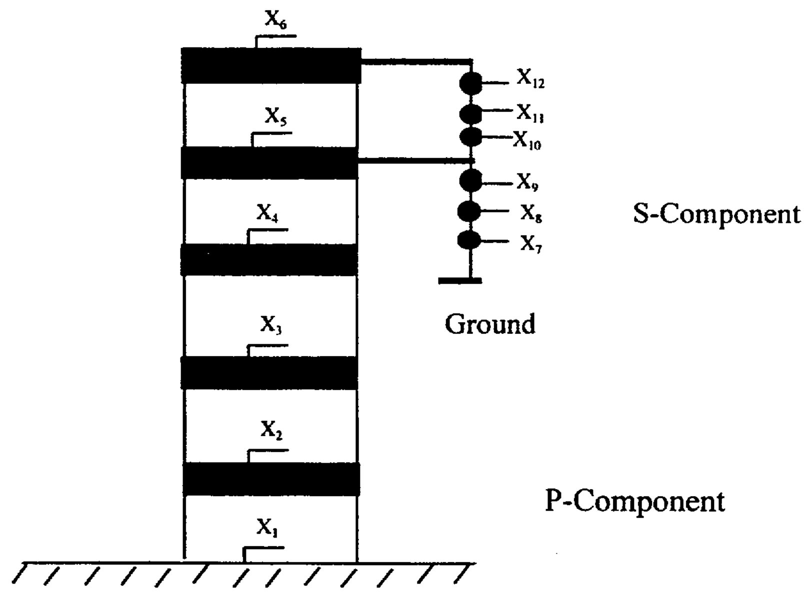

Figure 3. Schematic Diagram of BNL Benchmark Problem No. 3

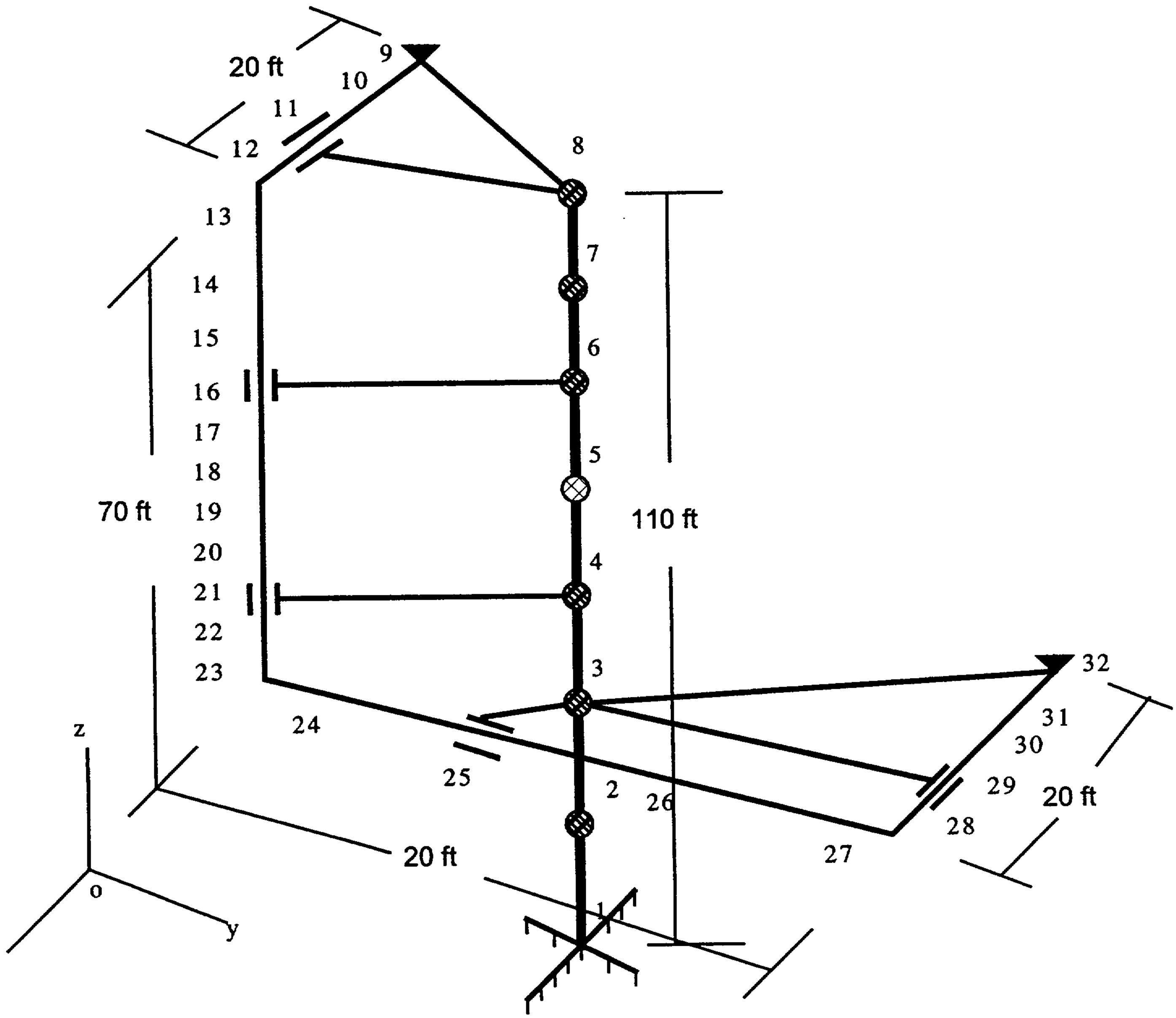

Figure 4. Schematic Diagram of BNL Benchmark Problem No. 4

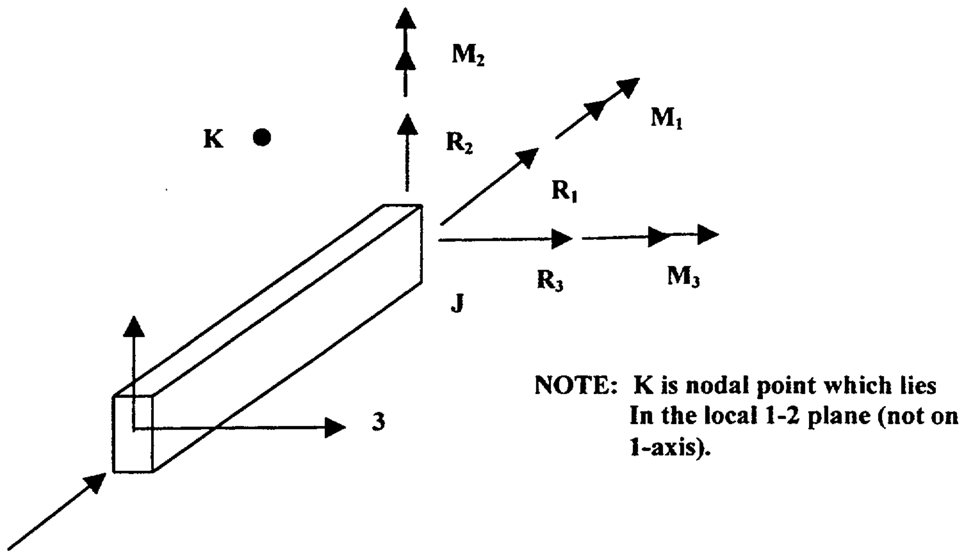

Figure 5. Sign convention for element nodal forces and moments of 3-D beam element.

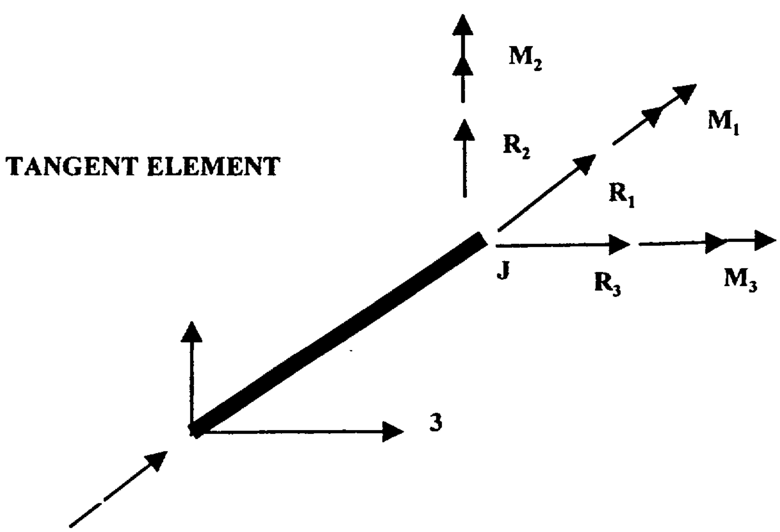

Figure 6. Sign convention for element nodal forces and moments of tangent pipe element.

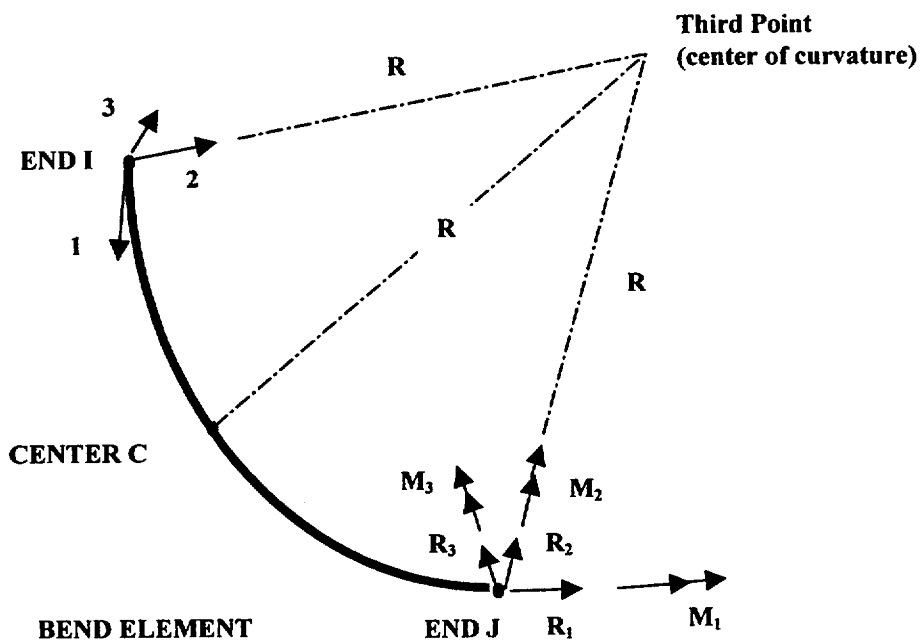

Figure 7. Sign convention for element nodal forces and moments of bend pipe element.

Table 1. BNL Benchmark Problem 1, 2 & 3 Load Cases

Parameter/Load Variations		Load Case															
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
Frequency Ratio (Secondary/Primary)	0.5		X														
	0.9			X													
	1.0	X					X	X	X	X	X	X	X	X	X	X	X
	1.1				X												
	2.0					X											
Mass Ratio (Secondary/Primary)	.0001						X										
	.005	X	X	X	X	X				X	X	X	X	X	X	X	X
	.1							X									
	.5								X								
Modal Damping (Primary, Secondary)	7%, 2%	X	X	X	X	X	X	X	X			X	X	X	X	X	X
	7%, 5%									X							
	7%,20%										X						
Earthquake Input Motion (see Notes)	EQ #1	X	X	X	X	X	X	X	X	X	X						
	EQ #2											X					
	EQ #3												X				
	EQ #4													X			
	EQ #5														X		
	EQ #6															X	
	EQ #7																X

*Notes: Earthquake Input Motions, as defined in Section 2.2, are given below:

- EQ #1: EL CENTRO, SOOE (1940)
- EQ #2: TAFT COMP. S69E (1952)
- EQ #3: OLYMPIA COMP. N86E (1949)
- EQ #4: EL CENTRO COMP. S40E (1979)
- EQ #5: LOMA PRIETA, FOSTER CITY (1989)
- EQ #6: NORTHRIDGE COMP. N30W (1994)
- EQ #7: REG. GUIDE 1.60 COMPATIBLE ACCELERATION TIME HISTORY

Table 2. BNL Benchmark Problem 4a and 4b Load Cases

Parameter/Load Variations		Load Case						
		a	b	c	d	e	f	g
Frequency Ratio (Secondary/Primary)	0.5							
	0.9							
	1.0	X	X	X	X	X	X	X
	1.1							
	2.0							
Ratio of S/P component masses (Total mass)	.0001							
	.0005	X	X	X	X	X	X	X
	.1							
	.5							
Modal Damping (Primary, Secondary)	7%, 2%	X	X	X	X	X	X	X
	7%, 5%							
	7%,20%							
Earthquake Input Motion (See Notes for Table 1)	EQ #1	X						
	EQ #2		X					
	EQ #3			X				
	EQ #4				X			
	EQ #5					X		
	EQ #6						X	
	EQ #7							X

Table 3. Frequencies of P-component for BNL benchmark problems No. 1, No. 2 and No. 3

Modes	Frequency (cps)
1	5
2	14.6
3	23.01
4	29.56
5	33.71

Table 4. Frequencies of fixed-constraint S-component for BNL benchmark problems No. 1

Modes	Load cases				
	a	b	c	d	e
1	5.00	2.50	4.50	5.51	10.01
2	14.40	7.21	12.97	15.85	28.83
3	22.06	11.04	19.87	24.29	44.16
4	27.06	13.54	24.37	29.79	54.17

Table 5. Frequencies of fixed-constraint S-component for BNL benchmark problems No. 2 and No. 3

Modes	Load cases				
	a	b	c	d	e
1	5.00	2.50	4.50	5.50	10.02
2	5.00	2.50	4.50	5.50	10.02
3	9.24	4.62	8.32	10.16	18.51
4	9.24	4.62	8.32	10.16	18.51
5	12.07	6.04	10.86	13.28	24.18
6	12.07	6.04	10.86	13.28	24.18

Table 6. Frequencies of P-component for BNL benchmark problem No. 4a

Modes	Frequency (cps)
1	8.24
2	8.3
3	22.09
4	33.38
5	33.47
6	67.41
7	67.5
8	68.04
9	91.97
10	92.04
11	111.29
12	111.34
13	115.09
14	130.12
15	130.15
16	149.68
17	149.71
18	149.87
19	176.86
20	204.01
21	234.57

Table 7. Frequencies of fixed-constraint S-component for BNL benchmark problem No. 4a

Modes	Frequency (cps)
1	8.25
2	8.56
3	14.95
4	16.67
5	17.35
6	24.37
7	25.56
8	26.09
9	26.25
10	27.48
11	28.55
12	30.21
13	33.48
14	33.70
15	41.20
16	44.78
17	52.49
18	54.69
19	57.59
20	60.39
21	63.97
22	73.12
23	74.39
24	77.40
25	80.08
26	80.14
27	81.34
28	88.18
29	107.97
30	110.17
31	111.09
32	112.42
33	125.75
34	140.88
35	143.25
36	159.39
37	160.81
38	203.12
39	222.87
40	253.03

41	278.63
42	312.82
43	349.87
44	389.02
45	414.87
46	426.30
47	447.23
48	482.75
49	503.37
50	513.97
51	530.18
52	539.88
53	552.58
54	620.30
55	627.06
56	729.17

Table 8. Frequencies of P-component for BNL benchmark problem No. 4b

Modes	Frequency (cps)
1	4.60
2	4.63
3	12.33
4	18.63
5	18.68
6	37.62
7	37.68
8	37.98
9	51.33
10	51.37
11	62.12
12	62.14
13	64.24
14	72.63
15	72.64
16	83.55
17	83.56
18	83.65
19	98.71
20	113.87
21	130.92

Table 9. Frequencies of fixed-constraint S-component for BNL benchmark problem No. 4b

Modes	Frequency (cps)
1	4.60
2	4.77
3	8.34
4	9.29
5	9.67
6	13.59
7	14.25
8	14.55
9	14.64
10	15.32
11	15.92
12	16.84
13	18.67
14	18.79
15	22.97
16	24.97
17	29.27
18	30.49
19	32.11
20	33.67
21	35.67
22	40.77
23	41.48
24	43.16
25	44.65
26	44.68
27	45.35
28	49.17
29	60.20
30	61.43
31	61.94
32	62.68
33	70.12
34	78.55
35	79.87
36	88.87
37	89.66
38	113.26
39	124.27
40	141.09

41	155.36
42	174.42
43	195.08
44	216.91
45	231.32
46	237.69
47	249.36
48	269.17
49	280.67
50	286.58
51	295.62
52	301.02
53	308.10
54	345.87
55	349.63
56	406.57

Table 10. Comparison of maximum displacements of S&A results for benchmark problem No.1 using modal superposition time history analysis

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	0.997	1.004	0.997	0.999	1.004	1.003	1.004	1.003	0.998	1.004	0.999	0.996	0.999	1.004	0.998	1.002
3	0.998	1.003	1.000	1.001	1.006	1.001	1.002	1.002	1.002	1.006	1.000	0.999	1.001	1.003	0.996	1.003
4	1.005	1.002	1.004	1.003	1.002	1.002	1.003	1.001	1.005	1.002	1.003	0.996	1.001	1.004	1.000	1.000
5	1.003	1.002	1.005	1.004	1.004	1.003	1.001	1.001	1.005	1.004	0.997	0.997	1.002	1.006	0.996	1.003
6	1.004	1.002	1.003	1.002	1.004	1.004	1.005	0.999	1.002	1.002	1.002	0.998	1.001	1.005	0.999	1.002
7	1.000	0.998	1.001	1.001	1.003	1.000	1.002	1.000	1.000	1.002	1.002	1.009	1.002	0.999	0.997	1.000
8	1.001	0.997	0.996	1.000	1.003	1.000	1.005	0.999	1.001	1.002	0.997	1.010	1.001	0.999	0.996	0.998
9	1.003	1.001	1.000	1.001	1.001	1.002	1.003	0.999	1.000	1.002	1.002	1.008	1.002	1.001	0.998	1.001
10	1.003	0.999	1.001	1.003	1.000	1.001	1.010	0.999	1.005	1.001	1.000	1.010	1.000	0.999	0.997	1.002

Table 11. Comparison of maximum displacements of Igusa/Der Kiureghian results for benchmark problem No.1 using modal superposition time history analysis

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	0.999	1.002	0.999	1.000	1.002	1.002	1.003	1.001	0.999	1.002	1.000	0.998	1.001	1.004	0.999	1.002
3	0.999	1.001	1.000	1.001	1.001	1.001	1.002	1.000	0.999	1.001	1.000	0.998	1.001	1.004	0.999	1.002
4	1.001	1.001	1.002	1.001	1.001	1.001	1.003	1.000	1.001	1.001	1.000	0.998	1.001	1.004	0.998	1.001
5	1.001	1.001	1.002	1.001	1.001	1.001	1.001	1.000	1.001	1.001	1.000	0.998	1.001	1.003	0.998	1.001
6	1.001	1.001	1.002	1.001	1.001	1.001	1.003	1.000	1.001	1.001	1.000	0.998	1.001	1.004	0.998	1.001
7	1.000	1.000	0.999	1.005	1.001	1.000	1.003	1.000	1.000	1.001	1.001	1.002	1.000	0.999	0.998	0.998
8	1.000	0.991	0.998	1.006	1.001	1.000	1.003	1.000	1.001	1.001	1.001	1.003	1.000	1.000	0.998	0.998
9	1.001	0.992	0.998	1.007	1.002	1.001	1.004	0.999	1.001	1.001	1.000	1.003	1.000	1.000	0.998	0.998
10	1.001	0.992	0.999	1.008	1.001	1.001	1.004	0.999	1.001	1.001	1.001	1.003	1.000	1.000	0.998	0.998

Table 12. Comparison of maximum displacements of Gupta results for benchmark problem No.1 using modal superposition time history analysis

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	1.002	1.002	1.002	1.002	1.000	1.001	1.001	1.000	1.001	1.000	1.001	1.001	0.978	1.001	1.001	1.000
3	1.002	1.000	1.002	1.001	1.001	1.001	1.001	1.000	1.002	1.001	1.001	1.001	1.038	1.001	1.000	1.001
4	1.001	1.000	1.002	1.001	1.001	1.001	1.001	1.000	1.000	1.001	1.000	1.001	1.003	1.001	1.001	1.001
5	1.001	1.000	1.001	1.001	1.001	1.000	1.001	1.000	1.001	1.000	1.001	1.001	0.996	1.001	1.001	1.001
6	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.000	1.000	1.001	1.001	1.016	1.001	1.000	1.001
7	1.001	1.002	1.000	0.998	1.001	1.001	1.002	1.000	1.002	1.001	1.001	1.000	0.988	1.001	1.001	1.001
8	1.001	0.994	0.999	0.997	1.001	1.001	1.001	1.000	1.001	1.001	1.001	0.999	1.002	1.000	1.001	1.001
9	1.001	0.994	0.999	0.996	1.001	1.001	1.002	1.001	1.001	1.001	1.000	0.999	0.997	1.000	1.001	1.001
10	1.001	0.994	0.999	0.996	1.002	1.001	1.001	1.000	1.001	1.001	1.000	0.998	1.005	1.000	1.001	1.001

Table 13. Comparison of maximum displacements for benchmark problem No.1
S&A RSM-I method

Nodes	Load cases															
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**I**	**j**	**k**	**l**	**m**	**n**	**o**	**p**
2	0.971	1.051	0.982	1.072	1.044	1.045	1.061	1.025	1.012	1.042	1.069	0.949	0.886	1.034	0.961	1.134
3	0.959	1.035	0.974	1.060	1.025	1.026	1.055	1.033	1.002	1.026	1.069	0.953	0.891	1.034	0.972	1.139
4	0.957	1.020	0.972	1.041	1.015	1.016	1.061	1.044	0.995	1.012	1.066	0.958	0.897	1.033	0.971	1.149
5	0.940	1.009	0.955	1.027	1.000	1.000	1.061	1.049	0.978	0.997	1.070	0.961	0.901	1.030	0.967	1.148
6	0.932	0.995	0.943	1.020	0.990	0.990	1.061	1.061	0.970	0.985	1.069	0.965	0.903	1.032	0.964	1.150
7	1.009	0.943	1.033	0.973	0.999	0.982	0.998	1.009	1.086	0.924	1.082	1.153	1.514	0.967	1.116	0.914
8	1.013	1.041	0.967	1.000	1.006	0.985	1.011	0.980	1.070	0.909	1.106	1.213	1.612	0.990	1.098	0.925
9	1.016	0.986	0.958	1.015	1.007	0.983	1.021	0.963	1.066	0.904	1.124	1.233	1.656	1.001	1.097	0.931
10	1.018	0.960	0.949	1.022	1.006	0.984	1.027	0.956	1.063	0.903	1.130	1.243	1.674	1.011	1.092	0.935

Table 14. Comparison of maximum displacements for benchmark problem No.1
S&A RSM-II method

Nodes	Load cases															
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**I**	**j**	**k**	**l**	**m**	**n**	**o**	**p**
2	1.174	1.007	0.952	1.052	1.001	1.002	1.004	1.003	1.021	1.000	1.266	1.180	1.037	1.112	1.387	1.348
3	1.189	1.009	0.962	1.060	1.006	1.007	1.018	1.017	1.034	1.006	1.287	1.203	1.054	1.145	1.410	1.386
4	1.205	1.011	0.976	1.060	1.006	1.007	1.034	1.031	1.042	1.002	1.303	1.220	1.067	1.171	1.413	1.402
5	1.200	1.009	0.971	1.054	1.000	1.003	1.042	1.043	1.037	1.000	1.314	1.232	1.074	1.186	1.410	1.412
6	1.195	1.002	0.964	1.048	0.997	0.997	1.043	1.052	1.030	0.992	1.320	1.242	1.078	1.194	1.406	1.423
7	1.043	0.935	1.104	1.016	1.016	1.000	1.012	1.009	1.126	0.919	1.172	1.173	1.668	1.189	1.051	1.026
8	1.043	1.048	1.040	1.063	1.030	1.015	1.040	0.983	1.114	0.923	1.206	1.219	1.780	1.246	1.014	1.031
9	1.047	0.996	1.021	1.085	1.038	1.021	1.057	0.969	1.112	0.932	1.216	1.238	1.831	1.272	1.002	1.041
10	1.050	0.969	1.019	1.098	1.041	1.025	1.068	0.963	1.116	0.937	1.225	1.247	1.849	1.281	1.001	1.047

Table 15. Comparison of maximum displacements for benchmark problem No.1
Chen Classical RSM method

Nodes	Load cases															
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**I**	**j**	**k**	**l**	**m**	**n**	**o**	**p**
2	1.117	0.986	0.964	1.127	0.965	1.100	0.909	0.905	0.990	0.861	1.028	0.990	0.886	1.029	1.224	1.113
3	1.051	1.035	0.955	1.120	1.013	1.155	0.901	0.939	1.047	0.903	1.090	0.986	0.895	1.026	1.215	1.190
4	1.095	1.020	1.018	1.083	0.997	1.149	0.912	0.959	1.038	0.924	1.105	1.001	0.908	1.039	1.221	1.235
5	1.102	0.998	0.994	1.089	1.012	1.140	0.905	0.960	1.052	0.916	1.123	1.036	0.923	1.069	1.203	1.241
6	1.080	1.016	0.978	1.105	0.994	1.111	0.906	0.974	1.034	0.908	1.161	1.035	0.926	1.081	1.238	1.246
7	0.960	0.908	1.155	1.030	1.019	0.982	0.864	0.920	1.118	1.009	0.984	0.932	1.426	1.027	0.892	0.895
8	0.954	1.019	1.084	1.071	1.021	0.990	0.890	0.906	1.114	1.097	1.007	0.970	1.520	1.084	0.863	0.898
9	0.958	0.966	1.069	1.085	1.049	0.994	0.914	0.891	1.112	1.135	1.025	0.986	1.561	1.107	0.859	0.900
10	0.959	0.943	1.061	1.098	1.044	0.998	0.920	0.883	1.110	1.150	1.028	0.990	1.580	1.117	0.859	0.904

Table 16. Comparison of maximum displacements for benchmark problem No.1
Igusa/Der Kiureghian RSM method

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	0.988	1.040	0.968	1.061	1.033	1.034	1.052	1.023	1.013	1.031	1.105	1.010	0.830	1.086	1.129	1.106
3	0.983	1.029	0.962	1.052	1.022	1.023	1.053	1.032	1.009	1.019	1.103	1.017	0.835	1.083	1.137	1.118
4	0.983	1.018	0.963	1.040	1.011	1.011	1.059	1.043	1.002	1.007	1.102	1.023	0.839	1.083	1.134	1.122
5	0.970	1.005	0.949	1.027	0.999	0.998	1.062	1.050	0.989	0.994	1.102	1.027	0.842	1.083	1.127	1.124
6	0.960	0.995	0.940	1.019	0.989	0.989	1.061	1.061	0.980	0.985	1.103	1.030	0.842	1.083	1.123	1.128
7	0.962	0.926	1.042	0.984	1.001	0.998	0.996	1.009	1.057	0.912	1.043	1.092	1.586	0.887	0.962	0.954
8	0.961	1.034	0.982	1.011	1.004	1.007	1.008	0.979	1.031	0.907	1.060	1.130	1.704	0.880	0.927	0.967
9	0.964	0.982	0.969	1.028	1.008	1.012	1.020	0.962	1.026	0.910	1.069	1.145	1.754	0.881	0.919	0.975
10	0.966	0.957	0.966	1.036	1.006	1.014	1.027	0.955	1.025	0.913	1.073	1.151	1.774	0.882	0.916	0.979

Table 17. Comparison of maximum displacements for benchmark problem No.1
Gupta RSM method

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	1.023	1.057	0.990	1.086	1.050	1.051	1.092	1.059	1.039	1.051	1.072	1.010	0.861	1.036	1.104	1.133
3	1.009	1.038	0.976	1.069	1.030	1.031	1.085	1.062	1.025	1.030	1.070	1.012	0.860	1.034	1.112	1.138
4	1.002	1.020	0.971	1.050	1.013	1.013	1.086	1.066	1.013	1.011	1.070	1.015	0.859	1.034	1.109	1.138
5	0.984	1.004	0.952	1.032	0.997	0.996	1.083	1.068	0.995	0.994	1.071	1.017	0.859	1.034	1.102	1.135
6	0.972	0.992	0.941	1.022	0.985	0.985	1.082	1.080	0.983	0.984	1.072	1.019	0.858	1.035	1.099	1.138
7	0.930	0.938	1.019	0.958	0.991	1.015	0.989	1.014	1.022	0.904	1.075	1.096	1.529	0.973	1.000	0.929
8	0.927	1.043	0.953	0.987	0.990	1.032	0.992	0.979	0.989	0.915	1.103	1.138	1.642	0.996	0.974	0.942
9	0.930	0.989	0.938	1.004	0.990	1.039	0.999	0.959	0.982	0.930	1.116	1.155	1.690	1.009	0.968	0.950
10	0.932	0.962	0.935	1.012	0.987	1.043	1.005	0.951	0.981	0.938	1.122	1.162	1.710	1.014	0.965	0.954

Table 18. Comparison of statistics of maximum displacements for benchmark problem No.1
S&A RSM-I method

Nodes	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
2	1.000	0.084	0.083	1.134	0.886
3	1.002	0.083	0.083	1.139	0.891
4	1.004	0.084	0.084	1.149	0.897
5	1.003	0.085	0.085	1.148	0.901
6	1.002	0.087	0.086	1.150	0.903
7	1.108	0.198	0.179	1.514	0.914
8	1.137	0.229	0.202	1.612	0.925
9	1.151	0.243	0.211	1.656	0.931
10	1.158	0.230	0.198	1.674	0.935

Table 19. Comparison of statistics of maximum displacements for benchmark problem No.1
S&A RSM-II method

Nodes	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
2	1.215	0.126	0.104	1.387	1.037
3	1.239	0.129	0.104	1.410	1.054
4	1.254	0.126	0.100	1.413	1.067
5	1.261	0.125	0.099	1.412	1.074
6	1.265	0.125	0.099	1.423	1.078
7	1.189	0.223	0.187	1.668	1.026
8	1.220	0.266	0.218	1.780	1.014
9	1.235	0.284	0.230	1.831	1.002
10	1.243	0.290	0.233	1.849	1.001

Table 20. Comparison of statistics of maximum displacements for benchmark problem No.1
Chen classical RSM method

Nodes	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
2	1.055	0.108	0.103	1.224	0.886
3	1.065	0.112	0.105	1.215	0.895
4	1.086	0.117	0.108	1.235	0.908
5	1.100	0.106	0.096	1.241	0.923
6	1.110	0.115	0.103	1.246	0.926
7	1.017	0.187	0.184	1.426	0.892
8	1.042	0.223	0.214	1.520	0.863
9	1.056	0.237	0.224	1.561	0.859
10	1.062	0.243	0.229	1.580	0.859

Table 21. Comparison of statistics of maximum displacements for benchmark problem No.1
Igusa/Der Kiureghian RSM method

Nodes	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
2	1.036	0.105	0.101	1.129	0.830
3	1.039	0.106	0.102	1.137	0.835
4	1.041	0.104	0.100	1.134	0.839
5	1.039	0.104	0.100	1.127	0.842
6	1.039	0.105	0.101	1.128	0.842
7	1.069	0.237	0.222	1.586	0.887
8	1.090	0.283	0.260	1.704	0.880
9	1.101	0.301	0.274	1.754	0.881
10	1.106	0.309	0.279	1.774	0.882

Table 22. Comparison of statistics of maximum displacements for benchmark problem No.1 Gupta RSM method

Nodes	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
2	1.034	0.088	0.086	1.133	0.861
3	1.034	0.091	0.088	1.138	0.860
4	1.032	0.091	0.088	1.138	0.859
5	1.029	0.091	0.088	1.135	0.859
6	1.028	0.092	0.090	1.138	0.858
7	1.076	0.210	0.195	1.529	0.929
8	1.103	0.250	0.227	1.642	0.927
9	1.117	0.267	0.239	1.690	0.930
10	1.123	0.273	0.243	1.710	0.932

Table 23. Comparison of maximum shear forces of S&A results for benchmark problem No.1 using modal superposition time history analysis

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	0.996	1.004	0.997	0.997	1.003	1.004	1.003	1.002	0.997	1.003	0.998	0.997	1.002	1.007	1.000	1.004
2	0.999	1.002	0.998	1.004	1.004	1.002	1.005	1.001	1.001	1.002	1.001	0.997	1.001	1.006	0.998	1.002
3	1.005	1.003	1.003	1.002	1.003	1.003	1.002	0.998	1.000	1.001	0.998	0.995	1.001	1.006	0.998	1.001
4	1.000	1.004	1.000	0.999	1.003	0.999	1.003	1.003	1.005	1.000	1.001	0.996	1.002	1.004	1.001	1.002
5	0.996	0.997	0.997	0.996	0.996	0.996	1.011	0.996	0.996	0.996	1.000	0.996	1.001	1.005	0.998	1.001
6	1.003	1.000	1.000	1.004	1.011	1.003	1.008	0.998	1.002	1.002	1.000	1.004	0.997	1.000	0.998	1.000
7	1.002	1.002	1.000	1.002	1.007	1.002	1.008	0.995	1.003	0.998	1.001	1.004	0.997	1.001	0.998	1.001
8	1.003	0.999	1.001	1.005	0.994	1.006	1.011	0.999	1.001	0.999	1.000	1.004	1.000	1.001	0.997	1.000
9	1.003	0.999	1.004	1.006	0.987	1.002	1.009	1.001	1.003	0.999	1.000	1.004	1.001	1.002	0.997	0.999

Table 24. Comparison of maximum shear forces of Igusa/Der Kiureghian results for benchmark problem No.1 using modal superposition time history analysis

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	0.999	1.002	0.999	1.000	1.002	1.002	1.003	1.001	0.999	1.002	1.000	0.998	1.001	1.004	0.999	1.002
2	1.000	1.001	1.000	1.000	1.001	1.001	1.002	1.000	1.001	1.001	1.000	0.998	1.001	1.004	0.998	1.001
3	1.001	1.001	1.001	1.000	1.001	1.001	1.002	0.999	1.001	1.000	1.000	0.998	1.000	1.003	0.998	1.001
4	1.001	1.000	1.001	1.000	1.000	1.000	1.002	1.001	1.001	1.001	1.001	0.998	1.001	1.004	0.998	1.000
5	0.997	0.997	0.998	0.998	0.997	0.997	1.005	0.999	0.997	0.997	1.001	0.997	1.000	1.004	0.998	1.000
6	1.001	0.989	0.998	1.008	1.006	1.001	1.004	0.998	1.001	1.001	1.001	1.001	1.000	1.000	0.998	0.999
7	1.001	0.991	0.999	1.007	1.003	1.001	1.005	0.998	1.002	1.001	1.001	1.002	1.000	1.000	0.998	0.999
8	1.001	0.993	0.998	1.008	0.999	1.001	1.006	0.999	1.002	1.001	1.001	1.002	0.999	1.000	0.998	0.999
9	1.001	0.992	0.999	1.009	0.996	1.001	1.004	1.000	1.002	1.000	1.001	1.002	0.999	1.000	0.998	0.999

Table 25. Comparison of maximum shear forces of Gupta results for benchmark problem No.1 using modal superposition time history analysis

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	1.002	1.002	1.003	1.002	1.001	1.001	1.001	1.000	1.002	1.000	1.001	1.001	1.001	1.001	1.001	1.001
2	1.002	1.000	1.002	1.001	1.000	1.000	1.001	1.000	1.001	1.000	1.000	1.001	1.001	1.001	1.000	1.001
3	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.000	1.001	1.001	1.000	1.001	1.001	1.000	1.001	1.001
4	1.000	1.001	1.001	1.001	1.001	1.001	1.001	1.000	1.000	1.001	1.000	1.001	1.001	1.000	1.000	1.001
5	1.001	1.001	1.001	1.002	1.001	1.001	0.999	1.000	1.001	1.001	1.000	1.001	1.001	1.001	1.000	1.000
6	1.001	0.996	1.000	0.995	1.000	1.001	1.002	1.001	1.000	1.001	1.001	0.999	1.001	1.000	1.001	1.001
7	1.001	0.995	1.000	0.995	1.001	1.001	1.002	1.001	1.000	1.001	1.001	0.999	1.001	1.000	1.001	1.001
8	1.001	0.994	1.001	0.994	1.001	1.001	1.001	1.001	1.001	1.001	1.000	0.999	1.001	1.000	1.000	1.001
9	1.001	0.994	0.999	0.994	1.002	1.001	1.002	1.000	1.001	1.001	1.000	0.999	1.001	1.000	1.000	1.001

Table 26. Comparison of maximum shear forces for benchmark problem No.1 S&A RSM-I Method

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	0.973	1.051	0.982	1.072	1.045	1.047	1.061	1.028	1.013	1.042	1.069	0.950	0.884	1.035	0.961	1.135
2	0.951	1.019	0.964	1.039	1.013	1.015	1.055	1.042	0.993	1.006	1.067	0.957	0.901	1.033	0.966	1.153
3	0.925	0.992	0.935	1.008	0.982	0.982	1.056	1.065	0.958	0.975	1.070	0.973	0.913	1.034	0.953	1.159
4	0.878	0.941	0.882	0.957	0.935	0.936	1.052	1.049	0.913	0.931	1.072	0.981	0.923	1.033	0.948	1.155
5	0.826	0.882	0.848	0.918	0.885	0.883	0.921	0.886	0.858	0.880	1.086	0.999	0.930	1.042	0.948	1.212
6	1.030	1.042	0.935	1.057	0.854	0.989	1.078	0.901	1.064	0.900	1.160	1.265	1.771	1.044	1.083	0.955
7	1.033	0.969	0.933	1.074	0.836	0.992	1.105	0.879	1.066	0.897	1.170	1.259	1.800	1.053	1.081	0.960
8	1.039	0.907	0.934	1.090	0.827	0.991	1.125	0.872	1.069	0.888	1.174	1.258	1.823	1.058	1.078	0.965
9	1.042	0.864	0.935	1.100	0.823	0.991	1.124	0.870	1.072	0.878	1.175	1.256	1.811	1.064	1.075	0.970

Table 27. Comparison of maximum shear forces for benchmark problem No.1 S&A RSM-II Method

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	1.173	1.008	0.951	1.052	1.003	1.000	1.006	1.000	1.021	0.999	1.265	1.181	1.035	1.110	1.388	1.347
2	1.211	1.019	0.977	1.065	1.013	1.015	1.034	1.034	1.045	1.011	1.318	1.233	1.075	1.184	1.412	1.419
3	1.212	1.018	0.977	1.065	1.013	1.013	1.056	1.068	1.042	1.006	1.351	1.270	1.102	1.238	1.395	1.459
4	1.171	0.990	0.945	1.035	0.990	0.985	1.068	1.059	1.019	0.979	1.368	1.289	1.118	1.277	1.391	1.477
5	1.140	0.950	0.932	1.016	0.951	0.950	0.968	0.932	0.986	0.952	1.427	1.361	1.134	1.334	1.404	1.578
6	1.067	1.062	1.002	1.167	0.949	1.041	1.141	0.919	1.126	0.982	1.271	1.265	1.971	1.351	0.992	1.073
7	1.072	0.991	0.999	1.189	0.936	1.046	1.174	0.900	1.127	0.993	1.279	1.262	2.003	1.365	0.987	1.077
8	1.077	0.933	0.999	1.207	0.927	1.049	1.200	0.902	1.128	0.986	1.285	1.260	2.024	1.373	0.984	1.082
9	1.078	0.895	1.000	1.219	0.926	1.047	1.202	0.900	1.131	0.984	1.286	1.260	2.008	1.377	0.982	1.088

Table 28. Comparison of maximum shear forces for benchmark problem No.1
Chen Classical RSM Method

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	1.068	1.010	0.969	1.084	1.001	1.132	0.881	0.923	1.032	0.909	1.093	0.985	0.886	0.992	1.203	1.165
2	1.099	1.023	0.995	1.099	1.012	1.146	0.905	0.953	1.059	0.915	1.134	1.027	0.919	1.055	1.222	1.228
3	1.101	1.023	0.998	1.097	1.012	1.145	0.920	0.983	1.057	0.911	1.163	1.059	0.942	1.104	1.211	1.262
4	1.070	0.998	0.966	1.068	0.988	1.112	0.926	0.974	1.028	0.886	1.181	1.079	0.958	1.144	1.203	1.278
5	1.039	0.956	0.951	1.046	0.954	1.072	0.876	0.884	0.999	0.857	1.236	1.142	0.974	1.195	1.221	1.369
6	0.966	1.037	1.052	1.157	0.954	0.989	0.995	0.848	1.134	1.257	1.067	0.998	1.676	1.175	0.856	0.917
7	0.967	0.975	1.048	1.168	0.942	1.024	1.027	0.836	1.129	1.247	1.072	0.999	1.708	1.199	0.848	0.920
8	0.966	0.920	1.038	1.194	0.919	1.020	1.055	0.839	1.141	1.241	1.084	0.993	1.722	1.197	0.842	0.934
9	0.977	0.903	1.039	1.189	0.968	0.958	1.060	0.841	1.126	1.234	1.111	0.987	1.715	1.182	0.836	0.919

Table 29. Comparison of maximum shear forces for benchmark problem No.1
Igusa/Der Kiureghian RSM Method

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	0.988	1.040	0.968	1.061	1.033	1.034	1.053	1.023	1.013	1.031	1.105	1.010	0.830	1.086	1.129	1.106
2	0.979	1.018	0.958	1.039	1.011	1.012	1.056	1.044	1.002	1.007	1.101	1.025	0.842	1.081	1.128	1.133
3	0.955	0.995	0.936	1.013	0.988	0.987	1.058	1.069	0.976	0.982	1.101	1.041	0.851	1.082	1.105	1.139
4	0.910	0.951	0.886	0.968	0.945	0.942	1.056	1.053	0.931	0.938	1.103	1.051	0.858	1.085	1.091	1.135
5	0.863	0.894	0.857	0.929	0.896	0.895	0.931	0.897	0.883	0.893	1.120	1.076	0.860	1.095	1.090	1.194
6	0.974	1.042	0.949	1.076	0.856	1.025	1.074	0.900	1.023	0.937	1.100	1.157	1.879	0.896	0.904	0.999
7	0.978	0.972	0.948	1.093	0.839	1.029	1.099	0.878	1.024	0.943	1.106	1.153	1.913	0.900	0.900	1.005
8	0.982	0.909	0.950	1.108	0.828	1.031	1.121	0.873	1.025	0.936	1.110	1.150	1.934	0.902	0.896	1.009
9	0.985	0.869	0.952	1.120	0.822	1.030	1.120	0.868	1.027	0.932	1.111	1.149	1.924	0.903	0.894	1.014

Table 30. Comparison of maximum shear forces for benchmark problem No.1
Gupta RSM Method

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	1.023	1.058	0.990	1.086	1.050	1.051	1.092	1.059	1.039	1.050	1.072	1.010	0.861	1.036	1.104	1.133
2	0.994	1.017	0.962	1.045	1.009	1.010	1.079	1.066	1.008	1.008	1.069	1.016	0.859	1.033	1.102	1.145
3	0.955	0.981	0.927	1.005	0.973	0.973	1.069	1.079	0.968	0.970	1.072	1.024	0.858	1.035	1.080	1.139
4	0.901	0.929	0.868	0.951	0.922	0.919	1.056	1.053	0.914	0.916	1.077	1.031	0.859	1.038	1.067	1.126
5	0.848	0.867	0.833	0.908	0.869	0.867	0.936	0.937	0.860	0.868	1.096	1.054	0.860	1.046	1.068	1.180
6	0.939	1.046	0.917	1.059	0.817	1.058	1.041	0.890	0.975	0.994	1.156	1.171	1.814	1.049	0.957	0.975
7	0.944	0.972	0.916	1.077	0.797	1.063	1.064	0.867	0.976	1.012	1.164	1.168	1.847	1.058	0.954	0.981
8	0.948	0.905	0.917	1.093	0.785	1.067	1.083	0.861	0.977	1.011	1.169	1.167	1.868	1.064	0.951	0.986
9	0.951	0.859	0.919	1.105	0.777	1.066	1.082	0.857	0.979	1.011	1.172	1.165	1.859	1.067	0.949	0.990

Table 31. Comparison of statistics of maximum shear forces for benchmark problem No.1 S&A RSM-I method

Elements	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
1	1.001	0.084	0.084	1.135	0.884
2	1.004	0.086	0.085	1.153	0.901
3	1.004	0.089	0.088	1.159	0.913
4	0.999	0.095	0.095	1.155	0.878
5	1.006	0.124	0.123	1.212	0.826
6	1.187	0.276	0.233	1.771	0.955
7	1.194	0.284	0.238	1.800	0.960
8	1.199	0.291	0.243	1.823	0.965
9	1.199	0.286	0.238	1.811	0.970

Table 32. Comparison of statistics of maximum shear forces for benchmark problem No.1 S&A RSM-II method

Elements	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
1	1.214	0.127	0.104	1.388	1.035
2	1.265	0.126	0.099	1.419	1.075
3	1.289	0.121	0.094	1.459	1.102
4	1.299	0.125	0.097	1.477	1.118
5	1.340	0.159	0.119	1.578	1.134
6	1.284	0.330	0.257	1.971	0.992
7	1.292	0.342	0.264	2.003	0.987
8	1.298	0.348	0.268	2.024	0.984
9	1.297	0.343	0.264	2.008	0.982

Table 33. Comparison of statistics of maximum shear forces for benchmark problem No.1 Chen Classical RSM method

Elements	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
1	1.056	0.110	0.105	1.203	0.886
2	1.098	0.110	0.100	1.228	0.919
3	1.120	0.105	0.094	1.262	0.942
4	1.130	0.105	0.093	1.278	0.958
5	1.168	0.131	0.112	1.369	0.974
6	1.094	0.277	0.253	1.676	0.856
7	1.102	0.290	0.263	1.708	0.848
8	1.106	0.294	0.266	1.722	0.842
9	1.104	0.293	0.265	1.715	0.836

Table 34. Comparison of statistics of maximum shear forces for benchmark problem No.1 Igusa/Der Kiureghian RSM method

Elements	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
1	1.036	0.105	0.101	1.129	0.830
2	1.041	0.104	0.100	1.133	0.842
3	1.039	0.102	0.098	1.139	0.851
4	1.033	0.106	0.103	1.135	0.858
5	1.042	0.129	0.124	1.194	0.860
6	1.130	0.344	0.305	1.879	0.896
7	1.136	0.356	0.313	1.913	0.900
8	1.141	0.363	0.318	1.934	0.896
9	1.140	0.359	0.315	1.924	0.894

Table 35. Comparison of statistics of maximum shear forces for benchmark problem No.1 Gupta RSM method

Elements	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
1	1.034	0.088	0.086	1.133	0.861
2	1.031	0.092	0.089	1.145	0.859
3	1.024	0.092	0.090	1.139	0.858
4	1.014	0.097	0.096	1.126	0.859
5	1.022	0.123	0.120	1.180	0.848
6	1.151	0.306	0.266	1.814	0.939
7	1.159	0.317	0.274	1.847	0.944
8	1.165	0.324	0.278	1.868	0.948
9	1.165	0.320	0.275	1.859	0.949

Table 36. Comparison of maximum displacements of S&A results for benchmark problem No.2 using modal superposition time analysis

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	0.997	0.998	0.998	1.002	1.004	1.003	0.998	1.003	0.998	1.004	1.000	0.996	0.999	1.005	0.997	1.001
3	0.999	1.002	1.002	1.006	1.003	1.001	0.997	0.999	1.002	1.004	0.999	0.997	1.000	1.008	0.999	1.006
4	1.005	1.003	1.000	1.002	1.004	1.002	0.999	1.000	1.004	1.001	0.999	0.993	1.002	1.003	0.998	1.001
5	1.002	1.002	1.002	1.004	1.003	1.004	1.002	0.999	1.004	1.005	1.000	0.997	1.002	1.003	0.998	1.003
6	1.004	1.002	1.003	1.002	1.003	1.004	0.999	0.999	1.004	1.003	0.999	0.994	1.001	1.007	0.998	1.001
7	1.002	0.999	1.000	1.002	1.002	0.999	1.005	1.001	0.999	1.000	1.002	1.003	1.001	1.000	0.996	1.002
8	1.000	1.001	0.999	1.004	1.000	0.999	1.006	0.999	0.999	1.002	0.999	1.006	1.001	0.998	0.998	0.999
9	1.003	0.999	0.999	1.002	1.000	1.000	1.006	1.000	0.998	0.998	1.000	1.003	1.000	0.999	0.999	1.001
10	1.000	1.000	0.998	1.005	1.002	1.002	1.006	1.001	1.000	1.000	1.001	1.006	1.003	1.000	0.994	1.000
11	1.001	0.998	1.001	1.003	1.003	1.000	1.010	0.999	1.001	1.001	1.001	1.009	1.000	1.000	0.996	1.000
12	0.999	0.996	1.000	1.007	1.002	1.000	1.006	1.000	0.998	1.001	1.001	1.007	1.001	0.997	0.999	1.001

Table 37. Comparison of maximum displacements of Igusa/Der Kiureghian results for benchmark problem No.2 using modal superposition time analysis

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	0.999	0.998	0.999	1.001	1.002	1.002	1.000	1.000	0.999	1.002	1.000	0.998	1.002	1.003	0.999	1.002
3	0.999	1.001	1.000	1.001	1.001	1.001	1.000	1.000	0.999	1.001	1.000	0.998	1.001	1.003	0.999	1.002
4	1.001	1.001	1.000	1.001	1.001	1.001	1.000	1.000	1.001	1.001	1.000	0.997	1.001	1.003	0.998	1.001
5	1.001	1.001	1.001	1.001	1.001	1.001	1.001	0.999	1.001	1.001	1.000	0.997	1.001	1.003	0.998	1.001
6	1.001	1.001	1.001	1.001	1.001	1.001	1.000	0.999	1.001	1.001	1.000	0.997	1.001	1.003	0.998	1.001
7	1.000	1.001	1.000	1.002	1.001	1.000	1.003	1.000	1.001	1.000	1.001	1.003	1.001	1.000	0.998	0.998
8	1.001	1.001	1.001	1.002	1.001	1.001	1.004	1.000	1.001	1.002	1.000	1.003	1.001	1.000	0.998	0.998
9	1.000	0.999	1.000	1.002	1.001	1.000	1.003	1.000	0.999	0.997	1.000	1.002	1.000	0.999	0.997	0.998
10	1.000	1.001	1.000	1.002	1.002	1.000	1.003	1.000	1.001	1.001	1.001	1.003	1.000	1.000	0.998	0.998
11	1.001	1.000	1.001	1.003	1.002	1.001	1.004	1.000	1.001	1.001	1.000	1.003	1.000	1.000	0.998	0.998
12	1.000	1.000	1.001	1.002	1.002	1.000	1.004	1.000	1.001	1.001	1.000	1.003	1.001	1.000	0.998	0.998

Table 38. Comparison of maximum displacements of Gupta results for benchmark problem No.2 using modal superposition time analysis

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	1.002	1.003	1.002	1.000	1.000	1.000	1.002	1.000	1.001	1.000	1.000	1.002	0.978	1.001	1.000	1.001
3	1.002	1.001	1.002	1.001	1.000	1.000	1.002	1.000	1.002	1.000	1.001	1.002	1.036	1.001	1.000	1.001
4	1.001	1.001	1.002	1.001	1.000	1.001	1.001	1.000	1.001	1.001	1.001	1.001	1.002	1.001	1.001	1.001
5	1.001	1.001	1.000	1.001	1.000	1.001	1.001	1.000	1.001	1.001	1.001	1.001	0.997	1.001	1.001	1.001
6	1.001	1.001	1.001	1.000	1.001	1.001	1.001	1.001	1.001	1.001	1.000	1.001	1.016	1.000	1.001	1.001
7	1.001	1.002	1.001	1.002	1.001	1.001	1.001	1.000	1.002	1.000	1.000	0.999	1.002	1.000	1.001	1.001
8	1.001	1.002	1.001	1.001	1.001	1.001	1.001	1.000	1.002	1.002	1.001	0.999	1.026	1.000	1.001	1.001
9	1.001	1.002	1.001	1.002	1.000	1.001	1.001	1.001	1.000	0.998	1.001	0.999	0.986	1.000	1.001	1.001
10	1.001	1.002	1.001	1.002	1.001	1.001	1.001	1.001	1.001	1.001	1.002	0.999	1.001	1.000	1.001	1.001
11	1.001	1.002	1.002	1.002	1.001	1.001	1.001	1.001	1.000	1.001	1.000	0.999	0.998	1.000	1.001	1.001
12	1.001	1.002	1.001	1.002	1.001	1.001	1.001	1.001	1.000	1.001	1.002	0.999	0.995	1.000	1.001	1.001

Table 39. Comparison of maximum displacements for benchmark problem No.2 S&A RSM-I method

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	0.974	1.050	0.972	1.074	1.044	1.045	1.025	1.003	1.016	1.039	1.074	0.946	0.881	1.038	0.959	1.113
3	0.966	1.041	0.964	1.058	1.028	1.026	1.021	1.012	1.008	1.023	1.073	0.952	0.888	1.032	0.975	1.124
4	0.957	1.026	0.958	1.040	1.013	1.016	1.020	1.018	0.994	1.010	1.071	0.956	0.893	1.032	0.974	1.129
5	0.943	1.009	0.948	1.031	1.000	1.000	1.028	1.022	0.980	0.993	1.073	0.957	0.897	1.038	0.974	1.132
6	0.935	0.999	0.940	1.020	0.990	0.990	1.035	1.026	0.972	0.982	1.073	0.961	0.899	1.034	0.971	1.134
7	1.002	1.060	0.973	0.984	0.998	0.986	1.004	1.025	1.069	0.918	1.087	1.204	1.566	0.981	1.093	0.906
8	1.006	0.948	0.961	0.995	0.978	0.980	0.995	1.020	1.065	0.906	1.094	1.220	1.604	0.990	1.089	0.917
9	1.003	1.021	0.980	0.984	0.985	0.980	0.984	1.042	1.069	0.907	1.080	1.190	1.557	0.976	1.095	0.913
10	1.012	1.072	0.975	0.996	1.006	0.986	1.047	0.953	1.073	0.909	1.092	1.209	1.604	0.982	1.083	0.916
11	1.014	0.935	0.960	1.011	0.997	0.985	1.055	0.943	1.067	0.902	1.100	1.232	1.648	0.993	1.076	0.924
12	1.011	1.038	0.978	0.997	0.993	0.985	1.030	0.968	1.070	0.903	1.089	1.201	1.599	0.979	1.080	0.924

Table 40. Comparison of maximum displacements for benchmark problem No.2
S&A RSM-II method

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	1.166	1.004	0.942	1.055	1.002	1.002	0.980	0.985	1.021	0.998	1.260	1.158	1.024	1.102	1.373	1.309
3	1.183	1.015	0.951	1.058	1.009	1.007	0.988	0.999	1.034	1.004	1.279	1.178	1.045	1.134	1.397	1.341
4	1.195	1.017	0.968	1.058	1.008	1.007	0.999	1.009	1.037	1.001	1.301	1.201	1.057	1.159	1.408	1.361
5	1.192	1.009	0.964	1.058	1.003	1.004	1.010	1.016	1.035	0.997	1.313	1.215	1.064	1.179	1.407	1.384
6	1.184	1.002	0.961	1.052	0.996	0.997	1.021	1.022	1.029	0.993	1.320	1.222	1.068	1.188	1.405	1.392
7	1.034	1.060	1.045	1.034	0.985	1.013	1.022	1.025	1.111	0.927	1.173	1.204	1.716	1.208	0.996	1.002
8	1.034	0.953	1.030	1.059	0.974	1.014	1.021	1.025	1.115	0.928	1.189	1.220	1.756	1.236	0.987	1.019
9	1.034	1.021	1.053	1.031	0.981	1.006	1.002	1.043	1.112	0.917	1.167	1.190	1.705	1.202	0.999	1.018
10	1.037	1.065	1.042	1.062	1.022	1.017	1.072	0.959	1.118	0.928	1.185	1.215	1.763	1.234	0.994	1.014
11	1.041	0.939	1.027	1.089	1.021	1.023	1.091	0.951	1.113	0.935	1.198	1.232	1.814	1.264	0.983	1.030
12	1.036	1.038	1.045	1.063	1.011	1.011	1.054	0.973	1.115	0.921	1.181	1.207	1.761	1.228	0.992	1.022

Table 41. Comparison of maximum displacements for benchmark problem No.2
Chen Classical RSM method

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	1.166	1.004	0.942	1.055	1.002	1.002	0.980	0.985	1.021	0.998	1.260	1.158	1.024	1.102	1.373	1.309
3	1.183	1.015	0.951	1.058	1.009	1.007	0.988	0.999	1.034	1.004	1.279	1.178	1.045	1.134	1.397	1.341
4	1.195	1.017	0.968	1.058	1.008	1.007	0.999	1.009	1.037	1.001	1.301	1.201	1.057	1.159	1.408	1.361
5	1.192	1.009	0.964	1.058	1.003	1.004	1.010	1.016	1.035	0.997	1.313	1.215	1.064	1.179	1.407	1.384
6	1.184	1.002	0.961	1.052	0.996	0.997	1.021	1.022	1.029	0.993	1.320	1.222	1.068	1.188	1.405	1.392
7	1.034	1.060	1.045	1.034	0.985	1.013	1.022	1.025	1.111	0.927	1.173	1.204	1.716	1.208	0.996	1.002
8	1.034	0.953	1.030	1.059	0.974	1.014	1.021	1.025	1.115	0.928	1.189	1.220	1.756	1.236	0.987	1.019
9	1.034	1.021	1.053	1.031	0.981	1.006	1.002	1.043	1.112	0.917	1.167	1.190	1.705	1.202	0.999	1.018
10	1.037	1.065	1.042	1.062	1.022	1.017	1.072	0.959	1.118	0.928	1.185	1.215	1.763	1.234	0.994	1.014
11	1.041	0.939	1.027	1.089	1.021	1.023	1.091	0.951	1.113	0.935	1.198	1.232	1.814	1.264	0.983	1.030
12	1.036	1.038	1.045	1.063	1.011	1.011	1.054	0.973	1.115	0.921	1.181	1.207	1.761	1.228	0.992	1.022

Table 42. Comparison of maximum displacements for benchmark problem No.2
Igusa/Der Kiureghian RSM method

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	0.992	1.037	0.957	1.063	1.033	1.034	1.022	0.999	1.016	1.029	1.111	1.006	0.830	1.090	1.131	1.086
3	0.987	1.033	0.951	1.050	1.022	1.023	1.019	1.009	1.012	1.016	1.109	1.012	0.835	1.087	1.139	1.096
4	0.984	1.021	0.952	1.039	1.011	1.011	1.021	1.016	1.004	1.005	1.108	1.018	0.839	1.087	1.144	1.103
5	0.972	1.007	0.943	1.029	0.999	0.998	1.029	1.022	0.992	0.993	1.109	1.023	0.841	1.088	1.136	1.109
6	0.962	0.997	0.935	1.021	0.990	0.989	1.036	1.027	0.982	0.984	1.110	1.027	0.842	1.088	1.133	1.114
7	0.955	1.062	0.981	0.995	0.997	1.004	1.003	1.026	1.035	0.914	1.040	1.126	1.647	0.871	0.918	0.947
8	0.956	0.954	0.972	1.010	0.980	1.006	0.995	1.023	1.030	0.908	1.048	1.138	1.690	0.872	0.911	0.960
9	0.954	1.022	0.989	0.994	0.987	1.000	0.984	1.044	1.037	0.903	1.036	1.115	1.634	0.873	0.924	0.954
10	0.958	1.070	0.984	1.006	1.007	1.007	1.043	0.953	1.032	0.910	1.040	1.128	1.690	0.870	0.911	0.954
11	0.959	0.939	0.970	1.023	0.998	1.011	1.052	0.942	1.027	0.910	1.048	1.142	1.741	0.872	0.903	0.964
12	0.957	1.042	0.986	1.006	0.995	1.005	1.027	0.967	1.033	0.902	1.038	1.121	1.686	0.871	0.914	0.958

Table 43. Comparison of maximum displacements for benchmark problem No.2
Gupta RSM method

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	1.028	1.055	0.981	1.088	1.050	1.051	1.055	1.016	1.043	1.046	1.080	1.010	0.860	1.039	1.107	1.115
3	1.014	1.042	0.966	1.065	1.030	1.031	1.045	1.022	1.030	1.025	1.078	1.012	0.860	1.038	1.115	1.119
4	1.005	1.024	0.962	1.048	1.013	1.014	1.043	1.025	1.015	1.007	1.079	1.015	0.859	1.038	1.119	1.121
5	0.987	1.006	0.948	1.033	0.997	0.996	1.049	1.031	0.998	0.991	1.080	1.018	0.858	1.039	1.112	1.124
6	0.975	0.993	0.937	1.023	0.985	0.985	1.056	1.036	0.986	0.980	1.082	1.021	0.858	1.039	1.109	1.127
7	0.925	1.061	0.955	0.982	0.999	1.014	0.992	1.028	0.997	0.918	1.083	1.134	1.593	0.984	0.966	0.929
8	0.924	0.949	0.944	0.997	0.978	1.017	0.980	1.021	0.989	0.917	1.095	1.147	1.634	0.994	0.960	0.942
9	0.923	1.019	0.963	0.979	0.985	1.008	0.974	1.044	0.999	0.900	1.077	1.122	1.579	0.980	0.969	0.936
10	0.925	1.069	0.957	0.990	0.996	1.018	1.027	0.949	0.992	0.918	1.085	1.137	1.632	0.991	0.959	0.934
11	0.926	0.935	0.941	1.008	0.983	1.024	1.031	0.936	0.985	0.927	1.097	1.153	1.682	1.004	0.953	0.945
12	0.924	1.040	0.959	0.988	0.983	1.016	1.011	0.964	0.993	0.905	1.081	1.130	1.628	0.989	0.961	0.938

Table 44. Comparison of statistics of maximum displacements for benchmark problem No.2
S&A RSM-I method

Nodes	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
2	0.998	0.081	0.081	1.113	0.881
3	1.001	0.080	0.080	1.124	0.888
4	1.002	0.080	0.080	1.129	0.893
5	1.002	0.082	0.082	1.132	0.897
6	1.001	0.083	0.083	1.134	0.899
7	1.120	0.219	0.195	1.566	0.906
8	1.131	0.230	0.203	1.604	0.917
9	1.116	0.214	0.192	1.557	0.913
10	1.128	0.230	0.204	1.604	0.916
11	1.141	0.244	0.213	1.648	0.924
12	1.126	0.227	0.201	1.599	0.924

Table 45. Comparison of statistics of maximum displacements for benchmark problem No.2
S&A RSM-II method

Nodes	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
2	1.199	0.122	0.101	1.373	1.024
3	1.223	0.123	0.100	1.397	1.045
4	1.240	0.123	0.099	1.408	1.057
5	1.251	0.123	0.098	1.407	1.064
6	1.254	0.123	0.098	1.405	1.068
7	1.190	0.250	0.210	1.716	0.996
8	1.206	0.263	0.218	1.756	0.987
9	1.188	0.244	0.205	1.705	0.999
10	1.206	0.265	0.220	1.763	0.994
11	1.223	0.283	0.231	1.814	0.983
12	1.204	0.264	0.219	1.761	0.992

Table 46. Comparison of statistics of maximum displacements for benchmark problem No.2
Chen Classical RSM method

Nodes	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
2	1.052	0.110	0.104	1.227	0.885
3	1.061	0.112	0.106	1.218	0.895
4	1.085	0.118	0.109	1.232	0.908
5	1.101	0.111	0.101	1.234	0.910
6	1.105	0.112	0.102	1.239	0.914
7	1.027	0.205	0.200	1.467	0.860
8	1.037	0.218	0.210	1.502	0.855
9	1.022	0.200	0.196	1.455	0.863
10	1.035	0.219	0.211	1.504	0.856
11	1.051	0.235	0.223	1.550	0.849
12	1.035	0.219	0.211	1.504	0.854

Table 47. Comparison of statistics of maximum displacements for benchmark problem No.2
Igusa/Der Kiureghian RSM method

Nodes	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
2	1.035	0.104	0.101	1.131	0.830
3	1.038	0.105	0.101	1.139	0.835
4	1.040	0.105	0.101	1.144	0.839
5	1.040	0.105	0.101	1.136	0.841
6	1.039	0.106	0.102	1.133	0.842
7	1.072	0.267	0.249	1.647	0.871
8	1.082	0.282	0.261	1.690	0.872
9	1.070	0.261	0.244	1.634	0.873
10	1.079	0.283	0.262	1.690	0.870
11	1.090	0.301	0.276	1.741	0.872
12	1.078	0.281	0.260	1.686	0.871

Table 48. Comparison of statistics of maximum displacements for benchmark problem No.2
Gupta RSM method

Nodes	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
2	1.034	0.086	0.083	1.115	0.860
3	1.034	0.089	0.086	1.119	0.860
4	1.033	0.090	0.087	1.121	0.859
5	1.031	0.091	0.088	1.124	0.858
6	1.030	0.092	0.090	1.127	0.858
7	1.088	0.236	0.217	1.593	0.925
8	1.100	0.250	0.227	1.634	0.924
9	1.084	0.230	0.213	1.579	0.923
10	1.095	0.250	0.228	1.632	0.925
11	1.108	0.266	0.240	1.682	0.926
12	1.093	0.248	0.227	1.628	0.924

Table 49. Comparison of maximum shear forces of S&A results for benchmark problem No.2 using modal superposition time history analysis

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	0.997	0.996	0.997	1.001	1.003	1.004	0.998	1.002	0.997	1.004	1.001	0.998	1.002	1.006	0.998	1.000
2	1.000	1.004	0.998	1.004	1.001	1.002	1.000	0.999	1.003	1.003	1.003	0.994	1.002	1.003	0.996	1.005
3	1.002	1.001	1.003	1.002	1.002	1.003	1.002	0.998	1.002	1.001	0.997	0.996	1.001	1.009	0.996	1.003
4	1.002	1.001	1.001	1.005	1.004	0.999	1.009	0.995	0.999	1.004	1.001	0.997	1.001	1.006	0.998	1.002
5	0.997	0.997	0.997	0.995	0.996	0.996	1.012	0.996	0.997	0.996	1.002	0.994	1.003	1.007	0.998	1.002
6	1.002	0.999	0.999	1.004	1.000	1.001	1.007	1.000	1.001	1.004	1.004	1.006	1.001	1.002	0.996	0.999
7	1.004	0.998	1.002	1.001	0.993	1.004	1.009	0.995	1.003	1.003	0.998	1.007	0.997	1.000	1.000	1.000
8	1.003	1.005	1.000	1.004	0.949	1.001	1.006	0.993	1.004	1.070	1.000	1.000	1.002	1.002	0.996	1.000
9	1.001	0.997	0.999	1.002	0.991	1.001	1.010	0.999	1.005	0.987	1.003	1.003	1.000	0.998	0.997	1.001
10	1.002	0.999	0.999	1.006	1.007	1.000	1.010	1.001	1.002	1.001	1.000	1.005	1.000	1.002	0.998	1.000
11	1.007	1.000	0.998	1.003	0.992	1.001	1.011	0.996	1.002	1.001	1.000	1.005	1.003	1.001	1.001	0.999
12	1.002	1.004	1.006	1.004	1.001	1.003	1.006	1.001	1.004	1.000	1.002	1.003	1.002	1.000	0.999	0.998
13	1.003	0.998	1.000	1.002	1.001	1.000	1.011	0.998	1.002	1.001	1.001	1.004	1.002	1.003	0.998	1.001

Table 50. Comparison of maximum shear forces of Igusa/Der Kiureghian results for benchmark problem No.2 using modal superposition time history analysis

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	0.999	0.998	0.999	1.001	1.002	1.002	1.000	1.000	0.999	1.002	1.000	0.998	1.002	1.003	0.999	1.002
2	1.001	1.001	1.000	1.001	1.001	1.001	1.000	0.999	1.001	1.001	1.000	0.998	1.001	1.003	0.998	1.001
3	1.000	1.001	1.001	1.000	1.001	1.001	1.002	1.000	1.000	1.000	1.000	0.998	1.000	1.003	0.998	1.000
4	1.000	1.000	1.001	1.001	1.000	1.000	1.003	0.997	1.000	1.001	1.001	0.997	1.000	1.003	0.998	1.000
5	0.997	0.997	0.997	0.998	0.997	0.997	1.005	0.998	0.997	0.997	1.001	0.997	1.001	1.004	0.998	1.000
6	1.000	1.001	1.000	1.003	0.997	1.001	1.004	1.000	1.001	1.005	1.001	1.001	1.001	1.000	0.998	0.998
7	1.002	1.000	1.002	1.002	0.993	1.001	1.005	0.996	1.001	1.003	0.999	1.001	1.001	1.000	0.997	0.999
8	1.003	1.005	1.000	1.003	0.959	1.002	1.004	0.991	1.004	1.069	1.000	1.002	1.002	1.001	0.998	0.999
9	1.000	0.998	1.000	1.003	0.994	1.000	1.005	0.999	1.000	0.987	1.000	1.001	1.000	1.000	0.997	0.998
10	1.001	1.000	1.000	1.003	1.006	1.001	1.005	1.000	1.001	1.001	1.001	1.001	1.000	1.000	0.998	0.998
11	1.001	1.000	1.001	1.003	0.995	1.001	1.005	0.999	1.002	1.001	1.000	1.002	1.002	1.000	0.998	0.998
12	1.001	1.002	1.001	1.004	1.000	1.001	1.003	1.001	1.002	1.002	1.001	1.001	1.000	1.000	0.998	0.999
13	1.001	1.000	1.001	1.003	1.006	1.001	1.005	0.999	1.002	1.001	1.000	1.001	1.001	1.000	0.998	0.998

Table 51. Comparison of maximum shear forces of Gupta results for benchmark problem No.2 using modal superposition time history analysis

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	1.002	1.002	1.003	1.001	1.001	1.000	1.001	1.000	1.002	1.001	1.001	1.001	1.001	1.001	1.000	1.000
2	1.002	1.000	1.002	1.001	1.001	1.000	1.002	1.000	1.000	1.000	1.001	1.001	1.001	1.001	1.000	1.001
3	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.002	1.001	1.001	1.000	1.001
4	1.001	1.001	1.000	1.001	1.001	1.000	1.000	1.001	1.001	1.001	1.000	1.008	1.002	1.001	1.001	1.001
5	1.001	1.001	1.001	1.001	1.001	1.001	0.999	1.001	1.001	1.000	1.000	1.001	1.002	1.001	1.000	1.001
6	1.001	1.002	1.001	1.002	1.000	1.001	1.001	1.000	1.002	1.005	1.000	0.999	1.018	1.001	1.001	1.001
7	1.000	1.001	1.002	1.001	1.002	1.000	1.001	1.002	1.000	1.002	1.001	0.998	1.001	1.000	1.000	1.001
8	1.001	1.002	1.000	1.002	0.963	1.002	1.002	0.994	1.005	1.070	1.001	1.000	1.040	1.002	1.001	1.000
9	1.000	1.002	1.001	1.002	1.001	1.001	1.001	1.002	1.000	0.987	1.001	0.999	1.045	1.000	1.001	1.001
10	1.001	1.002	1.001	1.002	0.999	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.001	1.000	1.000	1.001
11	1.001	1.000	1.002	1.002	1.002	1.001	1.001	1.002	1.000	1.001	1.001	0.999	1.025	1.000	1.001	1.001
12	1.001	0.998	1.001	1.002	1.004	1.001	1.002	1.001	1.001	1.003	1.000	0.999	1.025	1.000	1.001	1.001
13	1.001	1.003	1.001	1.002	0.998	1.001	1.001	1.001	1.000	1.001	1.001	0.999	1.012	1.000	1.001	1.001

Table 52. Comparison of maximum shear forces for benchmark problem No.2 S&A RSM-I method

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	0.974	1.051	0.974	1.072	1.045	1.047	1.026	1.004	1.017	1.039	1.073	0.947	0.881	1.038	0.959	1.115
2	0.956	1.026	0.951	1.039	1.013	1.015	1.013	1.020	0.990	1.003	1.070	0.955	0.896	1.036	0.974	1.131
3	0.922	0.991	0.931	1.007	0.982	0.982	1.025	1.030	0.960	0.976	1.071	0.969	0.910	1.036	0.958	1.145
4	0.879	0.938	0.889	0.969	0.935	0.930	1.047	0.980	0.913	0.927	1.083	0.980	0.919	1.046	0.953	1.168
5	0.827	0.883	0.844	0.920	0.886	0.883	0.957	0.840	0.860	0.879	1.094	0.996	0.926	1.048	0.951	1.203
6	1.013	1.034	0.944	1.021	0.941	0.987	1.048	0.993	1.063	0.911	1.123	1.256	1.686	1.019	1.083	0.927
7	1.013	0.830	0.929	1.041	0.872	0.985	0.980	1.014	1.058	0.872	1.129	1.256	1.715	1.026	1.081	0.950
8	1.032	0.842	0.931	1.072	0.752	0.989	1.044	0.882	1.070	0.951	1.160	1.260	1.776	1.057	1.077	0.947
9	1.016	0.997	0.935	1.042	0.876	0.987	1.034	1.020	1.062	0.873	1.131	1.256	1.725	1.027	1.080	0.940
10	1.026	1.037	0.942	1.050	0.909	0.990	1.134	0.871	1.065	0.904	1.137	1.255	1.748	1.034	1.068	0.946
11	1.028	0.801	0.927	1.072	0.946	0.989	1.117	0.900	1.064	0.889	1.140	1.250	1.793	1.040	1.071	0.957
12	1.032	0.799	0.928	1.091	0.742	0.987	1.140	0.801	1.073	0.879	1.158	1.253	1.793	1.058	1.063	0.957
13	1.027	1.012	0.935	1.065	0.914	0.990	1.120	0.878	1.065	0.891	1.139	1.255	1.777	1.036	1.069	0.953

Table 53. Comparison of maximum shear forces for benchmark problem No.2
S&A RSM-II method

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	1.167	1.004	0.940	1.056	1.003	1.000	0.981	0.983	1.021	0.996	1.262	1.160	1.026	1.103	1.372	1.309
2	1.199	1.021	0.964	1.065	1.013	1.015	0.997	1.016	1.043	1.008	1.306	1.209	1.064	1.171	1.402	1.376
3	1.200	1.022	0.972	1.065	1.012	1.013	1.025	1.033	1.045	1.007	1.345	1.248	1.091	1.227	1.391	1.422
4	1.176	0.987	0.952	1.048	0.983	0.985	1.066	0.990	1.020	0.983	1.392	1.302	1.109	1.285	1.397	1.489
5	1.131	0.952	0.928	1.019	0.952	0.950	1.003	0.878	0.987	0.952	1.424	1.342	1.125	1.328	1.402	1.550
6	1.047	1.045	1.009	1.109	0.956	1.031	1.094	1.009	1.120	0.974	1.222	1.260	1.855	1.296	0.978	1.034
7	1.041	0.834	0.996	1.127	0.917	1.027	1.032	1.037	1.113	0.942	1.230	1.266	1.890	1.306	0.973	1.065
8	1.069	0.873	0.995	1.182	0.843	1.044	1.108	0.919	1.131	1.062	1.270	1.260	1.957	1.356	0.969	1.057
9	1.050	1.009	1.004	1.134	0.909	1.033	1.086	1.043	1.119	0.949	1.231	1.260	1.901	1.315	0.978	1.053
10	1.060	1.051	1.011	1.159	0.985	1.040	1.189	0.891	1.124	0.989	1.243	1.255	1.935	1.334	0.977	1.051
11	1.058	0.809	0.988	1.176	1.035	1.040	1.174	0.922	1.125	0.982	1.245	1.258	1.979	1.350	0.973	1.066
12	1.069	0.827	0.987	1.217	0.880	1.046	1.204	0.830	1.131	0.992	1.269	1.253	1.978	1.382	0.971	1.065
13	1.060	1.028	1.004	1.176	1.008	1.042	1.180	0.899	1.129	0.981	1.246	1.258	1.967	1.348	0.975	1.063

Table 54. Comparison of maximum shear forces for benchmark problem No.2
Chen Classical RSM method

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	1.066	1.009	0.952	1.038	1.001	1.137	0.843	0.900	1.032	0.909	1.092	0.973	0.881	0.986	1.200	1.147
2	1.098	1.028	0.977	1.046	1.012	1.151	0.855	0.929	1.056	0.914	1.131	1.013	0.914	1.049	1.226	1.207
3	1.099	1.026	0.986	1.049	1.012	1.149	0.880	0.944	1.056	0.912	1.165	1.050	0.937	1.101	1.216	1.249
4	1.073	0.995	0.966	1.034	0.987	1.117	0.927	0.913	1.032	0.888	1.204	1.093	0.954	1.150	1.219	1.303
5	1.037	0.958	0.941	1.005	0.954	1.076	0.892	0.831	0.999	0.858	1.240	1.132	0.968	1.194	1.227	1.359
6	0.949	1.027	1.038	1.054	0.948	1.000	0.939	0.924	1.131	1.236	1.057	0.994	1.581	1.152	0.862	0.897
7	0.913	0.844	1.013	1.083	0.923	0.993	0.880	0.949	1.112	1.216	1.039	1.055	1.618	1.147	0.846	0.928
8	0.946	0.865	1.010	1.129	0.670	1.017	0.965	0.861	1.141	1.342	1.070	1.000	1.681	1.191	0.842	0.924
9	0.955	1.000	1.033	1.094	0.873	1.004	0.935	0.955	1.142	1.212	1.070	1.003	1.622	1.174	0.862	0.914
10	0.966	1.031	1.015	1.133	0.978	1.020	1.014	0.813	1.129	1.307	1.058	1.011	1.652	1.170	0.849	0.919
11	0.948	0.814	0.960	1.143	1.035	1.004	1.001	0.845	1.092	1.251	1.055	0.997	1.697	1.144	0.846	0.916
12	0.965	0.816	1.044	1.171	0.863	1.012	1.044	0.770	1.120	1.268	1.076	1.018	1.697	1.181	0.844	0.915
13	0.969	1.016	1.008	1.114	0.994	1.023	1.007	0.821	1.133	1.206	1.065	1.016	1.681	1.183	0.849	0.929

Table 55. Comparison of maximum shear forces for benchmark problem No.2
Igusa/Der Kiureghian RSM method

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	0.992	1.037	0.957	1.063	1.033	1.034	1.022	0.999	1.016	1.029	1.111	1.006	0.830	1.089	1.131	1.086
2	0.983	1.022	0.946	1.037	1.011	1.012	1.016	1.021	1.003	1.004	1.107	1.020	0.842	1.085	1.137	1.110
3	0.957	0.996	0.930	1.015	0.988	0.987	1.030	1.031	0.978	0.981	1.109	1.037	0.850	1.087	1.114	1.123
4	0.913	0.946	0.892	0.978	0.944	0.942	1.055	0.986	0.934	0.940	1.118	1.056	0.855	1.095	1.104	1.150
5	0.865	0.895	0.852	0.932	0.897	0.895	0.968	0.850	0.885	0.893	1.128	1.072	0.858	1.103	1.099	1.182
6	0.963	1.043	0.953	1.038	0.950	1.018	1.047	0.998	1.024	0.935	1.069	1.163	1.780	0.880	0.899	0.972
7	0.961	0.841	0.940	1.057	0.883	1.015	0.980	1.019	1.019	0.899	1.073	1.163	1.817	0.885	0.897	0.996
8	0.976	0.853	0.944	1.090	0.776	1.027	1.040	0.884	1.029	1.007	1.099	1.152	1.873	0.895	0.888	0.991
9	0.964	1.008	0.948	1.057	0.892	1.019	1.033	1.027	1.022	0.905	1.073	1.160	1.822	0.884	0.895	0.986
10	0.969	1.048	0.956	1.065	0.913	1.025	1.126	0.871	1.025	0.940	1.074	1.150	1.850	0.885	0.891	0.983
11	0.968	0.808	0.939	1.086	0.955	1.024	1.105	0.899	1.023	0.930	1.077	1.147	1.896	0.890	0.889	0.997
12	0.977	0.808	0.942	1.104	0.751	1.027	1.124	0.798	1.031	0.935	1.093	1.141	1.893	0.897	0.882	0.993
13	0.969	1.025	0.949	1.079	0.920	1.026	1.112	0.877	1.024	0.931	1.076	1.149	1.881	0.889	0.890	0.992

Table 56. Comparison of maximum shear forces for benchmark problem No.2
Gupta RSM method

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	1.028	1.055	0.980	1.088	1.050	1.051	1.055	1.016	1.043	1.046	1.080	1.010	0.860	1.039	1.107	1.115
2	0.999	1.021	0.952	1.042	1.009	1.010	1.034	1.028	1.010	1.003	1.076	1.015	0.859	1.037	1.112	1.125
3	0.959	0.982	0.922	1.006	0.973	0.973	1.039	1.033	0.971	0.966	1.081	1.025	0.859	1.039	1.091	1.128
4	0.905	0.923	0.874	0.962	0.922	0.919	1.063	0.988	0.917	0.916	1.094	1.040	0.859	1.046	1.081	1.146
5	0.851	0.867	0.829	0.910	0.870	0.867	0.975	0.858	0.862	0.865	1.107	1.054	0.860	1.052	1.078	1.172
6	0.932	1.036	0.922	1.031	0.940	1.033	1.023	0.989	0.979	0.971	1.123	1.176	1.723	1.024	0.953	0.954
7	0.929	0.829	0.909	1.049	0.864	1.030	0.955	1.004	0.974	0.931	1.128	1.177	1.758	1.030	0.951	0.977
8	0.945	0.846	0.911	1.090	0.754	1.046	1.009	0.863	0.983	1.082	1.162	1.170	1.818	1.059	0.945	0.975
9	0.932	0.998	0.916	1.052	0.875	1.035	1.007	1.014	0.977	0.946	1.129	1.175	1.764	1.034	0.950	0.968
10	0.935	1.041	0.924	1.056	0.878	1.043	1.095	0.856	0.978	0.993	1.130	1.164	1.789	1.040	0.945	0.964
11	0.934	0.798	0.908	1.077	0.911	1.043	1.072	0.882	0.976	0.987	1.134	1.162	1.835	1.048	0.942	0.977
12	0.944	0.801	0.909	1.099	0.703	1.047	1.089	0.778	0.983	1.014	1.154	1.158	1.834	1.064	0.938	0.974
13	0.936	1.016	0.917	1.071	0.880	1.044	1.081	0.861	0.977	0.988	1.133	1.163	1.819	1.046	0.944	0.972

Table 57. Comparison of statistics of maximum shear forces for benchmark problem No.2 S&A RSM-I method

Elements	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
1	0.998	0.081	0.081	1.115	0.881
2	1.002	0.080	0.080	1.131	0.896
3	1.001	0.086	0.086	1.145	0.910
4	1.004	0.101	0.101	1.168	0.879
5	1.006	0.122	0.122	1.203	0.827
6	1.158	0.255	0.220	1.686	0.927
7	1.167	0.261	0.223	1.715	0.950
8	1.187	0.278	0.234	1.776	0.947
9	1.168	0.265	0.227	1.725	0.940
10	1.174	0.272	0.231	1.748	0.946
11	1.183	0.285	0.241	1.793	0.957
12	1.188	0.283	0.238	1.793	0.957
13	1.179	0.280	0.238	1.777	0.953

Table 58. Comparison of statistics of maximum shear forces for benchmark problem No.2 S&A RSM-II method

Elements	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
1	1.200	0.121	0.101	1.372	1.026
2	1.247	0.120	0.097	1.402	1.064
3	1.275	0.117	0.092	1.422	1.091
4	1.307	0.132	0.101	1.489	1.109
5	1.329	0.155	0.116	1.550	1.125
6	1.242	0.297	0.239	1.855	0.978
7	1.253	0.308	0.246	1.890	0.973
8	1.277	0.331	0.259	1.957	0.969
9	1.256	0.311	0.248	1.901	0.978
10	1.265	0.323	0.255	1.935	0.977
11	1.275	0.338	0.265	1.979	0.973
12	1.284	0.338	0.263	1.978	0.971
13	1.274	0.333	0.262	1.967	0.975

Table 59. Comparison of statistics of maximum shear forces for benchmark problem No.2
Chen Classical RSM method

Elements	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
1	1.049	0.110	0.105	1.200	0.881
2	1.091	0.110	0.101	1.226	0.914
3	1.117	0.106	0.095	1.249	0.937
4	1.142	0.114	0.100	1.303	0.954
5	1.165	0.132	0.113	1.359	0.968
6	1.070	0.245	0.229	1.581	0.862
7	1.078	0.259	0.240	1.618	0.846
8	1.093	0.282	0.258	1.681	0.842
9	1.086	0.258	0.238	1.622	0.862
10	1.089	0.268	0.246	1.652	0.849
11	1.086	0.286	0.264	1.697	0.846
12	1.100	0.285	0.259	1.697	0.844
13	1.099	0.278	0.253	1.681	0.849

Table 60. Comparison of statistics of maximum shear forces for benchmark problem No.2
Igusa/Der Kiureghian RSM method

Elements	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
1	1.035	0.104	0.101	1.131	0.830
2	1.040	0.103	0.099	1.137	0.842
3	1.040	0.102	0.098	1.123	0.850
4	1.042	0.112	0.108	1.150	0.855
5	1.044	0.129	0.124	1.182	0.858
6	1.104	0.314	0.285	1.780	0.880
7	1.113	0.325	0.292	1.817	0.885
8	1.125	0.344	0.306	1.873	0.888
9	1.112	0.328	0.295	1.822	0.884
10	1.115	0.338	0.303	1.850	0.885
11	1.123	0.354	0.315	1.896	0.889
12	1.125	0.351	0.312	1.893	0.882
13	1.121	0.348	0.310	1.881	0.889

Table 61. Comparison of statistics of maximum shear forces for benchmark problem No.2 Gupta RSM method

Elements	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
1	1.034	0.086	0.084	1.115	0.860
2	1.032	0.090	0.087	1.125	0.859
3	1.026	0.091	0.089	1.128	0.859
4	1.024	0.104	0.102	1.146	0.859
5	1.025	0.123	0.120	1.172	0.851
6	1.126	0.279	0.248	1.723	0.932
7	1.136	0.289	0.255	1.758	0.929
8	1.153	0.308	0.267	1.818	0.945
9	1.136	0.292	0.257	1.764	0.932
10	1.138	0.301	0.264	1.789	0.935
11	1.148	0.316	0.275	1.835	0.934
12	1.152	0.315	0.273	1.834	0.938
13	1.145	0.311	0.271	1.819	0.936

Table 62. Comparison of maximum displacements of S&A results for benchmark problem No.3 using modal superposition time analysis

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	0.996	0.999	0.996	0.997	1.005	1.004	1.019	1.052	0.994	1.003	1.002	1.004	0.999	1.009	0.998	1.008
3	0.998	1.001	0.996	1.006	1.004	1.001	1.021	1.048	0.993	1.009	1.002	1.006	1.000	1.010	1.002	1.006
4	1.002	1.002	1.000	1.004	1.006	1.002	1.020	1.045	1.005	1.013	0.999	1.003	1.001	1.012	1.000	1.009
5	1.004	1.002	1.002	1.005	1.005	1.004	1.022	1.048	1.007	1.011	1.003	1.003	1.000	1.008	0.998	1.005
6	1.004	1.000	1.003	1.004	1.004	1.004	1.021	1.047	1.006	1.012	1.000	1.004	1.000	1.011	0.996	1.005
7	1.011	0.998	1.009	1.017	1.010	1.008	1.027	1.012	1.027	1.098	1.016	1.025	1.006	1.009	1.013	1.015
8	1.009	1.001	1.007	1.015	1.009	1.011	1.029	1.001	1.028	1.090	1.014	1.025	1.007	1.009	1.012	1.012
9	1.015	0.997	1.009	1.007	1.004	1.014	1.030	1.026	1.029	1.081	1.014	1.016	1.006	1.009	1.013	1.014
10	1.008	0.999	1.004	1.005	1.001	1.003	1.028	1.037	1.015	1.040	1.011	1.018	1.000	1.004	1.002	1.009
11	1.008	0.999	1.004	1.007	1.002	1.004	1.027	1.034	1.015	1.047	1.010	1.019	1.001	1.006	1.002	1.005
12	1.006	1.002	1.003	1.006	1.003	1.006	1.028	1.036	1.013	1.059	1.005	1.022	1.004	1.000	1.002	1.009

Table 63. Comparison of maximum displacements of Igusa/Der Kiureghian results for benchmark problem No.3 using modal superposition time analysis

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	0.997	0.999	0.998	0.998	1.003	1.002	1.019	1.048	0.996	1.001	1.002	1.006	1.001	1.007	0.999	1.007
3	0.998	1.001	0.999	1.004	1.002	1.001	1.020	1.048	0.997	1.009	1.002	1.006	1.000	1.007	0.999	1.007
4	0.999	1.001	0.999	1.004	1.002	1.001	1.021	1.047	1.003	1.010	1.003	1.007	1.000	1.007	0.998	1.006
5	1.002	1.001	1.001	1.004	1.002	1.001	1.022	1.047	1.004	1.010	1.003	1.007	1.000	1.007	0.999	1.007
6	1.002	1.001	1.001	1.003	1.002	1.001	1.022	1.048	1.003	1.009	1.003	1.007	1.000	1.007	0.998	1.007
7	1.012	0.999	1.007	1.016	1.011	1.010	1.025	1.010	1.027	1.098	1.015	1.020	1.004	1.010	1.014	1.013
8	1.013	1.003	1.009	1.015	1.007	1.011	1.027	1.001	1.028	1.090	1.014	1.019	1.007	1.010	1.014	1.012
9	1.014	0.999	1.009	1.008	1.005	1.011	1.027	1.026	1.030	1.079	1.013	1.018	1.010	1.010	1.015	1.012
10	1.006	1.000	1.004	1.006	1.002	1.003	1.025	1.037	1.012	1.040	1.008	1.015	1.000	1.003	1.005	1.005
11	1.006	1.002	1.004	1.006	1.003	1.003	1.026	1.034	1.013	1.048	1.008	1.016	1.001	1.004	1.005	1.004
12	1.007	1.002	1.004	1.006	1.004	1.004	1.025	1.036	1.016	1.058	1.008	1.015	1.002	1.004	1.006	1.005

Table 64. Comparison of maximum displacements of Gupta results for benchmark problem No.3 using modal superposition time analysis

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	1.000	1.002	1.001	1.001	1.001	1.000	1.022	1.049	1.000	1.000	1.003	1.010	1.000	1.004	1.001	1.006
3	1.000	1.000	1.001	1.003	1.001	1.000	1.022	1.049	1.000	1.008	1.003	1.010	1.000	1.005	1.001	1.006
4	1.000	1.000	1.001	1.004	1.002	1.001	1.023	1.049	1.003	1.009	1.003	1.010	1.001	1.004	1.001	1.007
5	1.001	1.000	1.005	1.004	1.001	1.001	1.022	1.048	1.003	1.009	1.003	1.011	1.001	1.005	1.001	1.006
6	1.001	1.000	1.004	1.003	1.002	1.001	1.023	1.049	1.003	1.009	1.003	1.011	1.001	1.004	1.001	1.007
7	1.013	0.998	1.007	1.015	1.008	1.011	1.024	1.007	1.028	1.099	1.014	1.016	1.007	1.010	1.016	1.014
8	1.013	1.004	1.010	1.014	1.006	1.011	1.024	1.003	1.029	1.091	1.014	1.016	1.007	1.010	1.016	1.015
9	1.014	0.999	1.012	1.009	1.004	1.012	1.024	1.026	1.032	1.080	1.011	1.015	1.008	1.011	1.019	1.016
10	1.006	1.002	1.005	1.005	1.003	1.004	1.023	1.038	1.011	1.040	1.009	1.011	1.001	1.003	1.008	1.008
11	1.006	1.003	1.004	1.005	1.002	1.004	1.023	1.035	1.013	1.048	1.009	1.011	1.001	1.004	1.007	1.008
12	1.007	1.004	1.005	1.005	1.003	1.005	1.023	1.037	1.016	1.059	1.009	1.011	1.003	1.004	1.009	1.008

Table 65. Comparison of maximum displacements for benchmark problem No.3 S&A RSM-I method

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	0.968	1.047	0.974	1.072	1.045	1.045	1.070	1.084	1.010	1.040	1.077	0.954	0.881	1.043	0.958	1.131
3	0.958	1.033	0.965	1.066	1.029	1.027	1.058	1.093	0.999	1.029	1.076	0.960	0.886	1.042	0.969	1.142
4	0.959	1.020	0.959	1.046	1.015	1.016	1.054	1.103	0.996	1.018	1.079	0.965	0.892	1.041	0.976	1.145
5	0.945	1.006	0.949	1.032	1.001	1.000	1.050	1.105	0.983	1.003	1.076	0.967	0.896	1.038	0.974	1.140
6	0.935	0.997	0.940	1.022	0.990	0.990	1.055	1.104	0.974	0.990	1.074	0.971	0.899	1.042	0.970	1.144
7	1.009	0.950	0.938	0.990	1.029	0.999	0.984	1.103	1.091	1.037	1.115	1.248	1.553	1.003	1.122	0.893
8	1.001	0.964	0.973	0.988	1.014	0.991	0.935	1.124	1.093	0.993	1.107	1.220	1.549	0.999	1.126	0.915
9	1.001	0.968	1.014	0.969	1.000	0.997	0.917	1.169	1.113	0.987	1.075	1.162	1.486	0.979	1.138	0.931
10	1.019	1.069	0.977	1.005	1.007	0.989	1.083	0.968	1.080	0.940	1.103	1.234	1.621	0.988	1.085	0.928
11	1.020	0.925	0.962	1.026	0.994	0.987	1.112	0.944	1.080	0.945	1.118	1.257	1.669	1.006	1.081	0.938
12	1.017	1.058	0.976	1.006	1.009	0.987	1.077	0.971	1.086	0.953	1.107	1.230	1.625	0.992	1.091	0.928

Table 66. Comparison of maximum displacements for benchmark problem No.3
S&A RSM-II method

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	1.161	1.004	0.942	1.053	1.003	1.001	1.019	1.052	1.015	0.998	1.264	1.174	1.024	1.109	1.377	1.330
3	1.175	1.014	0.952	1.066	1.010	1.007	1.021	1.073	1.025	1.009	1.291	1.199	1.043	1.138	1.401	1.364
4	1.198	1.016	0.968	1.065	1.006	1.007	1.028	1.086	1.043	1.013	1.303	1.214	1.056	1.169	1.411	1.381
5	1.190	1.010	0.964	1.059	1.001	1.004	1.034	1.096	1.038	1.007	1.317	1.224	1.064	1.185	1.407	1.394
6	1.185	1.004	0.958	1.054	0.997	0.997	1.041	1.095	1.031	1.001	1.321	1.230	1.068	1.192	1.403	1.398
7	1.039	0.950	1.001	1.027	0.971	1.027	1.002	1.093	1.131	1.033	1.206	1.248	1.684	1.215	1.008	1.001
8	1.040	0.969	1.040	1.023	0.983	1.017	0.955	1.124	1.136	1.004	1.200	1.236	1.687	1.208	1.020	1.030
9	1.048	0.975	1.088	0.992	0.992	1.006	0.930	1.169	1.156	0.994	1.167	1.191	1.624	1.173	1.062	1.054
10	1.047	1.069	1.044	1.080	1.036	1.021	1.115	0.970	1.128	0.964	1.196	1.234	1.785	1.253	0.996	1.027
11	1.052	0.929	1.028	1.107	1.033	1.027	1.147	0.953	1.127	0.984	1.213	1.257	1.841	1.279	0.987	1.041
12	1.044	1.058	1.044	1.080	1.040	1.019	1.109	0.973	1.135	0.975	1.190	1.230	1.789	1.248	1.002	1.034

Table 67. Comparison of maximum displacements for benchmark problem No.3
Chen Classical RSM method

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	1.117	0.986	0.960	1.002	0.969	1.100	0.908	1.028	0.988	0.862	1.040	0.997	0.885	1.037	1.231	1.116
3	1.050	1.040	0.952	1.059	1.017	1.155	0.894	0.986	1.045	0.911	1.103	0.993	0.895	1.034	1.222	1.193
4	1.098	1.025	0.968	1.041	1.001	1.149	0.897	1.008	1.043	0.934	1.119	1.008	0.908	1.047	1.235	1.238
5	1.107	1.002	0.995	1.056	1.016	1.140	0.885	1.030	1.058	0.926	1.137	1.044	0.909	1.077	1.217	1.244
6	1.084	1.021	0.979	1.036	0.997	1.146	0.900	1.018	1.038	0.916	1.173	1.038	0.914	1.088	1.206	1.244
7	0.960	0.984	1.012	0.990	0.961	0.999	0.882	1.036	1.131	1.269	1.026	1.017	1.436	1.062	0.872	0.883
8	0.962	0.953	1.057	0.992	1.004	0.991	0.843	1.059	1.138	1.199	1.024	1.001	1.442	1.064	0.881	0.906
9	0.975	1.011	1.101	0.977	0.976	0.997	0.818	1.089	1.153	1.128	0.994	0.968	1.394	1.037	0.924	0.943
10	0.959	1.055	1.057	1.046	1.051	1.003	0.943	0.902	1.128	1.145	1.001	0.985	1.524	1.093	0.857	0.903
11	0.960	0.925	1.037	1.076	1.025	1.007	0.975	0.890	1.127	1.206	1.017	1.003	1.573	1.119	0.853	0.906
12	0.962	1.044	1.057	1.047	1.045	1.001	0.941	0.908	1.127	1.156	1.005	0.983	1.525	1.088	0.862	0.903

Table 68. Comparison of maximum displacements for benchmark problem No.3
Igusa/Der Kiureghian RSM method

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	0.986	1.036	0.959	1.061	1.034	1.034	1.063	1.084	1.010	1.029	1.114	1.015	0.829	1.095	1.132	1.102
3	0.981	1.029	0.953	1.057	1.023	1.023	1.057	1.095	1.006	1.025	1.112	1.022	0.834	1.093	1.140	1.113
4	0.983	1.018	0.954	1.045	1.012	1.011	1.055	1.104	1.007	1.015	1.112	1.028	0.838	1.092	1.144	1.117
5	0.973	1.005	0.944	1.032	1.000	0.999	1.053	1.108	0.994	1.002	1.112	1.032	0.840	1.092	1.136	1.118
6	0.963	0.995	0.934	1.023	0.990	0.989	1.057	1.104	0.984	0.993	1.112	1.034	0.841	1.093	1.133	1.120
7	0.968	0.948	0.946	1.009	1.023	1.018	0.988	1.117	1.057	1.034	1.075	1.177	1.621	0.882	0.934	0.949
8	0.963	0.970	0.981	1.007	1.010	1.010	0.941	1.139	1.060	0.992	1.069	1.157	1.621	0.887	0.940	0.969
9	0.965	0.970	1.016	0.983	1.000	1.002	0.923	1.181	1.087	0.980	1.045	1.112	1.538	0.899	0.975	0.983
10	0.963	1.070	0.988	1.016	1.006	1.011	1.078	0.965	1.041	0.942	1.051	1.144	1.710	0.875	0.915	0.966
11	0.965	0.932	0.971	1.034	0.994	1.016	1.102	0.944	1.038	0.955	1.059	1.160	1.765	0.877	0.906	0.974
12	0.964	1.057	0.987	1.016	1.008	1.011	1.070	0.967	1.046	0.954	1.050	1.141	1.713	0.876	0.917	0.968

Table 69. Comparison of maximum displacements for benchmark problem No.3
Gupta RSM method

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	1.022	1.053	0.982	1.086	1.051	1.051	1.103	1.118	1.037	1.047	1.082	1.021	0.860	1.044	1.108	1.131
3	1.008	1.038	0.968	1.073	1.032	1.031	1.090	1.122	1.023	1.034	1.081	1.022	0.859	1.043	1.116	1.136
4	1.004	1.021	0.962	1.054	1.014	1.014	1.081	1.125	1.019	1.017	1.081	1.025	0.858	1.043	1.119	1.135
5	0.988	1.004	0.949	1.037	0.998	0.996	1.073	1.125	1.001	1.000	1.083	1.027	0.858	1.043	1.112	1.132
6	0.976	0.992	0.937	1.025	0.986	0.985	1.076	1.119	0.988	0.988	1.083	1.028	0.858	1.043	1.109	1.132
7	0.940	0.946	0.917	1.005	1.043	1.027	0.980	1.134	1.021	1.051	1.122	1.187	1.573	0.998	0.986	0.934
8	0.934	0.964	0.952	0.998	1.017	1.018	0.932	1.151	1.022	0.993	1.112	1.166	1.569	0.994	0.989	0.952
9	0.936	0.961	0.991	0.968	1.001	1.003	0.919	1.195	1.053	0.964	1.075	1.115	1.485	0.977	1.014	0.964
10	0.929	1.069	0.960	0.997	0.989	1.024	1.059	0.965	0.999	0.951	1.096	1.154	1.649	0.999	0.963	0.945
11	0.931	0.929	0.942	1.017	0.973	1.031	1.078	0.942	0.994	0.977	1.109	1.172	1.703	1.013	0.957	0.953
12	0.930	1.056	0.960	0.998	0.991	1.023	1.052	0.967	1.003	0.961	1.095	1.151	1.652	0.999	0.965	0.947

Table 70. Comparison of statistics of maximum displacements for benchmark problem No.3
S&A RSM-I method

Nodes	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
2	1.002	0.085	0.085	1.131	0.881
3	1.005	0.086	0.086	1.142	0.886
4	1.008	0.085	0.085	1.145	0.892
5	1.005	0.084	0.084	1.140	0.896
6	1.005	0.086	0.085	1.144	0.899
7	1.135	0.216	0.191	1.553	0.893
8	1.131	0.210	0.186	1.549	0.915
9	1.110	0.186	0.167	1.486	0.931
10	1.140	0.234	0.205	1.621	0.928
11	1.156	0.248	0.215	1.669	0.938
12	1.141	0.234	0.205	1.625	0.928

Table 71. Comparison of statistics of maximum displacements for benchmark problem No.3
S&A RSM-II method

Nodes	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
2	1.206	0.125	0.103	1.377	1.024
3	1.230	0.128	0.104	1.401	1.043
4	1.247	0.125	0.100	1.411	1.056
5	1.254	0.124	0.099	1.407	1.064
6	1.257	0.123	0.098	1.403	1.068
7	1.200	0.238	0.198	1.684	1.001
8	1.203	0.233	0.194	1.687	1.020
9	1.188	0.202	0.170	1.624	1.048
10	1.220	0.270	0.221	1.785	0.996
11	1.238	0.290	0.234	1.841	0.987
12	1.219	0.270	0.222	1.789	1.002

Table 72. Comparison of statistics of maximum displacements for benchmark problem No.3
Chen Classical RSM method

Nodes	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
2	1.060	0.109	0.103	1.231	0.885
3	1.070	0.114	0.106	1.222	0.895
4	1.093	0.119	0.109	1.238	0.908
5	1.105	0.112	0.102	1.244	0.909
6	1.107	0.113	0.102	1.244	0.914
7	1.037	0.190	0.184	1.436	0.872
8	1.040	0.189	0.181	1.442	0.881
9	1.033	0.163	0.158	1.394	0.924
10	1.046	0.224	0.214	1.524	0.857
11	1.062	0.241	0.227	1.573	0.853
12	1.047	0.223	0.213	1.525	0.862

Table 73. Comparison of statistics of maximum displacements for benchmark problem No.3
Igusa/Der Kiureghian RSM method

Nodes	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
2	1.039	0.107	0.103	1.132	0.829
3	1.042	0.108	0.103	1.140	0.834
4	1.045	0.107	0.102	1.144	0.838
5	1.043	0.106	0.102	1.136	0.840
6	1.042	0.107	0.102	1.133	0.841
7	1.086	0.256	0.235	1.621	0.882
8	1.087	0.252	0.232	1.621	0.887
9	1.074	0.215	0.201	1.538	0.899
10	1.089	0.288	0.264	1.710	0.875
11	1.101	0.308	0.280	1.765	0.877
12	1.090	0.288	0.264	1.713	0.876

Table 74. Comparison of statistics of maximum displacements for benchmark problem No.3
Gupta RSM method

Nodes	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
2	1.038	0.089	0.086	1.131	0.860
3	1.038	0.092	0.089	1.136	0.859
4	1.038	0.093	0.089	1.135	0.858
5	1.035	0.093	0.089	1.132	0.858
6	1.033	0.093	0.090	1.132	0.858
7	1.106	0.227	0.205	1.573	0.934
8	1.102	0.223	0.202	1.569	0.934
9	1.081	0.189	0.175	1.485	0.936
10	1.105	0.254	0.230	1.649	0.929
11	1.120	0.272	0.243	1.703	0.931
12	1.106	0.254	0.230	1.652	0.930

Table 75. Comparison of maximum shear forces of S&A results for benchmark problem No.3 using modal superposition time history analysis

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	0.996	1.001	0.998	0.997	1.006	1.004	1.018	1.049	0.995	1.003	1.003	1.004	1.000	1.010	1.000	1.006
2	0.999	1.002	0.999	1.004	1.004	1.002	1.021	1.047	0.998	1.013	0.999	1.004	1.001	1.008	0.999	1.005
3	1.004	1.002	1.004	1.002	1.002	1.003	1.026	1.014	1.006	1.012	1.001	1.007	0.999	1.007	0.997	1.010
4	1.004	1.002	1.002	1.004	1.002	0.999	1.027	1.043	1.003	1.012	1.005	1.002	1.000	1.012	0.996	1.005
5	0.996	0.996	0.997	0.998	0.997	0.996	1.016	1.043	0.996	1.001	1.003	1.005	0.999	1.010	0.997	1.008
6	1.010	1.000	1.011	1.015	1.013	1.010	1.027	1.013	1.030	1.099	1.012	1.023	1.007	1.011	1.013	1.015
7	1.016	1.001	1.007	1.007	0.998	1.013	1.033	1.025	1.031	1.078	1.015	1.021	1.002	1.009	1.011	1.016
8	1.004	1.001	1.009	1.023	1.000	1.007	0.991	0.986	1.022	0.953	1.021	1.019	1.003	1.007	1.005	1.008
9	1.011	0.999	1.002	1.016	1.062	1.008	1.032	1.016	1.012	0.928	1.013	1.021	1.004	1.010	1.008	1.012
10	1.007	0.998	1.002	1.006	1.011	1.002	1.029	1.026	1.009	0.972	1.008	1.012	0.999	1.001	1.001	1.005
11	1.006	1.007	1.007	1.018	1.005	1.006	0.997	1.019	1.014	1.116	1.009	1.017	1.002	1.004	1.005	1.007
12	1.006	1.001	1.009	1.016	1.019	1.002	1.000	1.020	1.004	0.951	1.009	1.011	1.002	1.002	1.002	1.007
13	1.006	1.000	1.001	1.006	1.009	1.004	1.028	1.021	1.015	1.027	1.006	1.012	1.000	1.003	1.002	1.007

Table 76. Comparison of maximum shear forces of Igusa/Der Kiureghian results for benchmark problem No.3 using modal superposition time history analysis

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	0.997	0.999	0.998	0.998	1.003	1.002	1.019	1.048	0.996	1.001	1.002	1.006	1.001	1.007	0.999	1.007
2	0.998	1.001	0.999	1.003	1.002	1.001	1.021	1.047	0.999	1.010	1.003	1.007	1.000	1.007	0.998	1.007
3	1.002	1.000	1.001	1.003	1.002	1.001	1.024	1.016	1.003	1.010	1.003	1.007	1.000	1.007	0.999	1.006
4	1.002	1.000	1.001	1.003	1.001	1.000	1.025	1.043	1.004	1.011	1.004	1.007	1.000	1.008	1.000	1.006
5	0.997	0.996	0.997	1.000	0.998	0.997	1.018	1.041	0.998	1.002	1.003	1.007	1.000	1.007	0.998	1.006
6	1.012	0.999	1.007	1.015	1.007	1.010	1.025	1.010	1.027	1.098	1.015	1.020	1.004	1.010	1.014	1.013
7	1.015	1.000	1.008	1.007	0.999	1.012	1.029	1.022	1.030	1.076	1.013	1.018	1.000	1.010	1.013	1.015
8	1.006	1.000	1.006	1.020	0.994	1.006	0.988	0.979	1.020	0.952	1.016	1.015	1.004	1.005	1.007	1.007
9	1.011	0.998	1.004	1.016	1.067	1.008	1.029	1.016	1.016	0.929	1.012	1.016	1.000	1.008	1.009	1.012
10	1.005	0.999	1.002	1.005	1.009	1.002	1.026	1.025	1.008	0.976	1.007	1.010	0.998	1.002	1.002	1.004
11	1.006	1.007	1.002	1.009	1.005	1.004	1.000	1.019	1.015	1.116	1.009	1.011	1.003	1.004	1.004	1.004
12	1.004	0.999	1.004	1.008	1.014	1.001	1.002	1.019	1.002	0.953	1.008	1.010	1.001	1.002	1.002	1.005
13	1.005	1.002	1.003	1.005	1.007	1.003	1.026	1.023	1.012	1.031	1.007	1.011	1.001	1.003	1.002	1.004

Table 77. Comparison of maximum shear forces of Gupta results for benchmark problem No.3 using modal superposition time history analysis

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	1.000	1.003	1.001	1.001	1.001	1.000	1.022	1.049	0.999	1.000	1.003	1.010	1.000	1.005	1.001	1.006
2	1.000	1.000	1.001	1.004	1.002	1.001	1.022	1.049	0.999	1.010	1.003	1.010	1.000	1.004	1.001	1.007
3	1.002	1.000	1.000	1.004	1.002	1.001	1.024	1.017	1.003	1.010	1.004	1.011	1.001	1.005	1.001	1.007
4	1.002	1.000	1.001	1.004	1.002	1.001	1.023	1.043	1.004	1.010	1.004	1.011	1.001	1.005	1.002	1.007
5	1.002	1.001	1.001	1.003	1.002	1.001	1.022	1.039	1.002	1.006	1.002	1.010	1.000	1.005	1.000	1.006
6	1.013	0.999	1.007	1.014	1.008	1.011	1.024	1.008	1.029	1.099	1.014	1.016	1.007	1.010	1.016	1.015
7	1.014	1.000	1.012	1.010	1.005	1.012	1.025	1.022	1.031	1.077	1.011	1.015	1.005	1.011	1.018	1.015
8	1.008	1.001	1.003	1.015	0.997	1.008	0.986	0.976	1.018	0.951	1.012	1.014	1.001	1.006	1.010	1.008
9	1.010	0.999	1.006	1.015	1.080	1.008	1.024	1.018	1.014	0.929	1.014	1.014	1.004	1.008	1.012	1.012
10	1.004	1.001	1.003	1.004	1.004	1.002	1.022	1.028	1.006	0.977	1.007	1.007	0.999	1.002	1.005	1.007
11	1.005	1.005	1.004	1.005	0.998	1.004	1.000	1.020	1.014	1.116	1.008	1.009	1.003	1.004	1.006	1.007
12	1.004	0.996	1.004	1.004	1.008	1.002	1.001	1.019	1.003	0.954	1.007	1.007	1.002	1.002	1.004	1.007
13	1.005	1.005	1.003	1.004	1.003	1.003	1.022	1.026	1.010	1.031	1.008	1.008	1.001	1.003	1.005	1.007

Table 78. Comparison of maximum shear forces for benchmark problem No.3 S&A RSM-I method

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	0.968	1.047	0.975	1.072	1.045	1.047	1.069	1.086	1.010	1.039	1.075	0.956	0.880	1.043	0.961	1.133
2	0.950	1.020	0.952	1.044	1.013	1.015	1.049	1.104	0.989	1.017	1.073	0.964	0.895	1.041	0.972	1.150
3	0.924	0.992	0.931	1.012	0.982	0.982	1.047	1.091	0.964	0.986	1.074	0.980	0.910	1.042	0.958	1.154
4	0.882	0.939	0.876	0.961	0.933	0.936	1.048	1.084	0.918	0.935	1.080	0.994	0.918	1.041	0.951	1.146
5	0.829	0.888	0.832	0.914	0.887	0.883	1.085	1.036	0.862	0.883	1.087	0.998	0.923	1.047	0.951	1.164
6	1.010	0.949	0.940	0.986	1.030	0.994	0.986	1.103	1.092	1.037	1.119	1.246	1.549	1.004	1.120	0.890
7	0.999	0.785	0.969	0.978	0.996	0.989	0.872	1.097	1.104	0.943	1.090	1.175	1.446	0.991	1.136	0.940
8	1.015	0.870	0.891	1.267	0.988	0.932	1.048	0.896	1.112	0.808	1.280	1.281	1.570	1.118	1.088	0.936
9	1.017	0.921	0.919	1.061	0.963	0.994	0.922	0.986	1.069	0.789	1.148	1.281	1.687	1.052	1.110	0.937
10	1.033	1.035	0.944	1.072	0.816	0.992	1.196	0.854	1.073	0.880	1.149	1.265	1.779	1.043	1.071	0.960
11	1.032	0.790	0.929	1.084	0.881	0.992	1.204	0.865	1.083	0.989	1.156	1.264	1.828	1.051	1.067	0.963
12	1.038	0.780	0.932	1.094	0.750	0.989	1.185	0.837	1.072	0.834	1.165	1.261	1.803	1.064	1.064	0.963
13	1.036	1.027	0.939	1.080	0.837	0.993	1.188	0.850	1.080	0.921	1.153	1.263	1.798	1.045	1.072	0.961

Table 79. Comparison of maximum shear forces for benchmark problem No.3
S&A RSM-II method

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	1.161	1.004	0.944	1.052	1.003	1.000	1.015	1.054	1.014	1.000	1.266	1.174	1.026	1.109	1.376	1.330
2	1.197	1.020	0.969	1.071	1.013	1.015	1.028	1.091	1.046	1.017	1.312	1.224	1.065	1.182	1.406	1.400
3	1.202	1.023	0.973	1.070	1.012	1.013	1.047	1.091	1.048	1.017	1.350	1.262	1.091	1.234	1.391	1.440
4	1.169	0.995	0.946	1.039	0.988	0.985	1.064	1.091	1.017	0.991	1.373	1.281	1.108	1.277	1.390	1.447
5	1.123	0.957	0.915	1.006	0.954	0.950	1.118	1.043	0.982	0.953	1.399	1.316	1.122	1.316	1.389	1.494
6	1.041	0.950	1.004	1.030	0.970	1.023	1.001	1.094	1.131	1.034	1.207	1.251	1.682	1.218	1.008	1.004
7	1.048	0.783	1.050	1.015	1.004	1.009	0.906	1.116	1.160	0.987	1.191	1.209	1.582	1.213	1.051	1.068
8	1.071	0.928	0.952	1.468	1.038	1.002	1.154	0.943	1.196	0.953	1.425	1.298	1.726	1.432	0.983	1.063
9	1.055	0.935	0.996	1.152	1.054	1.037	0.974	1.024	1.134	0.862	1.264	1.298	1.852	1.317	0.997	1.067
10	1.068	1.051	1.009	1.183	0.917	1.046	1.260	0.868	1.137	0.972	1.258	1.265	1.974	1.358	0.978	1.069
11	1.071	0.804	0.989	1.208	0.989	1.049	1.269	0.884	1.142	1.106	1.271	1.264	2.023	1.370	0.974	1.073
12	1.071	0.806	0.992	1.221	0.880	1.048	1.253	0.859	1.141	0.942	1.278	1.261	1.995	1.387	0.971	1.073
13	1.071	1.044	1.005	1.197	0.948	1.047	1.253	0.864	1.140	1.017	1.263	1.266	1.996	1.365	0.979	1.074

Table 80. Comparison of maximum shear forces for benchmark problem No.3
Chen Classical RSM method

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	1.061	1.006	0.953	1.036	1.002	1.137	0.884	0.989	1.026	0.909	1.097	0.986	0.881	0.992	1.202	1.164
2	1.093	1.023	0.979	1.054	1.014	1.151	0.896	1.023	1.056	0.924	1.139	1.029	0.914	1.056	1.228	1.226
3	1.100	1.023	0.986	1.052	1.013	1.149	0.909	1.020	1.059	0.920	1.168	1.060	0.937	1.106	1.217	1.259
4	1.070	0.998	0.955	1.024	0.989	1.117	0.920	1.020	1.030	0.895	1.189	1.079	0.953	1.145	1.210	1.273
5	1.032	0.964	0.927	0.992	0.958	1.076	0.967	0.974	0.993	0.860	1.217	1.109	0.965	1.183	1.213	1.313
6	0.933	0.979	1.030	0.956	0.967	1.003	0.887	1.034	1.162	1.263	1.065	1.007	1.438	1.034	0.853	0.855
7	0.979	0.961	1.068	0.989	1.005	0.989	0.796	1.051	1.155	1.127	1.005	0.987	1.360	1.076	0.914	0.945
8	0.949	1.021	0.970	1.329	1.048	0.959	1.063	0.901	1.211	1.015	1.199	1.036	1.480	1.253	0.854	0.911
9	0.973	0.996	1.021	1.088	0.993	1.014	0.870	0.966	1.142	1.094	1.061	1.038	1.568	1.160	0.862	0.931
10	0.964	1.036	1.020	1.152	0.915	1.026	1.082	0.809	1.125	1.251	1.041	1.014	1.687	1.173	0.849	0.939
11	0.974	0.826	1.032	1.141	0.994	1.028	1.100	0.827	1.181	1.413	1.075	1.030	1.757	1.236	0.868	0.955
12	0.980	0.810	1.026	1.172	0.889	1.027	1.088	0.810	1.181	1.201	1.078	0.970	1.732	1.251	0.866	0.955
13	0.966	1.038	1.016	1.165	0.944	1.028	1.078	0.806	1.132	1.322	1.044	1.017	1.705	1.180	0.850	0.943

Table 81. Comparison of maximum shear forces for benchmark problem No.3
Igusa/Der Kiureghian RSM method

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	0.986	1.036	0.959	1.061	1.034	1.034	1.063	1.084	1.010	1.029	1.114	1.015	0.829	1.095	1.132	1.102
2	0.977	1.018	0.948	1.044	1.012	1.012	1.053	1.107	1.002	1.015	1.110	1.031	0.841	1.091	1.137	1.128
3	0.958	0.995	0.930	1.018	0.988	0.987	1.052	1.094	0.981	0.991	1.112	1.046	0.850	1.092	1.115	1.133
4	0.913	0.950	0.881	0.973	0.945	0.942	1.055	1.087	0.936	0.947	1.114	1.057	0.857	1.095	1.102	1.127
5	0.865	0.899	0.839	0.925	0.898	0.894	1.094	1.034	0.886	0.895	1.120	1.068	0.859	1.101	1.095	1.146
6	0.968	0.949	0.946	1.009	1.020	1.017	0.988	1.117	1.057	1.034	1.075	1.177	1.621	0.882	0.934	0.949
7	0.961	0.789	0.972	0.994	0.997	1.000	0.883	1.112	1.077	0.948	1.055	1.121	1.501	0.902	0.962	0.993
8	0.972	0.874	0.903	1.311	0.988	0.979	1.042	0.885	1.072	0.883	1.214	1.179	1.630	0.916	0.890	0.990
9	0.970	0.931	0.929	1.093	0.955	1.023	0.927	0.999	1.034	0.821	1.102	1.195	1.773	0.902	0.913	1.002
10	0.975	1.047	0.956	1.083	0.817	1.030	1.184	0.847	1.032	0.922	1.087	1.155	1.882	0.893	0.892	0.997
11	0.977	0.797	0.943	1.097	0.881	1.033	1.189	0.857	1.040	1.046	1.092	1.152	1.934	0.899	0.890	1.002
12	0.979	0.788	0.943	1.109	0.750	1.030	1.168	0.827	1.031	0.888	1.098	1.147	1.905	0.900	0.885	1.001
13	0.976	1.040	0.951	1.091	0.838	1.031	1.176	0.842	1.035	0.968	1.088	1.155	1.902	0.895	0.892	1.001

Table 82. Comparison of maximum shear forces for benchmark problem No.3
Gupta RSM method

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	1.022	1.053	0.982	1.086	1.051	1.051	1.103	1.118	1.037	1.047	1.082	1.021	0.860	1.044	1.108	1.131
2	0.993	1.017	0.954	1.050	1.011	1.010	1.076	1.127	1.010	1.014	1.080	1.026	0.858	1.042	1.113	1.143
3	0.960	0.981	0.923	1.010	0.974	0.973	1.062	1.102	0.974	0.975	1.084	1.034	0.858	1.044	1.091	1.137
4	0.905	0.927	0.865	0.955	0.922	0.919	1.054	1.087	0.919	0.923	1.089	1.041	0.859	1.047	1.078	1.122
5	0.850	0.872	0.817	0.902	0.871	0.867	1.090	1.030	0.863	0.866	1.098	1.050	0.859	1.052	1.072	1.135
6	0.940	0.946	0.917	1.006	1.043	1.028	0.980	1.134	1.021	1.051	1.121	1.187	1.573	0.997	0.986	0.934
7	0.928	0.772	0.944	0.976	0.991	1.001	0.871	1.113	1.035	0.921	1.090	1.125	1.445	0.991	1.004	0.971
8	0.948	0.865	0.868	1.347	0.969	1.002	1.011	0.868	1.023	0.959	1.301	1.207	1.595	1.107	0.958	0.981
9	0.939	0.916	0.896	1.097	0.912	1.037	0.905	0.980	0.988	0.852	1.159	1.210	1.718	1.046	0.970	0.985
10	0.941	1.039	0.924	1.073	0.772	1.049	1.149	0.835	0.984	0.981	1.144	1.171	1.820	1.052	0.946	0.975
11	0.943	0.787	0.911	1.089	0.830	1.053	1.152	0.843	0.991	1.125	1.151	1.168	1.871	1.064	0.944	0.982
12	0.945	0.780	0.911	1.101	0.700	1.050	1.130	0.812	0.983	0.964	1.159	1.164	1.844	1.069	0.940	0.980
13	0.942	1.031	0.919	1.081	0.790	1.051	1.140	0.830	0.987	1.031	1.146	1.171	1.839	1.056	0.946	0.980

Table 83. Comparison of statistics of maximum shear forces for benchmark problem No.3 S&A RSM-I method

Elements	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
1	1.002	0.086	0.085	1.133	0.880
2	1.006	0.086	0.086	1.150	0.895
3	1.006	0.088	0.088	1.154	0.910
4	1.002	0.093	0.093	1.146	0.882
5	1.000	0.111	0.111	1.164	0.829
6	1.134	0.215	0.189	1.549	0.890
7	1.111	0.170	0.153	1.446	0.940
8	1.184	0.213	0.180	1.570	0.936
9	1.176	0.250	0.213	1.687	0.937
10	1.186	0.279	0.235	1.779	0.960
11	1.194	0.296	0.248	1.828	0.963
12	1.194	0.285	0.239	1.803	0.963
13	1.190	0.285	0.240	1.798	0.961

Table 84. Comparison of statistics of maximum shear forces for benchmark problem No.3 S&A RSM-II method

Elements	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
1	1.206	0.124	0.103	1.376	1.026
2	1.255	0.124	0.099	1.406	1.065
3	1.281	0.121	0.094	1.440	1.091
4	1.292	0.122	0.094	1.447	1.108
5	1.308	0.141	0.108	1.494	1.122
6	1.202	0.237	0.197	1.682	1.004
7	1.195	0.186	0.156	1.582	1.048
8	1.285	0.265	0.207	1.726	0.983
9	1.264	0.290	0.229	1.852	0.997
10	1.281	0.334	0.261	1.974	0.978
11	1.292	0.351	0.272	2.023	0.974
12	1.291	0.342	0.265	1.995	0.971
13	1.288	0.341	0.265	1.996	0.979

Table 85. Comparison of statistics of maximum shear forces for benchmark problem No.3
Chen Classical RSM method

Elements	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
1	1.055	0.111	0.106	1.202	0.881
2	1.098	0.112	0.102	1.228	0.914
3	1.121	0.107	0.096	1.259	0.937
4	1.131	0.107	0.094	1.273	0.953
5	1.147	0.119	0.104	1.313	0.965
6	1.027	0.200	0.195	1.438	0.853
7	1.038	0.151	0.145	1.360	0.914
8	1.097	0.224	0.204	1.480	0.854
9	1.085	0.234	0.215	1.568	0.862
10	1.095	0.279	0.255	1.687	0.849
11	1.128	0.300	0.266	1.757	0.868
12	1.119	0.297	0.265	1.732	0.866
13	1.101	0.285	0.259	1.705	0.850

Table 86. Comparison of statistics of maximum shear forces for benchmark problem No.3
Igusa/Der Kiureghian RSM method

Elements	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
1	1.039	0.107	0.103	1.132	0.829
2	1.045	0.107	0.102	1.137	0.841
3	1.044	0.104	0.100	1.133	0.850
4	1.038	0.108	0.104	1.127	0.857
5	1.036	0.121	0.117	1.146	0.859
6	1.086	0.256	0.235	1.621	0.882
7	1.071	0.203	0.189	1.501	0.902
8	1.113	0.260	0.233	1.630	0.890
9	1.122	0.305	0.272	1.773	0.902
10	1.126	0.347	0.308	1.882	0.892
11	1.135	0.365	0.321	1.934	0.890
12	1.131	0.354	0.314	1.905	0.885
13	1.130	0.354	0.313	1.902	0.892

Table 87. Comparison of statistics of maximum shear forces for benchmark problem No.3 Gupta RSM method

Elements	Mean	Standard deviation	COV	Max. Ratio	Min. Ratio
1	1.038	0.089	0.086	1.131	0.860
2	1.036	0.094	0.090	1.143	0.858
3	1.030	0.094	0.091	1.137	0.858
4	1.020	0.099	0.097	1.122	0.859
5	1.017	0.114	0.113	1.135	0.850
6	1.105	0.227	0.205	1.573	0.934
7	1.079	0.175	0.162	1.445	0.928
8	1.157	0.235	0.203	1.595	0.948
9	1.147	0.271	0.236	1.718	0.939
10	1.150	0.309	0.269	1.820	0.941
11	1.160	0.327	0.281	1.871	0.943
12	1.157	0.317	0.274	1.844	0.940
13	1.154	0.316	0.274	1.839	0.942

Table 88. Comparison of maximum displacements U_y of S&A results for benchmark problem No.4a using modal superposition time history analysis

Nodes	Load cases							Bounds	
	a	b	c	d	e	f	g	Max ratios	Min ratios
2	1.020	1.000	0.993	1.009	1.023	1.042	1.004	1.042	0.993
3	1.022	1.005	0.997	1.012	1.024	1.050	1.006	1.050	0.997
4	1.023	1.002	0.998	1.013	1.029	1.049	1.012	1.049	0.998
5	1.023	1.007	0.999	1.016	1.032	1.049	1.013	1.049	0.999
6	1.024	1.007	1.000	1.015	1.032	1.051	1.012	1.051	1.000
7	1.025	1.008	0.999	1.013	1.034	1.052	1.013	1.052	0.999
8	1.029	1.008	1.000	1.014	1.034	1.054	1.014	1.054	1.000
9	1.029	1.008	1.000	1.014	1.034	1.054	1.014	1.054	1.000
10	1.022	1.008	0.998	1.014	1.033	1.056	1.020	1.056	0.998
11	1.025	1.009	0.996	1.016	1.034	1.059	1.019	1.059	0.996
12	1.029	1.008	1.000	1.014	1.034	1.054	1.014	1.054	1.000
13	1.035	1.005	1.033	1.021	1.041	1.028	1.007	1.041	1.005
14	1.040	1.010	1.113	1.068	1.061	1.082	1.236	1.236	1.010
15	1.082	1.010	1.133	1.079	1.069	1.194	1.270	1.270	1.010
16	1.024	1.007	1.000	1.015	1.032	1.051	1.012	1.051	1.000
17	1.046	1.239	1.172	1.168	1.237	1.214	1.170	1.239	1.046
18	1.042	1.279	1.247	1.171	1.275	1.251	1.186	1.279	1.042
19	1.043	1.277	1.255	1.173	1.277	1.249	1.187	1.277	1.043
20	1.044	1.256	1.182	1.173	1.255	1.226	1.177	1.256	1.044
21	1.023	1.002	0.998	1.013	1.029	1.049	1.012	1.049	0.998
22	1.107	1.020	1.203	1.129	1.085	1.304	1.367	1.367	1.020
23	0.980	0.963	1.039	1.061	1.013	0.915	1.000	1.061	0.915
24	1.005	0.982	1.004	0.995	1.010	1.016	0.985	1.016	0.982
25	1.005	0.982	1.001	0.995	1.011	1.014	0.990	1.014	0.982
26	1.007	0.986	1.000	0.995	1.010	1.019	0.988	1.019	0.986
27	1.008	0.982	1.000	0.995	1.010	1.020	0.991	1.020	0.982
28	1.022	1.005	0.997	1.012	1.024	1.050	1.006	1.050	0.997
29	0.966	0.979	1.009	1.002	0.992	1.052	1.011	1.052	0.966
30	0.954	0.980	1.003	0.998	0.997	1.053	1.006	1.053	0.954
31	0.993	0.996	0.978	1.005	1.013	1.046	1.007	1.046	0.978
32	1.022	1.005	0.997	1.012	1.024	1.050	1.006	1.050	0.997

Table 89. Comparison of maximum displacements U_y of Igusa/Der Kiureghian results for benchmark problem No.4a using modal superposition time history analysis

Nodes	Load cases							Bounds	
	a	b	c	d	e	f	g	Max ratios	Min ratios
2	1.001	0.999	0.999	0.998	1.005	1.005	0.999	1.005	0.998
3	1.001	0.998	0.998	0.998	1.006	1.005	0.999	1.006	0.998
4	1.001	0.998	0.999	0.999	1.006	1.006	0.999	1.006	0.998
5	1.001	0.998	0.999	0.999	1.006	1.006	0.999	1.006	0.998
6	1.001	0.998	0.998	0.999	1.006	1.006	0.999	1.006	0.998
7	1.001	0.998	0.998	0.998	1.006	1.006	0.999	1.006	0.998
8	1.001	0.998	0.998	0.998	1.006	1.006	0.999	1.006	0.998
9	1.001	0.998	0.998	0.998	1.006	1.006	0.999	1.006	0.998
10	1.001	1.000	0.997	0.998	1.006	1.007	1.001	1.007	0.997
11	1.002	1.001	0.996	0.998	1.005	1.009	1.003	1.009	0.996
12	1.001	0.998	0.998	0.998	1.006	1.006	0.999	1.006	0.998
13	1.005	0.989	1.009	0.996	1.016	0.992	0.990	1.016	0.989
14	1.075	1.048	1.074	1.089	1.044	1.111	1.263	1.263	1.044
15	1.128	1.054	1.095	1.101	1.049	1.218	1.298	1.298	1.049
16	1.001	0.998	0.998	0.999	1.006	1.006	0.999	1.006	0.998
17	1.035	1.176	1.131	1.162	1.164	1.124	1.156	1.176	1.035
18	1.040	1.204	1.274	1.162	1.196	1.156	1.170	1.274	1.040
19	1.040	1.206	1.279	1.163	1.197	1.158	1.170	1.279	1.040
20	1.034	1.183	1.168	1.156	1.173	1.133	1.158	1.183	1.034
21	1.001	0.998	0.999	0.999	1.006	1.006	0.999	1.006	0.998
22	1.236	1.049	1.138	1.118	1.053	1.237	1.363	1.363	1.049
23	0.994	0.987	1.021	1.033	1.020	0.991	1.007	1.033	0.987
24	0.989	0.991	1.008	1.004	1.011	1.000	0.993	1.011	0.989
25	0.989	0.991	1.008	0.998	1.011	1.001	0.993	1.011	0.989
26	0.990	0.992	1.007	0.995	1.010	1.002	0.994	1.010	0.990
27	0.991	0.992	1.006	0.995	1.010	1.002	0.994	1.010	0.991
28	1.001	0.998	0.998	0.998	1.006	1.005	0.999	1.006	0.998
29	0.971	1.002	0.995	1.001	1.002	1.013	1.015	1.015	0.971
30	0.962	1.001	0.995	1.001	1.001	1.014	1.015	1.015	0.962
31	0.977	0.999	0.997	0.999	1.003	1.009	1.006	1.009	0.977
32	1.001	0.998	0.998	0.998	1.006	1.005	0.999	1.006	0.998

Table 90. Comparison of maximum displacements U_y of Gupta results for benchmark problem No.4a using modal superposition time history analysis

Nodes	Load cases							Bounds	
	a	b	c	d	e	f	g	Max ratios	Min ratios
2	1.000	1.001	1.004	1.001	1.003	0.999	1.001	1.004	0.999
3	1.000	1.001	1.004	1.001	1.003	0.999	1.001	1.004	0.999
4	1.000	1.001	1.004	1.001	1.003	0.999	1.001	1.004	0.999
5	1.000	1.001	1.004	1.001	1.003	0.999	1.001	1.004	0.999
6	1.001	1.000	1.004	1.001	1.003	0.999	1.001	1.004	0.999
7	1.001	1.000	1.004	1.001	1.003	0.999	1.001	1.004	0.999
8	1.000	1.000	1.004	1.001	1.003	0.999	1.001	1.004	0.999
9	1.000	1.000	1.004	1.001	1.003	0.999	1.001	1.004	0.999
10	1.000	1.002	1.003	1.001	1.002	1.000	1.003	1.003	1.000
11	1.001	1.003	1.003	1.001	1.001	1.001	1.005	1.005	1.001
12	1.000	1.000	1.004	1.001	1.003	0.999	1.001	1.004	0.999
13	1.006	0.992	1.009	1.001	1.014	0.993	1.001	1.014	0.992
14	1.092	1.069	1.060	1.099	1.037	1.117	1.276	1.276	1.037
15	1.150	1.077	1.079	1.112	1.041	1.224	1.312	1.312	1.041
16	1.001	1.000	1.004	1.001	1.003	0.999	1.001	1.004	0.999
17	1.045	1.148	1.136	1.155	1.146	1.090	1.153	1.155	1.045
18	1.051	1.173	1.279	1.161	1.175	1.117	1.167	1.279	1.051
19	1.050	1.173	1.283	1.161	1.176	1.119	1.167	1.283	1.050
20	1.043	1.155	1.171	1.152	1.152	1.098	1.155	1.171	1.043
21	1.000	1.001	1.004	1.001	1.003	0.999	1.001	1.004	0.999
22	1.279	1.080	1.120	1.132	1.045	1.209	1.379	1.379	1.045
23	1.012	0.991	1.019	1.045	1.018	0.989	1.016	1.045	0.989
24	1.010	0.996	1.010	1.014	1.011	0.991	0.999	1.014	0.991
25	1.010	0.996	1.009	1.009	1.011	0.991	0.999	1.011	0.991
26	1.010	0.996	1.009	0.999	1.010	0.991	1.000	1.010	0.991
27	1.010	0.996	1.008	0.998	1.010	0.992	1.000	1.010	0.992
28	1.000	1.001	1.004	1.001	1.003	0.999	1.001	1.004	0.999
29	1.028	1.004	1.006	1.003	1.001	0.999	1.013	1.028	0.999
30	1.039	1.005	1.006	1.003	1.001	0.997	1.011	1.039	0.997
31	1.019	1.002	1.005	1.002	1.002	0.997	1.005	1.019	0.997
32	1.000	1.001	1.004	1.001	1.003	0.999	1.001	1.004	0.999

Table 91. Comparison of maximum displacements U_y for benchmark problem No.4a S&A RSM-I method

Nodes	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
2	1.020	1.009	1.048	1.054	1.018	1.023	1.021	1.028	0.017	0.016	1.054	1.009
3	1.019	1.005	1.027	1.035	1.024	1.037	1.020	1.024	0.011	0.011	1.037	1.005
4	1.021	1.008	1.017	1.025	1.029	1.040	1.017	1.023	0.010	0.010	1.040	1.008
5	1.021	1.007	1.005	1.016	1.029	1.046	1.015	1.020	0.014	0.014	1.046	1.005
6	1.024	1.007	1.000	1.015	1.032	1.051	1.014	1.020	0.017	0.017	1.051	1.000
7	1.025	1.008	0.997	1.013	1.034	1.054	1.013	1.021	0.019	0.019	1.054	0.997
8	1.029	1.008	0.995	1.014	1.034	1.055	1.013	1.021	0.020	0.019	1.055	0.995
9	1.029	1.008	0.995	1.014	1.034	1.055	1.013	1.021	0.020	0.019	1.055	0.995
10	1.022	1.008	1.003	1.018	1.037	1.058	1.010	1.022	0.019	0.019	1.058	1.003
11	1.025	1.009	1.013	1.021	1.039	1.057	1.019	1.026	0.017	0.016	1.057	1.009
12	1.029	1.008	0.995	1.014	1.034	1.055	1.013	1.021	0.020	0.019	1.055	0.995
13	0.999	0.992	0.922	0.987	1.032	1.089	1.016	1.005	0.050	0.050	1.089	0.922
14	0.985	0.906	0.927	0.893	0.977	1.365	1.082	1.019	0.165	0.162	1.365	0.893
15	1.034	0.896	0.987	0.892	0.976	1.395	1.073	1.036	0.172	0.166	1.395	0.892
16	1.024	1.007	1.000	1.015	1.032	1.051	1.014	1.020	0.017	0.017	1.051	1.000
17	1.117	1.130	1.555	1.382	1.143	1.097	1.176	1.229	0.173	0.141	1.555	1.097
18	1.158	1.169	1.725	1.366	1.162	1.142	1.186	1.273	0.214	0.168	1.725	1.142
19	1.164	1.174	1.737	1.372	1.160	1.142	1.191	1.277	0.217	0.170	1.737	1.142
20	1.134	1.142	1.612	1.393	1.150	1.108	1.185	1.246	0.188	0.150	1.612	1.108
21	1.021	1.008	1.017	1.025	1.029	1.040	1.017	1.023	0.010	0.010	1.040	1.008
22	1.305	0.928	1.237	0.924	1.008	1.289	1.168	1.123	0.167	0.149	1.305	0.924
23	0.951	0.963	0.915	0.947	0.977	1.021	0.971	0.963	0.033	0.034	1.021	0.915
24	0.988	0.982	0.966	1.020	0.998	1.029	0.994	0.997	0.022	0.022	1.029	0.966
25	0.988	0.982	0.972	1.020	0.999	1.033	0.994	0.999	0.021	0.021	1.033	0.972
26	0.990	0.986	0.971	1.022	0.997	1.032	0.996	0.999	0.021	0.021	1.032	0.971
27	0.991	0.982	0.976	1.021	0.997	1.026	1.000	0.999	0.019	0.019	1.026	0.976
28	1.019	1.005	1.027	1.035	1.024	1.037	1.020	1.024	0.011	0.011	1.037	1.005
29	0.978	1.003	1.077	1.054	0.998	1.002	1.015	1.018	0.035	0.034	1.077	0.978
30	0.959	1.012	1.077	1.061	0.997	1.000	1.013	1.017	0.040	0.039	1.077	0.959
31	0.996	1.004	1.053	1.048	1.013	1.017	1.015	1.021	0.021	0.021	1.053	0.996
32	1.019	1.005	1.027	1.035	1.024	1.037	1.020	1.024	0.011	0.011	1.037	1.005

Table 92. Comparison of maximum displacements U_y for benchmark problem No.4a S&A RSM-II method

Nodes	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
2	0.942	0.886	0.961	0.979	0.873	0.953	0.973	0.938	0.042	0.045	0.979	0.873
3	0.974	0.931	0.977	0.994	0.932	0.992	0.989	0.970	0.027	0.028	0.994	0.931
4	0.993	0.961	0.986	1.002	0.970	1.016	1.001	0.990	0.019	0.019	1.016	0.961
5	1.011	0.987	0.994	1.008	1.005	1.038	1.007	1.007	0.016	0.016	1.038	0.987
6	1.024	1.007	1.000	1.015	1.032	1.051	1.014	1.020	0.017	0.017	1.051	1.000
7	1.025	1.016	1.002	1.019	1.044	1.060	1.016	1.026	0.019	0.019	1.060	1.002
8	1.038	1.023	1.005	1.019	1.053	1.064	1.019	1.031	0.021	0.020	1.064	1.005
9	1.038	1.023	1.005	1.019	1.053	1.064	1.019	1.031	0.021	0.020	1.064	1.005
10	1.039	1.035	1.013	1.028	1.074	1.070	1.020	1.040	0.024	0.023	1.074	1.013
11	1.033	1.041	1.018	1.030	1.081	1.069	1.019	1.041	0.024	0.023	1.081	1.018
12	1.038	1.023	1.005	1.019	1.053	1.064	1.019	1.031	0.021	0.020	1.064	1.005
13	1.062	1.054	1.026	1.050	1.084	1.148	1.078	1.072	0.039	0.036	1.148	1.026
14	1.302	1.162	1.241	1.106	1.230	1.759	1.309	1.301	0.214	0.165	1.759	1.106
15	1.421	1.184	1.310	1.123	1.270	1.892	1.314	1.359	0.254	0.187	1.892	1.123
16	1.024	1.007	1.000	1.015	1.032	1.051	1.014	1.020	0.017	0.017	1.051	1.000
17	1.187	1.287	1.392	1.452	1.368	1.146	1.146	1.283	0.125	0.098	1.452	1.146
18	1.300	1.410	1.599	1.492	1.483	1.251	1.190	1.389	0.147	0.106	1.599	1.190
19	1.308	1.414	1.618	1.501	1.495	1.256	1.199	1.399	0.151	0.108	1.618	1.199
20	1.225	1.325	1.456	1.479	1.408	1.179	1.170	1.320	0.131	0.099	1.479	1.170
21	0.993	0.961	0.986	1.002	0.970	1.016	1.001	0.990	0.019	0.019	1.016	0.961
22	1.826	1.200	1.514	1.170	1.256	1.859	1.419	1.463	0.286	0.196	1.859	1.170
23	0.977	0.929	0.994	0.992	0.883	1.047	1.037	0.980	0.058	0.059	1.047	0.883
24	0.945	0.894	0.952	0.993	0.876	0.990	0.990	0.949	0.048	0.050	0.993	0.876
25	0.945	0.895	0.954	0.993	0.877	0.995	0.990	0.950	0.048	0.051	0.995	0.877
26	0.947	0.898	0.952	0.991	0.881	0.993	0.988	0.950	0.045	0.048	0.993	0.881
27	0.947	0.894	0.952	0.990	0.886	0.987	0.987	0.949	0.044	0.046	0.990	0.886
28	0.974	0.931	0.977	0.994	0.932	0.992	0.989	0.970	0.027	0.028	0.994	0.931
29	0.895	0.889	0.955	0.969	0.865	0.931	0.945	0.921	0.039	0.042	0.969	0.865
30	0.868	0.872	0.941	0.961	0.845	0.916	0.938	0.906	0.044	0.049	0.961	0.845
31	0.921	0.895	0.955	0.974	0.880	0.947	0.962	0.933	0.036	0.038	0.974	0.880
32	0.974	0.931	0.977	0.994	0.932	0.992	0.989	0.970	0.027	0.028	0.994	0.931

Table 93. Comparison of maximum displacements U_Y for benchmark problem No.4a
Chen Classical RSM method

Nodes	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
2	0.908	0.872	0.963	0.969	0.847	0.866	0.968	0.913	0.053	0.058	0.969	0.847
3	0.942	0.921	0.987	0.988	0.919	0.908	0.980	0.949	0.035	0.037	0.988	0.908
4	0.962	0.949	0.998	0.998	0.961	0.927	0.990	0.969	0.027	0.028	0.998	0.927
5	0.979	0.978	1.007	1.005	0.997	0.945	0.998	0.987	0.022	0.022	1.007	0.945
6	0.991	0.997	1.013	1.011	1.023	0.957	1.002	0.999	0.021	0.021	1.023	0.957
7	0.997	1.005	1.015	1.013	1.034	0.963	1.004	1.004	0.022	0.022	1.034	0.963
8	1.001	1.011	1.016	1.015	1.043	0.968	1.006	1.008	0.022	0.022	1.043	0.968
9	1.001	1.011	1.017	1.015	1.043	0.968	1.007	1.009	0.022	0.022	1.043	0.968
10	0.998	1.017	1.011	1.008	1.062	0.974	1.000	1.010	0.027	0.026	1.062	0.974
11	0.993	1.013	1.003	1.000	1.066	0.975	0.990	1.006	0.029	0.029	1.066	0.975
12	1.001	1.011	1.016	1.015	1.043	0.968	1.007	1.008	0.022	0.022	1.043	0.968
13	1.090	1.126	1.182	1.182	1.090	1.044	1.171	1.126	0.054	0.048	1.182	1.044
14	1.560	1.485	1.774	1.545	1.352	1.718	1.722	1.593	0.152	0.095	1.774	1.352
15	1.745	1.552	1.925	1.603	1.427	1.889	1.767	1.701	0.182	0.107	1.925	1.427
16	0.991	0.997	1.013	1.011	1.023	0.957	1.002	0.999	0.021	0.021	1.023	0.957
17	1.237	1.359	1.558	1.586	1.503	1.190	1.207	1.377	0.172	0.125	1.586	1.190
18	1.417	1.570	1.925	1.750	1.673	1.325	1.333	1.571	0.227	0.144	1.925	1.325
19	1.430	1.583	1.946	1.766	1.687	1.333	1.343	1.584	0.231	0.146	1.946	1.333
20	1.294	1.422	1.668	1.653	1.556	1.228	1.251	1.439	0.188	0.131	1.668	1.228
21	0.962	0.949	0.998	0.998	0.961	0.927	0.990	0.969	0.027	0.028	0.998	0.927
22	2.325	1.614	2.265	1.703	1.457	1.942	1.951	1.894	0.325	0.172	2.325	1.457
23	1.065	1.064	1.283	1.248	0.901	0.961	1.236	1.108	0.150	0.135	1.283	0.901
24	0.952	0.929	1.066	1.088	0.864	0.906	1.054	0.980	0.088	0.090	1.088	0.864
25	0.952	0.921	1.063	1.082	0.865	0.904	1.050	0.977	0.087	0.089	1.082	0.865
26	0.950	0.924	1.052	1.074	0.869	0.903	1.044	0.974	0.082	0.084	1.074	0.869
27	0.950	0.920	1.047	1.067	0.874	0.903	1.039	0.972	0.078	0.080	1.067	0.874
28	0.942	0.921	0.987	0.988	0.919	0.908	0.980	0.949	0.035	0.037	0.988	0.908
29	0.839	0.832	0.882	0.882	0.848	0.848	0.879	0.859	0.022	0.025	0.882	0.832
30	0.812	0.817	0.876	0.881	0.824	0.836	0.878	0.846	0.031	0.036	0.881	0.812
31	0.878	0.861	0.932	0.936	0.863	0.866	0.930	0.895	0.036	0.040	0.936	0.861
32	0.942	0.921	0.987	0.988	0.919	0.908	0.980	0.949	0.035	0.037	0.988	0.908

Table 94. Comparison of maximum displacements U_y for benchmark problem No.4a
Igusa/Der Kiureghian RSM method

Nodes	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
2	0.977	0.977	1.040	1.026	0.959	0.973	1.002	0.993	0.030	0.030	1.040	0.959
3	0.990	0.997	1.031	1.021	0.990	0.993	1.006	1.004	0.016	0.016	1.031	0.990
4	0.995	1.002	1.022	1.014	1.002	1.001	1.005	1.006	0.009	0.009	1.022	0.995
5	0.999	1.002	1.010	1.005	1.007	1.005	1.003	1.004	0.003	0.003	1.010	0.999
6	1.001	0.999	0.999	0.999	1.007	1.006	1.000	1.002	0.003	0.003	1.007	0.999
7	1.002	0.998	0.995	0.995	1.007	1.007	0.999	1.000	0.005	0.005	1.007	0.995
8	1.003	0.996	0.991	0.993	1.007	1.007	0.998	0.999	0.006	0.006	1.007	0.991
9	1.003	0.996	0.991	0.993	1.007	1.007	0.998	0.999	0.006	0.006	1.007	0.991
10	1.003	0.997	0.995	1.002	1.013	1.008	1.002	1.003	0.006	0.006	1.013	0.995
11	1.006	1.000	1.002	1.011	1.016	1.008	1.005	1.007	0.006	0.005	1.016	1.000
12	1.003	0.996	0.991	0.993	1.007	1.007	0.998	0.999	0.006	0.006	1.007	0.991
13	0.972	0.986	0.952	0.944	1.005	1.038	0.986	0.983	0.032	0.033	1.038	0.944
14	1.017	0.953	1.006	0.871	0.991	1.337	1.051	1.032	0.146	0.141	1.337	0.871
15	1.091	0.957	1.058	0.884	0.996	1.379	1.049	1.059	0.157	0.149	1.379	0.884
16	1.001	0.999	0.999	0.999	1.007	1.006	1.000	1.002	0.003	0.003	1.007	0.999
17	1.205	1.132	1.329	1.506	1.088	1.023	1.199	1.212	0.162	0.134	1.506	1.023
18	1.278	1.181	1.470	1.498	1.101	1.061	1.209	1.257	0.171	0.136	1.498	1.061
19	1.282	1.183	1.477	1.501	1.102	1.062	1.209	1.260	0.172	0.137	1.501	1.062
20	1.225	1.143	1.367	1.510	1.092	1.030	1.201	1.224	0.166	0.135	1.510	1.030
21	0.995	1.002	1.022	1.014	1.002	1.001	1.005	1.006	0.009	0.009	1.022	0.995
22	1.390	0.977	1.207	0.926	0.993	1.263	1.119	1.125	0.171	0.152	1.390	0.926
23	0.960	1.004	1.003	0.948	0.992	1.047	0.980	0.991	0.033	0.033	1.047	0.948
24	0.966	1.002	1.023	1.020	0.992	1.013	0.992	1.001	0.020	0.020	1.023	0.966
25	0.966	1.002	1.023	1.020	0.992	1.012	0.993	1.001	0.020	0.020	1.023	0.966
26	0.967	1.001	1.024	1.019	0.992	1.010	0.995	1.001	0.019	0.019	1.024	0.967
27	0.969	1.000	1.023	1.018	0.991	1.008	0.996	1.001	0.018	0.018	1.023	0.969
28	0.990	0.997	1.031	1.021	0.990	0.993	1.006	1.004	0.016	0.016	1.031	0.990
29	0.967	1.022	1.076	1.061	0.990	0.975	1.011	1.014	0.042	0.041	1.076	0.967
30	0.952	1.030	1.084	1.071	0.995	0.974	1.014	1.017	0.048	0.048	1.084	0.952
31	1.001	1.012	1.067	1.053	0.991	0.994	1.024	1.020	0.030	0.029	1.067	0.991
32	0.990	0.997	1.031	1.021	0.990	0.993	1.006	1.004	0.016	0.016	1.031	0.990

Table 95. Comparison of maximum displacements U_y for benchmark problem No.4a Gupta RSM method

Nodes	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
2	1.008	0.990	1.063	1.060	0.990	0.973	1.026	1.016	0.035	0.035	1.063	0.973
3	1.002	0.993	1.038	1.034	0.995	0.983	1.016	1.009	0.021	0.021	1.038	0.983
4	1.000	0.996	1.024	1.020	0.998	0.989	1.010	1.005	0.013	0.013	1.024	0.989
5	1.000	0.999	1.012	1.009	1.001	0.995	1.005	1.003	0.006	0.006	1.012	0.995
6	1.000	1.001	1.005	1.002	1.003	0.999	1.002	1.002	0.002	0.002	1.005	0.999
7	1.001	1.002	1.001	0.998	1.004	1.001	1.000	1.001	0.002	0.002	1.004	0.998
8	1.001	1.003	0.999	0.996	1.005	1.002	0.999	1.001	0.003	0.003	1.005	0.996
9	1.001	1.003	0.999	0.996	1.005	1.002	0.999	1.001	0.003	0.003	1.005	0.996
10	0.993	1.005	1.001	0.999	1.006	1.004	0.998	1.001	0.004	0.004	1.006	0.993
11	0.992	1.007	1.007	1.005	1.006	1.004	0.998	1.003	0.006	0.006	1.007	0.992
12	1.001	1.003	0.999	0.996	1.005	1.002	0.999	1.001	0.003	0.003	1.005	0.996
13	0.986	0.986	0.966	0.967	1.008	1.034	1.002	0.993	0.024	0.025	1.034	0.966
14	1.071	0.996	1.078	0.944	0.993	1.428	1.120	1.090	0.161	0.148	1.428	0.944
15	1.159	1.018	1.149	0.965	0.997	1.526	1.127	1.135	0.189	0.167	1.526	0.965
16	1.000	1.001	1.005	1.002	1.003	0.999	1.002	1.002	0.002	0.002	1.005	0.999
17	1.157	1.321	1.444	1.500	1.042	1.141	1.192	1.257	0.169	0.135	1.500	1.042
18	1.233	1.414	1.621	1.508	1.050	1.225	1.212	1.323	0.198	0.150	1.621	1.050
19	1.237	1.417	1.629	1.512	1.051	1.228	1.213	1.327	0.200	0.151	1.629	1.051
20	1.176	1.343	1.490	1.507	1.042	1.159	1.196	1.273	0.177	0.139	1.507	1.042
21	1.000	0.996	1.024	1.020	0.998	0.989	1.010	1.005	0.013	0.013	1.024	0.989
22	1.509	1.059	1.331	1.018	1.002	1.514	1.216	1.236	0.222	0.180	1.514	1.002
23	0.999	0.972	1.008	0.987	0.989	1.030	1.015	1.000	0.020	0.020	1.030	0.972
24	0.992	0.973	1.021	1.046	0.988	0.991	1.015	1.004	0.025	0.025	1.046	0.973
25	0.992	0.973	1.021	1.045	0.989	0.991	1.015	1.004	0.025	0.025	1.045	0.973
26	0.992	0.974	1.022	1.044	0.989	0.989	1.016	1.004	0.024	0.024	1.044	0.974
27	0.993	0.974	1.023	1.042	0.989	0.988	1.016	1.004	0.024	0.024	1.042	0.974
28	1.002	0.993	1.038	1.034	0.995	0.983	1.016	1.009	0.021	0.021	1.038	0.983
29	0.986	1.015	1.080	1.071	0.990	0.963	1.023	1.018	0.044	0.043	1.080	0.963
30	0.972	1.012	1.083	1.078	0.987	0.957	1.026	1.016	0.049	0.049	1.083	0.957
31	0.993	1.001	1.060	1.057	0.990	0.969	1.022	1.013	0.035	0.034	1.060	0.969
32	1.002	0.993	1.038	1.034	0.995	0.983	1.016	1.009	0.021	0.021	1.038	0.983

Table 96. Comparison of maximum SRSS moments of the piping of S&A results for benchmark problem No.4a using modal superposition time history analysis

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	1.016	1.132	1.095	1.042	1.118	1.113	1.100	1.088	0.043	0.039	1.132	1.016
2	1.099	1.174	1.169	1.099	1.159	1.172	1.260	1.161	0.054	0.047	1.260	1.099
3	1.036	1.176	1.142	1.070	1.159	1.152	1.173	1.130	0.054	0.048	1.176	1.036
4	1.233	1.149	1.245	1.114	1.229	1.352	1.361	1.240	0.093	0.075	1.361	1.114
5	0.926	0.871	0.847	0.842	0.957	1.005	0.930	0.911	0.060	0.066	1.005	0.842
6	1.318	1.109	1.251	1.070	1.272	1.381	1.372	1.253	0.122	0.097	1.381	1.070
7	1.217	1.347	1.266	1.170	1.447	1.412	1.295	1.308	0.101	0.077	1.447	1.170
8	1.035	1.260	1.186	1.176	1.265	1.240	1.174	1.191	0.079	0.067	1.265	1.035
9	1.191	1.336	1.275	1.158	1.375	1.365	1.249	1.278	0.085	0.066	1.375	1.158
10	1.132	1.329	1.304	1.171	1.338	1.310	1.195	1.254	0.085	0.068	1.338	1.132
11	1.133	1.326	1.321	1.175	1.336	1.304	1.200	1.256	0.084	0.067	1.336	1.133
12	1.139	1.348	1.370	1.230	1.358	1.327	1.241	1.288	0.086	0.067	1.370	1.139
13	1.097	1.295	1.288	1.153	1.299	1.273	1.176	1.226	0.082	0.067	1.299	1.097
14	1.235	1.410	1.341	1.182	1.432	1.384	1.267	1.322	0.095	0.072	1.432	1.182
15	0.615	0.645	0.624	0.581	0.675	0.679	0.573	0.628	0.042	0.067	0.679	0.573
16	0.882	1.035	0.965	0.855	1.057	1.020	0.942	0.965	0.077	0.080	1.057	0.855
17	1.010	0.947	0.931	0.864	0.954	0.918	0.919	0.935	0.044	0.047	1.010	0.864
18	1.221	0.745	0.930	0.729	0.724	1.030	0.888	0.895	0.185	0.207	1.221	0.724
19	0.722	0.608	0.771	0.705	0.652	0.795	0.825	0.725	0.078	0.107	0.825	0.608
20	1.211	1.304	1.581	1.493	1.429	1.474	1.810	1.472	0.194	0.132	1.810	1.211
21	0.857	1.007	1.167	1.152	0.886	1.109	1.229	1.058	0.144	0.137	1.229	0.857
22	0.820	0.915	1.052	1.066	0.927	1.040	1.027	0.978	0.092	0.094	1.066	0.820
23	1.165	1.180	1.294	1.264	1.213	1.251	1.291	1.237	0.052	0.042	1.294	1.165

Table 97. Comparison of maximum SRSS moments of the piping of Igusa/Der Kuireghian results for benchmark problem No.4a using modal superposition time history analysis

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	1.011	1.082	1.061	1.017	1.073	1.058	1.071	1.053	0.028	0.026	1.082	1.011
2	1.073	1.083	1.148	1.064	1.123	1.099	1.237	1.118	0.060	0.054	1.237	1.064
3	1.027	1.111	1.102	1.039	1.111	1.090	1.138	1.088	0.041	0.037	1.138	1.027
4	1.240	1.123	1.224	1.120	1.202	1.279	1.376	1.223	0.089	0.073	1.376	1.120
5	1.164	1.058	1.132	1.082	1.100	1.069	1.146	1.107	0.041	0.037	1.164	1.058
6	1.334	1.102	1.305	1.121	1.300	1.317	1.442	1.274	0.121	0.095	1.442	1.102
7	1.227	1.219	1.331	1.183	1.350	1.334	1.304	1.278	0.067	0.052	1.350	1.183
8	1.028	1.197	1.209	1.168	1.188	1.153	1.163	1.158	0.061	0.052	1.209	1.028
9	1.231	1.239	1.345	1.174	1.298	1.306	1.269	1.266	0.057	0.045	1.345	1.174
10	1.136	1.253	1.348	1.176	1.252	1.217	1.195	1.225	0.068	0.056	1.348	1.136
11	1.118	1.244	1.344	1.176	1.245	1.206	1.185	1.217	0.071	0.058	1.344	1.118
12	1.060	1.227	1.335	1.171	1.214	1.186	1.168	1.195	0.082	0.069	1.335	1.060
13	1.101	1.239	1.337	1.170	1.233	1.198	1.183	1.209	0.073	0.060	1.337	1.101
14	1.208	1.283	1.353	1.154	1.289	1.261	1.225	1.253	0.064	0.051	1.353	1.154
15	1.119	1.237	1.360	1.171	1.236	1.181	1.190	1.213	0.076	0.063	1.360	1.119
16	1.181	1.288	1.343	1.148	1.314	1.275	1.256	1.258	0.070	0.056	1.343	1.148
17	1.211	1.218	1.205	1.174	1.234	1.147	1.243	1.205	0.034	0.028	1.243	1.147
18	1.245	1.042	1.291	1.141	1.049	1.256	1.384	1.201	0.128	0.107	1.384	1.042
19	1.031	1.025	1.197	1.137	1.042	1.214	1.303	1.136	0.108	0.095	1.303	1.025
20	1.073	1.021	1.116	1.096	1.014	1.138	1.326	1.112	0.105	0.094	1.326	1.014
21	0.934	1.035	1.076	1.099	1.011	1.067	1.140	1.052	0.067	0.063	1.140	0.934
22	1.002	1.021	1.015	1.056	0.993	1.037	1.066	1.027	0.027	0.026	1.066	0.993
23	1.017	1.016	1.059	1.051	1.035	1.076	1.080	1.048	0.026	0.025	1.080	1.016

Table 98. Comparison of maximum SRSS moments of the piping of Gupta results for benchmark problem No.4a using modal superposition time history analysis

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	1.032	1.067	1.054	1.024	1.071	1.040	1.096	1.055	0.025	0.024	1.096	1.024
2	1.086	1.070	1.147	1.069	1.115	1.075	1.245	1.115	0.064	0.057	1.245	1.069
3	1.078	1.096	1.097	1.047	1.108	1.075	1.164	1.095	0.036	0.033	1.164	1.047
4	1.250	1.124	1.202	1.126	1.205	1.265	1.398	1.224	0.094	0.077	1.398	1.124
5	1.148	1.054	1.140	1.070	1.078	1.073	1.151	1.102	0.042	0.038	1.151	1.054
6	1.398	1.142	1.306	1.127	1.296	1.289	1.470	1.290	0.125	0.097	1.470	1.127
7	1.231	1.165	1.344	1.194	1.356	1.294	1.305	1.270	0.074	0.059	1.356	1.165
8	1.050	1.165	1.219	1.163	1.165	1.115	1.161	1.148	0.053	0.046	1.219	1.050
9	1.231	1.198	1.363	1.184	1.280	1.280	1.269	1.258	0.060	0.048	1.363	1.184
10	1.142	1.214	1.356	1.179	1.230	1.172	1.194	1.212	0.070	0.057	1.356	1.142
11	1.126	1.207	1.347	1.176	1.220	1.164	1.184	1.204	0.070	0.058	1.347	1.126
12	1.092	1.184	1.334	1.167	1.178	1.144	1.170	1.181	0.074	0.063	1.334	1.092
13	1.113	1.201	1.337	1.170	1.205	1.154	1.180	1.194	0.070	0.059	1.337	1.113
14	1.201	1.237	1.368	1.159	1.273	1.236	1.230	1.244	0.065	0.053	1.368	1.159
15	1.128	1.203	1.354	1.174	1.220	1.157	1.188	1.203	0.073	0.060	1.354	1.128
16	1.204	1.236	1.352	1.152	1.294	1.249	1.264	1.250	0.064	0.051	1.352	1.152
17	1.317	1.255	1.276	1.162	1.245	1.217	1.248	1.246	0.048	0.039	1.317	1.162
18	1.385	1.144	1.326	1.145	1.058	1.349	1.432	1.263	0.144	0.114	1.432	1.058
19	1.210	1.079	1.188	1.150	1.044	1.205	1.302	1.168	0.087	0.074	1.302	1.044
20	1.293	1.076	1.094	1.106	1.031	1.156	1.329	1.155	0.113	0.098	1.329	1.031
21	1.130	1.020	1.052	1.096	0.993	1.028	1.108	1.061	0.051	0.048	1.130	0.993
22	1.192	1.003	1.009	1.055	0.998	0.983	1.039	1.040	0.071	0.069	1.192	0.983
23	1.152	1.041	1.048	1.059	1.030	1.097	1.073	1.071	0.042	0.039	1.152	1.030

Table 99. Comparison of maximum SRSS moments of the piping for benchmark problem No.4a S&A RSM-I method

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	0.951	1.025	1.206	1.077	1.129	1.117	1.100	1.086	0.081	0.075	1.206	0.951
2	1.054	1.166	1.366	1.180	1.215	1.233	1.227	1.206	0.093	0.078	1.366	1.054
3	1.009	1.048	1.312	1.148	1.145	1.141	1.157	1.137	0.096	0.085	1.312	1.009
4	1.204	1.107	1.424	1.136	1.253	1.390	1.233	1.250	0.120	0.096	1.424	1.107
5	0.863	0.896	0.907	0.826	0.974	1.009	0.881	0.908	0.064	0.070	1.009	0.826
6	1.436	1.109	1.567	1.131	1.317	1.413	1.247	1.317	0.168	0.127	1.567	1.109
7	1.342	1.388	1.750	1.355	1.515	1.443	1.295	1.441	0.154	0.107	1.750	1.295
8	1.135	1.130	1.665	1.452	1.130	1.129	1.192	1.262	0.213	0.169	1.665	1.129
9	1.321	1.350	1.769	1.314	1.351	1.375	1.257	1.391	0.171	0.123	1.769	1.257
10	1.249	1.266	1.810	1.364	1.233	1.245	1.217	1.340	0.212	0.159	1.810	1.217
11	1.239	1.248	1.819	1.380	1.224	1.224	1.223	1.337	0.220	0.164	1.819	1.223
12	1.245	1.239	1.915	1.472	1.232	1.212	1.275	1.370	0.256	0.187	1.915	1.212
13	1.209	1.214	1.775	1.326	1.191	1.175	1.183	1.296	0.217	0.168	1.775	1.175
14	1.366	1.390	1.906	1.466	1.360	1.404	1.314	1.458	0.203	0.139	1.906	1.314
15	0.607	0.619	0.839	0.654	0.663	0.598	0.555	0.648	0.092	0.142	0.839	0.555
16	0.972	1.026	1.371	1.070	1.026	1.034	0.970	1.067	0.139	0.130	1.371	0.970
17	0.506	0.772	1.081	1.054	0.828	0.738	0.864	0.835	0.196	0.235	1.081	0.506
18	0.511	0.611	0.931	0.762	0.673	0.655	0.767	0.701	0.134	0.191	0.931	0.511
19	0.692	0.606	1.045	0.658	0.664	0.709	0.738	0.730	0.145	0.199	1.045	0.606
20	1.135	1.252	1.781	1.233	1.379	1.276	1.517	1.368	0.219	0.160	1.781	1.135
21	0.781	1.021	1.589	1.172	0.892	0.946	1.198	1.086	0.267	0.246	1.589	0.781
22	0.652	0.964	1.166	1.069	0.929	0.871	1.040	0.956	0.165	0.173	1.166	0.652
23	1.127	1.146	1.279	1.054	1.184	1.231	1.175	1.171	0.073	0.062	1.279	1.054

Table 100. Comparison of maximum SRSS moments of the piping for benchmark problem No.4a S&A RSM-II method

Element	Load cases							Statistics					
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	1.209	1.593	1.439	1.331	1.932	1.347	1.264	1.445	0.248	0.172	1.932	1.209
2	1.438	1.759	1.624	1.473	2.022	1.616	1.427	1.623	0.213	0.131	2.022	1.427
3	1.322	1.664	1.543	1.441	2.015	1.425	1.338	1.535	0.242	0.158	2.015	1.322
4	1.864	1.772	1.791	1.482	2.300	2.140	1.493	1.834	0.305	0.166	2.300	1.482
5	1.081	1.294	1.074	1.001	1.545	1.217	0.989	1.172	0.199	0.170	1.545	0.989
6	2.182	1.689	1.881	1.440	2.229	2.150	1.482	1.865	0.335	0.179	2.229	1.440
7	1.801	1.947	1.853	1.642	2.323	1.908	1.433	1.844	0.276	0.150	2.323	1.433
8	1.288	1.386	1.539	1.589	1.501	1.253	1.202	1.394	0.152	0.109	1.589	1.202
9	1.698	1.839	1.811	1.556	1.992	1.725	1.358	1.711	0.206	0.120	1.992	1.358
10	1.523	1.653	1.768	1.569	1.745	1.483	1.283	1.575	0.168	0.106	1.768	1.283
11	1.503	1.616	1.773	1.581	1.717	1.445	1.278	1.559	0.168	0.108	1.773	1.278
12	1.470	1.589	1.839	1.666	1.702	1.391	1.316	1.567	0.185	0.118	1.839	1.316
13	1.428	1.542	1.711	1.500	1.620	1.360	1.227	1.484	0.162	0.109	1.711	1.227
14	1.734	1.882	1.905	1.718	2.037	1.747	1.407	1.776	0.199	0.112	2.037	1.407
15	0.681	0.735	0.797	0.718	0.809	0.651	0.567	0.708	0.084	0.119	0.809	0.567
16	1.251	1.408	1.379	1.268	1.566	1.306	1.042	1.317	0.162	0.123	1.566	1.042
17	0.755	1.621	1.429	1.607	2.159	1.059	1.068	1.386	0.467	0.337	2.159	0.755
18	0.957	1.625	1.521	1.413	2.166	1.287	1.183	1.450	0.385	0.266	2.166	0.957
19	0.969	0.824	1.147	0.833	0.930	1.045	0.859	0.944	0.120	0.127	1.147	0.824
20	1.340	1.324	1.831	1.408	1.382	1.599	1.703	1.512	0.199	0.132	1.831	1.324
21	0.905	1.290	1.580	1.336	1.174	1.055	1.252	1.227	0.215	0.175	1.580	0.905
22	0.569	0.833	0.969	0.950	0.794	0.737	0.913	0.824	0.141	0.171	0.969	0.569
23	1.255	1.227	1.359	1.189	1.232	1.385	1.305	1.279	0.073	0.057	1.385	1.189

Table 101. Comparison of maximum SRSS moments of the piping for benchmark problem No.4a Chen Classical RSM method

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	1.065	1.330	1.362	1.245	1.563	1.192	1.194	1.279	0.159	0.124	1.563	1.065
2	1.607	1.999	2.115	1.880	2.052	1.625	1.738	1.859	0.207	0.111	2.115	1.607
3	1.227	1.480	1.622	1.489	1.690	1.303	1.363	1.453	0.168	0.115	1.690	1.227
4	2.306	2.268	2.582	2.086	2.548	2.296	2.008	2.299	0.213	0.093	2.582	2.008
5	1.065	1.280	1.191	1.089	1.424	1.118	1.052	1.174	0.136	0.116	1.424	1.052
6	2.831	2.296	2.788	2.083	2.720	2.419	2.028	2.452	0.334	0.136	2.831	2.028
7	2.244	2.516	2.609	2.258	2.800	2.144	1.865	2.348	0.315	0.134	2.800	1.865
8	1.358	1.493	1.784	1.794	1.648	1.298	1.297	1.525	0.219	0.143	1.794	1.297
9	2.051	2.307	2.479	2.075	2.366	1.924	1.719	2.132	0.268	0.126	2.479	1.719
10	1.759	1.973	2.302	1.996	2.020	1.609	1.541	1.886	0.266	0.141	2.302	1.541
11	1.718	1.913	2.284	1.990	1.980	1.561	1.523	1.853	0.270	0.146	2.284	1.523
12	1.623	1.791	2.266	2.007	1.890	1.474	1.511	1.795	0.285	0.159	2.266	1.474
13	1.629	1.814	2.186	1.876	1.864	1.468	1.456	1.756	0.259	0.148	2.186	1.456
14	2.035	2.284	2.528	2.228	2.375	1.909	1.727	2.155	0.279	0.130	2.528	1.727
15	0.707	0.785	0.941	0.829	0.841	0.655	0.622	0.769	0.113	0.147	0.941	0.622
16	1.466	1.710	1.830	1.648	1.821	1.422	1.284	1.597	0.210	0.132	1.830	1.284
17	0.578	0.988	1.192	1.313	1.291	0.848	0.944	1.022	0.265	0.259	1.313	0.578
18	0.624	0.930	1.288	1.172	0.990	0.824	1.043	0.982	0.220	0.224	1.288	0.624
19	1.082	0.889	1.499	1.060	0.851	1.045	1.077	1.072	0.210	0.196	1.499	0.851
20	1.444	1.363	2.385	1.791	1.140	1.489	2.149	1.680	0.450	0.268	2.385	1.140
21	0.887	1.236	1.800	1.484	1.064	1.030	1.336	1.262	0.311	0.246	1.800	0.887
22	0.401	0.517	0.668	0.659	0.504	0.596	0.688	0.576	0.106	0.184	0.688	0.401
23	1.031	0.900	1.408	1.201	0.667	1.027	1.381	1.088	0.265	0.243	1.408	0.667

Table 102. Comparison of maximum SRSS moments of the piping for benchmark problem No.4a Igusa/Der Kiureghian RSM method

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	1.013	1.053	1.132	1.132	1.208	1.060	1.124	1.103	0.065	0.059	1.208	1.013
2	1.143	1.188	1.239	1.197	1.226	1.148	1.193	1.191	0.036	0.030	1.239	1.143
3	1.102	1.097	1.208	1.225	1.244	1.091	1.182	1.164	0.066	0.056	1.244	1.091
4	1.376	1.178	1.331	1.153	1.287	1.310	1.193	1.261	0.086	0.068	1.376	1.153
5	1.222	1.181	1.136	1.131	1.356	1.092	1.157	1.182	0.087	0.073	1.356	1.092
6	1.742	1.238	1.495	1.202	1.397	1.381	1.252	1.387	0.188	0.136	1.742	1.202
7	1.585	1.485	1.551	1.487	1.477	1.360	1.312	1.465	0.098	0.067	1.585	1.312
8	1.256	1.146	1.416	1.596	1.086	1.056	1.217	1.253	0.193	0.154	1.596	1.056
9	1.565	1.449	1.558	1.456	1.350	1.317	1.292	1.427	0.111	0.078	1.565	1.292
10	1.428	1.314	1.554	1.512	1.175	1.163	1.246	1.342	0.159	0.118	1.554	1.163
11	1.406	1.284	1.556	1.522	1.161	1.137	1.242	1.330	0.168	0.126	1.556	1.137
12	1.358	1.260	1.578	1.558	1.222	1.116	1.244	1.334	0.175	0.131	1.578	1.116
13	1.386	1.273	1.543	1.486	1.164	1.118	1.229	1.314	0.162	0.123	1.543	1.118
14	1.534	1.414	1.591	1.573	1.273	1.268	1.299	1.422	0.144	0.101	1.591	1.268
15	1.423	1.285	1.594	1.572	1.217	1.130	1.249	1.353	0.180	0.133	1.594	1.130
16	1.525	1.462	1.594	1.608	1.351	1.286	1.332	1.451	0.131	0.090	1.608	1.286
17	1.484	2.092	2.083	2.754	3.378	1.242	1.931	2.138	0.730	0.341	3.378	1.242
18	1.550	1.731	1.886	2.041	2.729	1.229	1.840	1.858	0.465	0.250	2.729	1.229
19	1.456	1.190	1.649	1.265	1.357	1.144	1.270	1.333	0.173	0.130	1.649	1.144
20	1.372	1.209	1.542	1.266	1.441	1.136	1.472	1.348	0.149	0.111	1.542	1.136
21	0.944	1.199	1.359	1.214	1.177	0.944	1.152	1.141	0.150	0.131	1.359	0.944
22	0.969	1.269	1.431	1.474	1.314	1.005	1.374	1.262	0.200	0.159	1.474	0.969
23	1.237	1.138	1.245	1.113	1.191	1.188	1.215	1.190	0.049	0.041	1.245	1.113

Table 103. Comparison of maximum SRSS moments of the piping for benchmark problem No.4a Gupta RSM method

Element	**Load cases**							**Statistics**				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	0.896	1.118	1.150	1.076	1.069	1.103	1.062	1.068	0.082	0.077	1.150	0.896
2	1.096	1.369	1.356	1.229	1.147	1.306	1.206	1.244	0.104	0.084	1.369	1.096
3	0.976	1.186	1.249	1.179	1.064	1.164	1.130	1.135	0.090	0.079	1.249	0.976
4	1.396	1.408	1.504	1.232	1.226	1.652	1.253	1.381	0.159	0.115	1.652	1.226
5	1.082	1.291	1.199	1.097	1.121	1.210	1.109	1.158	0.077	0.066	1.291	1.082
6	1.773	1.492	1.699	1.290	1.312	1.788	1.323	1.525	0.225	0.147	1.788	1.290
7	1.579	1.834	1.762	1.559	1.400	1.743	1.361	1.606	0.183	0.114	1.834	1.361
8	1.200	1.370	1.551	1.593	1.023	1.212	1.213	1.309	0.206	0.158	1.593	1.023
9	1.528	1.773	1.760	1.508	1.241	1.623	1.324	1.537	0.203	0.132	1.773	1.241
10	1.393	1.615	1.742	1.548	1.118	1.417	1.267	1.443	0.212	0.147	1.742	1.118
11	1.369	1.576	1.741	1.555	1.105	1.378	1.262	1.426	0.214	0.150	1.741	1.105
12	1.272	1.469	1.723	1.555	1.063	1.263	1.240	1.369	0.224	0.164	1.723	1.063
13	1.342	1.545	1.720	1.513	1.093	1.332	1.244	1.398	0.209	0.150	1.720	1.093
14	1.496	1.743	1.788	1.615	1.194	1.579	1.325	1.534	0.215	0.140	1.788	1.194
15	1.357	1.550	1.768	1.585	1.098	1.349	1.258	1.423	0.225	0.158	1.768	1.098
16	1.477	1.794	1.786	1.645	1.248	1.620	1.354	1.561	0.210	0.134	1.794	1.248
17	0.704	1.327	1.457	1.623	1.049	1.099	1.244	1.214	0.300	0.247	1.623	0.704
18	0.775	1.153	1.430	1.344	1.009	1.090	1.241	1.149	0.219	0.191	1.430	0.775
19	1.258	1.138	1.645	1.194	1.045	1.355	1.211	1.264	0.194	0.153	1.645	1.045
20	0.986	0.972	1.339	1.030	0.973	1.077	1.215	1.084	0.141	0.130	1.339	0.972
21	0.847	1.190	1.349	1.117	0.998	0.967	1.082	1.078	0.163	0.151	1.349	0.847
22	0.745	1.019	1.157	1.109	0.962	0.876	1.089	0.994	0.145	0.146	1.157	0.745
23	1.033	0.978	1.115	0.977	0.980	1.106	1.071	1.037	0.061	0.059	1.115	0.977

Table 104. Comparison of maximum axial component of reaction forces of the links of S&A results for benchmark problem No.4a modal superposition time history analysis

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	0.953	1.073	1.027	1.018	1.050	1.069	1.030	1.031	0.041	0.039	1.073	0.953
2	0.971	0.897	0.869	0.890	0.928	1.043	0.905	0.929	0.060	0.064	1.043	0.869
3	1.023	1.004	1.129	1.066	1.057	1.131	1.227	1.091	0.077	0.070	1.227	1.004
4	1.029	1.193	1.133	1.118	1.196	1.181	1.122	1.139	0.059	0.052	1.196	1.029
5	1.028	1.232	1.245	1.131	1.234	1.208	1.140	1.174	0.079	0.067	1.245	1.028
6	1.050	0.896	0.983	0.800	0.698	0.894	0.827	0.878	0.117	0.133	1.050	0.698
7	1.015	0.962	1.137	1.052	1.037	1.065	1.259	1.075	0.097	0.090	1.259	0.962

Table 105. Comparison of maximum axial component of reaction forces of the links of Gupta results for benchmark problem No.4a modal superposition time history analysis

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	0.959	0.794	0.787	0.748	0.799	0.738	0.771	0.800	0.074	0.092	0.959	0.738
2	0.789	0.794	0.793	0.764	0.787	0.771	0.777	0.782	0.012	0.015	0.794	0.764
3	1.041	1.074	1.064	1.105	1.059	1.192	1.280	1.116	0.088	0.079	1.280	1.041
4	1.023	1.121	1.064	1.126	1.118	1.076	1.127	1.094	0.040	0.037	1.127	1.023
5	1.034	1.172	1.302	1.152	1.162	1.117	1.160	1.157	0.080	0.069	1.302	1.034
6	1.348	1.193	1.444	1.157	1.114	1.408	1.415	1.297	0.138	0.106	1.444	1.114
7	1.217	1.069	1.088	1.096	1.028	1.139	1.311	1.135	0.098	0.086	1.311	1.028

Table 106. Comparison of maximum axial component of reaction forces of the links for benchmark problem No.4a S&A RSM-I method

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	0.869	1.017	1.104	1.006	1.086	1.104	1.039	1.032	0.083	0.080	1.104	0.869
2	0.945	0.917	0.980	0.965	0.937	0.935	0.914	0.942	0.024	0.026	0.980	0.914
3	0.875	0.898	0.914	0.951	0.995	1.345	1.061	1.006	0.162	0.161	1.345	0.875
4	1.067	1.071	1.414	1.297	1.099	1.069	1.167	1.169	0.136	0.117	1.414	1.067
5	1.123	1.152	1.697	1.259	1.149	1.074	1.130	1.226	0.215	0.175	1.697	1.074
6	0.151	0.467	0.447	0.823	0.578	0.301	0.564	0.476	0.214	0.450	0.823	0.151
7	1.022	0.928	1.251	0.859	0.998	0.945	1.063	1.009	0.126	0.125	1.251	0.859

Table 107. Comparison of maximum axial component of reaction forces of the links for benchmark problem No.4a S&A RSM-II method

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	1.018	1.380	1.218	1.128	1.571	1.237	1.118	1.239	0.185	0.150	1.571	1.018
2	0.728	0.691	0.740	0.762	0.697	0.701	0.722	0.720	0.026	0.036	0.762	0.691
3	1.277	1.359	1.326	1.230	1.605	1.893	1.334	1.432	0.236	0.164	1.893	1.230
4	1.142	1.234	1.271	1.355	1.356	1.131	1.138	1.233	0.099	0.081	1.356	1.131
5	1.269	1.381	1.593	1.383	1.428	1.184	1.144	1.340	0.155	0.115	1.593	1.144
6	0.281	1.122	0.910	1.654	1.714	0.553	0.864	1.014	0.531	0.524	1.714	0.281
7	1.167	0.953	1.269	0.962	0.979	1.138	1.177	1.092	0.126	0.115	1.269	0.953

Table 108. Comparison of maximum axial component of reaction forces of the links for benchmark problem No.4a Chen Classical RSM method

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	0.786	1.101	0.861	0.805	1.348	1.023	0.843	0.967	0.205	0.212	1.348	0.786
2	0.386	0.309	0.322	0.344	0.328	0.440	0.409	0.363	0.050	0.137	0.440	0.309
3	1.552	1.739	1.882	1.706	1.777	1.880	1.741	1.754	0.113	0.064	1.882	1.552
4	1.124	1.224	1.276	1.327	1.444	1.113	1.102	1.230	0.128	0.104	1.444	1.102
5	1.391	1.590	1.972	1.659	1.630	1.275	1.317	1.548	0.243	0.157	1.972	1.275
6	0.220	0.509	0.707	1.246	0.742	0.449	0.797	0.667	0.324	0.486	1.246	0.220
7	1.243	0.951	1.662	1.213	0.765	1.053	1.472	1.194	0.306	0.256	1.662	0.765

Table 109. Comparison of maximum axial component of reaction forces of the links for benchmark problem No.4a Gupta RSM method

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	0.669	0.874	0.841	0.770	0.790	0.851	0.789	0.798	0.068	0.086	0.874	0.669
2	0.841	0.780	0.829	0.810	0.783	0.739	0.781	0.795	0.035	0.043	0.841	0.739
3	0.954	1.052	1.080	0.985	1.046	1.428	1.077	1.089	0.157	0.144	1.428	0.954
4	1.091	1.237	1.305	1.383	1.012	1.108	1.171	1.187	0.130	0.110	1.383	1.012
5	1.244	1.442	1.653	1.435	1.077	1.203	1.195	1.321	0.197	0.149	1.653	1.077
6	0.261	0.774	0.798	1.196	0.841	0.505	1.031	0.773	0.312	0.404	1.196	0.261
7	1.199	1.003	1.333	1.006	0.979	1.096	1.194	1.116	0.132	0.118	1.333	0.979

Table 110. Comparison of maximum displacements U_x of S&A results for benchmark problem No.4b using modal superposition time history analysis

Nodes	Load cases							Bounds	
	a	b	c	d	e	f	g	Max ratios	Min ratios
2	0.994	0.994	1.014	0.997	0.995	1.020	0.992	1.020	0.992
3	0.990	0.989	1.011	0.994	0.991	1.018	0.990	1.018	0.989
4	0.988	0.988	1.012	0.991	0.989	1.016	0.991	1.016	0.988
5	0.985	0.986	1.010	0.991	0.986	1.014	0.989	1.014	0.985
6	0.985	0.983	1.010	0.989	0.988	1.014	0.987	1.014	0.983
7	0.983	0.985	1.006	0.989	0.986	1.015	0.986	1.015	0.983
8	0.984	0.985	1.007	0.988	0.988	1.015	0.986	1.015	0.984
9	0.984	0.985	1.007	0.988	0.988	1.015	0.986	1.015	0.984
10	0.983	0.982	1.005	0.986	0.988	1.014	0.986	1.014	0.982
11	0.984	0.984	1.007	0.984	0.986	1.014	0.984	1.014	0.984
12	0.982	0.983	1.007	0.993	0.987	1.015	0.986	1.015	0.982
13	0.984	1.004	1.030	0.991	0.991	1.045	0.991	1.045	0.984
14	1.048	1.067	1.015	1.009	0.982	1.040	1.009	1.067	0.982
15	1.034	1.054	1.005	1.006	0.975	1.028	1.035	1.054	0.975
16	0.985	0.983	1.010	0.989	0.988	1.014	0.987	1.014	0.983
17	0.969	0.989	0.952	0.986	0.981	0.997	0.973	0.997	0.952
18	0.975	0.998	0.957	0.991	0.975	0.989	0.978	0.998	0.957
19	0.975	0.997	0.957	0.993	0.970	0.985	0.979	0.997	0.957
20	0.969	0.993	0.954	0.987	0.986	0.998	0.977	0.998	0.954
21	0.988	0.988	1.012	0.991	0.989	1.016	0.991	1.016	0.988
22	1.026	1.035	0.994	1.039	0.994	1.010	1.005	1.039	0.994
23	1.023	1.053	1.011	1.052	1.006	1.024	1.023	1.053	1.006
24	1.004	1.038	0.999	1.036	1.017	1.015	1.017	1.038	0.999
25	0.990	0.989	1.011	0.994	0.991	1.018	0.990	1.018	0.989
26	1.057	1.006	0.980	0.984	1.002	1.014	1.014	1.057	0.980
27	0.995	1.003	0.987	1.013	0.992	1.020	0.990	1.020	0.987
28	0.988	0.989	1.011	0.994	0.991	1.018	0.990	1.018	0.988
29	0.989	0.990	1.011	0.995	0.990	1.018	0.990	1.018	0.989
30	0.989	0.989	1.011	0.993	0.991	1.018	0.990	1.018	0.989
31	0.989	0.990	1.011	0.995	0.991	1.018	0.989	1.018	0.989
32	0.990	0.989	1.011	0.994	0.991	1.018	0.990	1.018	0.989

Table 111. Comparison of maximum displacements U_x of Igusa/Der Kiureghian results for benchmark problem No.4b using modal superposition time history analysis

Nodes	Load cases							Bounds	
	a	b	c	d	e	f	g	Max ratios	Min ratios
2	1.007	1.004	0.994	1.005	1.007	0.991	1.006	1.007	0.991
3	1.007	1.004	0.994	1.005	1.007	0.992	1.006	1.007	0.992
4	1.007	1.004	0.994	1.005	1.007	0.992	1.006	1.007	0.992
5	1.007	1.005	0.994	1.005	1.007	0.992	1.006	1.007	0.992
6	1.007	1.005	0.994	1.005	1.007	0.992	1.006	1.007	0.992
7	1.007	1.005	0.994	1.005	1.006	0.992	1.006	1.007	0.992
8	1.007	1.005	0.994	1.005	1.006	0.991	1.006	1.007	0.991
9	1.007	1.005	0.994	1.005	1.006	0.991	1.006	1.007	0.991
10	1.007	1.005	0.994	1.004	1.006	0.990	1.006	1.007	0.990
11	1.007	1.005	0.994	1.004	1.006	0.990	1.006	1.007	0.990
12	1.007	1.004	0.994	1.004	1.006	0.990	1.006	1.007	0.990
13	1.007	0.998	0.993	1.004	1.005	0.990	1.006	1.007	0.990
14	0.985	0.998	0.989	1.006	0.996	0.986	0.998	1.006	0.985
15	0.986	0.999	0.988	1.007	0.994	0.986	0.981	1.007	0.981
16	1.007	1.005	0.994	1.005	1.007	0.992	1.006	1.007	0.992
17	0.996	1.000	0.993	1.003	1.003	1.011	0.997	1.011	0.993
18	0.995	0.999	0.992	1.002	1.000	0.999	0.995	1.002	0.992
19	0.995	0.998	0.992	1.001	1.000	0.994	0.995	1.001	0.992
20	0.996	0.999	0.992	1.002	1.001	1.010	0.996	1.010	0.992
21	1.007	1.004	0.994	1.005	1.007	0.992	1.006	1.007	0.992
22	0.986	0.993	0.990	0.988	0.995	0.976	0.989	0.995	0.976
23	0.991	0.999	0.995	0.994	1.000	0.979	0.995	1.000	0.979
24	0.994	1.003	0.999	0.995	0.998	0.981	0.995	1.003	0.981
25	1.007	1.004	0.994	1.005	1.007	0.992	1.006	1.007	0.992
26	0.984	1.006	1.001	1.020	1.007	1.010	1.002	1.020	0.984
27	1.002	1.004	1.004	1.003	1.009	1.008	1.005	1.009	1.002
28	1.007	1.004	0.994	1.005	1.007	0.991	1.006	1.007	0.991
29	1.007	1.004	0.994	1.005	1.007	0.991	1.006	1.007	0.991
30	1.007	1.004	0.994	1.005	1.007	0.992	1.006	1.007	0.992
31	1.007	1.004	0.994	1.005	1.007	0.992	1.006	1.007	0.992
32	1.007	1.004	0.994	1.005	1.007	0.992	1.006	1.007	0.992

Table 112. Comparison of maximum displacements U_x of Gupta results for benchmark problem No.4b using modal superposition time history analysis

Nodes	Load cases							Bounds	
	a	b	c	d	e	f	g	Max ratios	Min ratios
2	1.001	1.000	1.001	1.001	1.002	1.001	1.001	1.002	1.000
3	1.001	1.000	1.001	1.001	1.002	1.001	1.001	1.002	1.000
4	1.001	1.000	1.001	1.001	1.002	1.001	1.001	1.002	1.000
5	1.001	1.000	1.001	1.001	1.002	1.001	1.001	1.002	1.000
6	1.001	1.000	1.001	1.001	1.002	1.002	1.001	1.002	1.000
7	1.001	1.000	1.001	1.001	1.002	1.001	1.001	1.002	1.000
8	1.001	1.000	1.001	1.001	1.002	1.001	1.001	1.002	1.000
9	1.001	1.000	1.001	1.001	1.002	1.001	1.001	1.002	1.000
10	1.001	1.000	1.001	1.001	1.002	1.000	1.001	1.002	1.000
11	1.001	1.000	1.001	1.001	1.002	1.001	1.001	1.002	1.000
12	1.001	1.000	1.001	1.001	1.002	1.001	1.001	1.002	1.000
13	1.013	1.011	1.009	1.011	1.011	1.009	1.008	1.013	1.008
14	0.997	0.998	1.006	1.015	1.016	1.006	1.007	1.016	0.997
15	0.992	0.986	1.002	1.008	1.012	1.000	0.995	1.012	0.986
16	1.001	1.000	1.001	1.001	1.002	1.002	1.001	1.002	1.000
17	0.987	0.985	0.993	0.988	0.989	0.982	0.992	0.993	0.982
18	0.986	0.984	0.992	0.986	0.992	0.992	0.991	0.992	0.984
19	0.986	0.984	0.992	0.985	0.992	0.992	0.991	0.992	0.984
20	0.987	0.985	0.993	0.985	0.989	0.984	0.991	0.993	0.984
21	1.001	1.000	1.001	1.001	1.002	1.001	1.001	1.002	1.000
22	0.985	0.980	0.988	0.984	0.989	0.990	0.985	0.990	0.980
23	0.990	0.981	0.990	0.987	0.990	0.992	0.980	0.992	0.980
24	0.991	0.980	0.990	0.987	0.989	0.994	0.981	0.994	0.980
25	1.001	1.000	1.001	1.001	1.002	1.001	1.001	1.002	1.000
26	1.009	0.990	0.995	0.985	0.993	0.991	1.002	1.009	0.985
27	1.003	0.999	1.003	0.998	1.002	0.998	1.003	1.003	0.998
28	1.001	1.000	1.001	1.001	1.002	1.001	1.001	1.002	1.000
29	1.001	1.000	1.001	1.001	1.002	1.001	1.001	1.002	1.000
30	1.001	1.000	1.001	1.001	1.002	1.001	1.001	1.002	1.000
31	1.001	1.000	1.001	1.001	1.002	1.001	1.001	1.002	1.000
32	1.001	1.000	1.001	1.001	1.002	1.001	1.001	1.002	1.000

Table 113. Comparison of maximum displacements U_x for benchmark problem No.4b
S&A RSM-I method

Nodes	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
2	0.989	1.011	1.011	0.991	1.001	1.012	0.964	0.997	0.017	0.017	1.012	0.964
3	0.984	0.999	1.008	0.990	0.995	1.013	0.972	0.994	0.014	0.014	1.013	0.972
4	0.982	0.993	1.005	0.991	0.989	1.012	0.976	0.993	0.013	0.013	1.012	0.976
5	0.985	0.986	1.005	0.991	0.992	1.014	0.984	0.994	0.011	0.012	1.014	0.984
6	0.985	0.983	1.006	0.990	0.988	1.014	0.987	0.993	0.012	0.012	1.014	0.983
7	0.986	0.985	1.006	0.990	0.986	1.015	0.990	0.994	0.012	0.012	1.015	0.985
8	0.984	0.980	1.007	0.989	0.985	1.015	0.989	0.993	0.013	0.013	1.015	0.980
9	0.984	0.980	1.007	0.989	0.985	1.015	0.989	0.993	0.013	0.013	1.015	0.980
10	0.986	0.982	1.005	0.986	0.985	1.010	0.989	0.992	0.011	0.011	1.010	0.982
11	0.986	0.984	1.005	0.994	0.986	1.010	0.990	0.994	0.010	0.010	1.010	0.984
12	0.985	0.983	1.004	0.993	0.984	1.011	0.989	0.993	0.011	0.011	1.011	0.983
13	0.996	1.009	0.982	0.991	0.972	0.972	1.006	0.990	0.015	0.015	1.009	0.972
14	1.181	1.092	1.035	1.172	1.005	0.852	1.123	1.066	0.115	0.108	1.181	0.852
15	1.114	1.088	1.072	1.259	1.047	0.853	1.127	1.080	0.121	0.112	1.259	0.853
16	0.985	0.983	1.006	0.990	0.988	1.014	0.987	0.993	0.012	0.012	1.014	0.983
17	1.009	1.031	0.900	1.170	1.133	1.073	1.110	1.061	0.091	0.085	1.170	0.900
18	0.967	1.044	0.928	1.141	1.141	1.169	1.089	1.068	0.093	0.087	1.169	0.928
19	0.967	1.044	0.933	1.145	1.141	1.173	1.082	1.069	0.093	0.087	1.173	0.933
20	0.980	1.032	0.918	1.165	1.150	1.118	1.088	1.064	0.092	0.086	1.165	0.918
21	0.982	0.993	1.005	0.991	0.989	1.012	0.976	0.993	0.013	0.013	1.012	0.976
22	1.033	1.104	1.087	1.205	1.165	0.954	1.107	1.094	0.083	0.076	1.205	0.954
23	1.030	1.137	1.084	1.206	1.143	0.962	1.169	1.105	0.085	0.077	1.206	0.962
24	1.045	1.126	1.078	1.226	1.168	0.924	1.125	1.099	0.097	0.088	1.226	0.924
25	0.984	0.999	1.008	0.990	0.995	1.013	0.972	0.994	0.014	0.014	1.013	0.972
26	1.119	1.014	0.916	1.268	1.142	0.875	1.120	1.065	0.138	0.130	1.268	0.875
27	1.004	1.022	1.133	1.040	1.041	0.949	1.000	1.027	0.056	0.055	1.133	0.949
28	0.983	0.998	1.016	0.994	0.998	1.019	0.971	0.997	0.017	0.017	1.019	0.971
29	0.984	0.999	1.014	0.991	0.997	1.018	0.971	0.996	0.016	0.016	1.018	0.971
30	0.983	0.998	1.012	0.993	0.996	1.016	0.971	0.996	0.016	0.016	1.016	0.971
31	0.983	0.998	1.010	0.991	0.996	1.014	0.972	0.995	0.015	0.015	1.014	0.972
32	0.984	0.999	1.008	0.990	0.995	1.013	0.972	0.994	0.014	0.014	1.013	0.972

Table 114. Comparison of maximum displacements U_x for benchmark problem No.4b S&A RSM-II method

Nodes	Load cases							Statistics					
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
2	0.939	0.967	0.975	0.963	0.924	1.003	0.921	0.956	0.030	0.031	1.003	0.921
3	0.954	0.975	0.990	0.974	0.950	1.008	0.947	0.971	0.023	0.023	1.008	0.947
4	0.963	0.979	0.998	0.981	0.965	1.010	0.960	0.979	0.019	0.019	1.010	0.960
5	0.976	0.979	1.005	0.986	0.976	1.014	0.979	0.988	0.016	0.016	1.014	0.976
6	0.985	0.983	1.006	0.990	0.988	1.014	0.987	0.993	0.012	0.012	1.014	0.983
7	0.989	0.985	1.009	0.991	0.993	1.015	0.990	0.996	0.012	0.012	1.015	0.985
8	0.989	0.985	1.010	0.989	0.994	1.015	0.995	0.997	0.011	0.011	1.015	0.985
9	0.989	0.985	1.010	0.989	0.994	1.015	0.995	0.997	0.011	0.011	1.015	0.985
10	0.991	0.986	1.008	0.996	0.994	1.014	0.996	0.998	0.010	0.010	1.014	0.986
11	0.991	0.989	1.007	0.994	0.995	1.010	0.994	0.997	0.008	0.008	1.010	0.989
12	0.990	0.987	1.007	0.993	0.993	1.011	0.995	0.997	0.009	0.009	1.011	0.987
13	1.004	1.004	0.935	1.010	0.997	0.949	1.006	0.986	0.031	0.031	1.010	0.935
14	1.190	1.089	0.896	1.284	1.142	0.772	1.166	1.077	0.180	0.167	1.284	0.772
15	1.124	1.091	0.932	1.426	1.221	0.770	1.191	1.108	0.210	0.190	1.426	0.770
16	0.985	0.983	1.006	0.990	0.988	1.014	0.987	0.993	0.012	0.012	1.014	0.983
17	1.036	1.077	0.981	1.229	1.305	1.125	1.316	1.153	0.133	0.115	1.316	0.981
18	1.001	1.081	0.981	1.234	1.372	1.201	1.320	1.170	0.153	0.131	1.372	0.981
19	0.992	1.081	0.987	1.240	1.378	1.204	1.307	1.170	0.153	0.131	1.378	0.987
20	1.009	1.076	0.986	1.243	1.357	1.159	1.305	1.162	0.145	0.125	1.357	0.986
21	0.963	0.979	0.998	0.981	0.965	1.010	0.960	0.979	0.019	0.019	1.010	0.960
22	1.050	1.127	1.011	1.430	1.485	0.898	1.288	1.184	0.222	0.187	1.485	0.898
23	1.046	1.156	1.013	1.425	1.455	0.918	1.355	1.195	0.216	0.181	1.455	0.918
24	1.054	1.136	0.989	1.445	1.446	0.864	1.275	1.173	0.225	0.192	1.446	0.864
25	0.954	0.975	0.990	0.974	0.950	1.008	0.947	0.971	0.023	0.023	1.008	0.947
26	1.149	1.065	1.043	1.285	1.234	0.944	1.275	1.142	0.130	0.114	1.285	0.944
27	0.975	1.015	1.206	1.009	0.990	0.979	0.997	1.024	0.081	0.079	1.206	0.975
28	0.952	0.972	1.001	0.974	0.947	1.018	0.945	0.973	0.028	0.029	1.018	0.945
29	0.953	0.973	0.997	0.975	0.947	1.015	0.945	0.972	0.026	0.027	1.015	0.945
30	0.953	0.974	0.994	0.973	0.948	1.012	0.946	0.972	0.025	0.026	1.012	0.946
31	0.954	0.974	0.991	0.975	0.948	1.009	0.947	0.971	0.023	0.024	1.009	0.947
32	0.954	0.975	0.990	0.974	0.950	1.008	0.947	0.971	0.023	0.023	1.008	0.947

Table 115. Comparison of maximum displacements U_x for benchmark problem No.4b
Chen Classical RSM method

Nodes	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
2	0.997	1.160	1.082	0.932	0.998	1.130	1.017	1.045	0.082	0.078	1.160	0.932
3	1.019	1.174	1.102	0.947	1.030	1.138	1.050	1.066	0.078	0.073	1.174	0.947
4	1.034	1.182	1.113	0.954	1.048	1.144	1.068	1.078	0.076	0.070	1.182	0.954
5	1.046	1.189	1.121	0.960	1.065	1.148	1.085	1.088	0.075	0.069	1.189	0.960
6	1.056	1.192	1.127	0.964	1.076	1.151	1.097	1.095	0.074	0.067	1.192	0.964
7	1.060	1.194	1.130	0.966	1.080	1.152	1.103	1.098	0.073	0.067	1.194	0.966
8	1.063	1.196	1.131	0.967	1.084	1.152	1.107	1.100	0.073	0.067	1.196	0.967
9	1.063	1.196	1.131	0.967	1.084	1.152	1.107	1.100	0.073	0.066	1.196	0.967
10	1.063	1.191	1.125	0.966	1.083	1.148	1.104	1.097	0.072	0.065	1.191	0.966
11	1.062	1.187	1.118	0.965	1.081	1.144	1.102	1.094	0.070	0.064	1.187	0.965
12	1.061	1.182	1.112	0.964	1.080	1.140	1.100	1.091	0.069	0.063	1.182	0.964
13	0.993	0.868	0.725	0.893	0.981	0.921	0.934	0.902	0.090	0.100	0.993	0.725
14	1.005	1.031	0.864	0.936	0.917	0.575	0.843	0.881	0.151	0.172	1.031	0.575
15	0.991	1.294	1.134	1.100	1.047	0.662	1.038	1.038	0.193	0.185	1.294	0.662
16	1.056	1.193	1.128	0.964	1.076	1.151	1.098	1.095	0.074	0.068	1.193	0.964
17	1.579	2.328	2.188	1.907	2.171	2.153	2.577	2.129	0.316	0.148	2.577	1.579
18	1.611	2.310	2.186	1.902	2.233	2.321	2.641	2.172	0.330	0.152	2.641	1.611
19	1.540	2.330	2.153	1.895	2.270	2.351	2.542	2.155	0.336	0.156	2.542	1.540
20	1.645	2.271	2.201	1.917	2.283	2.219	2.506	2.149	0.282	0.131	2.506	1.645
21	1.035	1.184	1.114	0.955	1.049	1.145	1.070	1.079	0.076	0.071	1.184	0.955
22	1.310	2.060	1.906	1.691	1.934	1.334	2.003	1.748	0.313	0.179	2.060	1.310
23	1.334	2.145	1.934	1.711	1.949	1.386	2.143	1.800	0.335	0.186	2.145	1.334
24	1.248	2.005	1.793	1.619	1.790	1.209	1.854	1.645	0.307	0.186	2.005	1.209
25	1.019	1.174	1.102	0.947	1.030	1.138	1.050	1.066	0.078	0.073	1.174	0.947
26	1.722	2.280	2.229	1.871	1.978	1.726	2.363	2.024	0.267	0.132	2.363	1.722
27	1.192	1.714	1.941	1.148	1.256	1.373	1.404	1.433	0.292	0.204	1.941	1.148
28	1.027	1.210	1.153	0.957	1.040	1.169	1.068	1.089	0.091	0.083	1.210	0.957
29	1.025	1.203	1.141	0.954	1.037	1.162	1.063	1.084	0.088	0.081	1.203	0.954
30	1.023	1.194	1.129	0.952	1.035	1.155	1.058	1.078	0.085	0.079	1.194	0.952
31	1.023	1.187	1.116	0.950	1.033	1.148	1.054	1.073	0.082	0.076	1.187	0.950
32	1.021	1.178	1.104	0.948	1.031	1.140	1.051	1.068	0.078	0.073	1.178	0.948

Table 116. Comparison of maximum displacements U_x for benchmark problem No.4b Igusa/Der Kiureghian RSM method

Nodes	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
2	0.982	1.015	0.982	0.984	1.000	0.988	0.955	0.987	0.018	0.019	1.015	0.955
3	0.993	1.015	0.990	0.996	1.010	0.992	0.978	0.996	0.012	0.012	1.015	0.978
4	0.999	1.012	0.993	1.001	1.012	0.993	0.990	1.000	0.009	0.009	1.012	0.990
5	1.004	1.009	0.994	1.004	1.010	0.993	1.000	1.002	0.007	0.007	1.010	0.993
6	1.008	1.005	0.994	1.005	1.007	0.992	1.007	1.003	0.007	0.007	1.008	0.992
7	1.009	1.004	0.993	1.006	1.006	0.992	1.010	1.003	0.007	0.007	1.010	0.992
8	1.010	1.002	0.993	1.006	1.004	0.991	1.011	1.003	0.008	0.008	1.011	0.991
9	1.010	1.002	0.993	1.006	1.004	0.991	1.012	1.003	0.008	0.008	1.012	0.991
10	1.010	1.002	0.991	1.006	1.004	0.989	1.012	1.002	0.009	0.009	1.012	0.989
11	1.010	1.002	0.990	1.006	1.003	0.987	1.012	1.001	0.010	0.010	1.012	0.987
12	1.010	1.003	0.988	1.007	1.003	0.985	1.012	1.001	0.010	0.010	1.012	0.985
13	1.004	1.011	0.909	1.012	0.985	0.912	1.011	0.978	0.047	0.048	1.012	0.909
14	1.115	1.026	0.865	1.229	1.021	0.734	1.118	1.015	0.167	0.165	1.229	0.734
15	1.052	1.031	0.918	1.354	1.082	0.746	1.148	1.047	0.188	0.180	1.354	0.746
16	1.008	1.005	0.994	1.005	1.007	0.992	1.007	1.003	0.007	0.007	1.008	0.992
17	1.067	1.022	0.992	1.244	1.235	1.197	1.332	1.156	0.129	0.111	1.332	0.992
18	1.013	1.024	0.996	1.236	1.259	1.283	1.321	1.162	0.144	0.124	1.321	0.996
19	1.007	1.022	0.998	1.241	1.260	1.284	1.315	1.161	0.144	0.124	1.315	0.998
20	1.030	1.016	0.997	1.248	1.261	1.234	1.313	1.157	0.136	0.117	1.313	0.997
21	1.000	1.012	0.993	1.001	1.012	0.993	0.990	1.000	0.009	0.009	1.012	0.990
22	0.983	1.049	1.016	1.346	1.278	0.921	1.245	1.120	0.166	0.149	1.346	0.921
23	0.971	1.066	1.008	1.324	1.244	0.929	1.297	1.120	0.165	0.147	1.324	0.929
24	0.995	1.076	1.006	1.370	1.276	0.891	1.246	1.123	0.176	0.157	1.370	0.891
25	0.993	1.015	0.990	0.996	1.010	0.992	0.978	0.996	0.012	0.012	1.015	0.978
26	1.159	0.998	1.018	1.275	1.202	0.959	1.256	1.124	0.131	0.116	1.275	0.959
27	1.021	1.017	1.180	1.029	1.050	0.968	1.021	1.041	0.066	0.064	1.180	0.968
28	0.994	1.014	1.003	0.997	1.013	1.003	0.978	1.000	0.013	0.013	1.014	0.978
29	0.994	1.015	1.000	0.996	1.012	1.000	0.978	0.999	0.012	0.012	1.015	0.978
30	0.993	1.015	0.997	0.996	1.012	0.998	0.978	0.998	0.012	0.012	1.015	0.978
31	0.993	1.015	0.993	0.996	1.011	0.995	0.978	0.997	0.012	0.012	1.015	0.978
32	0.993	1.015	0.990	0.996	1.010	0.992	0.978	0.996	0.012	0.012	1.015	0.978

Table 117. Comparison of maximum displacements U_x for benchmark problem No.4b
Gupta RSM method

Nodes	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
2	1.009	1.024	1.008	0.968	1.004	1.006	0.974	0.999	0.020	0.020	1.024	0.968
3	1.003	1.014	1.005	0.983	1.003	1.004	0.985	1.000	0.011	0.011	1.014	0.983
4	1.001	1.009	1.004	0.991	1.002	1.003	0.991	1.000	0.007	0.007	1.009	0.991
5	1.001	1.005	1.003	0.998	1.003	1.003	0.997	1.001	0.003	0.003	1.005	0.997
6	1.001	1.002	1.002	1.002	1.002	1.002	1.002	1.002	0.000	0.000	1.002	1.001
7	1.001	1.001	1.002	1.004	1.002	1.002	1.004	1.002	0.001	0.001	1.004	1.001
8	1.002	1.000	1.001	1.005	1.002	1.001	1.006	1.002	0.002	0.002	1.006	1.000
9	1.002	1.000	1.001	1.005	1.002	1.001	1.006	1.002	0.002	0.002	1.006	1.000
10	1.002	1.001	1.000	1.005	1.002	0.999	1.006	1.002	0.003	0.003	1.006	0.999
11	1.002	1.001	0.998	1.005	1.002	0.998	1.006	1.002	0.003	0.003	1.006	0.998
12	1.002	1.001	0.996	1.005	1.001	0.996	1.006	1.001	0.004	0.004	1.006	0.996
13	1.012	1.031	0.935	1.027	1.001	0.939	1.019	0.995	0.041	0.041	1.031	0.935
14	1.173	1.106	0.924	1.278	1.097	0.777	1.166	1.074	0.169	0.158	1.278	0.777
15	1.117	1.112	0.977	1.403	1.173	0.786	1.202	1.110	0.192	0.173	1.403	0.786
16	1.001	1.002	1.002	1.002	1.002	1.002	1.002	1.002	0.000	0.000	1.002	1.001
17	1.070	1.046	0.997	1.220	1.266	1.173	1.331	1.158	0.124	0.107	1.331	0.997
18	1.031	1.058	1.009	1.220	1.318	1.266	1.334	1.176	0.140	0.119	1.334	1.009
19	1.028	1.058	1.012	1.227	1.322	1.269	1.329	1.178	0.141	0.120	1.329	1.012
20	1.043	1.047	1.008	1.230	1.309	1.216	1.321	1.168	0.133	0.114	1.321	1.008
21	1.001	1.009	1.004	0.991	1.002	1.003	0.991	1.000	0.007	0.007	1.009	0.991
22	1.072	1.120	1.062	1.383	1.414	0.949	1.316	1.188	0.181	0.152	1.414	0.949
23	1.056	1.130	1.045	1.356	1.370	0.951	1.364	1.182	0.178	0.150	1.370	0.951
24	1.087	1.140	1.044	1.403	1.400	0.915	1.315	1.186	0.189	0.159	1.403	0.915
25	1.003	1.014	1.005	0.983	1.003	1.004	0.985	1.000	0.011	0.011	1.014	0.983
26	1.125	1.002	1.010	1.251	1.186	0.935	1.229	1.106	0.124	0.112	1.251	0.935
27	1.020	1.006	1.182	1.007	1.037	0.966	1.018	1.034	0.069	0.067	1.182	0.966
28	1.004	1.012	1.018	0.982	1.005	1.015	0.984	1.003	0.014	0.014	1.018	0.982
29	1.003	1.013	1.015	0.982	1.004	1.012	0.984	1.002	0.013	0.013	1.015	0.982
30	1.003	1.013	1.011	0.983	1.004	1.009	0.984	1.001	0.013	0.013	1.013	0.983
31	1.003	1.014	1.008	0.983	1.003	1.007	0.984	1.000	0.012	0.012	1.014	0.983
32	1.003	1.014	1.005	0.984	1.003	1.004	0.985	1.000	0.011	0.011	1.014	0.984

Table 118. Comparison of maximum SRSS moments of the piping of S&A results for benchmark problem No.4b using modal superposition time history analysis

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	0.880	0.917	0.900	0.822	0.904	0.918	0.868	0.887	0.034	0.038	0.918	0.822
2	0.791	1.003	0.869	0.711	1.009	0.891	0.770	0.863	0.114	0.133	1.009	0.711
3	0.897	0.922	0.906	0.852	0.908	0.917	0.906	0.901	0.023	0.026	0.922	0.852
4	0.897	0.936	0.903	0.980	0.910	0.915	0.959	0.929	0.031	0.034	0.980	0.897
5	0.855	0.940	0.890	0.996	0.972	0.985	0.880	0.931	0.056	0.060	0.996	0.855
6	0.999	1.046	1.010	1.049	1.002	1.038	1.028	1.025	0.021	0.021	1.049	0.999
7	0.989	1.016	0.969	1.009	0.973	0.981	0.999	0.991	0.018	0.018	1.016	0.969
8	0.956	0.981	0.944	0.982	0.951	0.988	0.980	0.969	0.018	0.018	0.988	0.944
9	1.008	1.021	0.976	0.985	0.979	0.993	0.996	0.994	0.016	0.016	1.021	0.976
10	0.978	1.003	0.961	0.987	0.962	0.956	0.978	0.975	0.017	0.017	1.003	0.956
11	0.976	0.999	0.958	0.999	0.960	0.950	0.987	0.976	0.020	0.021	0.999	0.950
12	1.011	1.003	0.967	1.017	0.976	0.970	1.002	0.992	0.021	0.021	1.017	0.967
13	0.969	0.994	0.949	1.001	0.960	0.944	0.982	0.971	0.022	0.023	1.001	0.944
14	0.972	0.997	0.957	0.988	0.957	0.956	1.005	0.976	0.021	0.021	1.005	0.956
15	0.947	0.945	0.916	0.970	0.917	0.914	0.942	0.936	0.021	0.022	0.970	0.914
16	1.011	0.978	0.940	0.956	0.940	0.934	0.983	0.963	0.028	0.029	1.011	0.934
17	1.011	1.004	0.962	1.025	0.965	0.981	1.010	0.994	0.025	0.025	1.025	0.962
18	1.052	1.021	1.001	0.993	1.004	0.984	1.022	1.011	0.023	0.023	1.052	0.984
19	0.739	1.027	1.071	0.989	1.222	1.025	0.901	0.996	0.149	0.150	1.222	0.739
20	0.951	0.878	0.866	0.860	0.860	0.859	0.942	0.888	0.041	0.046	0.951	0.859
21	0.810	0.888	0.861	0.917	0.857	0.901	0.901	0.876	0.036	0.042	0.917	0.810
22	0.884	0.888	0.904	0.894	0.862	0.917	0.982	0.904	0.038	0.043	0.982	0.862
23	0.944	0.841	0.841	0.853	0.837	0.848	0.929	0.870	0.046	0.052	0.944	0.837

Table 119. Comparison of maximum SRSS moments of the piping of Igusa/Der Kuireghian results for benchmark problem No.4b using modal superposition time history analysis

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	1.007	0.996	0.995	0.970	0.999	0.985	0.975	0.990	0.014	0.014	1.007	0.970
2	0.982	0.998	0.997	1.013	1.012	0.990	0.955	0.992	0.020	0.020	1.013	0.955
3	1.004	0.996	0.995	0.971	0.999	0.985	0.975	0.989	0.013	0.013	1.004	0.971
4	0.989	0.997	0.993	0.998	0.999	0.983	0.987	0.992	0.006	0.006	0.999	0.983
5	0.997	1.000	0.995	1.001	1.004	0.996	0.985	0.997	0.006	0.006	1.004	0.985
6	0.987	0.995	0.992	0.993	0.997	0.982	0.981	0.990	0.006	0.006	0.997	0.981
7	0.993	0.997	0.991	0.996	0.997	0.974	0.988	0.991	0.008	0.008	0.997	0.974
8	0.995	0.998	0.991	1.001	1.000	1.010	0.992	0.998	0.007	0.007	1.010	0.991
9	0.997	1.000	0.992	1.005	0.998	0.979	0.990	0.994	0.008	0.009	1.005	0.979
10	0.994	0.999	0.991	1.001	0.998	0.978	0.994	0.994	0.008	0.008	1.001	0.978
11	0.994	0.998	0.991	0.999	0.998	0.979	0.992	0.993	0.007	0.007	0.999	0.979
12	0.994	0.996	0.992	1.002	0.995	0.976	0.994	0.993	0.008	0.008	1.002	0.976
13	0.998	1.000	0.993	1.002	1.000	0.983	0.993	0.996	0.007	0.007	1.002	0.983
14	0.988	0.990	0.987	0.991	0.989	0.968	0.984	0.985	0.008	0.008	0.991	0.968
15	0.930	0.931	0.933	0.927	0.941	0.930	0.914	0.930	0.008	0.009	0.941	0.914
16	1.020	1.033	1.034	1.054	1.037	1.004	1.020	1.029	0.016	0.015	1.054	1.004
17	0.989	1.004	1.000	0.992	1.006	0.978	0.989	0.994	0.010	0.010	1.006	0.978
18	0.994	1.010	1.009	1.008	1.012	0.991	0.989	1.002	0.010	0.010	1.012	0.989
19	1.074	1.352	1.385	1.243	1.407	1.245	1.112	1.260	0.131	0.104	1.407	1.074
20	1.019	1.043	1.050	1.039	1.052	1.001	1.005	1.030	0.021	0.021	1.052	1.001
21	0.992	1.033	1.044	1.024	1.045	1.007	0.986	1.019	0.024	0.024	1.045	0.986
22	0.965	1.008	1.039	0.971	1.037	0.979	0.956	0.993	0.035	0.035	1.039	0.956
23	1.000	1.002	1.026	1.026	1.038	0.976	0.985	1.007	0.023	0.023	1.038	0.976

Table 120. Comparison of maximum SRSS moments of the piping of Gupta results for benchmark problem No.4b using modal superposition time history analysis

Element	Load cases							Statistics					
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	0.995	0.998	1.006	1.001	1.005	1.011	1.010	1.004	0.006	0.006	1.011	0.995
2	1.003	0.957	0.929	0.965	0.985	0.968	1.019	0.975	0.030	0.031	1.019	0.929
3	0.992	0.994	1.006	1.003	1.002	0.992	1.000	0.998	0.006	0.006	1.006	0.992
4	0.997	0.996	1.001	0.995	0.999	0.998	0.999	0.998	0.002	0.002	1.001	0.995
5	1.001	1.003	1.005	1.004	1.008	1.004	1.009	1.005	0.003	0.003	1.009	1.001
6	1.002	0.999	1.006	0.997	1.005	1.002	1.003	1.002	0.003	0.003	1.006	0.997
7	0.998	0.998	1.005	0.998	1.004	1.005	1.004	1.002	0.003	0.003	1.005	0.998
8	1.002	1.000	1.008	1.000	1.006	0.994	1.006	1.002	0.005	0.005	1.008	0.994
9	1.002	0.998	1.007	0.997	1.004	1.008	1.004	1.003	0.004	0.004	1.008	0.997
10	1.001	0.999	1.007	0.998	1.006	1.009	1.004	1.003	0.004	0.004	1.009	0.998
11	1.001	0.998	1.007	1.000	1.007	1.009	1.004	1.004	0.004	0.004	1.009	0.998
12	0.994	0.999	1.005	0.995	1.005	1.009	1.001	1.001	0.006	0.006	1.009	0.994
13	1.002	0.998	1.007	1.000	1.007	1.009	1.005	1.004	0.004	0.004	1.009	0.998
14	1.000	0.998	1.005	0.997	1.005	1.008	1.003	1.002	0.004	0.004	1.008	0.997
15	1.004	0.999	1.007	1.002	1.006	1.004	1.004	1.004	0.003	0.003	1.007	0.999
16	1.003	1.000	1.008	0.996	1.007	1.006	1.005	1.004	0.004	0.004	1.008	0.996
17	1.006	0.999	1.006	1.001	1.006	1.005	1.007	1.004	0.003	0.003	1.007	0.999
18	1.004	0.998	1.004	0.993	1.009	1.008	1.011	1.004	0.006	0.006	1.011	0.993
19	1.003	1.001	1.005	1.003	1.001	0.997	0.994	1.001	0.004	0.004	1.005	0.994
20	0.996	0.999	1.004	0.992	1.013	1.006	1.012	1.003	0.008	0.008	1.013	0.992
21	1.010	1.000	1.007	1.003	1.014	1.006	1.012	1.008	0.005	0.005	1.014	1.000
22	1.012	0.998	1.002	0.995	0.998	1.011	1.023	1.006	0.010	0.010	1.023	0.995
23	0.994	0.989	0.992	0.988	0.990	1.000	1.005	0.994	0.006	0.006	1.005	0.988

Table 121. Comparison of maximum SRSS moments of the piping for benchmark problem No.4b S&A RSM-I method

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	0.744	0.955	0.961	0.924	1.053	0.918	0.880	0.919	0.094	0.102	1.053	0.744
2	0.714	0.997	0.912	0.767	1.160	0.927	0.731	0.887	0.162	0.182	1.160	0.714
3	0.784	0.948	0.984	0.951	1.056	0.874	0.924	0.932	0.085	0.092	1.056	0.784
4	0.872	0.958	1.009	1.030	1.072	0.855	0.993	0.970	0.081	0.083	1.072	0.855
5	0.865	0.966	0.912	1.133	1.144	1.021	0.997	1.005	0.105	0.104	1.144	0.865
6	0.974	1.063	1.141	1.155	1.242	0.930	1.162	1.095	0.112	0.102	1.242	0.930
7	0.979	1.064	1.030	1.120	1.117	1.038	1.070	1.060	0.050	0.047	1.120	0.979
8	0.965	1.032	0.918	1.168	1.148	1.144	1.069	1.063	0.097	0.091	1.168	0.918
9	0.982	1.079	0.997	1.102	1.122	1.087	0.996	1.052	0.058	0.055	1.122	0.982
10	0.953	1.063	0.964	1.122	1.127	1.143	1.090	1.066	0.078	0.073	1.143	0.953
11	0.951	1.055	0.965	1.145	1.133	1.164	1.075	1.070	0.085	0.080	1.164	0.951
12	0.940	1.049	0.994	1.196	1.161	1.179	1.076	1.085	0.098	0.090	1.196	0.940
13	0.973	1.043	0.923	1.119	1.123	1.125	1.069	1.054	0.080	0.076	1.125	0.923
14	0.933	1.063	0.992	1.108	1.124	1.144	1.093	1.065	0.077	0.072	1.144	0.933
15	0.879	1.021	0.963	1.101	1.019	0.940	1.079	1.000	0.078	0.078	1.101	0.879
16	0.906	1.061	0.996	1.085	1.064	1.025	1.052	1.027	0.061	0.059	1.085	0.906
17	0.926	1.097	1.013	1.166	1.057	1.008	1.173	1.063	0.090	0.084	1.173	0.926
18	0.907	1.039	0.994	0.991	1.170	1.089	1.060	1.036	0.083	0.081	1.170	0.907
19	0.661	1.100	1.043	0.942	1.358	1.060	0.835	1.000	0.219	0.219	1.358	0.661
20	0.797	0.885	0.845	0.839	1.003	0.950	0.930	0.893	0.072	0.081	1.003	0.797
21	0.599	0.881	0.881	0.969	1.009	0.891	0.785	0.859	0.135	0.157	1.009	0.599
22	0.754	0.884	0.940	1.001	1.048	0.907	0.879	0.916	0.095	0.104	1.048	0.754
23	0.806	0.854	0.817	0.854	0.979	0.883	0.933	0.875	0.062	0.071	0.979	0.806

Table 122. Comparison of maximum SRSS moments of the piping for benchmark problem No.4b S&A RSM-II method

Element	Load cases							Statistics					
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	0.880	0.917	0.900	0.822	0.904	0.918	0.868	0.887	0.034	0.038	0.918	0.822
2	0.791	1.003	0.869	0.711	1.009	0.891	0.770	0.863	0.114	0.133	1.009	0.711
3	0.897	0.922	0.906	0.852	0.908	0.917	0.906	0.901	0.023	0.026	0.922	0.852
4	0.897	0.936	0.903	0.980	0.910	0.915	0.959	0.929	0.031	0.034	0.980	0.897
5	0.855	0.940	0.890	0.996	0.972	0.985	0.880	0.931	0.056	0.060	0.996	0.855
6	0.999	1.046	1.010	1.049	1.002	1.038	1.028	1.025	0.021	0.021	1.049	0.999
7	0.989	1.016	0.969	1.009	0.973	0.981	0.999	0.991	0.018	0.018	1.016	0.969
8	0.956	0.981	0.944	0.982	0.951	0.988	0.980	0.969	0.018	0.018	0.988	0.944
9	1.008	1.021	0.976	0.985	0.979	0.993	0.996	0.994	0.016	0.016	1.021	0.976
10	0.978	1.003	0.961	0.987	0.962	0.956	0.978	0.975	0.017	0.017	1.003	0.956
11	0.976	0.999	0.958	0.999	0.960	0.950	0.987	0.976	0.020	0.021	0.999	0.950
12	1.011	1.003	0.967	1.017	0.976	0.970	1.002	0.992	0.021	0.021	1.017	0.967
13	0.969	0.994	0.949	1.001	0.960	0.944	0.982	0.971	0.022	0.023	1.001	0.944
14	0.972	0.997	0.957	0.988	0.957	0.956	1.005	0.976	0.021	0.021	1.005	0.956
15	0.947	0.945	0.916	0.970	0.917	0.914	0.942	0.936	0.021	0.022	0.970	0.914
16	1.011	0.978	0.940	0.956	0.940	0.934	0.983	0.963	0.028	0.029	1.011	0.934
17	1.011	1.004	0.962	1.025	0.965	0.981	1.010	0.994	0.025	0.025	1.025	0.962
18	1.052	1.021	1.001	0.993	1.004	0.984	1.022	1.011	0.023	0.023	1.052	0.984
19	0.739	1.027	1.071	0.989	1.222	1.025	0.901	0.996	0.149	0.150	1.222	0.739
20	0.951	0.878	0.866	0.860	0.860	0.859	0.942	0.888	0.041	0.046	0.951	0.859
21	0.810	0.888	0.861	0.917	0.857	0.901	0.901	0.876	0.036	0.042	0.917	0.810
22	0.884	0.888	0.904	0.894	0.862	0.917	0.982	0.904	0.038	0.043	0.982	0.862
23	0.944	0.841	0.841	0.853	0.837	0.848	0.929	0.870	0.046	0.052	0.944	0.837

Table 123. Comparison of maximum SRSS moments of the piping for benchmark problem No.4b Chen Classical RSM method

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	1.334	1.934	1.888	1.550	2.104	1.492	1.808	1.730	0.276	0.160	2.104	1.334
2	2.200	2.164	1.868	1.827	3.238	1.660	1.650	2.087	0.553	0.265	3.238	1.650
3	1.201	1.856	1.848	1.456	1.981	1.319	1.783	1.635	0.304	0.186	1.981	1.201
4	1.189	1.799	1.799	1.462	1.866	1.186	1.808	1.587	0.303	0.191	1.866	1.186
5	1.411	2.106	2.013	1.820	2.306	1.904	2.191	1.964	0.295	0.150	2.306	1.411
6	1.166	1.881	1.887	1.490	1.994	1.166	1.904	1.641	0.362	0.220	1.994	1.166
7	1.428	2.184	2.143	1.773	2.181	1.697	2.287	1.956	0.323	0.165	2.287	1.428
8	1.607	2.326	2.180	1.946	2.332	2.290	2.614	2.185	0.323	0.148	2.614	1.607
9	1.500	2.279	2.094	1.793	2.263	1.884	2.215	2.004	0.291	0.145	2.279	1.500
10	1.521	2.339	2.120	1.870	2.314	2.128	2.637	2.133	0.359	0.168	2.637	1.521
11	1.527	2.347	2.151	1.921	2.331	2.178	2.625	2.154	0.351	0.163	2.625	1.527
12	1.495	2.296	2.191	1.977	2.383	2.187	2.496	2.146	0.331	0.154	2.496	1.495
13	1.567	2.268	2.072	1.820	2.274	2.143	2.539	2.098	0.320	0.153	2.539	1.567
14	1.476	2.298	2.230	1.843	2.330	2.090	2.551	2.117	0.357	0.169	2.551	1.476
15	1.329	2.102	1.939	1.781	2.041	1.590	2.316	1.871	0.333	0.178	2.316	1.329
16	1.415	2.248	2.082	1.805	2.220	1.811	2.368	1.993	0.334	0.167	2.368	1.415
17	1.410	2.257	2.004	1.835	2.115	1.714	2.528	1.980	0.368	0.186	2.528	1.410
18	1.487	2.247	2.147	1.704	2.582	1.948	2.281	2.056	0.372	0.181	2.582	1.487
19	1.266	2.445	2.322	1.852	3.137	2.019	1.753	2.113	0.595	0.282	3.137	1.266
20	1.394	1.957	1.862	1.619	2.681	1.766	2.006	1.898	0.404	0.213	2.681	1.394
21	0.944	1.875	1.829	1.601	2.361	1.521	1.403	1.648	0.441	0.268	2.361	0.944
22	1.286	2.450	2.378	2.032	5.697	1.896	1.553	2.470	1.482	0.600	5.697	1.286
23	1.693	1.899	1.803	1.781	2.657	1.667	2.076	1.940	0.345	0.178	2.657	1.667

Table 124. Comparison of maximum SRSS moments of the piping for benchmark problem No.4b Igusa/Der Kiureghian RSM method

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	0.859	1.006	1.032	1.153	1.333	1.006	1.141	1.076	0.150	0.139	1.333	0.859
2	0.987	1.090	1.092	1.062	1.749	1.057	1.024	1.151	0.266	0.231	1.749	0.987
3	0.873	0.997	1.040	1.176	1.312	0.940	1.173	1.073	0.154	0.143	1.312	0.873
4	0.925	1.003	1.049	1.277	1.304	0.899	1.228	1.098	0.170	0.155	1.304	0.899
5	0.925	0.998	1.015	1.246	1.298	1.149	1.228	1.123	0.144	0.128	1.298	0.925
6	0.916	0.998	1.047	1.270	1.342	0.857	1.263	1.099	0.192	0.174	1.342	0.857
7	0.974	1.032	1.027	1.262	1.259	1.057	1.269	1.126	0.131	0.116	1.269	0.974
8	1.024	1.026	1.006	1.258	1.267	1.273	1.318	1.167	0.141	0.121	1.318	1.006
9	0.986	1.038	1.005	1.222	1.257	1.123	1.185	1.117	0.109	0.098	1.257	0.986
10	0.980	1.039	1.007	1.239	1.261	1.224	1.330	1.154	0.141	0.122	1.330	0.980
11	0.980	1.032	1.010	1.261	1.267	1.249	1.309	1.158	0.143	0.124	1.309	0.980
12	0.959	1.018	1.024	1.308	1.289	1.248	1.283	1.161	0.153	0.132	1.308	0.959
13	1.021	1.032	0.988	1.244	1.256	1.227	1.312	1.154	0.135	0.117	1.312	0.988
14	0.947	1.035	1.021	1.227	1.266	1.216	1.325	1.148	0.145	0.126	1.325	0.947
15	0.868	0.979	0.955	1.213	1.148	0.972	1.269	1.058	0.151	0.143	1.269	0.868
16	0.974	1.097	1.072	1.280	1.299	1.152	1.355	1.176	0.139	0.118	1.355	0.974
17	0.934	1.077	1.022	1.316	1.217	1.064	1.413	1.149	0.172	0.150	1.413	0.934
18	0.897	1.015	1.023	1.064	1.352	1.124	1.226	1.100	0.150	0.137	1.352	0.897
19	1.056	1.425	1.441	1.371	2.158	1.445	1.426	1.475	0.332	0.225	2.158	1.056
20	0.900	1.047	1.052	1.024	1.504	1.156	1.266	1.136	0.198	0.175	1.504	0.900
21	0.715	1.042	1.080	1.229	1.464	1.075	0.991	1.085	0.228	0.210	1.464	0.715
22	0.840	1.173	1.223	1.090	2.600	0.984	1.092	1.286	0.593	0.461	2.600	0.840
23	0.887	1.015	1.019	1.020	1.468	1.068	1.238	1.102	0.192	0.174	1.468	0.887

Table 125. Comparison of maximum SRSS moments of the piping for benchmark problem No.4b
Gupta RSM method

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	0.888	1.089	1.084	1.194	1.441	1.031	1.182	1.130	0.171	0.151	1.441	0.888
2	0.864	1.150	1.051	0.906	1.297	1.011	0.967	1.035	0.149	0.144	1.297	0.864
3	0.917	1.079	1.097	1.222	1.448	0.965	1.220	1.136	0.180	0.158	1.448	0.917
4	0.986	1.087	1.110	1.322	1.467	0.927	1.285	1.169	0.195	0.167	1.467	0.927
5	0.952	1.056	1.048	1.299	1.397	1.165	1.262	1.168	0.159	0.136	1.397	0.952
6	0.978	1.091	1.116	1.320	1.515	0.891	1.328	1.177	0.220	0.187	1.515	0.891
7	1.045	1.109	1.078	1.326	1.402	1.082	1.331	1.196	0.150	0.125	1.402	1.045
8	1.058	1.075	1.032	1.298	1.346	1.279	1.351	1.206	0.143	0.119	1.351	1.032
9	1.040	1.110	1.049	1.273	1.379	1.139	1.230	1.174	0.125	0.106	1.379	1.040
10	1.035	1.103	1.045	1.294	1.374	1.239	1.381	1.210	0.149	0.123	1.381	1.035
11	1.033	1.095	1.049	1.316	1.380	1.265	1.360	1.214	0.151	0.124	1.380	1.033
12	1.008	1.084	1.066	1.364	1.403	1.271	1.335	1.219	0.162	0.133	1.403	1.008
13	1.058	1.088	1.020	1.283	1.345	1.232	1.348	1.197	0.139	0.116	1.348	1.020
14	1.015	1.112	1.071	1.299	1.403	1.248	1.394	1.220	0.156	0.128	1.403	1.015
15	0.994	1.125	1.069	1.374	1.355	1.066	1.419	1.200	0.176	0.146	1.419	0.994
16	0.983	1.132	1.079	1.295	1.367	1.138	1.356	1.193	0.148	0.124	1.367	0.983
17	0.995	1.146	1.061	1.391	1.334	1.087	1.474	1.212	0.185	0.153	1.474	0.995
18	0.863	1.071	1.050	1.077	1.408	1.129	1.216	1.116	0.167	0.149	1.408	0.863
19	0.732	1.112	1.023	0.990	1.348	1.051	1.093	1.050	0.183	0.174	1.348	0.732
20	0.752	1.067	1.027	0.965	1.401	1.110	1.151	1.068	0.197	0.184	1.401	0.752
21	0.655	1.071	1.066	1.180	1.409	1.043	0.941	1.052	0.229	0.217	1.409	0.655
22	0.593	1.234	1.058	0.873	1.382	0.890	0.891	0.989	0.261	0.264	1.382	0.593
23	0.743	1.061	1.021	0.958	1.371	1.043	1.134	1.047	0.189	0.180	1.371	0.743

Table 126. Comparison of maximum axial component of reaction forces of the links of S&A results for benchmark problem No.4b modal superposition time history analysis

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	1.029	0.981	1.009	1.008	0.982	1.025	1.013	1.007	0.019	0.019	1.029	0.981
2	1.185	0.993	0.939	0.956	0.998	1.028	0.968	1.010	0.083	0.082	1.185	0.939
3	0.829	0.970	0.913	0.923	0.872	0.802	0.955	0.895	0.063	0.070	0.970	0.802
4	0.991	0.964	0.952	0.962	0.957	0.970	0.941	0.962	0.016	0.016	0.991	0.941
5	0.909	0.967	0.945	0.905	0.941	0.871	0.951	0.927	0.033	0.036	0.967	0.871
6	1.052	1.013	0.968	1.054	0.975	0.982	0.976	1.003	0.037	0.037	1.054	0.968
7	0.768	0.746	0.782	0.776	0.770	0.813	0.755	0.773	0.021	0.028	0.813	0.746

Table 127. Comparison of maximum axial component of reaction forces of the links of Gupta results for benchmark problem No.4b modal superposition time history analysis

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	0.889	0.916	0.913	0.870	0.885	0.903	0.872	0.893	0.019	0.021	0.916	0.870
2	0.962	0.949	0.989	0.962	0.950	0.950	0.961	0.961	0.014	0.014	0.989	0.949
3	1.044	0.982	0.977	0.930	1.013	0.967	1.073	0.998	0.049	0.049	1.073	0.930
4	1.056	1.048	1.041	1.110	1.065	1.092	1.088	1.071	0.026	0.024	1.110	1.041
5	1.010	1.040	1.040	1.040	1.046	0.989	1.051	1.031	0.023	0.022	1.051	0.989
6	1.014	0.998	1.001	1.009	1.006	1.005	0.988	1.003	0.008	0.008	1.014	0.988
7	1.000	0.962	0.995	0.976	0.982	0.975	0.985	0.982	0.013	0.013	1.000	0.962

Table 128. Comparison of maximum axial component of reaction forces of the links for benchmark problem No.4b S&A RSM-I method

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	1.162	0.981	0.975	1.101	0.958	0.814	1.100	1.013	0.117	0.116	1.162	0.814
2	1.179	0.881	0.875	1.079	1.122	0.899	1.143	1.025	0.135	0.132	1.179	0.875
3	0.821	1.073	0.951	1.105	0.988	0.927	1.014	0.983	0.095	0.097	1.105	0.821
4	1.087	0.969	0.921	1.233	1.126	1.019	1.030	1.055	0.104	0.099	1.233	0.921
5	0.816	0.959	0.925	0.955	1.004	0.963	0.975	0.942	0.061	0.064	1.004	0.816
6	0.888	1.109	1.031	1.121	1.051	0.986	1.145	1.047	0.090	0.086	1.145	0.888
7	0.768	0.768	0.727	0.865	0.881	0.930	0.807	0.821	0.073	0.089	0.930	0.727

Table 129. Comparison of maximum axial component of reaction forces of the links for benchmark problem No.4b S&A RSM-II method

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	1.029	0.981	1.009	1.008	0.982	1.025	1.013	1.007	0.019	0.019	1.029	0.981
2	1.185	0.993	0.939	0.956	0.998	1.028	0.968	1.010	0.083	0.082	1.185	0.939
3	0.829	0.970	0.913	0.923	0.872	0.802	0.955	0.895	0.063	0.070	0.970	0.802
4	0.991	0.964	0.952	0.962	0.957	0.970	0.941	0.962	0.016	0.016	0.991	0.941
5	0.909	0.967	0.945	0.905	0.941	0.871	0.951	0.927	0.033	0.036	0.967	0.871
6	1.052	1.013	0.968	1.054	0.975	0.982	0.976	1.003	0.037	0.037	1.054	0.968
7	0.768	0.746	0.782	0.776	0.770	0.813	0.755	0.773	0.021	0.028	0.813	0.746

Table 130. Comparison of maximum axial component of reaction forces of the links for benchmark problem No.4b Chen Classical RSM method

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	1.052	0.562	0.475	0.876	0.913	0.534	0.743	0.736	0.220	0.299	1.052	0.475
2	1.443	1.805	1.947	1.413	1.532	1.578	1.919	1.662	0.224	0.135	1.947	1.413
3	0.998	2.440	2.126	1.474	1.834	1.561	2.053	1.784	0.481	0.270	2.440	0.998
4	1.754	2.108	2.122	1.885	2.119	1.977	2.299	2.038	0.180	0.088	2.299	1.754
5	1.258	2.028	1.947	1.518	1.928	1.677	2.054	1.773	0.299	0.169	2.054	1.258
6	1.276	2.198	1.961	1.809	2.016	1.613	2.316	1.884	0.355	0.189	2.316	1.276
7	1.487	2.650	2.219	2.193	7.787	2.382	1.807	2.932	2.174	0.742	7.787	1.487

Table 131. Comparison of maximum axial component of reaction forces of the links for benchmark problem No.4b Gupta RSM method

Element	Load cases							Statistics				
	a	b	c	d	e	f	g	Mean	Standard deviation	COV	Max ratios	Min ratios
1	1.212	1.088	0.967	1.264	1.055	0.809	1.161	1.080	0.155	0.144	1.264	0.809
2	0.121	0.099	0.108	0.112	0.081	0.132	0.119	0.110	0.017	0.153	0.132	0.081
3	5.261	7.521	6.455	8.454	9.311	6.721	7.374	7.300	1.332	0.182	9.311	5.261
4	0.629	0.831	0.834	0.721	0.788	0.707	0.703	0.745	0.076	0.101	0.834	0.629
5	2.298	2.706	2.823	2.399	2.553	2.788	2.807	2.625	0.212	0.081	2.823	2.298
6	0.475	0.145	0.175	0.487	0.116	0.227	0.517	0.306	0.179	0.584	0.517	0.116
7	0.139	0.490	0.384	0.216	0.970	0.388	0.199	0.398	0.282	0.708	0.970	0.139

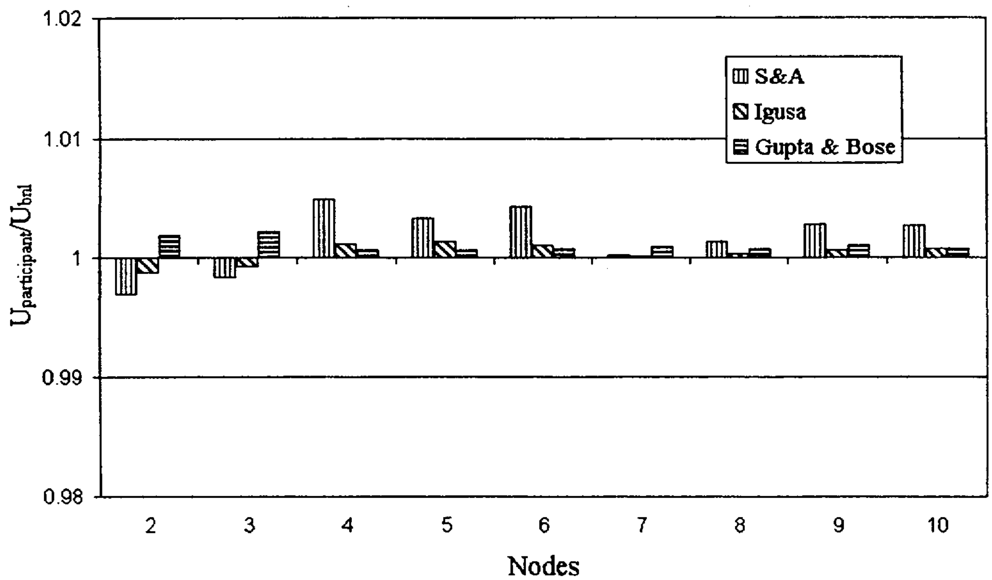

Figure 8. Comparison of maximum displacements for benchmark problem No. 1, Case a—Modal superposition time history analyses.

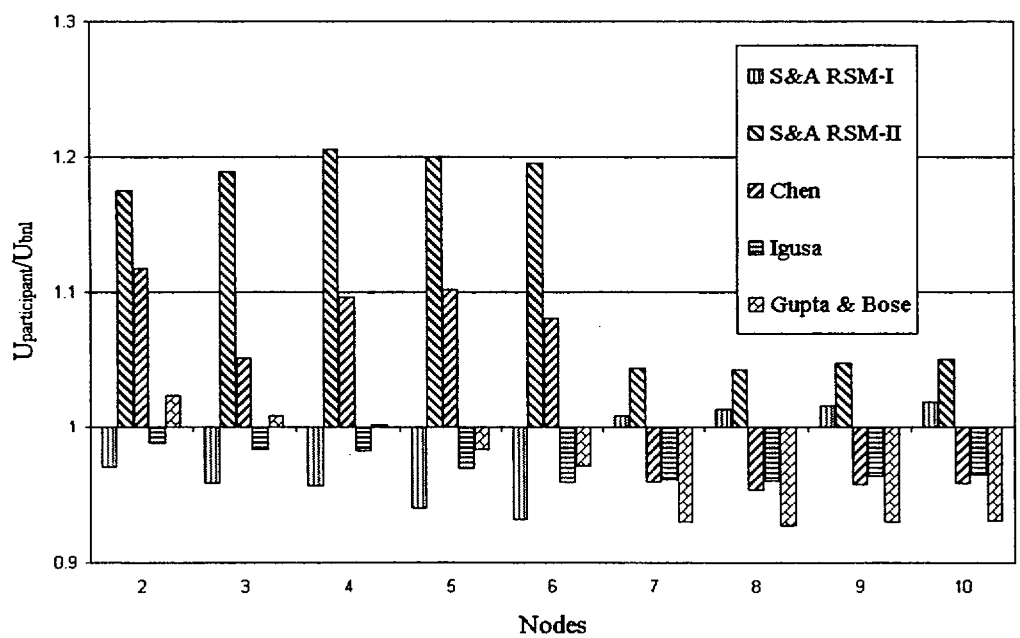

Figure 9. Comparison of maximum displacements for benchmark problem No. 1, Case a—Response spectrum methods.

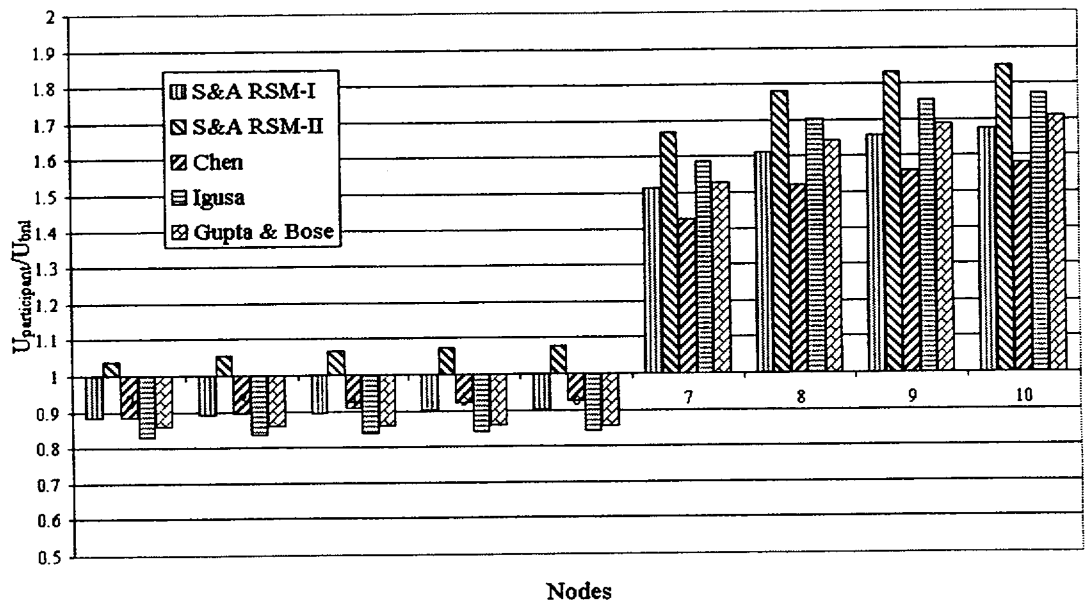

Figure 10.Comparison of maximum displacements for benchmark problem No. 1, Case m—Response spectrum methods.

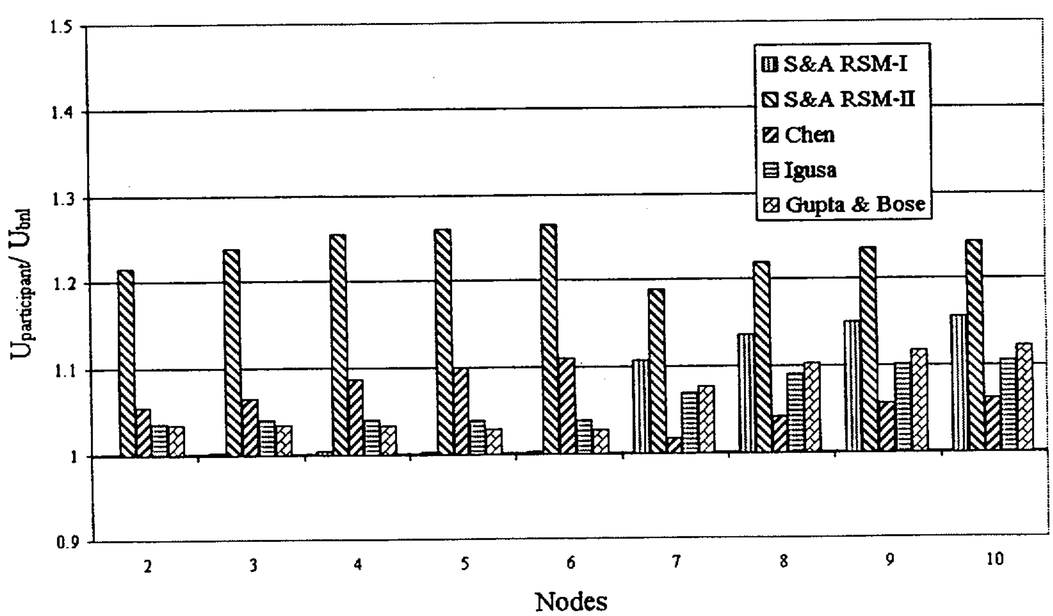

Figure 11.Comparison of mean responses of maximum displacements for benchmark problem No. 1 for seven earthquakes—Response spectrum methods.

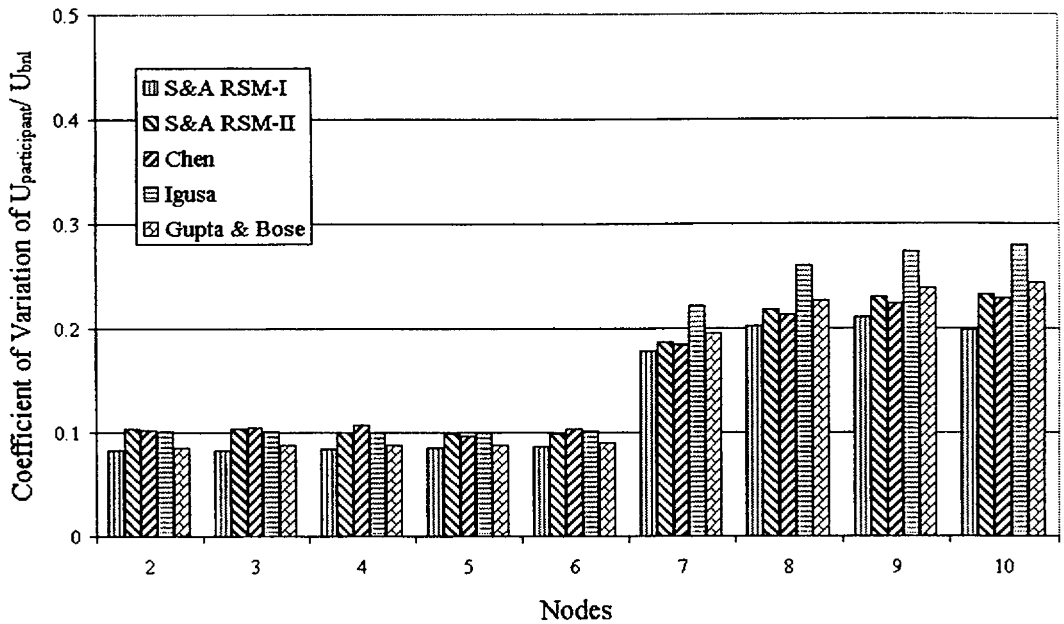

Figure 12. Comparison of Coefficients of variation of maximum displacements for benchmark problem No. 1 for seven earthquakes---Response spectrum methods

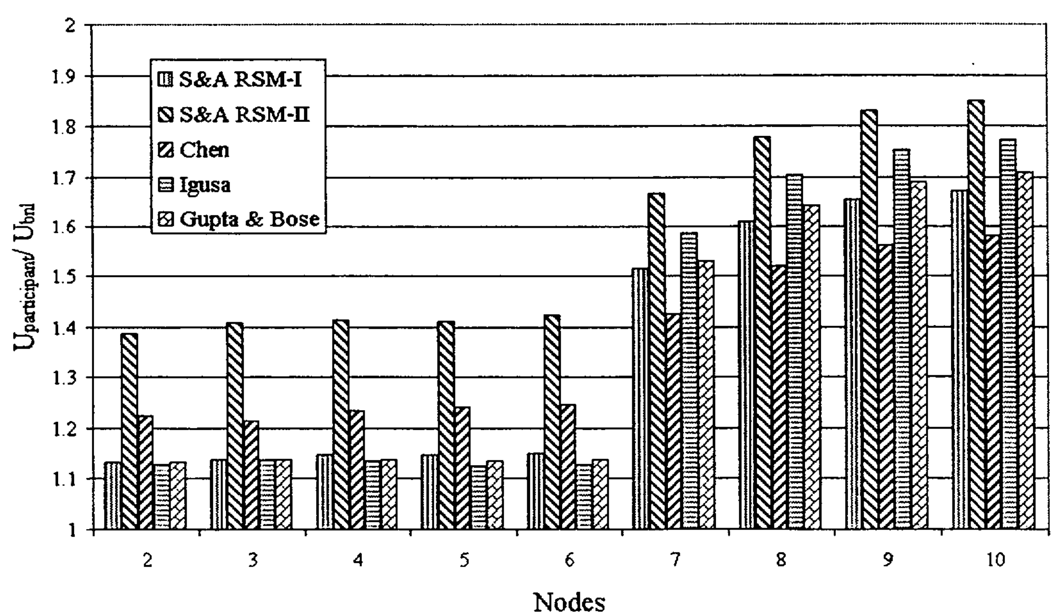

Figure 13. Comparison of maximum ratios of maximum displacements for benchmark problem No. 1 for seven earthquakes---Response spectrum methods

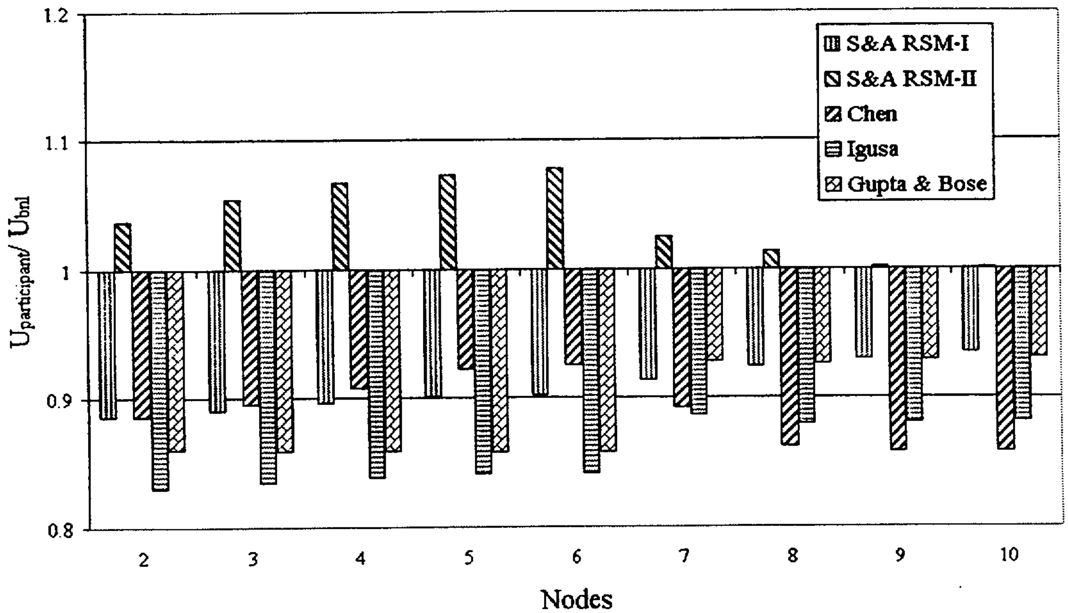

Figure 14. Comparison of minimum ratios of maximum displacements for benchmark problem No. 1 for seven earthquakes---Response spectrum methods

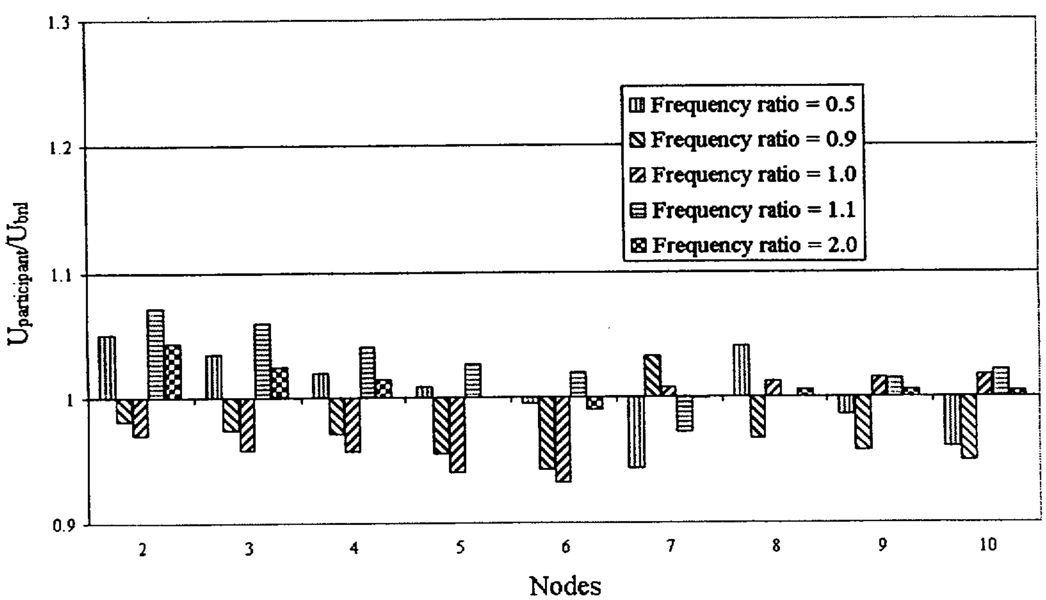

Figure 15. Effects of frequency variations for benchmark problem No. 1---S&A RSM-I.

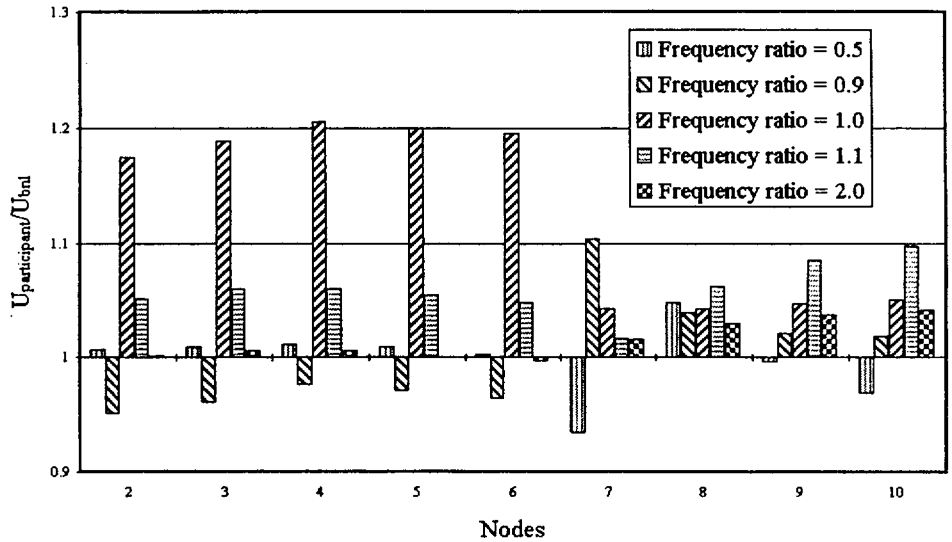

Figure 16. Effects of frequency variations for benchmark problem No. 1---S&A RSM-II.

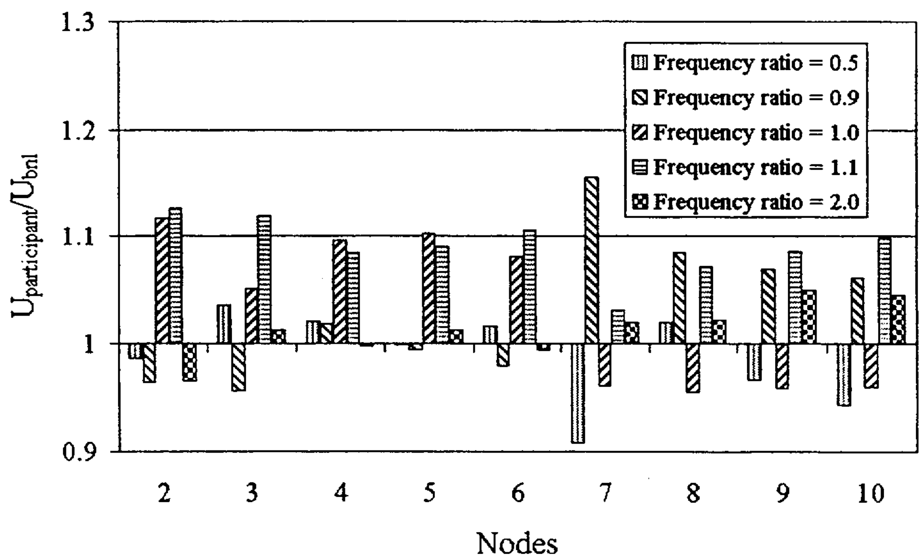

Figure 17. Effects of frequency variations for benchmark problem No. 1---Chen classical RSM.

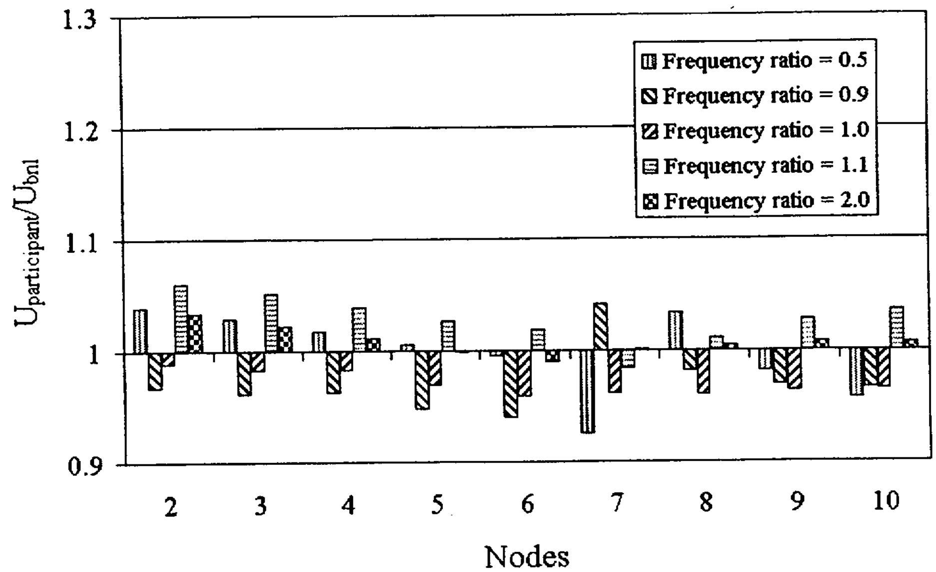

Figure 18. Effects of frequency variations for benchmark problem No. 1---Igusa/Der Kiureghian RSM

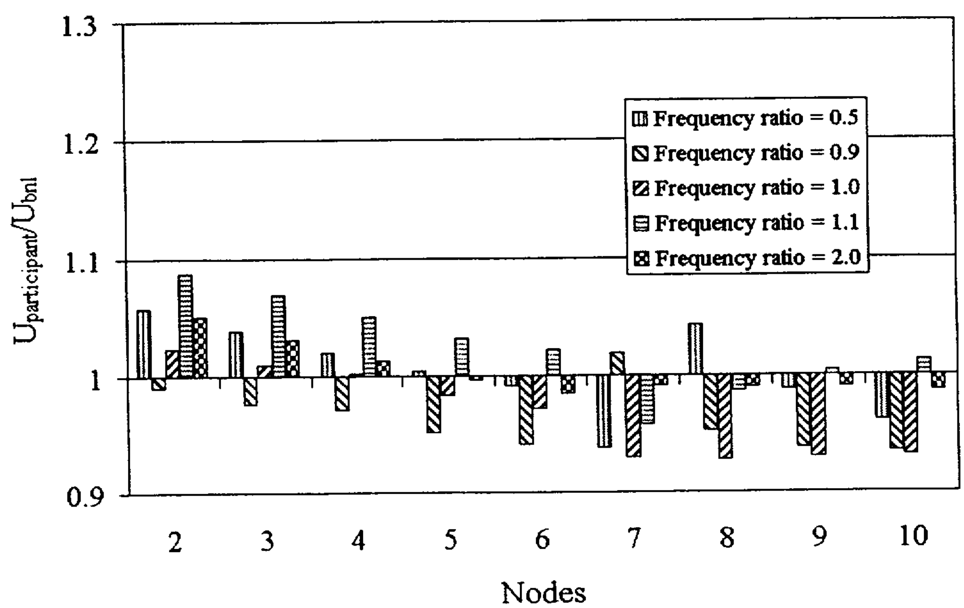

Figure 19. Effects of frequency variations for benchmark problem No. 1---Gupta RSM

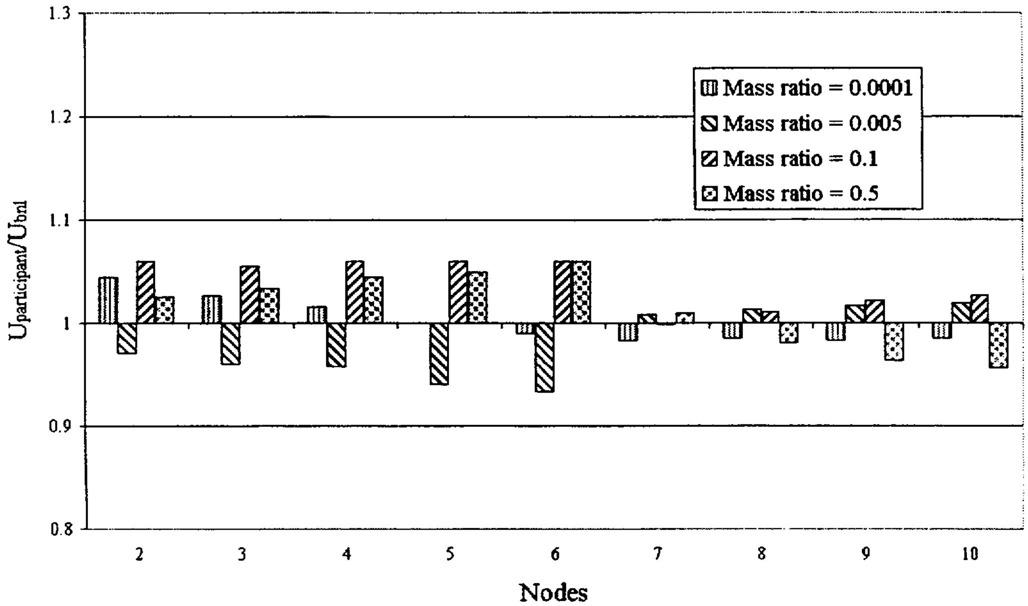

Figure 20. Effects of mass ratio variations for benchmark problem No. 1---S&A RSM-I.

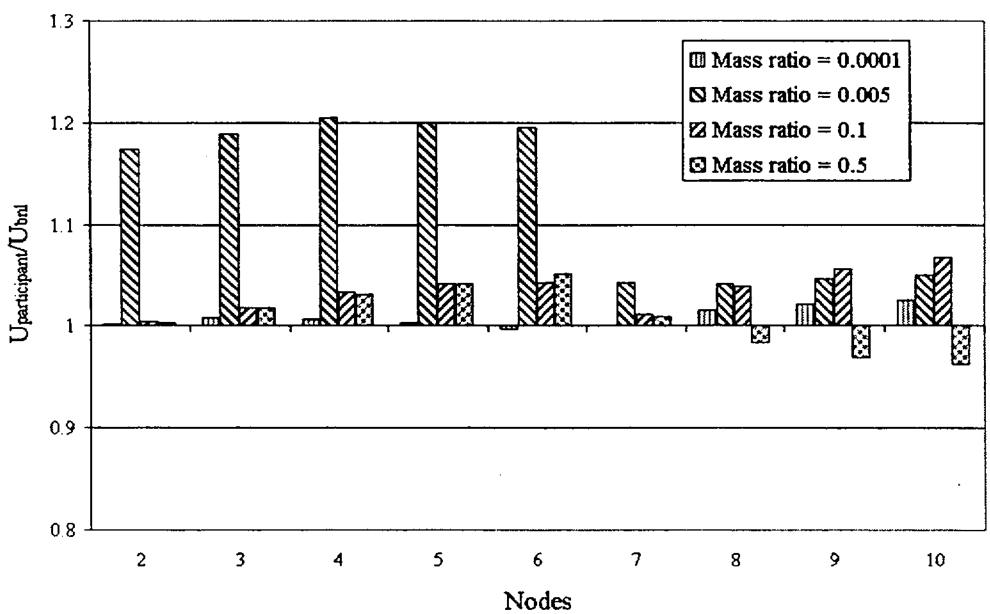

Figure 21. Effects of mass ratio variations for benchmark problem No. 1---S&A RSM-II.

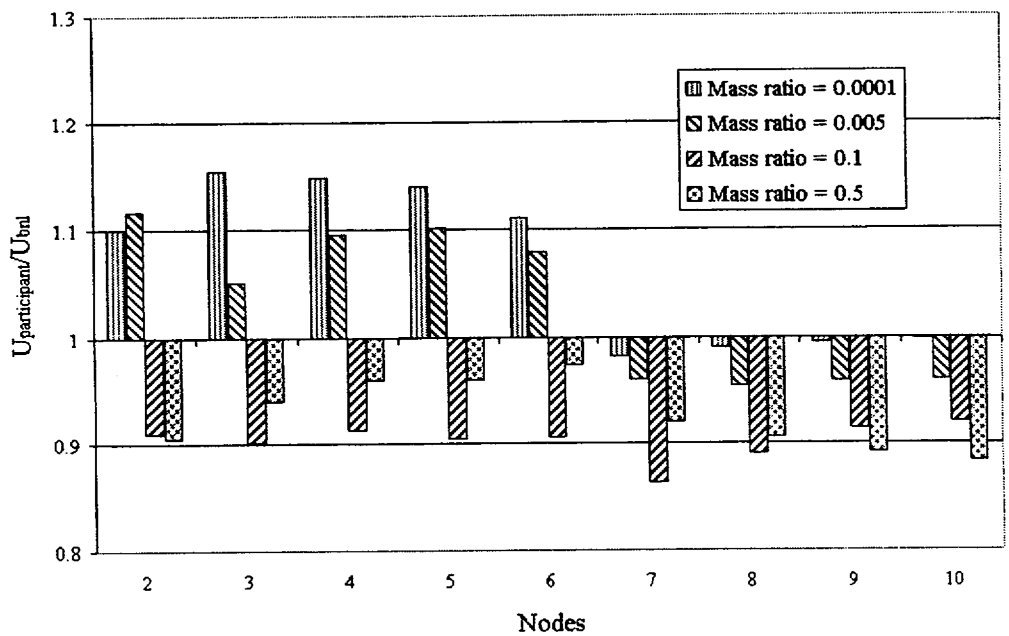

Figure 22. Effects of mass ratio variations for benchmark problem No. 1---Chen classical RSM.

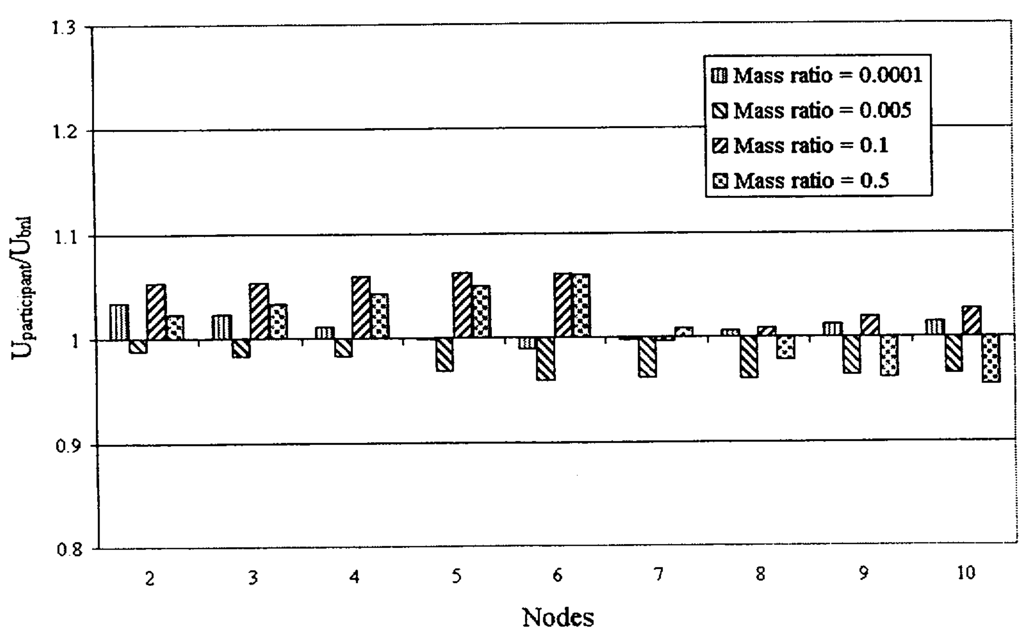

Figure 23. Effects of mass ratio variations for benchmark problem No. 1---Igusa/Der Kiureghian RSM.

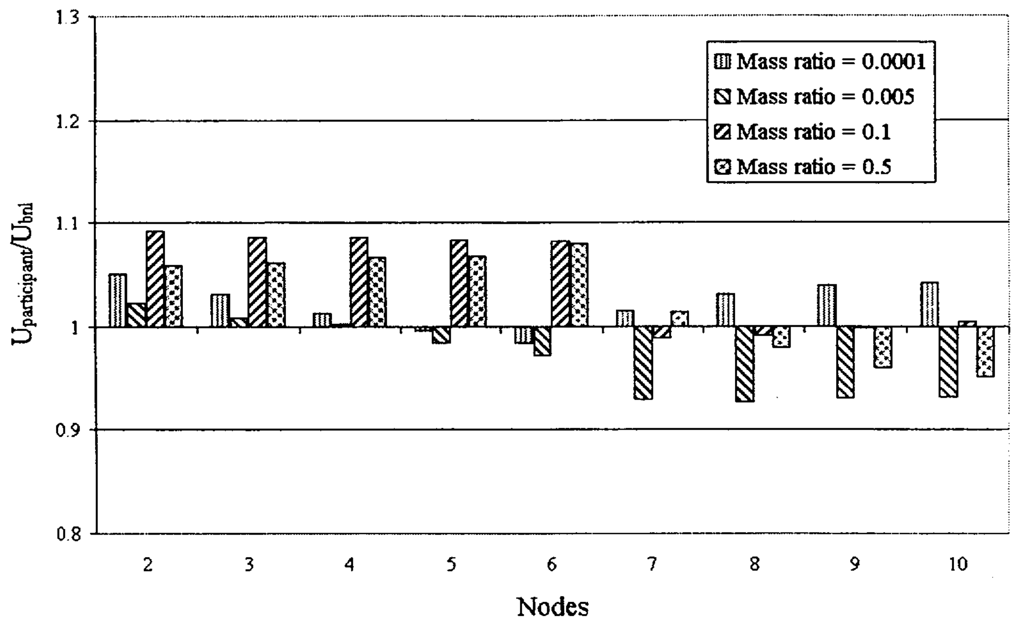

Figure 24. Effects of mass ratio variations for benchmark problem No. 1---Gupta RSM.

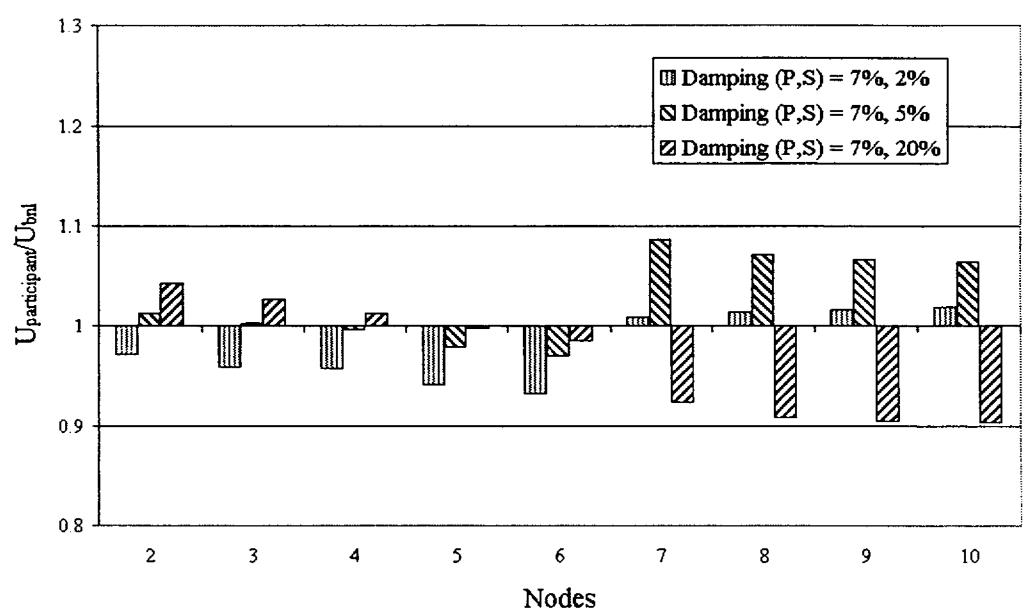

Figure 25. Effects of damping variations for benchmark problem No. 1---S&A RSM-I.

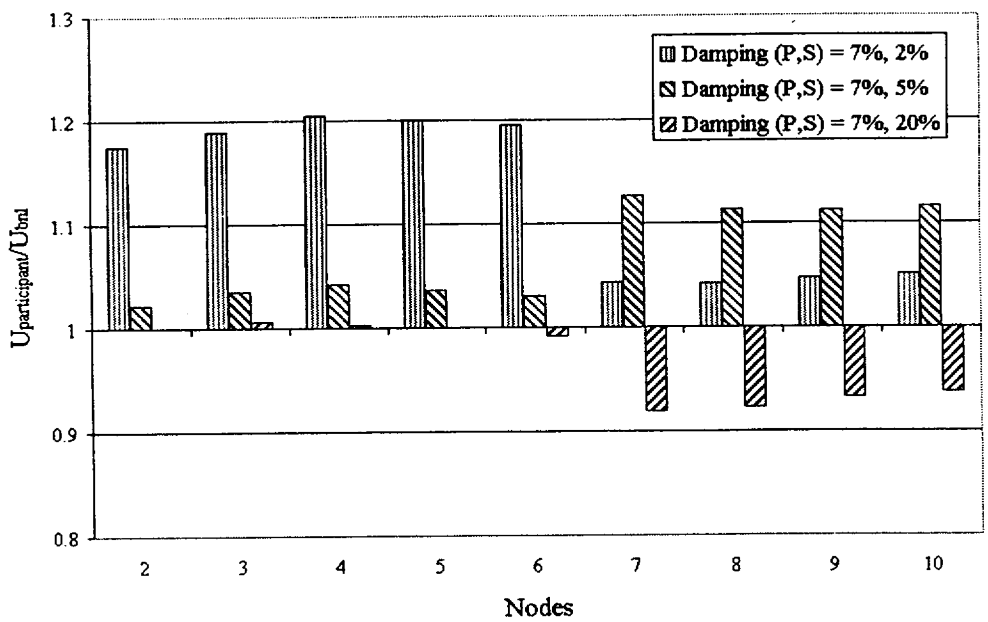

Figure 26. Effects of damping variations for benchmark problem No. 1---S&A RSM-II.

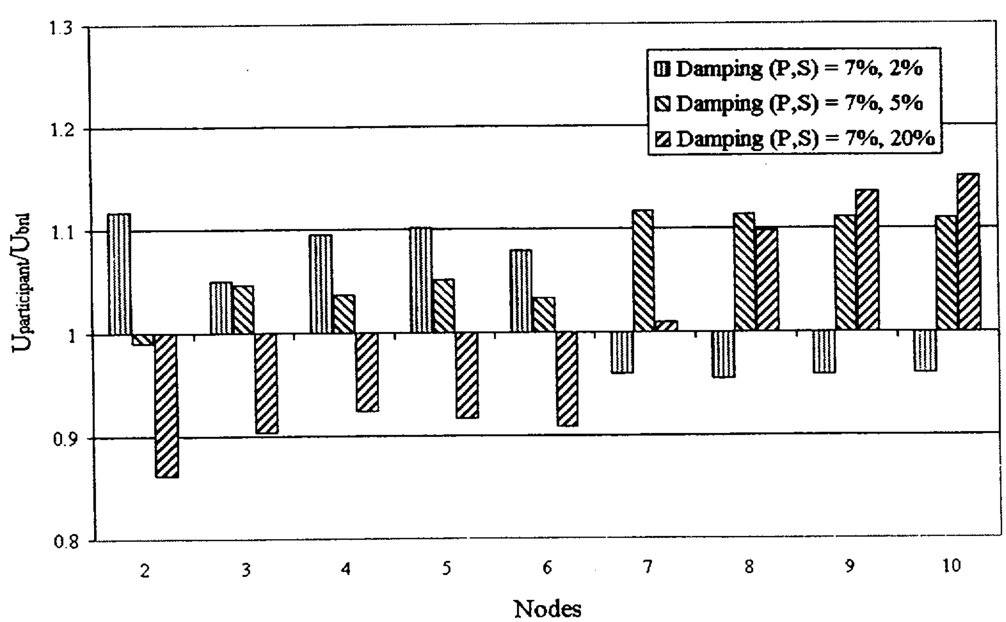

Figure 27. Effects of damping variations for benchmark problem No. 1-----Chen classical RSM.

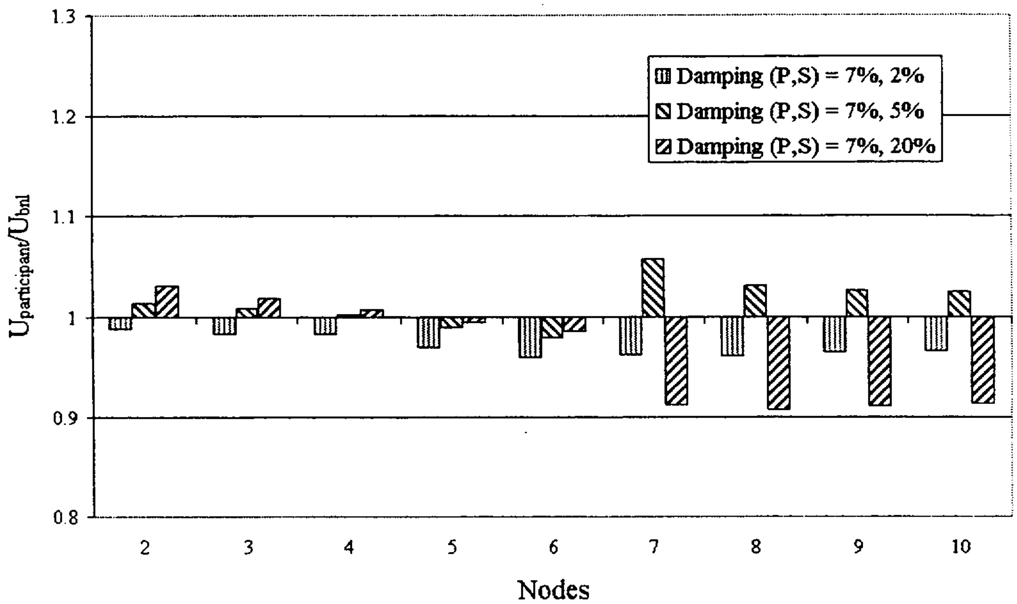

Figure 28. Effects of damping variations for benchmark problem No. 1-----Igusa/Der Kiureghian RSM.

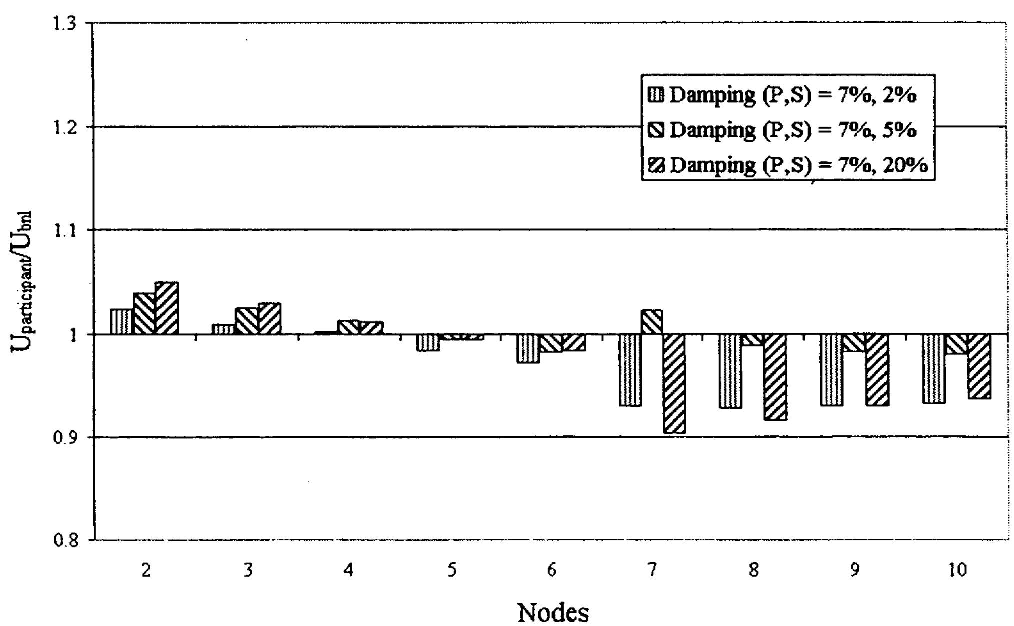

Figure 29. Effects of damping variations for benchmark problem No. 1-----Gupta RSM.

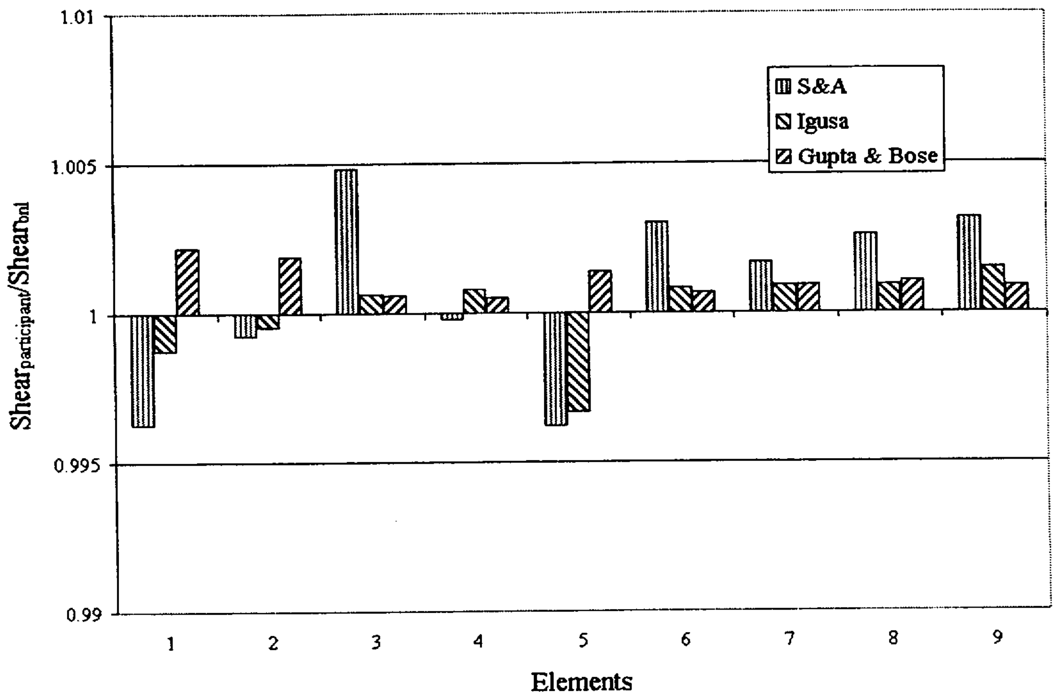

Figure 30. Comparison of maximum element shear forces for benchmark problem No. 1, Case a—Modal superposition time history analyses.

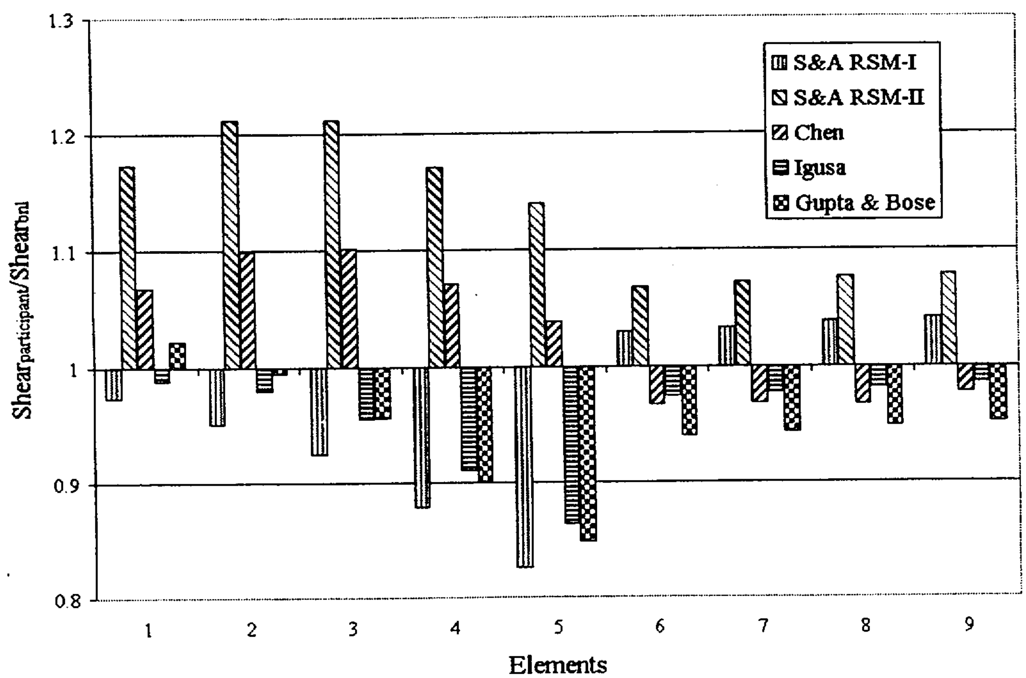

Figure 31. Comparison of maximum element shear forces of benchmark problem No. 1, Case a—Response spectrum methods.

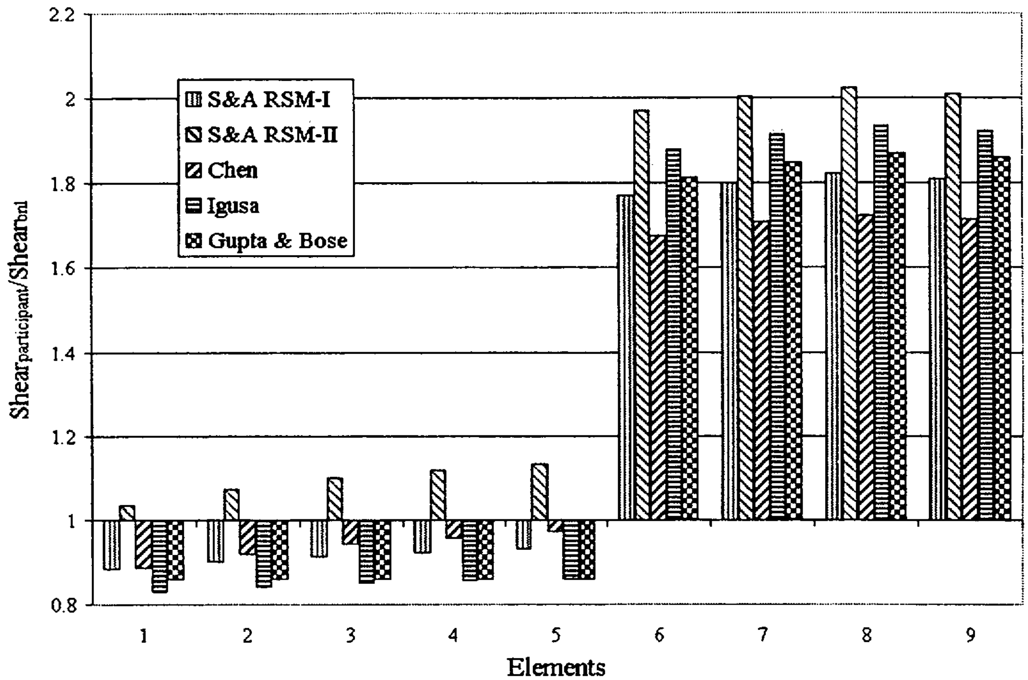

Figure 32.Comparison of maximum element shear forces for benchmark problem No. 1, Case m—Response spectrum methods.

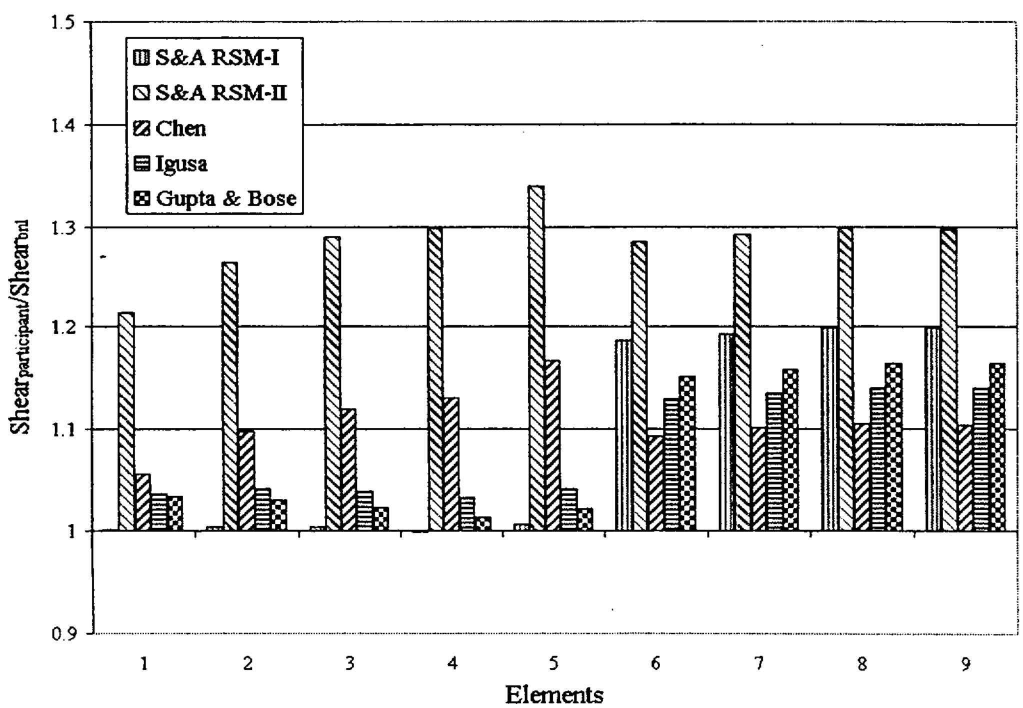

Figure 33.Comparison of mean responses of maximum element shear forces for benchmark problem No. 1 for seven earthquakes—Response spectrum methods.

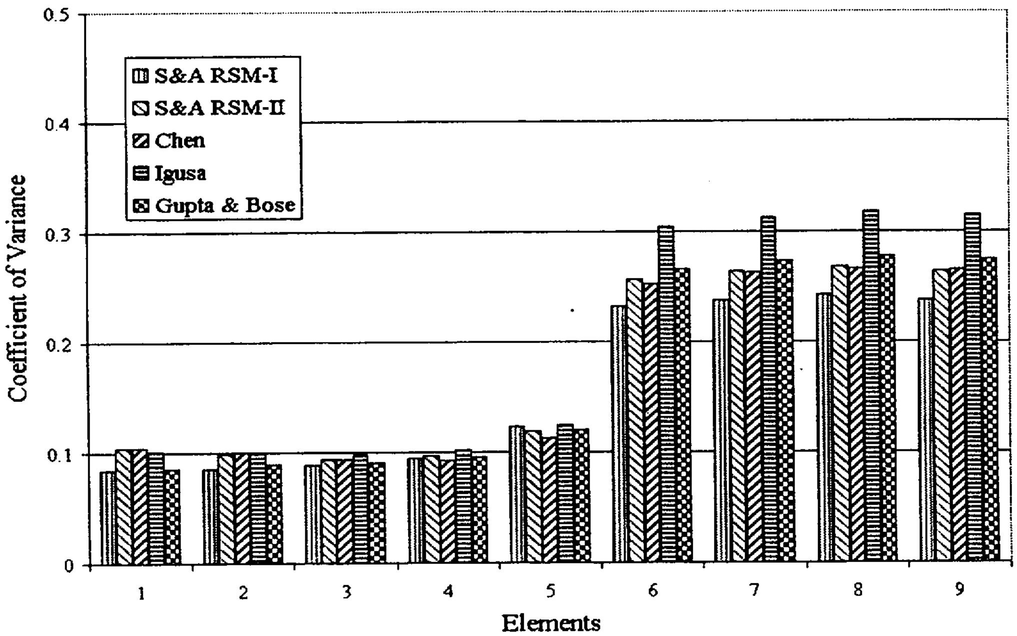

Figure 34. Comparison of Coefficients of variation of maximum element shear forces for benchmark problem No. 1 for seven earthquakes---Response spectrum methods

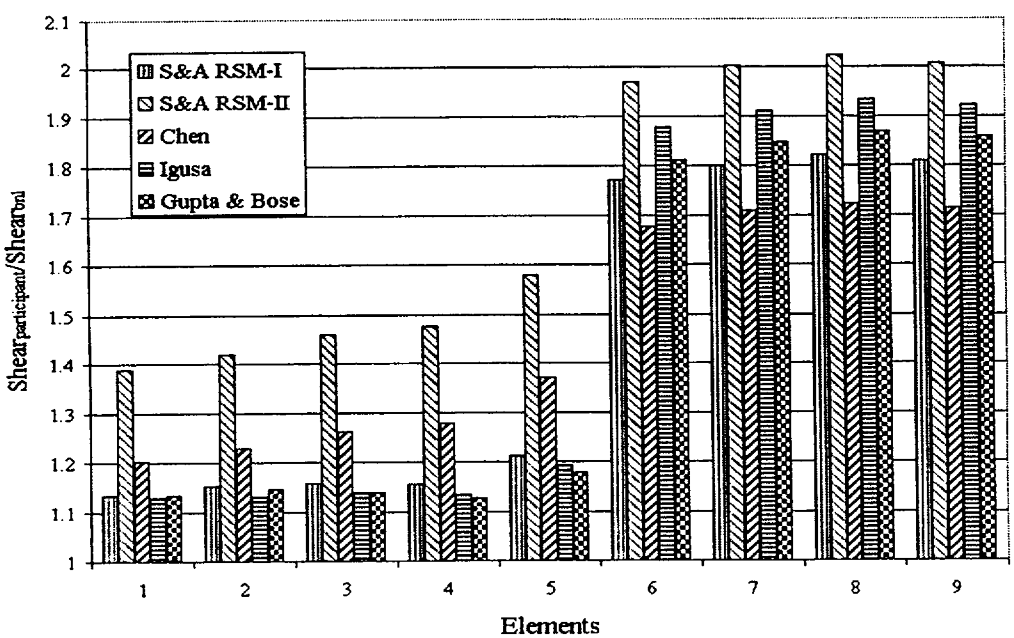

Figure 35. Comparison of maximum ratios of maximum element shear forces for benchmark problem No. 1 for seven earthquakes---Response spectrum methods

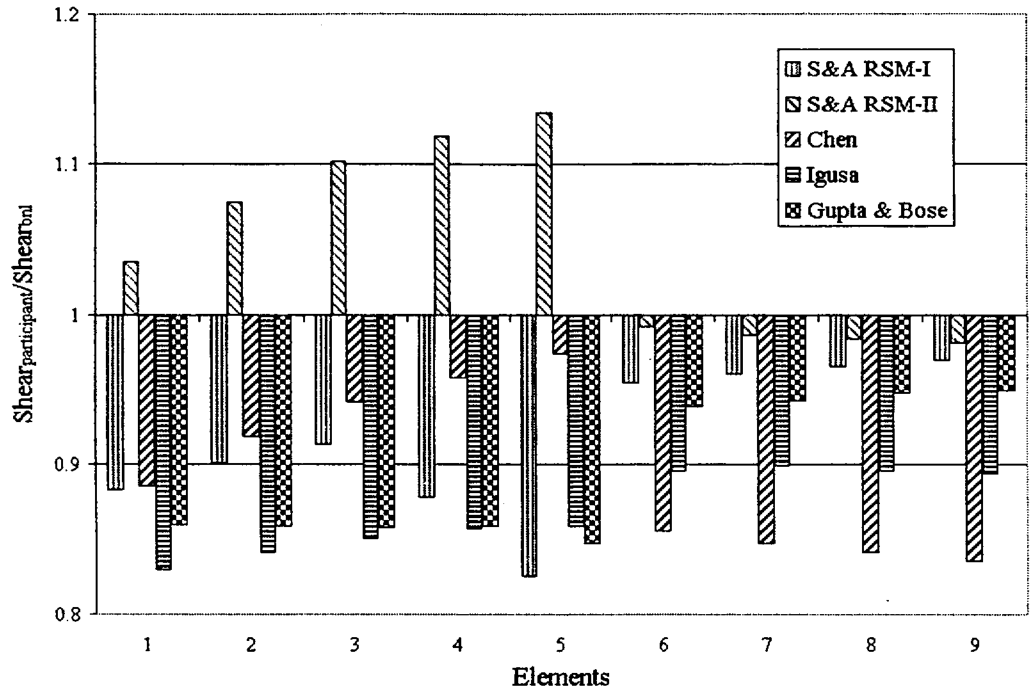

Figure 36. Comparison of minimum ratios of maximum element shear forces for benchmark problem No. 1 for seven earthquakes---Response spectrum methods

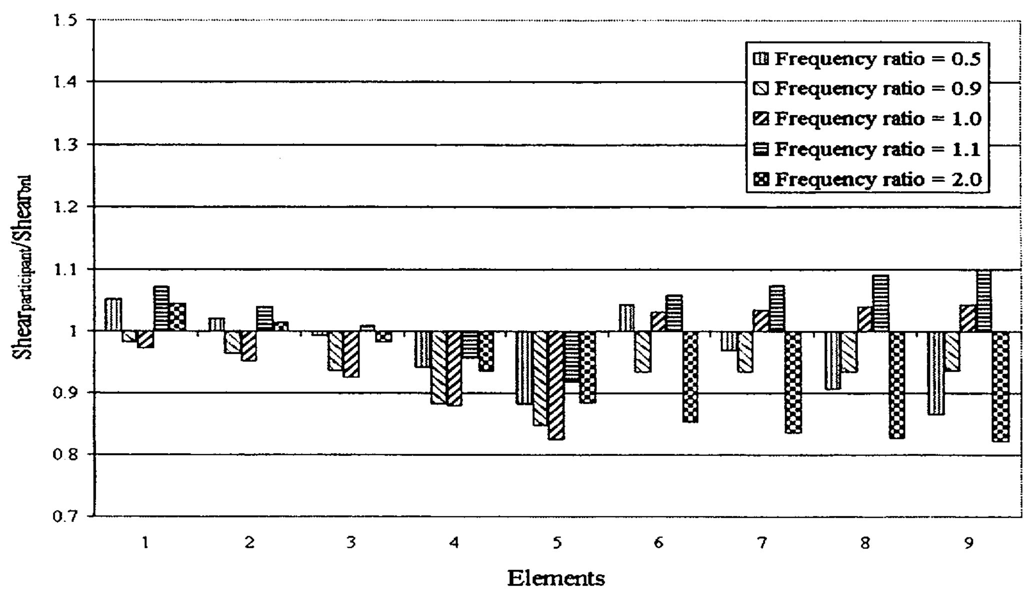

Figure 37. Effects of frequency variations for benchmark problem No. 1---S&A RSM-I.

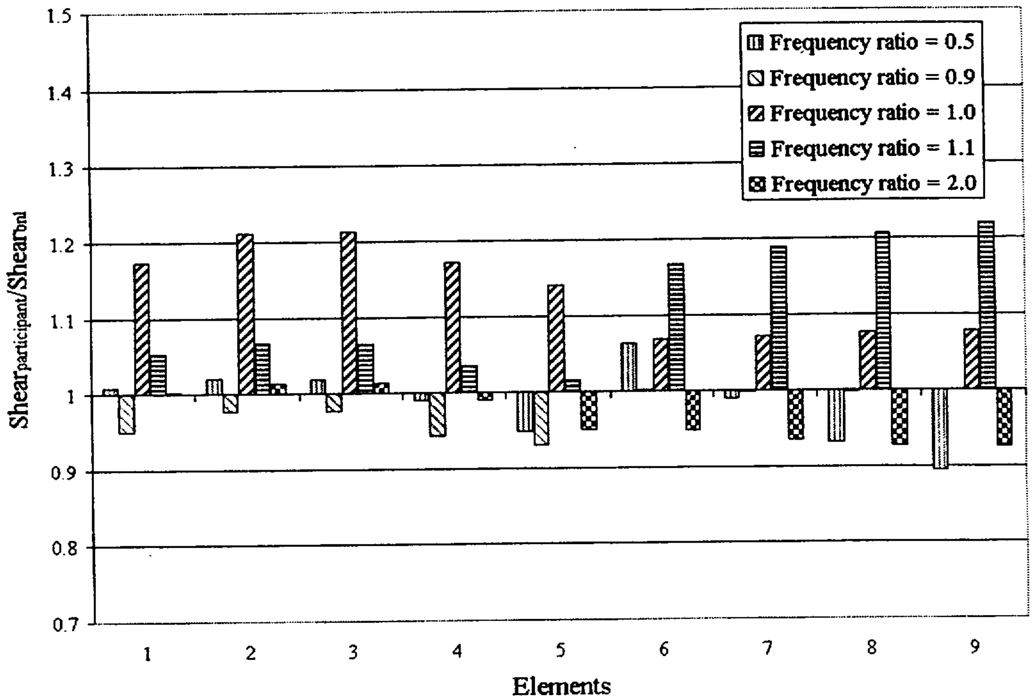

Figure 38. Effects of frequency variations for benchmark problem No. 1---S&A RSM-II.

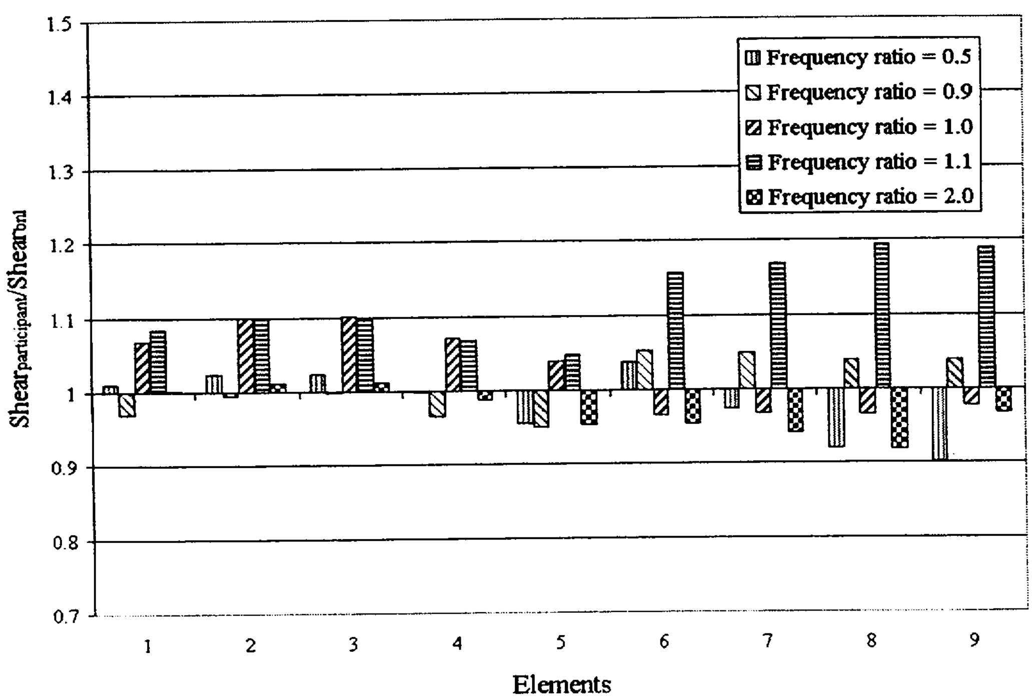

Figure 39. Effects of frequency variations for benchmark problem No. 1---Chen classical RSM.

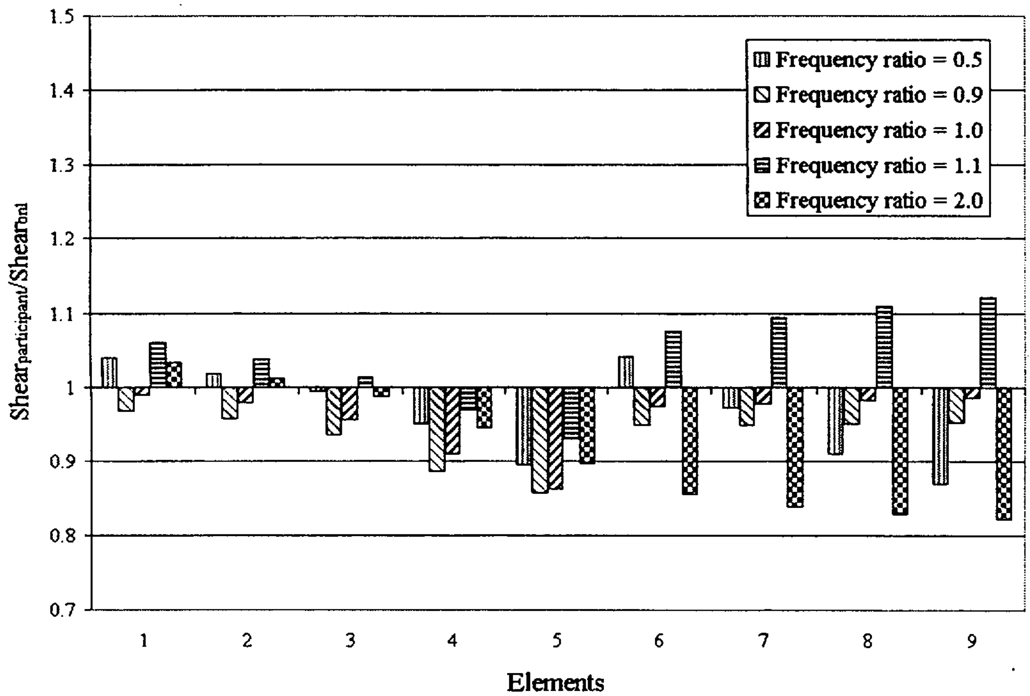

Figure 40. Effects of frequency variations for benchmark problem No. 1---Igusa/Der Kiureghian RSM

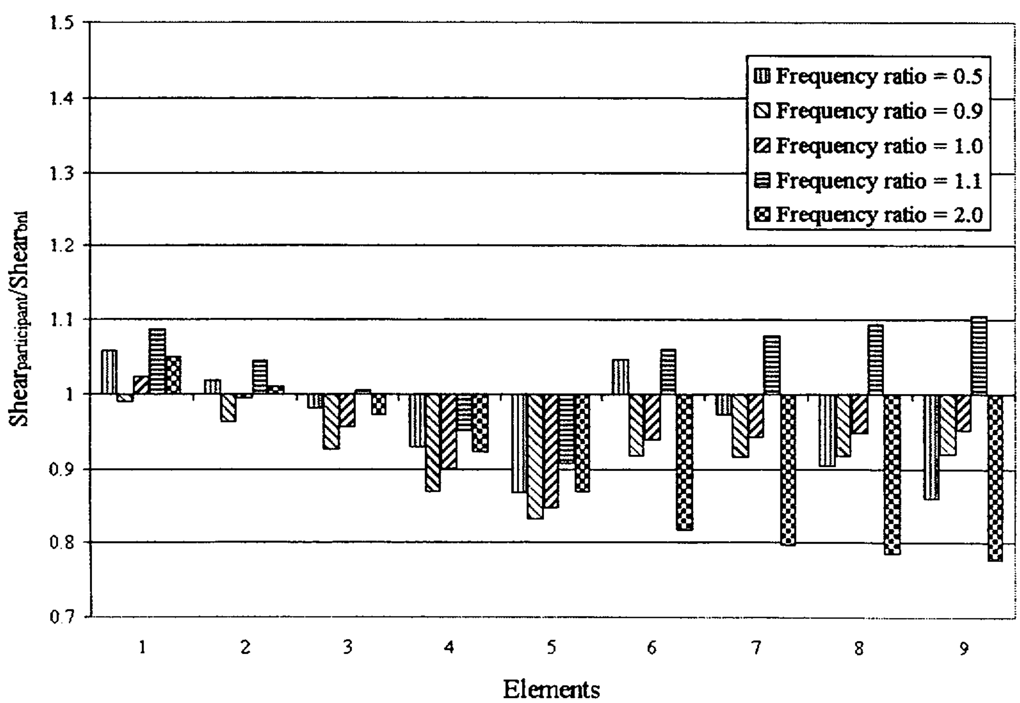

Figure 41. Effects of frequency variations for benchmark problem No. 1---Gupta RSM

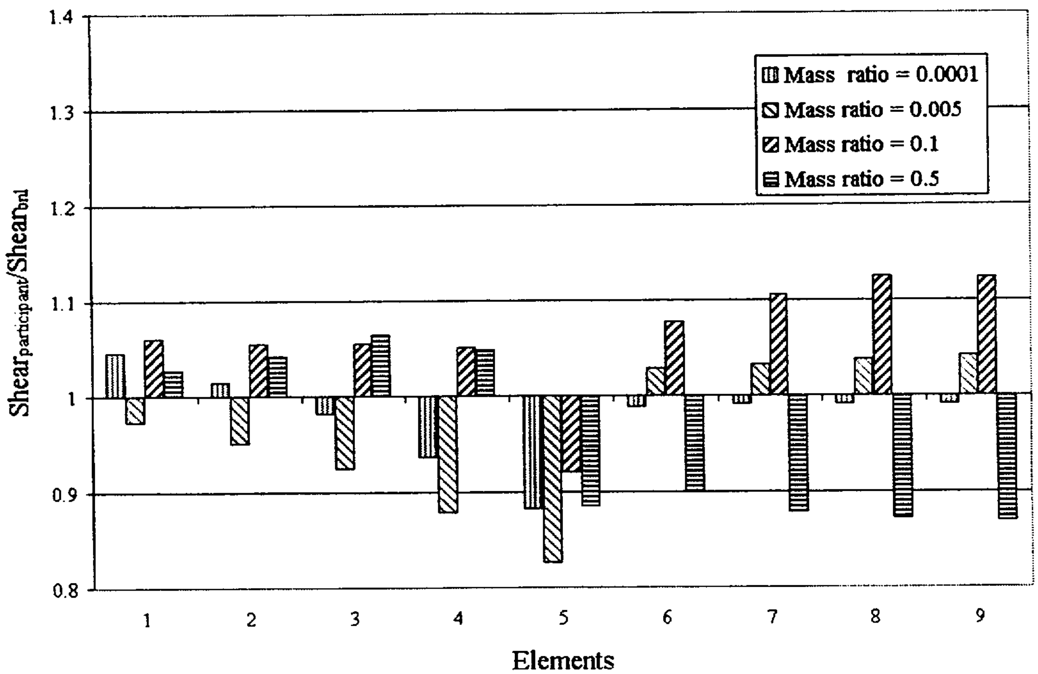

Figure 42. Effects of mass ratio variations for benchmark problem No. 1---S&A RSM-I.

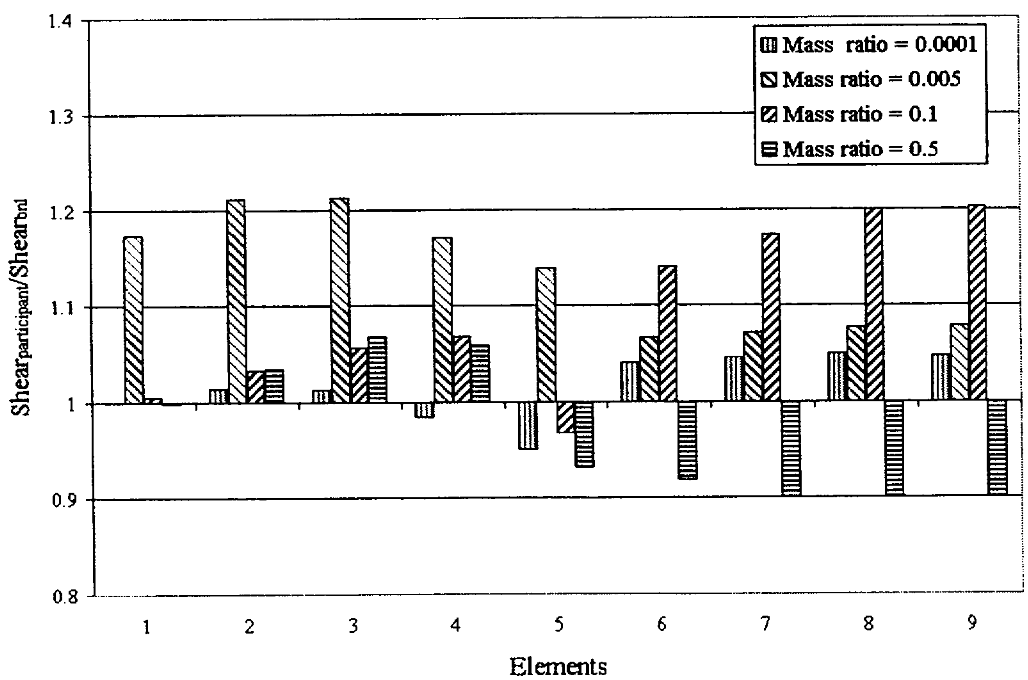

Figure 43. Effects of mass ratio variations for benchmark problem No. 1---S&A RSM-II.

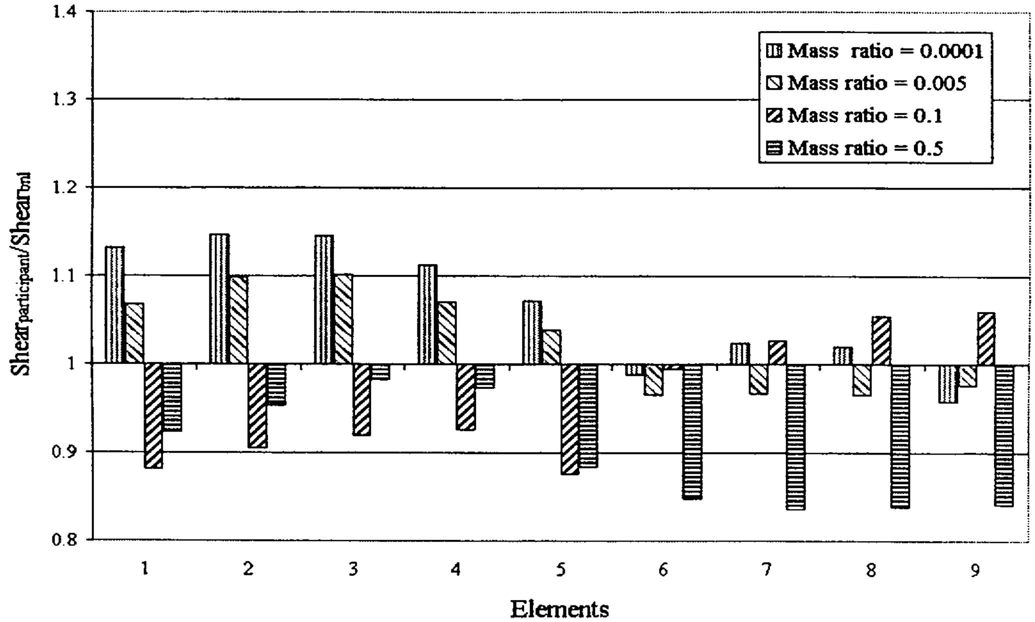

Figure 44. Effects of mass ratio variations for benchmark problem No. 1---Chen classical RSM.

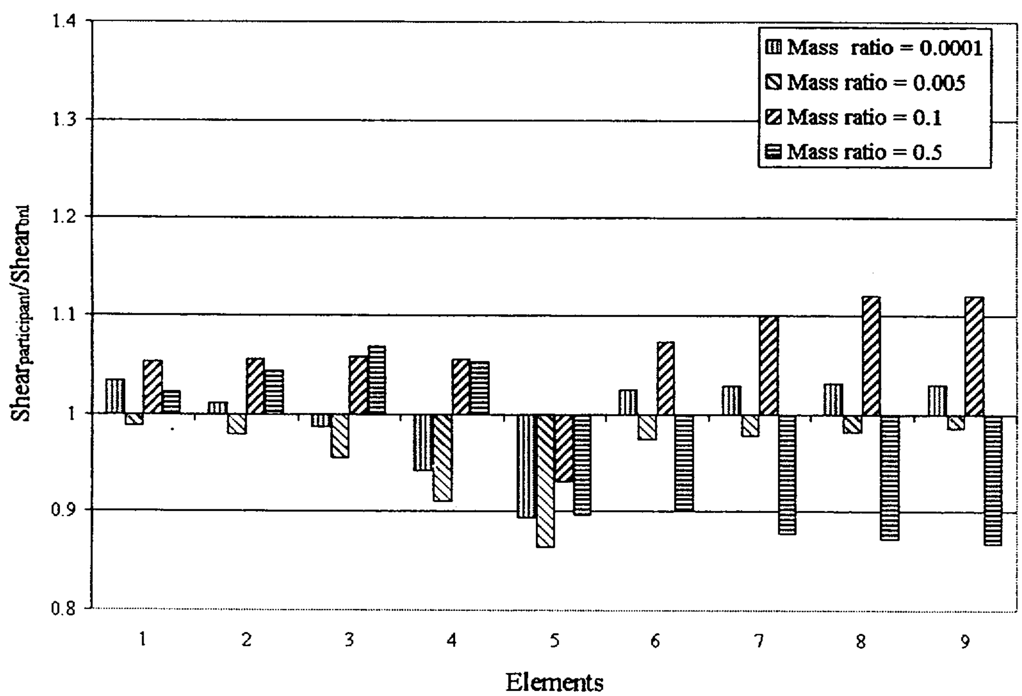

Figure 45. Effects of mass ratio variations for benchmark problem No. 1---Igusa/Der Kiureghian RSM.

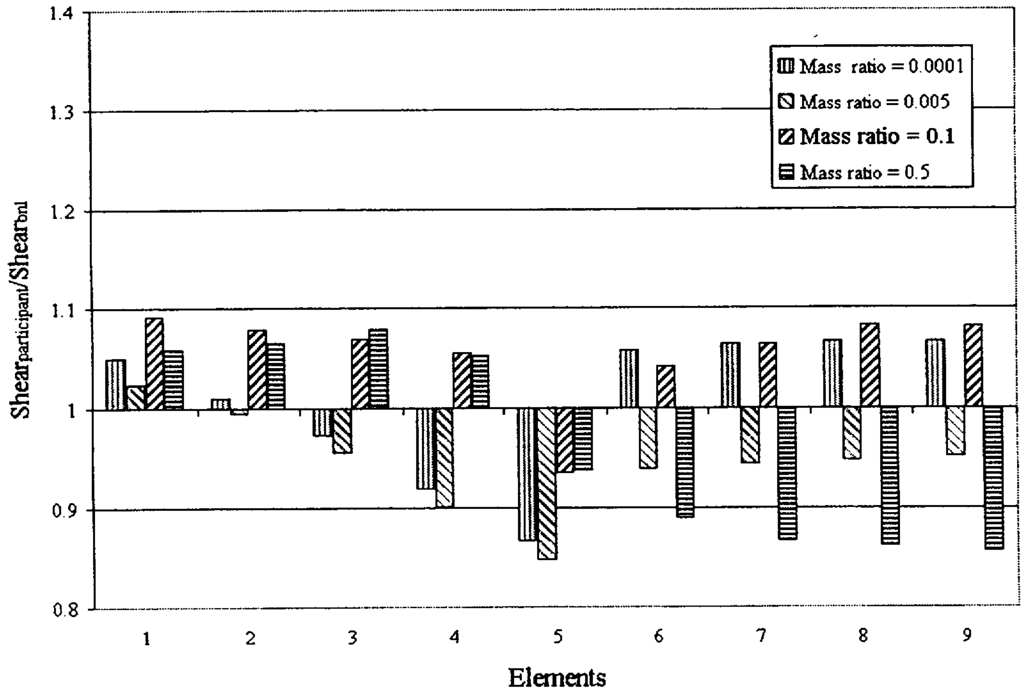

Figure 46. Effects of mass ratio variations for benchmark problem No. 1---Gupta RSM.

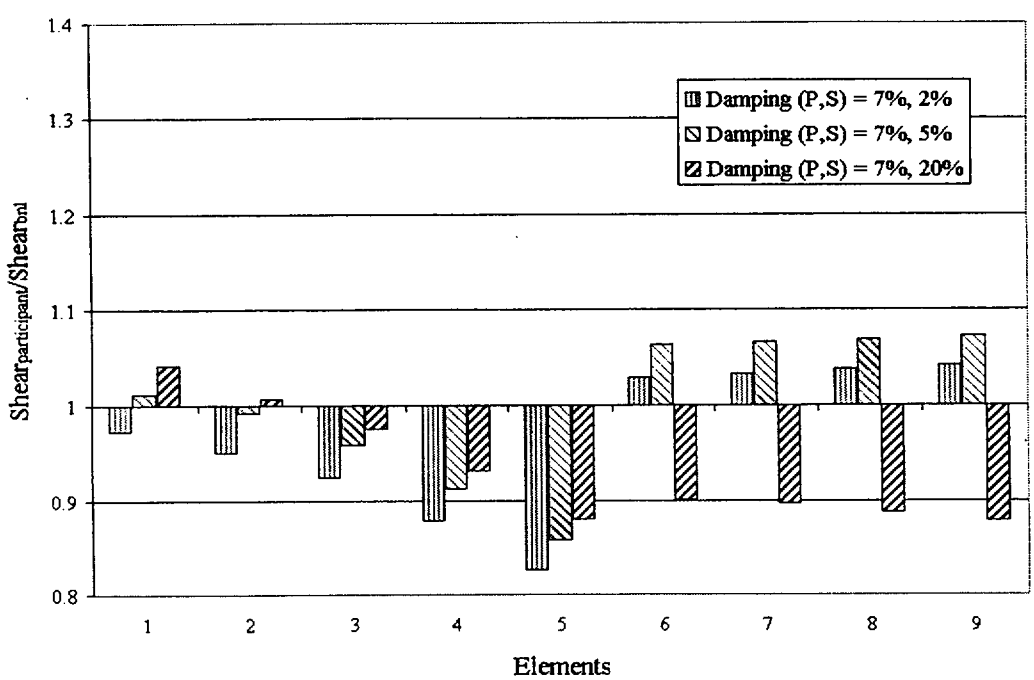

Figure 47. Effects of damping variations for benchmark problem No. 1---S&A RSM-I.

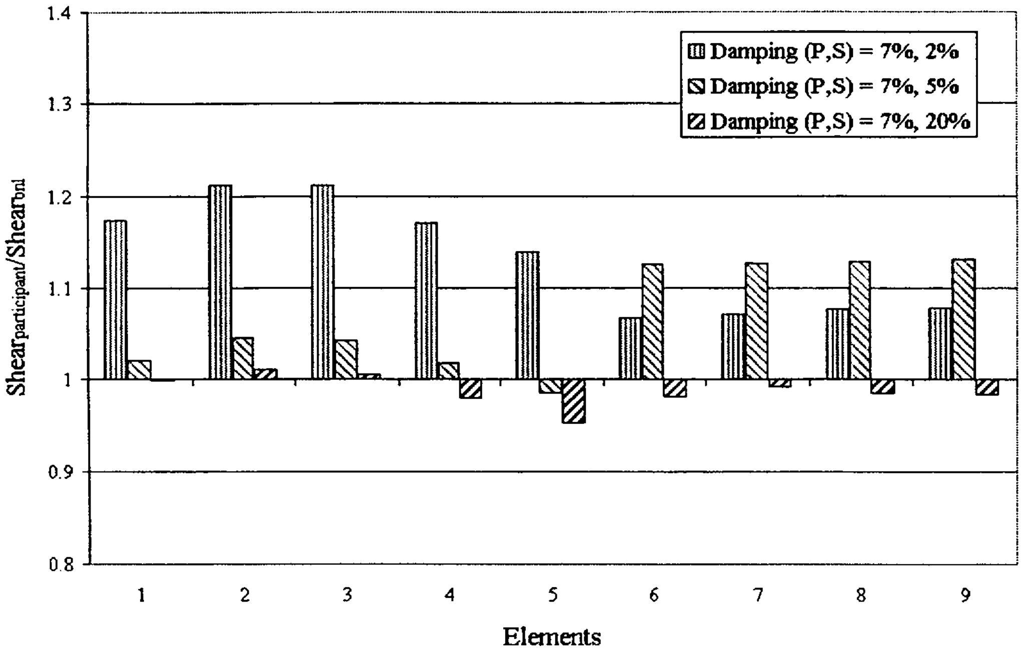

Figure 48. Effects of damping variations for benchmark problem No. 1---S&A RSM-II.

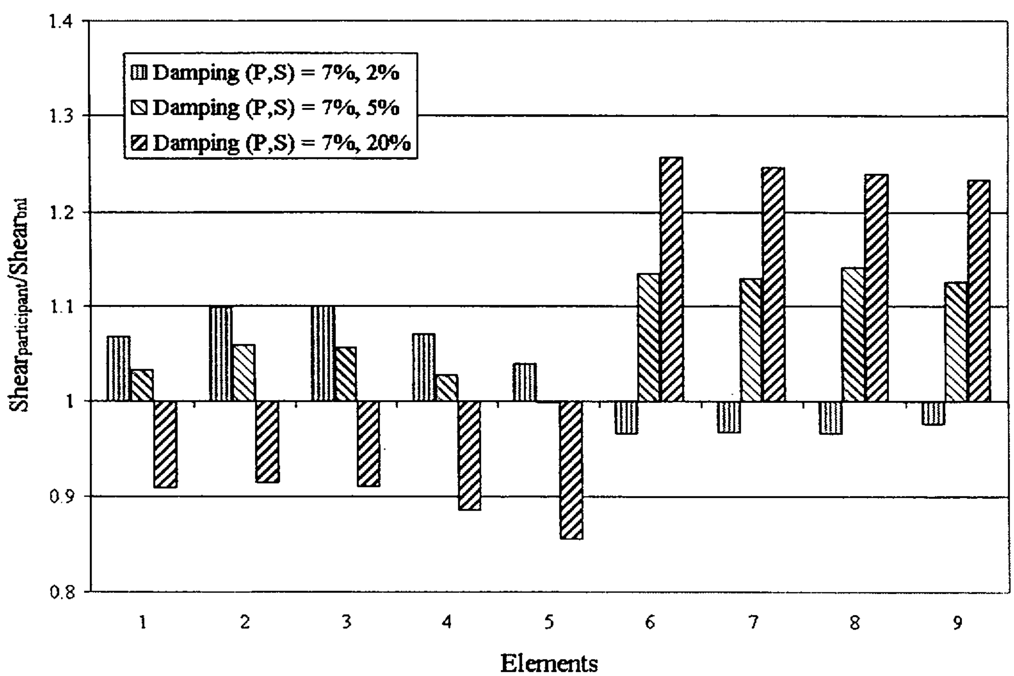

Figure 49. Effects of damping variations for benchmark problem No. 1-----Chen classical RSM.

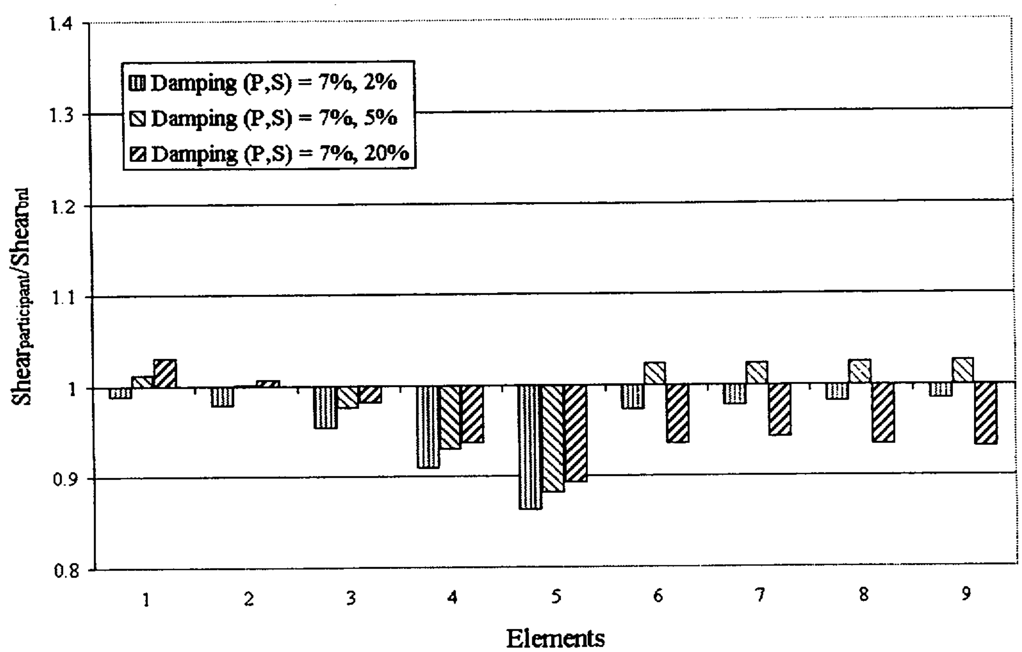

Figure 50. Effects of damping variations for benchmark problem No. 1-----Igusa/Der Kiureghian RSM.

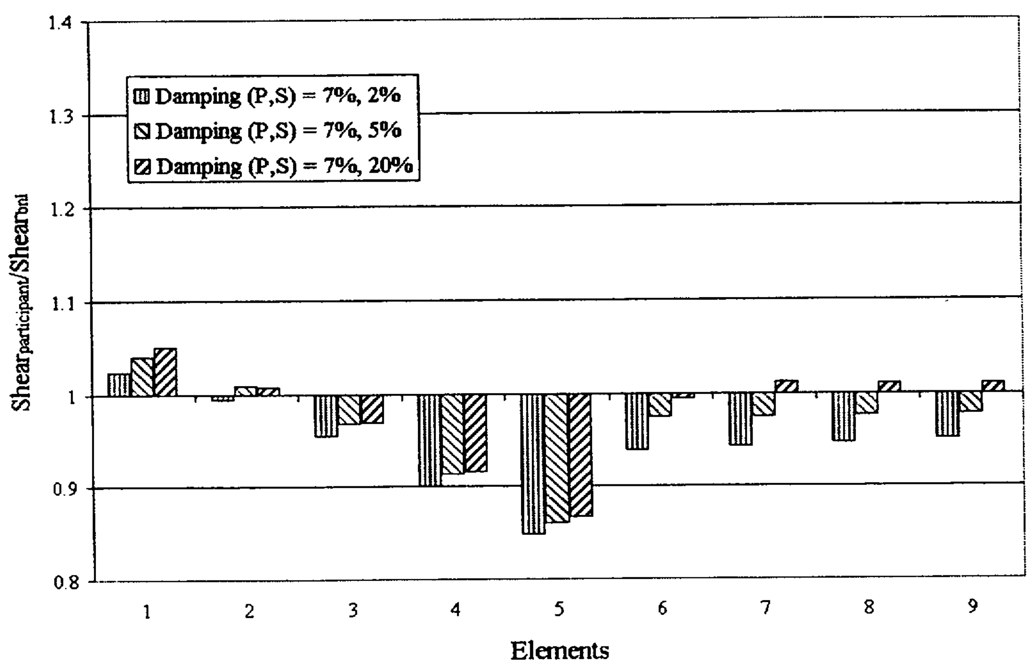

Figure 51. Effects of damping variations for benchmark problem No. 1-----Gupta RSM.

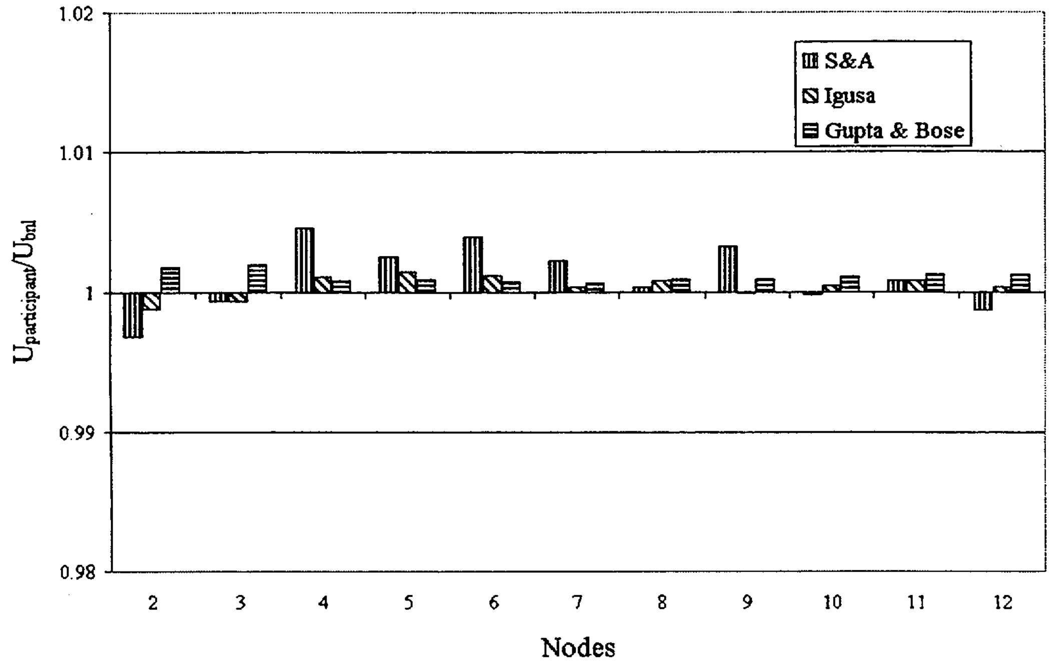

Figure 52.Comparison of maximum displacements for benchmark problem No. 2, Case a—Modal superposition time history analyses.

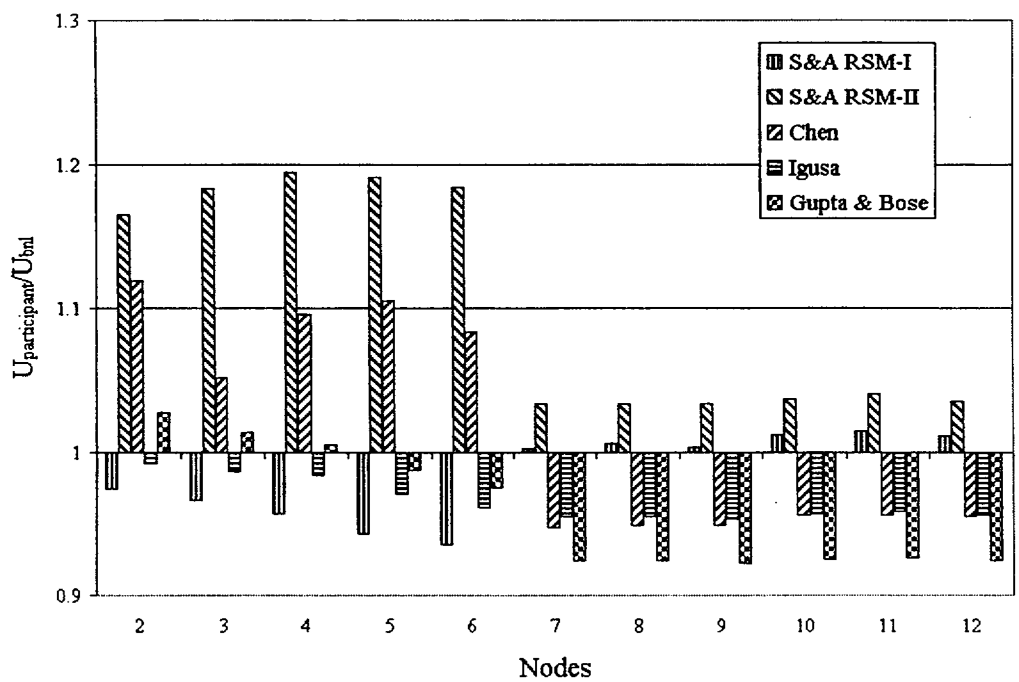

Figure 53. Comparison of maximum displacements for benchmark problem No. 2, Case a—Response spectrum methods.

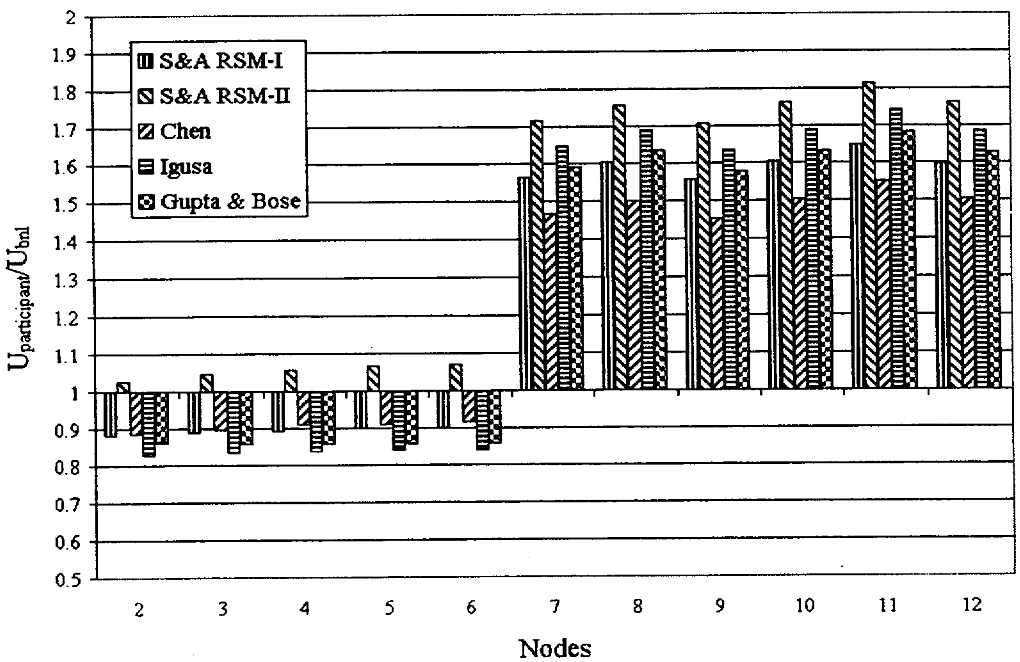

Figure 54.Comparison of maximum displacements for benchmark problem No. 2, Case m—Response spectrum methods.

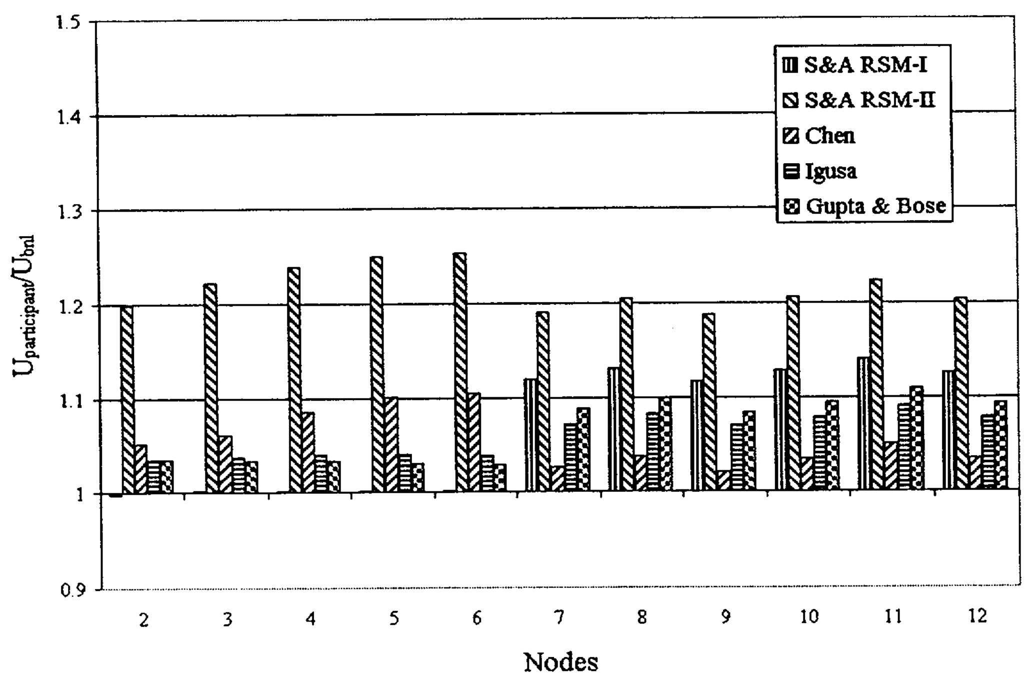

Figure 55.Comparison of mean responses of maximum displacements for benchmark problem No. 2 for seven earthquakes—Response spectrum methods.

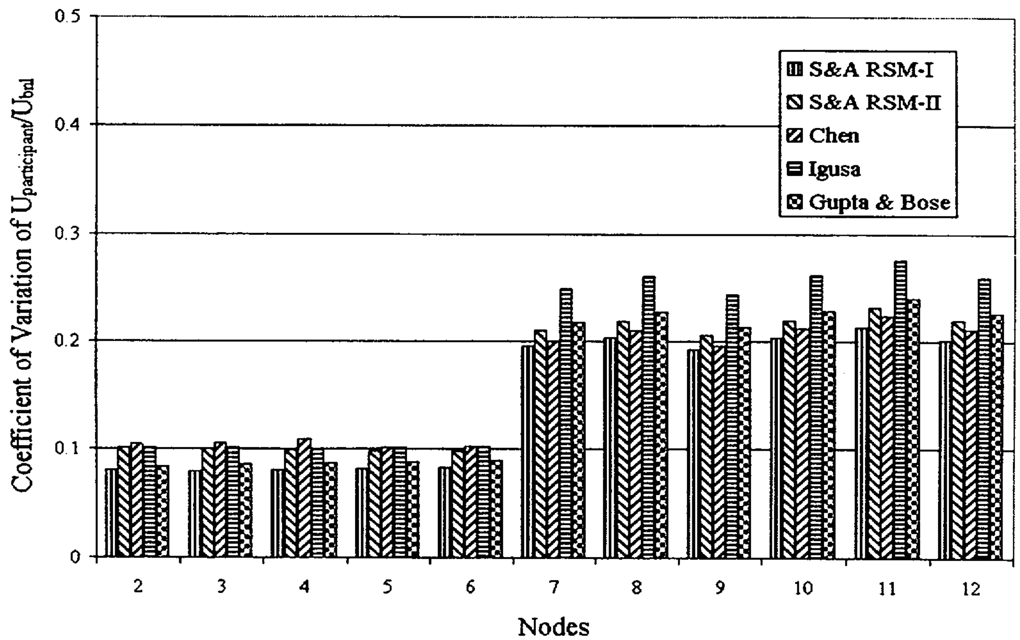

Figure 56. Comparison of Coefficients of variation of maximum displacements for benchmark problem No. 2 for seven earthquakes---Response spectrum methods

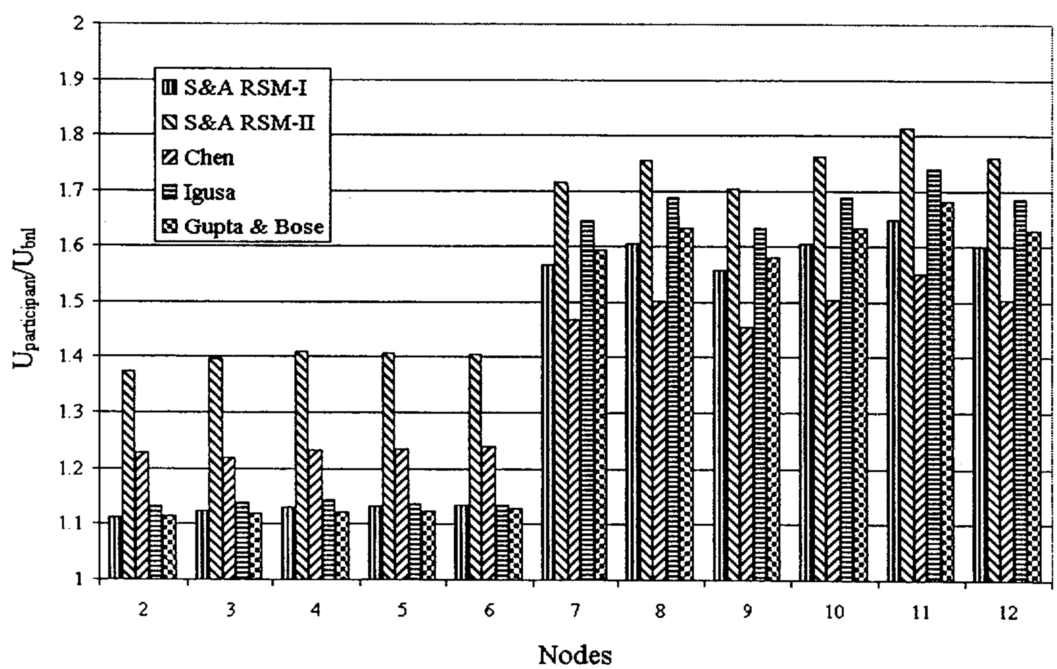

Figure 57. Comparison of maximum ratios of maximum displacements for benchmark problem No. 2 for seven earthquakes---Response spectrum methods

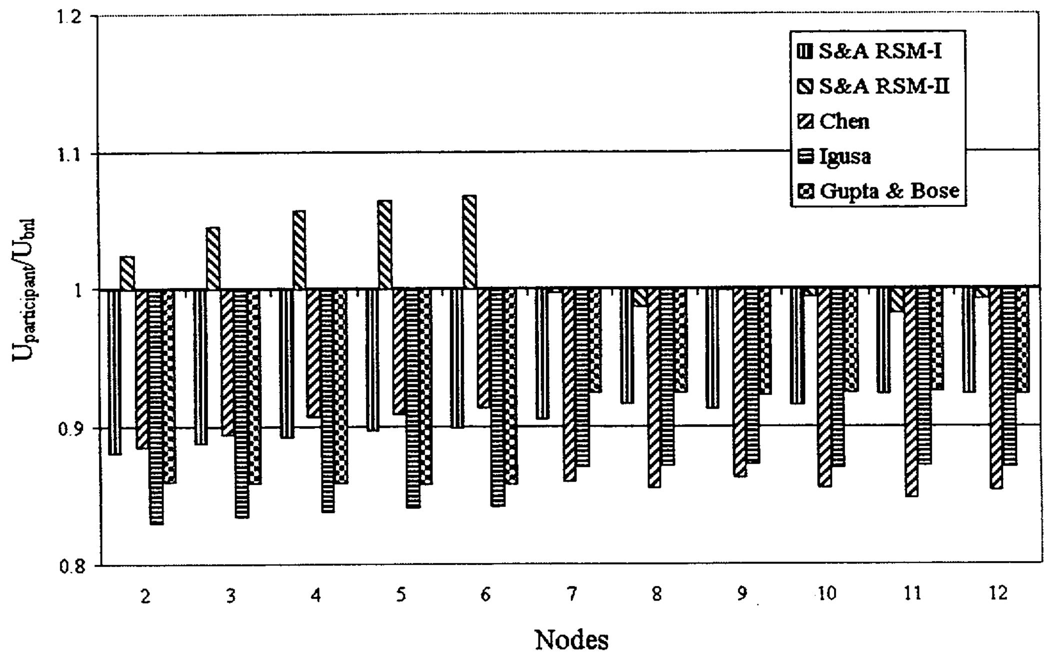

Figure 58. Comparison of minimum ratios of maximum displacements for benchmark problem No. 2 for seven earthquakes---Response spectrum methods

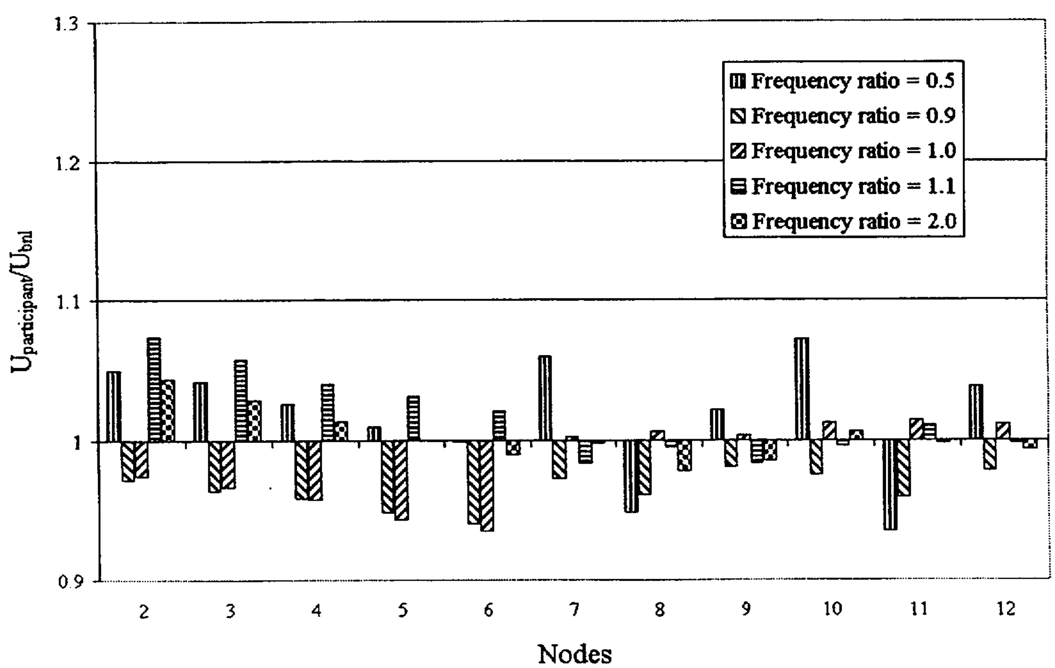

Figure 59. Effects of frequency variations for benchmark problem No. 2---S&A RSM-I.

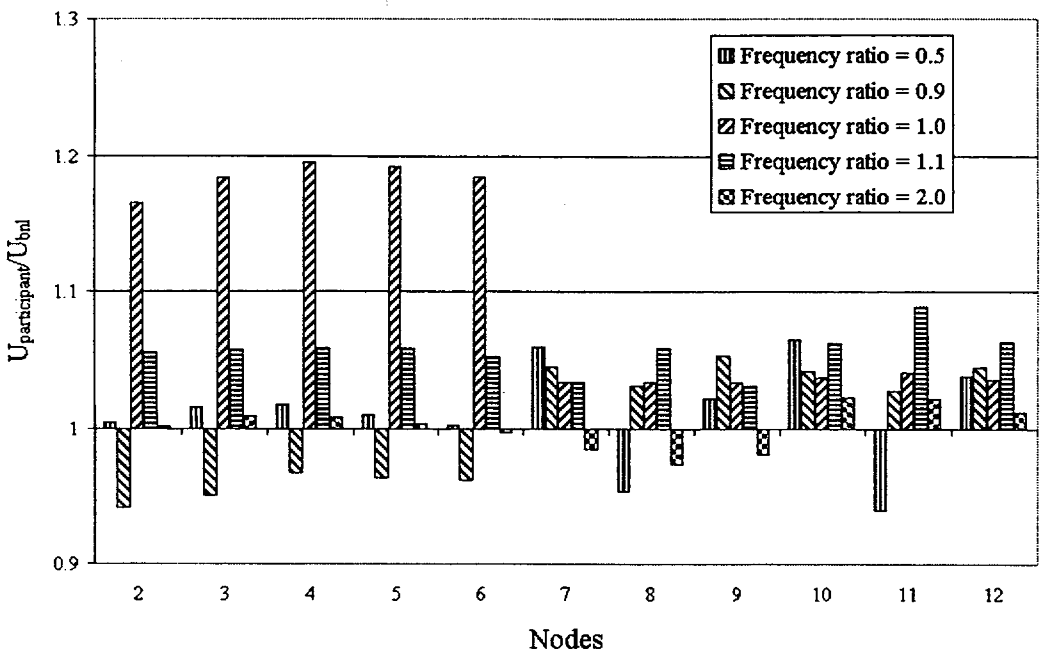

Figure 60. Effects of frequency variations for benchmark problem No. 2---S&A RSM-II.

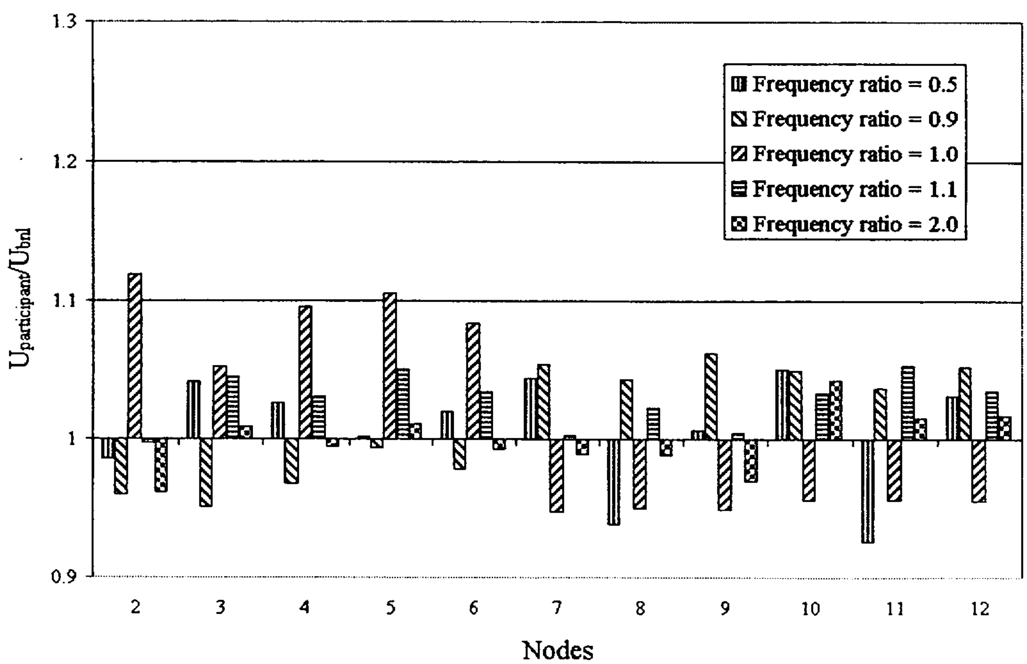

Figure 61. Effects of frequency variations for benchmark problem No. 2---Chen classical RSM.

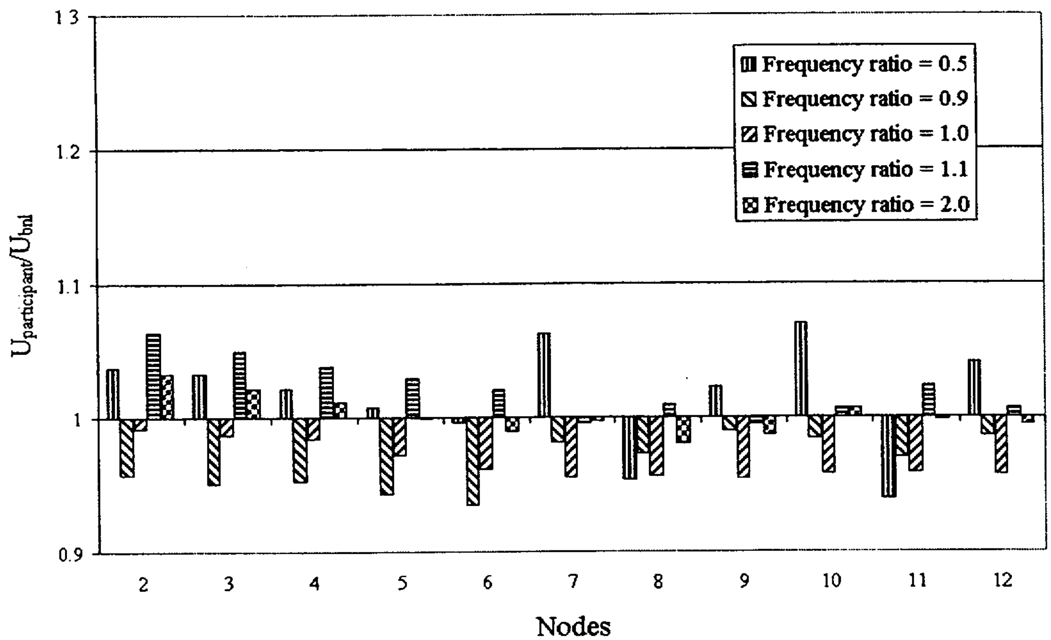

Figure 62. Effects of frequency variations for benchmark problem No. 2---Igusa/Der Kiureghian RSM

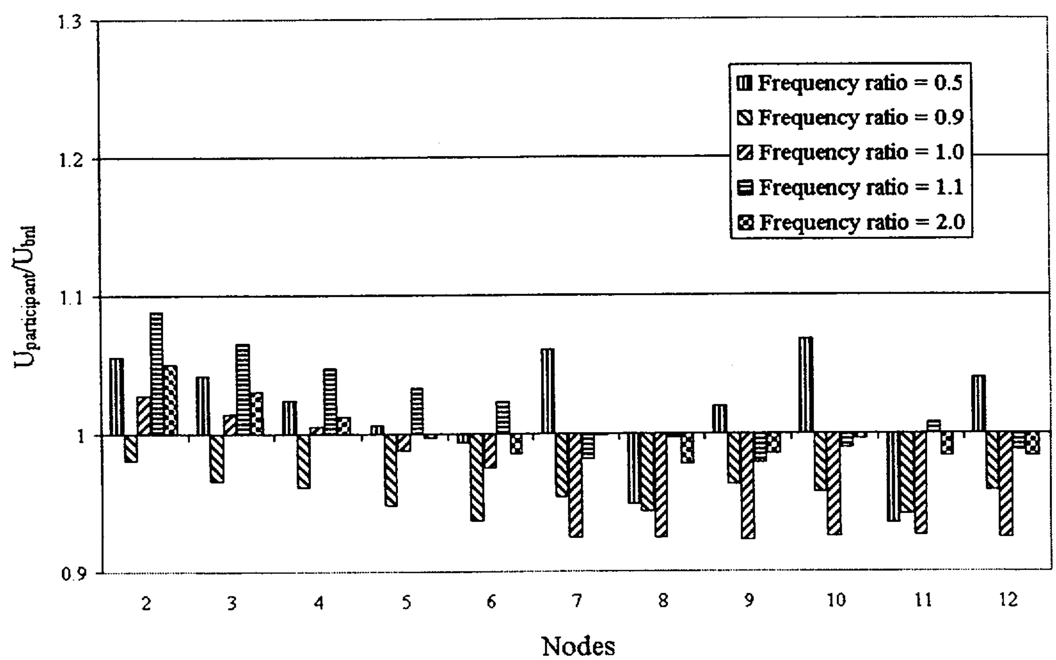

Figure 63. Effects of frequency variations for benchmark problem No. 2---Gupta RSM

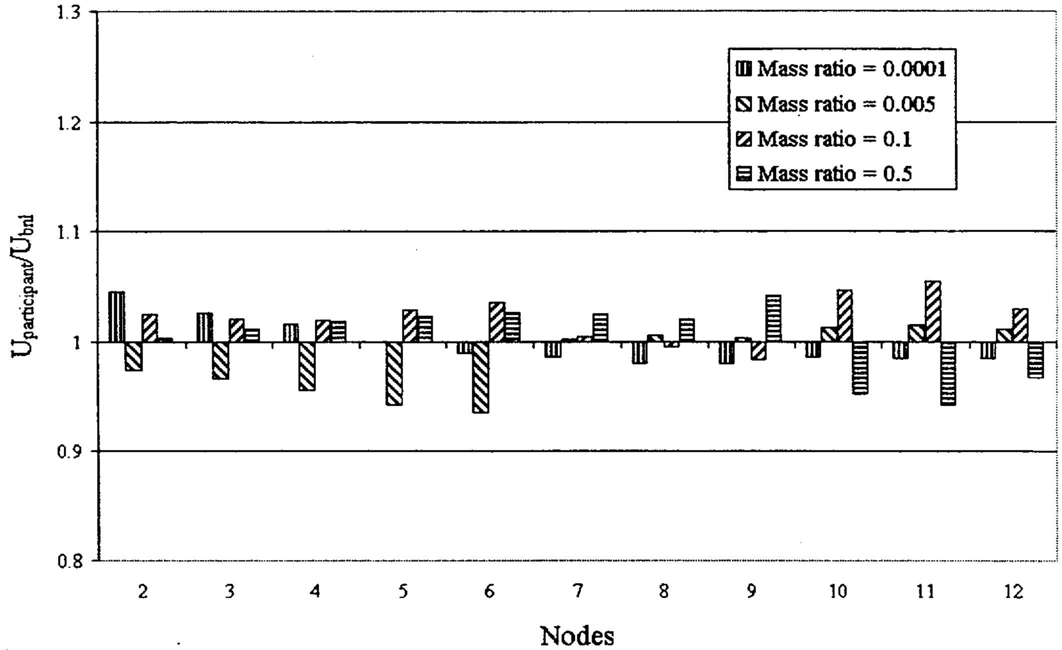

Figure 64. Effects of mass ratio variations for benchmark problem No. 2---S&A RSM-I.

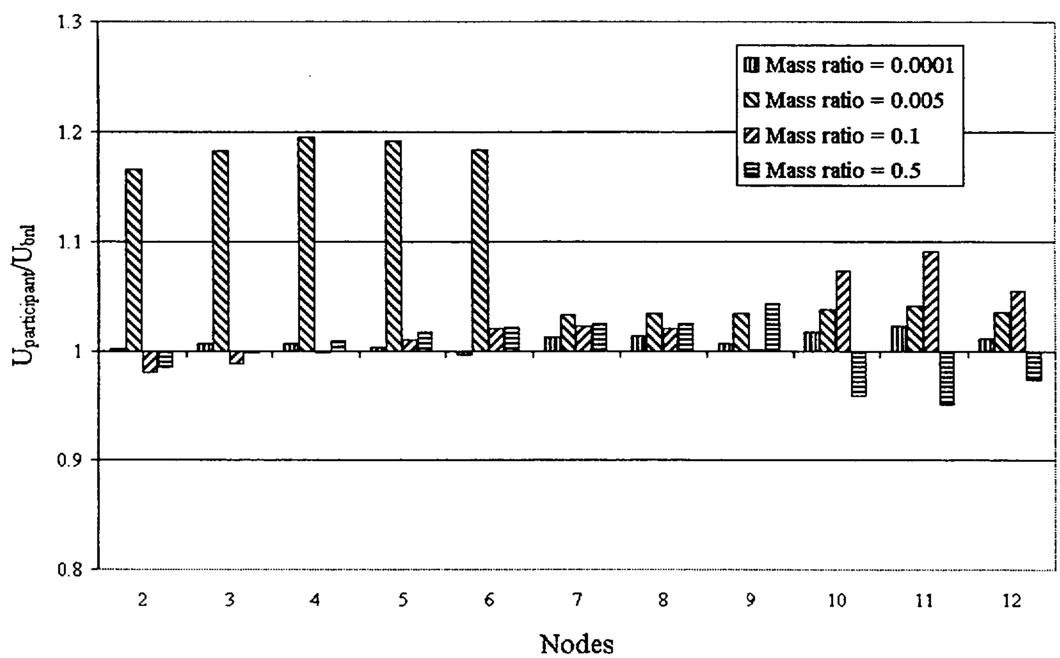

Figure 65. Effects of mass ratio variations for benchmark problem No. 2---S&A RSM-II.

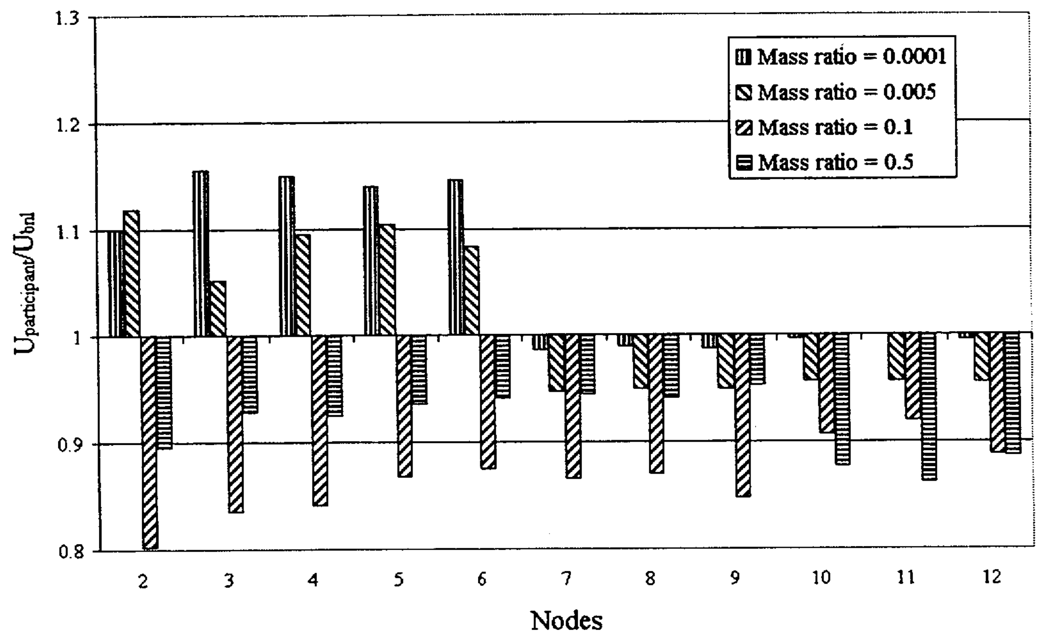

Figure 66. Effects of mass ratio variations for benchmark problem No. 2---Chen classical RSM.

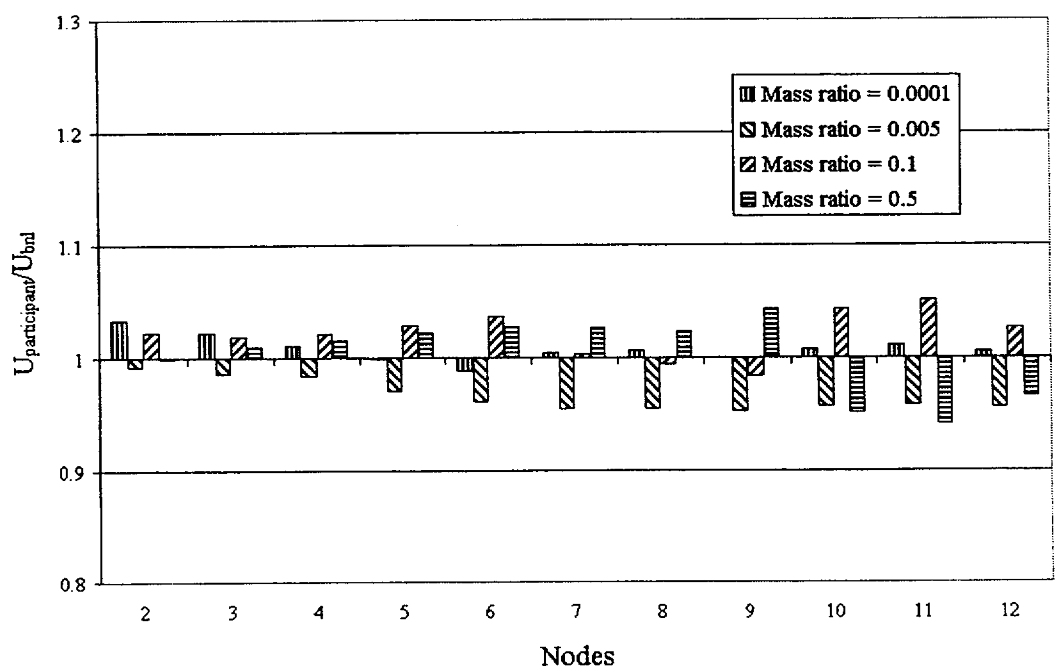

Figure 67. Effects of mass ratio variations for benchmark problem No. 2---Igusa/Der Kiureghian RSM.

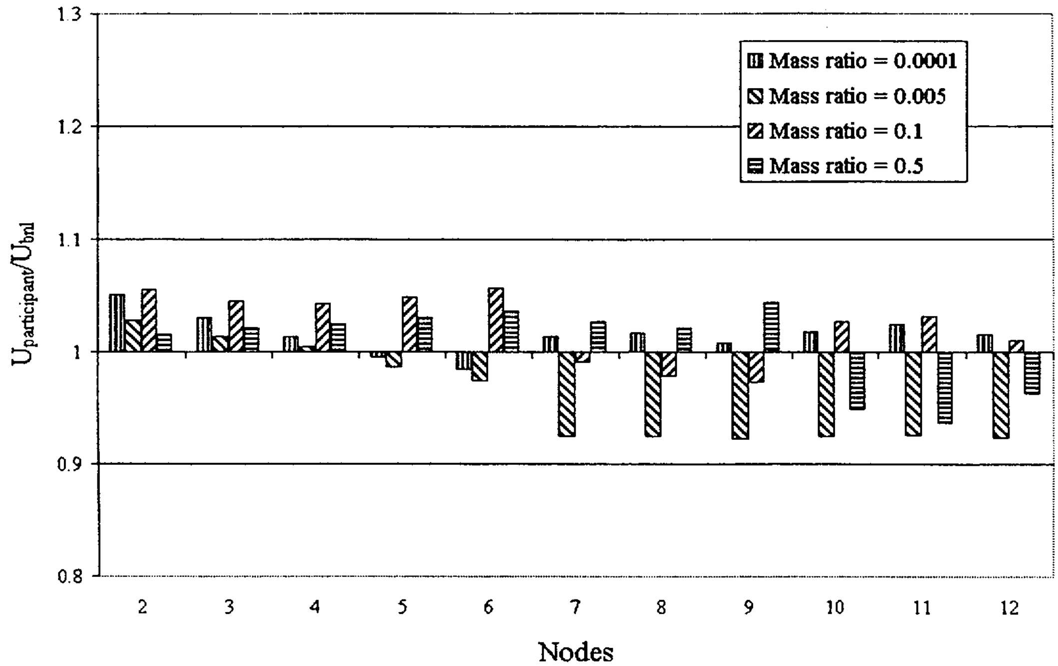

Figure 68. Effects of mass ratio variations for benchmark problem No. 2---Gupta RSM.

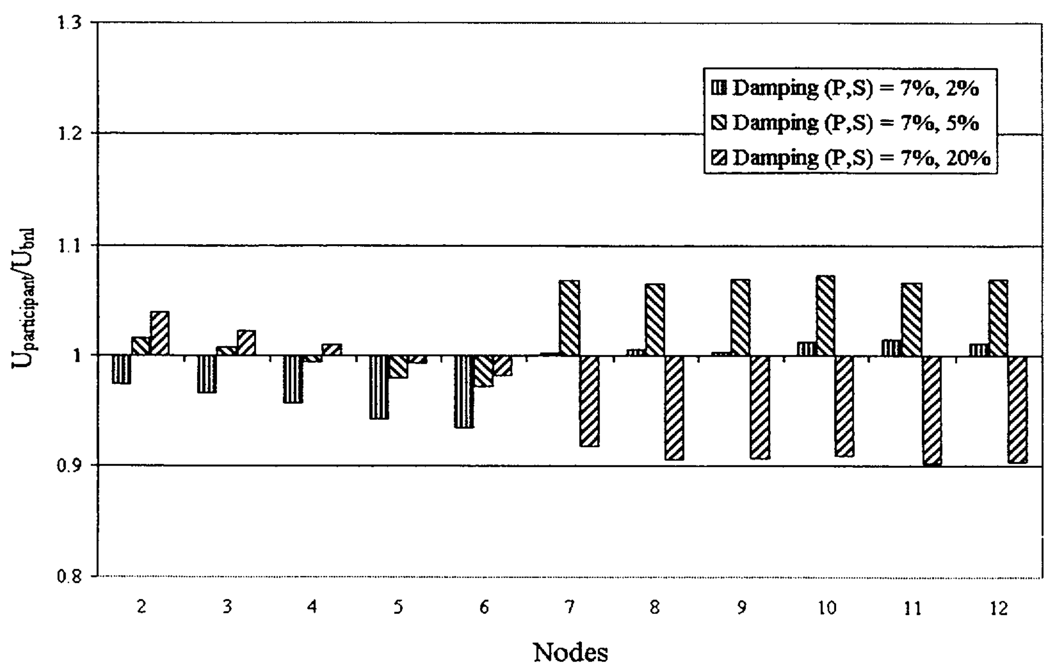

Figure 69. Effects of damping variations for benchmark problem No. 2---S&A RSM-I.

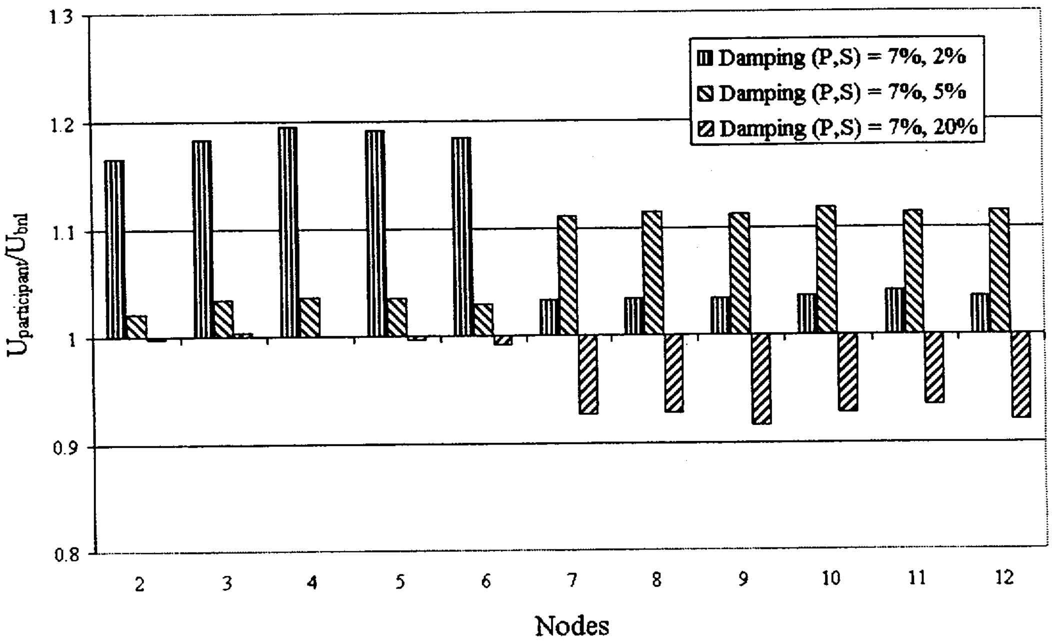

Figure 70. Effects of damping variations for benchmark problem No. 2---S&A RSM-II.

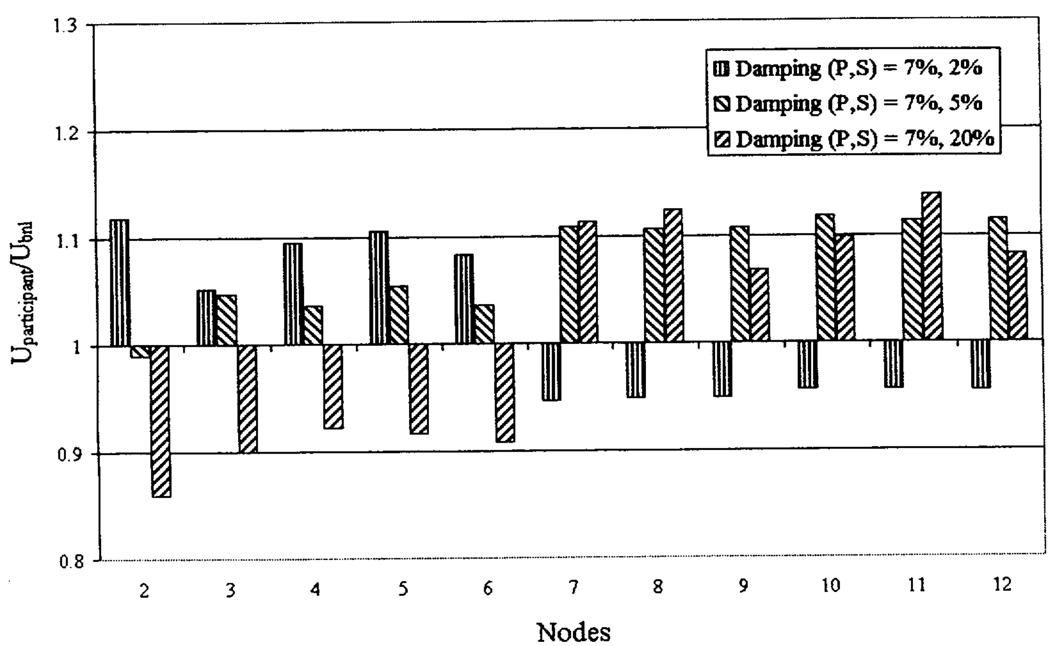

Figure 71. Effects of damping variations for benchmark problem No. 2-----Chen classical RSM.

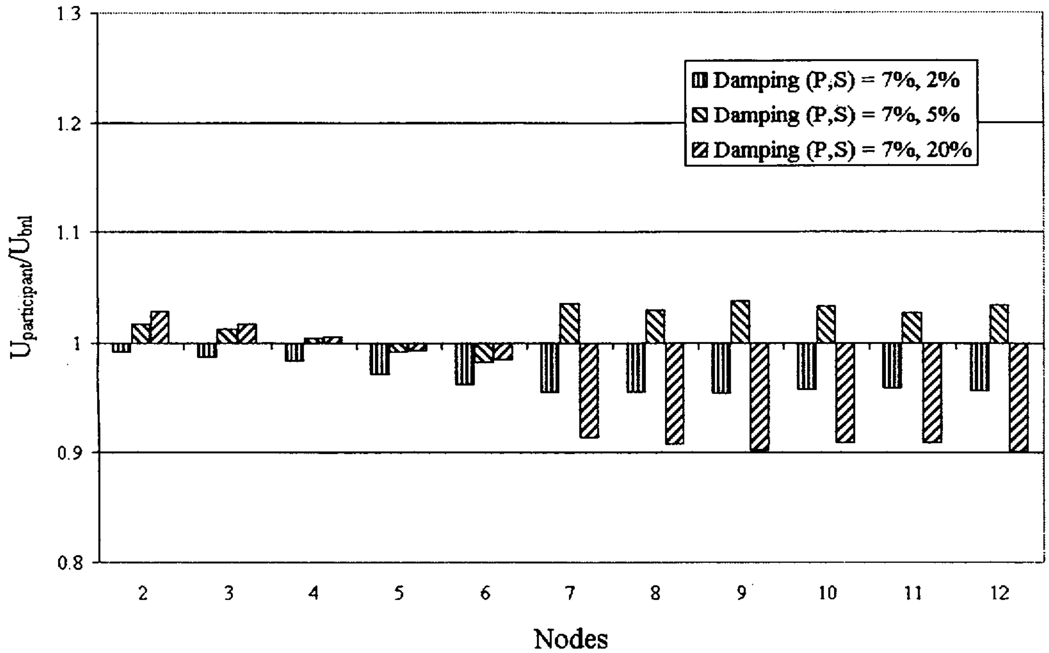

Figure 72. Effects of damping variations for benchmark problem No. 2-----Igusa/Der Kiureghian RSM.

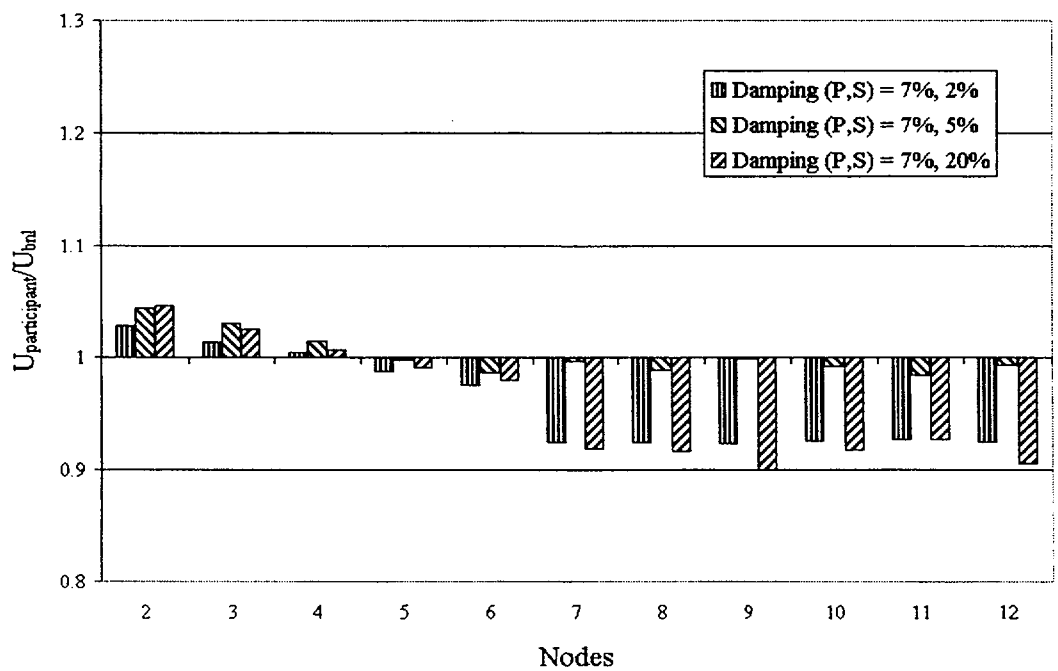

Figure 73. Effects of damping variations for benchmark problem No. 2-----Gupta RSM.

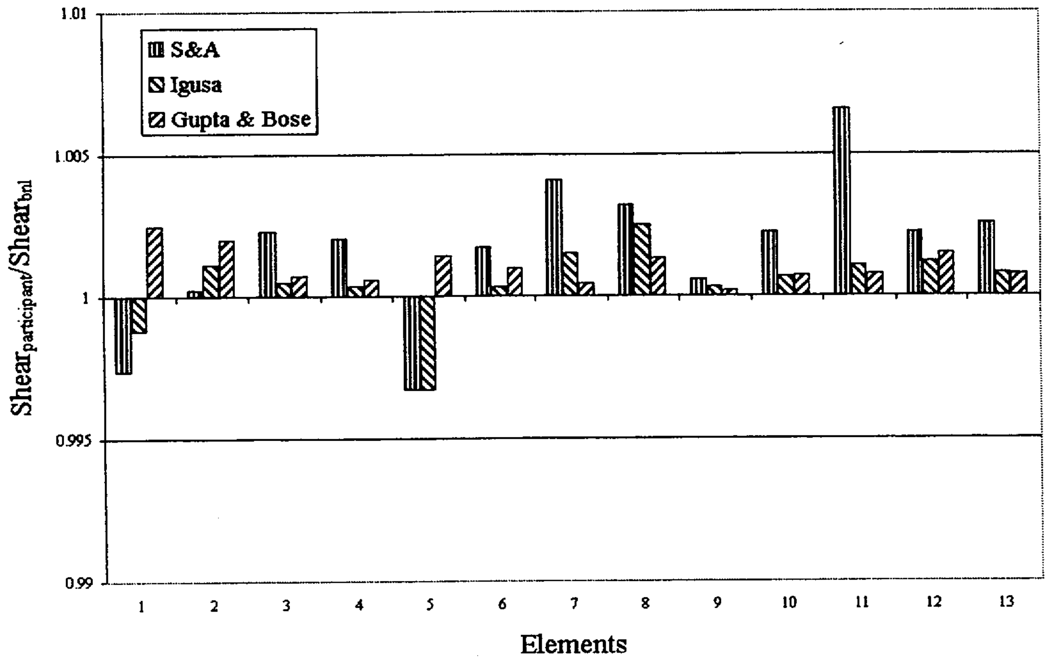

Figure 74. Comparison of maximum element shear forces for benchmark problem No. 2, Case a—Modal superposition time history analyses.

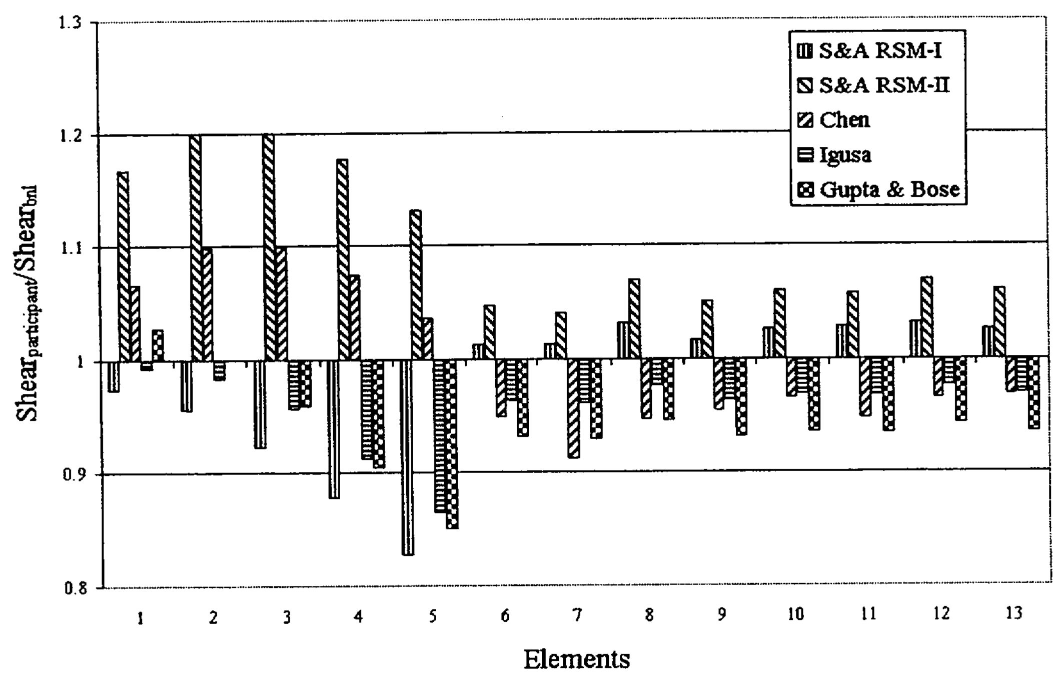

Figure 75. Comparison of maximum element shear forces of benchmark problem No. 2, Case a—Response spectrum methods.

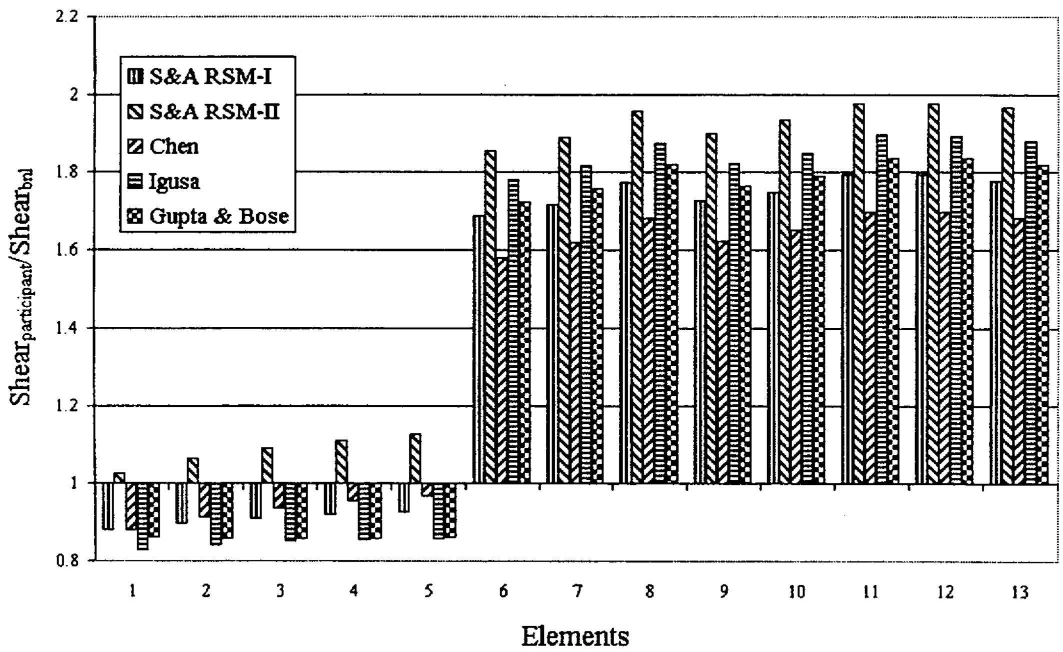

Figure 76.Comparison of maximum element shear forces for benchmark problem No. 2, Case m—Response spectrum methods.

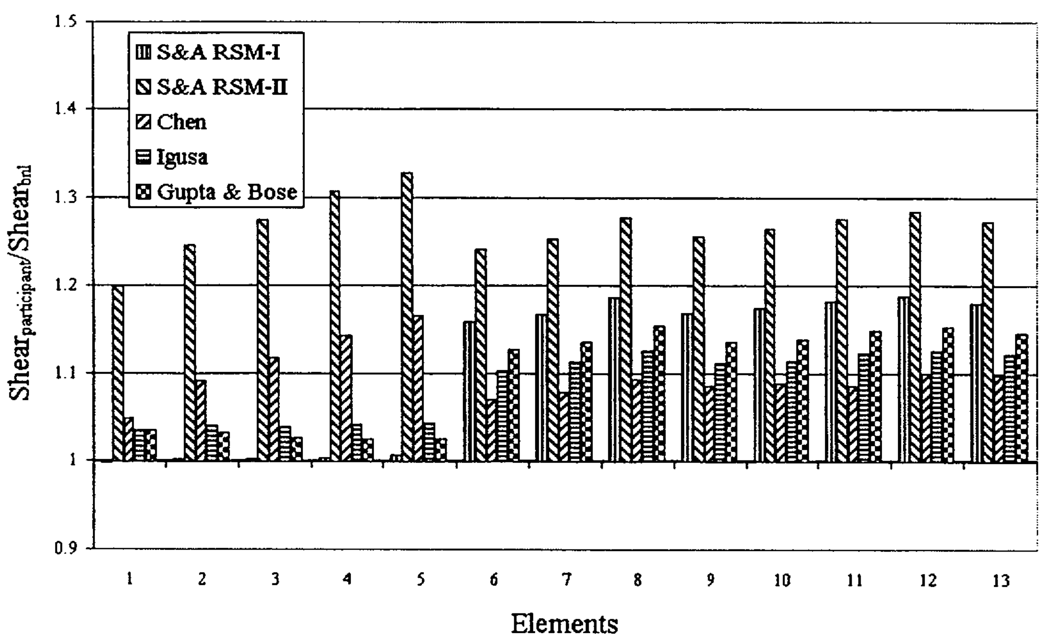

Figure 77.Comparison of mean responses of maximum element shear forces for benchmark problem No. 2 for seven earthquakes—Response spectrum methods.

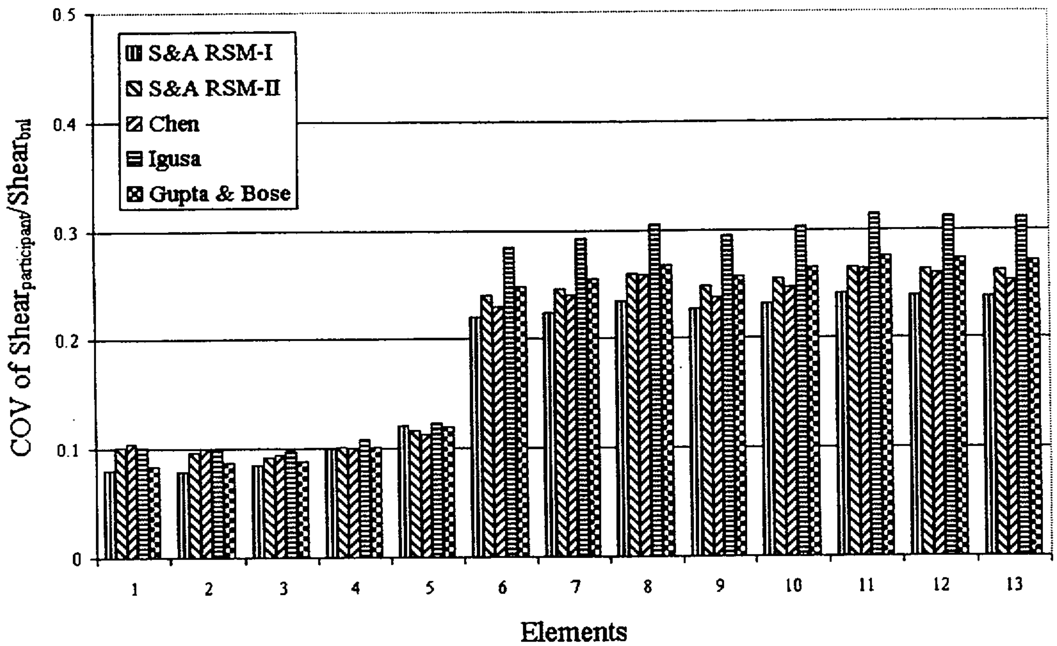

Figure 78. Comparison of Coefficients of variation of maximum element shear forces for benchmark problem No. 2 for seven earthquakes---Response spectrum methods

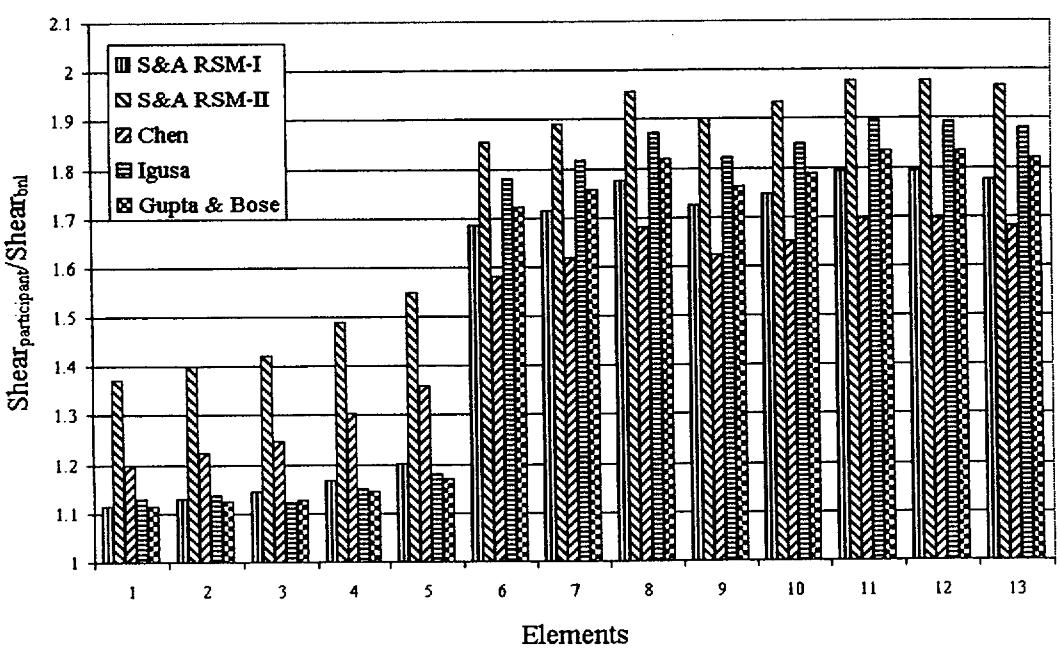

Figure 79. Comparison of maximum ratios of maximum element shear forces for benchmark problem No. 2 for seven earthquakes---Response spectrum methods

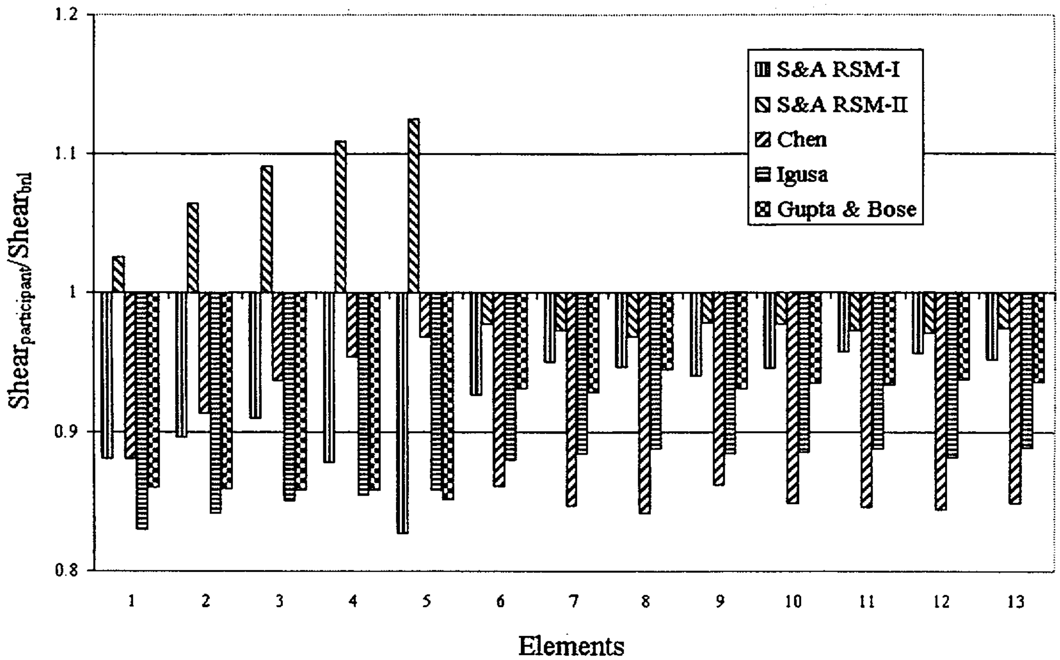

Figure 80. Comparison of minimum ratios of maximum element shear forces for benchmark problem No. 2 for seven earthquakes---Response spectrum methods

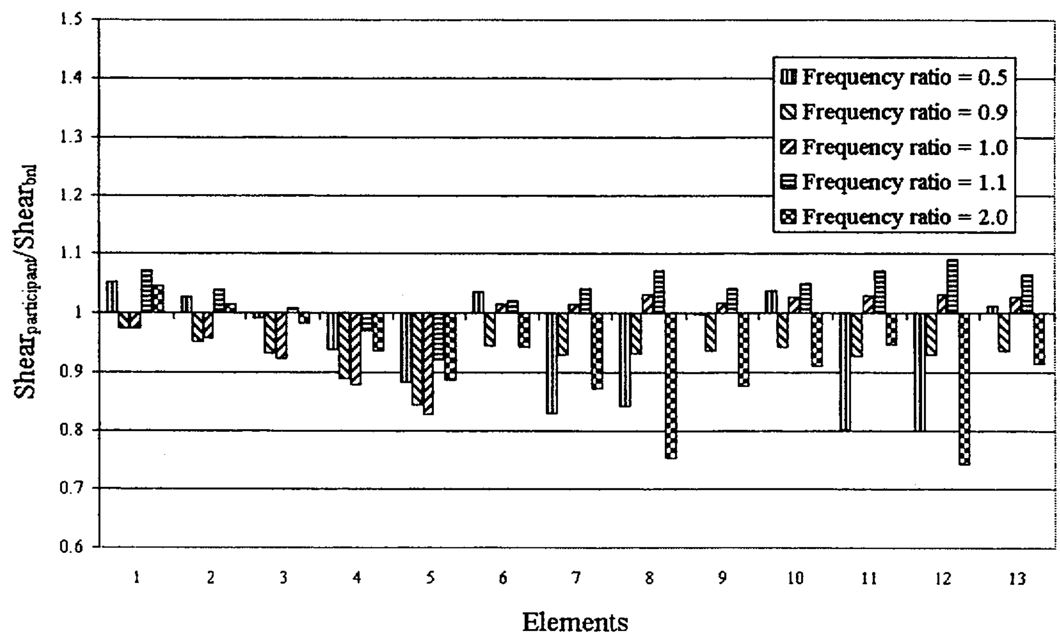

Figure 81. Effects of frequency variations for benchmark problem No. 2---S&A RSM-I.

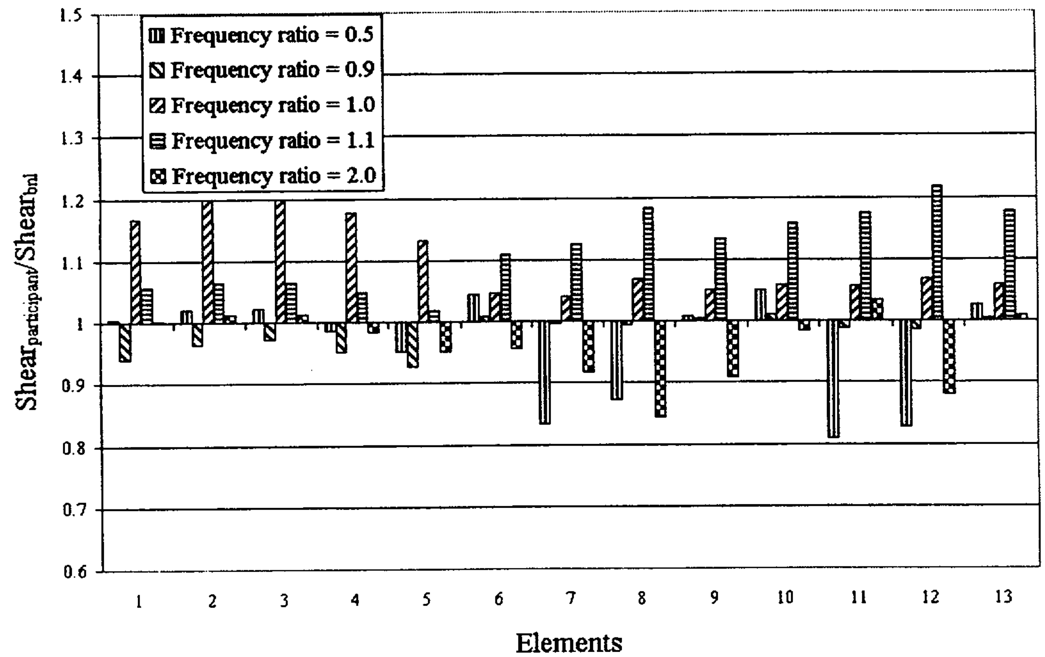

Figure 82. Effects of frequency variations for benchmark problem No. 2---S&A RSM-II.

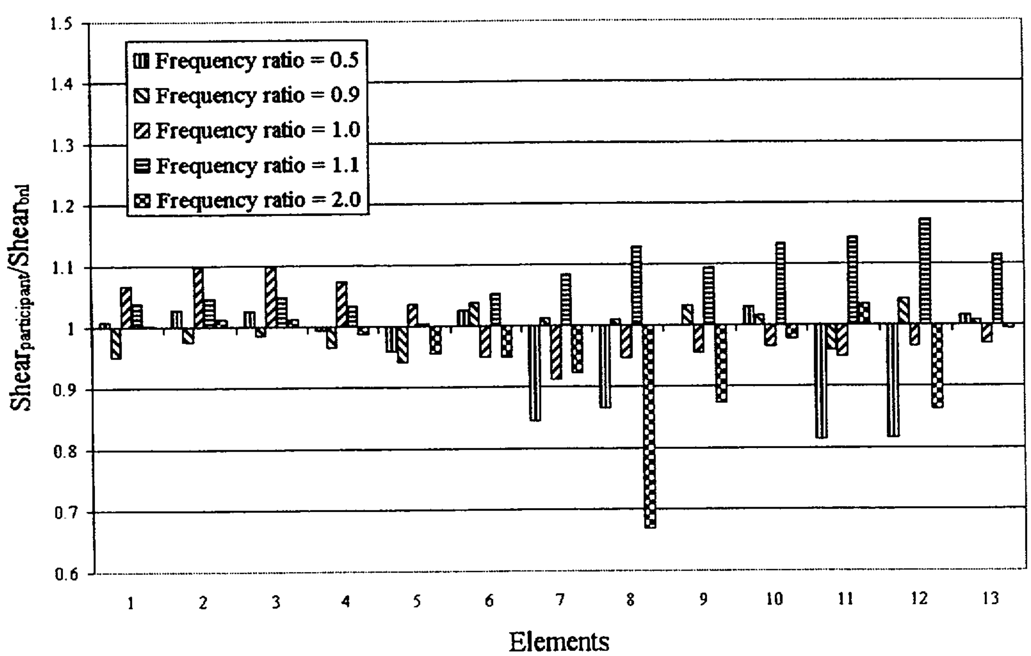

Figure 83. Effects of frequency variations for benchmark problem No. 2---Chen classical RSM.

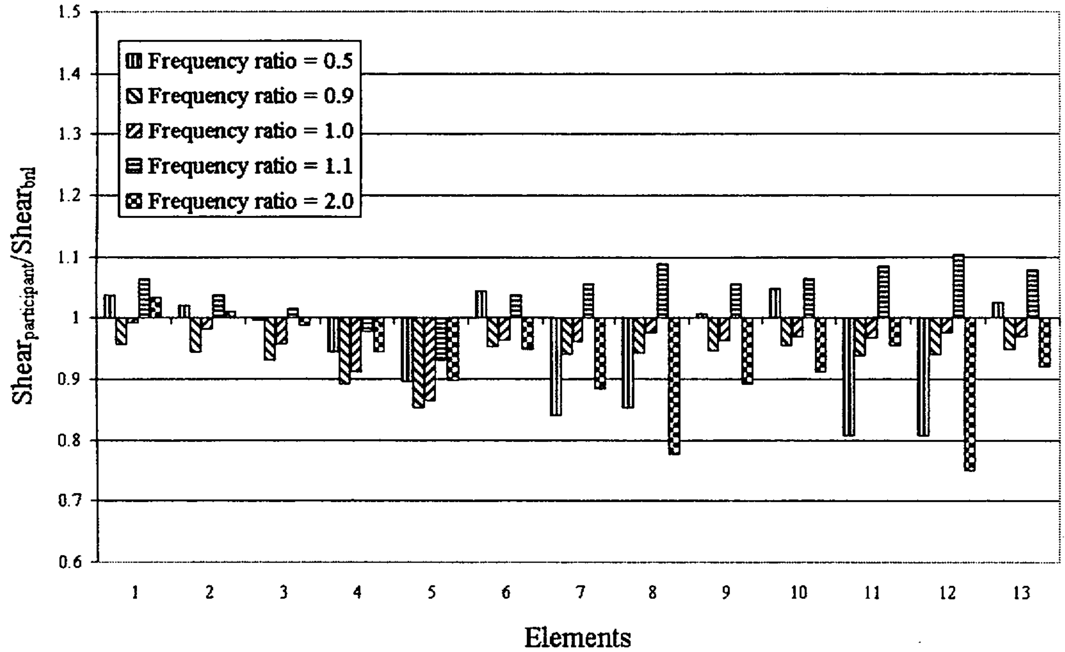

Figure 84. Effects of frequency variations for benchmark problem No. 2---Igusa/Der Kiureghian RSM

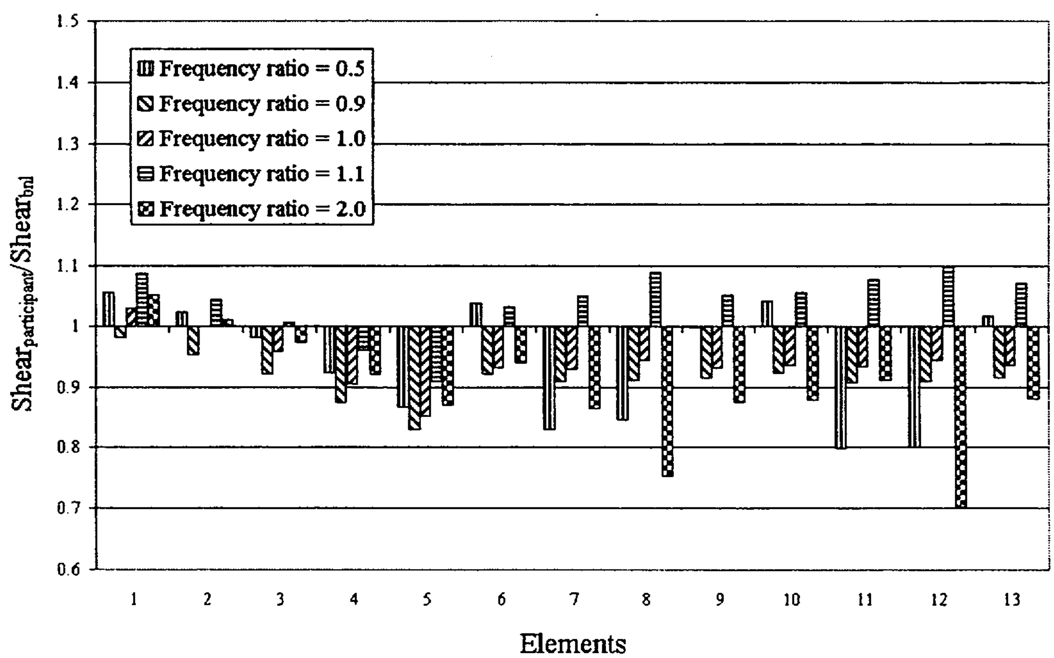

Figure 85. Effects of frequency variations for benchmark problem No. 2---Gupta RSM

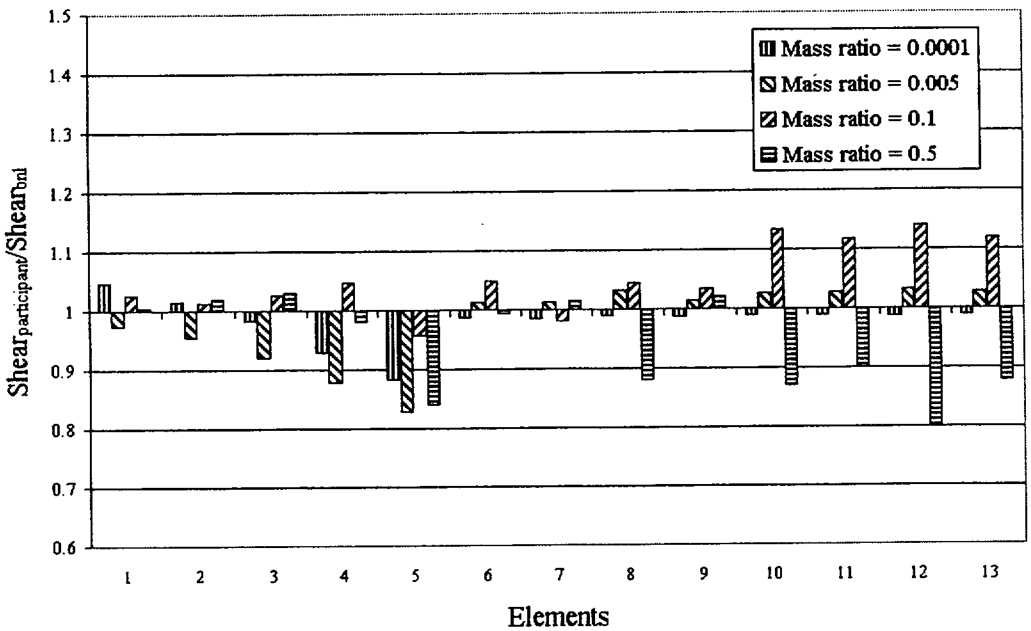

Figure 86. Effects of mass ratio variations for benchmark problem No. 2---S&A RSM-I.

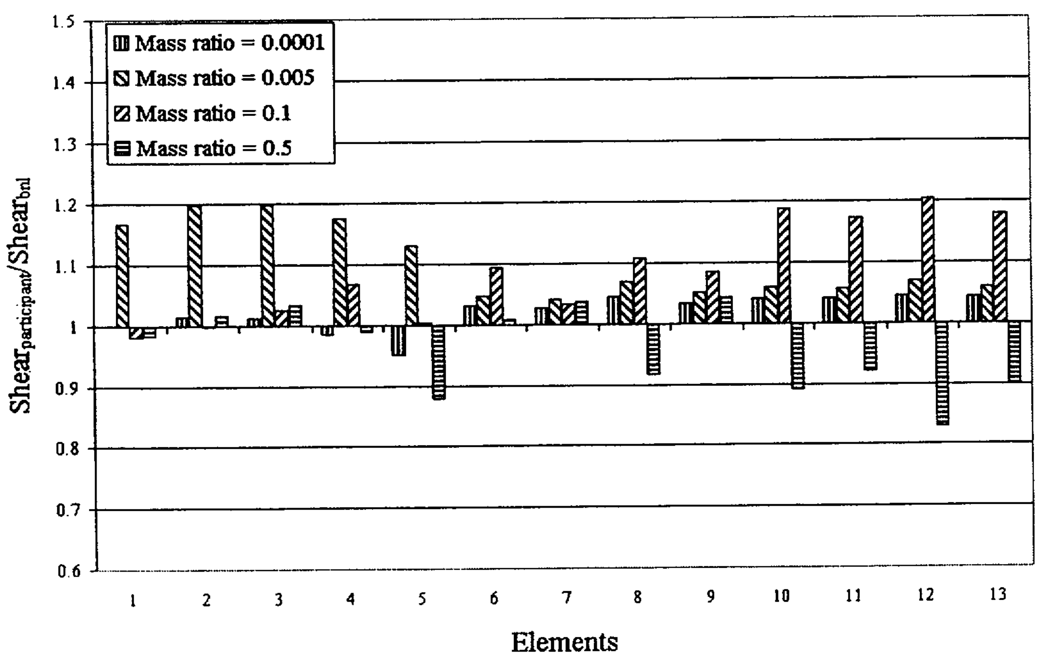

Figure 87. Effects of mass ratio variations for benchmark problem No. 2---S&A RSM-II.

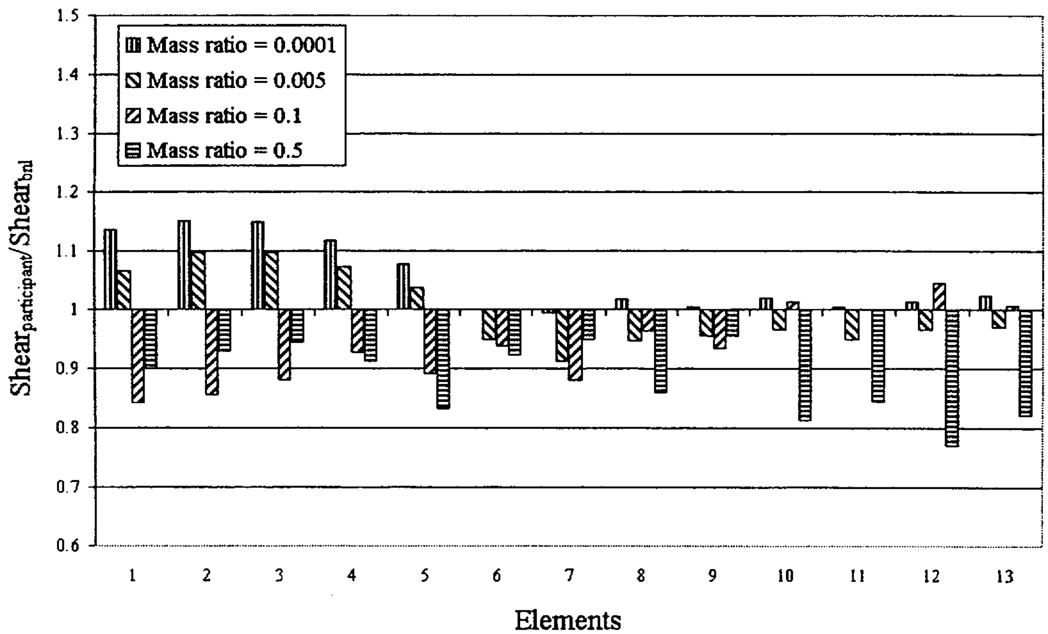

Figure 88. Effects of mass ratio variations for benchmark problem No. 2---Chen classical RSM.

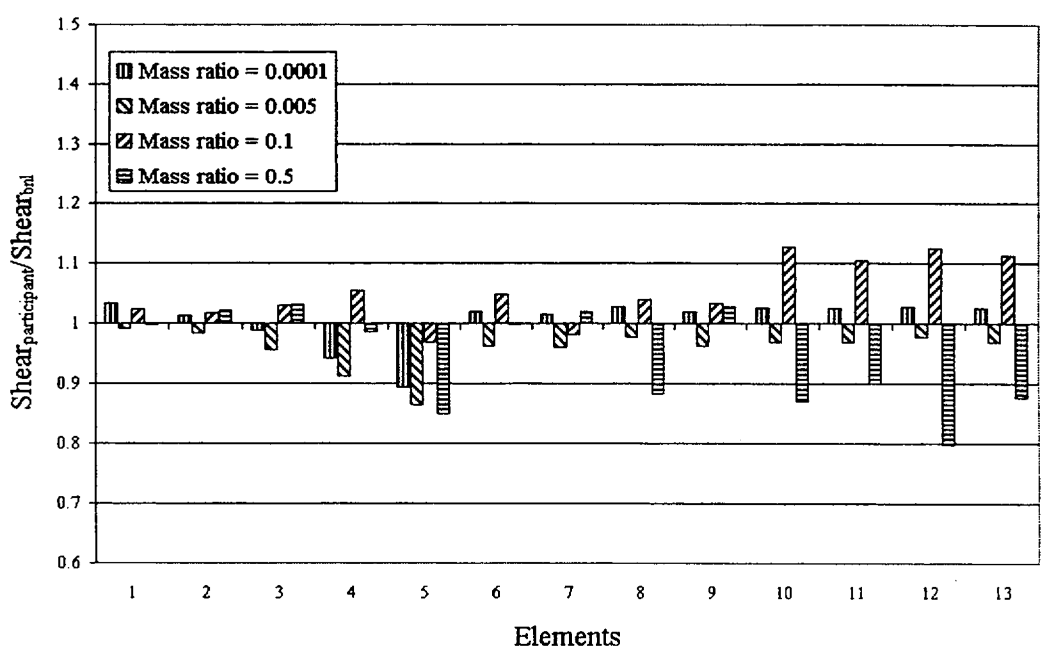

Figure 89. Effects of mass ratio variations for benchmark problem No. 2---Igusa/Der Kiureghian RSM.

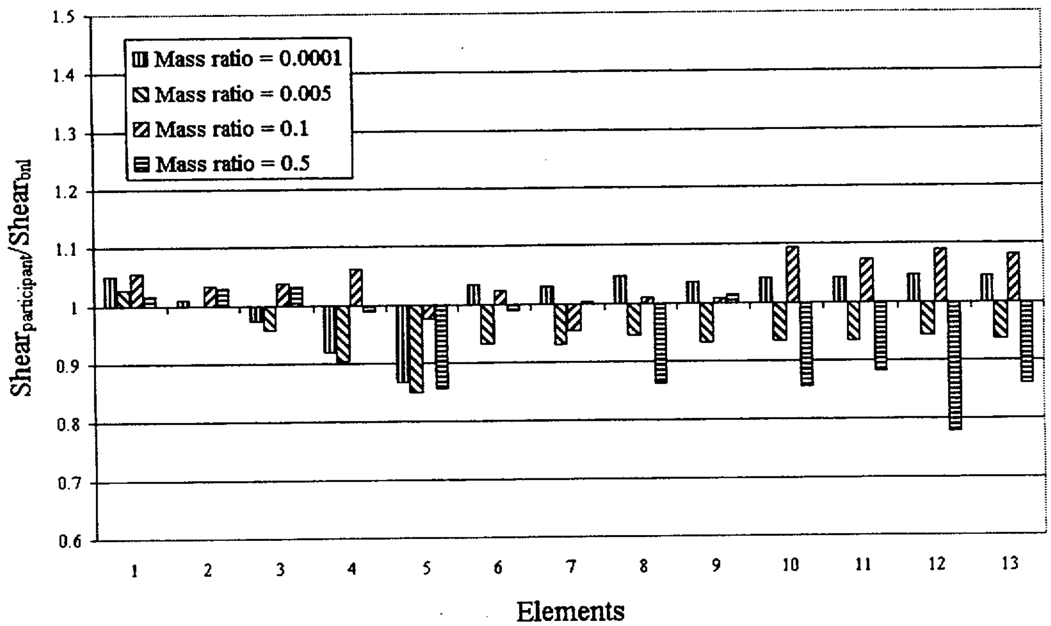

Figure 90. Effects of mass ratio variations for benchmark problem No. 2---Gupta RSM.

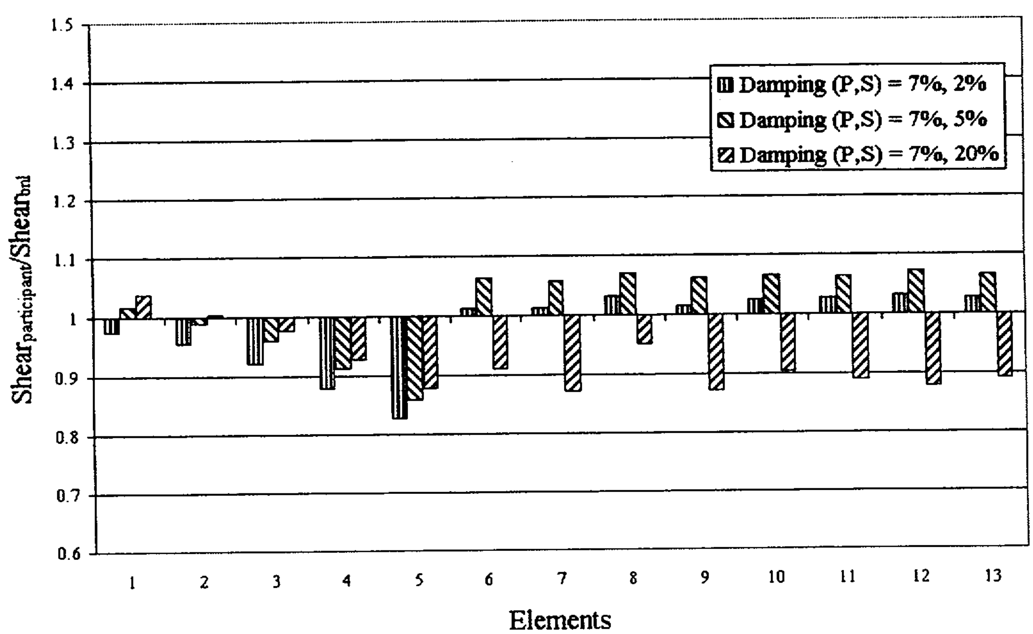

Figure 91. Effects of damping variations for benchmark problem No. 2---S&A RSM-I.

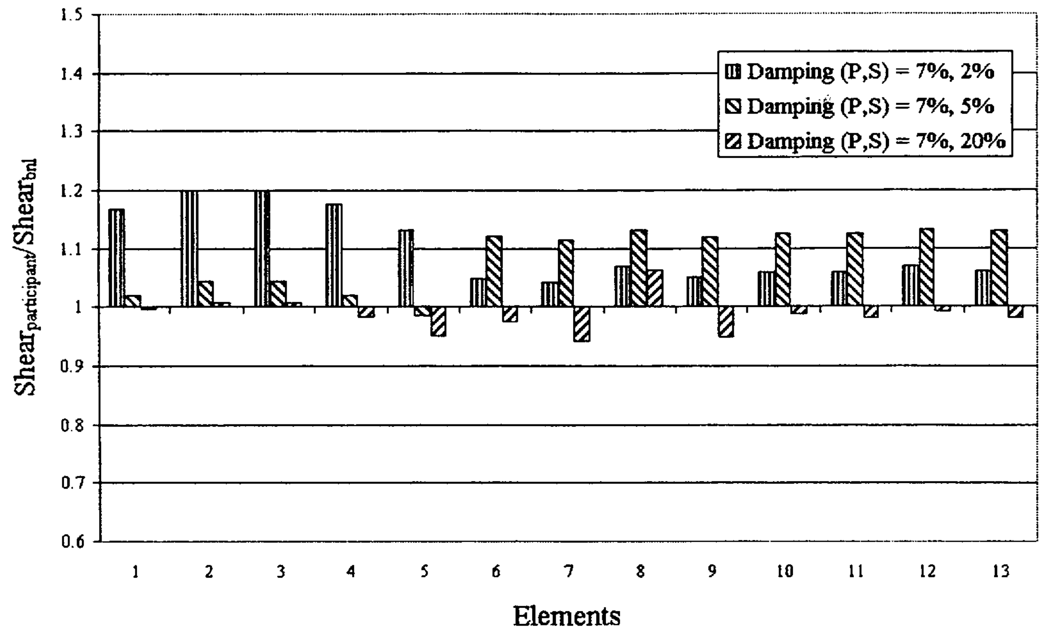

Figure 92. Effects of damping variations for benchmark problem No. 2---S&A RSM-II.

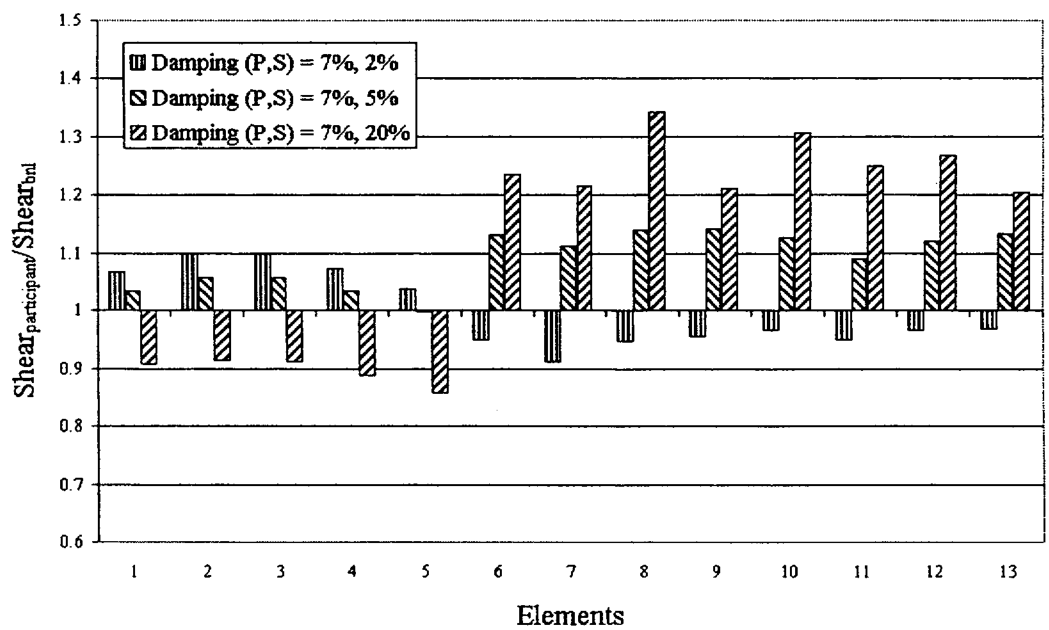

Figure 93. Effects of damping variations for benchmark problem No. 2-----Chen classical RSM.

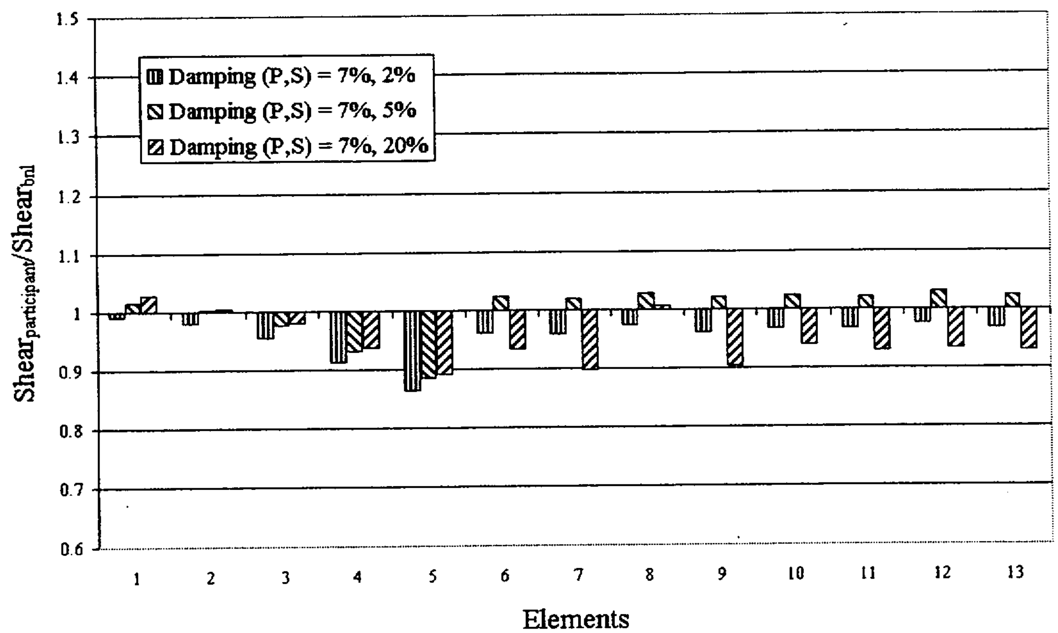

Figure 94. Effects of damping variations for benchmark problem No. 2-----Igusa/Der Kiureghian RSM.

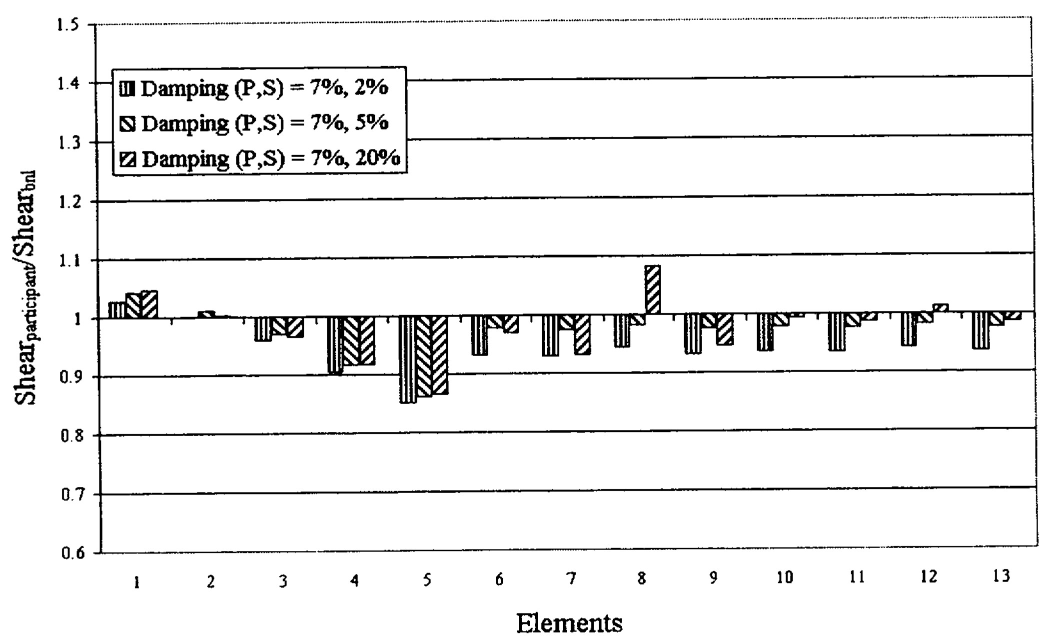

Figure 95. Effects of damping variations for benchmark problem No. 2-----Gupta RSM.

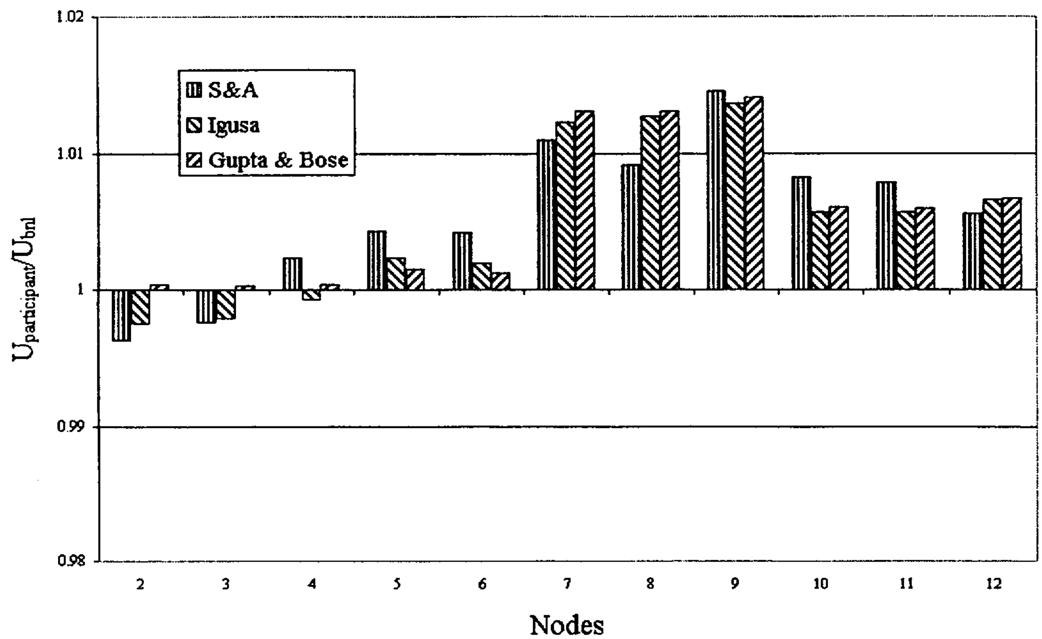

Figure 96.Comparison of maximum displacements for benchmark problem No. 3, Case a—Modal superposition time history analyses.

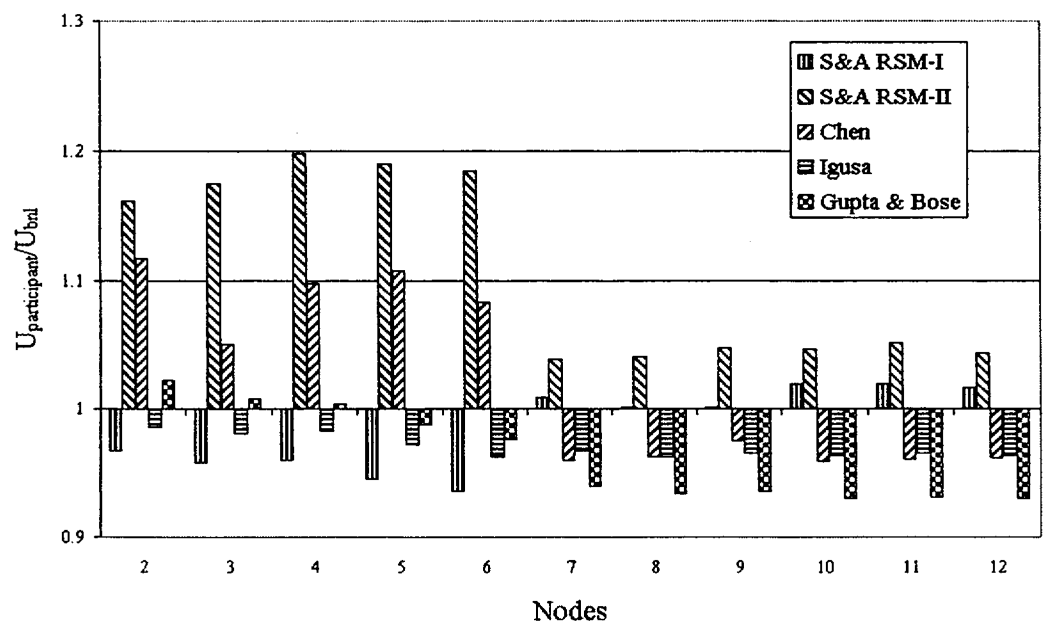

Figure 97.Comparison of maximum displacements for benchmark problem No. 3, Case a—Response spectrum methods.

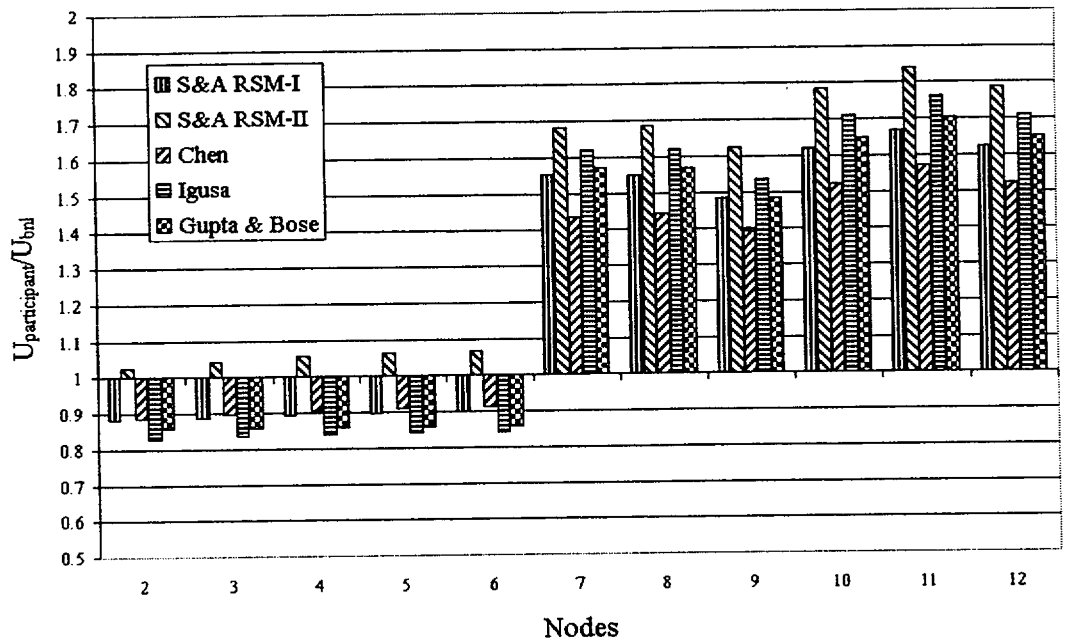

Figure 98.Comparison of maximum displacements for benchmark problem No. 3, Case m—Response spectrum methods.

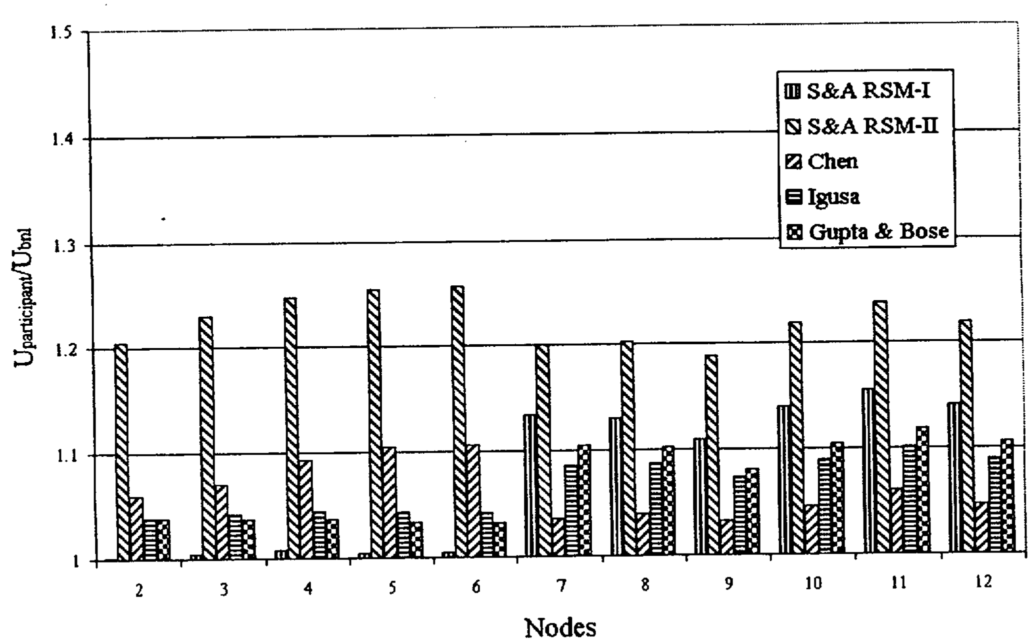

Figure 99.Comparison of mean responses of maximum displacements for benchmark problem No. 3 for seven earthquakes—Response spectrum methods.

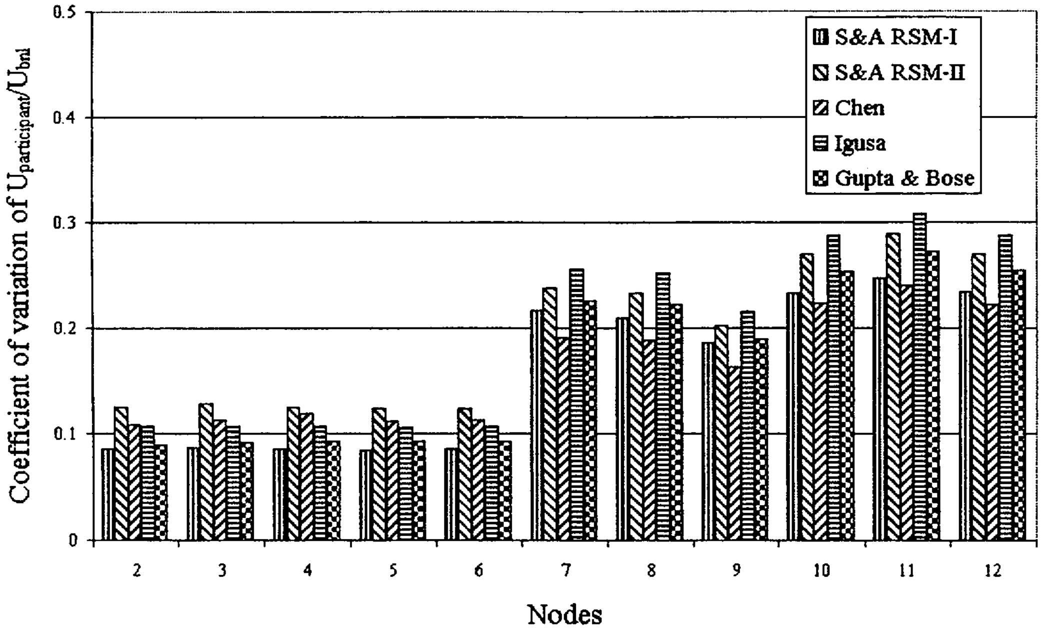

Figure 100. Comparison of Coefficients of variation of maximum displacements for benchmark problem No. 3 for seven earthquakes---Response spectrum methods

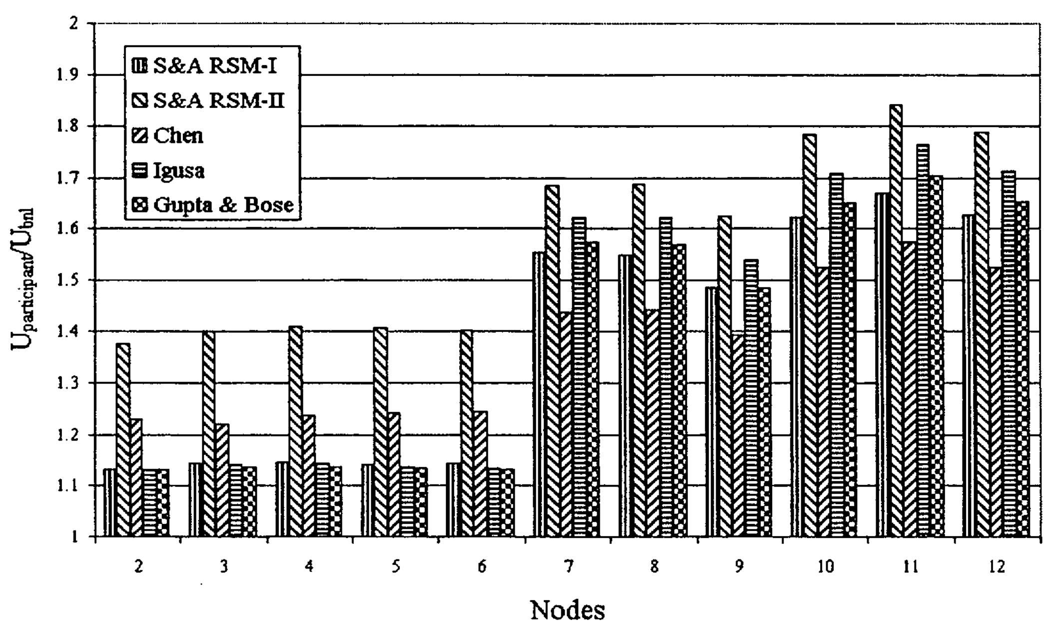

Figure 101. Comparison of maximum ratios of maximum displacements for benchmark problem No. 3 for seven earthquakes---Response spectrum methods

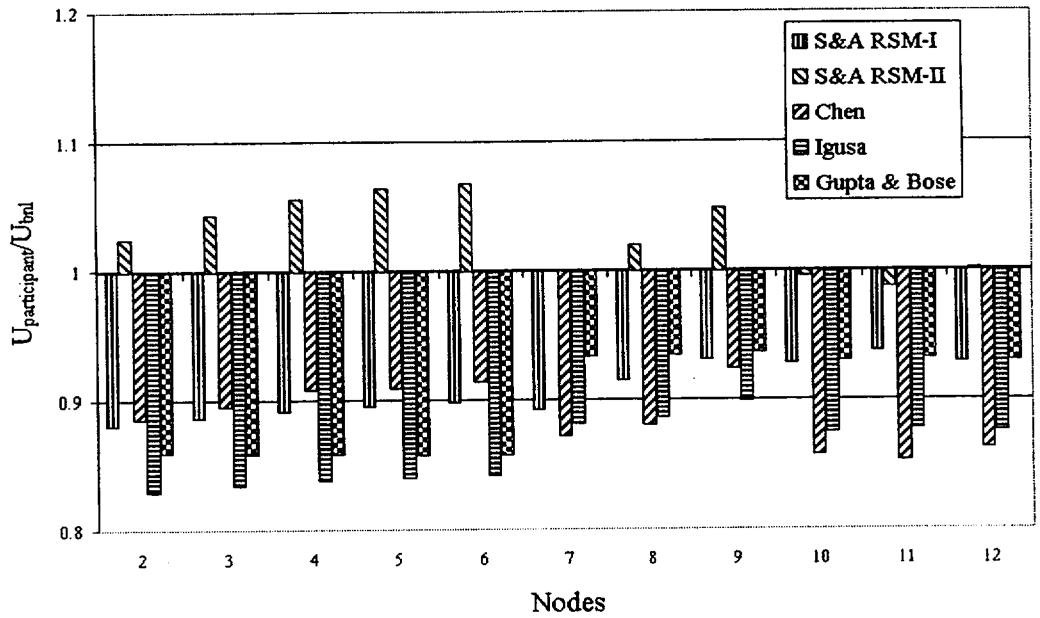

Figure 102. Comparison of minimum ratios of maximum displacements for benchmark problem No. 3 for seven earthquakes---Response spectrum methods

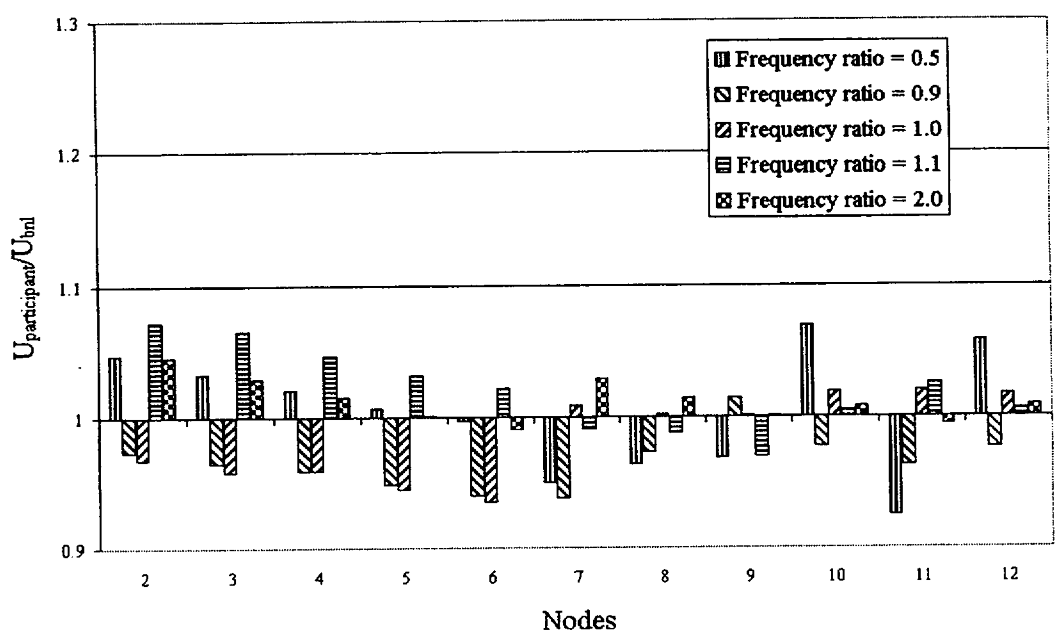

Figure 103. Effects of frequency variations for benchmark problem No. 3---S&A RSM-I.

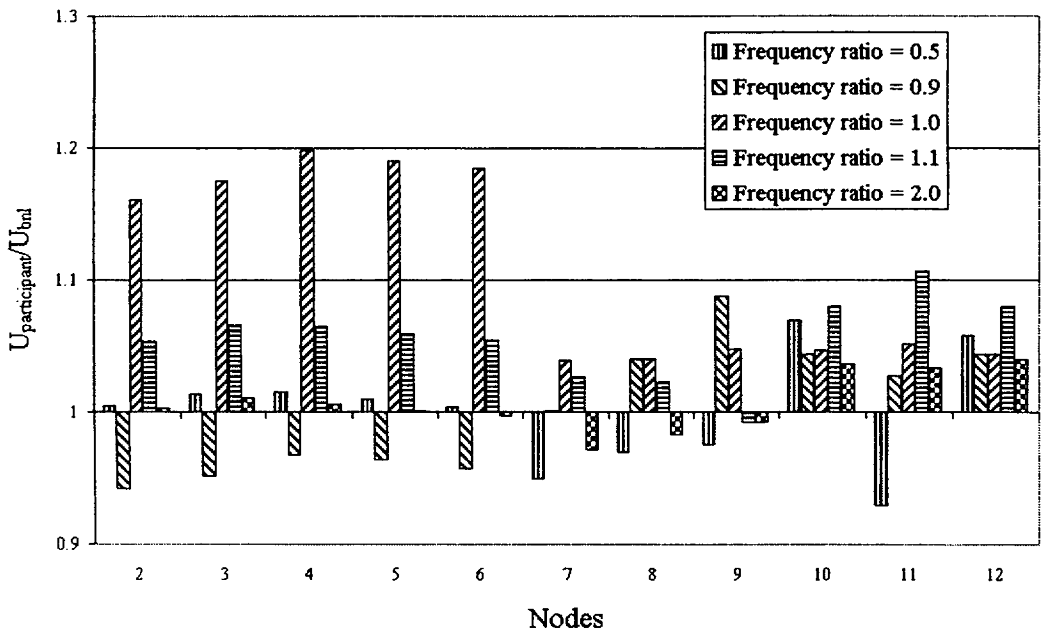

Figure 104. Effects of frequency variations for benchmark problem No. 3---S&A RSM-II.

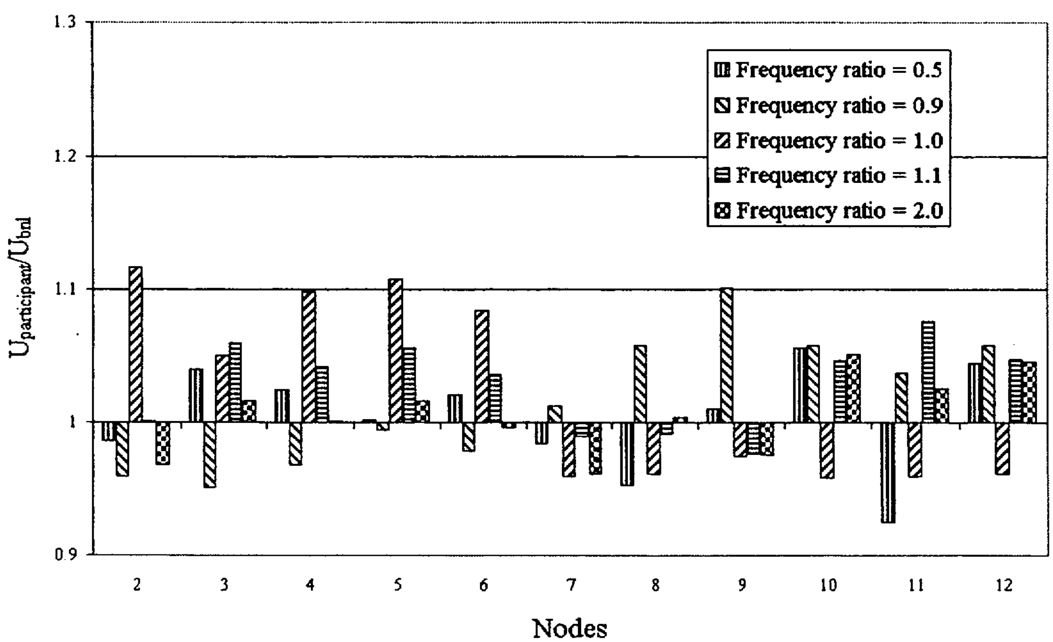

Figure 105. Effects of frequency variations for benchmark problem No. 3---Chen classical RSM.

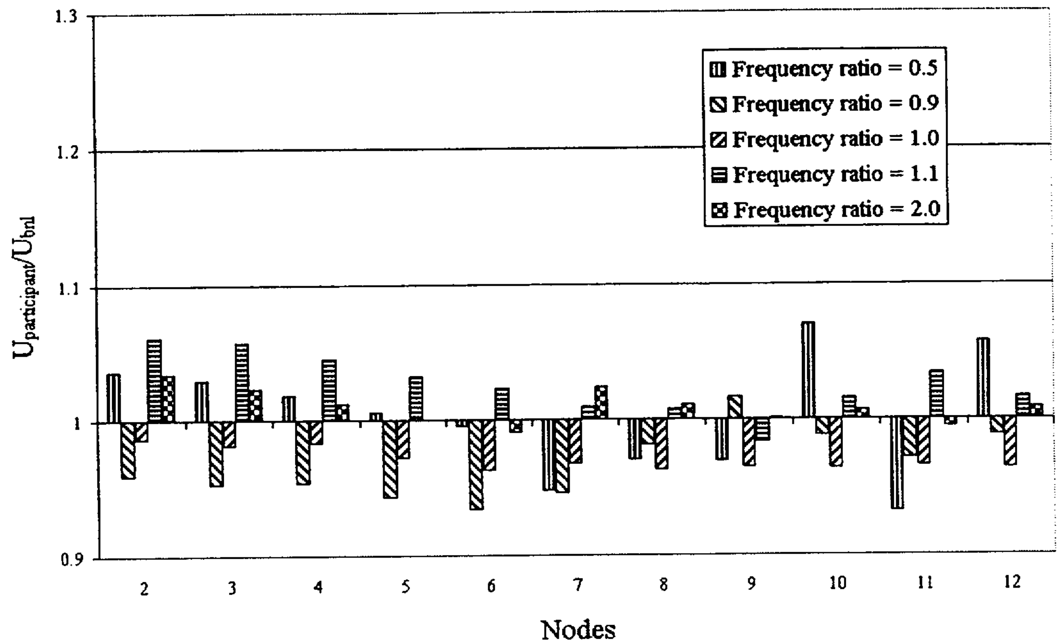

Figure 106. Effects of frequency variations for benchmark problem No. 3---Igusa/Der Kiureghian RSM

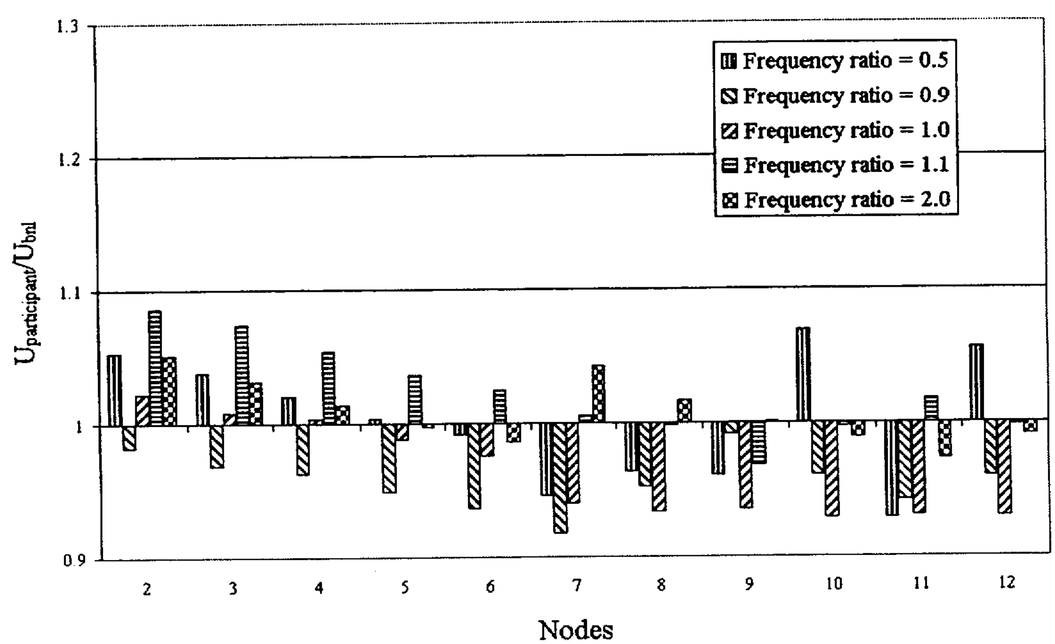

Figure 107. Effects of frequency variations for benchmark problem No. 3---Gupta RSM

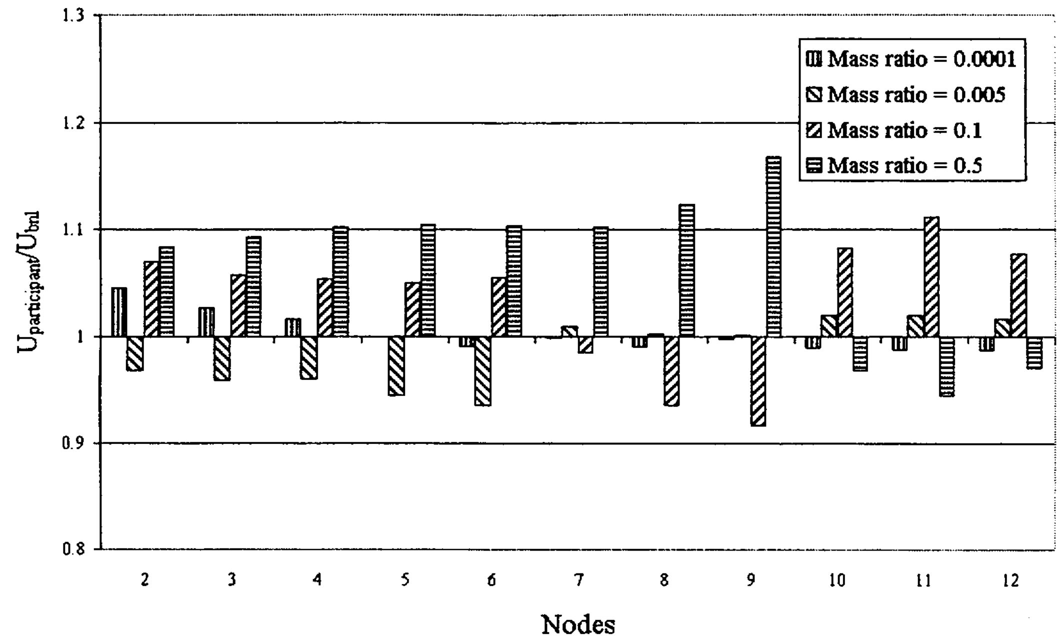

Figure 108. Effects of mass ratio variations for benchmark problem No. 3---S&A RSM-I.

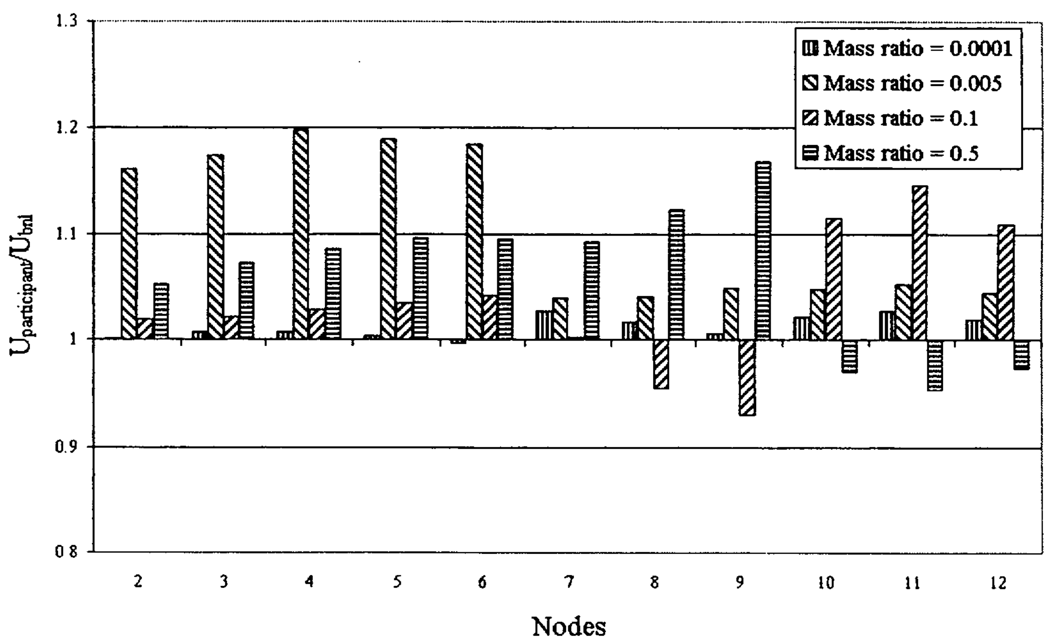

Figure 109. Effects of mass ratio variations for benchmark problem No. 3---S&A RSM-II.

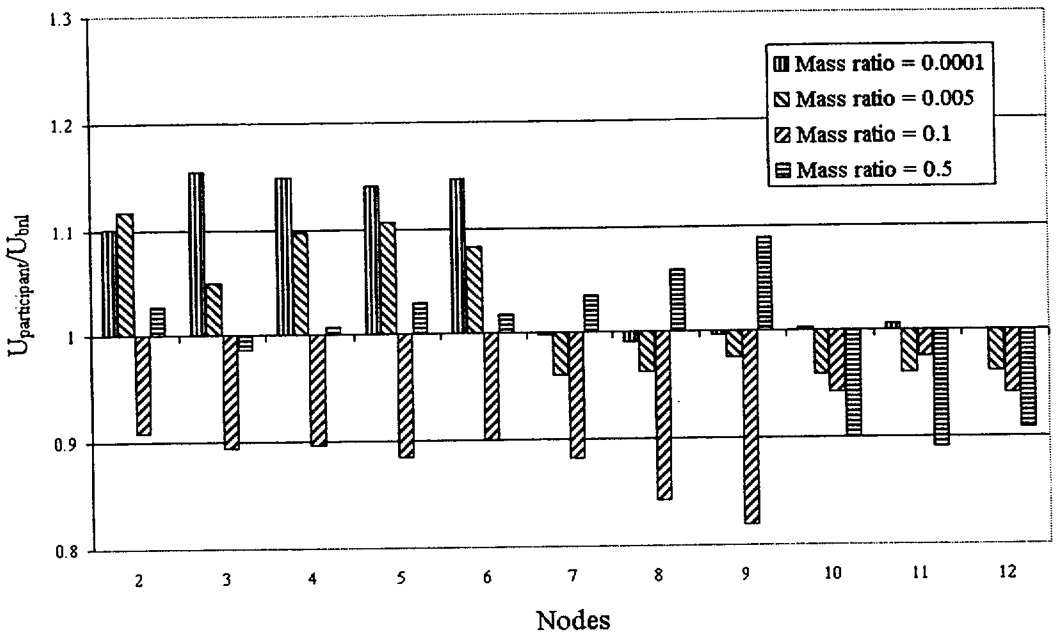

Figure 110. Effects of mass ratio variations for benchmark problem No. 3---Chen classical RSM.

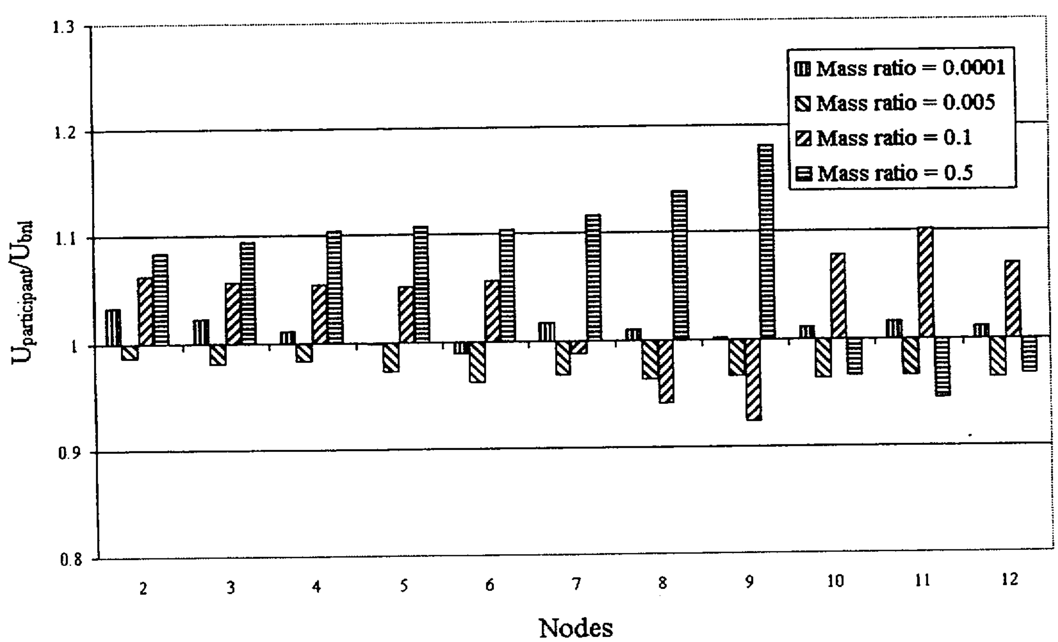

Figure 111. Effects of mass ratio variations for benchmark problem No. 3---Igusa/Der Kiureghian RSM.

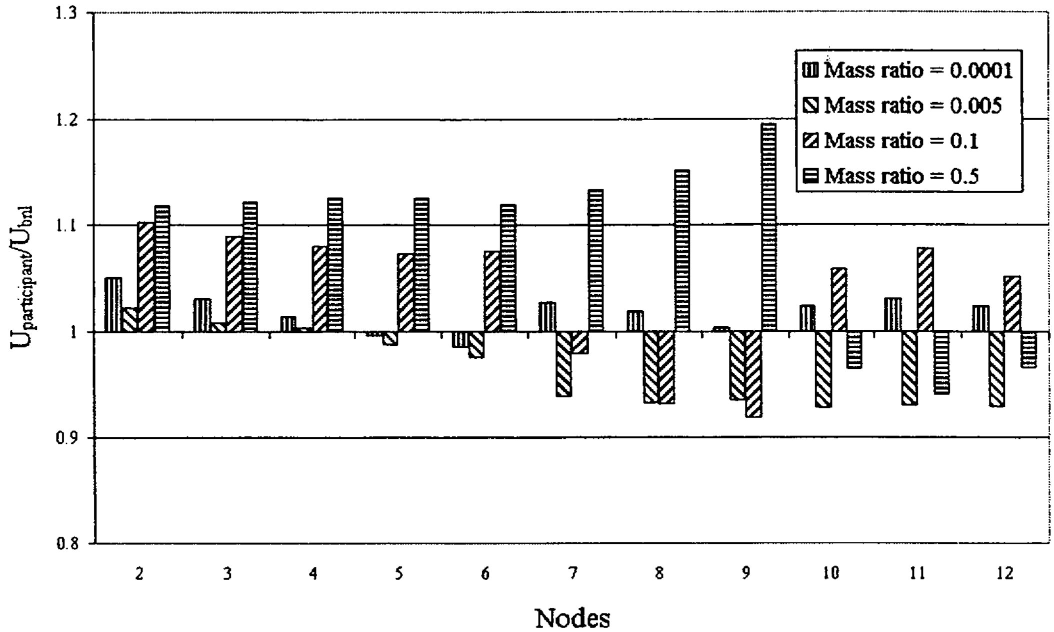

Figure 112. Effects of mass ratio variations for benchmark problem No. 3---Gupta RSM.

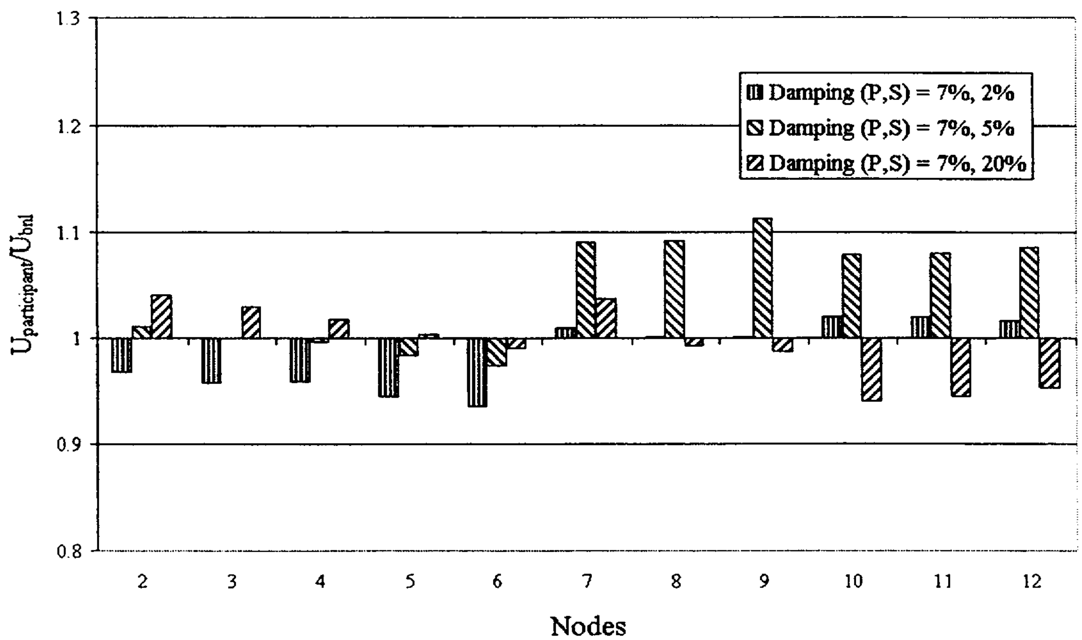

Figure 113. Effects of damping variations for benchmark problem No. 3---S&A RSM-I.

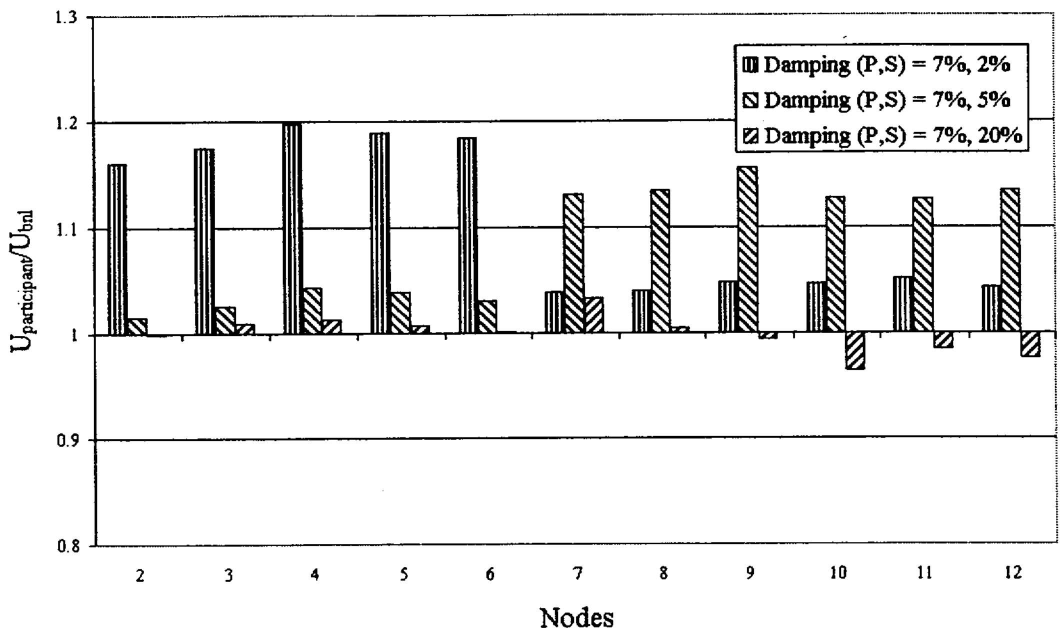

Figure 114. Effects of damping variations for benchmark problem No. 3---S&A RSM-II.

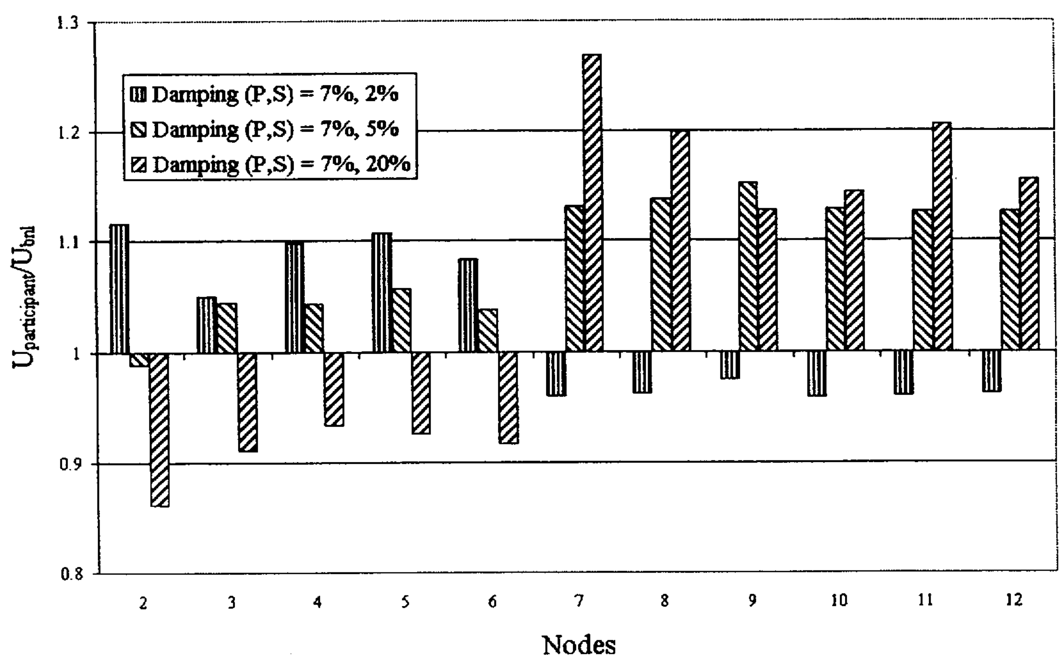

Figure 115. Effects of damping variations for benchmark problem No. 3-----Chen classical RSM.

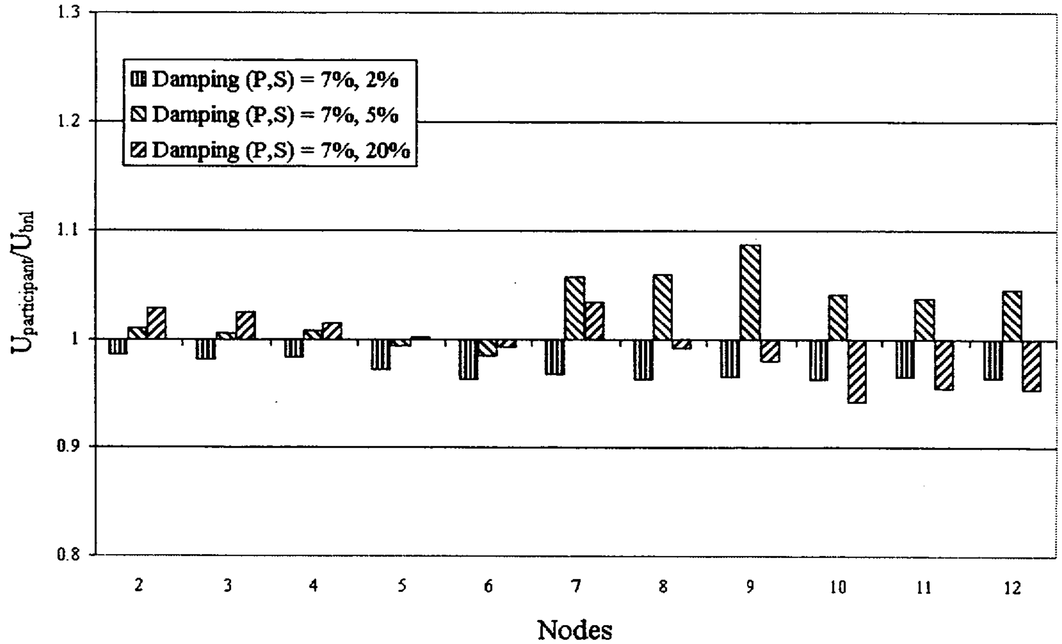

Figure 116. Effects of damping variations for benchmark problem No. 3-----Igusa/Der Kiureghian RSM.

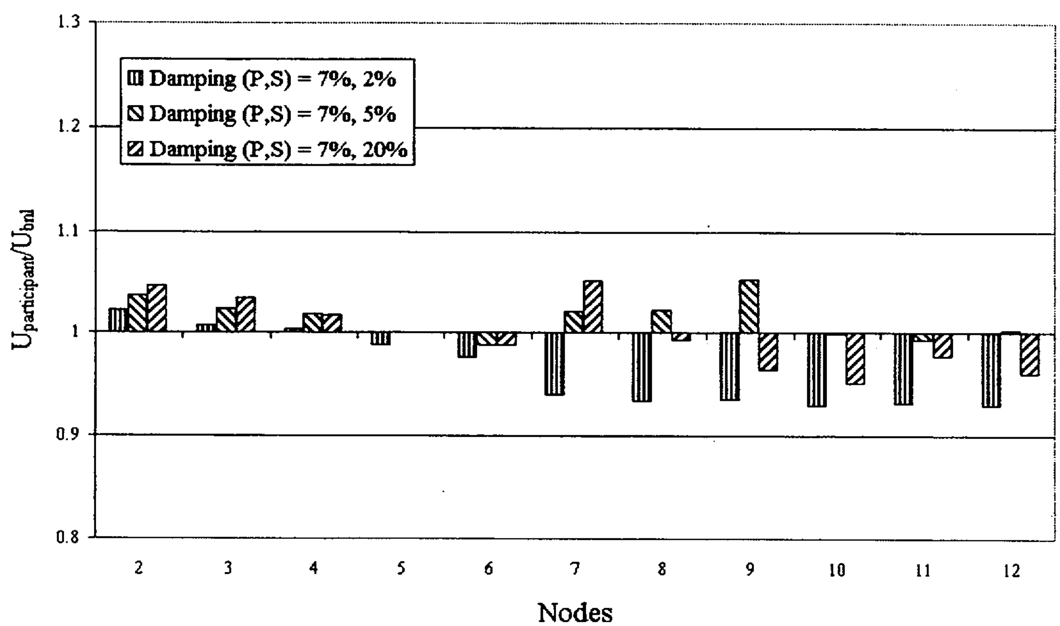

Figure 117. Effects of damping variations for benchmark problem No. 3-----Gupta RSM.

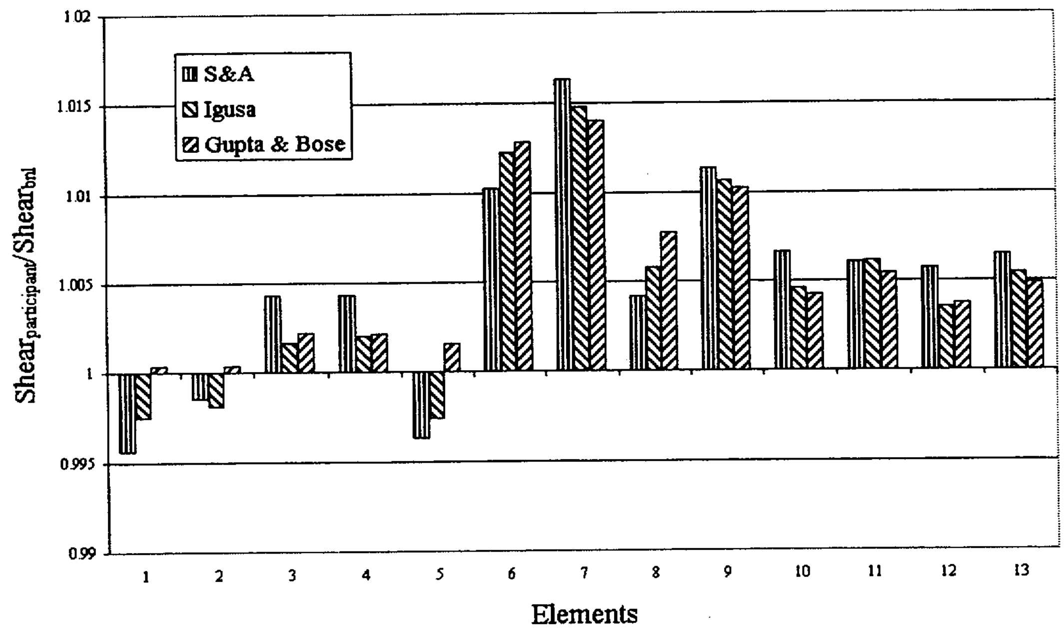

Figure 118. Comparison of maximum element shear forces for benchmark problem No. 3, Case a—Modal superposition time history analyses.

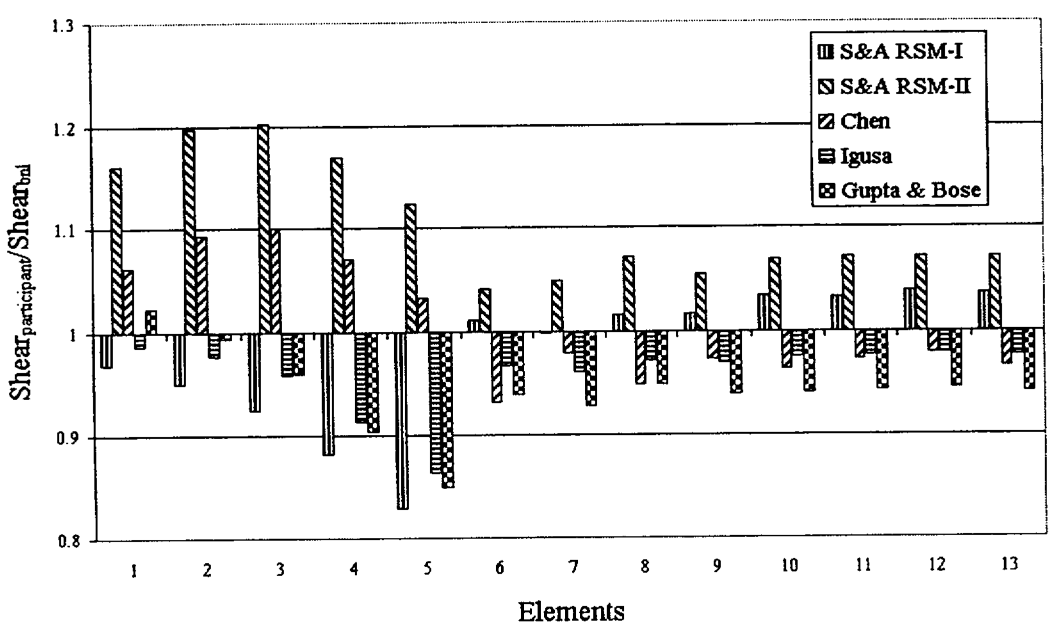

Figure 119. Comparison of maximum element shear forces of benchmark problem No. 3, Case a—Response spectrum methods.

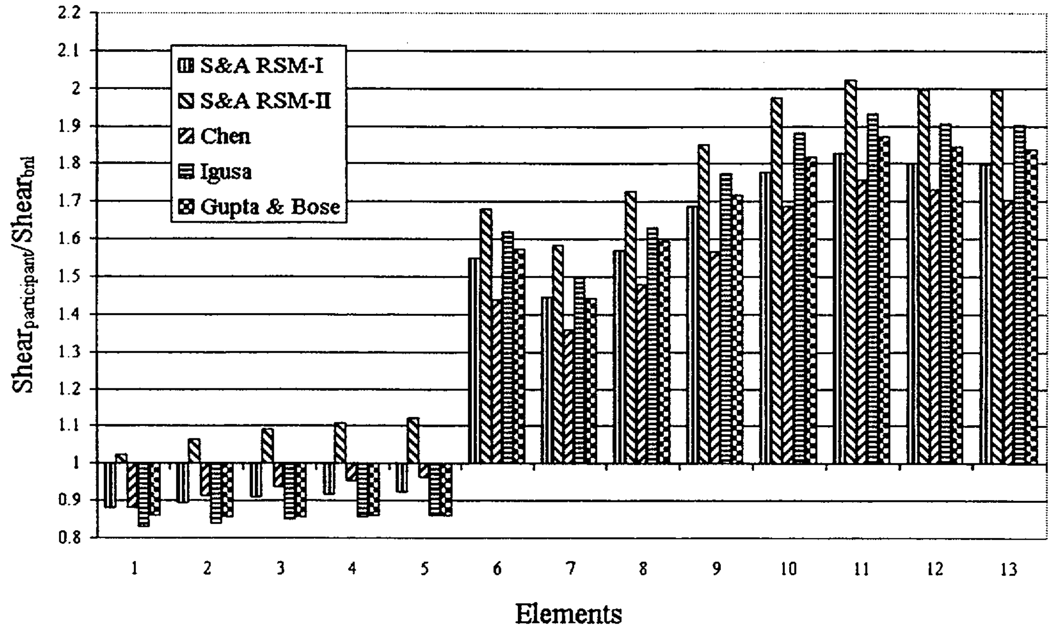

Figure 120. Comparison of maximum element shear forces for benchmark problem No. 3, Case m—Response spectrum methods.

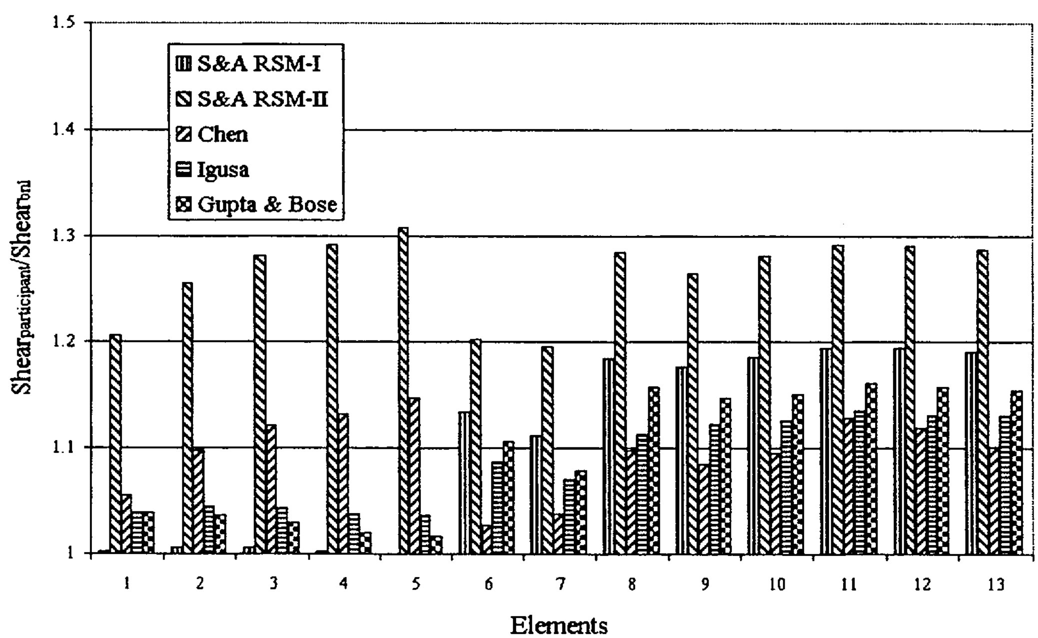

Figure 121. Comparison of mean responses of maximum element shear forces for benchmark problem No. 3 for seven earthquakes—Response spectrum methods.

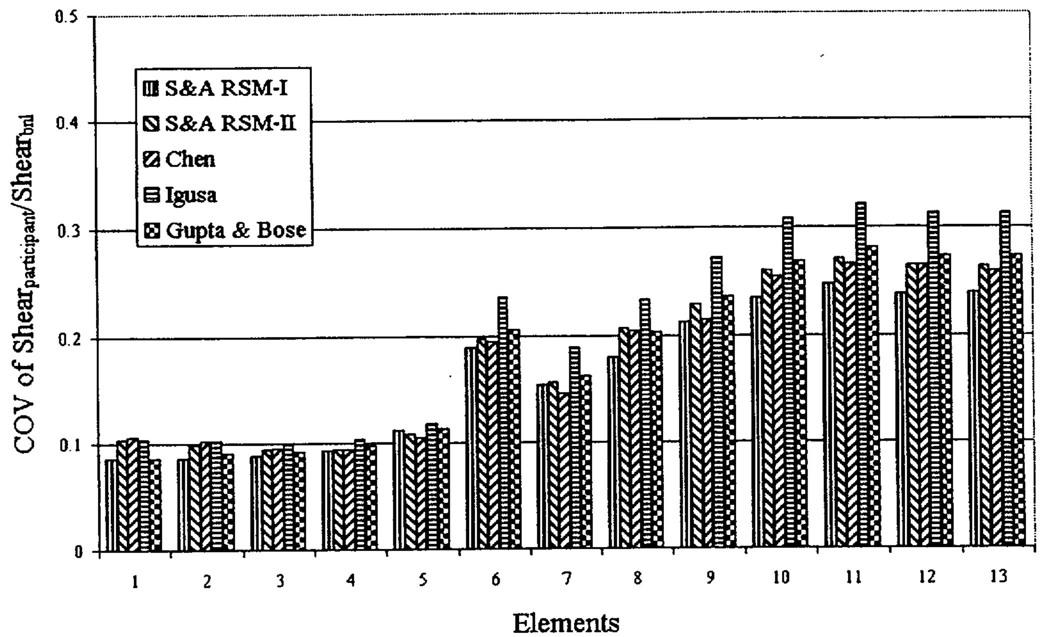

Figure 122. Comparison of Coefficients of variation of maximum element shear forces for benchmark problem No. 3 for seven earthquakes---Response spectrum methods

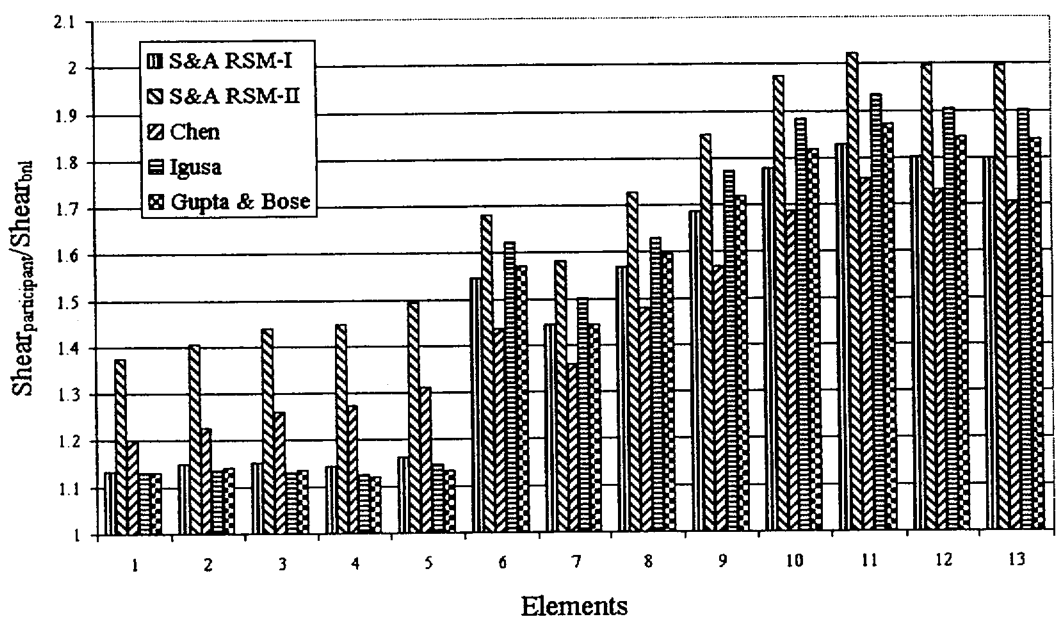

Figure 123. Comparison of maximum ratios of maximum element shear forces for benchmark problem No. 3 for seven earthquakes---Response spectrum methods

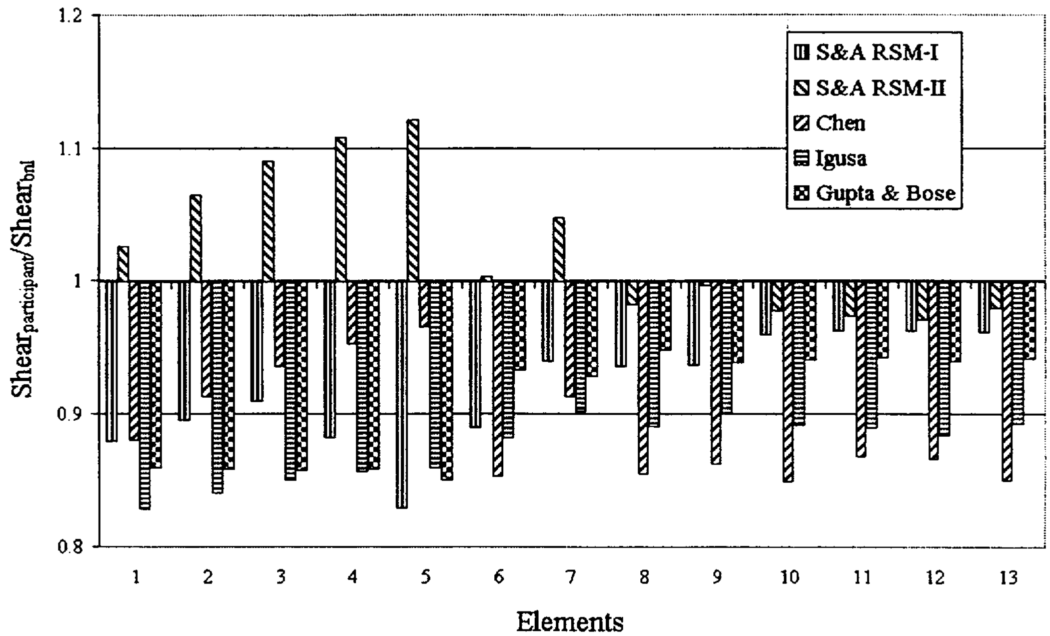

Figure 124. Comparison of minimum ratios of maximum element shear forces for benchmark problem No. 3 for seven earthquakes---Response spectrum methods

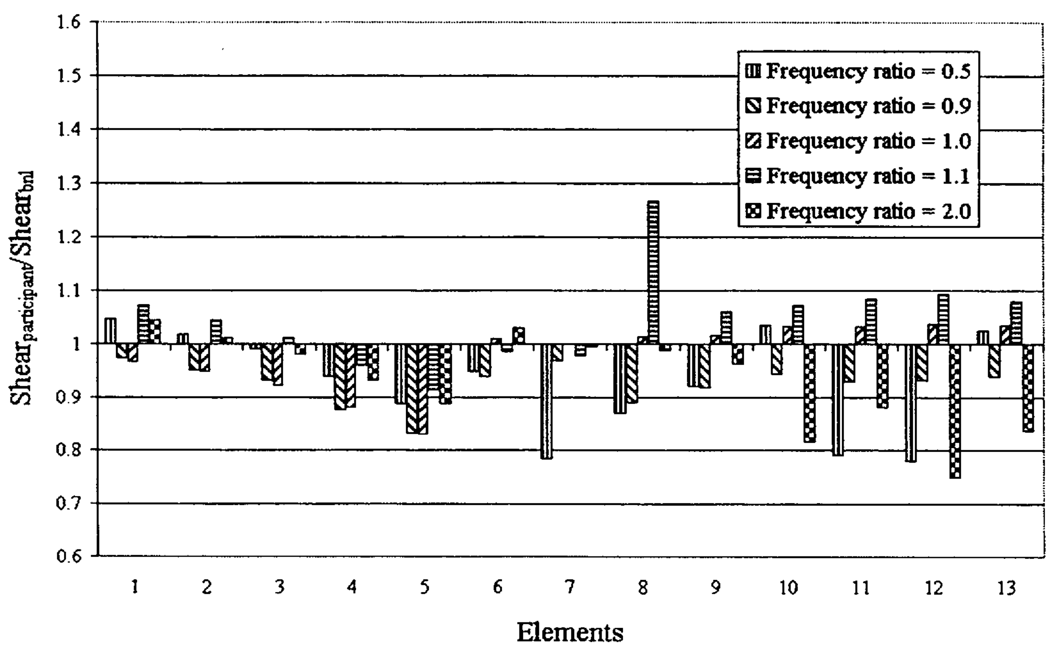

Figure 125. Effects of frequency variations for benchmark problem No. 3---S&A RSM-I.

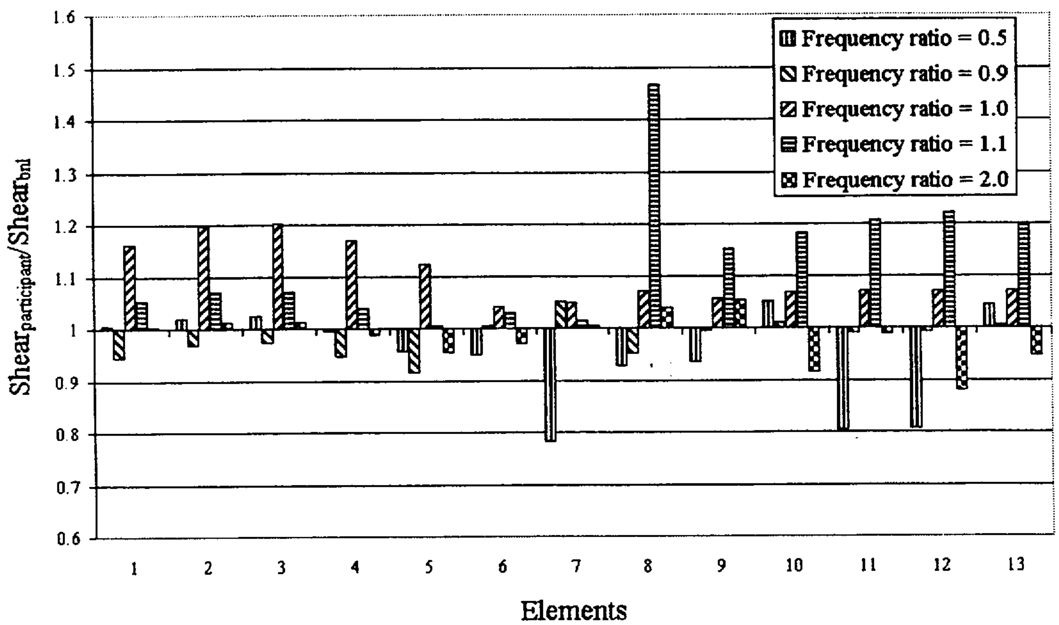

Figure 126. Effects of frequency variations for benchmark problem No. 3---S&A RSM-II.

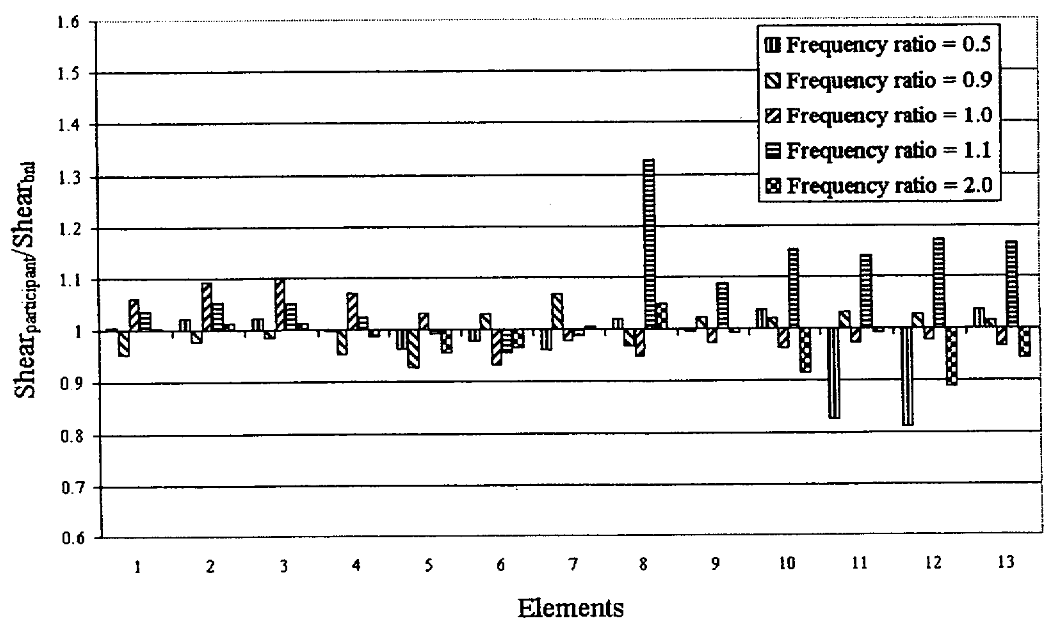

Figure 127. Effects of frequency variations for benchmark problem No. 3---Chen classical RSM.

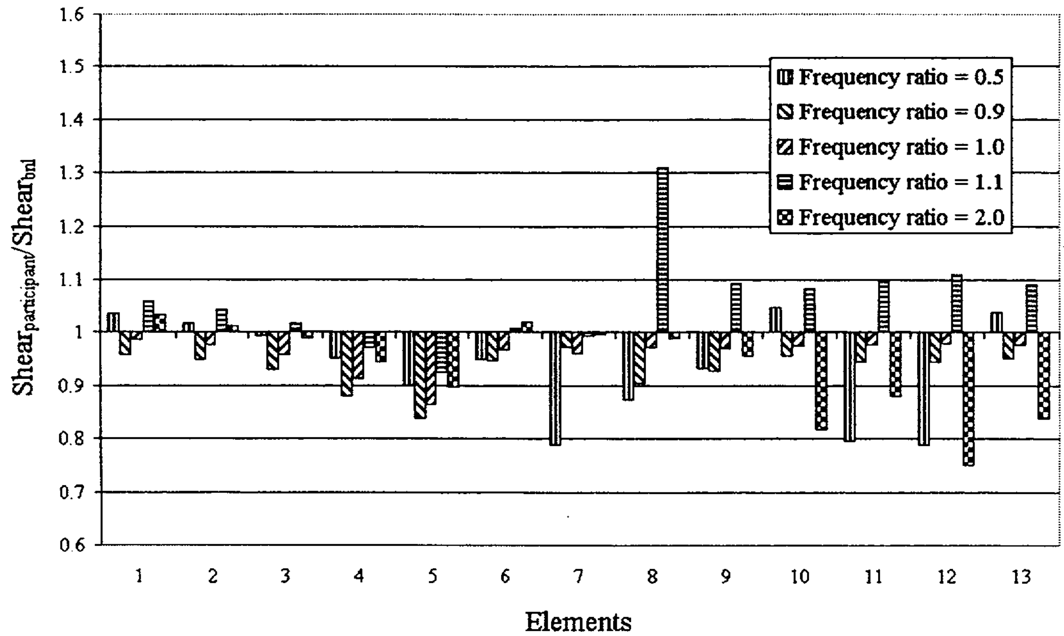

Figure 128. Effects of frequency variations for benchmark problem No. 3---Igusa/Der Kiureghian RSM

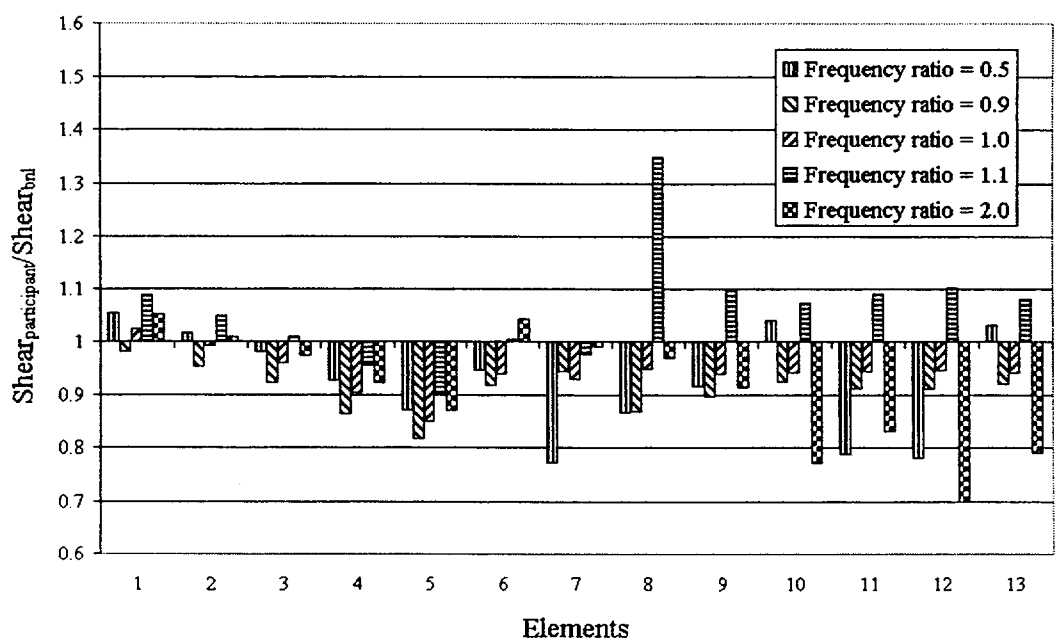

Figure 129. Effects of frequency variations for benchmark problem No. 3---Gupta RSM

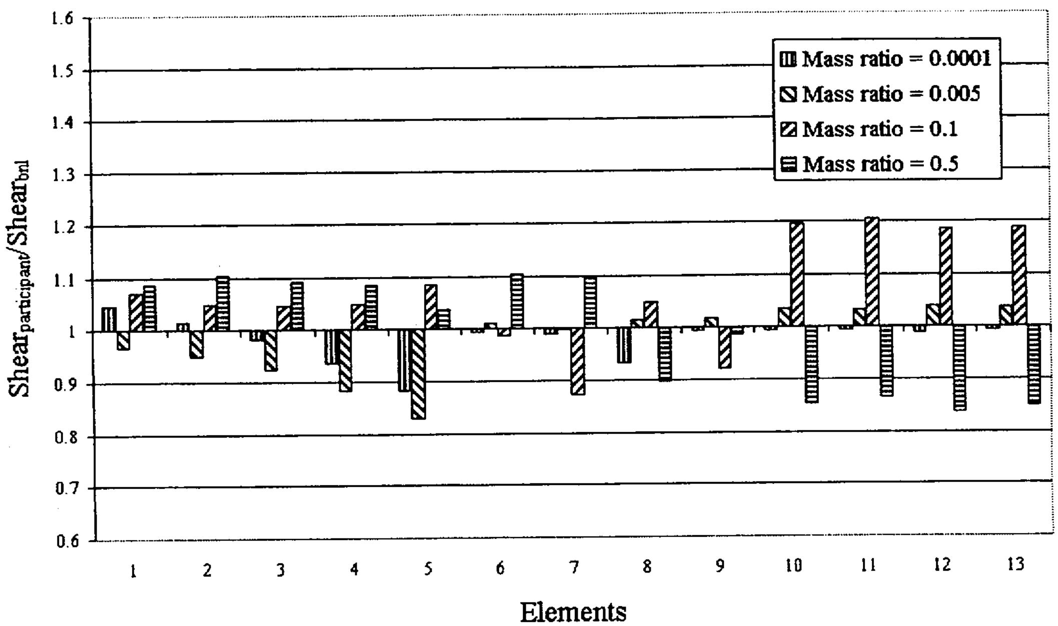

Figure 130. Effects of mass ratio variations for benchmark problem No. 3---S&A RSM-I.

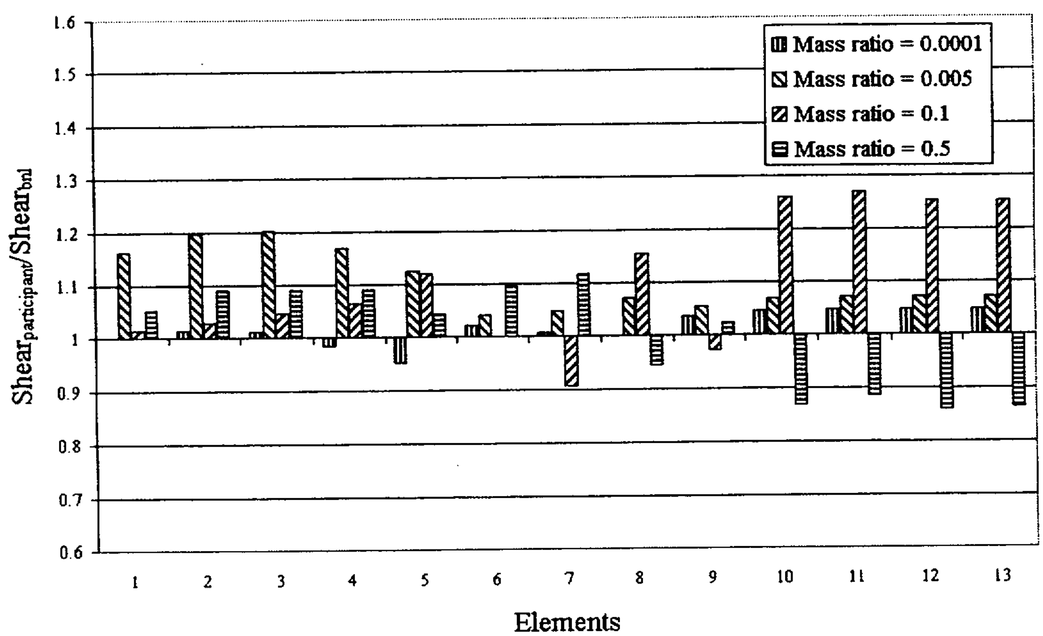

Figure 131. Effects of mass ratio variations for benchmark problem No. 3---S&A RSM-II.

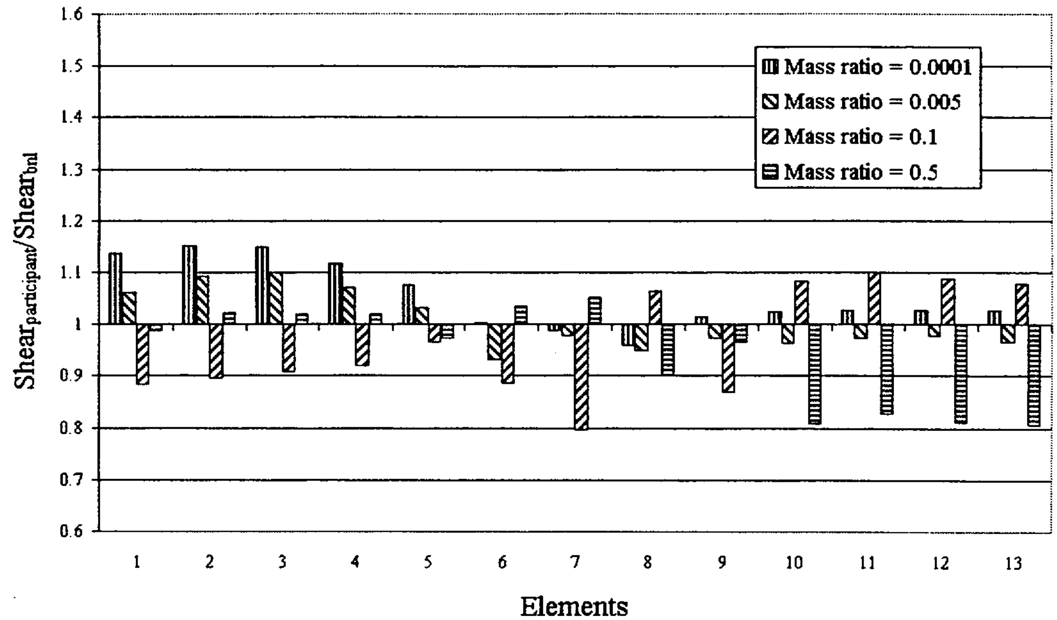

Figure 132. Effects of mass ratio variations for benchmark problem No. 3---Chen classical RSM.

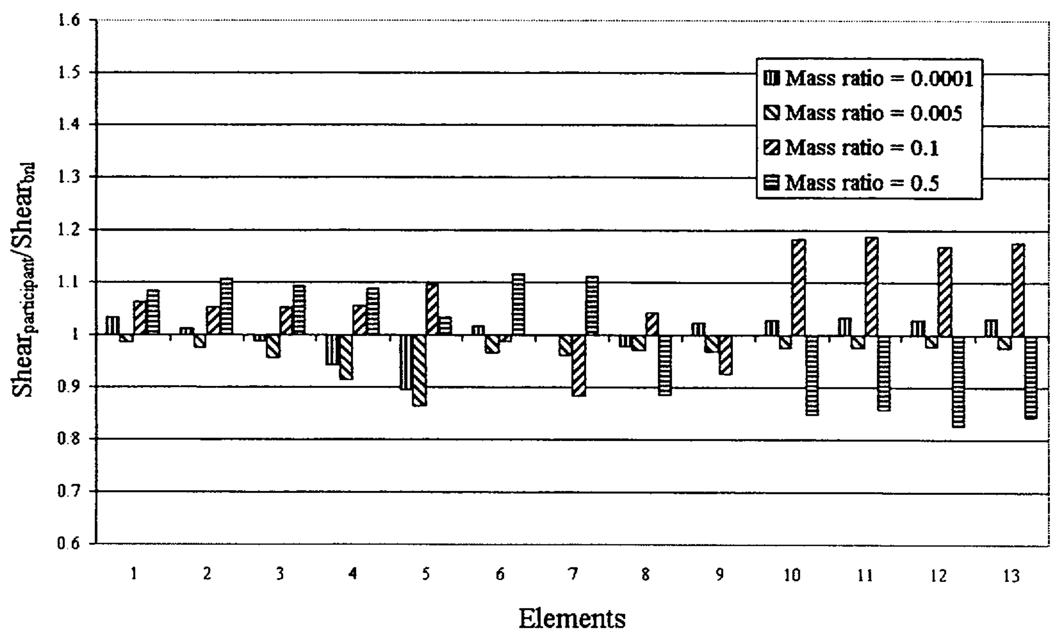

Figure 133. Effects of mass ratio variations for benchmark problem No. 3---Igusa/Der Kiureghian RSM.

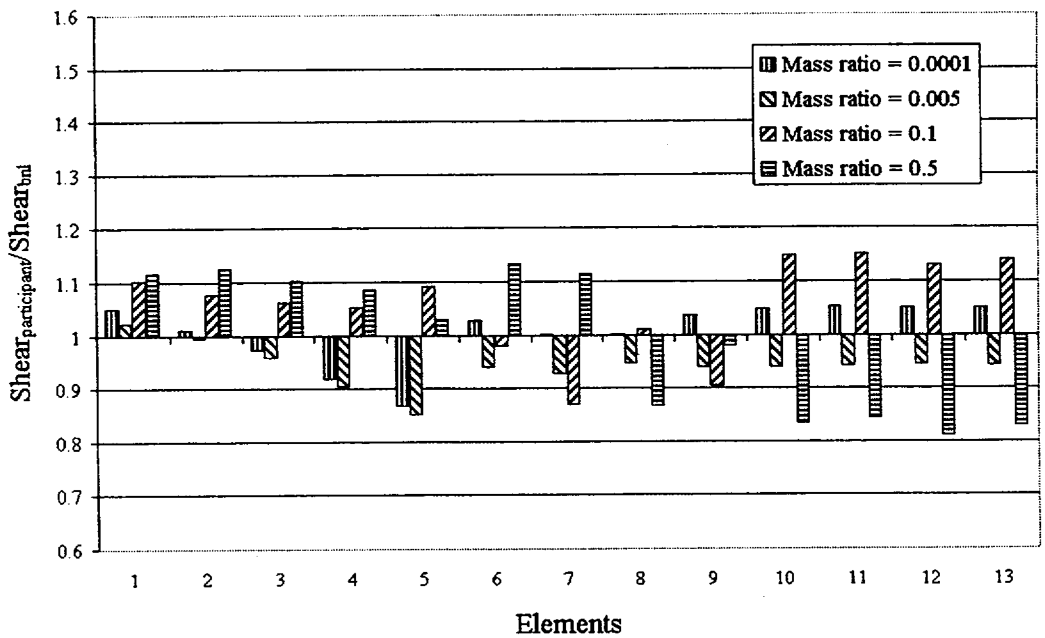

Figure 134. Effects of mass ratio variations for benchmark problem No. 3---Gupta RSM.

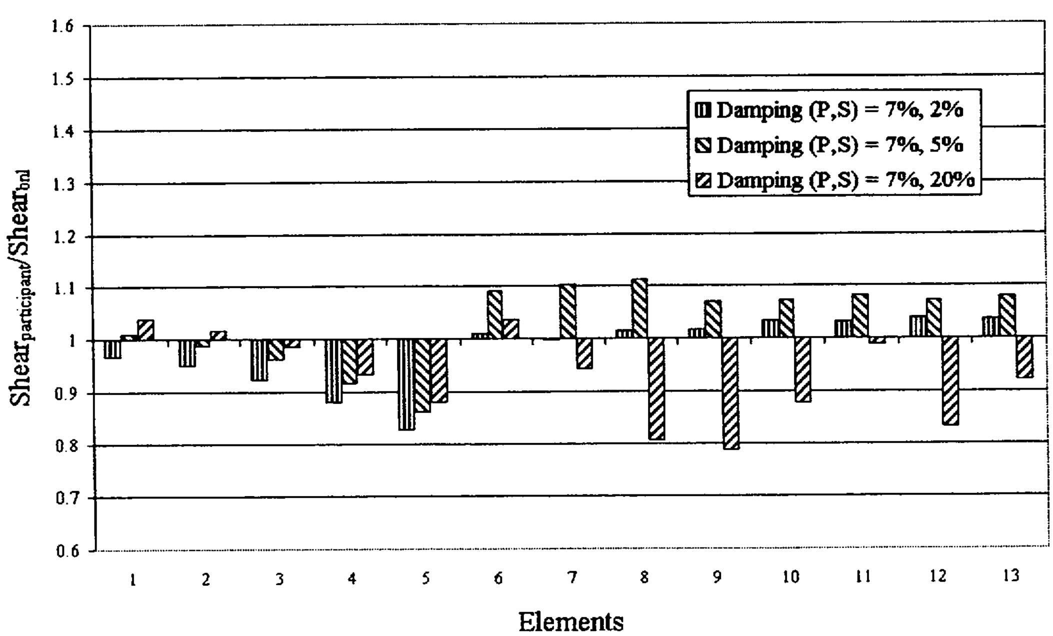

Figure 135. Effects of damping variations for benchmark problem No. 3----S&A RSM-I.

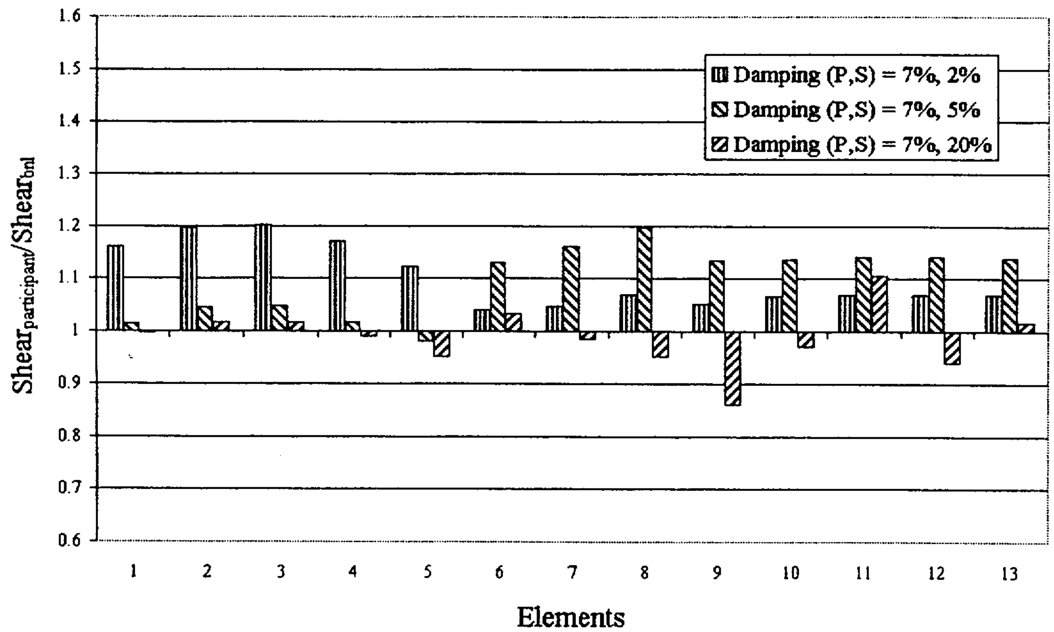

Figure 136. Effects of damping variations for benchmark problem No. 3---S&A RSM-II.

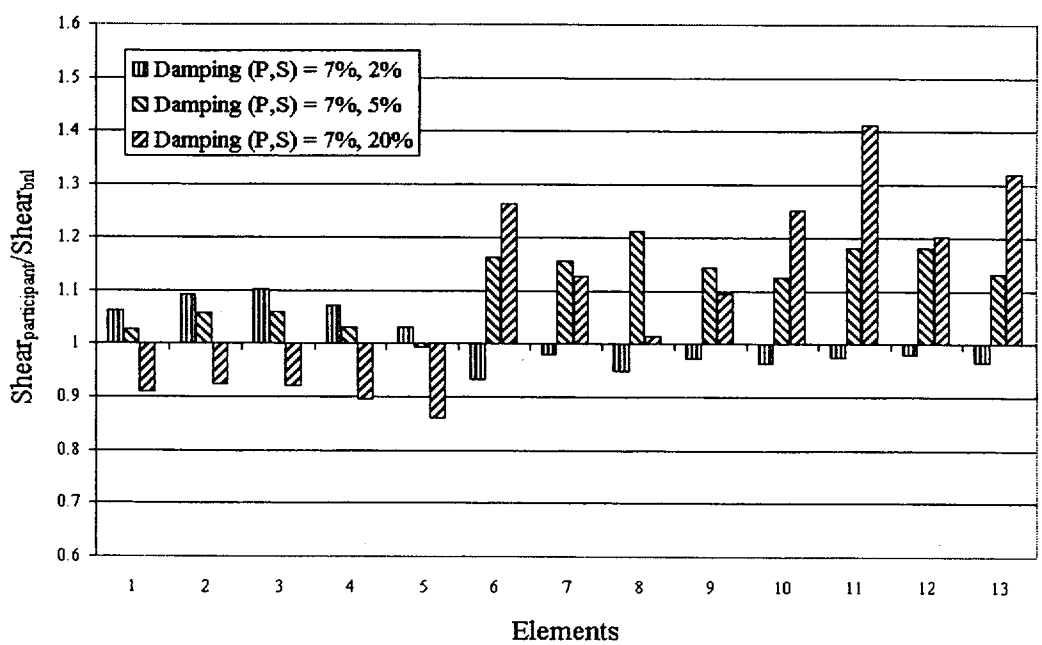

Figure 137. Effects of damping variations for benchmark problem No. 3-----Chen classical RSM.

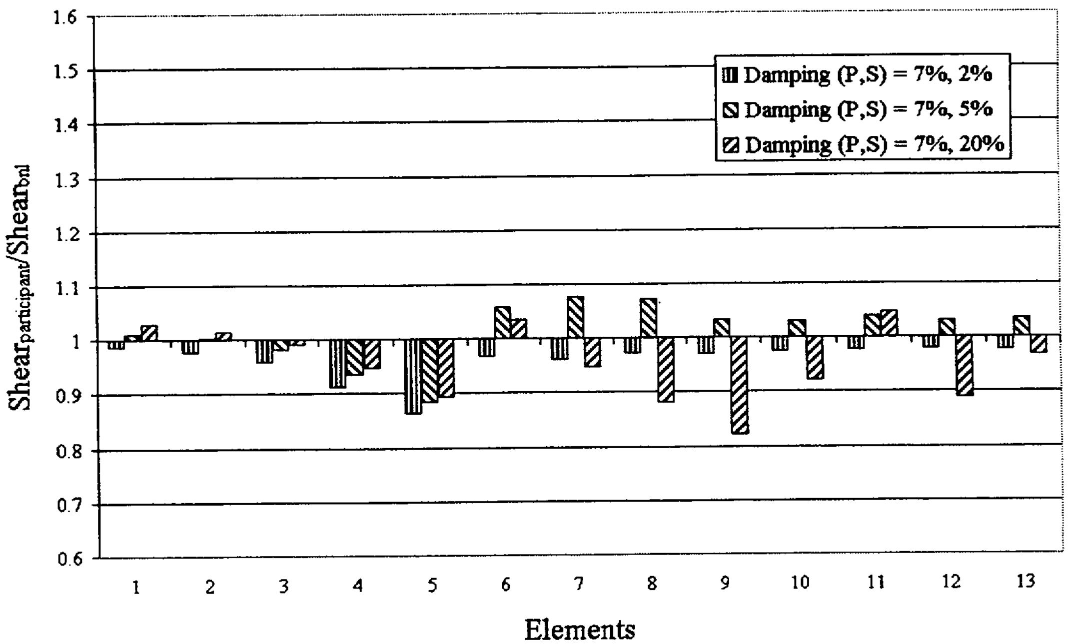

Figure 138. Effects of damping variations for benchmark problem No. 3-----
Igusa/Der Kiureghian RSM.

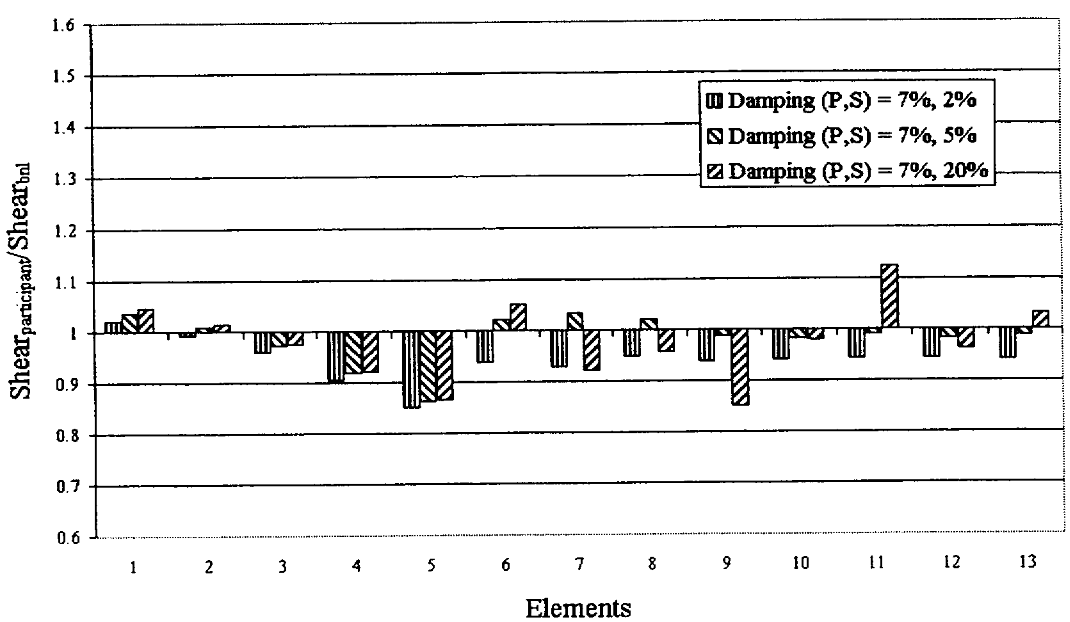

Figure 139. Effects of damping variations for benchmark problem No. 3-----Gupta
RSM.

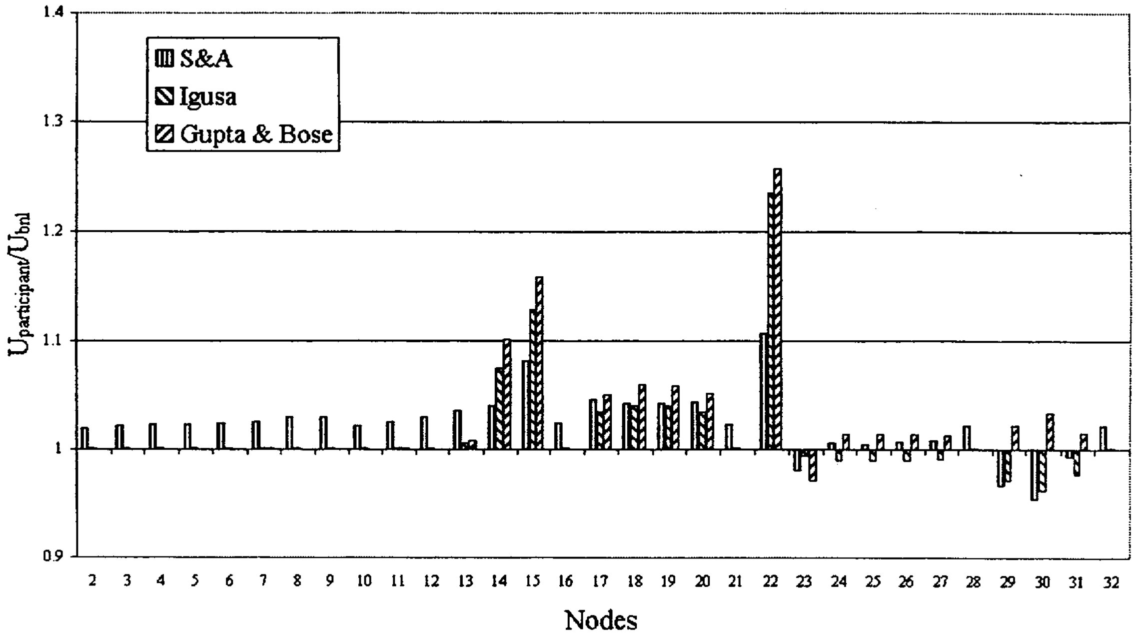

Figure 140. Comparison of maximum displacements U_y for benchmark problem No. 4a, Case a—Modal superposition time history analyses.

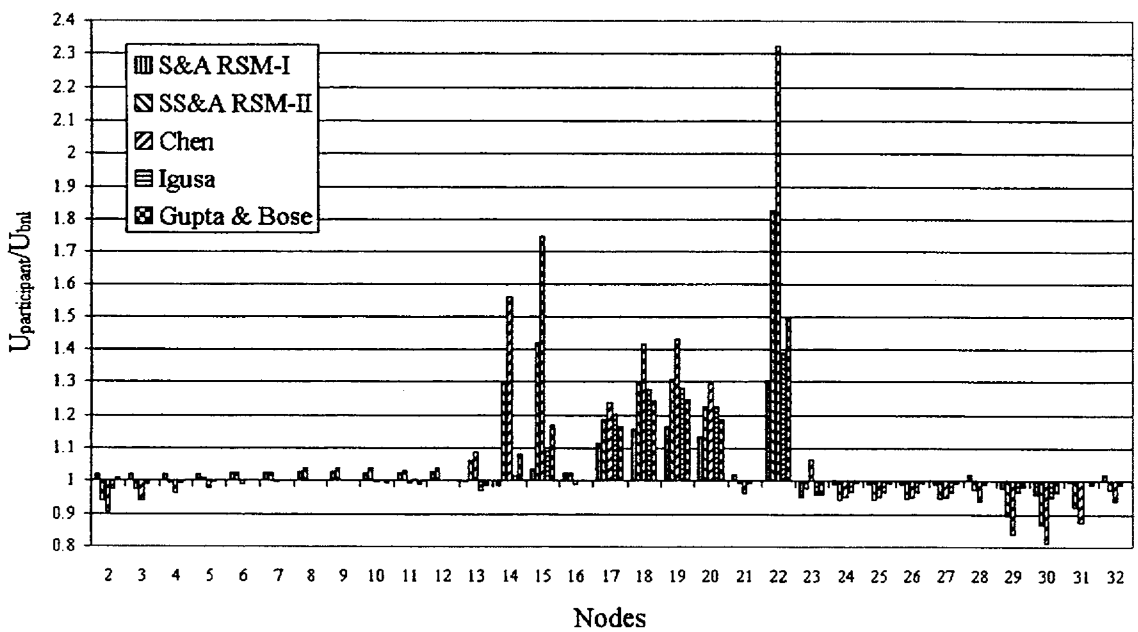

Figure 141. Comparison of maximum displacements U_y for benchmark problem No. 4a, Case a—Response spectrum methods.

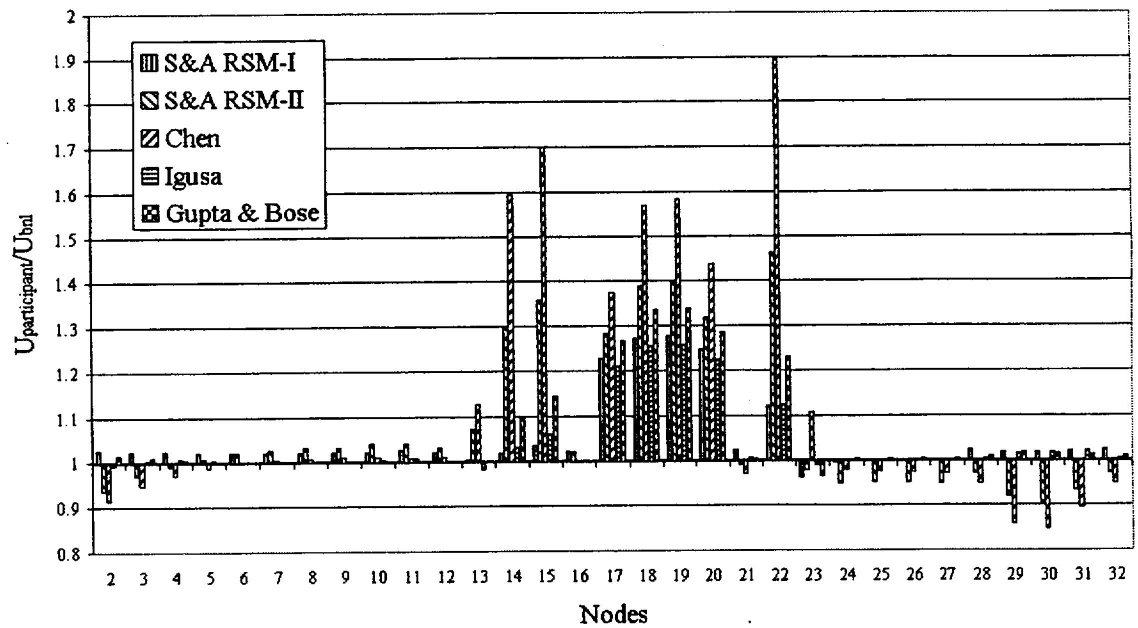

Figure 142. Comparison of mean responses of maximum displacements U_y for benchmark problem No. 4a for seven earthquakes—Response spectrum methods.

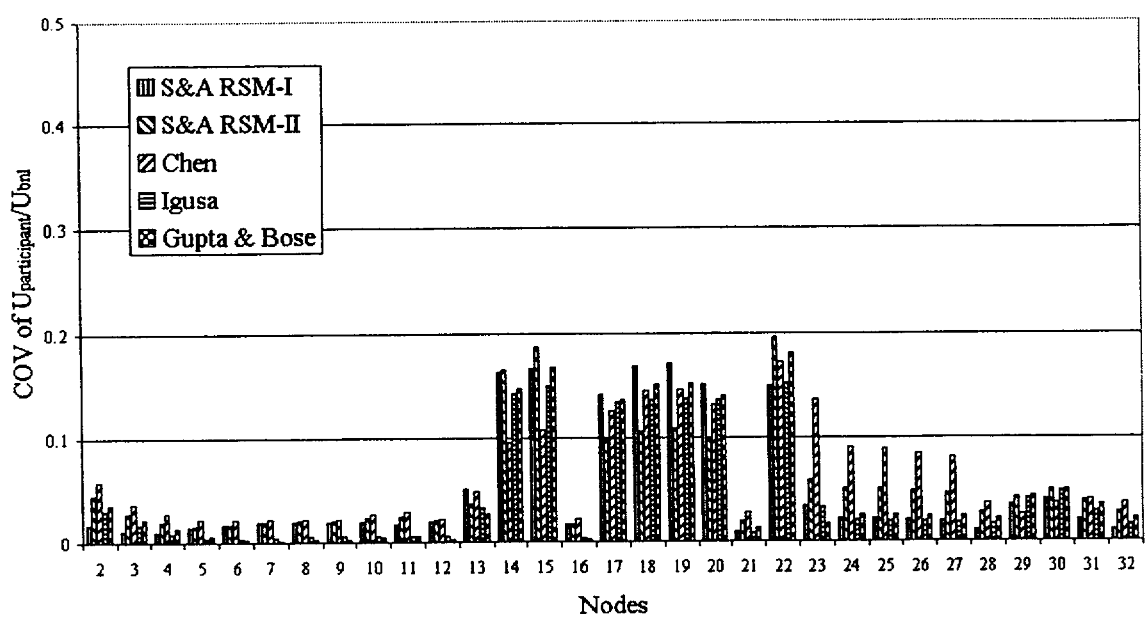

Figure 143. Comparison of Coefficients of variation of maximum displacements U_y for benchmark problem No. 4a for seven earthquakes —Response spectrum methods.

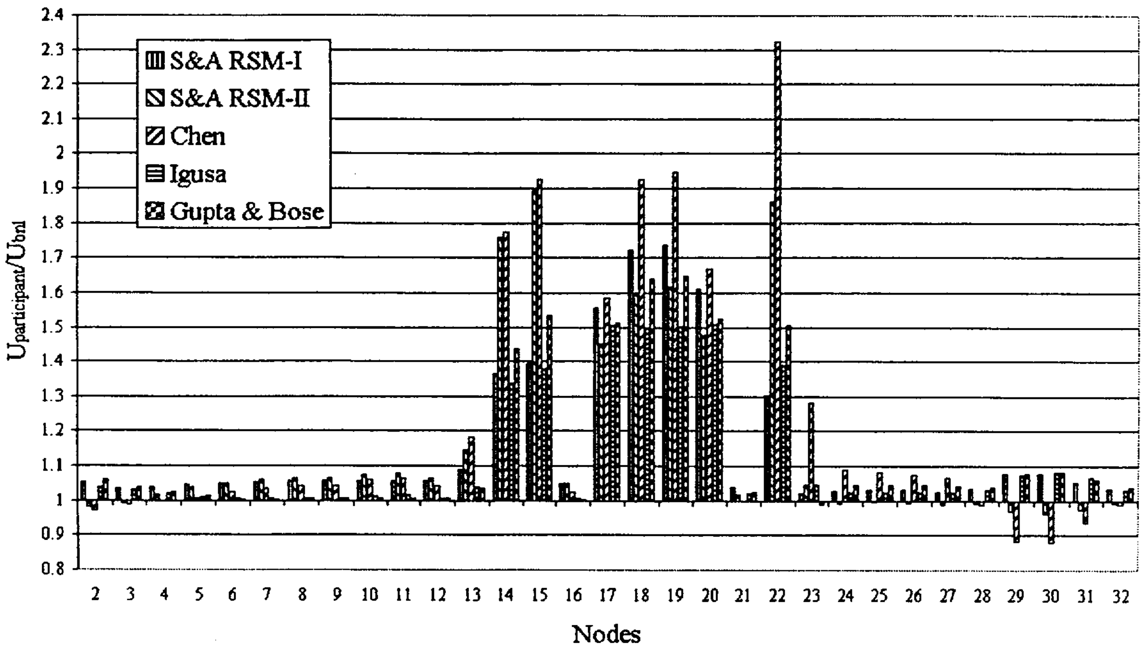

Figure 144. Comparison of maximum ratios of maximum displacements U_y for benchmark problem No. 4a for seven earthquakes---Response spectrum methods

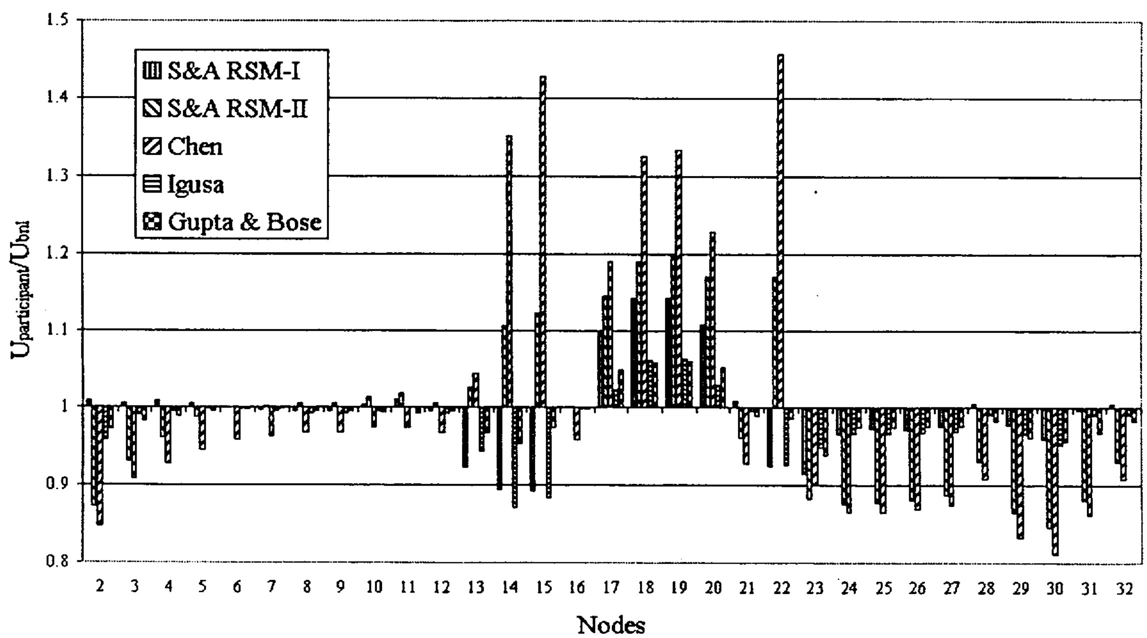

Figure 145. Comparison of minimum ratios of maximum displacements U_y for benchmark problem No. 4a for seven earthquakes---Response spectrum methods

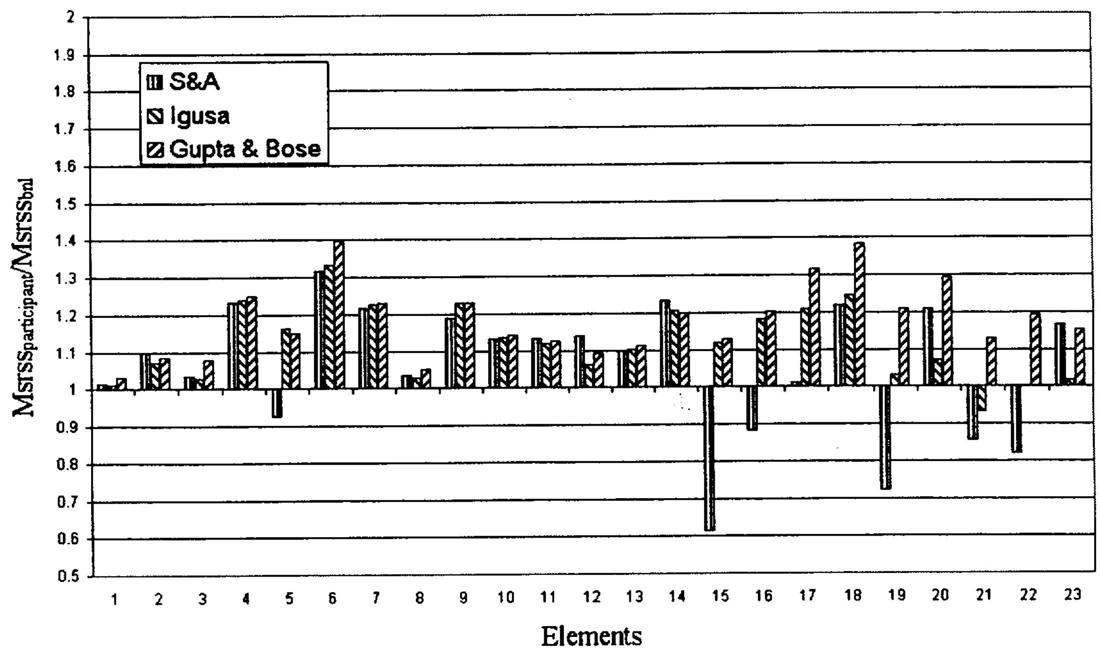

Figure 146. Comparison of maximum SRSS element moments of S-component for benchmark problem No. 4a, Case a—Modal superposition time history analyses

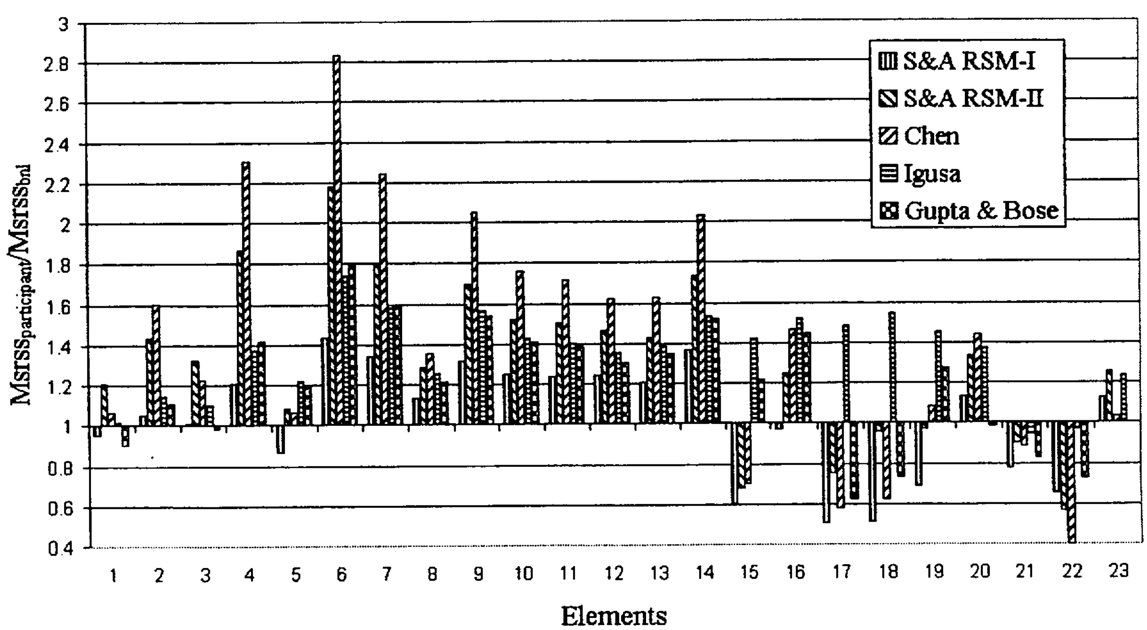

Figure 147. Comparison of maximum SRSS element moments of S-component for benchmark problem No. 4a, Case a—Response spectrum methods.

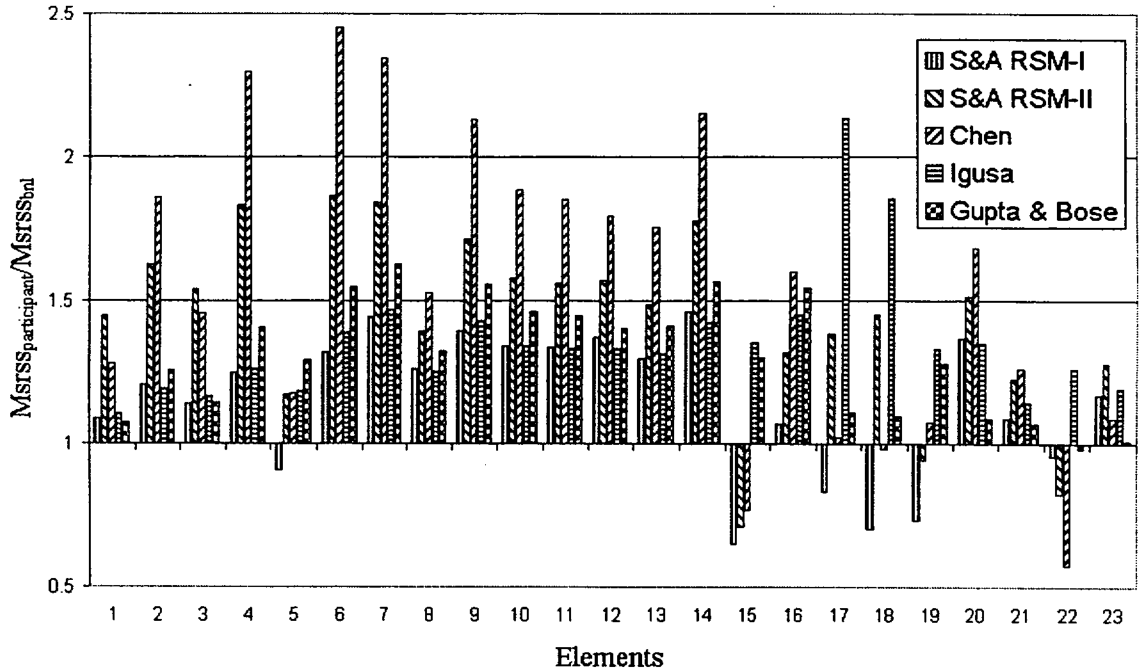

Figure 148. Comparison of mean responses of maximum SRSS element moments of S-component for benchmark problem No. 4a for seven earthquakes—Response spectrum methods.

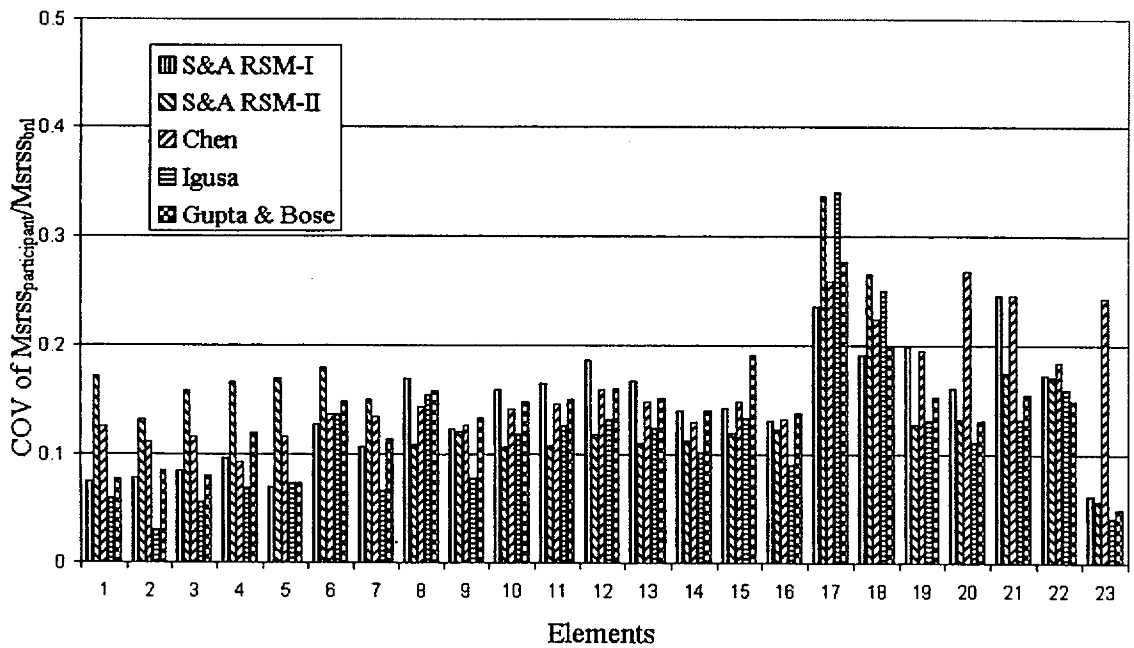

Figure 149. Comparison of Coefficients of variation of maximum SRSS element moments of S-component for benchmark problem No. 4a for seven earthquakes —Response spectrum methods.

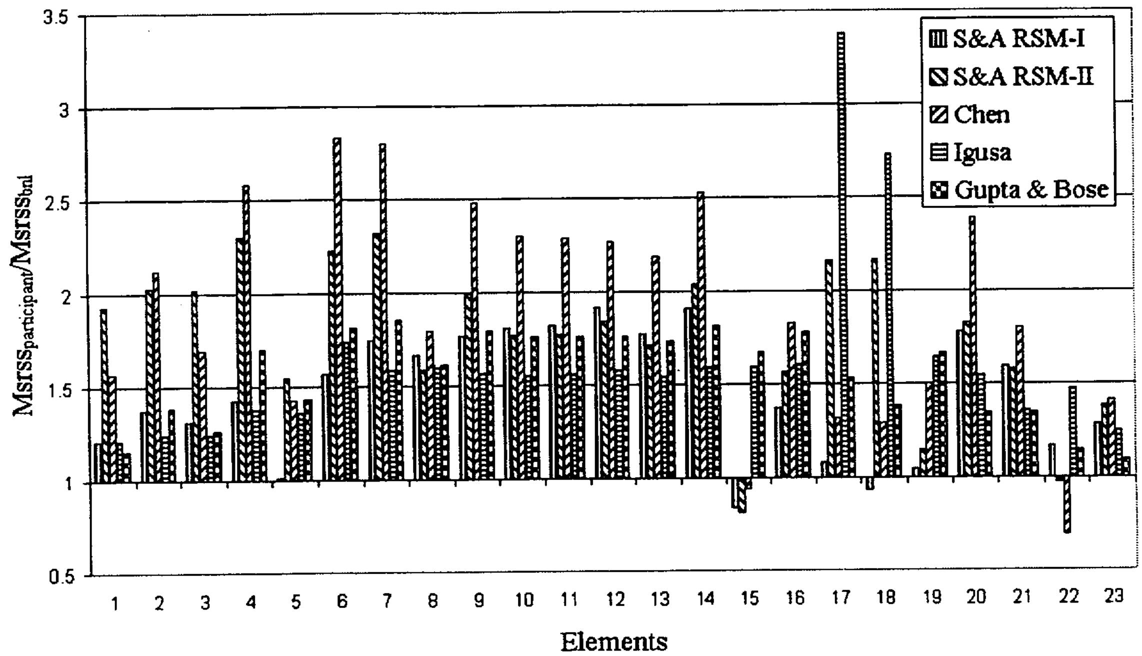

Figure 150. Comparison of maximum ratios of maximum SRSS element moments of S-component for benchmark problem No. 4a for seven earthquakes---Response spectrum methods

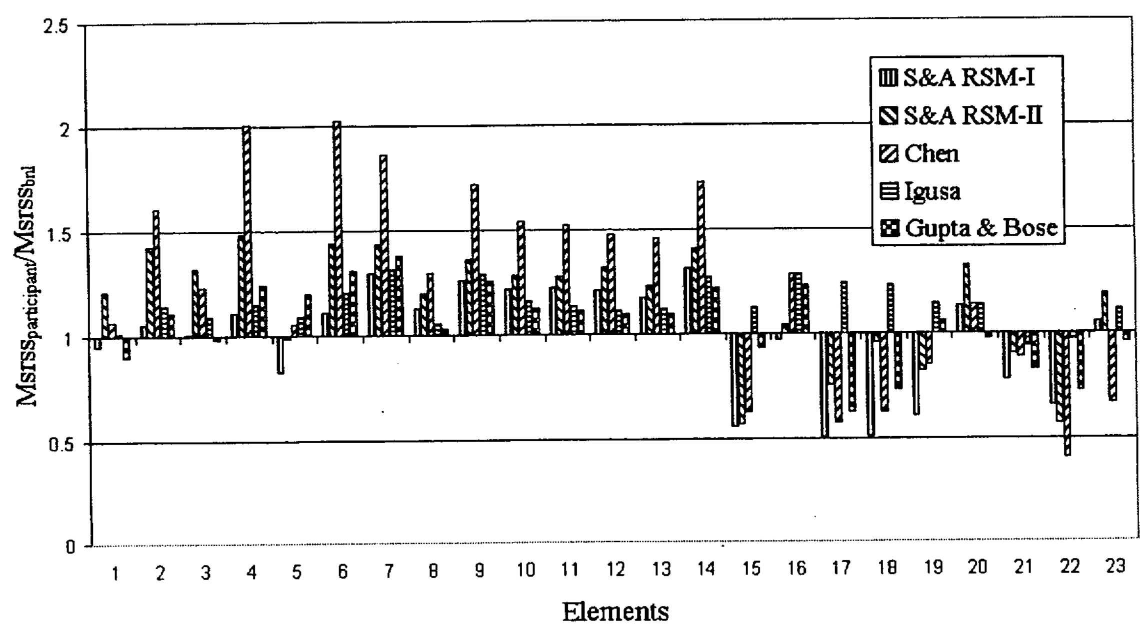

Figure 151. Comparison of minimum ratios of maximum SRSS element moments of S-component for benchmark problem No. 4a for seven earthquakes---Response spectrum methods

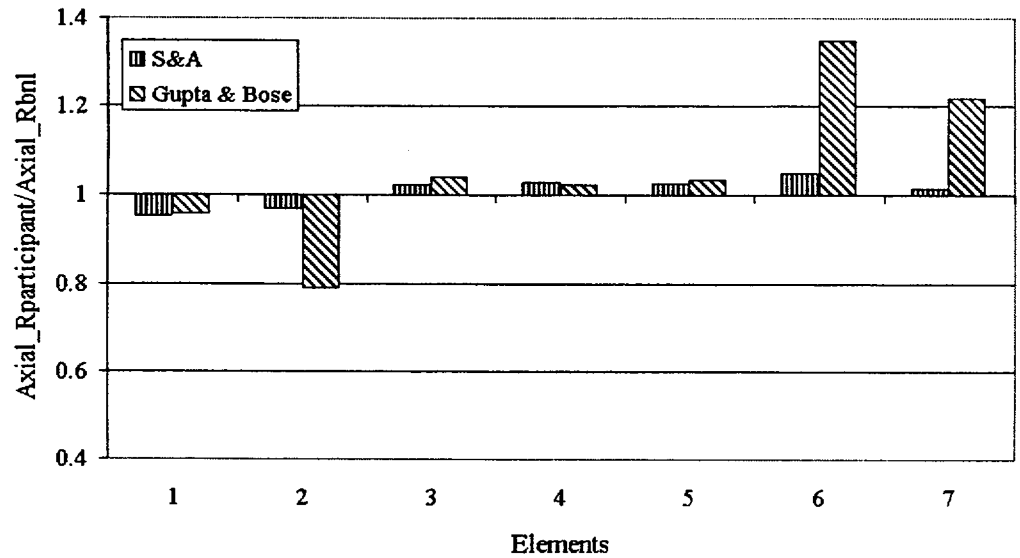

Figure 152. Comparison of maximum axial reaction forces of links for benchmark problem No. 4a, Case a—Modal superposition time history analyses

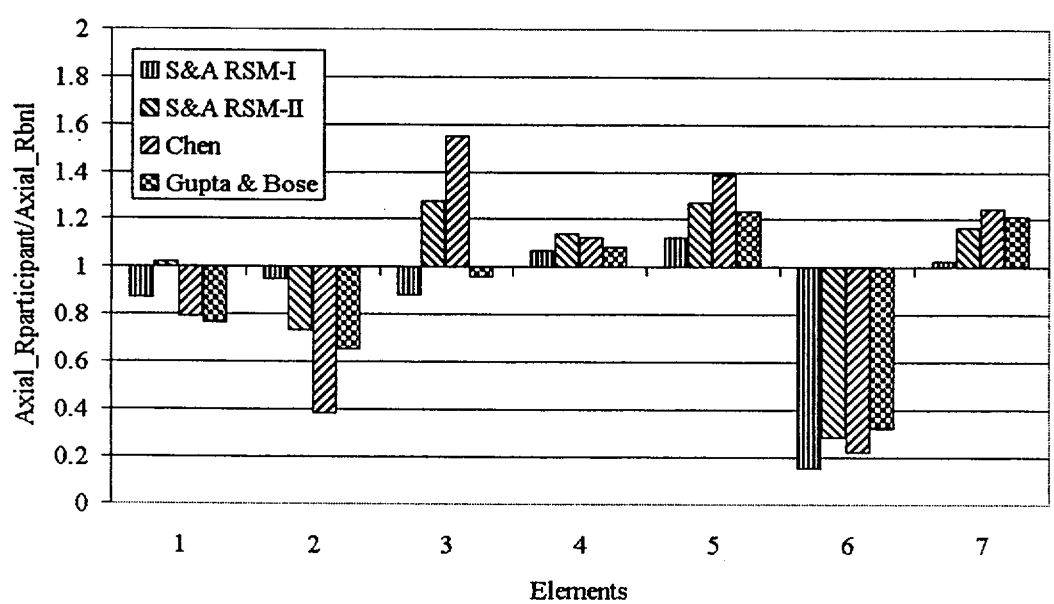

Figure 153. Comparison of maximum axial reaction forces of links for benchmark problem No. 4a, Case a—Response spectrum methods.

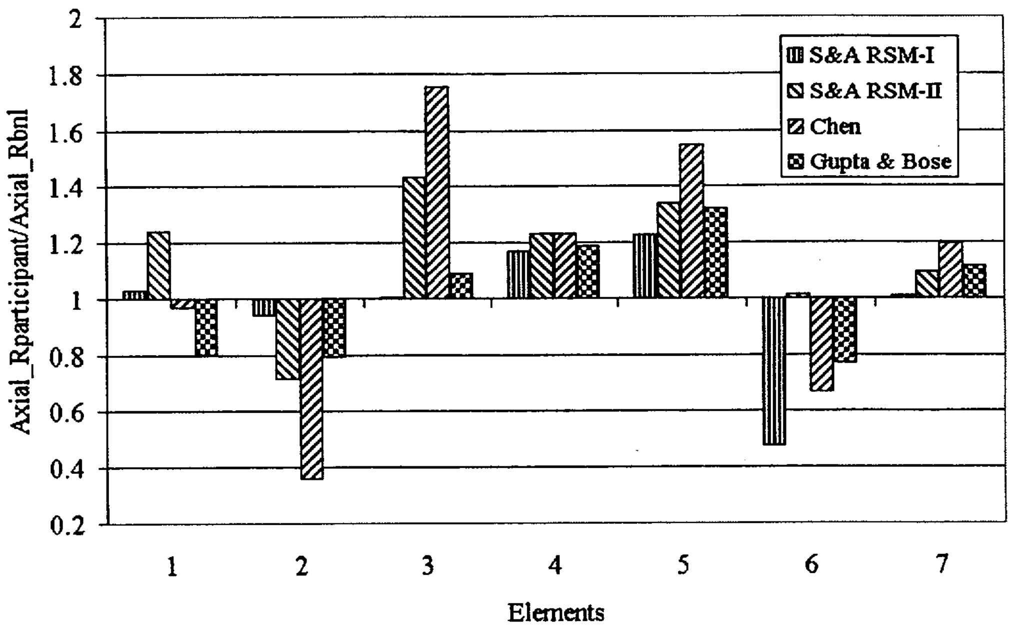

Figure 154. Comparison of mean responses of maximum axial reaction forces of links for benchmark problem No. 4a for seven earthquakes—Response spectrum methods.

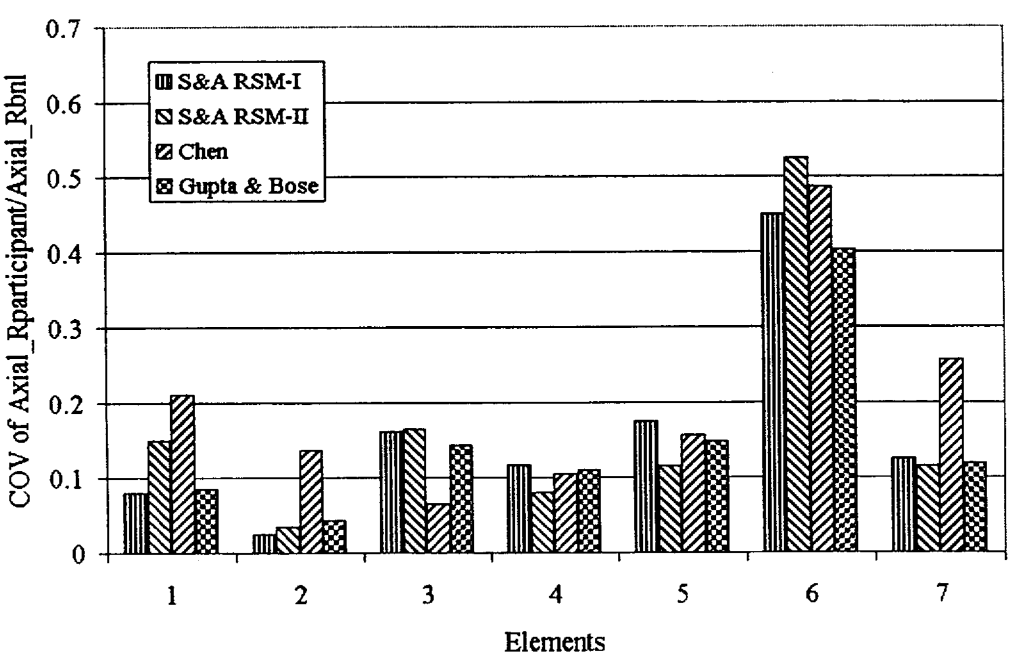

Figure 155. Comparison of Coefficients of variation of maximum axial reaction forces of links for benchmark problem No. 4a for seven earthquakes — Response spectrum methods.

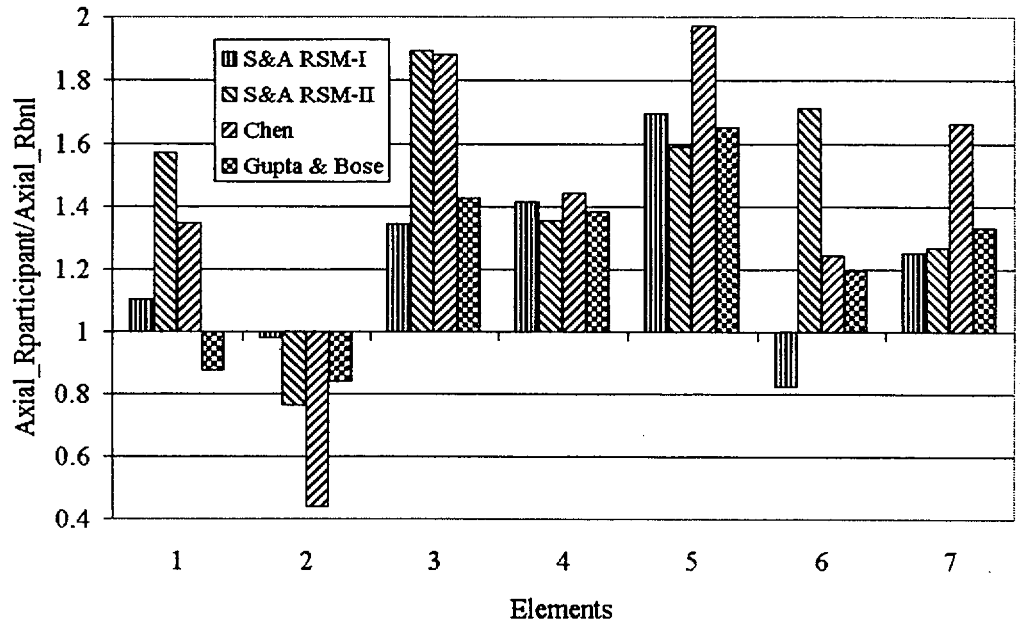

Figure 156. Comparison of maximum ratios of maximum axial reaction forces of links for benchmark problem No. 4a for seven earthquakes---Response spectrum methods

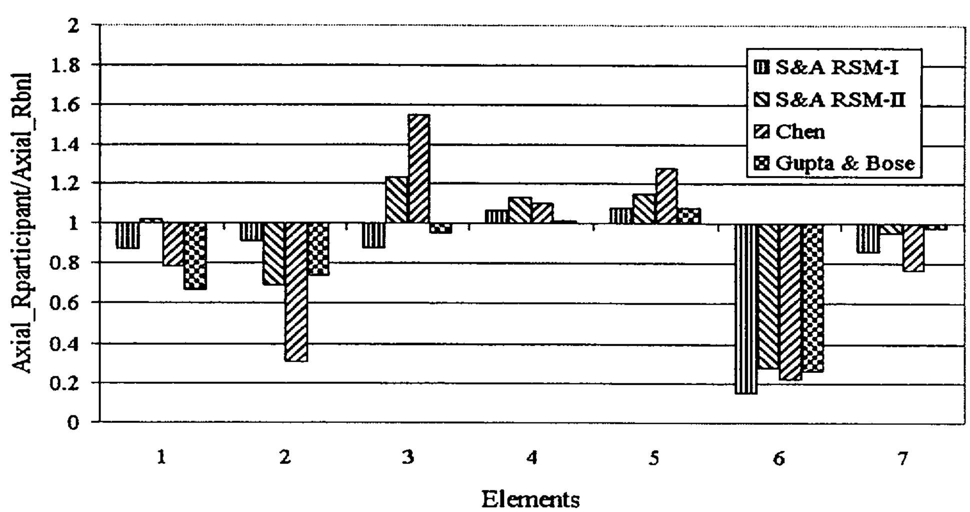

Figure 157. Comparison of minimum ratios of maximum axial reaction forces of links for benchmark problem No. 4a for seven earthquakes---Response spectrum methods

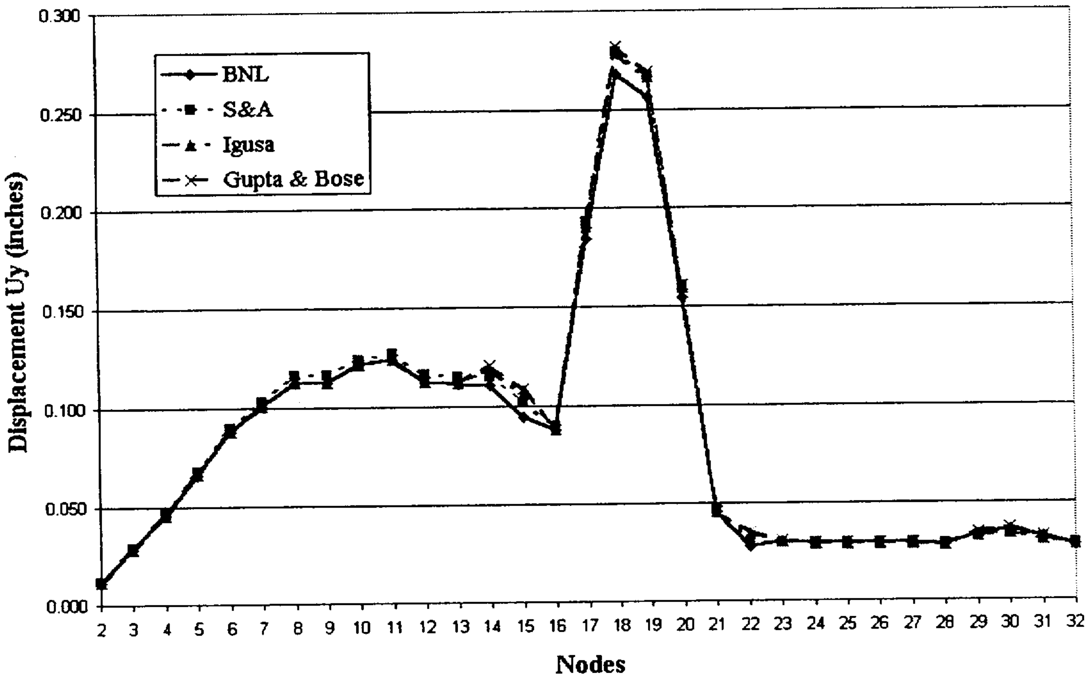

Figure 158. Comparison of actual maximum displacements U_y for benchmark problem No. 4a, Case a--- Modal superposition time history analyses

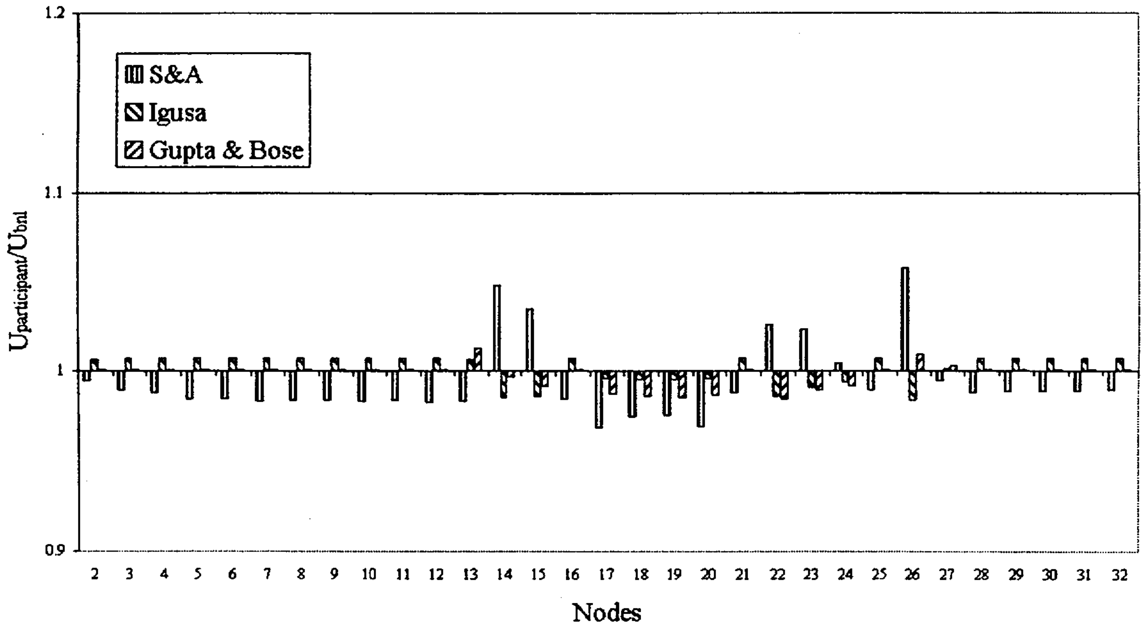

Figure 159. Comparison of maximum displacements U_x for benchmark problem No. 4b, Case a—Modal superposition time history analyses.

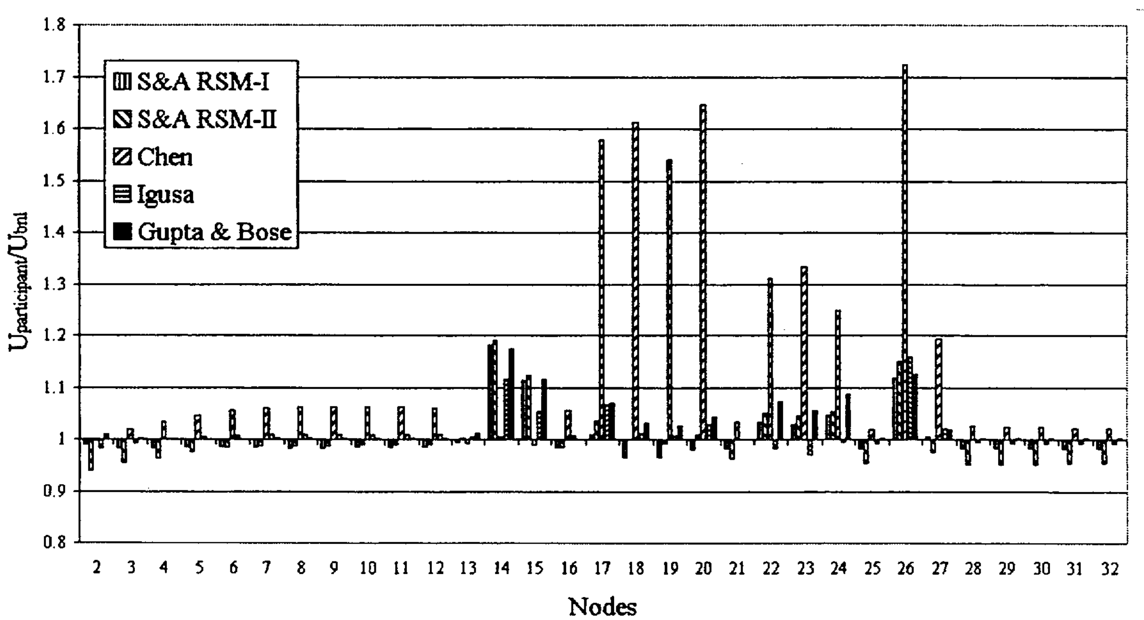

Figure 160. Comparison of maximum displacements U_x for benchmark problem No. 4b, Case a—Response spectrum methods.

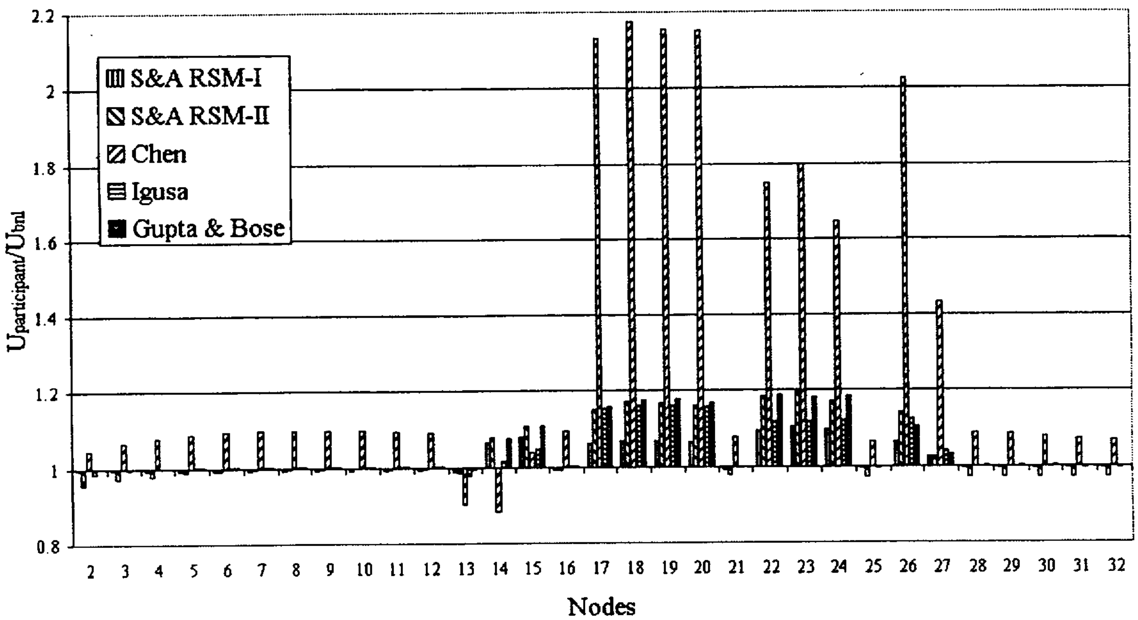

Figure 161. Comparison of mean responses of maximum displacements U_x for benchmark problem No. 4b for seven earthquakes—Response spectrum methods.

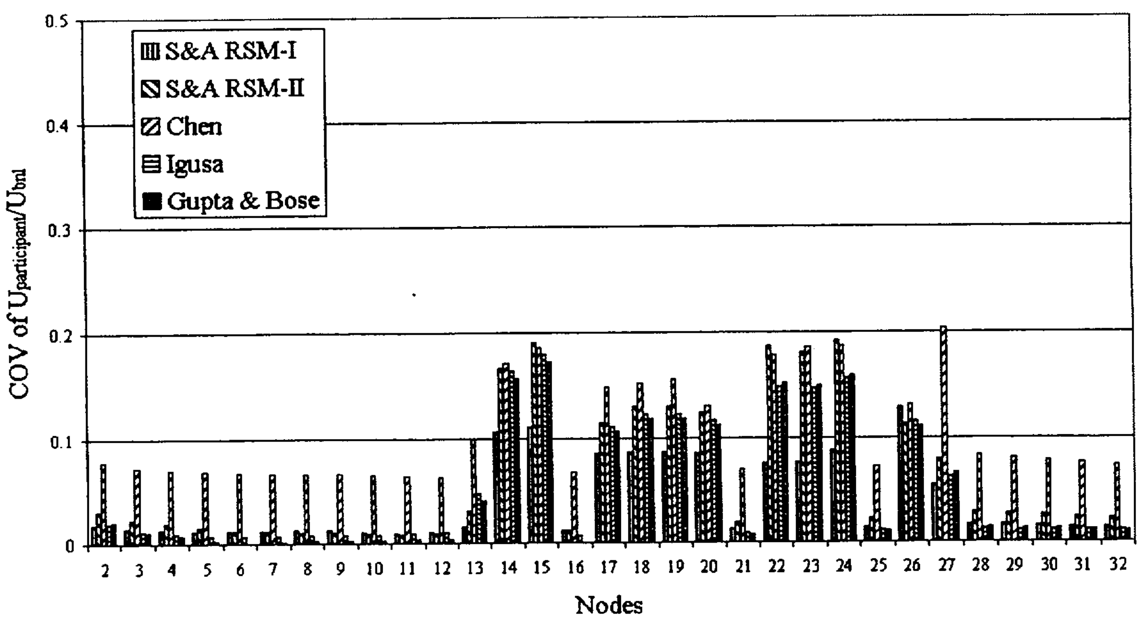

Figure 162. Comparison of Coefficients of variation of maximum displacements U_x for benchmark problem No. 4b for seven earthquakes —Response spectrum methods.

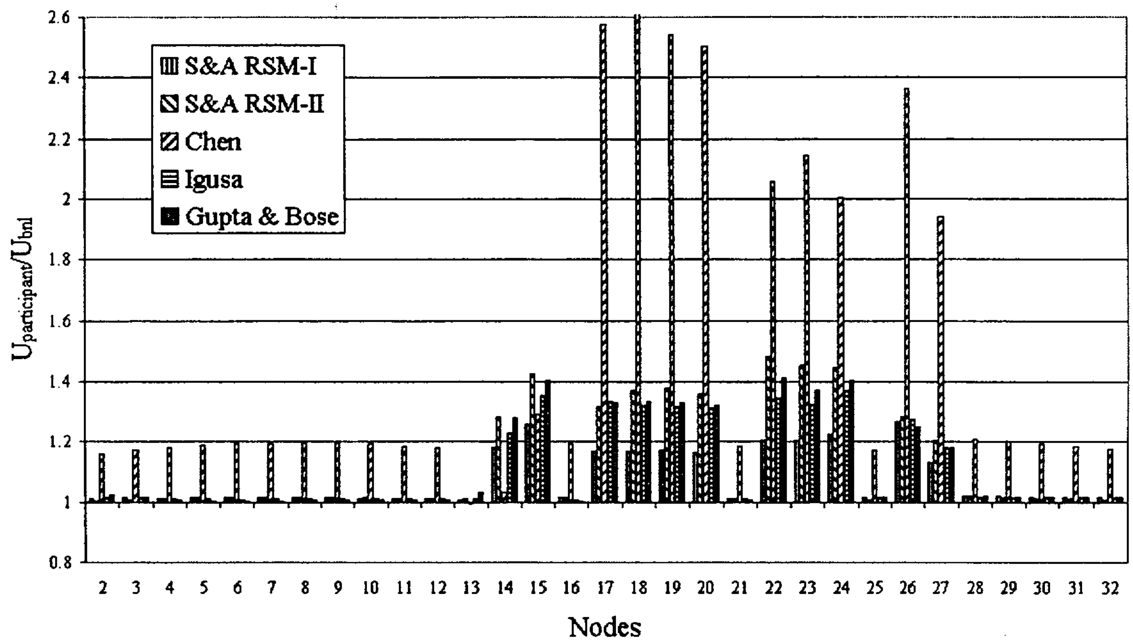

Figure 163. Comparison of maximum ratios of maximum displacements U_x for benchmark problem No. 4b for seven earthquakes---Response spectrum methods

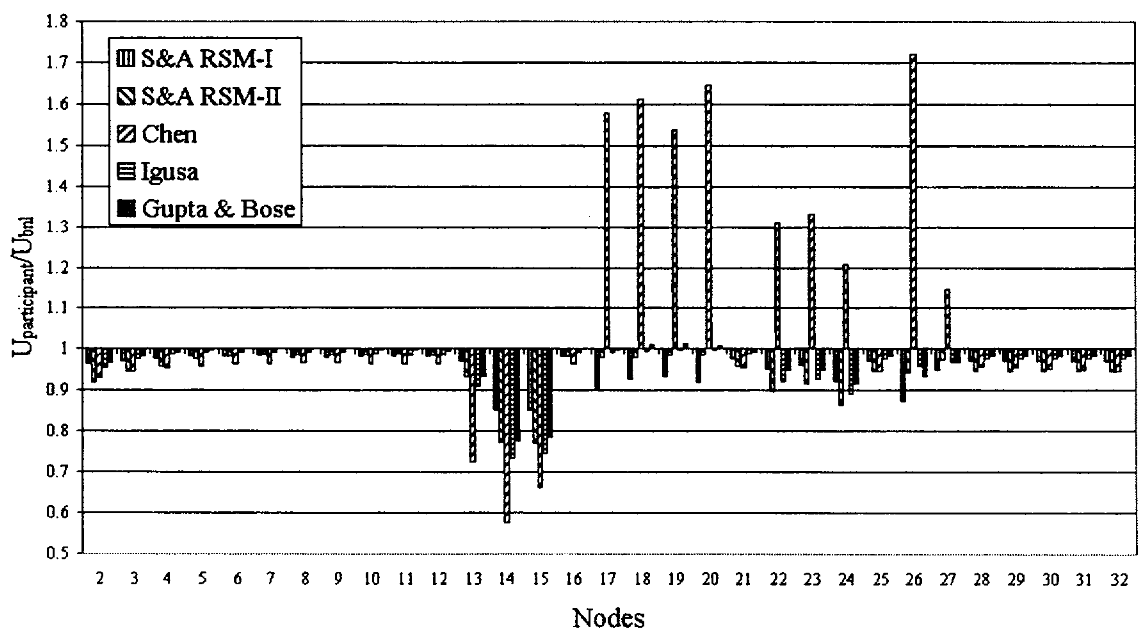

Figure 164. Comparison of minimum ratios of maximum displacements U_x for benchmark problem No. 4b for seven earthquakes---Response spectrum methods

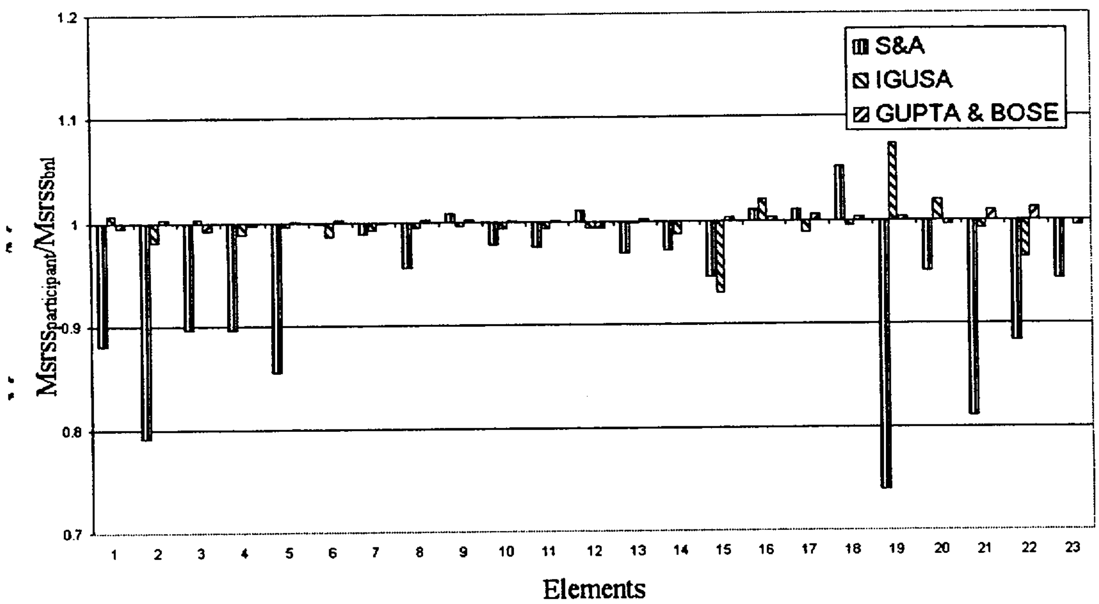

Figure 165. Comparison of maximum SRSS element moments of S-component for benchmark problem No. 4b, Case a—Modal superposition time history analyses

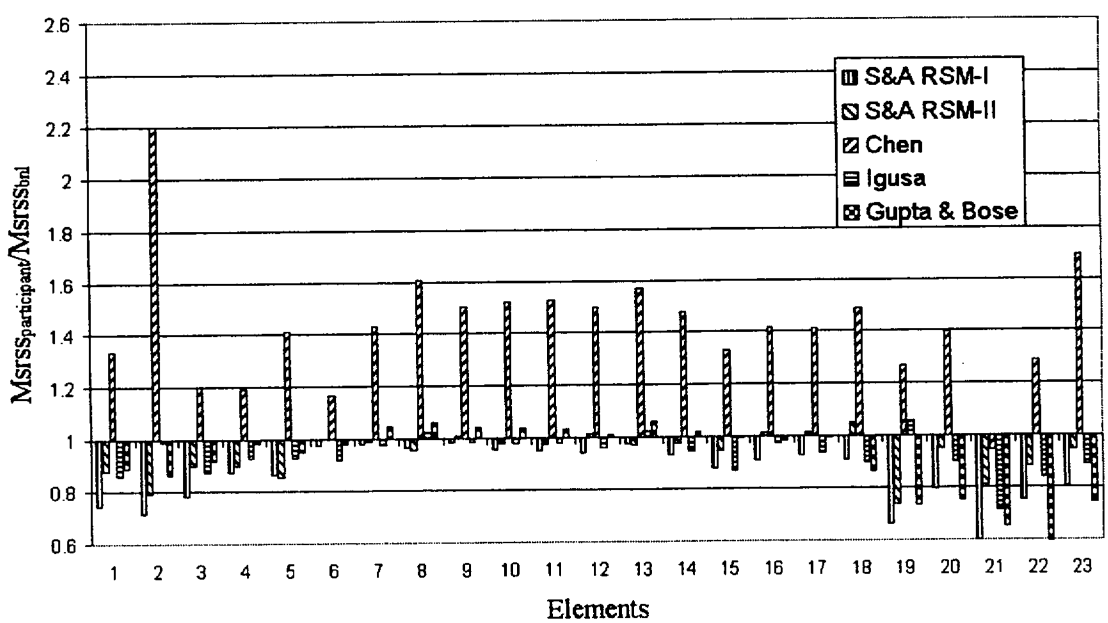

Figure 166. Comparison of maximum SRSS element moments of S-component for benchmark problem No. 4b, Case a—Response spectrum methods.

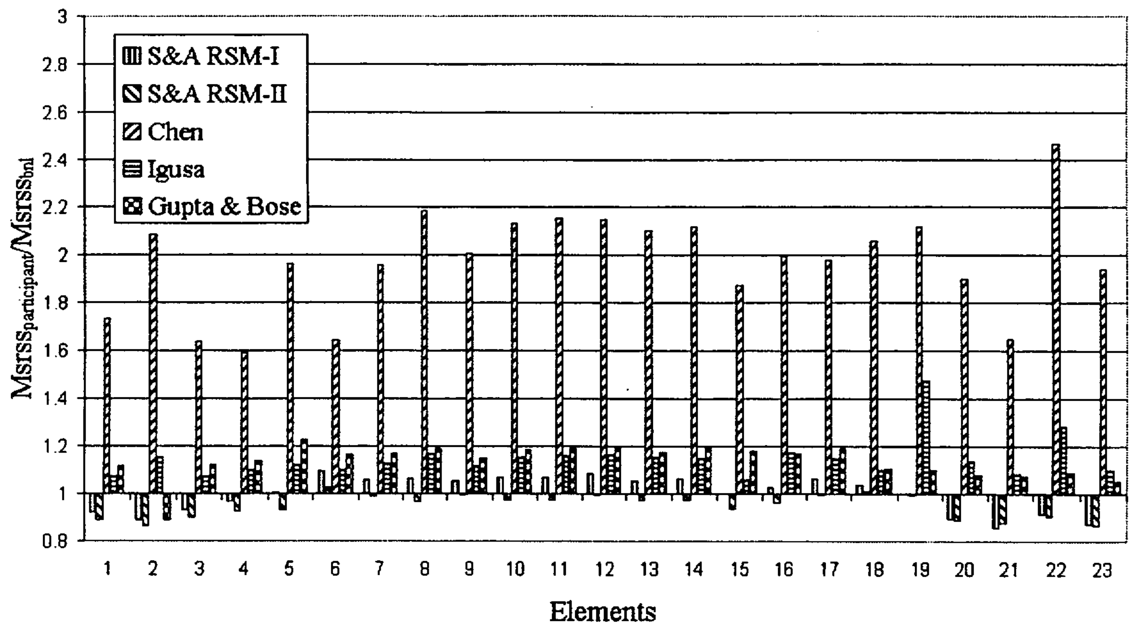

Figure 167. Comparison of mean responses of maximum SRSS element moments of S-component for benchmark problem No. 4b for seven earthquakes—Response spectrum methods.

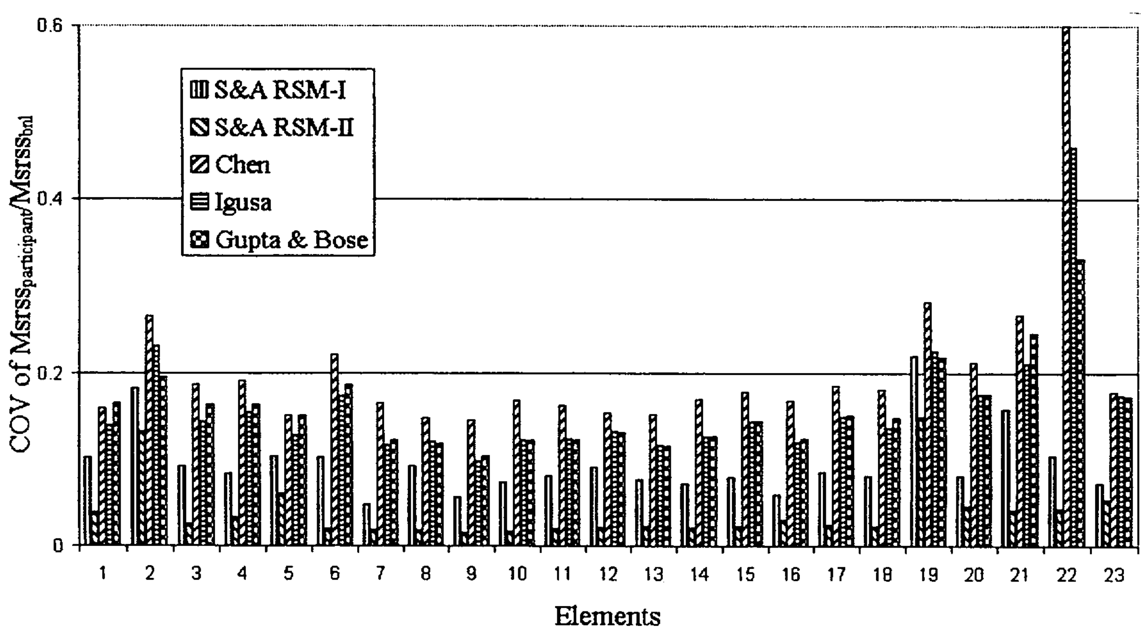

Figure 168. Comparison of Coefficients of variation of maximum SRSS element moments of S-component for benchmark problem No. 4b for seven earthquakes —Response spectrum methods.

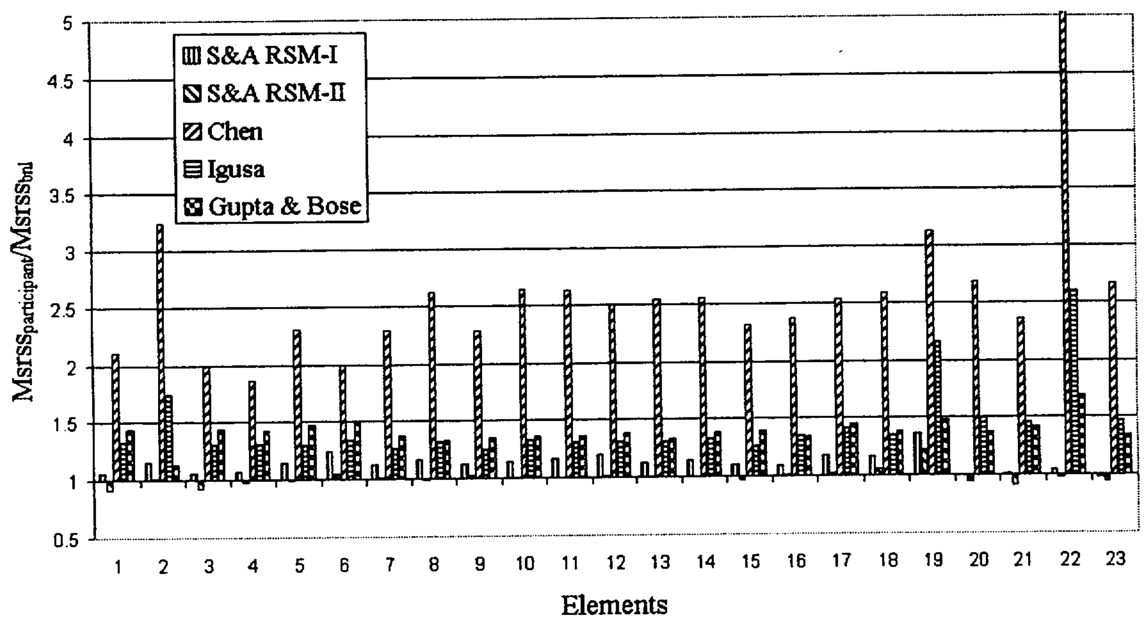

Figure 169. Comparison of maximum ratios of maximum SRSS element moments of S-component for benchmark problem No. 4b for seven earthquakes---Response spectrum methods

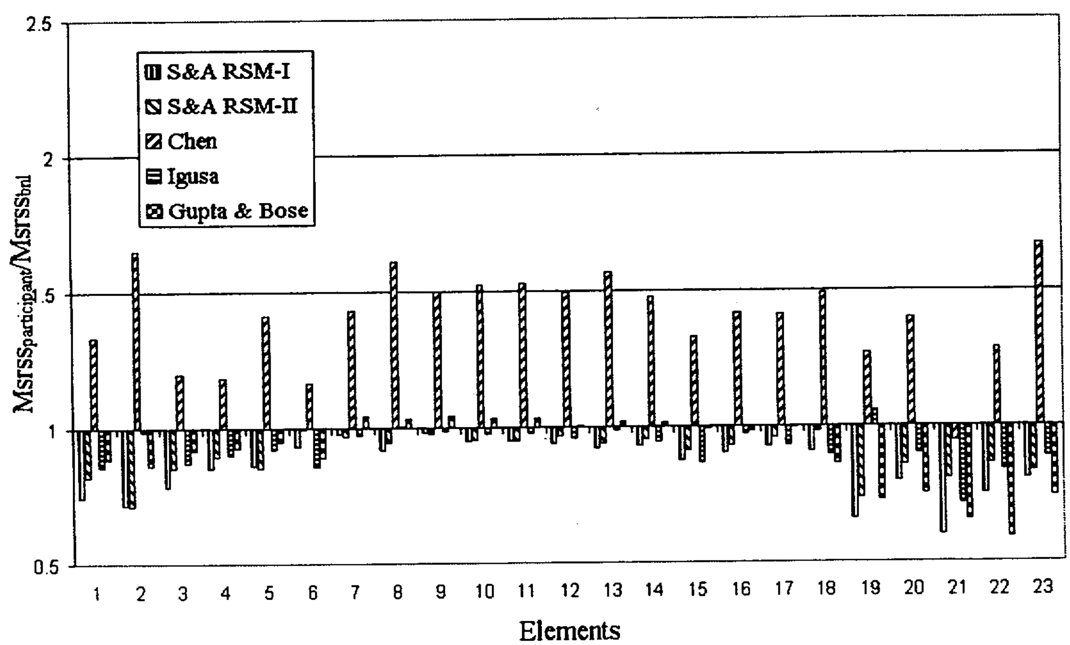

Figure 170. Comparison of minimum ratios of maximum SRSS element moments of S-component for benchmark problem No. 4b for seven earthquakes---Response spectrum methods

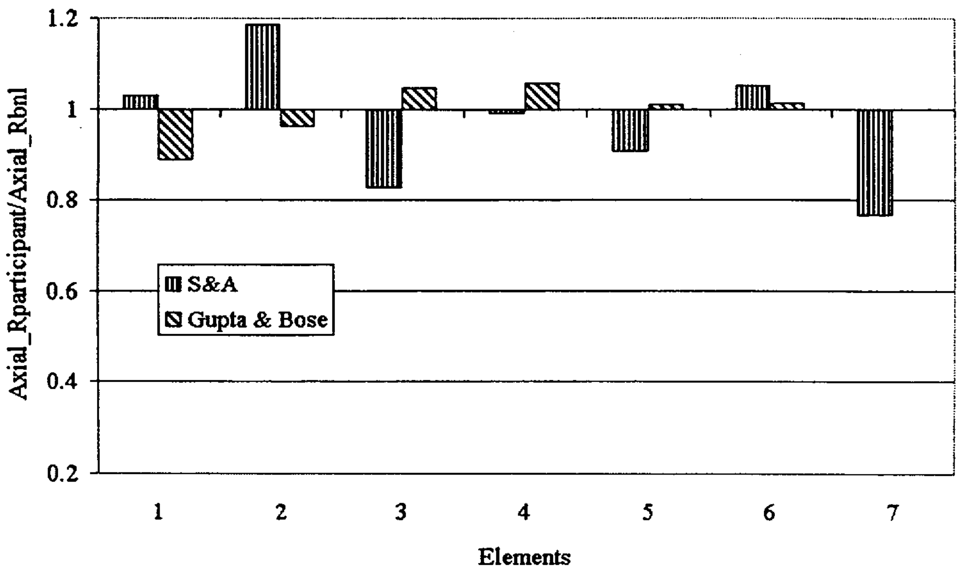

Figure 171. Comparison of maximum axial reaction forces of links for benchmark problem No. 4b, Case a—Modal superposition time history analyses

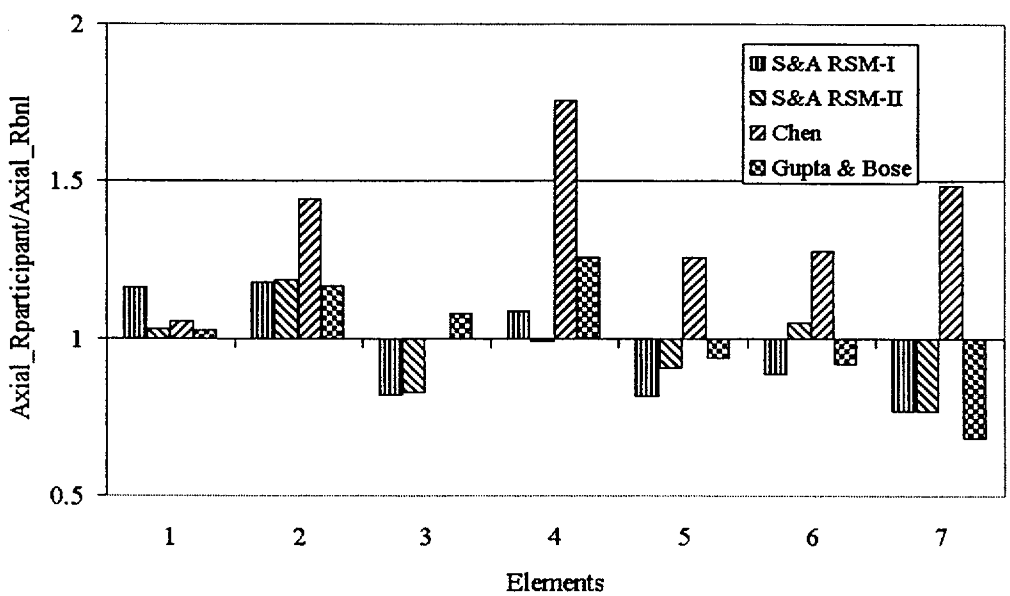

Figure 172. Comparison of maximum axial reaction forces of links for benchmark problem No. 4b, Case a—Response spectrum methods.

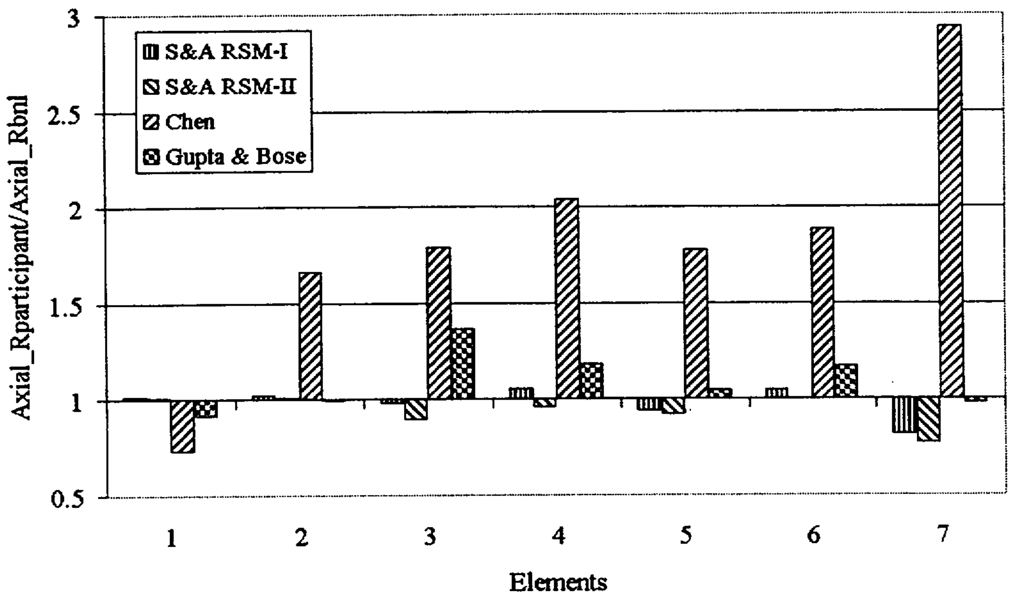

Figure 173. Comparison of mean responses of maximum axial reaction forces of links for benchmark problem No. 4b for seven earthquakes—Response spectrum methods.

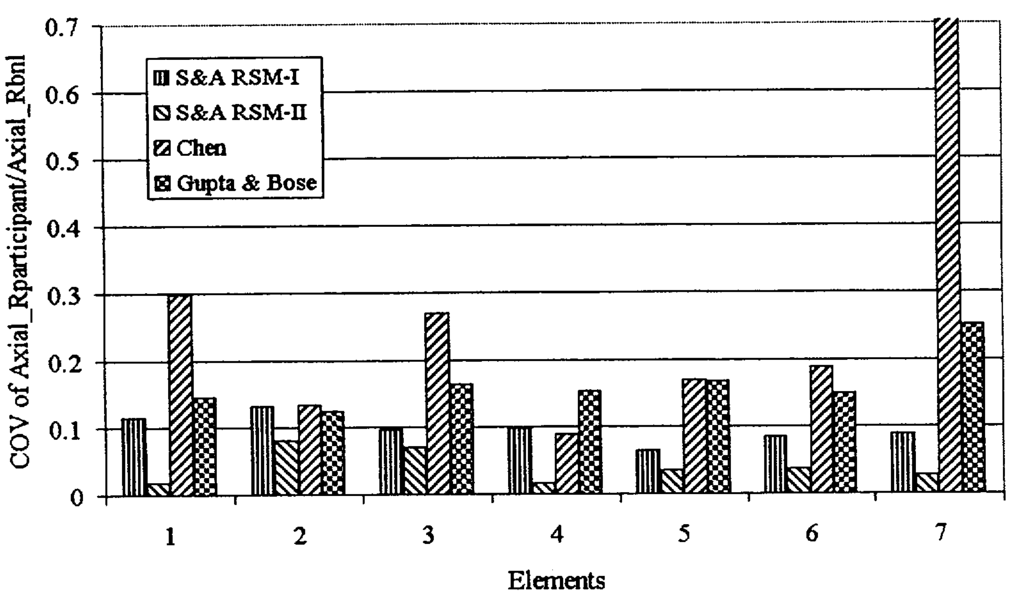

Figure 174. Comparison of Coefficients of variation of maximum axial reaction forces of links for benchmark problem No. 4b for seven earthquakes — Response spectrum methods.

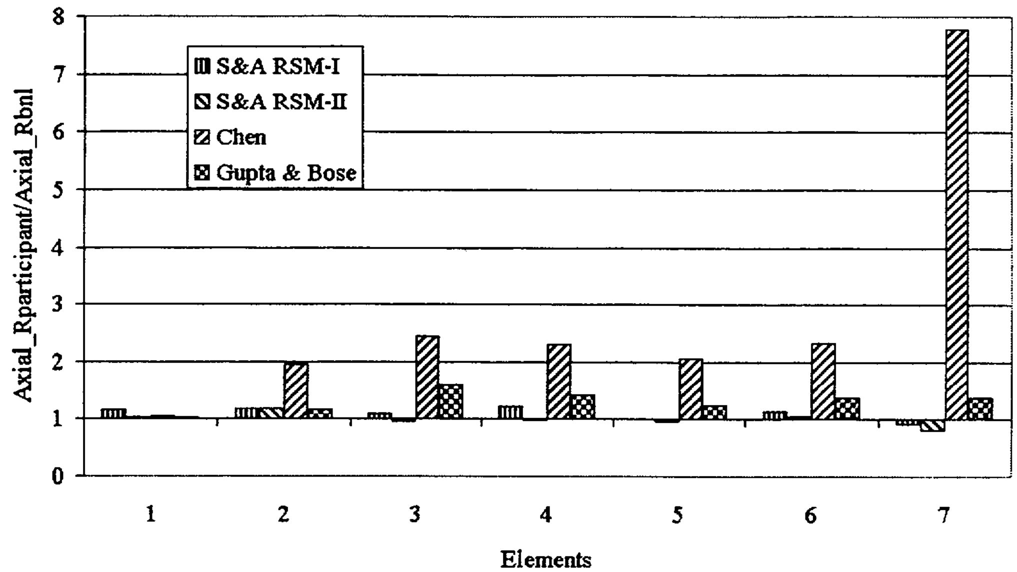

Figure 175. Comparison of maximum ratios of maximum axial reaction forces of links for benchmark problem No. 4b for seven earthquakes---Response spectrum methods

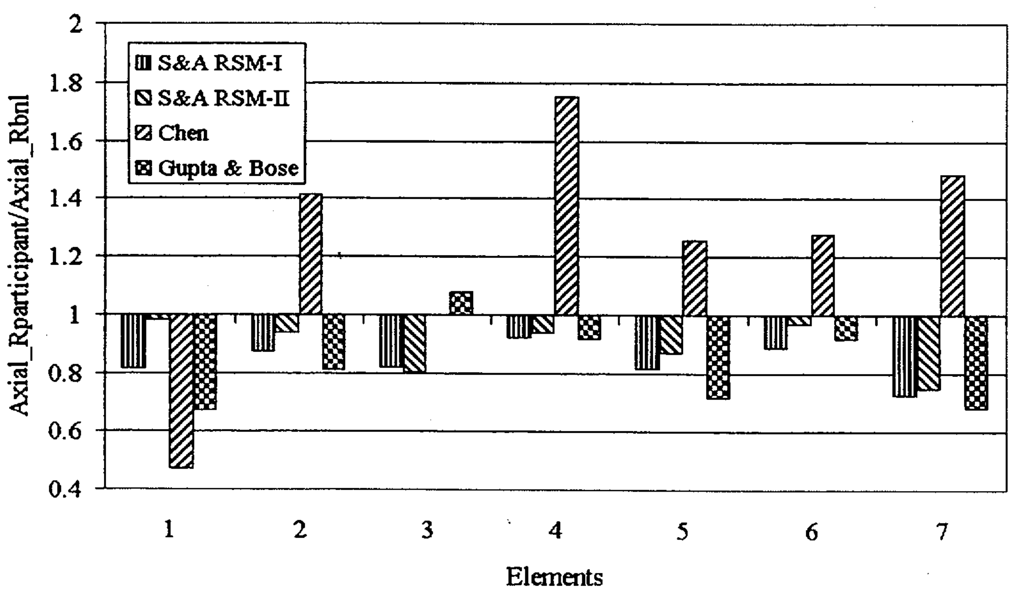

Figure 176. Comparison of minimum ratios of maximum axial reaction forces of links for benchmark problem No. 4b for seven earthquakes---Response spectrum methods

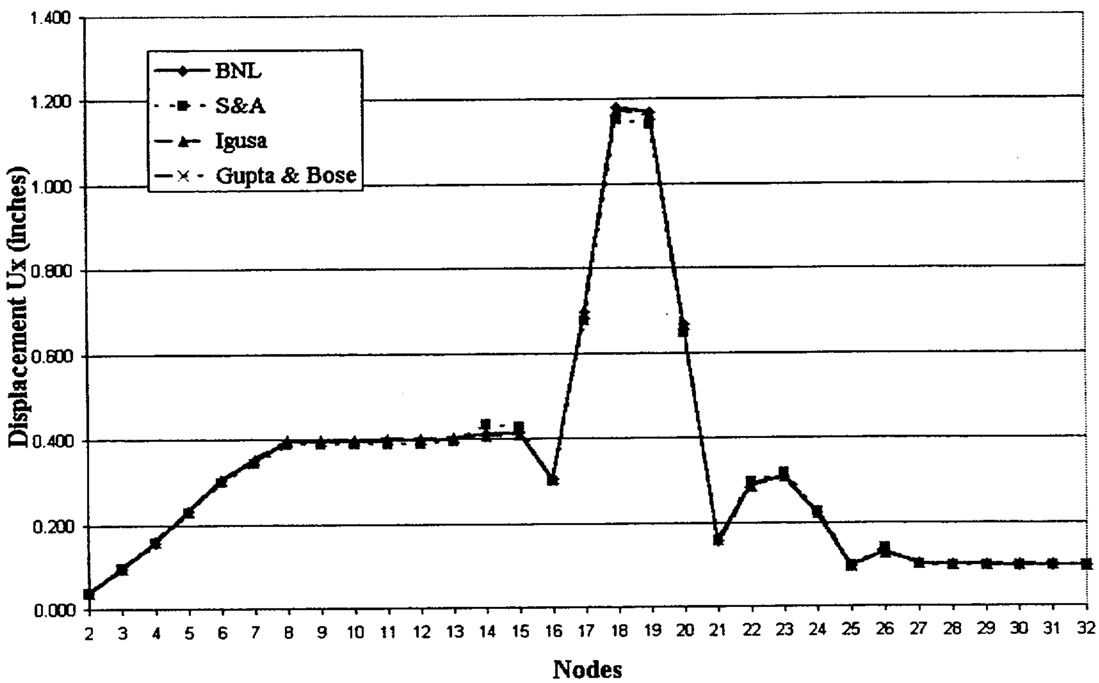

Figure 177. Comparison of actual maximum displacement U_x for benchmark problem No. 4b, Case a---Modal superposition time history analyses

APPENDIX A

GROUND MOTION INPUTS

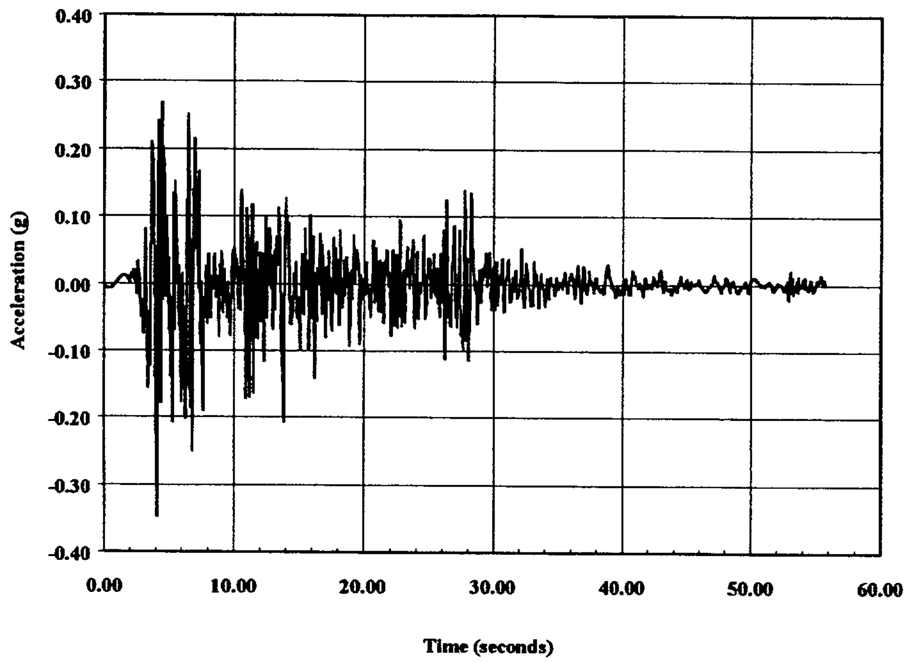

Figure A.1 EL CENTRO Earthquake acceleration time history (1940)

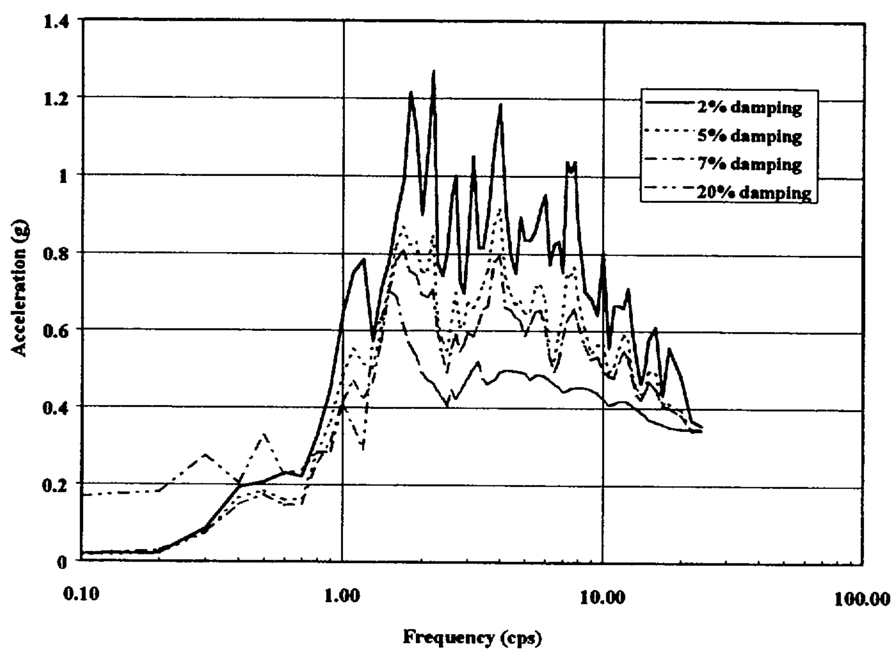

Figure A.2 EL CENTRO earthquake (1940) response spectra

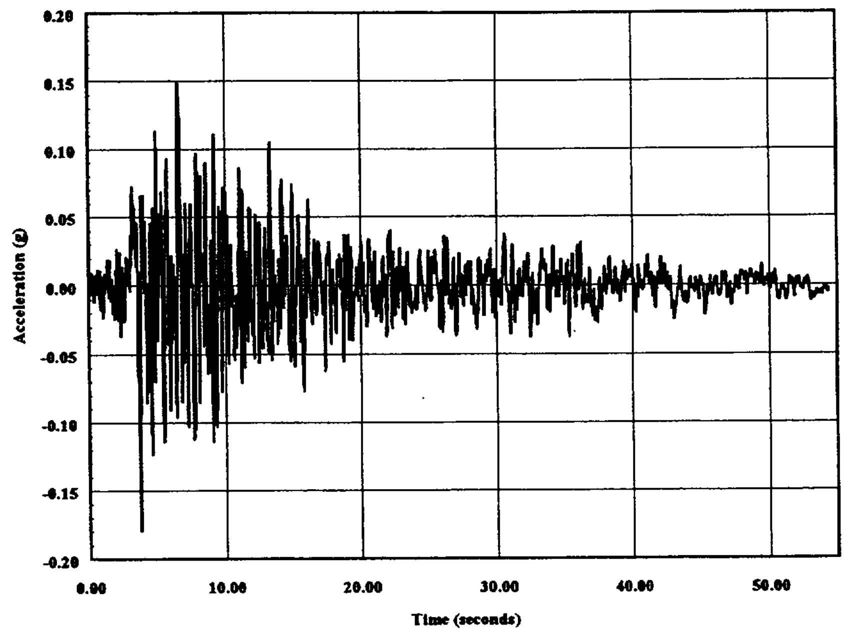

Figure A.3. TAFT earthquake acceleration time history (1952)

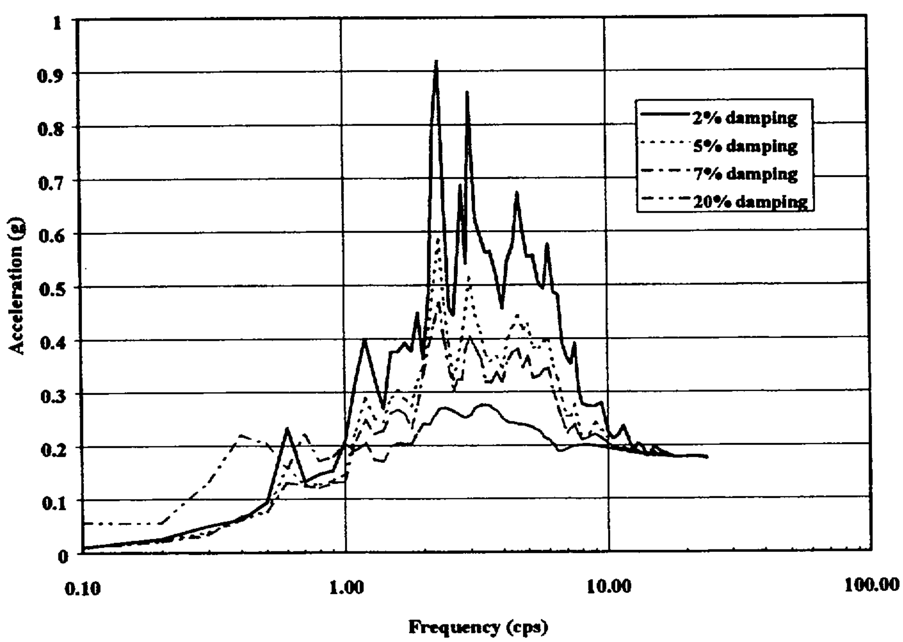

Figure A.4 TAFT earthquake (1952) response spectra

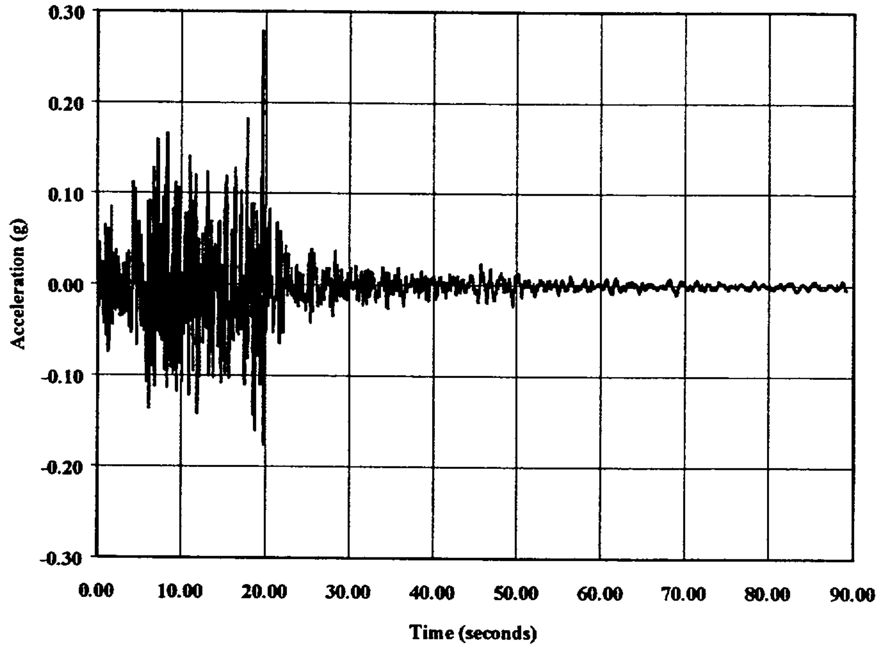

Figure A.5 OLYMPIA earthquake acceleration time history (1949)

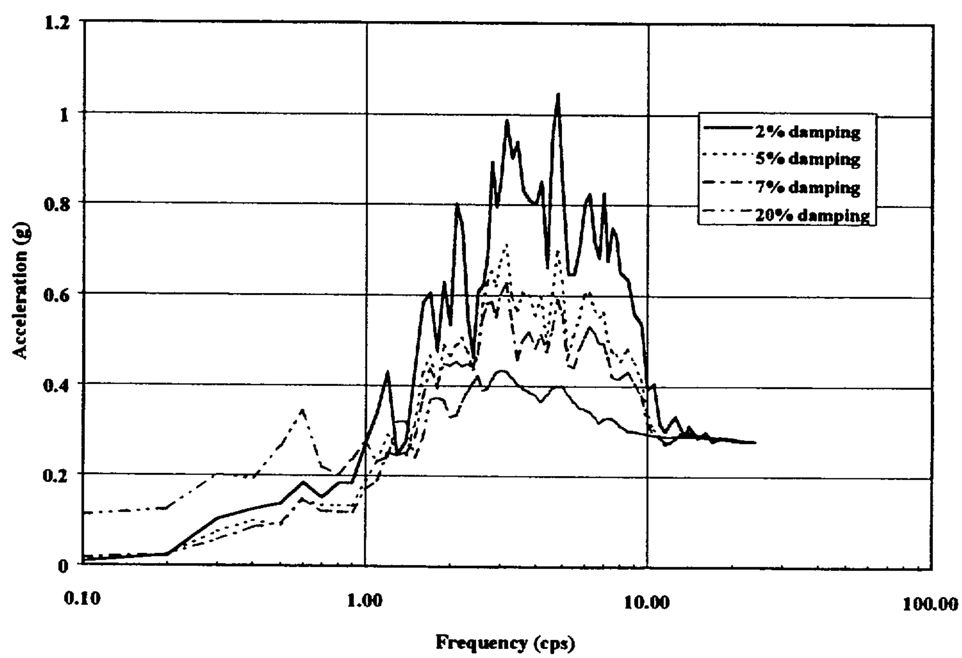

Figure A.6 OLYMPIA earthquake (1949) response spectra

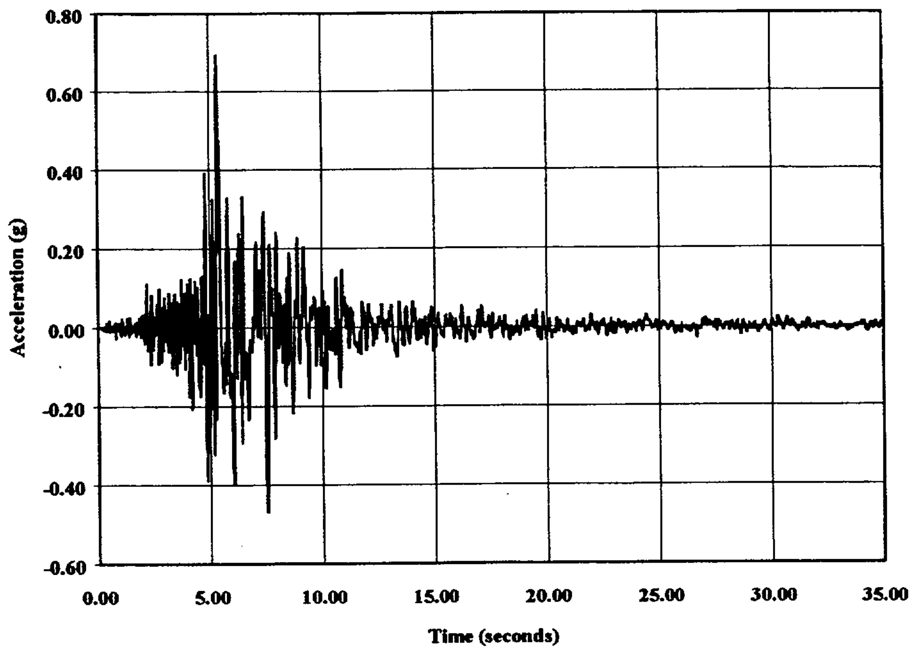

Figure A.7 EL CENTRO earthquake acceleration time history (1979)

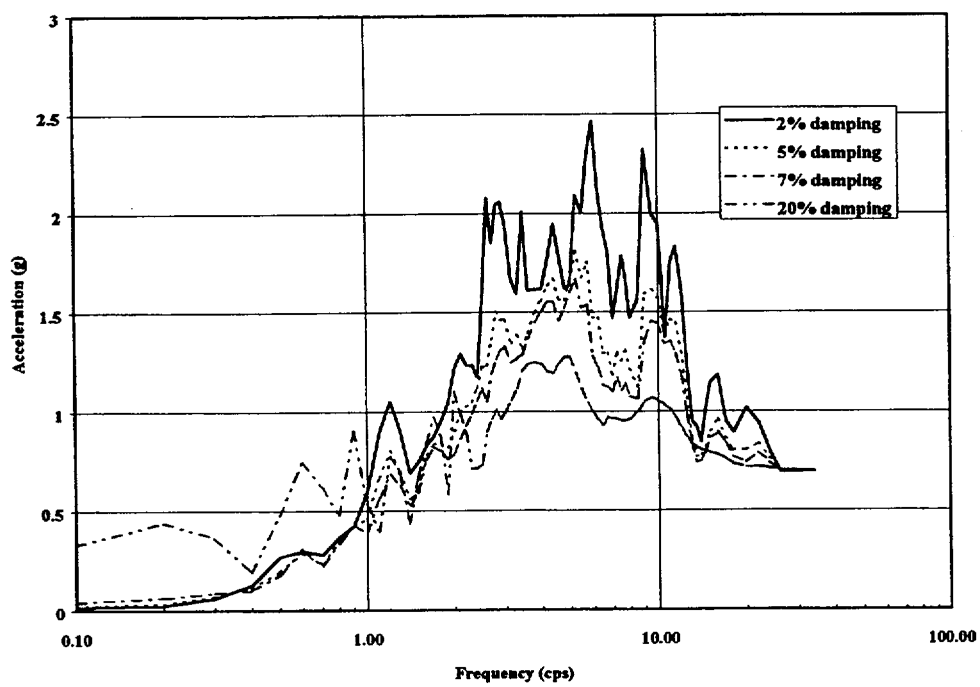

Figure A.8 EL CENTRO earthquake (1979) response spectra

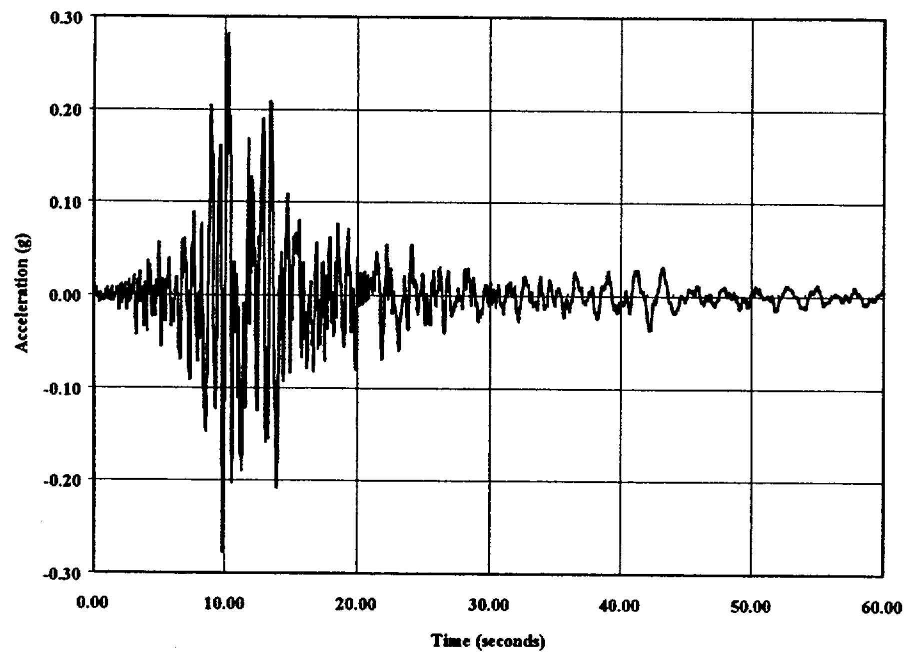

Figure A.9 LOMA PRIETA earthquake acceleration time history (1989)

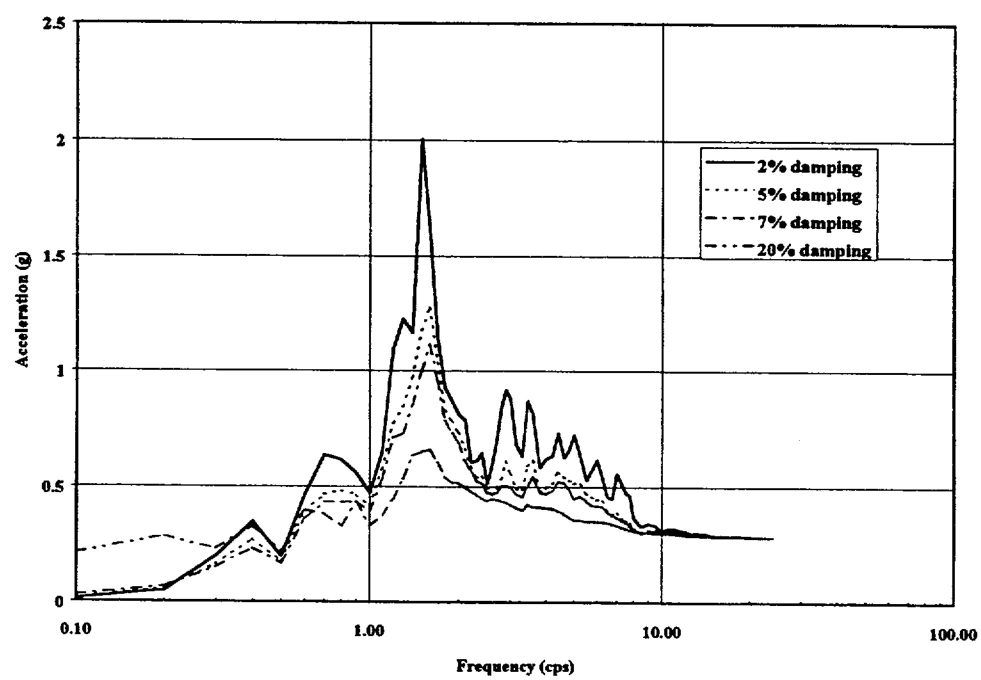

Figure A.10 LOMA PRIETA earthquake (1989) response spectra

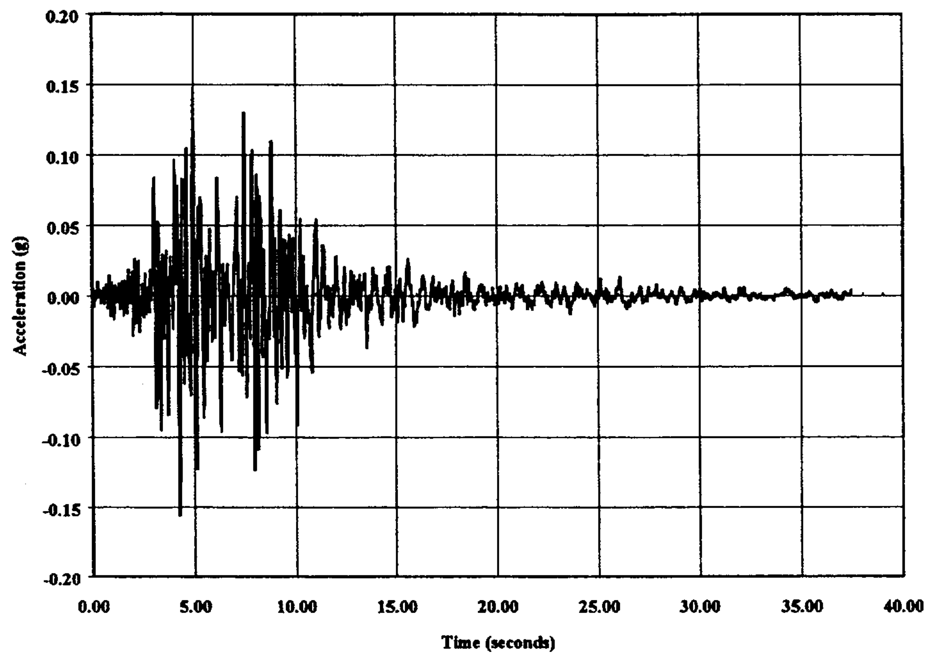

Figure A.11 NORTHRIDGE earthquake acceleration time history (1994)

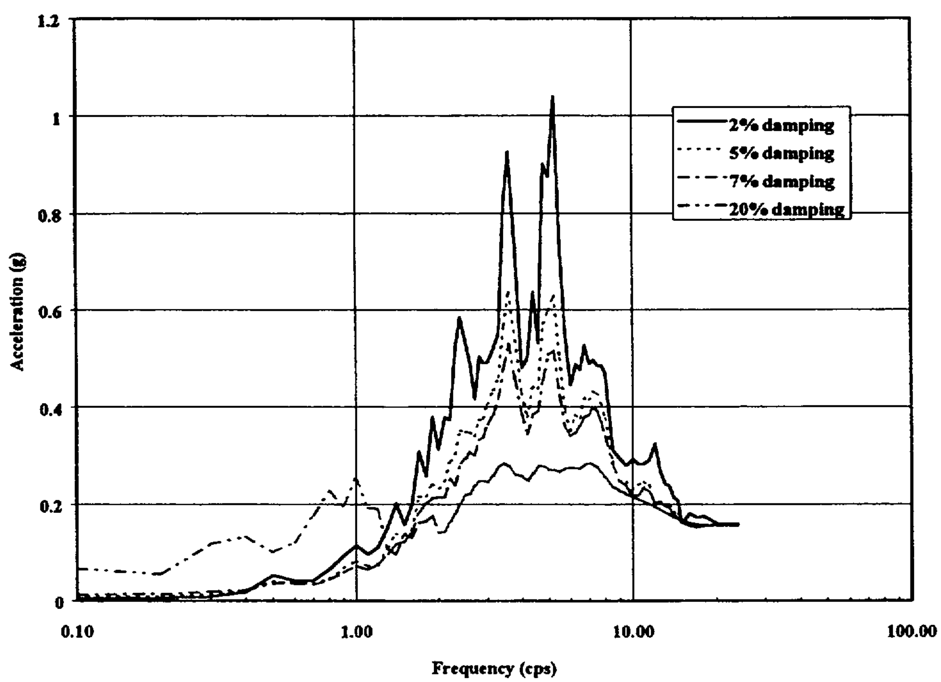

Figure A.12 NORTHRIDGE earthquake (1994) response spectra

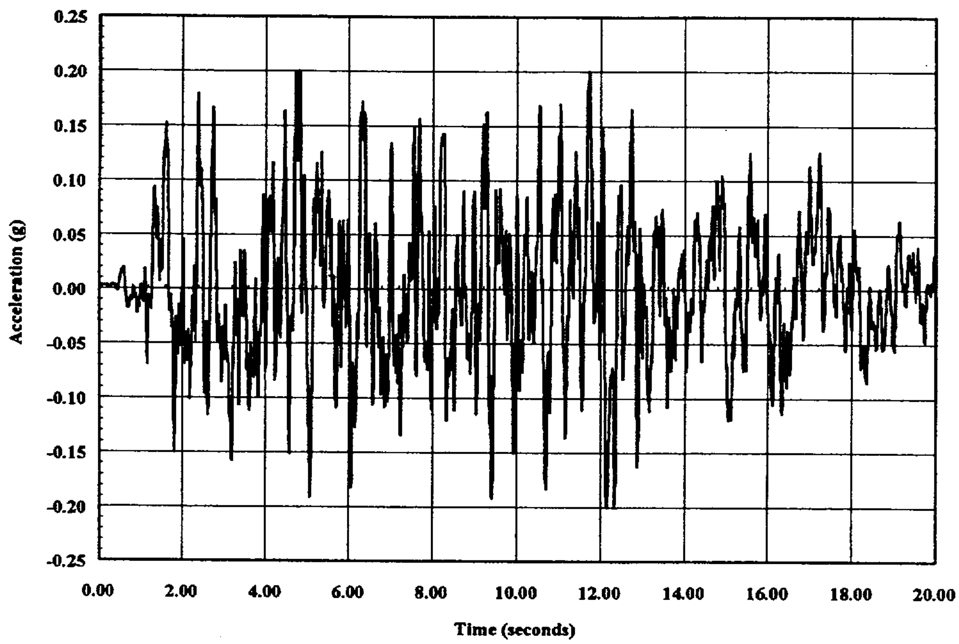

Figure A.13 REG. Guide 1.60 compatible artificial acceleration time history

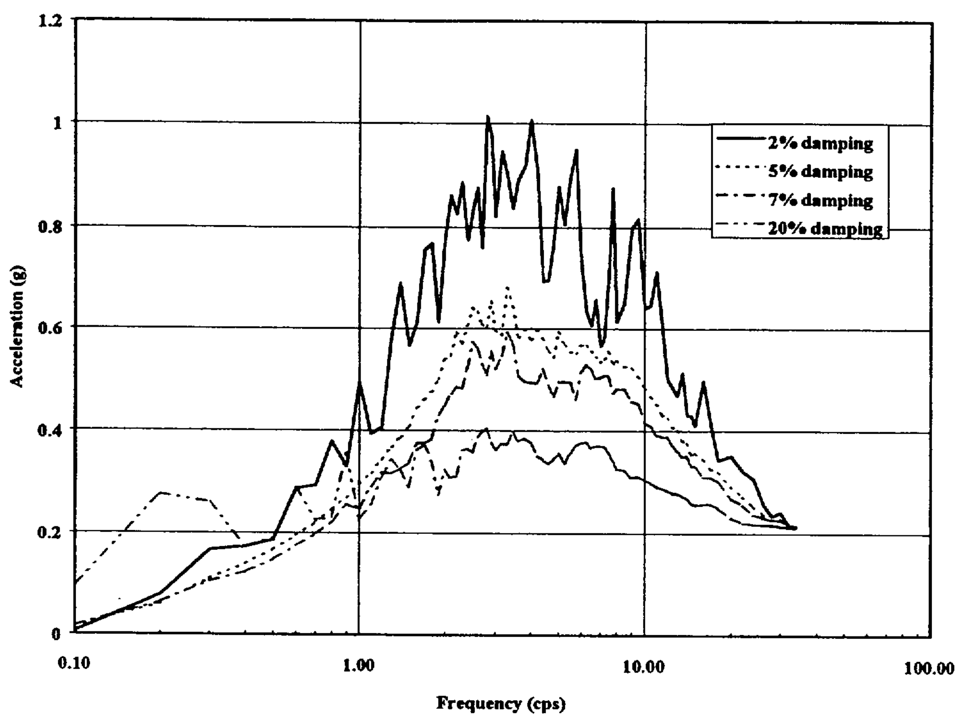

Figure A.14 REG. GUIDE 1.60 compatible artificial acceleration response spectra

APPENDIX B

BNL FORMULATION FOR EXPLICIT DAMPING MATRIX OF NON-CLASSICALLY DAMPED SYSTEM

This Appendix provides the formulation for the damping matrix of non-classical coupled structures, which the BNL "exact"solutions to the benchmark problems were based upon. In what follows, the system level damping matrix is first derived, which is then followed by the formulation of component damping matrices.

System-Level Damping Matrix

Consider a linear, **n**-degree-of-freedom (DOF), multiply connected non-classically damped system consisting of N structural components, each being classically damped in the fixed-constraint conditions. An example of a primary-secondary (P-S) system (in which case N=2) is shown in Figure 1. The equations of motion for this coupled system may be expressed in the system global coordinates as:

$$\mathbf{M}\,\ddot{\mathbf{U}} + \mathbf{C}\,\dot{\mathbf{U}} + \mathbf{K}\,\mathbf{U} = \mathbf{Q(t)} \qquad (1)$$

Where **M**, **C** and **K** represent the mass, damping, and stiffness matrices of the system, respectively, and **Q(t)** is a vector of time-dependent forces; **U** is a vector of **n**-dimensions representing the nodal displacements of the system relative to its base. A dot over **U** represents a derivative with respect to time.

In a similar manner to Equation (1), the equations of motion for each component may be written in the system global coordinates in terms of component DOFs. Suppose the s-component in the coupled system has **m**-DOF, then the equations of motion for the s-component may be written as:

$$\mathbf{M_s}\;\ddot{\mathbf{U}}_s\; + \mathbf{C_s}\;\dot{\mathbf{U}}_s\; + \mathbf{K_s}\;\mathbf{U_s} = \mathbf{Q_s}\;\mathbf{(t)} \qquad (2)$$

In the above equation, the subscript s denotes the s component properties; matrices $\mathbf{M_s}$, $\mathbf{C_s}$ and $\mathbf{K_s}$ represent the mass, damping, and stiffness of the s-component, respectively, and $\mathbf{Q_s(t)}$ is a vector of time-dependent forces; $\mathbf{U_s}$ is a vector of **m**-dimensions representing the nodal displacements of the s-component relative to the system base. If there are N-components in the coupled system, equation (2) should be repeated **N** times. Since the s-component displacement vector $\mathbf{U_s}$ is also defined in the system global coordinates, a transformation matrix can be easily formulated to relate the s-component displacements $\mathbf{U_s}$ to the system displacements U. Denoting this transformation matrix by $\boldsymbol{\beta}_s$, the following relation is readily obtained

$$\mathbf{U_s} = \boldsymbol{\beta}_s\,\mathbf{U} \qquad (3)$$

In equation (3), the matrix $\boldsymbol{\beta}_s$ with a dimension of **m x n** establishes the linkage between component DOFs and the system DOFs. Let $\boldsymbol{\beta}_s^{ij}$ represent an element in matrix $\boldsymbol{\beta}_s$ in which superscript **i** represents the **i**th DOF of the s-component and superscript **j** represents the **j**th DOF of the system. If there is a correspondence between the **i**th DOF displacement of the s-component $\mathbf{U_s}$ and **j**th DOF displacement of the system U, $\boldsymbol{\beta}_s^{ij}$ equals one, otherwise $\boldsymbol{\beta}_s^{ij}$ equals zero.

The transformation represented by Equation (3) may then be substituted into Equation (2), which is then pre-multiplied by the transpose of $\boldsymbol{\beta}_s$, yielding

$$\beta_s^T M_s \beta_s \ddot{U} + \beta_s^T C_s \beta_s \dot{U} + \beta_s^T K_s \beta_s U = \beta_s^T Q_s(t) \qquad (4)$$

For a system consisting of N-components, summation of Equation (4) over N-components should be performed, leading to the system equations of motion:

$$\sum_{s=1}^{N} \beta_s^T M_s \beta_s \ddot{U} + \sum_{s=1}^{N} \beta_s^T C_s \beta_s \dot{U} + \sum_{s=1}^{N} \beta_s^T K_s \beta_s U = \sum_{s=1}^{N} \beta_s^T Q_s(t) \qquad (5)$$

Equation (5) may then be compared to Equation (1), yielding the following relationships:

$$M = \sum_{s=1}^{N} \beta_s^T M_s \beta_s \qquad (6a)$$

$$C = \sum_{s=1}^{N} \beta_s^T C_s \beta_s \qquad (6b)$$

$$K = \sum_{s=1}^{N} \beta_s^T K_s \beta_s \qquad (6c)$$

and

$$Q = \sum_{s=1}^{N} \beta_s^T Q_s \qquad (6d)$$

Equations (6a) – (6d) represent the relations between the system properties and the properties of its components, and therefore, complete the process of combining the component property matrices into system-level property matrices. This process of synthesizing the system-level properties is accomplished through application of the component transformation matrix β_s.

However, Equations (6a) – (6d) only consider connections that are perfectly joined by components, which is not always true in real world. In other words, there is always some portion of energy escaping at the interconnections or supports. In order to simulate energy dissipation via supports or connections, the capability for local damping should be added to Equation (6b). To this end, the approach of using physical elements for interconnecting components, as delineated by Singh (Ref. 8), is employed. The effect of such energy loss on the system damping may be denoted by ΔC which can be added to the system damping matrix C in Equation (6b), leading to:

$$C = \sum_{s=1}^{N} \beta_s^T C_s \beta_s + \Delta C \qquad (7)$$

Once the structural type and number of connecting elements are determined for the coupled system, ΔC may readily be obtained using conventional assembling techniques. As an example, one-dimensional dampers can be used as interconnecting elements. Suppose that the components are connected by L_c dampers, and the damper coefficient is designated by C_d. The damping matrix for n_c^{th} damper may be written as

$$\Delta C_{n_c} = C_d \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \qquad (8)$$

and ΔC is readily assembled as:

$$\Delta C = \sum_{n_c=1}^{L_c} \Delta C_{n_c} \tag{9}$$

Component Damping Matrix

In this section, a synthesis formulation of the component damping matrix C_s is described. The kenematic model developed by Hurty (Ref. 13) is employed to represent the component motions.. In Hurty's model, the component displacements are simulated with three independent displacement modes, namely, "rigid-body", "constraint", and "normal" modes. The rigid-body modes are defined as the movement of the component while it remains undeformed. A component may possess a maximum of six rigid-body modes that can be determined with respect to the movement of a reference point, which is usually affixed to the component. Constraint modes account for the effects of multiple support motions provided by other components. In determining the number of constraint modes, one should weigh a number of considerations. First, a component may be interconnected with a number other components, some of which provide primary structural supports, while others may not, albeit they are connected to the considered component. The components that provide primary supports to the considered component are defined as primary components (with respect to the considered component), and the constraints that the primary components provide are defined as primary constraints. Engineering judgement may be required to identify primary components and the associated primary constraints because only the primary constraints are considered for the constraint modes. Once the support condition is established, the constraint effects of the considered component on its primary component will be ignored in the formulation for that primary component to avoid double counting. Second, if the supports to the component are sufficient only to the extent to which the rigid-body movements of the component are constrained, no constraint modes are required for the component. In other words, constraint modes only represent the effects of supports in excess to rigid-body movements of the component. The remaining normal modes represent the natural vibration motions of the component with all primary supports fixed. The advantage of representing the component motion with Hurty's model is that, in many engineering applications, damping associated with these displacement modes may be easily identified and therefore allow direct incorporation of the damping for these modes into the component damping matrix.

Next, let's define the notations for each of three displacement modes. Suppose the rigid body displacements of the component are designated by $\mathbf{u}^r$, and the rigid body displacement function by φ_l^r. φ_l^r represents the displacement of the component when the l^{th} rigid-body constraint displaces a unit value in the l^{th} constraint direction. In general, six independent rigid body displacement modes may exist.

The constraint modes are associated with motions of the redundant constraints. The number of constraint modes is equal the number of the component primary constraints minus the number of rigid-body constraints. Let's designate the component displacements associated with the constraint modes by $\mathbf{u}^c$, and the constraint displacement function by φ_j^c. The component displacement function φ_j^c represents the displacement of the component when the j^{th} redundant constraint is displaced by a unit value in the j^{th} constraint direction while holding all other constraints fixed including the constraints associated with rigid body modes.

The normal modes are characterized by the free vibration modes of the component with all constraints fixed. As they are infinite in number, for continuous systems it is usual to characterize the component with a truncated set, increasing the set size as more accuracy is desired. For a discrete system, one may use a complete set of modes or a subset, assuming that modes being excluded are considered undamped. Denote the component displacements associated with the normal modes by $\mathbf{u}^n$, the normal displacement functions by φ_k^n. φ_k^n is the k^{th} vibration mode of the component with fixed constraints.

With the aid of notations defined for the three displacement modes, and assuming that the component has L_r rigid-body modes, L_j constraint modes and L_n normal modes, the vector displacement of any point $\mathbf{x}$ in the component may be written as a superposition of the displacements associated with the three displacement modes:

$$\mathbf{u}(\mathbf{x}) = \mathbf{u}^r(\mathbf{x}) + \mathbf{u}^c(\mathbf{x}) + \mathbf{u}^n(\mathbf{x}) \tag{10}$$

or expressed in terms of the displacement functions:

$$\mathbf{u}(\mathbf{x}) = \sum_{l=1}^{L_r} \varphi_l^r(\mathbf{x})\,\mathbf{p}_l^r + \sum_{j=1}^{L_j} \varphi_j^c(\mathbf{x})\,\mathbf{p}_j^c + \sum_{k=1}^{L_n} \varphi_k^n(\mathbf{x})\,\mathbf{p}_k^n \tag{11}$$

where, the summations are taken over all the rigid body modes, constraint modes, and normal modes, respectively. The $\mathbf{p}$'s are generalized coordinates expressing the magnitude of the displacement functions.

When the component is modeled as a discrete system, Equation (11) may be expressed in a matrix form:

$$\mathbf{U}_s = \varphi_r\,\mathbf{p}_r + \varphi_c\,\mathbf{p}_c + \varphi_n\,\mathbf{p}_n \tag{12}$$

where, if the component has m-DOF, φ_r assumes the dimensions of mxL_r, φ_c and φ_n have the dimensions of mxL_j and mxL_n, respectively. The vectors $\mathbf{p}_r$, $\mathbf{p}_c$ and $\mathbf{p}_n$ contain the generalized coordinates associated with each of the three displacement modes and have the dimension of L_r, L_j and L_n, respectively.

For convenience, Equation (12) may also be written in partitioned form as:

$$\begin{aligned}\mathbf{U}_s &= \begin{bmatrix}\varphi_r & \varphi_c & \varphi_n\end{bmatrix}\begin{Bmatrix}\mathbf{p}_r\\ \mathbf{p}_c\\ \mathbf{p}_n\end{Bmatrix}\\ &= \Phi_s\,\mathbf{P}_s\end{aligned} \tag{13}$$

It is clear that Φ_s in Equation (13) defines a transformation for the component between displacement in the physical coordinates to the displacements in the generalized coordinates associated with the three displacement modes. Note also that the generalized coordinates in p's for the three modes are independent of each other. And for convenience, $\mathbf{U_s}$ in Equation (13) are re-arranged in the similar order, i.e.:

$$\mathbf{U_s} = \begin{Bmatrix} \mathbf{u_{sr}} \\ \mathbf{u_{sc}} \\ \mathbf{u_{sn}} \end{Bmatrix} \tag{14}$$

in which, the subscripts **sr**, **sc** and **sn** represent the nodal displacements associated with the generalized coordinates for rigid-body modes, constraint modes, and normal modes, respectively.

In Equation (13), the modal matrix $\boldsymbol{\varphi_r}$ for rigid-body motions is developed by simple application of rigid-body mechanics. The construction is columnwise, the i^{th} column being the vector of mass point rigid-body displacements of the component produced by the unit displacement of the i^{th} determinate constraint. The matrix has a maximum column order of six and a row order equal to the number of mass degrees of freedom in the component.

The development of the constraint matrix $\boldsymbol{\varphi_c}$ requires a consideration of the component stiffness characteristics. Either matrix force or displacement techniques may be employed in its construction. The i^{th} column is the vector of mass point displacements of the component produced by the unit displacement of the i^{th} redundant constraint, all other constraints being held fixed. The matrix has a column order equal to the number of component redundant constraints and a row order equal to the number of mass degrees of freedom in the component. The generalized coordinates associated with the rigid body modes are unaffected by the constraint modes. Therefore, elements in $\boldsymbol{\varphi_c}$ that correspond to the rigid-body constraints are set equal to zero.

The normal mode matrix is formed by free vibration eigenvectors of the component with all primary constraints fixed, assembled columnwise into the usual modal matrix; the i^{th} column corresponding to the i^{th} natural frequency. The matrix column order is equal to the number eigenvectors used; the row order, equal to the number of mass degrees of freedom. Since only the degrees of freedom associated with the normal modes are affected, the constraints associated with the generalized coordinates for the rigid body modes and the constraint modes are unaffected. Therefore, elements in $\boldsymbol{\varphi_n}$ that are associated with all constraints are set equal to zero.

Next, let us transform the equations of motion for the component, as given in Equation (2) from physical coordinates to the generalized coordinates defined by the three displacment modes. This may be easily performed by applying the transformation matrix $\boldsymbol{\Phi_s}$ in Equation (13) to Equation (2), and pre-multiply it by the transpose of $\boldsymbol{\Phi_s}$. By examining the damping term, the following relationship holds:

$$\boldsymbol{\Phi}_s^T \; \mathbf{C}_s \; \boldsymbol{\Phi}_s = \overline{\mathbf{C}}_s \tag{15}$$

where $\overline{\mathbf{C}}_s$ is the damping matrix defined in the generalized coordinates, and because of the three displacment modes being independent of each other, $\overline{\mathbf{C}}_s$ may be expressed in a diagonalized matrix in terms of modal damping associated with the three independent displacement modes. It follows that:

$$\overline{\mathbf{C}}_s = \begin{bmatrix} \mathbf{C}_r & & \\ & \mathbf{C}_c & \\ & & \mathbf{C}_n \end{bmatrix} \tag{16}$$

where, $\mathbf{C}_r$ and $\mathbf{C}_c$ are the damping matrices associated with the rigid-body modes and the constraint modes, and $\mathbf{C}_n$ is the modal damping matrix associated with the normal modes. If the total number of degrees of freedom of the component in the normal modes is denoted by $\mathbf{L}_n$, the damping ratio, natural mode and natural circular frequency associated with the $\mathbf{i}_s$ th normal mode are denoted by ξ_{is}, φ_{is} and ω_{is}, respectively, then $\mathbf{C}_n$ is readily determined by:

$$\mathbf{C}_n = \mathbf{m}_I \begin{bmatrix} 2\xi_{1s}\omega_{1s} & & \\ & \ddots & \\ & & 2\xi_{L_n}\omega_{L_n} \end{bmatrix} \tag{17}$$

where, $\mathbf{m}_I$ is some reference mass, so that $\mathbf{C}_n$ has units of lb-sec/ in, consistent with the units of $\mathbf{C}_s$.

In order to simplify Equation (15), the transformation matrix $\mathbf{\Phi}_s$ may be rewritten in terms of influence functions as:

$$\mathbf{\Phi}_s = \begin{bmatrix} \mathbf{I}_{rr} & \mathbf{0} & \mathbf{0} \\ \mathbf{T}_{rc} & \mathbf{I}_{cc} & \mathbf{0} \\ \mathbf{T}_{rn} & \mathbf{T}_{cn} & \varphi_{ns} \end{bmatrix} \tag{18}$$

In Equation (18), $\mathbf{I}_{rr}$ is an identity matrix with dimension equal to the total number of the degrees of freedom associated with rigid body modes; $\mathbf{I}_{cc}$ is an identity matrix with dimension equal to the total number of the degrees of freedom associated with the constraint modes; φ_{ns} is the matrix of eigenvectors associated with the normal modes of the component; $\mathbf{T}_{rc}$ and $\mathbf{T}_{rn}$ are matrices of influence functions representing displacements of DOFs associated with the constraint modes and normal modes and induced in turn by unit displacement in each of the rigid-body DOFs. Elements in $\mathbf{T}_{rc}$ and $\mathbf{T}_{rn}$ may be expressed as:

$$(\mathbf{T}_{rc})_{ij} = \frac{\partial(\mathbf{u}_{sc})_i}{\partial(\mathbf{p}_r)_j} \tag{19a}$$

and

$$(T_{rn})_{ij} = \frac{\partial(u_{sn})_i}{\partial(p_r)_j} \tag{19b}$$

Similarly, T_{cn} is a matrix of influence functions representing displacements of DOFs associated with the normal modes and induced in turn by unit displacement in each of the redundant constraint DOFs, while keeping all other constraints fixed. Its elements may be expressed as:

$$(T_{cn})_{ij} = \frac{\partial(u_{sn})_i}{\partial(p_c)_j} \tag{20}$$

With all the influence functions defined, the damping matrix C_s of the component is readily obtained by inverting Equation (15), yielding:

$$C_s = \begin{bmatrix} c_{s11} & c_{s12} & c_{s13} \\ & c_{s22} & c_{s23} \\ \text{Symm.} & & c_{s33} \end{bmatrix} \tag{21}$$

in which,

$$c_{s11} = C_r + T_{rc}^T C_c T_{rc} + (T_{rn} - T_{cn} T_{rc})^T \varphi_{sn}^{-T} C_n \varphi_{sn}^{-1} (T_{rn} - T_{cn} T_{rc}) \tag{22a}$$

$$c_{s12} = -T_{rc}^T C_c + (T_{rn} - T_{cn} T_{rc})^T \varphi_{sn}^{-T} C_n \varphi_{sn}^{-1} T_{cn} \tag{22b}$$

$$c_{s13} = -(T_{rn} - T_{cn} T_{rc})^T \varphi_{sn}^{-T} C_n \varphi_{sn}^{-1} \tag{22c}$$

$$c_{s22} = C_c + T_{cn}{}^T \varphi_{sn}^{-T} C_n \varphi_{sn}^{-1} T_{cn} \tag{22d}$$

$$c_{s23} = -T_{cn}{}^T \varphi_{sn}^{-T} C_n \varphi_{sn}^{-1} \tag{22e}$$

$$c_{s33} = \varphi_{sn}^{-T} C_n \varphi_{sn}^{-1} \tag{22f}$$

Equation (21) in conjunction with (22a)-(22f) completes the formulation of the component damping matrix.

Since c_{s33} in Equation (22f) is embedded in the other elements in Equations (22a)-(22e) as well, therefore, simplifying it further (by removing the transposes) may provide some level of computational convenience. It can be shown that the matrices φ_{sn}^{-T} and φ_{sn}^{-1} may be conveniently determined from orthogonality properties of the fixed-constraint eigenmodes, which lead to the following relationship:

$$\varphi_{sn}^{T}\, \mathbf{M}_{sn}\, \varphi_{sn} \; = \mathbf{m}_{I}\, \mathbf{I} \tag{23}$$

where the modes φ_{sn} are presumed to have been normalized so that **I** is a diagonal unity or the identity matrix.

From Equation (23), it follows that

$$\varphi_{sn}^{-1} \; = \varphi_{sn}^{T}\, \mathbf{M}_{sn} / \, \mathbf{m}_{I} \tag{24a}$$

and

$$\varphi_{sn}^{-T} \; = \mathbf{M}_{sn} \varphi_{sn} \, / \, \mathbf{m}_{I} \tag{24b}$$

Substituting Equations (24a) and (24b) into Equation (22f) yields:

$$\mathbf{c}_{s33} = \frac{\mathbf{M}_{sn}}{\mathbf{m}_{I}} \varphi_{sn}\, \mathbf{C}_{n}\, \varphi_{p}{}^{T} \frac{\mathbf{M}_{sn}}{\mathbf{m}_{I}} \tag{25}$$

Equation (25) may also be rewritten as

$$\mathbf{c}_{s33} = \frac{\mathbf{M}_{sn}}{\mathbf{m}_{I}} \{ \mathbf{m}_{I} \sum_{is=1}^{Ln} 2\xi_{is}\omega_{is}\, \varphi_{is}\, \varphi_{is}^{T} \} \frac{\mathbf{M}_{sn}}{\mathbf{m}_{I}} \tag{26}$$

Note that the summation in (26) represents the sum of $\mathbf{L}_n$ square matrices each of size $\mathbf{L}_n$x$\mathbf{L}_n$. Accordingly, matrix $\mathbf{c}_{s33}$ is of the same size. When a particular mode is not considered in the solution (the summation), that mode is effectively considered undamped and the corresponding ξ is equal to zero. Therefore, if there exist $\mathbf{l}_n$ modes with non-zero damping in modal matrix φ_{sn}, where $\mathbf{l}_n$ is less than $\mathbf{L}_n$, one can significantly reduce the computational effort by retaining only $\mathbf{l}_n$ modes in φ_{sn} in Equation (25). The modal matrix φ_{sn} after reduction will have dimension of $\mathbf{L}_n \times \mathbf{l}_n$. However, one should be cautioned that unless the contribution of a particular mode to the response is indeed negligible, deleting that mode from the summation in (25) or (26) may adversely affect the accuracy of the solution.

APPENDIX C

THE BNL BENCHMARK ANALYSIS RESULTS

Table C.1. Maximum nodal displacements for benchmark problem No.1 (inches)

Nodes	Load cases															
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**I**	**j**	**k**	**l**	**m**	**n**	**o**	**p**
2	0.081	0.081	0.083	0.080	0.083	0.082	0.099	0.133	0.081	0.081	0.049	0.081	0.237	0.068	0.065	0.063
3	0.152	0.155	0.157	0.152	0.158	0.156	0.189	0.256	0.153	0.155	0.092	0.152	0.447	0.127	0.123	0.118
4	0.210	0.216	0.216	0.212	0.221	0.218	0.263	0.365	0.212	0.216	0.127	0.210	0.617	0.173	0.172	0.162
5	0.254	0.261	0.262	0.257	0.267	0.263	0.321	0.459	0.257	0.262	0.151	0.251	0.737	0.206	0.208	0.193
6	0.278	0.285	0.286	0.280	0.292	0.288	0.342	0.472	0.281	0.286	0.164	0.271	0.799	0.222	0.226	0.209
7	0.959	0.859	0.701	0.708	0.304	1.110	0.648	0.663	0.671	0.446	0.590	1.040	1.486	0.701	0.896	0.849
8	1.698	1.384	1.375	1.120	0.333	1.980	0.921	0.839	1.158	0.620	1.003	1.722	2.506	1.172	1.657	1.504
9	2.244	1.958	1.880	1.419	0.353	2.625	1.116	0.965	1.520	0.749	1.308	2.222	3.255	1.518	2.225	1.988
10	2.533	2.291	2.149	1.576	0.364	2.966	1.217	1.031	1.712	0.817	1.469	2.486	3.651	1.701	2.527	2.245

Table C.2. Maximum element shear forces for benchmark problem No.1 (Kips)

Elements	Load cases															
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**I**	**j**	**k**	**l**	**m**	**n**	**o**	**p**
1	2,539.5	2,558.8	2,617.3	2,518.3	2,613.3	2,579.6	3,120.9	4,181.9	2,547.3	2,562.8	1,533.8	2,548.6	7,476.8	2,144.2	2,060.2	1,982.9
2	2,261.7	2,315.2	2,334.3	2,280.9	2,370.1	2,336.0	2,825.1	3,876.3	2,276.7	2,325.0	1,358.4	2,246.9	6,613.0	1,849.3	1,863.2	1,726.2
3	1,880.9	1,925.0	1,934.8	1,905.7	1,974.7	1,944.8	2,395.8	3,446.7	1,899.3	1,938.2	1,102.7	1,819.3	5,364.5	1,470.5	1,563.2	1,398.0
4	1,400.3	1,423.7	1,439.6	1,420.9	1,465.2	1,441.8	1,863.5	3,040.5	1,413.4	1,439.6	782.1	1,295.2	3,790.8	1,025.7	1,128.9	995.4
5	752.9	786.5	779.3	748.4	792.5	788.1	798.2	730.6	759.7	776.2	386.8	621.8	1,957.1	510.4	579.2	486.6
6	90.0	19.3	65.6	62.2	21.0	2.1	695.8	2,274.7	60.0	24.7	50.6	86.2	125.3	57.9	92.3	79.6
7	78.6	18.5	58.2	53.1	17.0	1.9	578.4	1,889.5	52.3	20.9	43.9	75.1	108.3	50.1	81.4	69.6
8	58.0	15.2	43.3	38.5	12.0	1.4	413.4	1,341.9	38.5	15.3	32.3	55.4	79.5	36.8	60.6	51.4
9	30.7	8.9	23.1	20.2	6.2	0.7	218.0	699.1	20.4	8.1	17.1	29.4	42.6	19.5	32.3	27.2

Table C.3. Maximum nodal displacements for benchmark problem No.2 (inches)

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	0.080	0.081	0.083	0.080	0.083	0.082	0.112	0.167	0.081	0.081	0.048	0.082	0.237	0.068	0.065	0.064
3	0.152	0.154	0.158	0.153	0.159	0.156	0.216	0.323	0.153	0.155	0.091	0.154	0.447	0.127	0.123	0.119
4	0.210	0.214	0.217	0.214	0.221	0.218	0.297	0.443	0.212	0.217	0.126	0.212	0.617	0.173	0.170	0.164
5	0.253	0.260	0.261	0.257	0.267	0.263	0.345	0.503	0.256	0.262	0.150	0.252	0.737	0.205	0.205	0.194
6	0.277	0.284	0.286	0.280	0.292	0.288	0.365	0.520	0.280	0.286	0.162	0.272	0.799	0.221	0.224	0.210
7	1.277	1.321	1.110	0.817	0.233	1.511	0.716	0.625	0.875	0.476	0.765	1.296	1.929	0.894	1.245	1.137
8	1.780	2.077	1.582	1.095	0.273	2.111	0.942	0.765	1.211	0.623	1.051	1.770	2.637	1.222	1.753	1.571
9	1.296	1.371	1.102	0.846	0.268	1.530	0.778	0.682	0.894	0.515	0.782	1.336	1.959	0.915	1.251	1.139
10	1.610	1.380	1.343	1.055	0.297	1.907	0.871	0.855	1.100	0.583	0.962	1.621	2.394	1.110	1.589	1.430
11	2.238	2.225	1.928	1.405	0.335	2.659	1.109	1.021	1.519	0.747	1.318	2.200	3.259	1.511	2.239	1.980
12	1.622	1.416	1.340	1.073	0.324	1.919	0.912	0.879	1.112	0.610	0.973	1.648	2.407	1.124	1.592	1.429

Table C.4. Maximum element shear forces for benchmark problem No.2 (Kips)

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	2,536.7	2,559.2	2,628.3	2,527.5	2,621.6	2,579.6	3,537.8	5,279.3	2,547.0	2,569.3	1,528.8	2,586.4	7,478.5	2,148.0	2,054.9	2,009.0
2	2,259.5	2,300.9	2,345.1	2,300.3	2,378.1	2,336.0	3,258.8	4,913.2	2,282.9	2,332.0	1,355.5	2,283.2	6,616.8	1,853.9	1,847.9	1,751.3
3	1,875.7	1,917.3	1,933.4	1,906.0	1,975.6	1,944.7	2,574.8	3,796.1	1,895.6	1,937.2	1,092.8	1,827.2	5,362.2	1,466.7	1,545.6	1,406.3
4	1,377.2	1,428.8	1,427.9	1,383.0	1,454.4	1,441.3	1,566.0	2,050.1	1,391.7	1,424.0	754.1	1,244.3	3,776.8	1,004.0	1,102.2	967.1
5	749.5	784.7	778.2	746.6	792.1	788.0	779.5	808.3	757.1	775.0	382.1	622.7	1,954.9	507.5	571.9	487.2
6	26.4	7.3	20.2	18.0	6.5	0.6	219.5	697.9	17.7	7.7	15.1	25.2	38.0	17.4	26.7	23.4
7	11.0	4.1	8.5	7.4	3.6	0.3	98.8	305.6	7.4	3.3	6.3	10.4	15.5	7.2	11.1	9.5
8	10.6	3.9	8.6	6.6	0.7	0.3	76.7	189.4	7.0	2.6	5.9	10.0	14.9	6.7	11.0	9.4
9	26.2	7.6	20.3	17.4	4.2	0.6	210.8	568.4	17.5	7.7	14.9	24.9	37.0	17.0	26.7	23.0
10	33.1	7.7	24.6	23.0	7.6	0.8	250.6	930.8	22.2	9.2	18.9	31.6	46.6	21.4	34.2	29.4
11	13.7	4.7	10.4	9.3	3.3	0.3	103.9	363.3	9.2	3.8	7.8	13.0	18.9	8.7	14.2	12.0
12	13.5	4.5	10.5	8.8	1.7	0.3	93.8	320.7	8.9	3.5	7.5	12.8	18.9	8.5	14.2	12.0
13	33.0	7.9	24.8	22.4	5.7	0.8	247.4	858.8	22.1	9.1	18.8	31.5	45.8	21.1	34.2	29.1

Table C.5. Maximum nodal displacements for benchmark problem No.3 (inches)

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	0.081	0.081	0.083	0.080	0.083	0.082	0.099	0.126	0.081	0.081	0.048	0.080	0.237	0.068	0.065	0.063
3	0.152	0.154	0.158	0.151	0.157	0.156	0.190	0.243	0.153	0.154	0.091	0.151	0.447	0.126	0.123	0.117
4	0.210	0.215	0.217	0.211	0.220	0.218	0.268	0.347	0.211	0.214	0.125	0.208	0.617	0.172	0.170	0.162
5	0.253	0.259	0.261	0.256	0.266	0.263	0.328	0.437	0.255	0.259	0.150	0.249	0.737	0.204	0.205	0.193
6	0.277	0.284	0.286	0.280	0.291	0.288	0.355	0.481	0.279	0.284	0.162	0.270	0.799	0.221	0.224	0.209
7	0.885	1.442	0.879	0.515	0.104	1.051	0.442	0.299	0.592	0.276	0.517	0.865	1.371	0.621	0.860	0.804
8	1.278	1.898	1.192	0.766	0.189	1.514	0.712	0.481	0.861	0.442	0.752	1.279	1.956	0.902	1.226	1.126
9	0.964	1.405	0.827	0.655	0.246	1.134	0.672	0.505	0.668	0.426	0.594	1.033	1.521	0.714	0.888	0.827
10	1.815	1.422	1.485	1.204	0.343	2.154	0.933	0.920	1.232	0.629	1.079	1.807	2.690	1.245	1.797	1.606
11	2.520	2.313	2.141	1.599	0.380	2.999	1.169	1.112	1.695	0.788	1.475	2.443	3.655	1.689	2.534	2.229
12	1.820	1.437	1.485	1.213	0.354	2.158	0.956	0.947	1.234	0.632	1.084	1.821	2.689	1.250	1.797	1.605

Table C.6. Maximum element shear forces for benchmark problem No.3 (Kips)

Elements	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	2,541.1	2,558.5	2,626.4	2,518.2	2,603.4	2,579.3	3,124.2	3,986.5	2,553.5	2,561.1	1,516.0	2,530.7	7,478.2	2,128.4	2,049.6	1,977.3
2	2,263.2	2,304.8	2,342.9	2,269.8	2,360.1	2,335.7	2,868.6	3,685.5	2,274.8	2,300.9	1,341.9	2,230.9	6,612.8	1,835.1	1,842.4	1,721.6
3	1,871.9	1,916.1	1,932.4	1,896.8	1,965.8	1,944.6	2,445.4	3,383.0	1,888.7	1,917.0	1,088.9	1,807.0	5,363.4	1,459.1	1,545.1	1,395.5
4	1,394.0	1,416.9	1,437.7	1,414.8	1,457.8	1,441.6	1,899.0	2,942.9	1,405.7	1,423.1	772.2	1,287.7	3,789.1	1,018.1	1,115.0	995.0
5	759.8	778.2	784.0	767.8	796.8	788.2	890.0	1,457.7	767.0	779.5	393.7	652.0	1,961.0	516.6	579.7	505.9
6	19.3	7.9	15.5	13.6	9.1	0.5	192.8	652.6	12.9	6.0	11.3	18.9	29.9	13.5	18.8	17.5
7	8.6	5.0	6.3	6.8	7.5	0.2	118.1	432.1	5.9	3.6	5.2	9.0	14.0	6.1	8.0	7.3
8	7.4	4.1	7.2	3.2	5.0	0.2	47.0	235.4	4.5	2.3	3.6	6.4	12.2	4.4	7.7	6.7
9	18.5	8.1	15.7	11.0	2.3	0.4	155.1	364.2	12.3	6.0	10.4	17.3	26.8	12.1	18.6	16.1
10	37.4	7.9	27.4	26.0	9.6	0.9	264.3	1,072.4	24.9	10.4	21.1	35.5	52.2	23.9	38.9	33.0
11	15.4	5.0	11.6	10.5	3.6	0.4	106.4	421.8	10.2	3.7	8.7	14.6	21.1	9.7	16.1	13.6
12	15.3	4.9	11.7	10.2	3.1	0.4	103.0	367.8	10.2	4.2	8.5	14.4	21.4	9.6	16.2	13.6
13	37.3	8.0	27.6	25.7	8.5	0.9	262.6	1,028.4	24.7	9.8	21.1	35.4	51.6	23.7	38.8	32.9

Table C.7. Maximum nodal displacements for benchmark problem No.4a (inches)

Nodes	Load cases						
	a	b	c	d	e	f	g
2ux	1.60E-06	1.81E-07	4.98E-07	3.67E-07	1.30E-07	4.92E-07	3.72E-07
2uy	1.17E-02	4.47E-03	8.00E-03	2.00E-02	6.49E-03	6.35E-03	9.09E-03
2uz	2.07E-07	2.48E-08	6.51E-08	2.02E-07	1.88E-08	4.62E-08	1.01E-07
2θx	3.12E-05	1.13E-05	2.22E-05	5.58E-05	1.58E-05	1.68E-05	2.53E-05
2θy	9.47E-10	2.20E-10	6.13E-10	1.13E-09	2.48E-10	3.94E-10	8.29E-10
2θz	7.43E-10	2.93E-10	6.04E-10	1.47E-09	4.03E-10	3.60E-10	6.35E-10
3ux	2.78E-06	3.56E-07	1.00E-06	9.41E-07	2.84E-07	9.10E-07	8.68E-07
3uy	2.88E-02	1.07E-02	2.00E-02	5.01E-02	1.53E-02	1.55E-02	2.28E-02
3uz	4.06E-07	4.87E-08	1.28E-07	4.00E-07	3.73E-08	9.05E-08	1.98E-07
3θx	5.42E-05	1.95E-05	3.88E-05	9.76E-05	2.71E-05	2.90E-05	4.43E-05
3θy	1.56E-09	3.89E-10	1.05E-09	2.02E-09	4.31E-10	7.13E-10	1.39E-09
3θz	1.49E-09	5.86E-10	1.21E-09	2.94E-09	8.05E-10	7.20E-10	1.27E-09
4ux	3.10E-06	4.51E-07	1.30E-06	1.53E-06	4.04E-07	1.09E-06	1.29E-06
4uy	4.57E-02	1.69E-02	3.21E-02	8.05E-02	2.38E-02	2.46E-02	3.66E-02
4uz	5.37E-07	7.04E-08	2.04E-07	6.96E-07	6.74E-08	1.35E-07	3.22E-07
4θx	6.76E-05	2.43E-05	4.87E-05	1.22E-04	3.34E-05	3.62E-05	5.56E-05
4θy	3.20E-09	5.64E-10	1.62E-09	2.57E-09	5.79E-10	1.25E-09	1.80E-09
4θz	1.85E-09	7.09E-10	1.52E-09	3.78E-09	9.44E-10	8.30E-10	1.61E-09
5ux	2.77E-06	4.92E-07	1.49E-06	2.33E-06	5.46E-07	1.07E-06	1.79E-06
5uy	6.64E-02	2.42E-02	4.70E-02	1.18E-01	3.39E-02	3.56E-02	5.36E-02
5uz	6.67E-07	1.01E-07	2.86E-07	1.02E-06	1.05E-07	1.82E-07	4.53E-07
5θx	7.73E-05	2.76E-05	5.59E-05	1.41E-04	3.79E-05	4.14E-05	6.39E-05
5θy	4.97E-09	7.49E-10	2.19E-09	3.01E-09	7.12E-10	1.82E-09	2.15E-09
5θz	2.38E-09	8.72E-10	1.93E-09	4.62E-09	1.15E-09	1.09E-09	2.07E-09
6ux	2.00E-06	6.01E-07	1.54E-06	3.15E-06	6.84E-07	8.89E-07	2.26E-06
6uy	8.74E-02	3.17E-02	6.23E-02	1.57E-01	4.41E-02	4.69E-02	7.11E-02
6uz	7.75E-07	1.33E-07	3.62E-07	1.32E-06	1.41E-07	2.23E-07	5.75E-07
6θx	8.22E-05	2.93E-05	5.97E-05	1.50E-04	4.02E-05	4.41E-05	6.82E-05
6θy	6.19E-09	8.66E-10	2.56E-09	3.27E-09	8.03E-10	2.20E-09	2.35E-09
6θz	2.93E-09	1.05E-09	2.33E-09	5.46E-09	1.36E-09	1.34E-09	2.54E-09
7ux	2.79E-06	7.17E-07	1.92E-06	3.70E-06	7.97E-07	1.28E-06	2.57E-06
7uy	1.00E-01	3.63E-02	7.18E-02	1.81E-01	5.04E-02	5.39E-02	8.21E-02
7uz	8.24E-07	1.54E-07	4.07E-07	1.51E-06	1.63E-07	2.46E-07	6.46E-07
7θx	8.34E-05	2.98E-05	6.06E-05	1.52E-04	4.07E-05	4.47E-05	6.93E-05
7θy	6.57E-09	9.00E-10	2.67E-09	3.34E-09	8.30E-10	2.31E-09	2.41E-09
7θz	3.39E-09	1.20E-09	2.65E-09	6.05E-09	1.54E-09	1.59E-09	2.91E-09

8ux	4.01E-06	8.37E-07	2.38E-06	4.21E-06	9.22E-07	1.69E-06	2.90E-06
8uy	1.13E-01	4.07E-02	8.08E-02	2.03E-01	5.63E-02	6.05E-02	9.23E-02
8uz	8.56E-07	1.73E-07	4.48E-07	1.67E-06	1.84E-07	2.65E-07	7.09E-07
8θx	8.38E-05	2.99E-05	6.09E-05	1.53E-04	4.08E-05	4.49E-05	6.96E-05
8θy	6.68E-09	9.09E-10	2.71E-09	3.36E-09	8.37E-10	2.35E-09	2.43E-09
8θz	3.86E-09	1.34E-09	2.97E-09	6.80E-09	1.71E-09	1.83E-09	3.29E-09
9ux	4.00E-06	8.79E-07	2.32E-06	4.35E-06	8.95E-07	1.71E-06	2.89E-06
9uy	1.13E-01	4.07E-02	8.08E-02	2.03E-01	5.63E-02	6.05E-02	9.23E-02
9uz	6.53E-03	2.33E-03	4.75E-03	1.19E-02	3.18E-03	3.50E-03	5.43E-03
9θx	8.38E-05	2.99E-05	6.09E-05	1.53E-04	4.08E-05	4.49E-05	6.96E-05
9θy	6.68E-09	9.09E-10	2.71E-09	3.36E-09	8.37E-10	2.35E-09	2.43E-09
9θz	3.86E-09	1.34E-09	2.97E-09	6.80E-09	1.71E-09	1.83E-09	3.29E-09
10ux	1.30E-05	2.09E-06	5.98E-06	1.37E-05	1.87E-06	4.48E-06	8.26E-06
10uy	1.21E-01	4.33E-02	8.62E-02	2.17E-01	5.96E-02	6.49E-02	9.90E-02
10uz	6.86E-03	2.40E-03	4.92E-03	1.23E-02	3.28E-03	3.75E-03	5.83E-03
10θx	1.53E-04	5.23E-05	1.18E-04	3.46E-04	6.32E-05	7.58E-05	1.65E-04
10θy	1.88E-05	3.45E-06	7.70E-06	1.85E-05	3.64E-06	4.62E-06	1.12E-05
10θz	1.28E-04	3.90E-05	7.78E-05	2.04E-04	4.68E-05	6.15E-05	9.54E-05
11ux	2.70E-05	3.92E-06	1.01E-05	2.39E-05	3.19E-06	8.59E-06	1.41E-05
11uy	1.24E-01	4.40E-02	8.75E-02	2.20E-01	6.06E-02	6.64E-02	1.01E-01
11uz	6.90E-03	2.42E-03	4.97E-03	1.24E-02	3.37E-03	3.91E-03	5.97E-03
11θx	2.57E-04	9.08E-05	2.21E-04	6.44E-04	9.43E-05	1.18E-04	3.02E-04
11θy	8.55E-06	1.33E-06	2.85E-06	6.77E-06	1.17E-06	1.63E-06	3.56E-06
11θz	7.90E-05	2.18E-05	4.74E-05	1.24E-04	2.68E-05	3.43E-05	5.60E-05
12ux	4.09E-05	5.71E-06	1.42E-05	3.40E-05	4.59E-06	1.26E-05	1.98E-05
12uy	1.13E-01	4.07E-02	8.08E-02	2.03E-01	5.63E-02	6.05E-02	9.23E-02
12uz	6.53E-03	2.33E-03	4.75E-03	1.19E-02	3.18E-03	3.50E-03	5.43E-03
12θx	3.71E-04	1.31E-04	3.31E-04	9.42E-04	1.42E-04	1.64E-04	4.42E-04
12θy	3.31E-05	8.07E-06	1.86E-05	5.90E-05	8.20E-06	1.00E-05	2.89E-05
12θz	1.86E-04	5.83E-05	1.12E-04	2.75E-04	6.96E-05	8.88E-05	1.38E-04
13ux	8.77E-04	2.95E-04	6.68E-04	2.36E-03	2.98E-04	3.67E-04	1.04E-03
13uy	1.11E-01	4.04E-02	8.28E-02	2.07E-01	5.51E-02	5.60E-02	9.02E-02
13uz	7.01E-03	2.34E-03	5.10E-03	1.31E-02	3.11E-03	3.16E-03	5.41E-03
13θx	5.04E-04	1.78E-04	4.55E-04	1.29E-03	1.96E-04	2.22E-04	6.04E-04
13θy	4.56E-05	1.35E-05	2.67E-05	1.01E-04	1.25E-05	1.61E-05	4.50E-05
13θz	2.14E-04	6.72E-05	1.49E-04	4.22E-04	8.09E-05	9.67E-05	2.11E-04
14ux	3.57E-03	9.41E-04	1.68E-03	6.54E-03	8.20E-04	1.08E-03	3.09E-03
14uy	1.11E-01	4.61E-02	9.43E-02	2.68E-01	5.68E-02	4.14E-02	9.71E-02
14uz	7.04E-03	2.34E-03	5.13E-03	1.32E-02	3.11E-03	3.14E-03	5.43E-03
14θx	3.42E-04	1.18E-04	2.67E-04	7.78E-04	1.44E-04	1.75E-04	3.82E-04
14θy	1.54E-05	2.86E-06	5.38E-06	1.46E-05	2.73E-06	4.99E-06	1.04E-05
14θz	1.95E-04	6.12E-05	1.34E-04	3.80E-04	7.40E-05	8.85E-05	1.91E-04

15ux	2.66E-03	7.14E-04	1.29E-03	4.06E-03	6.31E-04	9.24E-04	2.08E-03
15uy	9.43E-02	4.24E-02	8.47E-02	2.51E-01	5.07E-02	3.53E-02	9.13E-02
15uz	7.07E-03	2.34E-03	5.16E-03	1.32E-02	3.11E-03	3.12E-03	5.44E-03
15θx	2.80E-04	1.36E-04	2.68E-04	8.69E-04	1.21E-04	1.22E-04	3.55E-04
15θy	2.90E-05	6.66E-06	1.43E-05	5.05E-05	6.32E-06	8.53E-06	2.39E-05
15θz	1.75E-04	5.51E-05	1.19E-04	3.39E-04	6.72E-05	8.02E-05	1.72E-04
16ux	2.00E-06	6.24E-07	1.53E-06	3.25E-06	6.75E-07	9.39E-07	2.20E-06
16uy	8.74E-02	3.17E-02	6.23E-02	1.57E-01	4.41E-02	4.69E-02	7.11E-02
16uz	7.10E-03	2.34E-03	5.19E-03	1.33E-02	3.11E-03	3.09E-03	5.45E-03
16θx	9.95E-04	3.53E-04	8.22E-04	2.38E-03	3.92E-04	4.80E-04	1.15E-03
16θy	2.79E-05	9.22E-06	1.67E-05	3.73E-05	9.30E-06	1.31E-05	2.77E-05
16θz	1.56E-04	4.91E-05	1.04E-04	2.97E-04	6.03E-05	7.20E-05	1.53E-04
17ux	2.93E-03	8.97E-04	1.56E-03	3.82E-03	8.60E-04	1.22E-03	2.58E-03
17uy	1.84E-01	6.23E-02	1.23E-01	2.99E-01	7.97E-02	1.02E-01	1.64E-01
17uz	7.12E-03	2.34E-03	5.21E-03	1.33E-02	3.11E-03	3.06E-03	5.46E-03
17θx	1.33E-03	4.62E-04	9.94E-04	2.86E-03	5.65E-04	6.96E-04	1.47E-03
17θy	3.47E-05	1.10E-05	1.94E-05	5.46E-05	9.92E-06	1.55E-05	3.33E-05
17θz	1.36E-04	4.30E-05	8.96E-05	2.55E-04	5.34E-05	6.38E-05	1.34E-04
18ux	4.79E-03	1.62E-03	2.76E-03	7.66E-03	1.50E-03	2.10E-03	4.85E-03
18uy	2.68E-01	9.15E-02	1.76E-01	4.77E-01	1.15E-01	1.46E-01	2.56E-01
18uz	7.13E-03	2.34E-03	5.22E-03	1.34E-02	3.11E-03	3.04E-03	5.47E-03
18θx	4.98E-04	1.74E-04	3.69E-04	1.06E-03	2.10E-04	2.62E-04	5.52E-04
18θy	3.22E-05	5.67E-06	1.60E-05	3.67E-05	5.65E-06	1.13E-05	1.96E-05
18θz	1.17E-04	3.70E-05	7.50E-05	2.14E-04	4.65E-05	5.56E-05	1.15E-04
19ux	5.43E-03	1.64E-03	3.04E-03	8.46E-03	1.56E-03	2.19E-03	5.22E-03
19uy	2.56E-01	8.77E-02	1.68E-01	4.58E-01	1.10E-01	1.40E-01	2.46E-01
19uz	7.14E-03	2.35E-03	5.24E-03	1.34E-02	3.11E-03	3.01E-03	5.47E-03
19θx	7.56E-04	2.60E-04	5.30E-04	1.49E-03	3.23E-04	4.02E-04	7.79E-04
19θy	2.24E-05	5.13E-06	8.85E-06	1.93E-05	4.51E-06	7.75E-06	1.37E-05
19θz	9.80E-05	3.09E-05	6.12E-05	1.72E-04	3.97E-05	4.77E-05	9.55E-05
20ux	3.62E-03	9.30E-04	2.00E-03	5.46E-03	9.19E-04	1.30E-03	3.13E-03
20uy	1.54E-01	5.25E-02	1.02E-01	2.56E-01	6.68E-02	8.56E-02	1.40E-01
20uz	7.14E-03	2.36E-03	5.25E-03	1.34E-02	3.11E-03	2.97E-03	5.46E-03
20θx	1.48E-03	5.13E-04	1.04E-03	2.93E-03	6.34E-04	7.94E-04	1.54E-03
20θy	4.04E-05	1.10E-05	2.12E-05	5.75E-05	1.06E-05	1.52E-05	3.52E-05
20θz	8.27E-05	2.49E-05	5.16E-05	1.32E-04	3.28E-05	4.01E-05	7.66E-05
21ux	3.06E-06	4.43E-07	1.28E-06	1.62E-06	4.03E-07	1.12E-06	1.25E-06
21uy	4.57E-02	1.69E-02	3.21E-02	8.05E-02	2.38E-02	2.46E-02	3.66E-02
21uz	7.13E-03	2.37E-03	5.25E-03	1.34E-02	3.11E-03	2.94E-03	5.46E-03
21θx	9.38E-04	3.24E-04	6.55E-04	1.82E-03	4.00E-04	5.00E-04	9.66E-04
21θy	3.73E-05	9.94E-06	2.30E-05	6.74E-05	1.05E-05	1.46E-05	3.34E-05
21θz	7.10E-05	1.95E-05	4.20E-05	9.42E-05	2.83E-05	3.30E-05	5.79E-05

22ux	3.21E-03	8.75E-04	1.82E-03	5.24E-03	9.27E-04	1.17E-03	2.35E-03
22uy	2.78E-02	1.62E-02	2.92E-02	9.57E-02	1.94E-02	1.33E-02	3.31E-02
22uz	7.12E-03	2.38E-03	5.25E-03	1.33E-02	3.10E-03	2.91E-03	5.45E-03
22θx	5.31E-05	2.45E-05	4.80E-05	1.73E-04	2.24E-05	2.52E-05	6.46E-05
22θy	3.08E-05	1.07E-05	1.82E-05	5.62E-05	1.11E-05	1.00E-05	2.38E-05
22θz	6.15E-05	1.57E-05	3.27E-05	7.91E-05	2.53E-05	2.65E-05	3.94E-05
23ux	4.44E-03	1.69E-03	2.87E-03	9.38E-03	1.81E-03	1.60E-03	3.83E-03
23uy	3.05E-02	1.18E-02	2.25E-02	5.75E-02	1.70E-02	1.51E-02	2.42E-02
23uz	7.09E-03	2.39E-03	5.25E-03	1.33E-02	3.10E-03	2.87E-03	5.44E-03
23θx	2.78E-04	9.54E-05	2.27E-04	6.41E-04	1.02E-04	1.28E-04	3.13E-04
23θy	3.23E-05	9.04E-06	1.45E-05	4.47E-05	1.12E-05	8.53E-06	2.08E-05
23θz	6.39E-05	1.69E-05	2.77E-05	8.34E-05	2.34E-05	2.06E-05	3.37E-05
24ux	3.32E-03	1.42E-03	2.36E-03	7.92E-03	1.53E-03	1.29E-03	3.21E-03
24uy	2.98E-02	1.14E-02	2.11E-02	5.16E-02	1.64E-02	1.55E-02	2.32E-02
24uz	7.56E-03	2.36E-03	4.92E-03	1.28E-02	3.01E-03	3.97E-03	6.43E-03
24θx	1.05E-04	3.39E-05	7.26E-05	1.92E-04	4.39E-05	5.04E-05	8.37E-05
24θy	2.71E-05	6.18E-06	9.44E-06	2.15E-05	8.59E-06	9.60E-06	1.17E-05
24θz	6.57E-05	2.37E-05	3.92E-05	1.28E-04	2.55E-05	2.26E-05	5.17E-05
25ux	2.78E-06	3.56E-07	1.00E-06	9.41E-07	2.84E-07	9.10E-07	8.68E-07
25uy	2.98E-02	1.14E-02	2.11E-02	5.16E-02	1.64E-02	1.55E-02	2.32E-02
25uz	4.02E-07	5.25E-08	1.22E-07	4.15E-07	3.32E-08	9.87E-08	2.02E-07
25θx	1.20E-04	3.82E-05	7.93E-05	2.02E-04	4.85E-05	6.32E-05	1.03E-04
25θy	2.29E-05	5.59E-06	8.33E-06	2.14E-05	7.61E-06	8.41E-06	1.09E-05
25θz	6.06E-05	2.23E-05	3.88E-05	1.32E-04	2.59E-05	2.29E-05	5.30E-05
26ux	5.49E-03	1.79E-03	3.07E-03	9.74E-03	2.04E-03	1.85E-03	4.01E-03
26uy	2.98E-02	1.14E-02	2.10E-02	5.15E-02	1.63E-02	1.55E-02	2.32E-02
26uz	8.16E-03	2.47E-03	5.35E-03	1.39E-02	3.41E-03	4.22E-03	6.82E-03
26θx	4.89E-05	1.81E-05	3.61E-05	8.79E-05	2.52E-05	2.50E-05	3.93E-05
26θy	1.62E-05	4.65E-06	7.24E-06	2.16E-05	6.27E-06	6.44E-06	9.81E-06
26θz	1.97E-05	5.04E-06	9.16E-06	2.51E-05	5.52E-06	5.34E-06	1.24E-05
27ux	1.94E-03	6.85E-04	1.35E-03	3.93E-03	7.13E-04	7.27E-04	1.84E-03
27uy	2.97E-02	1.13E-02	2.09E-02	5.13E-02	1.62E-02	1.55E-02	2.31E-02
27uz	1.04E-02	3.64E-03	7.26E-03	1.84E-02	5.07E-03	5.55E-03	8.52E-03
27θx	3.59E-05	1.57E-05	2.82E-05	8.80E-05	2.24E-05	1.43E-05	2.84E-05
27θy	1.12E-05	4.02E-06	7.20E-06	2.21E-05	5.21E-06	4.91E-06	9.84E-06
27θz	9.94E-05	3.62E-05	5.47E-05	1.90E-04	4.35E-05	3.53E-05	7.29E-05
28ux	9.44E-05	1.78E-05	2.99E-05	6.36E-05	2.00E-05	2.73E-05	2.74E-05
28uy	2.88E-02	1.07E-02	2.00E-02	5.01E-02	1.53E-02	1.55E-02	2.28E-02
28uz	1.07E-02	3.87E-03	7.68E-03	1.93E-02	5.36E-03	5.75E-03	8.77E-03
28θx	4.15E-05	1.66E-05	3.09E-05	8.86E-05	2.38E-05	1.74E-05	3.07E-05
28θy	1.38E-05	2.70E-06	6.39E-06	2.19E-05	2.29E-06	3.55E-06	8.42E-06
28θz	9.50E-05	2.65E-05	4.58E-05	1.46E-04	3.70E-05	4.28E-05	6.86E-05

29ux	7.14E-05	1.34E-05	2.26E-05	4.78E-05	1.50E-05	2.07E-05	2.06E-05
29uy	3.40E-02	1.23E-02	2.20E-02	5.53E-02	1.80E-02	1.82E-02	2.57E-02
29uz	1.13E-02	3.94E-03	8.11E-03	2.04E-02	5.31E-03	5.88E-03	9.21E-03
29θx	4.40E-05	1.68E-05	3.22E-05	8.68E-05	2.42E-05	2.03E-05	3.35E-05
29θy	1.26E-05	2.57E-06	6.12E-06	1.83E-05	2.42E-06	2.88E-06	7.26E-06
29θz	8.35E-05	2.41E-05	3.57E-05	9.29E-05	3.80E-05	3.31E-05	3.90E-05
30ux	4.80E-05	8.97E-06	1.52E-05	3.19E-05	9.92E-06	1.40E-05	1.38E-05
30uy	3.60E-02	1.29E-02	2.28E-02	5.71E-02	1.90E-02	1.89E-02	2.65E-02
30uz	1.15E-02	3.98E-03	8.26E-03	2.08E-02	5.33E-03	5.96E-03	9.40E-03
30θx	4.67E-05	1.76E-05	3.39E-05	8.50E-05	2.51E-05	2.32E-05	3.66E-05
30θy	3.49E-06	6.57E-07	1.54E-06	5.27E-06	5.45E-07	8.55E-07	2.03E-06
30θz	2.37E-05	6.27E-06	1.08E-05	3.45E-05	8.73E-06	1.01E-05	1.63E-05
31ux	2.44E-05	4.50E-06	7.73E-06	1.60E-05	4.89E-06	7.12E-06	6.92E-06
31uy	3.21E-02	1.18E-02	2.15E-02	5.37E-02	1.73E-02	1.72E-02	2.46E-02
31uz	1.11E-02	3.93E-03	7.98E-03	2.01E-02	5.35E-03	5.86E-03	9.10E-03
31θx	4.97E-05	1.85E-05	3.61E-05	8.82E-05	2.59E-05	2.61E-05	3.98E-05
31θy	1.39E-05	2.82E-06	6.69E-06	2.04E-05	2.61E-06	3.17E-06	8.05E-06
31θz	9.26E-05	2.61E-05	3.92E-05	1.07E-04	4.15E-05	3.75E-05	4.45E-05
32ux	2.86E-06	3.79E-07	1.04E-06	1.13E-06	3.25E-07	9.38E-07	9.69E-07
32uy	2.88E-02	1.07E-02	2.00E-02	5.01E-02	1.53E-02	1.55E-02	2.28E-02
32uz	1.07E-02	3.87E-03	7.68E-03	1.93E-02	5.36E-03	5.75E-03	8.77E-03
32θx	5.42E-05	1.95E-05	3.88E-05	9.76E-05	2.71E-05	2.90E-05	4.43E-05
32θy	1.56E-09	3.89E-10	1.05E-09	2.02E-09	4.31E-10	7.13E-10	1.39E-09
32θz	1.49E-09	5.86E-10	1.21E-09	2.94E-09	8.05E-10	7.20E-10	1.27E-09

Table C.8. Maximum nodal displacements for benchmark problem No.4b (inches)

Nodes	Load cases						
	a	b	c	d	e	f	g
2ux	3.95E-02	2.28E-02	3.38E-02	9.85E-02	3.24E-02	2.27E-02	3.23E-02
2uy	1.57E-05	2.42E-06	5.00E-06	1.88E-05	1.42E-06	2.79E-06	8.24E-06
2uz	1.27E-06	7.03E-07	9.66E-07	2.52E-06	3.90E-07	8.46E-07	1.35E-06
2θx	7.62E-09	4.39E-09	7.46E-09	9.70E-09	3.23E-09	5.04E-09	5.39E-09
2θy	1.09E-04	6.52E-05	9.51E-05	2.79E-04	8.80E-05	6.53E-05	8.77E-05
2θz	6.90E-09	4.30E-09	6.48E-09	1.46E-08	3.12E-09	4.50E-09	4.87E-09
3ux	9.86E-02	5.77E-02	8.48E-02	2.47E-01	7.99E-02	5.75E-02	7.97E-02
3uy	2.80E-05	5.25E-06	9.47E-06	3.35E-05	3.21E-06	6.11E-06	1.47E-05
3uz	2.49E-06	1.40E-06	1.92E-06	4.94E-06	7.76E-07	1.68E-06	2.64E-06
3θx	1.41E-08	7.77E-09	1.33E-08	1.79E-08	5.79E-09	8.86E-09	9.44E-09
3θy	1.91E-04	1.14E-04	1.66E-04	4.88E-04	1.53E-04	1.15E-04	1.52E-04
3θz	1.38E-08	8.61E-09	1.30E-08	2.91E-08	6.24E-09	9.01E-09	9.74E-09
4ux	1.58E-01	9.31E-02	1.36E-01	3.98E-01	1.27E-01	9.30E-02	1.27E-01
4uy	3.05E-05	7.55E-06	1.32E-05	3.73E-05	4.76E-06	8.72E-06	1.65E-05
4uz	3.25E-06	1.76E-06	2.46E-06	6.40E-06	9.77E-07	2.14E-06	3.48E-06
4θx	2.87E-08	1.06E-08	1.80E-08	3.55E-08	7.40E-09	1.22E-08	1.69E-08
4θy	2.39E-04	1.44E-04	2.09E-04	6.13E-04	1.91E-04	1.45E-04	1.90E-04
4θz	1.81E-08	1.38E-08	2.06E-08	4.58E-08	1.08E-08	1.38E-08	1.43E-08
5ux	2.30E-01	1.37E-01	2.00E-01	5.85E-01	1.86E-01	1.37E-01	1.85E-01
5uy	2.49E-05	9.79E-06	1.66E-05	3.12E-05	6.72E-06	1.13E-05	1.53E-05
5uz	3.98E-06	2.15E-06	3.05E-06	7.82E-06	1.20E-06	2.63E-06	4.29E-06
5θx	4.42E-08	1.30E-08	2.28E-08	5.44E-08	8.72E-09	1.51E-08	2.45E-08
5θy	2.74E-04	1.65E-04	2.40E-04	7.05E-04	2.19E-04	1.68E-04	2.18E-04
5θz	2.22E-08	1.69E-08	2.44E-08	5.90E-08	1.41E-08	1.72E-08	1.76E-08
6ux	3.05E-01	1.82E-01	2.65E-01	7.78E-01	2.45E-01	1.82E-01	2.44E-01
6uy	1.49E-05	1.19E-05	2.06E-05	1.78E-05	8.98E-06	1.35E-05	1.21E-05
6uz	4.58E-06	2.52E-06	3.61E-06	9.11E-06	1.40E-06	3.07E-06	4.91E-06
6θx	5.51E-08	1.46E-08	2.58E-08	6.71E-08	9.72E-09	1.69E-08	3.03E-08
6θy	2.92E-04	1.76E-04	2.56E-04	7.52E-04	2.33E-04	1.80E-04	2.32E-04
6θz	2.64E-08	2.01E-08	2.84E-08	7.22E-08	1.74E-08	2.06E-08	2.09E-08
7ux	3.51E-01	2.10E-01	3.06E-01	8.98E-01	2.82E-01	2.11E-01	2.81E-01
7uy	2.49E-05	1.40E-05	2.43E-05	3.11E-05	1.05E-05	1.61E-05	1.69E-05
7uz	4.85E-06	2.74E-06	3.96E-06	9.79E-06	1.53E-06	3.32E-06	5.18E-06
7θx	5.83E-08	1.51E-08	2.67E-08	7.10E-08	1.00E-08	1.75E-08	3.22E-08
7θy	2.96E-04	1.79E-04	2.60E-04	7.64E-04	2.37E-04	1.83E-04	2.36E-04
7θz	2.76E-08	2.04E-08	2.81E-08	7.61E-08	1.84E-08	2.13E-08	2.14E-08

8ux	3.94E-01	2.37E-01	3.45E-01	1.01E+00	3.17E-01	2.38E-01	3.15E-01
8uy	3.53E-05	1.64E-05	2.79E-05	4.42E-05	1.20E-05	1.88E-05	2.25E-05
8uz	5.03E-06	2.94E-06	4.28E-06	1.03E-05	1.65E-06	3.55E-06	5.32E-06
8θx	5.94E-08	1.52E-08	2.71E-08	7.19E-08	1.02E-08	1.76E-08	3.28E-08
8θy	2.98E-04	1.80E-04	2.61E-04	7.67E-04	2.38E-04	1.84E-04	2.36E-04
8θz	2.88E-08	2.07E-08	2.79E-08	8.01E-08	1.97E-08	2.20E-08	2.22E-08
9ux	3.94E-01	2.37E-01	3.45E-01	1.01E+00	3.17E-01	2.38E-01	3.15E-01
9uy	3.57E-05	1.92E-05	3.09E-05	5.38E-05	1.48E-05	2.13E-05	2.25E-05
9uz	7.14E-02	4.32E-02	6.26E-02	1.84E-01	5.70E-02	4.42E-02	5.67E-02
9θx	5.94E-08	1.52E-08	2.71E-08	7.19E-08	1.02E-08	1.76E-08	3.28E-08
9θy	2.98E-04	1.80E-04	2.61E-04	7.67E-04	2.38E-04	1.84E-04	2.36E-04
9θz	2.88E-08	2.07E-08	2.79E-08	8.01E-08	1.97E-08	2.20E-08	2.22E-08
10ux	3.96E-01	2.37E-01	3.46E-01	1.01E+00	3.18E-01	2.39E-01	3.16E-01
10uy	5.91E-03	3.60E-03	5.79E-03	9.27E-03	2.28E-03	2.58E-03	3.98E-03
10uz	4.71E-02	3.23E-02	4.46E-02	1.15E-01	3.41E-02	3.18E-02	3.84E-02
10θx	5.87E-05	4.20E-05	6.43E-05	1.08E-04	3.08E-05	5.05E-05	4.74E-05
10θy	4.57E-04	3.32E-04	5.81E-04	1.02E-03	3.21E-04	4.10E-04	3.59E-04
10θz	9.69E-05	6.26E-05	1.01E-04	1.56E-04	4.01E-05	4.34E-05	6.51E-05
11ux	3.96E-01	2.38E-01	3.47E-01	1.02E+00	3.19E-01	2.40E-01	3.17E-01
11uy	1.03E-02	6.82E-03	1.11E-02	1.68E-02	4.38E-03	4.70E-03	6.90E-03
11uz	3.98E-02	3.32E-02	5.48E-02	7.54E-02	2.42E-02	2.29E-02	2.86E-02
11θx	1.17E-04	8.41E-05	1.29E-04	2.16E-04	6.16E-05	1.01E-04	9.48E-05
11θy	3.34E-04	1.95E-04	2.51E-04	7.31E-04	2.41E-04	1.85E-04	2.44E-04
11θz	2.20E-05	6.75E-06	1.03E-05	3.45E-05	4.38E-06	7.94E-06	1.72E-05
12ux	3.97E-01	2.38E-01	3.48E-01	1.02E+00	3.19E-01	2.40E-01	3.17E-01
12uy	3.53E-05	1.64E-05	2.79E-05	4.42E-05	1.20E-05	1.88E-05	2.25E-05
12uz	8.06E-06	3.38E-06	5.64E-06	1.49E-05	2.39E-06	3.83E-06	6.45E-06
12θx	1.76E-04	1.26E-04	1.93E-04	3.23E-04	9.24E-05	1.52E-04	1.42E-04
12θy	9.65E-04	8.64E-04	1.35E-03	1.94E-03	5.40E-04	6.29E-04	7.29E-04
12θz	2.45E-04	1.83E-04	3.00E-04	4.27E-04	1.20E-04	1.24E-04	1.63E-04
13ux	4.01E-01	2.36E-01	3.79E-01	1.02E+00	3.25E-01	2.60E-01	3.19E-01
13uy	7.11E-03	6.43E-03	1.10E-02	1.25E-02	4.25E-03	4.62E-03	4.70E-03
13uz	4.72E-02	4.39E-02	6.59E-02	9.54E-02	2.65E-02	3.46E-02	3.58E-02
13θx	1.70E-04	1.35E-04	2.21E-04	2.88E-04	8.89E-05	1.29E-04	1.58E-04
13θy	3.11E-03	2.90E-03	4.39E-03	6.29E-03	1.77E-03	2.26E-03	2.32E-03
13θz	6.59E-04	5.72E-04	9.33E-04	1.25E-03	3.77E-04	4.07E-04	4.38E-04
14ux	4.13E-01	3.22E-01	5.69E-01	9.81E-01	3.49E-01	4.03E-01	3.49E-01
14uy	1.68E-02	1.48E-02	2.48E-02	3.07E-02	9.81E-03	1.27E-02	1.52E-02
14uz	4.74E-02	4.41E-02	6.63E-02	9.60E-02	2.67E-02	3.49E-02	3.61E-02
14θx	7.16E-05	6.14E-05	1.04E-04	1.09E-04	4.63E-05	7.79E-05	6.51E-05
14θy	2.00E-03	1.83E-03	2.90E-03	4.09E-03	1.16E-03	1.27E-03	1.43E-03
14θz	9.92E-04	8.72E-04	1.40E-03	1.88E-03	5.70E-04	6.36E-04	6.55E-04

15ux	4.14E-01	3.26E-01	5.50E-01	8.42E-01	3.10E-01	3.88E-01	3.28E-01
15uy	1.52E-02	1.37E-02	2.28E-02	2.66E-02	9.27E-03	1.26E-02	1.34E-02
15uz	4.77E-02	4.43E-02	6.65E-02	9.64E-02	2.68E-02	3.50E-02	3.64E-02
15θx	1.10E-04	8.94E-05	1.48E-04	2.00E-04	5.75E-05	7.38E-05	1.01E-04
15θy	1.72E-03	1.41E-03	2.10E-03	3.03E-03	9.08E-04	1.46E-03	1.19E-03
15θz	1.33E-03	1.17E-03	1.87E-03	2.51E-03	7.63E-04	8.65E-04	8.73E-04
16ux	3.05E-01	1.82E-01	2.65E-01	7.78E-01	2.45E-01	1.82E-01	2.44E-01
16uy	1.53E-05	1.18E-05	2.05E-05	1.76E-05	8.84E-06	1.33E-05	1.22E-05
16uz	4.78E-02	4.45E-02	6.68E-02	9.68E-02	2.69E-02	3.52E-02	3.66E-02
16θx	2.74E-04	2.32E-04	3.84E-04	4.07E-04	1.62E-04	2.34E-04	2.13E-04
16θy	5.93E-03	5.48E-03	8.54E-03	1.18E-02	3.41E-03	4.03E-03	4.29E-03
16θz	1.67E-03	1.47E-03	2.35E-03	3.14E-03	9.56E-04	1.09E-03	1.09E-03
17ux	6.97E-01	6.44E-01	1.01E+00	1.52E+00	4.61E-01	4.47E-01	5.05E-01
17uy	2.65E-02	2.21E-02	3.60E-02	3.84E-02	1.58E-02	2.36E-02	2.02E-02
17uz	4.80E-02	4.46E-02	6.69E-02	9.70E-02	2.70E-02	3.53E-02	3.68E-02
17θx	2.89E-04	2.53E-04	4.02E-04	4.15E-04	1.82E-04	2.71E-04	2.32E-04
17θy	7.49E-03	6.81E-03	1.07E-02	1.50E-02	4.27E-03	4.55E-03	5.15E-03
17θz	2.01E-03	1.78E-03	2.82E-03	3.77E-03	1.15E-03	1.32E-03	1.31E-03
18ux	1.18E+00	1.08E+00	1.69E+00	2.47E+00	7.17E-01	6.89E-01	8.33E-01
18uy	4.24E-02	3.77E-02	6.00E-02	6.02E-02	2.71E-02	3.98E-02	3.42E-02
18uz	4.80E-02	4.47E-02	6.70E-02	9.71E-02	2.70E-02	3.53E-02	3.69E-02
18θx	1.85E-04	9.87E-05	1.69E-04	2.42E-04	6.92E-05	1.05E-04	1.25E-04
18θy	3.17E-03	2.89E-03	4.47E-03	6.14E-03	1.79E-03	1.93E-03	2.21E-03
18θz	2.35E-03	2.08E-03	3.29E-03	4.40E-03	1.34E-03	1.55E-03	1.54E-03
19ux	1.17E+00	1.07E+00	1.67E+00	2.43E+00	7.05E-01	6.80E-01	8.26E-01
19uy	4.31E-02	3.63E-02	5.85E-02	6.10E-02	2.60E-02	3.79E-02	3.27E-02
19uz	4.81E-02	4.47E-02	6.71E-02	9.72E-02	2.70E-02	3.53E-02	3.70E-02
19θx	1.72E-04	1.27E-04	2.05E-04	2.44E-04	9.07E-05	1.43E-04	1.24E-04
19θy	3.39E-03	3.10E-03	4.92E-03	7.09E-03	2.03E-03	2.07E-03	2.37E-03
19θz	2.69E-03	2.38E-03	3.76E-03	5.03E-03	1.53E-03	1.78E-03	1.76E-03
20ux	6.69E-01	6.16E-01	9.54E-01	1.41E+00	4.15E-01	4.08E-01	4.79E-01
20uy	2.51E-02	1.93E-02	3.18E-02	3.40E-02	1.37E-02	2.00E-02	1.77E-02
20uz	4.81E-02	4.47E-02	6.70E-02	9.71E-02	2.70E-02	3.53E-02	3.70E-02
20θx	3.14E-04	2.48E-04	4.03E-04	4.48E-04	1.78E-04	2.62E-04	2.30E-04
20θy	7.63E-03	6.98E-03	1.09E-02	1.54E-02	4.45E-03	4.54E-03	5.32E-03
20θz	3.02E-03	2.68E-03	4.23E-03	5.65E-03	1.73E-03	2.01E-03	1.98E-03
21ux	1.58E-01	9.31E-02	1.36E-01	3.98E-01	1.27E-01	9.30E-02	1.27E-01
21uy	3.05E-05	7.40E-06	1.30E-05	3.68E-05	4.76E-06	8.61E-06	1.64E-05
21uz	4.80E-02	4.46E-02	6.69E-02	9.69E-02	2.70E-02	3.53E-02	3.70E-02
21θx	2.39E-04	1.66E-04	2.74E-04	3.16E-04	1.18E-04	1.62E-04	1.73E-04
21θy	5.98E-03	5.43E-03	8.36E-03	1.18E-02	3.39E-03	3.46E-03	4.12E-03
21θz	3.36E-03	2.98E-03	4.70E-03	6.28E-03	1.92E-03	2.24E-03	2.20E-03

22ux	2.90E-01	2.61E-01	4.11E-01	5.47E-01	1.69E-01	2.33E-01	2.15E-01
22uy	1.61E-02	6.47E-03	1.10E-02	1.85E-02	4.79E-03	6.27E-03	1.06E-02
22uz	4.79E-02	4.45E-02	6.68E-02	9.67E-02	2.69E-02	3.52E-02	3.69E-02
22θx	1.08E-04	5.05E-05	8.59E-05	1.70E-04	3.55E-05	5.93E-05	7.59E-05
22θy	1.59E-03	1.41E-03	2.17E-03	3.04E-03	8.86E-04	9.66E-04	1.06E-03
22θz	3.70E-03	3.28E-03	5.17E-03	6.91E-03	2.11E-03	2.47E-03	2.42E-03
23ux	3.10E-01	2.73E-01	4.41E-01	5.85E-01	1.83E-01	2.45E-01	2.20E-01
23uy	1.79E-02	1.04E-02	1.56E-02	3.08E-02	6.29E-03	8.88E-03	1.23E-02
23uz	4.77E-02	4.43E-02	6.66E-02	9.63E-02	2.68E-02	3.50E-02	3.68E-02
23θx	2.51E-04	2.21E-04	3.71E-04	4.51E-04	1.52E-04	1.46E-04	1.71E-04
23θy	6.40E-04	5.34E-04	8.74E-04	1.41E-03	3.50E-04	4.50E-04	4.76E-04
23θz	4.04E-03	3.58E-03	5.65E-03	7.54E-03	2.31E-03	2.70E-03	2.65E-03
24ux	2.23E-01	1.94E-01	3.16E-01	4.16E-01	1.33E-01	1.85E-01	1.67E-01
24uy	2.57E-02	1.87E-02	2.83E-02	5.03E-02	1.09E-02	1.35E-02	1.69E-02
24uz	3.95E-02	3.67E-02	5.46E-02	8.04E-02	2.20E-02	2.95E-02	3.09E-02
24θx	7.04E-04	6.45E-04	9.47E-04	1.39E-03	3.82E-04	5.26E-04	5.33E-04
24θy	8.19E-04	7.37E-04	1.15E-03	1.71E-03	4.55E-04	5.91E-04	6.05E-04
24θz	4.19E-03	3.71E-03	5.86E-03	7.86E-03	2.40E-03	2.83E-03	2.75E-03
25ux	9.86E-02	5.77E-02	8.48E-02	2.47E-01	7.99E-02	5.75E-02	7.97E-02
25uy	2.56E-02	1.86E-02	2.83E-02	5.00E-02	1.09E-02	1.34E-02	1.68E-02
25uz	3.43E-03	2.06E-03	2.99E-03	8.78E-03	2.75E-03	2.06E-03	2.74E-03
25θx	5.23E-04	4.79E-04	6.97E-04	1.05E-03	2.81E-04	3.99E-04	4.08E-04
25θy	7.04E-04	6.43E-04	9.91E-04	1.45E-03	3.93E-04	5.27E-04	5.24E-04
25θz	2.73E-03	2.45E-03	3.82E-03	5.37E-03	1.55E-03	1.84E-03	1.87E-03
26ux	1.31E-01	1.17E-01	1.73E-01	2.93E-01	9.80E-02	1.04E-01	1.04E-01
26uy	2.51E-02	1.85E-02	2.81E-02	4.95E-02	1.09E-02	1.33E-02	1.67E-02
26uz	2.35E-02	1.94E-02	2.79E-02	4.24E-02	1.10E-02	1.75E-02	1.74E-02
26θx	4.82E-05	4.02E-05	5.81E-05	9.30E-05	2.27E-05	3.47E-05	3.33E-05
26θy	5.23E-04	4.86E-04	7.24E-04	1.03E-03	2.89E-04	4.21E-04	4.07E-04
26θz	4.11E-04	3.59E-04	5.82E-04	7.43E-04	2.42E-04	2.79E-04	2.63E-04
27ux	1.03E-01	6.34E-02	7.89E-02	2.54E-01	8.18E-02	6.37E-02	8.22E-02
27uy	2.46E-02	1.85E-02	2.80E-02	4.88E-02	1.08E-02	1.33E-02	1.65E-02
27uz	8.87E-03	7.31E-03	1.08E-02	1.52E-02	4.78E-03	7.47E-03	6.77E-03
27θx	2.67E-04	2.10E-04	3.06E-04	4.72E-04	1.23E-04	1.76E-04	2.00E-04
27θy	4.08E-04	3.61E-04	5.40E-04	7.55E-04	2.08E-04	3.35E-04	3.26E-04
27θz	1.44E-03	1.13E-03	1.73E-03	2.86E-03	6.74E-04	8.20E-04	9.61E-04
28ux	9.97E-02	5.84E-02	8.47E-02	2.50E-01	8.08E-02	5.75E-02	8.06E-02
28uy	2.80E-05	5.25E-06	9.47E-06	3.35E-05	3.21E-06	6.11E-06	1.47E-05
28uz	3.72E-06	1.63E-06	2.43E-06	5.05E-06	1.06E-06	1.71E-06	2.67E-06
28θx	1.43E-04	9.49E-05	1.34E-04	2.31E-04	6.08E-05	9.79E-05	9.73E-05
28θy	2.32E-04	1.66E-04	2.99E-04	4.89E-04	1.79E-04	2.11E-04	2.07E-04
28θz	6.69E-04	4.03E-04	5.95E-04	9.60E-04	2.37E-04	3.02E-04	4.44E-04

29ux	9.95E-02	5.83E-02	8.48E-02	2.49E-01	8.07E-02	5.76E-02	8.05E-02
29uy	3.31E-02	1.42E-02	2.15E-02	4.12E-02	8.21E-03	1.11E-02	2.07E-02
29uz	1.30E-02	8.87E-03	1.51E-02	3.07E-02	1.05E-02	1.06E-02	1.19E-02
29θx	1.08E-04	7.12E-05	1.01E-04	1.73E-04	4.56E-05	7.34E-05	7.30E-05
29θy	2.12E-04	1.29E-04	2.07E-04	5.22E-04	1.68E-04	1.46E-04	1.83E-04
29θz	3.54E-04	9.63E-05	1.52E-04	4.22E-04	5.25E-05	8.89E-05	2.09E-04
30ux	9.93E-02	5.81E-02	8.49E-02	2.49E-01	8.05E-02	5.76E-02	8.03E-02
30uy	3.89E-02	1.34E-02	2.07E-02	4.70E-02	7.55E-03	1.07E-02	2.36E-02
30uz	2.50E-02	1.55E-02	2.52E-02	6.15E-02	2.00E-02	1.76E-02	2.16E-02
30θx	7.17E-05	4.74E-05	6.71E-05	1.15E-04	3.04E-05	4.89E-05	4.87E-05
30θy	1.88E-04	1.20E-04	1.46E-04	4.95E-04	1.48E-04	1.16E-04	1.52E-04
30θz	1.66E-04	9.56E-05	1.42E-04	2.31E-04	5.61E-05	7.21E-05	1.10E-04
31ux	9.90E-02	5.79E-02	8.49E-02	2.48E-01	8.02E-02	5.76E-02	8.01E-02
31uy	1.79E-02	5.33E-03	8.38E-03	2.15E-02	2.95E-03	4.59E-03	1.07E-02
31uz	3.55E-02	2.10E-02	3.22E-02	8.97E-02	2.84E-02	2.24E-02	2.90E-02
31θx	3.59E-05	2.37E-05	3.36E-05	5.77E-05	1.52E-05	2.45E-05	2.43E-05
31θy	1.68E-04	1.12E-04	1.53E-04	4.52E-04	1.36E-04	1.09E-04	1.53E-04
31θz	4.17E-04	1.36E-04	2.12E-04	5.03E-04	7.63E-05	1.10E-04	2.52E-04
32ux	9.86E-02	5.77E-02	8.48E-02	2.47E-01	7.99E-02	5.75E-02	7.97E-02
32uy	2.81E-05	6.71E-06	1.12E-05	3.77E-05	4.14E-06	7.10E-06	1.50E-05
32uz	4.58E-02	2.74E-02	3.99E-02	1.17E-01	3.67E-02	2.75E-02	3.66E-02
32θx	1.41E-08	7.77E-09	1.33E-08	1.79E-08	5.79E-09	8.86E-09	9.44E-09
32θy	1.91E-04	1.14E-04	1.66E-04	4.88E-04	1.53E-04	1.15E-04	1.52E-04
32θz	1.38E-08	8.61E-09	1.30E-08	2.91E-08	6.24E-09	9.01E-09	9.74E-09

Table C.9. Maximum element forces and moments for P-components of benchmark problem No. 4a (kips-inches)

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	8.532E-01	1.021E-01	2.677E-01	8.320E-01	7.731E-02	1.903E-01	4.143E-01
1Ri2	2.580E+00	2.673E-01	7.232E-01	4.159E-01	1.771E-01	7.652E-01	4.714E-01
1Ri3	1.380E+04	5.401E+03	9.316E+03	2.325E+04	7.966E+03	7.551E+03	1.057E+04
1Mi1	1.673E+02	6.602E+01	1.360E+02	3.314E+02	9.070E+01	8.110E+01	1.430E+02
1Mi2	1.271E+07	4.662E+06	8.974E+06	2.255E+07	6.551E+06	6.838E+06	1.024E+07
1Mi3	5.761E+02	9.899E+01	2.958E+02	4.414E+02	1.043E+02	2.204E+02	3.431E+02
1Rj1	8.532E-01	1.021E-01	2.677E-01	8.320E-01	7.731E-02	1.903E-01	4.143E-01
1Rj2	2.580E+00	2.673E-01	7.232E-01	4.159E-01	1.771E-01	7.652E-01	4.714E-01
1Rj3	1.380E+04	5.401E+03	9.316E+03	2.325E+04	7.966E+03	7.551E+03	1.057E+04
1Mj1	1.673E+02	6.602E+01	1.360E+02	3.314E+02	9.070E+01	8.110E+01	1.430E+02
1Mj2	9.648E+06	3.466E+06	6.916E+06	1.740E+07	4.785E+06	5.163E+06	7.903E+06
1Mj3	3.085E+02	6.923E+01	1.921E+02	3.537E+02	7.655E+01	1.353E+02	2.412E+02
2Ri1	8.161E-01	9.820E-02	2.608E-01	8.131E-01	7.600E-02	1.820E-01	4.014E-01
2Ri2	1.910E+00	2.117E-01	5.789E-01	4.032E-01	1.470E-01	5.796E-01	4.234E-01
2Ri3	1.280E+04	4.787E+03	8.767E+03	2.203E+04	6.871E+03	6.876E+03	9.990E+03
2Mi1	1.673E+02	6.602E+01	1.360E+02	3.314E+02	9.070E+01	8.110E+01	1.430E+02
2Mi2	9.648E+06	3.466E+06	6.916E+06	1.740E+07	4.785E+06	5.163E+06	7.903E+06
2Mi3	3.085E+02	6.923E+01	1.921E+02	3.537E+02	7.655E+01	1.353E+02	2.412E+02
2Rj1	8.161E-01	9.820E-02	2.608E-01	8.131E-01	7.600E-02	1.820E-01	4.014E-01
2Rj2	1.910E+00	2.117E-01	5.789E-01	4.032E-01	1.470E-01	5.796E-01	4.234E-01
2Rj3	1.280E+04	4.787E+03	8.767E+03	2.203E+04	6.871E+03	6.876E+03	9.990E+03
2Mj1	1.673E+02	6.602E+01	1.360E+02	3.314E+02	9.070E+01	8.110E+01	1.430E+02
2Mj2	6.807E+06	2.403E+06	4.974E+06	1.252E+07	3.261E+06	3.636E+06	5.689E+06
2Mj3	6.425E+02	8.399E+01	2.394E+02	2.682E+02	7.130E+01	2.196E+02	1.981E+02
3Ri1	7.777E-01	1.603E-01	3.957E-01	1.456E+00	1.684E-01	2.266E-01	6.272E-01
3Ri2	8.032E-01	1.112E-01	3.189E-01	3.489E-01	9.843E-02	2.838E-01	2.943E-01
3Ri3	1.140E+04	4.127E+03	7.999E+03	2.016E+04	5.764E+03	6.076E+03	9.144E+03
3Mi1	1.236E+02	3.488E+01	8.511E+01	2.289E+02	3.798E+01	3.559E+01	9.174E+01
3Mi2	6.806E+06	2.403E+06	4.974E+06	1.252E+07	3.261E+06	3.636E+06	5.689E+06
3Mi3	6.480E+02	8.167E+01	2.437E+02	2.643E+02	7.146E+01	2.183E+02	2.025E+02
3Rj1	7.777E-01	1.603E-01	3.957E-01	1.456E+00	1.684E-01	2.266E-01	6.272E-01
3Rj2	8.032E-01	1.112E-01	3.189E-01	3.489E-01	9.843E-02	2.838E-01	2.943E-01
3Rj3	1.140E+04	4.127E+03	7.999E+03	2.016E+04	5.764E+03	6.076E+03	9.144E+03
3Mj1	1.236E+02	3.488E+01	8.511E+01	2.289E+02	3.798E+01	3.559E+01	9.174E+01
3Mj2	4.685E+06	1.636E+06	3.489E+06	8.769E+06	2.189E+06	2.506E+06	3.991E+06
3Mj3	7.267E+02	8.007E+01	2.398E+02	2.020E+02	6.401E+01	2.339E+02	1.609E+02
4Ri1	6.631E-01	1.544E-01	3.782E-01	1.400E+00	1.642E-01	2.067E-01	5.911E-01
4Ri2	6.675E-01	9.852E-02	2.796E-01	3.684E-01	9.096E-02	2.341E-01	2.729E-01
4Ri3	9.667E+03	3.413E+03	6.996E+03	1.763E+04	4.645E+03	5.144E+03	8.011E+03
4Mi1	1.430E+02	4.223E+01	9.706E+01	2.328E+02	5.072E+01	6.114E+01	1.106E+02
4Mi2	4.685E+06	1.636E+06	3.489E+06	8.769E+06	2.189E+06	2.506E+06	3.991E+06
4Mi3	7.267E+02	8.007E+01	2.398E+02	2.020E+02	6.401E+01	2.339E+02	1.609E+02
4Rj1	6.631E-01	1.544E-01	3.782E-01	1.400E+00	1.642E-01	2.067E-01	5.911E-01

4Rj2	6.675E-01	9.852E-02	2.796E-01	3.684E-01	9.096E-02	2.341E-01	2.729E-01
4Rj3	9.667E+03	3.413E+03	6.996E+03	1.763E+04	4.645E+03	5.144E+03	8.011E+03
4Mj1	1.430E+02	4.223E+01	9.706E+01	2.328E+02	5.072E+01	6.114E+01	1.106E+02
4Mj2	2.656E+06	9.190E+05	2.019E+06	5.067E+06	1.214E+06	1.426E+06	2.309E+06
4Mj3	5.915E+02	6.314E+01	1.832E+02	1.247E+02	4.579E+01	1.857E+02	1.050E+02
5Ri1	5.289E-01	1.471E-01	3.713E-01	1.326E+00	1.582E-01	1.832E-01	5.446E-01
5Ri2	1.333E+00	1.434E-01	4.190E-01	2.883E-01	1.090E-01	4.230E-01	2.592E-01
5Ri3	7.579E+03	2.635E+03	5.679E+03	1.428E+04	3.509E+03	4.056E+03	6.502E+03
5Mi1	1.430E+02	4.223E+01	9.706E+01	2.328E+02	5.072E+01	6.114E+01	1.106E+02
5Mi2	2.656E+06	9.190E+05	2.019E+06	5.067E+06	1.214E+06	1.426E+06	2.309E+06
5Mi3	5.915E+02	6.314E+01	1.832E+02	1.247E+02	4.579E+01	1.857E+02	1.050E+02
5Rj1	5.289E-01	1.471E-01	3.713E-01	1.326E+00	1.582E-01	1.832E-01	5.446E-01
5Rj2	1.333E+00	1.434E-01	4.190E-01	2.883E-01	1.090E-01	4.230E-01	2.592E-01
5Rj3	7.579E+03	2.635E+03	5.679E+03	1.428E+04	3.509E+03	4.056E+03	6.502E+03
5Mj1	1.430E+02	4.223E+01	9.706E+01	2.328E+02	5.072E+01	6.114E+01	1.106E+02
5Mj2	1.077E+06	3.666E+05	8.268E+05	2.069E+06	4.771E+05	5.738E+05	9.441E+05
5Mj3	3.123E+02	3.323E+01	9.549E+01	6.538E+01	2.454E+01	9.785E+01	5.626E+01
6Ri1	4.714E-01	1.385E-01	3.761E-01	1.234E+00	1.510E-01	1.759E-01	4.926E-01
6Ri2	1.383E+00	1.461E-01	4.219E-01	3.084E-01	1.048E-01	4.405E-01	2.498E-01
6Ri3	5.233E+03	1.794E+03	4.010E+03	1.005E+04	2.352E+03	2.802E+03	4.582E+03
6Mi1	1.894E+02	5.552E+01	1.224E+02	3.173E+02	7.051E+01	9.017E+01	1.433E+02
6Mi2	1.077E+06	3.666E+05	8.268E+05	2.069E+06	4.771E+05	5.738E+05	9.441E+05
6Mi3	3.123E+02	3.323E+01	9.549E+01	6.538E+01	2.454E+01	9.785E+01	5.626E+01
6Rj1	4.714E-01	1.385E-01	3.761E-01	1.234E+00	1.510E-01	1.759E-01	4.926E-01
6Rj2	1.383E+00	1.461E-01	4.219E-01	3.084E-01	1.048E-01	4.405E-01	2.498E-01
6Rj3	5.233E+03	1.794E+03	4.010E+03	1.005E+04	2.352E+03	2.802E+03	4.582E+03
6Mj1	1.894E+02	5.552E+01	1.224E+02	3.173E+02	7.051E+01	9.017E+01	1.433E+02
6Mj2	3.705E+05	1.257E+05	2.854E+05	7.128E+05	1.597E+05	1.955E+05	3.256E+05
6Mj3	1.281E+02	1.351E+01	3.853E+01	3.000E+01	1.081E+01	3.838E+01	2.254E+01
7Ri1	4.774E-01	1.389E-01	3.811E-01	1.133E+00	1.437E-01	1.692E-01	4.584E-01
7Ri2	9.189E-01	9.540E-02	2.717E-01	1.700E-01	6.463E-02	2.876E-01	1.472E-01
7Ri3	2.745E+03	9.311E+02	2.114E+03	5.279E+03	1.183E+03	1.449E+03	2.412E+03
7Mi1	1.894E+02	5.552E+01	1.224E+02	3.173E+02	7.051E+01	9.017E+01	1.433E+02
7Mi2	3.705E+05	1.257E+05	2.854E+05	7.128E+05	1.597E+05	1.955E+05	3.256E+05
7Mi3	1.281E+02	1.351E+01	3.853E+01	3.000E+01	1.081E+01	3.838E+01	2.254E+01
7Rj1	4.774E-01	1.389E-01	3.811E-01	1.133E+00	1.437E-01	1.692E-01	4.584E-01
7Rj2	9.189E-01	9.540E-02	2.717E-01	1.700E-01	6.463E-02	2.876E-01	1.472E-01
7Rj3	2.745E+03	9.311E+02	2.114E+03	5.279E+03	1.183E+03	1.449E+03	2.412E+03
7Mj1	1.894E+02	5.552E+01	1.224E+02	3.173E+02	7.051E+01	9.017E+01	1.433E+02
7Mj2	3.868E+01	8.467E+00	2.126E+01	6.287E+01	7.576E+00	1.044E+01	2.389E+01
7Mj3	1.718E+01	3.378E+00	7.133E+00	1.706E+01	3.412E+00	4.423E+00	9.179E+00

Table C.10. Maximum element forces and moments for P-components of benchmark problem No. 4b (kips-inches)

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	5.239E+00	2.893E+00	3.972E+00	1.036E+01	1.603E+00	3.479E+00	5.561E+00
1Ri2	4.612E+04	2.625E+04	3.911E+04	1.138E+05	3.799E+04	2.612E+04	3.786E+04
1Ri3	2.492E+01	3.466E+00	7.571E+00	2.976E+01	1.862E+00	4.197E+00	1.304E+01
1Mi1	1.555E+03	9.693E+02	1.460E+03	3.278E+03	7.027E+02	1.015E+03	1.097E+03
1Mi2	5.494E+03	1.927E+03	3.253E+03	6.775E+03	1.290E+03	2.216E+03	3.243E+03
1Mi3	4.350E+07	2.582E+07	3.777E+07	1.105E+08	3.514E+07	2.582E+07	3.502E+07
1Rj1	5.239E+00	2.893E+00	3.972E+00	1.036E+01	1.603E+00	3.479E+00	5.561E+00
1Rj2	4.612E+04	2.625E+04	3.911E+04	1.138E+05	3.799E+04	2.612E+04	3.786E+04
1Rj3	2.492E+01	3.466E+00	7.571E+00	2.976E+01	1.862E+00	4.197E+00	1.304E+01
1Mj1	1.555E+03	9.693E+02	1.460E+03	3.278E+03	7.027E+02	1.015E+03	1.097E+03
1Mj2	2.810E+03	1.411E+03	2.397E+03	3.573E+03	1.036E+03	1.612E+03	1.823E+03
1Mj3	3.338E+07	2.000E+07	2.909E+07	8.535E+07	2.671E+07	2.016E+07	2.662E+07
2Ri1	5.010E+00	2.860E+00	3.942E+00	9.962E+00	1.588E+00	3.420E+00	5.298E+00
2Ri2	4.352E+04	2.504E+04	3.686E+04	1.074E+05	3.497E+04	2.506E+04	3.498E+04
2Ri3	1.895E+01	2.780E+00	5.795E+00	2.229E+01	1.606E+00	3.220E+00	9.742E+00
2Mi1	1.555E+03	9.693E+02	1.460E+03	3.278E+03	7.027E+02	1.015E+03	1.097E+03
2Mi2	2.810E+03	1.411E+03	2.397E+03	3.573E+03	1.036E+03	1.612E+03	1.823E+03
2Mi3	3.338E+07	2.000E+07	2.909E+07	8.535E+07	2.671E+07	2.016E+07	2.662E+07
2Rj1	5.010E+00	2.860E+00	3.942E+00	9.962E+00	1.588E+00	3.420E+00	5.298E+00
2Rj2	4.352E+04	2.504E+04	3.686E+04	1.074E+05	3.497E+04	2.506E+04	3.498E+04
2Rj3	1.895E+01	2.780E+00	5.795E+00	2.229E+01	1.606E+00	3.220E+00	9.742E+00
2Mj1	1.555E+03	9.693E+02	1.460E+03	3.278E+03	7.027E+02	1.015E+03	1.097E+03
2Mj2	6.105E+03	1.358E+03	2.425E+03	7.333E+03	8.657E+02	1.552E+03	3.262E+03
2Mj3	2.388E+07	1.445E+07	2.091E+07	6.156E+07	1.895E+07	1.497E+07	1.885E+07
3Ri1	3.816E+00	1.783E+00	2.646E+00	7.350E+00	1.042E+00	2.267E+00	4.148E+00
3Ri2	3.925E+04	2.308E+04	3.366E+04	9.847E+04	3.124E+04	2.318E+04	3.124E+04
3Ri3	7.727E+00	1.877E+00	3.458E+00	9.578E+00	1.187E+00	2.127E+00	4.453E+00
3Mi1	1.614E+03	1.444E+03	2.198E+03	4.479E+03	1.248E+03	1.294E+03	1.378E+03
3Mi2	6.146E+03	1.310E+03	2.360E+03	7.184E+03	8.683E+02	1.513E+03	3.260E+03
3Mi3	2.388E+07	1.445E+07	2.091E+07	6.156E+07	1.895E+07	1.497E+07	1.885E+07
3Rj1	3.816E+00	1.783E+00	2.646E+00	7.350E+00	1.042E+00	2.267E+00	4.148E+00
3Rj2	3.925E+04	2.308E+04	3.366E+04	9.847E+04	3.124E+04	2.318E+04	3.124E+04
3Rj3	7.727E+00	1.877E+00	3.458E+00	9.578E+00	1.187E+00	2.127E+00	4.453E+00
3Mj1	1.614E+03	1.444E+03	2.198E+03	4.479E+03	1.248E+03	1.294E+03	1.378E+03
3Mj2	6.811E+03	1.166E+03	2.413E+03	8.325E+03	7.358E+02	1.312E+03	3.684E+03
3Mj3	1.672E+07	1.015E+07	1.465E+07	4.327E+07	1.314E+07	1.074E+07	1.304E+07
4Ri1	3.330E+00	1.699E+00	2.573E+00	6.604E+00	9.909E-01	2.117E+00	3.489E+00
4Ri2	3.378E+04	2.032E+04	2.943E+04	8.655E+04	2.675E+04	2.094E+04	2.667E+04
4Ri3	6.939E+00	1.658E+00	2.830E+00	7.539E+00	1.105E+00	1.918E+00	3.640E+00
4Mi1	1.196E+03	8.000E+02	1.017E+03	3.154E+03	8.726E+02	8.200E+02	8.741E+02
4Mi2	6.811E+03	1.166E+03	2.413E+03	8.325E+03	7.358E+02	1.312E+03	3.684E+03
4Mi3	1.672E+07	1.015E+07	1.465E+07	4.327E+07	1.314E+07	1.074E+07	1.304E+07
4Rj1	3.330E+00	1.699E+00	2.573E+00	6.604E+00	9.909E-01	2.117E+00	3.489E+00
4Rj2	3.378E+04	2.032E+04	2.943E+04	8.655E+04	2.675E+04	2.094E+04	2.667E+04
4Rj3	6.939E+00	1.658E+00	2.830E+00	7.539E+00	1.105E+00	1.918E+00	3.640E+00

4Mj1	1.196E+03	8.000E+02	1.017E+03	3.154E+03	8.726E+02	8.200E+02	8.741E+02
4Mj2	5.532E+03	8.590E+02	1.903E+03	6.819E+03	5.056E+02	1.021E+03	3.029E+03
4Mj3	9.715E+06	5.886E+06	8.471E+06	2.510E+07	7.519E+06	6.340E+06	7.438E+06
5Ri1	2.802E+00	1.597E+00	2.468E+00	5.675E+00	9.263E-01	1.934E+00	2.731E+00
5Ri2	2.726E+04	1.655E+04	2.385E+04	7.053E+04	2.131E+04	1.763E+04	2.113E+04
5Ri3	1.279E+01	1.929E+00	4.324E+00	1.549E+01	1.186E+00	2.363E+00	6.748E+00
5Mi1	1.196E+03	8.000E+02	1.017E+03	3.154E+03	8.726E+02	8.200E+02	8.741E+02
5Mi2	5.532E+03	8.590E+02	1.903E+03	6.819E+03	5.056E+02	1.021E+03	3.029E+03
5Mi3	9.715E+06	5.886E+06	8.471E+06	2.510E+07	7.519E+06	6.340E+06	7.438E+06
5Rj1	2.802E+00	1.597E+00	2.468E+00	5.675E+00	9.263E-01	1.934E+00	2.731E+00
5Rj2	2.726E+04	1.655E+04	2.385E+04	7.053E+04	2.131E+04	1.763E+04	2.113E+04
5Rj3	1.279E+01	1.929E+00	4.324E+00	1.549E+01	1.186E+00	2.363E+00	6.748E+00
5Mj1	1.196E+03	8.000E+02	1.017E+03	3.154E+03	8.726E+02	8.200E+02	8.741E+02
5Mj2	2.939E+03	4.548E+02	1.004E+03	3.580E+03	2.564E+02	5.269E+02	1.646E+03
5Mj3	4.007E+06	2.412E+06	3.463E+06	1.029E+07	3.044E+06	2.638E+06	3.001E+06
6Ri1	2.307E+00	1.482E+00	2.328E+00	4.606E+00	8.813E-01	1.724E+00	2.287E+00
6Ri2	1.938E+04	1.169E+04	1.681E+04	4.989E+04	1.483E+04	1.272E+04	1.464E+04
6Ri3	1.284E+01	1.831E+00	4.280E+00	1.609E+01	1.064E+00	2.334E+00	6.974E+00
6Mi1	6.044E+02	4.483E+02	7.673E+02	1.525E+03	4.974E+02	5.860E+02	5.118E+02
6Mi2	2.939E+03	4.548E+02	1.004E+03	3.580E+03	2.564E+02	5.269E+02	1.646E+03
6Mi3	4.007E+06	2.412E+06	3.463E+06	1.029E+07	3.044E+06	2.638E+06	3.001E+06
6Rj1	2.307E+00	1.482E+00	2.328E+00	4.606E+00	8.813E-01	1.724E+00	2.287E+00
6Rj2	1.938E+04	1.169E+04	1.681E+04	4.989E+04	1.483E+04	1.272E+04	1.464E+04
6Rj3	1.284E+01	1.831E+00	4.280E+00	1.609E+01	1.064E+00	2.334E+00	6.974E+00
6Mj1	6.044E+02	4.483E+02	7.673E+02	1.525E+03	4.974E+02	5.860E+02	5.118E+02
6Mj2	1.206E+03	2.093E+02	4.405E+02	1.454E+03	1.130E+02	2.311E+02	7.233E+02
6Mj3	1.393E+06	8.332E+05	1.194E+06	3.554E+06	1.042E+06	9.208E+05	1.025E+06
7Ri1	2.209E+00	1.363E+00	2.167E+00	4.058E+00	8.345E-01	1.503E+00	1.946E+00
7Ri2	1.032E+04	6.171E+03	8.843E+03	2.633E+04	7.719E+03	6.821E+03	7.591E+03
7Ri3	8.605E+00	1.162E+00	2.753E+00	1.074E+01	6.371E-01	1.524E+00	4.613E+00
7Mi1	6.044E+02	4.483E+02	7.673E+02	1.525E+03	4.974E+02	5.860E+02	5.118E+02
7Mi2	1.206E+03	2.093E+02	4.405E+02	1.454E+03	1.130E+02	2.311E+02	7.233E+02
7Mi3	1.393E+06	8.332E+05	1.194E+06	3.554E+06	1.042E+06	9.208E+05	1.025E+06
7Rj1	2.209E+00	1.363E+00	2.167E+00	4.058E+00	8.345E-01	1.503E+00	1.946E+00
7Rj2	1.032E+04	6.171E+03	8.843E+03	2.633E+04	7.719E+03	6.821E+03	7.591E+03
7Rj3	8.605E+00	1.162E+00	2.753E+00	1.074E+01	6.371E-01	1.524E+00	4.613E+00
7Mj1	6.044E+02	4.483E+02	7.673E+02	1.525E+03	4.974E+02	5.860E+02	5.118E+02
7Mj2	2.041E+02	9.992E+01	1.576E+02	3.146E+02	6.160E+01	1.056E+02	1.642E+02
7Mj3	2.074E+02	1.340E+02	2.167E+02	3.565E+02	8.535E+01	9.246E+01	1.379E+02

Table C.11. Maximum element forces and moments for link elements of benchmark problem No. 4a (kips-inches)

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	3.212E-01	8.693E-02	1.830E-01	5.051E-01	1.114E-01	1.422E-01	2.281E-01
1Ri2	9.389E-02	1.806E-02	3.820E-02	9.079E-02	1.829E-02	2.379E-02	4.872E-02
1Ri3	9.193E-01	2.665E-01	5.829E-01	1.527E+00	3.386E-01	4.358E-01	6.898E-01
1Mi1	9.277E+00	3.554E+00	8.586E+00	2.609E+01	3.848E+00	4.193E+00	1.148E+01
1Mi2	4.267E+01	1.241E+01	2.508E+01	6.816E+01	1.496E+01	1.984E+01	3.108E+01
1Mi3	4.679E+00	9.715E-01	2.204E+00	6.408E+00	7.997E-01	1.154E+00	2.944E+00
1Rj1	3.212E-01	8.693E-02	1.830E-01	5.051E-01	1.114E-01	1.422E-01	2.281E-01
1Rj2	9.389E-02	1.806E-02	3.820E-02	9.079E-02	1.829E-02	2.379E-02	4.872E-02
1Rj3	9.193E-01	2.665E-01	5.829E-01	1.527E+00	3.386E-01	4.358E-01	6.898E-01
1Mj1	9.277E+00	3.554E+00	8.586E+00	2.609E+01	3.848E+00	4.193E+00	1.148E+01
1Mj2	1.894E+02	5.552E+01	1.224E+02	3.173E+02	7.051E+01	9.017E+01	1.433E+02
1Mj3	2.014E+01	4.329E+00	8.625E+00	2.186E+01	4.412E+00	5.581E+00	1.185E+01
2Ri1	3.079E-01	1.461E-01	2.244E-01	5.484E-01	2.210E-01	1.583E-01	2.188E-01
2Ri2	8.815E-02	2.034E-02	4.976E-02	1.396E-01	2.009E-02	2.316E-02	5.864E-02
2Ri3	5.166E-01	1.428E-01	2.185E-01	5.452E-01	2.293E-01	2.029E-01	2.371E-01
2Mi1	2.109E+00	4.474E-01	1.044E+00	3.426E+00	3.514E-01	5.455E-01	1.313E+00
2Mi2	2.808E+01	8.372E+00	1.243E+01	3.206E+01	1.318E+01	1.142E+01	1.354E+01
2Mi3	3.739E+00	7.895E-01	1.887E+00	5.272E+00	8.011E-01	9.291E-01	2.357E+00
2Rj1	3.079E-01	1.461E-01	2.244E-01	5.484E-01	2.210E-01	1.583E-01	2.188E-01
2Rj2	8.815E-02	2.034E-02	4.976E-02	1.396E-01	2.009E-02	2.316E-02	5.864E-02
2Rj3	5.166E-01	1.428E-01	2.185E-01	5.452E-01	2.293E-01	2.029E-01	2.371E-01
2Mj1	2.109E+00	4.474E-01	1.044E+00	3.426E+00	3.514E-01	5.455E-01	1.313E+00
2Mj2	1.327E+02	3.610E+01	5.609E+01	1.380E+02	5.817E+01	5.172E+01	6.023E+01
2Mj3	2.371E+01	5.539E+00	1.360E+01	3.815E+01	5.449E+00	6.286E+00	1.590E+01
3Ri1	1.418E+00	4.989E-01	1.116E+00	3.048E+00	5.476E-01	4.782E-01	1.207E+00
3Ri2	5.087E-01	1.459E-01	3.867E-01	1.151E+00	1.441E-01	1.740E-01	4.697E-01
3Ri3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3Mi1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3Mi2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3Mi3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3Rj1	1.418E+00	4.989E-01	1.116E+00	3.048E+00	5.476E-01	4.782E-01	1.207E+00
3Rj2	5.087E-01	1.459E-01	3.867E-01	1.151E+00	1.441E-01	1.740E-01	4.697E-01
3Rj3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3Mj1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3Mj2	1.151E-06	1.482E-07	3.563E-07	8.465E-07	1.178E-07	3.377E-07	5.193E-07
3Mj3	3.967E+01	1.138E+01	3.016E+01	8.974E+01	1.124E+01	1.357E+01	3.664E+01
4Ri1	2.935E+00	9.806E-01	1.959E+00	4.671E+00	1.246E+00	1.618E+00	2.451E+00
4Ri2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4Ri3	7.675E-01	2.173E-01	4.490E-01	1.103E+00	2.792E-01	3.682E-01	5.494E-01
4Mi1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4Mi2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4Mi3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4Rj1	2.935E+00	9.806E-01	1.959E+00	4.671E+00	1.246E+00	1.618E+00	2.451E+00

4Rj2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4Rj3	7.675E-01	2.173E-01	4.490E-01	1.103E+00	2.792E-01	3.682E-01	5.494E-01
4Mj1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4Mj2	6.144E+01	1.740E+01	3.594E+01	8.827E+01	2.235E+01	2.948E+01	4.398E+01
4Mj3	2.485E-04	8.203E-05	1.816E-04	4.652E-04	1.090E-04	1.083E-04	1.910E-04
5Ri1	2.948E+00	1.007E+00	1.927E+00	5.606E+00	1.288E+00	1.647E+00	2.886E+00
5Ri2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5Ri3	7.187E-01	2.386E-01	4.614E-01	1.266E+00	3.003E-01	3.954E-01	6.512E-01
5Mi1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5Mi2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5Mi3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5Rj1	2.948E+00	1.007E+00	1.927E+00	5.606E+00	1.288E+00	1.647E+00	2.886E+00
5Rj2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5Rj3	7.187E-01	2.386E-01	4.614E-01	1.266E+00	3.003E-01	3.954E-01	6.512E-01
5Mj1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5Mj2	5.754E+01	1.910E+01	3.694E+01	1.013E+02	2.404E+01	3.165E+01	5.213E+01
5Mj3	2.497E-04	8.296E-05	1.840E-04	4.680E-04	1.088E-04	1.030E-04	1.912E-04
6Ri1	4.057E-01	4.778E-02	9.143E-02	1.288E-01	4.756E-02	9.302E-02	9.114E-02
6Ri2	4.293E-01	1.429E-01	3.048E-01	8.359E-01	1.696E-01	2.118E-01	4.457E-01
6Ri3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6Mi1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6Mi2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6Mi3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6Rj1	4.057E-01	4.778E-02	9.143E-02	1.288E-01	4.756E-02	9.302E-02	9.114E-02
6Rj2	4.293E-01	1.429E-01	3.048E-01	8.359E-01	1.696E-01	2.118E-01	4.457E-01
6Rj3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6Mj1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6Mj2	9.318E-05	3.806E-05	5.756E-05	2.042E-04	4.412E-05	3.631E-05	8.300E-05
6Mj3	7.728E+00	2.573E+00	5.486E+00	1.505E+01	3.052E+00	3.811E+00	8.022E+00
7Ri1	1.448E+00	7.651E-01	1.143E+00	3.794E+00	1.042E+00	7.050E-01	1.223E+00
7Ri2	1.738E-01	4.424E-02	9.633E-02	2.480E-01	4.879E-02	6.138E-02	1.323E-01
7Ri3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7Mi1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7Mi2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7Mi3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7Rj1	1.448E+00	7.651E-01	1.143E+00	3.794E+00	1.042E+00	7.050E-01	1.223E+00
7Rj2	1.738E-01	4.424E-02	9.633E-02	2.480E-01	4.879E-02	6.138E-02	1.323E-01
7Rj3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7Mj1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7Mj2	9.192E-07	1.730E-07	2.900E-07	6.160E-07	1.958E-07	2.654E-07	2.672E-07
7Mj3	3.441E+01	8.759E+00	1.907E+01	4.910E+01	9.661E+00	1.216E+01	2.620E+01

Table C.12. Maximum element forces and moments for joint elements of benchmark problem No. 4b (kips-inches)

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	6.937E+00	5.339E+00	9.058E+00	1.816E+01	6.026E+00	6.930E+00	5.921E+00
1Ri2	1.222E+00	8.251E-01	1.291E+00	2.143E+00	5.018E-01	5.824E-01	8.243E-01
1Ri3	2.454E+00	1.794E+00	3.081E+00	6.087E+00	1.977E+00	2.351E+00	2.064E+00
1Mi1	2.458E+01	1.716E+01	2.692E+01	4.364E+01	1.070E+01	1.322E+01	1.661E+01
1Mi2	2.377E+01	1.384E+01	2.220E+01	3.633E+01	8.797E+00	1.023E+01	1.596E+01
1Mi3	8.439E+01	6.200E+01	9.191E+01	1.518E+02	3.598E+01	4.938E+01	5.768E+01
1Rj1	6.937E+00	5.339E+00	9.058E+00	1.816E+01	6.026E+00	6.930E+00	5.921E+00
1Rj2	1.222E+00	8.251E-01	1.291E+00	2.143E+00	5.018E-01	5.824E-01	8.243E-01
1Rj3	2.454E+00	1.794E+00	3.081E+00	6.087E+00	1.977E+00	2.351E+00	2.064E+00
1Mj1	2.458E+01	1.716E+01	2.692E+01	4.364E+01	1.070E+01	1.322E+01	1.661E+01
1Mj2	6.044E+02	4.483E+02	7.673E+02	1.525E+03	4.974E+02	5.860E+02	5.118E+02
1Mj3	2.258E+02	1.464E+02	2.363E+02	3.890E+02	9.281E+01	1.008E+02	1.503E+02
2Ri1	2.910E+00	2.771E+00	3.749E+00	7.217E+00	2.416E+00	2.091E+00	2.397E+00
2Ri2	4.060E-01	1.746E-01	2.856E-01	6.687E-01	1.403E-01	2.582E-01	2.925E-01
2Ri3	4.135E+00	1.846E+00	2.592E+00	5.647E+00	1.860E+00	1.615E+00	2.186E+00
2Mi1	1.731E+01	8.784E+00	1.226E+01	2.344E+01	5.190E+00	1.008E+01	1.209E+01
2Mi2	1.144E+02	3.186E+01	5.113E+01	1.378E+02	1.763E+01	2.895E+01	6.779E+01
2Mi3	1.840E+01	6.687E+00	9.906E+00	2.407E+01	4.272E+00	8.415E+00	1.201E+01
2Rj1	2.910E+00	2.771E+00	3.749E+00	7.217E+00	2.416E+00	2.091E+00	2.397E+00
2Rj2	4.060E-01	1.746E-01	2.856E-01	6.687E-01	1.403E-01	2.582E-01	2.925E-01
2Rj3	4.135E+00	1.846E+00	2.592E+00	5.647E+00	1.860E+00	1.615E+00	2.186E+00
2Mj1	1.731E+01	8.784E+00	1.226E+01	2.344E+01	5.190E+00	1.008E+01	1.209E+01
2Mj2	1.211E+03	6.004E+02	8.390E+02	1.781E+03	5.846E+02	5.116E+02	6.651E+02
2Mj3	1.082E+02	4.893E+01	7.956E+01	1.840E+02	4.021E+01	7.251E+01	7.901E+01
3Ri1	3.581E-01	2.433E-01	4.196E-01	5.903E-01	1.639E-01	2.006E-01	2.210E-01
3Ri2	2.968E+00	2.067E+00	3.164E+00	5.079E+00	1.236E+00	1.813E+00	2.322E+00
3Ri3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3Mi1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3Mi2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3Mi3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3Rj1	3.581E-01	2.433E-01	4.196E-01	5.903E-01	1.639E-01	2.006E-01	2.210E-01
3Rj2	2.968E+00	2.067E+00	3.164E+00	5.079E+00	1.236E+00	1.813E+00	2.322E+00
3Rj3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3Mj1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3Mj2	8.884E-05	6.374E-05	1.104E-04	1.893E-04	6.543E-05	8.467E-05	6.720E-05
3Mj3	2.315E+02	1.612E+02	2.468E+02	3.962E+02	9.639E+01	1.414E+02	1.811E+02
4Ri1	2.281E+00	2.230E+00	3.205E+00	5.200E+00	1.652E+00	1.619E+00	1.914E+00
4Ri2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4Ri3	9.947E+00	9.181E+00	1.413E+01	2.200E+01	6.749E+00	7.106E+00	7.620E+00
4Mi1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4Mi2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

4Mi3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4Rj1	2.281E+00	2.230E+00	3.205E+00	5.200E+00	1.652E+00	1.619E+00	1.914E+00
4Rj2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4Rj3	9.947E+00	9.181E+00	1.413E+01	2.200E+01	6.749E+00	7.106E+00	7.620E+00
4Mj1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4Mj2	7.963E+02	7.349E+02	1.131E+03	1.761E+03	5.403E+02	5.688E+02	6.100E+02
4Mj3	1.675E-03	1.558E-03	2.338E-03	3.389E-03	9.423E-04	1.231E-03	1.282E-03
5Ri1	3.101E+00	2.367E+00	3.493E+00	6.389E+00	1.763E+00	1.849E+00	2.093E+00
5Ri2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5Ri3	1.071E+01	9.857E+00	1.576E+01	2.206E+01	6.820E+00	6.419E+00	7.817E+00
5Mi1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5Mi2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5Mi3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5Rj1	3.101E+00	2.367E+00	3.493E+00	6.389E+00	1.763E+00	1.849E+00	2.093E+00
5Rj2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5Rj3	1.071E+01	9.857E+00	1.576E+01	2.206E+01	6.820E+00	6.419E+00	7.817E+00
5Mj1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5Mj2	8.569E+02	7.891E+02	1.262E+03	1.766E+03	5.460E+02	5.139E+02	6.257E+02
5Mj3	1.681E-03	1.562E-03	2.344E-03	3.395E-03	9.450E-04	1.235E-03	1.296E-03
6Ri1	8.072E+00	5.914E+00	9.689E+00	1.338E+01	4.217E+00	4.836E+00	4.793E+00
6Ri2	1.595E+00	1.318E+00	1.851E+00	3.084E+00	7.473E-01	1.121E+00	1.139E+00
6Ri3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6Mi1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6Mi2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6Mi3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6Rj1	8.072E+00	5.914E+00	9.689E+00	1.338E+01	4.217E+00	4.836E+00	4.793E+00
6Rj2	1.595E+00	1.318E+00	1.851E+00	3.084E+00	7.473E-01	1.121E+00	1.139E+00
6Rj3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6Mj1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6Mj2	7.983E-04	5.820E-04	8.835E-04	1.564E-03	3.409E-04	4.196E-04	5.257E-04
6Mj3	2.866E+01	2.368E+01	3.323E+01	5.542E+01	1.342E+01	2.016E+01	2.047E+01
7Ri1	4.506E+00	9.433E-01	1.803E+00	5.747E+00	4.880E-01	9.657E-01	2.491E+00
7Ri2	7.720E-01	4.507E-01	6.845E-01	1.165E+00	2.692E-01	3.650E-01	5.119E-01
7Ri3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7Mi1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7Mi2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7Mi3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7Rj1	4.506E+00	9.433E-01	1.803E+00	5.747E+00	4.880E-01	9.657E-01	2.491E+00
7Rj2	7.720E-01	4.507E-01	6.845E-01	1.165E+00	2.692E-01	3.650E-01	5.119E-01
7Rj3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7Mj1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7Mj2	1.920E-05	1.486E-05	2.111E-05	3.621E-05	1.190E-05	1.130E-05	1.339E-05
7Mj3	1.529E+02	8.924E+01	1.355E+02	2.307E+02	5.330E+01	7.227E+01	1.014E+02

Table C.13. Maximum element forces and moments for S-components of benchmark problem No. 4a (kips-inches)

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	7.746E-02	1.005E-02	2.379E-02	5.641E-02	7.863E-03	2.260E-02	3.466E-02
1Ri2	7.295E-01	2.074E-01	4.298E-01	1.162E+00	2.554E-01	3.350E-01	5.250E-01
1Ri3	8.888E-02	1.494E-02	3.212E-02	7.326E-02	1.504E-02	1.976E-02	3.910E-02
1Mi1	9.269E+00	3.680E+00	8.892E+00	2.682E+01	3.887E+00	4.207E+00	1.135E+01
1Mi2	5.521E+00	9.593E-01	2.026E+00	4.686E+00	9.824E-01	1.273E+00	2.715E+00
1Mi3	4.258E+01	1.238E+01	2.508E+01	6.776E+01	1.495E+01	1.983E+01	3.094E+01
1Rj1	7.746E-02	1.005E-02	2.379E-02	5.641E-02	7.863E-03	2.260E-02	3.466E-02
1Rj2	7.295E-01	2.074E-01	4.298E-01	1.162E+00	2.554E-01	3.350E-01	5.250E-01
1Rj3	8.888E-02	1.494E-02	3.212E-02	7.326E-02	1.504E-02	1.976E-02	3.910E-02
1Mj1	9.269E+00	3.680E+00	8.892E+00	2.682E+01	3.887E+00	4.207E+00	1.135E+01
1Mj2	1.590E+00	2.674E-01	5.599E-01	1.380E+00	2.228E-01	3.077E-01	7.145E-01
1Mj3	1.578E+01	4.445E+00	9.811E+00	2.533E+01	5.482E+00	6.964E+00	1.142E+01
2Ri1	7.688E-02	9.961E-03	2.368E-02	5.624E-02	7.839E-03	2.246E-02	3.454E-02
2Ri2	1.685E-01	5.189E-02	9.866E-02	2.406E-01	6.088E-02	7.683E-02	1.227E-01
2Ri3	3.227E-02	7.208E-03	1.686E-02	5.219E-02	7.177E-03	8.851E-03	2.582E-02
2Mi1	9.269E+00	3.680E+00	8.892E+00	2.682E+01	3.887E+00	4.207E+00	1.135E+01
2Mi2	1.590E+00	2.674E-01	5.599E-01	1.380E+00	2.228E-01	3.077E-01	7.145E-01
2Mi3	1.578E+01	4.445E+00	9.811E+00	2.533E+01	5.482E+00	6.964E+00	1.142E+01
2Rj1	7.688E-02	9.961E-03	2.368E-02	5.624E-02	7.839E-03	2.246E-02	3.454E-02
2Rj2	1.685E-01	5.189E-02	9.866E-02	2.406E-01	6.088E-02	7.683E-02	1.227E-01
2Rj3	3.227E-02	7.208E-03	1.686E-02	5.219E-02	7.177E-03	8.851E-03	2.582E-02
2Mj1	9.269E+00	3.680E+00	8.892E+00	2.682E+01	3.887E+00	4.207E+00	1.135E+01
2Mj2	4.141E+00	7.464E-01	1.685E+00	4.061E+00	7.874E-01	1.000E+00	2.439E+00
2Mj3	2.757E+01	8.355E+00	1.661E+01	4.344E+01	9.991E+00	1.309E+01	2.034E+01
3Ri1	7.562E-02	9.783E-03	2.346E-02	5.591E-02	7.788E-03	2.217E-02	3.431E-02
3Ri2	4.851E-01	1.322E-01	3.045E-01	7.682E-01	1.610E-01	1.847E-01	3.473E-01
3Ri3	6.060E-02	9.505E-03	2.527E-02	6.862E-02	7.628E-03	1.144E-02	2.830E-02
3Mi1	9.269E+00	3.680E+00	8.892E+00	2.682E+01	3.887E+00	4.207E+00	1.135E+01
3Mi2	4.141E+00	7.464E-01	1.685E+00	4.061E+00	7.874E-01	1.000E+00	2.439E+00
3Mi3	2.757E+01	8.355E+00	1.661E+01	4.344E+01	9.991E+00	1.309E+01	2.034E+01
3Rj1	7.562E-02	9.783E-03	2.346E-02	5.591E-02	7.788E-03	2.217E-02	3.431E-02
3Rj2	4.851E-01	1.322E-01	3.045E-01	7.682E-01	1.610E-01	1.847E-01	3.473E-01
3Rj3	6.060E-02	9.505E-03	2.527E-02	6.862E-02	7.628E-03	1.144E-02	2.830E-02
3Mj1	9.269E+00	3.680E+00	8.892E+00	2.682E+01	3.887E+00	4.207E+00	1.135E+01
3Mj2	3.510E+00	9.817E-01	2.443E+00	8.233E+00	1.026E+00	1.249E+00	3.473E+00
3Mj3	1.209E+01	5.138E+00	1.075E+01	3.297E+01	4.811E+00	4.716E+00	1.331E+01
4Ri1	4.667E-01	1.395E-01	3.693E-01	1.093E+00	1.397E-01	1.680E-01	4.603E-01
4Ri2	7.431E-02	9.603E-03	2.323E-02	5.558E-02	7.734E-03	2.187E-02	3.408E-02
4Ri3	7.013E-01	3.039E-01	6.234E-01	1.973E+00	2.748E-01	2.778E-01	7.995E-01
4Mi1	1.209E+01	5.138E+00	1.075E+01	3.297E+01	4.811E+00	4.716E+00	1.331E+01
4Mi2	9.269E+00	3.680E+00	8.892E+00	2.682E+01	3.887E+00	4.207E+00	1.135E+01
4Mi3	3.510E+00	9.817E-01	2.443E+00	8.233E+00	1.026E+00	1.249E+00	3.473E+00

4Rj1	3.676E-01	1.035E-01	2.775E-01	7.877E-01	1.040E-01	1.225E-01	3.303E-01
4Rj2	3.088E-01	9.381E-02	2.448E-01	7.582E-01	9.573E-02	1.155E-01	3.206E-01
4Rj3	7.013E-01	3.039E-01	6.234E-01	1.973E+00	2.748E-01	2.778E-01	7.995E-01
4Mj1	8.463E+00	2.774E+00	6.513E+00	1.682E+01	3.327E+00	3.324E+00	6.883E+00
4Mj2	5.577E+00	2.352E+00	5.505E+00	1.697E+01	2.405E+00	2.581E+00	6.894E+00
4Mj3	1.345E+00	3.439E-01	8.006E-01	2.733E+00	3.423E-01	4.182E-01	1.143E+00
5Ri1	4.689E-01	1.380E-01	3.641E-01	1.072E+00	1.388E-01	1.661E-01	4.549E-01
5Ri2	4.738E-01	2.075E-01	4.712E-01	1.478E+00	2.067E-01	2.199E-01	5.956E-01
5Ri3	7.351E-02	9.948E-03	2.557E-02	5.667E-02	8.611E-03	2.169E-02	3.251E-02
5Mi1	1.528E+00	4.851E-01	1.183E+00	3.225E+00	5.302E-01	6.768E-01	1.630E+00
5Mi2	4.960E+00	1.430E+00	3.788E+00	1.109E+01	1.447E+00	1.720E+00	4.708E+00
5Mi3	7.117E+00	2.341E+00	5.307E+00	1.403E+01	2.899E+00	3.623E+00	6.119E+00
5Rj1	4.689E-01	1.380E-01	3.641E-01	1.072E+00	1.388E-01	1.661E-01	4.549E-01
5Rj2	4.738E-01	2.075E-01	4.712E-01	1.478E+00	2.067E-01	2.199E-01	5.956E-01
5Rj3	7.351E-02	9.948E-03	2.557E-02	5.667E-02	8.611E-03	2.169E-02	3.251E-02
5Mj1	1.528E+00	4.851E-01	1.183E+00	3.225E+00	5.302E-01	6.768E-01	1.630E+00
5Mj2	5.316E+00	1.128E+00	2.465E+00	8.547E+00	1.070E+00	1.580E+00	4.093E+00
5Mj3	3.829E+01	1.919E+01	4.015E+01	1.325E+02	1.774E+01	1.842E+01	5.362E+01
6Ri1	4.692E-01	1.356E-01	3.555E-01	1.039E+00	1.371E-01	1.631E-01	4.462E-01
6Ri2	5.182E-01	1.749E-01	3.406E-01	8.054E-01	2.183E-01	2.837E-01	4.615E-01
6Ri3	3.690E-02	8.923E-03	2.698E-02	7.709E-02	1.051E-02	1.645E-02	3.393E-02
6Mi1	1.528E+00	4.851E-01	1.183E+00	3.225E+00	5.302E-01	6.768E-01	1.630E+00
6Mi2	5.316E+00	1.128E+00	2.465E+00	8.547E+00	1.070E+00	1.580E+00	4.093E+00
6Mi3	3.829E+01	1.919E+01	4.015E+01	1.325E+02	1.774E+01	1.842E+01	5.362E+01
6Rj1	4.692E-01	1.356E-01	3.555E-01	1.039E+00	1.371E-01	1.631E-01	4.462E-01
6Rj2	5.182E-01	1.749E-01	3.406E-01	8.054E-01	2.183E-01	2.837E-01	4.615E-01
6Rj3	3.690E-02	8.923E-03	2.698E-02	7.709E-02	1.051E-02	1.645E-02	3.393E-02
6Mj1	1.528E+00	4.851E-01	1.183E+00	3.225E+00	5.302E-01	6.768E-01	1.630E+00
6Mj2	3.137E+00	6.775E-01	1.251E+00	3.053E+00	6.478E-01	1.125E+00	2.344E+00
6Mj3	6.828E+01	2.420E+01	5.885E+01	1.675E+02	2.529E+01	3.166E+01	8.028E+01
7Ri1	4.668E-01	1.329E-01	3.460E-01	1.006E+00	1.354E-01	1.600E-01	4.374E-01
7Ri2	9.488E-01	2.693E-01	5.844E-01	1.669E+00	3.513E-01	4.333E-01	7.114E-01
7Ri3	9.138E-02	1.233E-02	4.002E-02	1.057E-01	1.403E-02	2.969E-02	5.467E-02
7Mi1	1.528E+00	4.851E-01	1.183E+00	3.225E+00	5.302E-01	6.768E-01	1.630E+00
7Mi2	3.137E+00	6.775E-01	1.251E+00	3.053E+00	6.478E-01	1.125E+00	2.344E+00
7Mi3	6.828E+01	2.420E+01	5.885E+01	1.675E+02	2.529E+01	3.166E+01	8.028E+01
7Rj1	4.668E-01	1.329E-01	3.460E-01	1.006E+00	1.354E-01	1.600E-01	4.374E-01
7Rj2	9.488E-01	2.693E-01	5.844E-01	1.669E+00	3.513E-01	4.333E-01	7.114E-01
7Rj3	9.138E-02	1.233E-02	4.002E-02	1.057E-01	1.403E-02	2.969E-02	5.467E-02
7Mj1	1.528E+00	4.851E-01	1.183E+00	3.225E+00	5.302E-01	6.768E-01	1.630E+00
7Mj2	6.620E+00	1.095E+00	3.137E+00	7.175E+00	1.096E+00	2.534E+00	4.029E+00
7Mj3	1.188E+02	4.055E+01	7.804E+01	1.922E+02	5.081E+01	6.507E+01	1.099E+02
8Ri1	4.619E-01	1.301E-01	3.362E-01	9.710E-01	1.335E-01	1.581E-01	4.289E-01
8Ri2	1.864E+00	6.394E-01	1.250E+00	3.427E+00	7.995E-01	1.003E+00	1.855E+00
8Ri3	1.004E-01	1.455E-02	3.751E-02	7.920E-02	1.313E-02	3.816E-02	4.681E-02
8Mi1	1.528E+00	4.851E-01	1.183E+00	3.224E+00	5.300E-01	6.766E-01	1.630E+00
8Mi2	6.620E+00	1.095E+00	3.137E+00	7.175E+00	1.096E+00	2.534E+00	4.029E+00
8Mi3	1.188E+02	4.055E+01	7.804E+01	1.922E+02	5.081E+01	6.507E+01	1.099E+02

8Rj1	4.619E-01	1.301E-01	3.362E-01	9.710E-01	1.335E-01	1.581E-01	4.289E-01
8Rj2	1.864E+00	6.394E-01	1.250E+00	3.427E+00	7.995E-01	1.003E+00	1.855E+00
8Rj3	1.004E-01	1.455E-02	3.751E-02	7.920E-02	1.313E-02	3.816E-02	4.681E-02
8Mj1	1.528E+00	4.851E-01	1.183E+00	3.224E+00	5.300E-01	6.766E-01	1.630E+00
8Mj2	4.012E+00	5.445E-01	1.129E+00	2.663E+00	4.690E-01	1.013E+00	1.429E+00
8Mj3	3.979E+01	1.400E+01	3.255E+01	9.588E+01	1.636E+01	1.948E+01	4.598E+01
9Ri1	4.547E-01	1.269E-01	3.257E-01	9.355E-01	1.314E-01	1.625E-01	4.206E-01
9Ri2	1.065E+00	3.697E-01	7.269E-01	2.003E+00	4.532E-01	5.747E-01	1.087E+00
9Ri3	4.621E-02	8.649E-03	2.373E-02	6.047E-02	9.144E-03	1.632E-02	3.461E-02
9Mi1	1.528E+00	4.851E-01	1.183E+00	3.224E+00	5.300E-01	6.766E-01	1.630E+00
9Mi2	4.012E+00	5.445E-01	1.129E+00	2.663E+00	4.690E-01	1.013E+00	1.429E+00
9Mi3	3.979E+01	1.400E+01	3.255E+01	9.588E+01	1.636E+01	1.948E+01	4.598E+01
9Rj1	4.547E-01	1.269E-01	3.257E-01	9.355E-01	1.314E-01	1.625E-01	4.206E-01
9Rj2	1.065E+00	3.697E-01	7.269E-01	2.003E+00	4.532E-01	5.747E-01	1.087E+00
9Rj3	4.621E-02	8.649E-03	2.373E-02	6.047E-02	9.144E-03	1.632E-02	3.461E-02
9Mj1	1.528E+00	4.851E-01	1.183E+00	3.224E+00	5.300E-01	6.766E-01	1.630E+00
9Mj2	4.060E+00	9.499E-01	1.731E+00	4.581E+00	8.365E-01	1.616E+00	2.744E+00
9Mj3	1.281E+02	4.426E+01	9.283E+01	2.640E+02	5.442E+01	6.745E+01	1.373E+02
10Ri1	4.455E-01	1.255E-01	3.148E-01	8.988E-01	1.296E-01	1.669E-01	4.170E-01
10Ri2	1.216E-01	3.420E-02	9.043E-02	2.395E-01	3.538E-02	4.230E-02	1.159E-01
10Ri3	6.419E-02	7.492E-03	1.848E-02	2.605E-02	5.205E-03	1.876E-02	1.621E-02
10Mi1	1.528E+00	4.851E-01	1.183E+00	3.224E+00	5.300E-01	6.766E-01	1.630E+00
10Mi2	4.060E+00	9.499E-01	1.731E+00	4.581E+00	8.365E-01	1.616E+00	2.744E+00
10Mi3	1.281E+02	4.426E+01	9.283E+01	2.640E+02	5.442E+01	6.745E+01	1.373E+02
10Rj1	4.455E-01	1.255E-01	3.148E-01	8.988E-01	1.296E-01	1.669E-01	4.170E-01
10Rj2	1.216E-01	3.420E-02	9.043E-02	2.395E-01	3.538E-02	4.230E-02	1.159E-01
10Rj3	6.419E-02	7.492E-03	1.848E-02	2.605E-02	5.205E-03	1.876E-02	1.621E-02
10Mj1	1.528E+00	4.851E-01	1.183E+00	3.224E+00	5.300E-01	6.766E-01	1.630E+00
10Mj2	5.389E+00	9.805E-01	2.515E+00	5.694E+00	1.016E+00	1.940E+00	3.330E+00
10Mj3	1.218E+02	4.230E+01	8.631E+01	2.442E+02	5.188E+01	6.510E+01	1.284E+02
11Ri1	4.344E-01	1.249E-01	3.071E-01	8.616E-01	1.344E-01	1.711E-01	4.156E-01
11Ri2	1.171E+00	4.066E-01	8.433E-01	2.391E+00	4.959E-01	6.205E-01	1.250E+00
11Ri3	4.441E-02	8.274E-03	1.570E-02	4.033E-02	7.310E-03	1.294E-02	2.577E-02
11Mi1	1.528E+00	4.851E-01	1.183E+00	3.224E+00	5.300E-01	6.766E-01	1.630E+00
11Mi2	5.389E+00	9.805E-01	2.515E+00	5.694E+00	1.016E+00	1.940E+00	3.330E+00
11Mi3	1.218E+02	4.230E+01	8.631E+01	2.442E+02	5.188E+01	6.510E+01	1.284E+02
11Rj1	4.344E-01	1.249E-01	3.071E-01	8.616E-01	1.344E-01	1.711E-01	4.156E-01
11Rj2	1.171E+00	4.066E-01	8.433E-01	2.391E+00	4.959E-01	6.205E-01	1.250E+00
11Rj3	4.441E-02	8.274E-03	1.570E-02	4.033E-02	7.310E-03	1.294E-02	2.577E-02
11Mj1	1.528E+00	4.851E-01	1.183E+00	3.224E+00	5.300E-01	6.766E-01	1.630E+00
11Mj2	3.360E+00	6.014E-01	1.450E+00	3.544E+00	4.912E-01	1.101E+00	1.745E+00
11Mj3	2.360E+01	8.227E+00	1.552E+01	4.342E+01	1.023E+01	1.302E+01	2.337E+01
12Ri1	4.219E-01	1.242E-01	2.989E-01	8.240E-01	1.394E-01	1.750E-01	4.136E-01
12Ri2	1.854E+00	6.436E-01	1.284E+00	3.677E+00	8.006E-01	1.009E+00	1.919E+00
12Ri3	1.074E-01	1.497E-02	3.751E-02	7.089E-02	1.312E-02	3.358E-02	4.349E-02
12Mi1	1.528E+00	4.851E-01	1.183E+00	3.224E+00	5.300E-01	6.766E-01	1.630E+00
12Mi2	3.360E+00	6.014E-01	1.450E+00	3.544E+00	4.912E-01	1.101E+00	1.745E+00
12Mi3	2.360E+01	8.227E+00	1.552E+01	4.342E+01	1.023E+01	1.302E+01	2.337E+01

12Rj1	4.219E-01	1.242E-01	2.989E-01	8.240E-01	1.394E-01	1.750E-01	4.136E-01
12Rj2	1.854E+00	6.436E-01	1.284E+00	3.677E+00	8.006E-01	1.009E+00	1.919E+00
12Rj3	1.074E-01	1.497E-02	3.751E-02	7.089E-02	1.312E-02	3.358E-02	4.349E-02
12Mj1	1.528E+00	4.851E-01	1.183E+00	3.224E+00	5.300E-01	6.766E-01	1.630E+00
12Mj2	6.747E+00	9.391E-01	1.961E+00	3.707E+00	8.642E-01	1.855E+00	2.861E+00
12Mj3	1.322E+02	4.587E+01	9.239E+01	2.655E+02	5.703E+01	7.173E+01	1.378E+02
13Ri1	4.083E-01	1.234E-01	2.901E-01	7.977E-01	1.444E-01	1.788E-01	4.111E-01
13Ri2	8.991E-01	3.111E-01	5.892E-01	1.738E+00	3.989E-01	5.155E-01	8.830E-01
13Ri3	1.156E-01	1.252E-02	2.822E-02	3.067E-02	8.625E-03	2.898E-02	2.682E-02
13Mi1	1.527E+00	4.850E-01	1.183E+00	3.224E+00	5.299E-01	6.766E-01	1.630E+00
13Mi2	6.747E+00	9.391E-01	1.961E+00	3.707E+00	8.642E-01	1.855E+00	2.861E+00
13Mi3	1.322E+02	4.587E+01	9.239E+01	2.655E+02	5.703E+01	7.173E+01	1.378E+02
13Rj1	4.083E-01	1.234E-01	2.901E-01	7.977E-01	1.444E-01	1.788E-01	4.111E-01
13Rj2	8.991E-01	3.111E-01	5.892E-01	1.738E+00	3.989E-01	5.155E-01	8.830E-01
13Rj3	1.156E-01	1.252E-02	2.822E-02	3.067E-02	8.625E-03	2.898E-02	2.682E-02
13Mj1	1.527E+00	4.850E-01	1.183E+00	3.224E+00	5.299E-01	6.766E-01	1.630E+00
13Mj2	5.447E+00	7.555E-01	1.505E+00	2.580E+00	5.813E-01	1.609E+00	1.813E+00
13Mj3	5.678E+01	1.978E+01	4.415E+01	1.235E+02	2.354E+01	2.867E+01	6.370E+01
14Ri1	3.937E-01	1.271E-01	2.809E-01	7.771E-01	1.493E-01	1.844E-01	4.081E-01
14Ri2	7.940E-01	2.773E-01	6.026E-01	1.700E+00	3.319E-01	4.066E-01	8.831E-01
14Ri3	4.758E-02	7.090E-03	1.357E-02	2.406E-02	5.920E-03	1.339E-02	1.763E-02
14Mi1	1.527E+00	4.850E-01	1.183E+00	3.224E+00	5.299E-01	6.766E-01	1.630E+00
14Mi2	5.447E+00	7.555E-01	1.505E+00	2.580E+00	5.813E-01	1.609E+00	1.813E+00
14Mi3	5.678E+01	1.978E+01	4.415E+01	1.235E+02	2.354E+01	2.867E+01	6.370E+01
14Rj1	3.937E-01	1.271E-01	2.809E-01	7.771E-01	1.493E-01	1.844E-01	4.081E-01
14Rj2	7.940E-01	2.773E-01	6.026E-01	1.700E+00	3.319E-01	4.066E-01	8.831E-01
14Rj3	4.758E-02	7.090E-03	1.357E-02	2.406E-02	5.920E-03	1.339E-02	1.763E-02
14Mj1	1.527E+00	4.850E-01	1.183E+00	3.224E+00	5.299E-01	6.766E-01	1.630E+00
14Mj2	1.867E+00	2.459E-01	6.582E-01	1.064E+00	1.803E-01	5.389E-01	6.353E-01
14Mj3	9.930E+00	3.518E+00	6.873E+00	1.944E+01	4.340E+00	5.487E+00	1.049E+01
15Ri1	7.953E-01	2.622E-01	6.197E-01	1.632E+00	2.983E-01	3.614E-01	8.590E-01
15Ri2	3.842E-01	1.300E-01	2.745E-01	7.642E-01	1.527E-01	1.888E-01	4.058E-01
15Ri3	1.198E-01	1.306E-02	3.531E-02	4.591E-02	1.107E-02	3.297E-02	3.152E-02
15Mi1	1.867E+00	2.459E-01	6.582E-01	1.064E+00	1.803E-01	5.389E-01	6.353E-01
15Mi2	1.527E+00	4.850E-01	1.183E+00	3.224E+00	5.299E-01	6.766E-01	1.630E+00
15Mi3	9.930E+00	3.518E+00	6.873E+00	1.944E+01	4.340E+00	5.487E+00	1.049E+01
15Rj1	8.181E-01	2.690E-01	6.318E-01	1.693E+00	3.122E-01	3.857E-01	8.831E-01
15Rj2	3.259E-01	1.124E-01	2.450E-01	6.885E-01	1.268E-01	1.335E-01	3.365E-01
15Rj3	1.198E-01	1.306E-02	3.531E-02	4.591E-02	1.107E-02	3.297E-02	3.152E-02
15Mj1	2.240E+00	3.981E-01	8.792E-01	1.776E+00	4.033E-01	5.382E-01	1.096E+00
15Mj2	1.071E+00	3.697E-01	8.774E-01	2.318E+00	3.838E-01	4.844E-01	1.208E+00
15Mj3	8.699E+00	3.127E+00	6.465E+00	1.819E+01	3.803E+00	4.723E+00	9.628E+00
16Ri1	8.307E-01	2.862E-01	6.261E-01	1.714E+00	3.311E-01	3.527E-01	8.719E-01
16Ri2	3.829E-01	1.341E-01	2.793E-01	7.764E-01	1.581E-01	1.956E-01	4.135E-01
16Ri3	1.578E-01	1.658E-02	4.720E-02	6.660E-02	1.441E-02	4.157E-02	4.420E-02
16Mi1	5.300E-01	9.423E-02	1.947E-01	4.810E-01	1.190E-01	1.291E-01	2.264E-01
16Mi2	2.699E+00	5.376E-01	1.271E+00	2.696E+00	5.423E-01	7.283E-01	1.527E+00
16Mi3	1.634E+01	5.509E+00	1.270E+01	3.490E+01	6.392E+00	7.973E+00	1.790E+01

16Rj1	8.307E-01	2.862E-01	6.261E-01	1.714E+00	3.311E-01	3.527E-01	8.719E-01
16Rj2	3.829E-01	1.341E-01	2.793E-01	7.764E-01	1.581E-01	1.956E-01	4.135E-01
16Rj3	1.578E-01	1.658E-02	4.720E-02	6.660E-02	1.441E-02	4.157E-02	4.420E-02
16Mj1	5.300E-01	9.423E-02	1.947E-01	4.810E-01	1.190E-01	1.291E-01	2.264E-01
16Mj2	1.204E+01	1.289E+00	2.484E+00	4.170E+00	7.696E-01	2.901E+00	3.076E+00
16Mj3	7.912E+00	2.548E+00	5.082E+00	1.213E+01	3.098E+00	4.082E+00	6.927E+00
17Ri1	8.998E-01	3.952E-01	6.369E-01	2.174E+00	4.332E-01	3.808E-01	9.399E-01
3Ri2	6.438E-02	1.084E-02	2.622E-02	5.997E-02	1.131E-02	1.842E-02	3.194E-02
17Ri3	2.479E-01	4.202E-02	7.998E-02	1.686E-01	4.335E-02	6.278E-02	8.410E-02
17Mi1	5.300E-01	9.423E-02	1.947E-01	4.810E-01	1.190E-01	1.291E-01	2.264E-01
17Mi2	1.204E+01	1.289E+00	2.484E+00	4.170E+00	7.696E-01	2.901E+00	3.076E+00
17Mi3	7.912E+00	2.548E+00	5.082E+00	1.213E+01	3.098E+00	4.082E+00	6.927E+00
17Rj1	8.998E-01	3.952E-01	6.369E-01	2.174E+00	4.332E-01	3.808E-01	9.399E-01
17Rj2	6.438E-02	1.084E-02	2.622E-02	5.997E-02	1.131E-02	1.842E-02	3.194E-02
17Rj3	2.479E-01	4.202E-02	7.998E-02	1.686E-01	4.335E-02	6.278E-02	8.410E-02
17Mj1	5.300E-01	9.423E-02	1.947E-01	4.810E-01	1.190E-01	1.291E-01	2.264E-01
17Mj2	1.340E+01	3.468E+00	6.213E+00	1.744E+01	3.891E+00	4.374E+00	7.140E+00
17Mj3	6.728E+00	1.777E+00	3.537E+00	8.578E+00	2.020E+00	2.589E+00	4.986E+00
18Ri1	1.070E+00	5.198E-01	7.694E-01	2.695E+00	6.364E-01	4.804E-01	1.023E+00
18Ri2	7.185E-02	1.923E-02	·3.836E-02	9.198E-02	2.210E-02	2.821E-02	5.387E-02
18Ri3	1.261E-01	3.124E-02	4.775E-02	1.267E-01	3.632E-02	3.825E-02	5.306E-02
18Mi1	5.300E-01	9.423E-02	1.947E-01	4.810E-01	1.190E-01	1.291E-01	2.264E-01
18Mi2	1.340E+01	3.468E+00	6.213E+00	1.744E+01	3.891E+00	4.374E+00	7.140E+00
18Mi3	6.728E+00	1.777E+00	3.537E+00	8.578E+00	2.020E+00	2.589E+00	4.986E+00
18Rj1	1.070E+00	5.198E-01	7.694E-01	2.695E+00	6.364E-01	4.804E-01	1.023E+00
18Rj2	7.185E-02	1.923E-02	3.836E-02	9.198E-02	2.210E-02	2.821E-02	5.387E-02
18Rj3	1.261E-01	3.124E-02	4.775E-02	1.267E-01	3.632E-02	3.825E-02	5.306E-02
18Mj1	5.300E-01	9.423E-02	1.947E-01	4.810E-01	1.190E-01	1.291E-01	2.264E-01
18Mj2	1.086E+01	5.285E+00	7.928E+00	2.754E+01	6.358E+00	4.880E+00	1.076E+01
18Mj3	9.847E-01	2.382E-01	5.007E-01	1.259E+00	2.586E-01	3.327E-01	6.875E-01
19Ri1	1.645E-01	3.203E-02	5.253E-02	1.149E-01	3.644E-02	4.724E-02	4.961E-02
19Ri2	1.180E+00	5.951E-01	8.760E-01	3.010E+00	7.589E-01	5.466E-01	1.078E+00
19Ri3	1.037E-01	2.687E-02	5.263E-02	1.346E-01	2.966E-02	3.781E-02	7.584E-02
19Mi1	9.847E-01	2.382E-01	5.007E-01	1.259E+00	2.586E-01	3.327E-01	6.875E-01
19Mi2	5.300E-01	9.423E-02	1.947E-01	4.810E-01	1.190E-01	1.291E-01	2.264E-01
19Mi3	1.086E+01	5.285E+00	7.928E+00	2.754E+01	6.358E+00	4.880E+00	1.076E+01
19Rj1	8.299E-01	4.362E-01	6.451E-01	2.209E+00	5.583E-01	3.964E-01	7.964E-01
19Rj2	8.788E-01	4.064E-01	5.960E-01	2.047E+00	5.155E-01	3.776E-01	7.276E-01
19Rj3	1.037E-01	2.687E-02	5.263E-02	1.346E-01	2.966E-02	3.781E-02	7.584E-02
19Mj1	1.235E+00	3.081E-01	6.730E-01	1.693E+00	3.571E-01	4.630E-01	8.931E-01
19Mj2	6.338E-01	1.801E-01	3.591E-01	9.074E-01	2.129E-01	2.775E-01	4.837E-01
19Mj3	5.365E+00	2.240E+00	3.407E+00	1.027E+01	3.148E+00	2.022E+00	3.129E+00
20Ri1	1.676E-01	3.222E-02	5.325E-02	1.154E-01	3.660E-02	4.831E-02	4.972E-02
20Ri2	3.713E-01	1.240E-01	1.920E-01	5.176E-01	1.901E-01	1.348E-01	1.913E-01
20Ri3	5.786E-02	1.266E-02	3.004E-02	7.920E-02	1.300E-02	1.628E-02	3.804E-02
20Mi1	8.826E-01	2.455E-01	4.786E-01	1.184E+00	2.760E-01	3.478E-01	6.829E-01
20Mi2	1.830E+00	4.778E-01	9.798E-01	2.541E+00	5.593E-01	7.212E-01	1.372E+00
20Mi3	1.192E+01	5.123E+00	7.480E+00	2.462E+01	6.768E+00	4.738E+00	8.016E+00

20Rj1	1.676E-01	3.222E-02	5.325E-02	1.154E-01	3.660E-02	4.831E-02	4.972E-02
20Rj2	3.713E-01	1.240E-01	1.920E-01	5.176E-01	1.901E-01	1.348E-01	1.913E-01
20Rj3	5.786E-02	1.266E-02	3.004E-02	7.920E-02	1.300E-02	1.628E-02	3.804E-02
20Mj1	8.826E-01	2.455E-01	4.786E-01	1.184E+00	2.760E-01	3.478E-01	6.829E-01
20Mj2	1.894E+00	3.718E-01	8.524E-01	2.861E+00	3.062E-01	4.464E-01	1.116E+00
20Mj3	1.246E+01	3.427E+00	5.669E+00	1.688E+01	5.238E+00	5.397E+00	7.580E+00
21Ri1	1.709E-01	3.242E-02	5.400E-02	1.159E-01	3.678E-02	4.942E-02	4.985E-02
21Ri2	9.492E-02	3.598E-02	5.200E-02	1.665E-01	4.711E-02	3.448E-02	5.306E-02
21Ri3	1.355E-02	3.332E-03	7.181E-03	1.816E-02	3.835E-03	5.006E-03	9.797E-03
21Mi1	8.826E-01	2.455E-01	4.786E-01	1.184E+00	2.760E-01	3.478E-01	6.829E-01
21Mi2	1.894E+00	3.718E-01	8.524E-01	2.861E+00	3.062E-01	4.464E-01	1.116E+00
21Mi3	1.246E+01	3.427E+00	5.669E+00	1.688E+01	5.238E+00	5.397E+00	7.580E+00
21Rj1	1.709E-01	3.242E-02	5.400E-02	1.159E-01	3.678E-02	4.942E-02	4.985E-02
21Rj2	9.492E-02	3.598E-02	5.200E-02	1.665E-01	4.711E-02	3.448E-02	5.306E-02
21Rj3	1.355E-02	3.332E-03	7.181E-03	1.816E-02	3.835E-03	5.006E-03	9.797E-03
21Mj1	8.826E-01	2.455E-01	4.786E-01	1.184E+00	2.760E-01	3.478E-01	6.829E-01
21Mj2	2.606E+00	5.284E-01	1.255E+00	3.706E+00	4.967E-01	5.962E-01	1.499E+00
21Mj3	1.740E+01	4.928E+00	7.316E+00	1.863E+01	7.749E+00	6.690E+00	7.975E+00
22Ri1	1.731E-01	3.255E-02	5.450E-02	1.163E-01	3.690E-02	5.017E-02	4.994E-02
22Ri2	2.570E-01	6.440E-02	1.002E-01	2.732E-01	1.023E-01	9.577E-02	1.173E-01
22Ri3	3.822E-02	7.409E-03	1.680E-02	5.290E-02	6.515E-03	8.481E-03	2.090E-02
22Mi1	8.826E-01	2.455E-01	4.786E-01	1.184E+00	2.760E-01	3.478E-01	6.829E-01
22Mi2	2.606E+00	5.284E-01	1.255E+00	3.706E+00	4.967E-01	5.962E-01	1.499E+00
22Mi3	1.740E+01	4.928E+00	7.316E+00	1.863E+01	7.749E+00	6.690E+00	7.975E+00
22Rj1	1.731E-01	3.255E-02	5.450E-02	1.163E-01	3.690E-02	5.017E-02	4.994E-02
22Rj2	2.570E-01	6.440E-02	1.002E-01	2.732E-01	1.023E-01	9.577E-02	1.173E-01
22Rj3	3.822E-02	7.409E-03	1.680E-02	5.290E-02	6.515E-03	8.481E-03	2.090E-02
22Mj1	8.826E-01	2.455E-01	4.786E-01	1.184E+00	2.760E-01	3.478E-01	6.829E-01
22Mj2	3.846E-01	1.063E-01	2.464E-01	6.212E-01	1.167E-01	1.463E-01	3.083E-01
22Mj3	2.268E+00	1.095E+00	1.736E+00	5.043E+00	1.627E+00	9.740E-01	1.636E+00
23Ri1	1.743E-01	3.262E-02	5.476E-02	1.165E-01	3.696E-02	5.055E-02	5.000E-02
23Ri2	4.998E-01	1.570E-01	2.349E-01	5.799E-01	2.468E-01	2.059E-01	2.502E-01
23Ri3	7.534E-02	1.634E-02	3.936E-02	1.129E-01	1.569E-02	1.849E-02	4.658E-02
23Mi1	8.826E-01	2.455E-01	4.786E-01	1.184E+00	2.760E-01	3.478E-01	6.829E-01
23Mi2	3.846E-01	1.063E-01	2.464E-01	6.212E-01	1.167E-01	1.463E-01	3.083E-01
23Mi3	2.268E+00	1.095E+00	1.736E+00	5.043E+00	1.627E+00	9.740E-01	1.636E+00
23Rj1	1.743E-01	3.262E-02	5.476E-02	1.165E-01	3.696E-02	5.055E-02	5.000E-02
23Rj2	4.998E-01	1.570E-01	2.349E-01	5.799E-01	2.468E-01	2.059E-01	2.502E-01
23Rj3	7.534E-02	1.634E-02	3.936E-02	1.129E-01	1.569E-02	1.849E-02	4.658E-02
23Mj1	8.826E-01	2.455E-01	4.786E-01	1.184E+00	2.760E-01	3.478E-01	6.829E-01
23Mj2	4.207E+00	8.818E-01	2.116E+00	6.239E+00	8.353E-01	9.872E-01	2.489E+00
23Mj3	2.790E+01	8.353E+00	1.239E+01	3.206E+01	1.319E+01	1.141E+01	1.347E+01

Table C.14. Maximum element forces and moments for s-components of benchmark problem No. 4b (kips-inches)

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	6.883E+00	5.136E+00	8.852E+00	1.703E+01	5.689E+00	6.780E+00	5.699E+00
1Ri2	3.399E-01	1.837E-01	2.908E-01	5.043E-01	1.145E-01	1.419E-01	2.302E-01
1Ri3	1.241E+00	8.369E-01	1.266E+00	2.167E+00	4.908E-01	6.441E-01	8.748E-01
1Mi1	4.729E+00	3.387E+00	5.178E+00	8.688E+00	2.482E+00	4.073E+00	3.818E+00
1Mi2	8.819E+01	6.428E+01	9.577E+01	1.589E+02	3.750E+01	5.058E+01	6.005E+01
1Mi3	2.375E+01	1.389E+01	2.223E+01	3.653E+01	8.755E+00	1.021E+01	1.603E+01
1Rj1	6.883E+00	5.136E+00	8.852E+00	1.703E+01	5.689E+00	6.780E+00	5.699E+00
1Rj2	3.399E-01	1.837E-01	2.908E-01	5.043E-01	1.145E-01	1.419E-01	2.302E-01
1Rj3	1.241E+00	8.369E-01	1.266E+00	2.167E+00	4.908E-01	6.441E-01	8.748E-01
1Mj1	4.729E+00	3.387E+00	5.178E+00	8.688E+00	2.482E+00	4.073E+00	3.818E+00
1Mj2	1.481E+01	4.154E+00	7.446E+00	2.791E+01	2.747E+00	4.383E+00	1.081E+01
1Mj3	3.630E+00	8.709E-01	1.785E+00	5.754E+00	5.796E-01	1.235E+00	2.889E+00
2Ri1	5.924E+00	4.249E+00	7.354E+00	1.261E+01	4.359E+00	5.644E+00	4.478E+00
2Ri2	2.231E-01	1.611E-01	2.631E-01	3.834E-01	1.048E-01	1.097E-01	1.496E-01
2Ri3	8.772E-01	7.702E-01	1.107E+00	1.723E+00	4.460E-01	6.833E-01	6.428E-01
2Mi1	4.729E+00	3.387E+00	5.178E+00	8.688E+00	2.482E+00	4.073E+00	3.818E+00
2Mi2	1.481E+01	4.154E+00	7.446E+00	2.791E+01	2.747E+00	4.383E+00	1.081E+01
2Mi3	3.630E+00	8.709E-01	1.785E+00	5.754E+00	5.796E-01	1.235E+00	2.889E+00
2Rj1	5.924E+00	4.249E+00	7.354E+00	1.261E+01	4.359E+00	5.644E+00	4.478E+00
2Rj2	2.231E-01	1.611E-01	2.631E-01	3.834E-01	1.048E-01	1.097E-01	1.496E-01
2Rj3	8.772E-01	7.702E-01	1.107E+00	1.723E+00	4.460E-01	6.833E-01	6.428E-01
2Mj1	4.729E+00	3.387E+00	5.178E+00	8.688E+00	2.482E+00	4.073E+00	3.818E+00
2Mj2	8.111E+01	6.429E+01	9.383E+01	1.511E+02	3.727E+01	5.402E+01	5.588E+01
2Mj3	2.129E+01	1.364E+01	2.207E+01	3.432E+01	8.725E+00	9.507E+00	1.434E+01
3Ri1	4.969E+00	3.631E+00	5.867E+00	8.298E+00	3.027E+00	4.505E+00	3.415E+00
3Ri2	2.066E-01	1.284E-01	2.116E-01	3.886E-01	8.926E-02	1.100E-01	1.434E-01
3Ri3	8.748E-01	6.103E-01	9.272E-01	1.571E+00	3.588E-01	6.070E-01	5.786E-01
3Mi1	4.729E+00	3.387E+00	5.178E+00	8.688E+00	2.482E+00	4.073E+00	3.818E+00
3Mi2	8.111E+01	6.429E+01	9.383E+01	1.511E+02	3.727E+01	5.402E+01	5.588E+01
3Mi3	2.129E+01	1.364E+01	2.207E+01	3.432E+01	8.725E+00	9.507E+00	1.434E+01
3Rj1	4.969E+00	3.631E+00	5.867E+00	8.298E+00	3.027E+00	4.505E+00	3.415E+00
3Rj2	2.066E-01	1.284E-01	2.116E-01	3.886E-01	8.926E-02	1.100E-01	1.434E-01
3Rj3	8.748E-01	6.103E-01	9.272E-01	1.571E+00	3.588E-01	6.070E-01	5.786E-01
3Mj1	4.729E+00	3.387E+00	5.178E+00	8.688E+00	2.482E+00	4.073E+00	3.818E+00
3Mj2	1.283E+02	1.131E+02	1.641E+02	2.440E+02	6.589E+01	1.003E+02	9.176E+01
3Mj3	2.742E+01	2.350E+01	3.895E+01	5.205E+01	1.576E+01	1.694E+01	1.711E+01
4Ri1	2.262E+00	1.449E+00	2.278E+00	3.661E+00	8.777E-01	1.219E+00	1.789E+00
4Ri2	4.343E+00	3.440E+00	5.139E+00	7.398E+00	2.331E+00	3.736E+00	2.977E+00
4Ri3	2.923E-01	1.523E-01	2.463E-01	3.905E-01	9.831E-02	1.507E-01	2.460E-01
4Mi1	2.742E+01	2.350E+01	3.895E+01	5.205E+01	1.576E+01	1.694E+01	1.711E+01
4Mi2	4.729E+00	3.387E+00	5.178E+00	8.688E+00	2.482E+00	4.073E+00	3.818E+00
4Mi3	1.283E+02	1.131E+02	1.641E+02	2.440E+02	6.589E+01	1.003E+02	9.176E+01
4Rj1	2.073E+00	1.584E+00	2.453E+00	3.704E+00	1.257E+00	1.969E+00	1.782E+00
4Rj2	4.205E+00	3.453E+00	4.977E+00	7.452E+00	2.040E+00	3.488E+00	3.045E+00

4Rj3	2.923E-01	1.523E-01	2.463E-01	3.905E-01	9.831E-02	1.507E-01	2.460E-01
4Mj1	2.149E+01	1.893E+01	3.034E+01	4.132E+01	1.233E+01	1.410E+01	1.405E+01
4Mj2	1.667E+01	1.417E+01	2.356E+01	3.077E+01	9.561E+00	1.013E+01	1.007E+01
4Mj3	6.641E+01	6.188E+01	9.310E+01	1.337E+02	3.752E+01	4.922E+01	5.010E+01
5Ri1	2.106E+00	1.295E+00	2.058E+00	3.357E+00	7.891E-01	1.089E+00	1.663E+00
5Ri2	2.165E-01	1.275E-01	2.073E-01	3.084E-01	8.781E-02	1.451E-01	1.888E-01
5Ri3	3.617E+00	3.214E+00	4.721E+00	7.026E+00	1.871E+00	2.843E+00	2.459E+00
5Mi1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
5Mi2	3.810E+01	3.147E+01	4.665E+01	6.984E+01	1.811E+01	2.052E+01	2.763E+01
5Mi3	4.763E+00	3.521E+00	5.633E+00	8.559E+00	2.246E+00	2.618E+00	2.892E+00
5Rj1	2.106E+00	1.295E+00	2.058E+00	3.357E+00	7.891E-01	1.089E+00	1.663E+00
5Rj2	2.165E-01	1.275E-01	2.073E-01	3.084E-01	8.781E-02	1.451E-01	1.888E-01
5Rj3	3.617E+00	3.214E+00	4.721E+00	7.026E+00	1.871E+00	2.843E+00	2.459E+00
5Mj1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
5Mj2	2.823E+02	2.448E+02	3.564E+02	5.345E+02	1.407E+02	2.272E+02	1.923E+02
5Mj3	1.942E+01	1.317E+01	2.136E+01	3.122E+01	8.266E+00	1.157E+01	1.733E+01
6Ri1	1.861E+00	1.063E+00	1.725E+00	2.892E+00	6.558E-01	8.936E-01	1.468E+00
6Ri2	1.792E-01	6.212E-02	1.174E-01	2.231E-01	4.826E-02	8.490E-02	1.159E-01
6Ri3	2.256E+00	2.070E+00	3.179E+00	4.739E+00	1.364E+00	1.351E+00	1.628E+00
6Mi1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
6Mi2	2.823E+02	2.448E+02	3.564E+02	5.345E+02	1.407E+02	2.272E+02	1.923E+02
6Mi3	1.942E+01	1.317E+01	2.136E+01	3.122E+01	8.266E+00	1.157E+01	1.733E+01
6Rj1	1.861E+00	1.063E+00	1.725E+00	2.892E+00	6.558E-01	8.936E-01	1.468E+00
6Rj2	1.792E-01	6.212E-02	1.174E-01	2.231E-01	4.826E-02	8.490E-02	1.159E-01
6Rj3	2.256E+00	2.070E+00	3.179E+00	4.739E+00	1.364E+00	1.351E+00	1.628E+00
6Mj1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
6Mj2	4.227E+02	3.948E+02	6.066E+02	8.460E+02	2.426E+02	3.006E+02	3.093E+02
6Mj3	1.886E+01	1.608E+01	2.660E+01	3.000E+01	1.109E+01	1.676E+01	1.558E+01
7Ri1	1.605E+00	8.293E-01	1.388E+00	2.415E+00	5.223E-01	7.002E-01	1.269E+00
7Ri2	2.017E-01	5.825E-02	1.333E-01	3.851E-01	4.599E-02	6.759E-02	1.849E-01
7Ri3	2.960E+00	1.854E+00	2.202E+00	7.260E+00	2.154E+00	1.815E+00	2.009E+00
7Mi1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
7Mi2	4.227E+02	3.948E+02	6.066E+02	8.460E+02	2.426E+02	3.006E+02	3.093E+02
7Mi3	1.886E+01	1.608E+01	2.660E+01	3.000E+01	1.109E+01	1.676E+01	1.558E+01
7Rj1	1.605E+00	8.293E-01	1.388E+00	2.415E+00	5.223E-01	7.002E-01	1.269E+00
7Rj2	2.017E-01	5.825E-02	1.333E-01	3.851E-01	4.599E-02	6.759E-02	1.849E-01
7Rj3	2.960E+00	1.854E+00	2.202E+00	7.260E+00	2.154E+00	1.815E+00	2.009E+00
7Mj1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
7Mj2	5.176E+02	4.729E+02	7.338E+02	1.079E+03	3.145E+02	3.056E+02	3.683E+02
7Mj3	2.838E+01	1.510E+01	2.593E+01	3.407E+01	1.057E+01	1.826E+01	2.029E+01
8Ri1	1.440E+00	5.955E-01	1.048E+00	2.025E+00	4.069E-01	5.264E-01	1.084E+00
8Ri2	5.587E-01	2.892E-01	4.679E-01	7.257E-01	2.005E-01	3.456E-01	3.813E-01
8Ri3	8.602E+00	7.809E+00	1.228E+01	1.789E+01	5.134E+00	5.108E+00	5.957E+00
8Mi1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
8Mi2	5.176E+02	4.729E+02	7.338E+02	1.079E+03	3.145E+02	3.056E+02	3.683E+02
8Mi3	2.838E+01	1.510E+01	2.593E+01	3.407E+01	1.057E+01	1.826E+01	2.029E+01
8Rj1	1.440E+00	5.955E-01	1.048E+00	2.025E+00	4.069E-01	5.264E-01	1.084E+00
8Rj2	5.587E-01	2.892E-01	4.679E-01	7.257E-01	2.005E-01	3.456E-01	3.813E-01

8Rj3	8.602E+00	7.809E+00	1.228E+01	1.789E+01	5.134E+00	5.108E+00	5.957E+00
8Mj1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
8Mj2	2.060E+02	1.901E+02	3.004E+02	4.275E+02	1.195E+02	1.378E+02	1.628E+02
8Mj3	2.447E+01	9.678E+00	1.758E+01	2.796E+01	6.526E+00	1.086E+01	1.552E+01
9Ri1	1.260E+00	3.958E-01	7.048E-01	1.735E+00	2.922E-01	3.826E-01	9.108E-01
9Ri2	2.442E-01	1.658E-01	2.814E-01	3.610E-01	1.206E-01	1.874E-01	1.964E-01
9Ri3	5.380E+00	4.927E+00	7.669E+00	1.084E+01	3.146E+00	3.153E+00	3.769E+00
9Mi1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
9Mi2	2.060E+02	1.901E+02	3.004E+02	4.275E+02	1.195E+02	1.378E+02	1.628E+02
9Mi3	2.447E+01	9.678E+00	1.758E+01	2.796E+01	6.526E+00	1.086E+01	1.552E+01
9Rj1	1.260E+00	3.958E-01	7.048E-01	1.735E+00	2.922E-01	3.826E-01	9.108E-01
9Rj2	2.442E-01	1.658E-01	2.814E-01	3.610E-01	1.206E-01	1.874E-01	1.964E-01
9Rj3	5.380E+00	4.927E+00	7.669E+00	1.084E+01	3.146E+00	3.153E+00	3.769E+00
9Mj1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
9Mj2	6.572E+02	5.984E+02	9.432E+02	1.337E+03	3.815E+02	3.994E+02	4.547E+02
9Mj3	2.953E+01	2.281E+01	3.654E+01	4.092E+01	1.650E+01	2.558E+01	2.186E+01
10Ri1	1.066E+00	2.250E-01	4.374E-01	1.476E+00	1.784E-01	2.483E-01	7.442E-01
10Ri2	3.573E-01	4.634E-02	9.935E-02	4.011E-01	3.084E-02	6.966E-02	2.000E-01
10Ri3	6.426E-01	1.461E-01	3.121E-01	9.963E-01	1.219E-01	1.992E-01	4.399E-01
10Mi1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
10Mi2	6.572E+02	5.984E+02	9.432E+02	1.337E+03	3.815E+02	3.994E+02	4.547E+02
10Mi3	2.953E+01	2.281E+01	3.654E+01	4.092E+01	1.650E+01	2.558E+01	2.186E+01
10Rj1	1.066E+00	2.250E-01	4.374E-01	1.476E+00	1.784E-01	2.483E-01	7.442E-01
10Rj2	3.573E-01	4.634E-02	9.935E-02	4.011E-01	3.084E-02	6.966E-02	2.000E-01
10Rj3	6.426E-01	1.461E-01	3.121E-01	9.963E-01	1.219E-01	1.992E-01	4.399E-01
10Mj1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
10Mj2	6.513E+02	5.963E+02	9.294E+02	1.301E+03	3.761E+02	3.872E+02	4.567E+02
10Mj3	3.589E+01	2.091E+01	3.555E+01	4.912E+01	1.505E+01	2.289E+01	2.325E+01
11Ri1	8.578E-01	2.501E-01	4.464E-01	1.250E+00	1.640E-01	2.456E-01	6.256E-01
11Ri2	3.199E-01	2.057E-01	3.314E-01	4.414E-01	1.500E-01	2.253E-01	2.262E-01
11Ri3	5.443E+00	4.996E+00	7.915E+00	1.116E+01	3.212E+00	3.336E+00	3.808E+00
11Mi1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
11Mi2	6.513E+02	5.963E+02	9.294E+02	1.301E+03	3.761E+02	3.872E+02	4.567E+02
11Mi3	3.589E+01	2.091E+01	3.555E+01	4.912E+01	1.505E+01	2.289E+01	2.325E+01
11Rj1	8.578E-01	2.501E-01	4.464E-01	1.250E+00	1.640E-01	2.456E-01	6.256E-01
11Rj2	3.199E-01	2.057E-01	3.314E-01	4.414E-01	1.500E-01	2.253E-01	2.262E-01
11Rj3	5.443E+00	4.996E+00	7.915E+00	1.116E+01	3.212E+00	3.336E+00	3.808E+00
11Mj1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
11Mj2	1.957E+02	1.767E+02	2.682E+02	3.674E+02	1.077E+02	1.126E+02	1.368E+02
11Mj3	1.413E+01	5.031E+00	8.694E+00	1.603E+01	3.363E+00	4.541E+00	1.012E+01
12Ri1	8.549E-01	4.180E-01	6.333E-01	1.245E+00	2.460E-01	3.889E-01	5.304E-01
12Ri2	6.805E-01	3.030E-01	5.269E-01	9.086E-01	2.181E-01	3.396E-01	4.098E-01
12Ri3	8.549E+00	7.878E+00	1.234E+01	1.741E+01	5.058E+00	5.129E+00	6.124E+00
12Mi1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
12Mi2	1.957E+02	1.767E+02	2.682E+02	3.674E+02	1.077E+02	1.126E+02	1.368E+02
12Mi3	1.413E+01	5.031E+00	8.694E+00	1.603E+01	3.363E+00	4.541E+00	1.012E+01
12Rj1	8.549E-01	4.180E-01	6.333E-01	1.245E+00	2.460E-01	3.889E-01	5.304E-01
12Rj2	6.805E-01	3.030E-01	5.269E-01	9.086E-01	2.181E-01	3.396E-01	4.098E-01

12Rj3	8.549E+00	7.878E+00	1.234E+01	1.741E+01	5.058E+00	5.129E+00	6.124E+00
12Mj1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
12Mj2	5.245E+02	4.851E+02	7.722E+02	1.098E+03	3.187E+02	3.239E+02	3.776E+02
12Mj3	4.718E+01	2.181E+01	3.616E+01	6.281E+01	1.585E+01	2.450E+01	2.858E+01
13Ri1	9.640E-01	5.919E-01	8.683E-01	1.461E+00	3.594E-01	5.510E-01	6.152E-01
13Ri2	7.247E-01	1.768E-01	3.377E-01	8.914E-01	1.210E-01	2.379E-01	3.889E-01
13Ri3	2.601E+00	2.018E+00	3.402E+00	4.988E+00	1.651E+00	1.482E+00	1.816E+00
13Mi1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
13Mi2	5.245E+02	4.851E+02	7.722E+02	1.098E+03	3.187E+02	3.239E+02	3.776E+02
13Mi3	4.718E+01	2.181E+01	3.616E+01	6.281E+01	1.585E+01	2.450E+01	2.858E+01
13Rj1	9.640E-01	5.919E-01	8.683E-01	1.461E+00	3.594E-01	5.510E-01	6.152E-01
13Rj2	7.247E-01	1.768E-01	3.377E-01	8.914E-01	1.210E-01	2.379E-01	3.889E-01
13Rj3	2.601E+00	2.018E+00	3.402E+00	4.988E+00	1.651E+00	1.482E+00	1.816E+00
13Mj1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
13Mj2	3.543E+02	3.180E+02	4.929E+02	7.055E+02	1.974E+02	2.112E+02	2.396E+02
13Mj3	3.769E+01	1.873E+01	3.328E+01	4.681E+01	1.323E+01	1.524E+01	2.124E+01
14Ri1	1.071E+00	8.217E-01	1.162E+00	1.950E+00	4.732E-01	7.171E-01	7.259E-01
14Ri2	3.875E-01	1.676E-01	2.907E-01	5.703E-01	1.386E-01	2.383E-01	2.786E-01
14Ri3	3.408E+00	3.080E+00	4.815E+00	6.965E+00	1.927E+00	2.035E+00	2.327E+00
14Mi1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
14Mi2	3.543E+02	3.180E+02	4.929E+02	7.055E+02	1.974E+02	2.112E+02	2.396E+02
14Mi3	3.769E+01	1.873E+01	3.328E+01	4.681E+01	1.323E+01	1.524E+01	2.124E+01
14Rj1	1.071E+00	8.217E-01	1.162E+00	1.950E+00	4.732E-01	7.171E-01	7.259E-01
14Rj2	3.875E-01	1.676E-01	2.907E-01	5.703E-01	1.386E-01	2.383E-01	2.786E-01
14Rj3	3.408E+00	3.080E+00	4.815E+00	6.965E+00	1.927E+00	2.035E+00	2.327E+00
14Mj1	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
14Mj2	6.936E+01	5.948E+01	9.538E+01	1.252E+02	3.923E+01	4.645E+01	4.410E+01
14Mj3	2.755E+01	2.385E+01	3.352E+01	5.029E+01	1.348E+01	2.094E+01	2.060E+01
15Ri1	9.125E-01	2.107E-01	4.041E-01	1.112E+00	1.655E-01	2.898E-01	5.051E-01
15Ri2	1.144E+00	9.776E-01	1.368E+00	2.276E+00	5.505E-01	8.410E-01	8.072E-01
15Ri3	4.435E+00	3.888E+00	6.112E+00	8.257E+00	2.502E+00	2.884E+00	2.930E+00
15Mi1	6.936E+01	5.948E+01	9.538E+01	1.252E+02	3.923E+01	4.645E+01	4.410E+01
15Mi2	2.601E+01	2.310E+01	3.618E+01	4.838E+01	1.480E+01	1.763E+01	1.711E+01
15Mi3	2.755E+01	2.385E+01	3.352E+01	5.029E+01	1.348E+01	2.094E+01	2.060E+01
15Rj1	1.423E+00	8.108E-01	1.082E+00	2.355E+00	4.935E-01	7.738E-01	8.868E-01
15Rj2	8.297E-01	5.717E-01	9.360E-01	1.474E+00	3.706E-01	4.574E-01	5.810E-01
15Rj3	4.435E+00	3.888E+00	6.112E+00	8.257E+00	2.502E+00	2.884E+00	2.930E+00
15Mj1	5.505E+01	4.623E+01	7.409E+01	9.819E+01	3.046E+01	3.559E+01	3.510E+01
15Mj2	1.126E+01	9.007E+00	1.529E+01	2.251E+01	6.388E+00	8.609E+00	7.327E+00
15Mj3	1.461E+01	1.230E+01	1.655E+01	2.678E+01	6.929E+00	1.155E+01	1.147E+01
16Ri1	1.302E+00	2.840E-01	5.343E-01	1.578E+00	1.906E-01	3.499E-01	7.340E-01
16Ri2	1.242E+00	1.081E+00	1.508E+00	2.500E+00	6.096E-01	9.328E-01	9.288E-01
16Ri3	5.166E+00	4.321E+00	7.034E+00	9.173E+00	2.931E+00	3.440E+00	3.188E+00
16Mi1	1.264E+01	1.053E+01	1.725E+01	2.805E+01	7.079E+00	7.474E+00	8.684E+00
16Mi2	5.482E+01	4.689E+01	7.385E+01	1.034E+02	3.023E+01	3.430E+01	3.646E+01
16Mi3	1.537E+01	9.307E+00	1.239E+01	2.660E+01	5.926E+00	1.037E+01	1.158E+01
16Rj1	1.302E+00	2.840E-01	5.343E-01	1.578E+00	1.906E-01	3.499E-01	7.340E-01
16Rj2	1.242E+00	1.081E+00	1.508E+00	2.500E+00	6.096E-01	9.328E-01	9.288E-01

16Rj3	5.166E+00	4.321E+00	7.034E+00	9.173E+00	2.931E+00	3.440E+00	3.188E+00
16Mj1	1.264E+01	1.053E+01	1.725E+01	2.805E+01	7.079E+00	7.474E+00	8.684E+00
16Mj2	3.648E+02	3.061E+02	4.959E+02	6.493E+02	2.061E+02	2.407E+02	2.277E+02
16Mj3	6.266E+01	5.556E+01	8.002E+01	1.234E+02	3.232E+01	4.573E+01	4.462E+01
17Ri1	2.058E+00	4.161E-01	8.040E-01	2.548E+00	2.441E-01	4.582E-01	1.175E+00
3Ri2	4.296E-01	2.412E-01	3.571E-01	6.541E-01	1.378E-01	2.031E-01	2.589E-01
17Ri3	2.680E+00	1.601E+00	2.597E+00	4.194E+00	1.118E+00	1.325E+00	1.588E+00
17Mi1	1.264E+01	1.053E+01	1.725E+01	2.805E+01	7.079E+00	7.474E+00	8.684E+00
17Mi2	3.648E+02	3.061E+02	4.959E+02	6.493E+02	2.061E+02	2.407E+02	2.277E+02
17Mi3	6.266E+01	5.556E+01	8.002E+01	1.234E+02	3.232E+01	4.573E+01	4.462E+01
17Rj1	2.058E+00	4.161E-01	8.040E-01	2.548E+00	2.441E-01	4.582E-01	1.175E+00
17Rj2	4.296E-01	2.412E-01	3.571E-01	6.541E-01	1.378E-01	2.031E-01	2.589E-01
17Rj3	2.680E+00	1.601E+00	2.597E+00	4.194E+00	1.118E+00	1.325E+00	1.588E+00
17Mj1	1.264E+01	1.053E+01	1.725E+01	2.805E+01	7.079E+00	7.474E+00	8.684E+00
17Mj2	2.180E+02	1.653E+02	2.521E+02	4.317E+02	9.838E+01	1.168E+02	1.436E+02
17Mj3	4.331E+01	3.148E+01	4.619E+01	7.173E+01	1.857E+01	2.681E+01	3.132E+01
18Ri1	2.875E+00	5.622E-01	1.097E+00	3.603E+00	3.129E-01	5.845E-01	1.650E+00
18Ri2	4.641E-01	3.429E-01	4.988E-01	7.835E-01	2.011E-01	2.930E-01	3.386E-01
18Ri3	2.601E+00	2.094E+00	3.196E+00	5.130E+00	1.263E+00	1.477E+00	1.732E+00
18Mi1	1.264E+01	1.053E+01	1.725E+01	2.805E+01	7.079E+00	7.474E+00	8.684E+00
18Mi2	2.180E+02	1.653E+02	2.521E+02	4.317E+02	9.838E+01	1.168E+02	1.436E+02
18Mi3	4.331E+01	3.148E+01	4.619E+01	7.173E+01	1.857E+01	2.681E+01	3.132E+01
18Rj1	2.875E+00	5.622E-01	1.097E+00	3.603E+00	3.129E-01	5.845E-01	1.650E+00
18Rj2	4.641E-01	3.429E-01	4.988E-01	7.835E-01	2.011E-01	2.930E-01	3.386E-01
18Rj3	2.601E+00	2.094E+00	3.196E+00	5.130E+00	1.263E+00	1.477E+00	1.732E+00
18Mj1	1.264E+01	1.053E+01	1.725E+01	2.805E+01	7.079E+00	7.474E+00	8.684E+00
18Mj2	3.226E+01	8.594E+00	1.186E+01	3.773E+01	4.707E+00	7.929E+00	1.845E+01
18Mj3	6.208E+00	4.047E+00	6.293E+00	1.029E+01	2.490E+00	3.370E+00	4.248E+00
19Ri1	2.827E+00	2.264E+00	3.400E+00	5.824E+00	1.425E+00	1.544E+00	1.961E+00
19Ri2	3.342E+00	6.480E-01	1.266E+00	4.212E+00	3.535E-01	6.820E-01	1.923E+00
19Ri3	5.589E-01	3.658E-01	5.413E-01	8.477E-01	2.157E-01	3.251E-01	3.809E-01
19Mi1	6.208E+00	4.047E+00	6.293E+00	1.029E+01	2.490E+00	3.370E+00	4.248E+00
19Mi2	1.264E+01	1.053E+01	1.725E+01	2.805E+01	7.079E+00	7.474E+00	8.684E+00
19Mi3	3.226E+01	8.594E+00	1.186E+01	3.773E+01	4.707E+00	7.929E+00	1.845E+01
19Rj1	2.477E+00	1.355E+00	2.054E+00	4.181E+00	8.531E-01	9.880E-01	1.485E+00
19Rj2	4.275E+00	2.007E+00	3.075E+00	7.013E+00	1.168E+00	1.562E+00	2.486E+00
19Rj3	5.589E-01	3.658E-01	5.413E-01	8.477E-01	2.157E-01	3.251E-01	3.809E-01
19Mj1	1.593E+01	1.198E+01	1.943E+01	3.120E+01	7.648E+00	8.908E+00	1.115E+01
19Mj2	1.114E+01	8.976E+00	1.453E+01	2.275E+01	5.742E+00	6.555E+00	7.988E+00
19Mj3	3.738E+01	2.121E+01	3.319E+01	6.453E+01	1.315E+01	1.608E+01	2.070E+01
20Ri1	2.896E+00	2.366E+00	3.549E+00	6.051E+00	1.683E+00	1.732E+00	2.102E+00
20Ri2	1.427E+00	3.337E-01	5.473E-01	1.856E+00	1.775E-01	3.149E-01	7.763E-01
20Ri3	2.707E-01	1.006E-01	1.586E-01	3.582E-01	6.909E-02	1.282E-01	1.616E-01
20Mi1	3.854E+00	2.549E+00	3.607E+00	6.198E+00	1.633E+00	2.630E+00	2.614E+00
20Mi2	2.187E+01	1.674E+01	2.682E+01	4.233E+01	1.053E+01	1.262E+01	1.554E+01
20Mi3	8.834E+01	5.303E+01	8.142E+01	1.572E+02	3.097E+01	3.802E+01	5.245E+01
20Rj1	2.896E+00	2.366E+00	3.549E+00	6.051E+00	1.683E+00	1.732E+00	2.102E+00
20Rj2	1.427E+00	3.337E-01	5.473E-01	1.856E+00	1.775E-01	3.149E-01	7.763E-01

20Rj3	2.707E-01	1.006E-01	1.586E-01	3.582E-01	6.909E-02	1.282E-01	1.616E-01
20Mj1	3.854E+00	2.549E+00	3.607E+00	6.198E+00	1.633E+00	2.630E+00	2.614E+00
20Mj2	1.864E+01	1.180E+01	1.793E+01	2.579E+01	7.411E+00	1.110E+01	1.167E+01
20Mj3	7.186E+01	3.582E+01	5.359E+01	9.205E+01	2.091E+01	2.748E+01	4.621E+01
21Ri1	3.276E+00	2.641E+00	3.812E+00	6.356E+00	2.042E+00	1.986E+00	2.370E+00
21Ri2	6.610E-01	3.372E-01	5.264E-01	1.095E+00	1.939E-01	2.445E-01	3.719E-01
21Ri3	1.518E-01	1.036E-01	1.705E-01	2.871E-01	6.917E-02	7.476E-02	1.001E-01
21Mi1	3.854E+00	2.549E+00	3.607E+00	6.198E+00	1.633E+00	2.630E+00	2.614E+00
21Mi2	1.864E+01	1.180E+01	1.793E+01	2.579E+01	7.411E+00	1.110E+01	1.167E+01
21Mi3	7.186E+01	3.582E+01	5.359E+01	9.205E+01	2.091E+01	2.748E+01	4.621E+01
21Rj1	3.276E+00	2.641E+00	3.812E+00	6.356E+00	2.042E+00	1.986E+00	2.370E+00
21Rj2	6.610E-01	3.372E-01	5.264E-01	1.095E+00	1.939E-01	2.445E-01	3.719E-01
21Rj3	1.518E-01	1.036E-01	1.705E-01	2.871E-01	6.917E-02	7.476E-02	1.001E-01
21Mj1	3.854E+00	2.549E+00	3.607E+00	6.198E+00	1.633E+00	2.630E+00	2.614E+00
21Mj2	1.547E+01	5.795E+00	8.499E+00	2.017E+01	3.577E+00	7.168E+00	1.034E+01
21Mj3	7.316E+01	1.774E+01	2.842E+01	8.680E+01	9.706E+00	1.780E+01	4.273E+01
22Ri1	3.901E+00	2.914E+00	4.081E+00	7.350E+00	2.406E+00	2.240E+00	2.635E+00
22Ri2	1.248E+00	3.936E-01	6.122E-01	1.498E+00	2.194E-01	3.276E-01	7.513E-01
22Ri3	2.799E-01	1.271E-01	1.867E-01	3.229E-01	7.925E-02	1.340E-01	1.809E-01
22Mi1	3.854E+00	2.549E+00	3.607E+00	6.198E+00	1.633E+00	2.630E+00	2.614E+00
22Mi2	1.547E+01	5.795E+00	8.499E+00	2.017E+01	3.577E+00	7.168E+00	1.034E+01
22Mi3	7.316E+01	1.774E+01	2.842E+01	8.680E+01	9.706E+00	1.780E+01	4.273E+01
22Rj1	3.901E+00	2.914E+00	4.081E+00	7.350E+00	2.406E+00	2.240E+00	2.635E+00
22Rj2	1.248E+00	3.936E-01	6.122E-01	1.498E+00	2.194E-01	3.276E-01	7.513E-01
22Rj3	2.799E-01	1.271E-01	1.867E-01	3.229E-01	7.925E-02	1.340E-01	1.809E-01
22Mj1	3.854E+00	2.549E+00	3.607E+00	6.198E+00	1.633E+00	2.630E+00	2.614E+00
22Mj2	2.655E+00	2.131E+00	3.507E+00	5.854E+00	1.529E+00	1.760E+00	2.042E+00
22Mj3	1.132E+01	6.541E+00	1.015E+01	1.998E+01	3.796E+00	4.676E+00	6.592E+00
23Ri1	4.517E+00	3.185E+00	4.357E+00	8.522E+00	2.774E+00	2.493E+00	2.896E+00
23Ri2	1.886E+00	4.375E-01	7.086E-01	2.240E+00	2.402E-01	4.506E-01	1.095E+00
23Ri3	4.003E-01	1.506E-01	2.348E-01	5.802E-01	1.067E-01	2.034E-01	2.741E-01
23Mi1	3.854E+00	2.549E+00	3.607E+00	6.198E+00	1.633E+00	2.630E+00	2.614E+00
23Mi2	2.655E+00	2.131E+00	3.507E+00	5.854E+00	1.529E+00	1.760E+00	2.042E+00
23Mi3	1.132E+01	6.541E+00	1.015E+01	1.998E+01	3.796E+00	4.676E+00	6.592E+00
23Rj1	4.517E+00	3.185E+00	4.357E+00	8.522E+00	2.774E+00	2.493E+00	2.896E+00
23Rj2	1.886E+00	4.375E-01	7.086E-01	2.240E+00	2.402E-01	4.506E-01	1.095E+00
23Rj3	4.003E-01	1.506E-01	2.348E-01	5.802E-01	1.067E-01	2.034E-01	2.741E-01
23Mj1	3.854E+00	2.549E+00	3.607E+00	6.198E+00	1.633E+00	2.630E+00	2.614E+00
23Mj2	2.529E+01	1.081E+01	1.527E+01	3.392E+01	6.630E+00	1.291E+01	1.696E+01
23Mj3	1.149E+02	3.210E+01	5.080E+01	1.374E+02	1.759E+01	2.889E+01	6.795E+01

ATTACHMENT 1

Evaluation of Non-Classically Damped Coupled Systems Using Classical Normal Modes

By

C. Chen

Apollo Consulting, Inc.

Evaluations of Non-Classically Damped Coupled Systems Using Classical Normal Modes

Revision 1, September 1998
Revision 2, November 1998
Revision 3, May 1999
Revision 4, August 1999

by

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for

Participation in the Brookhaven National Laboratory's
Benchmark Program Sponsored by
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1.0 Introduction

Under a contract to the US Nuclear Regulatory Commission (NRC), Brookhaven National Laboratory developed a benchmark program for seismic analyses of coupled structures with non-classical damping. Apollo Consulting, Inc. (ACI) is one of the many program participants from the nuclear industry and universities specializing in earthquake engineering research. ACI applied the classical normal mode response spectrum method in the analyses.

1.1 Background

Floor response spectra are applied in the traditional seismic analyses of nuclear power plant equipment and piping systems. Since the basic assumption in the generation of floor response spectra is that the mass ratio of the equipment to the building is zero, no energy feedback from the equipment to the building is considered. This method yields very conservative results when the equipment is in resonance with the building, especially when the equipment is heavy and has a low damping value.

This conservatism is compounded by the broadening of peak regions of floor response spectra and the absolute addition of close modes. To circumvent this issue, some coupled analyses were performed in the past, mostly based on classical normal modes. For example, Chen (Refs. 4.1 & 4.2) discussed this method in two different conferences in 1973. The coupled analyses with a classical normal mode assumption will produce realistic answers when it is properly applied and the damping values are within the range of USNRC Regulatory Guide 1.61. (Ref. 4.3).

One of the complications of the coupled analyses is the non-classical nature of the coupled damping matrix. It is neither diagonal nor proportional to stiffness or mass matrix. An ingenious solution method, which utilized the complex eigenvalue solution method for a non-classically damped system, was derived by Foss as early as in 1957 (Ref. 4.4). This method was extended by Hurty (Ref. 4.5). Its application to nuclear power plant facilities was presented by Gupta (Ref. 4.6).

The non-classically damped system method based on complex eigenvalues is mathematically elegant but tedious. The results are not as easily interpreted physically as the classical normal mode method. For this reason, engineers prefer to apply the classical normal mode method when damping values are low. Furthermore, most general purpose finite element programs available in the public domain are based on the classical normal mode method.

1.2 Scope and Objective

The classical normal method was verified against the non-classically damped system method for two specific examples as shown in Section 2.5. It is the objective of this report to verify this classical normal mode method against more sample problems. The scope of this report follows BNL's benchmark program scope.

2.0 Classical Normal Mode Method

Classical normal mode method was discussed extensively in textbooks and other literature, and will not be duplicated here. However, for non-classically damped systems, the weighted modal damping value calculations will be discussed here. For coupled systems with close modes, the modal combination method needs some special attention. Method to handle rigid mass contribution will be discussed also.

2.1 Weighted Modal Damping Values

When the building and the equipment or piping have different damping values, it is a general practice to calculate the weighted damping values of the coupled system. This calculation is based on energy principle, either with strain energy using a stiffness matrix or with kinetic energy using a mass matrix (Ref. 4.7). Both methods are expected to produce similar results.

2.2 Modal Combination Methods

When the root sum square modal combination method was first applied to one dimensional stick model seismic building analysis, the results were satisfactory in general because modal frequencies were well separated. As seismic models became more complicated to include torsional building models, three dimensional piping systems, and coupled tuned systems, the resulting close modes made the modal combination method even more complicated.

Literature in the mid to late 1960's showed that the straight root sum square method overestimate time history responses of systems with close modes (Refs. 4.8, 4.9). At about the same time, many variations of modal combination methods were proposed to include the cross coupling terms which can have positive or negative signs. (Refs. 4.10, 4.11). Chen discussed the above methods in a 1972 symposium and pointed out that realistic modal responses for systems with close modes can be less than the straight root sum square method due to negative cross coupling terms (Ref. 4.12). However, at that time the observation was based on a single time history. The current BNL benchmark program will have the opportunity to test multiple time histories.

2.3 Contribution of Rigid Modes

In some seismic models, modal frequencies far exceed the frequency contents of the input time histories. For these cases, the root sum square combination break down because those high frequency modes behaves more like rigid oscillators and are in phase. Under this condition, the method described in the Appendix A of USNRC Standard Review Plan Section 3.7.2 will be applied.

2.4 Computer program Applied

There are many general purpose finite element programs available in the public domain, e.g., STARDYNE, ANSYS, NASTRAN, SAP2000, STRUDL, etc. Anyone of these programs can be applied so long as they calculate the weighted modal damping values and apply the cross coupling terms in the modal combination method, e.g., the double sum method (Refs. 4.6 and 4.10) or the Complete Quadratic Combination (CQC) method (Ref. 4.13). In general, the proper application of a program is more important than the decision of which program to apply.

The specific program applied in the benchmark program is the PC version of STARDYNE-3.5, Version May0189. It calculates weighted modal damping values based on strain energy, and it also applies cross coupling terms in the modal combination method. The responses are sensitive to the damping value assumed for the cross coupling term calculations for systems with close modes. The rigid mode contribution was handled by a user supplied MATHCAD post-processor.

2.5 Verification of the classical Normal Mode Method

The classical normal mode method was verified against the non-classically damped system direct integration method for two specific examples, tuned and un-tuned. They are discussed in separate sections.

2.5.1 Verification of Un-tuned Case

To verify the classical normal mode method, a comparison was made with a published "exact" solution based on the non-classical damping method. The case 2 of the example on p. 82 of Reference 4.6 as shown in Fig. 1 was selected for comparison purpose. The frequencies for both methods are almost identical as expected. The resulting modal damping values for both methods are close and are compared as shown in Table 1a.

Table 1a. Comparisons of modal Damping Values

Modes	1	2	3	4	5	6	7	8
Damping (Ref. 6)	5.7	3.2	2.2	6.7	7.0	7.0	7.0	7.0
Weighted Damping	6.4	2.6	2.4	6.5	7.0	7.0	7.0	7.0

The classical normal mode method using 1940 El Centro NS Component as input was compared with the non-classical direct integration results from p. 84 and non-classical response spectrum results from p. 87 of Reference 4.6. The nodal point displacement and element force comparisons are as shown in Tables 1b and 1c.

Table 1b. Comparisons of Nodal Displacements (in), 1-6 Building, 7-8 Equipment

Nodes	1	2	3	4	5	6	7	8
Ref. 4.6	0.2670	0.5094	0.7223	0.8776	0.9846	1.0422	1.3585	1.4955
Normal Mode	0.2522	0.4911	0.7054	0.8614	0.9764	1.0444	1.4691	1.5945

Table 1c. Comparisons of Element Forces (kip), 1-6 Building, 7-9 Equipment

Elements	1	2	3	4	5	6	7	8	9
Ref. 4.6	1289.8	1180.5	1038.9	759.5	554.4	324.3	132.1	27.4	105.8
Normal Mode	1261.1	1195.4	1076.9	790.8	588.2	351.7	144.2	28.3	114.3

The classical normal mode results are very close to the direct integration and response spectrum results of non-classically damped method. In the normal mode method, the rigid mode contribution was not considered because the highest modal frequency is comparable to the time history frequency contents. Based on the above example, the non-classical damping in the 2-7% damping range has little impact on dynamic responses of systems assumed to be classically damped. It is important to note that the equipment responses are represented by nodal points 7 and 8, and elements 7, 8, and 9. As shown in Tables 1b and 1c, the equipment normal mode responses are all higher than those of the non-classically damped method.

2.5.2 Verification of Tuned Case

Dr. Abhinav Gupta of the N. C. State University furnished a tuned system model as shown in Fig 2 with a very small mass ratio and also furnished its direct integration results based on a non-classical damping matrix. The equipment damping is assumed to be 2%, and building damping 7%.

Apollo Consulting, Inc. performed response spectrum analyses using the same model and the assumption of classical damping. Two different modal combination methods were used in the analyses. One is the modified Double Sum method of the NRC Regulatory Guide (RG) 1.92, and the other onè is the CQC of classical normal mode method. The system responses are sensitive to the modal damping values used in the cross coupling term calculations.

The building responses compare well with the direct integration method by both modal combination methods. However, the equipment responses are overestimated approximately by a factor of 10 using the RG 1.92 method, and by a factor of only about 2.3 using the classical normal mode method.

It appears that for small mass ratios in the tuned case, the equipment responses are more influenced by the modal combination method than other factors. This modal combination problem of tuned system with small mass ratios which created a pair of close modes, e.g., 2.49 Hz and 2.52 Hz in Table 2a, has been pointed out in the literature many times in the past (Ref. 4.12). The numerical results are presented in Tables 2a, 2b, and 2c:

Table 2a. Frequencies and Damping

Modes	1	2	3	4	5	6	7	8	9
Frequencies	2.49	2.52	4.07	5.30	5.83	7.36	11.61	14.91	17.01
Damping	.026	.064	.020	.020	.020	.070	.070	.070	.070

Table 2b. Displacements (in), 1 - 5 Building, 6 - 9 Equipment

Nodes	1	2	3	4	5	6	7	8	9
RG 1.92	0.32	0.61	0.85	1.03	1.12	40.85	79.52	103.95	51.99
Normal Mode	0.33	0.62	0.87	1.04	1.14	9.94	18.22	23.43	12.30
Direct Integration (DI)	0.32	0.60	0.81	0.95	1.02	4.19	7.89	10.36	5.31

Table 2c. Member Forces (kip), 1 - 5 Building, 6 - 11 Equipment

Members	1	2	3	4	5
RG 1.92	9920.	9075.	7565.	5499.	2949.
Normal Mode	10083.	9217.	7673.	5566.	2972.
Direct Integration	9926.	8640.	6958.	5381.	3017.

Members	6	7	8	9	10	11
RG 1.92	20.7	11.6	7.33	15.83	25.96	18.51
Normal Mode	4.57	2.49	1.56	3.34	5.64	3.99
Direct Integration	2.03	1.12	0.75	1.55	2.58	1.55

It is important to point out here that the classical normal mode method is on the conservative side in comparison with the non-classically damped direct integration method. This amount of conservatism is desirable for the safety of nuclear power plant facilities.

3.0 Benchmark Program

In Revision 1 of the report, HQR modal extraction method was applied. The sectional properties of the artificial linkage members in Problems 4a and 4b were reduced to avoid numerical instability problem. Rigid mode contribution was considered only in Problems 4a and 4b. It is not considered for Problems 1, 2, and 3 because the highest modal frequency is comparable to the time history frequency contents. Results are presented in Tables 3 through 19. In revision 2, Figures 1 and 2 for the verification models were added. In Revision 3, errors in release codes of the artificial link members were corrected in Problems 4a and 4b. But the rigid mode contribution for Problems 4a and 4b were removed because of its insignificant contribution. Tables 16 through 19 were modified.

After the submittal of Revision 3, the Brookhaven National Laboratory's (BNL's) draft NUREG report dated July 1999 on this benchmark program was received. This draft NUREG report was reviewed and additional studies were performed to see whether the results of Problems 4a and 4b can be improved. The Lanczos modal extraction method instead of HQR modal extraction method was applied to Problems 4a and 4b with artificial linkage member stiffness properties increased to the values close to the original BNL values. This study showed only slight improvement in comparison with Revision 3.

Another method to avoid this numerical instability problem is to use master-slave nodal relationship to replace the artificial rigid linkage members. However, this relationship in STARDYNE can not have end releases or must be applied to all six degrees of freedom per node. Thus, this option was not applied in the benchmark program. Furthermore, when the master slave relationship is used, the member forces and moments will not be available for the rigid link elements.

The rigid mode effects was studied again and did not result in significant contribution. Thus, in Revision 4, only Section 3 was rewritten, and a new Section 4.0 on Discussion and Conclusions were added. All Tables remains the same as in Revision 3. However, four more tables were added in Revision 4 and they are Tables 16c, 17c, 18c, and 19c.

The above four new Tables showed the differences between 16 bit program and 32 bit program. STARDYNE 3.5 is a 16 bits per word program. In order to examine the potential improvements from the 32 bits per word program, a new version 5.11 of STARDYNE was applied to Problem 4a, Case a. The comparisons are as shown in Tables 16c, 17c, 18c, and 19c. The columns under the title of 16 bits in the above four Tables are the same as Case a of Tables 16a, 17a, 18a, and 19a.

In Figure 153 of the NUREG report, there is a large underprediction of axial force by all four participants at Element 6. Table 18c showed the improvement of a 32 bit program at Element 6 from 0.089 kip to 0.135 kip. On the surface, Element 6 reaction was under predicted by a large margin by everyone . In reality, this is not significant at all because Element 6 was not intended to resist earthquake input in Y direction as shown in NUREG Figure 4. Element 6 is only important for X directional earthquake input which is for Problem 4b. As shown in NUREG Figure 171 for X directional input, Element 6 reaction was overpredicted by Chen. Thus, after taking the SRSS combination of three directional input, the Element 6 design will still be on the conservative side even with a 16 bit per word program.

Another example is in NUREG Figure 151, the SRSS moment was under predicted at Element 22. As shown in Table 19c, the 32 bit program increased the SRSS moment at Element 22 from 7.1 in-kips to 11.7 in-kips. Furthermore, in NUGEG Figure 165, the SRSS moment at Element 22 for X directional input was overpredicted by Chen. Again, after taking the SRSS of three directional input, the Element 22 design will still be on the conservative side even with a 16 bit per word program.

A suggestion was also made to BNL on S-component SRSS moment comparisons in problems 4a and 4b of the draft NUREG report. At each element, the moments are calculated at two end nodes. For practical purpose, only the larger one of the two sets of end moments is used in design. Thus, the ratios of participant calculations to BNL calculations should be based only on the larger one of the end moments to be compatible with design practice. For example, in Figure 165 of the draft NUREG report, the ratios for Chen at elements 2 and 23 are 2.2 and 1.7 respectively. When the suggested procedure is applied, the ratios dropped down to 1.2 and 1.21 respectively which are much better comparisons.

4.0 Discussion and Conclusions

Based on comparisons of the results in Tables 3 through 19 with BNL's exact time history solutions, the classical normal mode method provides conservative results for Problems 1, 2, and 3 in general.

For Problems 4a and 4b, the classical normal mode method is more conservative in general when the effects of three directional earthquake input are taken into account. The SRSS moment comparisons will be much more favorable when only the larger end moment will be used in the ratio calculations. The 32 bits per word program can provide a more conservative result than a 16 bit per word program.

Based on the above discussions and the verification in Section 2.5, the following conclusions can be reached:

1. The classical normal mode method can be applied to non-classically damped systems with damping values within the range of NRC Regulatory Guide 1.61.

2. In some more complex models with artificial rigid links and piping elements, classical normal mode method can produce conservative results when three directional earthquake inputs are considered..

3. It was discovered in the mid 1960's that close modes can have opposite signs, which produced negative cross coupling terms, based on the study of 1940 El Centro time history. This benchmark program showed that it is true for multiple time histories as well.

4. The application of a correct modal combination method is a very important factor in obtaining realistic responses. Thus, the absolute signs in the double sum method of NRC Regulatory Guide 1.92 should be removed.

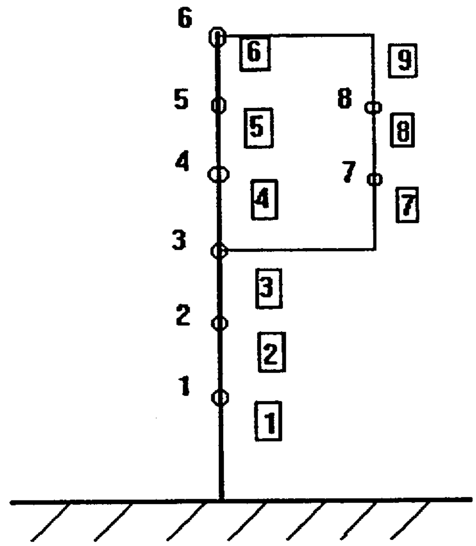

Figure 1 Coupled Building Equipment Model

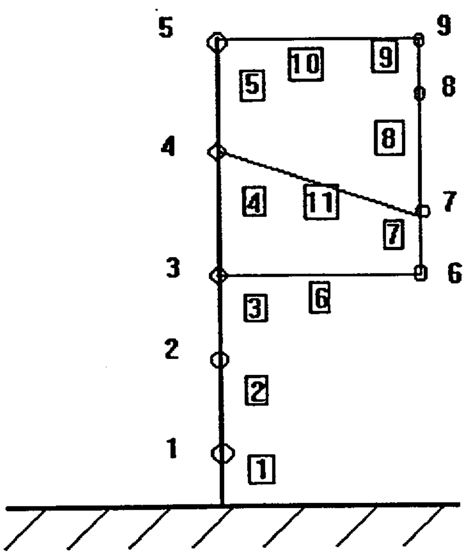

Figure 2 Coupled Building Equipment Model

Table 3. Frequencies of P-components for BNL Benchmark Problems #1, 2, and 3

Mode	Frequencies (cps)
1	5.00
2	14.60
3	23.01
4	29.56
5	33.71

Table 4. Frequencies of Fixed-constraint S-components for BNL Benchmark Problem #1 (cps)

Modes	Case a	Case b	Case c	Case d	Case e
1	5.00	2.50	4.50	5.51	10.01
2	14.40	7.21	12.97	15.85	28.83
3	22.06	11.04	19.87	24.29	44.16
4	27.06	13.54	24.37	29.79	54.17

Table 5. Frequencies of Fixed-constraint S-components for BNL Benchmark Problems #2 & 3 (cps)

Modes	Case a	Case b	Case c	Case d	Case e
1	5.00	2.50	4.50	5.50	10.02
2	5.00	2.50	4.50	5.50	10.02
3	9.24	4.62	8.32	10.16	18.51
4	9.24	4.62	8.32	10.16	18.51
5	12.07	6.04	10.86	13.28	24.18
6	12.07	6.04	10.86	13.28	24.18

Table 6. Frequencies of P-components for BNL Benchmark Problem #4a

Modes	Frequencies (cps)	Modes	Frequencies (cps)	Modes	Frequencies (cps)
1	8.24	8	68.04	15	130.15
2	8.30	9	91.97	16	149.68
3	22.09	10	92.04	17	149.71
4	33.38	11	111.29	18	149.87
5	33.47	12	111.34	19	176.86
6	67.41	13	115.09	20	204.01
7	67.50	14	130.12	21	234.57

Table 7. Frequencies of Fixed-constraint S-components for BNL Benchmark Problem #4a

Modes	Frequencies (cps)	Modes	Frequencies (cps)	Modes	Frequencies (cps)
1	8.23	20	59.17	39	226.78
2	8.54	21	62.76	40	261.73
3	14.91	22	72.92	41	288.09
4	16.86	23	75.03	42	315.69
5	17.30	24	76.04	43	357.33
6	22.70	25	80.10	44	393.73
7	24.90	26	80.25	45	417.38
8	25.88	27	83.96	46	427.55
9	26.07	28	88.05	47	450.64
10	27.39	29	89.70	48	484.45
11	28.24	30	93.44	49	505.20
12	31.15	31	114.30	50	515.84
13	33.58	32	115.65	51	530.97
14	34.15	33	125.62	52	540.27
15	39.31	34	127.87	53	553.93
16	44.83	35	141.74	54	620.69
17	51.23	36	142.01	55	630.94
18	53.65	37	161.18	56	729.14
19	54.77	38	210.04		

Table 8. Frequencies of P-components for BNL Benchmark Problem #4b

Modes	Frequencies (cps)	Modes	Frequencies (cps)	Modes	Frequencies (cps)
1	4.60	8	37.98	15	72.64
2	4.63	9	51.33	16	83.55
3	12.33	10	51.37	17	83.56
4	18.63	11	62.12	18	83.65
5	18.68	12	62.14	19	98.71
6	37.62	13	64.24	20	113.87
7	37.68	14	72.63	21	130.92

Table 9. Frequencies of Fixed-constraint S-components for BNL Benchmark Problem #4b

Modes	Frequencies (cps)	Modes	Frequencies (cps)	Modes	Frequencies (cps)
1	4.59	20	32.99	39	126.45
2	4.76	21	34.99	40	145.94
3	8.31	22	40.66	41	160.63
4	9.40	23	41.84	42	176.02
5	9.65	24	42.40	43	199.24
6	12.65	25	44.66	44	219.53
7	13.88	26	44.74	45	232.72
8	14.43	27	46.82	46	238.39
9	14.54	28	49.10	47	251.27
10	15.27	29	50.13	48	270.12
11	15.75	30	52.10	49	281.69
12	17.37	31	63.73	50	287.62
13	18.72	32	64.48	51	296.05
14	19.04	33	70.05	52	301.24
15	21.92	34	71.30	53	308.86
16	24.99	35	79.03	54	346.08
17	28.57	36	79.18	55	351.80
18	29.92	37	89.87	56	406.55
19	30.54	38	117.11		

Table 10. Maximum Nodal Displacement for Benchmark Problem #1 (inches)

Load Cases

Nodes	a	b	c	d	e	f	g	h
2	.09	.08	.08	.09	.08	.09	.09	.12
3	.16	.16	.15	.17	.16	.18	.17	.24
4	.23	.22	.22	.23	.22	.25	.24	.35
5	.28	.26	.26	.28	.27	.30	.29	.44
6	.30	.29	.28	.31	.29	.32	.31	.46
7	.92	.78	.81	.73	.31	1.09	.56	.61
8	1.62	1.41	1.49	1.20	.34	1.96	.82	.76
9	2.15	1.89	2.01	1.54	.37	2.61	1.02	.86
10	2.43	2.16	2.28	1.73	.38	2.96	1.12	.91

Nodes	i	j	k	l	m	n	o	p
2	.08	.07	.05	.08	.21	.07	.08	.07
3	.16	.14	.10	.15	.40	.13	.15	.14
4	.22	.20	.14	.21	.56	.18	.21	.20
5	.27	.24	.17	.26	.68	.22	.25	.24
6	.29	.26	.19	.28	.74	.24	.28	.26
7	.75	.45	.58	.97	2.12	.72	.80	.76
8	1.29	.68	1.01	1.67	3.81	1.27	1.43	1.35
9	1.69	.85	1.34	2.19	5.08	1.68	1.91	1.79
10	1.90	.94	1.51	2.46	5.77	1.90	2.17	2.03

Table 11. Maximum Element Forces for Benchmark Problem #1 (Kips)

Load Cases

Elements	a	b	c	d	e	f	g	h
1	2711.	2584.	2537.	2731.	2616.	2920.	2749.	3861.
2	2486.	2368.	2323.	2506.	2399.	2677.	2556.	3696.
3	2071.	1969.	1931.	2090.	1999.	2226.	2204.	3389.
4	1499.	1421.	1391.	1517.	1447.	1604.	1725.	2962.
5	782.	752.	741.	783.	756.	845.	699.	646.
6	87.	20.	69.	72.	20.	2.1	692.	1929.
7	76.	18.	61.	62.	16.	1.9	594.	1580.
8	56.	14.	45.	46.	11.	1.4	436.	1126.
9	30.	8.	24.	24.	6.	.7	231.	588.

Elements	i	j	k	l	m	n	o	p
1	2630.	2330.	1677.	2511.	6625.	2126.	2479.	2311.
2	2410.	2127.	1540.	2308.	6078.	1951.	2277.	2119.
3	2007.	1766.	1282.	1927.	5053.	1624.	1893.	1764.
4	1453.	1275.	924.	1397.	3633.	1173.	1358.	1272.
5	759.	665.	478.	710.	1906.	610.	707.	666.
6	68.	31.	54.	86.	210.	68.	79.	73.
7	59.	26.	47.	75.	185.	60.	69.	64.
8	44.	19.	35.	55.	137.	44.	51.	48.
9	23.	10.	19.	29.	73.	23.	27.	25.

Table 12. Maximum Nodal Displacement for Benchmark Problem #2 (inches)

Load Cases

Nodes	a	b	c	d	e	f	g	h
2	.09	.08	.08	.08	.08	.09	.09	.15
3	.16	.16	.15	.16	.16	.18	.18	.30
4	.23	.22	.21	.22	.22	.25	.25	.41
5	.28	.26	.26	.27	.27	.30	.30	.47
6	.30	.29	.28	.29	.29	.33	.32	.49
7	1.21	1.38	1.17	.82	.23	1.49	.62	.59
8	1.69	1.95	1.65	1.12	.27	2.09	.82	.72
9	1.23	1.38	1.17	.85	.26	1.51	.66	.65
10	1.54	1.45	1.41	1.09	.31	1.90	.79	.75
11	2.14	2.06	2.00	1.48	.34	2.66	1.02	.88
12	1.55	1.46	1.41	1.11	.33	1.91	.81	.78

Nodes	i	j	k	l	m	n	o	p
2	.08	.07	.05	.08	.21	.07	.08	.07
3	.16	.14	.10	.15	.40	.13	.15	.14
4	.22	.20	.14	.21	.56	.18	.21	.20
5	.27	.24	.17	.26	.67	.22	.25	.24
6	.29	.26	.19	.28	.73	.24	.27	.26
7	.97	.53	.76	1.26	2.83	.95	1.07	1.01
8	1.34	.70	1.05	1.74	3.96	1.32	1.50	1.40
9	.99	.55	.77	1.28	2.85	.96	1.08	1.02
10	1.23	.64	.95	1.58	3.60	1.20	1.36	1.27
11	1.69	.85	1.33	2.17	5.05	1.67	1.90	1.78
12	1.24	.66	.96	1.60	3.62	1.21	1.36	1.28

Table 13. Maximum Element Forces for Benchmark Problem #2 (kips)

Load Cases

Elements	a	b	c	d	e	f	g	h
1	2705.	2582.	2501.	2623.	2625.	2932.	2983.	4753.
2	2482.	2366.	2290.	2407.	2407.	2688.	2787.	4564.
3	2061.	1968.	1906.	1999.	1999.	2235.	2267.	3585.
4	1478.	1421.	1379.	1430.	1436.	1610.	1452.	1872.
5	777.	752.	732.	750.	756.	848.	695.	672.
6	25.	7.5	21.	19.	6.2	.63	206.	645.
7	10.	3.5	8.6	8.0	3.3	.26	87.	290.
8	10.	3.4	8.7	7.5	0.5	.26	74.	163.
9	25.	7.6	21.	19.	3.7	.63	197.	543.
10	32.	7.9	25.	26.	7.4	.81	254.	757.
11	13.	3.8	10.	10.6	3.4	.33	104.	307.
12	13.	3.7	11.	10.3	1.5	.33	98.	247.
13	32.	8.0	25.	25.	5.7	.81	249.	705.

Elements	i	j	k	l	m	n	o	p
1	2629.	2335.	1669.	2517.	6586.	2118.	2465.	2304.
2	2410.	2132.	1533.	2314.	6045.	1945.	2265.	2114.
3	2002.	1766.	1273.	1919.	5022.	1615.	1880.	1756.
4	1436.	1265.	908.	1360.	3604.	1155.	1344.	1260.
5	756.	665.	474.	705.	1893.	606.	702.	662.
6	20.	9.5	16.	25.	60.	20.	23.	21.
7	8.2	4.0	6.5	11.	25.	8.2	9.4	8.8
8	8.0	3.5	6.3	10.	25.	8.0	9.3	8.7
9	20.	9.3	16.	25.	60.	20.	23.	21.
10	25.	12.	20.	32.	77.	25.	29.	27.
11	10.	4.7	8.2	13.	32.	10.	12.	11.
12	10.	4.5	8.1	13.	32.	10.	12.	11.
13	25.	11.	20.	32.	77.	25.	29.	27.

Table 14. Maximum Nodal Displacement for Benchmark Problem #3 (inches)

Load Cases

Nodes	a	b	c	d	e	f	g	h
2	.09	.08	.08	.08	.08	.09	.09	.13
3	.16	.16	.15	.16	.16	.18	.17	.24
4	.23	.22	.21	.22	.22	.25	.24	.35
5	.28	.26	.26	.27	.27	.30	.29	.45
6	.30	.29	.28	.29	.29	.33	.32	.49
7	.85	1.42	.89	.51	.10	1.05	.39	.31
8	1.23	1.81	1.26	.76	.19	1.50	.60	.51
9	.94	1.42	.91	.64	.24	1.13	.55	.55
10	1.74	1.50	1.57	1.26	.36	2.16	.88	.83
11	2.42	2.14	2.22	1.72	.39	3.02	1.14	.99
12	1.75	1.50	1.57	1.27	.37	2.16	.90	.86

Nodes	i	j	k	l	m	n	o	p
2	.08	.07	.05	.08	.21	.07	.08	.07
3	.16	.14	.10	.15	.40	.13	.15	.14
4	.22	.20	.14	.21	.56	.18	.21	.20
5	.27	.24	.17	.26	.67	.22	.25	.24
6	.29	.26	.19	.28	.73	.24	.27	.26
7	.67	.35	.53	.88	1.97	.66	.75	.71
8	.98	.53	.77	1.28	2.82	.96	1.08	1.02
9	.77	.48	.59	1.00	2.12	.74	.82	.78
10	1.39	.72	1.08	1.78	4.10	1.36	1.54	1.45
11	1.91	.95	1.50	2.45	5.75	1.89	2.16	2.02
12	1.39	.73	1.09	1.79	4.10	1.36	1.55	1.45

Table 15. Maximum Element Forces for Benchmark Problem #3 (kips-inches)

	Load Cases							
Elements	a	b	c	d	e	f	g	h
1	2696.	2573.	2504.	2609.	2608.	2932.	2762.	3944.
2	2473.	2358.	2293.	2393.	2392.	2688.	2571.	3771.
3	2060.	1961.	1906.	1996.	1992.	2235.	2222.	3450.
4	1492.	1414.	1373.	1449.	1442.	1610.	1747.	3003.
5	784.	750.	727.	762.	763.	848.	861.	1420.
6	18.	7.7	16.	13.	8.8	.46	171.	675.
7	8.4	4.8	6.7	6.7	7.5	.20	94.	454.
8	7.0	4.2	7.0	4.3	5.2	.18	50.	212.
9	18.	8.1	16.	12.	2.3	.45	135.	352.
10	36.	8.2	28.	30.	8.8	.92	286.	868.
11	15.	4.1	12.	12.	3.6	.38	117.	349.
12	15.	4.0	12.	12.	2.8	.38	112.	298.
13	36.	8.3	28.	30.	8.0	.92	283.	829.

Elements	i	j	k	l	m	n	o	p
1	2621.	2328.	1663.	2496.	6585.	2112.	2464.	2302.
2	2402.	2125.	1528.	2295.	6042.	1938.	2263.	2111.
3	2001.	1764.	1272.	1916.	5023.	1614.	1881.	1757.
4	1448.	1274.	918.	1390.	3610.	1166.	1349.	1267.
5	762.	670.	479.	723.	1893.	611.	703.	664.
6	15.	7.6	12.	19.	43.	14.	16.	15.
7	6.8	4.1	5.2	8.9	19.	6.6	7.3	6.9
8	5.5	2.3	4.3	6.6	18.	5.5	6.6	6.1
9	14.	6.6	11.	18.	42.	14.	16.	15.
10	28.	13.	22.	36.	88.	28.	33.	31.
11	12.	5.2	9.3	15.	37.	12.	14.	13.
12	12.	5.1	9.2	14.	37.	12.	14.	13.
13	28.	13.	22.	36.	88.	28.	33.	31.

Table 16a Maximum Nodal Displacements for Benchmark Problem #4a
(inches)

Nodes	Case a	Case b	Case c	Case d	Case e	Case f	Case g
2ux	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
2uy	10.6E-3	3.9E-3	7.7E-3	19.4E-3	5.5E-3	5.5E-3	8.8E-3
2uz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
2θx	30.8E-6	11.2E-6	22.4E-6	56.3E-6	16.0E-6	16.0E-6	25.3E-6
2θy	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
2θz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3ux	000.0E+0	000.0E+0	000.0E+0	16.5E-6	000.0E+0	000.0E+0	10.2E-6
3uy	27.1E-3	9.9E-3	19.7E-3	49.5E-3	14.1E-3	14.1E-3	22.3E-3
3uz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3θx	54.1E-6	19.7E-6	39.4E-6	98.9E-6	28.2E-6	28.1E-6	44.6E-6
3θy	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3θz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
4ux	14.9E-6	000.0E+0	12.3E-6	26.8E-6	000.0E+0	000.0E+0	16.6E-6
4uy	44.0E-3	16.0E-3	32.0E-3	80.4E-3	22.9E-3	22.8E-3	36.2E-3
4uz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
4θx	68.2E-6	24.9E-6	49.7E-6	125.0E-6	35.5E-6	35.4E-6	56.2E-6
4θy	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
4θz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5ux	22.1E-6	000.0E+0	18.2E-6	39.8E-6	000.0E+0	000.0E+0	24.6E-6
5uy	65.0E-3	23.7E-3	47.3E-3	118.7E-3	33.8E-3	33.7E-3	53.5E-3
5uz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5θx	78.6E-6	28.7E-6	57.3E-6	144.0E-6	40.9E-6	40.8E-6	64.7E-6
5θy	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5θz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6ux	29.6E-6	000.0E+0	24.3E-6	53.3E-6	000.0E+0	000.0E+0	32.9E-6
6uy	86.6E-3	31.6E-3	63.1E-3	158.3E-3	45.1E-3	44.9E-3	71.3E-3
6uz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6θx	84.0E-6	30.6E-6	61.2E-6	154.0E-6	43.7E-6	43.6E-6	69.2E-6
6θy	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6θz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7ux	34.3E-6	000.0E+0	28.2E-6	61.8E-6	000.0E+0	000.0E+0	38.2E-6
7uy	100.1E-3	36.5E-3	72.9E-3	183.0E-3	52.1E-3	51.9E-3	82.4E-3
7uz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7θx	85.4E-6	31.1E-6	62.2E-6	156.0E-6	44.4E-6	44.3E-6	70.3E-6
7θy	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7θz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
8ux	38.6E-6	000.0E+0	31.9E-6	69.7E-6	000.0E+0	10.5E-6	43.0E-6
8uy	112.8E-3	41.1E-3	82.1E-3	206.1E-3	58.7E-3	58.5E-3	92.8E-3
8uz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
8θx	85.8E-6	31.3E-6	62.5E-6	157.0E-6	44.6E-6	44.5E-6	70.6E-6
8θy	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
8θz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
9ux	47.4E-6	000.0E+0	38.0E-6	85.0E-6	000.0E+0	15.1E-6	50.2E-6

9uy	112.8E-3	41.1E-3	82.2E-3	206.1E-3	58.7E-3	58.5E-3	92.9E-3
9uz	6.7E-3	2.4E-3	4.9E-3	12.2E-3	3.5E-3	3.5E-3	5.5E-3
9θx	85.7E-6	31.3E-6	62.4E-6	157.0E-6	44.6E-6	44.5E-6	70.6E-6
9θy	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
9θz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
10ux	56.1E-6	000.0E+0	47.6E-6	108.0E-6	000.0E+0	17.7E-6	59.0E-6
10uy	121.0E-3	44.0E-3	87.1E-3	218.8E-3	63.3E-3	63.2E-3	99.0E-3
10uz	6.9E-3	2.5E-3	4.8E-3	12.0E-3	3.6E-3	3.7E-3	5.5E-3
10θx	296.7E-6	116.7E-6	290.7E-6	717.0E-6	141.0E-6	136.0E-6	285.0E-6
10θy	17.3E-6	000.0E+0	15.2E-6	39.1E-6	000.0E+0	000.0E+0	15.7E-6
10θz	118.7E-6	41.4E-6	75.2E-6	191.0E-6	65.8E-6	67.4E-6	90.4E-6
11ux	65.4E-6	000.0E+0	57.5E-6	132.0E-6	13.5E-6	20.6E-6	68.2E-6
11uy	123.1E-3	44.6E-3	87.7E-3	220.3E-3	64.6E-3	64.7E-3	100.1E-3
11uz	6.9E-3	2.4E-3	4.6E-3	11.6E-3	3.7E-3	3.8E-3	5.4E-3
11θx	605.7E-6	241.2E-6	610.2E-6	1.5E-3	278.0E-6	264.0E-6	594.0E-6
11θy	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
11θz	73.2E-6	26.5E-6	51.7E-6	130.0E-6	38.6E-6	38.6E-6	59.3E-6
12ux	75.1E-6	13.1E-6	67.5E-6	157.0E-6	17.3E-6	23.8E-6	77.8E-6
12uy	112.8E-3	41.1E-3	82.1E-3	206.1E-3	58.7E-3	58.5E-3	92.9E-3
12uz	6.7E-3	2.4E-3	4.9E-3	12.2E-3	3.5E-3	3.5E-3	5.5E-3
12θx	918.6E-6	367.0E-6	931.3E-6	2.3E-3	417.0E-6	395.0E-6	906.0E-6
12θy	51.1E-6	20.5E-6	47.9E-6	122.0E-6	24.4E-6	22.3E-6	48.3E-6
12θz	188.4E-6	67.3E-6	137.9E-6	346.0E-6	103.0E-6	106.0E-6	152.0E-6
13ux	1.3E-3	529.0E-6	1.1E-3	2.9E-3	660.0E-6	585.0E-6	1.2E-3
13uy	121.1E-3	45.5E-3	97.9E-3	244.2E-3	60.0E-3	58.5E-3	105.6E-3
13uz	7.2E-3	2.8E-3	5.7E-3	14.4E-3	3.7E-3	3.6E-3	6.2E-3
13θx	1.2E-3	467.9E-6	1.2E-3	2.9E-3	534.0E-6	507.0E-6	1.2E-3
13θy	41.2E-6	14.1E-6	28.7E-6	80.3E-6	20.6E-6	18.2E-6	33.4E-6
13θz	452.4E-6	178.6E-6	445.1E-6	1.1E-3	212.0E-6	204.0E-6	437.0E-6
14ux	3.4E-3	1.1E-3	2.4E-3	6.6E-3	1.6E-3	1.5E-3	2.8E-3
14uy	172.5E-3	68.5E-3	167.3E-3	413.5E-3	76.8E-3	71.1E-3	167.1E-3
14uz	7.3E-3	2.8E-3	5.8E-3	14.6E-3	3.8E-3	3.6E-3	6.3E-3
14θx	647.7E-6	253.2E-6	626.7E-6	1.5E-3	311.0E-6	304.0E-6	617.0E-6
14θy	23.9E-6	000.0E+0	24.9E-6	58.9E-6	000.0E+0	000.0E+0	23.7E-6
14θz	408.4E-6	161.1E-6	399.8E-6	988.0E-6	192.0E-6	185.0E-6	393.0E-6
15ux	3.3E-3	795.5E-6	2.8E-3	6.8E-3	1.2E-3	1.3E-3	2.9E-3
15uy	164.5E-3	65.8E-3	163.1E-3	402.6E-3	72.4E-3	66.6E-3	161.4E-3
15uz	7.4E-3	2.8E-3	5.9E-3	14.9E-3	3.8E-3	3.6E-3	6.4E-3
15θx	700.9E-6	282.7E-6	717.6E-6	1.8E-3	307.0E-6	282.0E-6	700.0E-6
15θy	24.0E-6	000.0E+0	16.6E-6	48.4E-6	12.5E-6	10.5E-6	19.6E-6
15θz	364.6E-6	143.6E-6	354.5E-6	877.0E-6	172.0E-6	166.0E-6	349.0E-6
16ux	27.2E-6	000.0E+0	23.7E-6	51.8E-6	000.0E+0	000.0E+0	31.5E-6
16uy	86.6E-3	31.6E-3	63.1E-3	158.3E-3	45.1E-3	44.9E-3	71.3E-3
16uz	7.5E-3	2.9E-3	6.0E-3	15.1E-3	3.8E-3	3.6E-3	6.5E-3
16θx	2.1E-3	846.9E-6	2.1E-3	5.2E-3	1.0E-3	970.0E-6	2.1E-3
16θy	63.4E-6	14.3E-6	63.6E-6	147.0E-6	15.6E-6	22.0E-6	61.0E-6
16θz	320.9E-6	126.1E-6	309.3E-6	766.0E-6	152.0E-6	147.0E-6	306.0E-6
17ux	7.0E-3	1.7E-3	7.3E-3	17.0E-3	1.6E-3	2.3E-3	6.9E-3
17uy	228.1E-3	84.7E-3	191.4E-3	474.1E-3	119.8E-3	121.5E-3	198.0E-3
17uz	7.5E-3	2.9E-3	6.1E-3	15.3E-3	3.8E-3	3.7E-3	6.6E-3

17θx	2.5E-3	971.0E-6	2.4E-3	5.9E-3	1.2E-3	1.2E-3	2.4E-3
17θy	88.6E-6	22.9E-6	94.3E-6	219.0E-6	21.3E-6	29.3E-6	88.8E-6
17θz	277.4E-6	108.6E-6	264.3E-6	656.0E-6	132.0E-6	128.0E-6	262.0E-6
18ux	13.0E-3	3.3E-3	13.8E-3	32.0E-3	3.1E-3	4.3E-3	13.0E-3
18uy	379.3E-3	143.7E-3	338.2E-3	835.4E-3	193.0E-3	193.8E-3	341.7E-3
18uz	7.6E-3	2.9E-3	6.2E-3	15.5E-3	3.9E-3	3.7E-3	6.7E-3
18θx	956.7E-6	372.8E-6	918.6E-6	2.3E-3	462.0E-6	453.0E-6	906.0E-6
18θy	43.8E-6	12.7E-6	46.8E-6	111.0E-6	12.6E-6	14.5E-6	44.3E-6
18θz	234.3E-6	91.2E-6	219.6E-6	546.0E-6	112.0E-6	110.0E-6	219.0E-6
19ux	13.3E-3	3.5E-3	14.2E-3	33.1E-3	3.3E-3	4.4E-3	13.4E-3
19uy	366.2E-3	138.8E-3	327.2E-3	808.3E-3	186.2E-3	186.8E-3	330.4E-3
19uz	7.7E-3	3.0E-3	6.3E-3	15.7E-3	3.9E-3	3.7E-3	6.7E-3
19θx	1.2E-3	471.3E-6	1.1E-3	2.8E-3	605.0E-6	601.0E-6	1.1E-3
19θy	35.7E-6	000.0E+0	37.0E-6	85.6E-6	000.0E+0	12.1E-6	35.1E-6
19θz	191.8E-6	74.0E-6	175.3E-6	437.0E-6	91.9E-6	91.0E-6	177.0E-6
20ux	7.7E-3	2.1E-3	8.2E-3	19.2E-3	1.9E-3	2.5E-3	7.7E-3
20uy	199.7E-3	74.6E-3	170.7E-3	422.5E-3	103.9E-3	105.2E-3	175.3E-3
20uz	7.7E-3	3.0E-3	6.4E-3	15.9E-3	3.9E-3	3.7E-3	6.8E-3
20θx	2.5E-3	949.9E-6	2.3E-3	5.7E-3	1.2E-3	1.2E-3	2.3E-3
20θy	89.8E-6	23.6E-6	95.8E-6	223.0E-6	22.1E-6	29.7E-6	90.2E-6
20θz	150.5E-6	56.9E-6	131.9E-6	330.0E-6	72.3E-6	72.7E-6	135.0E-6
21ux	14.6E-6	000.0E+0	13.9E-6	31.1E-6	000.0E+0	000.0E+0	17.2E-6
21uy	44.0E-3	16.0E-3	32.0E-3	80.4E-3	22.9E-3	22.8E-3	36.2E-3
21uz	7.8E-3	3.0E-3	6.4E-3	16.1E-3	3.9E-3	3.7E-3	6.9E-3
21θx	1.6E-3	606.6E-6	1.5E-3	3.6E-3	780.0E-6	774.0E-6	1.5E-3
21θy	76.8E-6	21.6E-6	82.8E-6	194.0E-6	20.3E-6	25.3E-6	77.9E-6
21θz	111.5E-6	40.3E-6	90.6E-6	229.0E-6	53.2E-6	55.0E-6	96.3E-6
22ux	4.4E-3	1.3E-3	4.8E-3	11.3E-3	1.3E-3	1.5E-3	4.5E-3
22uy	64.7E-3	26.1E-3	66.1E-3	163.0E-3	28.2E-3	25.9E-3	64.5E-3
22uz	7.8E-3	3.0E-3	6.5E-3	16.3E-3	3.9E-3	3.7E-3	6.9E-3
22θx	113.7E-6	45.9E-6	115.5E-6	285.0E-6	49.6E-6	45.6E-6	113.0E-6
22θy	32.0E-6	10.9E-6	33.5E-6	82.3E-6	11.9E-6	11.2E-6	32.3E-6
22θz	78.5E-6	25.0E-6	56.5E-6	145.0E-6	35.5E-6	38.8E-6	63.9E-6
23ux	5.8E-3	1.9E-3	6.2E-3	15.0E-3	2.0E-3	2.0E-3	5.9E-3
23uy	32.5E-3	12.6E-3	28.9E-3	71.7E-3	15.3E-3	14.5E-3	29.9E-3
23uz	7.8E-3	3.0E-3	6.6E-3	16.4E-3	3.9E-3	3.7E-3	7.0E-3
23θx	646.1E-6	255.3E-6	640.1E-6	1.6E-3	302.0E-6	292.0E-6	626.0E-6
23θy	15.2E-6	000.0E+0	11.6E-6	33.4E-6	000.0E+0	000.0E+0	13.3E-6
23θz	62.1E-6	15.9E-6	48.4E-6	121.0E-6	22.7E-6	26.7E-6	52.7E-6
24ux	4.7E-3	1.6E-3	5.0E-3	12.2E-3	1.7E-3	1.6E-3	4.8E-3
24uy	28.4E-3	10.6E-3	22.5E-3	56.1E-3	14.2E-3	14.0E-3	24.5E-3
24uz	6.3E-3	2.3E-3	3.9E-3	10.1E-3	3.6E-3	3.6E-3	4.8E-3
24θx	98.7E-6	37.4E-6	74.3E-6	187.0E-6	52.0E-6	50.3E-6	82.9E-6
24θy	23.2E-6	000.0E+0	25.3E-6	61.9E-6	10.1E-6	000.0E+0	23.9E-6
24θz	76.7E-6	25.3E-6	80.7E-6	197.0E-6	27.0E-6	26.4E-6	77.7E-6
25ux	000.0E+0	000.0E+0	000.0E+0	16.5E-6	000.0E+0	000.0E+0	10.3E-6
25uy	28.4E-3	10.5E-3	22.4E-3	55.8E-3	14.2E-3	14.0E-3	24.4E-3
25uz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
25θx	101.9E-6	36.2E-6	64.5E-6	164.0E-6	58.2E-6	59.0E-6	77.3E-6
25θy	21.6E-6	000.0E+0	23.6E-6	57.7E-6	000.0E+0	000.0E+0	22.3E-6

25θz	73.4E-6	27.1E-6	79.4E-6	194.0E-6	28.8E-6	26.6E-6	75.6E-6
26ux	5.2E-3	2.0E-3	5.5E-3	13.6E-3	2.2E-3	2.1E-3	5.3E-3
26uy	28.3E-3	10.5E-3	22.1E-3	55.3E-3	14.2E-3	14.0E-3	24.2E-3
26uz	7.2E-3	2.6E-3	4.6E-3	11.8E-3	4.0E-3	4.0E-3	5.6E-3
26θx	51.0E-6	18.9E-6	39.3E-6	98.2E-6	25.9E-6	25.5E-6	43.3E-6
26θy	19.3E-6	000.0E+0	21.0E-6	51.2E-6	000.0E+0	000.0E+0	19.9E-6
26θz	20.0E-6	000.0E+0	18.5E-6	45.8E-6	000.0E+0	000.0E+0	18.6E-6
27ux	3.2E-3	1.3E-3	3.3E-3	8.0E-3	1.4E-3	1.3E-3	3.1E-3
27uy	28.2E-3	10.4E-3	21.9E-3	54.8E-3	14.2E-3	14.0E-3	24.0E-3
27uz	10.1E-3	3.7E-3	7.1E-3	17.8E-3	5.3E-3	5.3E-3	8.1E-3
27θx	40.6E-6	15.8E-6	38.9E-6	96.3E-6	17.9E-6	16.7E-6	39.0E-6
27θy	17.8E-6	000.0E+0	19.1E-6	46.4E-6	000.0E+0	000.0E+0	18.1E-6
27θz	75.6E-6	29.7E-6	80.0E-6	196.0E-6	32.7E-6	30.3E-6	76.7E-6
28ux	32.7E-6	12.2E-6	27.1E-6	69.2E-6	16.4E-6	16.4E-6	28.6E-6
28uy	27.1E-3	9.9E-3	19.7E-3	49.5E-3	14.1E-3	14.1E-3	22.3E-3
28uz	10.7E-3	3.9E-3	7.8E-3	19.6E-3	5.6E-3	5.6E-3	8.8E-3
28θx	39.1E-6	15.2E-6	35.9E-6	89.1E-6	18.0E-6	16.9E-6	36.7E-6
28θy	16.3E-6	000.0E+0	14.8E-6	36.4E-6	000.0E+0	000.0E+0	15.1E-6
28θz	123.3E-6	48.1E-6	118.9E-6	293.0E-6	59.9E-6	58.6E-6	117.0E-6
29ux	25.4E-6	000.0E+0	21.6E-6	54.9E-6	12.9E-6	12.8E-6	22.6E-6
29uy	28.5E-3	10.2E-3	19.4E-3	48.8E-3	15.3E-3	15.4E-3	22.6E-3
29uz	11.7E-3	4.3E-3	8.6E-3	21.5E-3	6.0E-3	6.0E-3	9.7E-3
29θx	41.7E-6	15.9E-6	35.9E-6	89.3E-6	19.9E-6	19.1E-6	37.7E-6
29θy	11.8E-6	000.0E+0	000.0E+0	23.0E-6	000.0E+0	000.0E+0	10.1E-6
29θz	34.6E-6	12.5E-6	25.1E-6	62.7E-6	19.3E-6	19.7E-6	27.7E-6
30ux	18.3E-6	000.0E+0	16.1E-6	40.6E-6	000.0E+0	000.0E+0	16.9E-6
30uy	29.2E-3	10.5E-3	20.0E-3	50.3E-3	15.7E-3	15.8E-3	23.3E-3
30uz	11.9E-3	4.3E-3	8.8E-3	22.0E-3	6.2E-3	6.1E-3	9.9E-3
30θx	45.1E-6	16.9E-6	36.5E-6	91.1E-6	22.3E-6	21.8E-6	39.4E-6
30θy	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
30θz	29.2E-6	11.4E-6	28.1E-6	69.3E-6	14.2E-6	13.9E-6	27.7E-6
31ux	11.4E-6	000.0E+0	10.9E-6	26.7E-6	000.0E+0	000.0E+0	11.5E-6
31uy	28.2E-3	10.2E-3	20.0E-3	50.3E-3	14.9E-3	14.9E-3	22.9E-3
31uz	11.3E-3	4.1E-3	8.3E-3	20.8E-3	5.9E-3	5.9E-3	9.4E-3
31θx	49.4E-6	18.2E-6	37.7E-6	94.4E-6	25.1E-6	24.8E-6	41.7E-6
31θy	13.4E-6	000.0E+0	10.7E-6	26.5E-6	000.0E+0	000.0E+0	11.5E-6
31θz	45.1E-6	16.6E-6	35.6E-6	88.5E-6	24.5E-6	24.9E-6	37.8E-6
32ux	000.0E+0	000.0E+0	000.0E+0	14.4E-6	000.0E+0	000.0E+0	000.0E+0
32uy	27.1E-3	9.9E-3	19.7E-3	49.5E-3	14.1E-3	14.1E-3	22.3E-3
32uz	10.7E-3	3.9E-3	7.8E-3	19.6E-3	5.6E-3	5.6E-3	8.8E-3
32θx	54.2E-6	19.7E-6	39.4E-6	99.0E-6	28.2E-6	28.1E-6	44.6E-6
32θy	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
32θz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0

Table 16b Maximum Nodal Displacements for Benchmark Problem #4b (inches)

Nodes	Case a	Case b	Case c	Case d	Case e	Case f	Case g
2ux	39.4E-3	26.5E-3	36.6E-3	91.8E-3	32.3E-3	25.7E-3	32.8E-3
2uy	47.6E-6	13.5E-6	20.2E-6	91.2E-6	20.0E-6	11.4E-6	33.0E-6
2uz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
2θx	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
2θy	115.0E-6	77.6E-6	107.0E-6	268.0E-6	94.2E-6	75.1E-6	95.8E-6
2θz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3ux	100.5E-3	67.7E-3	93.4E-3	234.2E-3	82.3E-3	65.5E-3	83.7E-3
3uy	80.1E-6	24.6E-6	35.7E-6	155.0E-6	34.3E-6	21.2E-6	57.0E-6
3uz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3θx	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3θy	202.0E-6	137.0E-6	188.0E-6	472.0E-6	166.0E-6	132.0E-6	169.0E-6
3θz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
4ux	163.2E-3	110.0E-3	151.7E-3	380.3E-3	133.6E-3	106.4E-3	135.8E-3
4uy	84.7E-6	29.9E-6	41.0E-6	167.0E-6	37.0E-6	26.5E-6	63.2E-6
4uz	000.0E+0	000.0E+0	000.0E+0	11.7E-6	000.0E+0	000.0E+0	000.0E+0
4θx	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
4θy	255.0E-6	172.0E-6	237.0E-6	595.0E-6	209.0E-6	166.0E-6	212.0E-6
4θz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5ux	241.1E-3	162.7E-3	224.2E-3	562.0E-3	197.5E-3	157.3E-3	200.7E-3
5uy	59.8E-6	33.6E-6	41.1E-6	130.0E-6	30.1E-6	31.1E-6	56.2E-6
5uz	10.1E-6	000.0E+0	000.0E+0	15.1E-6	000.0E+0	000.0E+0	000.0E+0
5θx	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5θy	294.0E-6	198.0E-6	273.0E-6	686.0E-6	241.0E-6	192.0E-6	245.0E-6
5θz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6ux	321.7E-3	217.0E-3	299.1E-3	749.9E-3	263.5E-3	209.9E-3	267.8E-3
6uy	25.2E-6	40.6E-6	45.8E-6	96.7E-6	25.4E-6	38.2E-6	55.1E-6
6uz	11.6E-6	000.0E+0	000.0E+0	17.5E-6	000.0E+0	000.0E+0	000.0E+0
6θx	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6θy	315.0E-6	212.0E-6	292.0E-6	733.0E-6	258.0E-6	205.0E-6	262.0E-6
6θz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7ux	372.1E-3	251.0E-3	345.9E-3	867.3E-3	304.7E-3	242.8E-3	309.8E-3
7uy	42.2E-6	48.0E-6	54.9E-6	126.0E-6	32.1E-6	44.9E-6	67.3E-6
7uz	12.0E-6	000.0E+0	000.0E+0	18.2E-6	000.0E+0	000.0E+0	000.0E+0
7θx	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7θy	320.0E-6	216.0E-6	297.0E-6	745.0E-6	262.0E-6	208.0E-6	266.0E-6
7θz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
8ux	419.3E-3	282.9E-3	389.8E-3	977.4E-3	343.4E-3	273.6E-3	349.1E-3
8uy	71.5E-6	56.2E-6	65.9E-6	175.0E-6	42.5E-6	52.1E-6	84.4E-6
8uz	11.8E-6	000.0E+0	000.0E+0	18.2E-6	000.0E+0	000.0E+0	000.0E+0
8θx	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
8θy	321.0E-6	216.0E-6	298.0E-6	748.0E-6	263.0E-6	209.0E-6	267.0E-6
8θz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
9ux	419.4E-3	282.9E-3	389.8E-3	977.5E-3	343.4E-3	273.6E-3	349.1E-3
9uy	122.0E-6	75.8E-6	100.0E-6	311.0E-6	97.9E-6	88.5E-6	119.0E-6

9uz	77.1E-3	52.0E-3	71.7E-3	179.6E-3	63.1E-3	50.3E-3	64.2E-3
9θx	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
9θy	321.0E-6	216.0E-6	298.0E-6	748.0E-6	263.0E-6	209.0E-6	267.0E-6
9θz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
10ux	420.3E-3	282.6E-3	389.3E-3	979.5E-3	344.1E-3	274.0E-3	349.4E-3
10uy	6.4E-3	8.9E-3	13.0E-3	15.5E-3	5.4E-3	5.2E-3	7.3E-3
10uz	66.4E-3	64.4E-3	91.5E-3	157.4E-3	55.1E-3	48.6E-3	65.0E-3
10θx	74.1E-6	64.9E-6	91.3E-6	174.0E-6	60.3E-6	51.3E-6	68.7E-6
10θy	455.0E-6	363.0E-6	538.0E-6	935.0E-6	307.0E-6	236.0E-6	328.0E-6
10θz	110.0E-6	156.0E-6	228.0E-6	269.0E-6	94.2E-6	91.7E-6	128.0E-6
11ux	420.9E-3	282.1E-3	388.6E-3	980.6E-3	344.5E-3	274.1E-3	349.5E-3
11uy	12.0E-3	17.0E-3	24.9E-3	29.3E-3	10.3E-3	10.0E-3	14.0E-3
11uz	60.7E-3	74.8E-3	108.0E-3	144.8E-3	50.3E-3	47.8E-3	66.2E-3
11θx	148.0E-6	130.0E-6	183.0E-6	347.0E-6	121.0E-6	103.0E-6	138.0E-6
11θy	392.0E-6	274.0E-6	383.0E-6	873.0E-6	299.0E-6	245.0E-6	324.0E-6
11θz	16.5E-6	14.0E-6	20.6E-6	34.7E-6	10.5E-6	000.0E+0	14.3E-6
12ux	421.1E-3	281.4E-3	387.5E-3	980.9E-3	344.6E-3	273.9E-3	349.2E-3
12uy	71.7E-6	57.3E-6	67.1E-6	176.0E-6	42.9E-6	52.7E-6	85.2E-6
12uz	38.2E-6	31.1E-6	44.8E-6	69.5E-6	22.0E-6	20.2E-6	29.8E-6
12θx	222.0E-6	195.0E-6	274.0E-6	521.0E-6	181.0E-6	154.0E-6	206.0E-6
12θy	1.3E-3	1.8E-3	2.6E-3	3.1E-3	1.1E-3	1.1E-3	1.5E-3
12θz	319.0E-6	463.0E-6	676.0E-6	788.0E-6	278.0E-6	271.0E-6	378.0E-6
13ux	397.8E-3	204.8E-3	274.5E-3	910.2E-3	319.0E-3	239.8E-3	298.0E-3
13uy	12.5E-3	20.5E-3	30.2E-3	31.4E-3	11.1E-3	11.3E-3	15.9E-3
13uz	47.9E-3	68.1E-3	99.2E-3	117.8E-3	41.6E-3	40.1E-3	55.6E-3
13θx	130.0E-6	246.0E-6	383.0E-6	315.0E-6	109.0E-6	122.0E-6	177.0E-6
13θy	4.3E-3	6.1E-3	8.9E-3	10.6E-3	3.7E-3	3.6E-3	5.0E-3
13θz	998.0E-6	1.5E-3	2.1E-3	2.5E-3	876.0E-6	856.0E-6	1.2E-3
14ux	415.4E-3	332.2E-3	491.7E-3	918.1E-3	320.3E-3	231.6E-3	294.2E-3
14uy	17.4E-3	34.6E-3	52.5E-3	44.0E-3	15.5E-3	17.3E-3	25.0E-3
14uz	48.3E-3	68.5E-3	99.7E-3	118.5E-3	41.8E-3	40.3E-3	56.0E-3
14θx	62.1E-6	86.8E-6	139.0E-6	146.0E-6	51.7E-6	49.8E-6	68.5E-6
14θy	2.9E-3	4.1E-3	6.0E-3	7.3E-3	2.6E-3	2.5E-3	3.4E-3
14θz	1.5E-3	2.2E-3	3.2E-3	3.8E-3	1.3E-3	1.3E-3	1.8E-3
15ux	410.2E-3	422.4E-3	623.7E-3	925.5E-3	324.0E-3	256.9E-3	340.9E-3
15uy	13.5E-3	29.2E-3	44.8E-3	34.5E-3	12.3E-3	14.2E-3	20.5E-3
15uz	48.6E-3	68.8E-3	100.1E-3	119.1E-3	42.0E-3	40.5E-3	56.2E-3
15θx	117.0E-6	210.0E-6	318.0E-6	287.0E-6	99.7E-6	108.0E-6	156.0E-6
15θy	1.9E-3	2.5E-3	3.7E-3	4.5E-3	1.6E-3	1.4E-3	2.0E-3
15θz	2.0E-3	2.9E-3	4.2E-3	5.1E-3	1.8E-3	1.7E-3	2.4E-3
16ux	321.8E-3	217.2E-3	299.3E-3	750.2E-3	263.6E-3	210.0E-3	268.0E-3
16uy	22.3E-6	33.2E-6	50.4E-6	71.3E-6	19.9E-6	28.1E-6	40.7E-6
16uz	48.8E-3	69.0E-3	100.5E-3	119.6E-3	42.2E-3	40.7E-3	56.4E-3
16θx	219.0E-6	474.0E-6	735.0E-6	551.0E-6	199.0E-6	227.0E-6	331.0E-6
16θy	8.7E-3	12.4E-3	18.0E-3	21.6E-3	7.7E-3	7.4E-3	10.2E-3
16θz	2.6E-3	3.6E-3	5.3E-3	6.3E-3	2.2E-3	2.2E-3	3.0E-3
17ux	1.1E+0	1.5E+0	2.2E+0	2.9E+0	1.0E+0	962.8E-3	1.3E+0
17uy	20.9E-3	44.1E-3	68.7E-3	51.8E-3	18.7E-3	21.2E-3	30.8E-3
17uz	49.0E-3	69.2E-3	100.8E-3	120.0E-3	42.3E-3	40.8E-3	56.6E-3
17θx	224.0E-6	492.0E-6	768.0E-6	564.0E-6	206.0E-6	236.0E-6	341.0E-6

17θy	11.3E-3	15.8E-3	22.9E-3	28.0E-3	9.9E-3	9.6E-3	13.3E-3
17θz	3.1E-3	4.4E-3	6.4E-3	7.6E-3	2.7E-3	2.6E-3	3.6E-3
18ux	1.9E+0	2.5E+0	3.7E+0	4.7E+0	1.6E+0	1.6E+0	2.2E+0
18uy	33.0E-3	73.8E-3	115.1E-3	83.5E-3	30.6E-3	35.2E-3	50.9E-3
18uz	49.2E-3	69.3E-3	101.0E-3	120.2E-3	42.4E-3	40.8E-3	56.7E-3
18θx	149.0E-6	175.0E-6	276.0E-6	316.0E-6	105.0E-6	93.1E-6	147.0E-6
18θy	4.7E-3	6.7E-3	9.7E-3	11.8E-3	4.2E-3	4.0E-3	5.6E-3
18θz	3.6E-3	5.1E-3	7.4E-3	8.9E-3	3.2E-3	3.0E-3	4.2E-3
19ux	1.8E+0	2.5E+0	3.6E+0	4.6E+0	1.6E+0	1.6E+0	2.1E+0
19uy	31.9E-3	69.7E-3	108.9E-3	80.0E-3	29.2E-3	33.3E-3	48.2E-3
19uz	49.3E-3	69.4E-3	101.1E-3	120.4E-3	42.4E-3	40.9E-3	56.8E-3
19θx	139.0E-6	257.0E-6	399.0E-6	327.0E-6	115.0E-6	126.0E-6	186.0E-6
19θy	5.3E-3	7.3E-3	10.5E-3	13.2E-3	4.7E-3	4.5E-3	6.2E-3
19θz	4.1E-3	5.8E-3	8.5E-3	10.2E-3	3.6E-3	3.5E-3	4.8E-3
20ux	1.1E+0	1.4E+0	2.1E+0	2.7E+0	947.4E-3	905.5E-3	1.2E+0
20uy	17.2E-3	36.1E-3	56.5E-3	42.2E-3	15.3E-3	17.3E-3	25.0E-3
20uz	49.3E-3	69.4E-3	101.1E-3	120.4E-3	42.4E-3	40.9E-3	56.8E-3
20θx	233.0E-6	480.0E-6	750.0E-6	571.0E-6	206.0E-6	231.0E-6	336.0E-6
20θy	11.7E-3	16.3E-3	23.5E-3	29.2E-3	10.3E-3	9.9E-3	13.7E-3
20θz	4.7E-3	6.6E-3	9.5E-3	11.5E-3	4.1E-3	3.9E-3	5.4E-3
21ux	163.3E-3	110.2E-3	151.9E-3	380.5E-3	133.7E-3	106.5E-3	136.0E-3
21uy	83.2E-6	33.7E-6	55.2E-6	161.0E-6	38.0E-6	23.7E-6	59.6E-6
21uz	49.3E-3	69.3E-3	101.0E-3	120.3E-3	42.4E-3	40.8E-3	56.7E-3
21θx	171.0E-6	286.0E-6	450.0E-6	391.0E-6	134.0E-6	140.0E-6	209.0E-6
21θy	9.1E-3	12.6E-3	18.3E-3	22.6E-3	8.0E-3	7.7E-3	10.6E-3
21θz	5.2E-3	7.3E-3	10.6E-3	12.8E-3	4.5E-3	4.4E-3	6.0E-3
22ux	379.3E-3	537.2E-3	783.9E-3	924.4E-3	326.9E-3	310.4E-3	430.6E-3
22uy	16.1E-3	9.1E-3	14.6E-3	32.3E-3	10.0E-3	6.7E-3	12.1E-3
22uz	49.2E-3	69.2E-3	100.8E-3	120.1E-3	42.3E-3	40.8E-3	56.6E-3
22θx	150.0E-6	129.0E-6	191.0E-6	317.0E-6	103.0E-6	84.6E-6	133.0E-6
22θy	2.4E-3	3.3E-3	4.8E-3	5.9E-3	2.1E-3	2.0E-3	2.8E-3
22θz	5.7E-3	8.0E-3	11.7E-3	14.1E-3	5.0E-3	4.8E-3	6.6E-3
23ux	413.1E-3	584.7E-3	852.8E-3	1.0E+0	356.4E-3	339.8E-3	471.2E-3
23uy	21.3E-3	19.3E-3	28.1E-3	46.6E-3	15.5E-3	13.2E-3	19.5E-3
23uz	49.0E-3	69.0E-3	100.5E-3	119.7E-3	42.2E-3	40.7E-3	56.5E-3
23θx	247.0E-6	410.0E-6	610.0E-6	619.0E-6	220.0E-6	220.0E-6	316.0E-6
23θy	787.0E-6	1.0E-3	1.5E-3	1.9E-3	663.0E-6	620.0E-6	866.0E-6
23θz	6.2E-3	8.8E-3	12.7E-3	15.4E-3	5.4E-3	5.2E-3	7.3E-3
24ux	278.4E-3	388.1E-3	567.2E-3	673.5E-3	237.6E-3	223.8E-3	309.9E-3
24uy	26.3E-3	30.7E-3	44.6E-3	60.8E-3	20.9E-3	19.1E-3	27.3E-3
24uz	38.9E-3	54.3E-3	79.0E-3	95.3E-3	33.6E-3	32.3E-3	44.7E-3
24θx	680.0E-6	934.0E-6	1.4E-3	1.6E-3	570.0E-6	546.0E-6	761.0E-6
24θy	1.4E-3	2.0E-3	2.9E-3	3.5E-3	1.2E-3	1.2E-3	1.6E-3
24θz	6.0E-3	8.4E-3	12.3E-3	14.8E-3	5.2E-3	5.0E-3	7.0E-3
25ux	100.5E-3	67.7E-3	93.4E-3	234.2E-3	82.3E-3	65.5E-3	83.7E-3
25uy	26.2E-3	30.7E-3	44.6E-3	60.5E-3	20.8E-3	19.1E-3	27.2E-3
25uz	3.6E-3	2.5E-3	3.4E-3	8.5E-3	3.0E-3	2.4E-3	3.0E-3
25θx	508.0E-6	681.0E-6	992.0E-6	1.2E-3	420.0E-6	401.0E-6	558.0E-6
25θy	1.2E-3	1.7E-3	2.4E-3	3.0E-3	1.0E-3	995.0E-6	1.4E-3
25θz	4.0E-3	5.6E-3	8.1E-3	9.8E-3	3.5E-3	3.3E-3	4.6E-3

26ux	224.7E-3	267.6E-3	384.5E-3	547.7E-3	193.9E-3	178.8E-3	244.7E-3
26uy	25.8E-3	30.6E-3	44.5E-3	59.9E-3	20.6E-3	19.0E-3	27.0E-3
26uz	37.9E-3	27.6E-3	40.4E-3	64.9E-3	17.7E-3	16.6E-3	26.0E-3
26θx	96.7E-6	23.7E-6	35.6E-6	138.0E-6	23.2E-6	19.4E-6	45.8E-6
26θy	879.0E-6	1.2E-3	1.7E-3	2.1E-3	736.0E-6	697.0E-6	974.0E-6
26θz	563.0E-6	778.0E-6	1.1E-3	1.4E-3	484.0E-6	464.0E-6	646.0E-6
27ux	122.3E-3	108.7E-3	153.2E-3	291.3E-3	102.8E-3	87.5E-3	115.4E-3
27uy	25.4E-3	30.5E-3	44.4E-3	59.2E-3	20.4E-3	18.9E-3	26.8E-3
27uz	16.0E-3	13.4E-3	19.7E-3	29.3E-3	8.7E-3	7.9E-3	12.0E-3
27θx	481.0E-6	268.0E-6	392.0E-6	755.0E-6	177.0E-6	168.0E-6	287.0E-6
27θy	621.0E-6	796.0E-6	1.2E-3	1.4E-3	494.0E-6	461.0E-6	647.0E-6
27θz	2.0E-3	2.6E-3	3.7E-3	4.8E-3	1.7E-3	1.6E-3	2.2E-3
28ux	102.3E-3	70.7E-3	97.7E-3	238.9E-3	84.0E-3	67.2E-3	86.1E-3
28uy	66.2E-6	29.3E-6	45.0E-6	133.0E-6	42.9E-6	24.1E-6	53.1E-6
28uz	66.8E-6	24.2E-6	33.2E-6	99.9E-6	18.6E-6	17.9E-6	36.1E-6
28θx	437.0E-6	50.1E-6	79.1E-6	595.0E-6	69.1E-6	69.4E-6	191.0E-6
28θy	230.0E-6	174.0E-6	258.0E-6	497.0E-6	171.0E-6	124.0E-6	160.0E-6
28θz	628.0E-6	735.0E-6	1.1E-3	1.5E-3	503.0E-6	461.0E-6	658.0E-6
29ux	102.0E-3	70.1E-3	96.8E-3	237.9E-3	83.7E-3	66.9E-3	85.6E-3
29uy	32.0E-3	27.1E-3	39.9E-3	67.3E-3	23.0E-3	18.1E-3	28.2E-3
29uz	14.1E-3	4.7E-3	6.7E-3	28.5E-3	9.5E-3	6.3E-3	8.1E-3
29θx	328.0E-6	37.6E-6	59.4E-6	446.0E-6	51.8E-6	52.0E-6	143.0E-6
29θy	239.0E-6	101.0E-6	135.0E-6	501.0E-6	169.0E-6	124.0E-6	161.0E-6
29θz	421.0E-6	224.0E-6	342.0E-6	816.0E-6	274.0E-6	173.0E-6	313.0E-6
30ux	101.6E-3	69.4E-3	95.8E-3	236.9E-3	83.3E-3	66.5E-3	85.0E-3
30uy	41.7E-3	27.4E-3	41.0E-3	83.2E-3	28.2E-3	19.6E-3	33.1E-3
30uz	26.5E-3	10.6E-3	14.0E-3	56.8E-3	19.4E-3	14.0E-3	17.7E-3
30θx	218.0E-6	25.1E-6	39.6E-6	297.0E-6	34.6E-6	34.7E-6	95.6E-6
30θy	229.0E-6	200.0E-6	282.0E-6	545.0E-6	192.0E-6	163.0E-6	214.0E-6
30θz	154.0E-6	176.0E-6	255.0E-6	354.0E-6	122.0E-6	111.0E-6	159.0E-6
31ux	101.2E-3	68.7E-3	94.7E-3	235.8E-3	82.9E-3	66.1E-3	84.4E-3
31uy	20.7E-3	11.8E-3	17.8E-3	40.4E-3	13.6E-3	8.9E-3	15.7E-3
31uz	37.0E-3	22.3E-3	30.4E-3	85.0E-3	29.7E-3	23.1E-3	29.3E-3
31θx	109.0E-6	12.5E-6	19.8E-6	149.0E-6	17.3E-6	17.4E-6	47.8E-6
31θy	250.0E-6	210.0E-6	297.0E-6	552.0E-6	188.0E-6	162.0E-6	221.0E-6
31θz	460.0E-6	287.0E-6	431.0E-6	909.0E-6	307.0E-6	209.0E-6	358.0E-6
32ux	100.7E-3	67.9E-3	93.6E-3	234.5E-3	82.4E-3	65.6E-3	83.8E-3
32uy	202.0E-6	146.0E-6	222.0E-6	423.0E-6	151.0E-6	103.0E-6	175.0E-6
32uz	48.6E-3	32.8E-3	45.2E-3	113.3E-3	39.8E-3	31.7E-3	40.5E-3
32θx	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
32θy	202.0E-6	137.0E-6	188.0E-6	472.0E-6	166.0E-6	132.0E-6	169.0E-6
32θz	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0

Table 16c Maximum Nodal Displacements for Benchmark Problem #4a, Case a, 16 Bits Vs. 32 Bits (inches)

Nodes	16 Bits	32 Bits
2ux	0.00E+00	4.35E-06
2uy	1.06E-02	0.0106
2uz	0.00E+00	3.45E-07
2qx	3.08E-05	3.07E-05
2qy	0.00E+00	1.28E-08
2qz	0.00E+00	7.81E-10
3ux	0.00E+00	1.11E-05
3uy	2.71E-02	0.02703
3uz	0.00E+00	6.76E-07
3qx	5.41E-05	5.40E-05
3qy	0.00E+00	2.26E-08
3qz	0.00E+00	1.56E-09
4ux	1.49E-05	1.81E-05
4uy	4.40E-02	0.04387
4uz	0.00E+00	9.78E-07
4qx	6.82E-05	6.80E-05
4qy	0.00E+00	2.84E-08
4qz	0.00E+00	2.20E-09
5ux	2.21E-05	2.68E-05
5uy	6.50E-02	0.0648
5uz	0.00E+00	1.31E-06
5qx	7.86E-05	7.84E-05
5qy	0.00E+00	3.28E-08
5qz	0.00E+00	2.71E-09
6ux	2.96E-05	3.58E-05
6uy	8.66E-02	0.0864
6uz	0.00E+00	1.60E-06
6qx	8.40E-05	8.38E-05
6qy	0.00E+00	3.50E-08
6qz	0.00E+00	3.24E-09
7ux	3.43E-05	4.14E-05
7uy	1.00E-01	0.09987
7uz	0.00E+00	1.77E-06
7qx	8.54E-05	8.52E-05
7qy	0.00E+00	3.56E-08
7qz	0.00E+00	3.62E-09
8ux	3.86E-05	4.67E-05
8uy	1.13E-01	0.1125
8uz	0.00E+00	1.90E-06
8qx	8.58E-05	8.56E-05
8qy	0.00E+00	3.58E-08
8qz	0.00E+00	4.03E-09
9ux	4.74E-05	4.69E-05

9uy	1.13E-01	0.1125
9uz	6.70E-03	0.006666
9qx	8.57E-05	8.56E-05
9qy	0.00E+00	3.58E-08
9qz	0.00E+00	4.03E-09
10ux	5.61E-05	5.43E-05
10uy	1.21E-01	0.1225
10uz	6.90E-03	0.007464
10qx	2.97E-04	0.000547
10qy	1.73E-05	2.98E-05
10qz	1.19E-04	0.000164
11ux	6.54E-05	6.40E-05
11uy	1.23E-01	0.1262
11uz	6.90E-03	0.008138
11qx	6.06E-04	0.001074
11qy	0.00E+00	5.27E-06
11qz	7.32E-05	7.57E-05
12ux	7.51E-05	7.52E-05
12uy	1.13E-01	0.1125
12uz	6.70E-03	0.006673
12qx	9.19E-04	0.001603
12qy	5.11E-05	8.47E-05
12qz	1.88E-04	0.000333
13ux	1.30E-03	0.002125
13uy	1.21E-01	0.1128
13uz	7.20E-03	0.006888
13qx	1.20E-03	0.002058
13qy	4.12E-05	6.38E-05
13qz	4.52E-04	0.00082
14ux	3.40E-03	0.0052
14uy	1.73E-01	0.2053
14uz	7.30E-03	0.006959
14qx	6.48E-04	0.001209
14qy	2.39E-05	3.43E-05
14qz	4.08E-04	0.000741
15ux	3.30E-03	0.004883
15uy	1.65E-01	0.2101
15uz	7.40E-03	0.007028
15qx	7.01E-04	0.001073
15qy	2.40E-05	3.55E-05
15qz	3.65E-04	0.000661
16ux	2.72E-05	3.59E-05
16uy	8.66E-02	0.0864
16uz	7.50E-03	0.007095
16qx	2.10E-03	0.00392
16qy	6.34E-05	9.44E-05
16qz	3.21E-04	0.000582
17ux	7.00E-03	0.01026
17uy	2.28E-01	0.4317
17uz	7.50E-03	0.007161

17qx	2.50E-03	0.004679
17qy	8.86E-05	0.000129
17qz	2.77E-04	0.000503
18ux	1.30E-02	0.01886
18uy	3.79E-01	0.7235
18uz	7.60E-03	0.007224
18qx	9.57E-04	0.001794
18qy	4.38E-05	6.21E-05
18qz	2.34E-04	0.000424
19ux	1.33E-02	0.01929
19uy	3.66E-01	0.6986
19uz	7.70E-03	0.007285
19qx	1.20E-03	0.002324
19qy	3.57E-05	5.27E-05
19qz	1.92E-04	0.000346
20ux	7.70E-03	0.01106
20uy	2.00E-01	0.3793
20uz	7.70E-03	0.007343
20qx	2.50E-03	0.004675
20qy	8.98E-05	0.00013
20qz	1.51E-04	0.000269
21ux	1.46E-05	1.82E-05
21uy	4.40E-02	0.04387
21uz	7.80E-03	0.007398
21qx	1.60E-03	0.002992
21qy	7.68E-05	0.00011
21qz	1.12E-04	0.000193
22ux	4.40E-03	0.006293
22uy	6.47E-02	0.09605
22uz	7.80E-03	0.00745
22qx	1.14E-04	0.000162
22qy	3.20E-05	4.52E-05
22qz	7.85E-05	0.000124
23ux	5.80E-03	0.008258
23uy	3.25E-02	0.0321
23uz	7.80E-03	0.007499
23qx	6.46E-04	0.00118
23qy	1.52E-05	2.19E-05
23qz	6.21E-05	7.75E-05
24ux	4.70E-03	0.006861
24uy	2.84E-02	0.02655
24uz	6.30E-03	0.008907
24qx	9.87E-05	9.61E-05
24qy	2.32E-05	4.08E-05
24qz	7.67E-05	0.000107
25ux	0.00E+00	1.11E-05
25uy	2.84E-02	0.02654
25uz	0.00E+00	8.38E-07
25qx	1.02E-04	0.000153
25qy	2.16E-05	3.87E-05

25qz	7.34E-05	0.000115
26ux	5.20E-03	0.008773
26uy	2.83E-02	0.0265
26uz	7.20E-03	0.008976
26qx	5.10E-05	4.83E-05
26qy	1.93E-05	3.53E-05
26qz	2.00E-05	3.60E-05
27ux	3.20E-03	0.005573
27uy	2.82E-02	0.02646
27uz	1.01E-02	0.01052
27qx	4.06E-05	4.61E-05
27qy	1.78E-05	3.29E-05
27qz	7.56E-05	0.000128
28ux	3.27E-05	4.61E-05
28uy	2.71E-02	0.02703
28uz	1.07E-02	0.01069
28qx	3.91E-05	4.07E-05
28qy	1.63E-05	1.59E-05
28qz	1.23E-04	0.000233
29ux	2.54E-05	3.42E-05
29uy	2.85E-02	0.03161
29uz	1.17E-02	0.01148
29qx	4.17E-05	3.97E-05
29qy	1.18E-05	1.10E-05
29qz	3.46E-05	6.14E-05
30ux	1.83E-05	2.27E-05
30uy	2.92E-02	0.03201
30uz	1.19E-02	0.01176
30qx	4.51E-05	4.19E-05
30qy	0.00E+00	3.77E-06
30qz	2.92E-05	5.52E-05
31ux	1.14E-05	1.29E-05
31uy	2.82E-02	0.02914
31uz	1.13E-02	0.01124
31qx	4.94E-05	4.70E-05
31qy	1.34E-05	1.24E-05
31qz	4.51E-05	8.42E-05
32ux	0.00E+00	1.10E-05
32uy	2.71E-02	0.02703
32uz	1.07E-02	0.0107
32qx	5.42E-05	5.40E-05
32qy	0.00E+00	2.26E-08
32qz	0.00E+00	1.56E-09

Table 17a Maximum Element Forces and Moments for P-components of Benchmark Problem #4a (kips-inches)

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	1.5E+0	740.5E-3	1.2E+0	3.4E+0	1.2E+0	656.5E-3	1.1E+0
1Ri2	4.0E+0	236.4E-3	3.3E+0	7.3E+0	361.6E-3	1.1E+0	4.5E+0
1Ri3	12.1E+3	4.4E+3	8.8E+3	22.2E+3	6.3E+3	6.3E+3	10.0E+3
1Mi1	180.0E+0	70.4E+0	155.1E+0	388.4E+0	88.2E+0	82.6E+0	163.1E+0
1Mi2	12.4E+6	4.5E+6	9.0E+6	22.6E+6	6.4E+6	6.4E+6	10.2E+6
1Mi3	4.2E+3	246.3E+0	3.4E+3	7.5E+3	380.4E+0	1.1E+3	4.6E+3
1Rj1	1.5E+0	740.5E-3	1.2E+0	3.4E+0	1.2E+0	656.5E-3	1.1E+0
1Rj2	4.0E+0	236.4E-3	3.3E+0	7.3E+0	361.6E-3	1.1E+0	4.5E+0
1Rj3	12.1E+3	4.4E+3	8.8E+3	22.2E+3	6.3E+3	6.3E+3	10.0E+3
1Mj1	180.0E+0	70.4E+0	155.1E+0	388.4E+0	88.2E+0	82.6E+0	163.1E+0
1Mj2	9.7E+6	3.5E+6	7.1E+6	17.7E+6	5.0E+6	5.0E+6	8.0E+6
1Mj3	3.3E+3	194.0E+0	2.7E+3	5.9E+3	300.1E+0	893.5E+0	3.6E+3
2Ri1	1.4E+0	707.4E-3	1.1E+0	3.2E+0	1.1E+0	627.9E-3	1.1E+0
2Ri2	3.9E+0	230.3E-3	3.2E+0	7.1E+0	352.3E-3	1.1E+0	4.4E+0
2Ri3	11.8E+3	4.3E+3	8.6E+3	21.6E+3	6.2E+3	6.1E+3	9.7E+3
2Mi1	180.0E+0	70.4E+0	155.1E+0	388.4E+0	88.2E+0	82.6E+0	163.1E+0
2Mi2	9.7E+6	3.5E+6	7.1E+6	17.7E+6	5.0E+6	5.0E+6	8.0E+6
2Mi3	3.3E+3	194.0E+0	2.7E+3	5.9E+3	300.1E+0	893.5E+0	3.6E+3
2Rj1	1.4E+0	707.4E-3	1.1E+0	3.2E+0	1.1E+0	627.9E-3	1.1E+0
2Rj2	3.9E+0	230.3E-3	3.2E+0	7.1E+0	352.3E-3	1.1E+0	4.4E+0
2Rj3	11.8E+3	4.3E+3	8.6E+3	21.6E+3	6.2E+3	6.1E+3	9.7E+3
2Mj1	180.0E+0	70.4E+0	155.1E+0	388.4E+0	88.2E+0	82.6E+0	163.1E+0
2Mj2	7.0E+6	2.6E+6	5.1E+6	12.9E+6	3.7E+6	3.7E+6	5.8E+6
2Mj3	2.4E+3	143.1E+0	2.0E+3	4.3E+3	222.1E+0	655.0E+0	2.7E+3
3Ri1	1.5E+0	709.4E-3	1.3E+0	3.5E+0	1.1E+0	641.1E-3	1.2E+0
3Ri2	3.7E+0	215.5E-3	3.0E+0	6.5E+0	320.8E-3	990.7E-3	4.1E+0
3Ri3	11.1E+3	4.0E+3	8.1E+3	20.3E+3	5.8E+3	5.8E+3	9.1E+3
3Mi1	157.3E+0	63.8E+0	148.1E+0	369.6E+0	74.0E+0	66.8E+0	150.1E+0
3Mi2	7.0E+6	2.6E+6	5.1E+6	12.9E+6	3.7E+6	3.7E+6	5.8E+6
3Mi3	2.4E+3	147.1E+0	2.0E+3	4.3E+3	214.9E+0	644.5E+0	2.7E+3
3Rj1	1.5E+0	709.4E-3	1.3E+0	3.5E+0	1.1E+0	641.1E-3	1.2E+0
3Rj2	3.7E+0	215.5E-3	3.0E+0	6.5E+0	320.8E-3	990.7E-3	4.1E+0
3Rj3	11.1E+3	4.0E+3	8.1E+3	20.3E+3	5.8E+3	5.8E+3	9.1E+3
3Mj1	157.3E+0	63.8E+0	148.1E+0	369.6E+0	74.0E+0	66.8E+0	150.1E+0
3Mj2	5.0E+6	1.8E+6	3.6E+6	9.1E+6	2.6E+6	2.6E+6	4.1E+6
3Mj3	1.7E+3	107.4E+0	1.4E+3	3.1E+3	155.5E+0	460.3E+0	1.9E+3
4Ri1	1.3E+0	629.8E-3	1.2E+0	3.2E+0	924.1E-3	573.5E-3	1.1E+0
4Ri2	3.4E+0	200.6E-3	2.8E+0	6.0E+0	304.4E-3	912.4E-3	3.7E+0
4Ri3	9.9E+3	3.6E+3	7.2E+3	18.1E+3	5.2E+3	5.1E+3	8.2E+3
4Mi1	147.0E+0	55.4E+0	114.6E+0	288.2E+0	75.2E+0	72.8E+0	125.8E+0
4Mi2	5.0E+6	1.8E+6	3.6E+6	9.1E+6	2.6E+6	2.6E+6	4.1E+6
4Mi3	1.7E+3	107.4E+0	1.4E+3	3.1E+3	155.5E+0	460.3E+0	1.9E+3
4Rj1	1.3E+0	629.8E-3	1.2E+0	3.2E+0	924.1E-3	573.5E-3	1.1E+0
4Rj2	3.4E+0	200.6E-3	2.8E+0	6.0E+0	304.4E-3	912.4E-3	3.7E+0
4Rj3	9.9E+3	3.6E+3	7.2E+3	18.1E+3	5.2E+3	5.1E+3	8.2E+3

4Mj1	147.0E+0	55.4E+0	114.6E+0	288.2E+0	75.2E+0	72.8E+0	125.8E+0
4Mj2	2.9E+6	1.1E+6	2.1E+6	5.3E+6	1.5E+6	1.5E+6	2.4E+6
4Mj3	995.7E+0	65.4E+0	831.3E+0	1.8E+3	91.8E+0	268.7E+0	1.1E+3
5Ri1	1.2E+0	533.4E-3	1.1E+0	2.8E+0	758.6E-3	492.1E-3	1.0E+0
5Ri2	2.7E+0	162.3E-3	2.3E+0	4.9E+0	246.4E-3	746.1E-3	3.1E+0
5Ri3	8.1E+3	3.0E+3	5.9E+3	14.9E+3	4.2E+3	4.2E+3	6.7E+3
5Mi1	147.0E+0	55.4E+0	114.6E+0	288.2E+0	75.2E+0	72.8E+0	125.8E+0
5Mi2	2.9E+6	1.1E+6	2.1E+6	5.3E+6	1.5E+6	1.5E+6	2.4E+6
5Mi3	995.7E+0	65.4E+0	831.3E+0	1.8E+3	91.8E+0	268.7E+0	1.1E+3
5Rj1	1.2E+0	533.4E-3	1.1E+0	2.8E+0	758.6E-3	492.1E-3	1.0E+0
5Rj2	2.7E+0	162.3E-3	2.3E+0	4.9E+0	246.4E-3	746.1E-3	3.1E+0
5Rj3	8.1E+3	3.0E+3	5.9E+3	14.9E+3	4.2E+3	4.2E+3	6.7E+3
5Mj1	147.0E+0	55.4E+0	114.6E+0	288.2E+0	75.2E+0	72.8E+0	125.8E+0
5Mj2	1.2E+6	436.0E+3	871.0E+3	2.2E+6	622.0E+3	620.0E+3	984.0E+3
5Mj3	420.1E+0	31.7E+0	357.6E+0	786.9E+0	40.9E+0	112.3E+0	469.7E+0
6Ri1	972.0E-3	431.0E-3	918.6E-3	2.4E+0	576.8E-3	406.7E-3	892.7E-3
6Ri2	2.1E+0	138.0E-3	1.7E+0	3.8E+0	203.3E-3	561.5E-3	2.3E+0
6Ri3	5.8E+3	2.1E+3	4.2E+3	10.6E+3	3.0E+3	3.0E+3	4.8E+3
6Mi1	187.1E+0	66.6E+0	129.5E+0	325.8E+0	98.6E+0	99.7E+0	149.9E+0
6Mi2	1.2E+6	436.0E+3	871.0E+3	2.2E+6	622.0E+3	620.0E+3	984.0E+3
6Mi3	420.1E+0	31.7E+0	357.6E+0	786.9E+0	40.9E+0	112.3E+0	469.7E+0
6Rj1	972.0E-3	431.0E-3	918.6E-3	2.4E+0	576.8E-3	406.7E-3	892.7E-3
6Rj2	2.1E+0	138.0E-3	1.7E+0	3.8E+0	203.3E-3	561.5E-3	2.3E+0
6Rj3	5.8E+3	2.1E+3	4.2E+3	10.6E+3	3.0E+3	3.0E+3	4.8E+3
6Mj1	187.1E+0	66.6E+0	129.5E+0	325.8E+0	98.6E+0	99.7E+0	149.9E+0
6Mj2	413.9E+3	151.0E+3	302.0E+3	757.0E+3	215.0E+3	215.0E+3	341.0E+3
6Mj3	143.0E+0	13.2E+0	124.8E+0	274.9E+0	14.3E+0	36.7E+0	162.0E+0
7Ri1	823.0E-3	344.3E-3	810.8E-3	2.0E+0	413.0E-3	335.4E-3	794.1E-3
7Ri2	1.1E+0	77.6E-3	939.5E-3	2.1E+0	112.4E-3	304.0E-3	1.2E+0
7Ri3	3.1E+3	1.1E+3	2.2E+3	5.6E+3	1.6E+3	1.6E+3	2.5E+3
7Mi1	187.1E+0	66.6E+0	129.5E+0	325.8E+0	98.6E+0	99.7E+0	149.9E+0
7Mi2	413.9E+3	151.0E+3	302.0E+3	757.0E+3	215.0E+3	215.0E+3	341.0E+3
7Mi3	143.0E+0	13.2E+0	124.8E+0	274.9E+0	14.3E+0	36.7E+0	162.0E+0
7Rj1	823.0E-3	344.3E-3	810.8E-3	2.0E+0	413.0E-3	335.4E-3	794.1E-3
7Rj2	1.1E+0	77.6E-3	939.5E-3	2.1E+0	112.4E-3	304.0E-3	1.2E+0
7Rj3	3.1E+3	1.1E+3	2.2E+3	5.6E+3	1.6E+3	1.6E+3	2.5E+3
7Mj1	187.1E+0	66.6E+0	129.5E+0	325.8E+0	98.6E+0	99.7E+0	149.9E+0
7Mj2	34.5E+0	13.8E+0	33.4E+0	82.9E+0	15.6E+0	14.2E+0	33.4E+0
7Mj3	11.8E+0	4.0E+0	7.9E+0	20.6E+0	6.2E+0	6.4E+0	9.2E+0

Table 17b Maximum Element Forces and Moments for P-components of Benchmark Problem #4b (kips-inches)

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	11.0E+0	3.5E+0	5.6E+0	17.1E+0	3.9E+0	5.0E+0	6.6E+0
1Ri2	45.0E+3	30.1E+3	41.6E+3	104.0E+3	36.7E+3	29.1E+3	37.3E+3
1Ri3	77.9E+0	21.4E+0	32.5E+0	148.7E+0	32.6E+0	17.9E+0	53.6E+0
1Mi1	2.3E+3	2.4E+3	3.5E+3	5.4E+3	1.9E+3	1.7E+3	2.3E+3
1Mi2	13.0E+3	6.7E+3	8.3E+3	27.6E+3	6.4E+3	6.1E+3	11.6E+3
1Mi3	45.4E+6	30.6E+6	42.2E+6	106.0E+6	37.2E+6	29.6E+6	37.8E+6
1Rj1	11.0E+0	3.5E+0	5.6E+0	17.1E+0	3.9E+0	5.0E+0	6.6E+0
1Rj2	45.0E+3	30.1E+3	41.6E+3	104.0E+3	36.7E+3	29.1E+3	37.3E+3
1Rj3	77.9E+0	21.4E+0	32.5E+0	148.7E+0	32.6E+0	17.9E+0	53.6E+0
1Mj1	2.3E+3	2.4E+3	3.5E+3	5.4E+3	1.9E+3	1.7E+3	2.3E+3
1Mj2	5.5E+3	4.8E+3	5.5E+3	14.1E+3	3.4E+3	4.4E+3	7.0E+3
1Mj3	35.5E+6	24.0E+6	33.0E+6	82.7E+6	29.1E+6	23.2E+6	29.6E+6
2Ri1	10.2E+0	3.4E+0	5.5E+0	16.0E+0	3.7E+0	4.8E+0	6.2E+0
2Ri2	43.7E+3	29.4E+3	40.5E+3	102.0E+3	35.7E+3	28.4E+3	36.3E+3
2Ri3	56.0E+0	15.9E+0	24.0E+0	107.3E+0	23.8E+0	13.4E+0	39.0E+0
2Mi1	2.3E+3	2.4E+3	3.5E+3	5.4E+3	1.9E+3	1.7E+3	2.3E+3
2Mi2	5.5E+3	4.8E+3	5.5E+3	14.1E+3	3.4E+3	4.4E+3	7.0E+3
2Mi3	35.5E+6	24.0E+6	33.0E+6	82.7E+6	29.1E+6	23.2E+6	29.6E+6
2Rj1	10.2E+0	3.4E+0	5.5E+0	16.0E+0	3.7E+0	4.8E+0	6.2E+0
2Rj2	43.7E+3	29.4E+3	40.5E+3	102.0E+3	35.7E+3	28.4E+3	36.3E+3
2Rj3	56.0E+0	15.9E+0	24.0E+0	107.3E+0	23.8E+0	13.4E+0	39.0E+0
2Mj1	2.3E+3	2.4E+3	3.5E+3	5.4E+3	1.9E+3	1.7E+3	2.3E+3
2Mj2	17.3E+3	5.7E+3	8.0E+3	33.6E+3	7.5E+3	5.0E+3	12.6E+3
2Mj3	25.9E+6	17.5E+6	24.1E+6	60.3E+6	21.2E+6	16.9E+6	21.6E+6
3Ri1	13.0E+0	2.7E+0	4.4E+0	18.8E+0	3.5E+0	4.4E+0	6.7E+0
3Ri2	40.8E+3	27.5E+3	37.9E+3	95.0E+3	33.4E+3	26.6E+3	33.9E+3
3Ri3	24.3E+0	7.7E+0	10.8E+0	47.0E+0	10.1E+0	7.0E+0	17.3E+0
3Mi1	2.9E+3	3.4E+3	4.9E+3	7.1E+3	2.5E+3	2.3E+3	3.1E+3
3Mi2	16.8E+3	5.7E+3	8.0E+3	33.0E+3	7.5E+3	4.9E+3	12.4E+3
3Mi3	25.9E+6	17.5E+6	24.1E+6	60.3E+6	21.2E+6	16.9E+6	21.6E+6
3Rj1	13.0E+0	2.7E+0	4.4E+0	18.8E+0	3.5E+0	4.4E+0	6.7E+0
3Rj2	40.8E+3	27.5E+3	37.9E+3	95.0E+3	33.4E+3	26.6E+3	33.9E+3
3Rj3	24.3E+0	7.7E+0	10.8E+0	47.0E+0	10.1E+0	7.0E+0	17.3E+0
3Mj1	2.9E+3	3.4E+3	4.9E+3	7.1E+3	2.5E+3	2.3E+3	3.1E+3
3Mj2	21.2E+3	6.2E+3	9.2E+3	40.8E+3	9.0E+3	5.2E+3	14.8E+3
3Mj3	18.4E+6	12.4E+6	17.0E+6	42.8E+6	15.0E+6	12.0E+6	15.3E+6
4Ri1	10.3E+0	2.4E+0	3.9E+0	15.1E+0	3.0E+0	3.7E+0	5.4E+0
4Ri2	36.4E+3	24.5E+3	33.8E+3	84.7E+3	29.8E+3	23.7E+3	30.3E+3
4Ri3	14.8E+0	6.3E+0	8.3E+0	29.9E+0	7.1E+0	5.5E+0	12.0E+0
4Mi1	1.6E+3	1.6E+3	2.2E+3	3.9E+3	1.4E+3	1.2E+3	1.6E+3
4Mi2	21.2E+3	6.2E+3	9.2E+3	40.8E+3	9.0E+3	5.2E+3	14.8E+3
4Mi3	18.4E+6	12.4E+6	17.0E+6	42.8E+6	15.0E+6	12.0E+6	15.3E+6
4Rj1	10.3E+0	2.4E+0	3.9E+0	15.1E+0	3.0E+0	3.7E+0	5.4E+0
4Rj2	36.4E+3	24.5E+3	33.8E+3	84.7E+3	29.8E+3	23.7E+3	30.3E+3
4Rj3	14.8E+0	6.3E+0	8.3E+0	29.9E+0	7.1E+0	5.5E+0	12.0E+0
4Mj1	1.6E+3	1.6E+3	2.2E+3	3.9E+3	1.4E+3	1.2E+3	1.6E+3
4Mj2	18.1E+3	5.1E+3	7.7E+3	34.8E+3	7.6E+3	4.3E+3	12.5E+3
4Mj3	10.8E+6	7.2E+6	10.0E+6	25.0E+6	8.8E+6	7.0E+6	8.9E+6
5Ri1	6.8E+0	2.1E+0	3.3E+0	10.4E+0	2.3E+0	2.8E+0	3.9E+0

5Ri2	30.1E+3	20.2E+3	27.9E+3	69.9E+3	24.6E+3	19.5E+3	25.0E+3
5Ri3	40.9E+0	11.3E+0	17.0E+0	78.0E+0	16.8E+0	9.6E+0	28.1E+0
5Mi1	1.6E+3	1.6E+3	2.2E+3	3.9E+3	1.4E+3	1.2E+3	1.6E+3
5Mi2	18.1E+3	5.1E+3	7.7E+3	34.8E+3	7.6E+3	4.3E+3	12.5E+3
5Mi3	10.8E+6	7.2E+6	10.0E+6	25.0E+6	8.8E+6	7.0E+6	8.9E+6
5Rj1	6.8E+0	2.1E+0	3.3E+0	10.4E+0	2.3E+0	2.8E+0	3.9E+0
5Rj2	30.1E+3	20.2E+3	27.9E+3	69.9E+3	24.6E+3	19.5E+3	25.0E+3
5Rj3	40.9E+0	11.3E+0	17.0E+0	78.0E+0	16.8E+0	9.6E+0	28.1E+0
5Mj1	1.6E+3	1.6E+3	2.2E+3	3.9E+3	1.4E+3	1.2E+3	1.6E+3
5Mj2	9.6E+3	2.7E+3	4.1E+3	18.4E+3	4.1E+3	2.3E+3	6.6E+3
5Mj3	4.5E+6	3.0E+6	4.1E+6	10.3E+6	3.6E+6	2.9E+6	3.7E+6
6Ri1	3.4E+0	1.8E+0	2.8E+0	6.1E+0	1.7E+0	1.9E+0	2.4E+0
6Ri2	21.5E+3	14.4E+3	19.9E+3	49.9E+3	17.6E+3	13.9E+3	17.9E+3
6Ri3	43.9E+0	11.8E+0	17.8E+0	83.6E+0	17.8E+0	9.9E+0	29.9E+0
6Mi1	602.0E+0	298.7E+0	438.8E+0	1.3E+3	457.4E+0	303.4E+0	370.9E+0
6Mi2	9.6E+3	2.7E+3	4.1E+3	18.4E+3	4.1E+3	2.3E+3	6.6E+3
6Mi3	4.5E+6	3.0E+6	4.1E+6	10.3E+6	3.6E+6	2.9E+6	3.7E+6
6Rj1	3.4E+0	1.8E+0	2.8E+0	6.1E+0	1.7E+0	1.9E+0	2.4E+0
6Rj2	21.5E+3	14.4E+3	19.9E+3	49.9E+3	17.6E+3	13.9E+3	17.9E+3
6Rj3	43.9E+0	11.8E+0	17.8E+0	83.6E+0	17.8E+0	9.9E+0	29.9E+0
6Mj1	602.0E+0	298.7E+0	438.8E+0	1.3E+3	457.4E+0	303.4E+0	370.9E+0
6Mj2	3.6E+3	1.1E+3	1.7E+3	7.2E+3	1.7E+3	919.2E+0	2.6E+3
6Mj3	1.6E+6	1.0E+6	1.4E+6	3.6E+6	1.3E+6	998.0E+3	1.3E+6
7Ri1	3.6E+0	1.6E+0	2.5E+0	5.9E+0	1.4E+0	1.4E+0	2.2E+0
7Ri2	11.5E+3	7.7E+3	10.6E+3	26.6E+3	9.4E+3	7.4E+3	9.5E+3
7Ri3	29.6E+0	7.8E+0	11.9E+0	56.2E+0	12.0E+0	6.6E+0	20.0E+0
7Mi1	602.0E+0	298.7E+0	438.8E+0	1.3E+3	457.4E+0	303.4E+0	370.9E+0
7Mi2	3.6E+3	1.1E+3	1.7E+3	7.2E+3	1.7E+3	919.2E+0	2.6E+3
7Mi3	1.6E+6	1.0E+6	1.4E+6	3.6E+6	1.3E+6	998.0E+3	1.3E+6
7Rj1	3.6E+0	1.6E+0	2.5E+0	5.9E+0	1.4E+0	1.4E+0	2.2E+0
7Rj2	11.5E+3	7.7E+3	10.6E+3	26.6E+3	9.4E+3	7.4E+3	9.5E+3
7Rj3	29.6E+0	7.8E+0	11.9E+0	56.2E+0	12.0E+0	6.6E+0	20.0E+0
7Mj1	602.0E+0	298.7E+0	438.8E+0	1.3E+3	457.4E+0	303.4E+0	370.9E+0
7Mj2	554.7E+0	133.5E+0	205.2E+0	786.8E+0	134.5E+0	120.1E+0	267.4E+0
7Mj3	323.5E+0	298.9E+0	433.9E+0	642.2E+0	202.3E+0	190.1E+0	279.9E+0

Table 17c Maximum Element Forces and Moments for P-components of Benchmark Problem #4a, Case a, 16 Bits Vs. 32 Bits
(kips-inches)

Elements	16 Bits	32 Bits
1Ri1	1.50E+00	1.42E+00
1Ri2	4.00E+00	4.92E+00
1Ri3	1.21E+04	1.21E+04
1Mi1	1.80E+02	1.76E+02
1Mi2	1.24E+07	1.23E+07
1Mi3	4.20E+03	5.05E+03
1Rj1	1.50E+00	1.42E+00
1Rj2	4.00E+00	4.92E+00
1Rj3	1.21E+04	1.21E+04
1Mj1	1.80E+02	1.76E+02
1Mj2	9.70E+06	9.65E+06
1Mj3	3.30E+03	3.96E+03
2Ri1	1.40E+00	1.36E+00
2Ri2	3.90E+00	4.80E+00
2Ri3	1.18E+04	1.18E+04
2Mi1	1.80E+02	1.76E+02
2Mi2	9.70E+06	9.65E+06
2Mi3	3.30E+03	3.96E+03
2Rj1	1.40E+00	1.36E+00
2Rj2	3.90E+00	4.80E+00
2Rj3	1.18E+04	1.18E+04
2Mj1	1.80E+02	1.76E+02
2Mj2	7.00E+06	7.03E+06
2Mj3	2.40E+03	2.89E+03
3Ri1	1.50E+00	1.67E+00
3Ri2	3.70E+00	4.46E+00
3Ri3	1.11E+04	1.11E+04
3Mi1	1.57E+02	1.84E+02
3Mi2	7.00E+06	7.03E+06
3Mi3	2.40E+03	2.87E+03
3Rj1	1.50E+00	1.67E+00
3Rj2	3.70E+00	4.46E+00
3Rj3	1.11E+04	1.11E+04
3Mj1	1.57E+02	1.84E+02
3Mj2	5.00E+06	4.97E+06
3Mj3	1.70E+03	2.04E+03
4Ri1	1.30E+00	1.54E+00
4Ri2	3.40E+00	4.05E+00
4Ri3	9.90E+03	9.88E+03
4Mi1	1.47E+02	1.39E+02
4Mi2	5.00E+06	4.97E+06
4Mi3	1.70E+03	2.04E+03

4Rj1	1.30E+00	1.54E+00
4Rj2	3.40E+00	4.05E+00
4Rj3	9.90E+03	9.88E+03
4Mj1	1.47E+02	1.39E+02
4Mj2	2.90E+06	2.90E+06
4Mj3	9.96E+02	1.19E+03
5Ri1	1.20E+00	1.40E+00
5Ri2	2.70E+00	3.32E+00
5Ri3	8.10E+03	8.12E+03
5Mi1	1.47E+02	1.39E+02
5Mi2	2.90E+06	2.90E+06
5Mi3	9.96E+02	1.19E+03
5Rj1	1.20E+00	1.40E+00
5Rj2	2.70E+00	3.32E+00
5Rj3	8.10E+03	8.12E+03
5Mj1	1.47E+02	1.39E+02
5Mj2	1.20E+06	1.19E+06
5Mj3	4.20E+02	4.97E+02
6Ri1	9.72E-01	1.25E+00
6Ri2	2.10E+00	2.43E+00
6Ri3	5.80E+03	5.77E+03
6Mi1	1.87E+02	2.00E+02
6Mi2	1.20E+06	1.19E+06
6Mi3	4.20E+02	4.97E+02
6Rj1	9.72E-01	1.25E+00
6Rj2	2.10E+00	2.43E+00
6Rj3	5.80E+03	5.77E+03
6Mj1	1.87E+02	2.00E+02
6Mj2	4.14E+05	4.13E+05
6Mj3	1.43E+02	1.69E+02
7Ri1	8.23E-01	1.13E+00
7Ri2	1.10E+00	1.31E+00
7Ri3	3.10E+03	3.06E+03
7Mi1	1.87E+02	2.00E+02
7Mi2	4.14E+05	4.13E+05
7Mi3	1.43E+02	1.69E+02
7Rj1	8.23E-01	1.13E+00
7Rj2	1.10E+00	1.31E+00
7Rj3	3.10E+03	3.06E+03
7Mj1	1.87E+02	2.00E+02
7Mj2	3.45E+01	4.19E+01
7Mj3	1.18E+01	1.80E+01

Table 18a Maximum Element Forces and Moments for Joint Elements of Benchmark Problem #4a (kips-inches)

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	252.3E-3	95.7E-3	157.5E-3	406.7E-3	150.2E-3	145.5E-3	192.3E-3
1Ri2	64.0E-3	22.0E-3	44.6E-3	117.0E-3	33.6E-3	34.0E-3	51.0E-3
1Ri3	894.1E-3	317.4E-3	610.9E-3	1.5E+0	474.4E-3	480.7E-3	711.4E-3
1Mi1	25.1E+0	10.1E+0	25.5E+0	62.9E+0	11.3E+0	10.6E+0	24.8E+0
1Mi2	39.1E+0	13.8E+0	25.3E+0	64.1E+0	21.3E+0	21.7E+0	30.2E+0
1Mi3	5.5E+0	2.1E+0	5.6E+0	13.9E+0	2.3E+0	2.1E+0	5.5E+0
1Rj1	252.3E-3	95.7E-3	157.5E-3	406.7E-3	150.2E-3	145.5E-3	192.3E-3
1Rj2	64.0E-3	22.0E-3	44.6E-3	117.0E-3	33.6E-3	34.0E-3	51.0E-3
1Rj3	894.1E-3	317.4E-3	610.9E-3	1.5E+0	474.4E-3	480.7E-3	711.4E-3
1Mj1	25.1E+0	10.1E+0	25.5E+0	62.9E+0	11.3E+0	10.6E+0	24.8E+0
1Mj2	187.1E+0	66.6E+0	129.5E+0	325.8E+0	98.6E+0	99.7E+0	149.9E+0
1Mj3	17.4E+0	6.4E+0	14.1E+0	35.8E+0	9.0E+0	9.0E+0	14.9E+0
2Ri1	118.7E-3	45.2E-3	72.3E-3	188.8E-3	72.5E-3	69.7E-3	89.5E-3
2Ri2	91.8E-3	33.5E-3	69.6E-3	173.9E-3	46.5E-3	46.3E-3	77.2E-3
2Ri3	202.3E-3	69.0E-3	132.4E-3	332.3E-3	109.4E-3	114.8E-3	155.5E-3
2Mi1	2.3E+0	848.8E-3	1.9E+0	4.8E+0	1,1E+0	1.0E+0	2.0E+0
2Mi2	11.8E+0	4.2E+0	8.4E+0	21.1E+0	6.6E+0	6.7E+0	9.4E+0
2Mi3	3.5E+0	1.2E+0	2.6E+0	6.4E+0	1.8E+0	1.8E+0	2.9E+0
2Rj1	118.7E-3	45.2E-3	72.3E-3	188.8E-3	72.5E-3	69.7E-3	89.5E-3
2Rj2	91.8E-3	33.5E-3	69.6E-3	173.9E-3	46.5E-3	46.3E-3	77.2E-3
2Rj3	202.3E-3	69.0E-3	132.4E-3	332.3E-3	109.4E-3	114.8E-3	155.5E-3
2Mj1	2.3E+0	848.8E-3	1.9E+0	4.8E+0	1.1E+0	1.0E+0	2.0E+0
2Mj2	51.6E+0	17.4E+0	33.5E+0	84.1E+0	27.6E+0	29.1E+0	39.6E+0
2Mj3	25.1E+0	9.2E+0	19.1E+0	47.7E+0	12.7E+0	12.6E+0	21.2E+0
3Ri1	2.2E+0	867.7E-3	2.1E+0	5.2E+0	973.1E-3	898.9E-3	2.1E+0
3Ri2	761.2E-3	308.1E-3	770.8E-3	1.9E+0	337.0E-3	307.1E-3	755.5E-3
3Ri3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3Mi1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3Mi2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3Mi3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3Rj1	2.2E+0	867.7E-3	2.1E+0	5.2E+0	973.1E-3	898.9E-3	2.1E+0
3Rj2	761.2E-3	308.1E-3	770.8E-3	1.9E+0	337.0E-3	307.1E-3	755.5E-3
3Rj3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3Mj1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3Mj2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3Mj3	59.4E+0	24.0E+0	60.1E+0	148.8E+0	26.3E+0	24.0E+0	58.9E+0
4Ri1	3.3E+0	1.2E+0	2.5E+0	6.2E+0	1.8E+0	1.8E+0	2.7E+0
4Ri2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
4Ri3	774.2E-3	263.8E-3	539.6E-3	1.4E+0	406.0E-3	429.6E-3	611.5E-3
4Mi1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
4Mi2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
4Mi3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
4Rj1	3:3E+0	1.2E+0	2.5E+0	6.2E+0	1.8E+0	1.8E+0	2.7E+0
4Rj2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
4Rj3	774.2E-3	263.8E-3	539.6E-3	1.4E+0	406.0E-3	429.6E-3	611.5E-3

4Mj1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
4Mj2	62.0E+0	21.1E+0	43.2E+0	108.4E+0	32.5E+0	34.4E+0	49.0E+0
4Mj3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5Ri1	4.1E+0	1.6E+0	3.8E+0	9.3E+0	2.1E+0	2.1E+0	3.8E+0
5Ri2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5Ri3	955.0E-3	353.1E-3	814.6E-3	2.0E+0	476.6E-3	490.6E-3	840.0E-3
5Mi1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5Mi2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5Mi3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5Rj1	4.1E+0	1.6E+0	3.8E+0	9.3E+0	2.1E+0	2.1E+0	3.8E+0
5Rj2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5Rj3	955.0E-3	353.1E-3	814.6E-3	2.0E+0	476.6E-3	490.6E-3	840.0E-3
5Mj1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5Mj2	76.5E+0	28.3E+0	65.2E+0	161.7E+0	38.2E+0	39.3E+0	67.2E+0
5Mj3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6Ri1	89.2E-3	24.3E-3	64.6E-3	160.4E-3	35.3E-3	41.8E-3	72.6E-3
6Ri2	537.7E-3	207.9E-3	506.7E-3	1.3E+0	265.3E-3	261.7E-3	502.2E-3
6Ri3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6Mi1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6Mi2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6Mi3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6Rj1	89.2E-3	24.3E-3	64.6E-3	160.4E-3	35.3E-3	41.8E-3	72.6E-3
6Rj2	537.7E-3	207.9E-3	506.7E-3	1.3E+0	265.3E-3	261.7E-3	502.2E-3
6Rj3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6Mj1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6Mj2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6Mj3	9.7E+0	3.7E+0	9.1E+0	22.5E+0	4.8E+0	4.7E+0	9.0E+0
7Ri1	1.8E+0	727.2E-3	1.9E+0	4.6E+0	796.9E-3	742.5E-3	1.8E+0
7Ri2	146.6E-3	52.3E-3	93.4E-3	237.4E-3	82.0E-3	82.7E-3	112.5E-3
7Ri3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7Mi1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7Mi2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7Mi3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7Rj1	1.8E+0	727.2E-3	1.9E+0	4.6E+0	796.9E-3	742.5E-3	1.8E+0
7Rj2	146.6E-3	52.3E-3	93.4E-3	237.4E-3	82.0E-3	82.7E-3	112.5E-3
7Rj3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7Mj1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7Mj2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7Mj3	29.0E+0	10.4E+0	18.5E+0	47.0E+0	16.2E+0	16.4E+0	22.3E+0

Table 18b Maximum Element Forces and Moments for Joint Elements of Benchmark Problem #4b (kips-inches)

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	7.3E+0	3.0E+0	4.3E+0	15.9E+0	5.5E+0	3.7E+0	4.4E+0
1Ri2	1.8E+0	1.8E+0	2.6E+0	3.7E+0	1.2E+0	1.1E+0	1.6E+0
1Ri3	2.4E+0	1.3E+0	1.9E+0	5.2E+0	1.8E+0	1.2E+0	1.5E+0
1Mi1	33.3E+0	33.7E+0	49.7E+0	65.6E+0	20.2E+0	19.7E+0	29.5E+0
1Mi2	24.7E+0	34.2E+0	49.9E+0	59.9E+0	20.8E+0	20.2E+0	28.3E+0
1Mi3	114.8E+0	118.0E+0	172.1E+0	236.9E+0	75.8E+0	71.9E+0	104.9E+0
1Rj1	7.3E+0	3.0E+0	4.3E+0	15.9E+0	5.5E+0	3.7E+0	4.4E+0
1Rj2	1.8E+0	1.8E+0	2.6E+0	3.7E+0	1.2E+0	1.1E+0	1.6E+0
1Rj3	2.4E+0	1.3E+0	1.9E+0	5.2E+0	1.8E+0	1.2E+0	1.5E+0
1Mj1	33.3E+0	33.7E+0	49.7E+0	65.6E+0	20.2E+0	19.7E+0	29.5E+0
1Mj2	602.0E+0	298.7E+0	438.8E+0	1.3E+3	457.4E+0	303.4E+0	370.9E+0
1Mj3	350.8E+0	325.2E+0	472.3E+0	696.2E+0	219.1E+0	206.2E+0	303.8E+0
2Ri1	4.2E+0	5.0E+0	7.3E+0	10.2E+0	3.7E+0	3.3E+0	4.6E+0
2Ri2	732.7E-3	200.1E-3	304.5E-3	1.1E+0	285.3E-3	178.0E-3	355.5E-3
2Ri3	4.5E+0	3.6E+0	5.4E+0	9.6E+0	3.6E+0	2.6E+0	4.0E+0
2Mi1	19.2E+0	12.0E+0	17.9E+0	33.9E+0	10.4E+0	7.7E+0	12.5E+0
2Mi2	136.5E+0	73.9E+0	112.5E+0	265.0E+0	88.8E+0	56.7E+0	101.9E+0
2Mi3	37.7E+0	13.6E+0	20.2E+0	55.7E+0	12.5E+0	9.2E+0	19.0E+0
2Rj1	4.2E+0	5.0E+0	7.3E+0	10.2E+0	3.7E+0	3.3E+0	4.6E+0
2Rj2	732.7E-3	200.1E-3	304.5E-3	1.1E+0	285.3E-3	178.0E-3	355.5E-3
2Rj3	4.5E+0	3.6E+0	5.4E+0	9.6E+0	3.6E+0	2.6E+0	4.0E+0
2Mj1	19.2E+0	12.0E+0	17.9E+0	33.9E+0	10.4E+0	7.7E+0	12.5E+0
2Mj2	1.3E+3	1.2E+3	1.7E+3	2.9E+3	1.1E+3	804.4E+0	1.2E+3
2Mj3	191.4E+0	50.4E+0	76.6E+0	296.1E+0	77.9E+0	48.1E+0	93.3E+0
3Ri1	357.3E-3	593.5E-3	892.2E-3	869.9E-3	300.7E-3	313.1E-3	453.7E-3
3Ri2	6.2E+0	3.2E+0	4.8E+0	9.7E+0	2.2E+0	2.1E+0	3.7E+0
3Ri3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3Mi1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3Mi2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3Mi3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3Rj1	357.3E-3	593.5E-3	892.2E-3	869.9E-3	300.7E-3	313.1E-3	453.7E-3
3Rj2	6.2E+0	3.2E+0	4.8E+0	9.7E+0	2.2E+0	2.1E+0	3.7E+0
3Rj3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3Mj1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3Mj2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
3Mj3	485.2E+0	251.0E+0	372.2E+0	758.8E+0	174.7E+0	167.0E+0	287.7E+0
4Ri1	4.0E+0	4.7E+0	6.8E+0	9.8E+0	3.5E+0	3.2E+0	4.4E+0
4Ri2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
4Ri3	17.4E+0	22.0E+0	31.6E+0	42.9E+0	15.2E+0	14.3E+0	19.6E+0
4Mi1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
4Mi2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
4Mi3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
4Rj1	4.0E+0	4.7E+0	6.8E+0	9.8E+0	3.5E+0	3.2E+0	4.4E+0
4Rj2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
4Rj3	17.4E+0	22.0E+0	31.6E+0	42.9E+0	15.2E+0	14.3E+0	19.6E+0

4Mj1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
4Mj2	1.4E+3	1.8E+3	2.5E+3	3.4E+3	1.2E+3	1.1E+3	1.6E+3
4Mj3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5Ri1	3.9E+0	4.8E+0	6.8E+0	9.7E+0	3.4E+0	3.1E+0	4.3E+0
5Ri2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5Ri3	17.2E+0	23.1E+0	33.3E+0	42.5E+0	15.1E+0	14.4E+0	19.8E+0
5Mi1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5Mi2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5Mi3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5Rj1	3.9E+0	4.8E+0	6.8E+0	9.7E+0	3.4E+0	3.1E+0	4.3E+0
5Rj2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5Rj3	17.2E+0	23.1E+0	33.3E+0	42.5E+0	15.1E+0	14.4E+0	19.8E+0
5Mj1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
5Mj2	1.4E+3	1.8E+3	2.7E+3	3.4E+3	1.2E+3	1.2E+3	1.6E+3
5Mj3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6Ri1	10.3E+0	13.0E+0	19.0E+0	24.2E+0	8.5E+0	7.8E+0	11.1E+0
6Ri2	3.4E+0	1.7E+0	2.4E+0	5.3E+0	1.2E+0	1.1E+0	2.0E+0
6Ri3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6Mi1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6Mi2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6Mi3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6Rj1	10.3E+0	13.0E+0	19.0E+0	24.2E+0	8.5E+0	7.8E+0	11.1E+0
6Rj2	3.4E+0	1.7E+0	2.4E+0	5.3E+0	1.2E+0	1.1E+0	2.0E+0
6Rj3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6Mj1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6Mj2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
6Mj3	61.6E+0	29.8E+0	43.6E+0	95.6E+0	21.3E+0	19.6E+0	35.3E+0
7Ri1	6.7E+0	2.5E+0	4.0E+0	12.6E+0	3.8E+0	2.3E+0	4.5E+0
7Ri2	2.3E+0	790.9E-3	1.2E+0	3.4E+0	636.0E-3	558.0E-3	1.2E+0
7Ri3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7Mi1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7Mi2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7Mi3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7Rj1	6.7E+0	2.5E+0	4.0E+0	12.6E+0	3.8E+0	2.3E+0	4.5E+0
7Rj2	2.3E+0	790.9E-3	1.2E+0	3.4E+0	636.0E-3	558.0E-3	1.2E+0
7Rj3	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7Mj1	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7Mj2	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0	000.0E+0
7Mj3	461.1E+0	156.6E+0	230.5E+0	665.4E+0	125.9E+0	110.5E+0	230.7E+0

Table 18c Maximum Element Forces and Moments for Joint Elements of Benchmark Problem #4a, Case a, 16 Bits Vs. 32 Bits (kips-inches)

Elements	16 Bits	32 Bits
1Ri1	2.52E-01	3.28E-01
1Ri2	6.40E-02	1.03E-01
1Ri3	8.94E-01	9.80E-01
1Mi1	2.51E+01	4.26E+01
1Mi2	3.91E+01	4.81E+01
1Mi3	5.50E+00	7.57E+00
1Rj1	2.52E-01	3.28E-01
1Rj2	6.40E-02	1.03E-01
1Rj3	8.94E-01	9.80E-01
1Mj1	2.51E+01	4.26E+01
1Mj2	1.87E+02	2.00E+02
1Mj3	1.74E+01	3.12E+01
2Ri1	1.19E-01	1.67E-01
2Ri2	9.18E-02	8.78E-02
2Ri3	2.02E-01	3.11E-01
2Mi1	2.30E+00	2.12E+00
2Mi2	1.18E+01	2.08E+01
2Mi3	3.50E+00	3.39E+00
2Rj1	1.19E-01	1.67E-01
2Rj2	9.18E-02	8.78E-02
2Rj3	2.02E-01	3.11E-01
2Mj1	2.30E+00	2.12E+00
2Mj2	5.16E+01	7.62E+01
2Mj3	2.51E+01	2.39E+01
3Ri1	2.20E+00	2.61E+00
3Ri2	7.61E-01	1.13E+00
3Ri3	0.00E+00	0.00E+00
3Mi1	0.00E+00	0.00E+00
3Mi2	0.00E+00	0.00E+00
3Mi3	0.00E+00	0.00E+00
3Rj1	2.20E+00	2.61E+00
3Rj2	7.61E-01	1.13E+00
3Rj3	0.00E+00	0.00E+00
3Mj1	0.00E+00	0.00E+00
3Mj2	0.00E+00	0.00E+00
3Mj3	5.94E+01	8.83E+01
4Ri1	3.30E+00	5.99E+00
4Ri2	0.00E+00	0.00E+00
4Ri3	7.74E-01	1.28E+00
4Mi1	0.00E+00	0.00E+00
4Mi2	0.00E+00	0.00E+00
4Mi3	0.00E+00	0.00E+00
4Rj1	3.30E+00	5.99E+00

4Rj2	0.00E+00	0.00E+00
4Rj3	7.74E-01	1.28E+00
4Mj1	0.00E+00	0.00E+00
4Mj2	6.20E+01	1.02E+02
4Mj3	0.00E+00	0.00E+00
5Ri1	4.10E+00	7.91E+00
5Ri2	0.00E+00	0.00E+00
5Ri3	9.55E-01	1.77E+00
5Mi1	0.00E+00	0.00E+00
5Mi2	0.00E+00	0.00E+00
5Mi3	0.00E+00	0.00E+00
5Rj1	4.10E+00	7.91E+00
5Rj2	0.00E+00	0.00E+00
5Rj3	9.55E-01	1.77E+00
5Mj1	0.00E+00	0.00E+00
5Mj2	7.65E+01	1.42E+02
5Mj3	0.00E+00	0.00E+00
6Ri1	8.92E-02	1.35E-01
6Ri2	5.38E-01	1.02E+00
6Ri3	0.00E+00	0.00E+00
6Mi1	0.00E+00	0.00E+00
6Mi2	0.00E+00	0.00E+00
6Mi3	0.00E+00	0.00E+00
6Rj1	8.92E-02	1.35E-01
6Rj2	5.38E-01	1.02E+00
6Rj3	0.00E+00	0.00E+00
6Mj1	0.00E+00	0.00E+00
6Mj2	0.00E+00	0.00E+00
6Mj3	9.70E+00	1.84E+01
7Ri1	1.80E+00	2.95E+00
7Ri2	1.47E-01	1.88E-01
7Ri3	0.00E+00	0.00E+00
7Mi1	0.00E+00	0.00E+00
7Mi2	0.00E+00	0.00E+00
7Mi3	0.00E+00	0.00E+00
7Rj1	1.80E+00	2.95E+00
7Rj2	1.47E-01	1.88E-01
7Rj3	0.00E+00	0.00E+00
7Mj1	0.00E+00	0.00E+00
7Mj2	0.00E+00	0.00E+00
7Mj3	2.90E+01	3.72E+01

Table 19a Maximum Element Forces and Moments for S-components of Benchmark Problem #4a (kips-inches)

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	60.4E-3	19.2E-3	57.8E-3	147.1E-3	24.1E-3	20.7E-3	57.8E-3
1Ri2	671.1E-3	238.0E-3	444.4E-3	1.1E+0	363.3E-3	368.2E-3	525.3E-3
1Ri3	56.2E-3	20.1E-3	42.7E-3	112.1E-3	29.1E-3	28.5E-3	46.8E-3
1Mi1	25.4E+0	10.2E+0	25.9E+0	63.9E+0	11.3E+0	10.6E+0	25.2E+0
1Mi2	4.0E+0	1.5E+0	3.2E+0	8.5E+0	2.0E+0	1.9E+0	3.5E+0
1Mi3	39.1E+0	13.8E+0	25.3E+0	64.1E+0	21.3E+0	21.7E+0	30.2E+0
1Rj1	60.4E-3	19.2E-3	57.8E-3	147.1E-3	24.1E-3	20.7E-3	57.8E-3
1Rj2	671.1E-3	238.0E-3	444.4E-3	1.1E+0	363.3E-3	368.2E-3	525.3E-3
1Rj3	56.2E-3	20.1E-3	42.7E-3	112.1E-3	29.1E-3	28.5E-3	46.8E-3
1Mj1	25.4E+0	10.2E+0	25.9E+0	63.9E+0	11.3E+0	10.6E+0	25.2E+0
1Mj2	869.7E-3	305.9E-3	581.5E-3	1.5E+0	463.7E-3	461.4E-3	686.8E-3
1Mj3	15.0E+0	5.4E+0	10.7E+0	27.0E+0	7.9E+0	7.9E+0	12.2E+0
2Ri1	60.1E-3	19.1E-3	57.6E-3	146.6E-3	24.0E-3	20.6E-3	57.5E-3
2Ri2	165.2E-3	59.0E-3	121.0E-3	303.8E-3	90.3E-3	92.4E-3	133.4E-3
2Ri3	45.2E-3	18.1E-3	42.2E-3	107.4E-3	21.7E-3	19.7E-3	42.6E-3
2Mi1	25.4E+0	10.2E+0	25.9E+0	63.9E+0	11.3E+0	10.6E+0	25.2E+0
2Mi2	869.7E-3	305.9E-3	581.5E-3	1.5E+0	463.7E-3	461.4E-3	686.8E-3
2Mi3	15.0E+0	5.4E+0	10.7E+0	27.0E+0	7.9E+0	7.9E+0	12.2E+0
2Rj1	60.1E-3	19.1E-3	57.6E-3	146.6E-3	24.0E-3	20.6E-3	57.5E-3
2Rj2	165.2E-3	59.0E-3	121.0E-3	303.8E-3	90.3E-3	92.4E-3	133.4E-3
2Rj3	45.2E-3	18.1E-3	42.2E-3	107.4E-3	21.7E-3	19.7E-3	42.6E-3
2Mj1	25.4E+0	10.2E+0	25.9E+0	63.9E+0	11.3E+0	10.6E+0	25.2E+0
2Mj2	3.8E+0	1.5E+0	3.3E+0	8.6E+0	1.9E+0	1.7E+0	3.4E+0
2Mj3	25.3E+0	8.8E+0	16.1E+0	40.7E+0	14.1E+0	14.4E+0	19.3E+0
3Ri1	59.7E-3	19.0E-3	57.3E-3	145.8E-3	23.9E-3	20.5E-3	57.1E-3
3Ri2	480.7E-3	181.0E-3	390.4E-3	973.7E-3	237.9E-3	231.4E-3	420.2E-3
3Ri3	50.9E-3	21.0E-3	48.1E-3	119.9E-3	24.3E-3	21.8E-3	48.7E-3
3Mi1	25.4E+0	10.2E+0	25.9E+0	63.9E+0	11.3E+0	10.6E+0	25.2E+0
3Mi2	3.8E+0	1.5E+0	3.3E+0	8.6E+0	1.9E+0	1.7E+0	3.4E+0
3Mi3	25.3E+0	8.8E+0	16.1E+0	40.7E+0	14.1E+0	14.4E+0	19.3E+0
3Rj1	59.7E-3	19.0E-3	57.3E-3	145.8E-3	23.9E-3	20.5E-3	57.1E-3
3Rj2	480.7E-3	181.0E-3	390.4E-3	973.7E-3	237.9E-3	231.4E-3	420.2E-3
3Rj3	50.9E-3	21.0E-3	48.1E-3	119.9E-3	24.3E-3	21.8E-3	48.7E-3
3Mj1	25.4E+0	10.2E+0	25.9E+0	63.9E+0	11.3E+0	10.6E+0	25.2E+0
3Mj2	7.0E+0	2.9E+0	6.8E+0	17.1E+0	3.3E+0	2.9E+0	6.8E+0
3Mj3	24.6E+0	9.9E+0	24.9E+0	61.5E+0	10.8E+0	9.9E+0	24.5E+0
4Ri1	59.4E-3	18.9E-3	57.0E-3	145.1E-3	23.8E-3	20.3E-3	56.8E-3
4Ri2	702.3E-3	283.7E-3	713.5E-3	1.8E+0	310.9E-3	284.1E-3	697.9E-3
4Ri3	1.5E+0	622.2E-3	1.6E+0	3.9E+0	674.6E-3	618.2E-3	1.5E+0
4Mi1	25.4E+0	10.2E+0	25.9E+0	63.9E+0	11.3E+0	10.6E+0	25.2E+0
4Mi2	24.6E+0	9.9E+0	24.9E+0	61.5E+0	10.8E+0	9.9E+0	24.5E+0
4Mi3	7.0E+0	2.9E+0	6.8E+0	17.1E+0	3.3E+0	2.9E+0	6.8E+0
4Rj1	702.3E-3	283.7E-3	713.5E-3	1.8E+0	310.9E-3	284.1E-3	697.9E-3
4Rj2	59.4E-3	18.9E-3	57.0E-3	145.1E-3	23.8E-3	20.3E-3	56.8E-3

4Rj3	1.5E+0	622.2E-3	1.6E+0	3.9E+0	674.6E-3	618.2E-3	1.5E+0
4Mj1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
4Mj2	7.1E+0	2.6E+0	4.8E+0	12.3E+0	3.8E+0	3.8E+0	5.6E+0
4Mj3	5.1E+0	2.0E+0	5.2E+0	12.9E+0	2.2E+0	2.0E+0	5.1E+0
5Ri1	685.9E-3	277.0E-3	698.0E-3	1.7E+0	303.8E-3	278.4E-3	681.9E-3
5Ri2	57.6E-3	18.4E-3	58.3E-3	144.3E-3	21.3E-3	19.5E-3	56.7E-3
5Ri3	1.3E+0	513.9E-3	1.3E+0	3.2E+0	568.5E-3	530.0E-3	1.3E+0
5Mi1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
5Mi2	7.1E+0	2.6E+0	4.8E+0	12.3E+0	3.8E+0	3.8E+0	5.6E+0
5Mi3	5.1E+0	2.0E+0	5.2E+0	12.9E+0	2.2E+0	2.0E+0	5.1E+0
5Rj1	685.9E-3	277.0E-3	698.0E-3	1.7E+0	303.8E-3	278.4E-3	681.9E-3
5Rj2	57.6E-3	18.4E-3	58.3E-3	144.3E-3	21.3E-3	19.5E-3	56.7E-3
5Rj3	1.3E+0	513.9E-3	1.3E+0	3.2E+0	568.5E-3	530.0E-3	1.3E+0
5Mj1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
5Mj2	109.4E+0	44.1E+0	112.1E+0	276.4E+0	48.3E+0	44.7E+0	109.0E+0
5Mj3	4.0E+0	1.4E+0	2.7E+0	8.1E+0	2.1E+0	1.7E+0	3.3E+0
6Ri1	661.6E-3	266.9E-3	674.5E-3	1.7E+0	293.5E-3	270.4E-3	657.9E-3
6Ri2	52.2E-3	18.7E-3	55.2E-3	135.1E-3	19.9E-3	18.5E-3	52.9E-3
6Ri3	672.2E-3	249.4E-3	561.5E-3	1.4E+0	353.7E-3	358.5E-3	582.1E-3
6Mi1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
6Mi2	109.4E+0	44.1E+0	112.1E+0	276.4E+0	48.3E+0	44.7E+0	109.0E+0
6Mi3	4.0E+0	1.4E+0	2.7E+0	8.1E+0	2.1E+0	1.7E+0	3.3E+0
6Rj1	661.6E-3	266.9E-3	674.5E-3	1.7E+0	293.5E-3	270.4E-3	657.9E-3
6Rj2	52.2E-3	18.7E-3	55.2E-3	135.1E-3	19.9E-3	18.5E-3	52.9E-3
6Rj3	672.2E-3	249.4E-3	561.5E-3	1.4E+0	353.7E-3	358.5E-3	582.1E-3
6Mj1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
6Mj2	153.3E+0	60.9E+0	153.5E+0	378.1E+0	70.8E+0	67.9E+0	149.7E+0
6Mj3	4.8E+0	1.2E+0	4.7E+0	11.2E+0	1.4E+0	1.7E+0	4.6E+0
7Ri1	637.9E-3	257.0E-3	650.8E-3	1.6E+0	283.8E-3	263.1E-3	633.9E-3
7Ri2	64.3E-3	24.6E-3	54.0E-3	151.9E-3	33.1E-3	24.6E-3	58.1E-3
7Ri3	901.2E-3	327.0E-3	640.0E-3	1.6E+0	475.2E-3	469.4E-3	733.2E-3
7Mi1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
7Mi2	153.3E+0	60.9E+0	153.5E+0	378.1E+0	70.8E+0	67.9E+0	149.7E+0
7Mi3	4.8E+0	1.2E+0	4.7E+0	11.2E+0	1.4E+0	1.7E+0	4.6E+0
7Rj1	637.9E-3	257.0E-3	650.8E-3	1.6E+0	283.8E-3	263.1E-3	633.9E-3
7Rj2	64.3E-3	24.6E-3	54.0E-3	151.9E-3	33.1E-3	24.6E-3	58.1E-3
7Rj3	901.2E-3	327.0E-3	640.0E-3	1.6E+0	475.2E-3	469.4E-3	733.2E-3
7Mj1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
7Mj2	161.4E+0	60.5E+0	139.1E+0	344.4E+0	83.7E+0	84.5E+0	142.4E+0
7Mj3	7.7E+0	2.4E+0	8.2E+0	19.7E+0	2.5E+0	2.6E+0	7.8E+0
8Ri1	615.0E-3	247.2E-3	627.0E-3	1.5E+0	275.0E-3	256.7E-3	610.2E-3
8Ri2	106.1E-3	29.6E-3	113.9E-3	267.2E-3	28.2E-3	35.1E-3	107.3E-3
8Ri3	2.8E+0	1.1E+0	2.6E+0	6.4E+0	1.4E+0	1.4E+0	2.6E+0
8Mi1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
8Mi2	161.4E+0	60.5E+0	139.1E+0	344.4E+0	83.7E+0	84.5E+0	142.4E+0
8Mi3	7.7E+0	2.4E+0	8.2E+0	19.7E+0	2.5E+0	2.6E+0	7.8E+0
8Rj1	615.0E-3	247.2E-3	627.0E-3	1.5E+0	275.0E-3	256.7E-3	610.2E-3
8Rj2	106.1E-3	29.6E-3	113.9E-3	267.2E-3	28.2E-3	35.1E-3	107.3E-3
8Rj3	2.8E+0	1.1E+0	2.6E+0	6.4E+0	1.4E+0	1.4E+0	2.6E+0
8Mj1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0

8Mj2	82.0E+0	32.3E+0	80.7E+0	198.9E+0	38.7E+0	37.5E+0	79.0E+0
8Mj3	2.3E+0	586.3E-3	1.9E+0	4.7E+0	869.6E-3	866.7E-3	2.0E+0
9Ri1	593.1E-3	237.8E-3	603.1E-3	1.5E+0	267.1E-3	251.2E-3	586.8E-3
9Ri2	73.2E-3	21.5E-3	77.6E-3	184.7E-3	21.8E-3	24.4E-3	73.7E-3
9Ri3	1.7E+0	661.2E-3	1.6E+0	3.9E+0	857.8E-3	853.3E-3	1.6E+0
9Mi1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
9Mi2	82.0E+0	32.3E+0	80.7E+0	198.9E+0	38.7E+0	37.5E+0	79.0E+0
9Mi3	2.3E+0	586.3E-3	1.9E+0	4.7E+0	869.6E-3	866.7E-3	2.0E+0
9Rj1	593.1E-3	237.8E-3	603.1E-3	1.5E+0	267.1E-3	251.2E-3	586.8E-3
9Rj2	73.2E-3	21.5E-3	77.6E-3	184.7E-3	21.8E-3	24.4E-3	73.7E-3
9Rj3	1.7E+0	661.2E-3	1.6E+0	3.9E+0	857.8E-3	853.3E-3	1.6E+0
9Mj1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
9Mj2	225.3E+0	87.3E+0	213.6E+0	526.6E+0	109.9E+0	108.5E+0	211.4E+0
9Mj3	7.5E+0	1.9E+0	8.0E+0	18.6E+0	1.8E+0	2.5E+0	7.5E+0
10Ri1	572.6E-3	228.7E-3	579.4E-3	1.4E+0	260.3E-3	246.8E-3	563.9E-3
10Ri2	14.3E-3	5.5E-3	11.2E-3	32.8E-3	7.7E-3	5.6E-3	12.5E-3
10Ri3	205.4E-3	81.7E-3	204.3E-3	508.2E-3	95.2E-3	88.5E-3	200.3E-3
10Mi1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
10Mi2	225.3E+0	87.3E+0	213.6E+0	526.6E+0	109.9E+0	108.5E+0	211.4E+0
10Mi3	7.5E+0	1.9E+0	8.0E+0	18.6E+0	1.8E+0	2.5E+0	7.5E+0
10Rj1	572.6E-3	228.7E-3	579.4E-3	1.4E+0	260.3E-3	246.8E-3	563.9E-3
10Rj2	14.3E-3	5.5E-3	11.2E-3	32.8E-3	7.7E-3	5.6E-3	12.5E-3
10Rj3	205.4E-3	81.7E-3	204.3E-3	508.2E-3	95.2E-3	88.5E-3	200.3E-3
10Mj1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
10Mj2	209.3E+0	80.9E+0	197.0E+0	485.8E+0	102.7E+0	101.6E+0	195.4E+0
10Mj3	8.1E+0	2.2E+0	8.6E+0	20.2E+0	2.1E+0	2.7E+0	8.1E+0
11Ri1	553.5E-3	220.1E-3	555.9E-3	1.4E+0	254.6E-3	243.6E-3	541.6E-3
11Ri2	62.3E-3	15.8E-3	65.1E-3	152.0E-3	15.7E-3	20.9E-3	61.8E-3
11Ri3	2.0E+0	788.9E-3	1.9E+0	4.8E+0	994.7E-3	982.1E-3	1.9E+0
11Mi1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
11Mi2	209.3E+0	80.9E+0	197.0E+0	485.8E+0	102.7E+0	101.6E+0	195.4E+0
11Mi3	8.1E+0	2.2E+0	8.6E+0	20.2E+0	2.1E+0	2.7E+0	8.1E+0
11Rj1	553.5E-3	220.1E-3	555.9E-3	1.4E+0	254.6E-3	243.6E-3	541.6E-3
11Rj2	62.3E-3	15.8E-3	65.1E-3	152.0E-3	15.7E-3	20.9E-3	61.8E-3
11Rj3	2.0E+0	788.9E-3	1.9E+0	4.8E+0	994.7E-3	982.1E-3	1.9E+0
11Mj1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
11Mj2	38.5E+0	14.7E+0	35.1E+0	86.9E+0	19.3E+0	19.2E+0	35.2E+0
11Mj3	3.0E+0	942.9E-3	3.2E+0	7.7E+0	952.4E-3	1.0E+0	3.1E+0
12Ri1	536.2E-3	212.0E-3	532.8E-3	1.3E+0	250.3E-3	241.5E-3	520.3E-3
12Ri2	102.0E-3	27.2E-3	107.1E-3	251.7E-3	27.2E-3	34.0E-3	101.6E-3
12Ri3	3.0E+0	1.2E+0	2.8E+0	7.0E+0	1.5E+0	1.5E+0	2.8E+0
12Mi1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
12Mi2	38.5E+0	14.7E+0	35.1E+0	86.9E+0	19.3E+0	19.2E+0	35.2E+0
12Mi3	3.0E+0	942.9E-3	3.2E+0	7.7E+0	952.4E-3	1.0E+0	3.1E+0
12Rj1	536.2E-3	212.0E-3	532.8E-3	1.3E+0	250.3E-3	241.5E-3	520.3E-3
12Rj2	102.0E-3	27.2E-3	107.1E-3	251.7E-3	27.2E-3	34.0E-3	101.6E-3
12Rj3	3.0E+0	1.2E+0	2.8E+0	7.0E+0	1.5E+0	1.5E+0	2.8E+0
12Mj1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
12Mj2	215.6E+0	83.2E+0	201.9E+0	497.9E+0	106.3E+0	105.3E+0	200.6E+0
12Mj3	5.8E+0	1.5E+0	5.9E+0	13.8E+0	1.6E+0	2.0E+0	5.6E+0

13Ri1	520.9E-3	204.6E-3	510.2E-3	1.3E+0	247.3E-3	240.7E-3	500.0E-3
13Ri2	24.9E-3	7.3E-3	20.3E-3	54.7E-3	10.9E-3	9.5E-3	22.1E-3
13Ri3	1.2E+0	455.8E-3	1.1E+0	2.7E+0	605.6E-3	606.3E-3	1.1E+0
13Mi1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
13Mi2	215.6E+0	83.2E+0	201.9E+0	497.9E+0	106.3E+0	105.3E+0	200.6E+0
13Mi3	5.8E+0	1.5E+0	5.9E+0	13.8E+0	1.6E+0	2.0E+0	5.6E+0
13Rj1	520.9E-3	204.6E-3	510.2E-3	1.3E+0	247.3E-3	240.7E-3	500.0E-3
13Rj2	24.9E-3	7.3E-3	20.3E-3	54.7E-3	10.9E-3	9.5E-3	22.1E-3
13Rj3	1.2E+0	455.8E-3	1.1E+0	2.7E+0	605.6E-3	606.3E-3	1.1E+0
13Mj1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
13Mj2	116.0E+0	45.2E+0	111.6E+0	275.0E+0	55.9E+0	54.8E+0	110.0E+0
13Mj3	4.2E+0	1.1E+0	4.4E+0	10.2E+0	1.0E+0	1.4E+0	4.1E+0
14Ri1	508.0E-3	197.9E-3	488.3E-3	1.2E+0	245.9E-3	241.2E-3	481.1E-3
14Ri2	39.5E-3	10.2E-3	41.2E-3	96.5E-3	10.2E-3	13.3E-3	39.1E-3
14Ri3	1.5E+0	565.9E-3	1.4E+0	3.4E+0	702.9E-3	690.7E-3	1.4E+0
14Mi1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
14Mi2	116.0E+0	45.2E+0	111.6E+0	275.0E+0	55.9E+0	54.8E+0	110.0E+0
14Mi3	4.2E+0	1.1E+0	4.4E+0	10.2E+0	1.0E+0	1.4E+0	4.1E+0
14Rj1	508.0E-3	197.9E-3	488.3E-3	1.2E+0	245.9E-3	241.2E-3	481.1E-3
14Rj2	39.5E-3	10.2E-3	41.2E-3	96.5E-3	10.2E-3	13.3E-3	39.1E-3
14Rj3	1.5E+0	565.9E-3	1.4E+0	3.4E+0	702.9E-3	690.7E-3	1.4E+0
14Mj1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
14Mj2	6.3E+0	2.4E+0	5.5E+0	13.7E+0	3.3E+0	3.3E+0	5.6E+0
14Mj3	955.8E-3	283.3E-3	963.1E-3	2.4E+0	317.6E-3	330.1E-3	940.4E-3
15Ri1	500.7E-3	193.9E-3	474.0E-3	1.2E+0	245.7E-3	242.2E-3	469.2E-3
15Ri2	1.5E+0	588.9E-3	1.5E+0	3.6E+0	713.4E-3	695.3E-3	1.4E+0
15Ri3	59.6E-3	17.0E-3	62.6E-3	149.0E-3	17.4E-3	20.0E-3	59.8E-3
15Mi1	3.4E+0	1.4E+0	3.5E+0	8.6E+0	1.6E+0	1.5E+0	3.4E+0
15Mi2	955.8E-3	283.3E-3	963.1E-3	2.4E+0	317.6E-3	330.1E-3	940.4E-3
15Mi3	6.3E+0	2.4E+0	5.5E+0	13.7E+0	3.3E+0	3.3E+0	5.6E+0
15Rj1	1.5E+0	588.9E-3	1.5E+0	3.6E+0	713.4E-3	695.3E-3	1.4E+0
15Rj2	500.7E-3	193.9E-3	474.0E-3	1.2E+0	245.7E-3	242.2E-3	469.2E-3
15Rj3	59.6E-3	17.0E-3	62.6E-3	149.0E-3	17.4E-3	20.0E-3	59.8E-3
15Mj1	230.6E-3	75.7E-3	204.1E-3	549.4E-3	106.8E-3	80.8E-3	212.1E-3
15Mj2	3.0E+0	1.1E+0	2.7E+0	6.7E+0	1.4E+0	1.4E+0	2.7E+0
15Mj3	24.1E+0	9.4E+0	23.2E+0	57.3E+0	11.6E+0	11.3E+0	22.9E+0
16Ri1	1.5E+0	598.8E-3	1.5E+0	3.7E+0	713.5E-3	691.1E-3	1.5E+0
16Ri2	74.5E-3	22.6E-3	77.0E-3	186.9E-3	24.6E-3	25.4E-3	74.4E-3
16Ri3	509.3E-3	196.7E-3	478.2E-3	1.2E+0	251.7E-3	248.7E-3	474.6E-3
16Mi1	230.6E-3	75.7E-3	204.1E-3	549.4E-3	106.8E-3	80.8E-3	212.1E-3
16Mi2	24.1E+0	9.4E+0	23.2E+0	57.3E+0	11.6E+0	11.3E+0	22.9E+0
16Mi3	3.0E+0	1.1E+0	2.7E+0	6.7E+0	1.4E+0	1.4E+0	2.7E+0
16Rj1	1.5E+0	598.8E-3	1.5E+0	3.7E+0	713.5E-3	691.1E-3	1.5E+0
16Rj2	74.5E-3	22.6E-3	77.0E-3	186.9E-3	24.6E-3	25.4E-3	74.4E-3
16Rj3	509.3E-3	196.7E-3	478.2E-3	1.2E+0	251.7E-3	248.7E-3	474.6E-3
16Mj1	230.6E-3	75.7E-3	204.1E-3	549.4E-3	106.8E-3	80.8E-3	212.1E-3
16Mj2	7.0E+0	2.6E+0	5.7E+0	14.3E+0	3.8E+0	3.8E+0	6.0E+0
16Mj3	4.5E+0	1.1E+0	3.6E+0	8.9E+0	1.6E+0	1.9E+0	3.9E+0
17Ri1	1.6E+0	619.2E-3	1.6E+0	3.9E+0	717.9E-3	688.0E-3	1.5E+0
3Ri2	82.1E-3	32.0E-3	75.8E-3	188.2E-3	38.6E-3	38.4E-3	76.3E-3

17Ri3	28.9E-3	11.4E-3	28.8E-3	70.7E-3	13.7E-3	13.2E-3	28.0E-3
17Mi1	230.6E-3	75.7E-3	204.1E-3	549.4E-3	106.8E-3	80.8E-3	212.1E-3
17Mi2	7.0E+0	2.6E+0	5.7E+0	14.3E+0	3.8E+0	3.8E+0	6.0E+0
17Mi3	4.5E+0	1.1E+0	3.6E+0	8.9E+0	1.6E+0	1.9E+0	3.9E+0
17Rj1	1.6E+0	619.2E-3	1.6E+0	3.9E+0	717.9E-3	688.0E-3	1.5E+0
17Rj2	82.1E-3	32.0E-3	75.8E-3	188.2E-3	38.6E-3	38.4E-3	76.3E-3
17Rj3	28.9E-3	11.4E-3	28.8E-3	70.7E-3	13.7E-3	13.2E-3	28.0E-3
17Mj1	230.6E-3	75.7E-3	204.1E-3	549.4E-3	106.8E-3	80.8E-3	212.1E-3
17Mj2	4.7E+0	1.7E+0	3.3E+0	8.3E+0	2.7E+0	2.7E+0	3.7E+0
17Mj3	8.1E+0	3.2E+0	8.6E+0	21.2E+0	3.4E+0	3.2E+0	8.3E+0
18Ri1	1.6E+0	645.1E-3	1.6E+0	4.0E+0	729.4E-3	691.1E-3	1.6E+0
18Ri2	60.7E-3	22.1E-3	49.5E-3	125.6E-3	28.9E-3	29.6E-3	52.7E-3
18Ri3	51.9E-3	18.8E-3	37.3E-3	94.2E-3	29.3E-3	29.5E-3	41.5E-3
18Mi1	230.6E-3	75.7E-3	204.1E-3	549.4E-3	106.8E-3	80.8E-3	212.1E-3
18Mi2	4.7E+0	1.7E+0	3.3E+0	8.3E+0	2.7E+0	2.7E+0	3.7E+0
18Mi3	8.1E+0	3.2E+0	8.6E+0	21.2E+0	3.4E+0	3.2E+0	8.3E+0
18Rj1	1.6E+0	645.1E-3	1.6E+0	4.0E+0	729.4E-3	691.1E-3	1.6E+0
18Rj2	60.7E-3	22.1E-3	49.5E-3	125.6E-3	28.9E-3	29.6E-3	52.7E-3
18Rj3	51.9E-3	18.8E-3	37.3E-3	94.2E-3	29.3E-3	29.5E-3	41.5E-3
18Mj1	230.6E-3	75.7E-3	204.1E-3	549.4E-3	106.8E-3	80.8E-3	212.1E-3
18Mj2	649.5E-3	234.7E-3	405.4E-3	1.0E+0	374.3E-3	374.7E-3	492.4E-3
18Mj3	11.8E+0	4.7E+0	11.9E+0	29.2E+0	5.4E+0	5.1E+0	11.6E+0
19Ri1	1.7E+0	662.1E-3	1.7E+0	4.2E+0	739.5E-3	696.4E-3	1.6E+0
19Ri2	53.6E-3	18.7E-3	41.1E-3	106.0E-3	25.4E-3	26.3E-3	45.2E-3
19Ri3	76.5E-3	27.2E-3	48.8E-3	124.3E-3	43.7E-3	44.3E-3	58.2E-3
19Mi1	230.6E-3	75.7E-3	204.1E-3	549.4E-3	106.8E-3	80.8E-3	212.1E-3
19Mi2	649.5E-3	234.7E-3	405.4E-3	1.0E+0	374.3E-3	374.7E-3	492.4E-3
19Mi3	11.8E+0	4.7E+0	11.9E+0	29.2E+0	5.4E+0	5.1E+0	11.6E+0
19Rj1	53.6E-3	18.7E-3	41.1E-3	106.0E-3	25.4E-3	26.3E-3	45.2E-3
19Rj2	1.7E+0	662.1E-3	1.7E+0	4.2E+0	739.5E-3	696.4E-3	1.6E+0
19Rj3	76.5E-3	27.2E-3	48.8E-3	124.3E-3	43.7E-3	44.3E-3	58.2E-3
19Mj1	748.5E-3	265.3E-3	502.6E-3	1.3E+0	420.9E-3	428.2E-3	581.2E-3
19Mj2	1.3E+0	485.8E-3	847.2E-3	2.2E+0	789.2E-3	775.8E-3	993.2E-3
19Mj3	17.4E+0	7.0E+0	18.0E+0	44.3E+0	7.7E+0	7.1E+0	17.5E+0
20Ri1	53.7E-3	18.7E-3	41.2E-3	106.3E-3	25.4E-3	26.3E-3	45.3E-3
20Ri2	166.9E-3	65.0E-3	155.2E-3	384.0E-3	75.7E-3	71.4E-3	157.7E-3
20Ri3	48.5E-3	17.7E-3	33.6E-3	84.7E-3	26.1E-3	26.0E-3	38.9E-3
20Mi1	748.5E-3	265.3E-3	502.6E-3	1.3E+0	420.9E-3	428.2E-3	581.2E-3
20Mi2	1.3E+0	485.8E-3	847.2E-3	2.2E+0	789.2E-3	775.8E-3	993.2E-3
20Mi3	17.4E+0	7.0E+0	18.0E+0	44.3E+0	7.7E+0	7.1E+0	17.5E+0
20Rj1	53.7E-3	18.7E-3	41.2E-3	106.3E-3	25.4E-3	26.3E-3	45.3E-3
20Rj2	166.9E-3	65.0E-3	155.2E-3	384.0E-3	75.7E-3	71.4E-3	157.7E-3
20Rj3	48.5E-3	17.7E-3	33.6E-3	84.7E-3	26.1E-3	26.0E-3	38.9E-3
20Mj1	748.5E-3	265.3E-3	502.6E-3	1.3E+0	420.9E-3	428.2E-3	581.2E-3
20Mj2	2.0E+0	729.7E-3	1.7E+0	4.2E+0	912.9E-3	903.5E-3	1.8E+0
20Mj3	11.0E+0	4.2E+0	10.2E+0	25.1E+0	5.5E+0	5.5E+0	10.1E+0
21Ri1	53.8E-3	18.7E-3	41.3E-3	106.5E-3	25.5E-3	26.4E-3	45.4E-3
21Ri2	110.8E-3	44.5E-3	114.5E-3	281.7E-3	48.4E-3	45.0E-3	111.0E-3
21Ri3	9.3E-3	3.5E-3	5.9E-3	15.0E-3	5.6E-3	5.6E-3	7.1E-3
21Mi1	748.5E-3	265.3E-3	502.6E-3	1.3E+0	420.9E-3	428.2E-3	581.2E-3

21Mi2	2.0E+0	729.7E-3	1.7E+0	4.2E+0	912.9E-3	903.5E-3	1.8E+0
21Mi3	11.0E+0	4.2E+0	10.2E+0	25.1E+0	5.5E+0	5.5E+0	10.1E+0
21Rj1	53.8E-3	18.7E-3	41.3E-3	106.5E-3	25.5E-3	26.4E-3	45.4E-3
21Rj2	110.8E-3	44.5E-3	114.5E-3	281.7E-3	48.4E-3	45.0E-3	111.0E-3
21Rj3	9.3E-3	3.5E-3	5.9E-3	15.0E-3	5.6E-3	5.6E-3	7.1E-3
21Mj1	748.5E-3	265.3E-3	502.6E-3	1.3E+0	420.9E-3	428.2E-3	581.2E-3
21Mj2	2.4E+0	868.6E-3	1.8E+0	4.6E+0	1.2E+0	1.2E+0	2.0E+0
21Mj3	6.6E+0	2.4E+0	4.6E+0	11.6E+0	3.7E+0	3.8E+0	5.2E+0
22Ri1	53.9E-3	18.8E-3	41.3E-3	106.7E-3	25.5E-3	26.4E-3	45.4E-3
22Ri2	124.8E-3	46.3E-3	102.4E-3	254.1E-3	67.0E-3	67.7E-3	106.9E-3
22Ri3	34.2E-3	12.5E-3	27.6E-3	68.5E-3	16.6E-3	16.5E-3	29.7E-3
22Mi1	748.5E-3	265.3E-3	502.6E-3	1.3E+0	420.9E-3	428.2E-3	581.2E-3
22Mi2	2.4E+0	868.6E-3	1.8E+0	4.6E+0	1.2E+0	1.2E+0	2.0E+0
22Mi3	6.6E+0	2.4E+0	4.6E+0	11.6E+0	3.7E+0	3.8E+0	5.2E+0
22Rj1	53.9E-3	18.8E-3	41.3E-3	106.7E-3	25.5E-3	26.4E-3	45.4E-3
22Rj2	124.8E-3	46.3E-3	102.4E-3	254.1E-3	67.0E-3	67.7E-3	106.9E-3
22Rj3	34.2E-3	12.5E-3	27.6E-3	68.5E-3	16.6E-3	16.5E-3	29.7E-3
22Mj1	748.5E-3	265.3E-3	502.6E-3	1.3E+0	420.9E-3	428.2E-3	581.2E-3
22Mj2	357.4E-3	130.5E-3	226.8E-3	578.4E-3	204.2E-3	203.0E-3	274.2E-3
22Mj3	2.4E+0	971.3E-3	2.5E+0	6.1E+0	1.0E+0	962.9E-3	2.4E+0
23Ri1	53.9E-3	18.8E-3	41.4E-3	106.8E-3	25.6E-3	26.4E-3	45.5E-3
23Ri2	189.9E-3	67.1E-3	124.6E-3	314.2E-3	107.3E-3	109.8E-3	145.9E-3
23Ri3	73.3E-3	26.8E-3	56.1E-3	140.0E-3	36.9E-3	36.7E-3	61.9E-3
23Mi1	748.5E-3	265.3E-3	502.6E-3	1.3E+0	420.9E-3	428.2E-3	581.2E-3
23Mi2	357.4E-3	130.5E-3	226.8E-3	578.4E-3	204.2E-3	203.0E-3	274.2E-3
23Mi3	2.4E+0	971.3E-3	2.5E+0	6.1E+0	1.0E+0	962.9E-3	2.4E+0
23Rj1	53.9E-3	18.8E-3	41.4E-3	106.8E-3	25.6E-3	26.4E-3	45.5E-3
23Rj2	189.9E-3	67.1E-3	124.6E-3	314.2E-3	107.3E-3	109.8E-3	145.9E-3
23Rj3	73.3E-3	26.8E-3	56.1E-3	140.0E-3	36.9E-3	36.7E-3	61.9E-3
23Mj1	748.5E-3	265.3E-3	502.6E-3	1.3E+0	420.9E-3	428.2E-3	581.2E-3
23Mj2	4.1E+0	1.5E+0	3.2E+0	7.9E+0	2.0E+0	2.0E+0	3.5E+0
23Mj3	11.8E+0	4.2E+0	8.4E+0	21.1E+0	6.6E+0	6.7E+0	9.4E+0

Table 19b Maximum Element Forces and Moments for S-components of Benchmark Problem #4b (kips-inches)

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	6.9E+0	3.4E+0	5.0E+0	15.0E+0	5.2E+0	3.5E+0	4.2E+0
1Ri2	332.2E-3	446.2E-3	652.1E-3	795.8E-3	274.3E-3	264.2E-3	373.1E-3
1Ri3	1.9E+0	1.7E+0	2.4E+0	3.6E+0	1.1E+0	1.0E+0	1.5E+0
1Mi1	6.0E+0	5.2E+0	7.4E+0	14.0E+0	4.9E+0	4.1E+0	5.5E+0
1Mi2	119.3E+0	122.6E+0	178.9E+0	245.4E+0	78.3E+0	74.4E+0	108.8E+0
1Mi3	24.7E+0	34.2E+0	49.9E+0	59.9E+0	20.8E+0	20.2E+0	28.3E+0
1Rj1	6.9E+0	3.4E+0	5.0E+0	15.0E+0	5.2E+0	3.5E+0	4.2E+0
1Rj2	332.2E-3	446.2E-3	652.1E-3	795.8E-3	274.3E-3	264.2E-3	373.1E-3
1Rj3	1.9E+0	1.7E+0	2.4E+0	3.6E+0	1.1E+0	1.0E+0	1.5E+0
1Mj1	6.0E+0	5.2E+0	7.4E+0	14.0E+0	4.9E+0	4.1E+0	5.5E+0
1Mj2	34.5E+0	10.4E+0	15.4E+0	52.3E+0	11.0E+0	9.2E+0	18.6E+0
1Mj3	2.7E+0	1.7E+0	2.5E+0	5.4E+0	1.5E+0	1.2E+0	2.1E+0
2Ri1	5.5E+0	4.1E+0	6.0E+0	12.1E+0	4.2E+0	3.0E+0	3.8E+0
2Ri2	280.8E-3	405.5E-3	591.9E-3	692.4E-3	243.9E-3	237.9E-3	331.5E-3
2Ri3	987.2E-3	1.4E+0	2.0E+0	2.4E+0	828.0E-3	789.0E-3	1.1E+0
2Mi1	6.0E+0	5.2E+0	7.4E+0	14.0E+0	4.9E+0	4.1E+0	5.5E+0
2Mi2	34.5E+0	10.4E+0	15.4E+0	52.3E+0	11.0E+0	9.2E+0	18.6E+0
2Mi3	2.7E+0	1.7E+0	2.5E+0	5.4E+0	1.5E+0	1.2E+0	2.1E+0
2Rj1	5.5E+0	4.1E+0	6.0E+0	12.1E+0	4.2E+0	3.0E+0	3.8E+0
2Rj2	280.8E-3	405.5E-3	591.9E-3	692.4E-3	243.9E-3	237.9E-3	331.5E-3
2Rj3	987.2E-3	1.4E+0	2.0E+0	2.4E+0	828.0E-3	789.0E-3	1.1E+0
2Mj1	6.0E+0	5.2E+0	7.4E+0	14.0E+0	4.9E+0	4.1E+0	5.5E+0
2Mj2	97.8E+0	117.2E+0	171.2E+0	217.7E+0	73.0E+0	69.6E+0	99.1E+0
2Mj3	24.0E+0	33.9E+0	49.6E+0	58.6E+0	20.5E+0	20.0E+0	27.9E+0
3Ri1	4.6E+0	5.0E+0	7.3E+0	10.4E+0	3.6E+0	3.0E+0	4.0E+0
3Ri2	237.6E-3	331.9E-3	483.7E-3	578.9E-3	202.0E-3	195.5E-3	274.8E-3
3Ri3	1.5E+0	1.0E+0	1.5E+0	2.6E+0	708.8E-3	641.7E-3	1.0E+0
3Mi1	6.0E+0	5.2E+0	7.4E+0	14.0E+0	4.9E+0	4.1E+0	5.5E+0
3Mi2	97.8E+0	117.2E+0	171.2E+0	217.7E+0	73.0E+0	69.6E+0	99.1E+0
3Mi3	24.0E+0	33.9E+0	49.6E+0	58.6E+0	20.5E+0	20.0E+0	27.9E+0
3Rj1	4.6E+0	5.0E+0	7.3E+0	10.4E+0	3.6E+0	3.0E+0	4.0E+0
3Rj2	237.6E-3	331.9E-3	483.7E-3	578.9E-3	202.0E-3	195.5E-3	274.8E-3
3Rj3	1.5E+0	1.0E+0	1.5E+0	2.6E+0	708.8E-3	641.7E-3	1.0E+0
3Mj1	6.0E+0	5.2E+0	7.4E+0	14.0E+0	4.9E+0	4.1E+0	5.5E+0
3Mj2	150.5E+0	198.9E+0	290.5E+0	350.1E+0	121.1E+0	115.4E+0	161.5E+0
3Mj3	41.1E+0	60.3E+0	88.0E+0	102.1E+0	36.2E+0	35.3E+0	49.1E+0
4Ri1	4.4E+0	5.7E+0	8.3E+0	10.3E+0	3.6E+0	3.2E+0	4.5E+0
4Ri2	4.8E+0	2.2E+0	3.3E+0	7.4E+0	1.6E+0	1.6E+0	2.7E+0
4Ri3	226.1E-3	285.6E-3	445.4E-3	493.5E-3	159.2E-3	154.2E-3	235.1E-3
4Mi1	6.0E+0	5.2E+0	7.4E+0	14.0E+0	4.9E+0	4.1E+0	5.5E+0
4Mi2	41.1E+0	60.3E+0	88.0E+0	102.1E+0	36.2E+0	35.3E+0	49.1E+0
4Mi3	150.5E+0	198.9E+0	290.5E+0	350.1E+0	121.1E+0	115.4E+0	161.5E+0
4Rj1	4.8E+0	2.2E+0	3.3E+0	7.4E+0	1.6E+0	1.6E+0	2.7E+0
4Rj2	4.4E+0	5.7E+0	8.3E+0	10.3E+0	3.6E+0	3.2E+0	4.5E+0
4Rj3	226.1E-3	285.6E-3	445.4E-3	493.5E-3	159.2E-3	154.2E-3	235.1E-3

4Mj1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
4Mj2	6.5E+0	8.8E+0	12.7E+0	15.9E+0	5.6E+0	5.3E+0	7.4E+0
4Mj3	51.3E+0	60.0E+0	86.5E+0	118.7E+0	41.0E+0	38.9E+0	53.7E+0
5Ri1	4.6E+0	2.0E+0	3.0E+0	6.9E+0	1.5E+0	1.4E+0	2.6E+0
5Ri2	4.4E+0	6.2E+0	9.0E+0	10.6E+0	3.8E+0	3.6E+0	4.9E+0
5Ri3	166.7E-3	224.6E-3	353.3E-3	368.3E-3	120.8E-3	119.8E-3	179.2E-3
5Mi1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
5Mi2	6.5E+0	8.8E+0	12.7E+0	15.9E+0	5.6E+0	5.3E+0	7.4E+0
5Mi3	51.3E+0	60.0E+0	86.5E+0	118.7E+0	41.0E+0	38.9E+0	53.7E+0
5Rj1	4.6E+0	2.0E+0	3.0E+0	6.9E+0	1.5E+0	1.4E+0	2.6E+0
5Rj2	4.4E+0	6.2E+0	9.0E+0	10.6E+0	3.8E+0	3.6E+0	4.9E+0
5Rj3	166.7E-3	224.6E-3	353.3E-3	368.3E-3	120.8E-3	119.8E-3	179.2E-3
5Mj1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
5Mj2	17.0E+0	26.3E+0	40.5E+0	39.0E+0	13.1E+0	13.6E+0	20.2E+0
5Mj3	328.4E+0	458.9E+0	670.9E+0	794.1E+0	280.1E+0	263.6E+0	365.6E+0
6Ri1	4.1E+0	1.7E+0	2.5E+0	6.2E+0	1.3E+0	1.3E+0	2.3E+0
6Ri2	3.6E+0	4.8E+0	7.0E+0	9.0E+0	3.2E+0	3.0E+0	4.2E+0
6Ri3	177.3E-3	96.5E-3	154.0E-3	358.6E-3	113.0E-3	77.6E-3	135.0E-3
6Mi1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
6Mi2	17.0E+0	26.3E+0	40.5E+0	39.0E+0	13.1E+0	13.6E+0	20.2E+0
6Mi3	328.4E+0	458.9E+0	670.9E+0	794.1E+0	280.1E+0	263.6E+0	365.6E+0
6Rj1	4.1E+0	1.7E+0	2.5E+0	6.2E+0	1.3E+0	1.3E+0	2.3E+0
6Rj2	3.6E+0	4.8E+0	7.0E+0	9.0E+0	3.2E+0	3.0E+0	4.2E+0
6Rj3	177.3E-3	96.5E-3	154.0E-3	358.6E-3	113.0E-3	77.6E-3	135.0E-3
6Mj1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
6Mj2	14.7E+0	30.6E+0	47.7E+0	36.5E+0	13.1E+0	14.8E+0	21.4E+0
6Mj3	604.0E+0	861.9E+0	1.3E+3	1.5E+3	529.3E+0	510.4E+0	707.4E+0
7Ri1	3.6E+0	1.4E+0	2.1E+0	5.4E+0	1.1E+0	1.1E+0	1.9E+0
7Ri2	3.7E+0	3.1E+0	4.4E+0	8.7E+0	3.1E+0	2.6E+0	3.4E+0
7Ri3	229.9E-3	129.5E-3	199.9E-3	470.3E-3	141.5E-3	111.0E-3	178.2E-3
7Mi1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
7Mi2	14.7E+0	30.6E+0	47.7E+0	36.5E+0	13.1E+0	14.8E+0	21.4E+0
7Mi3	604.0E+0	861.9E+0	1.3E+3	1.5E+3	529.3E+0	510.4E+0	707.4E+0
7Rj1	3.6E+0	1.4E+0	2.1E+0	5.4E+0	1.1E+0	1.1E+0	1.9E+0
7Rj2	3.7E+0	3.1E+0	4.4E+0	8.7E+0	3.1E+0	2.6E+0	3.4E+0
7Rj3	229.9E-3	129.5E-3	199.9E-3	470.3E-3	141.5E-3	111.0E-3	178.2E-3
7Mj1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
7Mj2	23.2E+0	25.1E+0	39.9E+0	48.8E+0	16.1E+0	14.2E+0	22.0E+0
7Mj3	833.0E+0	1.1E+3	1.6E+3	2.1E+3	733.5E+0	701.2E+0	964.0E+0
8Ri1	3.1E+0	1.0E+0	1.6E+0	4.5E+0	876.4E-3	863.5E-3	1.6E+0
8Ri2	13.5E+0	18.4E+0	26.7E+0	33.6E+0	11.9E+0	11.4E+0	15.7E+0
8Ri3	539.4E-3	547.7E-3	859.6E-3	1.1E+0	361.7E-3	302.0E-3	496.9E-3
8Mi1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
8Mi2	23.2E+0	25.1E+0	39.9E+0	48.8E+0	16.1E+0	14.2E+0	22.0E+0
8Mi3	833.0E+0	1.1E+3	1.6E+3	2.1E+3	733.5E+0	701.2E+0	964.0E+0
8Rj1	3.1E+0	1.0E+0	1.6E+0	4.5E+0	876.4E-3	863.5E-3	1.6E+0
8Rj2	13.5E+0	18.4E+0	26.7E+0	33.6E+0	11.9E+0	11.4E+0	15.7E+0
8Rj3	539.4E-3	547.7E-3	859.6E-3	1.1E+0	361.7E-3	302.0E-3	496.9E-3
8Mj1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
8Mj2	24.4E+0	21.7E+0	33.6E+0	50.1E+0	16.0E+0	12.6E+0	21.4E+0

8Mj3	310.1E+0	432.9E+0	628.5E+0	764.9E+0	270.2E+0	260.0E+0	360.7E+0
9Ri1	2.5E+0	732.9E-3	1.1E+0	3.6E+0	681.4E-3	669.9E-3	1.3E+0
9Ri2	8.3E+0	11.5E+0	16.6E+0	20.7E+0	7.3E+0	7.1E+0	9.7E+0
9Ri3	218.1E-3	307.8E-3	484.3E-3	491.4E-3	166.6E-3	159.4E-3	241.9E-3
9Mi1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
9Mi2	24.4E+0	21.7E+0	33.6E+0	50.1E+0	16.0E+0	12.6E+0	21.4E+0
9Mi3	310.1E+0	432.9E+0	628.5E+0	764.9E+0	270.2E+0	260.0E+0	360.7E+0
9Rj1	2.5E+0	732.9E-3	1.1E+0	3.6E+0	681.4E-3	669.9E-3	1.3E+0
9Rj2	8.3E+0	11.5E+0	16.6E+0	20.7E+0	7.3E+0	7.1E+0	9.7E+0
9Rj3	218.1E-3	307.8E-3	484.3E-3	491.4E-3	166.6E-3	159.4E-3	241.9E-3
9Mj1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
9Mj2	23.5E+0	45.1E+0	70.3E+0	55.9E+0	19.9E+0	22.0E+0	32.2E+0
9Mj3	1.0E+3	1.4E+3	2.0E+3	2.5E+3	883.5E+0	851.3E+0	1.2E+3
10Ri1	1.9E+0	439.7E-3	715.6E-3	2.7E+0	504.6E-3	489.4E-3	952.2E-3
10Ri2	942.2E-3	371.4E-3	595.8E-3	1.8E+0	541.4E-3	343.4E-3	687.2E-3
10Ri3	402.4E-3	163.6E-3	258.8E-3	779.2E-3	239.5E-3	144.4E-3	288.5E-3
10Mi1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
10Mi2	23.5E+0	45.1E+0	70.3E+0	55.9E+0	19.9E+0	22.0E+0	32.2E+0
10Mi3	1.0E+3	1.4E+3	2.0E+3	2.5E+3	883.5E+0	851.3E+0	1.2E+3
10Rj1	1.9E+0	439.7E-3	715.6E-3	2.7E+0	504.6E-3	489.4E-3	952.2E-3
10Rj2	942.2E-3	371.4E-3	595.8E-3	1.8E+0	541.4E-3	343.4E-3	687.2E-3
10Rj3	402.4E-3	163.6E-3	258.8E-3	779.2E-3	239.5E-3	144.4E-3	288.5E-3
10Mj1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
10Mj2	29.2E+0	40.5E+0	63.4E+0	64.0E+0	21.7E+0	20.6E+0	31.9E+0
10Mj3	995.5E+0	1.4E+3	2.0E+3	2.5E+3	877.0E+0	844.6E+0	1.2E+3
11Ri1	1.3E+0	244.6E-3	423.8E-3	1.9E+0	379.0E-3	350.5E-3	660.7E-3
11Ri2	8.4E+0	11.7E+0	16.9E+0	20.9E+0	7.4E+0	7.1E+0	9.8E+0
11Ri3	297.0E-3	419.3E-3	653.3E-3	668.4E-3	224.6E-3	215.4E-3	331.8E-3
11Mi1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
11Mi2	29.2E+0	40.5E+0	63.4E+0	64.0E+0	21.7E+0	20.6E+0	31.9E+0
11Mi3	995.5E+0	1.4E+3	2.0E+3	2.5E+3	877.0E+0	844.6E+0	1.2E+3
11Rj1	1.3E+0	244.6E-3	423.8E-3	1.9E+0	379.0E-3	350.5E-3	660.7E-3
11Rj2	8.4E+0	11.7E+0	16.9E+0	20.9E+0	7.4E+0	7.1E+0	9.8E+0
11Rj3	297.0E-3	419.3E-3	653.3E-3	668.4E-3	224.6E-3	215.4E-3	331.8E-3
11Mj1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
11Mj2	12.9E+0	6.9E+0	11.1E+0	25.0E+0	7.3E+0	5.4E+0	9.7E+0
11Mj3	292.9E+0	405.5E+0	587.5E+0	726.0E+0	256.7E+0	247.1E+0	341.8E+0
12Ri1	750.1E-3	371.8E-3	556.4E-3	1.3E+0	367.1E-3	320.1E-3	503.3E-3
12Ri2	13.3E+0	18.3E+0	26.4E+0	33.0E+0	11.7E+0	11.2E+0	15.5E+0
12Ri3	610.1E-3	623.1E-3	974.6E-3	1.3E+0	412.0E-3	341.9E-3	563.7E-3
12Mi1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
12Mi2	12.9E+0	6.9E+0	11.1E+0	25.0E+0	7.3E+0	5.4E+0	9.7E+0
12Mi3	292.9E+0	405.5E+0	587.5E+0	726.0E+0	256.7E+0	247.1E+0	341.8E+0
12Rj1	750.1E-3	371.8E-3	556.4E-3	1.3E+0	367.1E-3	320.1E-3	503.3E-3
12Rj2	13.3E+0	18.3E+0	26.4E+0	33.0E+0	11.7E+0	11.2E+0	15.5E+0
12Rj3	610.1E-3	623.1E-3	974.6E-3	1.3E+0	412.0E-3	341.9E-3	563.7E-3
12Mj1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
12Mj2	44.7E+0	46.8E+0	73.0E+0	93.7E+0	30.7E+0	25.7E+0	42.1E+0
12Mj3	824.2E+0	1.1E+3	1.6E+3	2.0E+3	724.8E+0	695.9E+0	960.3E+0
13Ri1	634.3E-3	654.9E-3	950.7E-3	1.4E+0	479.6E-3	424.9E-3	608.1E-3

13Ri2	4.0E+0	4.8E+0	6.9E+0	9.6E+0	3.4E+0	3.1E+0	4.3E+0
13Ri3	891.5E-3	377.1E-3	598.8E-3	1.8E+0	558.9E-3	332.0E-3	651.9E-3
13Mi1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
13Mi2	44.7E+0	46.8E+0	73.0E+0	93.7E+0	30.7E+0	25.7E+0	42.1E+0
13Mi3	824.2E+0	1.1E+3	1.6E+3	2.0E+3	724.8E+0	695.9E+0	960.3E+0
13Rj1	634.3E-3	654.9E-3	950.7E-3	1.4E+0	479.6E-3	424.9E-3	608.1E-3
13Rj2	4.0E+0	4.8E+0	6.9E+0	9.6E+0	3.4E+0	3.1E+0	4.3E+0
13Rj3	891.5E-3	377.1E-3	598.8E-3	1.8E+0	558.9E-3	332.0E-3	651.9E-3
13Mj1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
13Mj2	38.4E+0	37.0E+0	56.8E+0	82.5E+0	26.7E+0	20.9E+0	35.2E+0
13Mj3	524.2E+0	731.0E+0	1.1E+3	1.3E+3	460.1E+0	442.4E+0	612.4E+0
14Ri1	1.1E+0	965.0E-3	1.4E+0	2.1E+0	655.5E-3	598.0E-3	888.0E-3
14Ri2	5.1E+0	7.2E+0	10.4E+0	12.8E+0	4.5E+0	4.4E+0	6.0E+0
14Ri3	428.1E-3	240.4E-3	380.4E-3	878.4E-3	269.8E-3	184.3E-3	327.4E-3
14Mi1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
14Mi2	38.4E+0	37.0E+0	56.8E+0	82.5E+0	26.7E+0	20.9E+0	35.2E+0
14Mi3	524.2E+0	731.0E+0	1.1E+3	1.3E+3	460.1E+0	442.4E+0	612.4E+0
14Rj1	1.1E+0	965.0E-3	1.4E+0	2.1E+0	655.5E-3	598.0E-3	888.0E-3
14Rj2	5.1E+0	7.2E+0	10.4E+0	12.8E+0	4.5E+0	4.4E+0	6.0E+0
14Rj3	428.1E-3	240.4E-3	380.4E-3	878.4E-3	269.8E-3	184.3E-3	327.4E-3
14Mj1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
14Mj2	20.7E+0	25.0E+0	36.4E+0	46.9E+0	16.1E+0	15.0E+0	21.1E+0
14Mj3	94.8E+0	129.4E+0	188.2E+0	230.6E+0	81.2E+0	77.4E+0	108.0E+0
15Ri1	1.5E+0	1.2E+0	1.7E+0	2.7E+0	787.6E-3	728.3E-3	1.1E+0
15Ri2	1.2E+0	453.1E-3	720.8E-3	2.3E+0	681.4E-3	413.2E-3	825.2E-3
15Ri3	6.5E+0	9.0E+0	13.0E+0	16.0E+0	5.6E+0	5.4E+0	7.5E+0
15Mi1	40.1E+0	56.0E+0	81.3E+0	99.0E+0	35.0E+0	33.7E+0	46.6E+0
15Mi2	94.8E+0	129.4E+0	188.2E+0	230.6E+0	81.2E+0	77.4E+0	108.0E+0
15Mi3	20.7E+0	25.0E+0	36.4E+0	46.9E+0	16.1E+0	15.0E+0	21.1E+0
15Rj1	1.2E+0	453.1E-3	720.8E-3	2.3E+0	681.4E-3	413.2E-3	825.1E-3
15Rj2	1.5E+0	1.2E+0	1.7E+0	2.7E+0	787.6E-3	728.3E-3	1.1E+0
15Rj3	6.5E+0	9.0E+0	13.0E+0	16.0E+0	5.6E+0	5.4E+0	7.5E+0
15Mj1	23.7E+0	31.8E+0	46.0E+0	58.0E+0	20.5E+0	19.5E+0	27.1E+0
15Mj2	78.5E+0	105.2E+0	153.0E+0	189.8E+0	66.8E+0	63.2E+0	88.6E+0
15Mj3	9.4E+0	5.4E+0	8.0E+0	18.6E+0	6.4E+0	4.5E+0	6.9E+0
16Ri1	1.8E+0	640.0E-3	1.0E+0	3.4E+0	994.7E-3	599.3E-3	1.2E+0
16Ri2	7.2E+0	9.9E+0	14.4E+0	17.6E+0	6.2E+0	5.9E+0	8.2E+0
16Ri3	1.7E+0	1.3E+0	1.9E+0	3.1E+0	882.4E-3	815.7E-3	1.3E+0
16Mi1	23.7E+0	31.8E+0	46.0E+0	58.0E+0	20.5E+0	19.5E+0	27.1E+0
16Mi2	9.4E+0	5.4E+0	8.0E+0	18.6E+0	6.4E+0	4.5E+0	6.9E+0
16Mi3	78.5E+0	105.2E+0	153.0E+0	189.8E+0	66.8E+0	63.2E+0	88.6E+0
16Rj1	1.8E+0	640.0E-3	1.0E+0	3.4E+0	994.7E-3	599.3E-3	1.2E+0
16Rj2	7.2E+0	9.9E+0	14.4E+0	17.6E+0	6.2E+0	5.9E+0	8.2E+0
16Rj3	1.7E+0	1.3E+0	1.9E+0	3.1E+0	882.4E-3	815.7E-3	1.3E+0
16Mj1	23.7E+0	31.8E+0	46.0E+0	58.0E+0	20.5E+0	19.5E+0	27.1E+0
16Mj2	101.2E+0	74.8E+0	109.1E+0	175.2E+0	48.1E+0	45.5E+0	71.4E+0
16Mj3	511.7E+0	697.9E+0	1.0E+3	1.2E+3	438.4E+0	417.1E+0	582.0E+0
17Ri1	2.9E+0	1.0E+0	1.6E+0	5.4E+0	1.6E+0	943.3E-3	1.9E+0
3Ri2	3.9E+0	3.5E+0	5.2E+0	8.2E+0	2.8E+0	2.2E+0	3.4E+0
17Ri3	1.8E+0	359.5E-3	539.6E-3	2.5E+0	351.1E-3	321.4E-3	827.0E-3

17Mi1	23.7E+0	31.8E+0	46.0E+0	58.0E+0	20.5E+0	19.5E+0	27.1E+0
17Mi2	101.2E+0	74.8E+0	109.1E+0	175.2E+0	48.1E+0	45.5E+0	71.4E+0
17Mi3	511.7E+0	697.9E+0	1.0E+3	1.2E+3	438.4E+0	417.1E+0	582.0E+0
17Rj1	2.9E+0	1.0E+0	1.6E+0	5.4E+0	1.6E+0	943.3E-3	1.9E+0
17Rj2	3.9E+0	3.5E+0	5.2E+0	8.2E+0	2.8E+0	2.2E+0	3.4E+0
17Rj3	1.8E+0	359.5E-3	539.6E-3	2.5E+0	351.1E-3	321.4E-3	827.0E-3
17Mj1	23.7E+0	31.8E+0	46.0E+0	58.0E+0	20.5E+0	19.5E+0	27.1E+0
17Mj2	99.8E+0	44.3E+0	64.9E+0	148.8E+0	30.6E+0	28.9E+0	54.0E+0
17Mj3	314.7E+0	374.8E+0	545.8E+0	729.9E+0	256.5E+0	231.2E+0	330.3E+0
18Ri1	4.0E+0	1.4E+0	2.2E+0	7.5E+0	2.2E+0	1.3E+0	2.7E+0
18Ri2	3.7E+0	4.6E+0	6.8E+0	8.8E+0	3.1E+0	2.8E+0	4.0E+0
18Ri3	1.0E+0	452.4E-3	663.3E-3	1.5E+0	309.8E-3	294.4E-3	550.3E-3
18Mi1	23.7E+0	31.8E+0	46.0E+0	58.0E+0	20.5E+0	19.5E+0	27.1E+0
18Mi2	99.8E+0	44.3E+0	64.9E+0	148.8E+0	30.6E+0	28.9E+0	54.0E+0
18Mi3	314.7E+0	374.8E+0	545.8E+0	729.9E+0	256.5E+0	231.2E+0	330.3E+0
18Rj1	4.0E+0	1.4E+0	2.2E+0	7.5E+0	2.2E+0	1.3E+0	2.7E+0
18Rj2	3.7E+0	4.6E+0	6.8E+0	8.8E+0	3.1E+0	2.8E+0	4.0E+0
18Rj3	1.0E+0	452.4E-3	663.3E-3	1.5E+0	309.8E-3	294.4E-3	550.3E-3
18Mj1	23.7E+0	31.8E+0	46.0E+0	58.0E+0	20.5E+0	19.5E+0	27.1E+0
18Mj2	18.5E+0	8.1E+0	11.9E+0	27.8E+0	5.9E+0	5.4E+0	10.1E+0
18Mj3	32.9E+0	11.2E+0	17.8E+0	61.7E+0	17.8E+0	11.0E+0	22.3E+0
19Ri1	4.7E+0	1.6E+0	2.6E+0	8.8E+0	2.5E+0	1.5E+0	3.1E+0
19Ri2	4.4E+0	5.0E+0	7.3E+0	10.2E+0	3.6E+0	3.2E+0	4.6E+0
19Ri3	1.7E+0	509.1E-3	752.7E-3	2.4E+0	397.2E-3	369.0E-3	805.0E-3
19Mi1	23.7E+0	31.8E+0	46.0E+0	58.0E+0	20.5E+0	19.5E+0	27.1E+0
19Mi2	18.5E+0	8.1E+0	11.9E+0	27.8E+0	5.9E+0	5.4E+0	10.1E+0
19Mi3	32.9E+0	11.2E+0	17.8E+0	61.7E+0	17.8E+0	11.0E+0	22.3E+0
19Rj1	4.4E+0	5.0E+0	7.3E+0	10.2E+0	3.6E+0	3.2E+0	4.6E+0
19Rj2	4.7E+0	1.6E+0	2.6E+0	8.8E+0	2.5E+0	1.5E+0	3.1E+0
19Rj3	1.7E+0	509.1E-3	752.7E-3	2.4E+0	397.2E-3	369.0E-3	805.0E-3
19Mj1	11.7E+0	1.3E+0	2.1E+0	16.0E+0	1.9E+0	1.9E+0	5.1E+0
19Mj2	40.8E+0	40.6E+0	59.0E+0	82.3E+0	26.5E+0	24.8E+0	36.2E+0
19Mj3	119.7E+0	101.1E+0	148.5E+0	250.2E+0	83.7E+0	66.4E+0	103.6E+0
20Ri1	4.6E+0	5.2E+0	7.6E+0	10.6E+0	3.8E+0	3.3E+0	4.8E+0
20Ri2	2.2E+0	990.9E-3	1.5E+0	4.2E+0	1.4E+0	821.7E-3	1.6E+0
20Ri3	695.5E-3	288.8E-3	423.0E-3	1.1E+0	263.6E-3	205.7E-3	384.2E-3
20Mi1	11.7E+0	1.3E+0	2.1E+0	16.0E+0	1.9E+0	1.9E+0	5.1E+0
20Mi2	40.8E+0	40.6E+0	59.0E+0	82.3E+0	26.5E+0	24.8E+0	36.2E+0
20Mi3	119.7E+0	101.1E+0	148.5E+0	250.2E+0	83.7E+0	66.4E+0	103.6E+0
20Rj1	4.6E+0	5.2E+0	7.6E+0	10.6E+0	3.8E+0	3.3E+0	4.8E+0
20Rj2	2.2E+0	990.9E-3	1.5E+0	4.2E+0	1.4E+0	821.7E-3	1.6E+0
20Rj3	695.5E-3	288.8E-3	423.0E-3	1.1E+0	263.6E-3	205.7E-3	384.2E-3
20Mj1	11.7E+0	1.3E+0	2.1E+0	16.0E+0	1.9E+0	1.9E+0	5.1E+0
20Mj2	21.1E+0	24.8E+0	36.2E+0	46.3E+0	15.6E+0	14.6E+0	20.9E+0
20Mj3	65.9E+0	66.4E+0	97.0E+0	145.3E+0	50.1E+0	42.8E+0	63.4E+0
21Ri1	4.9E+0	5.5E+0	8.0E+0	11.3E+0	4.1E+0	3.5E+0	5.1E+0
21Ri2	970.2E-3	671.8E-3	996.9E-3	1.9E+0	636.2E-3	463.2E-3	770.9E-3
21Ri3	319.9E-3	269.8E-3	391.7E-3	601.2E-3	184.6E-3	169.5E-3	254.1E-3
21Mi1	11.7E+0	1.3E+0	2.1E+0	16.0E+0	1.9E+0	1.9E+0	5.1E+0
21Mi2	21.1E+0	24.8E+0	36.2E+0	46.3E+0	15.6E+0	14.6E+0	20.9E+0

21Mi3	65.9E+0	66.4E+0	97.0E+0	145.3E+0	50.1E+0	42.8E+0	63.4E+0
21Rj1	4.9E+0	5.5E+0	8.0E+0	11.3E+0	4.1E+0	3.5E+0	5.1E+0
21Rj2	970.2E-3	671.8E-3	996.9E-3	1.9E+0	636.2E-3	463.2E-3	770.9E-3
21Rj3	319.9E-3	269.8E-3	391.7E-3	601.2E-3	184.6E-3	169.5E-3	254.1E-3
21Mj1	11.7E+0	1.3E+0	2.1E+0	16.0E+0	1.9E+0	1.9E+0	5.1E+0
21Mj2	27.4E+0	10.2E+0	15.2E+0	41.4E+0	9.9E+0	7.0E+0	14.2E+0
21Mj3	91.6E+0	45.0E+0	69.4E+0	176.0E+0	58.8E+0	36.0E+0	66.7E+0
22Ri1	5.2E+0	5.7E+0	8.3E+0	12.0E+0	4.4E+0	3.7E+0	5.4E+0
22Ri2	1.4E+0	839.5E-3	1.3E+0	2.7E+0	920.9E-3	617.6E-3	1.1E+0
22Ri3	418.0E-3	252.6E-3	371.7E-3	690.0E-3	188.5E-3	156.1E-3	263.6E-3
22Mi1	11.7E+0	1.3E+0	2.1E+0	16.0E+0	1.9E+0	1.9E+0	5.1E+0
22Mi2	27.4E+0	10.2E+0	15.2E+0	41.4E+0	9.9E+0	7.0E+0	14.2E+0
22Mi3	91.6E+0	45.0E+0	69.4E+0	176.0E+0	58.8E+0	36.0E+0	66.7E+0
22Rj1	5.2E+0	5.7E+0	8.3E+0	12.0E+0	4.4E+0	3.7E+0	5.4E+0
22Rj2	1.4E+0	839.5E-3	1.3E+0	2.7E+0	920.9E-3	617.6E-3	1.1E+0
22Rj3	418.0E-3	252.6E-3	371.7E-3	690.0E-3	188.5E-3	156.1E-3	263.6E-3
22Mj1	11.7E+0	1.3E+0	2.1E+0	16.0E+0	1.9E+0	1.9E+0	5.1E+0
22Mj2	5.8E+0	5.8E+0	8.4E+0	12.3E+0	4.1E+0	3.8E+0	5.4E+0
22Mj3	16.1E+0	12.6E+0	18.5E+0	33.0E+0	10.8E+0	8.4E+0	13.4E+0
23Ri1	5.5E+0	6.0E+0	8.7E+0	12.8E+0	4.7E+0	4.0E+0	5.7E+0
23Ri2	2.4E+0	1.2E+0	1.8E+0	4.7E+0	1.6E+0	938.8E-3	1.8E+0
23Ri3	725.9E-3	226.8E-3	343.2E-3	1.1E+0	262.4E-3	171.5E-3	358.6E-3
23Mi1	11.7E+0	1.3E+0	2.1E+0	16.0E+0	1.9E+0	1.9E+0	5.1E+0
23Mi2	5.8E+0	5.8E+0	8.4E+0	12.3E+0	4.1E+0	3.8E+0	5.4E+0
23Mi3	16.1E+0	12.6E+0	18.5E+0	33.0E+0	10.8E+0	8.4E+0	13.4E+0
23Rj1	5.5E+0	6.0E+0	8.7E+0	12.8E+0	4.7E+0	4.0E+0	5.7E+0
23Rj2	2.4E+0	1.2E+0	1.8E+0	4.7E+0	1.6E+0	938.8E-3	1.8E+0
23Rj3	725.9E-3	226.8E-3	343.2E-3	1.1E+0	262.4E-3	171.5E-3	358.6E-3
23Mj1	11.7E+0	1.3E+0	2.1E+0	16.0E+0	1.9E+0	1.9E+0	5.1E+0
23Mj2	40.7E+0	18.1E+0	26.9E+0	63.2E+0	16.2E+0	11.8E+0	22.1E+0
23Mj3	136.5E+0	73.9E+0	112.5E+0	265.0E+0	88.8E+0	56.7E+0	101.9E+0

Table 19c Maximum Element Forces and Moments for S-components of Benchmark Problem #4a, Case a, 16 Bits Vs. 32 Bits (kips-inches)

Elements	16 Bits	32 Bits
1Ri1	6.04E-02	0.07885
1Ri2	6.71E-01	0.7819
1Ri3	5.62E-02	0.09439
1Mi1	2.54E+01	42.72
1Mi2	4.00E+00	6.859
1Mi3	3.91E+01	48.07
1Rj1	6.04E-02	0.07885
1Rj2	6.71E-01	0.7819
1Rj3	5.62E-02	0.09439
1Mj1	2.54E+01	42.72
1Mj2	8.70E-01	0.9695
1Mj3	1.50E+01	15.26
2Ri1	6.01E-02	0.07866
2Ri2	1.65E-01	0.2923
2Ri3	4.52E-02	0.07461
2Mi1	2.54E+01	42.72
2Mi2	8.70E-01	0.9695
2Mi3	1.50E+01	15.26
2Rj1	6.01E-02	0.07866
2Rj2	1.65E-01	0.2923
2Rj3	4.52E-02	0.07461
2Mj1	2.54E+01	42.72
2Mj2	3.80E+00	6.486
2Mj3	2.53E+01	35.14
3Ri1	5.97E-02	0.07836
3Ri2	4.81E-01	0.4479
3Ri3	5.09E-02	0.06156
3Mi1	2.54E+01	42.72
3Mi2	3.80E+00	6.486
3Mi3	2.53E+01	35.14
3Rj1	5.97E-02	0.07836
3Rj2	4.81E-01	0.4479
3Rj3	5.09E-02	0.06156
3Mj1	2.54E+01	42.72
3Mj2	7.00E+00	10.76
3Mj3	2.46E+01	34.94
4Ri1	5.94E-02	0.07808
4Ri2	7.02E-01	1.074
4Ri3	1.50E+00	2.267
4Mi1	2.54E+01	42.72
4Mi2	2.46E+01	34.94
4Mi3	7.00E+00	10.76
4Rj1	7.02E-01	1.074
4Rj2	5.94E-02	0.07808

4Rj3	1.50E+00	2.267
4Mj1	3.40E+00	6.126
4Mj2	7.10E+00	7.778
4Mj3	5.10E+00	7.885
5Ri1	6.86E-01	1.065
5Ri2	5.76E-02	0.07827
5Ri3	1.30E+00	2.118
5Mi1	3.40E+00	6.126
5Mi2	7.10E+00	7.778
5Mi3	5.10E+00	7.885
5Rj1	6.86E-01	1.065
5Rj2	5.76E-02	0.07827
5Rj3	1.30E+00	2.118
5Mj1	3.40E+00	6.126
5Mj2	1.09E+02	175.7
5Mj3	4.00E+00	5.747
6Ri1	6.62E-01	1.053
6Ri2	5.22E-02	0.07426
6Ri3	6.72E-01	1.269
6Mi1	3.40E+00	6.126
6Mi2	1.09E+02	175.7
6Mi3	4.00E+00	5.747
6Rj1	6.62E-01	1.053
6Rj2	5.22E-02	0.07426
6Rj3	6.72E-01	1.269
6Mj1	3.40E+00	6.126
6Mj2	1.53E+02	275.6
6Mj3	4.80E+00	6.922
7Ri1	6.38E-01	1.04
7Ri2	6.43E-02	0.08077
7Ri3	9.01E-01	0.922
7Mi1	3.40E+00	6.126
7Mi2	1.53E+02	275.6
7Mi3	4.80E+00	6.922
7Rj1	6.38E-01	1.04
7Rj2	6.43E-02	0.08077
7Rj3	9.01E-01	0.922
7Mj1	3.40E+00	6.126
7Mj2	1.61E+02	306.9
7Mj3	7.70E+00	10.78
8Ri1	6.15E-01	1.027
8Ri2	1.06E-01	0.1523
8Ri3	2.80E+00	5.424
8Mi1	3.40E+00	6.126
8Mi2	1.61E+02	306.9
8Mi3	7.70E+00	10.78
8Rj1	6.15E-01	1.027
8Rj2	1.06E-01	0.1523
8Rj3	2.80E+00	5.424
8Mj1	3.40E+00	6.126

8Mj2	8.20E+01	150.8
8Mj3	2.30E+00	3.295
9Ri1	5.93E-01	1.014
9Ri2	7.32E-02	0.1031
9Ri3	1.70E+00	3.276
9Mi1	3.40E+00	6.126
9Mi2	8.20E+01	150.8
9Mi3	2.30E+00	3.295
9Rj1	5.93E-01	1.014
9Rj2	7.32E-02	0.1031
9Rj3	1.70E+00	3.276
9Mj1	3.40E+00	6.126
9Mj2	2.25E+02	425.3
9Mj3	7.50E+00	10.99
10Ri1	5.73E-01	1.002
10Ri2	1.43E-02	0.01843
10Ri3	2.05E-01	0.3556
10Mi1	3.40E+00	6.126
10Mi2	2.25E+02	425.3
10Mi3	7.50E+00	10.99
10Rj1	5.73E-01	1.002
10Rj2	1.43E-02	0:01843
10Rj3	2.05E-01	0.3556
10Mj1	3.40E+00	6.126
10Mj2	2.09E+02	396.1
10Mj3	8.10E+00	11.6
11Ri1	5.54E-01	0.99
11Ri2	6.23E-02	0.0902
11Ri3	2.00E+00	3.846
11Mi1	3.40E+00	6.126
11Mi2	2.09E+02	396.1
11Mi3	8.10E+00	11.6
11Rj1	5.54E-01	0.99
11Rj2	6.23E-02	0.0902
11Rj3	2.00E+00	3.846
11Mj1	3.40E+00	6.126
11Mj2	3.85E+01	73.05
11Mj3	3.00E+00	4.267
12Ri1	5.36E-01	0.9784
12Ri2	1.02E-01	0.1457
12Ri3	3.00E+00	5.736
12Mi1	3.40E+00	6.126
12Mi2	3.85E+01	73.05
12Mi3	3.00E+00	4.267
12Rj1	5.36E-01	0.9784
12Rj2	1.02E-01	0.1457
12Rj3	3.00E+00	5.736
12Mj1	3.40E+00	6.126
12Mj2	2.16E+02	408.8
12Mj3	5.80E+00	8.329

13Ri1	5.21E-01	0.9672
13Ri2	2.49E-02	0.03392
13Ri3	1.20E+00	2.285
13Mi1	3.40E+00	6.126
13Mi2	2.16E+02	408.8
13Mi3	5.80E+00	8.329
13Rj1	5.21E-01	0.9672
13Rj2	2.49E-02	0.03392
13Rj3	1.20E+00	2.285
13Mj1	3.40E+00	6.126
13Mj2	1.16E+02	217.3
13Mj3	4.20E+00	5.957
14Ri1	5.08E-01	0.9566
14Ri2	3.95E-02	0.05676
14Ri3	1.50E+00	2.73
14Mi1	3.40E+00	6.126
14Mi2	1.16E+02	217.3
14Mi3	4.20E+00	5.957
14Rj1	5.08E-01	0.9566
14Rj2	3.95E-02	0.05676
14Rj3	1.50E+00	2.73
14Mj1	3.40E+00	6.126
14Mj2	6.30E+00	12.16
14Mj3	9.56E-01	1.283
15Ri1	5.01E-01	0.9497
15Ri2	1.50E+00	2.785
15Ri3	5.96E-02	0.08396
15Mi1	3.40E+00	6.126
15Mi2	9.56E-01	1.283
15Mi3	6.30E+00	12.16
15Rj1	1.50E+00	2.785
15Rj2	5.01E-01	0.9497
15Rj3	5.96E-02	0.08396
15Mj1	2.31E-01	0.2974
15Mj2	3.00E+00	5.327
15Mj3	2.41E+01	45.05
16Ri1	1.50E+00	2.788
16Ri2	7.45E-02	0.1036
16Ri3	5.09E-01	0.9687
16Mi1	2.31E-01	0.2974
16Mi2	2.41E+01	45.05
16Mi3	3.00E+00	5.327
16Rj1	1.50E+00	2.788
16Rj2	7.45E-02	0.1036
16Rj3	5.09E-01	0.9687
16Mj1	2.31E-01	0.2974
16Mj2	7.00E+00	13.34
16Mj3	4.50E+00	5.953
17Ri1	1.60E+00	2.795
3Ri2	8.21E-02	0.1469

17Ri3	2.89E-02	0.05404
17Mi1	2.31E-01	0.2974
17Mi2	7.00E+00	13.34
17Mi3	4.50E+00	5.953
17Rj1	1.60E+00	2.795
17Rj2	8.21E-02	0.1469
17Rj3	2.89E-02	0.05404
17Mj1	2.31E-01	0.2974
17Mj2	4.70E+00	8.228
17Mj3	8.10E+00	13.41
18Ri1	1.60E+00	2.807
18Ri2	6.07E-02	0.1052
18Ri3	5.19E-02	0.0922
18Mi1	2.31E-01	0.2974
18Mi2	4.70E+00	8.228
18Mi3	8.10E+00	13.41
18Rj1	1.60E+00	2.807
18Rj2	6.07E-02	0.1052
18Rj3	5.19E-02	0.0922
18Mj1	2.31E-01	0.2974
18Mj2	6.50E-01	0.9018
18Mj3	1.18E+01	20.8
19Ri1	1.70E+00	2.816
19Ri2	5.36E-02	0.0896
19Ri3	7.65E-02	0.1177
19Mi1	2.31E-01	0.2974
19Mi2	6.50E-01	0.9018
19Mi3	1.18E+01	20.8
19Rj1	5.36E-02	0.0896
19Rj2	1.70E+00	2.816
19Rj3	7.65E-02	0.1177
19Mj1	7.49E-01	1.235
19Mj2	1.30E+00	2.217
19Mj3	1.74E+01	28.58
20Ri1	5.37E-02	0.08973
20Ri2	1.67E-01	0.177
20Ri3	4.85E-02	0.05187
20Mi1	7.49E-01	1.235
20Mi2	1.30E+00	2.217
20Mi3	1.74E+01	28.58
20Rj1	5.37E-02	0.08973
20Rj2	1.67E-01	0.177
20Rj3	4.85E-02	0.05187
20Mj1	7.49E-01	1.235
20Mj2	2.00E+00	1.837
20Mj3	1.10E+01	21.06
21Ri1	5.38E-02	0.08987
21Ri2	1.11E-01	0.1787
21Ri3	9.30E-03	0.01499
21Mi1	7.49E-01	1.235

21Mi2	2.00E+00	1.837
21Mi3	1.10E+01	21.06
21Rj1	5.38E-02	0.08987
21Rj2	1.11E-01	0.1787
21Rj3	9.30E-03	0.01499
21Mj1	7.49E-01	1.235
21Mj2	2.40E+00	2.23
21Mj3	6.60E+00	11.44
22Ri1	5.39E-02	0.08995
22Ri2	1.25E-01	0.2361
22Ri3	3.42E-02	0.03148
22Mi1	7.49E-01	1.235
22Mi2	2.40E+00	2.23
22Mi3	6.60E+00	11.44
22Rj1	5.39E-02	0.08995
22Rj2	1.25E-01	0.2361
22Rj3	3.42E-02	0.03148
22Mj1	7.49E-01	1.235
22Mj2	3.57E-01	0.4551
22Mj3	2.40E+00	3.511
23Ri1	5.39E-02	0.08998
23Ri2	1.90E-01	0.3061
23Ri3	7.33E-02	0.06943
23Mi1	7.49E-01	1.235
23Mi2	3.57E-01	0.4551
23Mi3	2.40E+00	3.511
23Rj1	5.39E-02	0.08998
23Rj2	1.90E-01	0.3061
23Rj3	7.33E-02	0.06943
23Mj1	7.49E-01	1.235
23Mj2	4.10E+00	3.8
23Mj3	1.18E+01	20.81

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ATTACHMENT 2

Evaluation of Methods for Analysis of Non-Classically Damped Coupled Systems: Benchmark Program

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INTRODUCTION

The current practice of calculating seismic response is to perform the analysis of primary structure (buildings) and secondary systems (equipment and piping) separately. Earthquake input to the primary system is defined in terms of a design response spectrum. An acceleration time history compatible with the design response spectrum is developed (a non unique process) and primary system is analyzed to obtain the acceleration histories at the desired floors. Floor time histories are used for generating the corresponding instructure response spectrum (IRS). The instructure response spectra are used as input at the supports of secondary systems. Further, in case of multiple supports, an envelope spectrum (a source of conservatism) is obtained from the individual support IRS. The enveloped spectrum is then used as an input at all the supports of secondary system. For multiply supported secondary systems, an alternate practice is to evaluate the responses due to individual support IRS and combine them using absolute sum (also conservative). In these two methods, the effect of relative support motion is incorporated by a separate response by square-root-of-sum-of-square (SRSS) rule. In the above methods, mass interaction between the secondary and primary system is ignored, which may significantly reduce the secondary system response that is otherwise excessively conservative.

The seismic response of secondary systems depend, in addition to their uncoupled dynamic characteristics, on the interaction with primary structures supporting them. Considerable effort has been made in the past to develop procedures for evaluating coupled response of non-classically damped primary-secondary systems using their uncoupled modal properties and design response spectra at the base of primary structure directly. Responses obtained from such analyses are more accurate and often reduce the conservatism in the design compared to an uncoupled analysis. In general, the secondary systems have damping that is different from the damping of primary structure. This makes the coupled system non-classically damped. The eigenvalues and eigenvectors of a non-classically damped system are complex and cannot be evaluated using conventional analytical tools.

Gupta and coworkers [2,3,6] developed a method to obtain the coupled frequencies, damping ratios and mode shapes of the nonclassically damped systems using the modal properties of the uncoupled primary and secondary systems. They simplified the analysis by algebraically replacing the complex mode shape by two real modal vectors and further extended their formulation to the response spectrum method. Computer programs CREST and CREST-TH implement this method. CREST evaluates the coupled response by response spectrum method and CREST-TH by a time-history analysis.

Computer programs CREST and CREST-TH can be used to perform coupled analysis of piping systems when interfaced with a piping analysis program. The piping is modeled using the piping program which then calls CREST as a sub-program to evaluate the coupled modal displacements. CREST and CREST-TH require additional information on the modal properties of uncoupled primary system, primary-secondary system connectivity data and earthquake input at the base of primary system. The coupled modal displacements evaluated by CREST (or CREST-TH) are used to evaluate coupled modal responses in terms of member forces and support reactions. The coupled modal responses are then combined appropriately to evaluate the final response values. CREST and CREST-TH are currently interfaced with the piping program PIPESTRESS [1].

COUPLED EQUATION OF MOTION

The equation of motion for an N-DOF coupled primary - secondary system can be written as

$$[M]\{\ddot{U}\} + [C]\{\dot{U}\} + [K]\{U\} = -[M]\{U_b\}\,\ddot{u}_g \tag{1}$$

where [M], [C] and [K] are the mass, damping and stiffness matrices, respectively, of the coupled system $\{U\}$ is the displacement vector; $\{U_b\}$is the static displacement vector of the coupled system when the base of primary system undergoes a unit deflection in the direction of earthquake; and $\ddot{u}_g$ is the ground acceleration. In the above equation, various matrices and vectors can be written using the matrices and vectors of primary and secondary systems.

$$\begin{aligned}
[M] &= \begin{bmatrix} [M_p] & [O] \\ [O] & [M_{ss}] \end{bmatrix} \\
[C] &= \begin{bmatrix} [C_p]+[C_p^s] & [C_{ps}] \\ [C_{sp}] & [C_{ss}] \end{bmatrix} \\
[K] &= \begin{bmatrix} [K_p]+[K_p^s] & [K_{ps}] \\ [K_{sp}] & [K_{ss}] \end{bmatrix} \\
\{U\} &= \begin{Bmatrix} \{U_p\} \\ \{U_s\} \end{Bmatrix} \\
\{U_b\} &= \begin{Bmatrix} \{U_{bp}\} \\ \{U_{bs}\} \end{Bmatrix}
\end{aligned} \tag{2}$$

The subscript p denotes a primary system property, and the subscript s a secondary system property. Matrices $[K_p^s]$ and $[C_p^s]$ are the stiffness and damping contributions of the secondary system with respect to the primary system's connecting DOF. It is assumed that both the uncoupled systems (primary and secondary) are classically damped. Therefore, the damping matrices $[C_p]$ and $[C_{ss}]$ are diagonalised when they are pre- and post-multiplied by the respective undamped modal matrices. Such systems are called classically damped. However, when the modal damping ratios of the two systems are unequal, the combined damping matrix $[C]$ would be no longer diagonal when pre- and post-multiplied by the undamped modal matrix of the coupled system. The combined system, therefore, becomes nonclassically damped. This implies that if the modal matrix of the coupled system be denoted by $[\Phi]$, then $[\Phi]^T\,[C]\,[\Phi]$ will not be diagonal.

SECONDARY SYSTEM DISPLACEMENT VECTOR RELATIVE TO THE PRIMARY SYSTEM CONNECTING DOF

Eq. 1 represents the equation of motion for a coupled system in which all the DOF are expressed relative to the fixed base of primary system. In this equation, the equation of motion for secondary system DOF can be written as.

$$[M_{ss}]\{\ddot{U}_s\}+[C_{sp}]\{\dot{U}_p\}+[C_{ss}]\{\dot{U}_s\}+[K_{sp}]\{U_p\}+[K_{ss}]\{U_s\} = -[M_{ss}]\{U_{bs}\}\ddot{u}_g \quad (3)$$

Let us solve a static problem, eliminating all the dynamic terms.

$$[K_{sp}]\{U_p\} + [K_{ss}]\{U_s\} = \{0\} \quad (4)$$

The equation can be also written as

$$[U_{so}] = -[K_{ss}]^{-1}[K_{sp}]\{U_p\} \quad (5)$$

Let us define

$$[U_{sp}] = -[K_{ss}]^{-1}[K_{sp}] \quad (6)$$

Matrix $[K_{sp}]$ will have several columns whose elements are all zero. These columns correspond to non connecting DOF of the primary system. Only those columns will have non zero values which correspond to primary system connecting DOF, *c*. We can, therefore, write

$$[U_{sc}] = -[K_{ss}]^{-1}[K_{sc}] \quad (7)$$

Thus we have,

$$\{U_{so}\} = -[K_{ss}]^{-1}[K_{sc}]\{U_c\}$$

$$= [\{U_{s1}\}\ \{U_{s2}\}\ \ldots\ \{U_{nc}\}]\begin{Bmatrix} u_1 \\ u_2 \\ \cdot \\ \cdot \\ \cdot \\ u_{nc} \end{Bmatrix} \quad (8)$$

where nc is the number of primary system connecting DOF. If we displace one of the connecting DOF i by unity, we get $\{U_{so}^i\} = \{U_{si}\}$ in which the RHS is the i^{th} column in the $[U_{sc}]$ matrix. Thus, each column in the $[U_{sc}]$ matrix represents a displacement vector of the secondary system when the primary system connecting DOF corresponding to the column displaces by unity.

The vector $\{U'_{so}\}$ in Eq.8 represents the effect of primary system connecting DOF on the secondary system displacements. The secondary system displacements relative to the primary system connecting DOF, $\{\overline{U}_s\}$ can be obtained by subtracting this effect from the secondary system displacements relative to the primary system fixed base.

$$\begin{aligned}\{\overline{U}_s\} &= \{U_s\} - \{U_{so}\} \\ &= \{U_s\} - [U_{sc}]\{U_c\} \\ &= \left[\,-[U_{sp}]\,[I]\,\right]\begin{Bmatrix}\{U_p\}\\ \{U_s\}\end{Bmatrix} \\ &= [Q]\{U\}\end{aligned} \tag{9}$$

The matrix $[U_{sp}]$ can be obtained from the matrix $[U_{sc}]$ by adding zero vectors for non-connecting primary system DOF. We can now define a new set of DOF for the coupled system denoted by $\{U\}$, in which the primary system displacements are expressed relative to its base and the secondary system displacements are expressed relative to the primary system connecting DOF. It is defined by the following transformation.

$$\begin{aligned}\{U\} &= \begin{Bmatrix}\{U_p\}\\ \{U_s\}\end{Bmatrix} = \begin{bmatrix}[I] & [O]\\ [U_{sp}] & [I]\end{bmatrix}\begin{Bmatrix}\{\overline{U}_p\}\\ \{\overline{U}_s\}\end{Bmatrix} \\ &= [T]\{\overline{U}\}\end{aligned} \tag{10}$$

in which $[I]$ is an identity matrix and $[T]$ is the transformation matrix and $\{U_p\} \equiv \{\overline{U}_p\}$.

DAMPING MATRIX OF THE COUPLED SYSTEM

Let the damping matrix of the fixed base uncoupled secondary system be denoted by $[C]$. Since the uncoupled secondary system is classically damped, we can write

$$\left[\ulcorner 2\omega_{sa}\,\zeta_{sa} \lrcorner\right] = [\Phi_s]^T\,[\overline{C}_s]\,[\Phi_s] \tag{11}$$

in which ω_{sa} and ζ_{sa} are the circular frequency and modal damping ratio, respectively, in the a^{th} uncoupled secondary system mode. The secondary system damping matrix relative to its own fixed base, $[\overline{C}_s]$, can be calculated using the undamped modal matrix $[\Phi_s]$ and the mass matrix $[M_{ss}]$ of the uncoupled secondary system.

$$\left[\overline{C}_s\right] = \left[\Phi_s^T\right]^{-1} \left[{}^{\frown}2\omega_{sa}\,\zeta_{sa}{}_{\smile}\right] \left[\Phi_s\right]^{-1} \tag{12}$$

Since $[\Phi_s]^T [M_{ss}] [\Phi_s] = [I]$, we can write

$$\begin{aligned} \left[\Phi_s^T\right]^{-1} &= \left[M_{ss}\right]\left[\Phi_s\right] \\ \left[\Phi_s\right]^{-1} &= \left[\Phi_s\right]^T \left[M_{ss}\right] \end{aligned} \tag{13}$$

Therefore,

$$\left[\overline{C}_s\right] = \left[M_{ss}\right]\left[\Phi_s\right]\left[{}^{\frown}2\omega_{sa}\,\zeta_{sa}{}_{\smile}\right] \left[\Phi_s\right]^T \left[M_{ss}\right] \tag{14}$$

The damping matrix $[C]$ is of order $(NS \times NS)$ where NS is the number of secondary system DOF.

For developing damping matrix of the coupled system, we need to express the secondary system damping matrix relative to the fixed base of primary system and not its own fixed base. This can be done by using the transformation developed in the previous section. If $[C_{ss}]$ denotes the secondary system damping matrix relative to the primary system fixed base, then we can write

$$\begin{aligned} \left[C_{ss}\right] &= \left[Q\right]^T \left[\overline{C}_s\right]\left[Q\right] \\ &= \begin{bmatrix} [U_{sp}]^T\,[\overline{C}_s]\,[U_{sp}] & -\,[U_{sp}]^T [\overline{C}_s] \\ -\,[\overline{C}_s]\,[U_{sp}] & [\overline{C}_s] \end{bmatrix} \end{aligned} \tag{15}$$

The transformed matrix $[C_{ss}]$ is of order $(NT \times NT)$ where NT is the total number of DOF for the coupled system (equal to the primary system DOF plus the secondary system DOF). The primary system damping matrix $[C_p]$ relative to its own base, can now be assembled with matrix $[C_{ss}]$ to obtain the total damping matrix of the nonclassically damped coupled system. The primary system damping matrix $[C_p]$ can be evaluated using the same procedure as for the secondary system, i.e.

$$\left[C_p\right] = \left[M_p\right]\left[\Phi_p\right]\left[{}^{\frown}2\omega_{pi}\,\zeta_{pi}{}_{\smile}\right] \left[\Phi_p\right]^T \left[M_p\right] \tag{16}$$

in which ω_{pi} and ζ_{pi} are the circular frequency and modal damping ratio of the i^{th} uncoupled primary system mode. Damping matrix of the coupled system can now be written as.

$$\left[C\right] = \begin{bmatrix} [C_p] + [U_{sp}]^T\,[\overline{C}_s]\,[U_{sp}] & -\,[U_{sp}]^T[\overline{C}_s] \\ -\,[\overline{C}_s]\,[U_{sp}] & [\overline{C}_s] \end{bmatrix} \tag{17}$$

which gives

$$\begin{aligned}
[C_p] + [C_p^s] &= [C_p] + [U_{sp}]^T [\overline{C}_s][U_{sp}] \\
[C_{ps}] &= -[U_{sp}]^T [\overline{C}_s] \\
[C_{sp}] &= -[\overline{C}_s][U_{sp}] \\
[C_{ss}] &= [\overline{C}_s]
\end{aligned} \tag{18}$$

ALTERNATIVE FORM OF EQUATION OF MOTION

Reduced eigenvalue problem obtained by transforming the original equation of motion in which the displacements at the secondary system DOF are expressed relative to the base of the primary system, gives incorrect results when all the modes of the secondary system are not included and missing mass effect is taken into account by residual modal vectors [3,4]. An alternate form of equation of motion is developed, in which the original equation of motion is transformed such that the displacements at the secondary system DOF are expressed relative to the primary system connecting DOF. The reduced eigenvalue problem is solved using the transformed equation of motion for the nonrigid and the residual modal vectors of the two uncoupled systems. Formulations to include the missing mass in a coupled analysis of multiply connected secondary systems by modal synthesis approach is given in reference [4] and described later in this report.

Substituting Eq.10 into Eq.1 and premultiplying by $[T]^T$, the transformed equation of motion becomes

$$[\overline{M}]\{\ddot{\overline{U}}\} + [\overline{C}]\{\dot{\overline{U}}\} + [\overline{K}]\{\overline{U}\} = -[\overline{M}]\{\overline{U}_b\}\ddot{u}_g \tag{19}$$

where

$$[\overline{M}] = [T]^T[M][T] = \begin{bmatrix} [\overline{M}_p] & [\overline{M}_{ps}] \\ [\overline{M}_{sp}] & [\overline{M}_{ss}] \end{bmatrix}$$

$$[\overline{C}] = [T]^T[C][T] = \begin{bmatrix} [\overline{C}_p] & [\overline{C}_{ps}] \\ [\overline{C}_{sp}] & [\overline{C}_{ss}] \end{bmatrix}$$

$$[\overline{K}] = [T]^T[K][T] = \begin{bmatrix} [\overline{K}_p] & [\overline{K}_{ps}] \\ [\overline{K}_{sp}] & [\overline{K}_{ss}] \end{bmatrix}$$

$$\{\overline{U}_b\} = [T]^{-1}\{U_b\} = \begin{Bmatrix} \{\overline{U}_{bp}\} \\ \{\overline{U}_{bs}\} \end{Bmatrix} = \begin{bmatrix} [I] & [O] \\ -[U_{sp}] & [I] \end{bmatrix} \begin{Bmatrix} \{U_{bp}\} \\ \{U_{bs}\} \end{Bmatrix}$$

and

$$
\begin{aligned}
[\overline{M}_p] &= [M_p] + [U_{sp}]^T [M_{ss}] [U_{sp}] \\
[\overline{M}_{ps}] &= [\overline{M}_{sp}]^T = [U_{sp}]^T [M_{ss}] \\
[\overline{M}_s] &= [M_{ss}] \\
[\overline{C}_p] &= [C_p] + [C_p^s] + [U_{sp}]^T [C_{sp}] + [C_{ps}][U_{sp}] + [U_{sp}]^T [C_{ss}][U_{sp}] \\
[\overline{C}_{ps}] &= [\overline{C}_{sp}]^T = [C_{sp}] + [U_{sp}]^T [C_{ss}] \\
[\overline{C}_s] &= [C_{ss}] \\
[\overline{K}_p] &= [K_p] + [K_p^s] + [U_{sp}]^T [K_{sp}] + [K_{ps}][U_{sp}] + [U_{sp}]^T [K_{ss}][U_{sp}] \\
[\overline{K}_{ps}] &= [\overline{K}_{sp}]^T = [K_{ps}] + [U_{sp}]^T [K_{ss}] \\
[\overline{K}_s] &= [K_{ss}]
\end{aligned}
$$

Various submatrices in the above equation can be simplified further. Eqs. 7 and 18 give

$$
\begin{aligned}
[\overline{K}_{ps}] &= [\overline{K}_{sp}]^T = [O] \\
[\overline{K}_p] &= [K_p] + [K_p^s] - [U_{sp}]^T [K_{ss}][U_{sp}] \\
[\overline{C}_{ps}] &= [\overline{C}_{sp}]^T = [O] \\
[\overline{C}_p] &= [C_p] + [C_p^s] - [U_{sp}]^T [C_{ss}][U_{sp}]
\end{aligned}
\tag{20}
$$

The term $\left([K_p^s] - [U_{sp}]^T [K_s][U_{sp}]\right)$ represents the static constraint of the secondary system on the primary system connecting DOF. The corresponding term in the transformed damping matrix is neglected, thereby giving $[\overline{C}_p] = [C_p]$. When the base of primary system undergoes a unit deflection in the direction of earthquake, no relative displacement exists between the two uncoupled systems, giving $\{\overline{U}_{bs}\} = \{O\}$.

PRIMARY SYSTEM RESIDUAL VECTOR

The effect of truncated high frequency modes is included through the use of residual modal vectors [3,4]. Since the primary system is assumed to be singly connected at its base, we get only one such residual mode. The equation of motion for *NP*-DOF uncoupled primary system is

$$
[M_p]\{\ddot{U}_p\} + [C_p]\{\dot{U}_p\} + [K_p]\{U_p\} = -[M_p]\{U_{bp}\}\ddot{u}_g \tag{21}
$$

in which $\{U_{bp}\}$and $\{U_p\}$are the subvectors of $\{U_b\}$and $\{U\}$, respectively. If $\{\phi_{pi}\}$ and γ_{pi} are the mass normalized mode shape and participation factor of the i^{th} uncoupled primary system mode, we can write

$$
\{U_{bp}\} = \sum_{i=1}^{NP} \{\phi_{pi}\}\gamma_{pi} \tag{22}
$$

Substituting Eq.22 into Eq.21, we get

$$\left[M_p\right]\left\{\ddot{U}_p\right\} + \left[C_p\right]\left\{\dot{U}_p\right\} + \left[K_p\right]\left\{U_p\right\} = -\sum_{i=1}^{NP} \gamma_{pi}\left[M_p\right]\left\{\phi_{pi}\right\}\ddot{u}_g \tag{23}$$

The response in the i^{th} mode is given by

$$\left[M_p\right]\left\{\ddot{U}_{pi}\right\} + \left[C_p\right]\left\{\dot{U}_{pi}\right\} + \left[K_p\right]\left\{U_{pi}\right\} = -\gamma_{pi}\left[M_p\right]\left\{\phi_{pi}\right\}\ddot{u}_g \tag{24}$$

The total number of primary system modes is *NP*, equal to the total number of primary system DOF. Further, let us assume that there are *np* modes having frequencies less than the rigid frequency and that their modal properties are known. We denote the response in these *np* modes by $\{U'_p\}$ and the response in the remaining modes by $\{U_o\}$.

$$\left\{U'_p\right\} = \sum_{i=1}^{np}\left\{U_{pi}\right\} \quad ; \quad \left\{U_o\right\} = \sum_{i=np+1}^{NP}\left\{U_{pi}\right\} \tag{25}$$

$$\left\{U_p\right\} = \left\{U'_p\right\} + \left\{U_o\right\} \tag{26}$$

Eqs. 23-26 give,

$$\left[M_p\right]\left\{\ddot{U}_o\right\} + \left[C_p\right]\left\{\dot{U}_o\right\} + \left[K_p\right]\left\{U_o\right\} = -\left[M_p\right]\left\{U_{bo}\right\}\ddot{u}_g \tag{27}$$

$$\left\{U_{bo}\right\} = \left\{U_{bp}\right\} - \sum_{i=1}^{np}\left\{\phi_{pi}\right\}\gamma_{pi} \tag{28}$$

Since the residual response in high frequency modes is pseudo-static, we can neglect the terms $\{\ddot{U}_o\}$ and $\{\dot{U}_o\}$ in Eq.27

$$\left[K_p\right]\left\{U_o\right\} = -\left[M_p\right]\left\{U_{bo}\right\}\ddot{u}_g \tag{29}$$

The term $\ddot{u}_g$ is a scalar and can be scaled out of the above equation. The solution of resulting equation yields a normalized vector $\{\phi_O\}$ such that $\{\phi_o\}^T[M_p]\{\phi_o\} = 1$. We can also evaluate a fictitious frequency corresponding to the residual mode

$$\omega_o^2 = \left\{\phi_o\right\}^T\left[K_p\right]\left\{\phi_o\right\} \tag{30}$$

The residual modal vector $\{\phi_O\}$ and the corresponding frequency ω_o can be directly included as modal properties of an additional primary system mode in the coupled analysis. The coupled problem is then solved for $np + 1$ primary system modes.

SECONDARY SYSTEM RESIDUAL VECTORS

For a multiply connected secondary system, number of residual modal vectors is equal to the number of primary system connecting DOF. The equation of motion of an *NS*-DOF secondary system in terms of the displacements relative to the primary system connecting DOF, as given by Eq. 19 is

$$[M_{ss}]\{\ddot{\bar{U}}_s\} + [C_{ss}]\{\dot{\bar{U}}_s\} + [K_{ss}]\{\bar{U}_s\} = -[M_{ss}][U_{sc}]\{\ddot{\bar{U}}_c\}^t \tag{31}$$

in which,

$$\{\ddot{\bar{U}}_c\}^t = \{\ddot{U}_c\} + \{U_{bc}\}\,\ddot{u}_g \tag{32}$$

where $\{\ddot{\bar{U}}_c\}^t$ represents the total acceleration at the primary system connecting DOF. $\{U_{bc}\}$ is a subvector of $\{U_{bp}\}$ and represents the static displacement vector of the primary system connecting DOF when the base of the primary system undergoes a unit displacement. If $\{\phi_{s\alpha}\}$ and $\gamma_{c\alpha}$ are the mass normalized mode shape and the corresponding participation factor associated with the c connecting DOF of the α^{th} uncoupled secondary system mode, respectively, reference [2] shows that $[U_{sc}]$ can be represented by the relation

$$[U_{sc}] = \sum_{\alpha=1}^{NS} \{\phi_{s\alpha}\}[\gamma_{c\alpha}], \qquad [\gamma_{c\alpha}] = \{\phi_{s\alpha}\}^T [M_{ss}][U_{sc}] \tag{33}$$

In Eq.33, $[\gamma_{c\alpha}]$ is a row matrix containing nc participation factors for the α^{th} mode of secondary system, one element for each connecting DOF. If $\ddot{u}_c^t$ is an element of vector $\{\ddot{\bar{U}}_c\}^t$, Eqs.31 and 33 give

$$[M_{ss}]\{\ddot{\bar{U}}_s\} + [C_{ss}]\{\dot{\bar{U}}_s\} + [K_{ss}]\{\bar{U}_s\} = -\sum_{\alpha=1}^{NS} [M_{ss}]\sum_{c} \{\phi_{s\alpha}\}\gamma_{c\alpha}\,\ddot{u}_c^t \tag{34}$$

The response in any α^{th} mode of secondary system is given by

$$[M_{ss}]\{\ddot{\bar{U}}_{s\alpha}\} + [C_{ss}]\{\dot{\bar{U}}_{s\alpha}\} + [K_{ss}]\{\bar{U}_{s\alpha}\} = -[M_{ss}]\sum_{c} \{\phi_{s\alpha}\}\gamma_{c\alpha}\,\ddot{u}_c^t \tag{35}$$

The total number of modes for the secondary system is *NS*, equal to the total number of secondary system DOF. Further, let us assume that there are *ns* modes having frequencies less than the cut-off frequency. We denote the response in these *ns* modes by $\{\bar{U}_s'\}$, and the response in the remaining modes by $\{\bar{U}_{so}\}$.

$$\{\overline{U}_s'\} = \sum_{\alpha=1}^{ns} \{\overline{U}_{s\alpha}\}, \qquad \{\overline{U}_{so}\} = \sum_{\alpha=ns+1}^{NS} \{\overline{U}_{s\alpha}\} \tag{36}$$

$$\{\overline{U}_s\} = \{\overline{U}_s'\} + \{\overline{U}_{so}\} \tag{37}$$

Eqs. 34-37 give

$$[M_{ss}]\{\ddot{\overline{U}}_{so}\} + [C_{ss}]\{\dot{\overline{U}}_{so}\} + [K_{ss}]\{\overline{U}_{so}\} = -[M_{ss}]\sum_c \{U_{sco}\}\ddot{u}_c' \tag{38}$$

where, for each connecting DOF

$$\{U_{sco}\} = \{U_{sc}\} - \sum_{\alpha=1}^{ns} \{\phi_{s\alpha}\}\gamma_{c\alpha} \tag{39}$$

As mentioned earlier, the residual response in high frequency modes is pseudo-static and can be evaluated by ignoring $\{\ddot{\overline{U}}_{so}\}$ and $\{\dot{\overline{U}}_{so}\}$ terms in the above equation. This gives

$$[K_{ss}]\{\overline{U}_{so}\} = -[M_{ss}]\sum_c \{U_{sco}\}\ddot{u}_c' \tag{40}$$

The term $\ddot{u}_c'$ is a scalar and can be scaled out. Eq.40 would then give one residual modal vector corresponding to each of the *nc* connecting DOF. The residual vectors are normalized such that, $\{\phi_R\}^T [M_{ss}]\{\phi_R\} = 1$. Each residual mode shape vector, $\{\phi_R\}$, is orthogonal with respect to the given *ns* modes of the secondary system but not with respect to the other residual mode shape vectors. All residual modal vectors are included in the residual modal matrix $[\Phi_R]$.

EIGENVALUE PROBLEM

The equation of motion of the coupled system (Eq.19) is transformed using the uncoupled mode shapes of the primary and the secondary systems. This results in a transformed eigenvalue problem which gives accurate eigenvalues and eigenvectors when all the modes of primary and secondary system are included in the analysis [2]. It also gives accurate results when the effect of the high frequency rigid modes of the two uncoupled systems is incorporated through residual modal vectors defined in the previous sections [3]. It is assumed that the uncoupled primary and the secondary systems are classically damped. Let the subscript i and other lower case letters denote the primary system modes, the subscript α and other Greek letters denote the secondary system modes in the non-rigid range and, the subscript R and other upper case letters denote the residual modes of the secondary system. In Eq.19, the secondary system displacements are expressed relative to the primary system connecting DOF. In terms of the mode shapes of the uncoupled systems we can write

$$\{\overline{U}\} = [\Phi]\{\overline{X}\} \tag{41}$$

where

$$\{\overline{X}\}^T = \left[\{\overline{X}_p\}^T \ \{\overline{X}_s\}^T \ \{\overline{X}_R\}^T\right] \tag{42}$$

and

$$[\Phi] = \begin{bmatrix} [\Phi_p] & [O] & [O] \\ [O] & [\Phi_s] & [\Phi_R] \end{bmatrix} \tag{43}$$

Substituting Eq.41 in Eq.19 and premultiplying by $[\Phi]^T$, we get

$$\left[\tilde{\overline{M}}\right]\{\ddot{\overline{X}}\} + \left[\tilde{\overline{C}}\right]\{\dot{\overline{X}}\} + \left[\tilde{\overline{K}}\right]\{\overline{X}\} = -[\Phi]^T[\overline{M}]\{\overline{U}_b\}\ddot{u}_g \tag{44}$$

The various matrices in the above equation can be written in terms of contributions from the primary, secondary and residual modal vectors.

$$\left[\tilde{\overline{M}}\right] = \begin{bmatrix} [\tilde{\overline{M}}_p] + [\tilde{\overline{M}}_p^s] & [\tilde{\overline{M}}_{ps}] & [\tilde{\overline{M}}_{pR}] \\ [\tilde{\overline{M}}_{sp}] & [\tilde{\overline{M}}_s] & [O] \\ [\tilde{\overline{M}}_{Rp}] & [O] & [\tilde{\overline{M}}_R] \end{bmatrix}$$

$$\left[\tilde{\overline{C}}\right] = \begin{bmatrix} [\tilde{\overline{C}}_p] & [O] & [O] \\ [O] & [\tilde{\overline{C}}_s] & [O] \\ [O] & [O] & [\tilde{\overline{C}}_R] \end{bmatrix} \tag{45}$$

$$\left[\tilde{\overline{K}}\right] = \begin{bmatrix} [\tilde{\overline{K}}_p] + [\tilde{\overline{K}}_p^s] & [O] & [O] \\ [O] & [\tilde{\overline{K}}_s] & [O] \\ [O] & [O] & [\tilde{\overline{K}}_R] \end{bmatrix}$$

in which

$$\left[\tilde{\bar{M}}_p\right] + \left[\tilde{\bar{M}}_p^s\right] = [I] + \left[\Phi_p\right]^T \left[U_{sp}\right]^T \left[M_{ss}\right]\left[U_{sp}\right]\left[\Phi_p\right]$$

$$\left[\tilde{\bar{M}}_{ps}\right] = \left[\tilde{\bar{M}}_{sp}\right]^T = \left[\Phi_p\right]^T \left[U_{sp}\right]^T \left[M_{ss}\right]\left[\Phi_s\right]$$

$$\left[\tilde{\bar{M}}_{pR}\right] = \left[\tilde{\bar{M}}_{Rp}\right]^T = \left[\Phi_p\right]^T \left[U_{sp}\right]^T \left[M_{ss}\right]\left[\Phi_R\right]$$

$$\left[\tilde{\bar{M}}_s\right] = \left[\Phi_s\right]^T \left[M_{ss}\right]\left[\Phi_s\right] = [I]$$

$$\left[\tilde{\bar{M}}_R\right] = \left[\Phi_R\right]^T \left[M_{ss}\right]\left[\Phi_R\right]$$

$$\left[\tilde{\bar{C}}_p\right] = \left[\Phi_p\right]^T \left[C_p\right]\left[\Phi_p\right]$$

$$\left[\tilde{\bar{C}}_s\right] = \left[\Phi_s\right]^T \left[C_{ss}\right]\left[\Phi_s\right]$$

$$\left[\tilde{\bar{C}}_R\right] = \left[\Phi_R\right]^T \left[C_{ss}\right]\left[\Phi_R\right]$$

$$\left[\tilde{\bar{K}}_p\right] + \left[\tilde{\bar{K}}_p^s\right] = \left[\Phi_p\right]^T \left[K_p\right]\left[\Phi_p\right] + \left[\Phi_p\right]^T \left([K_p^s] - [U_{sp}]^T [K_{ss}] [U_{sp}]\right)\left[\Phi_p\right] \tag{46}$$

$$\left[\tilde{\bar{K}}_s\right] = \left[\Phi_s\right]^T \left[K_{ss}\right]\left[\Phi_s\right]$$

$$\left[\tilde{\bar{K}}_R\right] = \left[\Phi_R\right]^T \left[K_{ss}\right]\left[\Phi_R\right]$$

where $[I]$ is an identity matrix and $[K_p^s]$ is the stiffness contribution of the secondary system with respect to the primary system's connecting DOF.

The elements of matrices $\left[\tilde{\bar{M}}_p\right]$, $\left[\tilde{\bar{C}}_p\right]$ and $\left[\tilde{\bar{K}}_p\right]$ can be defined as

$$
\begin{aligned}
\tilde{\tilde{M}}_{ij} &= 1 + \{\phi_{pi}\}^T [U_{sp}]^T [M_s][U_{sp}]\{\phi_{pi}\}, \; i = j \\
&= \{\phi_{pi}\}^T [U_{sp}]^T [M_s][U_{sp}]\{\phi_{pj}\}, \; i \neq j \\
\tilde{\tilde{C}}_{ij} &= 2\omega_{pi}\zeta_{pi}, \; i = j \\
&= 0, \; i \neq j \\
\tilde{\tilde{K}}_{ij} &= \omega_{pi}^2 + \Delta\omega_{pij}^2, \; i = j \\
&= \Delta\omega_{pij}^2, \; i \neq j \\
\Delta\omega_{pij}^2 &= \{\phi_{pi}\}^T \left([K_p^s] - [U_{sp}]^T [K_s][U_{sp}]\right)\{\phi_{pj}\}
\end{aligned}
\tag{47}
$$

where, $\Delta\omega_{pij}^2$ represents the effect of static constraint offered by the secondary system on the primary system. Matrices $\left[\tilde{\tilde{M}}_{ps}\right]$ and $\left[\tilde{\tilde{M}}_{pR}\right]$ have elements that are defined as

$$
\begin{aligned}
\tilde{\tilde{M}}_{i\alpha} &= \{\phi_{pi}\}^T [U_{sp}]^T [M_{ss}]\{\phi_{s\alpha}\} = \{\phi_{pi}\}^T [\Gamma_{c\alpha}]^T = r_{i\alpha}^{1/2} \\
\tilde{\tilde{M}}_{iR} &= \{\phi_{pi}\}^T [U_{sp}]^T [M_{ss}]\{\phi_R\}
\end{aligned}
\tag{48}
$$

where, $r_{i\alpha}$ is defined as the modal mass-ratio and is equal to the ratio of secondary system mass participating in the α^{th} mode to the primary system mass participating in the i^{th} mode. It is a parameter that describes the mass interaction between the α^{th} secondary system mode and the i^{th} primary system mode. For a SDOF primary and SDOF secondary system, $r_{i\alpha}$ becomes equal to the ratio of secondary system mass to the primary system mass.

The various elements of matrices $\left[\tilde{\tilde{M}}_p\right]$, $\left[\tilde{\tilde{C}}_p\right]$ and $\left[\tilde{\tilde{K}}_p\right]$ can be written as

$$
\begin{aligned}
\tilde{\tilde{M}}_{\alpha\beta} &= 1, \alpha = \beta \\
\tilde{\tilde{M}}_{\alpha\beta} &= 0, \alpha \neq \beta \\
\tilde{\tilde{C}}_{\alpha\beta} &= 2\omega_{s\alpha}\zeta_{s\alpha}, \; \alpha = \beta \\
\tilde{\tilde{C}}_{\alpha\beta} &= 0, \alpha \neq \beta \\
\tilde{\tilde{K}}_{\alpha\beta} &= \omega_{s\alpha}^2, \; \alpha = \beta \\
\tilde{\tilde{K}}_{\alpha\beta} &= 0, \alpha \neq \beta
\end{aligned}
\tag{49}
$$

Similarly, the elements of matrices are defined as

$$
\begin{aligned}
\tilde{\tilde{M}}_{RS} &= 1,\ R = S \\
&= \{\phi_R\}^T [M_{ss}] \{\phi_S\},\ R \neq S \\
\tilde{\tilde{C}}_{RS} &= \{\phi_R\}^T [C_{ss}] \{\phi_S\} \\
\tilde{\tilde{K}}_{RS} &= \{\phi_R\}^T [K_{ss}] \{\phi_S\}
\end{aligned}
\tag{50}
$$

As before, terms corresponding to $\{\ddot{\bar{X}}_R\}$ and $\{\dot{\bar{X}}_R\}$ can be ignored. This reduces the problem size by *nc*, number of terms in $\{\bar{X}_R\}$. Once again, let us denote the reduced mass, damping and stiffness matrices and the normal coordinate vector using the original notation. The eigenvalue problem for the coupled system can be written by setting the RHS of Eq. 44 as zero

$$
[\bar{K}*]\{\bar{X}\} = \{O\},\quad [\bar{K}*] = \left[\tilde{\tilde{K}}\right] + \lambda\left[\tilde{\tilde{C}}\right] + \lambda^2\left[\tilde{\tilde{M}}\right]
\tag{51}
$$

Eq.51 gives complex eigenvalues λ_i and eigenvectors $\{\bar{X}_i\}$ for the i^{th} coupled mode. The complex eigenvalue λ_i and its conjugate $\bar{\lambda}_i$ can be used to evaluate the coupled modal frequency ω_i and damping ratio ζ_i. The relationship between λ_i, ω_i and ζ_i can be written as

$$
\lambda_i = -\zeta_i\omega_i + j\omega_i\sqrt{1-\zeta_i^2};\qquad j = \sqrt{-1}
$$

COUPLED RESPONSE

We shall now use the complex eigenvalues, λ_i, and eigenvectors, $\{\bar{X}_i\}$, evaluated in previous section, to calculate the response of coupled primary-secondary system in non-rigid modes. The procedure to account for the response in uncalculated high frequency modes using residual modal vectors is described later. In terms of non-rigid mode shapes of the uncoupled systems we can write

$$
\{\bar{\psi}_i\} = [\Phi']\{\bar{X}_i\}
\tag{52}
$$

where

$$
[\Phi'] = \begin{bmatrix} [\Phi_p] & [O] \\ [O] & [\Phi_s] \end{bmatrix}
\tag{53}
$$

$$
\{\bar{X}\}^T = \left[\{\bar{X}_p\}^T \quad \{\bar{X}_s\}^T\right]
\tag{54}
$$

Following the procedure given in reference [2], we can evaluate two real vectors $\{\overline{\Psi}^d_{ni}\}$ and $\{\overline{\Psi}^v_{ni}\}$

$$\{\overline{\Psi}^d_{ni}\} = -2Re(\overline{\lambda}_i F_i \{\overline{\Psi}_i\}), \quad \{\overline{\Psi}^v_{ni}\} = -2Re(F_i \{\overline{\Psi}_i\}) \tag{55}$$

where subscript n denotes that the response calculated using Eq.55 includes only the non-rigid modes of secondary system. The term $\overline{\lambda}_i$ represents the conjugate of complex eigenvalue λ_i, and F_i is given by

$$\begin{aligned} F_i &= \frac{1}{a_i}\{\overline{\Psi}_i\}^T [\overline{M}]\{\overline{U}_b\} \\ a_i &= 2\lambda_i \{\overline{\Psi}_i\}^T [\overline{M}]\{\overline{\Psi}_i\} + \{\overline{\Psi}_i\}^T [\overline{C}]\{\overline{\Psi}_i\} \end{aligned} \tag{56}$$

Various terms in Eq.56 can be rearranged to write them in a form that can be readily calculated.

$$\begin{aligned} F_i &= \frac{1}{a_i}\{\overline{X}_i\}^T [\overline{\Gamma}], \quad [\overline{\Gamma}]^T = [\{\overline{\Gamma}_p\}^T \{\overline{\Gamma}_s\}^T] \\ a_i &= 2\lambda_i \{\overline{X}_i\}^T [\tilde{\overline{M}}]\{\tilde{\overline{X}}_i\} + \{\overline{X}_i\}^T [\tilde{\overline{C}}]\{\overline{X}_i\} \\ \{\overline{\Gamma}_p\}^T &= [\overline{\gamma}_{p1} \ \overline{\gamma}_{p1} \ . \ . \ .], \quad \{\overline{\Gamma}_s\}^T = [\overline{\gamma}_{s1} \ \overline{\gamma}_{s1} \ . \ . \ .] \\ \overline{\gamma}_{pi} &= \{\phi_{pi}\}^T [M_p] \{U_{bp}\} + \{\phi_{pi}\}^T [U_{sp}]^T [M_{ss}] \{U_{bs}\} \\ \overline{\gamma}_{s\alpha} &= \{\phi_{s\alpha}\}^T [M_{ss}] \{U_{bs}\} \end{aligned} \tag{57}$$

where $\{U_b\}$ is the static displacement vector of the coupled system relative to the base of primary system when the base of primary system undergoes a unit deflection in the direction of earthquake; and $\{\phi_{pi}\}$ and $\{\phi_{s\alpha}\}$ are the mass normalized mode shapes of the primary and secondary systems in the i^{th} and α^{th} uncoupled modes, respectively. Unlike matrix $[\overline{C}]$ in Eq.56, matrix $[\tilde{\overline{C}}]$ in the above equation can be evaluated explicitly using the modal damping ratios for the two uncoupled systems. The total response vector $\{\overline{\Psi}^d_i\}$ and $\{\overline{\Psi}^v_i\}$ can be evaluated by algebraically adding the response in non-rigid modes with the residual response vectors $\{\overline{\Psi}^d_{oi}\}$ and $\{\overline{\Psi}^v_{oi}\}$. Residual response vectors contain the residual response for secondary system DOF and zeros for primary system DOF. The procedure to obtain $\{\overline{\Psi}^d_{oi}\}$ and $\{\overline{\Psi}^v_{oi}\}$ is given in the next section.

$$\begin{aligned} \{\overline{\Psi}^d_i\} &= \{\overline{\Psi}^d_{ni}\} + \{\overline{\Psi}^d_{oi}\} \\ \{\overline{\Psi}^v_i\} &= \{\overline{\Psi}^v_{ni}\} + \{\overline{\Psi}^v_{oi}\} \end{aligned} \tag{58}$$

Using modal superposition, we can write

$$\{\bar{U}\} = \sum_{i=1}^{N} \{\bar{U}_i\} = \sum_{i=1}^{N} \{\bar{U}_i^d\} - \{\bar{U}_i^v\} = \sum_{i=1}^{N} \{\bar{\Psi}_i^d\} y_i - \{\bar{\Psi}_i^v\} \dot{y}_i \tag{59}$$

in which y is the relative displacement and $\dot{y}_i$ the relative velocity of an equivalent SDOF system and can be calculated from

$$\ddot{y}_i + 2\omega_i \zeta_i \dot{y}_i + \omega_i^2 y_i = -\ddot{u}_g \tag{60}$$

SECONDARY SYSTEM RESIDUAL RESPONSE

As stated earlier, the effect of uncalculated high frequency rigid modes for both the primary and secondary systems can be included in terms of residual modal vectors. Since the uncoupled primary system is assumed to be singly connected at its base, we get only one such residual mode which is orthogonal to the calculated non-rigid modes of the primary system and can be included directly in the coupled modal synthesis as an additional mode. For a multiply connected secondary system, number of residual modal vectors is equal to the number of primary system connecting DOF. Each residual mode shape vector, $\{\phi_R\}$, is orthogonal with respect to the calculated non-rigid modes of the secondary system but not with respect to the other residual mode shape vectors. All the secondary system residual modal vectors are included in the residual modal matrix $[\Phi_R]$.

Earlier we defined a matrix $[U_{sc}]$ in which each vector represents the static deformation shape of secondary system when the corresponding primary system connecting DOF undergoes a unit displacement. Matrix $[U_{sp}]$ is obtained from $[U_{sc}]$ by adding zeros for the non-connecting DOF of the primary system. Secondary system residual response can be evaluated using the residual mode part of Eq.44.

$$\begin{aligned} \left[\tilde{\tilde{M}}_{Rp}\right]\left\{\ddot{\bar{X}}_p\right\} + \left[\tilde{\tilde{M}}_R\right]\left\{\ddot{\bar{X}}_R\right\} + \left[\tilde{\tilde{C}}_R\right]\left\{\dot{\bar{X}}_R\right\} + \left[\tilde{\tilde{K}}_R\right]\left\{\bar{X}_R\right\} \\ = -[\Phi_R]^T\,[M_{ss}]\left[U_{sp}\right]\left\{U_{bp}\right\}\ddot{u}_g \end{aligned} \tag{61}$$

Since the residual response is pseudo-static, the rigid response of secondary system can be calculated from the above equation by ignoring the terms corresponding to $\left\{\ddot{\bar{X}}_R\right\}$ and $\left\{\dot{\bar{X}}_R\right\}$. This gives

$$\left[\tilde{\tilde{M}}_{Rp}\right]\left\{\ddot{\bar{X}}_p\right\} + \left[\tilde{\tilde{K}}_R\right]\left\{\bar{X}_R\right\} = -[\Phi_R]^T\,[M_{ss}]\left[U_{sp}\right]\left\{U_{bp}\right\}\ddot{u}_g \tag{62}$$

The above equation can be simplified further by substituting for $\left[\tilde{\tilde{M}}_{Rp}\right]$.

$$\left[\tilde{\tilde{K}}_R\right]\left\{\overline{X}_R\right\} = -[\Phi_R]^T\,[M_{ss}][U_{sc}]\{\ddot{\overline{U}}_c\}' \qquad \{\ddot{\overline{U}}_c\}' = \{\overline{U}_{bc}\}\,\ddot{u}_g + \{\ddot{\overline{U}}_c\} \tag{63}$$

It is shown in reference [2] that for N-DOF nonclassically damped coupled system we can write

$$\{\overline{U}_b\} = \sum_{i=1}^{N}\{\overline{\Psi}_i^d\} + \sum_{i=1}^{N} 2\omega_i\zeta_i\,\{\overline{\Psi}_i^v\} \tag{64}$$

$$\sum_{i=1}^{N}\{\overline{\Psi}_i^v\} = \{0\}$$

Eqs. 59 and 64 give

$$\{\ddot{\overline{U}}_c\}' = \sum_{i=1}^{N}\{\overline{\Psi}_{ci}^d\}\left(\ddot{u}_g + \ddot{y}_i\right) + \sum_{i=1}^{N}\{\overline{\Psi}_{ci}^v\}\left(2\omega_i\zeta_i\ddot{u}_g - \dddot{y}_i\right) \tag{65}$$

where $\dddot{y}_i$ is the acceleration rate of a SDOF system. Differentiating the SDOF equation of motion (Eq.60) and substituting for $\dddot{y}_i$ in the above equation we get

$$\{\ddot{\overline{U}}_c\}' = \sum_{i=1}^{N}\{\overline{\Psi}_{ci}^d\}\left(\ddot{u}_g + \ddot{y}_i\right) + \sum_{i=1}^{N}\{\overline{\Psi}_{ci}^v\}\left[2\omega_i\zeta_i\left(\ddot{u}_g + \ddot{y}_i\right) + \omega_i^2\dot{y}_i + \dddot{u}_g\right] \tag{66}$$

Eqs. 66 can be further simplified using Eqs.64 and 60

$$\{\ddot{\overline{U}}_c\}' = \sum_{i=1}^{N}\left[-\omega_i^2 y_i\left(\{\overline{\Psi}_{ci}^d\} + 2\omega_i\zeta_i\{\overline{\Psi}_{ci}^v\}\right) + \omega_i\dot{y}_i\left(\omega_i\{\overline{\Psi}_{ci}^v\} - 2\zeta_i\{\overline{\Psi}_{ci}^d\}\right)\right] \tag{67}$$

In deriving Eq.67, it is assumed that the modal damping ratio ζ_i is small such that the terms with ζ_i^2 can be neglected. If $\{\overline{\Psi}_i^d\}$ and $\{\overline{\Psi}_i^v\}$ vectors are of the same order, we can also neglect the terms containing ζ_i. Eqs.63 and 67 give

$$\left[\tilde{\tilde{K}}_R\right]\left\{\tilde{\tilde{X}}_{Ri}\right\} = -[\Phi_R]^T\,[M_{ss}][U_{sc}]\left(\omega_i^2\{\overline{\Psi}_{ci}^d\}\,y_i - \omega_i^2\{\overline{\Psi}_{ci}^v\}\,\dot{y}_i\right) \tag{68}$$

Solution of the above equation yields two vectors $\left\{\overline{X}_{Ri}^d\right\}$ and $\left\{\overline{X}_{Ri}^v\right\}$, which are used to evaluate the residual response, $\left\{\overline{U}_{soi}\right\}$, of the secondary system in i^{th} coupled mode.

$$\left\{\overline{U}_{soi}\right\} = \left\{\overline{U}_{soi}^d\right\} - \left\{\overline{U}_{soi}^v\right\} \tag{69}$$

where

$$\begin{aligned} \{\overline{U}^d_{soi}\} &= [\Phi_R]\{\overline{X}^d_{Ri}\} = \{\overline{\psi}^d_{Ri}\}y_i \\ \{\overline{U}^v_{soi}\} &= [\Phi_R]\{\overline{X}^v_{Ri}\} = \{\overline{\psi}^v_{Ri}\}\dot{y}_i \end{aligned} \tag{70}$$

and

$$\begin{aligned} \{\overline{\psi}^d_{Ri}\} &= \omega_i^2 [\Phi_R]\left[\tilde{\overline{K}}_R\right]^{-1}[\Phi_R]^T[M_{ss}][U_{sc}]\{\overline{\psi}^d_{ci}\} \\ \{\overline{\psi}^v_{Ri}\} &= \omega_i^2 [\Phi_R]\left[\tilde{\overline{K}}_R\right]^{-1}[\Phi_R]^T[M_{ss}][U_{sc}]\{\overline{\psi}^v_{ci}\} \end{aligned} \tag{71}$$

The response vectors $\{\overline{\psi}^d_{Ri}\}$ and $\{\overline{\psi}^v_{Ri}\}$ contain values for secondary system DOF only. The corresponding vectors that include values for all the DOF of the coupled system can be written by including zeros for the primary system DOF. Let us denote these modified vectors as $\{\overline{\psi}^d_{oi}\}$ and $\{\overline{\psi}^v_{oi}\}$. As described in the previous section, the residual response of the secondary system and the response in non-rigid modes are combined algebraically, to obtain the total response relative to the primary system connecting DOF.

TIME HISTORY ANALYSIS

As described in previous sections, the modal response for a nonclassically damped coupled system is represented in terms of two real $\{\overline{\psi}^d_i\}$ and $\{\overline{\psi}^v_i\}$. Further, response quantities such as displacements can be evaluated using Eq. 59 in which

$$\begin{aligned} \{\overline{U}^d_i\} &= \{\overline{\psi}^d_i\}y_i \\ \{\overline{U}^v_i\} &= \{\overline{\psi}^v_i\}\dot{y}_i \end{aligned} \tag{72}$$

where y_i is the relative displacement and $\dot{y}_i$ the relative velocity of a SDOF oscillator and can be calculated from the equation of motion for a SDOF system

$$\ddot{y}_i + 2\omega_i\zeta_i\dot{y}_i + \omega_i^2 y_i = -\ddot{u}_g \tag{73}$$

As seen in the above formulation, the superscript *d* denotes the response corresponding to y_i, the relative displacement part, and superscript *v* that corresponding to $\dot{y}_i$, the relative velocity part. If the earthquake input at the base of primary system is defined by an acceleration time history (history of $\ddot{u}_g$), then Eq. 73 can be directly integrated. At each time step of integration y_i and $\dot{y}_i$ can be calculated for all coupled modes *i* and the total response calculated by algebraically combining the response in each mode using Eq. 59. Therefore, this process yields a history for each response quantity of interest which can then be used to calculate the maximum response values. Integration of Eq. 73 can be performed using several numerical techniques. CREST-TH uses piecewise exact linear integration method given in reference [8].

RESPONSE SPECTRUM METHOD

For design purposes, earthquake input is defined in terms of a response spectrum and not an acceleration time history. The response spectrum curve gives the maximum response for a series of SDOF oscillators of varying frequencies for a given damping ratio. It means that only maximum values of y_i and $\dot{y}_i$ can be defined and therefore, only maximum values of response calculated in each mode. Thus, in response spectrum method, Eq. 72 becomes

$$\begin{aligned} \{\overline{U}_i^d\} &= \{\overline{\Psi}_i^d\} y_{i\max} = \{\overline{\Psi}_i^d\} S_{Di}^d \\ \{\overline{U}_i^v\} &= \{\overline{\Psi}_i^v\} \dot{y}_{i\max} = \{\overline{\Psi}_i^v\} S_{Vi}^v = \omega_i \{\overline{\Psi}_i^v\} S_{Di}^v \end{aligned} \tag{74}$$

where S_{Di}^d and S_{Vi}^v represent spectral (maximum) values of relative displacement and velocity in mode i. As before, superscripts d and v denote that the spectral values correspond to the relative displacement and relative velocity parts, respectively. The subscripts D and V denote that the spectral values are expressed in displacement and velocity units, respectively. Conventionally, the response spectrum is defined as that corresponding to relative displacement. The spectrum corresponding to relative velocity is not calculated and, therefore, not available. A method to evaluate spectrum curve corresponding to relative velocity from the relative displacement spectrum is explained in reference [2] and incorporated in CREST. However, if the earthquake time history is known, both the spectrum curves can be calculated directly by integrating Eq.73. In this study, the earthquake inputs are defined in terms of acceleration time histories. Therefore, both spectra are evaluated directly from the time history at exact frequency and damping ratio values for each mode.

The modal responses in the response spectrum method are then combined according to the mode combination procedure given in reference [7]. It has been shown in reference [7] that the coupled response R for any response quantity can be evaluated as

$$R^2 = \sum_{i=1}^{N}\sum_{j=1}^{N}\left(\overline{\varepsilon}_{ij}^d R_i^d R_j^d + \overline{\varepsilon}_{ij}^v R_i^v R_j^v - 2\overline{\mu}_{ij} R_i^v R_j^v\right) \tag{75}$$

where

$$\overline{\varepsilon}_{ij}^d = \sqrt{\{[1-(\alpha_i^d)^2][1-(\alpha_j^d)^2]\}}\,\varepsilon_{ij}^d + \alpha_i^d \alpha_j^d \tag{76}$$

$$\overline{\varepsilon}_{ij}^d = \sqrt{\{[1-(\alpha_i^v)^2][1-(\alpha_j^v)^2]\}}\,\varepsilon_{ij}^v + \alpha_i^v \alpha_j^v \tag{77}$$

$$\overline{\mu}_{ij} = \sqrt{\{[1-(\alpha_i^d)^2][1-(\alpha_j^v)^2]\}}\,\mu_{ij} \tag{78}$$

in which the modal correlation coefficients ε_{ij}^d , ε_{ij}^v and μ_{ij} are given by

$$\varepsilon_{ij}^{d} = \frac{a_{ij}}{a_{ij} - c_{ij}^{d}}\left(b_{ij} - c_{ij}^{d}\right) \tag{79}$$

$$\varepsilon_{ij}^{d} = \frac{a_{ij}}{a_{ij} - c_{ij}^{v}}\left(b_{ij} - c_{ij}^{v}\right) \tag{80}$$

$$\mu_{ij} = \frac{1}{c_{ij}^{\mu}} \frac{\omega_{Di} - \omega_{Dj}}{\zeta_i\omega_i + \zeta_i\omega_j} b_{ij} \tag{81}$$

where

$$a_{ij} = \frac{\sqrt{(\zeta_i\zeta_j)}}{\zeta_{ij}}, \quad c_{ij}^{d} = \zeta_{ij} = \left(\zeta_i + \zeta_j\right)/2 \tag{82}$$

$$c_{ij}^{v} = 0.005 + 0.684\zeta_{ij} \tag{83}$$

$$c_{ij}^{\mu} = 0.353 + 0.631\frac{\omega_j}{\omega_i}, \qquad 1.0 \le c_{ij}^{\mu} \le 3.0 \tag{84}$$

$$b_{ij} = \frac{\sqrt{(\zeta_i\zeta_j)}}{\zeta_{ij}}\left[1 + \left(\frac{\omega_{Di} - \omega_{Dj}}{\zeta_i\omega_i + \zeta_i\omega_j}\right)^2\right]^{-1} \tag{85}$$

in which, ω_i and ζ_i are the circular frequency and the damping ratio in coupled mode i, and ω_{Di} the corresponding damped frequency.

Rigid response coefficients are defined as

$$\begin{aligned} \alpha_i^{d} &= \alpha_{oi}^{d} + \alpha_{oi}^{d}\left(1 - \alpha_{oi}^{d}\right)\Delta\alpha_i^{d}, \ 0 \le \alpha_i^{d} \le 1 \\ \alpha_i^{v} &= \alpha_{oi}^{v} + \alpha_{oi}^{v}\left(1 - \alpha_{oi}^{v}\right)\Delta\alpha_i^{v}, \ 0 \le \alpha_i^{v} \le 1 \end{aligned} \tag{86}$$

here

$$\begin{aligned} \alpha_{oi}^{d} &= \frac{ln\left(f_i / f_1^{d}\right)}{ln\left(f_2^{d} / f_1^{d}\right)}, \ f_1^{d} \le f_2^{d} \\ \alpha_{oi}^{v} &= \frac{ln\left(f_i / f_1^{v}\right)}{ln\left(f_2^{d} / f_1^{v}\right)}, \ f_1^{v} \le f_2^{v} \\ \Delta\alpha_{oi}^{v} &= 2.12 + 0.60 ln\zeta_i \\ \Delta\alpha_{oi}^{v} &= 1.23 + 0.52 ln\zeta_i \end{aligned} \tag{87}$$

The key frequencies f_1^d, f_2^d, f_1^v, f_2^v in the above equations are defined as

$$
\begin{aligned}
f_{AV}^{dd} &= \frac{S_{A\max}^{d}}{2\pi S_{V\max}^{d}} \\
f^{1d} &= 0.86 f_{AV}^{dd} \\
f^{1v} &= 1.86 f_{AV}^{dd} \\
f^{2d} &= 0.84 f_r^{d} \\
f^{2v} &= 1.2 f_r^{d}
\end{aligned}
\tag{88}
$$

where f_r^d is the rigid frequency of the input earthquake motion.

BENCHMARK PROBLEMS AND RESULTS

Brookhaven National Laboratory (BNL) developed several benchmark problems and provided the structural and earthquake input data to the participating organizations. Figs. 1 - 4 show four types of structural systems considered for coupled analysis. The first three systems are simple spring-mass systems with one DOF at each mass point. These three systems are referred to as benchmark problems 1, 2 and 3, respectively. The fourth system represents a real-life like building-piping system. Two different mass densities are used for this system to represent two different structures. These two systems are referred to as problems 4a and 4b, respectively. Seven different earthquake time histories are considered as input ground motions for each problem. Same primary system is considered in all the three simple systems. It has a fundamental frequency of 5.0 Hz. and the damping ratio of 7% in all the modes. Properties of secondary systems are varied in each of the three simple systems to develop several cases with varying characteristics. A total of sixteen cases are considered for each of the problems 1,2 and 3 by varying the ratio of fundamental secondary to fundamental primary frequencies between 0.5 and 2.0; the ratio of secondary to primary system floor masses between 0.0001 and 0.5; modal damping ratios of the secondary system between 2% and 20%; and 7 input ground motions. For each of the problems 4a and 4b, 7 different analyses are performed for 7 input ground motions. Detailed input data for all the problems is described in reference [9].

We performed coupled analysis for all the cases using both the time history (CREST-TH) and the response spectrum methods (CREST). As a first step, we evaluated modal properties for the uncoupled primary and secondary systems for each problem and compared the frequencies with those provided by BNL. Table-1 compares the frequencies of uncoupled primary system and Tables 2 and 3 those of the uncoupled secondary systems considered in the three problems. As seen in these tables, the frequencies of uncoupled primary and secondary systems compare well with those provided by BNL. Similarly, the frequencies of uncoupled primary systems in problems 4a and 4b compare well with those provided by BNL, as shown in Tables 4 and 5.

Piping Elbow Element

As stated earlier, CREST and CREST-TH can be used to perform a piping analysis when interfaced with a piping program. They are currently interfaced with PIPESTRESS. We modeled the piping systems in problems 4a and 4b on PIPESTRESS to calculate their modal properties. In doing so, we used the bend element of PIPESTRESS to model the piping elbows. The piping frequencies evaluated from this model are given in Tables 6 and 7 and compared with the frequencies evaluated by BNL using the computer program SAP-V. As seen in these tables, the maximum difference was found to be 6% in the frequency of a particular mode. As an additional validation step, we modeled these piping systems in ANSYS and found that the frequencies evaluated by ANSYS were almost identical to those given by PIPESTRESS. Some of our previous studies have shown that an error of 2% in the piping frequencies can result in much larger error in the piping forces and support reactions. This is consistent with widely published observation that the error in frequencies is usually much smaller than the error in the corresponding mode shape. To eliminate this difference in the piping models of PIPESTRESS and SAP-V, we requested BNL to provide the mass and stiffness matrices of the piping model 4a. Comparison of these matrices (from SAP-V) with those evaluated by PIPETSRESS, illustrated that the stiffness matrix of the bend element in PIPETSRESS is different from that in SAP-V. We therefore, avoided the use of bend element in PIPESTRESS and used the SAP-V elbow stiffness matrix directly. Tables 6 and 7 also compare the piping frequencies of the new PIPESTRESS models with those given by SAP-V. As shown in these tables, the two sets of frequencies compare well with each other.

Coupled Analysis Results

Tables 8 through 12 give the frequencies of all the coupled systems as evaluated by CREST. BNL also provided the undamped frequencies of the coupled system for problem 4a. As shown in Table 11, the coupled frequencies evaluated by CREST compare well with those provided by BNL. Coupled analysis of the simple systems is performed by including all the modes for uncoupled primary and secondary systems. For problems 4a and 4b, it is impractical to calculate all the modes of the piping system. Therefore, we considered all the modes of the primary system but only the nonrigid modes of piping system. The effect of truncated high frequency modes is included in terms of missing mass effect using the procedure described earlier in this report.

At first, the rotational stiffnesses of piping supports were not considered in the piping models because the rotational support stiffnesses in real-life piping systems are negligible except at anchors. We found that even though the frequencies of our uncoupled and coupled system models were almost identical to those evaluated by BNL, the mode shapes for the 3rd coupled mode had some differences. As shown in Figs. 7 to 15, the mode shapes compared well for all the non-rigid modes except the 3rd mode. This is due to the high rotational stiffnesses of piping supports in this study. These high values of stiffness together with large dimensions of supports result in significant secondary system displacements due to what can otherwise be seen as negligible rotations in the primary system. This is exactly the case in 3rd coupled mode. Once these rotational stiffnesses were included in our model, the mode shapes were found to be identical to that evaluated by BNL, as shown in Figs. 7 to 15.

Tables 13 through 68 give the responses (nodal displacements, member forces and support reactions) for various cases evaluated from a time history analysis using CREST-TH. Responses evaluated from a response spectrum analysis using CREST are given in Tables 69 through 124. As seen in these tables, the displacements, rotations, forces and moments for some nodes and elements are zero, especially in problems 4a and 4b. A zero in these tables indicate that these response quantities are smaller than the number of significant digits considered. Fig. 5 gives the local coordinate system for each segment of the piping system and its relationship with the global coordinate system.

The response evaluated by a response spectrum analysis cannot be compared to the response evaluated by a time history analysis on one-to-one basis due to the inherent differences in the two methods. In general, if several input time histories and the corresponding response spectra are considered, the average responses from the two sets of analysis should be close to each other. As an example, let us consider the force in element number 8 (between nodes 8 and 9) in problem 1 and load case m (frequency ratio = 1.0, ratio of floor masses = 0.005, secondary system modal damping ratio = 2% and ElCentro 79 input ground motion). Tables 16 and 72 shows that the force in this element for a time history analysis is 79.64 kips and that for a response spectrum analysis is 148.6 kips. This means that response spectrum method gives a value which is almost twice of that given by the time history analysis. A detailed study of this force shows that it receives significant contribution from only the displacement part of the response in first two modes of the coupled system that have frequencies of 4.87 Hz and 5.13 Hz, respectively. Fig. 6 gives the two modal responses for this force evaluated from a time history analysis, between 5.20 and 6.20 seconds. This figure also gives the plot of combined force in this element between the same times. As shown in this figure, the maximum response in mode 1 is equal to -222.5 kips and occurs at 5.378 sec. Similarly, the maximum response in mode 2 is equal to +221.4 kips occuring at 5.372 sec. It can also be seen that maximum responses in the two modes have opposite signs and occur at almost same times. Therefore, in a time history analysis, the two maximum modal responses cancel each other. The maximum response in the time history analysis occurs at 5.94 sec. (Fig. 5) and the responses in two modes at this time are equal to +119.4 kips and -40.06 kips respectively, resulting in a combined response of +79.64 kips. In the response spectrum analysis, the maximum responses in two modes (-222.5 kips and +221.4 kips) are combined using appropriate correlation coefficients $\bar{\varepsilon}_{ij}^{d}$. The modal correlation coefficient between the modes with frequencies 4.87 Hz and 5.13 Hz and damping ratios of 2% and 7% is equal to 0.7798. Note that the frequency of the second mode is 5.4% different from that of the first mode. The combined force in the two modes can be calculated as

$$R = \sqrt{(-222.5)^2 + (221.4)^2 + 2(0.7798)(-222.5)(221.4)}$$

$$= 147.30$$

which is nearly equal to 148.6 evaluated by considering all the modes and given in Table 72. Therefore, on one-to-one basis the time history and response spectrum methods can give responses that are significantly different from each other.

Another observation made in this study is related to the evaluation of forces and moments in the links used for representing piping supports. All the elements in the building and piping are located along the global axes. Only a few links are inclined to the global axes. The modal values of the forces and moments in all the elements of the coupled system were at first calculated in the global coordinate system and the modal responses combined. The combined responses were then transformed into the local coordinate system. Even though this procedure produced correct results in the piping and building elements, it is incorrect for calculating responses in the links that are inclined to the global coordinate axes. This procedure was later modified by calculating modal responses in the local coordinate system and then combining them. It was found that the former method can give responses that can be as much as 60% in error. Another observation is related to high value of axial stiffness used for modeling the links. The axial stiffnesses of various links vary from a minimum of 4.12E+12 kips/in. to a maximum of 1.5E+14 kips/in. Such high values can cause numerical differences depending upon the numerical and convergence tolerances being used in solvers of various computer programs. For example, even very small differences in the displacements at the two ends of the links can cause significant differences in the axial link force due to multiplication with very high value of axial stiffness.

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Table 1: Frequencies of the Uncoupled Primary System for Problem #1,#2,#3

Mode No.	Frequency (Hz.)	
	BNL-SAP	PIPESTRESS
1	5.00	5.00
2	14.60	14.60
3	23.01	23.01
4	29.56	29.56
5	33.71	33.71

Table 2: Frequencies of the Uncoupled Secondary System for Problem #1

Mode No.	Load cases									
	a		b		c		d		e	
	B	P	B	P	B	P	B	P	B	P
1	5.00	5.00	2.50	2.50	4.50	4.50	5.51	5.51	10.01	10.01
2	14.40	14.40	7.21	7.21	12.97	12.97	15.85	15.85	28.83	28.83
3	22.06	22.06	11.04	11.04	19.87	19.87	24.29	24.29	44.16	44.16
4	27.06	27.06	13.54	13.54	24.37	24.37	29.79	29.79	54.17	54.17

B: BNL-SAP; P: PIPESTRESS

Table 3: Frequencies of the Uncoupled Secondary System for Problems #2 and #3

Mode No.	Load cases									
	a		b		c		d		e	
	B	P	B	P	B	P	B	P	B	P
1	5.00	5.00	2.50	2.50	4.50	4.50	5.50	5.50	10.02	10.02
2	5.00	5.00	2.50	2.50	4.50	4.50	5.50	5.50	10.02	10.02
3	9.24	9.24	4.62	4.62	8.32	8.32	10.16	10.16	18.51	18.51
4	9.24	9.24	4.62	4.62	8.32	8.32	10.16	10.16	18.51	18.51
5	12.07	12.07	6.04	6.04	10.86	10.86	13.28	13.28	24.18	24.18
6	12.07	12.07	6.04	6.04	10.86	10.86	13.28	13.28	24.18	24.18

B: BNL-SAP; P: PIPESTRESS

Table 4: Frequencies of the Uncoupled Primary System for Problem #4a

Mode No.	Frequency (Hz.)	
	BNL-SAP	PIPESTRESS
1	8.24	8.24
2	8.30	8.30
3	22.09	22.08
4	33.38	33.38
5	33.47	33.47
6	67.41	67.41
7	67.5	67.50
8	68.04	68.04

Table 5: Frequencies of the Uncoupled Primary System for Problem #4b

Mode No.	Frequency (Hz.)	
	BNL-SAP	PIPESTRESS
1	4.60	4.60
2	4.63	4.63
3	12.33	12.33
4	18.63	18.63
5	18.68	18.68
6	37.62	37.62
7	37.68	37.68
8	37.98	37.98
9	51.33	51.33
10	51.37	51.37

Table 6: Frequencies of the Uncoupled Secondary System for Problem #4a

Mode No.	Frequency (Hz.)				
No.	BNL-SAP B	PIPESTRESS P1	PIPESTRESS P2	% Difference (P1-B)*100/B	% Difference (P2-B)*100/B
1	8.25	8.26	8.24	0.08	-0.12
2	8.56	8.57	8.54	0.07	-0.23
3	14.95	14.96	14.91	0.05	-0.27
4	16.67	16.67	16.86	-0.01	1.14
5	17.35	17.35	17.30	0.01	-0.29
6	24.37	24.38	22.69	0.03	-6.89
7	25.56	25.56	24.89	-0.01	-2.62
8	26.09	26.09	25.87	-0.01	-0.84
9	26.25	26.25	26.06	0.01	-0.72
10	27.48	27.48	27.38	0.00	-0.36
11	28.55	28.54	28.23	-0.03	-1.12
12	30.21	30.21	31.13	-0.01	3.05
13	33.48	33.49	33.56	0.02	0.24
14	33.70	33.70	34.13	-0.01	1.28

P1: Matrix for Bend Element; P2: PIPESTRESS Bend Element

Table 7: Frequencies of the Uncoupled Secondary System for Problem #4b

Mode No. No.	Frequency (Hz.)				
	BNL-SAP B	PIPESTRESS P1	PIPESTRESS P2	% Difference (P1-B)*100/B	% Difference (P2-B)*100/B
1	4.60	4.60	4.59	0.09	-0.17
2	4.77	4.78	4.76	0.15	-0.19
3	8.34	8.34	8.31	0.00	-0.31
4	9.29	9.29	9.40	0.05	1.17
5	9.67	9.68	9.65	0.06	-0.23
6	13.59	13.59	12.65	0.03	-6.89
7	14.25	14.25	13.88	0.01	-2.60
8	14.55	14.55	14.42	-0.03	-0.87
9	14.64	14.64	14.53	-0.01	-0.77
10	15.32	15.32	15.27	0.03	-0.35
11	15.92	15.91	15.74	-0.03	-1.11
12	16.84	16.84	17.36	0.02	3.06
13	18.67	18.67	18.71	0.01	0.22
14	18.79	18.79	19.03	0.00	1.28
15	22.97	22.98	21.91	0.05	-4.61
16	24.97	24.98	24.98	0.02	0.05
17	29.27	29.28	28.55	0.03	-2.45
18	30.49	30.50	29.90	0.04	-1.94
19	32.11	32.11	30.52	-0.01	-4.96
20	33.67	33.68	32.96	0.04	-2.10

P1: Matrix for Bend Element; P2: PIPESTRESS Bend Element

Table 8: Frequencies of the Coupled System for Problem #1

Modes	Load cases									
	a	b	c	d	e	f	g	h	i	j
1	4.87	2.50	4.46	4.94	4.98	5.00	4.23	3.43	4.83	4.97
2	5.13	5.00	5.04	5.57	10.04	5.00	5.84	6.90	5.18	5.02
3	14.40	7.21	12.97	14.60	14.60	14.40	14.40	14.23	14.40	14.40
4	14.60	11.04	14.60	15.85	23.01	14.60	14.63	14.94	14.61	14.60
5	22.06	13.54	19.87	23.01	28.79	22.06	21.99	21.76	22.05	22.06
6	23.01	14.60	23.01	24.29	29.61	23.01	23.10	23.41	23.02	23.01
7	27.06	23.01	24.37	29.57	33.73	27.06	27.04	26.97	27.06	27.06
8	29.57	29.56	29.57	29.79	44.17	29.56	29.75	30.42	29.57	29.57
9	33.71	33.71	33.71	33.72	54.17	33.71	33.80	34.23	33.71	33.71

Table 9: Frequencies of the Coupled System for Problem #2

Modes	Load cases									
	a	b	c	d	e	f	g	h	i	j
1	4.86	2.50	4.45	4.94	4.98	5.00	4.21	3.41	4.82	4.97
2	5.00	2.50	4.50	5.50	10.01	5.00	4.99	4.94	5.00	5.00
3	5.15	4.62	5.05	5.57	10.05	5.00	5.90	7.11	5.19	5.03
4	9.24	4.62	8.32	10.16	14.62	9.24	9.22	9.15	9.24	9.24
5	9.24	5.00	8.32	10.16	18.50	9.24	9.23	9.19	9.24	9.24
6	12.07	6.04	10.86	13.28	18.51	12.07	12.05	12.00	12.07	12.07
7	12.07	6.04	10.86	13.28	23.02	12.07	12.08	12.14	12.07	12.07
8	14.61	14.60	14.60	14.61	24.18	14.60	14.72	15.18	14.61	14.61
9	23.01	23.01	23.01	23.02	24.19	23.01	23.09	23.38	23.01	23.01
10	29.56	29.56	29.56	29.56	29.57	29.56	29.61	29.80	29.56	29.56
11	33.71	33.71	33.71	33.72	33.73	33.71	33.79	34.12	33.71	33.71

Table 10: Frequencies of the Coupled System for Problem #3

Modes	Load cases									
	a	b	c	d	e	f	g	h	i	j
1	4.86	2.50	4.45	4.94	4.99	5.00	4.23	3.48	4.82	4.97
2	5.00	2.50	4.50	5.50	10.02	5.00	5.00	4.99	5.00	5.00
3	5.15	4.62	5.05	5.57	10.05	5.00	5.91	7.10	5.19	5.03
4	9.24	4.62	8.32	10.16	14.61	9.24	9.22	9.14	9.24	9.24
5	9.24	5.01	8.32	10.16	18.50	9.24	9.26	9.37	9.24	9.24
6	12.07	6.04	10.86	13.28	18.51	12.07	12.07	12.06	12.07	12.07
7	12.07	6.04	10.86	13.28	23.02	12.07	12.08	12.12	12.07	12.07
8	14.60	14.60	14.60	14.61	24.18	14.60	14.67	14.99	14.60	14.60
9	23.01	23.01	23.01	23.01	24.18	23.01	23.05	23.21	23.01	23.01
10	29.56	29.56	29.56	29.56	29.58	29.56	29.62	29.87	29.56	29.56
11	33.71	33.71	33.71	33.71	33.72	33.71	33.74	33.87	33.71	33.71

Table 11: Frequencies of the Coupled System for Problem #4a

Mode No.	Frequency (Hz.) (BNL-SAP)	(CREST)
1	8.22	8.23
2	8.27	8.27
3	8.29	8.29
4	8.56	8.57
5	14.95	14.96
6	16.67	16.67
7	17.35	17.35
8	22.08	22.08
9	24.38	24.38
10	25.56	25.56
11	26.09	26.09
12	26.25	26.25
13	27.48	27.48
14	28.55	28.54
15	30.21	30.21
16	33.19	33.19
17	33.40	33.41
18	33.71	33.68

Table 12: Frequencies of the Coupled System for Problem #4b

Mode No.	Frequency (Hz.)	
	BNL-SAP	CREST
1	4.59	4.59
2	4.61	4.61
3	4.63	4.63
4	4.78	4.78
5	8.34	8.34
6	9.29	9.29
7	9.67	9.68
8	12.32	12.32
9	13.59	13.60
10	14.25	14.25
11	14.55	14.55
12	14.64	14.64
13	15.32	15.32
14	15.92	15.92
15	16.84	16.84
16	18.52	18.52
17	18.64	18.64
18	18.78	18.78
19	18.82	18.82
20	22.98	22.98
21	24.97	24.98
22	29.27	29.28
23	30.49	30.50
24	32.11	32.11
25	33.67	33.68
26	35.67	37.62

Table 13: Nodal Displacements for Problem # 1 (Time History)

Nodes	Load cases							
	a	b	c	d	e	f	g	h
2	0.081	0.081	0.083	0.080	0.083	0.082	0.099	0.133
3	0.153	0.155	0.157	0.152	0.158	0.156	0.189	0.256
4	0.210	0.216	0.217	0.212	0.221	0.218	0.263	0.365
5	0.254	0.261	0.262	0.257	0.267	0.263	0.321	0.459
6	0.278	0.286	0.286	0.281	0.292	0.288	0.343	0.473
7	0.960	0.861	0.701	0.707	0.304	1.111	0.649	0.663
8	1.699	1.375	1.374	1.117	0.333	1.982	0.923	0.839
9	2.246	1.945	1.878	1.414	0.353	2.627	1.118	0.966
10	2.535	2.277	2.147	1.570	0.365	2.969	1.219	1.031

Displacement: in

Table 14: Nodal Displacements for Problem # 1 (Time History)

Nodes	Load cases							
	i	j	k	l	m	n	o	p
2	0.081	0.081	0.049	0.081	0.232	0.068	0.065	0.063
3	0.153	0.155	0.092	0.152	0.464	0.127	0.123	0.118
4	0.212	0.217	0.127	0.210	0.618	0.173	0.172	0.162
5	0.257	0.262	0.151	0.251	0.734	0.206	0.208	0.194
6	0.281	0.286	0.164	0.271	0.811	0.222	0.226	0.209
7	0.672	0.447	0.590	1.040	1.468	0.701	0.897	0.850
8	1.159	0.620	1.004	1.720	2.512	1.172	1.659	1.505
9	1.521	0.750	1.308	2.219	3.246	1.518	2.226	1.990
10	1.713	0.818	1.470	2.482	3.671	1.701	2.529	2.247

Displacement: in

Table 15: Element Forces for Problem # 1 (Time History)

Elements	Load cases							
	a	b	c	d	e	f	g	h
1	2545.00	2563.00	2624.00	2524.00	2615.00	2581.00	3125.00	4183.00
2	2266.00	2316.00	2340.00	2283.00	2371.00	2337.00	2829.00	3878.00
3	1882.00	1927.00	1937.00	1908.00	1977.00	1946.00	2398.00	3447.00
4	1401.00	1425.00	1441.00	1422.00	1466.00	1443.00	1865.00	3040.00
5	753.90	787.60	780.40	749.50	793.40	789.20	797.40	730.50
6	90.09	19.21	65.57	61.92	20.97	2.13	696.90	2277.00
7	78.64	18.37	58.21	52.82	17.00	1.86	579.30	1891.00
8	58.01	15.12	43.38	38.29	11.99	1.37	413.80	1343.00
9	30.73	8.81	23.08	20.06	6.208	0.73	218.30	699.10

Force: Kips

Table 16: Element Forces for Problem # 1 (Time History)

Elements	Load cases							
	i	j	k	l	m	n	o	p
1	2553.00	2564.00	1535.00	2552.00	7480.70	2146.00	2062.00	1984.00
2	2278.00	2326.00	1359.00	2250.00	6619.03	1851.00	1864.00	1728.00
3	1901.00	1940.00	1103.00	1821.00	5370.96	1471.00	1564.00	1399.00
4	14.00	1441.00	782.30	1297.00	3796.00	1026.00	1129.00	996.50
5	760.80	777.20	386.70	622.30	1959.43	510.70	579.20	486.60
6	59.99	24.69	50.63	86.12	125.46	57.89	92.36	79.65
7	52.28	20.87	43.89	75.01	108.46	50.04	81.42	69.62
8	38.57	15.33	32.3	55.34	79.64	36.77	60.58	51.43
9	20.44	8.118	17.11	29.35	42.62	19.46	32.3	27.25

Force: Kips

Table 17: Nodal Displacements for Problem # 2 (Time History)

Nodes	Load cases							
	a	b	c	d	e	f	g	h
2	0.081	0.081	0.084	0.080	0.083	0.082	0.112	0.167
3	0.152	0.154	0.158	0.153	0.159	0.156	0.216	0.323
4	0.210	0.215	0.217	0.214	0.221	0.218	0.298	0.443
5	0.254	0.260	0.262	0.257	0.267	0.263	0.346	0.503
6	0.277	0.285	0.286	0.281	0.292	0.288	0.366	0.521
7	1.278	1.324	1.111	0.819	0.233	1.513	0.717	0.625
8	1.781	2.082	1.584	1.097	0.273	2.113	0.943	0.765
9	1.297	1.373	1.103	0.847	0.268	1.531	0.778	0.682
10	1.612	1.383	1.344	1.057	0.297	1.909	0.872	0.856
11	2.241	2.229	1.931	1.408	0.335	2.662	1.110	1.022
12	1.624	1.419	1.342	1.075	0.325	1.921	0.913	0.880

Displacement: in

Table 18: Nodal Displacements for Problem # 2 (Time History)

Nodes	Load cases							
	i	j	k	l	m	n	o	p
2	0.081	0.082	0.049	0.082	0.232	0.068	0.065	0.064
3	0.153	0.155	0.092	0.155	0.463	0.127	0.123	0.119
4	0.212	0.217	0.126	0.213	0.618	0.174	0.171	0.164
5	0.256	0.262	0.150	0.252	0.734	0.205	0.205	0.195
6	0.280	0.286	0.162	0.272	0.811	0.222	0.224	0.210
7	0.876	0.476	0.765	1.295	1.932	0.895	1.246	1.138
8	1.213	0.624	1.052	1.769	2.705	1.222	1.755	1.572
9	0.894	0.514	0.782	1.335	1.932	0.915	1.252	1.141
10	1.101	0.584	0.964	1.619	2.396	1.110	1.590	1.431
11	1.519	0.748	1.319	2.198	3.253	1.511	2.241	1.982
12	1.112	0.611	0.975	1.647	2.396	1.123	1.594	1.431

Displacement: in

Table 19: Element Forces for Problem # 2 (Time History)

Elements	Load cases							
	a	b	c	d	e	f	g	h
1	2543.00	2565.00	2635.00	2529.00	2623.00	2580.00	3543.00	5279.00
2	2264.00	2302.00	2350.00	2302.00	2380.00	2337.00	3264.00	4914.00
3	1877.00	1919.00	1935.00	1907.00	1977.00	1946.00	2577.00	3801.00
4	1378.00	1430.00	1428.00	1384.00	1456.00	1442.00	1566.00	2053.00
5	750.50	785.40	779.10	747.60	793.20	789.10	778.70	809.20
6	26.38	7.32	20.24	18.07	6.54	0.63	219.60	697.60
7	10.96	4.15	8.51	7.39	3.58	0.26	98.97	306.20
8	10.58	3.94	8.61	6.65	0.72	0.26	76.87	188.30
9	26.19	7.62	20.35	17.40	4.24	0.63	211.00	569.30
10	33.15	7.68	24.64	23.00	7.56	0.79	250.80	931.70
11	13.72	4.67	10.44	9.29	3.29	0.33	104.00	364.00
12	13.49	4.53	10.55	8.81	1.75	0.33	94.01	321.00
13	33.04	7.89	24.84	22.49	5.72	0.79	247.60	860.10

Force: Kips

Table 20: Element Forces for Problem # 2 (Time History)

Elements	Load cases							
	i	j	k	l	m	n	o	p
1	2551.00	2571.00	1530.00	2590.00	7484.57	2150.00	2055.00	2010.00
2	2284.00	2333.00	1357.00	2286.00	6622.90	1855.00	1848.00	1753.00
3	1897.00	1939.00	1094.00	1830.00	5367.10	1468.00	1545.00	1408.00
4	1393.00	1425.00	754.40	1254.00	3782.86	1005.00	1103.00	968.20
5	758.10	774.90	382.00	623.20	1959.05	507.80	571.90	487.50
6	17.71	7.72	15.15	25.14	38.64	17.38	26.72	23.43
7	7.38	3.30	6.26	10.41	15.46	7.15	11.11	9.49
8	7.04	2.79	5.89	9.99	15.46	6.73	11.06	9.42
9	17.52	7.58	14.96	24.89	38.64	17.04	26.69	23.00
10	22.18	9.19	18.92	31.66	46.68	21.37	34.19	29.41
11	9.16	3.76	7.78	13.03	19.32	8.74	14.20	12.03
12	8.94	3.56	7.53	12.75	19.32	8.47	14.22	12.03
13	22.07	9.13	18.80	31.46	46.37	21.14	34.18	29.11

Force: Kips

Table 21: Nodal Displacements for Problem # 3 (Time History)

Nodes	Load cases							
	a	b	c	d	e	f	g	h
2	0.081	0.081	0.083	0.080	0.083	0.082	0.101	0.133
3	0.152	0.154	0.158	0.152	0.158	0.156	0.194	0.255
4	0.210	0.215	0.217	0.212	0.220	0.218	0.274	0.364
5	0.253	0.260	0.263	0.257	0.266	0.263	0.335	0.458
6	0.277	0.284	0.287	0.281	0.291	0.288	0.363	0.505
7	0.897	1.440	0.886	0.523	0.105	1.063	0.453	0.301
8	1.295	1.906	1.204	0.777	0.191	1.531	0.729	0.483
9	0.978	1.403	0.836	0.661	0.247	1.147	0.689	0.518
10	1.826	1.424	1.492	1.210	0.344	2.162	0.954	0.955
11	2.535	2.320	2.150	1.607	0.381	3.011	1.195	1.151
12	1.832	1.443	1.493	1.219	0.355	2.168	0.978	0.982

Displacement: in

Table 22: Nodal Displacements for Problem # 3 (Time History)

Nodes	Load cases							
	i	j	k	l	m	n	o	p
2	0.081	0.081	0.048	0.081	0.232	0.068	0.065	0.063
3	0.153	0.155	0.091	0.153	0.386	0.126	0.123	0.118
4	0.211	0.216	0.126	0.210	0.618	0.173	0.170	0.163
5	0.256	0.262	0.150	0.252	0.734	0.205	0.206	0.194
6	0.280	0.286	0.163	0.273	0.773	0.222	0.224	0.210
7	0.609	0.303	0.524	0.879	1.545	0.627	0.874	0.816
8	0.886	0.482	0.763	1.299	1.932	0.911	1.246	1.143
9	0.689	0.460	0.600	1.049	1.546	0.721	0.904	0.841
10	1.246	0.654	1.088	1.826	2.705	1.249	1.811	1.619
11	1.716	0.826	1.488	2.469	3.478	1.696	2.552	2.246
12	1.253	0.669	1.094	1.841	2.705	1.256	1.813	1.618

Displacement: in

Table 23: Element Forces for Problem # 3 (Time History)

Elements	Load cases							
	a	b	c	d	e	f	g	h
1	2542.00	2565.00	2630.00	2521.00	2607.00	2580.00	3193.00	4180.00
2	2264.00	2305.00	2345.00	2278.00	2364.00	2337.00	2933.00	3866.00
3	1876.00	1917.00	1933.00	1904.00	1969.00	1946.00	2503.00	3441.00
4	1397.00	1417.00	1439.00	1420.00	1460.00	1443.00	1943.00	3070.00
5	761.00	779.00	784.60	770.40	798.60	789.30	909.50	1514.00
6	19.55	7.85	15.64	13.78	9.17	0.46	197.40	657.50
7	8.70	5.00	6.35	6.84	7.50	0.20	121.00	441.40
8	7.44	4.12	7.24	3.29	4.95	0.19	46.36	229.70
9	18.68	8.12	15.76	11.19	2.50	0.45	158.80	370.80
10	37.51	7.92	27.52	26.13	9.66	0.90	270.20	1102.00
11	15.49	4.99	11.67	10.57	3.61	0.37	106.30	430.20
12	15.37	4.92	11.74	10.28	3.17	0.37	103.10	374.90
13	37.44	8.04	27.65	25.84	8.49	0.90	268.30	1055.00

Force: Kips

Table 24: Element Forces for Problem # 3 (Time History)

Elements	Load cases							
	i	j	k	l	m	n	o	p
1	2552.00	2560.00	1520.00	2556.00	7476.84	2138.00	2051.00	1989.00
2	2273.00	2323.00	1346.00	2254.00	6615.17	1843.00	1844.00	1733.00
3	1895.00	1937.00	1093.00	1826.00	5367.10	1466.00	1547.00	1405.00
4	1411.00	1438.00	775.30	1302.00	3790.58	1023.00	1117.00	1002.00
5	768.60	784.40	394.60	658.80	1962.91	519.00	579.70	509.10
6	13.28	6.61	11.42	19.16	30.91	13.68	19.05	17.79
7	6.07	3.92	5.23	9.15	15.46	6.20	8.13	7.41
8	4.62	2.15	3.63	6.46	11.59	4.42	7.80	6.75
9	12.43	5.61	10.51	17.57	27.05	12.17	18.78	16.31
10	25.03	10.15	21.29	35.75	50.23	23.92	39.03	33.25
11	10.30	4.11	8.72	14.69	19.32	9.75	16.21	13.70
12	10.19	4.05	8.59	14.53	23.18	9.61	16.23	13.70
13	24.99	10.14	21.23	35.67	50.23	23.80	39.01	33.09

Force: Kips

Table 25: Nodal Displacements for Problem # 4a (Time History)

Nodes	Load cases						
	a	b	c	d	e	f	g
2 u_x	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2 u_y	1.167	0.447	0.802	2.004	0.651	0.634	0.910
2 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2 θ_x	3.123	1.135	2.227	5.584	1.587	1.674	2.535
2 θ_y	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 u_x	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 u_y	2.877	1.075	2.004	5.018	1.538	1.551	2.277
3 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 θ_x	5.422	1.955	3.893	9.765	2.713	2.901	4.434
3 θ_y	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4 u_x	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4 u_y	4.576	1.687	3.217	8.065	2.388	2.458	3.660
4 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4 θ_x	6.768	2.427	4.886	12.260	3.352	3.619	5.567
4 θ_y	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5 u_x	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5 u_y	6.642	2.424	4.713	11.820	3.401	3.561	5.366
5 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5 θ_x	7.738	2.765	5.616	14.080	3.803	4.138	6.399
5 θ_y	0.001	0.000	0.000	0.001	0.000	0.000	0.000
5 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6 u_x	0.000	0.000	0.000	0.001	0.000	0.000	0.000
6 u_y	8.745	3.170	6.252	15.680	4.420	4.685	7.119
6 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6 θ_x	8.229	2.934	5.993	15.030	4.027	4.402	6.828
6 θ_y	0.001	0.000	0.000	0.001	0.000	0.000	0.000
6 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7 u_x	0.000	0.000	0.000	0.001	0.000	0.000	0.001
7 u_y	10.050	3.633	7.210	18.080	5.052	5.384	8.211
7 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7 θ_x	8.351	2.976	6.087	15.260	4.081	4.468	6.936
7 θ_y	0.001	0.000	0.000	0.001	0.000	0.000	0.000
7 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad*.

Table 26: Nodal Displacements for Problem # 4a (Time History) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
8 u_x	0.001	0.000	0.000	0.001	0.000	0.000	0.001
8 u_y	11.270	4.068	8.109	20.330	5.646	6.040	9.235
8 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8 θ_x	8.381	2.986	6.112	15.320	4.094	4.484	6.963
8 θ_y	0.001	0.000	0.000	0.001	0.000	0.000	0.000
8 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9 u_x	0.001	0.000	0.000	0.001	0.000	0.000	0.001
9 u_y	11.270	4.068	8.109	20.330	5.646	6.040	9.235
9 u_z	0.654	0.233	0.477	1.195	0.319	0.350	0.543
9 θ_x	8.381	2.986	6.112	15.320	4.094	4.484	6.963
9 θ_y	0.001	0.000	0.000	0.001	0.000	0.000	0.000
9 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10 u_x	0.002	0.000	0.001	0.002	0.000	0.001	0.001
10 u_y	12.130	4.334	8.641	21.720	5.971	6.487	9.929
10 u_z	0.688	0.241	0.492	1.220	0.327	0.377	0.592
10 θ_x	17.630	6.200	15.410	40.720	7.879	9.026	20.790
10 θ_y	2.350	0.424	0.956	2.207	0.433	0.637	1.432
10 θ_z	13.450	4.209	7.964	20.630	5.015	6.432	10.070
11 u_x	0.004	0.001	0.002	0.003	0.001	0.001	0.002
11 u_y	12.400	4.412	8.767	22.060	6.068	6.646	10.160
11 u_z	0.694	0.244	0.509	1.229	0.337	0.399	0.615
11 θ_x	31.310	10.680	29.400	76.610	12.750	15.210	39.430
11 θ_y	1.108	0.143	0.303	0.709	0.124	0.206	0.378
11 θ_z	8.057	2.201	4.686	12.400	2.684	3.443	5.636
12 u_x	0.006	0.001	0.002	0.004	0.001	0.002	0.003
12 u_y	11.270	4.068	8.109	20.330	5.646	6.040	9.235
12 u_z	0.654	0.233	0.477	1.195	0.319	0.350	0.543
12 θ_x	45.000	15.210	43.700	112.500	18.870	21.390	58.370
12 θ_y	3.979	1.035	2.350	6.902	1.045	1.391	3.706
12 θ_z	20.660	6.678	11.810	29.090	7.884	9.798	15.650
13 u_x	0.108	0.037	0.087	0.274	0.040	0.046	0.142
13 u_y	11.170	4.007	8.356	20.670	5.586	5.563	9.021
13 u_z	0.713	0.234	0.523	1.329	0.309	0.306	0.534
13 θ_x	61.130	20.970	60.060	153.500	25.960	28.990	79.920
13 θ_y	5.760	1.729	3.250	11.550	1.668	2.085	6.216
13 θ_z	24.310	8.476	19.700	49.880	10.120	11.870	26.960

Units: u_x, u_y and u_z: 10^{-2} in; θ_x, θ_y and θ_z: 10^{-5} rad.

Table 27: Nodal Displacements for Problem # 4a (Time History) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
14 u_x	0.473	0.126	0.208	0.742	0.109	0.147	0.421
14 u_y	12.080	4.933	9.996	29.410	5.892	4.624	12.380
14 u_z	0.717	0.236	0.526	1.338	0.309	0.304	0.535
14 θ_x	40.760	14.330	35.710	91.730	18.060	20.880	47.360
14 θ_y	2.209	0.616	1.076	2.585	0.590	0.935	1.890
14 θ_z	22.170	7.696	17.730	44.780	9.171	10.820	24.230
15 u_x	0.350	0.105	0.174	0.449	0.081	0.138	0.315
15 u_y	10.840	4.567	9.140	27.930	5.278	4.315	11.980
15 u_z	0.720	0.237	0.530	1.345	0.309	0.301	0.536
15 θ_x	37.550	15.240	31.780	101.200	14.090	15.970	50.760
15 θ_y	4.015	0.863	1.732	5.789	0.861	1.136	3.100
15 θ_z	20.040	6.916	15.760	39.690	8.226	9.774	21.510
16 u_x	0.000	0.000	0.000	0.001	0.000	0.000	0.000
16 u_y	8.745	3.170	6.252	15.680	4.420	4.685	7.119
16 u_z	0.723	0.239	0.533	1.351	0.309	0.298	0.536
16 θ_x	123.200	41.480	111.700	283.200	51.080	61.440	148.000
16 θ_y	4.195	1.635	2.992	7.446	1.545	2.251	4.826
16 θ_z	17.920	6.136	13.800	34.600	7.280	8.728	18.790
17 u_x	0.514	0.170	0.332	0.793	0.172	0.230	0.473
17 u_y	19.270	7.150	13.950	34.510	9.132	11.130	18.910
17 u_z	0.725	0.241	0.536	1.355	0.309	0.296	0.537
17 θ_x	156.800	56.590	136.200	338.200	70.180	82.710	177.200
17 θ_y	5.649	2.025	4.100	9.795	2.183	3.007	6.229
17 θ_z	15.830	5.356	11.830	29.510	6.334	7.685	16.080
18 u_x	0.749	0.300	0.591	1.444	0.316	0.414	0.905
18 u_y	28.140	10.730	22.470	55.400	13.550	16.340	29.920
18 u_z	0.727	0.243	0.538	1.358	0.309	0.293	0.537
18 θ_x	59.110	21.340	50.860	125.400	26.160	31.340	66.160
18 θ_y	4.962	0.955	2.692	4.748	1.114	1.982	3.741
18 θ_z	13.760	4.577	9.866	24.430	5.457	6.651	13.540
19 u_x	0.888	0.301	0.613	1.479	0.322	0.430	0.966
19 u_y	26.880	10.290	21.570	53.150	12.980	15.680	28.710
19 u_z	0.728	0.244	0.540	1.360	0.310	0.290	0.536
19 θ_x	82.850	31.160	70.500	174.500	39.090	46.260	92.260
19 θ_y	3.706	0.943	1.754	4.009	0.914	1.391	2.461
19 θ_z	11.720	3.798	7.902	19.370	4.582	5.636	11.140

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad*.

Table 28: Nodal Displacements for Problem # 4a (Time History) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
20 u_x	0.582	0.170	0.364	0.854	0.187	0.263	0.590
20 u_y	16.090	6.058	11.980	29.440	7.691	9.404	16.180
20 u_z	0.728	0.246	0.542	1.361	0.310	0.287	0.538
20 θ_x	163.900	61.620	139.100	343.800	76.840	91.660	181.900
20 θ_y	6.554	2.027	4.195	9.933	2.187	3.037	6.456
20 θ_z	9.699	3.020	5.940	14.350	3.710	4.679	8.776
21 u_x	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21 u_y	4.576	1.687	3.217	8.065	2.388	2.458	3.660
21 u_z	0.728	0.247	0.543	1.360	0.310	0.285	0.539
21 θ_x	102.800	38.890	87.530	213.600	48.430	57.620	114.100
21 θ_y	5.539	1.805	3.966	8.660	1.915	2.641	6.439
21 θ_z	8.182	2.307	4.803	10.970	3.058	3.844	6.490
22 u_x	0.440	0.114	0.290	0.636	0.122	0.195	0.422
22 u_y	3.559	1.746	3.269	10.830	2.022	1.613	4.557
22 u_z	0.726	0.249	0.544	1.357	0.310	0.282	0.540
22 θ_x	7.486	2.736	6.066	20.270	2.756	3.521	9.429
22 θ_y	3.945	1.100	2.763	6.770	1.191	1.531	3.717
22 θ_z	7.643	1.926	3.716	8.852	2.812	3.146	5.081
23 u_x	0.582	0.177	0.443	1.130	0.202	0.245	0.653
23 u_y	3.086	1.173	2.295	6.004	1.729	1.492	2.458
23 u_z	0.724	0.250	0.544	1.366	0.310	0.279	0.541
23 θ_x	33.460	11.180	30.950	74.050	13.630	16.550	41.000
23 θ_y	3.841	1.008	1.754	5.219	1.192	1.028	2.592
23 θ_z	8.274	1.974	4.151	10.060	2.591	2.894	5.525
24 u_x	0.410	0.147	0.352	0.951	0.168	0.178	0.537
24 u_y	3.015	1.136	2.132	5.230	1.661	1.531	2.322
24 u_z	0.757	0.254	0.504	1.297	0.329	0.405	0.691
24 θ_x	10.610	3.402	7.438	19.520	4.415	4.885	8.437
24 θ_y	3.437	0.632	1.137	2.473	0.926	1.160	1.506
24 θ_z	8.513	2.390	6.076	15.400	2.787	3.441	8.763
25 u_x	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25 u_y	3.014	1.135	2.128	5.201	1.659	1.534	2.322
25 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25 θ_x	12.040	4.155	8.209	20.570	5.348	6.539	11.200
25 θ_y	2.903	0.556	1.047	2.306	0.813	1.028	1.430
25 θ_z	7.633	2.429	5.058	15.750	2.817	3.210	8.704

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad*.

Table 29: Nodal Displacements for Problem # 4a (Time History) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
26 u_x	0.749	0.203	0.432	1.147	0.210	0.275	0.604
26 u_y	3.007	1.131	2.119	5.143	1.650	1.537	2.318
26 u_z	0.839	0.261	0.550	1.400	0.340	0.428	0.722
26 θ_x	4.819	1.809	3.628	8.758	2.569	2.510	3.940
26 θ_y	2.024	0.499	0.909	2.398	0.625	0.811	1.377
26 θ_z	2.340	0.570	1.193	3.024	0.623	0.651	1.459
27 u_x	0.259	0.078	0.189	0.473	0.083	0.094	0.252
27 u_y	2.996	1.126	2.108	5.125	1.640	1.537	2.311
27 u_z	1.026	0.367	0.729	1.841	0.507	0.556	0.863
27 θ_x	4.369	1.672	3.009	9.750	2.306	1.646	3.824
27 θ_y	1.445	0.471	0.941	2.477	0.520	0.646	1.374
27 θ_z	13.280	4.037	7.422	21.920	4.487	4.704	10.500
28 u_x	0.013	0.002	0.004	0.007	0.002	0.003	0.003
28 u_y	2.877	1.075	2.004	5.018	1.538	1.551	2.277
28 u_z	1.074	0.387	0.771	1.933	0.537	0.575	0.878
28 θ_x	4.600	1.729	3.171	9.588	2.426	1.694	3.588
28 θ_y	1.658	0.300	0.719	2.227	0.255	0.478	0.965
28 θ_z	10.390	2.768	5.378	16.500	3.669	4.508	7.860
29 u_x	0.010	0.001	0.003	0.005	0.002	0.003	0.002
29 u_y	3.489	1.231	2.212	5.548	1.805	1.813	2.605
29 u_z	1.131	0.394	0.814	2.047	0.532	0.587	0.921
29 θ_x	4.766	1.731	3.261	9.237	2.468	1.985	3.573
29 θ_y	1.443	0.274	0.600	1.803	0.232	0.333	0.745
29 θ_z	9.885	2.421	3.640	9.839	3.789	3.267	4.094
30 u_x	0.007	0.001	0.002	0.004	0.001	0.002	0.002
30 u_y	3.736	1.291	2.298	5.728	1.907	1.883	2.683
30 u_z	1.159	0.399	0.829	2.086	0.534	0.595	0.941
30 θ_x	4.939	1.737	3.408	8.886	2.529	2.285	3.717
30 θ_y	0.421	0.074	0.178	0.547	0.063	0.118	0.237
30 θ_z	2.596	0.653	1.273	3.909	0.865	1.067	1.867
31 u_x	0.003	0.000	0.001	0.002	0.001	0.001	0.001
31 u_y	3.274	1.187	2.158	5.382	1.731	1.716	2.475
31 u_z	1.108	0.394	0.801	2.012	0.537	0.586	0.911
31 θ_x	5.131	1.834	3.619	8.790	2.610	2.591	3.991
31 θ_y	1.600	0.303	0.655	2.019	0.247	0.378	0.839
31 θ_z	10.870	2.637	4.111	11.280	4.119	3.724	4.657

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad*.

Table 30: Nodal Displacements for Problem # 4a (Time History) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
32 u_x	0.000	0.000	0.000	0.000	0.000	0.000	0.000
32 u_y	2.877	1.075	2.004	5.018	1.538	1.551	2.277
32 u_z	1.074	0.387	0.771	1.933	0.537	0.575	0.878
32 θ_x	5.422	1.955	3.893	9.765	2.713	2.901	4.434
32 θ_y	0.000	0.000	0.000	0.000	0.000	0.000	0.000
32 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad.*

Table 31: Forces and Moments in Primary System for Problem # 4a (Time History)

Elements	Load cases			
	a	b	c	d
1 R_{I1}	1.054	0.124	0.299	0.805
1 R_{I2}	2.792	0.344	0.927	0.805
1 R_{I3}	12800.000	4789.000	8797.000	22060.000
1 M_{I1}	0.000	0.000	0.000	0.000
1 M_{I2}	9655000.000	3467000.000	6942000.000	17420000.000
1 M_{I3}	488.100	140.300	337.800	665.600
1 R_{J1}	1.054	0.124	0.299	0.805
1 R_{J2}	2.792	0.344	0.927	0.805
1 R_{J3}	12800.000	4789.000	8797.000	22060.000
1 M_{J1}	0.000	0.000	0.000	0.000
1 M_{J2}	6812000.000	2403000.000	4992000.000	12530000.000
1 M_{J3}	971.100	149.100	382.800	487.900
2 R_{I1}	0.863	0.167	0.433	1.262
2 R_{I2}	1.005	0.130	0.354	0.351
2 R_{I3}	5820.000	2112.000	4031.000	10150.000
2 M_{I1}	0.000	0.000	0.000	0.000
2 M_{I2}	5466000.000	1927000.000	4006000.000	10050000.000
2 M_{I3}	779.900	119.500	306.600	389.700
2 R_{J1}	0.863	0.167	0.433	1.262
2 R_{J2}	1.005	0.130	0.354	0.351
2 R_{J3}	5820.000	2112.000	4031.000	10150.000
2 M_{J1}	0.000	0.000	0.000	0.000
2 M_{J2}	4172000.000	1457000.000	3110000.000	7795000.000
2 M_{J3}	937.700	119.600	325.500	315.700
3 R_{I1}	0.951	0.214	0.559	1.656
3 R_{I2}	1.466	0.276	0.667	1.037
3 R_{I3}	14470.000	5123.000	10500.000	26370.000
3 M_{I1}	0.000	0.000	0.000	0.000
3 M_{I2}	5497000.000	1919000.000	4098000.000	10270000.000
3 M_{I3}	1233.000	157.200	427.600	414.200
3 R_{J1}	0.951	0.214	0.559	1.656
3 R_{J2}	1.466	0.276	0.667	1.037
3 R_{J3}	14470.000	5123.000	10500.000	26370.000
3 M_{J1}	0.000	0.000	0.000	0.000
3 M_{J2}	2809000.000	965400.000	2144000.000	5362000.000
3 M_{J3}	969.500	114.400	306.700	222.300

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 32: Forces and Moments in Primary System for Problem # 4a (Time History) (contd.)

Elements	Load cases			
	a	b	c	d
4 R_{I1}	0.644	0.178	0.482	1.413
4 R_{I2}	1.986	0.243	0.656	0.561
4 R_{I3}	7592.000	2636.000	5702.000	14280.000
4 M_{I1}	0.000	0.000	0.000	0.000
4 M_{I2}	2661000.000	918300.000	2025000.000	5066000.000
4 M_{I3}	871.800	103.700	278.500	209.000
4 R_{J1}	0.644	0.178	0.482	1.413
4 R_{J2}	1.986	0.243	0.656	0.561
4 R_{J3}	7592.000	2636.000	5702.000	14280.000
4 M_{J1}	0.000	0.000	0.000	0.000
4 M_{J2}	1079000.000	366800.000	831200.000	2075000.000
4 M_{J3}	458.000	52.930	142.900	94.210
5 R_{I1}	0.393	0.107	0.310	0.865
5 R_{I2}	0.485	0.116	0.289	0.528
5 R_{I3}	7758.000	2805.000	5509.000	13840.000
5 M_{I1}	0.000	0.000	0.000	0.000
5 M_{I2}	359100.000	138200.000	229500.000	568100.000
5 M_{I3}	228.400	22.630	63.250	25.060
5 R_{J1}	0.393	0.107	0.310	0.865
5 R_{J2}	0.485	0.116	0.289	0.528
5 R_{J3}	7758.000	2805.000	5509.000	13840.000
5 M_{J1}	0.000	0.000	0.000	0.000
5 M_{J2}	1276000.000	452700.000	938600.000	2351000.000
5 M_{J3}	203.900	29.560	79.360	94.830
6 R_{I1}	0.644	0.169	0.495	1.302
6 R_{I2}	1.345	0.153	0.414	0.247
6 R_{I3}	2739.000	926.700	2116.000	5277.000
6 M_{I1}	0.000	0.000	0.000	0.000
6 M_{I2}	370900.000	125500.000	286500.000	714400.000
6 M_{I3}	181.700	20.670	55.940	33.420
6 R_{J1}	0.644	0.169	0.495	1.302
6 R_{J2}	1.345	0.153	0.414	0.247
6 R_{J3}	2739.000	926.700	2116.000	5277.000
6 M_{J1}	0.000	0.000	0.000	0.000
6 M_{J2}	9.605	2.427	5.965	19.220
6 M_{J3}	0.047	0.008	0.020	0.027

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 33: Forces and Moments in Primary System for Problem # 4a (Time History) (contd.)

Elements	Load cases			
	a	b	c	d
7 R_{I1}	0.000	0.000	0.000	0.000
7 R_{I2}	3.795	0.640	1.624	2.301
7 R_{I3}	31660.000	11280.000	23090.000	57890.000
7 M_{I1}	0.000	0.000	0.000	0.000
7 M_{I2}	2137000.000	761500.000	1558000.000	3907000.000
7 M_{I3}	256.200	43.190	109.600	155.300
7 R_{J1}	0.000	0.000	0.000	0.000
7 R_{J2}	3.795	0.640	1.624	2.301
7 R_{J3}	31660.000	11280.000	23090.000	57890.000
7 M_{J1}	0.000	0.000	0.000	0.000
7 M_{J2}	2137000.000	761500.000	1558000.000	3907000.000
7 M_{J3}	256.200	43.190	109.600	155.300

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 34: Forces and Moments in Primary System for Problem # 4a (Time History) (contd.)

Elements	Load cases		
	e	f	g
1 R_{I1}	0.090	0.255	0.479
1 R_{I2}	0.285	0.915	0.795
1 R_{I3}	6889.000	6868.000	9999.000
1 M_{I1}	0.000	0.000	0.000
1 M_{I2}	4798000.000	5158000.000	7910000.000
1 M_{I3}	164.700	236.200	509.900
1 R_{J1}	0.090	0.255	0.479
1 R_{J2}	0.285	0.915	0.795
1 R_{J3}	6889.000	6868.000	9999.000
1 M_{J1}	0.000	0.000	0.000
1 M_{J2}	3269000.000	3632000.000	5693000.000
1 M_{J3}	143.800	348.100	407.900
2 R_{I1}	0.186	0.269	0.701
2 R_{I2}	0.118	0.355	0.304
2 R_{I3}	2979.000	3082.000	4599.000
2 M_{I1}	0.000	0.000	0.000
2 M_{I2}	2620000.000	2914000.000	4569000.000
2 M_{I3}	115.000	279.100	325.900
2 R_{J1}	0.186	0.269	0.701
2 R_{J2}	0.118	0.355	0.304
2 R_{J3}	2979.000	3082.000	4599.000
2 M_{J1}	0.000	0.000	0.000
2 M_{J2}	1958000.000	2228000.000	3547000.000
2 M_{J3}	106.600	316.400	282.500
3 R_{I1}	0.243	0.324	0.899
3 R_{I2}	0.281	0.569	0.829
3 R_{I3}	7008.000	7700.000	11980.000
3 M_{I1}	0.000	0.000	0.000
3 M_{I2}	2578000.000	2935000.000	4673000.000
3 M_{I3}	140.000	415.800	371.000
3 R_{J1}	0.243	0.324	0.899
3 R_{J2}	0.281	0.569	0.829
3 R_{J3}	7008.000	7700.000	11980.000
3 M_{J1}	0.000	0.000	0.000
3 M_{J2}	1274000.000	1501000.000	2445000.000
3 M_{J3}	88.560	313.300	221.000

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 35: Forces and Moments in Primary System for Problem # 4a (Time History) (contd.)

Elements	Load cases		
	e	f	g
4 R_{I1}	0.206	0.248	0.746
4 R_{I2}	0.208	0.649	0.514
4 R_{I3}	3519.000	4054.000	6507.000
4 M_{I1}	0.000	0.000	0.000
4 M_{I2}	1216000.000	1424000.000	2309000.000
4 M_{I3}	81.570	283.000	204.800
4 R_{J1}	0.206	0.248	0.746
4 R_{J2}	0.208	0.649	0.514
4 R_{J3}	3519.000	4054.000	6507.000
4 M_{J1}	0.000	0.000	0.000
4 M_{J2}	479300.000	575000.000	947200.000
4 M_{J3}	38.810	147.500	99.120
5 R_{I1}	0.125	0.135	0.444
5 R_{I2}	0.135	0.222	0.411
5 R_{I3}	3915.000	4140.000	6280.000
5 M_{I1}	0.000	0.000	0.000
5 M_{I2}	207800.000	188800.000	261300.000
5 M_{I3}	15.860	66.350	28.650
5 R_{J1}	0.125	0.135	0.444
5 R_{J2}	0.135	0.222	0.411
5 R_{J3}	3915.000	4140.000	6280.000
5 M_{J1}	0.000	0.000	0.000
5 M_{J2}	617200.000	683400.000	1069000.000
5 M_{J3}	28.520	72.780	81.470
6 R_{I1}	0.184	0.220	0.652
6 R_{I2}	0.109	0.430	0.274
6 R_{I3}	1182.000	1446.000	2411.000
6 M_{I1}	0.000	0.000	0.000
6 M_{I2}	160100.000	195800.000	326400.000
6 M_{I3}	14.720	58.060	37.000
6 R_{J1}	0.184	0.220	0.652
6 R_{J2}	0.109	0.430	0.274
6 R_{J3}	1182.000	1446.000	2411.000
6 M_{J1}	0.000	0.000	0.000
6 M_{J2}	2.878	2.753	7.767
6 M_{J3}	0.008	0.018	0.023

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 36: Forces and Moments in Primary System for Problem # 4a (Time History) (contd.)

Elements	Load cases		
	e	f	g
7 R_{I1}	0.000	0.000	0.000
7 R_{I2}	0.646	1.424	1.886
7 R_{I3}	15470.000	16940.000	26310.000
7 M_{I1}	0.000	0.000	0.000
7 M_{I2}	1044000.000	1143000.000	1776000.000
7 M_{I3}	43.590	96.130	127.300
7 R_{J1}	0.000	0.000	0.000
7 R_{J2}	0.646	1.424	1.886
7 R_{J3}	15470.000	16940.000	26310.000
7 M_{J1}	0.000	0.000	0.000
7 M_{J2}	1044000.000	1143000.000	1776000.000
7 M_{J3}	43.590	96.130	127.300

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 37: Forces and Moments in Support Elements for Problem # 4a (Time History)

Elements	Loadcases						
	a	b	c	d	e	f	g
$1R_{I1}$	0.308	0.069	0.144	0.378	0.089	0.105	0.176
$1R_{I2}$	0.112	0.017	0.036	0.074	0.017	0.026	0.051
$1R_{I3}$	0.701	0.206	0.410	1.104	0.246	0.325	0.510
$1M_{I1}$	0.995	0.350	0.959	2.455	0.425	0.454	1.340
$1M_{I2}$	3.606	1.091	2.120	5.685	1.311	1.699	2.675
$1M_{I3}$	0.487	0.094	0.252	0.619	0.089	0.142	0.356
$1R_{J1}$	0.308	0.069	0.144	0.378	0.089	0.105	0.176
$1R_{J2}$	0.112	0.017	0.036	0.074	0.017	0.026	0.051
$1R_{J3}$	0.701	0.206	0.410	1.104	0.246	0.325	0.510
$1M_{J1}$	0.995	0.350	0.959	2.455	0.425	0.454	1.340
$1M_{J2}$	11.140	3.240	6.502	17.540	3.873	5.134	8.061
$1M_{J3}$	1.952	0.352	0.815	1.582	0.361	0.511	1.132
$2R_{I1}$	0.243	0.116	0.178	0.419	0.174	0.122	0.170
$2R_{I2}$	0.085	0.017	0.039	0.109	0.015	0.020	0.047
$2R_{I3}$	0.565	0.114	0.192	0.459	0.176	0.165	0.199
$2M_{I1}$	0.199	0.040	0.088	0.280	0.028	0.058	0.117
$2M_{I2}$	2.739	0.699	1.044	2.828	1.096	0.938	1.169
$2M_{I3}$	0.354	0.067	0.154	0.430	0.067	0.084	0.203
$2R_{J1}$	0.243	0.116	0.178	0.419	0.174	0.122	0.170
$2R_{J2}$	0.085	0.017	0.039	0.109	0.015	0.020	0.047
$2R_{J3}$	0.565	0.114	0.192	0.459	0.176	0.165	0.199
$2M_{J1}$	0.199	0.040	0.088	0.280	0.028	0.058	0.117
$2M_{J2}$	11.900	2.293	3.931	9.071	3.473	3.333	3.993
$2M_{J3}$	1.852	0.371	0.849	2.404	0.326	0.445	1.026
$3R_{I1}$	1.475	0.536	1.187	3.367	0.580	0.570	1.544
$3R_{I2}$	0.685	0.177	0.511	1.334	0.189	0.233	0.640
$3R_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3R_{J1}$	1.475	0.536	1.187	3.367	0.580	0.570	1.544
$3R_{J2}$	0.685	0.177	0.511	1.334	0.189	0.233	0.640
$3R_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{J3}$	4.450	1.148	3.322	8.670	1.228	1.516	4.159
$4R_{I1}$	3.002	1.099	2.084	5.259	1.393	1.741	2.762
$4R_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4R_{I3}$	0.881	0.243	0.485	1.133	0.305	0.399	0.603
$4M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000

R = Force (Kips)   M = Moment (Kips-ft)

Table 38: Forces and Moments in Support Elements for Problem # 4a (Time History)

Elements	Loadcases						
	a	b	c	d	e	f	g
$4R_{J1}$	3.002	1.099	2.084	5.259	1.393	1.741	2.762
$4R_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4R_{J3}$	0.881	0.243	0.485	1.133	0.305	0.399	0.603
$4M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4M_{J2}$	5.878	1.621	3.239	7.561	2.033	2.662	4.025
$4M_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5R_{I1}$	3.049	1.180	2.509	6.456	1.497	1.840	3.347
$5R_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5R_{I3}$	0.807	0.283	0.561	1.464	0.336	0.442	0.766
$5M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5R_{J1}$	3.049	1.180	2.509	6.456	1.497	1.840	3.347
$5R_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5R_{J3}$	0.807	0.283	0.561	1.464	0.336	0.442	0.766
$5M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5M_{J2}$	5.382	1.886	3.745	9.769	2.244	2.948	5.114
$5M_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6R_{I1}$	0.547	0.057	0.132	0.149	0.053	0.131	0.129
$6R_{I2}$	0.484	0.160	0.397	0.944	0.199	0.237	0.527
$6R_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6R_{J1}$	0.547	0.057	0.132	0.149	0.053	0.131	0.129
$6R_{J2}$	0.484	0.160	0.397	0.944	0.199	0.237	0.527
$6R_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{J3}$	0.727	0.240	0.595	1.416	0.299	0.355	0.790
$7R_{I1}$	1.762	0.818	1.243	4.156	1.071	0.803	1.604
$7R_{I2}$	0.188	0.047	0.098	0.250	0.055	0.064	0.143
$7R_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7R_{J1}$	1.762	0.818	1.243	4.156	1.071	0.803	1.604
$7R_{J2}$	0.188	0.047	0.098	0.250	0.055	0.064	0.143
$7R_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{J3}$	3.107	0.783	1.623	4.130	0.905	1.064	2.352

R = Force (Kips) M = Moment (Kips-ft)

Table 39: Forces and Moments in Secondary System for Problem # 4a (Time History)

Elements	Load cases						
	a	b	c	d	e	f	g
1 R_{I1}	0.116	0.017	0.039	0.079	0.015	0.038	0.058
1 R_{I2}	0.112	0.017	0.036	0.074	0.017	0.026	0.051
1 R_{I3}	0.742	0.217	0.428	1.166	0.262	0.341	0.539
1 M_{I1}	0.969	0.354	0.976	2.524	0.425	0.443	1.371
1 M_{I2}	3.606	1.091	2.120	5.685	1.311	1.699	2.675
1 M_{I3}	0.580	0.095	0.204	0.399	0.094	0.142	0.296
1 R_{J1}	0.116	0.017	0.039	0.079	0.015	0.038	0.058
1 R_{J2}	0.112	0.017	0.036	0.074	0.017	0.026	0.051
1 R_{J3}	0.742	0.217	0.428	1.166	0.262	0.341	0.539
1 M_{J1}	0.969	0.354	0.976	2.524	0.425	0.443	1.371
1 M_{J2}	1.340	0.373	0.806	2.103	0.457	0.579	0.955
1 M_{J3}	0.170	0.023	0.047	0.114	0.019	0.031	0.060
2 R_{I1}	0.115	0.017	0.039	0.079	0.015	0.037	0.057
2 R_{I2}	0.040	0.009	0.021	0.061	0.009	0.013	0.033
2 R_{I3}	0.188	0.060	0.103	0.252	0.069	0.087	0.139
2 M_{I1}	0.969	0.354	0.976	2.524	0.425	0.443	1.371
2 M_{I2}	1.340	0.373	0.806	2.103	0.457	0.579	0.955
2 M_{I3}	0.170	0.023	0.047	0.114	0.019	0.031	0.060
2 R_{J1}	0.115	0.017	0.039	0.079	0.015	0.037	0.057
2 R_{J2}	0.040	0.009	0.021	0.061	0.009	0.013	0.033
2 R_{J3}	0.188	0.060	0.103	0.252	0.069	0.087	0.139
2 M_{J1}	0.969	0.354	0.976	2.524	0.425	0.443	1.371
2 M_{J2}	2.417	0.754	1.417	3.663	0.893	1.147	1.792
2 M_{J3}	0.434	0.077	0.175	0.403	0.079	0.116	0.262
3 R_{I1}	0.113	0.016	0.039	0.078	0.015	0.037	0.057
3 R_{I2}	0.074	0.011	0.028	0.070	0.009	0.015	0.030
3 R_{I3}	0.497	0.133	0.308	0.767	0.158	0.181	0.350
3 M_{I1}	0.969	0.354	0.976	2.524	0.425	0.443	1.371
3 M_{I2}	2.417	0.754	1.417	3.663	0.893	1.147	1.792
3 M_{I3}	0.434	0.077	0.175	0.403	0.079	0.116	0.262
3 R_{J1}	0.113	0.016	0.039	0.078	0.015	0.037	0.057
3 R_{J2}	0.074	0.011	0.028	0.070	0.009	0.015	0.030
3 R_{J3}	0.497	0.133	0.308	0.767	0.158	0.181	0.350
3 M_{J1}	0.969	0.354	0.976	2.524	0.425	0.443	1.371
3 M_{J2}	1.255	0.473	0.998	3.081	0.451	0.500	1.510
3 M_{J3}	0.374	0.100	0.257	0.789	0.110	0.123	0.395

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 40: Forces and Moments in Secondary System for Problem # 4a (Time History) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
4 R_{I1}	0.112	0.016	0.039	0.078	0.015	0.036	0.057
4 R_{I2}	0.655	0.168	0.487	1.270	0.182	0.221	0.617
4 R_{I3}	0.897	0.337	0.706	2.228	0.315	0.363	1.112
4 M_{I1}	0.969	0.354	0.976	2.524	0.425	0.443	1.371
4 M_{I2}	1.255	0.473	0.998	3.081	0.451	0.500	1.510
4 M_{I3}	0.374	0.100	0.257	0.789	0.110	0.123	0.395
4 R_{J1}	0.655	0.168	0.487	1.270	0.182	0.221	0.617
4 R_{J2}	0.112	0.016	0.039	0.078	0.015	0.036	0.057
4 R_{J3}	0.897	0.337	0.706	2.228	0.315	0.363	1.112
4 M_{J1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
4 M_{J2}	0.596	0.194	0.439	1.164	0.242	0.299	0.512
4 M_{J3}	0.577	0.141	0.429	1.079	0.158	0.195	0.528
5 R_{I1}	0.652	0.166	0.483	1.248	0.181	0.219	0.609
5 R_{I2}	0.110	0.016	0.040	0.071	0.015	0.036	0.058
5 R_{I3}	0.610	0.239	0.621	1.660	0.271	0.278	0.897
5 M_{I1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
5 M_{I2}	0.596	0.194	0.439	1.164	0.242	0.299	0.512
5 M_{I3}	0.577	0.141	0.429	1.079	0.158	0.195	0.528
5 R_{J1}	0.652	0.166	0.483	1.248	0.181	0.219	0.609
5 R_{J2}	0.110	0.016	0.040	0.071	0.015	0.036	0.058
5 R_{J3}	0.610	0.239	0.621	1.660	0.271	0.278	0.897
5 M_{J1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
5 M_{J2}	4.462	1.825	4.372	12.440	1.916	1.978	6.576
5 M_{J3}	0.631	0.123	0.249	0.815	0.122	0.176	0.439
6 R_{I1}	0.644	0.163	0.476	1.214	0.179	0.215	0.597
6 R_{I2}	0.055	0.013	0.037	0.092	0.015	0.026	0.057
6 R_{I3}	0.539	0.201	0.394	0.939	0.253	0.311	0.531
6 M_{I1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
6 M_{I2}	4.462	1.825	4.372	12.440	1.916	1.978	6.576
6 M_{I3}	0.631	0.123	0.249	0.815	0.122	0.176	0.439
6 R_{J1}	0.644	0.163	0.476	1.214	0.179	0.215	0.597
6 R_{J2}	0.055	0.013	0.037	0.092	0.015	0.026	0.057
6 R_{J3}	0.539	0.201	0.394	0.939	0.253	0.311	0.531
6 M_{J1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
6 M_{J2}	7.001	2.348	6.589	16.660	2.857	3.413	8.730
6 M_{J3}	0.367	0.111	0.188	0.455	0.099	0.157	0.342

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 41: Forces and Moments in Secondary System for Problem # 4a (Time History) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
7 R_{I1}	0.633	0.159	0.468	1.178	0.177	0.211	0.584
7 R_{I2}	0.144	0.018	0.051	0.124	0.020	0.045	0.074
7 R_{I3}	0.951	0.270	0.588	1.687	0.352	0.437	0.724
7 M_{I1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
7 M_{I2}	7.001	2.348	6.589	16.660	2.857	3.413	8.730
7 M_{I3}	0.367	0.111	0.188	0.455	0.099	0.157	0.342
7 R_{J1}	0.633	0.159	0.468	1.178	0.177	0.211	0.584
7 R_{J2}	0.144	0.018	0.051	0.124	0.020	0.045	0.074
7 R_{J3}	0.951	0.270	0.588	1.687	0.352	0.437	0.724
7 M_{J1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
7 M_{J2}	10.380	3.937	7.926	18.620	4.931	6.041	10.620
7 M_{J3}	0.838	0.140	0.379	0.753	0.167	0.350	0.632
8 R_{I1}	0.620	0.156	0.458	1.141	0.176	0.211	0.571
8 R_{I2}	0.163	0.028	0.066	0.114	0.030	0.064	0.095
8 R_{I3}	1.994	0.760	1.660	4.009	0.953	1.141	2.181
8 M_{I1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
8 M_{I2}	10.380	3.937	7.926	18.620	4.931	6.041	10.620
8 M_{I3}	0.838	0.140	0.379	0.753	0.167	0.350	0.632
8 R_{J1}	0.620	0.156	0.458	1.141	0.176	0.211	0.571
8 R_{J2}	0.163	0.028	0.066	0.114	0.030	0.064	0.095
8 R_{J3}	1.994	0.760	1.660	4.009	0.953	1.141	2.181
8 M_{J1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
8 M_{J2}	4.076	1.397	3.697	9.464	1.745	2.076	4.860
8 M_{J3}	0.467	0.065	0.130	0.259	0.054	0.137	0.182
9 R_{I1}	0.602	0.152	0.448	1.102	0.176	0.215	0.557
9 R_{I2}	0.067	0.015	0.039	0.077	0.018	0.027	0.064
9 R_{I3}	1.158	0.442	0.971	2.352	0.547	0.662	1.278
9 M_{I1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
9 M_{I2}	4.076	1.397	3.697	9.464	1.745	2.076	4.860
9 M_{I3}	0.467	0.065	0.130	0.259	0.054	0.137	0.182
9 R_{J1}	0.602	0.152	0.448	1.102	0.176	0.215	0.557
9 R_{J2}	0.067	0.015	0.039	0.077	0.018	0.027	0.064
9 R_{J3}	1.158	0.442	0.971	2.352	0.547	0.662	1.278
9 M_{J1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
9 M_{J2}	12.180	4.476	10.490	25.920	5.575	6.587	13.650
9 M_{J3}	0.581	0.150	0.310	0.695	0.161	0.253	0.463

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 42: Forces and Moments in Secondary System for Problem # 4a (Time History) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
10 R_{I1}	0.579	0.147	0.436	1.062	0.175	0.218	0.542
10 R_{I2}	0.098	0.010	0.028	0.032	0.007	0.028	0.021
10 R_{I3}	0.141	0.041	0.121	0.284	0.048	0.057	0.155
10 M_{I1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
10 M_{I2}	12.180	4.476	10.490	25.920	5.575	6.587	13.650
10 M_{I3}	0.581	0.150	0.310	0.695	0.161	0.253	0.463
10 R_{J1}	0.579	0.147	0.436	1.062	0.175	0.218	0.542
10 R_{J2}	0.098	0.010	0.028	0.032	0.007	0.028	0.021
10 R_{J3}	0.141	0.041	0.121	0.284	0.048	0.057	0.155
10 M_{J1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
10 M_{J2}	11.420	4.253	9.683	23.940	5.274	6.313	12.660
10 M_{J3}	0.706	0.155	0.370	0.738	0.168	0.292	0.525
11 R_{I1}	0.553	0.146	0.423	1.021	0.179	0.221	0.528
11 R_{I2}	0.062	0.015	0.031	0.068	0.015	0.023	0.047
11 R_{I3}	1.337	0.492	1.138	2.818	0.610	0.726	1.489
11 M_{I1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
11 M_{I2}	11.420	4.253	9.683	23.940	5.274	6.313	12.660
11 M_{I3}	0.706	0.155	0.370	0.738	0.168	0.292	0.525
11 R_{J1}	0.553	0.146	0.423	1.021	0.179	0.221	0.528
11 R_{J2}	0.062	0.015	0.031	0.068	0.015	0.023	0.047
11 R_{J3}	1.337	0.492	1.138	2.818	0.610	0.726	1.489
11 M_{J1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
11 M_{J2}	2.128	0.811	1.721	4.221	1.003	1.236	2.269
11 M_{J3}	0.420	0.066	0.195	0.358	0.069	0.147	0.254
12 R_{I1}	0.525	0.146	0.410	0.980	0.184	0.224	0.515
12 R_{I2}	0.170	0.029	0.066	0.109	0.027	0.059	0.080
12 R_{I3}	2.044	0.772	1.716	4.300	0.961	1.162	2.259
12 M_{I1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
12 M_{I2}	2.128	0.811	1.721	4.221	1.003	1.236	2.269
12 M_{I3}	0.420	0.066	0.195	0.358	0.069	0.147	0.254
12 R_{J1}	0.525	0.146	0.410	0.980	0.184	0.224	0.515
12 R_{J2}	0.170	0.029	0.066	0.109	0.027	0.059	0.080
12 R_{J3}	2.044	0.772	1.716	4.300	0.961	1.162	2.259
12 M_{J1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
12 M_{J2}	12.250	4.590	10.290	25.880	5.727	6.896	13.550
12 M_{J3}	0.860	0.149	0.298	0.524	0.129	0.271	0.404

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 43: Forces and Moments in Secondary System for Problem # 4a (Time History) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
13 R_{I1}	0.494	0.150	0.395	0.937	0.189	0.227	0.506
13 R_{I2}	0.163	0.015	0.034	0.036	0.012	0.041	0.030
13 R_{I3}	0.945	0.364	0.751	1.996	0.462	0.574	1.027
13 M_{I1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
13 M_{I2}	12.250	4.590	10.290	25.880	5.727	6.896	13.550
13 M_{I3}	0.860	0.149	0.298	0.524	0.129	0.271	0.404
13 R_{J1}	0.494	0.150	0.395	0.937	0.189	0.227	0.506
13 R_{J2}	0.163	0.015	0.034	0.036	0.012	0.041	0.030
13 R_{J3}	0.945	0.364	0.751	1.996	0.462	0.574	1.027
13 M_{J1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
13 M_{J2}	5.677	2.038	5.032	11.920	2.496	2.952	6.529
13 M_{J3}	0.601	0.112	0.227	0.380	0.099	0.197	0.252
14 R_{I1}	0.461	0.155	0.383	0.894	0.193	0.229	0.497
14 R_{I2}	0.060	0.012	0.022	0.042	0.011	0.019	0.032
14 R_{I3}	0.942	0.341	0.829	1.974	0.419	0.492	1.075
14 M_{I1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
14 M_{I2}	5.677	2.038	5.032	11.920	2.496	2.952	6.529
14 M_{I3}	0.601	0.112	0.227	0.380	0.099	0.197	0.252
14 R_{J1}	0.461	0.155	0.383	0.894	0.193	0.229	0.497
14 R_{J2}	0.060	0.012	0.022	0.042	0.011	0.019	0.032
14 R_{J3}	0.942	0.341	0.829	1.974	0.419	0.492	1.075
14 M_{J1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
14 M_{J2}	0.922	0.352	0.773	1.899	0.440	0.526	1.034
14 M_{J3}	0.224	0.032	0.086	0.115	0.027	0.071	0.090
15 R_{I1}	0.446	0.158	0.376	0.878	0.195	0.229	0.491
15 R_{I2}	0.174	0.024	0.058	0.062	0.019	0.051	0.054
15 R_{I3}	0.969	0.314	0.839	1.885	0.384	0.454	1.096
15 M_{I1}	0.147	0.050	0.138	0.326	0.060	0.072	0.178
15 M_{I2}	0.922	0.352	0.773	1.899	0.440	0.526	1.034
15 M_{I3}	0.224	0.032	0.086	0.115	0.027	0.071	0.090
15 R_{J1}	0.969	0.314	0.839	1.885	0.384	0.454	1.096
15 R_{J2}	0.446	0.158	0.376	0.878	0.195	0.229	0.491
15 R_{J3}	0.174	0.024	0.058	0.062	0.019	0.051	0.054
15 M_{J1}	0.060	0.009	0.019	0.044	0.010	0.012	0.023
15 M_{J2}	0.281	0.057	0.139	0.263	0.057	0.081	0.152
15 M_{J3}	1.637	0.567	1.431	3.349	0.689	0.830	1.886

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 44: Forces and Moments in Secondary System for Problem # 4a (Time History) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
16 R_{I1}	0.999	0.324	0.850	2.103	0.396	0.439	1.113
16 R_{I2}	0.451	0.162	0.382	0.891	0.199	0.234	0.499
16 R_{I3}	0.226	0.029	0.075	0.087	0.025	0.065	0.073
16 M_{I1}	0.060	0.009	0.019	0.044	0.010	0.012	0.023
16 M_{I2}	0.281	0.057	0.139	0.263	0.057	0.081	0.152
16 M_{I3}	1.637	0.567	1.431	3.349	0.689	0.830	1.886
16 R_{J1}	0.999	0.324	0.850	2.103	0.396	0.439	1.113
16 R_{J2}	0.451	0.162	0.382	0.891	0.199	0.234	0.499
16 R_{J3}	0.226	0.029	0.075	0.087	0.025	0.065	0.073
16 M_{J1}	0.060	0.009	0.019	0.044	0.010	0.012	0.023
16 M_{J2}	1.394	0.176	0.355	0.433	0.122	0.356	0.401
16 M_{J3}	0.744	0.241	0.485	1.164	0.308	0.362	0.679
17 R_{I1}	1.115	0.435	0.870	2.562	0.460	0.464	1.222
17 R_{I2}	0.079	0.012	0.031	0.071	0.014	0.022	0.039
17 R_{I3}	0.323	0.049	0.110	0.196	0.046	0.089	0.100
17 M_{I1}	0.060	0.009	0.019	0.044	0.010	0.012	0.023
17 M_{I2}	1.394	0.176	0.355	0.433	0.122	0.356	0.401
17 M_{I3}	0.744	0.241	0.485	1.164	0.308	0.362	0.679
17 R_{J1}	1.115	0.435	0.870	2.562	0.460	0.464	1.222
17 R_{J2}	0.079	0.012	0.031	0.071	0.014	0.022	0.039
17 R_{J3}	0.323	0.049	0.110	0.196	0.046	0.089	0.100
17 M_{J1}	0.060	0.009	0.019	0.044	0.010	0.012	0.023
17 M_{J2}	1.590	0.334	0.719	1.705	0.333	0.524	0.925
17 M_{J3}	0.684	0.163	0.329	0.730	0.197	0.229	0.473
18 R_{I1}	1.274	0.561	0.890	3.082	0.664	0.576	1.343
18 R_{I2}	0.088	0.021	0.044	0.095	0.026	0.030	0.062
18 R_{I3}	0.159	0.033	0.058	0.148	0.038	0.046	0.065
18 M_{I1}	0.060	0.009	0.019	0.044	0.010	0.012	0.023
18 M_{I2}	1.590	0.334	0.719	1.705	0.333	0.524	0.925
18 M_{I3}	0.684	0.163	0.329	0.730	0.197	0.229	0.473
18 R_{J1}	1.274	0.561	0.890	3.082	0.664	0.576	1.343
18 R_{J2}	0.088	0.021	0.044	0.095	0.026	0.030	0.062
18 R_{J3}	0.159	0.033	0.058	0.148	0.038	0.046	0.065
18 M_{J1}	0.060	0.009	0.019	0.044	0.010	0.012	0.023
18 M_{J2}	1.095	0.475	0.785	2.639	0.553	0.490	1.168
18 M_{J3}	0.098	0.020	0.043	0.104	0.024	0.028	0.061

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 45: Forces and Moments in Secondary System for Problem # 4a (Time History) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
19 R_{I1}	1.408	0.637	0.967	3.395	0.787	0.644	1.416
19 R_{I2}	0.123	0.028	0.058	0.136	0.034	0.039	0.084
19 R_{I3}	0.221	0.033	0.065	0.135	0.039	0.061	0.059
19 M_{I1}	0.060	0.009	0.019	0.044	0.010	0.012	0.023
19 M_{I2}	1.095	0.475	0.785	2.639	0.553	0.490	1.168
19 M_{I3}	0.098	0.020	0.043	0.104	0.024	0.028	0.061
19 R_{J1}	0.221	0.033	0.065	0.135	0.039	0.061	0.059
19 R_{J2}	0.123	0.028	0.058	0.136	0.034	0.039	0.084
19 R_{J3}	1.408	0.637	0.967	3.395	0.787	0.644	1.416
19 M_{J1}	0.088	0.022	0.045	0.101	0.027	0.032	0.065
19 M_{J2}	1.287	0.459	0.682	2.272	0.581	0.458	0.893
19 M_{J3}	0.184	0.043	0.086	0.211	0.053	0.063	0.125
20 R_{I1}	0.226	0.033	0.066	0.134	0.039	0.062	0.060
20 R_{I2}	0.064	0.013	0.030	0.078	0.014	0.017	0.040
20 R_{I3}	0.452	0.127	0.197	0.530	0.193	0.127	0.197
20 M_{I1}	0.088	0.022	0.045	0.101	0.027	0.032	0.065
20 M_{I2}	1.287	0.459	0.682	2.272	0.581	0.458	0.893
20 M_{I3}	0.184	0.043	0.086	0.211	0.053	0.063	0.125
20 R_{J1}	0.226	0.033	0.066	0.134	0.039	0.062	0.060
20 R_{J2}	0.064	0.013	0.030	0.078	0.014	0.017	0.040
20 R_{J3}	0.452	0.127	0.197	0.530	0.193	0.127	0.197
20 M_{J1}	0.088	0.022	0.045	0.101	0.027	0.032	0.065
20 M_{J2}	1.172	0.291	0.497	1.546	0.433	0.462	0.700
20 M_{J3}	0.186	0.034	0.070	0.241	0.027	0.047	0.102
21 R_{I1}	0.231	0.033	0.067	0.133	0.039	0.063	0.060
21 R_{I2}	0.016	0.003	0.007	0.017	0.004	0.005	0.010
21 R_{I3}	0.123	0.039	0.056	0.183	0.048	0.041	0.070
21 M_{I1}	0.088	0.022	0.045	0.101	0.027	0.032	0.065
21 M_{I2}	1.172	0.291	0.497	1.546	0.433	0.462	0.700
21 M_{I3}	0.186	0.034	0.070	0.241	0.027	0.047	0.102
21 R_{J1}	0.231	0.033	0.067	0.133	0.039	0.063	0.060
21 R_{J2}	0.016	0.003	0.007	0.017	0.004	0.005	0.010
21 R_{J3}	0.123	0.039	0.056	0.183	0.048	0.041	0.070
21 M_{J1}	0.088	0.022	0.045	0.101	0.027	0.032	0.065
21 M_{J2}	1.729	0.411	0.615	1.642	0.645	0.547	0.691
21 M_{J3}	0.249	0.047	0.102	0.306	0.040	0.057	0.126

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 46: Forces and Moments in Secondary System for Problem # 4a (Time History) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
22 R_{I1}	0.235	0.033	0.068	0.132	0.039	0.063	0.060
22 R_{I2}	0.044	0.008	0.016	0.054	0.006	0.010	0.022
22 R_{I3}	0.304	0.065	0.106	0.290	0.102	0.095	0.123
22 M_{I1}	0.088	0.022	0.045	0.101	0.027	0.032	0.065
22 M_{I2}	1.729	0.411	0.615	1.642	0.645	0.547	0.691
22 M_{I3}	0.249	0.047	0.102	0.306	0.040	0.057	0.126
22 R_{J1}	0.235	0.033	0.068	0.132	0.039	0.063	0.060
22 R_{J2}	0.044	0.008	0.016	0.054	0.006	0.010	0.022
22 R_{J3}	0.304	0.065	0.106	0.290	0.102	0.095	0.123
22 M_{J1}	0.088	0.022	0.045	0.101	0.027	0.032	0.065
22 M_{J2}	0.217	0.095	0.151	0.446	0.139	0.089	0.145
22 M_{J3}	0.035	0.009	0.020	0.051	0.011	0.013	0.027
23 R_{I1}	0.237	0.033	0.069	0.130	0.038	0.063	0.061
23 R_{I2}	0.085	0.017	0.039	0.109	0.015	0.020	0.047
23 R_{I3}	0.590	0.157	0.233	0.606	0.247	0.202	0.253
23 M_{I1}	0.088	0.022	0.045	0.101	0.027	0.032	0.065
23 M_{I2}	0.217	0.095	0.151	0.446	0.139	0.089	0.145
23 M_{I3}	0.035	0.009	0.020	0.051	0.011	0.013	0.027
23 R_{J1}	0.237	0.033	0.069	0.130	0.038	0.063	0.061
23 R_{J2}	0.085	0.017	0.039	0.109	0.015	0.020	0.047
23 R_{J3}	0.590	0.157	0.233	0.606	0.247	0.202	0.253
23 M_{J1}	0.088	0.022	0.045	0.101	0.027	0.032	0.065
23 M_{J2}	2.739	0.699	1.044	2.828	1.096	0.938	1.169
23 M_{J3}	0.399	0.078	0.173	0.508	0.066	0.093	0.210

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 47: Nodal Displacements for Problem # 4b (Time History)

Nodes	Load cases						
	a	b	c	d	e	f	g
2 u_x	3.957	2.285	3.386	9.861	3.245	2.276	3.230
2 u_y	0.002	0.000	0.001	0.002	0.000	0.000	0.001
2 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2 θ_x	0.001	0.000	0.001	0.001	0.000	0.001	0.001
2 θ_y	10.950	6.522	9.522	27.910	8.820	6.539	8.779
2 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 u_x	9.871	5.766	8.485	24.770	8.011	5.761	7.981
3 u_y	0.003	0.001	0.001	0.003	0.000	0.001	0.001
3 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 θ_x	0.001	0.001	0.001	0.002	0.001	0.001	0.001
3 θ_y	19.090	11.430	16.640	48.840	15.330	11.470	15.260
3 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4 u_x	15.800	9.307	13.640	39.890	12.770	9.315	12.720
4 u_y	0.003	0.001	0.001	0.004	0.000	0.001	0.002
4 u_z	0.000	0.000	0.000	0.001	0.000	0.000	0.000
4 θ_x	0.003	0.001	0.002	0.003	0.001	0.001	0.002
4 θ_y	23.910	14.360	20.880	61.350	19.160	14.530	19.060
4 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5 u_x	23.070	13.690	20.010	58.600	18.590	13.720	18.510
5 u_y	0.002	0.001	0.002	0.003	0.001	0.001	0.002
5 u_z	0.000	0.000	0.000	0.001	0.000	0.000	0.000
5 θ_x	0.004	0.001	0.002	0.005	0.001	0.002	0.002
5 θ_y	27.430	16.520	24.000	70.560	21.950	16.830	21.820
5 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6 u_x	30.500	18.210	26.560	77.880	24.550	18.270	24.430
6 u_y	0.001	0.001	0.002	0.002	0.001	0.001	0.001
6 u_z	0.000	0.000	0.000	0.001	0.000	0.000	0.000
6 θ_x	0.005	0.001	0.003	0.007	0.001	0.002	0.003
6 θ_y	29.230	17.640	25.610	75.330	23.370	18.040	23.230
6 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7 u_x	35.130	21.020	30.650	89.910	28.260	21.100	28.120
7 u_y	0.002	0.001	0.002	0.003	0.001	0.002	0.002
7 u_z	0.000	0.000	0.000	0.001	0.000	0.000	0.001
7 θ_x	0.006	0.001	0.003	0.007	0.001	0.002	0.003
7 θ_y	29.680	17.920	26.010	76.530	23.730	18.340	23.580
7 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad*.

Table 48: Nodal Displacements for Problem # 4b (Time History) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
8 u_x	39.490	23.670	34.480	101.200	31.740	23.770	31.580
8 u_y	0.004	0.002	0.003	0.004	0.001	0.002	0.002
8 u_z	0.000	0.000	0.000	0.001	0.000	0.000	0.001
8 θ_x	0.006	0.001	0.003	0.007	0.001	0.002	0.003
8 θ_y	29.800	17.990	26.110	76.830	23.820	18.420	23.670
8 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9 u_x	39.490	23.670	34.480	101.200	31.740	23.770	31.580
9 u_y	0.004	0.002	0.003	0.004	0.001	0.002	0.002
9 u_z	7.152	4.318	6.267	18.440	5.716	4.422	5.680
9 θ_x	0.006	0.001	0.003	0.007	0.001	0.002	0.003
9 θ_y	29.800	17.990	26.110	76.830	23.820	18.420	23.670
9 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10 u_x	39.600	23.730	34.640	101.500	31.850	23.880	31.670
10 u_y	0.588	0.361	0.583	0.944	0.229	0.259	0.401
10 u_z	4.694	3.237	4.491	11.610	3.416	3.161	3.858
10 θ_x	5.887	4.193	6.436	10.710	3.091	5.074	4.708
10 θ_y	45.480	33.090	58.240	102.100	32.180	40.960	36.040
10 θ_z	9.677	6.264	10.200	15.880	4.027	4.410	6.552
11 u_x	39.690	23.780	34.770	101.700	31.920	23.970	31.730
11 u_y	1.028	0.683	1.116	1.707	0.441	0.477	0.695
11 u_z	3.961	3.321	5.518	7.478	2.420	2.311	2.861
11 θ_x	11.780	8.386	12.870	21.420	6.182	10.150	9.415
11 θ_y	33.360	19.420	25.080	73.880	24.150	18.420	24.500
11 θ_z	2.222	0.679	1.017	3.513	0.433	0.814	1.698
12 u_x	39.740	23.800	34.870	101.900	31.980	24.050	31.780
12 u_y	0.004	0.002	0.003	0.004	0.001	0.002	0.002
12 u_z	0.001	0.000	0.001	0.001	0.000	0.000	0.001
12 θ_x	17.660	12.580	19.310	32.130	9.273	15.220	14.120
12 θ_y	96.100	85.950	135.800	194.100	54.120	63.000	72.970
12 θ_z	24.470	18.300	30.230	43.050	12.050	12.630	16.400
13 u_x	40.110	23.660	37.900	102.100	32.570	26.030	31.920
13 u_y	0.706	0.638	1.097	1.250	0.428	0.464	0.470
13 u_z	4.715	4.379	6.630	9.536	2.665	3.487	3.589
13 θ_x	16.940	13.470	21.980	28.540	8.899	12.990	15.720
13 θ_y	311.600	289.200	441.700	627.400	177.300	227.900	232.700
13 θ_z	66.060	57.090	93.850	125.300	37.910	41.020	44.100

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad*.

Table 49: Nodal Displacements for Problem # 4b (Time History) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
14 u_x	41.290	32.100	57.080	98.110	35.070	40.280	34.930
14 u_y	1.693	1.479	2.467	3.046	0.984	1.281	1.512
14 u_z	4.743	4.404	6.666	9.591	2.680	3.508	3.619
14 θ_x	7.142	6.103	10.470	10.730	4.632	7.820	6.554
14 θ_y	200.000	182.700	291.500	407.900	116.400	128.400	143.500
14 θ_z	99.080	87.120	141.200	188.100	57.280	64.010	65.850
15 u_x	41.350	32.490	55.190	84.140	31.110	38.830	33.000
15 u_y	1.523	1.367	2.271	2.648	0.928	1.267	1.341
15 u_z	4.766	4.425	6.695	9.635	2.692	3.525	3.645
15 θ_x	11.190	8.902	14.730	19.870	5.770	7.435	10.070
15 θ_y	171.600	140.900	210.600	302.600	90.700	145.900	120.000
15 θ_z	132.900	117.200	188.700	251.000	76.670	87.070	87.810
16 u_x	30.500	18.210	26.560	77.880	24.550	18.270	24.430
16 u_y	0.001	0.001	0.002	0.002	0.001	0.001	0.001
16 u_z	4.784	4.440	6.717	9.669	2.701	3.538	3.666
16 θ_x	27.550	23.120	38.160	40.240	16.250	23.560	21.360
16 θ_y	593.500	546.700	859.400	1176.000	342.500	405.500	430.800
16 θ_z	166.800	147.200	236.100	313.900	96.060	110.200	109.900
17 u_x	69.840	64.410	101.300	152.100	46.080	44.450	50.710
17 u_y	2.680	2.202	3.579	3.806	1.583	2.373	2.027
17 u_z	4.797	4.452	6.733	9.692	2.708	3.547	3.683
17 θ_x	29.100	25.250	40.420	41.210	18.190	27.250	23.330
17 θ_y	749.400	680.300	1076.000	1496.000	429.300	459.300	517.500
17 θ_z	200.700	177.300	283.600	376.800	115.400	133.200	132.000
18 u_x	118.100	108.200	170.500	247.000	72.110	69.560	83.710
18 u_y	4.263	3.756	6.012	5.986	2.710	4.012	3.435
18 u_z	4.805	4.459	6.743	9.706	2.712	3.553	3.696
18 θ_x	18.530	9.790	16.750	23.990	6.927	10.610	12.650
18 θ_y	317.000	288.100	449.400	613.800	179.600	194.000	221.800
18 θ_z	234.500	207.400	331.000	439.700	134.800	156.300	154.200
19 u_x	117.100	107.200	168.400	242.600	70.930	68.660	82.970
19 u_y	4.309	3.615	5.810	6.068	2.598	3.817	3.290
19 u_z	4.808	4.461	6.746	9.710	2.713	3.555	3.704
19 θ_x	17.260	12.620	20.350	24.020	9.078	14.330	12.340
19 θ_y	339.900	309.800	495.300	708.100	204.500	208.400	237.800
19 θ_z	268.400	237.400	378.500	502.600	154.200	179.400	176.500

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad*.

Table 50: Nodal Displacements for Problem # 4b (Time History) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
20 u_x	67.000	61.610	96.150	140.800	41.470	40.520	48.090
20 u_y	2.507	1.927	3.161	3.386	1.366	2.016	1.779
20 u_z	4.806	4.459	6.743	9.703	2.712	3.553	3.707
20 θ_x	31.380	24.660	39.930	44.530	17.810	26.370	23.070
20 θ_y	764.000	696.500	1098.000	1542.000	447.900	458.500	534.500
20 θ_z	302.300	267.500	426.000	565.500	173.600	202.500	198.800
21 u_x	15.800	9.307	13.640	39.890	12.770	9.315	12.720
21 u_y	0.003	0.001	0.001	0.004	0.000	0.001	0.002
21 u_z	4.799	4.452	6.733	9.687	2.708	3.547	3.706
21 θ_x	24.030	16.590	27.250	31.590	11.860	16.350	17.350
21 θ_y	598.400	542.400	841.900	1175.000	340.800	349.000	413.000
21 θ_z	336.100	297.600	473.400	628.400	193.000	225.600	221.000
22 u_x	29.000	26.030	41.290	54.630	16.970	23.360	21.560
22 u_y	1.610	0.641	1.081	1.836	0.477	0.629	1.051
22 u_z	4.788	4.441	6.717	9.661	2.702	3.537	3.700
22 θ_x	10.850	5.074	8.580	16.660	3.556	5.905	7.551
22 θ_y	158.600	140.800	218.500	303.500	89.080	97.260	106.500
22 θ_z	370.000	327.600	520.900	691.300	212.400	248.700	243.300
23 u_x	31.070	27.210	44.300	58.400	18.350	24.620	22.060
23 u_y	1.776	1.038	1.556	3.038	0.630	0.882	1.228
23 u_z	4.771	4.425	6.695	9.625	2.693	3.524	3.689
23 θ_x	25.060	22.000	37.210	44.860	15.260	14.630	17.210
23 θ_y	63.830	53.250	87.760	140.200	35.150	45.220	47.530
23 θ_z	403.900	357.700	568.400	754.300	231.800	271.900	265.600
24 u_x	22.360	19.320	31.740	41.530	13.250	18.580	16.770
24 u_y	2.552	1.859	2.841	4.985	1.102	1.358	1.705
24 u_z	3.951	3.666	5.496	8.037	2.208	2.965	3.088
24 θ_x	70.550	64.370	95.210	139.300	38.330	52.950	53.400
24 θ_y	81.650	73.490	115.600	170.100	45.670	59.400	60.450
24 θ_z	418.400	370.500	590.100	785.100	240.800	284.300	275.800
25 u_x	9.871	5.766	8.485	24.770	8.011	5.761	7.981
25 u_y	2.535	1.856	2.837	4.964	1.100	1.353	1.699
25 u_z	0.344	0.206	0.299	0.879	0.276	0.206	0.275
25 θ_x	52.310	47.830	70.060	104.900	28.160	40.140	40.760
25 θ_y	70.190	64.080	99.470	144.100	39.420	52.940	52.360
25 θ_z	273.400	244.400	385.000	536.000	155.600	185.500	187.900

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad*.

Table 51: Nodal Displacements for Problem # 4b (Time History) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
26 u_x	13.150	11.750	17.400	29.240	9.799	10.320	10.420
26 u_y	2.492	1.848	2.825	4.908	1.097	1.344	1.682
26 u_z	2.340	1.933	2.798	4.235	1.104	1.748	1.736
26 θ_x	4.861	4.018	5.836	9.285	2.274	3.524	3.353
26 θ_y	52.310	48.430	72.690	102.300	29.010	42.180	40.620
26 θ_z	40.990	35.800	58.530	74.320	24.310	28.030	26.420
27 u_x	10.310	6.341	7.942	25.430	8.199	6.371	8.241
27 u_y	2.443	1.840	2.811	4.846	1.094	1.336	1.664
27 u_z	0.884	0.730	1.083	1.519	0.476	0.745	0.671
27 θ_x	26.510	20.930	30.800	47.190	12.320	17.690	20.020
27 θ_y	40.830	35.990	54.130	74.790	20.730	33.590	32.450
27 θ_z	144.600	113.100	173.600	284.000	68.010	82.540	96.940
28 u_x	9.977	5.844	8.483	24.990	8.096	5.756	8.071
28 u_y	0.003	0.001	0.001	0.003	0.000	0.001	0.001
28 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28 θ_x	14.230	9.504	13.540	23.060	6.015	9.746	9.736
28 θ_y	23.400	16.800	30.040	48.840	17.960	21.130	20.900
28 θ_z	67.270	40.280	60.040	97.020	23.970	30.410	44.760
29 u_x	9.962	5.829	8.492	24.960	8.084	5.762	8.059
29 u_y	3.344	1.420	2.171	4.135	0.835	1.111	2.106
29 u_z	1.318	0.898	1.516	3.081	1.055	1.064	1.202
29 θ_x	10.670	7.128	10.160	17.290	4.512	7.309	7.302
29 θ_y	21.210	12.920	20.750	52.170	16.810	14.670	18.350
29 θ_z	35.860	9.627	15.300	41.990	5.382	8.994	21.430
30 u_x	9.939	5.812	8.495	24.910	8.066	5.765	8.039
30 u_y	3.930	1.336	2.081	4.680	0.771	1.069	2.406
30 u_z	2.508	1.552	2.517	6.138	2.000	1.761	2.162
30 θ_x	7.113	4.752	6.771	11.530	3.008	4.873	4.868
30 θ_y	18.530	11.860	14.620	49.020	14.730	11.400	15.220
30 θ_z	16.730	9.557	14.270	23.360	5.680	7.265	11.050
31 u_x	9.909	5.790	8.493	24.850	8.042	5.764	8.013
31 u_y	1.811	0.533	0.842	2.140	0.303	0.464	1.092
31 u_z	3.544	2.091	3.215	8.952	2.836	2.232	2.892
31 θ_x	3.556	2.376	3.385	5.764	1.504	2.436	2.434
31 θ_y	16.810	11.230	15.420	45.610	13.640	10.840	15.490
31 θ_z	42.210	13.610	21.290	50.090	7.808	11.110	25.690

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad*.

Table 52: Nodal Displacements for Problem # 4b (Time History) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
32 u_x	9.871	5.766	8.485	24.770	8.011	5.761	7.981
32 u_y	0.003	0.001	0.001	0.003	0.000	0.001	0.001
32 u_z	4.583	2.742	3.994	11.720	3.679	2.754	3.661
32 θ_x	0.001	0.001	0.001	0.002	0.001	0.001	0.001
32 θ_y	19.090	11.430	16.640	48.840	15.330	11.470	15.260
32 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad*.

Table 53: Forces and Moments in Primary System for Problem # 4b (Time History)

Elements	Load cases			
	a	b	c	d
1 R_{I1}	4.928	2.791	3.948	10.040
1 R_{I2}	43560.000	25030.000	36870.000	107500.000
1 R_{I3}	18.340	2.895	5.864	21.880
1 M_{I1}	0.000	0.000	0.000	0.000
1 M_{I2}	2824.000	1384.000	2368.000	3470.000
1 M_{I3}	33400000.000	20000000.000	29100000.000	85420000.000
1 R_{J1}	4.928	2.791	3.948	10.040
1 R_{J2}	43560.000	25030.000	36870.000	107500.000
1 R_{J3}	18.340	2.895	5.864	21.880
1 M_{J1}	0.000	0.000	0.000	0.000
1 M_{J2}	5972.000	1318.000	2352.000	7127.000
1 M_{J3}	23930000.000	14460000.000	20940000.000	61680000.000
2 R_{I1}	3.105	1.453	2.214	6.065
2 R_{I2}	19760.000	11420.000	16690.000	48780.000
2 R_{I3}	6.657	1.245	2.382	7.983
2 M_{I1}	0.000	0.000	0.000	0.000
2 M_{I2}	4820.000	1059.000	1892.000	5734.000
2 M_{I3}	19140000.000	11570000.000	16740000.000	49320000.000
2 R_{J1}	3.105	1.453	2.214	6.065
2 R_{J2}	19760.000	11420.000	16690.000	48780.000
2 R_{J3}	6.657	1.245	2.382	7.983
2 M_{J1}	0.000	0.000	0.000	0.000
2 M_{J2}	5881.000	1024.000	2111.000	7112.000
2 M_{J3}	14930000.000	9055000.000	13070000.000	38620000.000
3 R_{I1}	3.665	1.868	2.897	7.188
3 R_{I2}	50810.000	30550.000	44280.000	130300.000
3 R_{I3}	9.427	2.476	4.220	10.450
3 M_{I1}	0.000	0.000	0.000	0.000
3 M_{I2}	7737.000	1348.000	2780.000	9355.000
3 M_{I3}	19620000.000	11900000.000	17170000.000	50740000.000
3 R_{J1}	3.665	1.868	2.897	7.188
3 R_{J2}	50810.000	30550.000	44280.000	130300.000
3 R_{J3}	9.427	2.476	4.220	10.450
3 M_{J1}	0.000	0.000	0.000	0.000
3 M_{J2}	6185.000	939.200	2105.000	7484.000
3 M_{J3}	10310000.000	6224000.000	8948000.000	26550000.000

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 54: Forces and Moments in Primary System for Problem # 4b (Time History) (contd.)

Elements	Load cases			
	a	b	c	d
4 R_{I1}	2.720	1.561	2.460	5.493
4 R_{I2}	27320.000	16560.000	23860.000	70620.000
4 R_{I3}	12.490	2.034	4.403	15.170
4 M_{I1}	0.000	0.000	0.000	0.000
4 M_{I2}	5550.000	853.700	1899.000	6711.000
4 M_{I3}	9727000.000	5882000.000	8463000.000	25100000.000
4 R_{J1}	2.720	1.561	2.460	5.493
4 R_{J2}	27320.000	16560.000	23860.000	70620.000
4 R_{J3}	12.490	2.034	4.403	15.170
4 M_{J1}	0.000	0.000	0.000	0.000
4 M_{J2}	2934.000	431.600	978.000	3537.000
4 M_{J3}	4034000.000	2423000.000	3478000.000	10340000.000
5 R_{I1}	1.434	0.934	1.494	2.885
5 R_{I2}	27450.000	16290.000	23760.000	69630.000
5 R_{I3}	2.646	1.120	1.910	3.333
5 M_{I1}	0.000	0.000	0.000	0.000
5 M_{I2}	1406.000	205.700	449.800	1705.000
5 M_{I3}	1296000.000	675800.000	1013000.000	2987000.000
5 R_{J1}	1.434	0.934	1.494	2.885
5 R_{J2}	27450.000	16290.000	23760.000	69630.000
5 R_{J3}	2.646	1.120	1.910	3.333
5 M_{J1}	0.000	0.000	0.000	0.000
5 M_{J2}	1249.000	258.400	474.700	1483.000
5 M_{J3}	4560000.000	2763000.000	4005000.000	11800000.000
6 R_{I1}	2.128	1.342	2.168	3.974
6 R_{I2}	10330.000	6161.000	8829.000	26310.000
6 R_{I3}	8.743	1.282	2.877	10.470
6 M_{I1}	0.000	0.000	0.000	0.000
6 M_{I2}	1181.000	173.200	388.700	1415.000
6 M_{I3}	1398000.000	833800.000	1195000.000	3561000.000
6 R_{J1}	2.128	1.342	2.168	3.974
6 R_{J2}	10330.000	6161.000	8829.000	26310.000
6 R_{J3}	8.743	1.282	2.877	10.470
6 M_{J1}	0.000	0.000	0.000	0.000
6 M_{J2}	0.138	0.025	0.050	0.165
6 M_{J3}	545.200	331.000	478.400	1413.000

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 55: Forces and Moments in Primary System for Problem # 4b (Time History) (contd.)

Elements	Load cases			
	a	b	c	d
7 R_{I1}	0.000	0.000	0.000	0.000
7 R_{I2}	112600.000	67970.000	98650.000	290300.000
7 R_{I3}	22.410	5.649	9.958	26.680
7 M_{I1}	0.000	0.000	0.000	0.000
7 M_{I2}	1513.000	381.300	672.100	1801.000
7 M_{I3}	7599000.000	4588000.000	6659000.000	19590000.000
7 R_{J1}	0.000	0.000	0.000	0.000
7 R_{J2}	112600.000	67970.000	98650.000	290300.000
7 R_{J3}	22.410	5.649	9.958	26.680
7 M_{J1}	0.000	0.000	0.000	0.000
7 M_{J2}	1513.000	381.300	672.100	1801.000
7 M_{J3}	7599000.000	4588000.000	6659000.000	19590000.000

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 56: Forces and Moments in Primary System for Problem # 4b (Time History) (contd.)

Elements	Load cases		
	e	f	g
1 R_{I1}	1.590	3.222	5.349
1 R_{I2}	35030.000	25070.000	34990.000
1 R_{I3}	1.555	3.211	9.680
1 M_{I1}	0.000	0.000	0.000
1 M_{I2}	1015.000	1600.000	1830.000
1 M_{I3}	26750000.000	20160000.000	26630000.000
1 R_{J1}	1.590	3.222	5.349
1 R_{J2}	35030.000	25070.000	34990.000
1 R_{J3}	1.555	3.211	9.680
1 M_{J1}	0.000	0.000	0.000
1 M_{J2}	854.000	1533.000	3329.000
1 M_{J3}	18990000.000	14980000.000	18880000.000
2 R_{I1}	0.878	1.785	3.544
2 R_{I2}	15630.000	11500.000	15650.000
2 R_{I3}	0.687	1.286	3.732
2 M_{I1}	0.000	0.000	0.000
2 M_{I2}	685.500	1231.000	2679.000
2 M_{I3}	15180000.000	11990000.000	15090000.000
2 R_{J1}	0.878	1.785	3.544
2 R_{J2}	15630.000	11500.000	15650.000
2 R_{J3}	0.687	1.286	3.732
2 M_{J1}	0.000	0.000	0.000
2 M_{J2}	631.400	1161.000	3259.000
2 M_{J3}	11750000.000	9552000.000	11650000.000
3 R_{I1}	1.124	2.240	4.009
3 R_{I2}	40370.000	31370.000	40200.000
3 R_{I3}	1.639	2.884	5.023
3 M_{I1}	0.000	0.000	0.000
3 M_{I2}	830.900	1528.000	4287.000
3 M_{I3}	15430000.000	12550000.000	15300000.000
3 R_{J1}	1.124	2.240	4.009
3 R_{J2}	40370.000	31370.000	40200.000
3 R_{J3}	1.639	2.884	5.023
3 M_{J1}	0.000	0.000	0.000
3 M_{J2}	527.600	1129.000	3394.000
3 M_{J3}	7932000.000	6728000.000	7839000.000

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 57: Forces and Moments in Primary System for Problem # 4b (Time History) (contd.)

Elements	Load cases		
	e	f	g
4 R_{I1}	0.930	1.805	2.762
4 R_{I2}	21340.000	17630.000	21150.000
4 R_{I3}	1.191	2.369	6.948
4 M_{I1}	0.000	0.000	0.000
4 M_{I2}	485.300	1018.000	3047.000
4 M_{I3}	7520000.000	6330000.000	7434000.000
4 R_{J1}	0.930	1.805	2.762
4 R_{J2}	21340.000	17630.000	21150.000
4 R_{J3}	1.191	2.369	6.948
4 M_{J1}	0.000	0.000	0.000
4 M_{J2}	236.400	522.300	1593.000
4 M_{J3}	3061000.000	2646000.000	3016000.000
5 R_{I1}	0.556	1.030	1.454
5 R_{I2}	21990.000	16370.000	21920.000
5 R_{I3}	0.780	1.286	1.620
5 M_{I1}	0.000	0.000	0.000
5 M_{I2}	85.120	255.600	767.100
5 M_{I3}	1007000.000	693000.000	1018000.000
5 R_{J1}	0.556	1.030	1.454
5 R_{J2}	21990.000	16370.000	21920.000
5 R_{J3}	0.780	1.286	1.620
5 M_{J1}	0.000	0.000	0.000
5 M_{J2}	169.000	302.800	689.200
5 M_{J3}	3636000.000	2853000.000	3609000.000
6 R_{I1}	0.819	1.392	1.907
6 R_{I2}	7712.000	6806.000	7581.000
6 R_{I3}	0.670	1.531	4.720
6 M_{I1}	0.000	0.000	0.000
6 M_{I2}	90.610	206.800	637.700
6 M_{I3}	1044000.000	920900.000	1026000.000
6 R_{J1}	0.819	1.392	1.907
6 R_{J2}	7712.000	6806.000	7581.000
6 R_{J3}	0.670	1.531	4.720
6 M_{J1}	0.000	0.000	0.000
6 M_{J2}	0.015	0.028	0.076
6 M_{J3}	430.400	347.600	426.400

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 58: Forces and Moments in Primary System for Problem # 4b (Time History) (contd.)

Elements	Load cases		
	e	f	g
7 R_{I1}	0.000	0.000	0.000
7 R_{I2}	89980.000	69600.000	89410.000
7 R_{I3}	3.742	6.621	12.570
7 M_{I1}	0.000	0.000	0.000
7 M_{I2}	252.600	446.900	848.400
7 M_{I3}	6073000.000	4698000.000	6035000.000
7 R_{J1}	0.000	0.000	0.000
7 R_{J2}	89980.000	69600.000	89410.000
7 R_{J3}	3.742	6.621	12.570
7 M_{J1}	0.000	0.000	0.000
7 M_{J2}	252.600	446.900	848.400
7 M_{J3}	6073000.000	4698000.000	6035000.000

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 59: Forces and Moments in Support Elements for Problem # 4b (Time History)

Elements	Loadcases						
	a	b	c	d	e	f	g
$1R_{I1}$	6.166	4.890	8.273	15.800	5.330	6.259	5.162
$1R_{I2}$	1.237	0.837	1.275	2.165	0.494	0.656	0.886
$1R_{I3}$	2.224	1.657	2.832	5.378	1.758	2.151	1.816
$1M_{I1}$	2.045	1.427	2.257	3.651	0.900	1.121	1.401
$1M_{I2}$	1.966	1.158	1.867	3.104	0.730	0.849	1.344
$1M_{I3}$	7.027	5.158	7.715	12.740	3.013	4.139	4.859
$1R_{J1}$	6.166	4.890	8.273	15.800	5.330	6.259	5.162
$1R_{J2}$	1.237	0.837	1.275	2.165	0.494	0.656	0.886
$1R_{J3}$	2.224	1.657	2.832	5.378	1.758	2.151	1.816
$1M_{J1}$	2.045	1.427	2.257	3.651	0.900	1.121	1.401
$1M_{J2}$	45.510	34.440	58.680	111.900	36.810	44.550	37.460
$1M_{J3}$	18.990	12.440	19.090	32.800	7.377	9.666	13.780
$2R_{I1}$	2.801	2.630	3.707	6.944	2.295	1.987	2.303
$2R_{I2}$	0.396	0.143	0.211	0.537	0.091	0.182	0.263
$2R_{I3}$	3.912	1.731	2.541	5.312	1.704	1.530	2.101
$2M_{I1}$	1.452	0.722	1.015	1.934	0.430	0.802	0.994
$2M_{I2}$	9.678	2.677	4.253	11.390	1.507	2.434	5.798
$2M_{I3}$	1.534	0.544	0.821	1.955	0.347	0.658	0.972
$2R_{J1}$	2.801	2.630	3.707	6.944	2.295	1.987	2.303
$2R_{J2}$	0.396	0.143	0.211	0.537	0.091	0.182	0.263
$2R_{J3}$	3.912	1.731	2.541	5.312	1.704	1.530	2.101
$2M_{J1}$	1.452	0.722	1.015	1.934	0.430	0.802	0.994
$2M_{J2}$	95.130	47.050	68.620	140.100	44.600	40.380	53.050
$2M_{J3}$	8.745	3.173	4.739	11.990	2.070	4.079	5.865
$3R_{I1}$	0.374	0.239	0.410	0.549	0.166	0.194	0.237
$3R_{I2}$	2.956	2.078	3.159	5.094	1.249	1.946	2.283
$3R_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3R_{J1}$	0.374	0.239	0.410	0.549	0.166	0.194	0.237
$3R_{J2}$	2.956	2.078	3.159	5.094	1.249	1.946	2.283
$3R_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{J3}$	19.210	13.510	20.530	33.110	8.118	12.650	14.840
$4R_{I1}$	2.408	2.336	3.336	5.771	1.759	1.768	2.082
$4R_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4R_{I3}$	10.010	9.228	14.300	22.240	6.790	7.156	7.690
$4M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000

R = Force (Kips) M = Moment (Kips-ft)

Table 60: Forces and Moments in Support Elements for Problem # 4b (Time History)

Elements	Loadcases						
	a	b	c	d	e	f	g
$4R_{J1}$	2.408	2.336	3.336	5.771	1.759	1.768	2.082
$4R_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4R_{J3}$	10.010	9.228	14.300	22.240	6.790	7.156	7.690
$4M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4M_{J2}$	66.810	61.560	95.370	148.400	45.290	47.730	51.300
$4M_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5R_{I1}$	3.133	2.462	3.631	6.648	1.845	1.828	2.201
$5R_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5R_{I3}$	10.760	9.862	15.870	22.280	6.831	6.453	7.889
$5M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5R_{J1}$	3.133	2.462	3.631	6.648	1.845	1.828	2.201
$5R_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5R_{J3}$	10.760	9.862	15.870	22.280	6.831	6.453	7.889
$5M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5M_{J2}$	71.770	65.790	105.900	148.600	45.570	43.050	52.630
$5M_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6R_{I1}$	8.185	5.901	9.699	13.500	4.244	4.861	4.738
$6R_{I2}$	1.611	1.323	1.861	3.062	0.746	1.156	1.137
$6R_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6R_{J1}$	8.185	5.901	9.699	13.500	4.244	4.861	4.738
$6R_{J2}$	1.611	1.323	1.861	3.062	0.746	1.156	1.137
$6R_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{J3}$	2.417	1.984	2.791	4.593	1.119	1.734	1.705
$7R_{I1}$	4.504	0.907	1.793	5.607	0.479	0.942	2.453
$7R_{I2}$	0.761	0.448	0.704	1.193	0.275	0.343	0.506
$7R_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7R_{J1}$	4.504	0.907	1.793	5.607	0.479	0.942	2.453
$7R_{J2}$	0.761	0.448	0.704	1.193	0.275	0.343	0.506
$7R_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{J3}$	12.560	7.383	11.620	19.680	4.534	5.652	8.350

R = Force (Kips)   M = Moment (Kips-ft)

Table 61: Forces and Moments in Secondary System for Problem # 4b (Time History)

Elements	Load cases						
	a	b	c	d	e	f	g
1 R_{I1}	6.549	5.163	8.742	16.680	5.612	6.616	5.468
1 R_{I2}	1.237	0.837	1.275	2.165	0.494	0.656	0.886
1 R_{I3}	0.337	0.184	0.293	0.516	0.114	0.144	0.232
1 M_{I1}	0.395	0.281	0.432	0.719	0.208	0.341	0.316
1 M_{I2}	1.966	1.158	1.867	3.104	0.730	0.849	1.344
1 M_{I3}	7.313	5.344	8.032	13.240	3.141	4.265	5.053
1 R_{J1}	6.549	5.163	8.742	16.680	5.612	6.616	5.468
1 R_{J2}	1.237	0.837	1.275	2.165	0.494	0.656	0.886
1 R_{J3}	0.337	0.184	0.293	0.516	0.114	0.144	0.232
1 M_{J1}	0.395	0.281	0.432	0.719	0.208	0.341	0.316
1 M_{J2}	0.307	0.071	0.147	0.494	0.045	0.118	0.239
1 M_{J3}	1.237	0.321	0.551	2.232	0.223	0.336	0.922
2 R_{I1}	5.672	4.172	7.271	12.280	4.301	5.512	4.288
2 R_{I2}	0.867	0.763	1.111	1.727	0.445	0.666	0.639
2 R_{I3}	0.225	0.162	0.265	0.387	0.106	0.109	0.150
2 M_{I1}	0.395	0.281	0.432	0.719	0.208	0.341	0.316
2 M_{I2}	0.307	0.071	0.147	0.494	0.045	0.118	0.239
2 M_{I3}	1.237	0.321	0.551	2.232	0.223	0.336	0.922
2 R_{J1}	5.672	4.172	7.271	12.280	4.301	5.512	4.288
2 R_{J2}	0.867	0.763	1.111	1.727	0.445	0.666	0.639
2 R_{J3}	0.225	0.162	0.265	0.387	0.106	0.109	0.150
2 M_{J1}	0.395	0.281	0.432	0.719	0.208	0.341	0.316
2 M_{J2}	1.776	1.141	1.854	2.903	0.734	0.797	1.201
2 M_{J3}	6.700	5.323	7.867	12.620	3.112	4.462	4.654
3 R_{I1}	4.811	3.494	5.810	8.003	2.987	4.409	3.443
3 R_{I2}	0.858	0.609	0.924	1.542	0.359	0.611	0.575
3 R_{I3}	0.207	0.128	0.212	0.387	0.090	0.112	0.141
3 M_{I1}	0.395	0.281	0.432	0.719	0.208	0.341	0.316
3 M_{I2}	1.776	1.141	1.854	2.903	0.734	0.797	1.201
3 M_{I3}	6.700	5.323	7.867	12.620	3.112	4.462	4.654
3 R_{J1}	4.811	3.494	5.810	8.003	2.987	4.409	3.443
3 R_{J2}	0.858	0.609	0.924	1.542	0.359	0.611	0.575
3 R_{J3}	0.207	0.128	0.212	0.387	0.090	0.112	0.141
3 M_{J1}	0.395	0.281	0.432	0.719	0.208	0.341	0.316
3 M_{J2}	2.282	1.953	3.268	4.325	1.320	1.427	1.431
3 M_{J3}	10.660	9.383	13.690	20.230	5.484	8.338	7.636

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 62: Forces and Moments in Secondary System for Problem # 4b (Time History) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
4 R_{I1}	4.255	3.402	5.081	7.350	2.264	3.670	2.991
4 R_{I2}	2.291	1.462	2.281	3.743	0.890	1.262	1.789
4 R_{I3}	0.298	0.152	0.245	0.383	0.101	0.151	0.245
4 M_{I1}	0.395	0.281	0.432	0.719	0.208	0.341	0.316
4 M_{I2}	2.282	1.953	3.268	4.325	1.320	1.427	1.431
4 M_{I3}	10.660	9.383	13.690	20.230	5.484	8.338	7.636
4 R_{J1}	2.291	1.462	2.281	3.743	0.890	1.262	1.789
4 R_{J2}	4.255	3.402	5.081	7.350	2.264	3.670	2.991
4 R_{J3}	0.298	0.152	0.245	0.383	0.101	0.151	0.245
4 M_{J1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
4 M_{J2}	0.397	0.290	0.472	0.714	0.185	0.226	0.244
4 M_{J3}	3.183	2.636	3.903	5.858	1.525	1.713	2.328
5 R_{I1}	2.136	1.301	2.059	3.409	0.796	1.096	1.647
5 R_{I2}	3.624	3.211	4.752	7.001	1.882	2.848	2.468
5 R_{I3}	0.218	0.127	0.205	0.306	0.088	0.146	0.187
5 M_{I1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
5 M_{I2}	0.397	0.290	0.472	0.714	0.185	0.226	0.244
5 M_{I3}	3.183	2.636	3.903	5.858	1.525	1.713	2.328
5 R_{J1}	2.136	1.301	2.059	3.409	0.796	1.096	1.647
5 R_{J2}	3.624	3.211	4.752	7.001	1.882	2.848	2.468
5 R_{J3}	0.218	0.127	0.205	0.306	0.088	0.146	0.187
5 M_{J1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
5 M_{J2}	1.638	1.094	1.768	2.576	0.690	0.968	1.432
5 M_{J3}	23.570	20.370	29.880	44.420	11.780	18.970	16.070
6 R_{I1}	1.892	1.063	1.722	2.906	0.656	0.873	1.448
6 R_{I2}	2.249	2.056	3.191	4.707	1.369	1.331	1.631
6 R_{I3}	0.176	0.061	0.118	0.221	0.049	0.085	0.116
6 M_{I1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
6 M_{I2}	1.638	1.094	1.768	2.576	0.690	0.968	1.432
6 M_{I3}	23.570	20.370	29.880	44.420	11.780	18.970	16.070
6 R_{J1}	1.892	1.063	1.722	2.906	0.656	0.873	1.448
6 R_{J2}	2.249	2.056	3.191	4.707	1.369	1.331	1.631
6 R_{J3}	0.176	0.061	0.118	0.221	0.049	0.085	0.116
6 M_{J1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
6 M_{J2}	1.578	1.338	2.204	2.485	0.921	1.405	1.304
6 M_{J3}	35.170	32.840	50.800	70.340	20.290	25.180	25.880

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 63: Forces and Moments in Secondary System for Problem # 4b (Time History) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
7 R_{I1}	1.631	0.827	1.383	2.403	0.530	0.669	1.270
7 R_{I2}	2.971	1.864	2.223	7.266	2.157	1.802	2.010
7 R_{I3}	0.198	0.058	0.133	0.387	0.046	0.066	0.183
7 M_{I1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
7 M_{I2}	1.578	1.338	2.204	2.485	0.921	1.405	1.304
7 M_{I3}	35.170	32.840	50.800	70.340	20.290	25.180	25.880
7 R_{J1}	1.631	0.827	1.383	2.403	0.530	0.669	1.270
7 R_{J2}	2.971	1.864	2.223	7.266	2.157	1.802	2.010
7 R_{J3}	0.198	0.058	0.133	0.387	0.046	0.066	0.183
7 M_{J1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
7 M_{J2}	2.377	1.259	2.167	2.811	0.886	1.528	1.703
7 M_{J3}	43.210	39.410	61.630	89.920	26.370	25.310	30.870
8 R_{I1}	1.360	0.594	1.041	2.041	0.405	0.520	1.083
8 R_{I2}	8.613	7.808	12.370	17.870	5.166	5.148	5.997
8 R_{I3}	0.550	0.289	0.469	0.710	0.201	0.347	0.381
8 M_{I1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
8 M_{I2}	2.377	1.259	2.167	2.811	0.886	1.528	1.703
8 M_{I3}	43.210	39.410	61.630	89.920	26.370	25.310	30.870
8 R_{J1}	1.360	0.594	1.041	2.041	0.405	0.520	1.083
8 R_{J2}	8.613	7.808	12.370	17.870	5.166	5.148	5.997
8 R_{J3}	0.550	0.289	0.469	0.710	0.201	0.347	0.381
8 M_{J1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
8 M_{J2}	2.038	0.807	1.461	2.271	0.538	0.909	1.295
8 M_{J3}	17.200	15.810	25.200	35.510	10.000	11.580	13.620
9 R_{I1}	1.167	0.390	0.696	1.763	0.286	0.379	0.901
9 R_{I2}	5.386	4.918	7.720	10.820	3.166	3.184	3.783
9 R_{I3}	0.243	0.165	0.279	0.358	0.120	0.188	0.197
9 M_{I1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
9 M_{I2}	2.038	0.807	1.461	2.271	0.538	0.909	1.295
9 M_{I3}	17.200	15.810	25.200	35.510	10.000	11.580	13.620
9 R_{J1}	1.167	0.390	0.696	1.763	0.286	0.379	0.901
9 R_{J2}	5.386	4.918	7.720	10.820	3.166	3.184	3.783
9 R_{J3}	0.243	0.165	0.279	0.358	0.120	0.188	0.197
9 M_{J1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
9 M_{J2}	2.471	1.897	3.055	3.370	1.375	2.143	1.829
9 M_{J3}	54.810	49.790	79.130	111.200	31.990	33.580	38.040

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 64: Forces and Moments in Secondary System for Problem # 4b (Time History) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
10 R_{I1}	0.982	0.217	0.436	1.499	0.172	0.268	0.738
10 R_{I2}	0.621	0.147	0.322	1.004	0.121	0.198	0.437
10 R_{I3}	0.358	0.049	0.099	0.404	0.033	0.068	0.199
10 M_{I1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
10 M_{I2}	2.471	1.897	3.055	3.370	1.375	2.143	1.829
10 M_{I3}	54.810	49.790	79.130	111.200	31.990	33.580	38.040
10 R_{J1}	0.982	0.217	0.436	1.499	0.172	0.268	0.738
10 R_{J2}	0.621	0.147	0.322	1.004	0.121	0.198	0.437
10 R_{J3}	0.358	0.049	0.099	0.404	0.033	0.068	0.199
10 M_{J1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
10 M_{J2}	2.991	1.728	2.936	4.065	1.247	1.919	1.953
10 M_{J3}	54.340	49.610	77.960	108.400	31.550	32.570	38.220
11 R_{I1}	0.792	0.258	0.442	1.263	0.164	0.257	0.640
11 R_{I2}	5.450	4.987	7.967	11.150	3.233	3.366	3.830
11 R_{I3}	0.317	0.205	0.331	0.437	0.149	0.227	0.226
11 M_{I1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
11 M_{I2}	2.991	1.728	2.936	4.065	1.247	1.919	1.953
11 M_{I3}	54.340	49.610	77.960	108.400	31.550	32.570	38.220
11 R_{J1}	0.792	0.258	0.442	1.263	0.164	0.257	0.640
11 R_{J2}	5.450	4.987	7.967	11.150	3.233	3.366	3.830
11 R_{J3}	0.317	0.205	0.331	0.437	0.149	0.227	0.226
11 M_{J1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
11 M_{J2}	1.174	0.421	0.723	1.337	0.280	0.388	0.833
11 M_{J3}	16.210	14.710	22.460	30.470	9.023	9.472	11.410
12 R_{I1}	0.827	0.425	0.629	1.250	0.249	0.395	0.539
12 R_{I2}	8.566	7.866	12.430	17.410	5.093	5.176	6.146
12 R_{I3}	0.681	0.300	0.522	0.900	0.216	0.342	0.413
12 M_{I1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
12 M_{I2}	1.174	0.421	0.723	1.337	0.280	0.388	0.833
12 M_{I3}	16.210	14.710	22.460	30.470	9.023	9.472	11.410
12 R_{J1}	0.827	0.425	0.629	1.250	0.249	0.395	0.539
12 R_{J2}	8.566	7.866	12.430	17.410	5.093	5.176	6.146
12 R_{J3}	0.681	0.300	0.522	0.900	0.216	0.342	0.413
12 M_{J1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
12 M_{J2}	3.943	1.813	2.976	5.178	1.308	2.054	2.407
12 M_{J3}	43.800	40.360	64.780	91.560	26.740	27.230	31.610

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 65: Forces and Moments in Secondary System for Problem # 4b (Time History) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
13 R_{I1}	0.924	0.606	0.878	1.442	0.362	0.529	0.600
13 R_{I2}	2.610	2.015	3.421	5.018	1.647	1.472	1.819
13 R_{I3}	0.721	0.175	0.337	0.873	0.119	0.236	0.401
13 M_{I1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
13 M_{I2}	3.943	1.813	2.976	5.178	1.308	2.054	2.407
13 M_{I3}	43.800	40.360	64.780	91.560	26.740	27.230	31.610
13 R_{J1}	0.924	0.606	0.878	1.442	0.362	0.529	0.600
13 R_{J2}	2.610	2.015	3.421	5.018	1.647	1.472	1.819
13 R_{J3}	0.721	0.175	0.337	0.873	0.119	0.236	0.401
13 M_{J1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
13 M_{J2}	3.130	1.556	2.760	3.857	1.116	1.266	1.708
13 M_{J3}	29.510	26.460	41.280	58.630	16.530	17.750	20.030
14 R_{I1}	1.043	0.818	1.176	1.922	0.473	0.695	0.711
14 R_{I2}	3.407	3.074	4.845	6.947	1.938	2.054	2.333
14 R_{I3}	0.391	0.167	0.290	0.559	0.139	0.239	0.282
14 M_{I1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
14 M_{I2}	3.130	1.556	2.760	3.857	1.116	1.266	1.708
14 M_{I3}	29.510	26.460	41.280	58.630	16.530	17.750	20.030
14 R_{J1}	1.043	0.818	1.176	1.922	0.473	0.695	0.711
14 R_{J2}	3.407	3.074	4.845	6.947	1.938	2.054	2.333
14 R_{J3}	0.391	0.167	0.290	0.559	0.139	0.239	0.282
14 M_{J1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
14 M_{J2}	2.287	1.982	2.815	4.200	1.128	1.743	1.711
14 M_{J3}	5.813	4.955	8.004	10.460	3.290	3.891	3.699
15 R_{I1}	1.132	0.975	1.384	2.254	0.554	0.834	0.809
15 R_{I2}	4.426	3.886	6.157	8.231	2.519	2.901	2.946
15 R_{I3}	0.910	0.203	0.405	1.082	0.163	0.286	0.508
15 M_{I1}	2.166	1.923	3.036	4.029	1.240	1.478	1.430
15 M_{I2}	2.287	1.982	2.815	4.200	1.128	1.743	1.711
15 M_{I3}	5.813	4.955	8.004	10.460	3.290	3.891	3.699
15 R_{J1}	0.910	0.203	0.405	1.082	0.163	0.286	0.508
15 R_{J2}	1.132	0.975	1.384	2.254	0.554	0.834	0.809
15 R_{J3}	4.426	3.886	6.157	8.231	2.519	2.901	2.946
15 M_{J1}	1.054	0.876	1.446	2.333	0.592	0.628	0.725
15 M_{J2}	4.590	3.907	6.201	8.590	2.539	2.873	3.054
15 M_{J3}	1.265	0.775	1.045	2.200	0.490	0.873	0.968

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 66: Forces and Moments in Secondary System for Problem # 4b (Time History) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
16 R_{I1}	1.303	0.274	0.530	1.535	0.187	0.342	0.720
16 R_{I2}	1.251	1.079	1.515	2.489	0.611	0.939	0.929
16 R_{I3}	5.200	4.316	7.075	9.195	2.948	3.455	3.213
16 M_{I1}	1.054	0.876	1.446	2.333	0.592	0.628	0.725
16 M_{I2}	4.590	3.907	6.201	8.590	2.539	2.873	3.054
16 M_{I3}	1.265	0.775	1.045	2.200	0.490	0.873	0.968
16 R_{J1}	1.303	0.274	0.530	1.535	0.187	0.342	0.720
16 R_{J2}	1.251	1.079	1.515	2.489	0.611	0.939	0.929
16 R_{J3}	5.200	4.316	7.075	9.195	2.948	3.455	3.213
16 M_{J1}	1.054	0.876	1.446	2.333	0.592	0.628	0.725
16 M_{J2}	30.590	25.480	41.570	54.190	17.280	20.150	19.120
16 M_{J3}	5.252	4.623	6.706	10.250	2.706	3.834	3.721
17 R_{I1}	2.044	0.401	0.798	2.480	0.238	0.443	1.139
17 R_{I2}	0.423	0.241	0.359	0.648	0.140	0.204	0.257
17 R_{I3}	2.700	1.594	2.606	4.178	1.132	1.329	1.597
17 M_{I1}	1.054	0.876	1.446	2.333	0.592	0.628	0.725
17 M_{I2}	30.590	25.480	41.570	54.190	17.280	20.150	19.120
17 M_{I3}	5.252	4.623	6.706	10.250	2.706	3.834	3.721
17 R_{J1}	2.044	0.401	0.798	2.480	0.238	0.443	1.139
17 R_{J2}	0.423	0.241	0.359	0.648	0.140	0.204	0.257
17 R_{J3}	2.700	1.594	2.606	4.178	1.132	1.329	1.597
17 M_{J1}	1.054	0.876	1.446	2.333	0.592	0.628	0.725
17 M_{J2}	18.240	13.740	21.100	35.730	8.275	9.815	12.100
17 M_{J3}	3.589	2.618	3.866	5.967	1.545	2.244	2.610
18 R_{I1}	2.855	0.541	1.089	3.508	0.302	0.594	1.605
18 R_{I2}	0.462	0.342	0.501	0.783	0.200	0.295	0.339
18 R_{I3}	2.612	2.090	3.212	5.105	1.273	1.488	1.750
18 M_{I1}	1.054	0.876	1.446	2.333	0.592	0.628	0.725
18 M_{I2}	18.240	13.740	21.100	35.730	8.275	9.815	12.100
18 M_{I3}	3.589	2.618	3.866	5.967	1.545	2.244	2.610
18 R_{J1}	2.855	0.541	1.089	3.508	0.302	0.594	1.605
18 R_{J2}	0.462	0.342	0.501	0.783	0.200	0.295	0.339
18 R_{J3}	2.612	2.090	3.212	5.105	1.273	1.488	1.750
18 M_{J1}	1.054	0.876	1.446	2.333	0.592	0.628	0.725
18 M_{J2}	2.700	0.722	0.988	3.159	0.389	0.655	1.527
18 M_{J3}	0.512	0.336	0.534	0.866	0.210	0.272	0.351

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 67: Forces and Moments in Secondary System for Problem # 4b (Time History) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
19 R_{I1}	3.319	0.623	1.257	4.102	0.340	0.692	1.872
19 R_{I2}	0.553	0.365	0.544	0.841	0.217	0.319	0.379
19 R_{I3}	2.819	2.278	3.431	5.801	1.428	1.535	1.996
19 M_{I1}	1.054	0.876	1.446	2.333	0.592	0.628	0.725
19 M_{I2}	2.700	0.722	0.988	3.159	0.389	0.655	1.527
19 M_{I3}	0.512	0.336	0.534	0.866	0.210	0.272	0.351
19 R_{J1}	2.819	2.278	3.431	5.801	1.428	1.535	1.996
19 R_{J2}	0.553	0.365	0.544	0.841	0.217	0.319	0.379
19 R_{J3}	3.319	0.623	1.257	4.102	0.340	0.692	1.872
19 M_{J1}	0.318	0.213	0.303	0.516	0.135	0.218	0.218
19 M_{J2}	7.330	4.413	6.810	12.990	2.616	3.191	4.427
19 M_{J3}	1.814	1.392	2.258	3.519	0.885	1.047	1.292
20 R_{I1}	2.897	2.388	3.605	6.043	1.694	1.725	2.107
20 R_{I2}	0.272	0.102	0.165	0.369	0.075	0.139	0.165
20 R_{I3}	1.410	0.328	0.555	1.848	0.182	0.314	0.793
20 M_{I1}	0.318	0.213	0.303	0.516	0.135	0.218	0.218
20 M_{I2}	7.330	4.413	6.810	12.990	2.616	3.191	4.427
20 M_{I3}	1.814	1.392	2.258	3.519	0.885	1.047	1.292
20 R_{J1}	2.897	2.388	3.605	6.043	1.694	1.725	2.107
20 R_{J2}	0.272	0.102	0.165	0.369	0.075	0.139	0.165
20 R_{J3}	1.410	0.328	0.555	1.848	0.182	0.314	0.793
20 M_{J1}	0.318	0.213	0.303	0.516	0.135	0.218	0.218
20 M_{J2}	6.046	2.984	4.502	7.702	1.768	2.298	3.898
20 M_{J3}	1.572	0.987	1.495	2.118	0.622	0.948	0.989
21 R_{I1}	3.243	2.605	3.889	6.367	2.064	1.983	2.372
21 R_{I2}	0.151	0.104	0.170	0.277	0.066	0.078	0.103
21 R_{I3}	0.658	0.337	0.527	1.083	0.197	0.245	0.377
21 M_{I1}	0.318	0.213	0.303	0.516	0.135	0.218	0.218
21 M_{I2}	6.046	2.984	4.502	7.702	1.768	2.298	3.898
21 M_{I3}	1.572	0.987	1.495	2.118	0.622	0.948	0.989
21 R_{J1}	3.243	2.605	3.889	6.367	2.064	1.983	2.372
21 R_{J2}	0.151	0.104	0.170	0.277	0.066	0.078	0.103
21 R_{J3}	0.658	0.337	0.527	1.083	0.197	0.245	0.377
21 M_{J1}	0.318	0.213	0.303	0.516	0.135	0.218	0.218
21 M_{J2}	6.171	1.477	2.374	7.193	0.806	1.505	3.649
21 M_{J3}	1.297	0.479	0.709	1.700	0.299	0.589	0.853

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 68: Forces and Moments in Secondary System for Problem # 4b (Time History) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
22 R_{I1}	3.861	2.868	4.179	7.523	2.441	2.243	2.633
22 R_{I2}	0.284	0.129	0.186	0.350	0.080	0.140	0.183
22 R_{I3}	1.263	0.393	0.615	1.492	0.224	0.331	0.766
22 M_{I1}	0.318	0.213	0.303	0.516	0.135	0.218	0.218
22 M_{I2}	6.171	1.477	2.374	7.193	0.806	1.505	3.649
22 M_{I3}	1.297	0.479	0.709	1.700	0.299	0.589	0.853
22 R_{J1}	3.861	2.868	4.179	7.523	2.441	2.243	2.633
22 R_{J2}	0.284	0.129	0.186	0.350	0.080	0.140	0.183
22 R_{J3}	1.263	0.393	0.615	1.492	0.224	0.331	0.766
22 M_{J1}	0.318	0.213	0.303	0.516	0.135	0.218	0.218
22 M_{J2}	0.937	0.540	0.840	1.652	0.318	0.397	0.557
22 M_{J3}	0.224	0.171	0.283	0.450	0.114	0.127	0.156
23 R_{I1}	4.472	3.131	4.475	8.733	2.823	2.502	2.890
23 R_{I2}	0.396	0.143	0.211	0.537	0.091	0.182	0.263
23 R_{I3}	1.907	0.439	0.711	2.226	0.239	0.457	1.124
23 M_{I1}	0.318	0.213	0.303	0.516	0.135	0.218	0.218
23 M_{I2}	0.937	0.540	0.840	1.652	0.318	0.397	0.557
23 M_{I3}	0.224	0.171	0.283	0.450	0.114	0.127	0.156
23 R_{J1}	4.472	3.131	4.475	8.733	2.823	2.502	2.890
23 R_{J2}	0.396	0.143	0.211	0.537	0.091	0.182	0.263
23 R_{J3}	1.907	0.439	0.711	2.226	0.239	0.457	1.124
23 M_{J1}	0.318	0.213	0.303	0.516	0.135	0.218	0.218
23 M_{J2}	9.678	2.678	4.253	11.390	1.507	2.433	5.798
23 M_{J3}	2.105	0.878	1.250	2.728	0.537	1.017	1.381

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 69: Nodal Displacements for Problem # 1 (Response Spectrum)

Nodes	Load cases							
	a	b	c	d	e	f	g	h
2	0.084	0.086	0.082	0.087	0.087	0.086	0.108	0.140
3	0.156	0.160	0.154	0.163	0.163	0.161	0.205	0.271
4	0.213	0.220	0.210	0.223	0.224	0.220	0.285	0.389
5	0.254	0.262	0.250	0.266	0.266	0.262	0.347	0.490
6	0.274	0.283	0.270	0.287	0.288	0.283	0.370	0.510
7	0.895	0.806	0.714	0.671	0.301	1.052	0.641	0.673
8	1.575	1.443	1.307	1.089	0.330	1.896	0.913	0.821
9	2.086	1.935	1.759	1.403	0.349	2.528	1.115	0.926
10	2.358	2.203	2.002	1.571	0.359	2.865	1.222	0.980

Displacement: in

Table 70: Nodal Displacements for Problem # 1 (Response Spectrum)

Nodes	Load cases							
	i	j	k	l	m	n	o	p
2	0.085	0.085	0.054	0.082	0.212	0.071	0.073	0.072
3	0.158	0.160	0.102	0.155	0.400	0.131	0.138	0.135
4	0.216	0.219	0.141	0.214	0.553	0.180	0.192	0.186
5	0.257	0.260	0.168	0.257	0.660	0.213	0.231	0.222
6	0.278	0.281	0.181	0.277	0.716	0.230	0.250	0.240
7	0.687	0.386	0.613	1.140	2.275	0.678	0.899	0.787
8	1.146	0.521	1.062	1.960	4.105	1.166	1.615	1.416
9	1.493	0.626	1.398	2.567	5.483	1.532	2.153	1.890
10	1.678	0.683	1.576	2.889	6.220	1.727	2.439	2.142

Displacement: in

Table 71: Element Forces for Problem # 1 (Response Spectrum)

Elements	Load cases							
	a	b	c	d	e	f	g	h
1	2633.00	2706.00	2598.00	2741.00	2744.00	2710.00	3408.00	4427.00
2	2282.00	2355.00	2251.00	2388.00	2392.00	2360.00	3049.00	4131.00
3	1827.00	1888.00	1798.00	1920.00	1922.00	1892.00	2560.00	3718.00
4	1283.00	1322.00	1254.00	1353.00	1351.00	1325.00	1967.00	3201.00
5	649.50	681.70	650.70	681.30	689.00	683.00	746.10	683.70
6	84.37	20.19	59.92	64.78	17.06	2.08	724.30	2023.00
7	73.90	17.96	53.06	56.19	13.50	1.82	615.20	1638.00
8	54.74	13.76	39.59	41.37	9.36	1.35	447.60	1156.00
9	29.10	7.60	21.14	21.92	4.80	0.72	235.70	598.70

Force: Kips

Table 72: Element Forces for Problem # 1 (Response Spectrum)

Elements	Load cases							
	i	j	k	l	m	n	o	p
1	2665.00	2692.00	1713.00	2589.00	6701.00	2227.00	2292.00	2268.00
2	2314.00	2343.00	1504.00	2295.00	5931.00	1916.00	2070.00	1997.00
3	1854.00	1879.00	1216.00	1874.00	4814.00	1526.00	1703.00	1610.00
4	1303.00	1319.00	860.90	1343.00	3406.00	1067.00	1214.00	1133.00
5	659.20	673.10	432.00	659.30	1760.00	536.40	623.20	580.90
6	58.47	20.82	55.70	101.00	226.50	61.01	88.25	77.73
7	50.96	17.72	48.61	87.69	199.20	53.28	77.52	68.36
8	37.64	12.93	35.92	64.59	147.90	39.40	57.51	50.76
9	19.97	6.83	19.06	34.22	78.75	20.92	30.60	27.02

Force: Kips

Table 73: Nodal Displacements for Problem # 2 (Response Spectrum)

Nodes	Load cases							
	a	b	c	d	e	f	g	h
2	0.084	0.086	0.082	0.087	0.087	0.086	0.118	0.170
3	0.156	0.160	0.153	0.163	0.163	0.161	0.225	0.330
4	0.214	0.220	0.209	0.224	0.224	0.221	0.310	0.454
5	0.254	0.261	0.249	0.266	0.266	0.262	0.362	0.518
6	0.274	0.282	0.269	0.287	0.288	0.284	0.386	0.539
7	1.181	1.401	1.059	0.789	0.232	1.421	0.710	0.642
8	1.643	1.971	1.491	1.072	0.267	1.991	0.923	0.781
9	1.197	1.398	1.060	0.815	0.264	1.433	0.757	0.712
10	1.490	1.475	1.283	1.028	0.296	1.799	0.894	0.811
11	2.070	2.081	1.810	1.394	0.329	2.520	1.144	0.956
12	1.499	1.472	1.282	1.045	0.319	1.806	0.922	0.847

Displacement: in

Table 74: Nodal Displacements for Problem # 2 (Response Spectrum)

Nodes	Load cases							
	i	j	k	l	m	n	o	p
2	0.085	0.085	0.055	0.083	0.212	0.071	0.073	0.072
3	0.158	0.159	0.102	0.157	0.400	0.132	0.138	0.135
4	0.217	0.218	0.141	0.217	0.552	0.180	0.192	0.185
5	0.258	0.259	0.168	0.258	0.659	0.214	0.230	0.221
6	0.278	0.281	0.181	0.279	0.714	0.231	0.250	0.239
7	0.872	0.403	0.796	1.470	3.061	0.881	1.202	1.057
8	1.197	0.518	1.103	2.031	4.290	1.218	1.683	1.480
9	0.893	0.432	0.810	1.499	3.085	0.896	1.213	1.066
10	1.091	0.489	1.001	1.843	3.895	1.101	1.524	1.336
11	1.494	0.620	1.383	2.536	5.459	1.519	2.132	1.871
12	1.104	0.508	1.010	1.863	3.908	1.111	1.530	1.341

Displacement: in

Table 75: Element Forces for Problem # 2 (Response Spectrum)

Elements	Load cases							
	a	b	c	d	e	f	g	h
1	2640.00	2701.00	2584.00	2755.00	2753.00	2711.00	3732.00	5363.00
2	2290.00	2350.00	2238.00	2402.00	2400.00	2360.00	3369.00	5053.00
3	1827.00	1883.00	1788.00	1922.00	1923.00	1892.00	2674.00	3920.00
4	1267.00	1319.00	1252.00	1333.00	1341.00	1324.00	1662.00	2025.00
5	648.40	680.70	647.00	681.30	688.90	683.10	759.10	692.30
6	24.46	7.57	18.60	18.21	6.12	0.60	224.30	690.00
7	10.14	3.43	7.71	7.59	3.08	0.25	94.33	306.70
8	9.93	3.32	7.82	7.08	0.53	0.25	77.33	163.10
9	24.30	7.59	18.57	17.88	3.67	0.60	212.10	576.20
10	30.89	7.97	22.67	23.81	6.62	0.76	274.20	796.70
11	12.77	3.72	9.43	9.81	2.99	0.32	111.40	320.40
12	12.65	3.62	9.54	9.49	1.21	0.31	102.10	249.30
13	30.80	8.00	22.66	23.61	5.01	0.76	267.30	739.20

Force: Kips

Table 76: Element Forces for Problem # 2 (Response Spectrum)

Elements	Load cases							
.	i	j	k	l	m	n	o	p
1	2675.00	2687.00	1719.00	2625.00	6688.00	2236.00	2291.00	2260.00
2	2324.00	2339.00	1510.00	2328.00	5922.00	1925.00	2070.00	1990.00
3	1855.00	1872.00	1215.00	1883.00	4802.00	1527.00	1698.00	1602.00
4	1287.00	1304.00	843.30	1302.00	3385.00	1053.00	1201.00	1121.00
5	658.90	670.10	430.50	660.10	1754.00	536.20	621.10	577.70
6	17.30	6.45	16.23	29.57	65.06	17.88	25.39	22.37
7	7.17	2.63	6.73	12.26	27.00	7.40	10.54	9.28
8	6.88	2.34	6.50	11.68	26.83	7.17	10.41	9.21
9	17.10	6.20	16.08	29.25	64.89	17.71	25.29	22.29
10	21.66	7.71	20.36	36.84	83.04	22.35	32.24	28.39
11	8.93	3.11	8.39	15.15	34.41	9.22	13.35	11.76
12	8.77	2.97	8.26	14.77	34.39	9.09	13.30	11.75
13	21.54	7.58	20.27	36.62	82.98	22.25	32.18	28.35

Force: Kips

Table 77: Nodal Displacements for Problem # 3 (Response Spectrum)

Nodes	Load cases							
	a	b	c	d	e	f	g	h
2	0.083	0.086	0.082	0.087	0.087	0.086	0.109	0.141
3	0.156	0.160	0.153	0.163	0.162	0.161	0.207	0.273
4	0.213	0.219	0.209	0.223	0.223	0.221	0.289	0.391
5	0.254	0.261	0.249	0.266	0.265	0.262	0.352	0.491
6	0.274	0.282	0.269	0.288	0.287	0.284	0.382	0.539
7	0.830	1.362	0.806	0.506	0.108	1.004	0.433	0.339
8	1.193	1.829	1.135	0.749	0.192	1.434	0.663	0.554
9	0.905	1.352	0.821	0.624	0.246	1.064	0.618	0.604
10	1.688	1.520	1.422	1.185	0.339	2.040	0.988	0.888
11	2.345	2.149	2.010	1.603	0.370	2.857	1.260	1.047
12	1.693	1.518	1.422	1.194	0.351	2.044	1.006	0.916

Displacement: in

Table 78: Nodal Displacements for Problem # 3 (Response Spectrum)

Nodes	Load cases							
	i	j	k	l	m	n	o	p
2	0.085	0.085	0.054	0.082	0.209	0.071	0.073	0.072
3	0.158	0.159	0.102	0.155	0.395	0.131	0.138	0.135
4	0.216	0.218	0.140	0.215	0.546	0.180	0.192	0.185
5	0.257	0.259	0.167	0.257	0.654	0.213	0.230	0.221
6	0.278	0.280	0.181	0.279	0.709	0.231	0.250	0.239
7	0.604	0.265	0.557	1.026	2.185	0.621	0.847	0.751
8	0.880	0.406	0.805	1.490	3.115	0.898	1.212	1.072
9	0.704	0.394	0.620	1.154	2.305	0.696	0.902	0.797
10	1.231	0.544	1.133	2.085	4.514	1.243	1.731	1.517
11	1.683	0.684	1.564	2.862	6.332	1.714	2.422	2.125
12	1.237	0.554	1.138	2.096	4.521	1.248	1.735	1.519

Displacement: in

Table 79: Element Forces for Problem # 3 (Response Spectrum)

Elements	Load cases							
	a	b	c	d	e	f	g	h
1	2631.00	2696.00	2586.00	2741.00	2737.00	2711.00	3445.00	4454.00
2	2280.00	2345.00	2240.00	2388.00	2385.00	2360.00	3086.00	4153.00
3	1825.00	1879.00	1788.00	1920.00	1915.00	1892.00	2596.00	3729.00
4	1282.00	1315.00	1247.00	1354.00	1344.00	1325.00	2000.00	3200.00
5	656.80	678.50	643.00	694.20	693.60	683.20	969.90	1502.00
6	18.09	7.42	14.24	13.36	9.48	0.44	188.80	739.60
7	7.99	3.85	5.93	6.50	7.39	0.19	102.80	481.10
8	6.91	3.56	6.24	4.22	4.81	0.17	47.26	203.80
9	17.30	7.45	14.04	11.76	2.08	0.43	140.00	356.40
10	35.05	8.23	25.24	27.48	7.40	0.87	303.60	895.70
11	14.48	3.90	10.54	11.26	3.00	0.36	122.50	355.50
12	14.41	3.84	10.60	11.10	2.19	0.36	116.40	298.50
13	35.00	8.25	25.24	27.38	6.67	0.87	299.40	853.20

Force: Kips

Table 80: Element Forces for Problem # 3 (Response Spectrum)

Elements	Load cases							
	i	j	k	l	m	n	o	p
1	2666.00	2680.00	1709.00	2596.00	6594.00	2228.00	2287.00	2257.00
2	2314.00	2332.00	1500.00	2300.00	5866.00	1917.00	2065.00	1988.00
3	1854.00	1870.00	1213.00	1879.00	4785.00	1526.00	1699.00	1602.00
4	1303.00	1313.00	859.20	1347.00	3398.00	1068.00	1211.00	1127.00
5	667.90	675.10	439.90	688.40	1763.00	544.40	626.30	580.20
6	13.16	5.77	12.14	22.37	47.64	13.54	18.46	16.38
7	6.10	3.18	5.45	10.16	20.61	6.07	8.03	7.09
8	4.63	1.86	4.41	7.65	19.59	4.94	7.36	6.60
9	12.10	4.39	11.47	20.95	46.71	12.70	17.96	15.90
10	24.46	8.55	23.03	41.54	96.59	25.24	36.69	32.30
11	10.07	3.44	9.47	17.00	40.05	10.40	15.19	13.39
12	9.98	3.38	9.40	16.80	40.03	10.33	15.16	13.38
13	24.40	8.49	22.98	41.42	96.55	25.19	36.66	32.28

Force: Kips

Table 81: Nodal Displacements for Problem # 4a (Response Spectrum)

Nodes	Load cases						
	a	b	c	d	e	f	g
2 u_x	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2 u_y	1.177	0.443	0.850	2.121	0.643	0.618	0.933
2 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2 θ_x	3.123	1.134	2.235	5.602	1.586	1.671	2.541
2 θ_y	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 u_x	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 u_y	2.883	1.067	2.072	5.182	1.526	1.526	2.312
3 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 θ_x	5.419	1.959	3.875	9.719	2.719	2.910	4.427
3 θ_y	0.000	0.000	0.000	0.001	0.000	0.000	0.000
3 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4 u_x	0.000	0.000	0.000	0.001	0.000	0.000	0.000
4 u_y	4.575	1.679	3.282	8.217	2.377	2.434	3.694
4 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4 θ_x	6.767	2.437	4.836	12.130	3.366	3.641	5.544
4 θ_y	0.000	0.000	0.000	0.001	0.000	0.000	0.000
4 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5 u_x	0.000	0.000	0.000	0.001	0.000	0.000	0.000
5 u_y	6.638	2.419	4.755	11.910	3.394	3.546	5.389
5 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5 θ_x	7.744	2.782	5.531	13.880	3.824	4.174	6.358
5 θ_y	0.001	0.000	0.000	0.001	0.000	0.000	0.000
5 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6 u_x	0.001	0.000	0.000	0.001	0.000	0.000	0.000
6 u_y	8.744	3.171	6.258	15.690	4.422	4.685	7.125
6 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6 θ_x	8.242	2.956	5.885	14.770	4.053	4.448	6.776
6 θ_y	0.001	0.000	0.000	0.001	0.000	0.000	0.000
6 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7 u_x	0.001	0.000	0.001	0.001	0.000	0.000	0.001
7 u_y	10.050	3.638	7.192	18.030	5.059	5.394	8.205
7 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7 θ_x	8.366	2.999	5.973	14.990	4.109	4.516	6.880
7 θ_y	0.001	0.000	0.000	0.001	0.000	0.000	0.001
7 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad*.

Table 82: Nodal Displacements for Problem # 4a (Response Spectrum) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
8 u_x	0.001	0.000	0.001	0.001	0.000	0.000	0.001
8 u_y	11.280	4.077	8.069	20.230	5.658	6.058	9.218
8 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8 θ_x	8.397	3.010	5.995	15.050	4.123	4.533	6.907
8 θ_y	0.001	0.000	0.000	0.001	0.000	0.000	0.001
8 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9 u_x	0.001	0.000	0.001	0.001	0.000	0.000	0.001
9 u_y	11.280	4.077	8.069	20.230	5.658	6.058	9.218
9 u_z	0.655	0.235	0.468	1.174	0.322	0.354	0.539
9 θ_x	8.397	3.010	5.995	15.050	4.123	4.533	6.907
9 θ_y	0.001	0.000	0.000	0.001	0.000	0.000	0.001
9 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10 u_x	0.001	0.001	0.001	0.003	0.000	0.001	0.001
10 u_y	12.050	4.347	8.628	21.680	5.996	6.513	9.878
10 u_z	0.671	0.245	0.492	1.252	0.332	0.376	0.570
10 θ_x	21.550	8.699	19.910	50.270	7.408	11.150	21.230
10 θ_y	1.220	0.466	0.993	2.610	0.371	0.594	1.152
10 θ_z	11.240	4.063	8.363	21.610	4.790	6.572	9.799
11 u_x	0.002	0.001	0.002	0.005	0.001	0.001	0.002
11 u_y	12.290	4.433	8.802	22.150	6.098	6.663	10.090
11 u_z	0.689	0.253	0.507	1.301	0.339	0.388	0.590
11 θ_x	39.950	16.440	38.440	96.830	13.170	20.200	40.480
11 θ_y	0.436	0.129	0.234	0.633	0.105	0.183	0.298
11 θ_z	6.305	2.250	4.629	11.870	2.826	3.646	5.437
12 u_x	0.003	0.001	0.003	0.007	0.001	0.002	0.003
12 u_y	11.280	4.077	8.069	20.230	5.658	6.058	9.218
12 u_z	0.655	0.235	0.468	1.174	0.322	0.354	0.539
12 θ_x	58.860	24.350	57.270	144.100	19.300	29.530	60.110
12 θ_y	3.134	1.257	2.770	7.187	1.000	1.525	3.134
12 θ_z	17.690	6.642	14.140	36.440	6.868	10.150	16.090
13 u_x	0.117	0.047	0.104	0.268	0.037	0.056	0.117
13 u_y	10.950	3.985	7.999	19.970	5.552	5.794	9.037
13 u_z	0.643	0.235	0.480	1.186	0.314	0.348	0.543
13 θ_x	80.530	33.370	78.580	197.700	26.400	40.300	82.400
13 θ_y	4.926	1.934	3.920	10.420	1.554	2.506	4.857
13 θ_z	27.430	11.020	25.090	63.620	9.240	14.550	27.020

Units: u_x, u_y and u_z: 10^{-2} in; θ_x, θ_y and θ_z: 10^{-5} rad.

Table 83: Nodal Displacements for Problem # 4a (Response Spectrum) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
14 u_x	0.341	0.132	0.249	0.681	0.107	0.187	0.333
14 u_y	11.850	4.596	10.170	25.280	5.640	5.911	10.870
14 u_z	0.642	0.236	0.482	1.192	0.313	0.348	0.545
14 θ_x	49.990	20.190	46.240	116.700	16.930	26.110	49.340
14 θ_y	1.952	0.764	1.558	4.073	0.626	1.267	1.887
14 θ_z	24.540	9.834	22.320	56.660	8.311	13.020	24.120
15 u_x	0.290	0.112	0.199	0.546	0.094	0.186	0.282
15 u_y	10.930	4.316	9.734	24.250	5.058	5.382	10.290
15 u_z	0.641	0.236	0.484	1.197	0.313	0.347	0.546
15 θ_x	42.680	17.750	42.260	105.600	15.430	20.540	43.970
15 θ_y	2.491	0.966	1.931	5.250	0.751	1.208	2.432
15 θ_z	21.660	8.653	19.560	49.730	7.390	11.510	21.230
16 u_x	0.001	0.000	0.000	0.001	0.000	0.000	0.000
16 u_y	8.744	3.171	6.258	15.690	4.422	4.685	7.125
16 u_z	0.640	0.236	0.486	1.202	0.313	0.347	0.548
16 θ_x	155.200	63.430	147.000	370.700	51.200	80.620	155.700
16 θ_y	5.314	2.107	4.092	10.650	1.786	3.671	5.244
16 θ_z	18.810	7.479	16.820	42.850	6.482	10.010	18.360
17 u_x	0.585	0.234	0.486	1.243	0.196	0.396	0.580
17 u_y	21.350	8.230	17.740	44.840	8.305	11.650	19.560
17 u_z	0.639	0.237	0.488	1.207	0.312	0.346	0.549
17 θ_x	192.500	77.480	176.400	445.400	64.910	102.500	189.000
17 θ_y	7.424	2.987	6.382	16.270	2.472	4.890	7.374
17 θ_z	16.010	6.316	14.090	36.030	5.593	8.521	15.520
18 u_x	1.086	0.437	0.928	2.368	0.363	0.720	1.078
18 u_y	33.000	12.940	28.480	71.980	12.110	17.910	31.070
18 u_z	0.637	0.237	0.490	1.211	0.312	0.346	0.550
18 θ_x	72.710	29.340	66.770	168.700	24.380	38.900	71.540
18 θ_y	3.786	1.521	3.398	8.662	1.223	2.291	3.740
18 θ_z	13.260	5.173	11.400	29.330	4.734	7.066	12.740
19 u_x	1.122	0.452	0.976	2.488	0.373	0.732	1.114
19 u_y	31.670	12.430	27.390	69.210	11.600	17.210	29.860
19 u_z	0.636	0.237	0.492	1.216	0.311	0.345	0.551
19 θ_x	100.600	39.980	89.750	226.800	35.050	54.020	96.990
19 θ_y	2.987	1.185	2.383	6.115	0.992	2.034	2.945
19 θ_z	10.640	4.065	8.765	22.850	3.924	5.665	10.060

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad*.

Table 84: Nodal Displacements for Problem # 4a (Response Spectrum) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
20 u_x	0.652	0.264	0.577	1.471	0.217	0.418	0.649
20 u_y	18.150	7.044	15.250	38.530	6.956	9.922	16.760
20 u_z	0.635	0.237	0.494	1.220	0.311	0.344	0.552
20 θ_x	199.200	79.380	178.400	450.700	69.140	107.100	192.500
20 θ_y	7.543	3.036	6.530	16.670	2.503	4.919	7.478
20 θ_z	8.236	3.032	6.277	16.850	3.201	4.368	7.575
21 u_x	0.000	0.000	0.000	0.001	0.000	0.000	0.000
21 u_y	4.575	1.679	3.282	8.217	2.377	2.434	3.694
21 u_z	0.634	0.238	0.495	1.224	0.310	0.342	0.552
21 θ_x	125.300	49.900	112.100	283.300	43.330	67.480	121.100
21 θ_y	6.699	2.727	6.099	15.560	2.262	4.172	6.719
21 θ_z	6.327	2.183	4.197	12.060	2.637	3.301	5.579
22 u_x	0.416	0.168	0.385	0.994	0.144	0.239	0.418
22 u_y	4.200	1.712	3.885	9.741	1.940	2.020	4.018
22 u_z	0.632	0.238	0.497	1.227	0.310	0.341	0.553
22 θ_x	8.446	3.458	8.229	20.720	2.982	4.218	8.673
22 θ_y	3.694	1.414	3.261	8.670	1.333	1.758	3.574
22 θ_z	5.452	1.799	3.383	10.330	2.351	2.748	4.726
23 u_x	0.632	0.247	0.570	1.499	0.228	0.317	0.617
23 u_y	3.046	1.151	2.270	5.671	1.680	1.555	2.456
23 u_z	0.630	0.238	0.498	1.230	0.309	0.340	0.553
23 θ_x	43.150	17.680	41.060	103.600	14.140	22.480	43.460
23 θ_y	2.827	0.923	1.935	5.409	1.097	1.042	2.293
23 θ_z	6.076	2.148	4.572	12.950	2.441	3.006	5.568
24 u_x	0.517	0.201	0.465	1.223	0.189	0.252	0.501
24 u_y	2.960	1.110	2.155	5.392	1.624	1.532	2.358
24 u_z	0.741	0.276	0.567	1.424	0.312	0.424	0.648
24 θ_x	9.498	3.490	6.999	17.340	4.564	5.312	8.004
24 θ_y	2.133	0.639	1.182	3.396	0.905	0.910	1.444
24 θ_z	8.600	3.303	7.601	20.150	3.108	4.224	8.324
25 u_x	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25 u_y	2.960	1.109	2.153	5.389	1.623	1.534	2.359
25 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25 θ_x	11.910	4.494	9.315	23.430	4.943	6.855	10.580
25 θ_y	1.930	0.600	1.126	3.145	0.820	0.833	1.314
25 θ_z	8.172	3.217	7.456	19.430	3.086	3.902	7.872

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad*.

Table 85: Nodal Displacements for Problem # 4a (Response Spectrum) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
26 u_x	0.560	0.226	0.520	1.331	0.224	0.263	0.537
26 u_y	2.955	1.106	2.147	5.373	1.616	1.534	2.355
26 u_z	0.755	0.284	0.574	1.440	0.350	0.437	0.655
26 θ_x	4.876	1.782	3.536	8.876	2.537	2.558	3.966
26 θ_y	1.640	0.556	1.088	2.880	0.690	0.725	1.176
26 θ_z	1.428	0.624	1.336	3.325	0.602	0.737	1.411
27 u_x	0.243	0.101	0.234	0.593	0.091	0.122	0.242
27 u_y	2.946	1.101	2.138	5.351	1.607	1.531	2.349
27 u_z	1.023	0.372	0.736	1.843	0.509	0.556	0.839
27 θ_x	4.674	1.598	3.331	8.485	2.153	1.917	3.609
27 θ_y	1.470	0.543	1.110	2.835	0.601	0.665	1.156
27 θ_z	10.080	4.128	9.240	23.570	4.483	4.628	9.407
28 u_x	0.003	0.002	0.003	0.007	0.002	0.002	0.003
28 u_y	2.883	1.067	2.072	5.182	1.526	1.526	2.312
28 u_z	1.073	0.388	0.767	1.924	0.538	0.576	0.877
28 θ_x	4.707	1.593	3.243	8.268	2.291	2.025	3.590
28 θ_y	1.051	0.382	0.710	1.828	0.344	0.424	0.823
28 θ_z	9.020	3.483	7.122	17.730	3.856	4.610	7.700
29 u_x	0.002	0.001	0.002	0.005	0.001	0.001	0.002
29 u_y	3.349	1.244	2.376	5.922	1.785	1.748	2.632
29 u_z	1.085	0.395	0.792	1.991	0.539	0.598	0.913
29 θ_x	4.732	1.620	3.246	8.232	2.367	2.163	3.632
29 θ_y	0.805	0.286	0.531	1.395	0.246	0.413	0.669
29 θ_z	6.399	2.482	4.233	10.370	3.667	2.892	4.342
30 u_x	0.002	0.001	0.001	0.003	0.001	0.001	0.002
30 u_y	3.494	1.301	2.472	6.157	1.880	1.809	2.724
30 u_z	1.095	0.399	0.803	2.021	0.543	0.608	0.928
30 θ_x	4.866	1.694	3.361	8.480	2.466	2.367	3.797
30 θ_y	0.265	0.094	0.172	0.443	0.085	0.103	0.200
30 θ_z	2.149	0.824	1.685	4.195	0.908	1.093	1.828
31 u_x	0.001	0.000	0.001	0.002	0.000	0.000	0.001
31 u_y	3.190	1.186	2.275	5.676	1.710	1.667	2.518
31 u_z	1.086	0.394	0.787	1.976	0.542	0.593	0.904
31 θ_x	5.099	1.809	3.576	8.990	2.584	2.620	4.068
31 θ_y	0.894	0.318	0.589	1.544	0.274	0.449	0.738
31 θ_z	7.184	2.779	4.810	11.790	4.025	3.305	4.987

Units: u_x, u_y and u_z: 10^{-2} in; θ_x, θ_y and θ_z: 10^{-5} rad.

Table 86: Nodal Displacements for Problem # 4a (Response Spectrum) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
32 u_x	0.000	0.000	0.000	0.000	0.000	0.000	0.000
32 u_y	2.883	1.067	2.072	5.182	1.526	1.526	2.312
32 u_z	1.073	0.388	0.767	1.924	0.538	0.576	0.877
32 θ_x	5.419	1.959	3.875	9.719	2.719	2.910	4.427
32 θ_y	0.000	0.000	0.000	0.001	0.000	0.000	0.000
32 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad.*

Table 87: Forces and Moments in Primary System for Problem # 4a (Response Spectrum)

Elements	Load cases			
	a	b	c	d
1 R_{I1}	1.119	0.405	0.409	1.268
1 R_{I2}	4.231	0.695	1.160	3.009
1 R_{I3}	17780.000	6566.000	12730.000	31810.000
1 M_{I1}	0.000	0.000	0.000	0.000
1 M_{I2}	13690000.000	4947000.000	9795000.000	24570000.000
1 M_{I3}	1241.000	465.000	918.600	2427.000
1 R_{J1}	1.119	0.405	0.409	1.268
1 R_{J2}	4.231	0.695	1.160	3.009
1 R_{J3}	17780.000	6566.000	12730.000	31810.000
1 M_{J1}	0.000	0.000	0.000	0.000
1 M_{J2}	9759000.000	3505000.000	6987000.000	17550000.000
1 M_{J3}	1486.000	356.400	664.700	1764.000
2 R_{I1}	0.747	0.293	0.470	1.343
2 R_{I2}	1.595	0.300	0.540	1.403
2 R_{I3}	8070.000	2945.000	5771.000	14450.000
2 M_{I1}	0.000	0.000	0.000	0.000
2 M_{I2}	7831000.000	2812000.000	5606000.000	14090000.000
2 M_{I3}	1192.000	285.200	531.800	1411.000
2 R_{J1}	0.747	0.293	0.470	1.343
2 R_{J2}	1.595	0.300	0.540	1.403
2 R_{J3}	8070.000	2945.000	5771.000	14450.000
2 M_{J1}	0.000	0.000	0.000	0.000
2 M_{J2}	6043000.000	2162000.000	4328000.000	10890000.000
2 M_{J3}	1398.000	244.900	414.700	1104.000
3 R_{I1}	0.859	0.343	0.614	1.733
3 R_{I2}	2.395	0.730	1.412	3.741
3 R_{I3}	20600.000	7413.000	14740.000	37030.000
3 M_{I1}	0.000	0.000	0.000	0.000
3 M_{I2}	7961000.000	2849000.000	5702000.000	14340000.000
3 M_{I3}	1838.000	321.800	545.000	1451.000
3 R_{J1}	0.859	0.343	0.614	1.733
3 R_{J2}	2.395	0.730	1.412	3.741
3 R_{J3}	20600.000	7413.000	14740.000	37030.000
3 M_{J1}	0.000	0.000	0.000	0.000
3 M_{J2}	4131000.000	1472000.000	2961000.000	7459000.000
3 M_{J3}	1458.000	198.400	283.700	756.900

Units: R(Force): $Kips$; M(Moment): $In-Kips$

Table 88: Forces and Moments in Primary System for Problem # 4a (Response Spectrum) (contd.)

Elements	Load cases			
	a	b	c	d
4 R_{I1}	0.657	0.264	0.521	1.447
4 R_{I2}	2.975	0.474	0.774	2.054
4 R_{I3}	11050.000	3948.000	7917.000	19930.000
4 M_{I1}	0.000	0.000	0.000	0.000
4 M_{I2}	3907000.000	1393000.000	2800000.000	7052000.000
4 M_{I3}	1310.000	182.800	267.900	714.700
4 R_{J1}	0.657	0.264	0.521	1.447
4 R_{J2}	2.975	0.474	0.774	2.054
4 R_{J3}	11050.000	3948.000	7917.000	19930.000
4 M_{J1}	0.000	0.000	0.000	0.000
4 M_{J2}	1594000.000	567300.000	1143000.000	2882000.000
4 M_{J3}	689.500	85.530	107.100	287.600
5 R_{I1}	0.402	0.157	0.317	0.867
5 R_{I2}	1.057	0.382	0.761	1.998
5 R_{I3}	10920.000	3963.000	7816.000	19590.000
5 M_{I1}	0.000	0.000	0.000	0.000
5 M_{I2}	479300.000	184200.000	343600.000	856600.000
5 M_{I3}	346.900	37.470	38.040	93.140
5 R_{J1}	0.402	0.157	0.317	0.867
5 R_{J2}	1.057	0.382	0.761	1.998
5 R_{J3}	10920.000	3963.000	7816.000	19590.000
5 M_{J1}	0.000	0.000	0.000	0.000
5 M_{J2}	1833000.000	658800.000	1313000.000	3297000.000
5 M_{J3}	309.900	68.550	125.200	332.900
6 R_{I1}	0.686	0.253	0.466	1.253
6 R_{I2}	2.030	0.237	0.269	0.722
6 R_{I3}	4039.000	1436.000	2900.000	7313.000
6 M_{I1}	0.000	0.000	0.000	0.000
6 M_{I2}	546900.000	194500.000	392600.000	990100.000
6 M_{I3}	274.300	32.060	36.380	97.650
6 R_{J1}	0.686	0.253	0.466	1.253
6 R_{J2}	2.030	0.237	0.269	0.722
6 R_{J3}	4039.000	1436.000	2900.000	7313.000
6 M_{J1}	0.000	0.000	0.000	0.000
6 M_{J2}	13.920	6.233	10.670	27.680
6 M_{J3}	0.075	0.019	0.036	0.097

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 89: Forces and Moments in Primary System for Problem # 4a (Response Spectrum) (contd.)

Elements	Load cases			
	a	b	c	d
7 R_{I1}	0.000	0.000	0.000	0.000
7 R_{I2}	6.077	1.634	3.106	8.238
7 R_{I3}	45260.000	16300.000	32400.000	81350.000
7 M_{I1}	0.000	0.000	0.000	0.000
7 M_{I2}	3055000.000	1100000.000	2187000.000	5491000.000
7 M_{I3}	410.200	110.300	209.600	556.000
7 R_{J1}	0.000	0.000	0.000	0.000
7 R_{J2}	6.077	1.634	3.106	8.238
7 R_{J3}	45260.000	16300.000	32400.000	81350.000
7 M_{J1}	0.000	0.000	0.000	0.000
7 M_{J2}	3055000.000	1100000.000	2187000.000	5491000.000
7 M_{J3}	410.200	110.300	209.600	556.000

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 90: Forces and Moments in Primary System for Problem # 4a (Response Spectrum) (contd.)

Elements	Load cases		
	e	f	g
1 R_{I1}	0.191	0.245	0.800
1 R_{I2}	0.595	0.945	2.974
1 R_{I3}	9460.000	9328.000	14240.000
1 M_{I1}	0.000	0.000	0.000
1 M_{I2}	6844000.000	7364000.000	11190000.000
1 M_{I3}	480.200	747.300	1162.000
1 R_{J1}	0.191	0.245	0.800
1 R_{J2}	0.595	0.945	2.974
1 R_{J3}	9460.000	9328.000	14240.000
1 M_{J1}	0.000	0.000	0.000
1 M_{J2}	4760000.000	5301000.000	8038000.000
1 M_{J3}	349.100	543.500	1146.000
2 R_{I1}	0.227	0.242	0.626
2 R_{I2}	0.276	0.430	1.149
2 R_{I3}	4160.000	4287.000	6535.000
2 M_{I1}	0.000	0.000	0.000
2 M_{I2}	3817000.000	4254000.000	6451000.000
2 M_{I3}	279.300	434.700	918.600
2 R_{J1}	0.227	0.242	0.626
2 R_{J2}	0.276	0.430	1.149
2 R_{J3}	4160.000	4287.000	6535.000
2 M_{J1}	0.000	0.000	0.000
2 M_{J2}	2898000.000	3303000.000	5000000.000
2 M_{J3}	219.300	343.900	992.400
3 R_{I1}	0.300	0.319	0.754
3 R_{I2}	0.740	1.150	2.021
3 R_{I3}	10130.000	11150.000	16930.000
3 M_{I1}	0.000	0.000	0.000
3 M_{I2}	3818000.000	4352000.000	6588000.000
3 M_{I3}	288.100	451.700	1305.000
3 R_{J1}	0.300	0.319	0.754
3 R_{J2}	0.740	1.150	2.021
3 R_{J3}	10130.000	11150.000	16930.000
3 M_{J1}	0.000	0.000	0.000
3 M_{J2}	1936000.000	2277000.000	3439000.000
3 M_{J3}	151.100	240.100	993.400

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 91: Forces and Moments in Primary System for Problem # 4a (Response Spectrum) (contd.)

Elements	Load cases		
	e	f	g
4 R_{I1}	0.257	0.274	0.599
4 R_{I2}	0.405	0.631	2.071
4 R_{I3}	5257.000	6059.000	9164.000
4 M_{I1}	0.000	0.000	0.000
4 M_{I2}	1839000.000	2150000.000	3249000.000
4 M_{I3}	142.600	226.100	895.400
4 R_{J1}	0.257	0.274	0.599
4 R_{J2}	0.405	0.631	2.071
4 R_{J3}	5257.000	6059.000	9164.000
4 M_{J1}	0.000	0.000	0.000
4 M_{J2}	739300.000	882000.000	1330000.000
4 M_{J3}	58.300	94.920	465.600
5 R_{I1}	0.158	0.170	0.361
5 R_{I2}	0.393	0.608	0.974
5 R_{I3}	5532.000	5847.000	8896.000
5 M_{I1}	0.000	0.000	0.000
5 M_{I2}	277100.000	241900.000	371400.000
5 M_{I3}	18.060	29.520	231.600
5 R_{J1}	0.158	0.170	0.361
5 R_{J2}	0.393	0.608	0.974
5 R_{J3}	5532.000	5847.000	8896.000
5 M_{J1}	0.000	0.000	0.000
5 M_{J2}	896700.000	994900.000	1509000.000
5 M_{J3}	66.170	103.600	233.300
6 R_{I1}	0.232	0.254	0.571
6 R_{I2}	0.148	0.244	1.361
6 R_{I3}	1853.000	2245.000	3382.000
6 M_{I1}	0.000	0.000	0.000
6 M_{I2}	251000.000	303900.000	457800.000
6 M_{I3}	19.980	33.020	183.800
6 R_{J1}	0.232	0.254	0.571
6 R_{J2}	0.148	0.244	1.361
6 R_{J3}	1853.000	2245.000	3382.000
6 M_{J1}	0.000	0.000	0.000
6 M_{J2}	7.312	8.067	11.230
6 M_{J3}	0.019	0.030	0.059

Units: R(Force): $Kips$; M(Moment): $In-Kips$

Table 92: Forces and Moments in Primary System for Problem # 4a (Response Spectrum) (con

Elements	Load cases		
	e	f	g
7 R_{I1}	0.000	0.000	0.000
7 R_{I2}	1.633	2.546	4.883
7 R_{I3}	22310.000	24490.000	37170.000
7 M_{I1}	0.000	0.000	0.000
7 M_{I2}	1506000.000	1653000.000	2509000.000
7 M_{I3}	110.200	171.800	329.600
7 R_{J1}	0.000	0.000	0.000
7 R_{J2}	1.633	2.546	4.883
7 R_{J3}	22310.000	24490.000	37170.000
7 M_{J1}	0.000	0.000	0.000
7 M_{J2}	1506000.000	1653000.000	2509000.000
7 M_{J3}	110.200	171.800	329.600

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 93: Forces and Moments in Support Elements for Problem # 4a (Response Spectrum)

Elements	Loadcases						
	a	b	c	d	e	f	g
$1R_{I1}$	0.215	0.076	0.154	0.389	0.088	0.121	0.180
$1R_{I2}$	0.048	0.017	0.033	0.089	0.013	0.022	0.040
$1R_{I3}$	0.572	0.205	0.420	1.085	0.254	0.334	0.495
$1M_{I1}$	1.288	0.535	1.265	3.177	0.424	0.637	1.324
$1M_{I2}$	3.004	1.076	2.207	5.688	1.309	1.751	2.596
$1M_{I3}$	0.270	0.106	0.252	0.656	0.088	0.124	0.268
$1R_{J1}$	0.215	0.076	0.154	0.389	0.088	0.121	0.180
$1R_{J2}$	0.048	0.017	0.033	0.089	0.013	0.022	0.040
$1R_{J3}$	0.572	0.205	0.420	1.085	0.254	0.334	0.495
$1M_{J1}$	1.288	0.535	1.265	3.177	0.424	0.637	1.324
$1M_{J2}$	9.039	3.239	6.649	17.170	4.028	5.275	7.836
$1M_{J3}$	1.060	0.397	0.861	2.208	0.315	0.514	0.965
$2R_{I1}$	0.259	0.114	0.186	0.444	0.173	0.117	0.171
$2R_{I2}$	0.048	0.018	0.034	0.088	0.015	0.027	0.042
$2R_{I3}$	0.308	0.113	0.197	0.495	0.166	0.139	0.213
$2M_{I1}$	0.119	0.045	0.086	0.224	0.037	0.057	0.104
$2M_{I2}$	1.829	0.716	1.220	2.991	1.062	0.831	1.243
$2M_{I3}$	0.201	0.072	0.136	0.356	0.063	0.110	0.171
$2R_{J1}$	0.259	0.114	0.186	0.444	0.173	0.117	0.171
$2R_{J2}$	0.048	0.018	0.034	0.088	0.015	0.027	0.042
$2R_{J3}$	0.308	0.113	0.197	0.495	0.166	0.139	0.213
$2M_{J1}$	0.119	0.045	0.086	0.224	0.037	0.057	0.104
$2M_{J2}$	6.178	2.209	3.906	9.860	3.255	2.765	4.285
$2M_{J3}$	1.058	0.386	0.734	1.926	0.334	0.579	0.924
$3R_{I1}$	1.353	0.525	1.205	3.002	0.573	0.683	1.300
$3R_{I2}$	0.622	0.245	0.572	1.444	0.196	0.283	0.604
$3R_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3R_{J1}$	1.353	0.525	1.205	3.002	0.573	0.683	1.300
$3R_{J2}$	0.622	0.245	0.572	1.444	0.196	0.283	0.604
$3R_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{J3}$	4.045	1.594	3.718	9.387	1.270	1.841	3.928
$4R_{I1}$	3.202	1.213	2.557	6.462	1.261	1.792	2.871
$4R_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4R_{I3}$	0.684	0.252	0.515	1.287	0.273	0.380	0.599
$4M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000

R = Force (Kips)   M = Moment (Kips-ft)

Table 94: Forces and Moments in Support Elements for Problem # 4a (Response Spectrum)

Elements	Loadcases						
	a	b	c	d	e	f	g
$4R_{J1}$	3.202	1.213	2.557	6.462	1.261	1.792	2.871
$4R_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4R_{J3}$	0.684	0.252	0.515	1.287	0.273	0.380	0.599
$4M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4M_{J2}$	4.564	1.683	3.434	8.588	1.817	2.532	3.996
$4M_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5R_{I1}$	3.668	1.452	3.186	8.043	1.388	1.982	3.448
$5R_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5R_{I3}$	0.798	0.319	0.689	1.740	0.308	0.435	0.757
$5M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5R_{J1}$	3.668	1.452	3.186	8.043	1.388	1.982	3.448
$5R_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5R_{J3}$	0.798	0.319	0.689	1.740	0.308	0.435	0.757
$5M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5M_{J2}$	5.325	2.129	4.598	11.610	2.053	2.905	5.050
$5M_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6R_{I1}$	0.106	0.037	0.073	0.154	0.040	0.047	0.094
$6R_{I2}$	0.572	0.230	0.526	1.328	0.187	0.303	0.562
$6R_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6R_{J1}$	0.106	0.037	0.073	0.154	0.040	0.047	0.094
$6R_{J2}$	0.572	0.230	0.526	1.328	0.187	0.303	0.562
$6R_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{J3}$	0.859	0.344	0.788	1.991	0.281	0.455	0.843
$7R_{I1}$	1.737	0.767	1.523	3.817	1.020	0.773	1.460
$7R_{I2}$	0.129	0.049	0.100	0.256	0.045	0.077	0.118
$7R_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7R_{J1}$	1.737	0.767	1.523	3.817	1.020	0.773	1.460
$7R_{J2}$	0.129	0.049	0.100	0.256	0.045	0.077	0.118
$7R_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{J3}$	2.133	0.804	1.646	4.223	0.737	1.279	1.943

R = Force (Kips)   M = Moment (Kips-ft)

Table 95: Forces and Moments in Secondary System for Problem # 4a (Response Spectrum)

Elements	Load cases						
	a	b	c	d	e	f	g
1 R_{I1}	0.055	0.020	0.042	0.112	0.015	0.028	0.049
1 R_{I2}	0.048	0.017	0.033	0.089	0.013	0.022	0.040
1 R_{I3}	0.609	0.218	0.446	1.147	0.268	0.354	0.525
1 M_{I1}	1.289	0.537	1.275	3.202	0.426	0.637	1.331
1 M_{I2}	3.004	1.076	2.207	5.688	1.309	1.751	2.596
1 M_{I3}	0.262	0.095	0.196	0.519	0.076	0.125	0.232
1 R_{J1}	0.055	0.020	0.042	0.112	0.015	0.028	0.049
1 R_{J2}	0.048	0.017	0.033	0.089	0.013	0.022	0.040
1 R_{J3}	0.609	0.218	0.446	1.147	0.268	0.354	0.525
1 M_{J1}	1.289	0.537	1.275	3.202	0.426	0.637	1.331
1 M_{J2}	1.071	0.381	0.784	2.006	0.481	0.615	0.921
1 M_{J3}	0.069	0.020	0.036	0.098	0.017	0.029	0.046
2 R_{I1}	0.055	0.020	0.042	0.112	0.015	0.028	0.049
2 R_{I2}	0.028	0.011	0.024	0.064	0.009	0.014	0.028
2 R_{I3}	0.154	0.058	0.123	0.319	0.060	0.089	0.141
2 M_{I1}	1.289	0.537	1.275	3.202	0.426	0.637	1.331
2 M_{I2}	1.071	0.381	0.784	2.006	0.481	0.615	0.921
2 M_{I3}	0.069	0.020	0.036	0.098	0.017	0.029	0.046
2 R_{J1}	0.055	0.020	0.042	0.112	0.015	0.028	0.049
2 R_{J2}	0.028	0.011	0.024	0.064	0.009	0.014	0.028
2 R_{J3}	0.154	0.058	0.123	0.319	0.060	0.089	0.141
2 M_{J1}	1.289	0.537	1.275	3.202	0.426	0.637	1.331
2 M_{J2}	1.999	0.723	1.490	3.853	0.850	1.171	1.745
2 M_{J3}	0.222	0.085	0.180	0.475	0.067	0.108	0.210
3 R_{I1}	0.055	0.020	0.042	0.112	0.015	0.028	0.049
3 R_{I2}	0.036	0.011	0.023	0.059	0.009	0.014	0.027
3 R_{I3}	0.366	0.133	0.281	0.713	0.167	0.207	0.323
3 M_{I1}	1.289	0.537	1.275	3.202	0.426	0.637	1.331
3 M_{I2}	1.999	0.723	1.490	3.853	0.850	1.171	1.745
3 M_{I3}	0.222	0.085	0.180	0.475	0.067	0.108	0.210
3 R_{J1}	0.055	0.020	0.042	0.112	0.015	0.028	0.049
3 R_{J2}	0.036	0.011	0.023	0.059	0.009	0.014	0.027
3 R_{J3}	0.366	0.133	0.281	0.713	0.167	0.207	0.323
3 M_{J1}	1.289	0.537	1.275	3.202	0.426	0.637	1.331
3 M_{J2}	1.237	0.506	1.199	2.987	0.466	0.597	1.259
3 M_{J3}	0.338	0.132	0.295	0.756	0.106	0.154	0.328

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 96: Forces and Moments in Secondary System for Problem # 4a (Response Spectrum) (contd.

Elements	Load cases						
	a	b	c	d	e	f	g
4 R_{I1}	0.054	0.020	0.042	0.112	0.015	0.028	0.049
4 R_{I2}	0.597	0.237	0.553	1.397	0.189	0.276	0.584
4 R_{I3}	0.918	0.379	0.900	2.246	0.336	0.441	0.942
4 M_{I1}	1.289	0.537	1.275	3.202	0.426	0.637	1.331
4 M_{I2}	1.237	0.506	1.199	2.987	0.466	0.597	1.259
4 M_{I3}	0.338	0.132	0.295	0.756	0.106	0.154	0.328
4 R_{J1}	0.597	0.237	0.553	1.397	0.189	0.276	0.584
4 R_{J2}	0.054	0.020	0.042	0.112	0.015	0.028	0.049
4 R_{J3}	0.918	0.379	0.900	2.246	0.336	0.441	0.942
4 M_{J1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
4 M_{J2}	0.566	0.201	0.405	1.007	0.250	0.313	0.479
4 M_{J3}	0.524	0.209	0.492	1.241	0.166	0.246	0.516
5 R_{I1}	0.592	0.235	0.549	1.386	0.187	0.275	0.580
5 R_{I2}	0.054	0.020	0.044	0.115	0.015	0.028	0.049
5 R_{I3}	0.810	0.339	0.806	2.022	0.270	0.394	0.839
5 M_{I1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
5 M_{I2}	0.566	0.201	0.405	1.007	0.250	0.313	0.479
5 M_{I3}	0.524	0.209	0.492	1.241	0.166	0.246	0.516
5 R_{J1}	0.592	0.235	0.549	1.386	0.187	0.275	0.580
5 R_{J2}	0.054	0.020	0.044	0.115	0.015	0.028	0.049
5 R_{J3}	0.810	0.339	0.806	2.022	0.270	0.394	0.839
5 M_{J1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
5 M_{J2}	5.702	2.385	5.690	14.250	1.941	2.749	5.919
5 M_{J3}	0.356	0.136	0.268	0.738	0.105	0.170	0.344
6 R_{I1}	0.584	0.232	0.543	1.370	0.185	0.274	0.573
6 R_{I2}	0.052	0.021	0.049	0.125	0.016	0.026	0.052
6 R_{I3}	0.603	0.232	0.503	1.271	0.220	0.336	0.558
6 M_{I1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
6 M_{I2}	5.702	2.385	5.690	14.250	1.941	2.749	5.919
6 M_{I3}	0.356	0.136	0.268	0.738	0.105	0.170	0.344
6 R_{J1}	0.584	0.232	0.543	1.370	0.185	0.274	0.573
6 R_{J2}	0.052	0.021	0.049	0.125	0.016	0.026	0.052
6 R_{J3}	0.603	0.232	0.503	1.271	0.220	0.336	0.558
6 M_{J1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
6 M_{J2}	8.990	3.698	8.638	21.760	2.950	4.596	9.106
6 M_{J3}	0.331	0.129	0.248	0.659	0.107	0.219	0.320

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 97: Forces and Moments in Secondary System for Problem # 4a (Response Spectrum) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
7 R_{I1}	0.577	0.230	0.537	1.354	0.184	0.274	0.567
7 R_{I2}	0.062	0.023	0.050	0.136	0.016	0.024	0.058
7 R_{I3}	0.797	0.291	0.578	1.435	0.360	0.447	0.673
7 M_{I1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
7 M_{I2}	8.990	3.698	8.638	21.760	2.950	4.596	9.106
7 M_{I3}	0.331	0.129	0.248	0.659	0.107	0.219	0.320
7 R_{J1}	0.577	0.230	0.537	1.354	0.184	0.274	0.567
7 R_{J2}	0.062	0.023	0.050	0.136	0.016	0.024	0.058
7 R_{J3}	0.797	0.291	0.578	1.435	0.360	0.447	0.673
7 M_{J1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
7 M_{J2}	11.890	4.624	10.080	25.490	4.329	6.567	11.100
7 M_{J3}	0.568	0.227	0.513	1.309	0.178	0.323	0.561
8 R_{I1}	0.571	0.227	0.531	1.338	0.182	0.275	0.561
8 R_{I2}	0.092	0.036	0.080	0.202	0.030	0.057	0.091
8 R_{I3}	2.394	0.944	2.099	5.306	0.844	1.300	2.283
8 M_{I1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
8 M_{I2}	11.890	4.624	10.080	25.490	4.329	6.567	11.100
8 M_{I3}	0.568	0.227	0.513	1.309	0.178	0.323	0.561
8 R_{J1}	0.571	0.227	0.531	1.338	0.182	0.275	0.561
8 R_{J2}	0.092	0.036	0.080	0.202	0.030	0.057	0.091
8 R_{J3}	2.394	0.944	2.099	5.306	0.844	1.300	2.283
8 M_{J1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
8 M_{J2}	5.091	2.068	4.775	12.050	1.692	2.636	5.073
8 M_{J3}	0.178	0.064	0.116	0.305	0.052	0.105	0.168
9 R_{I1}	0.565	0.225	0.525	1.323	0.181	0.276	0.555
9 R_{I2}	0.062	0.025	0.055	0.142	0.020	0.038	0.062
9 R_{I3}	1.408	0.559	1.250	3.161	0.488	0.765	1.355
9 M_{I1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
9 M_{I2}	5.091	2.068	4.775	12.050	1.692	2.636	5.073
9 M_{I3}	0.178	0.064	0.116	0.305	0.052	0.105	0.168
9 R_{J1}	0.565	0.225	0.525	1.323	0.181	0.276	0.555
9 R_{J2}	0.062	0.025	0.055	0.142	0.020	0.038	0.062
9 R_{J3}	1.408	0.559	1.250	3.161	0.488	0.765	1.355
9 M_{J1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
9 M_{J2}	14.870	5.954	13.470	34.040	5.070	7.957	14.490
9 M_{J3}	0.528	0.211	0.445	1.134	0.175	0.349	0.522

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 98: Forces and Moments in Secondary System for Problem # 4a (Response Spectrum) (contd.

Elements	Load cases						
	a	b	c	d	e	f	g
10 R_{I1}	0.558	0.223	0.519	1.308	0.180	0.277	0.550
10 R_{I2}	0.022	0.006	0.013	0.033	0.004	0.006	0.018
10 R_{I3}	0.149	0.061	0.142	0.357	0.048	0.074	0.150
10 M_{I1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
10 M_{I2}	14.870	5.954	13.470	34.040	5.070	7.957	14.490
10 M_{I3}	0.528	0.211	0.445	1.134	0.175	0.349	0.522
10 R_{J1}	0.558	0.223	0.519	1.308	0.180	0.277	0.550
10 R_{J2}	0.022	0.006	0.013	0.033	0.004	0.006	0.018
10 R_{J3}	0.149	0.061	0.142	0.357	0.048	0.074	0.150
10 M_{J1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
10 M_{J2}	13.890	5.554	12.520	31.630	4.774	7.468	13.490
10 M_{J3}	0.571	0.229	0.498	1.272	0.186	0.361	0.563
11 R_{I1}	0.553	0.221	0.513	1.294	0.179	0.279	0.545
11 R_{I2}	0.052	0.020	0.042	0.109	0.017	0.034	0.051
11 R_{I3}	1.627	0.651	1.472	3.720	0.554	0.872	1.584
11 M_{I1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
11 M_{I2}	13.890	5.554	12.520	31.630	4.774	7.468	13.490
11 M_{I3}	0.571	0.229	0.498	1.272	0.186	0.361	0.563
11 R_{J1}	0.553	0.221	0.513	1.294	0.179	0.279	0.545
11 R_{J2}	0.052	0.020	0.042	0.109	0.017	0.034	0.051
11 R_{J3}	1.627	0.651	1.472	3.720	0.554	0.872	1.584
11 M_{J1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
11 M_{J2}	2.514	1.004	2.226	5.616	0.903	1.367	2.409
11 M_{J3}	0.234	0.094	0.216	0.557	0.076	0.131	0.231
12 R_{I1}	0.549	0.220	0.508	1.280	0.179	0.282	0.540
12 R_{I2}	0.089	0.034	0.071	0.184	0.027	0.054	0.084
12 R_{I3}	2.473	0.987	2.210	5.581	0.871	1.332	2.384
12 M_{I1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
12 M_{I2}	2.514	1.004	2.226	5.616	0.903	1.367	2.409
12 M_{I3}	0.234	0.094	0.216	0.557	0.076	0.131	0.231
12 R_{J1}	0.549	0.220	0.508	1.280	0.179	0.282	0.540
12 R_{J2}	0.089	0.034	0.071	0.184	0.027	0.054	0.084
12 R_{J3}	2.473	0.987	2.210	5.581	0.871	1.332	2.384
12 M_{J1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
12 M_{J2}	14.800	5.905	13.240	33.460	5.194	7.958	14.280
12 M_{J3}	0.422	0.156	0.306	0.817	0.131	0.262	0.397

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 99: Forces and Moments in Secondary System for Problem # 4a (Response Spectrum) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
13 R_{I1}	0.546	0.219	0.503	1.269	0.178	0.285	0.537
13 R_{I2}	0.031	0.009	0.017	0.047	0.006	0.012	0.029
13 R_{I3}	1.125	0.444	0.969	2.447	0.433	0.607	1.050
13 M_{I1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
13 M_{I2}	14.800	5.905	13.240	33.460	5.194	7.958	14.280
13 M_{I3}	0.422	0.156	0.306	0.817	0.131	0.262	0.397
13 R_{J1}	0.546	0.219	0.503	1.269	0.178	0.285	0.537
13 R_{J2}	0.031	0.009	0.017	0.047	0.006	0.012	0.029
13 R_{J3}	1.125	0.444	0.969	2.447	0.433	0.607	1.050
13 M_{J1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
13 M_{J2}	7.103	2.873	6.578	16.610	2.341	3.772	7.033
13 M_{J3}	0.306	0.116	0.248	0.624	0.097	0.194	0.290
14 R_{I1}	0.544	0.218	0.498	1.257	0.178	0.288	0.533
14 R_{I2}	0.035	0.013	0.026	0.067	0.011	0.022	0.032
14 R_{I3}	1.175	0.474	1.083	2.736	0.389	0.626	1.160
14 M_{I1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
14 M_{I2}	7.103	2.873	6.578	16.610	2.341	3.772	7.033
14 M_{I3}	0.306	0.116	0.248	0.624	0.097	0.194	0.290
14 R_{J1}	0.544	0.218	0.498	1.257	0.178	0.288	0.533
14 R_{J2}	0.035	0.013	0.026	0.067	0.011	0.022	0.032
14 R_{J3}	1.175	0.474	1.083	2.736	0.389	0.626	1.160
14 M_{J1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
14 M_{J2}	1.137	0.452	1.014	2.561	0.395	0.615	1.095
14 M_{J3}	0.084	0.031	0.071	0.185	0.024	0.044	0.084
15 R_{I1}	0.543	0.217	0.494	1.249	0.178	0.290	0.531
15 R_{I2}	0.054	0.020	0.045	0.112	0.016	0.031	0.053
15 R_{I3}	1.159	0.475	1.094	2.762	0.383	0.606	1.159
15 M_{I1}	0.189	0.077	0.179	0.452	0.062	0.099	0.189
15 M_{I2}	1.137	0.452	1.014	2.561	0.395	0.615	1.095
15 M_{I3}	0.084	0.031	0.071	0.185	0.024	0.044	0.084
15 R_{J1}	1.159	0.475	1.094	2.762	0.383	0.606	1.159
15 R_{J2}	0.543	0.217	0.494	1.249	0.178	0.290	0.531
15 R_{J3}	0.054	0.020	0.045	0.112	0.016	0.031	0.053
15 M_{J1}	0.025	0.007	0.015	0.045	0.009	0.010	0.021
15 M_{J2}	0.150	0.060	0.133	0.333	0.048	0.078	0.148
15 M_{J3}	2.034	0.826	1.895	4.788	0.665	1.078	2.021

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 100: Forces and Moments in Secondary System for Problem # 4a (Response Spectrum) (contc

Elements	Load cases						
	a	b	c	d	e	f	g
16 R_{I1}	1.161	0.482	1.107	2.794	0.406	0.596	1.161
16 R_{I2}	0.553	0.222	0.504	1.273	0.182	0.297	0.541
16 R_{I3}	0.070	0.026	0.057	0.146	0.020	0.037	0.070
16 M_{I1}	0.025	0.007	0.015	0.045	0.009	0.010	0.021
16 M_{I2}	0.150	0.060	0.133	0.333	0.048	0.078	0.148
16 M_{I3}	2.034	0.826	1.895	4.788	0.665	1.078	2.021
16 R_{J1}	1.161	0.482	1.107	2.794	0.406	0.596	1.161
16 R_{J2}	0.553	0.222	0.504	1.273	0.182	0.297	0.541
16 R_{J3}	0.070	0.026	0.057	0.146	0.020	0.037	0.070
16 M_{J1}	0.025	0.007	0.015	0.045	0.009	0.010	0.021
16 M_{J2}	0.337	0.115	0.233	0.590	0.087	0.178	0.328
16 M_{J3}	0.775	0.294	0.646	1.632	0.265	0.422	0.714
17 R_{I1}	1.212	0.516	1.156	2.915	0.501	0.598	1.185
17 R_{I2}	0.049	0.015	0.032	0.080	0.014	0.020	0.036
17 R_{I3}	0.098	0.037	0.083	0.201	0.039	0.041	0.089
17 M_{I1}	0.025	0.007	0.015	0.045	0.009	0.010	0.021
17 M_{I2}	0.337	0.115	0.233	0.590	0.087	0.178	0.328
17 M_{I3}	0.775	0.294	0.646	1.632	0.265	0.422	0.714
17 R_{J1}	1.212	0.516	1.156	2.915	0.501	0.598	1.185
17 R_{J2}	0.049	0.015	0.032	0.080	0.014	0.020	0.036
17 R_{J3}	0.098	0.037	0.083	0.201	0.039	0.041	0.089
17 M_{J1}	0.025	0.007	0.015	0.045	0.009	0.010	0.021
17 M_{J2}	0.847	0.327	0.756	1.935	0.332	0.375	0.788
17 M_{J3}	0.470	0.183	0.392	0.996	0.160	0.270	0.437
18 R_{I1}	1.331	0.580	1.247	3.137	0.656	0.629	1.243
18 R_{I2}	0.063	0.024	0.053	0.134	0.021	0.036	0.058
18 R_{I3}	0.058	0.030	0.056	0.137	0.035	0.031	0.056
18 M_{I1}	0.025	0.007	0.015	0.045	0.009	0.010	0.021
18 M_{I2}	0.847	0.327	0.756	1.935	0.332	0.375	0.788
18 M_{I3}	0.470	0.183	0.392	0.996	0.160	0.270	0.437
18 R_{J1}	1.331	0.580	1.247	3.137	0.656	0.629	1.243
18 R_{J2}	0.063	0.024	0.053	0.134	0.021	0.036	0.058
18 R_{J3}	0.058	0.030	0.056	0.137	0.035	0.031	0.056
18 M_{J1}	0.025	0.007	0.015	0.045	0.009	0.010	0.021
18 M_{J2}	1.143	0.501	1.088	2.741	0.554	0.552	1.087
18 M_{J3}	0.055	0.021	0.044	0.111	0.020	0.033	0.050

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 101: Forces and Moments in Secondary System for Problem # 4a (Response Spectrum) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
19 R_{I1}	1.428	0.629	1.316	3.308	0.761	0.661	1.291
19 R_{I2}	0.079	0.031	0.065	0.164	0.027	0.046	0.073
19 R_{I3}	0.056	0.029	0.052	0.123	0.034	0.029	0.054
19 M_{I1}	0.025	0.007	0.015	0.045	0.009	0.010	0.021
19 M_{I2}	1.143	0.501	1.088	2.741	0.554	0.552	1.087
19 M_{I3}	0.055	0.021	0.044	0.111	0.020	0.033	0.050
19 R_{J1}	0.056	0.029	0.052	0.123	0.034	0.029	0.054
19 R_{J2}	0.079	0.031	0.065	0.164	0.027	0.046	0.073
19 R_{J3}	1.428	0.629	1.316	3.308	0.761	0.661	1.291
19 M_{J1}	0.065	0.025	0.054	0.138	0.022	0.037	0.061
19 M_{J2}	0.984	0.414	0.836	2.109	0.549	0.423	0.817
19 M_{J3}	0.119	0.046	0.096	0.246	0.044	0.072	0.110
20 R_{I1}	0.056	0.029	0.052	0.123	0.034	0.029	0.054
20 R_{I2}	0.038	0.014	0.027	0.070	0.012	0.022	0.033
20 R_{I3}	0.295	0.118	0.201	0.495	0.182	0.124	0.194
20 M_{I1}	0.065	0.025	0.054	0.138	0.022	0.037	0.061
20 M_{I2}	0.984	0.414	0.836	2.109	0.549	0.423	0.817
20 M_{I3}	0.119	0.046	0.096	0.246	0.044	0.072	0.110
20 R_{J1}	0.056	0.029	0.052	0.123	0.034	0.029	0.054
20 R_{J2}	0.038	0.014	0.027	0.070	0.012	0.022	0.033
20 R_{J3}	0.295	0.118	0.201	0.495	0.182	0.124	0.194
20 M_{J1}	0.065	0.025	0.054	0.138	0.022	0.037	0.061
20 M_{J2}	0.883	0.340	0.640	1.581	0.435	0.433	0.686
20 M_{J3}	0.107	0.038	0.071	0.184	0.033	0.048	0.086
21 R_{I1}	0.057	0.029	0.052	0.124	0.034	0.029	0.054
21 R_{I2}	0.010	0.004	0.007	0.019	0.003	0.006	0.009
21 R_{I3}	0.081	0.033	0.066	0.167	0.045	0.034	0.065
21 M_{I1}	0.065	0.025	0.054	0.138	0.022	0.037	0.061
21 M_{I2}	0.883	0.340	0.640	1.581	0.435	0.433	0.686
21 M_{I3}	0.107	0.038	0.071	0.184	0.033	0.048	0.086
21 R_{J1}	0.057	0.029	0.052	0.124	0.034	0.029	0.054
21 R_{J2}	0.010	0.004	0.007	0.019	0.003	0.006	0.009
21 R_{J3}	0.081	0.033	0.066	0.167	0.045	0.034	0.065
21 M_{J1}	0.065	0.025	0.054	0.138	0.022	0.037	0.061
21 M_{J2}	1.083	0.418	0.710	1.737	0.621	0.484	0.728
21 M_{J3}	0.139	0.049	0.090	0.237	0.042	0.070	0.114

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 102: Forces and Moments in Secondary System for Problem # 4a (Response Spectrum) (contd

Elements	Load cases						
	a	b	c	d	e	f	g
22 R_{I1}	0.057	0.029	0.053	0.124	0.034	0.029	0.055
22 R_{I2}	0.025	0.008	0.015	0.040	0.007	0.011	0.019
22 R_{I3}	0.185	0.070	0.122	0.299	0.099	0.085	0.129
22 M_{I1}	0.065	0.025	0.054	0.138	0.022	0.037	0.061
22 M_{I2}	1.083	0.418	0.710	1.737	0.621	0.484	0.728
22 M_{I3}	0.139	0.049	0.090	0.237	0.042	0.070	0.114
22 R_{J1}	0.057	0.029	0.053	0.124	0.034	0.029	0.055
22 R_{J2}	0.025	0.008	0.015	0.040	0.007	0.011	0.019
22 R_{J3}	0.185	0.070	0.122	0.299	0.099	0.085	0.129
22 M_{J1}	0.065	0.025	0.054	0.138	0.022	0.037	0.061
22 M_{J2}	0.200	0.088	0.159	0.399	0.133	0.087	0.147
22 M_{J3}	0.026	0.010	0.020	0.051	0.010	0.016	0.024
23 R_{I1}	0.058	0.029	0.053	0.124	0.034	0.029	0.055
23 R_{I2}	0.048	0.018	0.034	0.088	0.015	0.027	0.042
23 R_{I3}	0.399	0.158	0.266	0.653	0.238	0.179	0.267
23 M_{I1}	0.065	0.025	0.054	0.138	0.022	0.037	0.061
23 M_{I2}	0.200	0.088	0.159	0.399	0.133	0.087	0.147
23 M_{I3}	0.026	0.010	0.020	0.051	0.010	0.016	0.024
23 R_{J1}	0.058	0.029	0.053	0.124	0.034	0.029	0.055
23 R_{J2}	0.048	0.018	0.034	0.088	0.015	0.027	0.042
23 R_{J3}	0.399	0.158	0.266	0.653	0.238	0.179	0.267
23 M_{J1}	0.065	0.025	0.054	0.138	0.022	0.037	0.061
23 M_{J2}	1.829	0.716	1.220	2.991	1.062	0.831	1.243
23 M_{J3}	0.224	0.081	0.152	0.398	0.070	0.118	0.191

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 103: Nodal Displacements for Problem # 4b (Response Spectrum)

Nodes	Load cases						
	a	b	c	d	e	f	g
2 u_x	3.988	2.339	3.412	9.906	3.250	2.288	3.141
2 u_y	0.001	0.000	0.000	0.002	0.000	0.000	0.001
2 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2 θ_x	0.001	0.001	0.001	0.002	0.001	0.001	0.001
2 θ_y	10.950	6.541	9.536	27.940	8.822	6.548	8.773
2 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 u_x	9.886	5.846	8.524	24.860	8.016	5.779	7.852
3 u_y	0.002	0.001	0.001	0.003	0.001	0.001	0.002
3 u_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3 θ_x	0.002	0.001	0.002	0.004	0.001	0.002	0.001
3 θ_y	19.080	11.430	16.660	48.860	15.340	11.480	15.320
3 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4 u_x	15.800	9.387	13.690	40.000	12.770	9.335	12.600
4 u_y	0.002	0.001	0.002	0.004	0.001	0.001	0.002
4 u_z	0.000	0.000	0.000	0.001	0.000	0.000	0.000
4 θ_x	0.003	0.001	0.002	0.006	0.001	0.002	0.002
4 θ_y	23.890	14.330	20.900	61.350	19.170	14.440	19.210
4 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5 u_x	23.060	13.750	20.050	58.700	18.600	13.740	18.450
5 u_y	0.002	0.001	0.002	0.005	0.001	0.002	0.002
5 u_z	0.000	0.000	0.000	0.001	0.000	0.000	0.000
5 θ_x	0.004	0.002	0.003	0.007	0.002	0.003	0.003
5 θ_y	27.400	16.470	24.000	70.510	21.960	16.620	22.060
5 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6 u_x	30.510	18.240	26.590	77.940	24.550	18.290	24.460
6 u_y	0.003	0.002	0.003	0.007	0.002	0.003	0.002
6 u_z	0.000	0.000	0.000	0.001	0.000	0.000	0.000
6 θ_x	0.005	0.002	0.003	0.008	0.002	0.003	0.004
6 θ_y	29.200	17.570	25.610	75.240	23.390	17.740	23.530
6 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7 u_x	35.140	21.040	30.670	89.940	28.270	21.120	28.210
7 u_y	0.003	0.002	0.003	0.008	0.002	0.003	0.003
7 u_z	0.000	0.000	0.000	0.001	0.000	0.000	0.000
7 θ_x	0.005	0.002	0.003	0.008	0.002	0.003	0.004
7 θ_y	29.650	17.840	26.010	76.430	23.740	18.030	23.900
7 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Units: u_x, u_y and u_z: 10^{-2} in; θ_x, θ_y and θ_z: 10^{-5} rad.

Table 104: Nodal Displacements for Problem # 4b (Response Spectrum) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
8 u_x	39.500	23.670	34.500	101.200	31.750	23.780	31.720
8 u_y	0.004	0.002	0.004	0.009	0.002	0.003	0.003
8 u_z	0.000	0.000	0.000	0.001	0.000	0.000	0.000
8 θ_x	0.005	0.002	0.003	0.009	0.002	0.003	0.004
8 θ_y	29.760	17.910	26.110	76.730	23.830	18.100	23.990
8 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9 u_x	39.500	23.670	34.500	101.200	31.750	23.780	31.720
9 u_y	0.004	0.002	0.004	0.009	0.002	0.003	0.003
9 u_z	7.143	4.299	6.266	18.420	5.720	4.344	5.758
9 θ_x	0.005	0.002	0.003	0.009	0.002	0.003	0.004
9 θ_y	29.760	17.910	26.110	76.730	23.830	18.100	23.990
9 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10 u_x	39.620	23.740	34.600	101.500	31.850	23.860	31.820
10 u_y	0.491	0.420	0.619	1.176	0.319	0.313	0.455
10 u_z	4.831	3.356	4.932	12.450	3.876	3.089	4.057
10 θ_x	5.823	4.365	8.100	12.880	4.196	5.758	5.405
10 θ_y	49.480	37.090	54.870	124.100	37.110	31.330	41.900
10 θ_z	8.223	7.305	10.760	19.990	5.587	5.430	7.646
11 u_x	39.710	23.790	34.680	101.800	31.920	23.910	31.890
11 u_y	0.884	0.797	1.174	2.161	0.611	0.590	0.822
11 u_z	3.981	3.687	5.490	10.010	3.040	2.808	3.663
11 θ_x	11.650	8.730	16.200	25.760	8.393	11.520	10.810
11 θ_y	30.550	19.020	27.680	79.260	24.480	18.960	25.020
11 θ_z	1.928	0.900	1.295	3.952	0.498	0.754	1.723
12 u_x	39.770	23.820	34.730	101.900	31.960	23.950	31.930
12 u_y	0.004	0.002	0.004	0.009	0.002	0.003	0.003
12 u_z	0.001	0.000	0.001	0.001	0.000	0.000	0.001
12 θ_x	17.470	13.090	24.300	38.630	12.590	17.270	16.210
12 θ_y	95.510	94.350	140.800	241.300	73.100	69.870	89.540
12 θ_z	22.570	21.420	31.580	56.440	16.570	15.760	21.080
13 u_x	40.160	24.090	35.100	103.000	32.220	24.200	32.230
13 u_y	0.858	0.779	1.136	2.131	0.629	0.627	0.796
13 u_z	4.806	4.775	7.128	12.220	3.703	3.541	4.500
13 θ_x	22.950	17.170	28.230	52.770	16.210	20.530	21.060
13 θ_y	318.800	317.500	474.100	810.000	246.000	235.300	298.300
13 θ_z	67.910	66.410	98.200	171.900	51.550	48.710	63.410

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad*.

Table 105: Nodal Displacements for Problem # 4b (Response Spectrum) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
14 u_x	48.240	35.780	52.810	123.900	38.110	31.210	40.580
14 u_y	2.335	1.853	2.910	5.500	1.672	1.994	2.144
14 u_z	4.832	4.800	7.164	12.280	3.722	3.559	4.525
14 θ_x	11.760	8.382	14.820	26.270	8.432	11.430	10.690
14 θ_y	206.000	203.200	303.400	522.800	159.300	151.200	191.800
14 θ_z	102.000	100.000	148.500	258.100	77.670	73.760	95.220
15 u_x	46.280	36.640	54.280	118.600	36.360	30.630	39.640
15 u_y	2.291	1.769	2.864	5.318	1.651	2.051	2.088
15 u_z	4.854	4.820	7.193	12.340	3.737	3.574	4.545
15 θ_x	13.800	10.860	16.890	32.520	9.643	11.350	12.790
15 θ_y	169.000	156.000	232.200	433.500	131.000	120.700	153.400
15 θ_z	136.200	133.600	198.900	344.500	103.800	98.910	127.100
16 u_x	30.510	18.240	26.590	77.940	24.550	18.290	24.460
16 u_y	0.003	0.002	0.003	0.007	0.002	0.003	0.002
16 u_z	4.871	4.835	7.216	12.380	3.749	3.585	4.561
16 θ_x	40.970	31.130	51.360	94.010	29.620	37.650	37.080
16 θ_y	619.100	611.800	913.800	1573.000	476.700	454.300	575.700
16 θ_z	170.400	167.300	249.400	431.000	130.000	124.100	159.100
17 u_x	75.590	68.410	101.900	192.300	59.110	53.230	68.120
17 u_y	4.039	3.040	5.064	9.219	2.920	3.753	3.646
17 u_z	4.883	4.846	7.231	12.410	3.757	3.593	4.572
17 θ_x	46.610	35.000	58.650	106.500	33.840	43.710	42.080
17 θ_y	772.800	755.300	1128.000	1966.000	595.300	564.100	715.300
17 θ_z	204.700	201.000	299.800	517.600	156.200	149.300	191.100
18 u_x	123.500	116.400	173.500	314.100	95.870	88.620	112.800
18 u_y	6.928	5.217	8.724	15.860	5.036	6.489	6.254
18 u_z	4.890	4.852	7.240	12.430	3.762	3.597	4.580
18 θ_x	18.930	13.410	22.400	41.750	12.870	16.740	17.090
18 θ_y	326.600	319.400	477.000	831.100	251.100	238.400	302.300
18 θ_z	239.000	234.600	350.300	604.100	182.400	174.600	223.100
19 u_x	121.900	115.400	172.000	310.300	94.610	87.670	111.500
19 u_y	6.695	5.032	8.414	15.330	4.862	6.261	6.044
19 u_z	4.893	4.854	7.242	12.440	3.763	3.598	4.582
19 θ_x	23.250	17.220	28.890	52.270	16.560	21.550	21.030
19 θ_y	353.400	339.300	506.300	898.300	273.100	255.900	325.500
19 θ_z	273.300	268.300	400.800	690.700	208.700	199.800	255.200

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad*.

Table 106: Nodal Displacements for Problem # 4b (Response Spectrum) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
20 u_x	70.710	65.540	97.680	179.900	55.050	50.340	64.180
20 u_y	3.572	2.677	4.460	8.205	2.584	3.311	3.224
20 u_z	4.891	4.851	7.237	12.430	3.761	3.596	4.580
20 θ_x	45.960	34.440	57.660	104.800	33.280	42.970	41.500
20 θ_y	787.600	762.000	1137.000	2004.000	608.200	572.300	726.300
20 θ_z	307.600	302.000	451.300	777.400	234.900	225.100	287.200
21 u_x	15.800	9.387	13.690	40.000	12.770	9.335	12.600
21 u_y	0.002	0.001	0.002	0.004	0.001	0.001	0.002
21 u_z	4.884	4.843	7.225	12.410	3.755	3.590	4.574
21 θ_x	30.480	22.640	37.180	70.530	21.720	27.320	27.490
21 θ_y	609.500	593.900	886.700	1551.000	470.300	445.000	563.800
21 θ_z	341.900	335.600	501.800	864.000	261.100	250.300	319.200
22 u_x	31.510	29.730	44.420	79.520	24.290	22.450	28.750
22 u_y	1.310	0.814	1.298	2.778	0.773	0.957	1.174
22 u_z	4.872	4.831	7.207	12.380	3.746	3.581	4.563
22 θ_x	8.907	5.569	7.982	17.260	4.511	4.655	8.120
22 θ_y	157.800	154.000	230.400	398.800	120.100	115.900	147.800
22 θ_z	376.200	369.300	552.300	950.600	287.300	275.600	351.300
23 u_x	33.190	31.340	46.900	83.350	25.430	23.680	30.450
23 u_y	1.373	0.997	1.511	2.967	0.816	0.842	1.266
23 u_z	4.856	4.815	7.182	12.340	3.733	3.568	4.548
23 θ_x	28.890	27.730	40.140	73.070	21.860	20.520	26.600
23 θ_y	64.550	58.290	87.320	160.200	46.040	44.940	60.030
23 θ_z	410.600	403.000	602.700	1037.000	313.500	300.800	383.300
24 u_x	24.530	22.440	33.580	61.380	18.830	17.180	22.260
24 u_y	2.137	1.981	2.969	5.193	1.544	1.503	1.994
24 u_z	3.977	3.942	5.907	10.090	3.057	2.948	3.732
24 θ_x	70.640	69.590	103.900	179.500	54.290	51.920	65.990
24 θ_y	84.590	81.410	121.600	213.600	63.750	60.970	78.290
24 θ_z	425.500	417.300	624.500	1074.000	324.700	311.900	397.500
25 u_x	9.886	5.846	8.524	24.860	8.016	5.779	7.852
25 u_y	2.131	1.978	2.965	5.186	1.542	1.500	1.989
25 u_z	0.343	0.206	0.300	0.879	0.276	0.207	0.276
25 θ_x	52.100	51.190	76.760	132.100	39.970	38.540	48.730
25 θ_y	73.580	70.750	105.700	185.900	55.510	53.030	68.060
25 θ_z	277.700	272.700	408.100	702.500	212.000	204.000	259.900

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad*.

Table 107: Nodal Displacements for Problem # 4b (Response Spectrum) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
26 u_x	14.800	11.900	17.640	37.210	11.730	9.786	12.830
26 u_y	2.116	1.972	2.955	5.165	1.538	1.494	1.976
26 u_z	2.198	2.082	3.115	5.551	1.663	1.589	2.032
26 θ_x	4.401	4.272	6.410	11.070	3.356	3.231	4.112
26 θ_y	55.910	53.220	79.480	141.500	42.290	40.150	51.510
26 θ_z	42.570	41.250	61.620	106.600	32.210	30.760	39.570
27 u_x	10.470	6.392	9.345	26.240	8.497	6.168	8.379
27 u_y	2.100	1.964	2.944	5.142	1.533	1.487	1.961
27 u_z	0.898	0.804	1.199	2.278	0.679	0.631	0.813
27 θ_x	23.370	22.480	33.670	58.520	17.510	16.960	21.790
27 θ_y	42.980	39.660	59.160	109.100	32.590	30.460	39.160
27 θ_z	128.300	122.800	183.700	318.900	95.530	92.260	120.000
28 u_x	10.000	5.916	8.626	25.100	8.117	5.834	7.938
28 u_y	0.002	0.001	0.001	0.003	0.001	0.001	0.002
28 u_z	0.000	0.000	0.000	0.001	0.000	0.000	0.000
28 θ_x	11.440	10.220	15.290	28.680	8.329	8.034	10.580
28 θ_y	25.780	18.670	27.480	66.020	19.530	16.510	21.880
28 θ_z	48.120	42.720	64.070	116.300	33.560	32.720	44.710
29 u_x	9.984	5.904	8.609	25.070	8.102	5.825	7.925
29 u_y	2.026	1.536	2.267	4.426	1.163	1.173	1.847
29 u_z	1.397	0.901	1.315	3.580	1.064	0.859	1.152
29 θ_x	8.582	7.666	11.470	21.510	6.247	6.025	7.933
29 θ_y	21.390	12.870	18.680	54.870	16.590	12.880	17.310
29 θ_z	20.750	11.450	15.850	37.390	7.410	8.491	18.390
30 u_x	9.959	5.889	8.586	25.010	8.080	5.813	7.906
30 u_y	2.285	1.492	2.150	4.541	1.069	1.128	2.052
30 u_z	2.533	1.537	2.233	6.506	1.974	1.530	2.050
30 θ_x	5.721	5.111	7.644	14.340	4.164	4.017	5.288
30 θ_y	19.040	11.830	17.360	48.420	15.400	11.570	15.440
30 θ_z	11.600	10.150	15.210	27.810	7.949	7.777	10.770
31 u_x	9.926	5.869	8.558	24.940	8.051	5.797	7.882
31 u_y	1.049	0.617	0.868	1.956	0.418	0.461	0.933
31 u_z	3.534	2.114	3.076	9.068	2.817	2.127	2.840
31 θ_x	2.860	2.555	3.822	7.169	2.082	2.008	2.644
31 θ_y	18.090	11.490	16.970	45.300	14.700	10.990	14.840
31 θ_z	24.450	15.360	21.970	47.460	10.810	11.570	21.880

Units: u_x, u_y and u_z: 10^{-2} *in*; θ_x, θ_y and θ_z: 10^{-5} *rad.*

Table 108: Nodal Displacements for Problem # 4b (Response Spectrum) (contd.)

Nodes	Load cases						
	a	b	c	d	e	f	g
32 u_x	9.886	5.846	8.524	24.860	8.016	5.779	7.852
32 u_y	0.002	0.001	0.001	0.003	0.001	0.001	0.002
32 u_z	4.579	2.743	3.998	11.730	3.681	2.755	3.677
32 θ_x	0.002	0.001	0.002	0.004	0.001	0.002	0.001
32 θ_y	19.080	11.430	16.660	48.860	15.340	11.480	15.320
32 θ_z	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Units: u_x, u_y and u_z: 10^{-2} in; θ_x, θ_y and θ_z: 10^{-5} rad.

Table 109: Forces and Moments in Primary System for Problem # 4b (Response Spectrum)

Elements	Load cases			
	a	b	c	d
1 R_{I1}	5.883	2.078	3.232	12.390
1 R_{I2}	60130.000	35530.000	51760.000	151200.000
1 R_{I3}	36.340	14.890	19.440	55.260
1 M_{I1}	0.000	0.000	0.000	0.000
1 M_{I2}	5505.000	3892.000	5970.000	12030.000
1 M_{I3}	47320000.000	28340000.000	41330000.000	21200000.000
1 R_{J1}	5.883	2.078	3.232	12.390
1 R_{J2}	60130.000	35530.000	51760.000	151200.000
1 R_{J3}	36.340	14.890	19.440	55.260
1 M_{J1}	0.000	0.000	0.000	0.000
1 M_{J2}	11400.000	5077.000	6881.000	18120.000
1 M_{J3}	34120000.000	20520000.000	29940000.000	87910000.000
2 R_{I1}	4.052	1.435	2.258	8.604
2 R_{I2}	27260.000	16210.000	23640.000	69210.000
2 R_{I3}	13.360	5.596	7.467	20.660
2 M_{I1}	0.000	0.000	0.000	0.000
2 M_{I2}	9162.000	4079.000	5529.000	14550.000
2 M_{I3}	27290000.000	16410000.000	23950000.000	70320000.000
2 R_{J1}	4.052	1.435	2.258	8.604
2 R_{J2}	27260.000	16210.000	23640.000	69210.000
2 R_{J3}	13.360	5.596	7.467	20.660
2 M_{J1}	0.000	0.000	0.000	0.000
2 M_{J2}	11830.000	4884.000	6372.000	18030.000
2 M_{J3}	21340000.000	12860000.000	18770000.000	55160000.000
3 R_{I1}	4.434	1.626	2.604	9.738
3 R_{I2}	72150.000	43340.000	63220.000	185600.000
3 R_{I3}	15.530	7.860	11.160	26.670
3 M_{I1}	0.000	0.000	0.000	0.000
3 M_{I2}	15550.000	6425.000	8386.000	23710.000
3 M_{I3}	28040000.000	16900000.000	24670000.000	72480000.000
3 R_{J1}	4.434	1.626	2.604	9.738
3 R_{J2}	72150.000	43340.000	63220.000	185600.000
3 R_{J3}	15.530	7.860	11.160	26.670
3 M_{J1}	0.000	0.000	0.000	0.000
3 M_{J2}	12810.000	5149.000	6620.000	19260.000
3 M_{J3}	14670000.000	8865000.000	12940000.000	38060000.000

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 110: Forces and Moments in Primary System for Problem # 4b (Response Spectrum) (contd.)

Elements	Load cases			
	a	b	c	d
4 R_{I1}	2.919	1.140	1.876	6.825
4 R_{I2}	39020.000	23540.000	34360.000	101000.000
4 R_{I3}	25.730	10.500	13.620	39.000
4 M_{I1}	0.000	0.000	0.000	0.000
4 M_{I2}	11470.000	4618.000	5946.000	17260.000
4 M_{I3}	13860000.000	8373000.000	12220000.000	35940000.000
4 R_{J1}	2.919	1.140	1.876	6.825
4 R_{J2}	39020.000	23540.000	34360.000	101000.000
4 R_{J3}	25.730	10.500	13.620	39.000
4 M_{J1}	0.000	0.000	0.000	0.000
4 M_{J2}	6080.000	2425.000	3105.000	9104.000
4 M_{J3}	5715000.000	3455000.000	5043000.000	14840000.000
5 R_{I1}	1.355	0.572	0.965	3.436
5 R_{I2}	38640.000	23090.000	33670.000	98670.000
5 R_{I3}	5.287	3.314	5.032	10.600
5 M_{I1}	0.000	0.000	0.000	0.000
5 M_{I2}	3119.000	1233.000	1577.000	4657.000
5 M_{I3}	1710000.000	980300.000	1429000.000	4148000.000
5 R_{J1}	1.355	0.572	0.965	3.436
5 R_{J2}	38640.000	23090.000	33670.000	98670.000
5 R_{J3}	5.287	3.314	5.032	10.600
5 M_{J1}	0.000	0.000	0.000	0.000
5 M_{J2}	2421.000	1048.000	1402.000	3788.000
5 M_{J3}	6517000.000	3919000.000	5715000.000	16780000.000
6 R_{I1}	2.047	0.819	1.335	4.939
6 R_{I2}	14550.000	8802.000	12850.000	37820.000
6 R_{I3}	18.040	7.166	9.164	26.970
6 M_{I1}	0.000	0.000	0.000	0.000
6 M_{I2}	2436.000	968.100	1238.000	3644.000
6 M_{I3}	1969000.000	1191000.000	1739000.000	5117000.000
6 R_{J1}	2.047	0.819	1.335	4.939
6 R_{J2}	14550.000	8802.000	12850.000	37820.000
6 R_{J3}	18.040	7.166	9.164	26.970
6 M_{J1}	0.000	0.000	0.000	0.000
6 M_{J2}	0.274	0.114	0.149	0.419
6 M_{J3}	779.900	469.900	685.500	2014.000

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 111: Forces and Moments in Primary System for Problem # 4b (Response Spectrum) (contd.)

Elements	Load cases			
	a	b	c	d
7 R_{I1}	0.000	0.000	0.000	0.000
7 R_{I2}	160500.000	96370.000	140600.000	412500.000
7 R_{I3}	42.830	20.020	27.680	70.040
7 M_{I1}	0.000	0.000	0.000	0.000
7 M_{I2}	2891.000	1351.000	1868.000	4728.000
7 M_{I3}	10830000.000	6505000.000	9487000.000	27840000.000
7 R_{J1}	0.000	0.000	0.000	0.000
7 R_{J2}	160500.000	96370.000	140600.000	412500.000
7 R_{J3}	42.830	20.020	27.680	70.040
7 M_{J1}	0.000	0.000	0.000	0.000
7 M_{J2}	2891.000	1351.000	1868.000	4728.000
7 M_{J3}	10830000.000	6505000.000	9487000.000	27840000.000

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 112: Forces and Moments in Primary System for Problem # 4b (Response Spectrum) (contd.)

Elements	Load cases		
	e	f	g
1 R_{I1}	2.005	2.304	5.239
1 R_{I2}	48800.000	35250.000	47800.000
1 R_{I3}	4.468	11.170	29.270
1 M_{I1}	0.000	0.000	0.000
1 M_{I2}	3574.000	4072.000	4819.000
1 M_{I3}	38000000.000	28470000.000	38010000.000
1 R_{J1}	2.005	2.304	5.239
1 R_{J2}	48800.000	35250.000	47800.000
1 R_{J3}	4.468	11.170	29.270
1 M_{J1}	0.000	0.000	0.000
1 M_{J2}	2604.000	4177.000	9269.000
1 M_{J3}	27260000.000	20700000.000	27510000.000
2 R_{I1}	1.333	1.616	3.697
2 R_{I2}	21990.000	16190.000	21810.000
2 R_{I3}	2.237	4.431	10.790
2 M_{I1}	0.000	0.000	0.000
2 M_{I2}	2093.000	3358.000	7446.000
2 M_{I3}	21800000.000	16560000.000	22000000.000
2 R_{J1}	1.333	1.616	3.697
2 R_{J2}	21990.000	16190.000	21810.000
2 R_{J3}	2.237	4.431	10.790
2 M_{J1}	0.000	0.000	0.000
2 M_{J2}	1611.000	3672.000	9537.000
2 M_{J3}	16980000.000	13010000.000	17240000.000
3 R_{I1}	1.587	1.904	4.158
3 R_{I2}	57750.000	43660.000	58110.000
3 R_{I3}	5.411	7.121	12.820
3 M_{I1}	0.000	0.000	0.000
3 M_{I2}	2125.000	4834.000	12550.000
3 M_{I3}	22300000.000	17090000.000	22650000.000
3 R_{J1}	1.587	1.904	4.158
3 R_{J2}	57750.000	43660.000	58110.000
3 R_{J3}	5.411	7.121	12.820
3 M_{J1}	0.000	0.000	0.000
3 M_{J2}	1127.000	3728.000	10310.000
3 M_{J3}	11590000.000	8989000.000	11880000.000

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 113: Forces and Moments in Primary System for Problem # 4b (Response Spectrum) (contd.)

Elements	Load cases		
	e	f	g
4 R_{I1}	1.201	1.414	2.870
4 R_{I2}	30970.000	23830.000	31550.000
4 R_{I3}	3.044	7.796	20.730
4 M_{I1}	0.000	0.000	0.000
4 M_{I2}	1062.000	3355.000	9228.000
4 M_{I3}	10970000.000	8486000.000	11220000.000
4 R_{J1}	1.201	1.414	2.870
4 R_{J2}	30970.000	23830.000	31550.000
4 R_{J3}	3.044	7.796	20.730
4 M_{J1}	0.000	0.000	0.000
4 M_{J2}	429.000	1735.000	4887.000
4 M_{J3}	4498000.000	3507000.000	4633000.000
5 R_{I1}	0.653	0.747	1.397
5 R_{I2}	31100.000	23140.000	30980.000
5 R_{I3}	2.876	3.404	4.510
5 M_{I1}	0.000	0.000	0.000
5 M_{I2}	147.500	878.600	2505.000
5 M_{I3}	1385000.000	953200.000	1341000.000
5 R_{J1}	0.653	0.747	1.397
5 R_{J2}	31100.000	23140.000	30980.000
5 R_{J3}	2.876	3.404	4.510
5 M_{J1}	0.000	0.000	0.000
5 M_{J2}	480.200	835.600	1961.000
5 M_{J3}	5209000.000	3950000.000	5251000.000
6 R_{I1}	0.904	1.009	1.951
6 R_{I2}	11400.000	8944.000	11810.000
6 R_{I3}	1.103	5.104	14.490
6 M_{I1}	0.000	0.000	0.000
6 M_{I2}	149.300	689.600	1958.000
6 M_{I3}	1543000.000	1210000.000	1598000.000
6 R_{J1}	0.904	1.009	1.951
6 R_{J2}	11400.000	8944.000	11810.000
6 R_{J3}	1.103	5.104	14.490
6 M_{J1}	0.000	0.000	0.000
6 M_{J2}	0.039	0.086	0.221
6 M_{J3}	620.900	474.800	629.600

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 114: Forces and Moments in Primary System for Problem # 4b (Response Spectrum) (contd.)

Elements	Load cases		
	e	f	g
7 R_{I1}	0.000	0.000	0.000
7 R_{I2}	128500.000	97030.000	129200.000
7 R_{I3}	11.870	17.180	34.990
7 M_{I1}	0.000	0.000	0.000
7 M_{I2}	801.100	1160.000	2362.000
7 M_{I3}	8673000.000	6549000.000	8718000.000
7 R_{J1}	0.000	0.000	0.000
7 R_{J2}	128500.000	97030.000	129200.000
7 R_{J3}	11.870	17.180	34.990
7 M_{J1}	0.000	0.000	0.000
7 M_{J2}	801.100	1160.000	2362.000
7 M_{J3}	8673000.000	6549000.000	8718000.000

Units: R(Force): $Kips$; M(Moment): $In - Kips$

Table 115: Forces and Moments in Support Elements for Problem # 4b (Response Spectrum)

Elements	Loadcases						
	a	b	c	d	e	f	g
$1R_{I1}$	7.112	5.012	7.373	18.700	5.549	4.657	5.964
$1R_{I2}$	1.089	0.916	1.361	2.543	0.705	0.678	0.973
$1R_{I3}$	2.429	1.776	2.617	6.353	1.892	1.604	2.058
$1M_{I1}$	1.908	1.648	2.401	4.595	1.284	1.195	1.715
$1M_{I2}$	1.625	1.352	1.990	3.852	1.022	1.014	1.503
$1M_{I3}$	6.288	5.581	8.329	15.080	4.332	4.162	5.693
$1R_{J1}$	7.112	5.012	7.373	18.700	5.549	4.657	5.964
$1R_{J2}$	1.089	0.916	1.361	2.543	0.705	0.678	0.973
$1R_{J3}$	2.429	1.776	2.617	6.353	1.892	1.604	2.058
$1M_{J1}$	1.908	1.648	2.401	4.595	1.284	1.195	1.715
$1M_{J2}$	50.320	36.430	53.650	131.800	39.240	33.170	42.510
$1M_{J3}$	16.660	13.690	20.300	38.500	10.500	10.100	14.810
$2R_{I1}$	3.390	2.490	3.713	7.766	2.671	1.964	2.790
$2R_{I2}$	0.248	0.168	0.247	0.558	0.136	0.145	0.225
$2R_{I3}$	2.648	1.710	2.461	5.402	1.894	1.280	2.116
$2M_{I1}$	1.004	0.798	1.190	2.389	0.641	0.654	0.924
$2M_{I2}$	5.612	3.157	4.391	10.200	2.075	2.345	4.978
$2M_{I3}$	0.917	0.630	0.929	2.033	0.491	0.533	0.837
$2R_{J1}$	3.390	2.490	3.713	7.766	2.671	1.964	2.790
$2R_{J2}$	0.248	0.168	0.247	0.558	0.136	0.145	0.225
$2R_{J3}$	2.648	1.710	2.461	5.402	1.894	1.280	2.116
$2M_{J1}$	1.004	0.798	1.190	2.389	0.641	0.654	0.924
$2M_{J2}$	68.400	45.730	66.430	143.400	50.490	34.620	54.800
$2M_{J3}$	5.528	3.726	5.493	12.510	3.039	3.247	5.001
$3R_{I1}$	0.386	0.306	0.457	0.923	0.262	0.285	0.354
$3R_{I2}$	2.562	2.167	3.215	6.389	1.710	1.678	2.410
$3R_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3R_{J1}$	0.386	0.306	0.457	0.923	0.262	0.285	0.354
$3R_{J2}$	2.562	2.167	3.215	6.389	1.710	1.678	2.410
$3R_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$3M_{J3}$	16.650	14.090	20.900	41.530	11.120	10.900	15.660
$4R_{I1}$	2.869	2.297	3.487	7.440	2.197	2.031	2.512
$4R_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4R_{I3}$	11.420	9.799	14.540	29.280	8.892	7.881	10.110
$4M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000

R = Force (Kips) M = Moment (Kips-ft)

Table 116: Forces and Moments in Support Elements for Problem # 4b (Response Spectrum)

Elements	Loadcases						
	a	b	c	d	e	f	g
$4R_{J1}$	2.869	2.297	3.487	7.440	2.197	2.031	2.512
$4R_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4R_{J3}$	11.420	9.799	14.540	29.280	8.892	7.881	10.110
$4M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$4M_{J2}$	76.180	65.370	96.980	195.300	59.310	52.570	67.440
$4M_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5R_{I1}$	2.912	2.472	3.838	7.239	2.195	2.156	2.601
$5R_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5R_{I3}$	11.540	10.580	15.750	29.050	8.929	8.062	10.430
$5M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5R_{J1}$	2.912	2.472	3.838	7.239	2.195	2.156	2.601
$5R_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5R_{J3}$	11.540	10.580	15.750	29.050	8.929	8.062	10.430
$5M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$5M_{J2}$	76.980	70.600	105.100	193.800	59.570	53.780	69.550
$5M_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6R_{I1}$	7.408	6.797	10.150	17.880	5.492	5.097	6.739
$6R_{I2}$	1.439	1.385	2.093	3.577	1.083	1.066	1.343
$6R_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6R_{J1}$	7.408	6.797	10.150	17.880	5.492	5.097	6.739
$6R_{J2}$	1.439	1.385	2.093	3.577	1.083	1.066	1.343
$6R_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$6M_{J3}$	2.159	2.077	3.139	5.365	1.625	1.599	2.015
$7R_{I1}$	3.074	1.297	1.610	4.155	0.575	0.925	2.665
$7R_{I2}$	0.548	0.497	0.739	1.310	0.381	0.373	0.504
$7R_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{I1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{I2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{I3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7R_{J1}$	3.074	1.297	1.610	4.155	0.575	0.925	2.665
$7R_{J2}$	0.548	0.497	0.739	1.310	0.381	0.373	0.504
$7R_{J3}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{J1}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{J2}$	0.000	0.000	0.000	0.000	0.000	0.000	0.000
$7M_{J3}$	9.045	8.199	12.200	21.620	6.287	6.151	8.319

R = Force (Kips)   M = Moment (Kips-ft)

Table 117: Forces and Moments in Secondary System for Problem # 4b (Response Spectrum)

Elements	Load cases						
	a	b	c	d	e	f	g
1 R_{I1}	7.510	5.313	7.817	19.740	5.860	4.923	6.304
1 R_{I2}	1.089	0.916	1.361	2.543	0.705	0.678	0.973
1 R_{I3}	0.276	0.215	0.316	0.638	0.160	0.163	0.254
1 M_{I1}	0.391	0.293	0.544	0.865	0.282	0.387	0.363
1 M_{I2}	1.625	1.352	1.990	3.852	1.022	1.014	1.503
1 M_{I3}	6.559	5.812	8.651	15.750	4.509	4.313	5.935
1 R_{J1}	7.510	5.313	7.817	19.740	5.860	4.923	6.304
1 R_{J2}	1.089	0.916	1.361	2.543	0.705	0.678	0.973
1 R_{J3}	0.276	0.215	0.316	0.638	0.160	0.163	0.254
1 M_{J1}	0.391	0.293	0.544	0.865	0.282	0.387	0.363
1 M_{J2}	0.278	0.113	0.161	0.561	0.051	0.098	0.247
1 M_{J3}	1.045	0.415	0.577	1.999	0.286	0.325	0.846
2 R_{I1}	6.087	4.615	6.818	15.930	4.740	4.072	5.198
2 R_{I2}	0.863	0.825	1.230	2.177	0.651	0.618	0.797
2 R_{I3}	0.202	0.189	0.278	0.500	0.145	0.139	0.188
2 M_{I1}	0.391	0.293	0.544	0.865	0.282	0.387	0.363
2 M_{I2}	0.278	0.113	0.161	0.561	0.051	0.098	0.247
2 M_{I3}	1.045	0.415	0.577	1.999	0.286	0.325	0.846
2 R_{J1}	6.087	4.615	6.818	15.930	4.740	4.072	5.198
2 R_{J2}	0.863	0.825	1.230	2.177	0.651	0.618	0.797
2 R_{J3}	0.202	0.189	0.278	0.500	0.145	0.139	0.188
2 M_{J1}	0.391	0.293	0.544	0.865	0.282	0.387	0.363
2 M_{J2}	1.503	1.329	1.957	3.647	1.015	0.989	1.398
2 M_{J3}	6.227	5.761	8.584	15.350	4.508	4.294	5.700
3 R_{I1}	4.830	4.057	6.023	12.540	3.750	3.342	4.248
3 R_{I2}	0.804	0.684	1.014	1.936	0.542	0.518	0.722
3 R_{I3}	0.184	0.154	0.227	0.440	0.117	0.113	0.168
3 M_{I1}	0.391	0.293	0.544	0.865	0.282	0.387	0.363
3 M_{I2}	1.503	1.329	1.957	3.647	1.015	0.989	1.398
3 M_{I3}	6.227	5.761	8.584	15.350	4.508	4.294	5.700
3 R_{J1}	4.830	4.057	6.023	12.540	3.750	3.342	4.248
3 R_{J2}	0.804	0.684	1.014	1.936	0.542	0.518	0.722
3 R_{J3}	0.184	0.154	0.227	0.440	0.117	0.113	0.168
3 M_{J1}	0.391	0.293	0.544	0.865	0.282	0.387	0.363
3 M_{J2}	2.358	2.307	3.401	5.983	1.792	1.685	2.201
3 M_{J3}	10.520	10.210	15.220	26.830	8.088	7.670	9.755

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 118: Forces and Moments in Secondary System for Problem # 4b (Response Spectrum) (contd.

Elements	Load cases						
	a	b	c	d	e	f	g
4 R_{I1}	4.156	3.793	5.650	10.700	3.220	2.966	3.759
4 R_{I2}	1.861	1.497	2.225	4.596	1.159	1.174	1.803
4 R_{I3}	0.272	0.188	0.312	0.613	0.177	0.229	0.253
4 M_{I1}	0.391	0.293	0.544	0.865	0.282	0.387	0.363
4 M_{I2}	2.358	2.307	3.401	5.983	1.792	1.685	2.201
4 M_{I3}	10.520	10.210	15.220	26.830	8.088	7.670	9.755
4 R_{J1}	1.861	1.497	2.225	4.596	1.159	1.174	1.803
4 R_{J2}	4.156	3.793	5.650	10.700	3.220	2.966	3.759
4 R_{J3}	0.272	0.188	0.312	0.613	0.177	0.229	0.253
4 M_{J1}	2.196	2.154	3.230	5.541	1.677	1.616	2.049
4 M_{J2}	0.345	0.328	0.490	0.861	0.254	0.247	0.326
4 M_{J3}	2.931	2.674	4.019	7.349	2.146	2.072	2.734
5 R_{I1}	1.696	1.335	1.982	4.150	1.028	1.048	1.645
5 R_{I2}	3.600	3.525	5.262	9.178	2.785	2.645	3.345
5 R_{I3}	0.234	0.164	0.279	0.523	0.158	0.209	0.216
5 M_{I1}	2.196	2.154	3.230	5.541	1.677	1.616	2.049
5 M_{I2}	0.345	0.328	0.490	0.861	0.254	0.247	0.326
5 M_{I3}	2.931	2.674	4.019	7.349	2.146	2.072	2.734
5 R_{J1}	1.696	1.335	1.982	4.150	1.028	1.048	1.645
5 R_{J2}	3.600	3.525	5.262	9.178	2.785	2.645	3.345
5 R_{J3}	0.234	0.164	0.279	0.523	0.158	0.209	0.216
5 M_{J1}	2.196	2.154	3.230	5.541	1.677	1.616	2.049
5 M_{J2}	1.803	1.334	2.141	4.137	1.221	1.510	1.674
5 M_{J3}	22.990	22.230	33.160	58.750	17.770	16.800	21.290
6 R_{I1}	1.456	1.096	1.625	3.507	0.837	0.865	1.415
6 R_{I2}	2.392	2.202	3.282	6.117	1.840	1.702	2.168
6 R_{I3}	0.140	0.082	0.145	0.280	0.079	0.113	0.127
6 M_{I1}	2.196	2.154	3.230	5.541	1.677	1.616	2.049
6 M_{I2}	1.803	1.334	2.141	4.137	1.221	1.510	1.674
6 M_{I3}	22.990	22.230	33.160	58.750	17.770	16.800	21.290
6 R_{J1}	1.456	1.096	1.625	3.507	0.837	0.865	1.415
6 R_{J2}	2.392	2.202	3.282	6.117	1.840	1.702	2.168
6 R_{J3}	0.140	0.082	0.145	0.280	0.079	0.113	0.127
6 M_{J1}	2.196	2.154	3.230	5.541	1.677	1.616	2.049
6 M_{J2}	2.398	1.789	2.994	5.473	1.722	2.222	2.178
6 M_{J3}	36.760	36.470	54.470	93.380	28.330	27.050	34.260

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 119: Forces and Moments in Secondary System for Problem # 4b (Response Spectrum) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
7 R_{I1}	1.225	0.862	1.276	2.897	0.653	0.691	1.193
7 R_{I2}	2.892	1.838	2.673	7.585	2.267	1.833	2.373
7 R_{I3}	0.151	0.068	0.106	0.324	0.045	0.067	0.154
7 M_{I1}	2.196	2.154	3.230	5.541	1.677	1.616	2.049
7 M_{I2}	2.398	1.789	2.994	5.473	1.722	2.222	2.178
7 M_{I3}	36.760	36.470	54.470	93.380	28.330	27.050	34.260
7 R_{J1}	1.225	0.862	1.276	2.897	0.653	0.691	1.193
7 R_{J2}	2.892	1.838	2.673	7.585	2.267	1.833	2.373
7 R_{J3}	0.151	0.068	0.106	0.324	0.045	0.067	0.154
7 M_{J1}	2.196	2.154	3.230	5.541	1.677	1.616	2.049
7 M_{J2}	2.479	1.714	2.952	5.446	1.679	2.258	2.246
7 M_{J3}	45.660	42.340	63.100	116.600	35.260	32.570	41.460
8 R_{I1}	1.011	0.635	0.940	2.338	0.480	0.532	0.984
8 R_{I2}	8.969	8.514	12.700	22.830	6.916	6.457	8.218
8 R_{I3}	0.573	0.393	0.659	1.222	0.374	0.496	0.514
8 M_{I1}	2.196	2.154	3.230	5.541	1.677	1.616	2.050
8 M_{I2}	2.479	1.714	2.952	5.446	1.679	2.258	2.246
8 M_{I3}	45.660	42.340	63.100	116.600	35.260	32.570	41.460
8 R_{J1}	1.011	0.635	0.940	2.338	0.480	0.532	0.984
8 R_{J2}	8.969	8.514	12.700	22.830	6.916	6.457	8.218
8 R_{J3}	0.573	0.393	0.659	1.222	0.374	0.496	0.514
8 M_{J1}	2.196	2.154	3.230	5.541	1.677	1.616	2.050
8 M_{J2}	1.652	1.074	1.719	3.349	0.962	1.243	1.485
8 M_{J3}	17.920	17.570	26.240	45.290	13.720	13.070	16.670
9 R_{I1}	0.808	0.421	0.625	1.794	0.311	0.383	0.786
9 R_{I2}	5.574	5.361	8.000	14.200	4.298	4.041	5.127
9 R_{I3}	0.322	0.233	0.396	0.720	0.227	0.299	0.292
9 M_{I1}	2.196	2.154	3.230	5.541	1.677	1.616	2.050
9 M_{I2}	1.652	1.074	1.719	3.349	0.962	1.243	1.485
9 M_{I3}	17.920	17.570	26.240	45.290	13.720	13.070	16.670
9 R_{J1}	0.808	0.421	0.625	1.794	0.311	0.383	0.786
9 R_{J2}	5.574	5.361	8.000	14.200	4.298	4.041	5.127
9 R_{J3}	0.322	0.233	0.396	0.720	0.227	0.299	0.292
9 M_{J1}	2.196	2.154	3.230	5.541	1.677	1.616	2.050
9 M_{J2}	3.540	2.630	4.416	8.005	2.539	3.300	3.195
9 M_{J3}	56.610	54.990	82.090	144.000	43.640	41.210	52.300

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 120: Forces and Moments in Secondary System for Problem # 4b (Response Spectrum) (contd.

Elements	Load cases						
	a	b	c	d	e	f	g
10 R_{I1}	0.637	0.255	0.390	1.327	0.172	0.273	0.618
10 R_{I2}	0.446	0.172	0.244	0.750	0.105	0.160	0.391
10 R_{I3}	0.214	0.082	0.101	0.302	0.032	0.067	0.188
10 M_{I1}	2.196	2.154	3.230	5.541	1.677	1.616	2.050
10 M_{I2}	3.540	2.630	4.416	8.005	2.539	3.300	3.195
10 M_{I3}	56.610	54.990	82.090	144.000	43.640	41.210	52.300
10 R_{J1}	0.637	0.255	0.390	1.327	0.172	0.273	0.618
10 R_{J2}	0.446	0.172	0.244	0.750	0.105	0.160	0.391
10 R_{J3}	0.214	0.082	0.101	0.302	0.032	0.067	0.188
10 M_{J1}	2.196	2.154	3.230	5.541	1.677	1.616	2.050
10 M_{J2}	3.362	2.441	4.082	7.470	2.347	3.048	3.031
10 M_{J3}	56.050	54.390	81.200	142.600	43.220	40.780	51.730
11 R_{I1}	0.544	0.260	0.414	1.093	0.182	0.264	0.521
11 R_{I2}	5.679	5.496	8.203	14.450	4.378	4.126	5.241
11 R_{I3}	0.388	0.283	0.478	0.856	0.273	0.359	0.352
11 M_{I1}	2.196	2.154	3.230	5.541	1.677	1.616	2.050
11 M_{I2}	3.362	2.441	4.082	7.470	2.347	3.048	3.031
11 M_{I3}	56.050	54.390	81.200	142.600	43.220	40.780	51.730
11 R_{J1}	0.544	0.260	0.414	1.093	0.182	0.264	0.521
11 R_{J2}	5.679	5.496	8.203	14.450	4.378	4.126	5.241
11 R_{J3}	0.388	0.283	0.478	0.856	0.273	0.359	0.352
11 M_{J1}	2.196	2.154	3.230	5.541	1.677	1.616	2.050
11 M_{J2}	0.893	0.519	0.818	1.848	0.462	0.595	0.822
11 M_{J3}	16.450	15.950	23.830	41.760	12.600	11.960	15.220
12 R_{I1}	0.571	0.430	0.669	1.241	0.327	0.366	0.537
12 R_{I2}	8.930	8.549	12.760	22.680	6.885	6.438	8.198
12 R_{I3}	0.619	0.426	0.711	1.304	0.404	0.532	0.556
12 M_{I1}	2.196	2.154	3.230	5.541	1.677	1.616	2.050
12 M_{I2}	0.893	0.519	0.818	1.848	0.462	0.595	0.822
12 M_{I3}	16.450	15.950	23.830	41.760	12.600	11.960	15.220
12 R_{J1}	0.571	0.430	0.669	1.241	0.327	0.366	0.537
12 R_{J2}	8.930	8.549	12.760	22.680	6.885	6.438	8.198
12 R_{J3}	0.619	0.426	0.711	1.304	0.404	0.532	0.556
12 M_{J1}	2.196	2.154	3.230	5.541	1.677	1.616	2.050
12 M_{J2}	3.642	2.514	4.234	7.599	2.393	3.188	3.279
12 M_{J3}	46.290	43.950	65.590	117.400	35.690	33.220	42.420

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 121: Forces and Moments in Secondary System for Problem # 4b (Response Spectrum) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
13 R_{I1}	0.704	0.645	0.990	1.665	0.499	0.514	0.659
13 R_{I2}	2.621	2.160	3.222	6.407	1.996	1.720	2.313
13 R_{I3}	0.461	0.220	0.356	0.683	0.169	0.259	0.409
13 M_{I1}	2.196	2.154	3.230	5.541	1.677	1.616	2.050
13 M_{I2}	3.642	2.514	4.234	7.599	2.393	3.188	3.279
13 M_{I3}	46.290	43.950	65.590	117.400	35.690	33.220	42.420
13 R_{J1}	0.704	0.645	0.990	1.665	0.499	0.514	0.659
13 R_{J2}	2.621	2.160	3.222	6.407	1.996	1.720	2.313
13 R_{J3}	0.461	0.220	0.356	0.683	0.169	0.259	0.409
13 M_{J1}	2.196	2.154	3.230	5.541	1.677	1.616	2.050
13 M_{J2}	2.674	2.067	3.049	5.983	1.734	1.890	2.407
13 M_{J3}	30.030	29.460	43.980	76.280	23.070	21.960	27.840
14 R_{I1}	0.897	0.870	1.326	2.208	0.677	0.677	0.840
14 R_{I2}	3.493	3.408	5.088	8.880	2.684	2.547	3.232
14 R_{I3}	0.311	0.199	0.373	0.596	0.193	0.285	0.286
14 M_{I1}	2.196	2.154	3.230	5.541	1.677	1.616	2.050
14 M_{I2}	2.674	2.067	3.049	5.983	1.734	1.890	2.407
14 M_{I3}	30.030	29.460	43.980	76.280	23.070	21.960	27.840
14 R_{J1}	0.897	0.870	1.326	2.208	0.677	0.677	0.840
14 R_{J2}	3.493	3.408	5.088	8.880	2.684	2.547	3.232
14 R_{J3}	0.311	0.199	0.373	0.596	0.193	0.285	0.286
14 M_{J1}	2.196	2.154	3.230	5.541	1.677	1.616	2.050
14 M_{J2}	2.116	2.063	3.138	5.300	1.621	1.607	1.983
14 M_{J3}	5.793	5.646	8.443	14.510	4.393	4.213	5.396
15 R_{I1}	1.046	1.023	1.554	2.608	0.798	0.791	0.980
15 R_{I2}	4.499	4.403	6.578	11.320	3.423	3.278	4.183
15 R_{I3}	0.622	0.288	0.448	0.905	0.204	0.321	0.548
15 M_{I1}	2.196	2.154	3.230	5.541	1.677	1.616	2.050
15 M_{I2}	2.116	2.063	3.138	5.300	1.621	1.607	1.983
15 M_{I3}	5.793	5.646	8.443	14.510	4.393	4.213	5.396
15 R_{J1}	0.622	0.288	0.448	0.905	0.204	0.321	0.548
15 R_{J2}	1.046	1.023	1.554	2.608	0.798	0.791	0.980
15 R_{J3}	4.499	4.403	6.578	11.320	3.423	3.278	4.183
15 M_{J1}	1.052	0.979	1.460	2.652	0.786	0.744	0.964
15 M_{J2}	4.566	4.452	6.641	11.450	3.459	3.304	4.237
15 M_{J3}	0.931	0.746	1.243	1.972	0.614	0.758	0.871

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 122: Forces and Moments in Secondary System for Problem # 4b (Response Spectrum) (contd.

Elements	Load cases						
	a	b	c	d	e	f	g
16 R_{I1}	0.896	0.384	0.544	1.230	0.223	0.368	0.783
16 R_{I2}	1.153	1.123	1.704	2.886	0.879	0.869	1.081
16 R_{I3}	5.147	4.970	7.434	12.830	3.886	3.716	4.780
16 M_{I1}	1.052	0.979	1.460	2.652	0.786	0.744	0.964
16 M_{I2}	4.566	4.452	6.641	11.450	3.459	3.304	4.237
16 M_{I3}	0.931	0.746	1.243	1.972	0.614	0.758	0.871
16 R_{J1}	0.896	0.384	0.544	1.230	0.223	0.368	0.783
16 R_{J2}	1.153	1.123	1.704	2.886	0.879	0.869	1.081
16 R_{J3}	5.147	4.970	7.434	12.830	3.886	3.716	4.780
16 M_{J1}	1.052	0.979	1.460	2.652	0.786	0.744	0.964
16 M_{J2}	30.260	29.300	43.800	75.540	22.870	21.870	28.110
16 M_{J3}	5.029	4.945	7.412	12.720	3.857	3.716	4.701
17 R_{I1}	1.407	0.575	0.747	1.867	0.268	0.471	1.223
17 R_{I2}	0.303	0.265	0.391	0.701	0.200	0.198	0.279
17 R_{I3}	2.181	1.822	2.695	4.855	1.472	1.355	1.947
17 M_{I1}	1.052	0.979	1.460	2.652	0.786	0.744	0.964
17 M_{I2}	30.260	29.300	43.800	75.540	22.870	21.870	28.110
17 M_{I3}	5.029	4.945	7.412	12.720	3.857	3.716	4.701
17 R_{J1}	1.407	0.575	0.747	1.867	0.268	0.471	1.223
17 R_{J2}	0.303	0.265	0.391	0.701	0.200	0.198	0.279
17 R_{J3}	2.181	1.822	2.695	4.855	1.472	1.355	1.947
17 M_{J1}	1.052	0.979	1.460	2.652	0.786	0.744	0.964
17 M_{J2}	15.700	14.750	22.030	38.560	11.540	11.070	14.620
17 M_{J3}	2.984	2.821	4.220	7.401	2.194	2.132	2.777
18 R_{I1}	1.964	0.791	0.987	2.583	0.329	0.599	1.705
18 R_{I2}	0.388	0.368	0.550	0.967	0.287	0.279	0.361
18 R_{I3}	2.368	2.276	3.394	5.913	1.776	1.698	2.210
18 M_{I1}	1.052	0.979	1.460	2.652	0.786	0.744	0.964
18 M_{I2}	15.700	14.750	22.030	38.560	11.540	11.070	14.620
18 M_{I3}	2.984	2.821	4.220	7.401	2.194	2.132	2.777
18 R_{J1}	1.964	0.791	0.987	2.583	0.329	0.599	1.705
18 R_{J2}	0.388	0.368	0.550	0.967	0.287	0.279	0.361
18 R_{J3}	2.368	2.276	3.394	5.913	1.776	1.698	2.210
18 M_{J1}	1.052	0.979	1.460	2.652	0.786	0.744	0.964
18 M_{J2}	1.828	0.794	1.016	2.787	0.539	0.606	1.591
18 M_{J3}	0.406	0.372	0.554	0.975	0.285	0.280	0.376

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 123: Forces and Moments in Secondary System for Problem # 4b (Response Spectrum) (contd.)

Elements	Load cases						
	a	b	c	d	e	f	g
19 R_{I1}	2.284	0.918	1.131	3.000	0.370	0.677	1.982
19 R_{I2}	0.428	0.396	0.591	1.043	0.305	0.299	0.399
19 R_{I3}	2.608	2.390	3.557	6.345	1.950	1.789	2.386
19 M_{I1}	1.052	0.979	1.460	2.652	0.786	0.744	0.964
19 M_{I2}	1.828	0.794	1.016	2.787	0.539	0.606	1.591
19 M_{I3}	0.406	0.372	0.554	0.975	0.285	0.280	0.376
19 R_{J1}	2.608	2.390	3.557	6.345	1.950	1.789	2.386
19 R_{J2}	0.428	0.396	0.591	1.043	0.305	0.299	0.399
19 R_{J3}	2.284	0.918	1.131	3.000	0.370	0.677	1.982
19 M_{J1}	0.256	0.229	0.342	0.642	0.186	0.180	0.237
19 M_{J2}	5.467	4.692	6.959	12.440	3.622	3.523	5.027
19 M_{J3}	1.626	1.552	2.319	4.054	1.213	1.164	1.505
20 R_{I1}	2.816	2.466	3.664	6.724	2.131	1.855	2.512
20 R_{I2}	0.183	0.121	0.177	0.408	0.100	0.102	0.161
20 R_{I3}	0.929	0.445	0.567	1.460	0.232	0.302	0.812
20 M_{I1}	0.256	0.229	0.342	0.642	0.186	0.180	0.237
20 M_{I2}	5.467	4.692	6.959	12.440	3.622	3.523	5.027
20 M_{I3}	1.626	1.552	2.319	4.054	1.213	1.164	1.505
20 R_{J1}	2.816	2.466	3.664	6.724	2.131	1.855	2.512
20 R_{J2}	0.183	0.121	0.177	0.408	0.100	0.102	0.161
20 R_{J3}	0.929	0.445	0.567	1.460	0.232	0.302	0.812
20 M_{J1}	0.256	0.229	0.342	0.642	0.186	0.180	0.237
20 M_{J2}	3.871	3.188	4.753	8.934	2.467	2.443	3.566
20 M_{J3}	1.192	1.075	1.610	2.907	0.835	0.830	1.115
21 R_{I1}	3.192	2.602	3.860	7.423	2.454	1.977	2.744
21 R_{I2}	0.124	0.117	0.174	0.307	0.091	0.088	0.115
21 R_{I3}	0.462	0.362	0.530	0.974	0.272	0.269	0.420
21 M_{I1}	0.256	0.229	0.342	0.642	0.186	0.180	0.237
21 M_{I2}	3.871	3.188	4.753	8.934	2.467	2.443	3.566
21 M_{I3}	1.192	1.075	1.610	2.907	0.835	0.830	1.115
21 R_{J1}	3.192	2.602	3.860	7.423	2.454	1.977	2.744
21 R_{J2}	0.124	0.117	0.174	0.307	0.091	0.088	0.115
21 R_{J3}	0.462	0.362	0.530	0.974	0.272	0.269	0.420
21 M_{J1}	0.256	0.229	0.342	0.642	0.186	0.180	0.237
21 M_{J2}	3.605	1.842	2.481	6.216	1.108	1.346	3.178
21 M_{J3}	0.798	0.553	0.818	1.789	0.437	0.471	0.729

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

Table 124: Forces and Moments in Secondary System for Problem # 4b (Response Spectrum) (contd.

Elements	Load cases						
	a	b	c	d	e	f	g
22 R_{I1}	3.647	2.771	4.105	8.285	2.836	2.130	3.031
22 R_{I2}	0.182	0.143	0.213	0.420	0.111	0.115	0.168
22 R_{I3}	0.729	0.447	0.636	1.396	0.310	0.336	0.651
22 M_{I1}	0.256	0.229	0.342	0.642	0.186	0.180	0.237
22 M_{I2}	3.605	1.842	2.481	6.216	1.108	1.346	3.178
22 M_{I3}	0.798	0.553	0.818	1.789	0.437	0.471	0.729
22 R_{J1}	3.647	2.771	4.105	8.285	2.836	2.130	3.031
22 R_{J2}	0.182	0.143	0.213	0.420	0.111	0.115	0.168
22 R_{J3}	0.729	0.447	0.636	1.396	0.310	0.336	0.651
22 M_{J1}	0.256	0.229	0.342	0.642	0.186	0.180	0.237
22 M_{J2}	0.684	0.576	0.853	1.530	0.442	0.433	0.628
22 M_{J3}	0.203	0.193	0.288	0.506	0.151	0.145	0.189
23 R_{I1}	4.153	2.968	4.392	9.267	3.258	2.309	3.360
23 R_{I2}	0.248	0.168	0.247	0.558	0.136	0.145	0.225
23 R_{I3}	1.123	0.559	0.744	1.903	0.327	0.406	0.988
23 M_{I1}	0.256	0.229	0.342	0.642	0.186	0.180	0.237
23 M_{I2}	0.684	0.576	0.853	1.530	0.442	0.433	0.628
23 M_{I3}	0.203	0.193	0.288	0.506	0.151	0.145	0.189
23 R_{J1}	4.153	2.968	4.392	9.267	3.258	2.309	3.360
23 R_{J2}	0.248	0.168	0.247	0.558	0.136	0.145	0.225
23 R_{J3}	1.123	0.559	0.744	1.903	0.327	0.406	0.988
23 M_{J1}	0.256	0.229	0.342	0.642	0.186	0.180	0.237
23 M_{J2}	5.612	3.157	4.391	10.200	2.075	2.345	4.978
23 M_{J3}	1.335	0.990	1.470	3.068	0.785	0.824	1.223

Units: R(Force): $Kips$; M(Moment): $Ft - Kips$

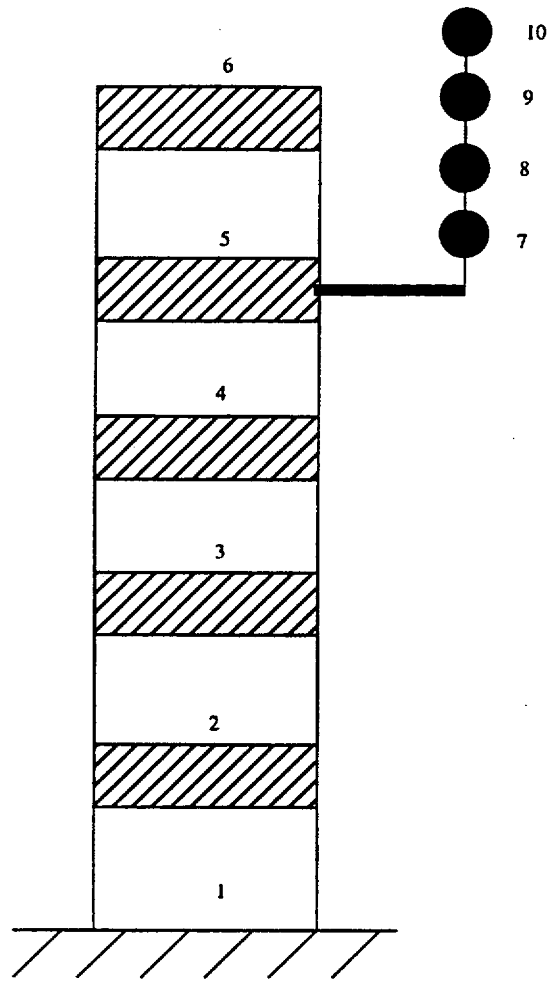

Figure 1: Benchmark Problem 1

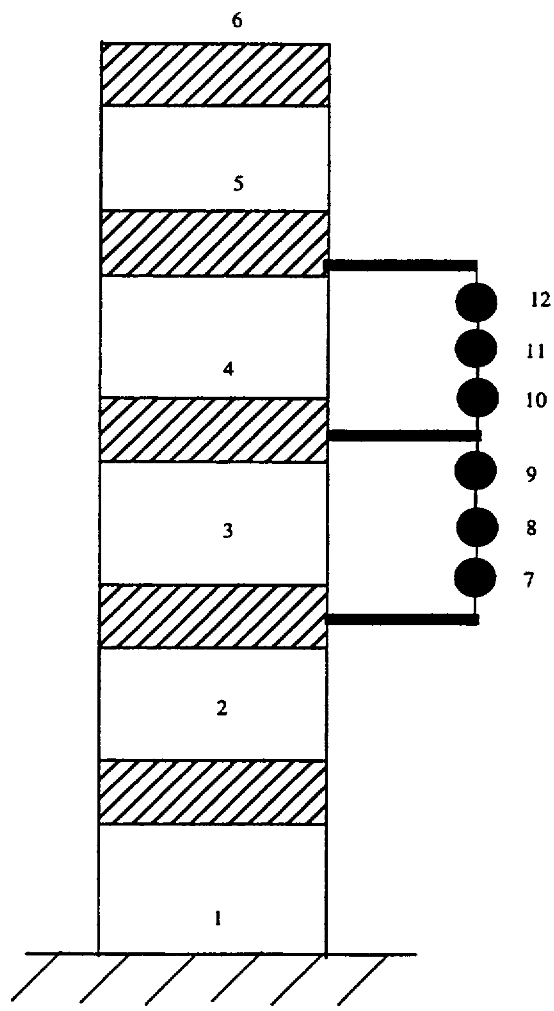

Figure 2: Benchmark Problem 2

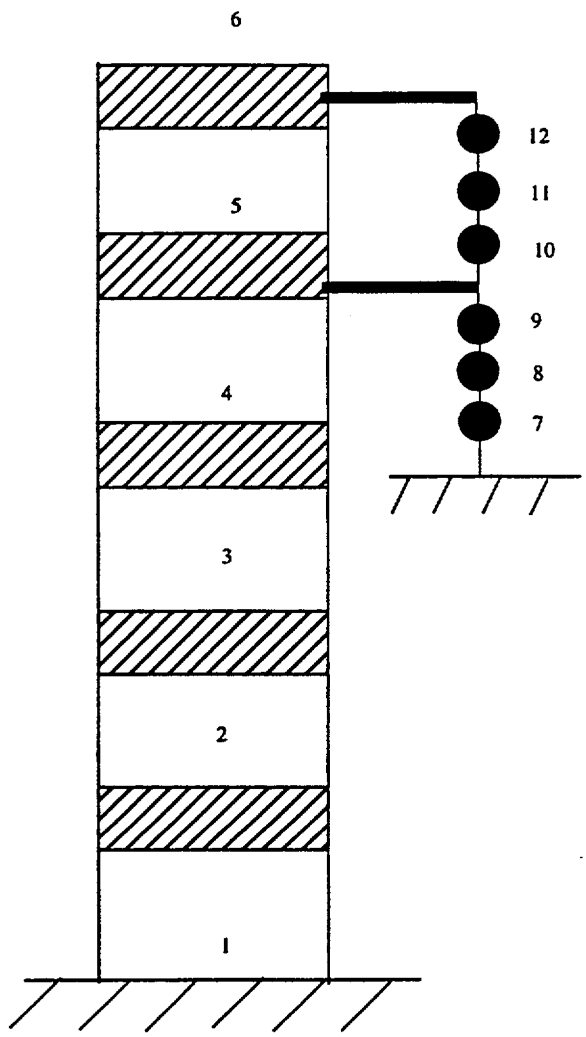

Figure 3: Benchmark Problem 3

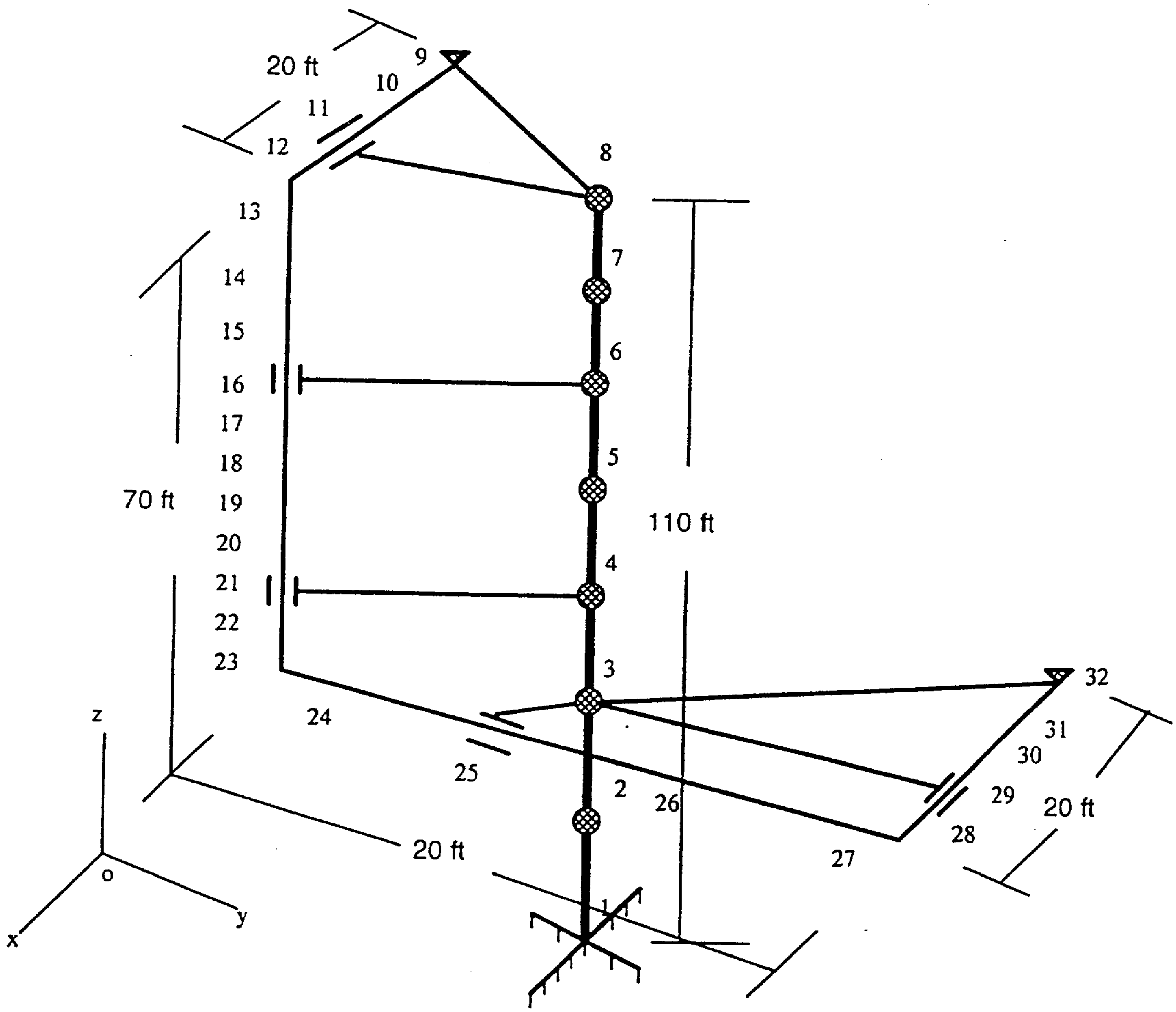

Figure 4: Benchmark Problem 4a and 4b

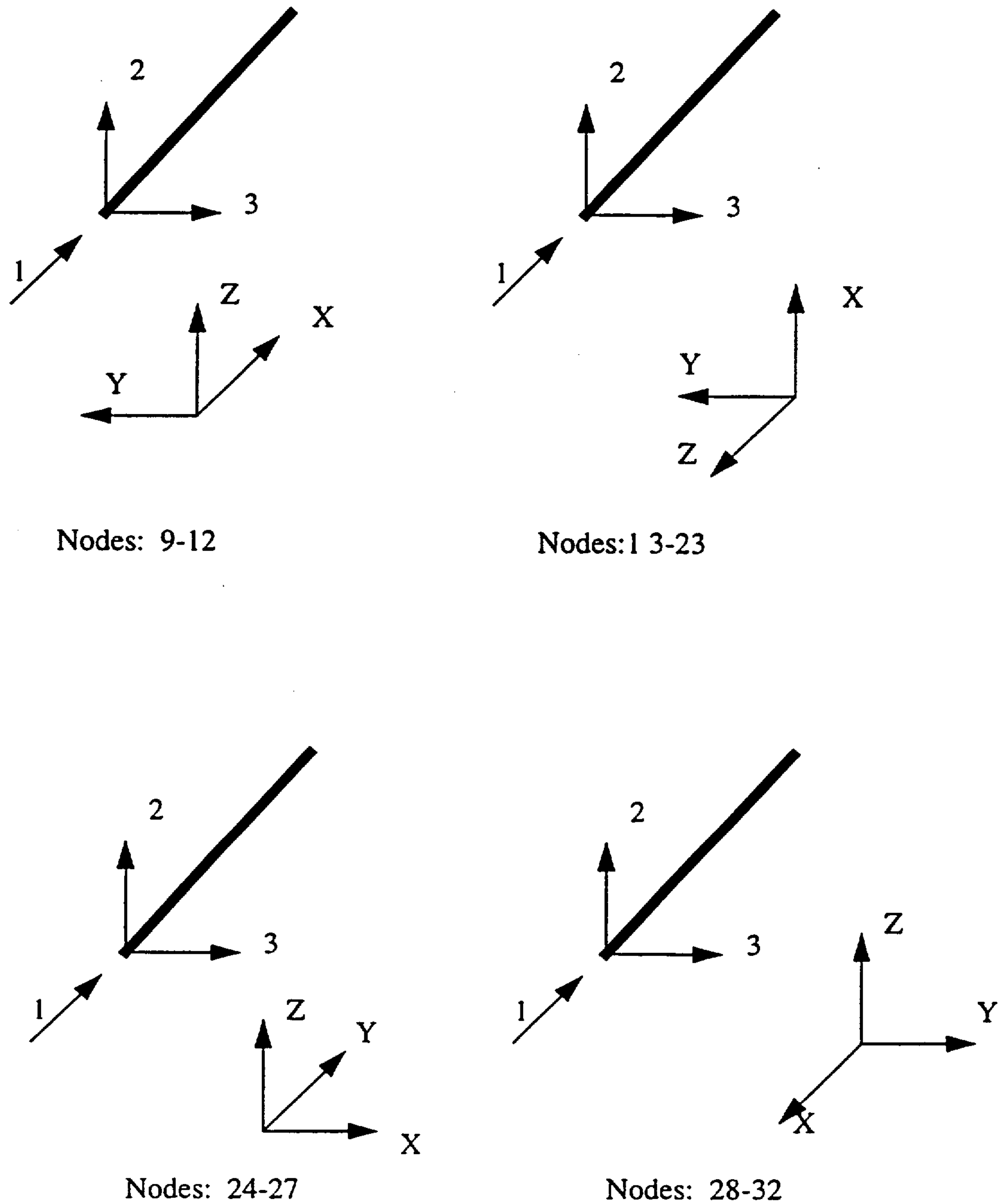

Figure 5: Local Coordinate System for Piping Segments

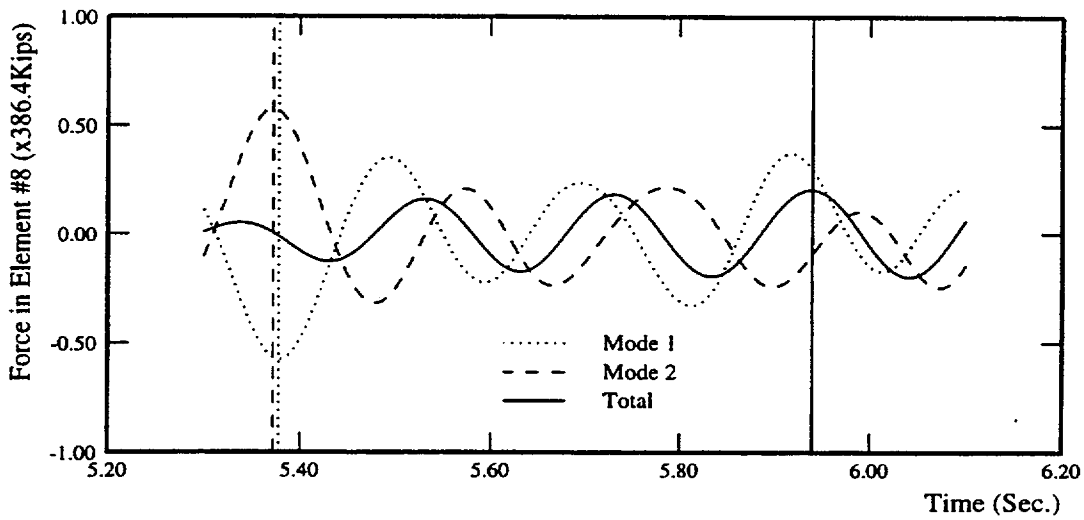

Figure 6: Benchmark Problem 1m (*El Centro* 79)

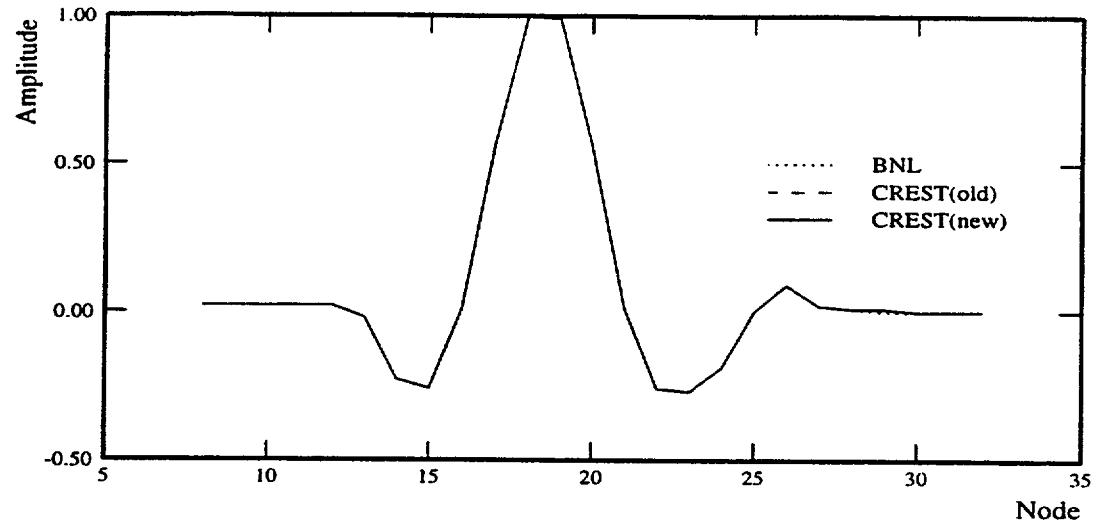

Fig. 7a: Problem 4a - Mode 1X

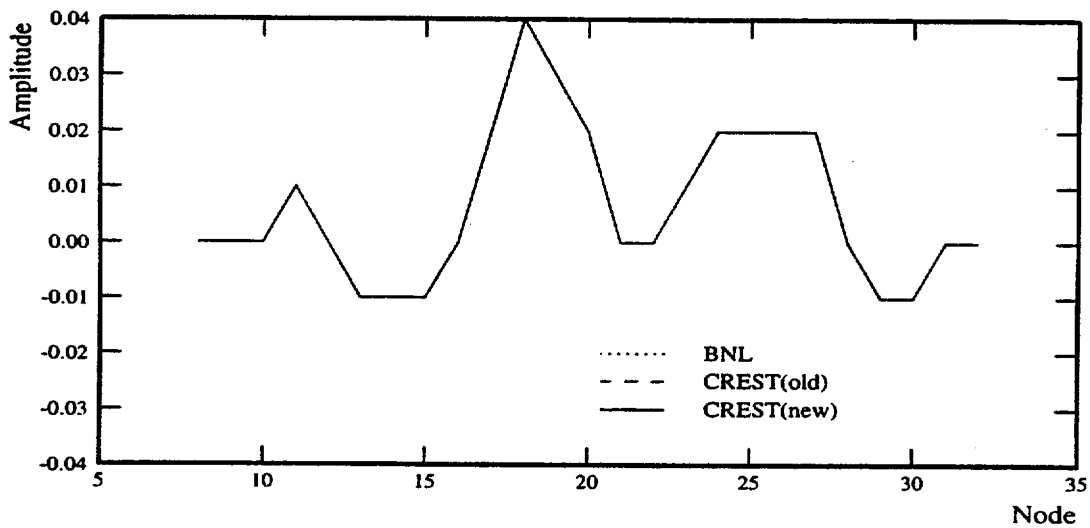

Fig. 7b: Problem 4a - Mode 1Y

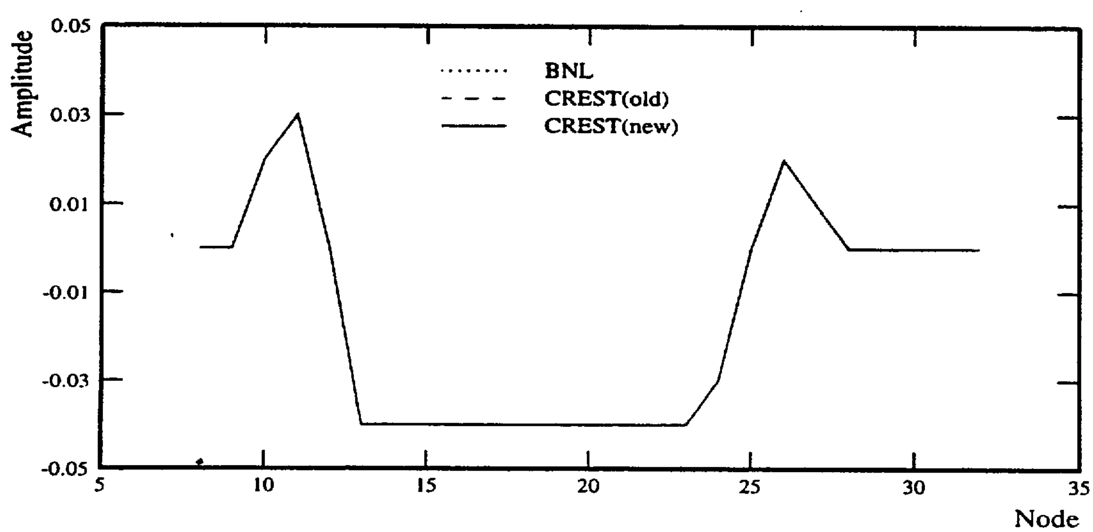

Fig. 7c: Problem 4a - Mode 1Z

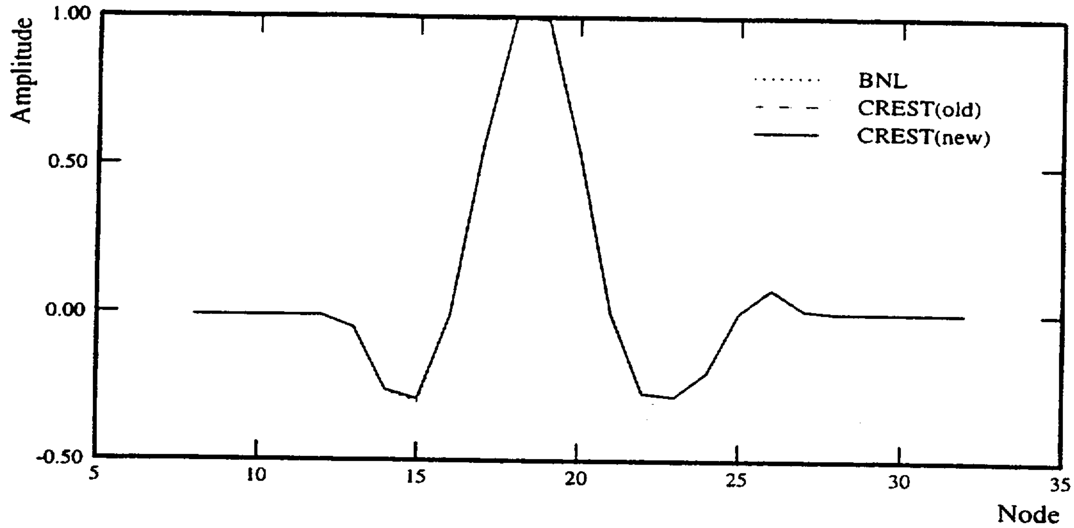

Fig. 8a: Problem 4a - Mode 2X

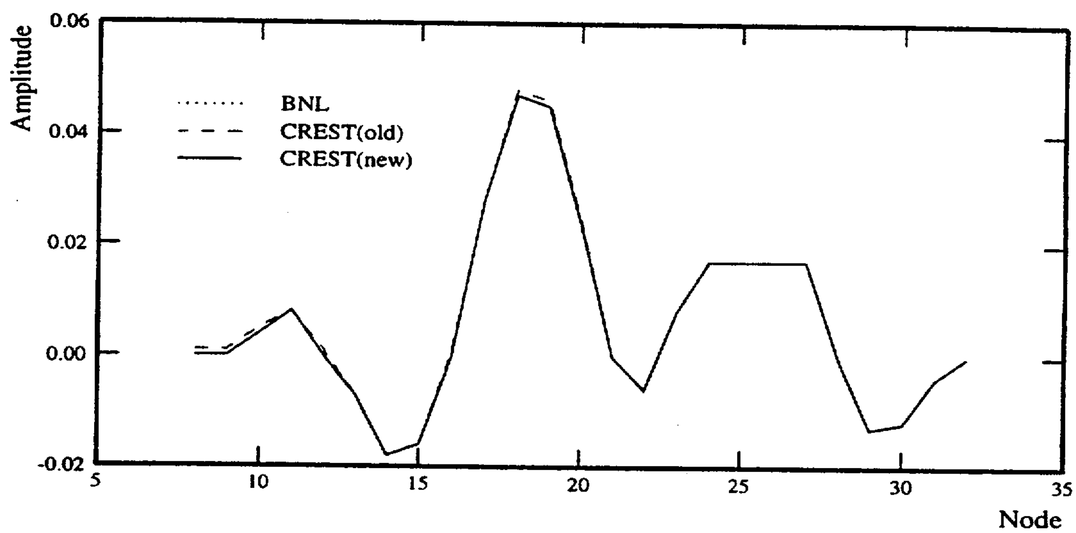

Fig. 8b: Problem 4a - Mode 2Y

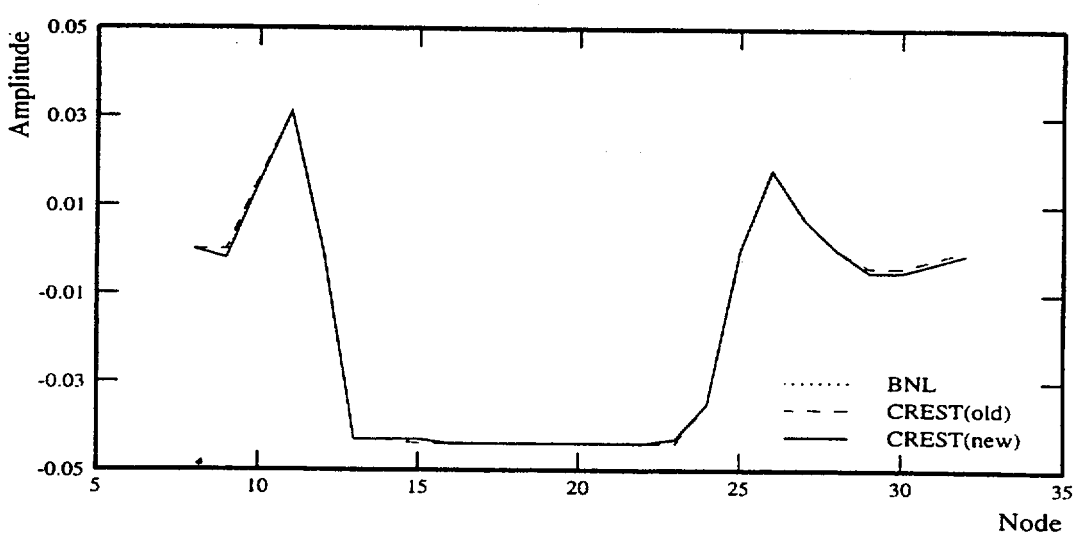

Fig. 8c: Problem 4a - Mode 2Z

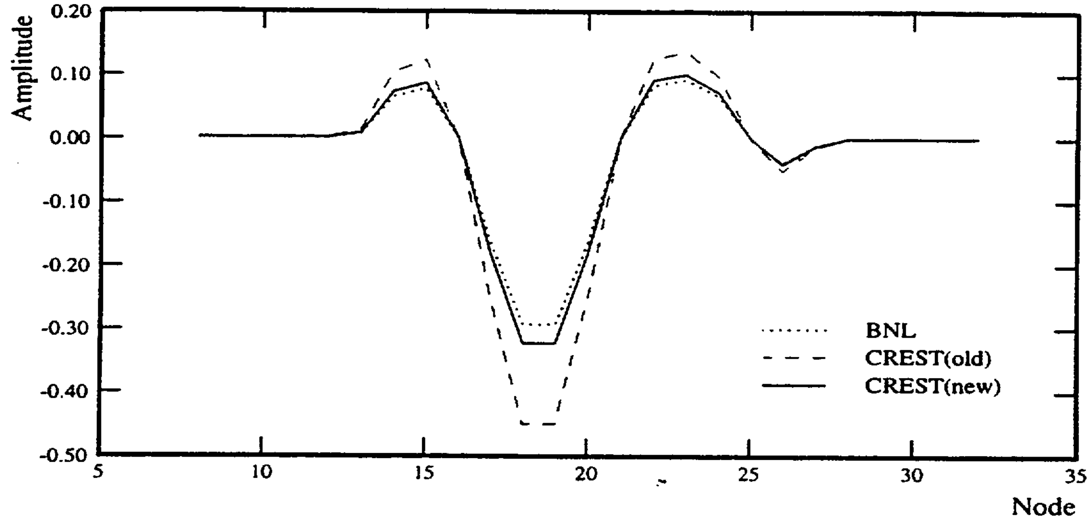

Fig. 9a: Problem 4a - Mode 3X

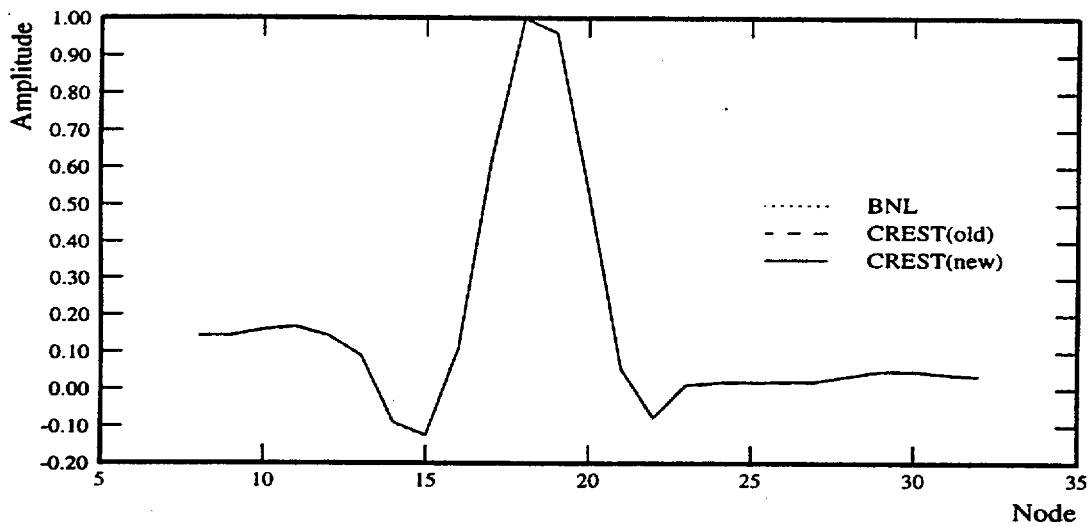

Fig. 9b: Problem 4a - Mode 3Y

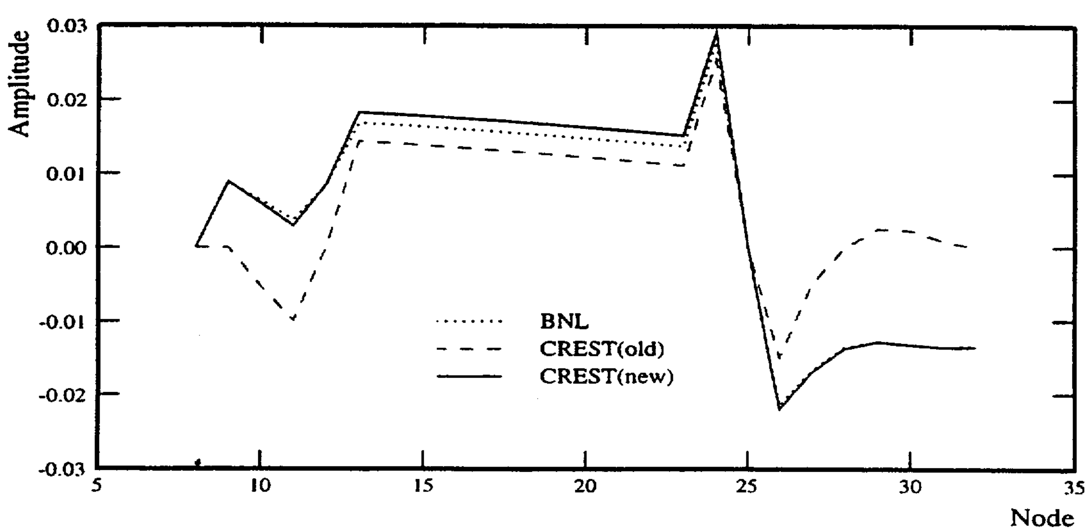

Fig. 9c: Problem 4a - Mode 3Z

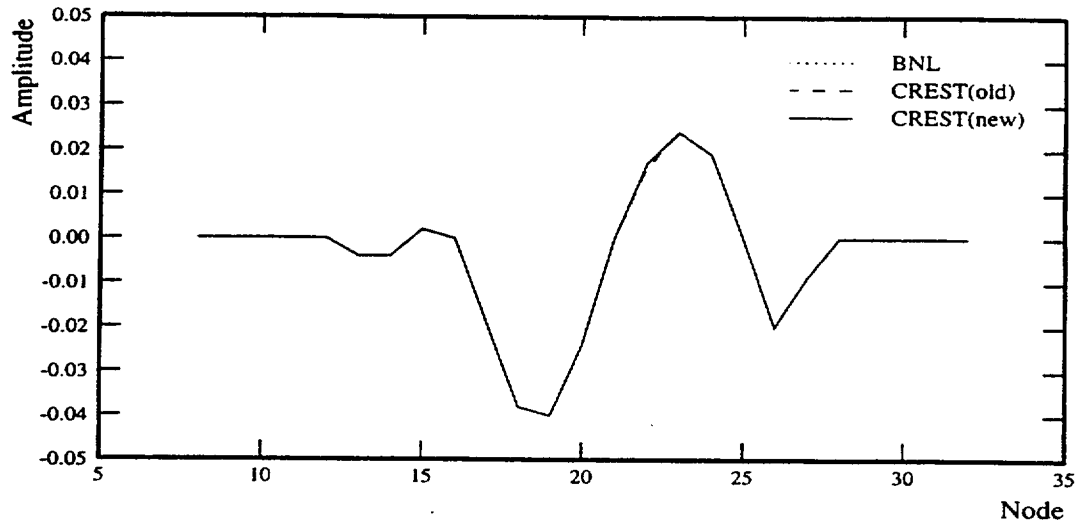

Fig. 10a: Problem 4a - Mode 4X

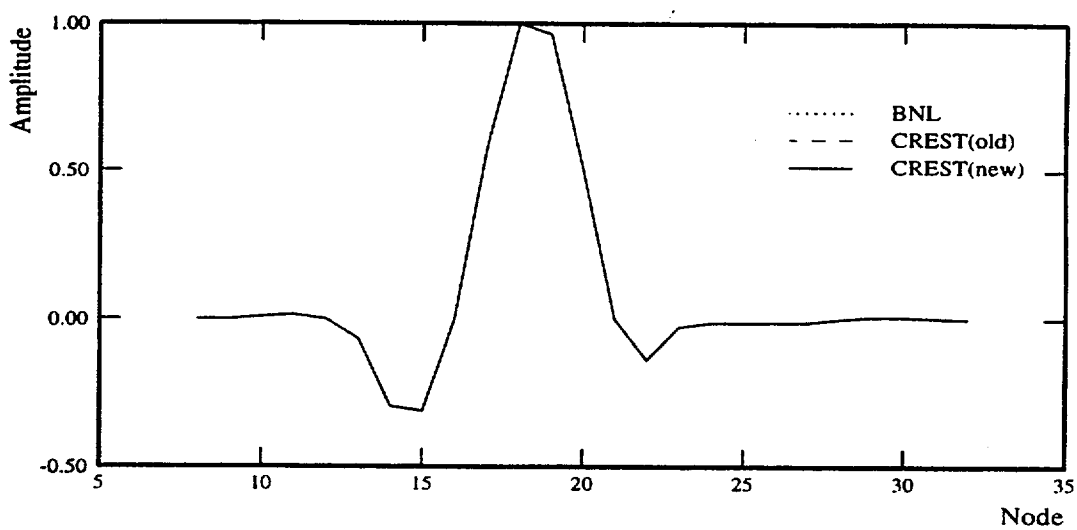

Fig. 10b: Problem 4a - Mode 4Y

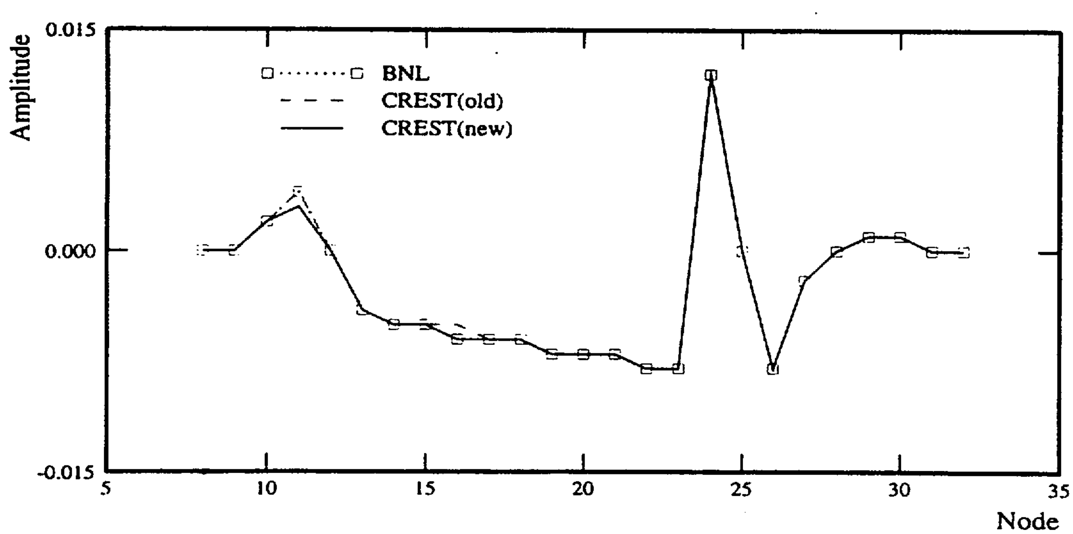

Fig. 10c: Problem 4a - Mode 4Z

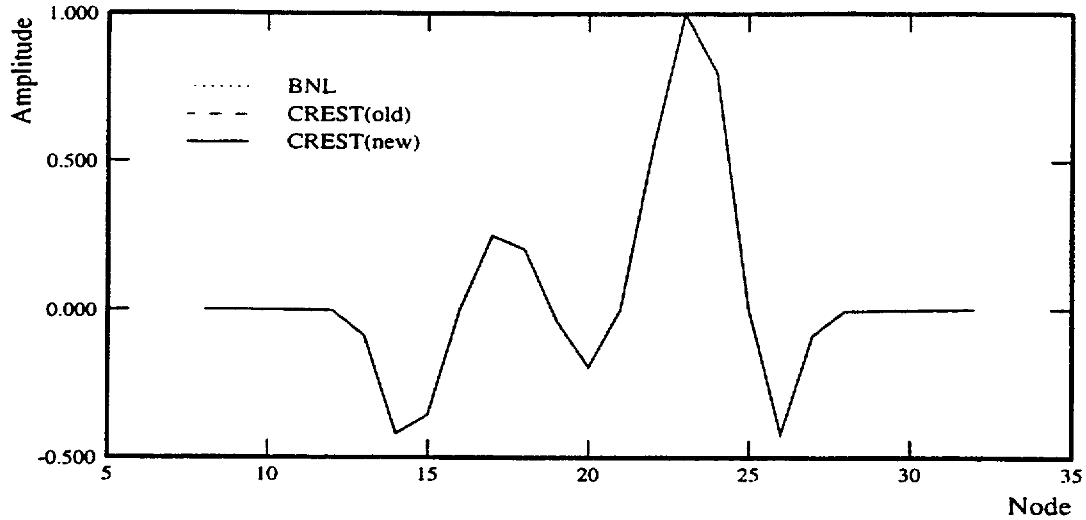

Fig. 11a: Problem 4a - Mode 5X

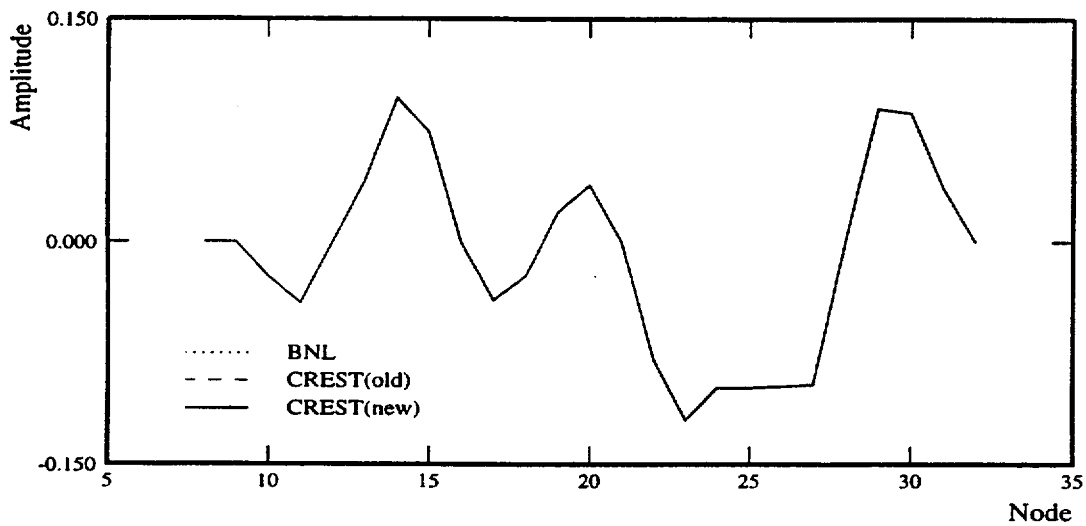

Fig. 11b: Problem 4a - Mode 5Y

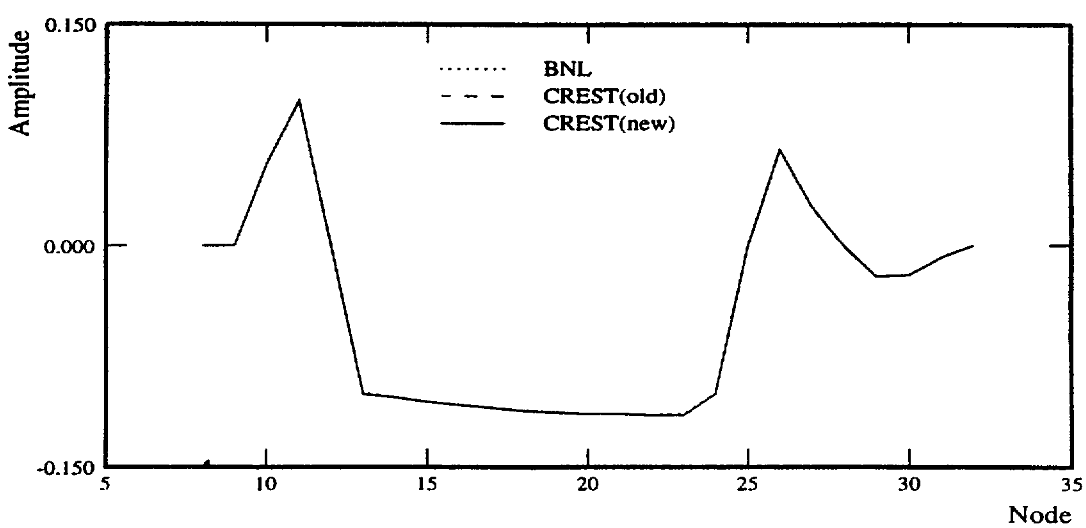

Fig. 11c: Problem 4a - Mode 5Z

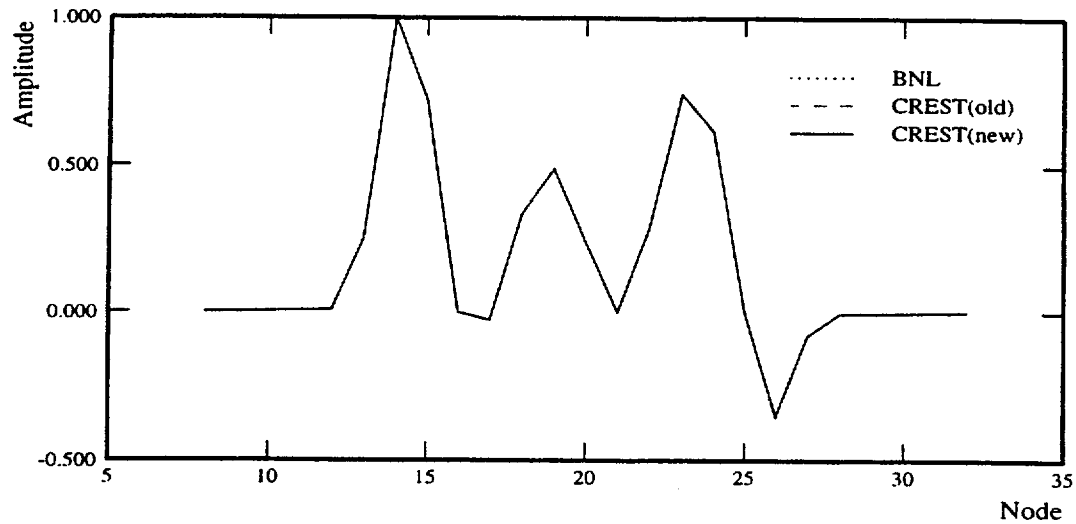

Fig. 12a: Problem 4a - Mode 6X

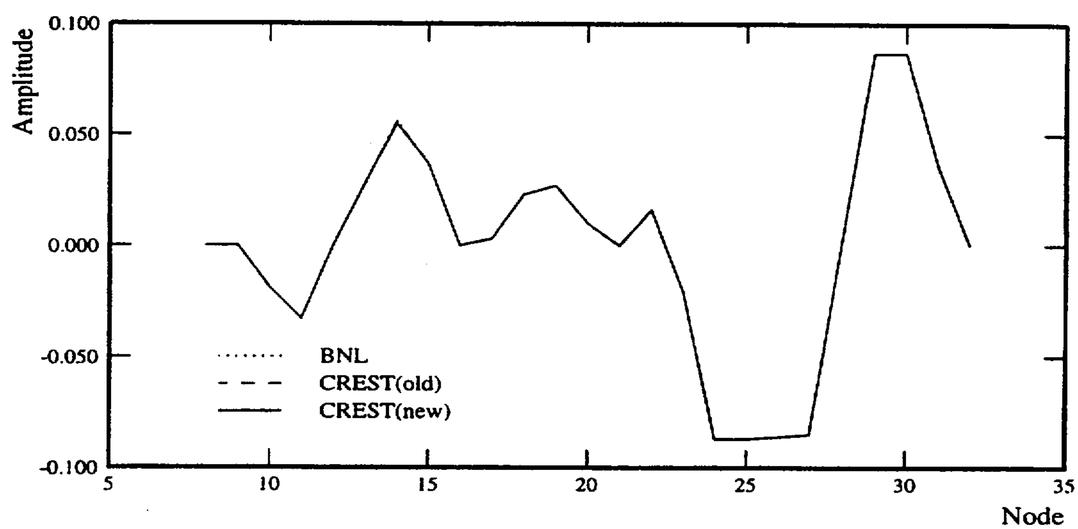

Fig. 12b: Problem 4a - Mode 6Y

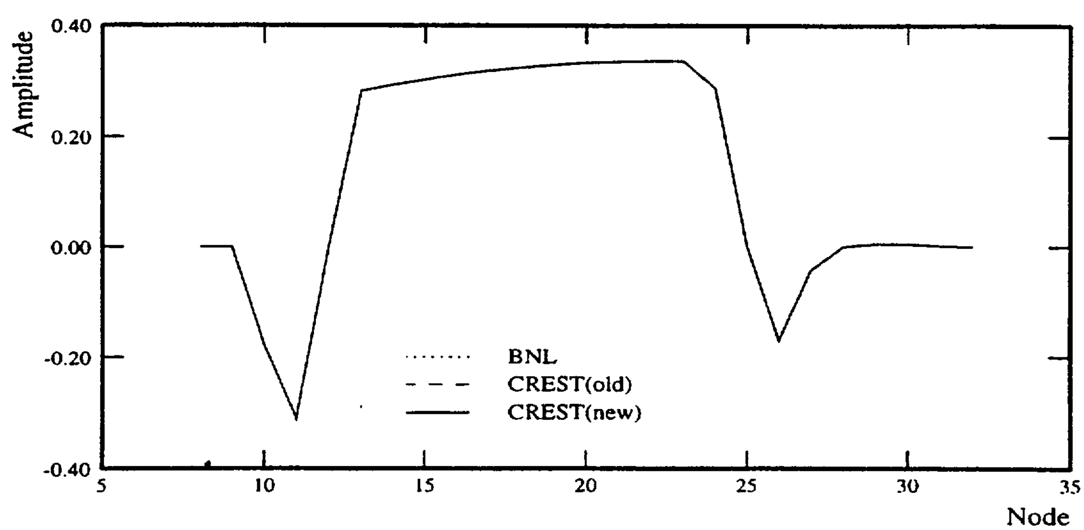

Fig.12c: Problem 4a - Mode 6Z

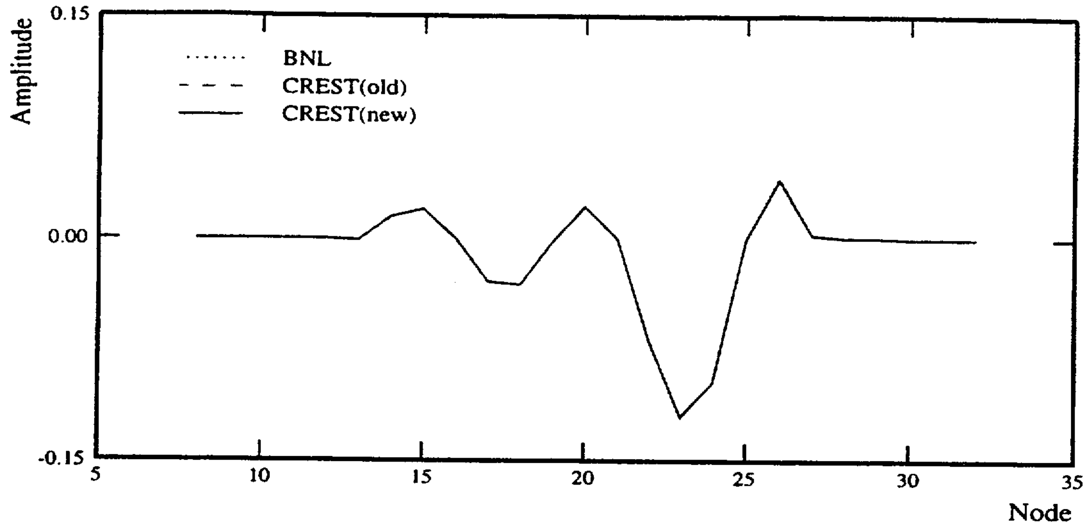

Fig. 13a: Problem 4a - Mode 7X

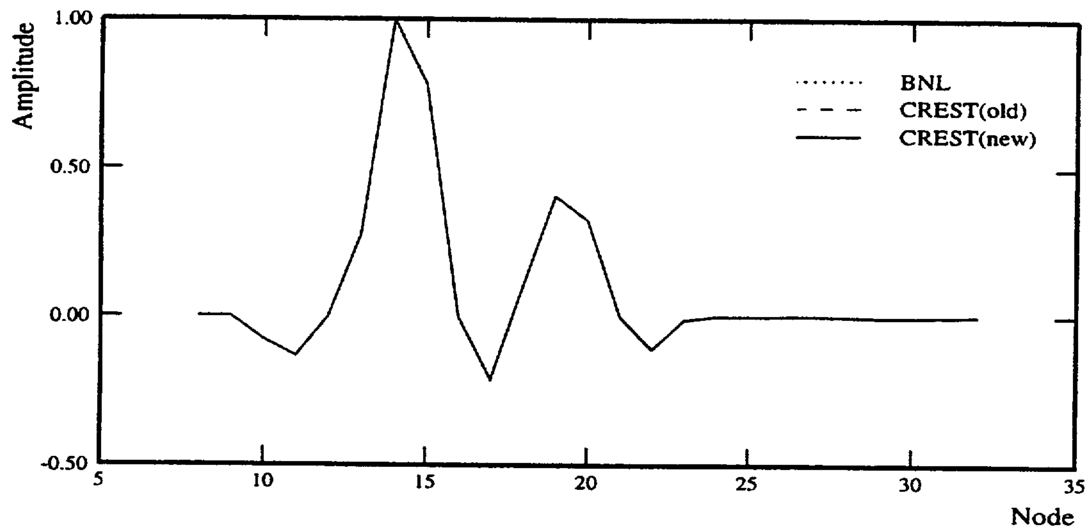

Fig. 13b: Problem 4a - Mode 7Y

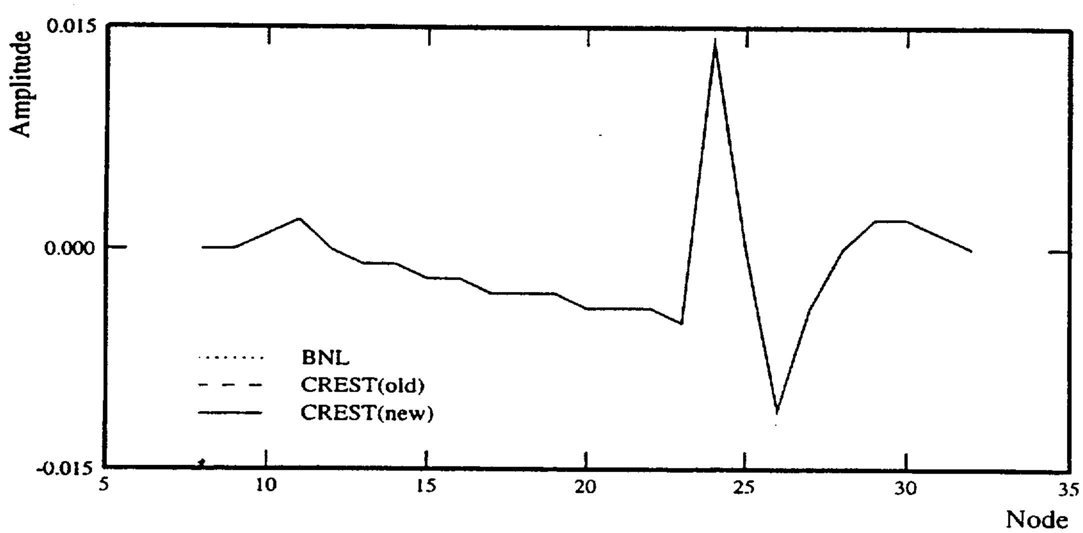

Fig. 13c: Problem 4a - Mode 7Z

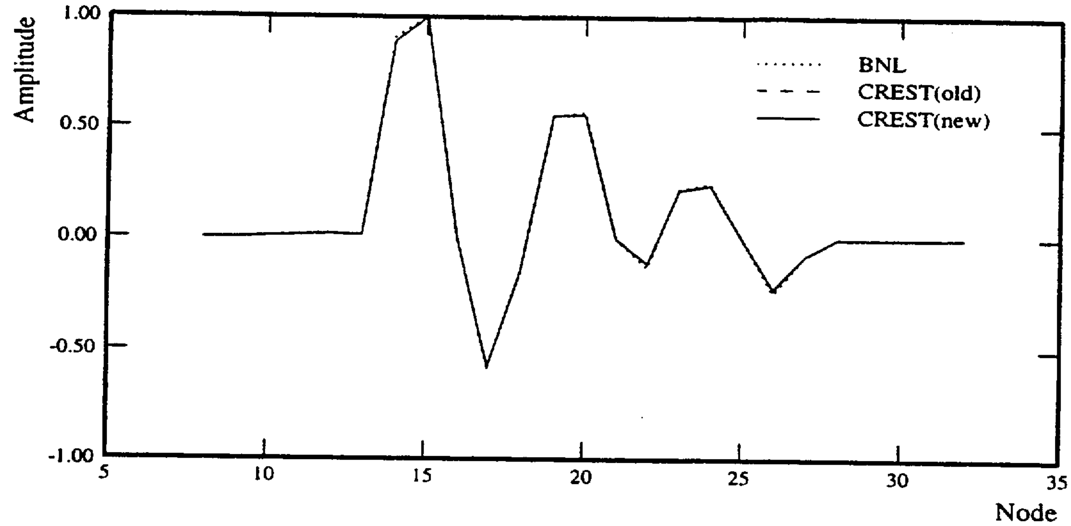

Fig. 14a: Problem 4a - Mode 8X

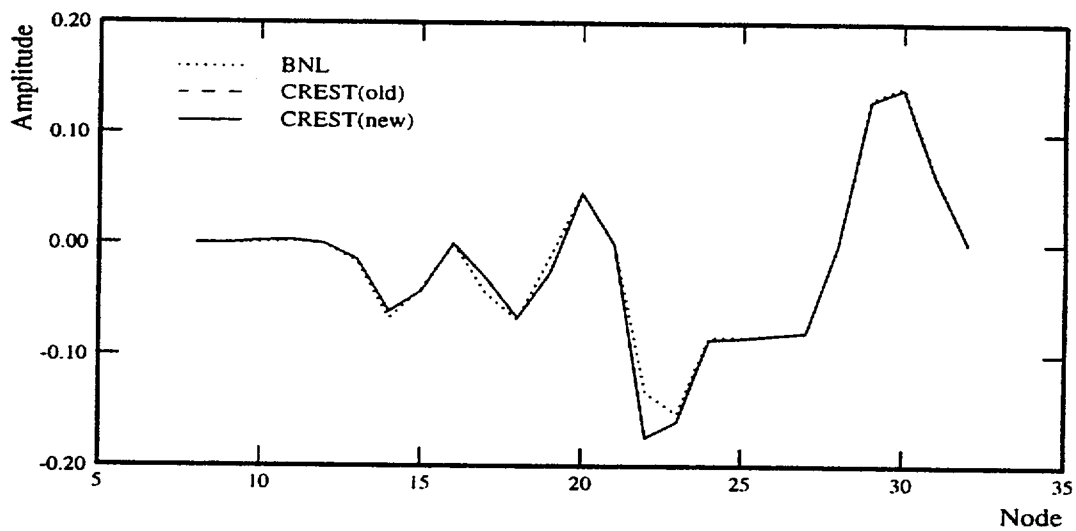

Fig. 14b: Problem 4a - Mode 8Y

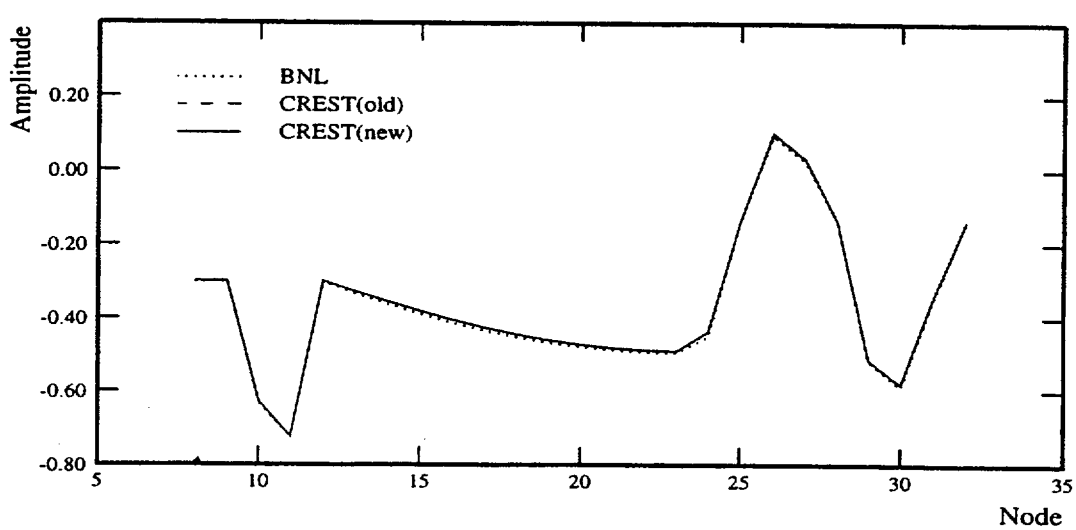

Fig. 14c: Problem 4a - Mode 8Z

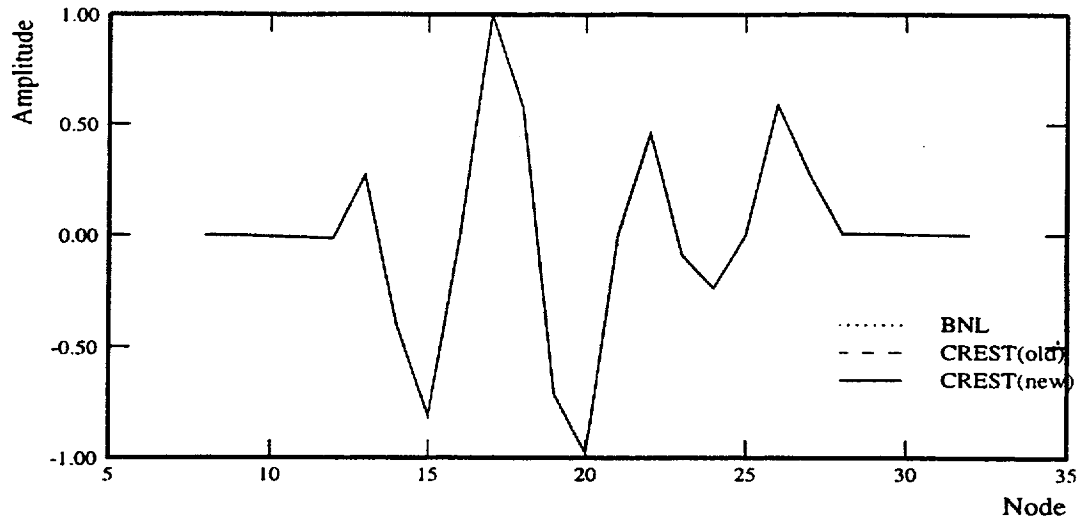

Fig. 15a: Problem 4a - Mode 9X

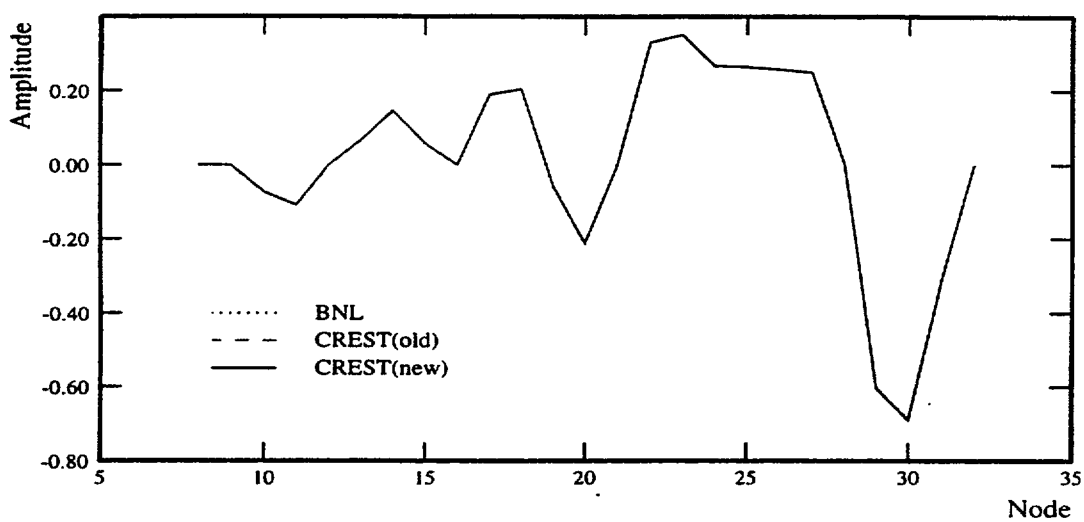

Fig. 15b: Problem 4a - Mode 9Y

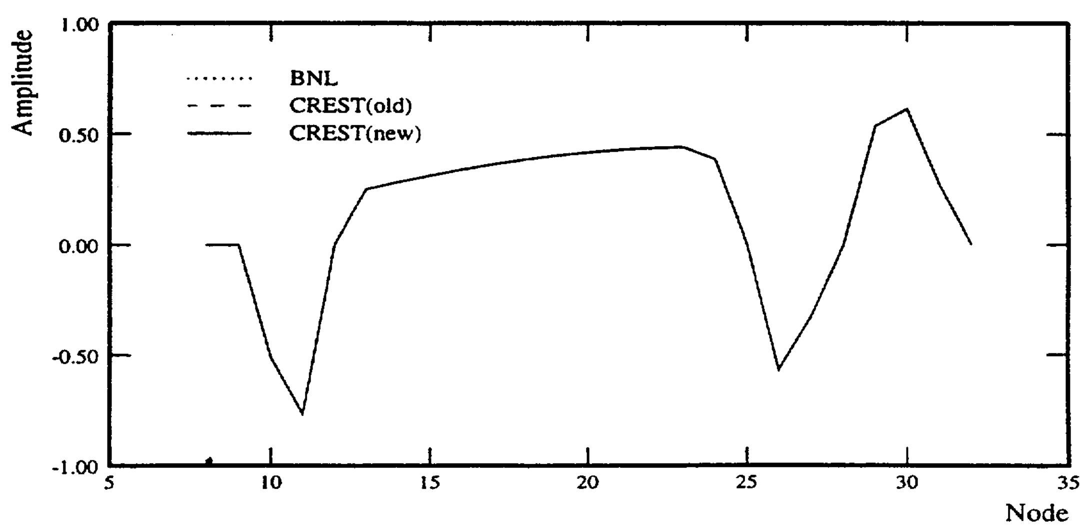

Fig. 15c: Problem 4a - Mode 9Z

ATTACHMENT 3

Description of the Igusa/Der Kiureghian Analysis Method and Results for Benchmark Program

By

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Description of the Igusa/Der Kiureghian Analysis Method and Results for the Benchmark Program

by

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for

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1. Background

The method is based on random vibrations of non-classically damped systems. Five journal papers are relevant. In 1980, Der Kiureghian (Ref. 1) derived expressions for the correlation between modal responses for classically damped systems. Der Kiureghian used these expressions to develop a response spectrum method in 1981 (Ref. 2).

In 1983, Igusa and Der Kiureghian (Ref. 3) derived expressions for the correlation between modal responses for non-classically damped systems. This is an extension of Reference 1 because it is shown that, for non-classically damped systems, both the modal responses and their time derivative are needed. Later in 1983, Igusa and Der Kiureghian (Ref. 4) used the results of Reference 3 to develop a response spectrum method for non-classically damped systems. Reference 5 provides a unified view of various methods based on random vibrations.

For practical purposes, simplified results are often attractive. In Reference 6, it is shown how the widely used SRSS method for classically damped systems can be extended to include modal correlation. The result was termed the CQC method. In Reference 7, it is shown how both the SRSS and CQC methods can be extended to non-classically damped systems.

The method used in the NRC/BNL Benchmark Program is a slight generalization of the CQC method in Reference 7. The essential difference is that filtered white noise is used instead of white noise to determine the correlation coefficients.

2. Analytical Formulation

The basic theory and equations of the Igusa/Der Kiureghian approach are summarized in this section.

2.1 Damping matrix

The coupled system damping matrix, **C**, was obtained following the rigorous and well presented set of equations in the *Preliminary Report* by Xu and DeGrassi (Ref. 8). Specifically, the equations in Sections 2.1.1 and 2.1.2 (pages 6-13) of the *Preliminary Report*, were used without modification. Numerical values for the three simple models (load cases 1a, 2a, and 3a) are presented in Section 3.1.

2.2 Modal equations of motion

In 1983, Igusa and Der Kiureghian (Ref. 3) showed how the modal equations of motion of non-classically damped systems can be expressed in terms of modal displacements and modal velocities. The results are summarized here.

The equations of motion of the coupled system, in system global coordinates, are given by Equation (1) of the *Preliminary Report*:

$$\mathbf{M}\ddot{\mathbf{U}}(t) + \mathbf{C}\dot{\mathbf{U}}(t) + \mathbf{K}\mathbf{U}(t) = -\mathbf{M}\mathbf{r}\ddot{x}_g(t) \tag{1}$$

The vector of time-dependent forces on the right side of the equation is in terms of the ground acceleration, $\ddot{x}_g(t)$, and the standard influence vector, **r**, which relates the degrees of freedom of the system with the direction of the ground motion. The corresponding complex-valued eigenvalue problem was first proposed by Foss in 1960. A symmetric form of this eigenvalue problem is:

$$\begin{bmatrix} \mathbf{M} & \mathbf{0} \\ \mathbf{0} & -\mathbf{K} \end{bmatrix} \Psi_i = \mu_i \begin{bmatrix} \mathbf{0} & \mathbf{M} \\ \mathbf{M} & \mathbf{C} \end{bmatrix} \Psi_i \tag{2}$$

which is easily solved using standard FORTRAN or MATLAB libraries. The eigenvalues, μ_i, and eigenvectors, Ψ_i, are in complex-conjugate pairs. Only the eigenvalues, μ_i, with positive imaginary components and the corresponding eigenvectors, Ψ_i, are needed in the analysis. The number of modes retained in the analysis will be denoted by n.

The complex-valued mode shapes, Φ_i, are given by the lower half of the eigenvectors, Ψ_i, of Equation (2). The natural frequencies, ω_i, and modal damping ratios, ζ_i, are obtained as follows:

$$\omega_i = |\mu_i| \tag{3}$$

$$\zeta_i = -\frac{\mathrm{Re}(\mu_i)}{|\mu_i|} \tag{4}$$

in which Re(.) represents the real part of a complex-valued quantity. The modal displacements $h_i(t)$, are given by the solution of the standard scalar equation

$$\ddot{h}_i(t) + 2\zeta_i\omega_i\dot{h}_i(t) + \omega_i^2 h_i(t) = \ddot{x}_g(t) \tag{5}$$

Thus, the modal displacements, $h_i(t)$, are the relative displacement responses of oscillators with natural frequencies, ω_i, and modal damping ratios, ζ_i.

The response of interest, $y(t)$, may be a displacement of a node, or an internal force or moment. Such responses can always be expressed as a linear combination of the displacement response vector:

$$y(t) = \mathbf{q}^{\mathrm{T}}\mathbf{U}(t) \tag{6}$$

The vector **q** would contain zeros and a single unit value if the displacement of a node is of interest. It would be in terms of an element-level matrix if an internal force or moment were of interest.

In 1983, Igusa and Der Kiureghian (Ref. 3) derived the an expansion for $y(t)$ in terms of the modal displacements, $h_i(t)$, given by Equation (4) and the modal velocities, $\dot{h}_i(t)$:

$$y(t) = \sum_{i=1}^{n} \left[a_i h_i(t) + c_i \dot{h}_i(t)\right] \tag{7}$$

The real-valued coefficients, a_i, and, c_i, are given by

$$a_i = -2\,\mathrm{Re}(b_i \bar{\mu}_i) \tag{8}$$

$$c_i = -2\,\mathrm{Re}(b_i) \tag{9}$$

in which the overbar represent the complex conjugate. The complex-valued coefficient, b_i, is given by

$$b_i = \frac{\left(\mathbf{q}_i^{\mathrm{T}}\boldsymbol{\Phi}_i\right)\left(\boldsymbol{\Phi}_i^{\mathrm{T}}\mathbf{M}\mathbf{r}\right)}{-\mu_i\boldsymbol{\Phi}_i^{\mathrm{T}}\mathbf{M}\boldsymbol{\Phi}_i + \mu_i^{-1}\boldsymbol{\Phi}_i^{\mathrm{T}}\mathbf{K}\boldsymbol{\Phi}_i} \tag{10}$$

2.3 Relationship between maximum response and response spectra

The displacement response spectrum ordinates are given by the maximum of the modal displacement responses:

$$S_{\mathrm{d}i} = \max_t \left|h_i(t)\right| \tag{11}$$

The final quantity of interest is the maximum response R defined by:

$$R = \max_t \left|y(t)\right| \tag{12}$$

The goal is to obtain an expression for the maximum response, R, in terms of the displacement response spectrum ordinates, $S_{\mathrm{d}i}$. There are two major issues here.

First, the correlation between modal responses must be included. Second, the maximum of the modal *velocity* responses, $\dot{h}_i(t)$, must be obtained in terms of the *displacement* response spectrum ordinates, S_{di}. These two issues are resolved using techniques of random vibrations. The theory behind this is explained in detail in Refs. 1-5. A summary of results is given in the following.

The expression in Equation (7) for the response, $y(t)$, can be rewritten as a sum of modal responses:

$$y(t) = \sum_{i=1}^{n} R_i(t) \tag{13}$$

in which $R_i(t)$ is the response of mode i:

$$R_i(t) = a_i h_i(t) + c_i \dot{h}_i(t) \tag{14}$$

For each mode i, the modal displacement, $h_i(t)$, and modal velocity, $\dot{h}_i(t)$, are uncorrelated. This property can be proven using arguments based on random vibrations (Ref. 9). Thus, the maximum of the modal response, $R_i(t)$, can be obtained by essentially the SRSS rule:

$$\max_t |R_i(t)| = \sqrt{\left[\max_t |a_i h_i(t)|\right]^2 + \left[\max_t |c_i \dot{h}_i(t)|\right]^2} \tag{15}$$

There are two maxima on the right side of the equality. The first is proportional to the displacement response spectrum, defined in Equation (11). The second maximum is evaluated using the following approximation:

$$\max_t |\dot{h}_i(t)| \approx \omega_{\text{eq}\,i} S_{\text{d}i} \tag{16}$$

Here, $\omega_{\text{eq}\,i}$ is an equivalent natural frequency given by Equation (23) in Section 2.4. Equation (16) is an approximation for the velocity response spectrum in terms of the displacement response spectrum. If the natural frequency, ω_i, is used instead of the equivalent natural frequency, $\omega_{\text{eq}\,i}$, then Equation (16) would become what is usually called the pseudo-velocity response spectrum.

Substituting Equations (11) and (16) into Equation (15) yields an expression for the maximum of the modal response, $R_i(t)$, which is proportional to the displacement response spectrum ordinates, S_{di}:

$$\max_t |R_i(t)| = B_i S_{\text{d}i} \tag{17}$$

in which B_i are real-valued participation factors given by:

$$B_i = \sqrt{a_i^2 + \omega_{\text{eq}\,i}^2 c_i^2} \tag{18}$$

To obtain the maximum of the response, $y(t)$, in terms of the maxima of the modal responses, $R_i(t)$, the correlation between the modal responses must be included. Thus, the formula for the maximum of $y(t)$ would be of the following form:

$$R = \max_t |y(t)| = \sqrt{\sum_{i=1}^{n} \max_t |R_i(t)|^2 + \sum_{i \neq j} \sum_{j=1}^{n} \rho_{ij} \max_t |R_i(t)| \max_t |R_j(t)|} \tag{19}$$

Within the square root, the first term is the SRSS of the modal responses, $R_i(t)$. The second term includes the correlation coefficient, ρ_{ij}, which quantifies the correlation between the modal responses. By combining Equations (17)-(19), the expression for the maximum response, R, can be rewritten in terms of the displacement response spectrum:

$$R = \sqrt{\sum_{i=1}^{n} B_i^2 S_{\text{d}i}^2 + \sum_{i \neq j} \sum_{j=1}^{n} \rho_{ij} B_i B_j S_{\text{d}i} S_{\text{d}j}} \tag{20}$$

The correlation coefficient, ρ_{ij}, is given by Equation (24) in Section 2.4.

2.4 Theoretical expressions for the equivalent frequencies and correlation coefficients

The modal equivalent frequencies, $\omega_{\text{eq}\,i}$, and correlation coefficients, ρ_{ij}, are obtained using expressions based on random vibrations. The theoretical expressions given in this section are in terms of frequency integrals. However, in numerical applications, such as those presented in this *Report*, it is not necessary to perform any numerical integration of any kind. Relatively simple polynomials, given in Section 3.2, are used to evaluate the modal equivalent frequencies, $\omega_{\text{eq}\,i}$, and correlation coefficients, ρ_{ij}.

The random vibrations approach begins with the power spectral density, which is rigorously defined in Ref. 9. The one-sided power spectral density function, $G(\omega)$, is used herein. The simplest form of the power spectral density is white noise, in which $G(\omega)$ is a constant function. For the purpose of this *Report*, the next simplest form of the power spectral density, filtered white noise, was used. Details of this form of the power spectral density are presented in Section 2.5.

One of the most important sets of expressions that can be used to relate the power spectral density with the displacement response spectra are the spectral moments. A detailed discussion of this important relationship can be found in Refs. 1 and 10. The modal cross-spectral moments, $\lambda_{k,ij}$, which are needed herein, are defined by the following frequency integrals:

$$\lambda_{k,ij} = \int_0^\infty \omega^k G(\omega) H_i(\omega) H_j(-\omega) d\omega \tag{21}$$

Here, $H_i(\omega)$ is the frequency response function of an oscillator with natural frequency, ω_i, and modal damping ratio, ζ_i, given by:

$$H_i(\omega) = \frac{1}{\omega_i^2 - \omega^2 + 2\mathrm{i}\,\omega_i \omega \zeta_i} \tag{22}$$

where $\mathrm{i} = \sqrt{-1}$.

The theoretical expressions for the modal equivalent frequencies, $\omega_{\mathrm{eq}\,i}$, and correlation coefficients, ρ_{ij}, are in terms of the spectral moments, $\lambda_{k,ij}$. For each mode i, the modal equivalent frequency, $\omega_{\mathrm{eq}\,i}$, is given by:

$$\omega_{\mathrm{eq}\,i} = \sqrt{\frac{\lambda_{2,ii}}{\lambda_{0,ii}}} \tag{23}$$

For each pair of modes i and j, the correlation coefficient, ρ_{ij}, is given by:

$$\rho_{ij} = \frac{\mathrm{Re}\left[a_i a_j \lambda_{0,ij} + (a_i c_j - a_j c_i)\mathrm{i}\lambda_{1,ij} + c_i c_j \lambda_{2,ij}\right]}{B_i B_j \sqrt{\lambda_{ii,0}\lambda_{jj,0}}} \tag{24}$$

2.5 Two-parameter models for the filtered-white-noise power spectral density

As stated in the beginning of Section 2.4, filtered white noise is used to model the power spectral density function, $G(\omega)$. Only two parameters are needed for this model: the central frequency, ω_g, and a bandwidth, ζ_g. In the Kanai-Tajimi filtered-white-noise model, suitable for a wide range of earthquakes, the values for these two parameters are $\omega_g = 5\pi$ radians/second and bandwidth, $\zeta_g = 0.6$ (Refs. 11 and 12). For the purpose of the NRC/BNL Benchmark Program, these two parameters are evaluated for each displacement response spectrum.

In the standard random vibration approach to modeling seismic motion, it is assumed that the ground accelerogram can be approximated by a stationary stochastic process. This approach is valid if the displacement response spectrum is averaged over many seismic motions with similar "frequency content." This is the approach used to determine the Kanai-Tajimi values for the two parameters, ω_g, and ζ_g (Refs. 11 and 12). With this approach, the two parameters of the filtered white noise would be obtained by fitting the square root of the spectral moment to the averaged displacement response spectrum. The expression for the maximum response, R, in Equation (20) would be accurate under the following conditions: R is the average of maximum responses for many seismic motions with similar frequency content and S_{di} is the average of response spectra for the same set of seismic motions.

In the NRC/BNL Benchmark Program, the intent was not to consider averages for many seismic events with similar frequency content. Instead, the maximum response, R, was computed separately for each seismic event. Since the seismic events of interest had widely differing frequency contents, averaging would not be appropriate.

Random vibration theory could still be used for analysis of single seismic events. Implicit in such applications of random vibrations is the ergodic property of random processes (Ref. 9). The only difficulty is that single seismic events are non-stationary because the amplitude and frequency content varies with time. Time-dependent, "evolutionary" power spectral density functions can be used to model such seismic events (Refs. 13-15). However, it is necessary to perform time-series analysis of the seismic accelerogram. It is not possible to determine the time-dependent power spectral density function directly from the response spectrum. Herein, an alternate, simplified method is used to model single seismic events with non-stationary properties. The model is determined using information only from the displacement response spectrum.

Let $S_d(\omega,\zeta)$ be the standard displacement response spectrum expressed as a function of circular frequency ω and damping ratio ζ. The filtered-white-noise power spectral density $G(\omega)$ is a function of circular frequency ω with parameters ω_0 and ζ_0:

$$G(\omega) = H_0(\omega)H_0(-\omega) \tag{25}$$

in which $H_0(\omega)$ is defined by Equation (22). This power spectral density is used to evaluate the cross-spectral moments, $\lambda_{k,ij}$. Then the cross-spectral moments are substituted into Equations (23) and (24) to evaluate the modal equivalent frequencies, $\omega_{\text{eq}\,i}$, and correlation coefficients, ρ_{ij}.

To include the effects of non-stationarity, three pairs of values of ω_0 and ζ_0 are used. These pairs of values are determined by the two parameters ω_g and ζ_g as follows:

$$\omega_0 = \omega_g,\ \ \omega_g(1+\zeta_0),\ \ \omega_g(1+\zeta_0)^{-1} \tag{26}$$

$$\zeta_0 = \frac{1}{3}\zeta_g \tag{27}$$

For each of the three pairs of values for ω_0 and ζ_0, the cross-spectral moments, $\lambda_{k,ij}$, and the corresponding modal equivalent frequencies, $\omega_{\text{eq}\,i}$, and correlation coefficients, ρ_{ij}, are evaluated. The three values for $\omega_{\text{eq}\,i}$ are combined by the SRSS rule. The three values for ρ_{ij} are also combined with the SRSS rule. The results are substituted into Equations (18) and (20) to obtain the final estimate for the maximum response, R.

As stated in the beginning of this section, there are only two parameters needed in the filtered-white-noise model: ω_g and ζ_g. To determine these two parameters, the square root of the spectral moment, $\lambda(\omega,\zeta)$, is fitted to the displacement response spectrum, $S_d(\omega,\zeta)$. The spectral moment is given by:

$$\lambda(\omega,\zeta) = \sum_{\omega_0} \lambda_{0,ii} \tag{28}$$

in which $\lambda_{0,ii}$ is the cross-modal spectral moment with $\omega_i = \omega$ and $\zeta_i = \zeta$ and the sum is over the three values for ω_0 given in Equation (26). The values for the parameters ω_g and ζ_g that were determined for each of the seven response spectra in the NRC/BNL Benchmark Program are tabulated in Section 3.3.

3. Computational Details

A few computational notes are summarized in this section. The most substantial set of results, presented in Section 3.2, is a computationally efficient procedure for determining the cross-spectral moments, $\lambda_{k,ij}$, without numerical integration.

3.1 System damping matrices

The stiffness and damping matrices for the three simple models (load cases 1a, 2a, and 3a) are presented below:

Load case 1a, stiffness matrix

row	column (starting from the diagonal element)					
i	i	i+1	i+2	i+3	i+4	i+5
1	63057	-31528				
2	63057	-31528				
3	63057	-31528				
4	63163	-31528	-105.89			
5	31528					
6	211.77	-105.89				
7	211.77	-105.89				
8	211.77	-105.89				
9	105.89					

Load case 1a, damping matrix

row	column (starting from the diagonal element)					
i	*i*	*i*+1	*i*+2	*i*+3	*i*+4	*i*+5
1	54.291	-15.564	-2.6674	-1.0766	-0.6860	
2	51.624	-16.641	-3.3534	-1.7626		
3	50.938	-17.327	-4.4300			
4	49.942	-19.994	-0.04036	-0.01720	-0.01233	-0.01074
5	34.297					
6	0.06353	-0.01830	-0.00328	-0.00159		
7	0.06025	-0.01989	-0.00487			
8	0.05866	-0.02317				
9	0.04036					

Load case 2a, stiffness matrix

row	column (starting from the diagonal element)						
i	*i*	*i*+1	*i*+2	*i*+3	*i*+4	*i*+5	*i*+6	*i*+7
1	63057	-31528						
2	63079	-31528			-21.802			
3	63101	-31528				-21.802	-21.802	
4	63079	-31528						-21.802
5	31528							
6	43.604	-21.802						
7	43.604	-21.802						
8	43.604							
9	43.604	-21.802						
10	43.604	-21.802						
11	43.604							

Load case 2a, damping matrix

row	column (starting from the diagonal element)								
i	*i*	*i*+1	*i*+2	*i*+3	*i*+4	*i*+5	*i*+6	*i*+7	*i*+8
1	54.291	-15.564	-2.6674	-1.0766	-0.6860				
2	51.641	-16.632	-3.3534	-1.7626	-0.01733	-0.00575	-0.00230		
3	50.971	-17.318	-4.4300	-0.0023	-0.00575	-0.01733	-0.01733	-0.00575	-0.00230
4	49.878	-19.994				-0.00230	-0.00575	-0.01733	
5	34.297								
6	0.02890	-0.00813	-0.00114						
7	0.02776	-0.00813							
8	0.02890								
9	0.02890	-0.00813	-0.00114						
10	0.02776	-0.00813							
11	0.02890								

Load case 3a, stiffness matrix

row	column (starting from the diagonal element)						
i	*i*	*i*+1	*i*+2	*i*+3	*i*+4	*i*+5	*i*+6
1	63057	-31528					
2	63057	-31528					
3	63057	-31528					
4	63101	-31528			-21.802	-21.802	
5	31550						-21.802
6	43.604	-21.802					
7	43.604	-21.802					
8	43.604						
9	43.604	-21.802					
10	43.604	-21.802					
11	43.604						

Load case 3a, damping matrix

row	column (starting from the diagonal element)							
i	*i*	*i*+1	*i*+2	*i*+3	*i*+4	*i*+5	*i*+6	*i*+7
1	54.291	-15.564	-2.6674	-1.0766	-0.68603			
2	51.624	-16.641	-3.3534	-1.7626				
3	50.938	-17.327	-4.4300					
4	49.894	-19.985	-0.00230	-0.00575	-0.01733	-0.01733	-0.00575	-0.00230
5	34.314				-0.00230	-0.00575	-0.01733	
6	0.02890	-0.00813	-0.00114					
7	0.02776	-0.00813						
8	0.02890							
9	0.02890	-0.00813	-0.00114					
10	0.02776	-0.00813						
11	0.02890							

3.2 Cross-spectral moments

In this section, it is shown how the cross-spectral moments, $\lambda_{k,ij}$, defined by Equation (21), can be efficiently evaluated without numerical integration. The theoretical details are in Reference 5; only the computational steps are shown herein.

The cross-spectral moments, $\lambda_{k,ij}$, are in terms of the natural frequencies ω_i and ω_j and damping ratios ζ_i and ζ_j of modes *i* and *j*, and the parameters ω_0 and ζ_0 given in Equations (26) and (27). The first step in determining $\lambda_{k,ij}$ is to compute the following intermediate values. For $m = 0$, *i* and *j*, the damped natural frequencies, ω_{dm}, and complex natural frequencies, μ_m, are given by

$$\omega_{dm} = \omega_m \sqrt{1-\zeta_m^2} \qquad \mu_m = -\zeta_m \omega_m + \mathrm{i}\omega_{dm} \tag{29}$$

It is noted that μ_i and μ_j are identical to the eigenvalues in equation (2). Next, the following additional intermediate values are needed, in which $m, p = 0$, *i* or *j* and $k =$ 0, 1 or 2:

$$\beta_0 = \frac{\mu_0}{\mu_0^2 - \omega_0^2} \tag{30}$$

$$b_0^{(m)} = -\frac{\mathrm{i}\omega_0^2 \mu_0^2 \beta_0}{2\omega_{dm}} \left(\frac{1}{\mu_0 - \mu_m} - \frac{1}{\mu_0 - \bar{\mu}_m} \right) \tag{31}$$

$$b_m^{(m)} = \frac{\mathrm{i}\omega_0^2 \mu_0^2}{2\omega_{dm}} \left(\frac{\beta_0}{\mu_0 - \mu_m} + \frac{\bar{\beta}_0}{\bar{\mu}_0 - \mu_m} \right) \tag{32}$$

$$a_{0,m}^{(i)} = -2\,\mathrm{Re}\left(b_m^{(i)}\bar{\mu}_m\right) \qquad a_{1,m}^{(i)} = a_{2,m}^{(i)} = 2\mathrm{i}\,\mathrm{Re}\left(b_m^{(i)}\omega_m^2\right) \tag{33}$$

$$a_{0,m}^{(j)} = a_{1,m}^{(j)} = -2\,\mathrm{Re}\left(b_m^{(j)}\bar{\mu}_m\right) \qquad a_{2,m}^{(j)} = 2\mathrm{i}\,\mathrm{Re}\left(b_m^{(j)}\omega_m^2\right) \tag{34}$$

$$c_{0,m}^{(i)} = 2\,\mathrm{Re}\left(b_m^{(i)}\right) \qquad c_{1,m}^{(i)} = c_{2,m}^{(i)} = 2\,\mathrm{Re}\left(b_m^{(i)}\mu_m\right) \tag{35}$$

$$c_{0,m}^{(j)} = c_{1,m}^{(j)} = 2\,\mathrm{Re}\left(b_m^{(j)}\right) \qquad c_{2,m}^{(j)} = 2\,\mathrm{Re}\left(b_m^{(j)}\mu_m\right) \tag{36}$$

$$C_{k,mp} = a_{k,m}^{(i)}a_{k,p}^{(j)} \qquad E_{k,mp} = c_{k,m}^{(i)}c_{k,p}^{(j)} \tag{37}$$

$$D_{k,mp} = a_{k,m}^{(i)}c_{k,p}^{(j)} - c_{k,m}^{(i)}a_{k,p}^{(j)} \tag{38}$$

$$A_{k,mp} = 2\left(\omega_m\zeta_m + \omega_p\zeta_p\right)C_{k,mp} + \left(\omega_m^2 - \omega_p^2\right)D_{k,mp} + 2\left(\omega_m\zeta_p + \omega_p\zeta_m\right)E_{k,mp} \tag{39}$$

The preceding expressions need not be computed for all possible combinations of m, p, and k. Specifically, Equations (31) and (32) are not evaluated for $m = 0$, Equations (33) and (35) are not evaluated for $m = j$, Equations (34) and (36) are not evaluated for $m = i$, and Equations (37)–(38) are not evaluated for $m = j$ or $p = i$.

The final result for the cross-spectral moments, $\lambda_{k,ij}$, is given as follows:

$$\lambda_{k,ij} = \sum_{m=0,i}\ \sum_{p=0,j} \frac{\left[\pi + \mathrm{i}\left(\log\mu_m - \log\mu_p\right)\right]A_{k,mp}}{\left(\omega_m^2 - \omega_p^2\right) + 4\omega_m\omega_p\left(\omega_m\zeta_m + \omega_p\zeta_p\right)\left(\omega_p\zeta_m + \omega_m\zeta_p\right)} \tag{40}$$

3.3 Two-parameter filtered-white-noise power spectral densities

By following the procedure described in Section 2.5, the following values were determined for the central frequency, ω_g, and bandwidth, ζ_g, for each seismic input considered in the NRC/BNL Benchmark Program:

Two-parameter description of each seismic input

Accelerogram	$\omega_g/2\pi$ (rad/s)	ζ_g
El Centro (1940)	4.0	0.90
Taft (1952)	3.5	0.50
Olympia (1949)	4.0	0.55
El Centro (1979)	3.0	0.10
Loma Prieta (1989)	1.5	0.15
Northridge (1994)	4.5	0.40
Reg. Guide 1.60	4.5	0.85

5. References

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Analysis Results

Table 1. Maximum Nodal Displacement for Benchmark Problem #1 (inches)
Response spectrum method

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	0.997	1.004	0.997	0.999	1.004	1.003	1.004	1.003	0.998	1.004	0.999	0.996	0.999	1.004	0.998	1.002
3	0.998	1.003	1.000	1.001	1.006	1.001	1.002	1.002	1.002	1.006	1.000	0.999	1.001	1.003	0.996	1.003
4	1.005	1.002	1.004	1.003	1.002	1.002	1.003	1.001	1.005	1.002	1.003	0.996	1.001	1.004	1.000	1.000
5	1.003	1.002	1.005	1.004	1.004	1.003	1.001	1.001	1.005	1.004	0.997	0.997	1.002	1.006	0.996	1.003
6	1.004	1.002	1.003	1.002	1.004	1.004	1.005	0.999	1.002	1.002	1.002	0.998	1.001	1.005	0.999	1.002
7	1.000	0.998	1.001	1.001	1.003	1.000	1.002	1.000	1.000	1.002	1.002	1.009	1.002	0.999	0.997	1.000
8	1.001	0.997	0.996	1.000	1.003	1.000	1.005	0.999	1.001	1.002	0.997	1.010	1.001	0.999	0.996	0.998
9	1.003	1.001	1.000	1.001	1.001	1.002	1.003	0.999	1.000	1.002	1.002	1.008	1.002	1.001	0.998	1.001
10	1.003	0.999	1.001	1.003	1.000	1.001	1.010	0.999	1.005	1.001	1.000	1.010	1.000	0.999	0.997	1.002

Table 2. Maximum Element Forces for Benchmark Problem #1 (Kips)
Response spectrum method

Element	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	2,510.1	2,660.0	2,533.0	2,671.9	2,700.0	2,666.5	3,284.7	4,276.7	2,580.1	2,641.0	1,694.2	2,574.7	6,206.3	2,327.7	2,326.0	2,193.2
2	2,214.3	2,356.9	2,235.5	2,369.8	2,395.7	2,363.1	2,982.8	4,045.6	2,281.2	2,340.6	1,495.4	2,303.6	5,566.9	1,999.7	2,100.8	1,955.0
3	1,796.5	1,914.7	1,810.0	1,931.2	1,950.2	1,920.1	2,535.3	3,683.3	1,853.7	1,903.9	1,214.5	1,893.1	4,564.4	1,591.0	1,727.6	1,591.9
4	1,275.0	1,353.9	1,275.7	1,376.1	1,384.1	1,358.0	1,968.0	3,202.4	1,316.5	1,350.7	862.7	1,361.5	3,252.0	1,112.9	1,231.7	1,129.6
5	649.8	703.4	667.7	695.6	710.3	705.0	743.5	655.2	670.7	693.5	433.1	669.0	1,682.2	558.8	631.1	580.8
6	87.7	20.1	62.2	67.0	17.9	2.2	747.1	2,047.5	61.3	23.1	55.6	99.7	235.5	51.9	83.4	79.5
7	76.8	17.9	55.2	58.0	14.3	1.9	635.9	1,659.0	53.5	19.7	48.5	86.6	207.2	45.0	73.2	69.9
8	56.9	13.8	41.2	42.7	9.9	1.4	463.3	1,171.0	39.5	14.3	35.8	63.7	153.9	33.2	54.3	51.9
9	30.3	7.7	22.0	22.6	5.1	0.8	244.2	606.8	21.0	7.6	19.0	33.7	81.9	17.6	28.9	27.6

Table 3. Maximum Nodal Displacement for Benchmark Problem #1 (inches)
Modal superposition time history method

Nodes	Load cases															
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**I**	**j**	**k**	**l**	**m**	**n**	**o**	**p**
2	0.080	0.081	0.083	0.080	0.083	0.082	0.099	0.133	0.081	0.081	0.049	0.081	0.237	0.068	0.065	0.063
3	0.152	0.155	0.157	0.152	0.158	0.156	0.189	0.256	0.153	0.155	0.092	0.152	0.447	0.127	0.123	0.118
4	0.210	0.216	0.217	0.212	0.221	0.218	0.264	0.365	0.212	0.217	0.127	0.209	0.617	0.174	0.172	0.162
5	0.254	0.261	0.262	0.257	0.267	0.263	0.321	0.459	0.257	0.262	0.151	0.250	0.738	0.207	0.207	0.194
6	0.278	0.286	0.287	0.281	0.292	0.288	0.343	0.472	0.281	0.287	0.164	0.270	0.800	0.223	0.226	0.209
7	0.959	0.859	0.701	0.712	0.305	1.110	0.650	0.663	0.671	0.446	0.590	1.043	1.487	0.700	0.895	0.848
8	1.698	1.371	1.373	1.127	0.334	1.981	0.924	0.839	1.160	0.620	1.004	1.727	2.506	1.171	1.654	1.501
9	2.245	1.942	1.877	1.429	0.353	2.626	1.121	0.964	1.521	0.749	1.309	2.229	3.256	1.517	2.221	1.985
10	2.535	2.273	2.146	1.588	0.364	2.968	1.222	1.030	1.714	0.818	1.470	2.494	3.652	1.701	2.523	2.241

Table 4. Maximum Element Forces for Benchmark Problem #1 (Kips)
Modal superposition time history method

Element	Load cases															
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**I**	**j**	**k**	**l**	**m**	**n**	**o**	**p**
1	2536.3	2562.9	2615.7	2517.6	2617.7	2583.5	3128.8	4184.9	2544.5	2567.3	1533.7	2543.4	7487.8	2151.9	2057.5	1986.5
2	2260.7	2317.5	2334.7	2281.2	2372.2	2338.1	2831.9	3876.3	2279.4	2327.5	1358.7	2242.8	6620.1	1855.8	1859.1	1728.6
3	1882.1	1926.4	1937.4	1905.6	1976.0	1946.2	2399.5	3443.5	1900.4	1939.2	1103.1	1816.0	5366.2	1475.3	1559.6	1398.8
4	1401.4	1424.0	1441.0	1421.4	1465.6	1442.0	1867.2	3042.1	1414.4	1440.4	782.5	1292.0	3793.3	1029.3	1126.9	995.6
5	750.4	783.9	777.5	746.5	790.1	785.4	802.2	729.7	757.3	773.9	387.1	619.8	1958.0	512.4	578.0	486.7
6	90.1	19.1	65.5	62.7	21.1	2.1	698.8	2269.7	60.1	24.7	50.6	86.3	125.4	57.9	92.1	79.5
7	78.6	18.3	58.1	53.5	17.0	1.9	581.3	1885.7	52.4	20.9	43.9	75.2	108.3	50.1	81.2	69.5
8	58.0	15.1	43.3	38.8	12.0	1.4	416.1	1340.5	38.6	15.3	32.3	55.5	79.5	36.8	60.4	51.3
9	30.7	8.8	23.1	20.4	6.2	0.7	218.8	699.0	20.5	8.1	17.1	29.4	42.5	19.5	32.2	27.2

Table 5. Maximum Nodal Displacement for Benchmark Problem #2 (inches)
Response spectrum method

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	0.080	0.084	0.080	0.085	0.086	0.085	0.115	0.167	0.082	0.084	0.054	0.082	0.197	0.074	0.074	0.069
3	0.150	0.159	0.150	0.161	0.162	0.159	0.220	0.326	0.155	0.158	0.101	0.156	0.373	0.138	0.140	0.131
4	0.207	0.219	0.207	0.222	0.224	0.220	0.303	0.450	0.213	0.218	0.140	0.216	0.517	0.189	0.195	0.181
5	0.246	0.261	0.247	0.264	0.267	0.263	0.355	0.514	0.254	0.260	0.166	0.258	0.619	0.223	0.233	0.216
6	0.266	0.283	0.267	0.286	0.289	0.285	0.379	0.535	0.275	0.282	0.180	0.279	0.672	0.241	0.253	0.234
7	1.220	1.404	1.090	0.813	0.232	1.517	0.719	0.641	0.906	0.435	0.796	1.459	3.177	0.779	1.143	1.077
8	1.701	1.981	1.538	1.106	0.268	2.125	0.937	0.782	1.247	0.565	1.102	2.013	4.456	1.066	1.597	1.507
9	1.236	1.402	1.090	0.841	0.264	1.531	0.766	0.711	0.927	0.465	0.810	1.489	3.201	0.799	1.156	1.087
10	1.542	1.477	1.322	1.061	0.299	1.921	0.909	0.815	1.136	0.530	1.001	1.828	4.046	0.966	1.448	1.364
11	2.146	2.090	1.870	1.438	0.334	2.689	1.166	0.962	1.560	0.680	1.382	2.512	5.674	1.318	2.022	1.909
12	1.552	1.474	1.321	1.079	0.323	1.929	0.936	0.850	1.149	0.550	1.010	1.848	4.060	0.979	1.455	1.370

Table 6. Maximum Element Forces for Benchmark Problem #2 (Kips)
Response spectrum method

Element	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	2,515.8	2,654.6	2,514.5	2,687.6	2,708.3	2,666.4	3,616.1	5,273.5	2,588.8	2,642.7	1,698.4	2,601.0	6,204.9	2,340.2	2,324.5	2,181.1
2	2,220.5	2,351.8	2,218.3	2,385.2	2,403.6	2,363.1	3,310.3	5,016.8	2,289.8	2,342.5	1,500.0	2,329.0	5,568.3	2,011.8	2,100.2	1,944.6
3	1,795.0	1,910.3	1,797.7	1,934.0	1,950.9	1,919.9	2,651.1	3,915.2	1,853.8	1,900.9	1,211.5	1,894.8	4,558.8	1,594.3	1,722.3	1,579.6
4	1,257.1	1,351.6	1,273.0	1,353.2	1,373.6	1,357.6	1,651.7	2,020.6	1,299.4	1,338.0	843.3	1,314.1	3,230.5	1,098.9	1,216.4	1,112.3
5	648.1	702.4	663.2	695.6	710.5	704.9	754.9	687.0	669.9	692.0	431.2	667.6	1,678.2	559.5	628.7	575.9
6	25.4	7.6	19.3	18.7	6.2	0.6	229.8	696.7	18.1	7.2	16.2	29.2	67.6	15.3	24.0	22.7
7	10.5	3.5	8.0	7.8	3.2	0.3	96.9	311.3	7.5	3.0	6.7	12.1	28.1	6.3	10.0	9.4
8	10.3	3.4	8.1	7.2	0.6	0.3	79.8	167.4	7.2	2.6	6.5	11.5	27.9	6.0	9.8	9.3
9	25.2	7.7	19.3	18.4	3.8	0.6	217.7	583.9	17.9	6.9	16.0	28.9	67.4	15.1	23.9	22.7
10	32.1	8.0	23.5	24.4	6.9	0.8	282.1	810.6	22.7	8.6	20.3	36.4	86.2	18.9	30.5	28.9
11	13.3	3.8	9.8	10.1	3.1	0.3	114.8	326.6	9.4	3.5	8.4	15.0	35.8	7.8	12.6	12.0
12	13.2	3.7	9.9	9.7	1.3	0.3	105.5	255.9	9.2	3.3	8.2	14.6	35.7	7.6	12.5	11.9
13	32.0	8.1	23.5	24.2	5.3	0.8	275.2	752.9	22.6	8.5	20.2	36.2	86.1	18.8	30.4	28.9

Table 7. Maximum Nodal Displacement for Benchmark Problem #2 (inches)
Modal superposition time history method

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	0.080	0.081	0.083	0.080	0.083	0.082	0.112	0.167	0.081	0.082	0.048	0.082	0.238	0.068	0.065	0.064
3	0.152	0.154	0.158	0.153	0.159	0.156	0.216	0.323	0.153	0.156	0.091	0.154	0.447	0.127	0.123	0.119
4	0.210	0.215	0.217	0.214	0.221	0.218	0.297	0.443	0.212	0.217	0.126	0.212	0.618	0.174	0.170	0.164
5	0.254	0.260	0.262	0.257	0.267	0.263	0.346	0.502	0.256	0.262	0.150	0.251	0.737	0.206	0.205	0.195
6	0.277	0.285	0.286	0.281	0.292	0.288	0.366	0.520	0.280	0.286	0.162	0.271	0.799	0.222	0.223	0.210
7	1.278	1.322	1.110	0.819	0.233	1.512	0.718	0.625	0.875	0.476	0.765	1.299	1.930	0.894	1.242	1.135
8	1.781	2.079	1.583	1.098	0.273	2.112	0.946	0.764	1.212	0.624	1.052	1.775	2.639	1.221	1.750	1.568
9	1.296	1.369	1.101	0.848	0.268	1.530	0.780	0.682	0.893	0.514	0.782	1.339	1.959	0.914	1.248	1.137
10	1.611	1.381	1.344	1.057	0.298	1.908	0.874	0.855	1.101	0.583	0.962	1.625	2.394	1.110	1.585	1.428
11	2.240	2.225	1.929	1.409	0.336	2.661	1.113	1.021	1.520	0.748	1.319	2.207	3.260	1.510	2.235	1.976
12	1.623	1.416	1.341	1.075	0.325	1.920	0.915	0.879	1.113	0.611	0.974	1.653	2.409	1.123	1.589	1.426

Table 8. Maximum Element Forces for Benchmark Problem #2 (Kips)
Modal superposition time history method

Element	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	2533.6	2555.3	2626.4	2531.0	2626.1	2583.5	3536.4	5279.9	2544.3	2574.0	1528.5	2580.1	7490.0	2154.9	2052.4	2012.7
2	2262.0	2303.3	2344.8	2301.6	2380.3	2338.1	3259.8	4910.2	2285.5	2334.5	1356.0	2277.8	6624.4	1859.6	1843.9	1753.5
3	1876.6	1918.7	1935.6	1906.4	1976.9	1946.0	2579.1	3794.7	1896.5	1938.2	1093.2	1823.2	5364.0	1471.6	1542.1	1406.9
4	1377.7	1429.1	1428.9	1384.0	1454.8	1441.5	1571.0	2043.9	1392.3	1424.7	754.5	1240.8	3778.4	1007.4	1100.1	967.1
5	747.0	782.1	776.2	745.0	789.7	785.3	783.6	806.4	754.7	772.8	382.4	620.8	1956.0	509.4	570.8	487.1
6	26.4	7.3	20.2	18.1	6.5	0.6	220.3	698.0	17.7	7.7	15.2	25.2	38.0	17.4	26.6	23.4
7	11.0	4.1	8.5	7.4	3.6	0.3	99.4	304.5	7.4	3.3	6.2	10.4	15.5	7.1	11.1	9.5
8	10.6	4.0	8.6	6.7	0.7	0.3	77.0	187.7	7.0	2.8	5.9	10.0	14.9	6.7	11.0	9.4
9	26.2	7.6	20.3	17.4	4.2	0.6	211.9	568.1	17.5	7.6	14.9	24.9	37.0	17.0	26.6	22.9
10	33.1	7.7	24.6	23.0	7.6	0.8	251.7	930.9	22.2	9.2	18.9	31.7	46.6	21.4	34.1	29.3
11	13.7	4.7	10.4	9.3	3.3	0.3	104.4	362.8	9.2	3.8	7.8	13.1	18.9	8.7	14.2	12.0
12	13.5	4.5	10.5	8.8	1.7	0.3	94.1	320.9	8.9	3.6	7.5	12.8	18.9	8.5	14.2	12.0
13	33.0	7.9	24.8	22.5	5.8	0.8	248.6	858.1	22.1	9.1	18.8	31.5	45.9	21.1	34.1	29.0

Table 9. Maximum Nodal Displacement for Benchmark Problem #3 (inches)
Response spectrum method

Nodes	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
2	0.079	0.084	0.080	0.085	0.085	0.085	0.105	0.137	0.082	0.084	0.054	0.082	0.197	0.074	0.074	0.069
3	0.149	0.158	0.150	0.160	0.161	0.159	0.201	0.266	0.154	0.157	0.101	0.154	0.373	0.137	0.140	0.131
4	0.206	0.218	0.207	0.221	0.222	0.220	0.282	0.383	0.212	0.217	0.139	0.214	0.517	0.188	0.195	0.180
5	0.246	0.261	0.247	0.264	0.266	0.263	0.345	0.484	0.254	0.260	0.166	0.257	0.619	0.223	0.233	0.216
6	0.266	0.283	0.267	0.286	0.288	0.285	0.376	0.531	0.275	0.282	0.180	0.279	0.672	0.241	0.254	0.234
7	0.857	1.368	0.832	0.520	0.106	1.070	0.437	0.334	0.626	0.285	0.555	1.018	2.223	0.548	0.803	0.763
8	1.231	1.841	1.169	0.772	0.191	1.530	0.670	0.548	0.913	0.438	0.804	1.480	3.170	0.800	1.153	1.091
9	0.930	1.362	0.840	0.644	0.246	1.136	0.620	0.596	0.726	0.417	0.620	1.149	2.340	0.642	0.866	0.813
10	1.748	1.521	1.467	1.223	0.345	2.179	1.006	0.888	1.283	0.592	1.133	2.067	4.598	1.089	1.645	1.551
11	2.433	2.157	2.079	1.653	0.378	3.049	1.288	1.050	1.759	0.752	1.563	2.834	6.450	1.482	2.296	2.171
12	1.754	1.520	1.466	1.233	0.357	2.183	1.023	0.916	1.290	0.602	1.138	2.078	4.606	1.096	1.649	1.554

Table 10. Maximum Element Forces for Benchmark Problem #3 (Kips)
Response spectrum method

Element	Load cases															
	a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p
1	2,505.9	2,649.5	2,517.9	2,671.8	2,692.7	2,666.2	3,320.5	4,321.5	2,578.9	2,635.0	1,688.5	2,569.9	6,197.3	2,330.7	2,319.9	2,178.6
2	2,210.4	2,346.8	2,221.1	2,369.7	2,388.4	2,362.9	3,019.2	4,078.5	2,279.9	2,335.0	1,490.2	2,299.5	5,558.5	2,002.3	2,095.0	1,941.4
3	1,793.4	1,905.7	1,797.7	1,931.3	1,943.1	1,919.9	2,571.5	3,699.3	1,852.5	1,899.2	1,210.3	1,890.3	4,557.4	1,593.2	1,722.7	1,580.4
4	1,273.2	1,346.6	1,266.6	1,376.4	1,377.5	1,357.9	2,003.0	3,199.8	1,315.8	1,347.3	860.0	1,360.7	3,247.5	1,114.5	1,228.2	1,121.4
5	656.9	699.9	658.0	710.2	715.6	705.0	974.0	1,507.1	679.2	697.5	441.1	696.5	1,685.1	568.5	634.6	579.9
6	18.7	7.5	14.7	13.7	9.3	0.5	190.4	728.6	13.7	6.2	12.1	22.2	48.5	11.9	17.5	16.6
7	8.2	3.9	6.1	6.7	7.4	0.2	104.2	480.4	6.3	3.4	5.5	10.1	21.0	5.5	7.7	7.2
8	7.2	3.6	6.5	4.2	4.9	0.2	49.0	208.4	4.9	2.0	4.4	7.5	19.8	4.0	6.9	6.6
9	17.9	7.6	14.6	12.1	2.2	0.5	143.8	363.8	12.7	5.0	11.4	20.7	47.5	10.9	16.9	16.1
10	36.4	8.3	26.2	28.2	7.9	0.9	313.0	908.4	25.7	9.6	23.0	41.0	98.2	21.3	34.7	32.9
11	15.1	4.0	11.0	11.5	3.2	0.4	126.5	361.6	10.6	3.9	9.4	16.8	40.7	8.7	14.3	13.6
12	15.0	3.9	11.0	11.4	2.4	0.4	120.3	304.3	10.5	3.8	9.4	16.6	40.7	8.6	14.3	13.6
13	36.4	8.3	26.2	28.1	7.1	0.9	308.8	865.8	25.6	9.5	22.9	40.9	98.2	21.2	34.6	32.9

Table 11. Maximum Nodal Displacement for Benchmark Problem #3 (inches)
Modal superposition time history method

Nodes	Load cases															
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**I**	**j**	**k**	**l**	**m**	**n**	**o**	**p**
2	0.080	0.081	0.083	0.080	0.083	0.082	0.101	0.132	0.081	0.081	0.048	0.081	0.237	0.068	0.065	0.063
3	0.152	0.154	0.157	0.152	0.158	0.156	0.194	0.255	0.153	0.155	0.091	0.152	0.447	0.127	0.123	0.118
4	0.209	0.215	0.217	0.212	0.220	0.218	0.273	0.364	0.212	0.216	0.125	0.210	0.617	0.173	0.170	0.163
5	0.254	0.260	0.262	0.257	0.266	0.263	0.335	0.458	0.256	0.262	0.150	0.251	0.737	0.206	0.205	0.194
6	0.277	0.284	0.286	0.281	0.291	0.288	0.363	0.504	0.280	0.286	0.162	0.272	0.799	0.222	0.223	0.210
7	0.896	1.441	0.886	0.523	0.105	1.062	0.453	0.302	0.608	0.303	0.525	0.883	1.377	0.627	0.872	0.815
8	1.295	1.903	1.203	0.778	0.191	1.530	0.731	0.482	0.886	0.482	0.763	1.303	1.969	0.911	1.243	1.140
9	0.977	1.403	0.834	0.660	0.247	1.146	0.690	0.518	0.688	0.459	0.601	1.051	1.536	0.721	0.901	0.837
10	1.825	1.422	1.491	1.211	0.343	2.161	0.957	0.954	1.247	0.654	1.087	1.834	2.689	1.249	1.806	1.614
11	2.534	2.318	2.149	1.608	0.381	3.009	1.199	1.149	1.717	0.825	1.488	2.481	3.658	1.695	2.546	2.239
12	1.832	1.440	1.492	1.220	0.356	2.167	0.980	0.981	1.253	0.668	1.093	1.849	2.695	1.255	1.808	1.613

Table 12. Maximum Element Forces for Benchmark Problem #3 (Kips)
Modal superposition time history method

Element	Load cases															
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**I**	**j**	**k**	**l**	**m**	**n**	**o**	**p**
1	2534.7	2554.8	2621.7	2513.0	2610.4	2583.3	3183.9	4176.8	2543.5	2563.4	1518.8	2546.2	7484.1	2142.9	2047.1	1991.1
2	2259.0	2306.4	2340.2	2277.5	2364.1	2337.8	2928.6	3858.8	2272.3	2324.0	1345.5	2245.9	6615.6	1847.8	1839.3	1733.2
3	1874.9	1916.7	1934.3	1902.8	1969.0	1946.0	2504.8	3436.5	1894.7	1936.2	1092.5	1820.0	5361.6	1469.7	1543.1	1404.2
4	1396.7	1416.8	1438.9	1419.6	1459.6	1441.8	1946.6	3070.8	1410.7	1438.3	775.7	1297.0	3790.1	1026.2	1115.3	1001.0
5	757.9	775.4	781.5	767.8	795.2	785.6	906.0	1517.6	765.5	781.2	394.9	656.4	1960.7	520.5	578.5	508.8
6	19.5	7.9	15.6	13.8	9.2	0.5	197.6	658.9	13.3	6.6	11.4	19.2	30.0	13.7	19.0	17.8
7	8.7	5.0	6.3	6.8	7.5	0.2	121.5	441.8	6.1	3.9	5.2	9.2	14.0	6.2	8.1	7.4
8	7.4	4.1	7.3	3.3	4.9	0.2	46.5	230.4	4.6	2.2	3.6	6.5	12.2	4.4	7.8	6.7
9	18.7	8.1	15.7	11.2	2.5	0.4	159.6	370.1	12.4	5.6	10.5	17.6	26.8	12.2	18.7	16.3
10	37.5	7.9	27.5	26.2	9.7	0.9	271.2	1099.2	25.1	10.1	21.3	35.8	52.1	23.9	38.9	33.2
11	15.5	5.0	11.7	10.6	3.6	0.4	106.4	429.7	10.3	4.1	8.7	14.7	21.1	9.8	16.2	13.7
12	15.4	4.9	11.7	10.3	3.2	0.4	103.2	374.9	10.2	4.0	8.6	14.6	21.4	9.6	16.2	13.7
13	37.5	8.0	27.6	25.9	8.5	0.9	269.4	1051.7	25.0	10.1	21.2	35.8	51.6	23.8	38.9	33.0

Table 13 Maximum Nodal Displacements for Benchmark Problem #4a (inches)
Response spectrum method

Nodes	Case a	Case b	Case c	Case d	Case e	Case f	Case g
2ux	0.000004	0.000001	0.000002	0.000005	0.000002	0.000001	0.000002
2uy	0.011398	0.004369	0.008311	0.020539	0.006224	0.006182	0.009110
2uz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2θx	0.000031	0.000011	0.000022	0.000056	0.000016	0.000017	0.000025
2θy	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3ux	0.000006	0.000002	0.000003	0.000010	0.000003	0.000001	0.000004
3uy	0.028467	0.010713	0.020596	0.051155	0.015187	0.015417	0.022886
3uz	0.000001	0.000000	0.000000	0.000001	0.000000	0.000000	0.000000
3θx	0.000054	0.000020	0.000039	0.000097	0.000027	0.000029	0.000044
3θy	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4ux	0.000007	0.000002	0.000004	0.000011	0.000003	0.000002	0.000005
4uy	0.045532	0.016898	0.032748	0.081659	0.023864	0.024626	0.036760
4uz	0.000001	0.000000	0.000000	0.000001	0.000000	0.000000	0.000000
4θx	0.000068	0.000024	0.000048	0.000121	0.000034	0.000037	0.000056
4θy	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5ux	0.000006	0.000002	0.000004	0.000011	0.000002	0.000002	0.000005
5uy	0.066328	0.024273	0.047419	0.118729	0.034145	0.035818	0.053767
5uz	0.000001	0.000000	0.000000	0.000001	0.000000	0.000000	0.000001
5θx	0.000078	0.000028	0.000055	0.000139	0.000038	0.000042	0.000064
5θy	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6ux	0.000006	0.000002	0.000004	0.000012	0.000002	0.000003	0.000005
6uy	0.087505	0.031664	0.062257	0.156408	0.044400	0.047189	0.071154
6uz	0.000001	0.000000	0.000001	0.000002	0.000000	0.000000	0.000001
6θx	0.000083	0.000029	0.000058	0.000148	0.000041	0.000045	0.000068
6θy	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
7ux	0.000007	0.000002	0.000005	0.000014	0.000002	0.000003	0.000006
7uy	0.100657	0.036228	0.071449	0.179794	0.050722	0.054244	0.081966
7uz	0.000001	0.000000	0.000001	0.000002	0.000000	0.000000	0.000001
7θx	0.000084	0.000030	0.000059	0.000150	0.000041	0.000045	0.000069
7θy	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
7θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
8ux	0.000008	0.000002	0.000006	0.000016	0.000003	0.000004	0.000007
8uy	0.113000	0.040520	0.080083	0.201750	0.056672	0.060866	0.092107
8uz	0.000001	0.000000	0.000001	0.000002	0.000000	0.000000	0.000001

8θx	0.000084	0.000030	0.000059	0.000150	0.000041	0.000045	0.000069
8θy	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
8θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
9ux	0.000008	0.000002	0.000006	0.000016	0.000003	0.000004	0.000007
9uy	0.113001	0.040521	0.080084	0.201751	0.056672	0.060867	0.092108
9uz	0.006584	0.002312	0.004625	0.011727	0.003214	0.003536	0.005395
9θx	0.000084	0.000030	0.000059	0.000150	0.000041	0.000045	0.000069
9θy	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
9θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
10ux	0.000025	0.000007	0.000014	0.000042	0.000012	0.000007	0.000018
10uy	0.121644	0.043139	0.085781	0.217441	0.060361	0.065412	0.099228
10uz	0.007195	0.002448	0.004961	0.012874	0.003431	0.003804	0.005884
10θx	0.000220	0.000071	0.000177	0.000487	0.000078	0.000092	0.000208
10θy	0.000021	0.000006	0.000012	0.000035	0.000009	0.000006	0.000015
10θz	0.000131	0.000039	0.000085	0.000235	0.000056	0.000064	0.000106
11ux	0.000047	0.000012	0.000025	0.000076	0.000022	0.000012	0.000033
11uy	0.124595	0.043990	0.087634	0.222843	0.061588	0.066929	0.101611
11uz	0.007531	0.002531	0.005143	0.013511	0.003553	0.003938	0.006148
11θx	0.000402	0.000133	0.000338	0.000924	0.000140	0.000159	0.000391
11θy	0.000011	0.000003	0.000005	0.000016	0.000005	0.000003	0.000007
11θz	0.000071	0.000022	0.000047	0.000127	0.000031	0.000036	0.000058
12ux	0.000070	0.000018	0.000036	0.000111	0.000033	0.000018	0.000048
12uy	0.113000	0.040520	0.080083	0.201750	0.056672	0.060866	0.092107
12uz	0.006585	0.002312	0.004625	0.011727	0.003214	0.003536	0.005396
12θx	0.000589	0.000198	0.000503	0.001368	0.000205	0.000230	0.000577
12θy	0.000038	0.000012	0.000026	0.000075	0.000015	0.000014	0.000033
12θz	0.000204	0.000061	0.000138	0.000389	0.000082	0.000095	0.000172
13ux	0.001235	0.000397	0.000937	0.002599	0.000442	0.000484	0.001151
13uy	0.107929	0.039826	0.078883	0.194924	0.055323	0.058148	0.088851
13uz	0.006504	0.002294	0.004684	0.011724	0.003176	0.003444	0.005415
13θx	0.000804	0.000271	0.000690	0.001874	0.000280	0.000312	0.000791
13θy	0.000055	0.000017	0.000037	0.000105	0.000020	0.000023	0.000049
13θz	0.000290	0.000092	0.000227	0.000629	0.000104	0.000121	0.000270
14ux	0.004224	0.001238	0.002475	0.007340	0.001653	0.001730	0.003526
14uy	0.112469	0.043985	0.094895	0.233166	0.056330	0.055322	0.102011
14uz	0.006513	0.002299	0.004705	0.011767	0.003179	0.003443	0.005433
14θx	0.000509	0.000164	0.000410	0.001130	0.000178	0.000213	0.000482
14θy	0.000025	0.000007	0.000015	0.000044	0.000011	0.000010	0.000020
14θz	0.000261	0.000083	0.000202	0.000562	0.000094	0.000109	0.000241
15ux	0.003505	0.001017	0.001910	0.005809	0.001369	0.001615	0.002928
15uy	0.102886	0.040559	0.089603	0.221967	0.050525	0.048612	0.095794
15uz	0.006521	0.002304	0.004725	0.011810	0.003183	0.003440	0.005448
15θx	0.000413	0.000150	0.000373	0.000976	0.000161	0.000162	0.000413

15θy	0.000035	0.000010	0.000020	0.000060	0.000014	0.000012	0.000028
15θz	0.000231	0.000073	0.000178	0.000495	0.000084	0.000098	0.000213
16ux	0.000006	0.000002	0.000004	0.000012	0.000002	0.000003	0.000005
16uy	0.087505	0.031664	0.062257	0.156408	0.044400	0.047189	0.071154
16uz	0.006527	0.002309	0.004745	0.011850	0.003187	0.003436	0.005462
16θx	0.001567	0.000513	0.001297	0.003555	0.000539	0.000637	0.001508
16θy	0.000053	0.000016	0.000034	0.000098	0.000019	0.000029	0.000049
16θz	0.000202	0.000064	0.000154	0.000429	0.000074	0.000086	0.000185
17ux	0.005972	0.001831	0.004044	0.011590	0.002227	0.003003	0.005422
17uy	0.222212	0.070555	0.163258	0.450151	0.086697	0.104490	0.196771
17uz	0.006530	0.002314	0.004763	0.011888	0.003191	0.003429	0.005475
17θx	0.001966	0.000629	0.001568	0.004330	0.000683	0.000834	0.001850
17θy	0.000073	0.000023	0.000052	0.000148	0.000026	0.000036	0.000068
17θz	0.000174	0.000055	0.000131	0.000364	0.000065	0.000075	0.000158
18ux	0.010464	0.003245	0.007525	0.021343	0.003611	0.005335	0.009814
18uy	0.342089	0.108072	0.258323	0.714886	0.126968	0.155195	0.309805
18uz	0.006531	0.002318	0.004781	0.011923	0.003194	0.003422	0.005485
18θx	0.000742	0.000237	0.000593	0.001638	0.000256	0.000314	0.000700
18θy	0.000049	0.000014	0.000032	0.000092	0.000021	0.000018	0.000039
18θz	0.000146	0.000046	0.000108	0.000301	0.000056	0.000064	0.000131
19ux	0.010834	0.003373	0.007966	0.022518	0.003749	0.005378	0.010159
19uy	0.328372	0.103746	0.248294	0.687114	0.121666	0.148816	0.297619
19uz	0.006529	0.002322	0.004797	0.011954	0.003196	0.003412	0.005492
19θx	0.001035	0.000328	0.000804	0.002227	0.000367	0.000452	0.000958
19θy	0.000041	0.000012	0.000023	0.000070	0.000018	0.000017	0.000032
19θz	0.000121	0.000038	0.000085	0.000240	0.000048	0.000054	0.000106
20ux	0.006508	0.002033	0.004819	0.013597	0.002348	0.003065	0.006015
20uy	0.188969	0.059946	0.139899	0.386034	0.072889	0.088176	0.168234
20uz	0.006524	0.002326	0.004812	0.011980	0.003197	0.003401	0.005497
20θx	0.002050	0.000650	0.001598	0.004422	0.000728	0.000894	0.001900
20θy	0.000075	0.000023	0.000054	0.000153	0.000027	0.000036	0.000069
20θz	0.000099	0.000031	0.000065	0.000186	0.000042	0.000044	0.000082
21ux	0.000007	0.000002	0.000004	0.000011	0.000003	0.000002	0.000005
21uy	0.045532	0.016898	0.032748	0.081659	0.023864	0.024626	0.036760
21uz	0.006514	0.002328	0.004824	0.012001	0.003197	0.003387	0.005500
21θx	0.001292	0.000409	0.001005	0.002783	0.000457	0.000565	0.001197
21θy	0.000067	0.000022	0.000052	0.000145	0.000024	0.000030	0.000062
21θz	0.000083	0.000026	0.000049	0.000145	0.000038	0.000035	0.000064
22ux	0.004981	0.001573	0.003587	0.010184	0.002147	0.001806	0.004219
22uy	0.038682	0.015795	0.035225	0.088603	0.019210	0.016849	0.036979
22uz	0.006500	0.002330	0.004835	0.012016	0.003196	0.003372	0.005499
22θx	0.000085	0.000029	0.000073	0.000193	0.000033	0.000032	0.000082
22θy	0.000045	0.000014	0.000031	0.000090	0.000020	0.000014	0.000037

22θz	0.000077	0.000024	0.000043	0.000129	0.000038	0.000030	0.000056
23ux	0.006734	0.002178	0.005108	0.014412	0.002718	0.002337	0.005906
23uy	0.029298	0.011888	0.022582	0.054474	0.016846	0.015802	0.023719
23uz	0.006482	0.002331	0.004843	0.012026	0.003193	0.003355	0.005495
23θx	0.000433	0.000143	0.000362	0.000991	0.000148	0.000175	0.000419
23θy	0.000033	0.000010	0.000020	0.000058	0.000016	0.000009	0.000024
23θz	0.000084	0.000026	0.000050	0.000148	0.000040	0.000028	0.000062
24ux	0.005125	0.001696	0.004060	0.011366	0.001963	0.001807	0.004649
24uy	0.028821	0.011432	0.021590	0.052594	0.016306	0.015653	0.023063
24uz	0.008009	0.002467	0.005443	0.014870	0.003279	0.004017	0.006737
24θx	0.000100	0.000034	0.000069	0.000178	0.000047	0.000053	0.000082
24θy	0.000024	0.000007	0.000013	0.000039	0.000012	0.000007	0.000016
24θz	0.000097	0.000031	0.000070	0.000199	0.000041	0.000032	0.000082
25ux	0.000006	0.000002	0.000003	0.000010	0.000003	0.000001	0.000004
25uy	0.028840	0.011419	0.021573	0.052589	0.016286	0.015666	0.023077
25uz	0.000001	0.000000	0.000000	0.000001	0.000000	0.000000	0.000000
25θx	0.000131	0.000040	0.000089	0.000246	0.000053	0.000064	0.000111
25θy	0.000019	0.000006	0.000011	0.000032	0.000009	0.000006	0.000013
25θz	0.000080	0.000027	0.000066	0.000181	0.000032	0.000028	0.000073
26ux	0.008195	0.002602	0.005545	0.015715	0.004093	0.002375	0.006271
26uy	0.028815	0.011367	0.021497	0.052473	0.016206	0.015657	0.023062
26uz	0.008589	0.002736	0.005754	0.015373	0.003824	0.004294	0.006993
26θx	0.000049	0.000018	0.000036	0.000088	0.000026	0.000026	0.000039
26θy	0.000029	0.000008	0.000015	0.000046	0.000015	0.000009	0.000019
26θz	0.000025	0.000008	0.000016	0.000045	0.000013	0.000007	0.000019
27ux	0.002995	0.000996	0.002275	0.006316	0.001356	0.000979	0.002566
27uy	0.028744	0.011298	0.021393	0.052284	0.016099	0.015622	0.023017
27uz	0.010514	0.003713	0.007367	0.018719	0.005204	0.005605	0.008524
27θx	0.000044	0.000017	0.000032	0.000082	0.000024	0.000017	0.000035
27θy	0.000020	0.000006	0.000011	0.000034	0.000010	0.000007	0.000014
27θz	0.000143	0.000048	0.000099	0.000277	0.000075	0.000043	0.000110
28ux	0.000151	0.000044	0.000079	0.000236	0.000084	0.000035	0.000093
28uy	0.028467	0.010713	0.020596	0.051155	0.015187	0.015417	0.022886
28uz	0.010771	0.003874	0.007643	0.019237	0.005423	0.005804	0.008772
28θx	0.000044	0.000017	0.000032	0.000080	0.000024	0.000020	0.000035
28θy	0.000017	0.000004	0.000008	0.000025	0.000008	0.000004	0.000011
28θz	0.000097	0.000032	0.000067	0.000182	0.000044	0.000042	0.000079
29ux	0.000114	0.000033	0.000060	0.000179	0.000064	0.000027	0.000071
29uy	0.032828	0.012529	0.023664	0.058662	0.017864	0.017700	0.025997
29uz	0.011171	0.003910	0.007878	0.020019	0.005459	0.006000	0.009215
29θx	0.000043	0.000017	0.000032	0.000078	0.000024	0.000021	0.000035
29θy	0.000013	0.000003	0.000007	0.000020	0.000006	0.000004	0.000010
29θz	0.000080	0.000030	0.000051	0.000132	0.000048	0.000033	0.000053

30ux	0.000077	0.000022	0.000040	0.000120	0.000043	0.000018	0.000047
30uy	0.034230	0.013231	0.024756	0.061128	0.018958	0.018413	0.026909
30uz	0.011389	0.003951	0.008003	0.020408	0.005516	0.006100	0.009411
30θx	0.000045	0.000017	0.000033	0.000081	0.000024	0.000024	0.000036
30θy	0.000004	0.000001	0.000002	0.000006	0.000002	0.000001	0.000003
30θz	0.000024	0.000008	0.000016	0.000044	0.000011	0.000010	0.000019
31ux	0.000039	0.000011	0.000020	0.000061	0.000022	0.000009	0.000024
31uy	0.031254	0.011999	0.022695	0.056060	0.017105	0.016922	0.024839
31uz	0.011097	0.003922	0.007840	0.019860	0.005481	0.005967	0.009107
31θx	0.000049	0.000018	0.000035	0.000087	0.000026	0.000026	0.000040
31θy	0.000015	0.000004	0.000007	0.000022	0.000006	0.000004	0.000011
31θz	0.000087	0.000033	0.000056	0.000146	0.000052	0.000036	0.000059
32ux	0.000006	0.000002	0.000003	0.000010	0.000003	0.000001	0.000004
32uy	0.028467	0.010713	0.020596	0.051155	0.015187	0.015417	0.022886
32uz	0.010771	0.003874	0.007643	0.019237	0.005423	0.005804	0.008772
32θx	0.000054	0.000020	0.000039	0.000097	0.000027	0.000029	0.000044
32θy	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
32θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Table 14 Maximum Nodal Displacements for Benchmark Problem #4a (inches)
Modal superposition time history method

Nodes	Case a	Case b	Case c	Case d	Case e	Case f	Case g
2ux	0.000002	0.000000	0.000001	0.000001	0.000000	0.000001	0.000001
2uy	0.011684	0.004465	0.007988	0.019971	0.006529	0.006384	0.009078
2uz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2θx	0.000031	0.000011	0.000022	0.000056	0.000016	0.000017	0.000025
2θy	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3ux	0.000004	0.000001	0.000001	0.000002	0.000001	0.000001	0.000002
3uy	0.028786	0.010726	0.019934	0.050032	0.015426	0.015610	0.022725
3uz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3θx	0.000054	0.000020	0.000039	0.000097	0.000027	0.000029	0.000044
3θy	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4ux	0.000004	0.000001	0.000002	0.000003	0.000001	0.000002	0.000002
4uy	0.045772	0.016828	0.032011	0.080438	0.023958	0.024742	0.036542
4uz	0.000001	0.000000	0.000000	0.000001	0.000000	0.000000	0.000000
4θx	0.000068	0.000024	0.000049	0.000122	0.000034	0.000036	0.000056
4θy	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5ux	0.000004	0.000001	0.000002	0.000005	0.000001	0.000002	0.000004
5uy	0.066432	0.024183	0.046895	0.117912	0.034120	0.035847	0.053582
5uz	0.000001	0.000000	0.000000	0.000001	0.000000	0.000000	0.000001
5θx	0.000077	0.000028	0.000056	0.000140	0.000038	0.000042	0.000064
5θy	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6ux	0.000003	0.000001	0.000003	0.000006	0.000001	0.000002	0.000005
6uy	0.087469	0.031635	0.062190	0.156396	0.044356	0.047164	0.071091
6uz	0.000001	0.000000	0.000000	0.000001	0.000000	0.000000	0.000001
6θx	0.000082	0.000029	0.000060	0.000150	0.000040	0.000044	0.000068
6θy	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
7ux	0.000004	0.000001	0.000003	0.000007	0.000002	0.000002	0.000005
7uy	0.100536	0.036258	0.071721	0.180367	0.050694	0.054197	0.081998
7uz	0.000001	0.000000	0.000001	0.000002	0.000000	0.000000	0.000001
7θx	0.000084	0.000030	0.000061	0.000152	0.000041	0.000045	0.000069
7θy	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
7θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
8ux	0.000005	0.000002	0.000004	0.000008	0.000002	0.000003	0.000006
8uy	0.112801	0.040603	0.080656	0.202839	0.056659	0.060799	0.092221
8uz	0.000001	0.000000	0.000001	0.000002	0.000000	0.000000	0.000001

8θx	0.000084	0.000030	0.000061	0.000153	0.000041	0.000045	0.000070
8θy	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
8θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
9ux	0.000005	0.000002	0.000004	0.000008	0.000002	0.000003	0.000006
9uy	0.112802	0.040603	0.080657	0.202840	0.056659	0.060800	0.092222
9uz	0.006542	0.002326	0.004739	0.011922	0.003206	0.003520	0.005423
9θx	0.000084	0.000030	0.000061	0.000153	0.000041	0.000045	0.000070
9θy	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
9θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
10ux	0.000018	0.000003	0.000009	0.000017	0.000004	0.000006	0.000014
10uy	0.121445	0.043263	0.085930	0.216624	0.059941	0.065348	0.099088
10uz	0.007107	0.002408	0.004902	0.012187	0.003325	0.003878	0.005846
10θx	0.000176	0.000064	0.000154	0.000403	0.000080	0.000093	0.000207
10θy	0.000023	0.000004	0.000010	0.000023	0.000005	0.000006	0.000015
10θz	0.000127	0.000043	0.000080	0.000205	0.000050	0.000065	0.000098
11ux	0.000036	0.000006	0.000017	0.000032	0.000006	0.000012	0.000024
11uy	0.124098	0.044042	0.087123	0.219990	0.060937	0.066998	0.101336
11uz	0.007247	0.002434	0.005124	0.012239	0.003436	0.004113	0.006045
11θx	0.000312	0.000110	0.000291	0.000757	0.000127	0.000157	0.000393
11θy	0.000010	0.000001	0.000003	0.000007	0.000001	0.000002	0.000004
11θz	0.000079	0.000022	0.000047	0.000123	0.000027	0.000035	0.000058
12ux	0.000054	0.000009	0.000024	0.000047	0.000009	0.000017	0.000034
12uy	0.112801	0.040603	0.080656	0.202839	0.056659	0.060799	0.092221
12uz	0.006543	0.002326	0.004739	0.011922	0.003206	0.003520	0.005423
12θx	0.000448	0.000160	0.000435	0.001110	0.000189	0.000221	0.000582
12θy	0.000039	0.000010	0.000023	0.000071	0.000011	0.000014	0.000037
12θz	0.000194	0.000068	0.000120	0.000292	0.000079	0.000099	0.000160
13ux	0.001124	0.000373	0.000855	0.002818	0.000395	0.000468	0.001387
13uy	0.111646	0.039966	0.083627	0.205792	0.055945	0.055580	0.089215
13uz	0.007214	0.002326	0.005208	0.013135	0.003099	0.003062	0.005347
13θx	0.000611	0.000221	0.000597	0.001515	0.000260	0.000300	0.000797
13θy	0.000053	0.000018	0.000031	0.000119	0.000016	0.000020	0.000060
13θz	0.000240	0.000087	0.000197	0.000494	0.000102	0.000122	0.000267
14ux	0.004197	0.001270	0.002126	0.007712	0.001066	0.001411	0.004007
14uy	0.118902	0.048377	0.101275	0.291393	0.059303	0.045995	0.122599
14uz	0.007279	0.002345	0.005247	0.013212	0.003099	0.003036	0.005357
14θx	0.000406	0.000149	0.000355	0.000912	0.000183	0.000215	0.000473
14θy	0.000022	0.000006	0.000010	0.000026	0.000006	0.000009	0.000018
14θz	0.000218	0.000079	0.000177	0.000444	0.000093	0.000111	0.000242
15ux	0.003156	0.001070	0.001785	0.004695	0.000810	0.001362	0.003089
15uy	0.106366	0.044666	0.092747	0.276552	0.053209	0.042942	0.118488
15uz	0.007336	0.002363	0.005282	0.013277	0.003098	0.003009	0.005363
15θx	0.000361	0.000147	0.000321	0.001006	0.000142	0.000158	0.000499

15θy	0.000035	0.000009	0.000017	0.000060	0.000008	0.000011	0.000030
15θz	0.000196	0.000071	0.000157	0.000394	0.000084	0.000100	0.000216
16ux	0.000003	0.000001	0.000003	0.000006	0.000001	0.000002	0.000005
16uy	0.087469	0.031635	0.062190	0.156396	0.044356	0.047164	0.071091
16uz	0.007384	0.002380	0.005313	0.013330	0.003101	0.002980	0.005366
16θx	0.001229	0.000431	0.001105	0.002813	0.000520	0.000632	0.001478
16θy	0.000041	0.000017	0.000029	0.000074	0.000015	0.000022	0.000047
16θz	0.000174	0.000063	0.000137	0.000345	0.000075	0.000090	0.000191
17ux	0.004648	0.001745	0.003168	0.007905	0.001679	0.002276	0.004683
17uy	0.190884	0.073245	0.138956	0.347257	0.092745	0.114754	0.189721
17uz	0.007424	0.002398	0.005340	0.013369	0.003104	0.002950	0.005367
17θx	0.001561	0.000585	0.001354	0.003374	0.000716	0.000860	0.001772
17θy	0.000055	0.000021	0.000039	0.000098	0.000021	0.000029	0.000061
17θz	0.000152	0.000055	0.000117	0.000295	0.000065	0.000079	0.000165
18ux	0.007482	0.003102	0.005736	0.014420	0.003119	0.004070	0.008911
18uy	0.278507	0.110204	0.223829	0.554800	0.137909	0.169064	0.299955
18uz	0.007455	0.002415	0.005364	0.013396	0.003107	0.002919	0.005379
18θx	0.000586	0.000220	0.000508	0.001253	0.000268	0.000325	0.000659
18θy	0.000045	0.000010	0.000025	0.000048	0.000011	0.000020	0.000035
18θz	0.000130	0.000047	0.000097	0.000246	0.000056	0.000068	0.000140
19ux	0.008592	0.003107	0.005896	0.014787	0.003213	0.004469	0.009489
19uy	0.266337	0.105742	0.214971	0.532354	0.132177	0.162263	0.287864
19uz	0.007480	0.002430	0.005383	0.013409	0.003110	0.002886	0.005400
19θx	0.000825	0.000321	0.000701	0.001742	0.000397	0.000480	0.000924
19θy	0.000032	0.000009	0.000017	0.000040	0.000009	0.000013	0.000024
19θz	0.000109	0.000039	0.000077	0.000196	0.000047	0.000057	0.000115
20ux	0.005593	0.001762	0.003517	0.008548	0.001869	0.002692	0.005693
20uy	0.159559	0.062085	0.119508	0.295438	0.078306	0.097059	0.162290
20uz	0.007498	0.002445	0.005397	0.013410	0.003113	0.002852	0.005417
20θx	0.001631	0.000635	0.001386	0.003437	0.000783	0.000950	0.001822
20θy	0.000062	0.000021	0.000039	0.000099	0.000022	0.000031	0.000064
20θz	0.000087	0.000031	0.000060	0.000147	0.000038	0.000047	0.000090
21ux	0.000004	0.000001	0.000002	0.000003	0.000001	0.000002	0.000002
21uy	0.045771	0.016828	0.032011	0.080438	0.023958	0.024742	0.036542
21uz	0.007505	0.002458	0.005408	0.013397	0.003115	0.002817	0.005431
21θx	0.001027	0.000401	0.000870	0.002134	0.000493	0.000597	0.001142
21θy	0.000055	0.000018	0.000038	0.000087	0.000019	0.000027	0.000063
21θz	0.000074	0.000024	0.000049	0.000109	0.000030	0.000037	0.000066
22ux	0.003991	0.001099	0.002828	0.006426	0.001225	0.001854	0.004137
22uy	0.034388	0.016961	0.033206	0.106979	0.020378	0.016501	0.045055
22uz	0.007501	0.002469	0.005415	0.013371	0.003118	0.002782	0.005440
22θx	0.000069	0.000027	0.000062	0.000201	0.000027	0.000034	0.000092
22θy	0.000036	0.000011	0.000027	0.000069	0.000012	0.000015	0.000036

22θz	0.000071	0.000019	0.000037	0.000089	0.000027	0.000031	0.000050
23ux	0.005498	0.001694	0.004289	0.011356	0.002017	0.002449	0.006352
23uy	0.030315	0.011681	0.022992	0.059343	0.017327	0.014948	0.024373
23uz	0.007485	0.002480	0.005418	0.013416	0.003120	0.002747	0.005445
23θx	0.000335	0.000118	0.000308	0.000737	0.000139	0.000171	0.000409
23θy	0.000030	0.000009	0.000016	0.000051	0.000011	0.000010	0.000025
23θz	0.000076	0.000019	0.000037	0.000096	0.000025	0.000030	0.000053
24ux	0.004017	0.001402	0.003430	0.009523	0.001690	0.001901	0.005187
24uy	0.029524	0.011308	0.021281	0.051755	0.016619	0.015461	0.023080
24uz	0.008043	0.002580	0.005104	0.013112	0.003303	0.004174	0.006956
24θx	0.000110	0.000034	0.000074	0.000193	0.000044	0.000050	0.000085
24θy	0.000019	0.000005	0.000010	0.000023	0.000007	0.000009	0.000013
24θz	0.000080	0.000023	0.000058	0.000154	0.000028	0.000035	0.000085
25ux	0.000004	0.000001	0.000001	0.000002	0.000001	0.000001	0.000002
25uy	0.029528	0.011302	0.021241	0.051472	0.016595	0.015499	0.023080
25uz	0.000001	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
25θx	0.000130	0.000042	0.000083	0.000207	0.000054	0.000068	0.000113
25θy	0.000015	0.000005	0.000009	0.000024	0.000006	0.000007	0.000013
25θz	0.000066	0.000023	0.000052	0.000157	0.000028	0.000031	0.000084
26ux	0.006409	0.001811	0.004221	0.011400	0.002074	0.002474	0.005810
26uy	0.029480	0.011266	0.021139	0.051210	0.016512	0.015531	0.023043
26uz	0.008980	0.002627	0.005522	0.014084	0.003437	0.004438	0.007179
26θx	0.000049	0.000018	0.000036	0.000087	0.000026	0.000025	0.000039
26θy	0.000024	0.000006	0.000011	0.000023	0.000008	0.000011	0.000014
26θz	0.000022	0.000005	0.000012	0.000029	0.000006	0.000007	0.000015
27ux	0.002237	0.000701	0.001840	0.004690	0.000877	0.000965	0.002411
27uy	0.029391	0.011214	0.021027	0.051081	0.016406	0.015528	0.022978
27uz	0.010419	0.003661	0.007265	0.018375	0.005093	0.005622	0.008606
27θx	0.000039	0.000016	0.000032	0.000097	0.000023	0.000016	0.000037
27θy	0.000016	0.000005	0.000009	0.000024	0.000006	0.000008	0.000013
27θz	0.000110	0.000037	0.000073	0.000218	0.000044	0.000043	0.000102
28ux	0.000114	0.000020	0.000036	0.000069	0.000022	0.000029	0.000035
28uy	0.028786	0.010726	0.019934	0.050032	0.015426	0.015610	0.022725
28uz	0.010738	0.003863	0.007666	0.019286	0.005391	0.005783	0.008767
28θx	0.000043	0.000017	0.000034	0.000097	0.000025	0.000017	0.000036
28θy	0.000016	0.000003	0.000007	0.000021	0.000003	0.000004	0.000010
28θz	0.000091	0.000028	0.000056	0.000165	0.000038	0.000047	0.000079
29ux	0.000086	0.000015	0.000027	0.000051	0.000016	0.000022	0.000026
29uy	0.032971	0.012283	0.021889	0.055346	0.018068	0.018394	0.026113
29uz	0.011462	0.003924	0.008048	0.020407	0.005336	0.005928	0.009147
29θx	0.000045	0.000017	0.000035	0.000093	0.000025	0.000020	0.000035
29θy	0.000014	0.000003	0.000006	0.000018	0.000002	0.000003	0.000008
29θz	0.000083	0.000025	0.000037	0.000098	0.000038	0.000034	0.000042

30ux	0.000058	0.000010	0.000018	0.000034	0.000011	0.000015	0.000017
30uy	0.034602	0.012869	0.022719	0.057181	0.019066	0.019157	0.026946
30uz	0.011759	0.003965	0.008201	0.020814	0.005351	0.006018	0.009340
30θx	0.000047	0.000017	0.000035	0.000089	0.000026	0.000023	0.000037
30θy	0.000004	0.000001	0.000002	0.000005	0.000001	0.000001	0.000002
30θz	0.000023	0.000007	0.000013	0.000039	0.000009	0.000011	0.000019
31ux	0.000030	0.000005	0.000009	0.000017	0.000005	0.000007	0.000009
31uy	0.031397	0.011842	0.021403	0.053670	0.017330	0.017371	0.024784
31uz	0.011193	0.003921	0.007947	0.020080	0.005379	0.005909	0.009063
31θx	0.000049	0.000018	0.000037	0.000088	0.000026	0.000026	0.000040
31θy	0.000015	0.000003	0.000007	0.000020	0.000003	0.000003	0.000009
31θz	0.000091	0.000027	0.000041	0.000114	0.000041	0.000039	0.000050
32ux	0.000004	0.000001	0.000001	0.000002	0.000001	0.000001	0.000002
32uy	0.028787	0.010727	0.019934	0.050033	0.015426	0.015610	0.022726
32uz	0.010738	0.003863	0.007666	0.019286	0.005391	0.005783	0.008767
32θx	0.000054	0.000020	0.000039	0.000097	0.000027	0.000029	0.000044
32θy	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
32θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Table 15 Maximum Nodal Displacements for Benchmark Problem #4b(inches)
Response spectrum method

Nodes	Case a	Case b	Case c	Case d	Case e	Case f	Case g
2ux	0.038819	0.023201	0.033221	0.096990	0.032364	0.022476	0.030826
2uy	0.000019	0.000005	0.000008	0.000027	0.000008	0.000004	0.000013
2uz	0.000001	0.000001	0.000001	0.000003	0.000001	0.000001	0.000001
2θx	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2θy	0.000110	0.000066	0.000095	0.000280	0.000089	0.000065	0.000088
2θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3ux	0.097938	0.058509	0.083952	0.246400	0.080735	0.057082	0.077989
3uy	0.000032	0.000008	0.000015	0.000048	0.000013	0.000009	0.000023
3uz	0.000002	0.000001	0.000002	0.000005	0.000001	0.000001	0.000002
3θx	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3θy	0.000192	0.000115	0.000165	0.000491	0.000154	0.000114	0.000154
3θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4ux	0.157771	0.094198	0.135374	0.398840	0.128922	0.092367	0.125880
4uy	0.000034	0.000010	0.000019	0.000056	0.000015	0.000013	0.000025
4uz	0.000003	0.000002	0.000002	0.000007	0.000001	0.000001	0.000003
4θx	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4θy	0.000242	0.000144	0.000208	0.000618	0.000192	0.000143	0.000194
4θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5ux	0.231420	0.138056	0.198724	0.587645	0.187408	0.136039	0.184982
5uy	0.000028	0.000012	0.000022	0.000057	0.000014	0.000018	0.000022
5uz	0.000004	0.000002	0.000003	0.000008	0.000002	0.000002	0.000003
5θx	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5θy	0.000277	0.000165	0.000238	0.000711	0.000220	0.000164	0.000223
5θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6ux	0.306969	0.182977	0.263731	0.782095	0.246773	0.180989	0.245713
6uy	0.000024	0.000015	0.000027	0.000063	0.000014	0.000024	0.000021
6uz	0.000004	0.000002	0.000004	0.000009	0.000002	0.000002	0.000004
6θx	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6θy	0.000296	0.000176	0.000254	0.000759	0.000233	0.000175	0.000237
6θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
7ux	0.354032	0.210939	0.304225	0.903376	0.283605	0.209017	0.283567
7uy	0.000031	0.000018	0.000032	0.000074	0.000017	0.000028	0.000026
7uz	0.000004	0.000002	0.000004	0.000010	0.000002	0.000002	0.000004
7θx	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
7θy	0.000300	0.000178	0.000258	0.000771	0.000237	0.000178	0.000241
7θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
8ux	0.398206	0.237185	0.342227	1.017133	0.318215	0.235307	0.319086
8uy	0.000040	0.000020	0.000037	0.000087	0.000020	0.000032	0.000033
8uz	0.000005	0.000003	0.000004	0.000010	0.000002	0.000002	0.000004

8θx	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
8θy	0.000301	0.000179	0.000259	0.000774	0.000238	0.000179	0.000242
8θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
9ux	0.398209	0.237186	0.342229	1.017139	0.318216	0.235308	0.319088
9uy	0.000041	0.000023	0.000038	0.000090	0.000022	0.000031	0.000033
9uz	0.072340	0.043002	0.062200	0.185776	0.057006	0.042945	0.058101
9θx	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
9θy	0.000301	0.000179	0.000259	0.000774	0.000238	0.000179	0.000242
9θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
10ux	0.399383	0.237832	0.343170	1.020324	0.319059	0.236009	0.320034
10uy	0.004968	0.003933	0.006007	0.011787	0.003143	0.003087	0.004601
10uz	0.050216	0.033753	0.049855	0.127318	0.039458	0.031420	0.041705
10θx	0.000056	0.000041	0.000078	0.000122	0.000039	0.000055	0.000053
10θy	0.000469	0.000341	0.000511	0.001200	0.000340	0.000297	0.000400
10θz	0.000082	0.000068	0.000104	0.000199	0.000054	0.000053	0.000076
11ux	0.400246	0.238296	0.343845	1.022683	0.319677	0.236519	0.320727
11uy	0.008719	0.007473	0.011362	0.021371	0.005806	0.005794	0.008165
11uz	0.039660	0.035201	0.053572	0.098908	0.029519	0.028322	0.036328
11θx	0.000113	0.000083	0.000155	0.000244	0.000077	0.000111	0.000106
11θy	0.000320	0.000191	0.000279	0.000817	0.000248	0.000190	0.000258
11θz	0.000022	0.000008	0.000013	0.000044	0.000010	0.000008	0.000020
12ux	0.400797	0.238577	0.344252	1.024215	0.320070	0.236840	0.321167
12uy	0.000040	0.000020	0.000037	0.000087	0.000020	0.000032	0.000033
12uz	0.000008	0.000004	0.000006	0.000015	0.000004	0.000004	0.000006
12θx	0.000169	0.000124	0.000233	0.000366	0.000116	0.000166	0.000159
12θy	0.000908	0.000883	0.001349	0.002327	0.000670	0.000691	0.000865
12θz	0.000216	0.000201	0.000305	0.000549	0.000152	0.000154	0.000205
13ux	0.402390	0.238480	0.344142	1.031998	0.320243	0.237349	0.322358
13uy	0.007919	0.007027	0.010464	0.020349	0.005326	0.005801	0.007454
13uz	0.044973	0.044224	0.067586	0.117153	0.033135	0.034559	0.042973
13θx	0.000210	0.000144	0.000246	0.000492	0.000129	0.000186	0.000194
13θy	0.002984	0.002944	0.004500	0.007756	0.002206	0.002298	0.002848
13θz	0.000640	0.000628	0.000951	0.001655	0.000469	0.000480	0.000611
14ux	0.460959	0.330555	0.492508	1.205668	0.356600	0.295774	0.390097
14uy	0.021204	0.015810	0.025451	0.051412	0.013306	0.018020	0.019662
14uz	0.045221	0.044447	0.067924	0.117821	0.033303	0.034736	0.043213
14θx	0.000107	0.000070	0.000129	0.000241	0.000067	0.000105	0.000098
14θy	0.001950	0.001906	0.002911	0.005020	0.001457	0.001493	0.001846
14θz	0.000961	0.000948	0.001442	0.002482	0.000710	0.000729	0.000919
15ux	0.435227	0.336370	0.505165	1.139561	0.334956	0.289595	0.376939
15uy	0.020598	0.014919	0.024860	0.049206	0.013004	0.018578	0.018988
15uz	0.045426	0.044630	0.068200	0.118374	0.033440	0.034881	0.043411
15θx	0.000129	0.000093	0.000149	0.000308	0.000078	0.000102	0.000119

15θy	0.001581	0.001424	0.002169	0.004175	0.001164	0.001153	0.001458
15θz	0.001285	0.001269	0.001934	0.003311	0.000951	0.000979	0.001228
16ux	0.306971	0.182978	0.263733	0.782101	0.246774	0.180990	0.245715
16uy	0.000024	0.000015	0.000027	0.000063	0.000014	0.000024	0.000021
16uz	0.045588	0.044771	0.068412	0.118812	0.033546	0.034992	0.043568
16θx	0.000369	0.000261	0.000445	0.000865	0.000234	0.000342	0.000336
16θy	0.005787	0.005709	0.008726	0.014969	0.004298	0.004450	0.005495
16θz	0.001608	0.001590	0.002427	0.004142	0.001193	0.001230	0.001538
17ux	0.743413	0.658326	0.997537	1.892440	0.568787	0.535428	0.672228
17uy	0.036521	0.025453	0.043854	0.084711	0.023065	0.034209	0.033079
17uz	0.045707	0.044870	0.068561	0.119133	0.033621	0.035071	0.043682
17θx	0.000419	0.000293	0.000507	0.000976	0.000266	0.000399	0.000380
17θy	0.007284	0.007095	0.010836	0.018767	0.005432	0.005556	0.006863
17θz	0.001933	0.001910	0.002919	0.004973	0.001435	0.001481	0.001848
18ux	1.194000	1.108289	1.686066	3.053349	0.902629	0.884366	1.100699
18uy	0.062102	0.043638	0.075463	0.145336	0.039557	0.059170	0.056482
18uz	0.045781	0.044928	0.068646	0.119337	0.033665	0.035116	0.043754
18θx	0.000189	0.000113	0.000197	0.000400	0.000108	0.000153	0.000164
18θy	0.003068	0.002994	0.004575	0.007903	0.002280	0.002340	0.002890
18θz	0.002257	0.002231	0.003412	0.005804	0.001676	0.001732	0.002159
19ux	1.176972	1.097087	1.669652	3.011248	0.888382	0.873663	1.086417
19uy	0.060218	0.042074	0.072775	0.140857	0.038212	0.057067	0.054663
19uz	0.045811	0.044944	0.068667	0.119424	0.033677	0.035128	0.043783
19θx	0.000214	0.000144	0.000251	0.000482	0.000133	0.000197	0.000193
19θy	0.003383	0.003214	0.004899	0.008672	0.002538	0.002544	0.003157
19θz	0.002581	0.002552	0.003904	0.006635	0.001918	0.001983	0.002469
20ux	0.688729	0.626569	0.951685	1.757355	0.523041	0.503493	0.628761
20uy	0.032291	0.022371	0.038572	0.075561	0.020323	0.030151	0.029233
20uz	0.045796	0.044919	0.068624	0.119391	0.033657	0.035107	0.043769
20θx	0.000416	0.000288	0.000499	0.000965	0.000263	0.000392	0.000377
20θy	0.007498	0.007193	0.010973	0.019259	0.005613	0.005665	0.007011
20θz	0.002906	0.002873	0.004397	0.007466	0.002160	0.002234	0.002780
21ux	0.157772	0.094199	0.135375	0.398844	0.128923	0.092368	0.125881
21uy	0.000034	0.000010	0.000019	0.000056	0.000015	0.000013	0.000025
21uz	0.045737	0.044851	0.068517	0.119240	0.033606	0.035052	0.043712
21θx	0.000280	0.000189	0.000322	0.000654	0.000172	0.000249	0.000252
21θy	0.005769	0.005589	0.008533	0.014844	0.004317	0.004386	0.005420
21θz	0.003230	0.003194	0.004890	0.008298	0.002402	0.002485	0.003090
22ux	0.284462	0.273631	0.418003	0.735953	0.216090	0.214381	0.267737
22uy	0.015030	0.006879	0.011854	0.028340	0.007460	0.008894	0.012275
22uz	0.045633	0.044742	0.068346	0.118971	0.033524	0.034964	0.043611
22θx	0.000117	0.000053	0.000083	0.000194	0.000056	0.000046	0.000093
22θy	0.001489	0.001448	0.002219	0.003800	0.001102	0.001138	0.001421

22θz	0.003555	0.003515	0.005383	0.009129	0.002644	0.002737	0.003401
23ux	0.300868	0.290489	0.444439	0.773993	0.227501	0.227727	0.285166
23uy	0.016807	0.009659	0.015433	0.031356	0.009145	0.008517	0.014004
23uz	0.045483	0.044592	0.068112	0.118582	0.033409	0.034842	0.043467
23θx	0.000268	0.000251	0.000371	0.000695	0.000187	0.000194	0.000248
23θy	0.000571	0.000498	0.000767	0.001425	0.000381	0.000405	0.000538
23θz	0.003880	0.003836	0.005875	0.009961	0.002886	0.002988	0.003711
24ux	0.221986	0.208251	0.318163	0.569848	0.169369	0.164891	0.208195
24uy	0.022438	0.018723	0.028927	0.051167	0.014891	0.014919	0.020194
24uz	0.037379	0.036620	0.056173	0.097130	0.027523	0.028870	0.035798
24θx	0.000659	0.000642	0.000982	0.001721	0.000483	0.000504	0.000629
24θy	0.000638	0.000609	0.000933	0.001639	0.000461	0.000479	0.000602
24θz	0.003970	0.003923	0.006011	0.010185	0.002951	0.003059	0.003802
25ux	0.097938	0.058509	0.083952	0.246400	0.080735	0.057082	0.077989
25uy	0.022329	0.018698	0.028878	0.051063	0.014855	0.014889	0.020120
25uz	0.003464	0.002064	0.002977	0.008841	0.002774	0.002046	0.002775
25θx	0.000491	0.000477	0.000732	0.001277	0.000360	0.000378	0.000469
25θy	0.000484	0.000455	0.000695	0.001250	0.000351	0.000360	0.000454
25θz	0.002607	0.002565	0.003931	0.006681	0.001932	0.002003	0.002494
26ux	0.151263	0.117078	0.175642	0.373230	0.117817	0.099314	0.130121
26uy	0.022039	0.018633	0.028757	0.050784	0.014761	0.014820	0.019927
26uz	0.021451	0.019786	0.030365	0.054924	0.015370	0.015836	0.020111
26θx	0.000035	0.000032	0.000049	0.000089	0.000026	0.000026	0.000033
26θy	0.000746	0.000714	0.001094	0.001914	0.000539	0.000560	0.000705
26θz	0.000397	0.000387	0.000593	0.001006	0.000293	0.000301	0.000378
27ux	0.104695	0.064532	0.093153	0.261273	0.085956	0.061662	0.083934
27uy	0.021721	0.018560	0.028625	0.050474	0.014659	0.014746	0.019715
27uz	0.009344	0.008377	0.012815	0.024123	0.006716	0.006780	0.008657
27θx	0.000224	0.000206	0.000316	0.000561	0.000158	0.000164	0.000210
27θy	0.000533	0.000505	0.000774	0.001376	0.000386	0.000399	0.000502
27θz	0.001287	0.001158	0.001780	0.003098	0.000898	0.000912	0.001187
28ux	0.099054	0.059266	0.085015	0.248734	0.081858	0.057680	0.078842
28uy	0.000032	0.000008	0.000015	0.000048	0.000013	0.000009	0.000023
28uz	0.000003	0.000002	0.000003	0.000008	0.000002	0.000003	0.000003
28θx	0.000097	0.000063	0.000097	0.000236	0.000061	0.000058	0.000084
28θy	0.000265	0.000201	0.000304	0.000689	0.000191	0.000174	0.000231
28θz	0.000483	0.000403	0.000623	0.001151	0.000322	0.000325	0.000446
29ux	0.098870	0.059134	0.084826	0.248351	0.081679	0.057577	0.078699
29uy	0.023550	0.014447	0.022643	0.046718	0.012898	0.011838	0.019897
29uz	0.013966	0.009030	0.013396	0.035995	0.010148	0.008475	0.011619
29θx	0.000072	0.000047	0.000073	0.000177	0.000045	0.000043	0.000063
29θy	0.000215	0.000126	0.000183	0.000551	0.000161	0.000125	0.000173
29θz	0.000287	0.000107	0.000176	0.000453	0.000127	0.000091	0.000221

30ux	0.098622	0.058963	0.084585	0.247833	0.081431	0.057443	0.078509
30uy	0.029329	0.014003	0.022348	0.051184	0.014188	0.011663	0.023475
30uz	0.025297	0.015018	0.021851	0.065082	0.019148	0.014857	0.020448
30θx	0.000048	0.000032	0.000049	0.000118	0.000030	0.000029	0.000042
30θy	0.000203	0.000128	0.000187	0.000511	0.000164	0.000123	0.000164
30θz	0.000118	0.000096	0.000148	0.000276	0.000077	0.000077	0.000108
31ux	0.098310	0.058754	0.084293	0.247180	0.081116	0.057277	0.078271
31uy	0.014171	0.005782	0.009376	0.023088	0.006444	0.004878	0.011049
31uz	0.035564	0.021002	0.030305	0.091168	0.028050	0.020925	0.028501
31θx	0.000024	0.000016	0.000024	0.000059	0.000015	0.000014	0.000021
31θy	0.000195	0.000127	0.000187	0.000479	0.000159	0.000118	0.000160
31θz	0.000320	0.000144	0.000231	0.000544	0.000151	0.000121	0.000254
32ux	0.097936	0.058508	0.083950	0.246395	0.080734	0.057081	0.077988
32uy	0.000032	0.000009	0.000016	0.000050	0.000013	0.000009	0.000023
32uz	0.046198	0.027525	0.039699	0.117900	0.036997	0.027277	0.037005
32θx	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
32θy	0.000192	0.000115	0.000165	0.000491	0.000154	0.000114	0.000154
32θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Table 16. Maximum Nodal Displacements for Benchmark Problem #4b(inches)
Modal superposition time history method

Nodes	Case a	Case b	Case c	Case d	Case e	Case f	Case g
2ux	0.039781	0.022936	0.033642	0.099023	0.032602	0.022543	0.032460
2uy	0.000016	0.000002	0.000005	0.000019	0.000001	0.000003	0.000008
2uz	0.000001	0.000001	0.000001	0.000002	0.000000	0.000001	0.000001
2θx	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2θy	0.000110	0.000065	0.000095	0.000280	0.000089	0.000065	0.000088
2θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3ux	0.099275	0.057886	0.084307	0.248670	0.080488	0.057072	0.080218
3uy	0.000029	0.000005	0.000010	0.000033	0.000003	0.000006	0.000014
3uz	0.000003	0.000001	0.000002	0.000005	0.000001	0.000002	0.000003
3θx	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3θy	0.000192	0.000115	0.000165	0.000490	0.000154	0.000114	0.000153
3θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4ux	0.158945	0.093472	0.135571	0.400463	0.128301	0.092296	0.127880
4uy	0.000031	0.000007	0.000014	0.000037	0.000005	0.000008	0.000017
4uz	0.000003	0.000002	0.000002	0.000006	0.000001	0.000002	0.000003
4θx	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4θy	0.000241	0.000144	0.000207	0.000615	0.000192	0.000144	0.000191
4θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5ux	0.232062	0.137514	0.198824	0.588100	0.186776	0.135974	0.186097
5uy	0.000026	0.000010	0.000017	0.000031	0.000006	0.000011	0.000015
5uz	0.000004	0.000002	0.000003	0.000008	0.000001	0.000003	0.000004
5θx	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5θy	0.000276	0.000166	0.000238	0.000707	0.000220	0.000166	0.000219
5θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6ux	0.306895	0.182869	0.263853	0.781493	0.246589	0.180934	0.245552
6uy	0.000015	0.000012	0.000020	0.000018	0.000009	0.000013	0.000012
6uz	0.000005	0.000003	0.000004	0.000009	0.000001	0.000003	0.000005
6θx	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6θy	0.000294	0.000177	0.000254	0.000755	0.000234	0.000178	0.000233
6θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
7ux	0.353431	0.211160	0.304392	0.902113	0.283822	0.209018	0.282534
7uy	0.000024	0.000014	0.000024	0.000031	0.000010	0.000015	0.000016
7uz	0.000005	0.000003	0.000004	0.000010	0.000002	0.000003	0.000005
7θx	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
7θy	0.000298	0.000180	0.000258	0.000767	0.000238	0.000181	0.000237
7θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
8ux	0.397130	0.237695	0.342425	1.015253	0.318787	0.235377	0.317266
8uy	0.000034	0.000016	0.000027	0.000044	0.000012	0.000018	0.000022
8uz	0.000005	0.000003	0.000004	0.000010	0.000002	0.000004	0.000005

8θx	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
8θy	0.000299	0.000180	0.000259	0.000770	0.000239	0.000182	0.000238
8θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
9ux	0.397132	0.237697	0.342426	1.015260	0.318788	0.235378	0.317267
9uy	0.000035	0.000019	0.000031	0.000053	0.000014	0.000021	0.000021
9uz	0.071841	0.043317	0.062167	0.184753	0.057335	0.043723	0.057006
9θx	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
9θy	0.000299	0.000180	0.000259	0.000770	0.000239	0.000182	0.000238
9θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
10ux	0.398303	0.238341	0.343986	1.018330	0.319806	0.236412	0.318179
10uy	0.005980	0.003669	0.005828	0.009006	0.002341	0.002703	0.003982
10uz	0.047522	0.032372	0.044599	0.113943	0.034507	0.031992	0.038392
10θx	0.000058	0.000043	0.000064	0.000110	0.000031	0.000050	0.000047
10θy	0.000453	0.000331	0.000574	0.001012	0.000318	0.000404	0.000353
10θz	0.000098	0.000064	0.000102	0.000153	0.000041	0.000045	0.000065
11ux	0.399168	0.238792	0.345273	1.020576	0.320582	0.237260	0.318854
11uy	0.010403	0.006965	0.011141	0.016467	0.004486	0.004846	0.006913
11uz	0.039921	0.033261	0.054541	0.077006	0.024241	0.023134	0.028188
11θx	0.000116	0.000085	0.000128	0.000220	0.000062	0.000100	0.000095
11θy	0.000336	0.000195	0.000249	0.000747	0.000243	0.000186	0.000243
11θz	0.000021	0.000007	0.000011	0.000033	0.000004	0.000008	0.000018
12ux	0.399732	0.239048	0.346284	1.021997	0.321116	0.237971	0.319290
12uy	0.000034	0.000016	0.000027	0.000044	0.000012	0.000018	0.000022
12uz	0.000008	0.000003	0.000006	0.000015	0.000002	0.000004	0.000006
12θx	0.000175	0.000128	0.000192	0.000330	0.000093	0.000150	0.000142
12θy	0.000961	0.000861	0.001343	0.001908	0.000540	0.000616	0.000717
12θz	0.000247	0.000187	0.000302	0.000423	0.000122	0.000121	0.000163
13ux	0.403242	0.235475	0.376174	1.023754	0.326633	0.257801	0.320796
13uy	0.007198	0.006489	0.011009	0.012604	0.004240	0.004608	0.004681
13uz	0.046974	0.043724	0.065447	0.094874	0.026511	0.033830	0.035359
13θx	0.000168	0.000133	0.000219	0.000284	0.000088	0.000127	0.000156
13θy	0.003100	0.002887	0.004356	0.006261	0.001761	0.002206	0.002292
13θz	0.000665	0.000582	0.000938	0.001258	0.000383	0.000401	0.000441
14ux	0.407331	0.321777	0.563037	0.987274	0.348022	0.397131	0.348387
14uy	0.016354	0.014694	0.024673	0.030424	0.009715	0.012342	0.015018
14uz	0.047254	0.043975	0.065796	0.095414	0.026658	0.034040	0.035669
14θx	0.000071	0.000061	0.000102	0.000109	0.000045	0.000076	0.000064
14θy	0.001983	0.001827	0.002872	0.004088	0.001156	0.001242	0.001418
14θz	0.001008	0.000888	0.001413	0.001894	0.000579	0.000628	0.000661
15ux	0.408171	0.325982	0.543436	0.847525	0.307697	0.382555	0.322161
15uy	0.014907	0.013548	0.022688	0.026452	0.009131	0.012262	0.013218
15uz	0.047484	0.044181	0.066083	0.095851	0.026779	0.034212	0.035936
15θx	0.000108	0.000089	0.000147	0.000199	0.000057	0.000072	0.000101

15θy	0.001694	0.001402	0.002083	0.002998	0.000901	0.001434	0.001169
15θz	0.001352	0.001194	0.001889	0.002532	0.000775	0.000855	0.000882
16ux	0.306897	0.182870	0.263854	0.781498	0.246590	0.180935	0.245553
16uy	0.000015	0.000011	0.000020	0.000017	0.000009	0.000013	0.000012
16uz	0.047665	0.044342	0.066307	0.096186	0.026874	0.034348	0.036159
16θx	0.000265	0.000229	0.000381	0.000409	0.000160	0.000227	0.000211
16θy	0.005892	0.005463	0.008467	0.011791	0.003400	0.003928	0.004247
16θz	0.001697	0.001501	0.002365	0.003169	0.000971	0.001081	0.001106
17ux	0.693986	0.643938	0.998660	1.525323	0.461811	0.452276	0.502893
17uy	0.025468	0.021795	0.035783	0.037819	0.015570	0.022874	0.019971
17uz	0.047797	0.044458	0.066470	0.096418	0.026943	0.034447	0.036337
17θx	0.000279	0.000250	0.000398	0.000407	0.000179	0.000263	0.000225
17θy	0.007442	0.006801	0.010597	0.014979	0.004256	0.004447	0.005109
17θz	0.002042	0.001807	0.002841	0.003807	0.001167	0.001308	0.001330
18ux	1.173562	1.080942	1.678984	2.475437	0.716731	0.688918	0.828827
18uy	0.041271	0.037164	0.059533	0.059180	0.026631	0.038709	0.033439
18uz	0.047880	0.044528	0.066570	0.096549	0.026986	0.034507	0.036470
18θx	0.000182	0.000098	0.000168	0.000237	0.000068	0.000103	0.000118
18θy	0.003148	0.002880	0.004421	0.006125	0.001780	0.001873	0.002189
18θz	0.002387	0.002114	0.003317	0.004444	0.001363	0.001535	0.001556
19ux	1.163012	1.071208	1.658441	2.430107	0.704602	0.676638	0.821605
19uy	0.042253	0.035761	0.058153	0.060038	0.025493	0.036784	0.031842
19uz	0.047913	0.044554	0.066607	0.096578	0.027003	0.034530	0.036556
19θx	0.000166	0.000125	0.000204	0.000246	0.000089	0.000138	0.000124
19θy	0.003376	0.003098	0.004880	0.007105	0.002032	0.002025	0.002361
19θz	0.002732	0.002420	0.003794	0.005081	0.001559	0.001762	0.001781
20ux	0.666038	0.615626	0.946312	1.410269	0.415358	0.412212	0.477117
20uy	0.024648	0.019037	0.031593	0.033449	0.013400	0.019445	0.017385
20uz	0.047897	0.044535	0.066581	0.096508	0.026994	0.034515	0.036595
20θx	0.000308	0.000244	0.000401	0.000441	0.000175	0.000254	0.000225
20θy	0.007589	0.006962	0.010805	0.015439	0.004442	0.004449	0.005285
20θz	0.003077	0.002727	0.004270	0.005719	0.001755	0.001989	0.002007
21ux	0.158946	0.093473	0.135572	0.400467	0.128302	0.092296	0.127881
21uy	0.000032	0.000007	0.000013	0.000036	0.000005	0.000008	0.000017
21uz	0.047832	0.044470	0.066492	0.096338	0.026959	0.034461	0.036586
21θx	0.000230	0.000162	0.000270	0.000301	0.000116	0.000158	0.000167
21θy	0.005944	0.005413	0.008288	0.011747	0.003375	0.003377	0.004086
21θz	0.003423	0.003033	0.004746	0.006356	0.001952	0.002216	0.002232
22ux	0.285532	0.259101	0.407341	0.540191	0.168251	0.227220	0.212675
22uy	0.015586	0.006437	0.011040	0.018839	0.004698	0.005996	0.010097
22uz	0.047718	0.044361	0.066341	0.096069	0.026898	0.034370	0.036530
22θx	0.000110	0.000051	0.000088	0.000177	0.000037	0.000059	0.000073
22θy	0.001588	0.001408	0.002166	0.003047	0.000887	0.000941	0.001051

22θz	0.003768	0.003340	0.005222	0.006994	0.002148	0.002443	0.002459
23ux	0.307004	0.272279	0.438932	0.580761	0.182906	0.240017	0.218752
23uy	0.018202	0.010545	0.015903	0.031444	0.006377	0.008887	0.011952
23uz	0.047555	0.044207	0.066127	0.095703	0.026811	0.034240	0.036425
23θx	0.000249	0.000220	0.000369	0.000448	0.000150	0.000144	0.000164
23θy	0.000591	0.000494	0.000796	0.001308	0.000323	0.000414	0.000445
23θz	0.004113	0.003646	0.005698	0.007631	0.002344	0.002671	0.002685
24ux	0.221689	0.194144	0.316039	0.414021	0.132488	0.181724	0.166312
24uy	0.025976	0.018790	0.028521	0.050761	0.011016	0.013415	0.016626
24uz	0.039420	0.036642	0.054357	0.079963	0.022022	0.028811	0.030608
24θx	0.000696	0.000642	0.000939	0.001382	0.000381	0.000514	0.000526
24θy	0.000652	0.000598	0.000906	0.001331	0.000361	0.000485	0.000486
24θz	0.004207	0.003730	0.005851	0.007873	0.002409	0.002769	0.002753
25ux	0.099275	0.057886	0.084307	0.248670	0.080488	0.057072	0.080218
25uy	0.025808	0.018755	0.028473	0.050539	0.011004	0.013374	0.016567
25uz	0.003455	0.002065	0.002973	0.008814	0.002770	0.002045	0.002759
25θx	0.000525	0.000481	0.000697	0.001042	0.000282	0.000392	0.000406
25θy	0.000493	0.000450	0.000663	0.000954	0.000263	0.000386	0.000381
25θz	0.002742	0.002462	0.003814	0.005403	0.001558	0.001809	0.001867
26ux	0.128450	0.118106	0.172693	0.298635	0.098723	0.104615	0.103801
26uy	0.025367	0.018672	0.028342	0.049950	0.010973	0.013288	0.016413
26uz	0.023825	0.019981	0.028629	0.042484	0.011389	0.017560	0.017726
26θx	0.000039	0.000032	0.000047	0.000079	0.000019	0.000030	0.000028
26θy	0.000769	0.000697	0.001072	0.001606	0.000427	0.000551	0.000570
26θz	0.000414	0.000362	0.000582	0.000742	0.000243	0.000273	0.000264
27ux	0.102714	0.063662	0.079276	0.254708	0.082592	0.064224	0.082617
27uy	0.024875	0.018582	0.028194	0.049289	0.010939	0.013207	0.016242
27uz	0.009634	0.008377	0.012241	0.017172	0.004961	0.007940	0.007442
27θx	0.000265	0.000208	0.000301	0.000452	0.000121	0.000171	0.000195
27θy	0.000539	0.000500	0.000740	0.001064	0.000296	0.000419	0.000412
27θz	0.001427	0.001142	0.001737	0.002880	0.000680	0.000812	0.000950
28ux	0.100363	0.058668	0.084277	0.250811	0.081363	0.056993	0.081122
28uy	0.000029	0.000005	0.000010	0.000033	0.000003	0.000006	0.000014
28uz	0.000004	0.000002	0.000002	0.000005	0.000001	0.000002	0.000003
28θx	0.000111	0.000061	0.000107	0.000204	0.000054	0.000080	0.000085
28θy	0.000255	0.000191	0.000327	0.000466	0.000172	0.000233	0.000208
28θz	0.000657	0.000403	0.000595	0.000929	0.000238	0.000297	0.000438
29ux	0.100204	0.058522	0.084367	0.250505	0.081242	0.057061	0.080994
29uy	0.032081	0.014102	0.021680	0.040999	0.008265	0.010825	0.020055
29uz	0.013070	0.009114	0.016059	0.030914	0.010287	0.011418	0.011518
29θx	0.000083	0.000046	0.000080	0.000153	0.000040	0.000060	0.000064
29θy	0.000216	0.000130	0.000214	0.000538	0.000167	0.000151	0.000179
29θz	0.000339	0.000094	0.000155	0.000407	0.000053	0.000087	0.000198

30ux	0.099969	0.058343	0.084402	0.250045	0.081056	0.057096	0.080800
30uy	0.037343	0.013190	0.020901	0.046081	0.007607	0.010884	0.022581
30uz	0.025335	0.015671	0.026030	0.062581	0.019863	0.018205	0.021100
30θx	0.000055	0.000030	0.000053	0.000102	0.000027	0.000040	0.000043
30θy	0.000192	0.000126	0.000160	0.000504	0.000151	0.000123	0.000159
30θz	0.000163	0.000096	0.000142	0.000222	0.000057	0.000071	0.000108
31ux	0.099658	0.058130	0.084382	0.249432	0.080805	0.057100	0.080541
31uy	0.017130	0.005244	0.008492	0.020747	0.002975	0.004635	0.010135
31uz	0.035822	0.020882	0.032411	0.090698	0.028446	0.022516	0.028809
31θx	0.000028	0.000015	0.000027	0.000051	0.000013	0.000020	0.000021
31θy	0.000194	0.000121	0.000174	0.000456	0.000139	0.000115	0.000161
31θz	0.000400	0.000134	0.000214	0.000490	0.000077	0.000113	0.000240
32ux	0.099273	0.057884	0.084306	0.248664	0.080487	0.057072	0.080216
32uy	0.000028	0.000007	0.000012	0.000038	0.000004	0.000007	0.000015
32uz	0.046085	0.027536	0.039665	0.117578	0.036944	0.027274	0.036785
32θx	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
32θy	0.000192	0.000115	0.000165	0.000490	0.000154	0.000114	0.000153
32θz	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Table 17 Maximum Element Forces and Moments for P-components of Benchmark Problem #4a (kips-inches)
Response spectrum method

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	1.157E+00	2.909E-01	5.382E-01	1.735E+00	5.554E-01	2.446E-01	7.557E-01
1Ri2	5.717E+00	1.461E+00	2.762E+00	8.621E+00	2.855E+00	1.212E+00	3.593E+00
1Ri3	1.336E+04	5.233E+03	9.829E+03	2.415E+04	7.498E+03	7.252E+03	1.059E+04
1Mi1	1.903E+02	6.658E+01	1.298E+02	3.392E+02	1.014E+02	8.725E+01	1.447E+02
1Mi2	1.266E+07	4.643E+06	9.059E+06	2.267E+07	6.536E+06	6.837E+06	1.025E+07
1Mi3	1.253E+03	3.196E+02	7.491E+02	2.216E+03	5.113E+02	4.495E+02	9.227E+02
1Rj1	1.157E+00	2.909E-01	5.382E-01	1.735E+00	5.554E-01	2.446E-01	7.557E-01
1Rj2	5.717E+00	1.461E+00	2.762E+00	8.621E+00	2.855E+00	1.212E+00	3.593E+00
1Rj3	1.336E+04	5.233E+03	9.829E+03	2.415E+04	7.498E+03	7.252E+03	1.059E+04
1Mj1	1.903E+02	6.658E+01	1.298E+02	3.392E+02	1.014E+02	8.725E+01	1.447E+02
1Mj2	9.709E+06	3.486E+06	6.884E+06	1.734E+07	4.877E+06	5.230E+06	7.911E+06
1Mj3	6.732E+02	1.853E+02	4.601E+02	1.330E+03	2.560E+02	3.180E+02	5.671E+02
2Ri1	1.067E+00	2.680E-01	4.977E-01	1.609E+00	5.098E-01	2.275E-01	7.003E-01
2Ri2	4.230E+00	1.079E+00	2.066E+00	6.429E+00	2.092E+00	9.258E-01	2.675E+00
2Ri3	1.275E+04	4.906E+03	9.312E+03	2.299E+04	6.997E+03	6.917E+03	1.018E+04
2Mi1	1.903E+02	6.658E+01	1.298E+02	3.392E+02	1.014E+02	8.725E+01	1.447E+02
2Mi2	9.709E+06	3.486E+06	6.884E+06	1.734E+07	4.877E+06	5.230E+06	7.911E+06
2Mi3	6.732E+02	1.853E+02	4.601E+02	1.330E+03	2.560E+02	3.180E+02	5.671E+02
2Rj1	1.067E+00	2.680E-01	4.977E-01	1.609E+00	5.098E-01	2.275E-01	7.003E-01
2Rj2	4.230E+00	1.079E+00	2.066E+00	6.429E+00	2.092E+00	9.258E-01	2.675E+00
2Rj3	1.275E+04	4.906E+03	9.312E+03	2.299E+04	6.997E+03	6.917E+03	1.018E+04
2Mj1	1.903E+02	6.658E+01	1.298E+02	3.392E+02	1.014E+02	8.725E+01	1.447E+02
2Mj2	6.894E+06	2.402E+06	4.826E+06	1.227E+07	3.331E+06	3.698E+06	5.660E+06
2Mj3	1.284E+03	3.398E+02	6.449E+02	1.995E+03	6.535E+02	3.310E+02	8.451E+02
3Ri1	9.071E-01	2.637E-01	6.039E-01	1.736E+00	3.840E-01	2.652E-01	7.438E-01
3Ri2	1.755E+00	4.472E-01	9.360E-01	2.833E+00	8.143E-01	4.765E-01	1.174E+00
3Ri3	1.150E+04	4.268E+03	8.270E+03	2.062E+04	6.028E+03	6.218E+03	9.282E+03
3Mi1	1.078E+02	3.317E+01	7.817E+01	2.109E+02	4.339E+01	4.696E+01	9.573E+01
3Mi2	6.894E+06	2.402E+06	4.826E+06	1.227E+07	3.331E+06	3.698E+06	5.660E+06
3Mi3	1.283E+03	3.398E+02	6.470E+02	2.000E+03	6.529E+02	3.272E+02	8.444E+02
3Rj1	9.071E-01	2.637E-01	6.039E-01	1.736E+00	3.840E-01	2.652E-01	7.438E-01
3Rj2	1.755E+00	4.472E-01	9.360E-01	2.833E+00	8.143E-01	4.765E-01	1.174E+00
3Rj3	1.150E+04	4.268E+03	8.270E+03	2.062E+04	6.028E+03	6.218E+03	9.282E+03
3Mj1	1.078E+02	3.317E+01	7.817E+01	2.109E+02	4.339E+01	4.696E+01	9.573E+01
3Mj2	4.766E+06	1.611E+06	3.293E+06	8.453E+06	2.215E+06	2.543E+06	3.938E+06
3Mj3	1.528E+03	3.999E+02	7.376E+02	2.306E+03	7.859E+02	3.384E+02	9.711E+02
4Ri1	7.754E-01	2.350E-01	5.619E-01	1.587E+00	3.088E-01	2.467E-01	6.777E-01
4Ri2	1.291E+00	3.451E-01	6.935E-01	2.112E+00	6.358E-01	3.901E-01	8.922E-01
4Ri3	9.797E+03	3.460E+03	6.898E+03	1.746E+04	4.819E+03	5.266E+03	8.016E+03
4Mi1	1.340E+02	4.010E+01	8.695E+01	2.365E+02	5.762E+01	6.555E+01	1.091E+02

4Mi2	4.766E+06	1.611E+06	3.293E+06	8.453E+06	2.215E+06	2.543E+06	3.938E+06
4Mi3	1.528E+03	3.999E+02	7.376E+02	2.306E+03	7.859E+02	3.384E+02	9.711E+02
4Rj1	7.754E-01	2.350E-01	5.619E-01	1.587E+00	3.088E-01	2.467E-01	6.777E-01
4Rj2	1.291E+00	3.451E-01	6.935E-01	2.112E+00	6.358E-01	3.901E-01	8.922E-01
4Rj3	9.797E+03	3.460E+03	6.898E+03	1.746E+04	4.819E+03	5.266E+03	8.016E+03
4Mj1	1.340E+02	4.010E+01	8.695E+01	2.365E+02	5.762E+01	6.555E+01	1.091E+02
4Mj2	2.713E+06	8.867E+05	1.847E+06	4.798E+06	1.206E+06	1.438E+06	2.257E+06
4Mj3	1.285E+03	3.352E+02	6.137E+02	1.923E+03	6.623E+02	2.709E+02	8.084E+02
5Ri1	6.780E-01	2.143E-01	5.307E-01	1.472E+00	2.531E-01	2.325E-01	6.278E-01
5Ri2	2.879E+00	7.488E-01	1.373E+00	4.311E+00	1.478E+00	6.213E-01	1.818E+00
5Ri3	7.720E+03	2.580E+03	5.307E+03	1.368E+04	3.533E+03	4.111E+03	6.395E+03
5Mi1	1.340E+02	4.010E+01	8.695E+01	2.365E+02	5.762E+01	6.555E+01	1.091E+02
5Mi2	2.713E+06	8.867E+05	1.847E+06	4.798E+06	1.206E+06	1.438E+06	2.257E+06
5Mi3	1.285E+03	3.352E+02	6.137E+02	1.923E+03	6.623E+02	2.709E+02	8.084E+02
5Rj1	6.780E-01	2.143E-01	5.307E-01	1.472E+00	2.531E-01	2.325E-01	6.278E-01
5Rj2	2.879E+00	7.488E-01	1.373E+00	4.311E+00	1.478E+00	6.213E-01	1.818E+00
5Rj3	7.720E+03	2.580E+03	5.307E+03	1.368E+04	3.533E+03	4.111E+03	6.395E+03
5Mj1	1.340E+02	4.010E+01	8.695E+01	2.365E+02	5.762E+01	6.555E+01	1.091E+02
5Mj2	1.093E+06	3.455E+05	7.333E+05	1.928E+06	4.646E+05	5.754E+05	9.151E+05
5Mj3	6.840E+02	1.789E+02	3.275E+02	1.024E+03	3.534E+02	1.422E+02	4.292E+02
6Ri1	6.607E-01	2.102E-01	5.201E-01	1.431E+00	2.509E-01	2.271E-01	6.113E-01
6Ri2	3.031E+00	7.930E-01	1.451E+00	4.537E+00	1.567E+00	6.356E-01	1.906E+00
6Ri3	5.334E+03	1.707E+03	3.598E+03	9.416E+03	2.305E+03	2.815E+03	4.455E+03
6Mi1	1.786E+02	5.479E+01	1.180E+02	3.178E+02	7.568E+01	9.225E+01	1.476E+02
6Mi2	1.093E+06	3.455E+05	7.333E+05	1.928E+06	4.646E+05	5.754E+05	9.151E+05
6Mi3	6.840E+02	1.789E+02	3.275E+02	1.024E+03	3.534E+02	1.422E+02	4.292E+02
6Rj1	6.607E-01	2.102E-01	5.201E-01	1.431E+00	2.509E-01	2.271E-01	6.113E-01
6Rj2	3.031E+00	7.930E-01	1.451E+00	4.537E+00	1.567E+00	6.356E-01	1.906E+00
6Rj3	5.334E+03	1.707E+03	3.598E+03	9.416E+03	2.305E+03	2.815E+03	4.455E+03
6Mj1	1.786E+02	5.479E+01	1.180E+02	3.178E+02	7.568E+01	9.225E+01	1.476E+02
6Mj2	3.735E+05	1.151E+05	2.478E+05	6.576E+05	1.535E+05	1.954E+05	3.138E+05
6Mj3	2.750E+02	7.196E+01	1.317E+02	4.120E+02	1.420E+02	5.668E+01	1.723E+02
7Ri1	7.335E-01	2.245E-01	5.332E-01	1.478E+00	3.051E-01	2.320E-01	6.339E-01
7Ri2	2.027E+00	5.278E-01	9.664E-01	3.026E+00	1.043E+00	4.179E-01	1.271E+00
7Ri3	2.767E+03	8.528E+02	1.835E+03	4.871E+03	1.137E+03	1.447E+03	2.324E+03
7Mi1	1.786E+02	5.479E+01	1.180E+02	3.178E+02	7.568E+01	9.225E+01	1.476E+02
7Mi2	3.735E+05	1.151E+05	2.478E+05	6.576E+05	1.535E+05	1.954E+05	3.138E+05
7Mi3	2.750E+02	7.196E+01	1.317E+02	4.120E+02	1.420E+02	5.668E+01	1.723E+02
7Rj1	7.335E-01	2.245E-01	5.332E-01	1.478E+00	3.051E-01	2.320E-01	6.339E-01
7Rj2	2.027E+00	5.278E-01	9.664E-01	3.026E+00	1.043E+00	4.179E-01	1.271E+00
7Rj3	2.767E+03	8.528E+02	1.835E+03	4.871E+03	1.137E+03	1.447E+03	2.324E+03
7Mj1	1.786E+02	5.479E+01	1.180E+02	3.178E+02	7.568E+01	9.225E+01	1.476E+02
7Mj2	5.901E+01	1.621E+01	3.373E+01	9.804E+01	2.777E+01	1.476E+01	4.281E+01
7Mj3	1.947E+01	5.006E+00	1.009E+01	3.062E+01	8.721E+00	5.893E+00	1.385E+01

Table 18 Maximum Element Forces and Moments for P-components of Benchmark Problem #4a (kips-inches)
Modal superposition time history method

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	1.044E+00	1.167E-01	3.331E-01	9.372E-01	9.034E-02	2.236E-01	4.613E-01
1Ri2	3.266E+00	3.607E-01	9.571E-01	8.299E-01	2.737E-01	9.066E-01	8.112E-01
1Ri3	1.381E+04	5.395E+03	9.313E+03	2.322E+04	8.007E+03	7.588E+03	1.056E+04
1Mi1	1.701E+02	6.800E+01	1.408E+02	3.480E+02	9.209E+01	7.978E+01	1.428E+02
1Mi2	1.272E+07	4.654E+06	8.962E+06	2.252E+07	6.590E+06	6.877E+06	1.023E+07
1Mi3	7.444E+02	1.915E+02	4.522E+02	8.589E+02	2.161E+02	3.569E+02	6.713E+02
1Rj1	1.044E+00	1.167E-01	3.331E-01	9.372E-01	9.034E-02	2.236E-01	4.613E-01
1Rj2	3.266E+00	3.607E-01	9.571E-01	8.299E-01	2.737E-01	9.066E-01	8.112E-01
1Rj3	1.381E+04	5.395E+03	9.313E+03	2.322E+04	8.007E+03	7.588E+03	1.056E+04
1Mj1	1.701E+02	6.800E+01	1.408E+02	3.480E+02	9.209E+01	7.978E+01	1.428E+02
1Mj2	9.654E+06	3.460E+06	6.903E+06	1.738E+07	4.815E+06	5.192E+06	7.898E+06
1Mj3	4.295E+02	1.413E+02	3.303E+02	6.748E+02	1.653E+02	2.257E+02	4.951E+02
2Ri1	9.765E-01	1.092E-01	3.225E-01	9.081E-01	8.870E-02	2.130E-01	4.481E-01
2Ri2	2.405E+00	3.037E-01	7.746E-01	8.092E-01	2.486E-01	7.113E-01	7.468E-01
2Ri3	1.280E+04	4.777E+03	8.755E+03	2.199E+04	6.909E+03	6.915E+03	9.974E+03
2Mi1	1.701E+02	6.800E+01	1.408E+02	3.480E+02	9.209E+01	7.978E+01	1.428E+02
2Mi2	9.654E+06	3.460E+06	6.903E+06	1.738E+07	4.815E+06	5.192E+06	7.898E+06
2Mi3	4.295E+02	1.413E+02	3.303E+02	6.748E+02	1.653E+02	2.257E+02	4.951E+02
2Rj1	9.765E-01	1.092E-01	3.225E-01	9.081E-01	8.870E-02	2.130E-01	4.481E-01
2Rj2	2.405E+00	3.037E-01	7.746E-01	8.092E-01	2.486E-01	7.113E-01	7.468E-01
2Rj3	1.280E+04	4.777E+03	8.755E+03	2.199E+04	6.909E+03	6.915E+03	9.974E+03
2Mj1	1.701E+02	6.800E+01	1.408E+02	3.480E+02	9.209E+01	7.978E+01	1.428E+02
2Mj2	6.812E+06	2.400E+06	4.961E+06	1.249E+07	3.283E+06	3.657E+06	5.684E+06
2Mj3	7.879E+02	1.346E+02	3.394E+02	4.955E+02	1.368E+02	2.756E+02	3.825E+02
3Ri1	9.835E-01	2.029E-01	5.230E-01	1.577E+00	2.117E-01	3.027E-01	8.082E-01
3Ri2	1.002E+00	1.891E-01	4.894E-01	7.297E-01	1.905E-01	4.160E-01	5.756E-01
3Ri3	1.139E+04	4.118E+03	7.986E+03	2.014E+04	5.799E+03	6.111E+03	9.141E+03
3Mi1	1.212E+02	3.672E+01	9.347E+01	2.528E+02	4.059E+01	4.035E+01	1.075E+02
3Mi2	6.812E+06	2.400E+06	4.961E+06	1.249E+07	3.283E+06	3.657E+06	5.684E+06
3Mi3	7.796E+02	1.319E+02	3.383E+02	4.898E+02	1.343E+02	2.749E+02	3.867E+02
3Rj1	9.835E-01	2.029E-01	5.230E-01	1.577E+00	2.117E-01	3.027E-01	8.082E-01
3Rj2	1.002E+00	1.891E-01	4.894E-01	7.297E-01	1.905E-01	4.160E-01	5.756E-01
3Rj3	1.139E+04	4.118E+03	7.986E+03	2.014E+04	5.799E+03	6.111E+03	9.141E+03
3Mj1	1.212E+02	3.672E+01	9.347E+01	2.528E+02	4.059E+01	4.035E+01	1.075E+02
3Mj2	4.693E+06	1.634E+06	3.478E+06	8.749E+06	2.205E+06	2.520E+06	3.986E+06
3Mj3	8.971E+02	1.150E+02	3.076E+02	3.559E+02	1.078E+02	2.751E+02	2.983E+02
4Ri1	8.303E-01	1.927E-01	4.952E-01	1.517E+00	2.080E-01	2.778E-01	7.747E-01
4Ri2	7.963E-01	1.744E-01	4.175E-01	6.998E-01	1.837E-01	3.236E-01	5.291E-01
4Ri3	9.660E+03	3.407E+03	6.980E+03	1.760E+04	4.676E+03	5.175E+03	8.005E+03
4Mi1	1.483E+02	4.244E+01	9.819E+01	2.286E+02	5.065E+01	6.135E+01	1.138E+02

4Mi2	4.693E+06	1.634E+06	3.478E+06	8.749E+06	2.205E+06	2.520E+06	3.986E+06
4Mi3	8.971E+02	1.150E+02	3.076E+02	3.559E+02	1.078E+02	2.751E+02	2.983E+02
4Rj1	8.303E-01	1.927E-01	4.952E-01	1.517E+00	2.080E-01	2.778E-01	7.747E-01
4Rj2	7.963E-01	1.744E-01	4.175E-01	6.998E-01	1.837E-01	3.236E-01	5.291E-01
4Rj3	9.660E+03	3.407E+03	6.980E+03	1.760E+04	4.676E+03	5.175E+03	8.005E+03
4Mj1	1.483E+02	4.244E+01	9.819E+01	2.286E+02	5.065E+01	6.135E+01	1.138E+02
4Mj2	2.665E+06	9.183E+05	2.014E+06	5.052E+06	1.223E+06	1.434E+06	2.308E+06
4Mj3	7.401E+02	8.032E+01	2.281E+02	2.096E+02	6.999E+01	2.113E+02	1.901E+02
5Ri1	6.812E-01	1.816E-01	4.693E-01	1.437E+00	2.035E-01	2.487E-01	7.374E-01
5Ri2	1.685E+00	2.004E-01	5.324E-01	5.685E-01	1.784E-01	4.860E-01	4.770E-01
5Ri3	7.592E+03	2.632E+03	5.664E+03	1.424E+04	3.534E+03	4.079E+03	6.495E+03
5Mi1	1.483E+02	4.244E+01	9.819E+01	2.286E+02	5.065E+01	6.135E+01	1.138E+02
5Mi2	2.665E+06	9.183E+05	2.014E+06	5.052E+06	1.223E+06	1.434E+06	2.308E+06
5Mi3	7.401E+02	8.032E+01	2.281E+02	2.096E+02	6.999E+01	2.113E+02	1.901E+02
5Rj1	6.812E-01	1.816E-01	4.693E-01	1.437E+00	2.035E-01	2.487E-01	7.374E-01
5Rj2	1.685E+00	2.004E-01	5.324E-01	5.685E-01	1.784E-01	4.860E-01	4.770E-01
5Rj3	7.592E+03	2.632E+03	5.664E+03	1.424E+04	3.534E+03	4.079E+03	6.495E+03
5Mj1	1.483E+02	4.244E+01	9.819E+01	2.286E+02	5.065E+01	6.135E+01	1.138E+02
5Mj2	1.075E+06	3.655E+05	8.247E+05	2.064E+06	4.807E+05	5.769E+05	9.440E+05
5Mj3	3.914E+02	4.049E+01	1.186E+02	9.226E+01	3.251E+01	1.092E+02	9.041E+01
6Ri1	6.371E-01	1.707E-01	4.771E-01	1.349E+00	1.985E-01	2.220E-01	6.957E-01
6Ri2	1.757E+00	1.831E-01	5.253E-01	4.555E-01	1.573E-01	4.957E-01	4.214E-01
6Ri3	5.238E+03	1.793E+03	4.000E+03	1.002E+04	2.369E+03	2.817E+03	4.581E+03
6Mi1	1.905E+02	5.618E+01	1.210E+02	3.155E+02	7.156E+01	9.269E+01	1.442E+02
6Mi2	1.075E+06	3.655E+05	8.247E+05	2.064E+06	4.807E+05	5.769E+05	9.440E+05
6Mi3	3.914E+02	4.049E+01	1.186E+02	9.226E+01	3.251E+01	1.092E+02	9.041E+01
6Rj1	6.371E-01	1.707E-01	4.771E-01	1.349E+00	1.985E-01	2.220E-01	6.957E-01
6Rj2	1.757E+00	1.831E-01	5.253E-01	4.555E-01	1.573E-01	4.957E-01	4.214E-01
6Rj3	5.238E+03	1.793E+03	4.000E+03	1.002E+04	2.369E+03	2.817E+03	4.581E+03
6Mj1	1.905E+02	5.618E+01	1.210E+02	3.155E+02	7.156E+01	9.269E+01	1.442E+02
6Mj2	3.695E+05	1.251E+05	2.847E+05	7.112E+05	1.609E+05	1.966E+05	3.256E+05
6Mj3	1.606E+02	1.597E+01	4.792E+01	3.208E+01	1.411E+01	4.232E+01	3.607E+01
7Ri1	6.355E-01	1.665E-01	4.871E-01	1.317E+00	1.942E-01	2.158E-01	6.490E-01
7Ri2	1.160E+00	1.155E-01	3.363E-01	2.534E-01	9.288E-02	3.223E-01	2.500E-01
7Ri3	2.737E+03	9.263E+02	2.108E+03	5.268E+03	1.192E+03	1.456E+03	2.412E+03
7Mi1	1.905E+02	5.618E+01	1.210E+02	3.155E+02	7.156E+01	9.269E+01	1.442E+02
7Mi2	3.695E+05	1.251E+05	2.847E+05	7.112E+05	1.609E+05	1.966E+05	3.256E+05
7Mi3	1.606E+02	1.597E+01	4.792E+01	3.208E+01	1.411E+01	4.232E+01	3.607E+01
7Rj1	6.355E-01	1.665E-01	4.871E-01	1.317E+00	1.942E-01	2.158E-01	6.490E-01
7Rj2	1.160E+00	1.155E-01	3.363E-01	2.534E-01	9.288E-02	3.223E-01	2.500E-01
7Rj3	2.737E+03	9.263E+02	2.108E+03	5.268E+03	1.192E+03	1.456E+03	2.412E+03
7Mj1	1.905E+02	5.618E+01	1.210E+02	3.155E+02	7.156E+01	9.269E+01	1.442E+02
7Mj2	4.799E+01	9.890E+00	2.744E+01	7.280E+01	9.678E+00	1.325E+01	3.261E+01
7Mj3	1.928E+01	3.744E+00	7.834E+00	1.835E+01	3.825E+00	5.432E+00	1.067E+01

Table 19. Maximum Element Forces and Moments for P-components of Benchmark Problem #4b (kips-inches)
Response spectrum method

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	4.885E+00	2.585E+00	4.084E+00	1.060E+01	2.363E+00	2.363E+00	4.326E+00
1Ri2	4.483E+04	2.679E+04	3.827E+04	1.110E+05	3.787E+04	2.572E+04	3.547E+04
1Ri3	3.016E+01	7.167E+00	1.296E+01	4.299E+01	1.227E+01	6.523E+00	2.143E+01
1Mi1	1.516E+03	1.041E+03	1.586E+03	3.780E+03	9.694E+02	9.443E+02	1.288E+03
1Mi2	5.943E+03	2.411E+03	4.385E+03	1.163E+04	2.849E+03	3.538E+03	4.531E+03
1Mi3	4.360E+07	2.602E+07	3.744E+07	1.106E+08	3.537E+07	2.561E+07	3.484E+07
1Rj1	4.885E+00	2.585E+00	4.084E+00	1.060E+01	2.363E+00	2.363E+00	4.326E+00
1Rj2	4.483E+04	2.679E+04	3.827E+04	1.110E+05	3.787E+04	2.572E+04	3.547E+04
1Rj3	3.016E+01	7.166E+00	1.295E+01	4.299E+01	1.227E+01	6.522E+00	2.143E+01
1Mj1	1.516E+03	1.041E+03	1.586E+03	3.780E+03	9.694E+02	9.443E+02	1.288E+03
1Mj2	3.289E+03	1.749E+03	3.178E+03	7.344E+03	1.714E+03	2.736E+03	2.702E+03
1Mj3	3.373E+07	2.009E+07	2.899E+07	8.613E+07	2.698E+07	1.993E+07	2.703E+07
2Ri1	4.654E+00	2.550E+00	4.019E+00	1.023E+01	2.298E+00	2.321E+00	4.157E+00
2Ri2	4.311E+04	2.577E+04	3.688E+04	1.075E+05	3.603E+04	2.492E+04	3.421E+04
2Ri3	2.222E+01	5.406E+00	9.782E+00	3.216E+01	9.086E+00	5.205E+00	1.579E+01
2Mi1	1.516E+03	1.041E+03	1.586E+03	3.780E+03	9.694E+02	9.443E+02	1.288E+03
2Mi2	3.289E+03	1.749E+03	3.178E+03	7.344E+03	1.714E+03	2.736E+03	2.702E+03
2Mi3	3.373E+07	2.009E+07	2.899E+07	8.613E+07	2.698E+07	1.993E+07	2.703E+07
2Rj1	4.654E+00	2.550E+00	4.019E+00	1.023E+01	2.298E+00	2.321E+00	4.157E+00
2Rj2	4.311E+04	2.577E+04	3.688E+04	1.075E+05	3.603E+04	2.492E+04	3.421E+04
2Rj3	2.222E+01	5.405E+00	9.779E+00	3.216E+01	9.084E+00	5.204E+00	1.579E+01
2Mj1	1.516E+03	1.041E+03	1.586E+03	3.779E+03	9.693E+02	9.441E+02	1.287E+03
2Mj2	7.010E+03	1.999E+03	3.610E+03	1.031E+04	2.890E+03	2.397E+03	5.079E+03
2Mj3	2.425E+07	1.440E+07	2.085E+07	6.239E+07	1.901E+07	1.442E+07	1.949E+07
3Ri1	3.522E+00	1.608E+00	2.590E+00	7.578E+00	1.580E+00	1.591E+00	3.204E+00
3Ri2	3.946E+04	2.356E+04	3.386E+04	9.974E+04	3.226E+04	2.310E+04	3.148E+04
3Ri3	8.997E+00	2.729E+00	4.902E+00	1.476E+01	3.961E+00	3.364E+00	6.609E+00
3Mi1	1.997E+03	1.514E+03	2.262E+03	5.093E+03	1.538E+03	1.324E+03	1.707E+03
3Mi2	6.991E+03	1.974E+03	3.589E+03	1.027E+04	2.870E+03	2.392E+03	5.060E+03
3Mi3	2.425E+07	1.440E+07	2.085E+07	6.239E+07	1.901E+07	1.442E+07	1.949E+07
3Rj1	3.522E+00	1.608E+00	2.590E+00	7.578E+00	1.580E+00	1.591E+00	3.204E+00
3Rj2	3.946E+04	2.356E+04	3.386E+04	9.974E+04	3.226E+04	2.310E+04	3.148E+04
3Rj3	8.991E+00	2.727E+00	4.899E+00	1.475E+01	3.959E+00	3.362E+00	6.605E+00
3Mj1	1.997E+03	1.514E+03	2.262E+03	5.092E+03	1.537E+03	1.324E+03	1.707E+03
3Mj2	8.256E+03	2.077E+03	3.769E+03	1.159E+04	3.341E+03	2.150E+03	5.914E+03
3Mj3	1.696E+07	1.003E+07	1.458E+07	4.391E+07	1.302E+07	1.013E+07	1.367E+07
4Ri1	2.997E+00	1.517E+00	2.422E+00	6.703E+00	1.420E+00	1.482E+00	2.802E+00

4Ri2	3.436E+04	2.044E+04	2.955E+04	8.812E+04	2.719E+04	2.038E+04	2.758E+04
4Ri3	7.124E+00	2.254E+00	4.131E+00	1.102E+01	2.984E+00	3.071E+00	5.214E+00
4Mi1	1.263E+03	8.128E+02	1.200E+03	3.275E+03	9.488E+02	7.857E+02	1.040E+03
4Mi2	8.256E+03	2.077E+03	3.769E+03	1.159E+04	3.341E+03	2.150E+03	5.914E+03
4Mi3	1.696E+07	1.003E+07	1.458E+07	4.391E+07	1.302E+07	1.013E+07	1.367E+07
4Rj1	2.997E+00	1.517E+00	2.422E+00	6.703E+00	1.420E+00	1.482E+00	2.802E+00
4Rj2	3.433E+04	2.042E+04	2.951E+04	8.802E+04	2.716E+04	2.035E+04	2.755E+04
4Rj3	7.127E+00	2.253E+00	4.129E+00	1.102E+01	2.985E+00	3.068E+00	5.216E+00
4Mj1	1.263E+03	8.125E+02	1.200E+03	3.273E+03	9.485E+02	7.854E+02	1.039E+03
4Mj2	6.883E+03	1.670E+03	3.023E+03	9.597E+03	2.782E+03	1.587E+03	4.921E+03
4Mj3	9.769E+06	5.753E+06	8.395E+06	2.545E+07	7.321E+06	5.864E+06	7.897E+06
5Ri1	2.453E+00	1.419E+00	2.242E+00	5.817E+00	1.253E+00	1.362E+00	2.370E+00
5Ri2	2.772E+04	1.638E+04	2.384E+04	7.195E+04	2.112E+04	1.660E+04	2.237E+04
5Ri3	1.555E+01	3.794E+00	6.865E+00	2.157E+01	6.275E+00	3.713E+00	1.111E+01
5Mi1	1.263E+03	8.125E+02	1.200E+03	3.273E+03	9.485E+02	7.854E+02	1.039E+03
5Mi2	6.883E+03	1.670E+03	3.023E+03	9.597E+03	2.782E+03	1.587E+03	4.921E+03
5Mi3	9.769E+06	5.753E+06	8.395E+06	2.545E+07	7.321E+06	5.864E+06	7.897E+06
5Rj1	2.453E+00	1.419E+00	2.242E+00	5.817E+00	1.253E+00	1.362E+00	2.370E+00
5Rj2	2.767E+04	1.635E+04	2.379E+04	7.181E+04	2.107E+04	1.656E+04	2.233E+04
5Rj3	1.555E+01	3.793E+00	6.864E+00	2.157E+01	6.275E+00	3.710E+00	1.111E+01
5Mj1	1.262E+03	8.121E+02	1.199E+03	3.272E+03	9.482E+02	7.850E+02	1.039E+03
5Mj2	3.629E+03	8.800E+02	1.591E+03	5.096E+03	1.469E+03	8.155E+02	2.597E+03
5Mj3	3.961E+06	2.319E+06	3.399E+06	1.037E+07	2.894E+06	2.385E+06	3.209E+06
6Ri1	2.054E+00	1.327E+00	2.077E+00	5.158E+00	1.120E+00	1.245E+00	2.006E+00
6Ri2	1.952E+04	1.146E+04	1.676E+04	5.101E+04	1.441E+04	1.174E+04	1.580E+04
6Ri3	1.617E+01	3.862E+00	7.007E+00	2.232E+01	6.554E+00	3.575E+00	1.157E+01
6Mi1	6.612E+02	4.382E+02	6.555E+02	1.760E+03	4.698E+02	4.184E+02	5.552E+02
6Mi2	3.629E+03	8.800E+02	1.591E+03	5.096E+03	1.469E+03	8.155E+02	2.597E+03
6Mi3	3.961E+06	2.319E+06	3.399E+06	1.037E+07	2.894E+06	2.385E+06	3.209E+06
6Rj1	2.053E+00	1.326E+00	2.076E+00	5.155E+00	1.119E+00	1.245E+00	2.005E+00
6Rj2	1.945E+04	1.142E+04	1.670E+04	5.084E+04	1.436E+04	1.170E+04	1.575E+04
6Rj3	1.617E+01	3.861E+00	7.004E+00	2.232E+01	6.553E+00	3.572E+00	1.157E+01
6Mj1	6.612E+02	4.382E+02	6.555E+02	1.760E+03	4.698E+02	4.184E+02	5.552E+02
6Mj2	1.455E+03	3.660E+02	6.557E+02	2.110E+03	5.884E+02	3.389E+02	1.044E+03
6Mj3	1.358E+06	7.913E+05	1.163E+06	3.565E+06	9.728E+05	8.186E+05	1.102E+06
7Ri1	2.006E+00	1.256E+00	1.956E+00	4.980E+00	1.063E+00	1.152E+00	1.844E+00
7Ri2	1.029E+04	6.001E+03	8.819E+03	2.701E+04	7.391E+03	6.203E+03	8.348E+03
7Ri3	1.079E+01	2.558E+00	4.638E+00	1.490E+01	4.382E+00	2.300E+00	7.717E+00
7Mi1	6.612E+02	4.382E+02	6.555E+02	1.760E+03	4.698E+02	4.184E+02	5.552E+02
7Mi2	1.455E+03	3.660E+02	6.557E+02	2.110E+03	5.884E+02	3.389E+02	1.044E+03
7Mi3	1.358E+06	7.913E+05	1.163E+06	3.565E+06	9.728E+05	8.186E+05	1.102E+06

7Rj1	2.005E+00	1.255E+00	1.954E+00	4.977E+00	1.062E+00	1.151E+00	1.843E+00
7Rj2	1.022E+04	5.956E+03	8.755E+03	2.682E+04	7.332E+03	6.159E+03	8.289E+03
7Rj3	1.079E+01	2.556E+00	4.635E+00	1.489E+01	4.380E+00	2.297E+00	7.714E+00
7Mj1	6.612E+02	4.382E+02	6.555E+02	1.760E+03	4.698E+02	4.184E+02	5.552E+02
7Mj2	1.820E+02	9.613E+01	1.505E+02	4.161E+02	8.669E+01	8.634E+01	1.521E+02
7Mj3	1.877E+02	1.425E+02	2.187E+02	4.302E+02	1.131E+02	1.125E+02	1.626E+02

Table 20. Maximum Element Forces and Moments for P-components of Benchmark Problem #4b (kips-inches)
Modal superposition time history method

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	5.362E+00	2.872E+00	3.891E+00	1.019E+01	1.611E+00	3.460E+00	5.377E+00
1Ri2	4.643E+04	2.634E+04	3.889E+04	1.144E+05	3.827E+04	2.590E+04	3.809E+04
1Ri3	2.585E+01	3.062E+00	7.032E+00	2.937E+01	1.778E+00	3.925E+00	1.347E+01
1Mi1	1.531E+03	9.729E+02	1.468E+03	3.339E+03	7.043E+02	1.018E+03	1.095E+03
1Mi2	5.594E+03	1.881E+03	3.306E+03	6.701E+03	1.242E+03	2.127E+03	3.238E+03
1Mi3	4.380E+07	2.593E+07	3.755E+07	1.110E+08	3.537E+07	2.561E+07	3.522E+07
1Rj1	5.362E+00	2.872E+00	3.891E+00	1.019E+01	1.611E+00	3.460E+00	5.377E+00
1Rj2	4.643E+04	2.634E+04	3.889E+04	1.144E+05	3.827E+04	2.590E+04	3.809E+04
1Rj3	2.585E+01	3.062E+00	7.032E+00	2.937E+01	1.778E+00	3.925E+00	1.347E+01
1Mj1	1.531E+03	9.728E+02	1.468E+03	3.339E+03	7.042E+02	1.018E+03	1.095E+03
1Mj2	2.717E+03	1.375E+03	2.353E+03	3.529E+03	1.009E+03	1.546E+03	1.742E+03
1Mj3	3.361E+07	2.009E+07	2.891E+07	8.572E+07	2.688E+07	1.996E+07	2.677E+07
2Ri1	5.117E+00	2.837E+00	3.871E+00	9.795E+00	1.596E+00	3.399E+00	5.130E+00
2Ri2	4.379E+04	2.516E+04	3.667E+04	1.080E+05	3.524E+04	2.486E+04	3.521E+04
2Ri3	1.950E+01	2.601E+00	5.386E+00	2.188E+01	1.542E+00	2.996E+00	1.009E+01
2Mi1	1.531E+03	9.728E+02	1.468E+03	3.339E+03	7.042E+02	1.018E+03	1.095E+03
2Mi2	2.717E+03	1.375E+03	2.353E+03	3.529E+03	1.009E+03	1.546E+03	1.742E+03
2Mi3	3.361E+07	2.009E+07	2.891E+07	8.572E+07	2.688E+07	1.996E+07	2.677E+07
2Rj1	5.117E+00	2.837E+00	3.871E+00	9.795E+00	1.596E+00	3.399E+00	5.130E+00
2Rj2	4.379E+04	2.516E+04	3.667E+04	1.080E+05	3.524E+04	2.486E+04	3.521E+04
2Rj3	1.950E+01	2.600E+00	5.384E+00	2.187E+01	1.542E+00	2.995E+00	1.009E+01
2Mj1	1.530E+03	9.727E+02	1.468E+03	3.339E+03	7.041E+02	1.018E+03	1.095E+03
2Mj2	6.196E+03	1.326E+03	2.472E+03	7.236E+03	8.341E+02	1.488E+03	3.157E+03
2Mj3	2.404E+07	1.451E+07	2.077E+07	6.179E+07	1.905E+07	1.482E+07	1.895E+07
3Ri1	4.056E+00	1.776E+00	2.650E+00	7.200E+00	1.060E+00	2.260E+00	3.969E+00
3Ri2	3.953E+04	2.322E+04	3.351E+04	9.908E+04	3.149E+04	2.303E+04	3.147E+04
3Ri3	8.053E+00	1.839E+00	3.494E+00	9.577E+00	1.137E+00	2.037E+00	4.188E+00
3Mi1	1.615E+03	1.446E+03	2.190E+03	4.473E+03	1.253E+03	1.304E+03	1.376E+03
3Mi2	6.247E+03	1.280E+03	2.408E+03	7.109E+03	8.402E+02	1.454E+03	3.191E+03
3Mi3	2.404E+07	1.451E+07	2.077E+07	6.179E+07	1.905E+07	1.482E+07	1.895E+07
3Rj1	4.056E+00	1.776E+00	2.650E+00	7.200E+00	1.060E+00	2.260E+00	3.969E+00
3Rj2	3.953E+04	2.322E+04	3.351E+04	9.908E+04	3.149E+04	2.303E+04	3.147E+04
3Rj3	8.047E+00	1.838E+00	3.492E+00	9.571E+00	1.136E+00	2.035E+00	4.185E+00
3Mj1	1.614E+03	1.446E+03	2.190E+03	4.472E+03	1.252E+03	1.303E+03	1.376E+03
3Mj2	7.083E+03	1.134E+03	2.274E+03	8.151E+03	7.151E+02	1.264E+03	3.695E+03
3Mj3	1.681E+07	1.019E+07	1.453E+07	4.337E+07	1.320E+07	1.062E+07	1.310E+07
4Ri1	3.568E+00	1.693E+00	2.577E+00	6.438E+00	1.009E+00	2.109E+00	3.353E+00

4Ri2	3.411E+04	2.047E+04	2.933E+04	8.716E+04	2.699E+04	2.080E+04	2.690E+04
4Ri3	6.771E+00	1.605E+00	2.860E+00	7.569E+00	1.073E+00	1.852E+00	3.507E+00
4Mi1	1.195E+03	8.012E+02	1.016E+03	3.160E+03	8.791E+02	8.236E+02	8.817E+02
4Mi2	7.083E+03	1.134E+03	2.274E+03	8.151E+03	7.151E+02	1.264E+03	3.695E+03
4Mi3	1.681E+07	1.019E+07	1.453E+07	4.337E+07	1.320E+07	1.062E+07	1.310E+07
4Rj1	3.568E+00	1.693E+00	2.577E+00	6.438E+00	1.009E+00	2.109E+00	3.353E+00
4Rj2	3.407E+04	2.044E+04	2.930E+04	8.706E+04	2.696E+04	2.077E+04	2.687E+04
4Rj3	6.774E+00	1.604E+00	2.858E+00	7.571E+00	1.073E+00	1.851E+00	3.507E+00
4Mj1	1.194E+03	8.010E+02	1.016E+03	3.159E+03	8.788E+02	8.233E+02	8.814E+02
4Mj2	5.721E+03	8.319E+02	1.792E+03	6.711E+03	4.911E+02	9.202E+02	3.020E+03
4Mj3	9.726E+06	5.894E+06	8.380E+06	2.510E+07	7.531E+06	6.254E+06	7.452E+06
5Ri1	2.991E+00	1.596E+00	2.469E+00	5.500E+00	9.460E-01	1.927E+00	2.680E+00
5Ri2	2.751E+04	1.668E+04	2.377E+04	7.100E+04	2.150E+04	1.751E+04	2.132E+04
5Ri3	1.322E+01	1.866E+00	4.055E+00	1.517E+01	1.152E+00	2.128E+00	6.950E+00
5Mi1	1.194E+03	8.010E+02	1.016E+03	3.159E+03	8.788E+02	8.233E+02	8.814E+02
5Mi2	5.721E+03	8.319E+02	1.792E+03	6.711E+03	4.911E+02	9.202E+02	3.020E+03
5Mi3	9.726E+06	5.894E+06	8.380E+06	2.510E+07	7.531E+06	6.254E+06	7.452E+06
5Rj1	2.991E+00	1.596E+00	2.469E+00	5.500E+00	9.460E-01	1.927E+00	2.680E+00
5Rj2	2.746E+04	1.664E+04	2.372E+04	7.087E+04	2.145E+04	1.748E+04	2.128E+04
5Rj3	1.322E+01	1.865E+00	4.054E+00	1.517E+01	1.151E+00	2.128E+00	6.950E+00
5Mj1	1.194E+03	8.006E+02	1.015E+03	3.158E+03	8.785E+02	8.229E+02	8.811E+02
5Mj2	2.952E+03	4.400E+02	9.446E+02	3.534E+03	2.491E+02	4.746E+02	1.580E+03
5Mj3	3.971E+06	2.396E+06	3.395E+06	1.020E+07	3.023E+06	2.582E+06	2.980E+06
6Ri1	2.423E+00	1.487E+00	2.327E+00	4.426E+00	8.925E-01	1.718E+00	2.198E+00
6Ri2	1.951E+04	1.180E+04	1.674E+04	5.025E+04	1.497E+04	1.263E+04	1.478E+04
6Ri3	1.345E+01	1.767E+00	4.043E+00	1.589E+01	1.042E+00	2.103E+00	7.088E+00
6Mi1	5.958E+02	4.415E+02	7.590E+02	1.522E+03	4.945E+02	5.768E+02	5.110E+02
6Mi2	2.952E+03	4.400E+02	9.446E+02	3.534E+03	2.491E+02	4.746E+02	1.580E+03
6Mi3	3.971E+06	2.396E+06	3.395E+06	1.020E+07	3.023E+06	2.582E+06	2.980E+06
6Rj1	2.421E+00	1.486E+00	2.326E+00	4.422E+00	8.920E-01	1.716E+00	2.196E+00
6Rj2	1.944E+04	1.176E+04	1.669E+04	5.008E+04	1.492E+04	1.259E+04	1.473E+04
6Rj3	1.345E+01	1.765E+00	4.041E+00	1.588E+01	1.040E+00	2.103E+00	7.087E+00
6Mj1	5.958E+02	4.415E+02	7.590E+02	1.522E+03	4.945E+02	5.768E+02	5.110E+02
6Mj2	1.219E+03	2.021E+02	4.060E+02	1.454E+03	1.100E+02	2.157E+02	6.934E+02
6Mj3	1.369E+06	8.219E+05	1.162E+06	3.499E+06	1.027E+06	8.952E+05	1.009E+06
7Ri1	2.252E+00	1.371E+00	2.164E+00	4.009E+00	8.445E-01	1.495E+00	1.921E+00
7Ri2	1.037E+04	6.229E+03	8.808E+03	2.652E+04	7.792E+03	6.774E+03	7.663E+03
7Ri3	8.921E+00	1.098E+00	2.612E+00	1.061E+01	6.278E-01	1.414E+00	4.735E+00
7Mi1	5.958E+02	4.415E+02	7.590E+02	1.522E+03	4.945E+02	5.768E+02	5.110E+02
7Mi2	1.219E+03	2.021E+02	4.060E+02	1.454E+03	1.100E+02	2.157E+02	6.934E+02
7Mi3	1.369E+06	8.219E+05	1.162E+06	3.499E+06	1.027E+06	8.952E+05	1.009E+06

7Rj1	2.251E+00	1.370E+00	2.162E+00	4.006E+00	8.439E-01	1.494E+00	1.920E+00
7Rj2	1.030E+04	6.184E+03	8.743E+03	2.633E+04	7.732E+03	6.730E+03	7.603E+03
7Rj3	8.917E+00	1.096E+00	2.609E+00	1.060E+01	6.258E-01	1.414E+00	4.733E+00
7Mj1	5.958E+02	4.415E+02	7.590E+02	1.522E+03	4.945E+02	5.768E+02	5.110E+02
7Mj2	2.000E+02	1.007E+02	1.571E+02	3.161E+02	6.234E+01	1.035E+02	1.637E+02
7Mj3	2.097E+02	1.336E+02	2.159E+02	3.494E+02	8.572E+01	9.054E+01	1.335E+02

Table 21 Maximum Element Forces and Moments for S-components of Benchmark Problem #4a (kips-inches)
Response spectrum method

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	0.127	0.033	0.065	0.198	0.061	0.031	0.085
1Ri2	0.692	0.210	0.451	1.232	0.297	0.349	0.565
1Ri3	0.103	0.027	0.053	0.160	0.048	0.028	0.071
1Mi1	15.283	5.262	13.414	36.085	5.400	5.836	15.193
1Mi2	6.229	1.644	3.308	9.950	2.845	1.783	4.420
1Mi3	41.302	12.472	26.867	73.695	17.679	20.662	33.643
1Rj1	0.127	0.033	0.065	0.198	0.061	0.031	0.085
1Rj2	0.692	0.210	0.451	1.232	0.297	0.349	0.565
1Rj3	0.103	0.027	0.053	0.160	0.048	0.028	0.071
1Mj1	15.283	5.262	13.414	36.085	5.400	5.836	15.193
1Mj2	2.099	0.531	1.010	3.099	1.004	0.526	1.391
1Mj3	14.247	4.375	9.412	25.288	6.147	7.283	11.705
2Ri1	0.126	0.033	0.064	0.196	0.061	0.031	0.084
2Ri2	0.187	0.056	0.125	0.351	0.078	0.085	0.154
2Ri3	0.036	0.011	0.024	0.069	0.014	0.013	0.030
2Mi1	15.283	5.262	13.414	36.085	5.400	5.836	15.193
2Mi2	2.099	0.531	1.010	3.099	1.004	0.526	1.391
2Mi3	14.247	4.375	9.412	25.288	6.147	7.283	11.705
2Rj1	0.126	0.033	0.064	0.196	0.061	0.031	0.084
2Rj2	0.187	0.056	0.125	0.351	0.078	0.085	0.154
2Rj3	0.036	0.011	0.024	0.069	0.014	0.013	0.030
2Mj1	15.283	5.262	13.414	36.085	5.400	5.836	15.193
2Mj2	4.549	1.240	2.590	7.670	2.009	1.387	3.390
2Mj3	28.172	8.474	18.313	50.730	12.064	13.790	22.890
3Ri1	0.123	0.032	0.063	0.193	0.059	0.030	0.083
3Ri2	0.410	0.132	0.284	0.742	0.186	0.208	0.340
3Ri3	0.077	0.020	0.039	0.117	0.037	0.018	0.052
3Mi1	15.283	5.262	13.414	36.085	5.400	5.836	15.193
3Mi2	4.549	1.240	2.590	7.670	2.009	1.387	3.390
3Mi3	28.172	8.474	18.313	50.730	12.064	13.790	22.890
3Rj1	0.123	0.032	0.063	0.193	0.059	0.030	0.083
3Rj2	0.410	0.132	0.284	0.742	0.186	0.208	0.340
3Rj3	0.077	0.020	0.039	0.117	0.037	0.018	0.052
3Mj1	15.283	5.262	13.414	36.085	5.400	5.836	15.193
3Mj2	4.627	1.439	3.332	9.240	1.839	1.619	4.089

3Mj3	14.427	5.199	12.819	33.198	5.707	5.880	14.301
4Ri1	0.120	0.032	0.062	0.189	0.058	0.030	0.081
4Ri2	0.763	0.231	0.539	1.500	0.327	0.236	0.642
4Ri3	0.891	0.320	0.798	2.081	0.344	0.352	0.889
4Mi1	15.283	5.262	13.414	36.085	5.400	5.836	15.193
4Mi2	14.427	5.199	12.819	33.198	5.707	5.880	14.301
4Mi3	4.627	1.439	3.332	9.240	1.839	1.619	4.089
4Rj1	0.763	0.231	0.539	1.500	0.327	0.236	0.642
4Rj2	0.120	0.032	0.062	0.189	0.058	0.030	0.081
4Rj3	0.891	0.320	0.798	2.081	0.344	0.352	0.889
4Mj1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
4Mj2	6.911	2.120	4.583	12.078	2.818	3.583	5.799
4Mj3	7.892	2.398	5.662	15.757	3.340	2.460	6.691
5Ri1	0.753	0.229	0.534	1.485	0.321	0.235	0.635
5Ri2	0.797	0.278	0.707	1.889	0.287	0.302	0.795
5Ri3	0.123	0.033	0.064	0.195	0.060	0.030	0.084
5Mi1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
5Mi2	7.892	2.398	5.662	15.757	3.340	2.460	6.691
5Mi3	6.911	2.120	4.583	12.078	2.818	3.583	5.799
5Rj1	0.753	0.229	0.534	1.485	0.321	0.235	0.635
5Rj2	0.797	0.278	0.707	1.889	0.287	0.302	0.795
5Rj3	0.123	0.033	0.064	0.195	0.060	0.030	0.084
5Mj1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
5Mj2	6.577	1.817	3.656	11.017	2.840	2.085	4.974
5Mj3	67.048	23.718	60.014	159.234	24.669	25.456	67.159
6Ri1	0.733	0.224	0.525	1.459	0.310	0.232	0.622
6Ri2	0.631	0.193	0.460	1.280	0.229	0.293	0.562
6Ri3	0.058	0.018	0.044	0.122	0.022	0.019	0.051
6Mi1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
6Mi2	6.577	1.817	3.656	11.017	2.840	2.085	4.974
6Mi3	67.048	23.718	60.014	159.234	24.669	25.456	67.159
6Rj1	0.733	0.224	0.525	1.459	0.310	0.232	0.622
6Rj2	0.631	0.193	0.460	1.280	0.229	0.293	0.562
6Rj3	0.058	0.018	0.044	0.122	0.022	0.019	0.051
6Mj1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
6Mj2	5.039	1.428	2.850	8.573	2.060	2.154	4.077
6Mj3	108.206	35.926	91.250	249.034	37.296	43.040	105.297
7Ri1	0.710	0.218	0.515	1.429	0.297	0.230	0.609
7Ri2	0.849	0.282	0.585	1.504	0.389	0.448	0.697
7Ri3	0.144	0.038	0.074	0.227	0.068	0.033	0.097
7Mi1	2.391	0.754	1.905	5.285	0.852	0.925	2.226

7Mi2	5.039	1.428	2.850	8.573	2.060	2.154	4.077
7Mi3	108.206	35.926	91.250	249.034	37.296	43.040	105.297
7Rj1	0.710	0.218	0.515	1.429	0.297	0.230	0.609
7Rj2	0.849	0.282	0.585	1.504	0.389	0.448	0.697
7Rj3	0.144	0.038	0.074	0.227	0.068	0.033	0.097
7Mj1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
7Mj2	10.311	2.866	6.286	18.399	4.609	3.184	7.818
7Mj3	149.074	46.397	110.437	306.300	54.993	68.685	133.597
8Ri1	0.685	0.212	0.504	1.397	0.282	0.228	0.595
8Ri2	2.484	0.781	1.894	5.250	0.898	1.109	2.269
8Ri3	0.177	0.049	0.098	0.293	0.086	0.053	0.125
8Mi1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
8Mi2	10.311	2.866	6.286	18.399	4.609	3.184	7.818
8Mi3	149.074	46.397	110.437	306.300	54.993	68.685	133.597
8Rj1	0.685	0.212	0.504	1.397	0.282	0.228	0.595
8Rj2	2.484	0.781	1.894	5.250	0.898	1.109	2.269
8Rj3	0.177	0.049	0.098	0.293	0.086	0.053	0.125
8Mj1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
8Mj2	5.904	1.616	2.928	9.037	3.047	1.588	3.844
8Mj3	62.309	20.230	50.666	139.363	21.869	25.641	59.279
9Ri1	0.659	0.205	0.492	1.364	0.266	0.226	0.580
9Ri2	1.448	0.455	1.121	3.109	0.506	0.633	1.339
9Ri3	0.069	0.020	0.047	0.136	0.026	0.028	0.059
9Mi1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
9Mi2	5.904	1.616	2.928	9.037	3.047	1.588	3.844
9Mi3	62.309	20.230	50.666	139.363	21.869	25.641	59.279
9Rj1	0.659	0.205	0.492	1.364	0.266	0.226	0.580
9Rj2	1.448	0.455	1.121	3.109	0.506	0.633	1.339
9Rj3	0.069	0.020	0.047	0.136	0.026	0.028	0.059
9Mj1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
9Mj2	7.765	2.243	4.850	14.122	3.243	3.266	6.416
9Mj3	182.835	58.124	144.228	398.899	63.859	78.422	170.941
10Ri1	0.633	0.198	0.481	1.332	0.249	0.225	0.566
10Ri2	0.174	0.055	0.133	0.368	0.070	0.061	0.156
10Ri3	0.123	0.033	0.060	0.185	0.065	0.026	0.076
10Mi1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
10Mi2	7.765	2.243	4.850	14.122	3.243	3.266	6.416
10Mi3	182.835	58.124	144.228	398.899	63.859	78.422	170.941
10Rj1	0.633	0.198	0.481	1.332	0.249	0.225	0.566
10Rj2	0.174	0.055	0.133	0.368	0.070	0.061	0.156
10Rj3	0.123	0.033	0.060	0.185	0.065	0.026	0.076

10Mj1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
10Mj2	8.694	2.534	5.599	16.229	3.773	3.398	7.046
10Mj3	171.126	54.283	134.225	371.419	60.108	73.976	159.332
11Ri1	0.608	0.192	0.470	1.301	0.232	0.225	0.553
11Ri2	1.662	0.527	1.312	3.630	0.575	0.710	1.556
11Ri3	0.066	0.019	0.039	0.117	0.028	0.027	0.053
11Mi1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
11Mi2	8.694	2.534	5.599	16.229	3.773	3.398	7.046
11Mi3	171.126	54.283	134.225	371.419	60.108	73.976	159.332
11Rj1	0.608	0.192	0.470	1.301	0.232	0.225	0.553
11Rj2	1.662	0.527	1.312	3.630	0.575	0.710	1.556
11Rj3	0.066	0.019	0.039	0.117	0.028	0.027	0.053
11Mj1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
11Mj2	5.458	1.533	3.175	9.385	2.613	1.469	3.927
11Mj3	31.902	10.270	24.379	67.181	12.230	14.490	28.869
12Ri1	0.587	0.186	0.460	1.273	0.217	0.225	0.541
12Ri2	2.559	0.816	1.985	5.487	0.931	1.126	2.356
12Ri3	0.179	0.049	0.096	0.291	0.089	0.053	0.123
12Mi1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
12Mi2	5.458	1.533	3.175	9.385	2.613	1.469	3.927
12Mi3	31.902	10.270	24.379	67.181	12.230	14.490	28.869
12Rj1	0.587	0.186	0.460	1.273	0.217	0.225	0.541
12Rj2	2.559	0.816	1.985	5.487	0.931	1.126	2.356
12Rj3	0.179	0.049	0.096	0.291	0.089	0.053	0.123
12Mj1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
12Mj2	10.768	2.945	5.532	16.992	5.424	3.211	7.238
12Mj3	183.188	58.330	142.520	394.028	66.159	80.164	169.174
13Ri1	0.570	0.181	0.451	1.249	0.203	0.227	0.531
13Ri2	1.182	0.382	0.887	2.443	0.472	0.533	1.052
13Ri3	0.190	0.052	0.093	0.289	0.102	0.043	0.116
13Mi1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
13Mi2	10.768	2.945	5.532	16.992	5.424	3.211	7.238
13Mi3	183.188	58.330	142.520	394.028	66.159	80.164	169.174
13Rj1	0.570	0.181	0.451	1.249	0.203	0.227	0.531
13Rj2	1.182	0.382	0.887	2.443	0.472	0.533	1.052
13Rj3	0.190	0.052	0.093	0.289	0.102	0.043	0.116
13Mj1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
13Mj2	7.517	2.151	4.148	12.385	3.869	2.235	5.169
13Mj3	87.165	27.903	70.176	193.862	29.710	36.353	82.647
14Ri1	0.559	0.177	0.444	1.231	0.193	0.229	0.525
14Ri2	1.202	0.384	0.963	2.663	0.411	0.505	1.137

14Ri3	0.064	0.018	0.035	0.104	0.032	0.020	0.045
14Mi1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
14Mi2	7.517	2.151	4.148	12.385	3.869	2.235	5.169
14Mi3	87.165	27.903	70.176	193.862	29.710	36.353	82.647
14Rj1	0.559	0.177	0.444	1.231	0.193	0.229	0.525
14Rj2	1.202	0.384	0.963	2.663	0.411	0.505	1.137
14Rj3	0.064	0.018	0.035	0.104	0.032	0.020	0.045
14Mj1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
14Mj2	2.904	0.802	1.528	4.677	1.514	0.705	1.894
14Mj3	14.047	4.441	10.899	30.204	5.032	6.167	12.960
15Ri1	0.556	0.175	0.440	1.223	0.188	0.232	0.522
15Ri2	1.193	0.391	0.979	2.697	0.419	0.470	1.138
15Ri3	0.204	0.056	0.104	0.318	0.109	0.049	0.128
15Mi1	2.391	0.754	1.905	5.285	0.852	0.925	2.226
15Mi2	2.904	0.802	1.528	4.677	1.514	0.705	1.894
15Mi3	14.047	4.441	10.899	30.204	5.032	6.167	12.960
15Rj1	1.193	0.391	0.979	2.697	0.419	0.470	1.138
15Rj2	0.556	0.175	0.440	1.223	0.188	0.232	0.522
15Rj3	0.204	0.056	0.104	0.318	0.109	0.049	0.128
15Mj1	1.098	0.296	0.541	1.663	0.563	0.263	0.702
15Mj2	3.607	1.046	2.106	6.178	1.807	1.074	2.577
15Mj3	24.982	8.020	20.237	55.914	8.457	10.236	23.771
16Ri1	1.212	0.414	1.006	2.753	0.466	0.456	1.146
16Ri2	0.570	0.179	0.450	1.252	0.193	0.239	0.535
16Ri3	0.267	0.073	0.135	0.416	0.142	0.063	0.168
16Mi1	1.098	0.296	0.541	1.663	0.563	0.263	0.702
16Mi2	3.607	1.046	2.106	6.178	1.807	1.074	2.577
16Mi3	24.982	8.020	20.237	55.914	8.457	10.236	23.771
16Rj1	1.212	0.414	1.006	2.753	0.466	0.456	1.146
16Rj2	0.570	0.179	0.450	1.252	0.193	0.239	0.535
16Rj3	0.267	0.073	0.135	0.416	0.142	0.063	0.168
16Mj1	1.098	0.296	0.541	1.663	0.563	0.263	0.702
16Mj2	18.935	5.197	9.388	29.046	10.168	4.441	11.720
16Mj3	9.884	2.940	7.113	20.093	3.565	4.351	8.743
17Ri1	1.315	0.489	1.096	2.954	0.617	0.468	1.194
3Ri2	0.092	0.024	0.048	0.143	0.044	0.023	0.063
17Ri3	0.390	0.110	0.202	0.613	0.212	0.091	0.244
17Mi1	1.098	0.296	0.541	1.663	0.563	0.263	0.702
17Mi2	18.935	5.197	9.388	29.046	10.168	4.441	11.720
17Mi3	9.884	2.940	7.113	20.093	3.565	4.351	8.743
17Rj1	1.315	0.489	1.096	2.954	0.617	0.468	1.194

17Rj2	0.092	0.024	0.048	0.143	0.044	0.023	0.063
17Rj3	0.390	0.110	0.202	0.613	0.212	0.091	0.244
17Mj1	1.098	0.296	0.541	1.663	0.563	0.263	0.702
17Mj2	21.647	6.345	12.490	36.799	11.424	5.481	14.628
17Mj3	8.455	2.276	5.069	14.720	3.522	2.985	6.519
18Ri1	1.509	0.604	1.244	3.296	0.830	0.534	1.290
18Ri2	0.091	0.025	0.056	0.161	0.038	0.032	0.071
18Ri3	0.192	0.062	0.110	0.316	0.111	0.050	0.124
18Mi1	1.098	0.296	0.541	1.663	0.563	0.263	0.702
18Mi2	21.647	6.345	12.490	36.799	11.424	5.481	14.628
18Mi3	8.455	2.276	5.069	14.720	3.522	2.985	6.519
18Rj1	1.509	0.604	1.244	3.296	0.830	0.534	1.290
18Rj2	0.091	0.025	0.056	0.161	0.038	0.032	0.071
18Rj3	0.192	0.062	0.110	0.316	0.111	0.050	0.124
18Mj1	1.098	0.296	0.541	1.663	0.563	0.263	0.702
18Mj2	15.819	6.283	13.077	34.784	8.600	5.576	13.645
18Mj3	1.191	0.320	0.676	1.944	0.520	0.439	0.878
19Ri1	1.650	0.681	1.349	3.541	0.966	0.591	1.364
19Ri2	0.260	0.076	0.136	0.407	0.145	0.061	0.162
19Ri3	0.127	0.034	0.075	0.215	0.054	0.047	0.096
19Mi1	1.098	0.296	0.541	1.663	0.563	0.263	0.702
19Mi2	1.191	0.320	0.676	1.944	0.520	0.439	0.878
19Mi3	15.819	6.283	13.077	34.784	8.600	5.576	13.645
19Rj1	0.260	0.076	0.136	0.407	0.145	0.061	0.162
19Rj2	1.650	0.681	1.349	3.541	0.966	0.591	1.364
19Rj3	0.127	0.034	0.075	0.215	0.054	0.047	0.096
19Mj1	1.128	0.310	0.696	2.004	0.465	0.414	0.886
19Mj2	2.093	0.559	1.245	3.622	0.859	0.853	1.630
19Mj3	16.418	6.193	11.570	31.089	9.744	5.377	11.870
20Ri1	0.267	0.078	0.139	0.418	0.149	0.063	0.165
20Ri2	0.389	0.152	0.253	0.659	0.246	0.148	0.251
20Ri3	0.060	0.015	0.032	0.096	0.025	0.021	0.045
20Mi1	1.128	0.310	0.696	2.004	0.465	0.414	0.886
20Mi2	2.093	0.559	1.245	3.622	0.859	0.853	1.630
20Mi3	16.418	6.193	11.570	31.089	9.744	5.377	11.870
20Rj1	0.267	0.078	0.139	0.418	0.149	0.063	0.165
20Rj2	0.389	0.152	0.253	0.659	0.246	0.148	0.251
20Rj3	0.060	0.015	0.032	0.096	0.025	0.021	0.045
20Mj1	1.128	0.310	0.696	2.004	0.465	0.414	0.886
20Mj2	2.103	0.533	1.024	3.116	0.908	0.568	1.463
20Mj3	11.691	4.097	7.717	20.509	6.099	5.075	8.696

21Ri1	0.273	0.080	0.143	0.428	0.153	0.064	0.169
21Ri2	0.133	0.048	0.087	0.238	0.079	0.041	0.091
21Ri3	0.016	0.004	0.009	0.026	0.006	0.006	0.012
21Mi1	1.128	0.310	0.696	2.004	0.465	0.414	0.886
21Mi2	2.103	0.533	1.024	3.116	0.908	0.568	1.463
21Mi3	11.691	4.097	7.717	20.509	6.099	5.075	8.696
21Rj1	0.273	0.080	0.143	0.428	0.153	0.064	0.169
21Rj2	0.133	0.048	0.087	0.238	0.079	0.041	0.091
21Rj3	0.016	0.004	0.009	0.026	0.006	0.006	0.012
21Mj1	1.128	0.310	0.696	2.004	0.465	0.414	0.886
21Mj2	2.774	0.684	1.375	4.211	1.172	0.842	1.990
21Mj3	16.805	6.251	10.533	27.649	10.136	6.691	10.978
22Ri1	0.278	0.081	0.145	0.435	0.155	0.065	0.172
22Ri2	0.244	0.086	0.149	0.399	0.140	0.095	0.162
22Ri3	0.043	0.011	0.020	0.063	0.019	0.011	0.029
22Mi1	1.128	0.310	0.696	2.004	0.465	0.414	0.886
22Mi2	2.774	0.684	1.375	4.211	1.172	0.842	1.990
22Mi3	16.805	6.251	10.533	27.649	10.136	6.691	10.978
22Rj1	0.278	0.081	0.145	0.435	0.155	0.065	0.172
22Rj2	0.244	0.086	0.149	0.399	0.140	0.095	0.162
22Rj3	0.043	0.011	0.020	0.063	0.019	0.011	0.029
22Mj1	1.128	0.310	0.696	2.004	0.465	0.414	0.886
22Mj2	0.440	0.130	0.279	0.766	0.184	0.212	0.354
22Mj3	2.796	1.239	2.136	5.399	1.905	1.151	1.967
23Ri1	0.280	0.082	0.146	0.439	0.157	0.066	0.173
23Ri2	0.482	0.188	0.314	0.809	0.300	0.203	0.317
23Ri3	0.077	0.019	0.040	0.122	0.031	0.027	0.058
23Mi1	1.128	0.310	0.696	2.004	0.465	0.414	0.886
23Mi2	0.440	0.130	0.279	0.766	0.184	0.212	0.354
23Mi3	2.796	1.239	2.136	5.399	1.905	1.151	1.967
23Rj1	0.280	0.082	0.146	0.439	0.157	0.066	0.173
23Rj2	0.482	0.188	0.314	0.809	0.300	0.203	0.317
23Rj3	0.077	0.019	0.040	0.122	0.031	0.027	0.058
23Mj1	1.128	0.310	0.696	2.004	0.465	0.414	0.886
23Mj2	4.368	1.072	2.225	6.757	1.804	1.418	3.216
23Mj3	26.600	10.177	17.159	44.430	16.211	11.138	17.657

Table 22 Maximum Element Forces and Moments for S-components of Benchmark Problem #4a (kips-inches)
Modal superposition time history method

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	0.100	0.016	0.040	0.084	0.014	0.031	0.056
1Ri2	0.726	0.220	0.431	1.160	0.262	0.347	0.535
1Ri3	0.105	0.017	0.037	0.081	0.018	0.025	0.053
1Mi1	11.698	4.370	11.664	30.092	5.116	5.464	16.094
1Mi2	6.571	1.125	2.428	5.201	1.179	1.670	3.686
1Mi3	42.341	13.260	25.677	67.711	15.756	20.726	31.332
1Rj1	0.100	0.016	0.040	0.084	0.014	0.031	0.056
1Rj2	0.726	0.220	0.431	1.160	0.262	0.347	0.535
1Rj3	0.105	0.017	0.037	0.081	0.018	0.025	0.053
1Mj1	11.698	4.370	11.664	30.092	5.116	5.464	16.094
1Mj2	1.854	0.296	0.630	1.400	0.243	0.357	0.794
1Mj3	15.755	4.471	9.753	25.219	5.544	7.078	11.744
2Ri1	0.099	0.016	0.040	0.084	0.014	0.031	0.056
2Ri2	0.175	0.060	0.104	0.255	0.069	0.087	0.144
2Ri3	0.039	0.009	0.021	0.063	0.009	0.013	0.033
2Mi1	11.698	4.370	11.664	30.092	5.116	5.464	16.094
2Mi2	1.854	0.296	0.630	1.400	0.243	0.357	0.794
2Mi3	15.755	4.471	9.753	25.219	5.544	7.078	11.744
2Rj1	0.099	0.016	0.040	0.084	0.014	0.031	0.056
2Rj2	0.175	0.060	0.104	0.255	0.069	0.087	0.144
2Rj3	0.039	0.009	0.021	0.063	0.009	0.013	0.033
2Mj1	11.698	4.370	11.664	30.092	5.116	5.464	16.094
2Mj2	4.986	0.912	2.114	5.053	0.978	1.360	3.251
2Mj3	27.360	9.147	17.156	43.616	10.753	13.931	20.993
3Ri1	0.098	0.015	0.039	0.083	0.014	0.031	0.056
3Ri2	0.487	0.132	0.315	0.763	0.159	0.182	0.354
3Ri3	0.072	0.011	0.030	0.070	0.009	0.013	0.034
3Mi1	11.698	4.370	11.664	30.092	5.116	5.464	16.094
3Mi2	4.986	0.912	2.114	5.053	0.978	1.360	3.251
3Mi3	27.360	9.147	17.156	43.616	10.753	13.931	20.993
3Rj1	0.098	0.015	0.039	0.083	0.014	0.031	0.056
3Rj2	0.487	0.132	0.315	0.763	0.159	0.182	0.354
3Rj3	0.072	0.011	0.030	0.070	0.009	0.013	0.034
3Mj1	11.698	4.370	11.664	30.092	5.116	5.464	16.094
3Mj2	4.492	1.235	3.071	9.697	1.352	1.504	4.594

3Mj3	14.799	5.565	12.450	36.773	5.361	5.981	17.943
4Ri1	0.096	0.015	0.039	0.083	0.014	0.031	0.056
4Ri2	0.680	0.166	0.482	1.287	0.191	0.206	0.608
4Ri3	0.875	0.330	0.733	2.217	0.311	0.360	1.102
4Mi1	11.698	4.370	11.664	30.092	5.116	5.464	16.094
4Mi2	14.799	5.565	12.450	36.773	5.361	5.981	17.943
4Mi3	4.492	1.235	3.071	9.697	1.352	1.504	4.594
4Rj1	0.680	0.166	0.482	1.287	0.191	0.206	0.608
4Rj2	0.096	0.015	0.039	0.083	0.014	0.031	0.056
4Rj3	0.875	0.330	0.733	2.217	0.311	0.360	1.102
4Mj1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
4Mj2	7.238	2.326	5.258	14.148	2.925	3.651	6.089
4Mj3	7.047	1.700	5.094	13.095	1.987	2.186	6.327
5Ri1	0.675	0.165	0.478	1.263	0.189	0.206	0.603
5Ri2	0.612	0.230	0.616	1.651	0.271	0.284	0.877
5Ri3	0.095	0.015	0.040	0.074	0.014	0.031	0.055
5Mi1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
5Mi2	7.047	1.700	5.094	13.095	1.987	2.186	6.327
5Mi3	7.238	2.326	5.258	14.148	2.925	3.651	6.089
5Rj1	0.675	0.165	0.478	1.263	0.189	0.206	0.603
5Rj2	0.612	0.230	0.616	1.651	0.271	0.284	0.877
5Rj3	0.095	0.015	0.040	0.074	0.014	0.031	0.055
5Mj1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
5Mj2	6.487	1.451	2.898	10.208	1.402	2.019	5.107
5Mj3	51.162	21.118	52.406	148.534	23.064	24.272	77.364
6Ri1	0.663	0.162	0.471	1.226	0.186	0.209	0.593
6Ri2	0.522	0.207	0.390	0.946	0.258	0.320	0.534
6Ri3	0.049	0.013	0.037	0.094	0.014	0.023	0.055
6Mi1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
6Mi2	6.487	1.451	2.898	10.208	1.402	2.019	5.107
6Mi3	51.162	21.118	52.406	148.534	23.064	24.272	77.364
6Rj1	0.663	0.162	0.471	1.226	0.186	0.209	0.593
6Rj2	0.522	0.207	0.390	0.946	0.258	0.320	0.534
6Rj3	0.049	0.013	0.037	0.094	0.014	0.023	0.055
6Mj1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
6Mj2	4.397	1.313	2.084	5.449	1.131	1.825	3.903
6Mj3	83.781	29.486	78.331	198.103	34.136	42.213	104.622
7Ri1	0.646	0.160	0.462	1.187	0.183	0.213	0.583
7Ri2	0.958	0.268	0.586	1.691	0.354	0.441	0.708
7Ri3	0.123	0.017	0.051	0.131	0.018	0.038	0.071
7Mi1	1.759	0.624	1.639	3.820	0.737	0.887	2.152

7Mi2	4.397	1.313	2.084	5.449	1.131	1.825	3.903
7Mi3	83.781	29.486	78.331	198.103	34.136	42.213	104.622
7Rj1	0.646	0.160	0.462	1.187	0.183	0.213	0.583
7Rj2	0.958	0.268	0.586	1.691	0.354	0.441	0.708
7Rj3	0.123	0.017	0.051	0.131	0.018	0.038	0.071
7Mj1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
7Mj2	8.664	1.700	4.639	9.018	1.967	3.660	6.959
7Mj3	121.993	48.514	94.335	224.454	60.367	74.989	127.751
8Ri1	0.626	0.157	0.453	1.147	0.179	0.217	0.571
8Ri2	1.958	0.784	1.644	4.013	0.972	1.184	2.185
8Ri3	0.125	0.028	0.063	0.114	0.028	0.055	0.088
8Mi1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
8Mi2	8.664	1.700	4.639	9.018	1.967	3.660	6.959
8Mi3	121.993	48.514	94.335	224.454	60.367	74.989	127.751
8Rj1	0.626	0.157	0.453	1.147	0.179	0.217	0.571
8Rj2	1.958	0.784	1.644	4.013	0.972	1.184	2.185
8Rj3	0.125	0.028	0.063	0.114	0.028	0.055	0.088
8Mj1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
8Mj2	4.951	0.750	1.323	3.136	0.593	1.361	2.064
8Mj3	49.002	17.339	43.779	112.611	21.239	25.442	58.317
9Ri1	0.602	0.155	0.443	1.107	0.175	0.221	0.559
9Ri2	1.150	0.454	0.968	2.356	0.558	0.684	1.282
9Ri3	0.063	0.016	0.037	0.078	0.018	0.029	0.060
9Mi1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
9Mi2	4.951	0.750	1.323	3.136	0.593	1.361	2.064
9Mi3	49.002	17.339	43.779	112.611	21.239	25.442	58.317
9Rj1	0.602	0.155	0.443	1.107	0.175	0.221	0.559
9Rj2	1.150	0.454	0.968	2.356	0.558	0.684	1.282
9Rj3	0.063	0.016	0.037	0.078	0.018	0.029	0.060
9Mj1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
9Mj2	5.818	1.825	3.490	8.348	1.869	2.747	5.170
9Mj3	145.476	55.437	125.117	310.485	68.145	82.069	164.012
10Ri1	0.575	0.153	0.431	1.065	0.176	0.224	0.546
10Ri2	0.129	0.041	0.119	0.277	0.047	0.059	0.151
10Ri3	0.078	0.009	0.025	0.031	0.006	0.022	0.021
10Mi1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
10Mi2	5.818	1.825	3.490	8.348	1.869	2.747	5.170
10Mi3	145.476	55.437	125.117	310.485	68.145	82.069	164.012
10Rj1	0.575	0.153	0.431	1.065	0.176	0.224	0.546
10Rj2	0.129	0.041	0.119	0.277	0.047	0.059	0.151
10Rj3	0.078	0.009	0.025	0.031	0.006	0.022	0.021

10Mj1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
10Mj2	7.519	1.884	4.106	8.907	2.008	3.483	5.988
10Mj3	136.065	52.604	116.010	287.231	64.592	78.486	152.107
11Ri1	0.545	0.152	0.419	1.023	0.180	0.227	0.533
11Ri2	1.324	0.506	1.135	2.814	0.621	0.752	1.490
11Ri3	0.055	0.016	0.029	0.068	0.015	0.024	0.045
11Mi1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
11Mi2	7.519	1.884	4.106	8.907	2.008	3.483	5.988
11Mi3	136.065	52.604	116.010	287.231	64.592	78.486	152.107
11Rj1	0.545	0.152	0.419	1.023	0.180	0.227	0.533
11Rj2	1.324	0.506	1.135	2.814	0.621	0.752	1.490
11Rj3	0.055	0.016	0.029	0.068	0.015	0.024	0.045
11Mj1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
11Mj2	4.440	0.835	2.187	4.349	0.819	1.632	2.909
11Mj3	24.878	10.089	20.685	50.835	12.401	15.408	27.195
12Ri1	0.512	0.152	0.406	0.979	0.184	0.230	0.520
12Ri2	2.027	0.796	1.717	4.304	0.985	1.206	2.264
12Ri3	0.143	0.028	0.059	0.110	0.026	0.054	0.077
12Mi1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
12Mi2	4.440	0.835	2.187	4.349	0.819	1.632	2.909
12Mi3	24.878	10.089	20.685	50.835	12.401	15.408	27.195
12Rj1	0.512	0.152	0.406	0.979	0.184	0.230	0.520
12Rj2	2.027	0.796	1.717	4.304	0.985	1.206	2.264
12Rj3	0.143	0.028	0.059	0.110	0.026	0.054	0.077
12Mj1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
12Mj2	8.854	1.686	2.933	6.411	1.488	3.004	5.065
12Mj3	145.432	56.795	123.523	310.681	70.306	85.896	162.955
13Ri1	0.478	0.155	0.393	0.935	0.189	0.232	0.506
13Ri2	0.955	0.375	0.765	2.003	0.476	0.599	1.033
13Ri3	0.135	0.015	0.033	0.041	0.010	0.032	0.038
13Mi1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
13Mi2	8.854	1.686	2.933	6.411	1.488	3.004	5.065
13Mi3	145.432	56.795	123.523	310.681	70.306	85.896	162.955
13Rj1	0.478	0.155	0.393	0.935	0.189	0.232	0.506
13Rj2	0.955	0.375	0.765	2.003	0.476	0.599	1.033
13Rj3	0.135	0.015	0.033	0.041	0.010	0.032	0.038
13Mj1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
13Mj2	5.689	1.240	2.424	4.556	1.152	2.137	3.125
13Mj3	68.658	25.360	59.729	142.445	30.330	36.135	78.030
14Ri1	0.448	0.160	0.379	0.890	0.193	0.234	0.493
14Ri2	0.949	0.354	0.822	1.967	0.425	0.503	1.074

14Ri3	0.049	0.011	0.022	0.042	0.011	0.019	0.032
14Mi1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
14Mi2	5.689	1.240	2.424	4.556	1.152	2.137	3.125
14Mi3	68.658	25.360	59.729	142.445	30.330	36.135	78.030
14Rj1	0.448	0.160	0.379	0.890	0.193	0.234	0.493
14Rj2	0.949	0.354	0.822	1.967	0.425	0.503	1.074
14Rj3	0.049	0.011	0.022	0.042	0.011	0.019	0.032
14Mj1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
14Mj2	2.125	0.303	0.925	1.555	0.284	0.696	1.130
14Mj3	11.095	4.349	9.339	22.743	5.352	6.461	12.414
15Ri1	0.441	0.163	0.371	0.875	0.196	0.235	0.487
15Ri2	0.920	0.326	0.836	1.879	0.396	0.479	1.086
15Ri3	0.158	0.020	0.048	0.063	0.018	0.043	0.056
15Mi1	1.759	0.624	1.639	3.820	0.737	0.887	2.152
15Mi2	2.125	0.303	0.925	1.555	0.284	0.696	1.130
15Mi3	11.095	4.349	9.339	22.743	5.352	6.461	12.414
15Rj1	0.920	0.326	0.836	1.879	0.396	0.479	1.086
15Rj2	0.441	0.163	0.371	0.875	0.196	0.235	0.487
15Rj3	0.158	0.020	0.048	0.063	0.018	0.043	0.056
15Mj1	1.037	0.177	0.347	0.865	0.204	0.233	0.469
15Mj2	2.947	0.688	1.598	3.108	0.680	0.880	1.818
15Mj3	19.324	7.093	17.072	40.058	8.399	10.171	22.476
16Ri1	0.926	0.329	0.847	2.071	0.417	0.475	1.105
16Ri2	0.447	0.168	0.380	0.891	0.202	0.240	0.497
16Ri3	0.204	0.024	0.064	0.088	0.021	0.055	0.075
16Mi1	1.037	0.177	0.347	0.865	0.204	0.233	0.469
16Mi2	2.947	0.688	1.598	3.108	0.680	0.880	1.818
16Mi3	19.324	7.093	17.072	40.058	8.399	10.171	22.476
16Rj1	0.926	0.329	0.847	2.071	0.417	0.475	1.105
16Rj2	0.447	0.168	0.380	0.891	0.202	0.240	0.497
16Rj3	0.204	0.024	0.064	0.088	0.021	0.055	0.075
16Mj1	1.037	0.177	0.347	0.865	0.204	0.233	0.469
16Mj2	15.216	1.736	3.213	5.222	1.197	3.703	4.705
16Mj3	8.493	3.012	6.007	14.110	3.750	4.390	8.153
17Ri1	0.984	0.408	0.867	2.528	0.481	0.485	1.219
3Ri2	0.072	0.012	0.033	0.069	0.014	0.023	0.041
17Ri3	0.299	0.045	0.103	0.192	0.046	0.068	0.098
17Mi1	1.037	0.177	0.347	0.865	0.204	0.233	0.469
17Mi2	15.216	1.736	3.213	5.222	1.197	3.703	4.705
17Mi3	8.493	3.012	6.007	14.110	3.750	4.390	8.153
17Rj1	0.984	0.408	0.867	2.528	0.481	0.485	1.219

17Rj2	0.072	0.012	0.033	0.069	0.014	0.023	0.041
17Rj3	0.299	0.045	0.103	0.192	0.046	0.068	0.098
17Mj1	1.037	0.177	0.347	0.865	0.204	0.233	0.469
17Mj2	16.707	3.557	8.372	20.312	3.941	5.614	10.600
17Mj3	8.300	1.954	3.879	8.861	2.363	3.037	5.735
18Ri1	1.056	0.533	0.917	3.045	0.660	0.579	1.345
18Ri2	0.089	0.021	0.044	0.096	0.026	0.033	0.062
18Ri3	0.139	0.035	0.059	0.139	0.040	0.042	0.066
18Mi1	1.037	0.177	0.347	0.865	0.204	0.233	0.469
18Mi2	16.707	3.557	8.372	20.312	3.941	5.614	10.600
18Mi3	8.300	1.954	3.879	8.861	2.363	3.037	5.735
18Rj1	1.056	0.533	0.917	3.045	0.660	0.579	1.345
18Rj2	0.089	0.021	0.044	0.096	0.026	0.033	0.062
18Rj3	0.139	0.035	0.059	0.139	0.040	0.042	0.066
18Mj1	1.037	0.177	0.347	0.865	0.204	0.233	0.469
18Mj2	11.154	5.413	9.492	31.314	6.619	5.924	14.021
18Mj3	1.185	0.245	0.558	1.301	0.281	0.373	0.743
19Ri1	1.182	0.607	1.022	3.356	0.781	0.643	1.420
19Ri2	0.199	0.036	0.064	0.125	0.040	0.051	0.064
19Ri3	0.126	0.029	0.057	0.139	0.034	0.043	0.085
19Mi1	1.037	0.177	0.347	0.865	0.204	0.233	0.469
19Mi2	1.185	0.245	0.558	1.301	0.281	0.373	0.743
19Mi3	11.154	5.413	9.492	31.314	6.619	5.924	14.021
19Rj1	0.199	0.036	0.064	0.125	0.040	0.051	0.064
19Rj2	1.182	0.607	1.022	3.356	0.781	0.643	1.420
19Rj3	0.126	0.029	0.057	0.139	0.034	0.043	0.085
19Mj1	1.084	0.271	0.534	1.223	0.324	0.408	0.788
19Mj2	2.058	0.528	1.114	2.634	0.638	0.819	1.485
19Mj3	12.760	5.225	8.341	26.997	6.855	5.392	10.686
20Ri1	0.203	0.036	0.064	0.125	0.040	0.052	0.064
20Ri2	0.379	0.125	0.195	0.527	0.193	0.136	0.194
20Ri3	0.064	0.013	0.031	0.078	0.014	0.018	0.040
20Mi1	1.084	0.271	0.534	1.223	0.324	0.408	0.788
20Mi2	2.058	0.528	1.114	2.634	0.638	0.819	1.485
20Mi3	12.760	5.225	8.341	26.997	6.855	5.392	10.686
20Rj1	0.203	0.036	0.064	0.125	0.040	0.052	0.064
20Rj2	0.379	0.125	0.195	0.527	0.193	0.136	0.194
20Rj3	0.064	0.013	0.031	0.078	0.014	0.018	0.040
20Mj1	1.084	0.271	0.534	1.223	0.324	0.408	0.788
20Mj2	2.058	0.368	0.802	2.744	0.327	0.514	1.222
20Mj3	11.572	3.548	6.111	18.626	5.293	5.755	8.645

21Ri1	0.207	0.036	0.065	0.125	0.040	0.053	0.065
21Ri2	0.099	0.037	0.057	0.181	0.048	0.038	0.070
21Ri3	0.015	0.004	0.008	0.019	0.004	0.006	0.011
21Mi1	1.084	0.271	0.534	1.223	0.324	0.408	0.788
21Mi2	2.058	0.368	0.802	2.744	0.327	0.514	1.222
21Mi3	11.572	3.548	6.111	18.626	5.293	5.755	8.645
21Rj1	0.207	0.036	0.065	0.125	0.040	0.053	0.065
21Rj2	0.099	0.037	0.057	0.181	0.048	0.038	0.070
21Rj3	0.015	0.004	0.008	0.019	0.004	0.006	0.011
21Mj1	1.084	0.271	0.534	1.223	0.324	0.408	0.788
21Mj2	2.885	0.515	1.240	3.630	0.513	0.614	1.605
21Mj3	17.380	5.033	7.428	19.722	7.693	6.939	8.496
22Ri1	0.210	0.036	0.066	0.125	0.040	0.054	0.065
22Ri2	0.254	0.066	0.107	0.293	0.101	0.100	0.134
22Ri3	0.042	0.007	0.016	0.051	0.007	0.009	0.023
22Mi1	1.084	0.271	0.534	1.223	0.324	0.408	0.788
22Mi2	2.885	0.515	1.240	3.630	0.513	0.614	1.605
22Mi3	17.380	5.033	7.428	19.722	7.693	6.939	8.496
22Rj1	0.210	0.036	0.066	0.125	0.040	0.054	0.065
22Rj2	0.254	0.066	0.107	0.293	0.101	0.100	0.134
22Rj3	0.042	0.007	0.016	0.051	0.007	0.009	0.023
22Mj1	1.084	0.271	0.534	1.223	0.324	0.408	0.788
22Mj2	0.417	0.112	0.261	0.633	0.128	0.159	0.324
22Mj3	2.220	1.107	1.831	5.307	1.676	1.035	1.747
23Ri1	0.211	0.037	0.066	0.125	0.040	0.055	0.065
23Ri2	0.494	0.160	0.230	0.607	0.246	0.212	0.258
23Ri3	0.083	0.016	0.039	0.111	0.016	0.019	0.048
23Mi1	1.084	0.271	0.534	1.223	0.324	0.408	0.788
23Mi2	0.417	0.112	0.261	0.633	0.128	0.159	0.324
23Mi3	2.220	1.107	1.831	5.307	1.676	1.035	1.747
23Rj1	0.211	0.037	0.066	0.125	0.040	0.055	0.065
23Rj2	0.494	0.160	0.230	0.607	0.246	0.212	0.258
23Rj3	0.083	0.016	0.039	0.111	0.016	0.019	0.048
23Mj1	1.084	0.271	0.534	1.223	0.324	0.408	0.788
23Mj2	4.623	0.855	2.077	6.116	0.855	1.002	2.663
23Mj3	27.478	8.538	12.597	33.965	13.075	11.825	14.394

Table 23. Maximum Element Forces and Moments for S-components of Benchmark Problem #4b (kips-inches)
Response spectrum method

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	7.529	5.045	7.555	20.051	5.355	4.797	6.344
1Ri2	0.289	0.200	0.309	0.654	0.169	0.162	0.264
1Ri3	1.071	0.847	1.299	2.483	0.665	0.664	0.942
1Mi1	4.550	3.333	6.255	9.821	3.116	4.453	4.281
1Mi2	75.850	64.426	98.694	182.108	49.845	50.471	68.460
1Mi3	19.991	15.170	23.230	46.685	12.328	12.020	18.413
1Rj1	7.529	5.045	7.555	20.051	5.355	4.797	6.344
1Rj2	0.289	0.200	0.309	0.654	0.169	0.162	0.264
1Rj3	1.071	0.847	1.299	2.483	0.665	0.664	0.942
1Mj1	4.550	3.333	6.255	9.821	3.116	4.453	4.281
1Mj2	14.566	4.755	7.652	29.121	5.510	4.493	10.804
1Mj3	3.917	1.155	2.061	7.452	1.694	1.298	3.392
2Ri1	6.021	4.334	6.530	16.044	4.291	3.953	5.173
2Ri2	0.195	0.177	0.268	0.490	0.135	0.136	0.184
2Ri3	0.814	0.761	1.164	2.103	0.580	0.602	0.765
2Mi1	4.550	3.333	6.255	9.821	3.116	4.453	4.281
2Mi2	14.566	4.755	7.652	29.121	5.510	4.493	10.804
2Mi3	3.917	1.155	2.061	7.452	1.694	1.298	3.392
2Rj1	6.021	4.334	6.530	16.044	4.291	3.953	5.173
2Rj2	0.195	0.177	0.268	0.490	0.135	0.136	0.184
2Rj3	0.814	0.761	1.164	2.103	0.580	0.602	0.765
2Mj1	4.550	3.333	6.255	9.821	3.116	4.453	4.281
2Mj2	70.946	63.798	97.626	176.953	48.843	50.185	65.558
2Mj3	17.995	14.932	22.742	43.546	11.733	11.651	16.778
3Ri1	4.678	3.764	5.712	12.440	3.359	3.233	4.157
3Ri2	0.188	0.145	0.221	0.432	0.117	0.114	0.172
3Ri3	0.817	0.627	0.960	1.989	0.508	0.504	0.708
3Mi1	4.550	3.333	6.255	9.821	3.116	4.453	4.281
3Mi2	70.946	63.798	97.626	176.953	48.843	50.185	65.558
3Mi3	17.995	14.932	22.742	43.546	11.733	11.651	16.778
3Rj1	4.678	3.764	5.712	12.440	3.359	3.233	4.157
3Rj2	0.188	0.145	0.221	0.432	0.117	0.114	0.172
3Rj3	0.817	0.627	0.960	1.989	0.508	0.504	0.708
3Mj1	4.550	3.333	6.255	9.821	3.116	4.453	4.281
3Mj2	118.394	112.876	172.402	311.060	86.192	89.193	111.832

3Mj3	26.557	26.094	39.399	68.917	19.454	19.839	25.361
4Ri1	3.952	3.495	5.327	10.453	2.866	2.865	3.626
4Ri2	1.931	1.354	2.094	4.632	1.099	1.146	1.799
4Ri3	0.268	0.158	0.274	0.586	0.150	0.207	0.244
4Mi1	4.550	3.333	6.255	9.821	3.116	4.453	4.281
4Mi2	26.557	26.094	39.399	68.917	19.454	19.839	25.361
4Mi3	118.394	112.876	172.402	311.060	86.192	89.193	111.832
4Rj1	1.931	1.354	2.094	4.632	1.099	1.146	1.799
4Rj2	3.952	3.495	5.327	10.453	2.866	2.865	3.626
4Rj3	0.268	0.158	0.274	0.586	0.150	0.207	0.244
4Mj1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
4Mj2	4.086	3.748	5.752	10.183	2.865	2.943	3.871
4Mj3	34.649	30.157	46.466	84.504	24.020	24.387	31.952
5Ri1	1.791	1.212	1.878	4.237	0.995	1.033	1.659
5Ri2	0.225	0.137	0.245	0.498	0.131	0.190	0.206
5Ri3	3.365	3.234	4.945	8.791	2.472	2.551	3.180
5Mi1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
5Mi2	34.649	30.157	46.466	84.504	24.020	24.387	31.952
5Mi3	4.086	3.748	5.752	10.183	2.865	2.943	3.871
5Rj1	1.791	1.212	1.878	4.237	0.995	1.033	1.659
5Rj2	0.225	0.137	0.245	0.498	0.131	0.190	0.206
5Rj3	3.365	3.234	4.945	8.791	2.472	2.551	3.180
5Mj1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
5Mj2	258.112	244.189	372.966	678.347	188.838	193.934	243.044
5Mj3	20.848	13.592	22.589	47.525	12.111	16.387	19.125
6Ri1	1.580	1.000	1.555	3.642	0.840	0.865	1.447
6Ri2	0.166	0.071	0.134	0.294	0.083	0.106	0.136
6Ri3	2.306	2.107	3.209	5.910	1.722	1.695	2.115
6Mi1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
6Mi2	258.112	244.189	372.966	678.347	188.838	193.934	243.044
6Mi3	20.848	13.592	22.589	47.525	12.111	16.387	19.125
6Rj1	1.580	1.000	1.555	3.642	0.840	0.865	1.447
6Rj2	0.166	0.071	0.134	0.294	0.083	0.106	0.136
6Rj3	2.306	2.107	3.209	5.910	1.722	1.695	2.115
6Mj1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
6Mj2	411.478	407.219	622.634	1066.422	305.397	317.255	391.944
6Mj3	25.994	17.972	31.130	60.523	16.330	24.226	23.813
7Ri1	1.370	0.788	1.234	3.050	0.688	0.698	1.237
7Ri2	0.189	0.061	0.110	0.356	0.075	0.065	0.172
7Ri3	3.002	1.835	2.693	7.779	2.281	1.815	2.442
7Mi1	24.922	24.634	37.819	63.834	18.565	19.284	23.842

7Mi2	411.478	407.219	622.634	1066.422	305.397	317.255	391.944
7Mi3	25.994	17.972	31.130	60.523	16.330	24.226	23.813
7Rj1	1.370	0.788	1.234	3.050	0.688	0.698	1.237
7Rj2	0.189	0.061	0.110	0.356	0.075	0.065	0.172
7Rj3	3.002	1.835	2.693	7.779	2.281	1.815	2.442
7Mj1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
7Mj2	529.871	484.891	737.638	1356.935	398.466	389.219	485.345
7Mj3	29.350	17.202	31.112	61.615	16.990	25.012	25.743
8Ri1	1.165	0.580	0.921	2.472	0.541	0.537	1.032
8Ri2	0.602	0.330	0.584	1.183	0.331	0.457	0.506
8Ri3	8.607	8.079	12.310	22.042	6.454	6.416	7.978
8Mi1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
8Mi2	529.871	484.891	737.638	1356.935	398.466	389.219	485.345
8Mi3	29.350	17.202	31.112	61.615	16.990	25.012	25.743
8Rj1	1.165	0.580	0.921	2.472	0.541	0.537	1.032
8Rj2	0.602	0.330	0.584	1.183	0.331	0.457	0.506
8Rj3	8.607	8.079	12.310	22.042	6.454	6.416	7.978
8Mj1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
8Mj2	203.378	197.303	301.528	521.444	150.036	154.621	192.582
8Mj3	23.064	11.011	18.877	41.499	11.523	13.802	18.770
9Ri1	0.973	0.381	0.630	1.926	0.407	0.390	0.841
9Ri2	0.305	0.195	0.346	0.676	0.186	0.275	0.273
9Ri3	5.299	5.067	7.730	13.615	3.961	3.997	4.947
9Mi1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
9Mi2	203.378	197.303	301.528	521.444	150.036	154.621	192.582
9Mi3	23.064	11.011	18.877	41.499	11.523	13.802	18.770
9Rj1	0.973	0.381	0.630	1.926	0.407	0.390	0.841
9Rj2	0.305	0.195	0.346	0.676	0.186	0.275	0.273
9Rj3	5.299	5.067	7.730	13.615	3.961	3.997	4.947
9Mj1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
9Mj2	643.577	621.834	949.116	1655.047	480.860	488.650	604.487
9Mj3	38.777	26.410	45.983	88.361	24.279	36.223	34.989
10Ri1	0.808	0.223	0.413	1.460	0.309	0.280	0.678
10Ri2	0.326	0.077	0.139	0.435	0.129	0.077	0.240
10Ri3	0.584	0.158	0.278	0.917	0.219	0.172	0.452
10Mi1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
10Mi2	643.577	621.834	949.116	1655.047	480.860	488.650	604.487
10Mi3	38.777	26.410	45.983	88.361	24.279	36.223	34.989
10Rj1	0.808	0.223	0.413	1.460	0.309	0.280	0.678
10Rj2	0.326	0.077	0.139	0.435	0.129	0.077	0.240
10Rj3	0.584	0.158	0.278	0.917	0.219	0.172	0.452

10Mj1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
10Mj2	638.160	615.009	938.641	1639.920	476.319	483.228	597.743
10Mj3	39.152	24.577	42.813	84.755	23.237	33.460	34.252
11Ri1	0.695	0.225	0.414	1.184	0.286	0.263	0.572
11Ri2	0.371	0.238	0.418	0.809	0.226	0.330	0.330
11Ri3	5.392	5.185	7.913	13.850	4.022	4.083	5.055
11Mi1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
11Mi2	638.160	615.009	938.641	1639.920	476.319	483.228	597.743
11Mi3	39.152	24.577	42.813	84.755	23.237	33.460	34.252
11Rj1	0.695	0.225	0.414	1.184	0.286	0.263	0.572
11Rj2	0.371	0.238	0.418	0.809	0.226	0.330	0.330
11Rj3	5.392	5.185	7.913	13.850	4.022	4.083	5.055
11Mj1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
11Mj2	187.806	179.689	274.510	480.409	138.885	140.917	175.425
11Mj3	12.209	5.239	9.009	23.125	5.864	6.583	10.362
12Ri1	0.665	0.385	0.633	1.239	0.355	0.351	0.561
12Ri2	0.662	0.359	0.631	1.281	0.361	0.487	0.552
12Ri3	8.574	8.091	12.332	21.911	6.398	6.391	7.944
12Mi1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
12Mi2	187.806	179.689	274.510	480.409	138.885	140.917	175.425
12Mi3	12.209	5.239	9.009	23.125	5.864	6.583	10.362
12Rj1	0.665	0.385	0.633	1.239	0.355	0.351	0.561
12Rj2	0.662	0.359	0.631	1.281	0.361	0.487	0.552
12Rj3	8.574	8.091	12.332	21.911	6.398	6.391	7.944
12Mj1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
12Mj2	535.600	500.582	762.582	1365.565	399.872	397.289	495.059
12Mj3	46.558	25.507	45.183	89.727	25.695	35.116	39.020
13Ri1	0.732	0.585	0.927	1.595	0.477	0.492	0.652
13Ri2	0.669	0.205	0.389	0.943	0.292	0.259	0.503
13Ri3	2.746	2.149	3.248	6.526	2.036	1.797	2.383
13Mi1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
13Mi2	535.600	500.582	762.582	1365.565	399.872	397.289	495.059
13Mi3	46.558	25.507	45.183	89.727	25.695	35.116	39.020
13Rj1	0.732	0.585	0.927	1.595	0.477	0.492	0.652
13Rj2	0.669	0.205	0.389	0.943	0.292	0.259	0.503
13Rj3	2.746	2.149	3.248	6.526	2.036	1.797	2.383
13Mj1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
13Mj2	335.689	329.082	502.997	864.204	249.790	256.820	317.364
13Mj3	34.787	21.527	33.267	72.092	19.105	20.910	29.033
14Ri1	0.876	0.794	1.243	2.107	0.623	0.651	0.812
14Ri2	0.359	0.178	0.351	0.633	0.202	0.267	0.303

14Ri3	3.330	3.240	4.949	8.575	2.475	2.536	3.137
14Mi1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
14Mi2	335.689	329.082	502.997	864.204	249.790	256.820	317.364
14Mi3	34.787	21.527	33.267	72.092	19.105	20.910	29.033
14Rj1	0.876	0.794	1.243	2.107	0.623	0.651	0.812
14Rj2	0.359	0.178	0.351	0.633	0.202	0.267	0.303
14Rj3	3.330	3.240	4.949	8.575	2.475	2.536	3.137
14Mj1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
14Mj2	59.345	57.654	88.398	149.775	43.636	44.979	56.574
14Mj3	23.794	22.807	35.510	61.075	17.495	18.676	22.770
15Ri1	1.001	0.937	1.459	2.488	0.726	0.763	0.941
15Ri2	0.926	0.271	0.511	1.238	0.399	0.328	0.686
15Ri3	4.247	4.148	6.352	10.781	3.132	3.226	4.027
15Mi1	24.922	24.634	37.819	63.834	18.565	19.284	23.842
15Mi2	59.345	57.654	88.398	149.775	43.636	44.979	56.574
15Mi3	23.794	22.807	35.510	61.075	17.495	18.676	22.770
15Rj1	0.926	0.271	0.511	1.238	0.399	0.328	0.686
15Rj2	1.001	0.937	1.459	2.488	0.726	0.763	0.941
15Rj3	4.247	4.148	6.352	10.781	3.132	3.226	4.027
15Mj1	19.148	17.462	26.681	48.363	13.650	13.884	17.687
15Mj2	51.899	50.059	76.577	130.516	37.887	38.818	48.865
15Mj3	12.925	8.523	14.673	24.756	7.938	8.910	11.172
16Ri1	1.381	0.370	0.682	1.779	0.573	0.400	1.008
16Ri2	1.098	1.030	1.602	2.754	0.797	0.837	1.037
16Ri3	4.822	4.672	7.162	12.123	3.544	3.639	4.579
16Mi1	19.148	17.462	26.681	48.363	13.650	13.884	17.687
16Mi2	51.899	50.059	76.577	130.516	37.887	38.818	48.865
16Mi3	12.925	8.523	14.673	24.756	7.938	8.910	11.172
16Rj1	1.381	0.370	0.682	1.779	0.573	0.400	1.008
16Rj2	1.098	1.030	1.602	2.754	0.797	0.837	1.037
16Rj3	4.822	4.672	7.162	12.123	3.544	3.639	4.579
16Mj1	19.148	17.462	26.681	48.363	13.650	13.884	17.687
16Mj2	340.865	330.309	506.173	857.247	250.355	257.023	323.309
16Mj3	56.160	53.954	82.885	144.544	41.042	42.658	53.283
17Ri1	2.208	0.562	1.015	2.793	0.898	0.550	1.600
3Ri2	0.341	0.235	0.364	0.694	0.204	0.186	0.288
17Ri3	2.392	1.716	2.643	4.786	1.483	1.336	2.019
17Mi1	19.148	17.462	26.681	48.363	13.650	13.884	17.687
17Mi2	340.865	330.309	506.173	857.247	250.355	257.023	323.309
17Mi3	56.160	53.954	82.885	144.544	41.042	42.658	53.283
17Rj1	2.208	0.562	1.015	2.793	0.898	0.550	1.600

17Rj2	0.341	0.235	0.364	0.694	0.204	0.186	0.288
17Rj3	2.392	1.716	2.643	4.786	1.483	1.336	2.019
17Mj1	19.148	17.462	26.681	48.363	13.650	13.884	17.687
17Mj2	195.508	167.231	256.963	455.940	132.744	131.840	176.648
17Mj3	35.655	31.499	48.484	87.052	24.454	25.138	32.974
18Ri1	3.104	0.776	1.389	3.907	1.253	0.727	2.245
18Ri2	0.374	0.331	0.510	0.919	0.257	0.265	0.346
18Ri3	2.363	2.146	3.286	5.765	1.671	1.679	2.182
18Mi1	19.148	17.462	26.681	48.363	13.650	13.884	17.687
18Mi2	195.508	167.231	256.963	455.940	132.744	131.840	176.648
18Mi3	35.655	31.499	48.484	87.052	24.454	25.138	32.974
18Rj1	3.104	0.776	1.389	3.907	1.253	0.727	2.245
18Rj2	0.374	0.331	0.510	0.919	0.257	0.265	0.346
18Rj3	2.363	2.146	3.286	5.765	1.671	1.679	2.182
18Mj1	19.148	17.462	26.681	48.363	13.650	13.884	17.687
18Mj2	31.289	8.821	14.821	42.654	12.784	7.914	23.260
18Mj3	5.945	5.057	7.780	13.930	3.967	4.014	5.401
19Ri1	3.615	0.901	1.607	4.547	1.456	0.833	2.614
19Ri2	2.735	2.262	3.455	6.357	1.902	1.784	2.420
19Ri3	0.437	0.360	0.555	1.026	0.287	0.290	0.396
19Mi1	19.148	17.462	26.681	48.363	13.650	13.884	17.687
19Mi2	5.945	5.057	7.780	13.930	3.967	4.014	5.401
19Mi3	31.289	8.821	14.821	42.654	12.784	7.914	23.260
19Rj1	2.735	2.262	3.455	6.357	1.902	1.784	2.420
19Rj2	3.615	0.901	1.607	4.547	1.456	0.833	2.614
19Rj3	0.437	0.360	0.555	1.026	0.287	0.290	0.396
19Mj1	2.597	1.696	2.615	6.353	1.628	1.552	2.258
19Mj2	25.550	23.616	36.173	63.810	18.159	18.642	23.759
19Mj3	77.816	53.264	82.666	154.105	45.771	42.457	65.073
20Ri1	2.972	2.341	3.561	6.812	2.116	1.858	2.568
20Ri2	1.422	0.419	0.710	1.974	0.594	0.353	1.048
20Ri3	0.254	0.145	0.226	0.511	0.134	0.121	0.207
20Mi1	2.597	1.696	2.615	6.353	1.628	1.552	2.258
20Mi2	25.550	23.616	36.173	63.810	18.159	18.642	23.759
20Mi3	77.816	53.264	82.666	154.105	45.771	42.457	65.073
20Rj1	2.972	2.341	3.561	6.812	2.116	1.858	2.568
20Rj2	1.422	0.419	0.710	1.974	0.594	0.353	1.048
20Rj3	0.254	0.145	0.226	0.511	0.134	0.121	0.207
20Mj1	2.597	1.696	2.615	6.353	1.628	1.552	2.258
20Mj2	17.766	15.880	24.418	43.865	12.205	12.744	16.581
20Mj3	50.031	36.021	56.011	109.112	30.154	29.283	44.229

21Ri1	3.359	2.483	3.751	7.565	2.476	1.990	2.817
21Ri2	0.598	0.342	0.536	1.055	0.317	0.274	0.477
21Ri3	0.172	0.151	0.231	0.419	0.119	0.120	0.156
21Mi1	2.597	1.696	2.615	6.353	1.628	1.552	2.258
21Mi2	17.766	15.880	24.418	43.865	12.205	12.744	16.581
21Mi3	50.031	36.021	56.011	109.112	30.154	29.283	44.229
21Rj1	3.359	2.483	3.751	7.565	2.476	1.990	2.817
21Rj2	0.598	0.342	0.536	1.055	0.317	0.274	0.477
21Rj3	0.172	0.151	0.231	0.419	0.119	0.120	0.156
21Mj1	2.597	1.696	2.615	6.353	1.628	1.552	2.258
21Mj2	12.525	7.603	11.914	26.428	6.653	6.578	10.590
21Mj3	61.551	20.685	34.454	93.473	26.348	17.811	46.835
22Ri1	3.794	2.657	3.985	8.428	2.883	2.148	3.106
22Ri2	0.964	0.419	0.675	1.617	0.449	0.352	0.760
22Ri3	0.229	0.169	0.263	0.513	0.138	0.140	0.203
22Mi1	2.597	1.696	2.615	6.353	1.628	1.552	2.258
22Mi2	12.525	7.603	11.914	26.428	6.653	6.578	10.590
22Mi3	61.551	20.685	34.454	93.473	26.348	17.811	46.835
22Rj1	3.794	2.657	3.985	8.428	2.883	2.148	3.106
22Rj2	0.964	0.419	0.675	1.617	0.449	0.352	0.760
22Rj3	0.229	0.169	0.263	0.513	0.138	0.140	0.203
22Mj1	2.597	1.696	2.615	6.353	1.628	1.552	2.258
22Mj2	3.676	3.120	4.757	9.165	2.631	2.562	3.303
22Mj3	9.893	6.548	10.182	19.133	5.680	5.236	8.212
23Ri1	4.257	2.855	4.253	9.361	3.315	2.327	3.422
23Ri2	1.615	0.523	0.876	2.416	0.684	0.451	1.222
23Ri3	0.338	0.197	0.307	0.731	0.178	0.175	0.283
23Mi1	2.597	1.696	2.615	6.353	1.628	1.552	2.258
23Mi2	3.676	3.120	4.757	9.165	2.631	2.562	3.303
23Mi3	9.893	6.548	10.182	19.133	5.680	5.236	8.212
23Rj1	4.257	2.855	4.253	9.361	3.315	2.327	3.422
23Rj2	1.615	0.523	0.876	2.416	0.684	0.451	1.222
23Rj3	0.338	0.197	0.307	0.731	0.178	0.175	0.283
23Mj1	2.597	1.696	2.615	6.353	1.628	1.552	2.258
23Mj2	20.895	14.002	21.774	46.458	11.768	11.938	18.038
23Mj3	92.721	35.491	58.001	147.276	41.256	30.115	71.632

Table 24. Maximum Element Forces and Moments for S-components of Benchmark Problem #4b (kips-inches)
Modal superposition time history method

Elements	Case a	Case b	Case c	Case d	Case e	Case f	Case g
1Ri1	6.771	5.056	8.750	17.077	5.655	6.679	5.682
1Ri2	0.344	0.186	0.293	0.486	0.118	0.150	0.230
1Ri3	1.256	0.833	1.260	2.097	0.490	0.633	0.852
1Mi1	4.687	3.435	5.146	8.860	2.491	4.022	3.818
1Mi2	88.784	63.947	95.274	154.003	37.412	49.677	58.406
1Mi3	24.035	14.148	22.405	35.391	9.016	10.720	16.011
1Rj1	6.771	5.056	8.750	17.077	5.655	6.679	5.682
1Rj2	0.344	0.186	0.293	0.486	0.118	0.150	0.230
1Rj3	1.256	0.833	1.260	2.097	0.490	0.633	0.852
1Mj1	4.687	3.435	5.146	8.860	2.491	4.022	3.818
1Mj2	14.538	4.095	7.428	28.315	2.799	4.342	10.197
1Mj3	3.517	0.894	1.824	5.545	0.580	1.251	2.977
2Ri1	5.837	4.231	7.271	12.647	4.322	5.550	4.459
2Ri2	0.225	0.164	0.265	0.378	0.107	0.109	0.150
2Ri3	0.874	0.766	1.100	1.681	0.445	0.671	0.627
2Mi1	4.687	3.435	5.146	8.860	2.491	4.022	3.818
2Mi2	14.538	4.095	7.428	28.315	2.799	4.342	10.197
2Mi3	3.517	0.894	1.824	5.545	0.580	1.251	2.977
2Rj1	5.837	4.231	7.271	12.647	4.322	5.550	4.459
2Rj2	0.225	0.164	0.265	0.378	0.107	0.109	0.150
2Rj3	0.874	0.766	1.100	1.681	0.445	0.671	0.627
2Mj1	4.687	3.435	5.146	8.860	2.491	4.022	3.818
2Mj2	81.383	63.937	93.323	146.637	37.173	53.100	54.361
2Mj3	21.535	13.927	22.220	33.500	8.948	9.928	14.352
3Ri1	4.908	3.622	5.791	8.317	2.985	4.426	3.329
3Ri2	0.206	0.130	0.215	0.387	0.089	0.110	0.146
3Ri3	0.901	0.609	0.917	1.574	0.358	0.591	0.572
3Mi1	4.687	3.435	5.146	8.860	2.491	4.022	3.818
3Mi2	81.383	63.937	93.323	146.637	37.173	53.100	54.361
3Mi3	21.535	13.927	22.220	33.500	8.948	9.928	14.352
3Rj1	4.908	3.622	5.791	8.317	2.985	4.426	3.329
3Rj2	0.206	0.130	0.215	0.387	0.089	0.110	0.146
3Rj3	0.901	0.609	0.917	1.574	0.358	0.591	0.572
3Mj1	4.687	3.435	5.146	8.860	2.491	4.022	3.818
3Mj2	126.808	112.618	162.810	243.253	65.747	98.496	90.498

3Mj3	27.838	23.927	39.201	52.858	15.963	16.758	17.394
4Ri1	4.292	3.414	5.102	7.292	2.314	3.666	2.908
4Ri2	2.215	1.457	2.269	3.497	0.888	1.217	1.780
4Ri3	0.276	0.149	0.242	0.386	0.096	0.148	0.246
4Mi1	4.687	3.435	5.146	8.860	2.491	4.022	3.818
4Mi2	27.838	23.927	39.201	52.858	15.963	16.758	17.394
4Mi3	126.808	112.618	162.810	243.253	65.747	98.496	90.498
4Rj1	2.215	1.457	2.269	3.497	0.888	1.217	1.780
4Rj2	4.292	3.414	5.102	7.292	2.314	3.666	2.908
4Rj3	0.276	0.149	0.242	0.386	0.096	0.148	0.246
4Mj1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
4Mj2	4.748	3.591	5.665	8.689	2.288	2.589	2.912
4Mj3	37.584	31.160	45.986	69.457	18.017	20.532	26.886
5Ri1	2.055	1.304	2.052	3.205	0.799	1.091	1.638
5Ri2	0.208	0.125	0.204	0.305	0.086	0.143	0.188
5Ri3	3.569	3.197	4.676	6.976	1.865	2.792	2.410
5Mi1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
5Mi2	37.584	31.160	45.986	69.457	18.017	20.532	26.886
5Mi3	4.748	3.591	5.665	8.689	2.288	2.589	2.912
5Rj1	2.055	1.304	2.052	3.205	0.799	1.091	1.638
5Rj2	0.208	0.125	0.204	0.305	0.086	0.143	0.188
5Rj3	3.569	3.197	4.676	6.976	1.865	2.792	2.410
5Mj1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
5Mj2	278.575	243.451	353.629	530.437	140.256	223.160	188.561
5Mj3	18.549	12.958	21.118	30.961	8.162	11.351	17.248
6Ri1	1.835	1.072	1.724	2.756	0.666	0.900	1.470
6Ri2	0.178	0.063	0.113	0.218	0.048	0.083	0.118
6Ri3	2.241	2.064	3.153	4.738	1.362	1.364	1.602
6Mi1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
6Mi2	278.575	243.451	353.629	530.437	140.256	223.160	188.561
6Mi3	18.549	12.958	21.118	30.961	8.162	11.351	17.248
6Rj1	1.835	1.072	1.724	2.756	0.666	0.900	1.470
6Rj2	0.178	0.063	0.113	0.218	0.048	0.083	0.118
6Rj3	2.241	2.064	3.153	4.738	1.362	1.364	1.602
6Mj1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
6Mj2	419.588	393.525	601.257	842.812	241.839	292.930	305.538
6Mj3	18.205	15.834	26.390	29.874	10.904	16.325	15.410
7Ri1	1.608	0.838	1.392	2.361	0.533	0.707	1.293
7Ri2	0.204	0.060	0.134	0.391	0.045	0.067	0.183
7Ri3	2.961	1.859	2.200	7.289	2.163	1.822	2.018
7Mi1	26.478	23.518	36.539	49.083	15.047	17.428	17.398

7Mi2	419.588	393.525	601.257	842.812	241.839	292.930	305.538
7Mi3	18.205	15.834	26.390	29.874	10.904	16.325	15.410
7Rj1	1.608	0.838	1.392	2.361	0.533	0.707	1.293
7Rj2	0.204	0.060	0.134	0.391	0.045	0.067	0.183
7Rj3	2.961	1.859	2.200	7.289	2.163	1.822	2.018
7Mj1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
7Mj2	515.177	472.011	727.054	1080.315	314.362	308.801	365.173
7Mj3	27.347	14.685	25.196	33.741	10.355	17.747	20.408
8Ri1	1.449	0.604	1.058	2.023	0.415	0.512	1.108
8Ri2	0.567	0.282	0.457	0.721	0.199	0.333	0.372
8Ri3	8.555	7.796	12.169	17.914	5.131	4.997	5.900
8Mi1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
8Mi2	515.177	472.011	727.054	1080.315	314.362	308.801	365.173
8Mi3	27.347	14.685	25.196	33.741	10.355	17.747	20.408
8Rj1	1.449	0.604	1.058	2.023	0.415	0.512	1.108
8Rj2	0.567	0.282	0.457	0.721	0.199	0.333	0.372
8Rj3	8.555	7.796	12.169	17.914	5.131	4.997	5.900
8Mj1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
8Mj2	205.298	190.046	297.856	429.431	119.248	134.838	161.116
8Mj3	23.965	9.686	17.530	27.998	6.422	10.451	15.282
9Ri1	1.275	0.403	0.722	1.696	0.299	0.372	0.917
9Ri2	0.240	0.164	0.281	0.357	0.117	0.182	0.190
9Ri3	5.354	4.917	7.598	10.834	3.140	3.090	3.738
9Mi1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
9Mi2	205.298	190.046	297.856	429.431	119.248	134.838	161.116
9Mi3	23.965	9.686	17.530	27.998	6.422	10.451	15.282
9Rj1	1.275	0.403	0.722	1.696	0.299	0.372	0.917
9Rj2	0.240	0.164	0.281	0.357	0.117	0.182	0.190
9Rj3	5.354	4.917	7.598	10.834	3.140	3.090	3.738
9Mj1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
9Mj2	653.280	597.454	935.040	1338.334	380.866	390.552	452.155
9Mj3	28.554	22.493	36.333	40.750	16.238	24.809	21.205
10Ri1	1.085	0.235	0.422	1.436	0.186	0.246	0.721
10Ri2	0.345	0.044	0.095	0.392	0.029	0.065	0.198
10Ri3	0.637	0.150	0.327	0.978	0.126	0.197	0.425
10Mi1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
10Mi2	653.280	597.454	935.040	1338.334	380.866	390.552	452.155
10Mi3	28.554	22.493	36.333	40.750	16.238	24.809	21.205
10Rj1	1.085	0.235	0.422	1.436	0.186	0.246	0.721
10Rj2	0.345	0.044	0.095	0.392	0.029	0.065	0.198
10Rj3	0.637	0.150	0.327	0.978	0.126	0.197	0.425

10Mj1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
10Mj2	647.594	594.945	920.776	1300.446	375.235	379.127	453.054
10Mj3	35.128	20.644	35.627	48.337	14.668	22.234	22.317
11Ri1	0.882	0.233	0.431	1.218	0.162	0.239	0.608
11Ri2	0.318	0.203	0.330	0.437	0.147	0.218	0.220
11Ri3	5.417	4.990	7.850	11.165	3.209	3.269	3.774
11Mi1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
11Mi2	647.594	594.945	920.776	1300.446	375.235	379.127	453.054
11Mi3	35.128	20.644	35.627	48.337	14.668	22.234	22.317
11Rj1	0.882	0.233	0.431	1.218	0.162	0.239	0.608
11Rj2	0.318	0.203	0.330	0.437	0.147	0.218	0.220
11Rj3	5.417	4.990	7.850	11.165	3.209	3.269	3.774
11Mj1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
11Mj2	194.371	175.959	266.081	367.904	107.168	109.921	136.013
11Mj3	13.884	4.956	8.671	16.620	3.287	4.488	9.941
12Ri1	0.848	0.401	0.605	1.193	0.237	0.377	0.514
12Ri2	0.663	0.299	0.532	0.892	0.212	0.330	0.387
12Ri3	8.509	7.870	12.242	17.415	5.051	5.034	6.085
12Mi1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
12Mi2	194.371	175.959	266.081	367.904	107.168	109.921	136.013
12Mi3	13.884	4.956	8.671	16.620	3.287	4.488	9.941
12Rj1	0.848	0.401	0.605	1.193	0.237	0.377	0.514
12Rj2	0.663	0.299	0.532	0.892	0.212	0.330	0.387
12Rj3	8.509	7.870	12.242	17.415	5.051	5.034	6.085
12Mj1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
12Mj2	523.705	485.099	766.860	1100.259	318.640	318.370	375.090
12Mj3	45.966	21.388	36.707	62.116	15.468	23.711	26.963
13Ri1	0.949	0.577	0.841	1.429	0.349	0.536	0.590
13Ri2	0.720	0.170	0.325	0.888	0.117	0.227	0.378
13Ri3	2.536	2.052	3.440	5.038	1.680	1.506	1.824
13Mi1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
13Mi2	523.705	485.099	766.860	1100.259	318.640	318.370	375.090
13Mi3	45.966	21.388	36.707	62.116	15.468	23.711	26.963
13Rj1	0.949	0.577	0.841	1.429	0.349	0.536	0.590
13Rj2	0.720	0.170	0.325	0.888	0.117	0.227	0.378
13Rj3	2.536	2.052	3.440	5.038	1.680	1.506	1.824
13Mj1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
13Mj2	350.085	314.826	486.325	698.948	195.144	204.479	235.531
13Mj3	36.897	18.705	33.479	44.900	13.007	15.207	21.704
14Ri1	1.046	0.801	1.135	1.933	0.461	0.697	0.697
14Ri2	0.378	0.162	0.284	0.564	0.137	0.231	0.261

14Ri3	3.430	3.107	4.824	7.062	1.944	2.012	2.341
14Mi1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
14Mi2	350.085	314.826	486.325	698.948	195.144	204.479	235.531
14Mi3	36.897	18.705	33.479	44.900	13.007	15.207	21.704
14Rj1	1.046	0.801	1.135	1.933	0.461	0.697	0.697
14Rj2	0.378	0.162	0.284	0.564	0.137	0.231	0.261
14Rj3	3.430	3.107	4.824	7.062	1.944	2.012	2.341
14Mj1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
14Mj2	63.099	53.973	87.236	113.317	36.232	42.388	38.911
14Mj3	26.905	23.611	32.994	49.092	13.372	20.390	20.227
15Ri1	1.116	0.956	1.337	2.266	0.543	0.808	0.785
15Ri2	0.891	0.206	0.400	1.118	0.165	0.290	0.492
15Ri3	4.469	3.912	6.111	8.355	2.518	2.824	2.909
15Mi1	26.478	23.518	36.539	49.083	15.047	17.428	17.398
15Mi2	63.099	53.973	87.236	113.317	36.232	42.388	38.911
15Mi3	26.905	23.611	32.994	49.092	13.372	20.390	20.227
15Rj1	0.891	0.206	0.400	1.118	0.165	0.290	0.492
15Rj2	1.116	0.956	1.337	2.266	0.543	0.808	0.785
15Rj3	4.469	3.912	6.111	8.355	2.518	2.824	2.909
15Mj1	19.735	16.494	26.819	44.699	11.087	11.543	13.524
15Mj2	53.971	46.891	73.835	103.956	30.287	33.427	35.992
15Mj3	15.471	9.273	12.114	27.025	5.808	10.019	11.121
16Ri1	1.270	0.280	0.509	1.623	0.190	0.352	0.731
16Ri2	1.199	1.058	1.476	2.494	0.601	0.898	0.905
16Ri3	5.113	4.352	7.036	9.117	2.950	3.366	3.151
16Mi1	19.735	16.494	26.819	44.699	11.087	11.543	13.524
16Mi2	53.971	46.891	73.835	103.956	30.287	33.427	35.992
16Mi3	15.471	9.273	12.114	27.025	5.808	10.019	11.121
16Rj1	1.270	0.280	0.509	1.623	0.190	0.352	0.731
16Rj2	1.199	1.058	1.476	2.494	0.601	0.898	0.905
16Rj3	5.113	4.352	7.036	9.117	2.950	3.366	3.151
16Mj1	19.735	16.494	26.819	44.699	11.087	11.543	13.524
16Mj2	360.685	307.494	495.557	643.328	207.284	235.411	225.036
16Mj3	59.917	54.252	77.910	122.633	31.801	44.313	43.491
17Ri1	2.008	0.413	0.769	2.611	0.237	0.464	1.165
3Ri2	0.408	0.226	0.340	0.600	0.132	0.191	0.240
17Ri3	2.617	1.595	2.603	4.181	1.126	1.283	1.570
17Mi1	19.735	16.494	26.819	44.699	11.087	11.543	13.524
17Mi2	360.685	307.494	495.557	643.328	207.284	235.411	225.036
17Mi3	59.917	54.252	77.910	122.633	31.801	44.313	43.491
17Rj1	2.008	0.413	0.769	2.611	0.237	0.464	1.165

17Rj2	0.408	0.226	0.340	0.600	0.132	0.191	0.240
17Rj3	2.617	1.595	2.603	4.181	1.126	1.283	1.570
17Mj1	19.735	16.494	26.819	44.699	11.087	11.543	13.524
17Mj2	216.119	166.513	253.569	434.371	99.217	115.466	141.556
17Mj3	43.832	31.759	46.285	69.791	18.584	26.240	31.165
18Ri1	2.809	0.559	1.053	3.686	0.302	0.588	1.633
18Ri2	0.453	0.335	0.483	0.740	0.195	0.281	0.327
18Ri3	2.561	2.109	3.207	5.155	1.272	1.461	1.715
18Mi1	19.735	16.494	26.819	44.699	11.087	11.543	13.524
18Mi2	216.119	166.513	253.569	434.371	99.217	115.466	141.556
18Mi3	43.832	31.759	46.285	69.791	18.584	26.240	31.165
18Rj1	2.809	0.559	1.053	3.686	0.302	0.588	1.633
18Rj2	0.453	0.335	0.483	0.740	0.195	0.281	0.327
18Rj3	2.561	2.109	3.207	5.155	1.272	1.461	1.715
18Mj1	19.735	16.494	26.819	44.699	11.087	11.543	13.524
18Mj2	31.336	8.438	11.718	37.633	4.800	7.322	18.129
18Mj3	7.595	4.953	7.704	12.744	3.056	3.847	5.020
19Ri1	3.266	0.644	1.219	4.307	0.341	0.660	1.901
19Ri2	2.835	2.283	3.433	5.849	1.441	1.546	1.936
19Ri3	0.553	0.363	0.531	0.822	0.211	0.310	0.377
19Mi1	19.735	16.494	26.819	44.699	11.087	11.543	13.524
19Mi2	7.595	4.953	7.704	12.744	3.056	3.847	5.020
19Mi3	31.336	8.438	11.718	37.633	4.800	7.322	18.129
19Rj1	2.835	2.283	3.433	5.849	1.441	1.546	1.936
19Rj2	3.266	0.644	1.219	4.307	0.341	0.660	1.901
19Rj3	0.553	0.363	0.531	0.822	0.211	0.310	0.377
19Mj1	2.977	1.635	2.874	5.473	1.446	2.140	2.292
19Mj2	29.107	22.519	36.184	59.038	14.390	16.206	20.305
19Mj3	88.054	53.464	82.503	158.498	31.279	36.728	51.099
20Ri1	2.901	2.396	3.546	6.063	1.696	1.728	2.063
20Ri2	1.448	0.327	0.559	1.832	0.180	0.310	0.829
20Ri3	0.310	0.133	0.212	0.499	0.089	0.141	0.178
20Mi1	2.977	1.635	2.874	5.473	1.446	2.140	2.292
20Mi2	29.107	22.519	36.184	59.038	14.390	16.206	20.305
20Mi3	88.054	53.464	82.503	158.498	31.279	36.728	51.099
20Rj1	2.901	2.396	3.546	6.063	1.696	1.728	2.063
20Rj2	1.448	0.327	0.559	1.832	0.180	0.310	0.829
20Rj3	0.310	0.133	0.212	0.499	0.089	0.141	0.178
20Mj1	2.977	1.635	2.874	5.473	1.446	2.140	2.292
20Mj2	23.022	15.730	24.399	34.300	9.798	13.002	13.270
20Mj3	69.986	35.693	53.759	91.765	21.029	26.902	45.096

21Ri1	3.377	2.671	3.804	6.365	2.051	1.984	2.329
21Ri2	0.654	0.340	0.535	1.104	0.196	0.238	0.359
21Ri3	0.199	0.140	0.229	0.396	0.094	0.099	0.130
21Mi1	2.977	1.635	2.874	5.473	1.446	2.140	2.292
21Mi2	23.022	15.730	24.399	34.300	9.798	13.002	13.270
21Mi3	69.986	35.693	53.759	91.765	21.029	26.902	45.096
21Rj1	3.377	2.671	3.804	6.365	2.051	1.984	2.329
21Rj2	0.654	0.340	0.535	1.104	0.196	0.238	0.359
21Rj3	0.199	0.140	0.229	0.396	0.094	0.099	0.130
21Mj1	2.977	1.635	2.874	5.473	1.446	2.140	2.292
21Mj2	18.040	7.559	10.735	22.348	4.466	7.812	11.921
21Mj3	69.863	17.339	28.993	83.592	9.793	17.146	40.311
22Ri1	4.019	2.947	4.068	7.507	2.418	2.245	2.599
22Ri2	1.197	0.387	0.620	1.459	0.221	0.333	0.716
22Ri3	0.332	0.168	0.256	0.431	0.103	0.149	0.208
22Mi1	2.977	1.635	2.874	5.473	1.446	2.140	2.292
22Mi2	18.040	7.559	10.735	22.348	4.466	7.812	11.921
22Mi3	69.863	17.339	28.993	83.592	9.793	17.146	40.311
22Rj1	4.019	2.947	4.068	7.507	2.418	2.245	2.599
22Rj2	1.197	0.387	0.620	1.459	0.221	0.333	0.716
22Rj3	0.332	0.168	0.256	0.431	0.103	0.149	0.208
22Mj1	2.977	1.635	2.874	5.473	1.446	2.140	2.292
22Mj2	3.597	2.835	4.634	7.758	2.014	2.250	2.537
22Mj3	11.317	6.581	10.264	20.170	3.843	4.550	6.413
23Ri1	4.647	3.221	4.340	8.680	2.793	2.505	2.864
23Ri2	1.800	0.428	0.723	2.158	0.245	0.432	1.031
23Ri3	0.464	0.193	0.272	0.628	0.115	0.232	0.314
23Mi1	2.977	1.635	2.874	5.473	1.446	2.140	2.292
23Mi2	3.597	2.835	4.634	7.758	2.014	2.250	2.537
23Mi3	11.317	6.581	10.264	20.170	3.843	4.550	6.413
23Rj1	4.647	3.221	4.340	8.680	2.793	2.505	2.864
23Rj2	1.800	0.428	0.723	2.158	0.245	0.432	1.031
23Rj3	0.464	0.193	0.272	0.628	0.115	0.232	0.314
23Mj1	2.977	1.635	2.874	5.473	1.446	2.140	2.292
23Mj2	29.693	14.077	19.898	38.991	8.337	14.532	19.444
23Mj3	109.767	31.505	51.551	132.549	17.707	28.733	64.276

ATTACHMENT 4

Benchmark Program for Evaluation of Methods to Analyze Non-Classically Damped Structures

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BENCHMARK PROGRAM FOR EVALUATION OF METHODS TO ANALYZE NON-CLASSICALLY DAMPED STRUCTURES

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CONTENTS

1. INTRODUCTION

The purpose of this report is to present the analytical method, the computer programs and set of solutions for the four benchmark problems developed by BNL in the scope of the "Benchmark Program for the Evaluation of Methods to Analyze Non-Classically Damped Coupled Systems". Report contains the detailed description of implemented Analytical Method, solution for each of the benchmark problem with comments and detailed output results. Appendix D contains tabulated Final Results Summary with all specified Load Cases (this Appendix is provided on the attached floppy disc).

2. METHOD OF ANALYSIS AND APPLIED SOFTWARE PROGRAMS

The equation of motion for coupled "primary-secondary" system may be expressed in the global system coordinates as:

$$\begin{bmatrix} Ks & Ksp \\ Kps & Kp+K^S p \end{bmatrix} * \begin{Bmatrix} u_S \\ u_P \end{Bmatrix} + \begin{bmatrix} Cs & Csp \\ Cps & Cp+C^S p \end{bmatrix} * \begin{Bmatrix} \dot{u}_S \\ \dot{u}_P \end{Bmatrix} + \begin{bmatrix} Ms & 0 \\ 0 & Mp \end{bmatrix} * \begin{Bmatrix} \ddot{u}_S \\ \ddot{u}_P \end{Bmatrix} = -\begin{bmatrix} Ms & 0 \\ 0 & Mp \end{bmatrix} * \begin{Bmatrix} Ugs \\ Ugp \end{Bmatrix} * a_g(t) \quad (1)$$

where:

Ks, Cs, Ms	- stiffness, damping and mass matrix for fixed in constrained points secondary system ;
Kp, Cp, Mp	- stiffness, damping and mass matrix for primary system;
Ksp, Kps, Cps, Csp	- components of stiffness and damping matrix for coupled system;
$K^S p, C^S p$	- components of stiffness and damping matrix for the constraining of the secondary system to the primary system;
$a_g(t)$	- earthquake ground acceleration;
$u_S, \dot{u}_S, \ddot{u}_S$	- displacements, velocities and accelerations of secondary system;
$u_P, \dot{u}_P, \ddot{u}_P$	- displacements, velocities and accelerations of primary system;
Ugs, Ugp	- influence vectors that coupled the ground motion to the corresponding degrees of freedom ;

The motion of the secondary system relatively to the primary may be expressed with aid of the following transformation:

$$u_S = \bar{u}_S + Usp * u_P \quad (2)$$

where:

$\bar{u}_S$	- "relative" displacements of the secondary system ;
Usp	- transformation matrix between "constraint" and "inner" points of secondary system;

It has to be noted, that Usp may be expressed in the following form:

$$Usp = -K^{-1}s * Ksp \quad (3)$$

Based on equations (2) and (3) it is possible to transform the initial system coordinates to the new "relative" coordinates with the following transformation:

$$\begin{Bmatrix} u_S \\ u_P \end{Bmatrix} = \begin{bmatrix} I & Usp \\ 0 & I \end{bmatrix} * \begin{Bmatrix} \bar{u}_S \\ u_P \end{Bmatrix} = T * \begin{Bmatrix} \bar{u}_S \\ u_P \end{Bmatrix} \quad (4)$$

where: I - Unit Matrix, T - transformation matrix defined by (4).

The assumption of negligible character of dissipation forces for "rigid body" and "constraint" modes may be expressed as the following equations:

$$\begin{bmatrix} Cs & Csp \\ Cps & C^S p \end{bmatrix} * \begin{Bmatrix} Usp * \dot{u}_C \\ \dot{u}_C \end{Bmatrix} = \begin{Bmatrix} 0 \\ 0 \end{Bmatrix} \quad (5)$$

and expanding (5):

$$Csp = -Cs * Usp, \quad C^S p = U^T sp * Cs * Usp \quad (5a)$$

Substituting (4) and (5a) into Equation (1) and multiplying both it parts by matrix T^T, after corresponding transformations with accounting of (3), the equation of motion may be readily rewritten in the following form:

$$\begin{bmatrix} Ks & 0 \\ 0 & Kp + \left[K^S p - Kps * K^{-1} s * Ksp\right] \end{bmatrix} * \begin{Bmatrix} \bar{u}_S \\ u_P \end{Bmatrix} + \begin{bmatrix} Cs & 0 \\ 0 & Cp \end{bmatrix} * \begin{Bmatrix} \dot{\bar{u}}_S \\ \dot{u}_P \end{Bmatrix} +$$

$$+ \begin{bmatrix} Ms & Ms * Usp \\ U^T sp * Ms & Mp + U^T sp * Ms * Usp \end{bmatrix} * \begin{Bmatrix} \ddot{\bar{u}}_S \\ \ddot{u}_P \end{Bmatrix} = -\begin{Bmatrix} Ms * Usg \\ U^T sp * Ms * Usg + Mp * Upg \end{Bmatrix} * A_g(t) \quad (6)$$

Given the following modal transformation:

$$\begin{Bmatrix} \bar{u}_S \\ u_P \end{Bmatrix} = \begin{bmatrix} \varphi_S & 0 \\ 0 & \varphi_P \end{bmatrix} * \begin{Bmatrix} Xs \\ Xp \end{Bmatrix} \quad (7)$$

Equation (6) may be presented in modal terms:

$$\begin{bmatrix} \Omega_S^2 & 0 \\ 0 & \Omega_P^2 + \varphi_P^T \tilde{K}_P^S \varphi_P \end{bmatrix} * \begin{Bmatrix} Xs \\ Xp \end{Bmatrix} + \begin{bmatrix} 2\xi_S \Omega_S & 0 \\ 0 & 2\xi_P \Omega_P \end{bmatrix} * \begin{Bmatrix} \dot{X}s \\ \dot{X}p \end{Bmatrix} + \begin{bmatrix} I & \varphi_S^T Ms U_{SP} \varphi_P \\ \varphi_P^T U_{SP}^T Ms \varphi_S & I + \varphi_P^T \tilde{M}s \varphi_P \end{bmatrix} * \begin{Bmatrix} \ddot{X}s \\ \ddot{X}p \end{Bmatrix} =$$

$$= -\begin{Bmatrix} \varphi_S^T Ms Usg \\ \varphi_P^T U_{SP}^T Ms * Usg + \varphi_P^T Mp Upg \end{Bmatrix} * A_g(t) \quad (8)$$

where:

$$\tilde{K}_P^S = K^S p - Kps * K^{-1} s * Ksp; \quad \tilde{M}s = U^T sp * Ms * Usp \quad (9)$$

As it was shown, Equation (8) is the modal transformation of initial Equation (1). Stiffness and Mass matrixes in this equation are partially populated, but advantage of this equation is the diagonal damping matrix, which reflects the modal dissipation for isolated primary and secondary systems.

From the other hand, it is possible to rewrite (1) in alternate form:

$$K*U+C*\dot{U}+M*\ddot{U}=F(t) \qquad (10),$$

where: $U,\dot{U},\ddot{U}$ - corresponding kinematic parameters of coupled system, K,M,C - matrixes of stiffness, mass and damping, $F(t)$ - right-hand vector of external forces. After modal decomposition of (10) we have:

$$\left[\Omega^2\right]*Y+\left[\Psi^T*C*\Psi\right]*\dot{Y}+\ddot{Y}=\Psi^T*F(t) \qquad (11)$$

where: Ω,Ψ - eigenfrequencies and eigenvectores of coupled undamped system, Y - corresponding modal coordinates, which can be expressed in form:

$$U=\Psi*Y \qquad (12)$$

At the same time, vector U may be expressed in terms of modal coordinates corresponding to Equation (8):

$$U=T\bmod*X=\begin{bmatrix}\varphi_S & Usp*\varphi_P\\ 0 & \varphi_P\end{bmatrix}*X \qquad (13)$$

From (12) and (13) follows:

$$X=T^{-1}\bmod*\Psi*Y \qquad (14)$$

After substituting X into Equation (8) and performing needed transformation the modal damping matrix corresponded to (11) may be obtained as:

$$C\bmod=\Psi^T*C*\Psi=\Psi^T*T^{-T}\begin{bmatrix}2\xi_S\Omega_S & 0\\ 0 & 2\xi_P\Omega_P\end{bmatrix}*T^{-1}*\Psi \qquad (15)$$

and in the final form:

$$\begin{gathered}C\bmod=\begin{bmatrix}A & C\\ B & D\end{bmatrix}\\ A=Ms*\varphi_S*\left[2\xi_S\Omega_S\right]*\varphi_S{}^T*Ms\\ B=-Ip*Usp^T*A\\ C=B^T=-Ms*\varphi_S*\left[2\xi_S\Omega_S\right]*\varphi_S{}^T*Ms*Usp*Ip\\ D=Mp*\varphi_P*\left[2\xi_P\Omega_P\right]*\varphi_P{}^T*Mp+Ip*Usp^T*A*Usp*Ip\end{gathered} \qquad (16)$$

Thus, the initial task leads to solution of modal Equation (11) with the diagonal Mass and Stiffness Matrix and fully populated Damping Matrix. Evidently, there are several ways to resolve this Equation. Among them are:

- numerical time-history integration. When number of accounted modes is equal to the number of DOF, this method provides the "exact" solution.
- complex eigenvalued analysis and implementation on the basis of this solution one of Response Spectrum Methods.

The equation (11) leads to the following complex 2Nx2N-eigenvalued problem:

$$\begin{bmatrix} 0 & I \\ -\Omega^2 & -\widetilde{C} \end{bmatrix} * \begin{Bmatrix} \Psi c_i \\ \lambda * \Psi c_i \end{Bmatrix} = \lambda * \begin{Bmatrix} \Psi c_i \\ \lambda * \Psi c_i \end{Bmatrix} \qquad (17)$$

from where:

$\omega_i = |\lambda_i|$ - natural frequencies of considered system; $\xi_i = -\mathrm{Re}(\lambda_i)/|\lambda_i|$ - damping ratios.

According to [1] the response of considered system may be obtained in the following form:

$$u(t) = \sum \left\{ u_i^d * x_i(t) + u_i^v * \dot{x}_i(t) \right\} \qquad (18)$$

where:

$$\begin{aligned} u_i^d &= \Phi * \Psi c_i^d \qquad \Psi c_i^d = -2\mathrm{Re}(\overline{\lambda}_i * f_i * \Psi c_i) \\ u_i^v &= \Phi * \Psi c_i^v \qquad \Psi c_i^v = -2\mathrm{Re}(f_i * \Psi c_i) \\ f_i &= \frac{\lambda_i * \Psi^T c_i * F}{\Psi^T c_i * (\lambda_i^2 * I - \Omega^2) * \Psi c_i} \end{aligned} \qquad (19)$$

the functions $x(t), \dot{x}(t)$ may be readily founded from the 1 DOF equation:

$$\ddot{x}_i + 2\xi_i \omega_i \dot{x}_i + \omega_i^2 x_i = -\ddot{u}_g(t) \qquad (20)$$

So, any response of considered system then may be obtained from:

$$\begin{aligned} R(t) &= \sum \left\{ R_i^d * x_i(t) + R_i^v * \dot{x}_i(t) \right\} \\ R_i^d &= q^T * u_i^d; \qquad R_i^v = q^T * u_i^v \end{aligned} \qquad (21)$$

For Response Spectrum Method the expressions (21) may be reformulated to double sum combination:

$$R^2 = \sum_i \sum_j \left\{ \begin{aligned} & R_i^d R_j^d \varepsilon_{ij}^d S_d(\omega_i \xi_i) S_d(\omega_j \xi_j) + R_i^v R_j^v \varepsilon_{ij}^v S_v(\omega_i \xi_i) S_v(\omega_j \xi_j) + \\ & + \ 2 R_i^d R_j^v \mu_{ij}^d S_d(\omega_i \xi_i) S_v(\omega_j \xi_j) \end{aligned} \right\} \qquad (22)$$

where:

$$\begin{aligned} S_d(\omega_i \xi_i) &= \max|x_i(t)| \\ S_v(\omega_i \xi_i) &= \max|\dot{x}_i(t)| \end{aligned} \qquad (23)$$

$\varepsilon_{ij}^d, \varepsilon_{ij}^v, \mu_{ij}$ - correletion coefficients

The values of $\varepsilon_{ij}^d, \varepsilon_{ij}^v, \mu_{ij}, S_d(\omega_i \xi_i), S_v(\omega_i \xi_i)$ may be obtained directly from the Time History Acceleration according to the following formulas:

$$\varepsilon_{ij}^{d} = \frac{\int x_i(t)x_j(t)dt}{\sqrt{\int x_i^2(t)dt * \int x_j^2(t)dt}}$$

$$\varepsilon_{ij}^{v} = \frac{\int \dot{x}_i(t)\dot{x}_j(t)dt}{\sqrt{\int \dot{x}_i^2(t)dt * \int \dot{x}_j^2(t)dt}} \qquad (24)$$

$$\mu_{ij} = \frac{\int x_i(t)\dot{x}_j(t)dt}{\sqrt{\int x_i^2(t)dt * \int \dot{x}_j^2(t)dt}}$$

This approach in the current evaluation has been realized for the considered benchmark problems (in the further consideration - RSM-I). Since the values of all cross-correlation coefficients are calculated here practically from the "exact" solution, such procedure may show the realistic limits of Response Spectrum Method versus Time History Analysis. But for engineering purposes for calculation of these cross-correlation coefficients the following expressions may be used [2]:

$$\varepsilon_{ij}^{d} = \varepsilon_{ij}^{v} = \frac{8\sqrt{\xi_i\xi_j}(\xi_i + r\xi_j)r^{\frac{3}{2}}}{(1-r^2)^2 + 4\xi_i\xi_j r(1+r^2)^2 + 4(\xi_i^2 + \xi_j^2)r^2}$$

$$\mu_{ij} = 0 \qquad (25)$$

$$S_v(\omega_i, \xi_i) = \omega_i * S_d(\omega_i, \xi_i)$$

where:

$$r = \frac{\omega_j}{\omega_i} \qquad (26)$$

Namely for the last expressions the alternate simplified CQC Response Spectrum Method (RSM-II) has been developed on the basis of technique described in [2]. The accounting of high frequency modes has been performed according to [1].

The figure 1 shows the principal flow chart for described above methodology.

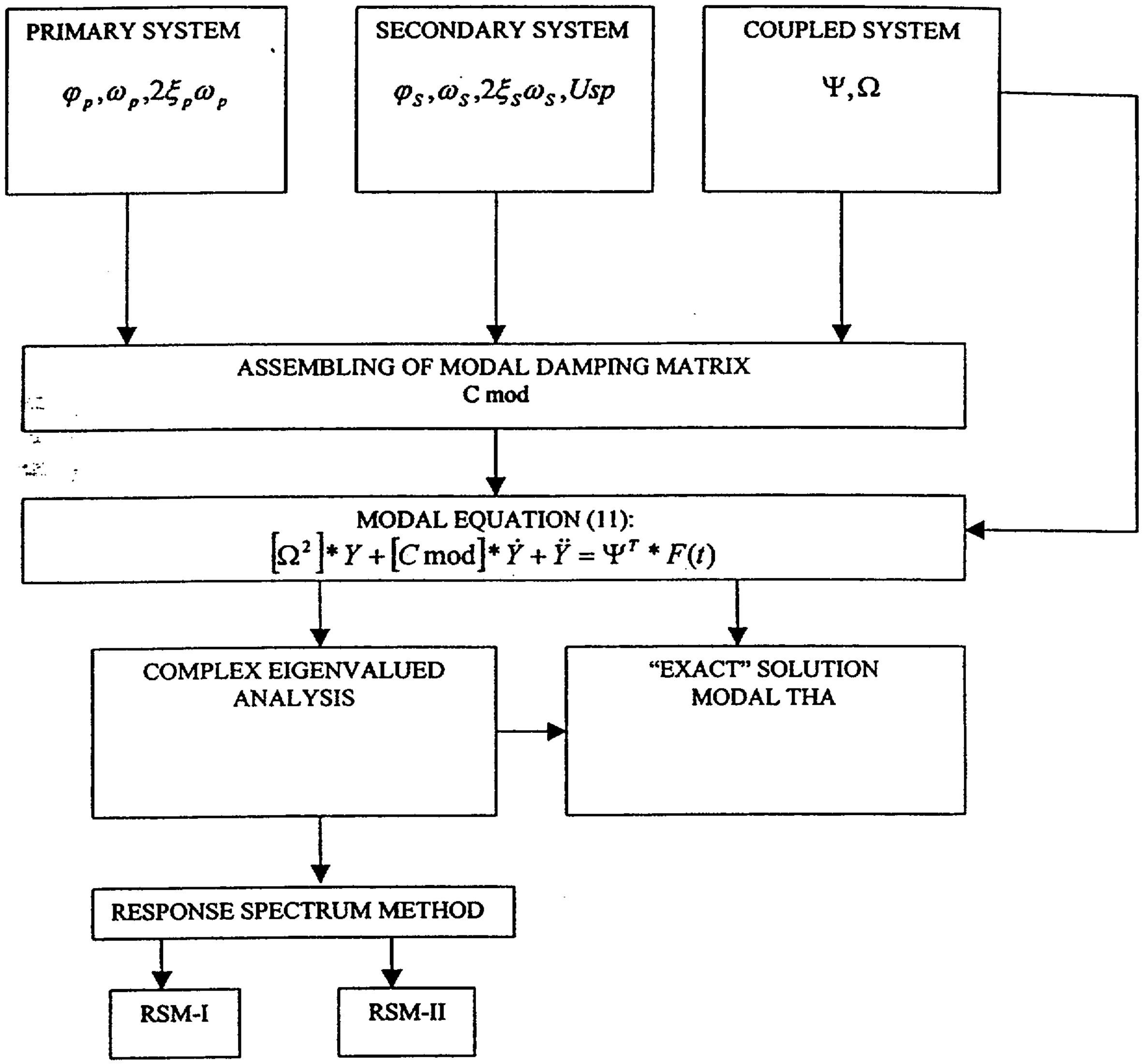

Figure 1. Principal Diagram for Proposed Analytical Method

The described above analytical procedure has been implemented in modified for these purposes computer program dPIPE ([3], [4]). Brief description of this program is given in the Appendix A. Also a series of postprocessor codes has been created for different variants of proposed methods.

3. RESULTS OF ANALYSES

This chapter provides the results of analyses for each of benchmark problems. Every set of solutions presents results for Time History Analysis and also for two described above variants of Response Spectrum Method (RSM-I and RSM-II). Additional information (e.g. eigenfrequencies for primary, secondary and coupled undamped systems, modal damping end frequencies for complex modes, etc.) is given in corresponding tables. All Time History Analyses have been performed with integration step DEL=0.004 sec. For RSM-II the value of Cut-of-Frequency was defined as 30 Hz.

It should be noted that for Benchmark Problem #4a and #4b some differences for values of frequencies of secondary systems in comparison with BNL data (Tables 7 and 9 of BNL Report) have been found. To verify the results of dPIPE natural frequency evaluation the additional comparative analysis of these systems has been performed using alternate well-known piping code CAEPIPE (Appendix B). The results of these evaluations clearly show the complete identification of dPIPE and CAEPIPE results.

The following system of units is used for the tables of results:

UNITS: LENGTH = INCHES, WEIGHTS = KIPS, MASSES = KIPS*SECOND2/INCH,
TIME = SECONDS.

3.1 Benchmark Problem N 1

Table 3.1.1 Frequencies (Hz) for undamped system, Benchmark Problem #1.

Mode	Load Case							
	a	b	c	d	e	f	g	h
	PRIMARY							
1	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
2	14.59	14.59	14.59	14.59	14.59	14.59	14.59	14.59
3	23.01	23.01	23.01	23.01	23.01	23.01	23.01	23.01
4	29.56	29.56	29.56	29.56	29.56	29.56	29.56	29.56
5	33.71	33.71	33.71	33.71	33.71	33.71	33.71	33.71
	SECONDARY							
1	5.00	2.50	4.50	5.51	10.01	5.00	5.00	5.00
2	14.40	7.21	12.97	15.85	28.82	14.40	14.40	14.40
3	22.06	11.04	19.87	24.29	44.16	22.06	22.06	22.06
4	27.06	13.54	24.37	29.79	54.17	27.06	27.06	27.06
	COUPLED							
1	4.82	2.50	4.46	4.93	4.98	4.97	4.23	3.43
2	5.19	5.00	5.05	5.58	10.04	5.03	5.85	6.90
3	14.39	7.21	12.97	14.59	14.60	14.40	14.28	14.09
4	14.61	11.04	14.60	15.86	23.01	14.60	14.76	15.08
5	22.05	13.54	19.86	23.01	28.69	22.06	21.95	21.69
6	23.01	14.60	23.01	24.29	29.71	23.01	23.14	23.48
7	27.06	23.01	24.37	29.54	33.73	27.06	27.03	26.95
8	29.57	29.56	29.56	29.82	44.18	29.56	29.75	30.44
9	33.71	33.71	33.71	33.72	54.18	33.71	33.80	34.24

Table 3.1.2 Frequencies (Hz) and Damping Ratios (%) from complex eigenvalued analysis for Benchmark Problem #1.

Mode	Load Case							
	a		b		c		d	
	Freq.	Damp.	Freq.	Damp.	Freq.	Damp.	Freq.	Damp.
1	4.87	4.41	2.50	2.00	4.46	2.33	4.94	6.47
2	5.13	4.59	5.00	6.99	5.05	6.66	5.57	2.53
3	14.40	2.02	7.21	2.01	12.97	2.01	14.59	6.99
4	14.60	6.98	11.04	2.00	14.60	7.00	15.86	2.01
5	22.05	2.01	13.54	2.00	19.86	2.00	23.01	6.99
6	23.01	6.99	14.60	7.00	23.01	7.00	24.29	2.01
7	27.06	2.00	23.01	7.00	24.37	2.00	29.57	6.99
8	29.57	7.00	29.56	7.00	29.56	7.00	29.79	2.01
9	33.71	7.00	33.71	7.00	33.71	7.00	33.72	7.00

Table 3.1.2 (Cont'd)

Mode	Load Case							
	e		f		g		h	
	Freq.	Damp.	Freq.	Damp.	Freq.	Damp.	Freq.	Damp.
1	4.98	6.96	5.00	6.95	4.24	4.16	3.43	3.68
2	10.04	2.04	5.00	2.05	5.84	4.76	6.90	4.92
3	14.60	7.00	14.40	2.00	14.40	2.52	14.22	4.20
4	23.01	6.99	14.59	7.00	14.63	6.53	14.94	5.04
5	28.79	2.24	22.06	2.00	22.00	2.23	21.76	2.71
6	29.60	6.78	23.01	7.00	23.10	6.80	23.41	6.43
7	33.73	6.99	27.06	2.00	27.04	2.06	26.97	2.21
8	44.18	2.01	29.56	7.00	29.74	6.96	30.42	6.91
9	54.18	2.00	33.71	7.00	33.80	7.01	34.23	7.07

Table 3.1.2 (Cont'd)

Mode	Load Case			
	i		j	
	Freq.	Damp.	Freq.	Damp.
1	4.83	5.81	4.97	8.07
2	5.18	6.19	5.02	18.97
3	14.39	5.04	14.40	19.99
4	14.60	6.96	14.59	7.01
5	22.05	5.01	22.06	19.99
6	23.01	7.00	23.01	7.02
7	27.06	5.00	27.06	20.00
8	29.57	7.01	29.56	7.04
9	33.71	7.00	33.71	7.02

<u>Results from Time History Analysis:</u>

Table 3.1.3 Maximum nodal displacements for benchmark problem #1.

Load Cases	Nodes								
	2	3	4	5	6	7	8	9	10
a	0.08	0.15	0.21	0.26	0.28	0.96	1.70	2.25	2.54
b	0.08	0.16	0.22	0.26	0.29	0.86	1.38	1.96	2.29
c	0.08	0.16	0.22	0.26	0.29	0.70	1.37	1.88	2.15
d	0.08	0.15	0.21	0.26	0.28	0.71	1.12	1.42	1.58
e	0.08	0.16	0.22	0.27	0.29	0.31	0.33	0.35	0.36
f	0.08	0.16	0.22	0.26	0.29	1.11	1.98	2.63	2.97
g	0.10	0.19	0.26	0.32	0.34	0.65	0.93	1.12	1.23
h	0.13	0.26	0.37	0.46	0.47	0.66	0.84	0.96	1.03
I	0.08	0.15	0.21	0.26	0.28	0.67	1.16	1.52	1.72
j	0.08	0.16	0.22	0.26	0.29	0.45	0.62	0.75	0.82
k	0.05	0.09	0.13	0.15	0.16	0.59	1.00	1.31	1.47

Table 3.1.3 (Cont'd)

Load Cases	Nodes								
	2	3	4	5	6	7	8	9	10
l	0.08	0.15	0.21	0.25	0.27	1.05	1.74	2.24	2.51
m	0.24	0.45	0.62	0.74	0.80	1.49	2.51	3.26	3.65
n	0.07	0.13	0.17	0.21	0.22	0.70	1.17	1.52	1.70
o	0.07	0.12	0.17	0.21	0.23	0.89	1.65	2.22	2.52
p	0.06	0.12	0.16	0.19	0.21	0.85	1.50	1.99	2.25

Table 3.1.4 Maximum element forces for benchmark problem #1.

Load Cases	Elements								
	1	2	3	4	5	6	7	8	9
a	2.53E+03	2.26E+03	1.89E+03	1.40E+03	7.50E+02	9.03E+01	7.87E+01	5.81E+01	3.08E+01
b	2.57E+03	2.32E+03	1.93E+03	1.43E+03	7.84E+02	1.93E+01	1.85E+01	1.52E+01	8.85E+00
c	2.61E+03	2.33E+03	1.94E+03	1.44E+03	7.77E+02	6.56E+01	5.82E+01	4.34E+01	2.32E+01
d	2.51E+03	2.29E+03	1.91E+03	1.42E+03	7.45E+02	6.25E+01	5.32E+01	3.87E+01	2.03E+01
e	2.62E+03	2.38E+03	1.98E+03	1.47E+03	7.89E+02	2.12E+01	1.71E+01	1.19E+01	6.12E+00
f	2.59E+03	2.34E+03	1.95E+03	1.44E+03	7.85E+02	2.13E+00	1.86E+00	1.38E+00	7.32E-01
g	3.13E+03	2.84E+03	2.40E+03	1.87E+03	8.07E+02	7.01E+02	5.83E+02	4.18E+02	2.20E+02
h	4.19E+03	3.88E+03	3.44E+03	3.05E+03	7.28E+02	2.27E+03	1.88E+03	1.34E+03	7.00E+02
I	2.54E+03	2.28E+03	1.90E+03	1.42E+03	7.57E+02	6.01E+01	5.24E+01	3.86E+01	2.05E+01
j	2.57E+03	2.33E+03	1.94E+03	1.44E+03	7.73E+02	2.47E+01	2.08E+01	1.53E+01	8.10E+00
k	1.53E+03	1.36E+03	1.10E+03	7.83E+02	3.87E+02	5.06E+01	4.39E+01	3.23E+01	1.71E+01
l	2.54E+03	2.24E+03	1.81E+03	1.29E+03	6.19E+02	8.65E+01	7.54E+01	5.56E+01	2.95E+01
m	7.49E+03	6.62E+03	5.37E+03	3.80E+03	1.96E+03	1.25E+02	1.08E+02	7.95E+01	4.26E+01
n	2.16E+03	1.86E+03	1.48E+03	1.03E+03	5.13E+02	5.79E+01	5.01E+01	3.68E+01	1.95E+01
o	2.06E+03	1.86E+03	1.56E+03	1.13E+03	5.78E+02	9.21E+01	8.12E+01	6.04E+01	3.22E+01
p	1.99E+03	1.73E+03	1.40E+03	9.97E+02	4.87E+02	7.96E+01	6.96E+01	5.14E+01	2.72E+01

Results from Response Spectrum Method (I):

Table 3.1.5 Maximum nodal displacements for benchmark problem #1.

Load Cases	Nodes								
	2	3	4	5	6	7	8	9	10
a	0.08	0.15	0.20	0.24	0.26	0.97	1.72	2.28	2.58
b	0.09	0.16	0.22	0.26	0.28	0.81	1.44	1.93	2.20
c	0.08	0.15	0.21	0.25	0.27	0.72	1.33	1.80	2.04
d	0.09	0.16	0.22	0.26	0.29	0.69	1.12	1.44	1.61
e	0.09	0.16	0.22	0.27	0.29	0.30	0.34	0.36	0.37
f	0.09	0.16	0.22	0.26	0.29	1.09	1.95	2.58	2.92
g	0.11	0.20	0.28	0.34	0.36	0.65	0.93	1.14	1.25
h	0.14	0.26	0.38	0.48	0.50	0.67	0.82	0.93	0.99
I	0.08	0.15	0.21	0.25	0.27	0.73	1.24	1.62	1.82
j	0.08	0.16	0.22	0.26	0.28	0.41	0.56	0.68	0.74

Table 3.1.5 (Cont'd)

Load Cases	Nodes								
	2	3	4	5	6	7	8	9	10
k	0.05	0.10	0.14	0.16	0.18	0.64	1.11	1.47	1.66
l	0.08	0.15	0.20	0.24	0.26	1.20	2.09	2.74	3.09
m	0.21	0.40	0.55	0.66	0.72	2.25	4.04	5.39	6.11
n	0.07	0.13	0.18	0.21	0.23	0.68	1.16	1.52	1.72
o	0.06	0.12	0.17	0.20	0.22	1.00	1.82	2.44	2.76
p	0.07	0.13	0.19	0.22	0.24	0.78	1.39	1.85	2.10

Table 3.1.6 Maximum element forces for benchmark problem #1.

Load Cases	Elements								
	1	2	3	4	5	6	7	8	9
a	2.47E+03	2.15E+03	1.74E+03	1.23E+03	6.22E+02	9.27E+01	8.12E+01	6.02E+01	3.20E+01
b	2.69E+03	2.36E+03	1.91E+03	1.34E+03	6.94E+02	2.01E+01	1.79E+01	1.38E+01	7.66E+00
c	2.57E+03	2.25E+03	1.81E+03	1.27E+03	6.61E+02	6.13E+01	5.43E+01	4.05E+01	2.16E+01
d	2.70E+03	2.37E+03	1.92E+03	1.36E+03	6.87E+02	6.58E+01	5.70E+01	4.20E+01	2.22E+01
e	2.73E+03	2.40E+03	1.94E+03	1.37E+03	7.01E+02	1.79E+01	1.42E+01	9.91E+00	5.10E+00
f	2.70E+03	2.37E+03	1.91E+03	1.35E+03	6.96E+02	2.10E+00	1.84E+00	1.36E+00	7.24E-01
g	3.31E+03	2.98E+03	2.53E+03	1.96E+03	7.35E+02	7.50E+02	6.39E+02	4.65E+02	2.45E+02
h	4.30E+03	4.04E+03	3.67E+03	3.19E+03	6.47E+02	2.05E+03	1.66E+03	1.17E+03	6.08E+02
I	2.58E+03	2.26E+03	1.82E+03	1.29E+03	6.52E+02	6.38E+01	5.57E+01	4.12E+01	2.19E+01
j	2.67E+03	2.34E+03	1.89E+03	1.34E+03	6.83E+02	2.22E+01	1.87E+01	1.36E+01	7.12E+00
k	1.64E+03	1.45E+03	1.18E+03	8.38E+02	4.20E+02	5.87E+01	5.13E+01	3.79E+01	2.01E+01
l	2.42E+03	2.15E+03	1.77E+03	1.27E+03	6.21E+02	1.09E+02	9.45E+01	6.97E+01	3.69E+01
m	6.61E+03	5.96E+03	4.90E+03	3.50E+03	1.82E+03	2.22E+02	1.95E+02	1.45E+02	7.71E+01
n	2.22E+03	1.91E+03	1.52E+03	1.06E+03	5.32E+02	6.04E+01	5.27E+01	3.89E+01	2.07E+01
o	1.98E+03	1.80E+03	1.49E+03	1.07E+03	5.49E+02	1.00E+02	8.80E+01	6.53E+01	3.47E+01
p	2.25E+03	1.99E+03	1.62E+03	1.15E+03	5.90E+02	7.60E+01	6.68E+01	4.96E+01	2.64E+01

Results from Response Spectrum Method (II):

Table 3.1.7 Maximum nodal displacements for benchmark problem #1.

Load Cases	Nodes								
	2	3	4	5	6	7	8	9	10
a	0.09	0.18	0.25	0.31	0.33	1.00	1.77	2.35	2.66
b	0.08	0.16	0.22	0.26	0.29	0.80	1.45	1.95	2.22
c	0.08	0.15	0.21	0.25	0.28	0.77	1.43	1.92	2.19
d	0.08	0.16	0.23	0.27	0.29	0.72	1.19	1.54	1.73
e	0.08	0.16	0.22	0.27	0.29	0.31	0.34	0.37	0.38
f	0.08	0.16	0.22	0.26	0.29	1.11	2.01	2.68	3.04
g	0.10	0.19	0.27	0.33	0.36	0.66	0.96	1.18	1.30
h	0.13	0.26	0.38	0.48	0.50	0.67	0.83	0.94	0.99
i	0.08	0.16	0.22	0.27	0.29	0.76	1.29	1.69	1.91

Table 3.1.7 (Cont'd)

Load Cases	Nodes								
	2	3	4	5	6	7	8	9	10
j	0.08	0.16	0.22	0.26	0.28	0.41	0.57	0.70	0.77
k	0.06	0.12	0.17	0.20	0.22	0.69	1.21	1.59	1.80
l	0.10	0.18	0.26	0.31	0.34	1.22	2.10	2.75	3.10
m	0.25	0.47	0.66	0.79	0.86	2.48	4.46	5.96	6.75
n	0.08	0.15	0.20	0.24	0.27	0.83	1.46	1.93	2.18
o	0.09	0.17	0.24	0.29	0.32	0.94	1.68	2.23	2.53
p	0.08	0.16	0.23	0.27	0.30	0.87	1.55	2.07	2.35

Table 3.1.8 Maximum element forces for benchmark problem #1.

Load Cases	Elements								
	1	2	3	4	5	6	7	8	9
a	2.98E+03	2.74E+03	2.28E+03	1.64E+03	8.58E+02	9.61E+01	8.42E+01	6.24E+01	3.31E+01
b	2.58E+03	2.36E+03	1.96E+03	1.41E+03	7.47E+02	2.05E+01	1.83E+01	1.42E+01	7.93E+00
c	2.49E+03	2.28E+03	1.89E+03	1.36E+03	7.26E+02	6.57E+01	5.81E+01	4.33E+01	2.31E+01
d	2.65E+03	2.43E+03	2.03E+03	1.47E+03	7.60E+02	7.26E+01	6.31E+01	4.65E+01	2.46E+01
e	2.62E+03	2.40E+03	2.00E+03	1.45E+03	7.54E+02	1.99E+01	1.59E+01	1.11E+01	5.74E+00
f	2.58E+03	2.37E+03	1.97E+03	1.42E+03	7.49E+02	2.21E+00	1.94E+00	1.44E+00	7.65E-01
g	3.14E+03	2.92E+03	2.53E+03	1.99E+03	7.73E+02	7.94E+02	6.79E+02	4.96E+02	2.62E+02
h	4.18E+03	4.01E+03	3.68E+03	3.22E+03	6.81E+02	2.09E+03	1.70E+03	1.21E+03	6.29E+02
I	2.60E+03	2.38E+03	1.98E+03	1.44E+03	7.49E+02	6.75E+01	5.89E+01	4.35E+01	2.31E+01
j	2.56E+03	2.35E+03	1.95E+03	1.41E+03	7.39E+02	2.42E+01	2.07E+01	1.51E+01	7.98E+00
k	1.94E+03	1.79E+03	1.49E+03	1.07E+03	5.52E+02	6.43E+01	5.61E+01	4.15E+01	2.20E+01
l	3.01E+03	2.77E+03	2.31E+03	1.67E+03	8.46E+02	1.09E+02	9.47E+01	6.98E+01	3.70E+01
m	7.74E+03	7.11E+03	5.91E+03	4.24E+03	2.22E+03	2.47E+02	2.17E+02	1.61E+02	8.55E+01
n	2.38E+03	2.19E+03	1.82E+03	1.31E+03	6.81E+02	7.82E+01	6.83E+01	5.05E+01	2.68E+01
o	2.86E+03	2.63E+03	2.18E+03	1.57E+03	8.13E+02	9.16E+01	8.03E+01	5.96E+01	3.17E+01
p	2.67E+03	2.45E+03	2.04E+03	1.47E+03	7.68E+02	8.54E+01	7.49E+01	5.56E+01	2.96E+01

3.2 Benchmark Problem N 2

Table 3.2.1 Frequencies, Hz for Benchmark Problem #2.

Mode	Load Case							
	a	b	c	d	e	f	g	h
	PRIMARY							
1	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
2	14.59	14.59	14.59	14.59	14.59	14.59	14.59	14.59
3	23.01	23.01	23.01	23.01	23.01	23.01	23.01	23.01
4	29.56	29.56	29.56	29.56	29.56	29.56	29.56	29.56
5	33.71	33.71	33.71	33.71	33.71	33.71	33.71	33.71
	SECONDARY							
1	5.00	2.50	4.50	5.50	10.02	5.00	5.00	5.00
2	5.00	2.50	4.50	5.50	10.02	5.00	5.00	5.00
3	9.24	4.62	8.32	10.16	18.51	9.24	9.24	9.24
4	9.24	4.62	8.32	10.16	18.51	9.24	9.24	9.24
5	12.07	6.04	10.86	13.28	24.18	12.07	12.07	12.07
6	12.07	6.04	10.86	13.28	24.18	12.07	12.07	12.07
	COUPLED							
1	4.81	2.50	4.45	4.93	4.98	4.97	4.21	3.41
2	5.00	2.50	4.50	5.50	10.01	5.00	4.99	4.94
3	5.19	4.62	5.06	5.58	10.05	5.03	5.91	7.12
4	9.24	4.62	8.31	10.16	14.61	9.24	9.22	9.15
5	9.24	5.00	8.31	10.16	18.50	9.24	9.23	9.19
6	12.07	6.04	10.86	13.28	18.51	12.07	12.06	12.00
7	12.07	6.04	10.87	13.28	23.01	12.07	12.08	12.14
8	14.60	14.60	14.60	14.60	24.18	14.60	14.72	15.18
9	23.01	23.01	23.01	23.01	24.20	23.01	23.08	23.38
10	29.56	29.56	29.56	29.56	29.57	29.56	29.6	29.79
11	33.71	33.71	33.71	33.72	33.73	33.71	33.79	34.12

Table 3.2.2 Frequencies (Hz) and Damping Ratios (%) from complex eigenvalued analysis for Benchmark Problem #2

Mode	Load Case							
	a		b		c		d	
	Freq.	Damp.	Freq.	Damp.	Freq.	Damp.	Freq.	Damp.
1	4.86	4.40	2.50	2.00	4.46	2.36	4.94	6.42
2	5.00	2.00	2.50	2.00	4.50	2.00	5.50	2.00
3	5.15	4.61	4.62	2.00	5.05	6.64	5.57	2.58
4	9.24	2.00	4.62	2.00	8.32	2.00	10.16	2.00
5	9.24	2.00	5.00	6.99	8.32	2.00	10.16	2.00
6	12.07	2.00	6.04	2.00	10.86	2.00	13.28	2.01
7	12.07	2.00	6.04	2.01	10.87	2.00	13.28	2.00
8	14.60	7.00	14.60	7.00	14.60	7.00	14.60	6.99
9	23.01	7.00	23.01	7.00	23.01	7.00	23.01	7.00
10	29.56	7.00	29.56	7.00	29.56	7.00	29.56	7.00
11	33.71	7.00	33.71	7.00	33.71	7.00	33.72	7.00

Table 3.2.2 (Cont'd)

Mode	Load Case							
	e		f		g		h	
	Freq.	Damp.	Freq.	Damp.	Freq.	Damp.	Freq.	Damp.
1	4.98	6.96	5.00	6.94	4.21	4.12	3.41	3.63
2	10.01	2.01	5.00	2.06	4.99	2.00	4.94	1.98
3	10.05	2.04	5.00	2.00	5.90	4.83	7.11	5.11
4	14.61	6.98	9.24	2.00	9.22	2.00	9.15	1.99
5	18.50	2.01	9.24	2.00	9.23	2.01	9.19	2.05
6	18.51	2.01	12.07	2.00	12.06	2.03	12.01	2.12
7	23.02	6.97	12.07	2.00	12.08	2.02	12.14	2.13
8	24.18	2.00	14.60	7.00	14.71	6.97	15.17	6.90
9	24.19	2.03	23.01	7.00	23.08	7.02	23.38	7.09
10	29.57	7.00	29.56	7.00	29.60	7.01	29.79	7.05
11	33.73	7.00	33.71	7.00	33.79	7.00	34.12	7.01

Table 3.2.2 (Cont'd)

Mode	Load Case			
	i		j	
	Freq.	Damp.	Freq.	Damp.
1	4.82	5.80	4.97	8.18
2	5.00	5.00	5.00	19.99
3	5.19	6.20	5.03	18.86
4	9.24	5.00	9.24	19.99
5	9.24	5.00	9.24	20.00
6	12.07	5.00	12.07	19.99
7	12.07	5.00	12.07	20.00
8	14.60	7.01	14.60	7.04
9	23.01	7.00	23.01	7.02
10	29.56	7.00	29.56	7.01
11	33.71	7.00	33.71	7.01

Results from Time History Analysis:

Table 3.2.3 Maximum nodal displacements for benchmark problem #2

Load Cases	Nodes										
	2	3	4	5	6	7	8	9	10	11	12
a	0.08	0.15	0.21	0.25	0.28	1.28	1.78	1.30	1.61	2.24	1.62
b	0.08	0.15	0.22	0.26	0.29	1.32	2.08	1.37	1.38	2.22	1.41
c	0.08	0.16	0.22	0.26	0.29	1.11	1.58	1.10	1.34	1.93	1.34
d	0.08	0.15	0.21	0.26	0.28	0.82	1.10	0.85	1.06	1.41	1.08
e	0.08	0.16	0.22	0.27	0.29	0.23	0.27	0.27	0.30	0.34	0.33
f	0.08	0.16	0.22	0.26	0.29	1.51	2.11	1.53	1.91	2.66	1.92
g	0.11	0.22	0.30	0.35	0.37	0.72	0.95	0.78	0.88	1.12	0.92
h	0.17	0.32	0.44	0.50	0.52	0.63	0.76	0.68	0.86	1.02	0.88
I	0.08	0.15	0.21	0.26	0.28	0.87	1.21	0.89	1.10	1.52	1.11
j	0.08	0.16	0.22	0.26	0.29	0.48	0.62	0.51	0.58	0.75	0.61
k	0.05	0.09	0.13	0.15	0.16	0.77	1.05	0.78	0.96	1.32	0.97
l	0.08	0.15	0.21	0.25	0.27	1.30	1.78	1.34	1.63	2.22	1.66
m	0.24	0.45	0.62	0.74	0.80	1.93	2.64	1.96	2.40	3.26	2.41
n	0.07	0.13	0.17	0.21	0.22	0.89	1.22	0.91	1.11	1.51	1.12
o	0.07	0.12	0.17	0.21	0.22	1.24	1.75	1.25	1.58	2.23	1.59
p	0.06	0.12	0.16	0.20	0.21	1.14	1.57	1.14	1.43	1.98	1.43

Table 3.2.4 Maximum element forces for benchmark problem #2.

Load Cases	Elements												
	1	2	3	4	5	6	7	8	9	10	11	12	13
a	2.53E+03	2.26E+03	1.88E+03	1.38E+03	7.47E+02	2.64E+01	1.10E+01	1.06E+01	2.62E+01	3.32E+01	1.38E+01	1.35E+01	3.31E+01
b	2.55E+03	2.31E+03	1.92E+03	1.43E+03	7.82E+02	7.29E+00	4.14E+00	3.95E+00	7.58E+00	7.65E+00	4.67E+00	4.55E+00	7.86E+00
c	2.62E+03	2.34E+03	1.94E+03	1.43E+03	7.76E+02	2.02E+01	8.51E+00	8.61E+00	2.03E+01	2.46E+01	1.04E+01	1.06E+01	2.48E+01
d	2.53E+03	2.31E+03	1.91E+03	1.39E+03	7.43E+02	1.81E+01	7.39E+00	6.67E+00	1.74E+01	2.31E+01	9.30E+00	8.83E+00	2.25E+01
e	2.63E+03	2.38E+03	1.98E+03	1.46E+03	7.89E+02	6.54E+00	3.55E+00	7.08E-01	4.20E+00	7.62E+00	3.26E+00	1.74E+00	5.74E+00
f	2.59E+03	2.34E+03	1.95E+03	1.44E+03	7.85E+02	6.31E-01	2.63E-01	2.56E-01	6.28E-01	7.94E-01	3.29E-01	3.27E-01	7.92E-01
g	3.53E+03	3.26E+03	2.58E+03	1.58E+03	7.89E+02	2.21E+02	9.97E+01	7.72E+01	2.13E+02	2.53E+02	1.05E+02	9.44E+01	2.50E+02
h	5.29E+03	4.91E+03	3.79E+03	2.04E+03	8.05E+02	6.98E+02	3.04E+02	1.88E+02	5.68E+02	9.32E+02	3.62E+02	3.21E+02	8.57E+02
I	2.54E+03	2.29E+03	1.90E+03	1.39E+03	7.55E+02	1.77E+01	7.40E+00	7.04E+00	1.76E+01	2.22E+01	9.18E+00	8.96E+00	2.21E+01
j	2.58E+03	2.34E+03	1.94E+03	1.43E+03	7.72E+02	7.72E+00	3.30E+00	2.79E+00	7.57E+00	9.19E+00	3.76E+00	3.55E+00	9.13E+00
k	1.53E+03	1.36E+03	1.09E+03	7.55E+02	3.83E+02	1.52E+01	6.24E+00	5.89E+00	1.50E+01	1.89E+01	7.77E+00	7.54E+00	1.88E+01
l	2.58E+03	2.27E+03	1.82E+03	1.24E+03	6.19E+02	2.53E+01	1.05E+01	1.00E+01	2.50E+01	3.18E+01	1.31E+01	1.28E+01	3.16E+01
m	7.49E+03	6.63E+03	5.37E+03	3.78E+03	1.96E+03	3.80E+01	1.54E+01	1.49E+01	3.70E+01	4.66E+01	1.89E+01	1.89E+01	4.59E+01
n	2.16E+03	1.86E+03	1.48E+03	1.01E+03	5.11E+02	1.74E+01	7.15E+00	6.73E+00	1.70E+01	2.14E+01	8.75E+00	8.47E+00	2.12E+01
o	2.05E+03	1.84E+03	1.54E+03	1.10E+03	5.71E+02	2.66E+01	1.11E+01	1.10E+01	2.66E+01	3.41E+01	1.42E+01	1.42E+01	3.41E+01
p	2.01E+03	1.76E+03	1.41E+03	9.69E+02	4.88E+02	2.34E+01	9.48E+00	9.42E+00	2.30E+01	2.94E+01	1.20E+01	1.20E+01	2.91E+01

Results from Response Spectrum Method (I):

Table 3.2.5 Maximum nodal displacements for benchmark problem #2

Load Cases	Nodes										
	2	3	4	5	6	7	8	9	10	11	12
a	0.08	0.15	0.20	0.24	0.26	1.28	1.79	1.30	1.63	2.27	1.64
b	0.09	0.16	0.22	0.26	0.28	1.40	1.97	1.40	1.48	2.08	1.47
c	0.08	0.15	0.21	0.25	0.27	1.08	1.52	1.08	1.31	1.85	1.31
d	0.09	0.16	0.22	0.27	0.29	0.80	1.09	0.83	1.05	1.42	1.07
e	0.09	0.16	0.22	0.27	0.29	0.23	0.27	0.26	0.30	0.33	0.32
f	0.09	0.16	0.22	0.26	0.29	1.49	2.07	1.50	1.88	2.62	1.89
g	0.12	0.22	0.30	0.36	0.38	0.72	0.94	0.77	0.91	1.17	0.94
h	0.17	0.33	0.45	0.51	0.53	0.64	0.78	0.71	0.82	0.96	0.85
I	0.08	0.15	0.21	0.25	0.27	0.94	1.29	0.96	1.18	1.62	1.19
j	0.08	0.16	0.22	0.26	0.28	0.44	0.56	0.47	0.53	0.67	0.55
k	0.05	0.10	0.14	0.16	0.17	0.83	1.15	0.84	1.05	1.45	1.06
l	0.08	0.15	0.20	0.24	0.26	1.56	2.16	1.59	1.96	2.71	1.98
m	0.21	0.40	0.55	0.66	0.72	3.02	4.23	3.05	3.84	5.37	3.85
n	0.07	0.13	0.18	0.21	0.23	0.88	1.21	0.89	1.09	1.50	1.10
o	0.06	0.12	0.17	0.20	0.22	1.36	1.91	1.37	1.72	2.41	1.72
p	0.07	0.13	0.19	0.22	0.24	1.03	1.44	1.04	1.31	1.83	1.32

Table 3.2.6 Maximum element forces for benchmark problem #2.

Load Cases	Elements												
	1	2	3	4	5	6	7	8	9	10	11	12	13
a	2.47E+03	2.16E+03	1.73E+03	1.21E+03	6.20E+02	2.67E+01	1.11E+01	1.09E+01	2.66E+01	3.40E+01	1.41E+01	1.39E+01	3.39E+01
b	2.69E+03	2.36E+03	1.90E+03	1.34E+03	6.93E+02	7.55E+00	3.44E+00	3.31E+00	7.58E+00	7.94E+00	3.74E+00	3.62E+00	7.97E+00
c	2.56E+03	2.23E+03	1.80E+03	1.27E+03	6.57E+02	1.91E+01	7.89E+00	8.02E+00	1.90E+01	2.32E+01	9.66E+00	9.78E+00	2.32E+01
d	2.71E+03	2.39E+03	1.92E+03	1.34E+03	6.87E+02	1.84E+01	7.69E+00	7.12E+00	1.81E+01	2.41E+01	9.94E+00	9.59E+00	2.39E+01
e	2.74E+03	2.41E+03	1.94E+03	1.36E+03	7.02E+02	6.15E+00	3.12E+00	5.61E-01	3.71E+00	6.88E+00	3.11E+00	1.29E+00	5.24E+00
f	2.70E+03	2.37E+03	1.91E+03	1.34E+03	6.96E+02	6.22E-01	2.58E-01	2.53E-01	6.19E-01	7.86E-01	3.25E-01	3.22E-01	7.84E-01
g	3.63E+03	3.30E+03	2.64E+03	1.64E+03	7.46E+02	2.30E+02	9.69E+01	8.01E+01	2.18E+02	2.84E+02	1.16E+02	1.07E+02	2.77E+02
h	5.30E+03	5.01E+03	3.91E+03	2.01E+03	6.79E+02	6.93E+02	3.10E+02	1.67E+02	5.80E+02	8.11E+02	3.27E+02	2.57E+02	7.54E+02
I	2.59E+03	2.26E+03	1.82E+03	1.27E+03	6.51E+02	1.88E+01	7.80E+00	7.50E+00	1.86E+01	2.36E+01	9.75E+00	9.58E+00	2.35E+01
j	2.67E+03	2.34E+03	1.89E+03	1.32E+03	6.81E+02	7.00E+00	2.87E+00	2.48E+00	6.70E+00	8.30E+00	3.34E+00	3.12E+00	8.13E+00
k	1.64E+03	1.45E+03	1.17E+03	8.17E+02	4.18E+02	1.70E+01	7.06E+00	6.83E+00	1.69E+01	2.15E+01	8.86E+00	8.72E+00	2.14E+01
l	2.45E+03	2.18E+03	1.77E+03	1.22E+03	6.20E+02	3.16E+01	1.31E+01	1.26E+01	3.13E+01	3.97E+01	1.63E+01	1.60E+01	3.95E+01
m	6.59E+03	5.93E+03	4.88E+03	3.47E+03	1.81E+03	6.40E+01	2.65E+01	2.64E+01	6.38E+01	8.15E+01	3.38E+01	3.38E+01	8.14E+01
n	2.23E+03	1.92E+03	1.52E+03	1.05E+03	5.32E+02	1.77E+01	7.34E+00	7.10E+00	1.75E+01	2.21E+01	9.09E+00	8.96E+00	2.19E+01
o	1.97E+03	1.80E+03	1.48E+03	1.05E+03	5.44E+02	2.89E+01	1.20E+01	1.19E+01	2.88E+01	3.65E+01	1.52E+01	1.51E+01	3.65E+01
p	2.24E+03	1.98E+03	1.61E+03	1.13E+03	5.86E+02	2.17E+01	9.01E+00	8.92E+00	2.16E+01	2.78E+01	1.15E+01	1.15E+01	2.77E+01

Results from Response Spectrum Method (II):

Table 3.2.7 Maximum nodal displacements for benchmark problem #2

Load Cases	Nodes										
	2	3	4	5	6	7	8	9	10	11	12
a	0.09	0.18	0.25	0.30	0.33	1.32	1.84	1.34	1.67	2.33	1.68
b	0.08	0.16	0.22	0.26	0.29	1.40	1.98	1.40	1.47	2.09	1.47
c	0.08	0.15	0.21	0.25	0.28	1.16	1.63	1.16	1.40	1.98	1.40
d	0.08	0.16	0.23	0.27	0.30	0.85	1.16	0.87	1.12	1.53	1.14
e	0.08	0.16	0.22	0.27	0.29	0.23	0.27	0.26	0.30	0.34	0.33
f	0.08	0.16	0.22	0.26	0.29	1.53	2.14	1.54	1.94	2.72	1.94
g	0.11	0.21	0.30	0.35	0.37	0.73	0.96	0.78	0.93	1.21	0.96
h	0.17	0.32	0.45	0.51	0.53	0.64	0.78	0.71	0.82	0.97	0.86
I	0.08	0.16	0.22	0.27	0.29	0.97	1.35	0.99	1.23	1.69	1.24
j	0.08	0.16	0.22	0.26	0.28	0.44	0.58	0.47	0.54	0.70	0.56
k	0.06	0.12	0.16	0.20	0.21	0.90	1.25	0.91	1.14	1.58	1.15
l	0.10	0.18	0.26	0.31	0.33	1.56	2.16	1.59	1.97	2.71	1.99
m	0.24	0.47	0.65	0.78	0.85	3.31	4.63	3.34	4.22	5.91	4.24
n	0.08	0.14	0.20	0.24	0.26	1.08	1.51	1.10	1.37	1.91	1.38
o	0.09	0.17	0.24	0.29	0.31	1.24	1.73	1.25	1.58	2.20	1.58
p	0.08	0.16	0.22	0.27	0.29	1.14	1.60	1.16	1.45	2.04	1.46

Table 3.2.8 Maximum element forces for benchmark problem #2.

Load Cases	Elements												
	1	2	3	4	5	6	7	8	9	10	11	12	13
a	2.96E+03	2.71E+03	2.25E+03	1.62E+03	8.48E+02	2.76E+01	1.14E+01	1.13E+01	2.75E+01	3.51E+01	1.45E+01	1.44E+01	3.50E+01
b	2.57E+03	2.35E+03	1.96E+03	1.41E+03	7.47E+02	7.63E+00	3.46E+00	3.43E+00	7.67E+00	8.05E+00	3.78E+00	3.75E+00	8.09E+00
c	2.47E+03	2.26E+03	1.88E+03	1.36E+03	7.22E+02	2.04E+01	8.46E+00	8.57E+00	2.04E+01	2.49E+01	1.03E+01	1.04E+01	2.49E+01
d	2.67E+03	2.45E+03	2.03E+03	1.45E+03	7.61E+02	2.00E+01	8.32E+00	7.85E+00	1.97E+01	2.66E+01	1.09E+01	1.07E+01	2.64E+01
e	2.63E+03	2.41E+03	2.00E+03	1.43E+03	7.54E+02	6.25E+00	3.28E+00	6.29E-01	3.85E+00	7.45E+00	3.40E+00	1.53E+00	5.78E+00
f	2.58E+03	2.37E+03	1.97E+03	1.42E+03	7.49E+02	6.50E-01	2.69E-01	2.67E-01	6.48E-01	8.26E-01	3.42E-01	3.41E-01	8.25E-01
g	3.47E+03	3.25E+03	2.64E+03	1.67E+03	7.82E+02	2.40E+02	1.02E+02	8.50E+01	2.29E+02	2.98E+02	1.22E+02	1.13E+02	2.92E+02
h	5.19E+03	4.99E+03	3.92E+03	2.03E+03	7.10E+02	7.04E+02	3.17E+02	1.74E+02	5.93E+02	8.29E+02	3.35E+02	2.66E+02	7.72E+02
I	2.60E+03	2.38E+03	1.98E+03	1.42E+03	7.47E+02	1.98E+01	8.21E+00	7.93E+00	1.96E+01	2.49E+01	1.03E+01	1.01E+01	2.49E+01
j	2.56E+03	2.35E+03	1.95E+03	1.40E+03	7.38E+02	7.49E+00	3.10E+00	2.77E+00	7.28E+00	9.08E+00	3.69E+00	3.52E+00	8.95E+00
k	1.93E+03	1.77E+03	1.47E+03	1.05E+03	5.44E+02	1.85E+01	7.69E+00	7.48E+00	1.84E+01	2.35E+01	9.68E+00	9.55E+00	2.34E+01
l	3.00E+03	2.76E+03	2.28E+03	1.62E+03	8.36E+02	3.17E+01	1.32E+01	1.26E+01	3.14E+01	3.97E+01	1.64E+01	1.60E+01	3.96E+01
m	7.67E+03	7.04E+03	5.85E+03	4.19E+03	2.20E+03	7.04E+01	2.92E+01	2.91E+01	7.03E+01	9.02E+01	3.73E+01	3.73E+01	9.01E+01
n	2.37E+03	2.17E+03	1.80E+03	1.29E+03	6.74E+02	2.25E+01	9.34E+00	9.11E+00	2.24E+01	2.85E+01	1.18E+01	1.17E+01	2.85E+01
o	2.82E+03	2.59E+03	2.15E+03	1.54E+03	8.02E+02	2.61E+01	1.08E+01	1.07E+01	2.61E+01	3.34E+01	1.38E+01	1.38E+01	3.33E+01
p	2.63E+03	2.41E+03	2.00E+03	1.44E+03	7.55E+02	2.42E+01	1.01E+01	9.96E+00	2.42E+01	3.09E+01	1.28E+01	1.28E+01	3.09E+01

3.3 Benchmark Problem N 3

Table 3.3.1 Frequencies, Hz for Benchmark Problem #3.

Mode	Load Case							
	a	b	c	d	e	f	g	h
	PRIMARY							
1	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
2	14.59	14.59	14.59	14.59	14.59	14.59	14.59	14.59
3	23.01	23.01	23.01	23.01	23.01	23.01	23.01	23.01
4	29.56	29.56	29.56	29.56	29.56	29.56	29.56	29.56
5	33.71	33.71	33.71	33.71	33.71	33.71	33.71	33.71
	SECONDARY							
1	5.00	2.50	4.50	5.50	10.02	5.00	5.00	5.00
2	5.00	2.50	4.50	5.50	10.02	5.00	5.00	5.00
3	9.24	4.62	8.32	10.16	18.51	9.24	9.24	9.24
4	9.24	4.62	8.32	10.16	18.51	9.24	9.24	9.24
5	12.07	6.04	10.86	13.28	24.18	12.07	12.07	12.07
6	12.07	6.04	10.86	13.28	24.18	12.07	12.07	12.07
	COUPLED							
1	4.81	2.50	4.45	4.93	4.99	4.97	4.22	3.48
2	5.00	2.50	4.50	5.50	10.02	5.00	5.00	4.99
3	5.20	4.62	5.06	5.58	10.05	5.03	5.92	7.10
4	9.24	4.62	8.31	10.16	14.61	9.24	9.22	9.14
5	9.24	5.01	8.32	10.17	18.50	9.24	9.26	9.37
6	12.07	6.04	10.86	13.28	18.51	12.07	12.07	12.06
7	12.07	6.04	10.87	13.28	23.02	12.07	12.08	12.13
8	14.60	14.60	14.60	14.60	24.18	14.60	14.67	14.99
9	23.01	23.01	23.01	23.01	24.19	23.01	23.05	23.21
10	29.56	29.56	29.56	29.56	29.57	29.56	29.62	29.86
11	33.71	33.71	33.71	33.71	33.72	33.71	33.74	33.87

Table 3.3.2 Frequencies (Hz) and Damping Ratios (%) from complex eigenvalued analysis for Benchmark Problem #3

Mode	Load Case							
	a		b		c		d	
	Freq.	Damp.	Freq.	Damp.	Freq.	Damp.	Freq.	Damp.
1	4.86	4.39	2.50	2.00	4.46	2.35	4.94	6.42
2	5.00	2.00	2.50	2.00	4.50	2.00	5.50	2.00
3	5.15	4.61	4.62	2.02	5.05	6.64	5.57	2.58
4	9.24	2.00	4.62	2.00	8.32	2.00	10.16	2.00
5	9.24	2.00	5.01	6.97	8.32	2.00	10.17	2.00
6	12.07	2.00	6.04	2.00	10.86	2.00	13.28	2.01
7	12.07	2.00	6.04	2.01	10.87	2.00	13.28	2.00
8	14.60	7.00	14.60	7.00	14.60	7.00	14.60	7.00
9	23.01	7.00	23.01	7.00	23.01	7.00	23.01	7.00
10	29.56	7.00	29.56	7.00	29.56	7.00	29.56	7.00
11	33.71	7.00	33.71	7.00	33.71	7.00	33.71	7.00

Table 3.3.2 (Cont'd)

Mode	Load Case							
	e		f		g		h	
	Freq.	Damp.	Freq.	Damp.	Freq.	Damp.	Freq.	Damp.
1	4.99	6.95	5.00	6.94	4.23	4.07	3.48	3.47
2	10.02	2.00	5.00	2.06	5.00	2.00	4.99	1.99
3	10.05	2.05	5.00	2.00	5.91	4.81	7.10	4.88
4	14.61	6.99	9.24	2.00	9.22	2.00	9.14	2.01
5	18.50	2.01	9.24	2.00	9.26	2.03	9.37	2.25
6	18.51	2.00	12.07	2.00	12.07	2.00	12.06	2.02
7	23.02	6.99	12.07	2.00	12.08	2.04	12.13	2.22
8	24.18	2.00	14.59	7.00	14.67	6.98	14.98	6.91
9	24.19	2.00	23.01	7.00	23.05	7.00	23.21	7.00
10	29.57	7.00	29.56	7.00	29.62	7.01	29.86	7.04
11	33.72	7.00	33.71	7.00	33.74	7.01	33.87	7.03

Table 3.3.2 (Cont'd)

Mode	Load Case			
	i		j	
	Freq.	Damp.	Freq.	Damp.
1	4.82	5.80	4.97	8.17
2	5.00	5.00	5.00	20.00
3	5.19	6.20	5.03	18.87
4	9.24	5.00	9.24	19.99
5	9.24	5.00	9.24	20.00
6	12.07	5.00	12.07	20.00
7	12.07	5.00	12.07	20.00
8	14.60	7.00	14.60	7.02
9	23.01	7.00	23.01	7.01
10	29.56	7.00	29.56	7.01
11	33.71	7.00	33.71	7.01

Results from Time History Analysis:

Table 3.3.3 Maximum nodal displacements for benchmark problem #3

Load Cases	Nodes 2	3	4	5	6	7	8	9	10	11	12
a	0.08	0.15	0.21	0.25	0.28	0.90	1.29	0.98	1.83	2.54	1.83
b	0.08	0.15	0.22	0.26	0.28	1.44	1.90	1.40	1.42	2.31	1.44
c	0.08	0.16	0.22	0.26	0.29	0.89	1.20	0.83	1.49	2.15	1.49
d	0.08	0.15	0.21	0.26	0.28	0.52	0.78	0.66	1.21	1.61	1.22
e	0.08	0.16	0.22	0.27	0.29	0.11	0.19	0.25	0.34	0.38	0.36
f	0.08	0.16	0.22	0.26	0.29	1.06	1.53	1.15	2.16	3.01	2.17
g	0.10	0.19	0.27	0.34	0.36	0.45	0.73	0.69	0.96	1.20	0.98
h	0.13	0.26	0.36	0.46	0.50	0.30	0.48	0.52	0.95	1.15	0.98
I	0.08	0.15	0.21	0.26	0.28	0.61	0.89	0.69	1.25	1.72	1.25
j	0.08	0.16	0.22	0.26	0.29	0.30	0.48	0.46	0.65	0.83	0.67
k	0.05	0.09	0.13	0.15	0.16	0.53	0.76	0.60	1.09	1.49	1.09
l	0.08	0.15	0.21	0.25	0.27	0.89	1.31	1.05	1.84	2.49	1.86
m	0.24	0.45	0.62	0.74	0.80	1.38	1.97	1.53	2.69	3.66	2.70
n	0.07	0.13	0.17	0.21	0.22	0.63	0.91	0.72	1.25	1.70	1.25
o	0.06	0.12	0.17	0.21	0.22	0.87	1.24	0.90	1.80	2.54	1.80
p	0.06	0.12	0.16	0.19	0.21	0.82	1.14	0.84	1.62	2.24	1.62

Table 3.3.4 Maximum element forces for benchmark problem #3.

Load Cases	Elements 1	2	3	4	5	6	7	8	9	10	11	12	13
a	2.53E+03	2.26E+03	1.88E+03	1.40E+03	7.57E+02	1.95E+01	8.72E+00	7.41E+00	1.87E+01	3.76E+01	1.55E+01	1.54E+01	3.75E+01
b	2.56E+03	2.31E+03	1.92E+03	1.42E+03	7.75E+02	7.86E+00	5.00E+00	4.12E+00	8.12E+00	7.90E+00	5.00E+00	4.94E+00	8.00E+00
c	2.62E+03	2.34E+03	1.94E+03	1.44E+03	7.82E+02	1.57E+01	6.32E+00	7.28E+00	1.57E+01	2.75E+01	1.17E+01	1.18E+01	2.76E+01
d	2.51E+03	2.28E+03	1.90E+03	1.42E+03	7.66E+02	1.38E+01	6.82E+00	3.31E+00	1.12E+01	2.62E+01	1.07E+01	1.04E+01	2.59E+01
e	2.62E+03	2.37E+03	1.97E+03	1.46E+03	7.94E+02	9.22E+00	7.45E+00	4.96E+00	2.46E+00	9.73E+00	3.64E+00	3.21E+00	8.55E+00
f	2.59E+03	2.34E+03	1.95E+03	1.44E+03	7.85E+02	4.63E-01	2.05E-01	1.89E-01	4.47E-01	8.99E-01	3.72E-01	3.71E-01	8.98E-01
g	3.18E+03	2.93E+03	2.51E+03	1.95E+03	9.04E+02	1.98E+02	1.22E+02	4.66E+01	1.60E+02	2.72E+02	1.06E+02	1.03E+02	2.70E+02
h	4.18E+03	3.86E+03	3.43E+03	3.07E+03	1.52E+03	6.61E+02	4.43E+02	2.32E+02	3.70E+02	1.10E+03	4.30E+02	3.75E+02	1.05E+03
I	2.54E+03	2.27E+03	1.90E+03	1.41E+03	7.64E+02	1.33E+01	6.07E+00	4.64E+00	1.24E+01	2.51E+01	1.03E+01	1.02E+01	2.51E+01
j	2.57E+03	2.33E+03	1.94E+03	1.44E+03	7.80E+02	6.61E+00	3.92E+00	2.16E+00	5.60E+00	1.01E+01	4.11E+00	4.04E+00	1.01E+01
k	1.52E+03	1.34E+03	1.09E+03	7.76E+02	3.95E+02	1.14E+01	5.25E+00	3.66E+00	1.05E+01	2.13E+01	8.73E+00	8.61E+00	2.12E+01
l	2.54E+03	2.24E+03	1.82E+03	1.29E+03	6.55E+02	1.93E+01	9.21E+00	6.49E+00	1.77E+01	3.59E+01	1.48E+01	1.46E+01	3.58E+01
m	7.48E+03	6.62E+03	5.36E+03	3.79E+03	1.96E+03	3.01E+01	1.40E+01	1.22E+01	2.69E+01	5.21E+01	2.11E+01	2.14E+01	5.16E+01
n	2.15E+03	1.85E+03	1.47E+03	1.03E+03	5.22E+02	1.37E+01	6.19E+00	4.42E+00	1.22E+01	2.39E+01	9.75E+00	9.61E+00	2.38E+01
o	2.05E+03	1.84E+03	1.54E+03	1.11E+03	5.78E+02	1.90E+01	8.08E+00	7.76E+00	1.87E+01	3.89E+01	1.62E+01	1.62E+01	3.89E+01
p	1.99E+03	1.73E+03	1.41E+03	1.00E+03	5.10E+02	1.78E+01	7.42E+00	6.75E+00	1.63E+01	3.32E+01	1.37E+01	1.37E+01	3.31E+01

Results from Response Spectrum Method (I):

Table 3.3.5 Maximum nodal displacements for benchmark problem #3

Load Cases	Nodes										
	2	3	4	5	6	7	8	9	10	11	12
a	0.08	0.15	0.20	0.24	0.26	0.89	1.28	0.97	1.85	2.57	1.85
b	0.09	0.16	0.22	0.26	0.28	1.37	1.83	1.36	1.52	2.14	1.52
c	0.08	0.15	0.21	0.25	0.27	0.83	1.16	0.84	1.45	2.06	1.45
d	0.09	0.16	0.22	0.26	0.29	0.51	0.76	0.64	1.21	1.64	1.22
e	0.09	0.16	0.22	0.27	0.29	0.11	0.19	0.25	0.35	0.38	0.36
f	0.09	0.16	0.22	0.26	0.29	1.05	1.50	1.13	2.13	2.96	2.13
g	0.11	0.20	0.28	0.34	0.38	0.44	0.67	0.62	1.01	1.30	1.03
h	0.14	0.27	0.38	0.48	0.53	0.33	0.54	0.59	0.89	1.05	0.92
I	0.08	0.15	0.21	0.25	0.27	0.65	0.94	0.74	1.33	1.83	1.34
j	0.08	0.16	0.22	0.26	0.28	0.29	0.44	0.42	0.59	0.74	0.60
k	0.05	0.10	0.14	0.16	0.17	0.58	0.83	0.64	1.19	1.65	1.20
l	0.08	0.15	0.20	0.24	0.26	1.08	1.56	1.20	2.23	3.07	2.24
m	0.21	0.40	0.55	0.66	0.72	2.13	3.03	2.26	4.36	6.10	4.37
n	0.07	0.13	0.18	0.21	0.23	0.62	0.90	0.70	1.23	1.70	1.24
o	0.06	0.12	0.17	0.20	0.22	0.97	1.38	1.01	1.95	2.74	1.96
p	0.07	0.13	0.19	0.22	0.24	0.72	1.03	0.77	1.49	2.09	1.49

Table 3.3.6 Maximum element forces for benchmark problem #3.

Load Cases	Elements												
	1	2	3	4	5	6	7	8	9	10	11	12	13
a	2.46E+03	2.15E+03	1.73E+03	1.23E+03	6.30E+02	1.95E+01	8.57E+00	7.49E+00	1.88E+01	3.86E+01	1.59E+01	1.59E+01	3.86E+01
b	2.68E+03	2.35E+03	1.90E+03	1.33E+03	6.91E+02	7.46E+00	3.92E+00	3.58E+00	7.49E+00	8.19E+00	3.92E+00	3.85E+00	8.21E+00
c	2.56E+03	2.23E+03	1.80E+03	1.26E+03	6.52E+02	1.46E+01	6.08E+00	6.43E+00	1.44E+01	2.59E+01	1.08E+01	1.09E+01	2.59E+01
d	2.70E+03	2.37E+03	1.92E+03	1.36E+03	7.02E+02	1.34E+01	6.63E+00	4.10E+00	1.17E+01	2.79E+01	1.14E+01	1.12E+01	2.78E+01
e	2.72E+03	2.39E+03	1.93E+03	1.36E+03	7.07E+02	9.37E+00	7.43E+00	4.90E+00	2.23E+00	7.85E+00	3.19E+00	2.36E+00	7.09E+00
f	2.70E+03	2.37E+03	1.91E+03	1.35E+03	6.96E+02	4.56E-01	2.00E-01	1.75E-01	4.41E-01	8.90E-01	3.67E-01	3.66E-01	8.89E-01
g	3.34E+03	3.01E+03	2.56E+03	1.99E+03	9.66E+02	1.90E+02	1.03E+02	4.93E+01	1.43E+02	3.16E+02	1.28E+02	1.22E+02	3.12E+02
h	4.33E+03	4.07E+03	3.69E+03	3.19E+03	1.51E+03	7.20E+02	4.74E+02	2.11E+02	3.59E+02	9.16E+02	3.65E+02	3.08E+02	8.74E+02
I	2.58E+03	2.25E+03	1.82E+03	1.29E+03	6.61E+02	1.41E+01	6.50E+00	5.05E+00	1.31E+01	2.67E+01	1.10E+01	1.09E+01	2.67E+01
j	2.66E+03	2.34E+03	1.89E+03	1.33E+03	6.88E+02	6.24E+00	3.43E+00	1.83E+00	4.76E+00	9.14E+00	3.64E+00	3.54E+00	9.06E+00
k	1.63E+03	1.44E+03	1.17E+03	8.34E+02	4.28E+02	1.26E+01	5.64E+00	4.59E+00	1.19E+01	2.43E+01	1.00E+01	9.94E+00	2.43E+01
l	2.42E+03	2.15E+03	1.77E+03	1.28E+03	6.51E+02	2.35E+01	1.06E+01	8.16E+00	2.22E+01	4.49E+01	1.84E+01	1.82E+01	4.47E+01
m	6.58E+03	5.92E+03	4.88E+03	3.48E+03	1.81E+03	4.63E+01	2.02E+01	1.91E+01	4.52E+01	9.28E+01	3.85E+01	3.85E+01	9.28E+01
n	2.22E+03	1.91E+03	1.52E+03	1.06E+03	5.41E+02	1.36E+01	6.08E+00	4.91E+00	1.27E+01	2.49E+01	1.02E+01	1.02E+01	2.48E+01
o	1.97E+03	1.79E+03	1.48E+03	1.06E+03	5.51E+02	2.10E+01	9.08E+00	8.40E+00	2.06E+01	4.16E+01	1.72E+01	1.72E+01	4.16E+01
p	2.24E+03	1.98E+03	1.61E+03	1.14E+03	5.89E+02	1.56E+01	6.86E+00	6.27E+00	1.51E+01	3.17E+01	1.31E+01	1.31E+01	3.16E+01

Results from Response Spectrum Method (II):

Table 3.3.7 Maximum nodal displacements for benchmark problem #3

Load Cases	Nodes										
	2	3	4	5	6	7	8	9	10	11	12
a	0.09	0.18	0.25	0.30	0.33	0.92	1.33	1.01	1.90	2.65	1.90
b	0.08	0.16	0.22	0.26	0.29	1.37	1.84	1.37	1.52	2.15	1.52
c	0.08	0.15	0.21	0.25	0.27	0.88	1.24	0.90	1.55	2.20	1.55
d	0.08	0.16	0.23	0.27	0.30	0.53	0.78	0.65	1.30	1.77	1.31
e	0.08	0.16	0.22	0.27	0.29	0.10	0.19	0.24	0.36	0.39	0.37
f	0.08	0.16	0.22	0.26	0.29	1.08	1.54	1.14	2.20	3.08	2.20
g	0.10	0.19	0.28	0.34	0.37	0.44	0.68	0.63	1.04	1.34	1.06
h	0.13	0.26	0.38	0.48	0.53	0.33	0.54	0.59	0.89	1.06	0.92
I	0.08	0.16	0.22	0.27	0.29	0.67	0.98	0.77	1.39	1.91	1.40
j	0.08	0.16	0.22	0.26	0.28	0.29	0.44	0.42	0.61	0.78	0.62
k	0.06	0.12	0.16	0.20	0.21	0.62	0.90	0.69	1.29	1.79	1.29
l	0.09	0.18	0.25	0.31	0.33	1.08	1.58	1.23	2.23	3.07	2.24
m	0.24	0.47	0.65	0.78	0.85	2.31	3.30	2.47	4.80	6.73	4.81
n	0.07	0.14	0.20	0.24	0.26	0.76	1.09	0.84	1.56	2.16	1.56
o	0.09	0.17	0.24	0.29	0.31	0.87	1.25	0.94	1.79	2.50	1.80
p	0.08	0.16	0.22	0.27	0.29	0.81	1.16	0.87	1.65	2.32	1.66

Table 3.3.8 Maximum element forces for benchmark problem #3.

Load Cases	Elements												
	1	2	3	4	5	6	7	8	9	10	11	12	13
a	2.95E+03	2.71E+03	2.25E+03	1.63E+03	8.53E+02	2.01E+01	8.99E+00	7.90E+00	1.95E+01	3.99E+01	1.65E+01	1.64E+01	3.99E+01
b	2.57E+03	2.35E+03	1.96E+03	1.41E+03	7.45E+02	7.47E+00	3.91E+00	3.82E+00	7.60E+00	8.32E+00	3.99E+00	3.98E+00	8.35E+00
c	2.48E+03	2.27E+03	1.88E+03	1.36E+03	7.17E+02	1.56E+01	6.59E+00	6.87E+00	1.56E+01	2.77E+01	1.15E+01	1.16E+01	2.77E+01
d	2.65E+03	2.43E+03	2.03E+03	1.47E+03	7.72E+02	1.40E+01	6.88E+00	4.75E+00	1.27E+01	3.08E+01	1.27E+01	1.25E+01	3.08E+01
e	2.61E+03	2.39E+03	1.99E+03	1.44E+03	7.60E+02	8.83E+00	7.49E+00	5.15E+00	2.44E+00	8.82E+00	3.58E+00	2.77E+00	8.03E+00
f	2.58E+03	2.37E+03	1.97E+03	1.42E+03	7.49E+02	4.69E-01	2.04E-01	1.88E-01	4.60E-01	9.38E-01	3.88E-01	3.88E-01	9.37E-01
g	3.17E+03	2.95E+03	2.56E+03	2.02E+03	9.95E+02	1.93E+02	1.07E+02	5.43E+01	1.51E+02	3.33E+02	1.35E+02	1.29E+02	3.29E+02
h	4.20E+03	4.02E+03	3.69E+03	3.21E+03	1.52E+03	7.14E+02	4.82E+02	2.22E+02	3.73E+02	9.31E+02	3.73E+02	3.16E+02	8.89E+02
I	2.59E+03	2.38E+03	1.98E+03	1.43E+03	7.53E+02	1.46E+01	6.83E+00	5.43E+00	1.39E+01	2.83E+01	1.16E+01	1.16E+01	2.82E+01
j	2.56E+03	2.34E+03	1.95E+03	1.41E+03	7.43E+02	6.22E+00	3.59E+00	2.16E+00	5.20E+00	1.01E+01	4.07E+00	4.00E+00	1.00E+01
k	1.92E+03	1.76E+03	1.47E+03	1.06E+03	5.51E+02	1.36E+01	6.16E+00	5.11E+00	1.31E+01	2.66E+01	1.10E+01	1.09E+01	2.66E+01
l	2.97E+03	2.73E+03	2.28E+03	1.65E+03	8.58E+02	2.36E+01	1.09E+01	8.27E+00	2.25E+01	4.49E+01	1.84E+01	1.82E+01	4.48E+01
m	7.67E+03	7.04E+03	5.85E+03	4.20E+03	2.20E+03	5.03E+01	2.21E+01	2.10E+01	4.96E+01	1.03E+02	4.26E+01	4.26E+01	1.03E+02
n	2.36E+03	2.17E+03	1.80E+03	1.30E+03	6.80E+02	1.65E+01	7.44E+00	6.29E+00	1.59E+01	3.24E+01	1.33E+01	1.33E+01	3.24E+01
o	2.82E+03	2.59E+03	2.15E+03	1.55E+03	8.05E+02	1.89E+01	8.40E+00	7.59E+00	1.85E+01	3.80E+01	1.57E+01	1.57E+01	3.80E+01
p	2.63E+03	2.41E+03	2.01E+03	1.44E+03	7.56E+02	1.76E+01	7.80E+00	7.12E+00	1.72E+01	3.53E+01	1.46E+01	1.46E+01	3.53E+01

3.4 Benchmark Problem N 4

Table 3.4.1 Frequencies, Hz for Benchmark Problem #4.

Mode	P4A			P4B		
	PRIMARY	SECONDARY	COUPLED	PRIMARY	SECONDARY	COUPLED
1	8.24	8.23	8.22	4.60	4.59	4.59
2	8.30	8.54	8.24	4.63	4.76	4.60
3	22.09	14.91	8.30	12.33	8.31	4.63
4	33.38	16.85	8.54	18.63	9.40	4.76
5	33.47	17.30	14.91	18.68	9.64	8.31
6	67.41	22.69	16.85	37.62	12.65	9.40
7	67.50	24.89	17.30	37.68	13.88	9.64
8	68.04	25.87	22.07	37.98	14.42	12.32
9	91.97	26.06	22.70	51.33	14.53	12.66
10	92.04	27.37	24.89	51.37	15.26	13.88
11	111.29	28.23	25.87	62.12	15.74	14.42
12	111.34	31.13	26.06	62.14	17.36	14.53
13	115.09	33.56	27.37	64.24	18.71	15.26
14	130.12	34.13	28.23	72.63	19.03	15.74
15	130.15	39.28	31.13	72.64	21.90	17.36
16	149.68	44.79	33.32	83.55	24.98	18.59
17	149.71	51.19	33.42	83.56	28.54	18.65
18	149.87	53.61	33.57	83.65	29.89	18.72
19	176.86	54.71	34.20	98.71	30.51	19.07
20	204.01	59.09	39.29	113.87	32.95	21.91
21	234.57	62.68	44.79	130.92	34.95	24.97
22	-	72.81	51.19	-	40.60	28.54
23	-	74.92	53.61	-	41.77	29.89
24	-	75.95	54.71	-	42.35	30.51
25	-	79.97	59.09	-	44.59	32.95
26	-	80.11	62.67	-	44.67	34.95
27	-	83.82	67.41	-	46.74	37.63
28	-	88.02	67.50	-	49.08	37.67
29	-	89.61	68.03	-	49.97	37.97
30	-	93.34	72.81	-	52.05	40.60
31	-	114.28	74.92	-	63.72	41.77
32	-	115.64	75.95	-	64.48	42.35
33	-	125.57	79.97	-	70.01	44.59
34	-	127.80	80.11	-	71.26	44.67
35	-	141.34	83.82	-	78.81	46.74
36	-	141.61	88.02	-	78.96	49.08
37	-	161.17	89.61	-	89.87	49.97
38	-	210.01	91.97	-	117.10	51.33

Table 3.4.1 (Cont'd)

Mode	P4A			P4B		
	PRIMARY	SECONDARY	COUPLED	PRIMARY	SECONDARY	COUPLED
39	-	226.76	92.03	-	126.44	51.37
40	-	261.71	93.34	-	145.92	52.05
41	-	288.06	111.24	-	160.61	62.09
42	-	315.68	111.29	-	176.01	62.12
43	-	357.31	114.27	-	199.23	63.72
44	-	393.71	115.08	-	219.52	64.23
45	-	417.36	115.69	-	232.71	64.51
46	-	427.53	125.54	-	238.38	70
47	-	450.62	127.8	-	251.25	71.26
48	-	484.44	130.11	-	270.11	72.62
49	-	505.19	130.19	-	281.68	72.66
50	-	515.82	141.34	-	287.61	78.81
51	-	530.96	141.61	-	296.05	78.96
52	-	540.27	149.68	-	301.24	83.54
53	-	553.91	149.71	-	308.85	83.56
54	-	620.67	149.87	-	346.07	83.65
55	-	630.9	161.17	-	351.78	89.87
56	-	729.14	176.86	-	406.55	98.71
57	-	-	204	-	-	113.86
58	-	-	210.01	-	-	117.1
59	-	-	226.74	-	-	126.43
60	-	-	234.57	-	-	130.92
61	-	-	261.71	-	-	145.92
62	-	-	288.03	-	-	160.6
63	-	-	315.67	-	-	176.01
64	-	-	357.3	-	-	199.22
65	-	-	393.7	-	-	219.52
66	-	-	417.3	-	-	232.67
67	-	-	427.45	-	-	238.34
68	-	-	450.6	-	-	251.25
69	-	-	484.44	-	-	270.11
70	-	-	505.17	-	-	281.67
71	-	-	515.82	-	-	287.61
72	-	-	530.96	-	-	296.05
73	-	-	540.27	-	-	301.24
74	-	-	553.9	-	-	308.84
75	-	-	620.57	-	-	346.01
76	-	-	630.9	-	-	351.78
77	-	-	729.11	-	-	406.53

Table 3.4.2 Frequencies (Hz) and Damping Ratios (%) from complex eigenvalued analysis for Benchmark Problem #4a, 4b.

Mode	4a		4b		Mode	4a		4b	
	Freq.	Damp	Freq.	Damp		Freq.	Damp	Freq.	Damp
1	8.23	2.01	4.59	2.01	40	93.34	2.00	52.05	2.00
2	8.24	6.99	4.60	6.99	41	111.30	7.00	62.12	7.00
3	8.30	6.98	4.63	6.99	42	111.30	6.96	62.12	6.96
4	8.54	2.01	4.76	2.01	43	114.30	2.01	63.71	2.01
5	14.91	2.00	8.31	2.00	44	115.10	7.00	64.24	7.00
6	16.85	2.00	9.40	2.00	45	115.60	2.04	64.47	2.04
7	17.30	2.00	9.65	2.00	46	125.60	2.01	70.01	2.01
8	22.08	6.97	12.32	6.97	47	127.80	2.00	71.26	2.00
9	22.69	2.03	12.65	2.03	48	130.10	7.00	72.62	7.00
10	24.89	2.00	13.88	2.00	49	130.20	6.98	72.65	6.98
11	25.87	2.00	14.42	2.00	50	141.30	2.00	78.81	2.00
12	26.06	2.00	14.53	2.00	51	141.60	2.00	78.96	2.00
13	27.37	2.00	15.26	2.00	52	149.70	7.00	83.54	7.00
14	28.23	2.00	15.74	2.00	53	149.70	7.00	83.56	7.00
15	31.13	2.00	17.36	2.00	54	149.90	7.00	83.65	7.00
16	33.36	6.94	18.62	6.94	55	161.20	2.00	89.87	2.00
17	33.45	6.95	18.67	6.95	56	176.90	7.00	98.71	7.00
18	33.57	2.01	18.72	2.01	57	204.00	7.00	113.90	7.00
19	34.14	2.09	19.03	2.10	58	210.00	2.00	117.10	2.00
20	39.29	2.01	21.91	2.01	59	226.70	2.00	126.40	2.00
21	44.79	2.00	24.97	2.00	60	234.60	7.00	130.90	7.00
22	51.19	2.00	28.54	2.00	61	261.70	2.00	145.90	2.00
23	53.61	2.00	29.89	2.00	62	288.00	2.00	160.60	2.00
24	54.71	2.00	30.51	2.00	63	315.70	2.00	176.00	2.00
25	59.09	2.00	32.95	2.00	64	357.30	2.00	199.20	2.00
26	62.68	2.00	34.95	2.00	65	393.70	2.00	219.50	2.00
27	67.41	7.00	37.63	7.00	66	417.30	2.00	232.70	2.00
28	67.50	7.00	37.67	7.00	67	427.50	2.00	238.30	2.00
29	68.03	7.00	37.97	7.00	68	450.60	2.00	251.20	2.00
30	72.81	2.00	40.60	2.00	69	484.40	2.00	270.10	2.00
31	74.92	2.00	41.77	2.00	70	505.20	2.00	281.70	2.00
32	75.95	2.00	42.35	2.00	71	515.80	2.00	287.60	2.00
33	79.97	2.00	44.59	2.00	72	531.00	2.00	296.00	2.00
34	80.11	2.00	44.67	2.00	73	540.30	2.00	301.20	2.00
35	83.82	2.00	46.74	2.00	74	553.90	2.00	308.80	2.00
36	88.02	2.00	49.08	2.00	75	620.60	2.00	346.00	2.00
37	89.61	2.00	49.97	2.00	76	630.90	2.00	351.80	2.00
38	91.97	7.00	51.33	7.00	77	729.10	2.00	406.50	2.00
39	92.03	7.00	51.37	7.00					

Results from Time History Analysis:

Table 3.4.3 Maximum nodal displacements for benchmark problem #4a & 4b.

Nodes	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
2Ux	2.11E-06	2.16E-07	5.47E-07	4.90E-07	1.67E-07	4.81E-07	4.86E-07	3.93E-02	2.27E-02	3.43E-02	9.82E-02	3.22E-02	2.32E-02	3.20E-02
2Uy	1.19E-02	4.47E-03	7.94E-03	2.02E-02	6.64E-03	6.62E-03	9.13E-03	1.27E-05	1.96E-06	4.07E-06	1.26E-05	1.03E-06	2.14E-06	6.44E-06
2Uz	2.49E-07	2.83E-08	7.77E-08	2.53E-07	2.23E-08	4.88E-08	1.26E-07	1.31E-06	6.39E-07	9.25E-07	2.14E-06	3.22E-07	6.84E-07	1.02E-06
2Θx	3.22E-05	1.15E-05	2.23E-05	5.70E-05	1.65E-05	1.77E-05	2.58E-05	5.83E-09	3.12E-09	5.36E-09	6.95E-09	2.26E-09	3.48E-09	3.67E-09
2Θy	9.62E-10	3.07E-10	7.13E-10	1.43E-09	3.61E-10	5.13E-10	1.13E-09	1.07E-04	6.38E-05	9.53E-05	2.74E-04	8.64E-05	6.57E-05	8.59E-05
2Θz	7.76E-10	2.84E-10	6.16E-10	1.48E-09	4.11E-10	3.57E-10	6.56E-10	7.42E-09	4.10E-09	5.98E-09	1.42E-08	2.97E-09	4.66E-09	4.80E-09
3Ux	3.61E-06	4.47E-07	1.10E-06	1.25E-06	3.75E-07	9.31E-07	1.15E-06	9.76E-02	5.70E-02	8.57E-02	2.46E-01	7.92E-02	5.86E-02	7.89E-02
3Uy	2.94E-02	1.08E-02	1.99E-02	5.07E-02	1.57E-02	1.63E-02	2.29E-02	2.23E-05	3.93E-06	7.54E-06	2.18E-05	2.29E-06	4.31E-06	1.15E-05
3Uz	4.81E-07	5.52E-08	1.53E-07	4.96E-07	4.40E-08	9.53E-08	2.47E-07	2.56E-06	1.26E-06	1.83E-06	4.23E-06	6.39E-07	1.36E-06	2.01E-06
3Θx	5.59E-05	1.98E-05	3.90E-05	9.97E-05	2.81E-05	3.08E-05	4.52E-05	1.01E-08	5.50E-09	9.31E-09	1.20E-08	4.08E-09	6.04E-09	6.28E-09
3Θy	1.68E-09	5.52E-10	1.32E-09	2.51E-09	6.31E-10	8.83E-10	1.94E-09	1.86E-04	1.12E-04	1.67E-04	4.79E-04	1.50E-04	1.16E-04	1.49E-04
3Θz	1.55E-09	5.69E-10	1.23E-09	2.96E-09	8.22E-10	7.13E-10	1.31E-09	1.48E-08	8.19E-09	1.20E-08	2.84E-08	5.95E-09	9.31E-09	9.59E-09
4Ux	3.90E-06	6.05E-07	1.49E-06	2.02E-06	5.62E-07	1.20E-06	1.74E-06	1.56E-01	9.19E-02	1.38E-01	3.95E-01	1.26E-01	9.45E-02	1.26E-01
4Uy	4.68E-02	1.69E-02	3.20E-02	8.16E-02	2.45E-02	2.58E-02	3.70E-02	2.46E-05	5.43E-06	9.93E-06	2.46E-05	3.33E-06	6.10E-06	1.29E-05
4Uz	6.51E-07	7.89E-08	2.36E-07	7.20E-07	6.80E-08	1.45E-07	3.59E-07	3.67E-06	1.68E-06	2.43E-06	5.81E-06	8.27E-07	1.75E-06	2.86E-06
4Θx	6.97E-05	2.46E-05	4.90E-05	1.25E-04	3.48E-05	3.84E-05	5.67E-05	2.24E-08	7.50E-09	1.32E-08	2.35E-08	5.21E-09	8.43E-09	1.22E-08
4Θy	3.35E-09	7.80E-10	1.93E-09	3.16E-09	8.28E-10	1.39E-09	2.45E-09	2.33E-04	1.40E-04	2.09E-04	6.02E-04	1.88E-04	1.46E-04	1.87E-04
4Θz	1.97E-09	6.87E-10	1.59E-09	3.86E-09	9.58E-10	8.06E-10	1.66E-09	1.93E-08	1.32E-08	1.91E-08	4.48E-08	1.04E-08	1.41E-08	1.40E-08
5Ux	3.01E-06	7.27E-07	1.74E-06	2.99E-06	7.82E-07	1.32E-06	2.45E-06	2.27E-01	1.35E-01	2.02E-01	5.80E-01	1.83E-01	1.39E-01	1.83E-01
5Uy	6.79E-02	2.44E-02	4.69E-02	1.20E-01	3.50E-02	3.74E-02	5.43E-02	1.99E-05	6.98E-06	1.22E-05	2.14E-05	4.66E-06	7.84E-06	1.09E-05
5Uz	8.02E-07	1.13E-07	3.23E-07	9.49E-07	1.04E-07	1.96E-07	4.72E-07	4.75E-06	2.10E-06	3.06E-06	7.43E-06	1.03E-06	2.16E-06	3.72E-06
5Θx	7.97E-05	2.80E-05	5.63E-05	1.44E-04	3.95E-05	4.39E-05	6.53E-05	3.58E-08	9.56E-09	1.70E-08	3.65E-08	6.20E-09	1.06E-08	1.95E-08
5Θy	5.43E-09	9.88E-10	2.52E-09	3.65E-09	9.92E-10	1.90E-09	2.93E-09	2.67E-04	1.61E-04	2.40E-04	6.92E-04	2.15E-04	1.69E-04	2.14E-04
5Θz	2.58E-09	8.55E-10	2.00E-09	4.70E-09	1.17E-09	1.06E-09	2.14E-09	2.33E-08	1.62E-08	2.25E-08	5.76E-08	1.37E-08	1.75E-08	1.72E-08
6Ux	2.03E-06	8.12E-07	1.89E-06	3.99E-06	9.91E-07	1.28E-06	3.14E-06	3.00E-01	1.79E-01	2.68E-01	7.69E-01	2.42E-01	1.85E-01	2.41E-01
6Uy	8.95E-02	3.19E-02	6.23E-02	1.59E-01	4.55E-02	4.93E-02	7.20E-02	1.05E-05	8.57E-06	1.42E-05	1.34E-05	6.26E-06	9.27E-06	8.42E-06
6Uz	9.07E-07	1.45E-07	4.04E-07	1.18E-06	1.38E-07	2.42E-07	5.79E-07	5.60E-06	2.48E-06	3.61E-06	8.83E-06	1.22E-06	2.54E-06	4.42E-06
6Θx	8.48E-05	2.97E-05	6.00E-05	1.53E-04	4.18E-05	4.67E-05	6.97E-05	4.50E-08	1.11E-08	1.95E-08	4.59E-08	6.98E-09	1.20E-08	2.46E-08
6Θy	7.06E-09	1.12E-09	2.90E-09	3.90E-09	1.09E-09	2.24E-09	3.20E-09	2.85E-04	1.72E-04	2.56E-04	7.39E-04	2.29E-04	1.81E-04	2.27E-04
6Θz	3.18E-09	1.03E-09	2.42E-09	5.55E-09	1.38E-09	1.32E-09	2.62E-09	2.74E-08	1.91E-08	2.58E-08	7.04E-08	1.71E-08	2.09E-08	2.03E-08
7Ux	3.00E-06	1.00E-06	2.42E-06	4.63E-06	1.15E-06	1.60E-06	3.60E-06	3.45E-01	2.07E-01	3.08E-01	8.88E-01	2.78E-01	2.14E-01	2.77E-01
7Uy	1.03E-01	3.66E-02	7.18E-02	1.83E-01	5.21E-02	5.67E-02	8.31E-02	1.79E-05	9.99E-06	1.68E-05	2.11E-05	7.33E-06	1.09E-05	1.14E-05
7Uz	9.42E-07	1.63E-07	4.50E-07	1.34E-06	1.59E-07	2.66E-07	6.57E-07	5.96E-06	2.68E-06	3.92E-06	9.56E-06	1.32E-06	2.76E-06	4.75E-06
7Θx	8.60E-05	3.02E-05	6.10E-05	1.56E-04	4.24E-05	4.74E-05	7.08E-05	4.79E-08	1.16E-08	2.03E-08	4.89E-08	7.24E-09	1.25E-08	2.63E-08
7Θy	7.57E-09	1.17E-09	3.01E-09	3.96E-09	1.12E-09	2.34E-09	3.28E-09	2.89E-04	1.75E-04	2.60E-04	7.50E-04	2.32E-04	1.84E-04	2.31E-04
7Θz	3.69E-09	1.18E-09	2.73E-09	6.09E-09	1.55E-09	1.58E-09	3.01E-09	2.85E-08	1.94E-08	2.52E-08	7.42E-08	1.84E-08	2.15E-08	2.08E-08

Table 3.4.3 (Cont'd)

Nodes	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
8Ux	4.22E-06	1.19E-06	2.92E-06	5.22E-06	1.33E-06	2.00E-06	4.05E-06	3.88E-01	2.33E-01	3.47E-01	9.99E-01	3.13E-01	2.41E-01	3.11E-01
8Uy	1.16E-01	4.10E-02	8.08E-02	2.06E-01	5.82E-02	6.37E-02	9.36E-02	2.68E-05	1.15E-05	1.98E-05	2.98E-05	8.35E-06	1.29E-05	1.50E-05
8Uz	9.45E-07	1.79E-07	4.92E-07	1.49E-06	1.79E-07	2.87E-07	7.29E-07	6.13E-06	2.83E-06	4.16E-06	1.01E-05	1.41E-06	2.96E-06	4.96E-06
8Θx	8.63E-05	3.03E-05	6.12E-05	1.56E-04	4.25E-05	4.76E-05	7.10E-05	4.88E-08	1.18E-08	2.07E-08	4.99E-08	7.34E-09	1.26E-08	2.69E-08
8Θy	7.72E-09	1.18E-09	3.04E-09	3.98E-09	1.12E-09	2.37E-09	3.31E-09	2.90E-04	1.76E-04	2.61E-04	7.53E-04	2.33E-04	1.85E-04	2.32E-04
8Θz	4.19E-09	1.33E-09	3.05E-09	6.75E-09	1.73E-09	1.84E-09	3.39E-09	2.96E-08	2.00E-08	2.51E-08	7.80E-08	1.98E-08	2.22E-08	2.13E-08
9Ux	4.16E-06	1.21E-06	2.93E-06	5.24E-06	1.35E-06	2.05E-06	4.00E-06	3.88E-01	2.33E-01	3.47E-01	9.99E-01	3.13E-01	2.41E-01	3.11E-01
9Uy	1.16E-01	4.10E-02	8.08E-02	2.06E-01	5.82E-02	6.37E-02	9.36E-02	2.80E-05	1.44E-05	2.49E-05	3.97E-05	1.08E-05	1.55E-05	1.71E-05
9Uz	6.73E-03	2.36E-03	4.77E-03	1.22E-02	3.32E-03	3.71E-03	5.54E-03	6.96E-02	4.22E-02	6.27E-02	1.81E-01	5.60E-02	4.44E-02	5.56E-02
9Θx	8.63E-05	3.03E-05	6.12E-05	1.56E-04	4.25E-05	4.76E-05	7.10E-05	4.88E-08	1.18E-08	2.07E-08	4.99E-08	7.34E-09	1.26E-08	2.69E-08
9Θy	7.72E-09	1.18E-09	3.04E-09	3.98E-09	1.12E-09	2.37E-09	3.31E-09	2.90E-04	1.76E-04	2.61E-04	7.53E-04	2.33E-04	1.85E-04	2.32E-04
9Θz	4.19E-09	1.33E-09	3.05E-09	6.75E-09	1.73E-09	1.84E-09	3.39E-09	2.96E-08	2.00E-08	2.51E-08	7.80E-08	1.98E-08	2.22E-08	2.13E-08
10Ux	1.35E-05	2.34E-06	6.52E-06	1.38E-05	2.46E-06	3.98E-06	9.52E-06	3.89E-01	2.33E-01	3.48E-01	1.00E+00	3.14E-01	2.42E-01	3.12E-01
10Uy	1.24E-01	4.36E-02	8.60E-02	2.20E-01	6.16E-02	6.85E-02	1.01E-01	5.28E-03	3.84E-03	6.00E-03	8.34E-03	2.44E-03	2.92E-03	3.40E-03
10Uz	7.71E-03	2.42E-03	5.04E-03	1.24E-02	3.46E-03	4.05E-03	6.02E-03	4.64E-02	3.15E-02	3.98E-02	1.12E-01	3.45E-02	3.16E-02	3.66E-02
10Θx	1.84E-04	7.01E-05	1.56E-04	4.22E-04	8.73E-05	1.02E-04	2.16E-04	6.08E-05	4.55E-05	5.92E-05	1.16E-04	3.00E-05	4.54E-05	4.98E-05
10Θy	2.81E-05	4.31E-06	1.08E-05	2.22E-05	4.57E-06	6.18E-06	1.53E-05	4.30E-04	3.22E-04	5.40E-04	9.46E-04	2.95E-04	3.90E-04	3.24E-04
10Θz	1.26E-04	4.40E-05	8.33E-05	2.09E-04	5.24E-05	6.85E-05	1.01E-04	8.87E-05	6.69E-05	1.05E-04	1.45E-04	4.26E-05	5.01E-05	5.69E-05
11Ux	2.46E-05	4.21E-06	1.14E-05	2.76E-05	4.02E-06	6.62E-06	1.76E-05	3.90E-01	2.34E-01	3.50E-01	1.00E+00	3.14E-01	2.43E-01	3.12E-01
11Uy	1.27E-01	4.44E-02	8.71E-02	2.24E-01	6.27E-02	7.03E-02	1.03E-01	9.49E-03	7.31E-03	1.15E-02	1.59E-02	4.65E-03	5.45E-03	6.09E-03
11Uz	7.84E-03	2.44E-03	5.32E-03	1.24E-02	3.58E-03	4.27E-03	6.17E-03	3.53E-02	3.01E-02	4.82E-02	7.15E-02	2.24E-02	2.16E-02	2.53E-02
11Θx	3.26E-04	1.27E-04	2.95E-04	7.88E-04	1.40E-04	1.71E-04	4.11E-04	1.22E-04	9.10E-05	1.18E-04	2.32E-04	5.99E-05	9.07E-05	9.95E-05
11Θy	1.43E-05	1.94E-06	3.68E-06	7.18E-06	1.39E-06	2.23E-06	4.19E-06	3.15E-04	1.90E-04	2.54E-04	7.29E-04	2.38E-04	1.85E-04	2.40E-04
11Θz	7.79E-05	2.23E-05	4.74E-05	1.25E-04	2.76E-05	3.62E-05	5.79E-05	1.57E-05	7.15E-06	9.53E-06	2.58E-05	4.01E-06	7.12E-06	1.40E-05
12Ux	3.63E-05	6.06E-06	1.61E-05	4.14E-05	5.56E-06	9.75E-06	2.58E-05	3.90E-01	2.34E-01	3.51E-01	1.01E+00	3.15E-01	2.44E-01	3.13E-01
12Uy	1.16E-01	4.10E-02	8.08E-02	2.06E-01	5.82E-02	6.37E-02	9.36E-02	2.68E-05	1.15E-05	1.98E-05	2.98E-05	8.35E-06	1.29E-05	1.50E-05
12Uz	6.74E-03	2.36E-03	4.77E-03	1.22E-02	3.32E-03	3.71E-03	5.54E-03	7.24E-06	3.10E-06	5.29E-06	1.24E-05	1.86E-06	3.06E-06	5.20E-06
12Θx	4.68E-04	1.87E-04	4.44E-04	1.15E-03	1.98E-04	2.43E-04	6.09E-04	1.82E-04	1.37E-04	1.78E-04	3.48E-04	8.99E-05	1.36E-04	1.49E-04
12Θy	4.43E-05	1.08E-05	2.49E-05	7.01E-05	1.12E-05	1.33E-05	4.05E-05	8.81E-04	7.85E-04	1.21E-03	1.73E-03	4.82E-04	5.40E-04	6.67E-04
12Θz	1.91E-04	7.03E-05	1.26E-04	2.95E-04	8.34E-05	1.05E-04	1.59E-04	2.36E-04	1.98E-04	3.10E-04	4.28E-04	1.25E-04	1.44E-04	1.52E-04
13Ux	9.36E-04	2.84E-04	5.87E-04	1.93E-03	2.81E-04	3.30E-04	1.03E-03	3.94E-01	2.37E-01	3.90E-01	1.01E+00	3.22E-01	2.72E-01	3.16E-01
13Uy	1.15E-01	4.06E-02	8.56E-02	2.11E-01	5.73E-02	5.76E-02	9.08E-02	9.27E-03	8.34E-03	1.32E-02	1.73E-02	5.15E-03	5.05E-03	5.75E-03
13Uz	7.38E-03	2.37E-03	5.22E-03	1.34E-02	3.18E-03	3.40E-03	5.52E-03	3.54E-02	3.31E-02	4.83E-02	7.31E-02	1.94E-02	2.54E-02	2.71E-02
13Θx	6.04E-04	2.40E-04	5.66E-04	1.48E-03	2.53E-04	3.16E-04	7.81E-04	1.29E-04	1.02E-04	1.73E-04	2.18E-04	6.29E-05	8.95E-05	1.24E-04
13Θy	3.43E-05	9.39E-06	1.57E-05	5.29E-05	7.34E-06	1.10E-05	3.21E-05	3.10E-03	2.96E-03	4.28E-03	6.43E-03	1.72E-03	2.25E-03	2.32E-03
13Θz	2.76E-04	1.01E-04	2.26E-04	5.91E-04	1.15E-04	1.39E-04	3.21E-04	7.01E-04	6.22E-04	9.71E-04	1.34E-03	3.93E-04	4.49E-04	4.47E-04

Table 3.4.3 (Cont'd)

Nodes	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
14Ux	2.88E-03	7.57E-04	1.18E-03	3.91E-03	5.35E-04	9.60E-04	2.71E-03	4.33E-01	3.44E-01	5.78E-01	9.90E-01	3.43E-01	4.19E-01	3.52E-01
14Uy	1.15E-01	4.66E-02	1.05E-01	2.86E-01	6.03E-02	4.48E-02	1.20E-01	1.44E-02	1.34E-02	2.27E-02	2.70E-02	8.40E-03	9.88E-03	1.25E-02
14Uz	7.45E-03	2.37E-03	5.26E-03	1.35E-02	3.17E-03	3.38E-03	5.52E-03	3.57E-02	3.33E-02	4.86E-02	7.37E-02	1.95E-02	2.56E-02	2.74E-02
14Θx	4.04E-04	1.59E-04	3.42E-04	9.04E-04	1.97E-04	2.35E-04	4.69E-04	5.46E-05	4.71E-05	7.37E-05	8.12E-05	3.48E-05	5.90E-05	5.27E-05
14Θy	1.56E-05	3.93E-06	7.93E-06	2.00E-05	3.76E-06	5.67E-06	1.22E-05	1.94E-03	1.81E-03	2.73E-03	3.99E-03	1.10E-03	1.21E-03	1.39E-03
14Θz	2.52E-04	9.22E-05	2.04E-04	5.35E-04	1.05E-04	1.26E-04	2.91E-04	1.06E-03	9.49E-04	1.46E-03	2.03E-03	5.93E-04	6.91E-04	6.78E-04
15Ux	2.19E-03	6.68E-04	9.85E-04	3.12E-03	4.91E-04	9.03E-04	2.31E-03	4.28E-01	3.44E-01	5.53E-01	8.47E-01	3.02E-01	3.99E-01	3.40E-01
15Uy	1.02E-01	4.28E-02	9.60E-02	2.71E-01	5.42E-02	4.21E-02	1.16E-01	1.19E-02	1.14E-02	1.94E-02	2.21E-02	7.23E-03	8.99E-03	1.09E-02
15Uz	7.52E-03	2.37E-03	5.30E-03	1.36E-02	3.17E-03	3.36E-03	5.52E-03	3.59E-02	3.35E-02	4.88E-02	7.42E-02	1.96E-02	2.58E-02	2.76E-02
15Θx	3.28E-04	1.39E-04	3.27E-04	9.79E-04	1.43E-04	1.66E-04	4.82E-04	9.17E-05	8.38E-05	1.39E-04	1.77E-04	5.11E-05	5.87E-05	8.44E-05
15Θy	2.32E-05	5.10E-06	9.51E-06	3.13E-05	4.37E-06	6.75E-06	1.91E-05	1.77E-03	1.52E-03	2.18E-03	3.28E-03	9.54E-04	1.54E-03	1.27E-03
15Θz	2.28E-04	8.31E-05	1.83E-04	4.79E-04	9.50E-05	1.13E-04	2.61E-04	1.42E-03	1.28E-03	1.95E-03	2.72E-03	7.95E-04	9.34E-04	9.12E-04
16Ux	2.05E-06	8.50E-07	1.89E-06	4.00E-06	9.92E-07	1.30E-06	3.09E-06	3.00E-01	1.79E-01	2.68E-01	7.69E-01	2.42E-01	1.85E-01	2.41E-01
16Uy	8.95E-02	3.19E-02	6.23E-02	1.59E-01	4.55E-02	4.93E-02	7.20E-02	1.03E-05	8.42E-06	1.41E-05	1.27E-05	6.11E-06	9.17E-06	8.26E-06
16Uz	7.58E-03	2.37E-03	5.34E-03	1.36E-02	3.17E-03	3.34E-03	5.51E-03	3.61E-02	3.36E-02	4.90E-02	7.46E-02	1.97E-02	2.59E-02	2.78E-02
16Θx	1.22E-03	4.75E-04	1.06E-03	2.79E-03	5.59E-04	6.66E-04	1.47E-03	2.08E-04	1.79E-04	3.07E-04	3.17E-04	1.20E-04	1.54E-04	1.53E-04
16Θy	3.62E-05	1.13E-05	1.80E-05	4.92E-05	9.80E-06	1.46E-05	3.15E-05	5.91E-03	5.57E-03	8.31E-03	1.18E-02	3.32E-03	3.97E-03	4.28E-03
16Θz	2.04E-04	7.39E-05	1.62E-04	4.23E-04	8.49E-05	1.01E-04	2.31E-04	1.78E-03	1.61E-03	2.45E-03	3.41E-03	9.96E-04	1.18E-03	1.15E-03
17Ux	3.48E-03	1.18E-03	2.06E-03	5.13E-03	1.09E-03	1.66E-03	3.33E-03	6.75E-01	6.37E-01	9.57E-01	1.50E+00	4.52E-01	4.46E-01	4.91E-01
17Uy	1.93E-01	7.72E-02	1.44E-01	3.49E-01	9.86E-02	1.24E-01	1.92E-01	2.02E-02	1.64E-02	2.76E-02	2.63E-02	1.14E-02	1.56E-02	1.38E-02
17Uz	7.62E-03	2.37E-03	5.37E-03	1.37E-02	3.16E-03	3.31E-03	5.50E-03	3.62E-02	3.37E-02	4.92E-02	7.49E-02	1.98E-02	2.60E-02	2.80E-02
17Θx	1.56E-03	6.23E-04	1.32E-03	3.36E-03	7.68E-04	9.29E-04	1.77E-03	2.10E-04	1.86E-04	3.02E-04	2.82E-04	1.29E-04	1.80E-04	1.60E-04
17Θy	3.86E-05	1.42E-05	2.60E-05	6.36E-05	1.40E-05	2.01E-05	4.25E-05	7.35E-03	6.85E-03	1.03E-02	1.49E-02	4.13E-03	4.41E-03	5.08E-03
17Θz	1.79E-04	6.48E-05	1.41E-04	3.66E-04	7.47E-05	8.78E-05	2.01E-04	2.14E-03	1.93E-03	2.94E-03	4.10E-03	1.20E-03	1.42E-03	1.38E-03
18Ux	5.21E-03	2.10E-03	3.74E-03	9.34E-03	2.05E-03	2.87E-03	6.08E-03	1.15E+00	1.08E+00	1.62E+00	2.45E+00	6.99E-01	6.82E-01	8.15E-01
18Uy	2.79E-01	1.17E-01	2.19E-01	5.59E-01	1.47E-01	1.83E-01	3.04E-01	3.03E-02	2.77E-02	4.52E-02	4.22E-02	1.93E-02	2.66E-02	2.33E-02
18Uz	7.66E-03	2.37E-03	5.39E-03	1.37E-02	3.16E-03	3.29E-03	5.48E-03	3.64E-02	3.38E-02	4.93E-02	7.52E-02	1.98E-02	2.61E-02	2.81E-02
18Θx	5.95E-04	2.37E-04	5.00E-04	1.26E-03	2.90E-04	3.53E-04	6.69E-04	1.32E-04	7.13E-05	1.22E-04	1.70E-04	4.79E-05	7.40E-05	9.29E-05
18Θy	3.94E-05	7.10E-06	1.79E-05	3.11E-05	7.26E-06	1.36E-05	2.27E-05	3.10E-03	2.90E-03	4.29E-03	6.21E-03	1.73E-03	1.85E-03	2.19E-03
18Θz	1.55E-04	5.57E-05	1.20E-04	3.10E-04	6.45E-05	7.60E-05	1.72E-04	2.50E-03	2.26E-03	3.43E-03	4.79E-03	1.40E-03	1.66E-03	1.62E-03
19Ux	6.13E-03	2.09E-03	4.19E-03	9.53E-03	2.13E-03	3.01E-03	6.36E-03	1.14E+00	1.07E+00	1.60E+00	2.41E+00	6.84E-01	6.70E-01	8.09E-01
19Uy	2.67E-01	1.12E-01	2.11E-01	5.37E-01	1.41E-01	1.75E-01	2.92E-01	3.00E-02	2.66E-02	4.40E-02	4.40E-02	1.84E-02	2.56E-02	2.26E-02
19Uz	7.69E-03	2.37E-03	5.41E-03	1.37E-02	3.16E-03	3.26E-03	5.46E-03	3.64E-02	3.38E-02	4.94E-02	7.53E-02	1.99E-02	2.61E-02	2.82E-02
19Θx	8.20E-04	3.39E-04	6.77E-04	1.73E-03	4.22E-04	5.16E-04	9.26E-04	1.28E-04	9.50E-05	1.60E-04	1.61E-04	6.62E-05	9.20E-05	8.95E-05
19Θy	2.41E-05	6.19E-06	1.09E-05	2.64E-05	5.65E-06	9.02E-06	1.83E-05	3.32E-03	3.10E-03	4.72E-03	7.01E-03	1.95E-03	1.97E-03	2.31E-03
19Θz	1.31E-04	4.66E-05	9.96E-05	2.54E-04	5.44E-05	6.43E-05	1.42E-04	2.86E-03	2.59E-03	3.92E-03	5.49E-03	1.60E-03	1.90E-03	1.86E-03

Table 3.4.3 (Cont'd)

Nodes	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
20Ux	3.97E-03	1.22E-03	2.53E-03	5.43E-03	1.22E-03	1.79E-03	3.72E-03	6.48E-01	6.12E-01	9.10E-01	1.39E+00	4.09E-01	4.07E-01	4.68E-01
20Uy	1.61E-01	6.59E-02	1.21E-01	3.00E-01	8.38E-02	1.05E-01	1.65E-01	1.67E-02	1.40E-02	2.37E-02	2.48E-02	9.64E-03	1.37E-02	1.30E-02
20Uz	7.71E-03	2.36E-03	5.43E-03	1.37E-02	3.16E-03	3.23E-03	5.44E-03	3.65E-02	3.38E-02	4.94E-02	7.53E-02	1.99E-02	2.61E-02	2.82E-02
20Θx	1.64E-03	6.76E-04	1.35E-03	3.44E-03	8.39E-04	1.03E-03	1.84E-03	2.24E-04	1.82E-04	3.03E-04	3.19E-04	1.26E-04	1.77E-04	1.63E-04
20Θy	4.54E-05	1.40E-05	2.90E-05	6.44E-05	1.44E-05	2.14E-05	4.29E-05	7.46E-03	6.97E-03	1.05E-02	1.54E-02	4.27E-03	4.33E-03	5.24E-03
20Θz	1.07E-04	3.74E-05	7.87E-05	2.04E-04	4.42E-05	5.25E-05	1.13E-04	3.22E-03	2.92E-03	4.41E-03	6.18E-03	1.80E-03	2.14E-03	2.10E-03
21Ux	3.94E-06	5.91E-07	1.46E-06	2.02E-06	5.61E-07	1.22E-06	1.71E-06	1.56E-01	9.19E-02	1.38E-01	3.95E-01	1.26E-01	9.45E-02	1.26E-01
21Uy	4.68E-02	1.69E-02	3.20E-02	8.16E-02	2.45E-02	2.58E-02	3.70E-02	2.47E-05	5.35E-06	9.73E-06	2.42E-05	3.40E-06	6.01E-06	1.29E-05
21Uz	7.72E-03	2.36E-03	5.44E-03	1.37E-02	3.16E-03	3.20E-03	5.41E-03	3.64E-02	3.37E-02	4.94E-02	7.53E-02	1.99E-02	2.61E-02	2.83E-02
21Θx	1.05E-03	4.34E-04	8.64E-04	2.18E-03	5.38E-04	6.57E-04	1.18E-03	1.68E-04	1.16E-04	2.03E-04	2.32E-04	8.07E-05	1.13E-04	1.38E-04
21Θy	3.38E-05	1.27E-05	2.62E-05	5.53E-05	1.22E-05	1.80E-05	3.87E-05	5.87E-03	5.46E-03	8.07E-03	1.17E-02	3.27E-03	3.30E-03	4.06E-03
21Θz	8.34E-05	2.83E-05	5.79E-05	1.54E-04	3.41E-05	4.08E-05	8.62E-05	3.58E-03	3.25E-03	4.91E-03	6.87E-03	2.00E-03	2.39E-03	2.34E-03
22Ux	3.15E-03	7.53E-04	1.88E-03	3.84E-03	7.89E-04	1.27E-03	2.39E-03	2.97E-01	2.70E-01	4.09E-01	5.68E-01	1.68E-01	2.35E-01	2.16E-01
22Uy	3.08E-02	1.65E-02	3.51E-02	1.08E-01	2.10E-02	1.74E-02	4.52E-02	1.26E-02	4.59E-03	7.95E-03	1.69E-02	3.59E-03	5.03E-03	8.41E-03
22Uz	7.72E-03	2.35E-03	5.45E-03	1.37E-02	3.16E-03	3.17E-03	5.37E-03	3.64E-02	3.37E-02	4.93E-02	7.52E-02	1.98E-02	2.60E-02	2.82E-02
22Θx	6.48E-05	2.27E-05	5.45E-05	1.72E-04	2.61E-05	2.77E-05	7.58E-05	9.80E-05	5.10E-05	8.43E-05	1.52E-04	3.04E-05	4.97E-05	5.76E-05
22Θy	2.65E-05	6.61E-06	1.60E-05	3.94E-05	8.05E-06	9.69E-06	1.98E-05	1.61E-03	1.46E-03	2.16E-03	3.16E-03	8.83E-04	9.80E-04	1.07E-03
22Θz	6.78E-05	2.04E-05	4.00E-05	1.05E-04	2.40E-05	2.90E-05	5.93E-05	3.94E-03	3.58E-03	5.40E-03	7.56E-03	2.21E-03	2.63E-03	2.57E-03
23Ux	3.85E-03	1.00E-03	2.60E-03	6.64E-03	1.33E-03	1.60E-03	3.55E-03	3.17E-01	2.87E-01	4.46E-01	6.15E-01	1.84E-01	2.51E-01	2.25E-01
23Uy	2.99E-02	1.14E-02	2.34E-02	6.10E-02	1.72E-02	1.38E-02	2.42E-02	1.49E-02	9.72E-03	1.41E-02	2.60E-02	5.65E-03	7.53E-03	9.81E-03
23Uz	7.71E-03	2.34E-03	5.46E-03	1.37E-02	3.15E-03	3.14E-03	5.34E-03	3.63E-02	3.36E-02	4.91E-02	7.49E-02	1.98E-02	2.59E-02	2.82E-02
23Θx	3.59E-04	1.39E-04	3.19E-04	7.81E-04	1.58E-04	1.94E-04	4.38E-04	1.82E-04	1.54E-04	2.58E-04	3.33E-04	1.01E-04	1.03E-04	1.13E-04
23Θy	2.73E-05	6.33E-06	9.40E-06	2.91E-05	7.72E-06	6.46E-06	1.50E-05	6.76E-04	4.77E-04	7.37E-04	1.29E-03	3.09E-04	3.96E-04	4.64E-04
23Θz	6.24E-05	1.40E-05	2.79E-05	6.80E-05	1.89E-05	2.05E-05	3.87E-05	4.30E-03	3.91E-03	5.89E-03	8.25E-03	2.41E-03	2.87E-03	2.81E-03
24Ux	2.59E-03	8.69E-04	2.09E-03	5.78E-03	1.14E-03	1.25E-03	3.04E-03	2.24E-01	2.01E-01	3.16E-01	4.31E-01	1.35E-01	1.88E-01	1.70E-01
24Uy	3.00E-02	1.12E-02	2.12E-02	5.13E-02	1.66E-02	1.57E-02	2.29E-02	1.86E-02	1.44E-02	2.13E-02	3.67E-02	8.30E-03	1.03E-02	1.31E-02
24Uz	7.39E-03	2.33E-03	4.75E-03	1.21E-02	3.00E-03	3.90E-03	6.04E-03	2.90E-02	2.66E-02	3.88E-02	5.92E-02	1.56E-02	2.04E-02	2.26E-02
24Θx	1.05E-04	3.22E-05	7.10E-05	1.88E-04	4.26E-05	4.88E-05	7.90E-05	5.20E-04	4.74E-04	6.76E-04	1.06E-03	2.73E-04	3.92E-04	3.92E-04
24Θy	3.69E-05	6.94E-06	1.74E-05	3.59E-05	7.79E-06	1.25E-05	1.92E-05	1.10E-03	9.01E-04	1.35E-03	2.06E-03	5.35E-04	6.79E-04	7.68E-04
24Θz	5.32E-05	1.38E-05	3.43E-05	9.01E-05	1.85E-05	2.14E-05	4.66E-05	4.16E-03	3.78E-03	5.72E-03	8.02E-03	2.34E-03	2.81E-03	2.75E-03
25Ux	3.61E-06	4.47E-07	1.10E-06	1.25E-06	3.75E-07	9.31E-07	1.15E-06	9.76E-02	5.70E-02	8.57E-02	2.46E-01	7.92E-02	5.86E-02	7.89E-02
25Uy	3.00E-02	1.12E-02	2.11E-02	5.13E-02	1.66E-02	1.57E-02	2.30E-02	1.84E-02	1.44E-02	2.12E-02	3.66E-02	8.29E-03	1.02E-02	1.30E-02
25Uz	4.90E-07	6.04E-08	1.43E-07	5.03E-07	3.97E-08	1.03E-07	2.61E-07	3.36E-03	2.01E-03	3.00E-03	8.62E-03	2.70E-03	2.08E-03	2.69E-03
25Θx	1.23E-04	3.84E-05	7.78E-05	1.90E-04	4.91E-05	6.37E-05	9.77E-05	3.87E-04	3.52E-04	4.98E-04	7.63E-04	2.01E-04	2.91E-04	3.05E-04
25Θy	3.17E-05	6.25E-06	1.54E-05	3.42E-05	7.20E-06	1.09E-05	1.82E-05	9.39E-04	7.82E-04	1.15E-03	1.75E-03	4.60E-04	6.00E-04	6.66E-04
25Θz	5.00E-05	1.51E-05	3.41E-05	9.91E-05	1.91E-05	2.15E-05	5.14E-05	2.74E-03	2.51E-03	3.75E-03	5.46E-03	1.52E-03	1.84E-03	1.89E-03

Table 3.4.3 (Cont'd)

Nodes	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
26Ux	5.94E-03	1.32E-03	3.02E-03	7.83E-03	1.56E-03	1.91E-03	3.89E-03	1.38E-01	1.18E-01	1.69E-01	2.88E-01	9.82E-02	1.05E-01	1.05E-01
26Uy	3.00E-02	1.12E-02	2.10E-02	5.12E-02	1.65E-02	1.58E-02	2.29E-02	1.82E-02	1.43E-02	2.12E-02	3.63E-02	8.26E-03	1.02E-02	1.29E-02
26Uz	9.16E-03	2.56E-03	5.46E-03	1.37E-02	3.46E-03	4.44E-03	6.73E-03	1.88E-02	1.55E-02	2.20E-02	3.55E-02	8.46E-03	1.41E-02	1.44E-02
26Θx	5.21E-05	1.86E-05	3.71E-05	9.14E-05	2.66E-05	2.73E-05	4.08E-05	2.71E-05	1.34E-05	2.13E-05	5.09E-05	9.76E-06	1.59E-05	2.00E-05
26Θy	2.31E-05	5.25E-06	1.23E-05	3.13E-05	6.23E-06	8.18E-06	1.66E-05	6.73E-04	5.84E-04	8.41E-04	1.24E-03	3.35E-04	4.68E-04	4.96E-04
26Θz	1.87E-05	5.22E-06	1.07E-05	3.22E-05	6.85E-06	7.11E-06	1.44E-05	3.87E-04	3.45E-04	5.35E-04	7.31E-04	2.23E-04	2.62E-04	2.45E-04
27Ux	2.26E-03	7.80E-04	1.69E-03	4.96E-03	9.98E-04	1.00E-03	2.37E-03	1.02E-01	6.36E-02	7.79E-02	2.57E-01	8.12E-02	6.50E-02	8.14E-02
27Uy	2.99E-02	1.11E-02	2.09E-02	5.11E-02	1.64E-02	1.58E-02	2.29E-02	1.78E-02	1.43E-02	2.11E-02	3.59E-02	8.24E-03	1.01E-02	1.27E-02
27Uz	1.08E-02	3.70E-03	7.27E-03	1.88E-02	5.25E-03	5.91E-03	8.73E-03	9.59E-03	7.82E-03	1.13E-02	1.74E-02	4.71E-03	7.52E-03	7.03E-03
27Θx	4.70E-05	1.55E-05	3.12E-05	8.56E-05	2.37E-05	1.72E-05	3.07E-05	1.91E-04	1.42E-04	2.04E-04	3.49E-04	7.99E-05	1.22E-04	1.42E-04
27Θy	2.06E-05	4.89E-06	1.07E-05	2.91E-05	5.94E-06	7.29E-06	1.53E-05	4.86E-04	4.25E-04	6.16E-04	8.92E-04	2.35E-04	3.73E-04	3.61E-04
27Θz	8.70E-05	1.99E-05	4.41E-05	1.17E-04	2.41E-05	2.73E-05	5.71E-05	1.46E-03	1.17E-03	1.73E-03	2.79E-03	6.82E-04	8.19E-04	9.73E-04
28Ux	1.34E-04	1.51E-05	3.23E-05	5.21E-05	1.39E-05	2.89E-05	2.34E-05	9.85E-02	5.78E-02	8.57E-02	2.48E-01	8.01E-02	5.85E-02	7.98E-02
28Uy	2.94E-02	1.08E-02	1.99E-02	5.07E-02	1.57E-02	1.63E-02	2.29E-02	2.23E-05	3.93E-06	7.54E-06	2.18E-05	2.29E-06	4.31E-06	1.15E-05
28Uz	1.11E-02	3.92E-03	7.73E-03	1.97E-02	5.57E-03	6.09E-03	8.94E-03	4.51E-06	1.47E-06	1.89E-06	4.61E-06	7.65E-07	1.36E-06	2.38E-06
28Θx	4.91E-05	1.61E-05	3.16E-05	8.39E-05	2.43E-05	1.94E-05	3.16E-05	1.08E-04	4.62E-05	7.79E-05	1.65E-04	4.01E-05	6.16E-05	7.50E-05
28Θy	1.69E-05	3.38E-06	8.34E-06	2.40E-05	2.55E-06	4.33E-06	1.03E-05	2.43E-04	1.77E-04	3.01E-04	5.32E-04	1.71E-04	2.20E-04	1.93E-04
28Θz	8.30E-05	3.18E-05	6.47E-05	1.74E-04	3.96E-05	4.90E-05	8.94E-05	5.19E-04	3.49E-04	5.04E-04	8.65E-04	1.99E-04	2.69E-04	3.84E-04
29Ux	1.01E-04	1.13E-05	2.44E-05	3.92E-05	1.04E-05	2.17E-05	1.76E-05	9.84E-02	5.77E-02	8.58E-02	2.48E-01	7.99E-02	5.86E-02	7.97E-02
29Uy	3.28E-02	1.20E-02	2.22E-02	5.54E-02	1.79E-02	1.91E-02	2.60E-02	2.70E-02	1.23E-02	1.80E-02	3.62E-02	6.87E-03	1.01E-02	1.92E-02
29Uz	1.19E-02	4.00E-03	8.21E-03	2.10E-02	5.55E-03	6.27E-03	9.43E-03	1.32E-02	8.53E-03	1.52E-02	3.33E-02	1.01E-02	1.11E-02	1.07E-02
29Θx	4.97E-05	1.67E-05	3.27E-05	8.31E-05	2.51E-05	2.21E-05	3.39E-05	8.09E-05	3.47E-05	5.84E-05	1.24E-04	3.00E-05	4.62E-05	5.62E-05
29Θy	1.60E-05	2.95E-06	6.56E-06	1.86E-05	2.56E-06	3.33E-06	8.07E-06	2.19E-04	1.25E-04	2.10E-04	5.50E-04	1.63E-04	1.51E-04	1.70E-04
29Θz	6.68E-05	2.16E-05	3.79E-05	1.00E-04	3.51E-05	3.46E-05	4.16E-05	3.02E-04	8.32E-05	1.30E-04	3.69E-04	4.40E-05	8.02E-05	2.05E-04
30Ux	6.82E-05	7.52E-06	1.64E-05	2.61E-05	6.85E-06	1.45E-05	1.18E-05	9.82E-02	5.75E-02	8.58E-02	2.47E-01	7.98E-02	5.86E-02	7.95E-02
30Uy	3.43E-02	1.26E-02	2.29E-02	5.70E-02	1.90E-02	1.99E-02	2.67E-02	3.24E-02	1.16E-02	1.73E-02	4.08E-02	6.30E-03	9.94E-03	2.25E-02
30Uz	1.23E-02	4.04E-03	8.36E-03	2.14E-02	5.57E-03	6.36E-03	9.63E-03	2.54E-02	1.50E-02	2.54E-02	6.43E-02	1.94E-02	1.82E-02	2.01E-02
30Θx	5.09E-05	1.77E-05	3.44E-05	8.23E-05	2.61E-05	2.49E-05	3.69E-05	5.39E-05	2.31E-05	3.89E-05	8.27E-05	2.00E-05	3.08E-05	3.75E-05
30Θy	4.22E-06	8.18E-07	2.02E-06	5.76E-06	6.11E-07	1.07E-06	2.51E-06	1.83E-04	1.17E-04	1.39E-04	4.71E-04	1.46E-04	1.15E-04	1.50E-04
30Θz	2.01E-05	7.57E-06	1.53E-05	4.13E-05	9.34E-06	1.17E-05	2.12E-05	1.28E-04	8.28E-05	1.20E-04	2.08E-04	4.70E-05	6.44E-05	9.50E-05
31Ux	3.45E-05	3.68E-06	8.20E-06	1.29E-05	3.31E-06	7.08E-06	5.93E-06	9.79E-02	5.73E-02	8.58E-02	2.47E-01	7.95E-02	5.86E-02	7.92E-02
31Uy	3.19E-02	1.18E-02	2.10E-02	5.40E-02	1.75E-02	1.80E-02	2.48E-02	1.51E-02	4.61E-03	7.06E-03	1.88E-02	2.46E-03	4.16E-03	1.04E-02
31Uz	1.16E-02	3.98E-03	8.05E-03	2.06E-02	5.57E-03	6.24E-03	9.30E-03	3.53E-02	2.06E-02	3.24E-02	8.99E-02	2.78E-02	2.27E-02	2.79E-02
31Θx	5.20E-05	1.87E-05	3.63E-05	8.92E-05	2.70E-05	2.77E-05	4.03E-05	2.70E-05	1.16E-05	1.95E-05	4.14E-05	1.00E-05	1.54E-05	1.87E-05
31Θy	1.76E-05	3.29E-06	7.37E-06	2.10E-05	2.79E-06	3.64E-06	9.00E-06	1.82E-04	1.10E-04	1.44E-04	4.14E-04	1.34E-04	1.08E-04	1.45E-04
31Θz	7.50E-05	2.30E-05	4.30E-05	1.17E-04	3.77E-05	3.95E-05	5.03E-05	3.49E-04	1.18E-04	1.77E-04	4.38E-04	6.37E-05	1.02E-04	2.41E-04

Table 3.4.3 (Cont'd)

Nodes	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
32Ux	3.53E-06	4.77E-07	1.16E-06	1.34E-06	4.25E-07	9.17E-07	1.26E-06	9.76E-02	5.70E-02	8.57E-02	2.46E-01	7.92E-02	5.86E-02	7.89E-02
32Uy	2.94E-02	1.08E-02	1.99E-02	5.07E-02	1.57E-02	1.63E-02	2.29E-02	2.23E-05	5.22E-06	8.86E-06	2.54E-05	3.10E-06	5.35E-06	1.14E-05
32Uz	1.11E-02	3.92E-03	7.72E-03	1.97E-02	5.57E-03	6.09E-03	8.94E-03	4.47E-02	2.68E-02	4.00E-02	1.15E-01	3.60E-02	2.77E-02	3.58E-02
32Θx	5.59E-05	1.98E-05	3.90E-05	9.97E-05	2.81E-05	3.08E-05	4.52E-05	1.01E-08	5.50E-09	9.31E-09	1.20E-08	4.08E-09	6.04E-09	6.28E-09
32Θy	1.68E-09	5.52E-10	1.32E-09	2.51E-09	6.31E-10	8.83E-10	1.94E-09	1.86E-04	1.12E-04	1.67E-04	4.79E-04	1.50E-04	1.16E-04	1.49E-04
32Θz	1.55E-09	5.69E-10	1.23E-09	2.96E-09	8.22E-10	7.13E-10	1.31E-09	1.48E-08	8.19E-09	1.20E-08	2.84E-08	5.95E-09	9.31E-09	9.59E-09

Table 3.4.4 Maximum element forces and moments for P-components (group#1) of bench-mark problem #4a and #4b.

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$1R_{i1}$	1.03E+00	1.16E-01	3.19E-01	1.04E+00	9.18E-02	2.01E-01	5.18E-01	5.39E+00	2.63E+00	3.80E+00	8.82E+00	1.32E+00	2.81E+00	4.21E+00
$1R_{i2}$	3.41E+00	3.06E-01	7.87E-01	5.58E-01	2.33E-01	7.15E-01	6.09E-01	4.61E+04	2.62E+04	3.99E+04	1.14E+05	3.80E+04	2.69E+04	3.78E+04
$1R_{i3}$	1.40E+04	5.37E+03	9.18E+03	2.33E+04	8.09E+03	7.82E+03	1.05E+04	2.02E+01	2.82E+00	6.25E+00	2.05E+01	1.37E+00	3.32E+00	1.03E+01
$1M_{i1}$	1.75E+02	6.41E+01	1.39E+02	3.34E+02	9.25E+01	8.03E+01	1.48E+02	1.67E+03	9.23E+02	1.35E+03	3.20E+03	6.70E+02	1.05E+03	1.08E+03
$1M_{i2}$	1.29E+07	4.63E+06	8.86E+06	2.26E+07	6.68E+06	7.10E+06	1.02E+07	4.28E+03	1.35E+03	2.39E+03	4.54E+03	8.90E+02	1.52E+03	2.30E+03
$1M_{i3}$	6.43E+02	1.44E+02	3.42E+02	5.73E+02	1.51E+02	2.62E+02	4.70E+02	4.34E+07	2.57E+07	3.85E+07	1.11E+08	3.51E+07	2.65E+07	3.50E+07
$1R_{j1}$	1.03E+00	1.16E-01	3.19E-01	1.04E+00	9.18E-02	2.01E-01	5.18E-01	5.39E+00	2.63E+00	3.80E+00	8.82E+00	1.32E+00	2.81E+00	4.21E+00
$1R_{j2}$	3.41E+00	3.06E-01	7.87E-01	5.58E-01	2.33E-01	7.15E-01	6.09E-01	4.61E+04	2.62E+04	3.99E+04	1.14E+05	3.80E+04	2.69E+04	3.78E+04
$1R_{j3}$	1.40E+04	5.37E+03	9.18E+03	2.33E+04	8.09E+03	7.82E+03	1.05E+04	2.02E+01	2.82E+00	6.25E+00	2.05E+01	1.37E+00	3.32E+00	1.03E+01
$1M_{j1}$	1.75E+02	6.41E+01	1.39E+02	3.34E+02	9.25E+01	8.03E+01	1.48E+02	1.67E+03	9.23E+02	1.35E+03	3.20E+03	6.70E+02	1.05E+03	1.08E+03
$1M_{j2}$	9.75E+06	3.45E+06	6.82E+06	1.74E+07	4.88E+06	5.36E+06	7.91E+06	2.04E+03	9.77E+02	1.66E+03	2.34E+03	7.16E+02	1.08E+03	1.19E+03
$1M_{j3}$	3.32E+02	1.01E+02	2.44E+02	4.49E+02	1.14E+02	1.66E+02	3.45E+02	3.32E+07	1.99E+07	2.97E+07	8.55E+07	2.67E+07	2.07E+07	2.66E+07
$2R_{i1}$	9.54E-01	1.11E-01	3.09E-01	1.00E+00	8.94E-02	1.91E-01	4.99E-01	5.15E+00	2.56E+00	3.73E+00	8.57E+00	1.30E+00	2.76E+00	4.04E+00
$2R_{i2}$	2.47E+00	2.49E-01	6.20E-01	5.43E-01	1.90E-01	5.51E-01	5.50E-01	4.34E+04	2.50E+04	3.76E+04	1.08E+05	3.50E+04	2.57E+04	3.49E+04
$2R_{i3}$	1.30E+04	4.76E+03	8.65E+03	2.21E+04	6.99E+03	7.13E+03	9.97E+03	1.52E+01	2.22E+00	4.64E+00	1.47E+01	1.16E+00	2.51E+00	7.70E+00
$2M_{i1}$	1.75E+02	6.41E+01	1.39E+02	3.34E+02	9.25E+01	8.03E+01	1.48E+02	1.67E+03	9.23E+02	1.35E+03	3.20E+03	6.70E+02	1.05E+03	1.08E+03
$2M_{i2}$	9.75E+06	3.45E+06	6.82E+06	1.74E+07	4.88E+06	5.36E+06	7.91E+06	2.04E+03	9.77E+02	1.66E+03	2.34E+03	7.16E+02	1.08E+03	1.19E+03
$2M_{i3}$	3.32E+02	1.01E+02	2.44E+02	4.49E+02	1.14E+02	1.66E+02	3.45E+02	3.32E+07	1.99E+07	2.97E+07	8.55E+07	2.67E+07	2.07E+07	2.66E+07
$2R_{j1}$	9.54E-01	1.11E-01	3.09E-01	1.00E+00	8.94E-02	1.91E-01	4.99E-01	5.15E+00	2.56E+00	3.73E+00	8.57E+00	1.30E+00	2.76E+00	4.04E+00
$2R_{j2}$	2.47E+00	2.49E-01	6.20E-01	5.43E-01	1.90E-01	5.51E-01	5.50E-01	4.34E+04	2.50E+04	3.76E+04	1.08E+05	3.50E+04	2.57E+04	3.49E+04
$2R_{j3}$	1.30E+04	4.76E+03	8.65E+03	2.21E+04	6.99E+03	7.13E+03	9.97E+03	1.52E+01	2.22E+00	4.64E+00	1.47E+01	1.16E+00	2.51E+00	7.70E+00
$2M_{j1}$	1.75E+02	6.41E+01	1.39E+02	3.34E+02	9.25E+01	8.03E+01	1.48E+02	1.67E+03	9.23E+02	1.35E+03	3.20E+03	6.70E+02	1.05E+03	1.08E+03
$2M_{j2}$	6.88E+06	2.39E+06	4.90E+06	1.25E+07	3.33E+06	3.78E+06	5.70E+06	4.77E+03	1.00E+03	1.82E+03	4.81E+03	6.05E+02	1.08E+03	2.55E+03
$2M_{j3}$	7.67E+02	1.06E+02	2.70E+02	3.28E+02	9.61E+01	2.19E+02	2.76E+02	2.37E+07	1.44E+07	2.13E+07	6.16E+07	1.89E+07	1.53E+07	1.88E+07

Table 3.4.4 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$3R_{i1}$	8.33E-01	1.61E-01	4.23E-01	1.30E+00	1.61E-01	2.45E-01	6.32E-01	5.47E+00	2.04E+00	2.95E+00	7.77E+00	9.60E-01	1.96E+00	4.21E+00
$3R_{i2}$	1.06E+00	1.51E-01	4.03E-01	4.88E-01	1.38E-01	3.36E-01	4.25E-01	3.90E+04	2.30E+04	3.44E+04	9.87E+04	3.12E+04	2.38E+04	3.12E+04
$3R_{i3}$	1.15E+04	4.10E+03	7.89E+03	2.02E+04	5.88E+03	6.31E+03	9.14E+03	6.76E+00	1.45E+00	2.60E+00	7.21E+00	8.29E-01	1.53E+00	3.59E+00
$3M_{i1}$	1.13E+02	3.54E+01	9.68E+01	2.45E+02	4.10E+01	4.12E+01	1.03E+02	1.62E+03	1.39E+03	2.03E+03	4.41E+03	1.21E+03	1.29E+03	1.33E+03
$3M_{i2}$	6.88E+06	2.39E+06	4.90E+06	1.25E+07	3.33E+06	3.78E+06	5.70E+06	4.81E+03	1.00E+03	1.80E+03	4.77E+03	6.16E+02	1.07E+03	2.58E+03
$3M_{i3}$	7.61E+02	1.03E+02	2.69E+02	3.23E+02	9.55E+01	2.17E+02	2.79E+02	2.37E+07	1.44E+07	2.13E+07	6.16E+07	1.89E+07	1.53E+07	1.88E+07
$3Rj_1$	8.33E-01	1.61E-01	4.23E-01	1.30E+00	1.61E-01	2.45E-01	6.32E-01	5.47E+00	2.04E+00	2.95E+00	7.77E+00	9.60E-01	1.96E+00	4.21E+00
$3Rj_2$	1.06E+00	1.51E-01	4.03E-01	4.88E-01	1.38E-01	3.36E-01	4.25E-01	3.90E+04	2.30E+04	3.44E+04	9.87E+04	3.12E+04	2.38E+04	3.12E+04
$3Rj_3$	1.15E+04	4.10E+03	7.89E+03	2.02E+04	5.88E+03	6.31E+03	9.14E+03	6.76E+00	1.45E+00	2.60E+00	7.21E+00	8.29E-01	1.53E+00	3.59E+00
$3Mj_1$	1.13E+02	3.54E+01	9.68E+01	2.45E+02	4.10E+01	4.12E+01	1.03E+02	1.62E+03	1.39E+03	2.03E+03	4.41E+03	1.21E+03	1.29E+03	1.33E+03
$3Mj_2$	4.73E+06	1.63E+06	3.43E+06	8.79E+06	2.24E+06	2.61E+06	4.00E+06	5.56E+03	9.57E+02	1.95E+03	5.76E+03	5.37E+02	9.86E+02	2.96E+03
$3Mj_3$	9.36E+02	9.70E+01	2.55E+02	2.32E+02	8.03E+01	2.18E+02	2.21E+02	1.65E+07	1.01E+07	1.49E+07	4.33E+07	1.31E+07	1.10E+07	1.30E+07
$3R_{i1}$	6.77E-01	1.50E-01	4.00E-01	1.24E+00	1.57E-01	2.23E-01	6.04E-01	4.71E+00	1.86E+00	2.72E+00	7.05E+00	8.91E-01	1.80E+00	3.71E+00
$4R_{i2}$	7.33E-01	1.33E-01	3.11E-01	4.64E-01	1.27E-01	2.38E-01	3.73E-01	3.35E+04	2.02E+04	3.01E+04	8.66E+04	2.67E+04	2.14E+04	2.66E+04
$4R_{i3}$	9.74E+03	3.39E+03	6.90E+03	1.77E+04	4.75E+03	5.35E+03	8.02E+03	5.07E+00	1.15E+00	2.12E+00	4.72E+00	7.53E-01	1.31E+00	2.54E+00
$4M_{i1}$	1.44E+02	4.19E+01	9.89E+01	2.32E+02	5.06E+01	6.15E+01	1.14E+02	1.23E+03	7.82E+02	9.25E+02	3.08E+03	8.72E+02	8.17E+02	8.75E+02
$4M_{i2}$	4.73E+06	1.63E+06	3.43E+06	8.79E+06	2.24E+06	2.61E+06	4.00E+06	5.56E+03	9.57E+02	1.95E+03	5.76E+03	5.37E+02	9.86E+02	2.96E+03
$4M_{i3}$	9.36E+02	9.70E+01	2.55E+02	2.32E+02	8.03E+01	2.18E+02	2.21E+02	1.65E+07	1.01E+07	1.49E+07	4.33E+07	1.31E+07	1.10E+07	1.30E+07
$4Rj_1$	6.77E-01	1.50E-01	4.00E-01	1.24E+00	1.57E-01	2.23E-01	6.04E-01	4.71E+00	1.86E+00	2.72E+00	7.05E+00	8.91E-01	1.80E+00	3.71E+00
$4Rj_2$	7.33E-01	1.33E-01	3.11E-01	4.64E-01	1.27E-01	2.38E-01	3.73E-01	3.35E+04	2.02E+04	3.01E+04	8.66E+04	2.67E+04	2.14E+04	2.66E+04
$4Rj_3$	9.74E+03	3.39E+03	6.90E+03	1.77E+04	4.75E+03	5.35E+03	8.02E+03	5.07E+00	1.15E+00	2.12E+00	4.72E+00	7.53E-01	1.31E+00	2.54E+00
$4Mj_1$	1.44E+02	4.19E+01	9.89E+01	2.32E+02	5.06E+01	6.15E+01	1.14E+02	1.23E+03	7.82E+02	9.25E+02	3.08E+03	8.72E+02	8.17E+02	8.75E+02
$4Mj_2$	2.70E+06	9.15E+05	1.99E+06	5.08E+06	1.24E+06	1.48E+06	2.32E+06	4.64E+03	7.22E+02	1.56E+03	4.97E+03	3.81E+02	7.92E+02	2.51E+03
$4Mj_3$	8.02E+02	7.15E+01	1.90E+02	1.35E+02	5.94E+01	1.68E+02	1.44E+02	9.56E+06	5.86E+06	8.64E+06	2.51E+07	7.52E+06	6.48E+06	7.42E+06
$4R_{i1}$	6.25E-01	1.37E-01	3.73E-01	1.18E+00	1.52E-01	1.96E-01	5.69E-01	3.68E+00	1.63E+00	2.43E+00	6.11E+00	8.03E-01	1.66E+00	3.05E+00
$5R_{i2}$	1.76E+00	1.68E-01	4.49E-01	3.74E-01	1.36E-01	3.92E-01	3.65E-01	2.69E+04	1.65E+04	2.43E+04	7.05E+04	2.13E+04	1.80E+04	2.11E+04
$5R_{i3}$	7.65E+03	2.62E+03	5.59E+03	1.43E+04	3.59E+03	4.22E+03	6.53E+03	1.02E+01	1.58E+00	3.51E+00	1.09E+01	8.60E-01	1.76E+00	5.34E+00
$5M_{i1}$	1.44E+02	4.19E+01	9.89E+01	2.32E+02	5.06E+01	6.15E+01	1.14E+02	1.23E+03	7.82E+02	9.25E+02	3.08E+03	8.72E+02	8.17E+02	8.75E+02
$5M_{i2}$	2.70E+06	9.15E+05	1.99E+06	5.08E+06	1.24E+06	1.48E+06	2.32E+06	4.64E+03	7.22E+02	1.56E+03	4.97E+03	3.81E+02	7.92E+02	2.51E+03
$5M_{i3}$	8.02E+02	7.15E+01	1.90E+02	1.35E+02	5.94E+01	1.68E+02	1.44E+02	9.56E+06	5.86E+06	8.64E+06	2.51E+07	7.52E+06	6.48E+06	7.42E+06
$5Rj_1$	6.25E-01	1.37E-01	3.73E-01	1.18E+00	1.52E-01	1.96E-01	5.69E-01	3.68E+00	1.63E+00	2.43E+00	6.11E+00	8.03E-01	1.66E+00	3.05E+00
$5Rj_2$	1.76E+00	1.68E-01	4.49E-01	3.74E-01	1.36E-01	3.92E-01	3.65E-01	2.69E+04	1.65E+04	2.43E+04	7.05E+04	2.13E+04	1.80E+04	2.11E+04
$5Rj_3$	7.65E+03	2.62E+03	5.59E+03	1.43E+04	3.59E+03	4.22E+03	6.53E+03	1.02E+01	1.58E+00	3.51E+00	1.09E+01	8.60E-01	1.76E+00	5.34E+00
$5Mj_1$	1.44E+02	4.19E+01	9.89E+01	2.32E+02	5.06E+01	6.15E+01	1.14E+02	1.23E+03	7.82E+02	9.25E+02	3.08E+03	8.72E+02	8.17E+02	8.75E+02
$5Mj_2$	1.10E+06	3.65E+05	8.16E+05	2.08E+06	4.89E+05	5.98E+05	9.49E+05	2.51E+03	3.91E+02	8.74E+02	2.68E+03	2.00E+02	4.31E+02	1.39E+03
$5Mj_3$	4.32E+02	3.72E+01	1.02E+02	5.83E+01	3.08E+01	8.84E+01	7.53E+01	3.92E+06	2.40E+06	3.53E+06	1.03E+07	3.05E+06	2.69E+06	3.00E+06

Table 3.4.4 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$6R_{i1}$	6.21E-01	1.34E-01	3.77E-01	1.10E+00	1.46E-01	1.84E-01	5.29E-01	2.66E+00	1.37E+00	2.09E+00	5.09E+00	7.23E-01	1.50E+00	2.30E+00
$6R_{i2}$	1.90E+00	1.63E-01	4.42E-01	2.91E-01	1.31E-01	3.91E-01	3.27E-01	1.90E+04	1.17E+04	1.71E+04	4.99E+04	1.48E+04	1.30E+04	1.46E+04
$6R_{i3}$	5.34E+03	1.79E+03	3.95E+03	1.01E+04	2.41E+03	2.92E+03	4.60E+03	1.08E+01	1.54E+00	3.51E+00	1.19E+01	7.98E-01	1.81E+00	5.81E+00
$6M_{i1}$	1.86E+02	5.76E+01	1.20E+02	3.19E+02	7.29E+01	9.57E+01	1.46E+02	6.23E+02	4.54E+02	7.76E+02	1.51E+03	4.89E+02	5.96E+02	5.13E+02
$6M_{i2}$	1.10E+06	3.65E+05	8.16E+05	2.08E+06	4.89E+05	5.98E+05	9.49E+05	2.51E+03	3.91E+02	8.74E+02	2.68E+03	2.00E+02	4.31E+02	1.39E+03
$6M_{i3}$	4.32E+02	3.72E+01	1.02E+02	5.83E+01	3.08E+01	8.84E+01	7.53E+01	3.92E+06	2.40E+06	3.53E+06	1.03E+07	3.05E+06	2.69E+06	3.00E+06
$6Rj_1$	6.21E-01	1.34E-01	3.77E-01	1.10E+00	1.46E-01	1.84E-01	5.29E-01	2.66E+00	1.37E+00	2.09E+00	5.09E+00	7.23E-01	1.50E+00	2.30E+00
$6Rj_2$	1.90E+00	1.63E-01	4.42E-01	2.91E-01	1.31E-01	3.91E-01	3.27E-01	1.90E+04	1.17E+04	1.71E+04	4.99E+04	1.48E+04	1.30E+04	1.46E+04
$6Rj_3$	5.34E+03	1.79E+03	3.95E+03	1.01E+04	2.41E+03	2.92E+03	4.60E+03	1.08E+01	1.54E+00	3.51E+00	1.19E+01	7.98E-01	1.81E+00	5.81E+00
$6Mj_1$	1.86E+02	5.76E+01	1.20E+02	3.19E+02	7.29E+01	9.57E+01	1.46E+02	6.23E+02	4.54E+02	7.76E+02	1.51E+03	4.89E+02	5.96E+02	5.13E+02
$6Mj_2$	3.76E+05	1.24E+05	2.82E+05	7.15E+05	1.64E+05	2.04E+05	3.27E+05	1.07E+03	1.87E+02	4.00E+02	1.16E+03	9.23E+01	1.98E+02	6.06E+02
$6Mj_3$	1.80E+02	1.51E+01	4.26E+01	2.67E+01	1.32E+01	3.61E+01	3.11E+01	1.36E+06	8.31E+05	1.21E+06	3.55E+06	1.04E+06	9.41E+05	1.02E+06
$7R_{i1}$	6.63E-01	1.31E-01	3.81E-01	1.01E+00	1.42E-01	1.80E-01	4.87E-01	2.03E+00	1.12E+00	1.73E+00	4.20E+00	6.74E-01	1.34E+00	1.78E+00
$7R_{i2}$	1.28E+00	1.06E-01	2.84E-01	1.63E-01	8.34E-02	2.56E-01	1.90E-01	1.01E+04	6.15E+03	8.99E+03	2.63E+04	7.73E+03	6.97E+03	7.59E+03
$7R_{i3}$	2.79E+03	9.18E+02	2.09E+03	5.30E+03	1.21E+03	1.51E+03	2.42E+03	7.24E+00	1.01E+00	2.31E+00	8.06E+00	4.96E-01	1.21E+00	3.89E+00
$7M_{i1}$	1.86E+02	5.76E+01	1.20E+02	3.19E+02	7.29E+01	9.57E+01	1.46E+02	6.23E+02	4.54E+02	7.76E+02	1.51E+03	4.89E+02	5.96E+02	5.13E+02
$7M_{i2}$	3.76E+05	1.24E+05	2.82E+05	7.15E+05	1.64E+05	2.04E+05	3.27E+05	1.07E+03	1.87E+02	4.00E+02	1.16E+03	9.23E+01	1.98E+02	6.06E+02
$7M_{i3}$	1.80E+02	1.51E+01	4.26E+01	2.67E+01	1.32E+01	3.61E+01	3.11E+01	1.36E+06	8.31E+05	1.21E+06	3.55E+06	1.04E+06	9.41E+05	1.02E+06
$7Rj_1$	6.63E-01	1.31E-01	3.81E-01	1.01E+00	1.42E-01	1.80E-01	4.87E-01	2.03E+00	1.12E+00	1.73E+00	4.20E+00	6.74E-01	1.34E+00	1.78E+00
$7Rj_2$	1.28E+00	1.06E-01	2.84E-01	1.63E-01	8.34E-02	2.56E-01	1.90E-01	1.01E+04	6.15E+03	8.99E+03	2.63E+04	7.73E+03	6.97E+03	7.59E+03
$7Rj_3$	2.79E+03	9.18E+02	2.09E+03	5.30E+03	1.21E+03	1.51E+03	2.42E+03	7.24E+00	1.01E+00	2.31E+00	8.06E+00	4.96E-01	1.21E+00	3.89E+00
$7Mj_1$	1.86E+02	5.76E+01	1.20E+02	3.19E+02	7.29E+01	9.57E+01	1.46E+02	6.23E+02	4.54E+02	7.76E+02	1.51E+03	4.89E+02	5.96E+02	5.13E+02
$7Mj_2$	5.07E+01	7.66E+00	2.03E+01	4.87E+01	6.43E+00	1.02E+01	2.08E+01	1.67E+02	7.76E+01	1.16E+02	2.85E+02	4.99E+01	9.59E+01	1.33E+02
$7M_{j3}$	2.62E+01	3.87E+00	8.64E+00	1.67E+01	4.05E+00	5.55E+00	1.04E+01	1.81E+02	1.23E+02	1.96E+02	3.10E+02	7.64E+01	8.15E+01	1.08E+02

Table 3.4.5 Maximum element forces and moments for joint elements (group#2) of benchmark problem #4a and #4b.

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$1R_{i1}$	3.06E-01	9.33E-02	1.88E-01	5.14E-01	1.17E-01	1.52E-01	2.35E-01	7.14E+00	5.24E+00	9.14E+00	1.83E+01	5.92E+00	7.10E+00	6.00E+00
$1R_{i2}$	9.01E-01	2.82E-01	5.76E-01	1.54E+00	3.50E-01	4.65E-01	7.05E-01	2.52E+00	1.84E+00	3.12E+00	5.99E+00	1.94E+00	2.39E+00	2.06E+00
$1R_{i3}$	1.44E-01	2.07E-02	4.64E-02	8.64E-02	2.19E-02	3.01E-02	5.88E-02	1.08E+00	7.45E-01	1.17E+00	1.77E+00	4.49E-01	5.27E-01	6.68E-01
$1M_{i1}$	1.31E+01	5.10E+00	1.15E+01	3.10E+01	5.35E+00	6.18E+00	1.65E+01	2.18E+01	1.49E+01	2.30E+01	3.48E+01	8.99E+00	1.17E+01	1.35E+01
$1M_{i2}$	6.97E+00	1.18E+00	3.16E+00	7.63E+00	1.09E+00	1.73E+00	3.77E+00	7.45E+01	5.66E+01	8.23E+01	1.26E+02	3.24E+01	4.46E+01	5.05E+01
$1M_{i3}$	4.20E+01	1.37E+01	2.65E+01	6.91E+01	1.64E+01	2.17E+01	3.23E+01	2.09E+01	1.48E+01	2.31E+01	3.21E+01	9.40E+00	1.13E+01	1.35E+01
$1Rj_1$	3.06E-01	9.33E-02	1.88E-01	5.14E-01	1.17E-01	1.52E-01	2.35E-01	7.14E+00	5.24E+00	9.14E+00	1.83E+01	5.92E+00	7.10E+00	6.00E+00
$1Rj_2$	9.01E-01	2.82E-01	5.76E-01	1.54E+00	3.50E-01	4.65E-01	7.05E-01	2.52E+00	1.84E+00	3.12E+00	5.99E+00	1.94E+00	2.39E+00	2.06E+00
$1Rj_3$	1.44E-01	2.07E-02	4.64E-02	8.64E-02	2.19E-02	3.01E-02	5.88E-02	1.08E+00	7.45E-01	1.17E+00	1.77E+00	4.49E-01	5.27E-01	6.68E-01
$1Mj_1$	1.31E+01	5.10E+00	1.15E+01	3.10E+01	5.35E+00	6.18E+00	1.65E+01	2.18E+01	1.49E+01	2.30E+01	3.48E+01	8.99E+00	1.17E+01	1.35E+01
$1Mj_2$	3.06E+01	5.28E+00	1.15E+01	2.25E+01	5.68E+00	7.43E+00	1.53E+01	1.98E+02	1.33E+02	2.13E+02	3.35E+02	8.29E+01	8.92E+01	1.18E+02
$1Mj_3$	1.86E+02	5.76E+01	1.20E+02	3.19E+02	7.29E+01	9.57E+01	1.46E+02	6.23E+02	4.54E+02	7.76E+02	1.51E+03	4.89E+02	5.96E+02	5.13E+02
$2R_{i1}$	2.99E-01	1.31E-01	1.95E-01	4.88E-01	2.05E-01	1.65E-01	1.98E-01	3.45E+00	2.75E+00	3.52E+00	6.90E+00	2.41E+00	2.15E+00	2.32E+00
$2R_{i2}$	5.08E-01	1.41E-01	2.41E-01	5.84E-01	2.25E-01	2.16E-01	2.35E-01	4.66E+00	1.87E+00	2.53E+00	5.71E+00	1.87E+00	1.64E+00	2.45E+00
$2R_{i3}$	1.09E-01	2.22E-02	5.20E-02	1.38E-01	2.11E-02	2.77E-02	6.13E-02	4.17E-01	1.82E-01	3.04E-01	6.67E-01	1.40E-01	2.75E-01	2.67E-01
$2M_{i1}$	2.60E+00	5.06E-01	1.20E+00	3.50E+00	4.20E-01	5.96E-01	1.51E+00	1.66E+01	8.43E+00	1.18E+01	2.60E+01	4.96E+00	9.83E+00	9.92E+00
$2M_{i2}$	4.75E+00	8.82E-01	1.95E+00	5.35E+00	8.45E-01	1.09E+00	2.41E+00	1.95E+01	8.47E+00	1.22E+01	3.10E+01	4.77E+00	9.42E+00	1.13E+01
$2M_{i3}$	2.26E+01	7.51E+00	1.30E+01	3.45E+01	1.22E+01	1.19E+01	1.42E+01	9.72E+01	2.78E+01	4.31E+01	1.20E+02	1.47E+01	2.61E+01	6.64E+01
$2Rj_1$	2.99E-01	1.31E-01	1.95E-01	4.88E-01	2.05E-01	1.65E-01	1.98E-01	3.45E+00	2.75E+00	3.52E+00	6.90E+00	2.41E+00	2.15E+00	2.32E+00
$2Rj_2$	5.08E-01	1.41E-01	2.41E-01	5.84E-01	2.25E-01	2.16E-01	2.35E-01	4.66E+00	1.87E+00	2.53E+00	5.71E+00	1.87E+00	1.64E+00	2.45E+00
$2Rj_3$	1.09E-01	2.22E-02	5.20E-02	1.38E-01	2.11E-02	2.77E-02	6.13E-02	4.17E-01	1.82E-01	3.04E-01	6.67E-01	1.40E-01	2.75E-01	2.67E-01
$2Mj_1$	2.60E+00	5.06E-01	1.20E+00	3.50E+00	4.20E-01	5.96E-01	1.51E+00	1.66E+01	8.43E+00	1.18E+01	2.60E+01	4.96E+00	9.83E+00	9.92E+00
$2Mj_2$	2.93E+01	6.03E+00	1.42E+01	3.76E+01	5.79E+00	7.52E+00	1.67E+01	1.10E+02	4.82E+01	8.40E+01	1.91E+02	4.03E+01	7.65E+01	7.16E+01
$2Mj_3$	1.36E+02	3.64E+01	6.19E+01	1.47E+02	5.78E+01	5.53E+01	5.93E+01	1.37E+03	6.06E+02	8.13E+02	1.78E+03	5.85E+02	5.20E+02	7.35E+02

Table 3.4.5 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$3R_{i1}$	1.45E+00	5.01E-01	1.26E+00	3.25E+00	5.79E-01	5.41E-01	1.48E+00	2.97E-01	2.36E-01	3.83E-01	5.45E-01	1.43E-01	1.61E-01	2.11E-01
$3R_{i2}$	1.33E-06	5.72E-07	8.54E-07	2.18E-06	8.85E-07	4.75E-07	8.08E-07	5.27E-04	3.13E-04	4.73E-04	1.35E-03	4.26E-04	3.26E-04	4.24E-04
$3R_{i3}$	6.02E-01	1.33E-01	3.93E-01	9.92E-01	1.45E-01	1.75E-01	4.86E-01	2.34E+00	1.68E+00	2.56E+00	5.04E+00	1.05E+00	1.60E+00	2.15E+00
$3M_{i1}$	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$3M_{i2}$	7.80E-03	2.73E-03	5.52E-03	1.41E-02	3.84E-03	4.29E-03	6.41E-03	3.87E-04	1.90E-04	2.40E-04	7.89E-04	3.11E-04	1.52E-04	2.68E-04
$3M_{i3}$	5.18E-05	2.23E-05	3.33E-05	8.51E-05	3.45E-05	1.85E-05	3.15E-05	2.05E-02	1.22E-02	1.85E-02	5.26E-02	1.66E-02	1.27E-02	1.65E-02
$3R_{j1}$	1.45E+00	5.01E-01	1.26E+00	3.25E+00	5.79E-01	5.41E-01	1.48E+00	2.97E-01	2.36E-01	3.83E-01	5.45E-01	1.43E-01	1.61E-01	2.11E-01
$3R_{j2}$	1.33E-06	5.72E-07	8.54E-07	2.18E-06	8.85E-07	4.75E-07	8.08E-07	5.27E-04	3.13E-04	4.73E-04	1.35E-03	4.26E-04	3.26E-04	4.24E-04
$3R_{j3}$	6.02E-01	1.33E-01	3.93E-01	9.92E-01	1.45E-01	1.75E-01	4.86E-01	2.34E+00	1.68E+00	2.56E+00	5.04E+00	1.05E+00	1.60E+00	2.15E+00
$3M_{j1}$	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$3M_{j2}$	4.69E+01	1.04E+01	3.07E+01	7.74E+01	1.13E+01	1.37E+01	3.79E+01	1.83E+02	1.31E+02	2.00E+02	3.93E+02	8.18E+01	1.25E+02	1.68E+02
$3M_{j3}$	5.19E-05	2.23E-05	3.32E-05	8.52E-05	3.44E-05	1.85E-05	3.15E-05	2.05E-02	1.22E-02	1.85E-02	5.26E-02	1.66E-02	1.27E-02	1.65E-02
$3R_{i1}$	3.02E+00	1.17E+00	2.22E+00	5.22E+00	1.49E+00	1.91E+00	2.75E+00	2.26E+00	2.15E+00	3.05E+00	5.00E+00	1.58E+00	1.57E+00	1.80E+00
$4R_{i2}$	7.52E-01	2.62E-01	5.19E-01	1.15E+00	3.34E-01	4.30E-01	6.10E-01	9.55E+00	8.89E+00	1.32E+01	2.18E+01	6.55E+00	7.02E+00	7.48E+00
$4R_{i3}$	9.09E-06	3.15E-06	6.55E-06	1.67E-05	4.37E-06	5.01E-06	7.61E-06	2.22E-05	1.31E-05	1.98E-05	5.66E-05	1.80E-05	1.36E-05	1.80E-05
$4M_{i1}$	8.05E-04	2.82E-04	5.70E-04	1.46E-03	3.96E-04	4.44E-04	6.63E-04	9.17E-05	4.49E-05	6.44E-05	1.72E-04	7.05E-05	3.67E-05	6.84E-05
$4M_{i2}$	1.87E-03	6.77E-04	1.28E-03	3.28E-03	9.78E-04	1.04E-03	1.49E-03	3.81E-03	2.25E-03	3.39E-03	9.68E-03	3.10E-03	2.32E-03	3.08E-03
$4M_{i3}$	2.03E-04	7.25E-05	1.45E-04	3.63E-04	1.04E-04	1.08E-04	1.59E-04	5.19E-03	3.11E-03	4.56E-03	1.33E-02	4.19E-03	3.14E-03	4.17E-03
$4R_{j1}$	3.02E+00	1.17E+00	2.22E+00	5.22E+00	1.49E+00	1.91E+00	2.75E+00	2.26E+00	2.15E+00	3.05E+00	5.00E+00	1.58E+00	1.57E+00	1.80E+00
$4R_{j2}$	7.52E-01	2.62E-01	5.19E-01	1.15E+00	3.34E-01	4.30E-01	6.10E-01	9.55E+00	8.89E+00	1.32E+01	2.18E+01	6.55E+00	7.02E+00	7.48E+00
$4R_{j3}$	9.09E-06	3.15E-06	6.55E-06	1.67E-05	4.37E-06	5.01E-06	7.61E-06	2.22E-05	1.31E-05	1.98E-05	5.66E-05	1.80E-05	1.36E-05	1.80E-05
$4M_{j1}$	8.05E-04	2.82E-04	5.70E-04	1.46E-03	3.96E-04	4.44E-04	6.63E-04	9.17E-05	4.49E-05	6.44E-05	1.72E-04	7.05E-05	3.67E-05	6.84E-05
$4M_{j2}$	1.87E-03	6.74E-04	1.28E-03	3.26E-03	9.74E-04	1.03E-03	1.48E-03	3.85E-03	2.27E-03	3.42E-03	9.78E-03	3.13E-03	2.34E-03	3.11E-03
$4M_{j3}$	6.02E+01	2.10E+01	4.15E+01	9.21E+01	2.68E+01	3.44E+01	4.88E+01	7.64E+02	7.12E+02	1.06E+03	1.75E+03	5.25E+02	5.62E+02	5.99E+02
$4R_{i1}$	3.03E+00	1.24E+00	2.40E+00	6.34E+00	1.59E+00	1.99E+00	3.29E+00	2.82E+00	2.29E+00	3.30E+00	5.78E+00	1.66E+00	1.61E+00	1.99E+00
$5R_{i2}$	7.30E-01	2.88E-01	5.15E-01	1.42E+00	3.60E-01	4.58E-01	7.47E-01	1.06E+01	9.79E+00	1.50E+01	2.26E+01	6.70E+00	6.36E+00	7.78E+00
$5R_{i3}$	9.41E-06	3.31E-06	6.61E-06	1.69E-05	4.67E-06	5.18E-06	7.69E-06	6.26E-06	3.71E-06	5.71E-06	1.60E-05	5.11E-06	3.92E-06	5.07E-06
$5M_{i1}$	8.08E-04	2.82E-04	5.73E-04	1.47E-03	3.96E-04	4.44E-04	6.65E-04	3.62E-03	2.18E-03	3.22E-03	9.32E-03	2.91E-03	2.24E-03	2.89E-03
$5M_{i2}$	3.07E-03	1.09E-03	2.16E-03	5.51E-03	1.54E-03	1.69E-03	2.50E-03	2.76E-03	1.59E-03	2.43E-03	6.89E-03	2.24E-03	1.66E-03	2.23E-03
$5M_{i3}$	1.36E-03	4.74E-04	9.65E-04	2.47E-03	6.63E-04	7.47E-04	1.12E-03	1.51E-02	8.96E-03	1.36E-02	3.86E-02	1.22E-02	9.41E-03	1.21E-02
$5R_{j1}$	3.03E+00	1.24E+00	2.40E+00	6.34E+00	1.59E+00	1.99E+00	3.29E+00	2.82E+00	2.29E+00	3.30E+00	5.78E+00	1.66E+00	1.61E+00	1.99E+00
$5R_{j2}$	7.30E-01	2.88E-01	5.15E-01	1.42E+00	3.60E-01	4.58E-01	7.47E-01	1.06E+01	9.79E+00	1.50E+01	2.26E+01	6.70E+00	6.36E+00	7.78E+00
$5R_{j3}$	9.41E-06	3.31E-06	6.61E-06	1.69E-05	4.67E-06	5.18E-06	7.69E-06	6.26E-06	3.71E-06	5.71E-06	1.60E-05	5.11E-06	3.92E-06	5.07E-06
$5M_{j1}$	8.08E-04	2.82E-04	5.73E-04	1.47E-03	3.96E-04	4.44E-04	6.65E-04	3.62E-03	2.18E-03	3.22E-03	9.32E-03	2.91E-03	2.24E-03	2.89E-03
$5M_{j2}$	4.33E-03	1.54E-03	3.03E-03	7.74E-03	2.19E-03	2.38E-03	3.50E-03	2.77E-03	1.63E-03	2.47E-03	7.02E-03	2.24E-03	1.69E-03	2.23E-03
$5M_{j3}$	5.85E+01	2.30E+01	4.13E+01	1.14E+02	2.88E+01	3.67E+01	5.98E+01	8.48E+02	7.84E+02	1.20E+03	1.81E+03	5.37E+02	5.09E+02	6.23E+02

Table 3.4.5 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$6R_{i1}$	4.26E-01	4.28E-02	8.99E-02	1.03E-01	3.32E-02	8.32E-02	7.54E-02	8.49E+00	5.99E+00	9.38E+00	1.41E+01	4.11E+00	4.75E+00	4.68E+00
$6R_{i2}$	1.20E-04	4.21E-05	8.52E-05	2.18E-04	5.91E-05	6.65E-05	9.94E-05	5.93E-05	2.95E-05	4.31E-05	1.12E-04	4.60E-05	2.44E-05	4.52E-05
$6R_{i3}$	4.02E-01	1.41E-01	2.95E-01	6.91E-01	1.70E-01	2.05E-01	4.04E-01	1.24E+00	8.44E-01	1.21E+00	2.43E+00	4.77E-01	7.36E-01	8.27E-01
$6M_{i1}$	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$6M_{i2}$	3.05E-05	1.48E-05	2.22E-05	6.14E-05	2.47E-05	1.83E-05	2.08E-05	7.08E-03	4.48E-03	5.46E-03	1.84E-02	5.51E-03	4.43E-03	5.60E-03
$6M_{i3}$	7.52E-04	2.96E-04	4.82E-04	1.21E-03	4.54E-04	4.18E-04	5.60E-04	5.39E-04	2.68E-04	3.90E-04	1.02E-03	4.18E-04	2.22E-04	4.10E-04
$6Rj_1$	4.26E-01	4.28E-02	8.99E-02	1.03E-01	3.32E-02	8.32E-02	7.54E-02	8.49E+00	5.99E+00	9.38E+00	1.41E+01	4.11E+00	4.75E+00	4.68E+00
$6Rj_2$	1.20E-04	4.21E-05	8.52E-05	2.18E-04	5.91E-05	6.65E-05	9.94E-05	5.93E-05	2.95E-05	4.31E-05	1.12E-04	4.60E-05	2.44E-05	4.52E-05
$6Rj_3$	4.02E-01	1.41E-01	2.95E-01	6.91E-01	1.70E-01	2.05E-01	4.04E-01	1.24E+00	8.44E-01	1.21E+00	2.43E+00	4.77E-01	7.36E-01	8.27E-01
$6Mj_1$	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$6Mj_2$	7.23E+00	2.54E+00	5.31E+00	1.24E+01	3.06E+00	3.68E+00	7.28E+00	2.24E+01	1.52E+01	2.18E+01	4.37E+01	8.59E+00	1.33E+01	1.49E+01
$6Mj_3$	2.92E-03	1.05E-03	2.01E-03	5.13E-03	1.52E-03	1.61E-03	2.33E-03	5.29E-04	2.62E-04	3.83E-04	9.92E-04	4.09E-04	2.18E-04	4.02E-04
$7R_{i1}$	1.47E+00	7.36E-01	1.30E+00	3.99E+00	1.08E+00	7.51E-01	1.54E+00	3.46E+00	7.04E-01	1.41E+00	4.46E+00	3.76E-01	7.85E-01	1.88E+00
$7R_{i2}$	9.58E-08	2.97E-08	4.33E-08	1.64E-07	4.55E-08	2.81E-08	6.96E-08	5.88E-05	3.52E-05	5.32E-05	1.51E-04	4.73E-05	3.72E-05	4.70E-05
$7R_{i3}$	2.13E-01	4.44E-02	8.97E-02	2.28E-01	4.72E-02	6.51E-02	1.21E-01	6.82E-01	3.60E-01	5.70E-01	1.20E+00	2.07E-01	2.88E-01	4.27E-01
$7M_{i1}$	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$7M_{i2}$	3.68E-03	1.31E-03	2.57E-03	6.56E-03	1.86E-03	2.03E-03	2.97E-03	2.43E-05	1.61E-05	1.97E-05	6.21E-05	1.79E-05	1.61E-05	1.88E-05
$7M_{i3}$	9.27E-06	2.88E-06	4.25E-06	1.61E-05	4.38E-06	2.72E-06	6.82E-06	5.73E-04	2.87E-04	4.21E-04	1.06E-03	4.29E-04	2.43E-04	4.18E-04
$7Rj_1$	1.47E+00	7.36E-01	1.30E+00	3.99E+00	1.08E+00	7.51E-01	1.54E+00	3.46E+00	7.04E-01	1.41E+00	4.46E+00	3.76E-01	7.85E-01	1.88E+00
$7Rj_2$	9.58E-08	2.97E-08	4.33E-08	1.64E-07	4.55E-08	2.81E-08	6.96E-08	5.88E-05	3.52E-05	5.32E-05	1.51E-04	4.73E-05	3.72E-05	4.70E-05
$7Rj_3$	2.13E-01	4.44E-02	8.97E-02	2.28E-01	4.72E-02	6.51E-02	1.21E-01	6.82E-01	3.60E-01	5.70E-01	1.20E+00	2.07E-01	2.88E-01	4.27E-01
$7Mj_1$	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$7Mj_2$	4.21E+01	8.79E+00	1.78E+01	4.51E+01	9.34E+00	1.29E+01	2.39E+01	1.35E+02	7.14E+01	1.13E+02	2.38E+02	4.10E+01	5.71E+01	8.45E+01
$7M_{j3}$	9.49E-06	2.92E-06	4.24E-06	1.61E-05	4.48E-06	2.79E-06	6.84E-06	1.19E-02	7.05E-03	1.06E-02	3.03E-02	9.63E-03	7.30E-03	9.58E-03

Table 3.4.6 Maximum element forces and moments for S-component (group#3) of benchmark problem #4a and #4b.

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$1R_{i1}$	6.53E-02	1.03E-02	2.66E-02	7.59E-02	9.07E-03	1.74E-02	4.56E-02	7.09E+00	5.19E+00	8.92E+00	1.71E+01	5.57E+00	6.92E+00	5.74E+00
$1R_{i2}$	7.20E-01	2.26E-01	4.45E-01	1.18E+00	2.72E-01	3.62E-01	5.42E-01	2.91E-01	1.97E-01	3.02E-01	4.24E-01	1.23E-01	1.52E-01	1.98E-01
$1R_{i3}$	1.40E-01	1.77E-02	4.16E-02	7.10E-02	1.84E-02	2.58E-02	5.50E-02	1.11E+00	7.57E-01	1.12E+00	1.75E+00	4.38E-01	5.81E-01	7.04E-01
$1M_{i1}$	1.24E+01	5.10E+00	1.20E+01	3.15E+01	5.37E+00	6.09E+00	1.65E+01	4.90E+00	3.67E+00	4.77E+00	9.36E+00	2.41E+00	3.66E+00	4.01E+00
$1M_{i2}$	8.54E+00	1.11E+00	2.80E+00	4.98E+00	1.22E+00	1.68E+00	3.78E+00	7.76E+01	5.84E+01	8.54E+01	1.30E+02	3.35E+01	4.60E+01	5.22E+01
$1M_{i3}$	4.20E+01	1.37E+01	2.65E+01	6.91E+01	1.64E+01	2.17E+01	3.22E+01	2.09E+01	1.48E+01	2.31E+01	3.21E+01	9.39E+00	1.13E+01	1.35E+01
$1R_{j1}$	6.53E-02	1.03E-02	2.66E-02	7.59E-02	9.07E-03	1.74E-02	4.56E-02	7.09E+00	5.19E+00	8.92E+00	1.71E+01	5.57E+00	6.92E+00	5.74E+00
$1R_{j2}$	7.20E-01	2.26E-01	4.45E-01	1.18E+00	2.72E-01	3.62E-01	5.42E-01	2.91E-01	1.97E-01	3.02E-01	4.24E-01	1.23E-01	1.52E-01	1.98E-01
$1R_{j3}$	1.40E-01	1.77E-02	4.16E-02	7.10E-02	1.84E-02	2.58E-02	5.50E-02	1.11E+00	7.57E-01	1.12E+00	1.75E+00	4.38E-01	5.81E-01	7.04E-01
$1M_{j1}$	1.24E+01	5.10E+00	1.20E+01	3.15E+01	5.37E+00	6.09E+00	1.65E+01	4.90E+00	3.67E+00	4.77E+00	9.36E+00	2.41E+00	3.66E+00	4.01E+00
$1M_{j2}$	2.75E+00	3.81E-01	7.74E-01	1.46E+00	2.58E-01	4.17E-01	8.20E-01	1.13E+01	3.92E+00	6.33E+00	1.85E+01	2.87E+00	3.89E+00	7.83E+00
$1M_{j3}$	1.57E+01	4.45E+00	9.76E+00	2.55E+01	5.64E+00	7.33E+00	1.18E+01	2.77E+00	9.13E-01	1.28E+00	4.32E+00	4.95E-01	1.04E+00	2.34E+00
$2R_{i1}$	6.51E-02	1.02E-02	2.64E-02	7.56E-02	9.06E-03	1.73E-02	4.54E-02	6.03E+00	4.45E+00	7.39E+00	1.27E+01	4.25E+00	5.76E+00	4.49E+00
$2R_{i2}$	1.71E-01	6.25E-02	1.09E-01	2.57E-01	7.29E-02	9.21E-02	1.42E-01	2.14E-01	1.74E-01	2.72E-01	3.75E-01	1.10E-01	1.28E-01	1.37E-01
$2R_{i3}$	4.41E-02	9.78E-03	2.30E-02	6.17E-02	9.93E-03	1.25E-02	3.63E-02	8.42E-01	7.08E-01	1.00E+00	1.54E+00	4.03E-01	6.21E-01	5.91E-01
$2M_{i1}$	1.24E+01	5.10E+00	1.20E+01	3.15E+01	5.37E+00	6.09E+00	1.65E+01	4.90E+00	3.67E+00	4.77E+00	9.36E+00	2.41E+00	3.66E+00	4.01E+00
$2M_{i2}$	2.75E+00	3.81E-01	7.74E-01	1.46E+00	2.58E-01	4.17E-01	8.20E-01	1.13E+01	3.92E+00	6.33E+00	1.85E+01	2.87E+00	3.89E+00	7.83E+00
$2M_{i3}$	1.57E+01	4.45E+00	9.76E+00	2.55E+01	5.64E+00	7.33E+00	1.18E+01	2.77E+00	9.13E-01	1.28E+00	4.32E+00	4.95E-01	1.04E+00	2.34E+00
$2R_{j1}$	6.51E-02	1.02E-02	2.64E-02	7.56E-02	9.06E-03	1.73E-02	4.54E-02	6.03E+00	4.45E+00	7.39E+00	1.27E+01	4.25E+00	5.76E+00	4.49E+00
$2R_{j2}$	1.71E-01	6.25E-02	1.09E-01	2.57E-01	7.29E-02	9.21E-02	1.42E-01	2.14E-01	1.74E-01	2.72E-01	3.75E-01	1.10E-01	1.28E-01	1.37E-01
$2R_{j3}$	4.41E-02	9.78E-03	2.30E-02	6.17E-02	9.93E-03	1.25E-02	3.63E-02	8.42E-01	7.08E-01	1.00E+00	1.54E+00	4.03E-01	6.21E-01	5.91E-01
$2M_{j1}$	1.24E+01	5.10E+00	1.20E+01	3.15E+01	5.37E+00	6.09E+00	1.65E+01	4.90E+00	3.67E+00	4.77E+00	9.36E+00	2.41E+00	3.66E+00	4.01E+00
$2M_{j2}$	6.19E+00	9.44E-01	2.37E+00	4.86E+00	9.91E-01	1.34E+00	3.35E+00	7.26E+01	5.88E+01	8.43E+01	1.28E+02	3.35E+01	4.91E+01	5.07E+01
$2M_{j3}$	2.71E+01	9.44E+00	1.78E+01	4.46E+01	1.12E+01	1.46E+01	2.17E+01	1.95E+01	1.46E+01	2.29E+01	3.17E+01	9.29E+00	1.10E+01	1.25E+01
$3R_{i1}$	6.45E-02	1.01E-02	2.62E-02	7.52E-02	9.03E-03	1.72E-02	4.52E-02	5.00E+00	3.78E+00	5.86E+00	8.52E+00	3.01E+00	4.59E+00	3.53E+00
$3R_{i2}$	4.78E-01	1.30E-01	3.20E-01	7.64E-01	1.59E-01	1.85E-01	3.53E-01	1.79E-01	1.43E-01	2.18E-01	3.48E-01	8.60E-02	1.04E-01	1.43E-01
$3R_{i3}$	1.04E-01	1.47E-02	3.97E-02	7.76E-02	1.08E-02	1.72E-02	3.63E-02	8.52E-01	5.77E-01	8.22E-01	1.46E+00	3.26E-01	5.33E-01	5.49E-01
$3M_{i1}$	1.24E+01	5.10E+00	1.20E+01	3.15E+01	5.37E+00	6.09E+00	1.65E+01	4.90E+00	3.67E+00	4.77E+00	9.36E+00	2.41E+00	3.66E+00	4.01E+00
$3M_{i2}$	6.19E+00	9.44E-01	2.37E+00	4.86E+00	9.91E-01	1.34E+00	3.35E+00	7.26E+01	5.88E+01	8.43E+01	1.28E+02	3.35E+01	4.91E+01	5.07E+01
$3M_{i3}$	2.71E+01	9.44E+00	1.78E+01	4.46E+01	1.12E+01	1.46E+01	2.17E+01	1.95E+01	1.46E+01	2.29E+01	3.17E+01	9.29E+00	1.10E+01	1.25E+01
$3R_{j1}$	6.45E-02	1.01E-02	2.62E-02	7.52E-02	9.03E-03	1.72E-02	4.52E-02	5.00E+00	3.78E+00	5.86E+00	8.52E+00	3.01E+00	4.59E+00	3.53E+00
$3R_{j2}$	4.78E-01	1.30E-01	3.20E-01	7.64E-01	1.59E-01	1.85E-01	3.53E-01	1.79E-01	1.43E-01	2.18E-01	3.48E-01	8.60E-02	1.04E-01	1.43E-01
$3R_{j3}$	1.04E-01	1.47E-02	3.97E-02	7.76E-02	1.08E-02	1.72E-02	3.63E-02	8.52E-01	5.77E-01	8.22E-01	1.46E+00	3.26E-01	5.33E-01	5.49E-01
$3M_{j1}$	1.24E+01	5.10E+00	1.20E+01	3.15E+01	5.37E+00	6.09E+00	1.65E+01	4.90E+00	3.67E+00	4.77E+00	9.36E+00	2.41E+00	3.66E+00	4.01E+00
$3M_{j2}$	5.96E+00	1.32E+00	3.66E+00	9.77E+00	1.44E+00	1.68E+00	4.87E+00	1.14E+02	1.05E+02	1.47E+02	2.38E+02	5.95E+01	9.12E+01	8.76E+01
$3M_{j3}$	1.35E+01	5.12E+00	1.24E+01	3.52E+01	5.33E+00	6.00E+00	1.71E+01	2.90E+01	2.57E+01	4.01E+01	5.61E+01	1.62E+01	1.85E+01	1.85E+01

Table 3.4.5 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$4R_{i1}$	6.39E-02	1.00E-02	2.60E-02	7.47E-02	9.00E-03	1.70E-02	4.50E-02	4.31E+00	3.59E+00	5.17E+00	7.77E+00	2.36E+00	3.80E+00	3.05E+00
$4R_{i2}$	4.96E-01	1.27E-01	3.59E-01	9.26E-01	1.37E-01	1.60E-01	4.65E-01	2.05E+00	1.11E+00	1.78E+00	4.06E+00	7.24E-01	1.07E+00	1.66E+00
$4R_{i3}$	8.09E-01	3.09E-01	7.47E-01	2.16E+00	3.22E-01	3.74E-01	1.07E+00	2.23E-01	1.28E-01	2.16E-01	3.27E-01	7.34E-02	1.13E-01	2.09E-01
$4M_{i1}$	1.24E+01	5.10E+00	1.20E+01	3.15E+01	5.37E+00	6.09E+00	1.65E+01	4.90E+00	3.67E+00	4.77E+00	9.36E+00	2.41E+00	3.66E+00	4.01E+00
$4M_{i2}$	1.35E+01	5.12E+00	1.24E+01	3.52E+01	5.33E+00	6.00E+00	1.71E+01	2.90E+01	2.57E+01	4.01E+01	5.61E+01	1.62E+01	1.85E+01	1.85E+01
$4M_{i3}$	5.96E+00	1.32E+00	3.66E+00	9.77E+00	1.44E+00	1.68E+00	4.87E+00	1.14E+02	1.05E+02	1.47E+02	2.38E+02	5.95E+01	9.12E+01	8.76E+01
$4R_{C1}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$4R_{C2}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$4R_{C3}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$4M_{C1}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$4M_{C2}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$4M_{C3}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$4R_{j1}$	4.96E-01	1.27E-01	3.59E-01	9.26E-01	1.37E-01	1.60E-01	4.65E-01	2.05E+00	1.11E+00	1.78E+00	4.06E+00	7.24E-01	1.07E+00	1.66E+00
$4R_{j2}$	6.39E-02	1.00E-02	2.60E-02	7.47E-02	9.00E-03	1.70E-02	4.50E-02	4.31E+00	3.59E+00	5.17E+00	7.77E+00	2.36E+00	3.80E+00	3.05E+00
$4R_{j3}$	8.09E-01	3.09E-01	7.47E-01	2.16E+00	3.22E-01	3.74E-01	1.07E+00	2.23E-01	1.28E-01	2.16E-01	3.27E-01	7.34E-02	1.13E-01	2.09E-01
$4M_{j1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$4M_{j2}$	7.19E+00	2.13E+00	4.72E+00	1.31E+01	2.87E+00	3.80E+00	6.07E+00	5.18E+00	3.97E+00	6.10E+00	9.11E+00	2.46E+00	3.08E+00	3.06E+00
$4M_{j3}$	3.37E+00	9.19E-01	2.49E+00	6.63E+00	9.97E-01	1.14E+00	3.43E+00	2.80E+01	2.66E+01	3.64E+01	6.59E+01	1.66E+01	1.90E+01	2.19E+01
$5R_{i1}$	4.89E-01	1.26E-01	3.53E-01	9.08E-01	1.35E-01	1.56E-01	4.59E-01	1.93E+00	9.94E-01	1.62E+00	3.77E+00	6.57E-01	9.69E-01	1.56E+00
$5R_{i2}$	6.14E-01	2.54E-01	6.00E-01	1.61E+00	2.68E-01	2.97E-01	8.45E-01	1.75E-01	1.01E-01	1.70E-01	2.39E-01	6.37E-02	1.04E-01	1.54E-01
$5R_{i3}$	6.20E-02	9.46E-03	2.60E-02	6.68E-02	9.49E-03	1.66E-02	3.93E-02	3.48E+00	3.29E+00	4.60E+00	7.15E+00	1.83E+00	2.85E+00	2.50E+00
$5M_{i1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$5M_{i2}$	3.37E+00	9.19E-01	2.49E+00	6.63E+00	9.97E-01	1.14E+00	3.43E+00	2.80E+01	2.66E+01	3.64E+01	6.59E+01	1.66E+01	1.90E+01	2.19E+01
$5M_{i3}$	7.19E+00	2.13E+00	4.72E+00	1.31E+01	2.87E+00	3.80E+00	6.07E+00	5.18E+00	3.97E+00	6.10E+00	9.11E+00	2.46E+00	3.08E+00	3.06E+00
$5R_{j1}$	4.89E-01	1.26E-01	3.53E-01	9.08E-01	1.35E-01	1.56E-01	4.59E-01	1.93E+00	9.94E-01	1.62E+00	3.77E+00	6.57E-01	9.69E-01	1.56E+00
$5R_{j2}$	6.14E-01	2.54E-01	6.00E-01	1.61E+00	2.68E-01	2.97E-01	8.45E-01	1.75E-01	1.01E-01	1.70E-01	2.39E-01	6.37E-02	1.04E-01	1.54E-01
$5R_{j3}$	6.20E-02	9.46E-03	2.60E-02	6.68E-02	9.49E-03	1.66E-02	3.93E-02	3.48E+00	3.29E+00	4.60E+00	7.15E+00	1.83E+00	2.85E+00	2.50E+00
$5M_{j1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$5M_{j2}$	4.25E+00	8.21E-01	1.58E+00	5.27E+00	6.91E-01	1.22E+00	3.38E+00	2.82E+02	2.56E+02	3.60E+02	5.61E+02	1.41E+02	2.36E+02	1.98E+02
$5M_{j3}$	5.08E+01	2.13E+01	5.03E+01	1.42E+02	2.26E+01	2.55E+01	7.37E+01	1.47E+01	1.10E+01	1.84E+01	2.53E+01	6.55E+00	8.11E+00	1.42E+01

Table 3.4.5 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$6R_{i1}$	4.74E-01	1.25E-01	3.43E-01	8.79E-01	1.33E-01	1.52E-01	4.48E-01	1.75E+00	8.39E-01	1.38E+00	3.30E+00	5.56E-01	8.13E-01	1.41E+00
$6R_{i2}$	5.32E-01	2.18E-01	4.01E-01	9.44E-01	2.75E-01	3.43E-01	5.43E-01	1.46E-01	5.17E-02	9.06E-02	2.03E-01	3.98E-02	6.63E-02	1.11E-01
$6R_{i3}$	3.95E-02	7.86E-03	2.24E-02	5.25E-02	8.87E-03	1.61E-02	3.48E-02	2.16E+00	2.00E+00	2.98E+00	4.67E+00	1.29E+00	1.34E+00	1.58E+00
$6M_{i1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$6M_{i2}$	4.25E+00	8.21E-01	1.58E+00	5.27E+00	6.91E-01	1.22E+00	3.38E+00	2.82E+02	2.56E+02	3.60E+02	5.61E+02	1.41E+02	2.36E+02	1.98E+02
$6M_{i3}$	5.08E+01	2.13E+01	5.03E+01	1.42E+02	2.26E+01	2.55E+01	7.37E+01	1.47E+01	1.10E+01	1.84E+01	2.53E+01	6.55E+00	8.11E+00	1.42E+01
$6R_{j1}$	4.74E-01	1.25E-01	3.43E-01	8.79E-01	1.33E-01	1.52E-01	4.48E-01	1.75E+00	8.39E-01	1.38E+00	3.30E+00	5.56E-01	8.13E-01	1.41E+00
$6R_{j2}$	5.32E-01	2.18E-01	4.01E-01	9.44E-01	2.75E-01	3.43E-01	5.43E-01	1.46E-01	5.17E-02	9.06E-02	2.03E-01	3.98E-02	6.63E-02	1.11E-01
$6R_{j3}$	3.95E-02	7.86E-03	2.24E-02	5.25E-02	8.87E-03	1.61E-02	3.48E-02	2.16E+00	2.00E+00	2.98E+00	4.67E+00	1.29E+00	1.34E+00	1.58E+00
$6M_{j1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$6M_{j2}$	3.24E+00	8.47E-01	1.43E+00	4.26E+00	7.38E-01	1.17E+00	2.70E+00	4.18E+02	4.01E+02	5.88E+02	8.54E+02	2.36E+02	2.95E+02	3.09E+02
$6M_{j3}$	8.31E+01	3.26E+01	7.45E+01	1.96E+02	3.66E+01	4.47E+01	1.04E+02	1.41E+01	1.21E+01	2.06E+01	2.30E+01	7.95E+00	1.15E+01	1.26E+01
$7R_{i1}$	4.57E-01	1.24E-01	3.32E-01	8.49E-01	1.31E-01	1.54E-01	4.37E-01	1.56E+00	6.96E-01	1.16E+00	2.83E+00	4.53E-01	6.57E-01	1.24E+00
$7R_{i2}$	9.71E-01	2.66E-01	5.78E-01	1.70E+00	3.59E-01	4.62E-01	7.21E-01	1.87E-01	7.23E-02	1.46E-01	3.51E-01	4.66E-02	6.69E-02	1.89E-01
$7R_{i3}$	7.93E-02	9.28E-03	2.78E-02	8.59E-02	1.08E-02	2.43E-02	5.20E-02	3.34E+00	1.86E+00	2.22E+00	7.44E+00	2.19E+00	1.82E+00	2.07E+00
$7M_{i1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$7M_{i2}$	3.24E+00	8.47E-01	1.43E+00	4.26E+00	7.38E-01	1.17E+00	2.70E+00	4.18E+02	4.01E+02	5.88E+02	8.54E+02	2.36E+02	2.95E+02	3.09E+02
$7M_{i3}$	8.31E+01	3.26E+01	7.45E+01	1.96E+02	3.66E+01	4.47E+01	1.04E+02	1.41E+01	1.21E+01	2.06E+01	2.30E+01	7.95E+00	1.15E+01	1.26E+01
$7R_{j1}$	4.57E-01	1.24E-01	3.32E-01	8.49E-01	1.31E-01	1.54E-01	4.37E-01	1.56E+00	6.96E-01	1.16E+00	2.83E+00	4.53E-01	6.57E-01	1.24E+00
$7R_{j2}$	9.71E-01	2.66E-01	5.78E-01	1.70E+00	3.59E-01	4.62E-01	7.21E-01	1.87E-01	7.23E-02	1.46E-01	3.51E-01	4.66E-02	6.69E-02	1.89E-01
$7R_{j3}$	7.93E-02	9.28E-03	2.78E-02	8.59E-02	1.08E-02	2.43E-02	5.20E-02	3.34E+00	1.86E+00	2.22E+00	7.44E+00	2.19E+00	1.82E+00	2.07E+00
$7M_{j1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$7M_{j2}$	5.61E+00	1.14E+00	3.08E+00	5.95E+00	1.23E+00	2.30E+00	4.67E+00	4.95E+02	4.64E+02	6.93E+02	1.06E+03	2.99E+02	3.02E+02	3.61E+02
$7M_{j3}$	1.23E+02	5.11E+01	9.26E+01	2.26E+02	6.43E+01	8.07E+01	1.29E+02	2.16E+01	1.10E+01	1.87E+01	2.66E+01	7.94E+00	1.32E+01	1.60E+01
$8R_{i1}$	4.42E-01	1.22E-01	3.21E-01	8.18E-01	1.28E-01	1.57E-01	4.25E-01	1.35E+00	5.51E-01	9.30E-01	2.34E+00	3.50E-01	5.00E-01	1.07E+00
$8R_{i2}$	1.94E+00	8.25E-01	1.59E+00	4.02E+00	1.03E+00	1.27E+00	2.20E+00	4.19E-01	2.07E-01	3.47E-01	4.81E-01	1.42E-01	2.31E-01	2.72E-01
$8R_{i3}$	1.07E-01	1.94E-02	4.47E-02	7.55E-02	1.81E-02	3.80E-02	6.14E-02	8.34E+00	7.75E+00	1.17E+01	1.76E+01	4.91E+00	4.85E+00	5.82E+00
$8M_{i1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$8M_{i2}$	5.61E+00	1.14E+00	3.08E+00	5.95E+00	1.23E+00	2.30E+00	4.67E+00	4.95E+02	4.64E+02	6.93E+02	1.06E+03	2.99E+02	3.02E+02	3.61E+02
$8M_{i3}$	1.23E+02	5.11E+01	9.26E+01	2.26E+02	6.43E+01	8.07E+01	1.29E+02	2.16E+01	1.10E+01	1.87E+01	2.66E+01	7.94E+00	1.32E+01	1.60E+01
$8R_{j1}$	4.42E-01	1.22E-01	3.21E-01	8.18E-01	1.28E-01	1.57E-01	4.25E-01	1.35E+00	5.51E-01	9.30E-01	2.34E+00	3.50E-01	5.00E-01	1.07E+00
$8R_{j2}$	1.94E+00	8.25E-01	1.59E+00	4.02E+00	1.03E+00	1.27E+00	2.20E+00	4.19E-01	2.07E-01	3.47E-01	4.81E-01	1.42E-01	2.31E-01	2.72E-01
$8R_{j3}$	1.07E-01	1.94E-02	4.47E-02	7.55E-02	1.81E-02	3.80E-02	6.14E-02	8.34E+00	7.75E+00	1.17E+01	1.76E+01	4.91E+00	4.85E+00	5.82E+00
$8M_{j1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$8M_{j2}$	4.69E+00	5.40E-01	9.49E-01	2.59E+00	3.91E-01	1.17E+00	1.96E+00	2.08E+02	1.94E+02	2.93E+02	4.21E+02	1.17E+02	1.37E+02	1.62E+02
$8M_{j3}$	4.74E+01	1.87E+01	4.15E+01	1.11E+02	2.25E+01	2.66E+01	5.74E+01	1.97E+01	8.10E+00	1.51E+01	2.18E+01	5.01E+00	7.08E+00	1.55E+01

Table 3.4.5 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$9R_{i1}$	4.27E-01	1.21E-01	3.11E-01	7.89E-01	1.27E-01	1.59E-01	4.14E-01	1.14E+00	4.04E-01	7.02E-01	1.85E+00	2.61E-01	3.54E-01	8.88E-01
$9R_{i2}$	1.16E+00	4.83E-01	9.49E-01	2.36E+00	5.98E-01	7.39E-01	1.30E+00	1.89E-01	1.23E-01	2.05E-01	2.71E-01	8.33E-02	1.34E-01	1.64E-01
$9R_{i3}$	5.49E-02	1.07E-02	2.81E-02	5.37E-02	1.18E-02	2.17E-02	3.85E-02	5.20E+00	4.89E+00	7.32E+00	1.08E+01	3.00E+00	2.98E+00	3.70E+00
$9M_{i1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$9M_{i2}$	4.69E+00	5.40E-01	9.49E-01	2.59E+00	3.91E-01	1.17E+00	1.96E+00	2.08E+02	1.94E+02	2.93E+02	4.21E+02	1.17E+02	1.37E+02	1.62E+02
$9M_{i3}$	4.74E+01	1.87E+01	4.15E+01	1.11E+02	2.25E+01	2.66E+01	5.74E+01	1.97E+01	8.10E+00	1.51E+01	2.18E+01	5.01E+00	7.08E+00	1.55E+01
$9R_{j1}$	4.27E-01	1.21E-01	3.11E-01	7.89E-01	1.27E-01	1.59E-01	4.14E-01	1.14E+00	4.04E-01	7.02E-01	1.85E+00	2.61E-01	3.54E-01	8.88E-01
$9R_{j2}$	1.16E+00	4.83E-01	9.49E-01	2.36E+00	5.98E-01	7.39E-01	1.30E+00	1.89E-01	1.23E-01	2.05E-01	2.71E-01	8.33E-02	1.34E-01	1.64E-01
$9R_{j3}$	5.49E-02	1.07E-02	2.81E-02	5.37E-02	1.18E-02	2.17E-02	3.85E-02	5.20E+00	4.89E+00	7.32E+00	1.08E+01	3.00E+00	2.98E+00	3.70E+00
$9M_{j1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$9M_{j2}$	4.27E+00	1.23E+00	2.30E+00	5.48E+00	1.19E+00	1.91E+00	3.70E+00	6.43E+02	6.00E+02	9.07E+02	1.32E+03	3.67E+02	3.82E+02	4.45E+02
$9M_{j3}$	1.45E+02	5.88E+01	1.21E+02	3.09E+02	7.28E+01	8.84E+01	1.64E+02	2.21E+01	1.68E+01	2.75E+01	2.61E+01	1.18E+01	1.68E+01	1.53E+01
$10R_{i1}$	4.10E-01	1.21E-01	3.01E-01	7.62E-01	1.31E-01	1.62E-01	4.02E-01	9.11E-01	2.57E-01	4.74E-01	1.34E+00	1.85E-01	2.33E-01	7.01E-01
$10R_{i2}$	1.34E-01	4.28E-02	1.04E-01	2.61E-01	4.48E-02	5.83E-02	1.42E-01	2.69E-01	4.97E-02	8.53E-02	3.68E-01	2.86E-02	6.38E-02	1.86E-01
$10R_{i3}$	7.90E-02	6.54E-03	1.59E-02	2.39E-02	4.36E-03	1.61E-02	1.93E-02	6.66E-01	1.53E-01	3.15E-01	9.62E-01	1.20E-01	2.08E-01	4.78E-01
$10M_{i1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$10M_{i2}$	4.27E+00	1.23E+00	2.30E+00	5.48E+00	1.19E+00	1.91E+00	3.70E+00	6.43E+02	6.00E+02	9.07E+02	1.32E+03	3.67E+02	3.82E+02	4.45E+02
$10M_{i3}$	1.45E+02	5.88E+01	1.21E+02	3.09E+02	7.28E+01	8.84E+01	1.64E+02	2.21E+01	1.68E+01	2.75E+01	2.61E+01	1.18E+01	1.68E+01	1.53E+01
$10R_{j1}$	4.10E-01	1.21E-01	3.01E-01	7.62E-01	1.31E-01	1.62E-01	4.02E-01	9.11E-01	2.57E-01	4.74E-01	1.34E+00	1.85E-01	2.33E-01	7.01E-01
$10R_{j2}$	1.34E-01	4.28E-02	1.04E-01	2.61E-01	4.48E-02	5.83E-02	1.42E-01	2.69E-01	4.97E-02	8.53E-02	3.68E-01	2.86E-02	6.38E-02	1.86E-01
$10R_{j3}$	7.90E-02	6.54E-03	1.59E-02	2.39E-02	4.36E-03	1.61E-02	1.93E-02	6.66E-01	1.53E-01	3.15E-01	9.62E-01	1.20E-01	2.08E-01	4.78E-01
$10M_{j1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$10M_{j2}$	6.50E+00	1.33E+00	3.12E+00	5.78E+00	1.34E+00	2.46E+00	4.07E+00	6.36E+02	5.96E+02	8.91E+02	1.30E+03	3.61E+02	3.68E+02	4.51E+02
$10M_{j3}$	1.38E+02	5.61E+01	1.14E+02	2.87E+02	6.93E+01	8.49E+01	1.54E+02	2.65E+01	1.54E+01	2.63E+01	3.42E+01	1.06E+01	1.57E+01	1.78E+01
$11R_{i1}$	3.90E-01	1.22E-01	2.92E-01	7.35E-01	1.35E-01	1.64E-01	3.90E-01	6.81E-01	1.59E-01	3.10E-01	9.73E-01	1.14E-01	1.94E-01	5.08E-01
$11R_{i2}$	1.32E+00	5.36E-01	1.10E+00	2.79E+00	6.60E-01	8.07E-01	1.49E+00	2.53E-01	1.53E-01	2.56E-01	3.55E-01	1.08E-01	1.50E-01	1.79E-01
$11R_{i3}$	5.16E-02	1.09E-02	2.22E-02	4.60E-02	1.05E-02	1.93E-02	3.07E-02	5.30E+00	4.99E+00	7.58E+00	1.11E+01	3.08E+00	3.17E+00	3.74E+00
$11M_{i1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$11M_{i2}$	6.50E+00	1.33E+00	3.12E+00	5.78E+00	1.34E+00	2.46E+00	4.07E+00	6.36E+02	5.96E+02	8.91E+02	1.30E+03	3.61E+02	3.68E+02	4.51E+02
$11M_{i3}$	1.38E+02	5.61E+01	1.14E+02	2.87E+02	6.93E+01	8.49E+01	1.54E+02	2.65E+01	1.54E+01	2.63E+01	3.42E+01	1.06E+01	1.57E+01	1.78E+01
$11R_{j1}$	3.90E-01	1.22E-01	2.92E-01	7.35E-01	1.35E-01	1.64E-01	3.90E-01	6.81E-01	1.59E-01	3.10E-01	9.73E-01	1.14E-01	1.94E-01	5.08E-01
$11R_{j2}$	1.32E+00	5.36E-01	1.10E+00	2.79E+00	6.60E-01	8.07E-01	1.49E+00	2.53E-01	1.53E-01	2.56E-01	3.55E-01	1.08E-01	1.50E-01	1.79E-01
$11R_{j3}$	5.16E-02	1.09E-02	2.22E-02	4.60E-02	1.05E-02	1.93E-02	3.07E-02	5.30E+00	4.99E+00	7.58E+00	1.11E+01	3.08E+00	3.17E+00	3.74E+00
$11M_{j1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$11M_{j2}$	3.72E+00	5.45E-01	1.34E+00	2.51E+00	5.17E-01	1.01E+00	1.83E+00	1.98E+02	1.77E+02	2.59E+02	3.73E+02	1.05E+02	1.09E+02	1.37E+02
$11M_{j3}$	2.69E+01	1.11E+01	2.13E+01	5.35E+01	1.39E+01	1.73E+01	2.90E+01	8.99E+00	3.81E+00	6.44E+00	1.44E+01	2.55E+00	3.93E+00	1.01E+01

Table 3.4.5 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$12R_{i1}$	3.71E-01	1.22E-01	2.85E-01	7.08E-01	1.41E-01	1.70E-01	3.79E-01	4.66E-01	2.39E-01	3.53E-01	9.06E-01	1.36E-01	2.22E-01	3.70E-01
$12R_{i2}$	2.05E+00	8.40E-01	1.67E+00	4.28E+00	1.05E+00	1.29E+00	2.27E+00	4.87E-01	2.25E-01	3.97E-01	6.22E-01	1.54E-01	2.32E-01	3.10E-01
$12R_{i3}$	1.25E-01	1.95E-02	4.57E-02	7.42E-02	1.80E-02	3.87E-02	5.49E-02	8.34E+00	7.84E+00	1.18E+01	1.75E+01	4.84E+00	4.85E+00	6.05E+00
$12M_{i1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$12M_{i2}$	3.72E+00	5.45E-01	1.34E+00	2.51E+00	5.17E-01	1.01E+00	1.83E+00	1.98E+02	1.77E+02	2.59E+02	3.73E+02	1.05E+02	1.09E+02	1.37E+02
$12M_{i3}$	2.69E+01	1.11E+01	2.13E+01	5.35E+01	1.39E+01	1.73E+01	2.90E+01	8.99E+00	3.81E+00	6.44E+00	1.44E+01	2.55E+00	3.93E+00	1.01E+01
$12R_{j1}$	3.71E-01	1.22E-01	2.85E-01	7.08E-01	1.41E-01	1.70E-01	3.79E-01	4.66E-01	2.39E-01	3.53E-01	9.06E-01	1.36E-01	2.22E-01	3.70E-01
$12R_{j2}$	2.05E+00	8.40E-01	1.67E+00	4.28E+00	1.05E+00	1.29E+00	2.27E+00	4.87E-01	2.25E-01	3.97E-01	6.22E-01	1.54E-01	2.32E-01	3.10E-01
$12R_{j3}$	1.25E-01	1.95E-02	4.57E-02	7.42E-02	1.80E-02	3.87E-02	5.49E-02	8.34E+00	7.84E+00	1.18E+01	1.75E+01	4.84E+00	4.85E+00	6.05E+00
$12M_{j1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$12M_{j2}$	8.22E+00	1.22E+00	2.58E+00	4.33E+00	1.08E+00	2.38E+00	3.53E+00	5.09E+02	4.82E+02	7.33E+02	1.10E+03	3.06E+02	3.06E+02	3.71E+02
$12M_{j3}$	1.45E+02	5.94E+01	1.19E+02	3.06E+02	7.41E+01	9.13E+01	1.62E+02	3.43E+01	1.70E+01	2.86E+01	4.37E+01	1.15E+01	1.63E+01	2.28E+01
$13R_{i1}$	3.50E-01	1.22E-01	2.77E-01	6.80E-01	1.47E-01	1.76E-01	3.71E-01	4.97E-01	3.60E-01	5.12E-01	9.15E-01	2.17E-01	3.13E-01	3.96E-01
$13R_{i2}$	9.71E-01	3.76E-01	7.12E-01	1.91E+00	4.83E-01	6.14E-01	9.82E-01	5.28E-01	1.14E-01	2.53E-01	7.96E-01	7.96E-02	1.63E-01	3.95E-01
$13R_{i3}$	1.53E-01	1.25E-02	2.72E-02	2.82E-02	8.15E-03	3.12E-02	2.14E-02	2.65E+00	2.00E+00	3.21E+00	5.15E+00	1.61E+00	1.51E+00	1.83E+00
$13M_{i1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$13M_{i2}$	8.22E+00	1.22E+00	2.58E+00	4.33E+00	1.08E+00	2.38E+00	3.53E+00	5.09E+02	4.82E+02	7.33E+02	1.10E+03	3.06E+02	3.06E+02	3.71E+02
$13M_{i3}$	1.45E+02	5.94E+01	1.19E+02	3.06E+02	7.41E+01	9.13E+01	1.62E+02	3.43E+01	1.70E+01	2.86E+01	4.37E+01	1.15E+01	1.63E+01	2.28E+01
$13R_{j1}$	3.50E-01	1.22E-01	2.77E-01	6.80E-01	1.47E-01	1.76E-01	3.71E-01	4.97E-01	3.60E-01	5.12E-01	9.15E-01	2.17E-01	3.13E-01	3.96E-01
$13R_{j2}$	9.71E-01	3.76E-01	7.12E-01	1.91E+00	4.83E-01	6.14E-01	9.82E-01	5.28E-01	1.14E-01	2.53E-01	7.96E-01	7.96E-02	1.63E-01	3.95E-01
$13R_{j3}$	1.53E-01	1.25E-02	2.72E-02	2.82E-02	8.15E-03	3.12E-02	2.14E-02	2.65E+00	2.00E+00	3.21E+00	5.15E+00	1.61E+00	1.51E+00	1.83E+00
$13M_{j1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$13M_{j2}$	5.65E+00	9.53E-01	2.18E+00	2.93E+00	7.97E-01	1.94E+00	2.09E+00	3.45E+02	3.17E+02	4.72E+02	6.97E+02	1.89E+02	2.02E+02	2.41E+02
$13M_{j3}$	7.02E+01	2.79E+01	5.92E+01	1.46E+02	3.37E+01	3.97E+01	8.07E+01	2.71E+01	1.41E+01	2.32E+01	3.89E+01	8.62E+00	1.03E+01	1.81E+01
$14R_{i1}$	3.43E-01	1.26E-01	2.69E-01	6.53E-01	1.52E-01	1.81E-01	3.64E-01	6.47E-01	5.18E-01	7.16E-01	1.32E+00	2.98E-01	4.47E-01	4.84E-01
$14R_{i2}$	8.95E-01	3.58E-01	7.50E-01	1.87E+00	4.34E-01	5.16E-01	1.02E+00	2.99E-01	1.06E-01	1.95E-01	4.47E-01	8.76E-02	1.44E-01	2.32E-01
$14R_{i3}$	5.04E-02	9.01E-03	2.00E-02	2.88E-02	7.43E-03	1.77E-02	2.17E-02	3.35E+00	3.09E+00	4.62E+00	6.95E+00	1.85E+00	1.96E+00	2.35E+00
$14M_{i1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$14M_{i2}$	5.65E+00	9.53E-01	2.18E+00	2.93E+00	7.97E-01	1.94E+00	2.09E+00	3.45E+02	3.17E+02	4.72E+02	6.97E+02	1.89E+02	2.02E+02	2.41E+02
$14M_{i3}$	7.02E+01	2.79E+01	5.92E+01	1.46E+02	3.37E+01	3.97E+01	8.07E+01	2.71E+01	1.41E+01	2.32E+01	3.89E+01	8.62E+00	1.03E+01	1.81E+01
$14R_{j1}$	3.43E-01	1.26E-01	2.69E-01	6.53E-01	1.52E-01	1.81E-01	3.64E-01	6.47E-01	5.18E-01	7.16E-01	1.32E+00	2.98E-01	4.47E-01	4.84E-01
$14R_{j2}$	8.95E-01	3.58E-01	7.50E-01	1.87E+00	4.34E-01	5.16E-01	1.02E+00	2.99E-01	1.06E-01	1.95E-01	4.47E-01	8.76E-02	1.44E-01	2.32E-01
$14R_{j3}$	5.04E-02	9.01E-03	2.00E-02	2.88E-02	7.43E-03	1.77E-02	2.17E-02	3.35E+00	3.09E+00	4.62E+00	6.95E+00	1.85E+00	1.96E+00	2.35E+00
$14M_{j1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$14M_{j2}$	2.08E+00	2.26E-01	6.27E-01	7.85E-01	1.79E-01	4.96E-01	5.62E-01	6.77E+01	5.77E+01	8.88E+01	1.25E+02	3.65E+01	4.41E+01	4.34E+01
$14M_{j3}$	5.63E+00	2.17E+00	3.96E+00	1.06E+01	2.84E+00	3.61E+00	5.62E+00	1.59E+01	1.34E+01	1.90E+01	2.99E+01	7.68E+00	1.18E+01	1.21E+01

Table 3.4.5 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$15R_{i1}$	3.39E-01	1.29E-01	2.63E-01	6.39E-01	1.56E-01	1.85E-01	3.65E-01	7.67E-01	6.29E-01	8.66E-01	1.60E+00	3.52E-01	5.51E-01	5.53E-01
$15R_{i2}$	8.91E-01	3.39E-01	7.69E-01	1.79E+00	4.03E-01	4.81E-01	1.05E+00	6.81E-01	1.37E-01	2.92E-01	8.93E-01	1.05E-01	1.88E-01	4.47E-01
$15R_{i3}$	1.41E-01	1.56E-02	4.12E-02	4.92E-02	1.29E-02	3.47E-02	3.55E-02	4.55E+00	3.94E+00	5.93E+00	8.39E+00	2.43E+00	2.85E+00	3.02E+00
$15M_{i1}$	1.87E+00	7.14E-01	1.74E+00	4.32E+00	7.95E-01	9.77E-01	2.30E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$15M_{i2}$	2.08E+00	2.26E-01	6.27E-01	7.85E-01	1.79E-01	4.96E-01	5.62E-01	6.77E+01	5.77E+01	8.88E+01	1.25E+02	3.65E+01	4.41E+01	4.34E+01
$15M_{i3}$	5.63E+00	2.17E+00	3.96E+00	1.06E+01	2.84E+00	3.61E+00	5.62E+00	1.59E+01	1.34E+01	1.90E+01	2.99E+01	7.68E+00	1.18E+01	1.21E+01
$15R_{C1}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$15R_{C2}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$15R_{C3}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$15M_{C1}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$15M_{C2}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$15M_{C3}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$15Rj_1$	8.91E-01	3.39E-01	7.69E-01	1.79E+00	4.03E-01	4.81E-01	1.05E+00	6.81E-01	1.37E-01	2.92E-01	8.93E-01	1.05E-01	1.88E-01	4.47E-01
$15Rj_2$	3.39E-01	1.29E-01	2.63E-01	6.39E-01	1.56E-01	1.85E-01	3.65E-01	7.67E-01	6.29E-01	8.66E-01	1.60E+00	3.52E-01	5.51E-01	5.53E-01
$15Rj_3$	1.41E-01	1.56E-02	4.12E-02	4.92E-02	1.29E-02	3.47E-02	3.55E-02	4.55E+00	3.94E+00	5.93E+00	8.39E+00	2.43E+00	2.85E+00	3.02E+00
$15Mj_1$	6.93E-01	7.51E-02	2.11E-01	3.12E-01	7.39E-02	1.93E-01	2.60E-01	1.71E+01	1.33E+01	2.05E+01	3.36E+01	8.30E+00	8.86E+00	1.09E+01
$15Mj_2$	2.97E+00	7.65E-01	1.73E+00	3.64E+00	7.63E-01	9.33E-01	2.00E+00	5.60E+01	4.58E+01	6.90E+01	9.93E+01	2.84E+01	3.27E+01	3.66E+01
$15Mj_3$	1.43E+01	5.68E+00	1.22E+01	2.97E+01	6.74E+00	8.11E+00	1.68E+01	6.69E+00	3.92E+00	5.90E+00	1.28E+01	2.49E+00	4.64E+00	5.33E+00
$16R_{i1}$	8.87E-01	3.42E-01	7.75E-01	1.96E+00	4.39E-01	4.77E-01	1.06E+00	9.48E-01	1.83E-01	3.80E-01	1.30E+00	1.25E-01	2.37E-01	5.89E-01
$16R_{i2}$	1.63E-01	1.92E-02	5.15E-02	6.85E-02	1.53E-02	4.00E-02	4.69E-02	5.25E+00	4.40E+00	6.85E+00	9.56E+00	2.86E+00	3.42E+00	3.26E+00
$16R_{i3}$	3.44E-01	1.34E-01	2.67E-01	6.46E-01	1.61E-01	1.91E-01	3.75E-01	8.70E-01	6.98E-01	9.69E-01	1.78E+00	3.91E-01	6.13E-01	6.10E-01
$16M_{i1}$	6.93E-01	7.51E-02	2.11E-01	3.12E-01	7.39E-02	1.93E-01	2.60E-01	1.71E+01	1.33E+01	2.05E+01	3.36E+01	8.30E+00	8.86E+00	1.09E+01
$16M_{i2}$	1.43E+01	5.68E+00	1.22E+01	2.97E+01	6.74E+00	8.11E+00	1.68E+01	6.69E+00	3.92E+00	5.90E+00	1.28E+01	2.49E+00	4.64E+00	5.33E+00
$16M_{i3}$	2.97E+00	7.65E-01	1.73E+00	3.64E+00	7.63E-01	9.33E-01	2.00E+00	5.60E+01	4.58E+01	6.90E+01	9.93E+01	2.84E+01	3.27E+01	3.66E+01
$16Rj_1$	8.87E-01	3.42E-01	7.75E-01	1.96E+00	4.39E-01	4.77E-01	1.06E+00	9.48E-01	1.83E-01	3.80E-01	1.30E+00	1.25E-01	2.37E-01	5.89E-01
$16Rj_2$	1.63E-01	1.92E-02	5.15E-02	6.85E-02	1.53E-02	4.00E-02	4.69E-02	5.25E+00	4.40E+00	6.85E+00	9.56E+00	2.86E+00	3.42E+00	3.26E+00
$16Rj_3$	3.44E-01	1.34E-01	2.67E-01	6.46E-01	1.61E-01	1.91E-01	3.75E-01	8.70E-01	6.98E-01	9.69E-01	1.78E+00	3.91E-01	6.13E-01	6.10E-01
$16Mj_1$	6.93E-01	7.51E-02	2.11E-01	3.12E-01	7.39E-02	1.93E-01	2.60E-01	1.71E+01	1.33E+01	2.05E+01	3.36E+01	8.30E+00	8.86E+00	1.09E+01
$16Mj_2$	7.43E+00	2.36E+00	4.60E+00	1.05E+01	2.92E+00	3.72E+00	6.30E+00	4.65E+01	3.80E+01	5.42E+01	9.80E+01	2.17E+01	3.24E+01	3.22E+01
$16Mj_3$	1.25E+01	1.32E+00	2.56E+00	3.56E+00	8.63E-01	2.70E+00	2.96E+00	3.71E+02	3.10E+02	4.80E+02	6.70E+02	2.00E+02	2.38E+02	2.32E+02

Table 3.4.5 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$17R_{i1}$	9.19E-01	3.83E-01	7.86E-01	2.40E+00	5.04E-01	5.00E-01	1.14E+00	1.42E+00	2.80E-01	5.59E-01	2.06E+00	1.62E-01	3.26E-01	8.62E-01
$17R_{i2}$	2.69E-01	3.05E-02	7.61E-02	1.28E-01	3.02E-02	5.87E-02	6.68E-02	2.94E+00	1.61E+00	2.53E+00	4.43E+00	1.08E+00	1.27E+00	1.63E+00
$17R_{i3}$	9.88E-02	1.32E-02	2.75E-02	4.87E-02	1.12E-02	2.19E-02	3.01E-02	4.22E-01	1.58E-01	2.58E-01	6.57E-01	8.97E-02	1.37E-01	2.46E-01
$17M_{i1}$	6.93E-01	7.51E-02	2.11E-01	3.12E-01	7.39E-02	1.93E-01	2.60E-01	1.71E+01	1.33E+01	2.05E+01	3.36E+01	8.30E+00	8.86E+00	1.09E+01
$17M_{i2}$	7.43E+00	2.36E+00	4.60E+00	1.05E+01	2.92E+00	3.72E+00	6.30E+00	4.65E+01	3.80E+01	5.42E+01	9.80E+01	2.17E+01	3.24E+01	3.22E+01
$17M_{i3}$	1.25E+01	1.32E+00	2.56E+00	3.56E+00	8.63E-01	2.70E+00	2.96E+00	3.71E+02	3.10E+02	4.80E+02	6.70E+02	2.00E+02	2.38E+02	2.32E+02
$17Rj_1$	9.19E-01	3.83E-01	7.86E-01	2.40E+00	5.04E-01	5.00E-01	1.14E+00	1.42E+00	2.80E-01	5.59E-01	2.06E+00	1.62E-01	3.26E-01	8.62E-01
$17Rj_2$	2.69E-01	3.05E-02	7.61E-02	1.28E-01	3.02E-02	5.87E-02	6.68E-02	2.94E+00	1.61E+00	2.53E+00	4.43E+00	1.08E+00	1.27E+00	1.63E+00
$17Rj_3$	9.88E-02	1.32E-02	2.75E-02	4.87E-02	1.12E-02	2.19E-02	3.01E-02	4.22E-01	1.58E-01	2.58E-01	6.57E-01	8.97E-02	1.37E-01	2.46E-01
$17Mj_1$	6.93E-01	7.51E-02	2.11E-01	3.12E-01	7.39E-02	1.93E-01	2.60E-01	1.71E+01	1.33E+01	2.05E+01	3.36E+01	8.30E+00	8.86E+00	1.09E+01
$17Mj_2$	8.90E+00	1.73E+00	3.50E+00	7.53E+00	2.03E+00	2.77E+00	4.42E+00	3.52E+01	2.32E+01	3.40E+01	6.07E+01	1.31E+01	2.01E+01	2.44E+01
$17M_{j3}$	1.60E+01	2.33E+00	5.65E+00	1.20E+01	2.44E+00	4.44E+00	6.34E+00	2.31E+02	1.70E+02	2.54E+02	4.30E+02	9.96E+01	1.16E+02	1.48E+02
$18R_{i1}$	1.04E+00	4.97E-01	9.19E-01	2.90E+00	6.71E-01	5.52E-01	1.26E+00	1.93E+00	4.02E-01	7.57E-01	2.88E+00	2.21E-01	4.66E-01	1.17E+00
$18R_{i2}$	1.65E-01	2.53E-02	5.10E-02	1.03E-01	2.58E-02	3.90E-02	4.60E-02	2.79E+00	2.09E+00	3.12E+00	5.24E+00	1.23E+00	1.44E+00	1.76E+00
$18R_{i3}$	9.46E-02	1.89E-02	3.79E-02	8.05E-02	2.23E-02	3.03E-02	4.79E-02	3.60E-01	2.43E-01	3.53E-01	6.30E-01	1.36E-01	2.16E-01	2.53E-01
$18M_{i1}$	6.93E-01	7.51E-02	2.11E-01	3.12E-01	7.39E-02	1.93E-01	2.60E-01	1.71E+01	1.33E+01	2.05E+01	3.36E+01	8.30E+00	8.86E+00	1.09E+01
$18M_{i2}$	8.90E+00	1.73E+00	3.50E+00	7.53E+00	2.03E+00	2.77E+00	4.42E+00	3.52E+01	2.32E+01	3.40E+01	6.07E+01	1.31E+01	2.01E+01	2.44E+01
$18M_{i3}$	1.60E+01	2.33E+00	5.65E+00	1.20E+01	2.44E+00	4.44E+00	6.34E+00	2.31E+02	1.70E+02	2.54E+02	4.30E+02	9.96E+01	1.16E+02	1.48E+02
$18Rj_1$	1.04E+00	4.97E-01	9.19E-01	2.90E+00	6.71E-01	5.52E-01	1.26E+00	1.93E+00	4.02E-01	7.57E-01	2.88E+00	2.21E-01	4.66E-01	1.17E+00
$18Rj_2$	1.65E-01	2.53E-02	5.10E-02	1.03E-01	2.58E-02	3.90E-02	4.60E-02	2.79E+00	2.09E+00	3.12E+00	5.24E+00	1.23E+00	1.44E+00	1.76E+00
$18Rj_3$	9.46E-02	1.89E-02	3.79E-02	8.05E-02	2.23E-02	3.03E-02	4.79E-02	3.60E-01	2.43E-01	3.53E-01	6.30E-01	1.36E-01	2.16E-01	2.53E-01
$18Mj_1$	6.93E-01	7.51E-02	2.11E-01	3.12E-01	7.39E-02	1.93E-01	2.60E-01	1.71E+01	1.33E+01	2.05E+01	3.36E+01	8.30E+00	8.86E+00	1.09E+01
$18Mj_2$	1.33E+00	2.25E-01	4.79E-01	1.12E+00	2.42E-01	3.47E-01	5.94E-01	6.45E+00	3.76E+00	5.76E+00	1.12E+01	2.22E+00	2.85E+00	4.20E+00
$18M_{j3}$	7.74E+00	3.21E+00	6.10E+00	1.94E+01	4.14E+00	3.87E+00	8.87E+00	1.85E+01	4.60E+00	9.74E+00	3.18E+01	6.58E+00	7.07E+00	1.47E+01

Table 3.4.5 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$19R_{i1}$	1.12E+00	5.67E-01	1.02E+00	3.21E+00	7.93E-01	5.99E-01	1.33E+00	2.22E+00	4.72E-01	8.71E-01	3.34E+00	2.62E-01	5.53E-01	1.35E+00
$19R_{i2}$	2.31E-01	2.69E-02	5.67E-02	9.39E-02	2.54E-02	5.07E-02	4.19E-02	3.21E+00	2.28E+00	3.37E+00	5.86E+00	1.43E+00	1.60E+00	2.11E+00
$19R_{i3}$	1.45E-01	2.70E-02	5.53E-02	1.28E-01	3.04E-02	4.21E-02	7.06E-02	5.04E-01	2.71E-01	4.10E-01	8.04E-01	1.52E-01	2.50E-01	3.18E-01
$19M_{i1}$	6.93E-01	7.51E-02	2.11E-01	3.12E-01	7.39E-02	1.93E-01	2.60E-01	1.71E+01	1.33E+01	2.05E+01	3.36E+01	8.30E+00	8.86E+00	1.09E+01
$19M_{i2}$	1.33E+00	2.25E-01	4.79E-01	1.12E+00	2.42E-01	3.47E-01	5.94E-01	6.45E+00	3.76E+00	5.76E+00	1.12E+01	2.22E+00	2.85E+00	4.20E+00
$19M_{i3}$	7.74E+00	3.21E+00	6.10E+00	1.94E+01	4.14E+00	3.87E+00	8.87E+00	1.85E+01	4.60E+00	9.74E+00	3.18E+01	6.58E+00	7.07E+00	1.47E+01
$19RC_1$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$19RC_2$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$19RC_3$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$19MC_1$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$19MC_2$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$19M_{C3}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$19Rj_1$	2.31E-01	2.69E-02	5.67E-02	9.39E-02	2.54E-02	5.07E-02	4.19E-02	3.21E+00	2.28E+00	3.37E+00	5.86E+00	1.43E+00	1.60E+00	2.11E+00
$19Rj_2$	1.12E+00	5.67E-01	1.02E+00	3.21E+00	7.93E-01	5.99E-01	1.33E+00	2.22E+00	4.72E-01	8.71E-01	3.34E+00	2.62E-01	5.53E-01	1.35E+00
$19Rj_3$	1.45E-01	2.70E-02	5.53E-02	1.28E-01	3.04E-02	4.21E-02	7.06E-02	5.04E-01	2.71E-01	4.10E-01	8.04E-01	1.52E-01	2.50E-01	3.18E-01
$19Mj_1$	1.28E+00	2.62E-01	5.24E-01	1.19E+00	3.05E-01	4.12E-01	6.79E-01	2.90E+00	1.24E+00	2.09E+00	4.44E+00	1.08E+00	1.65E+00	2.01E+00
$19Mj_2$	2.32E+00	5.18E-01	1.01E+00	2.31E+00	5.73E-01	7.76E-01	1.29E+00	2.41E+01	1.78E+01	2.72E+01	4.70E+01	1.08E+01	1.25E+01	1.67E+01
$19M_{j3}$	1.44E+01	6.69E+00	1.19E+01	3.69E+01	9.69E+00	7.03E+00	1.47E+01	8.32E+01	4.55E+01	6.91E+01	1.32E+02	2.60E+01	3.21E+01	4.88E+01
$20R_{i1}$	2.36E-01	2.73E-02	5.77E-02	9.45E-02	2.56E-02	5.18E-02	4.22E-02	3.34E+00	2.38E+00	3.45E+00	6.11E+00	1.68E+00	1.79E+00	2.25E+00
$20R_{i2}$	3.19E-01	1.36E-01	2.19E-01	5.74E-01	2.07E-01	1.34E-01	2.07E-01	1.44E+00	3.08E-01	5.37E-01	1.54E+00	1.46E-01	3.27E-01	7.67E-01
$20R_{i3}$	7.25E-02	1.36E-02	2.98E-02	7.63E-02	1.35E-02	1.86E-02	3.80E-02	2.77E-01	1.09E-01	1.79E-01	4.62E-01	6.75E-02	1.16E-01	1.46E-01
$20M_{i1}$	1.28E+00	2.62E-01	5.24E-01	1.19E+00	3.05E-01	4.12E-01	6.79E-01	2.90E+00	1.24E+00	2.09E+00	4.44E+00	1.08E+00	1.65E+00	2.01E+00
$20M_{i2}$	2.32E+00	5.18E-01	1.01E+00	2.31E+00	5.73E-01	7.76E-01	1.29E+00	2.41E+01	1.78E+01	2.72E+01	4.70E+01	1.08E+01	1.25E+01	1.67E+01
$20M_{i3}$	1.44E+01	6.69E+00	1.19E+01	3.69E+01	9.69E+00	7.03E+00	1.47E+01	8.32E+01	4.55E+01	6.91E+01	1.32E+02	2.60E+01	3.21E+01	4.88E+01
$20Rj_1$	2.36E-01	2.73E-02	5.77E-02	9.45E-02	2.56E-02	5.18E-02	4.22E-02	3.34E+00	2.38E+00	3.45E+00	6.11E+00	1.68E+00	1.79E+00	2.25E+00
$20Rj_2$	3.19E-01	1.36E-01	2.19E-01	5.74E-01	2.07E-01	1.34E-01	2.07E-01	1.44E+00	3.08E-01	5.37E-01	1.54E+00	1.46E-01	3.27E-01	7.67E-01
$20Rj_3$	7.25E-02	1.36E-02	2.98E-02	7.63E-02	1.35E-02	1.86E-02	3.80E-02	2.77E-01	1.09E-01	1.79E-01	4.62E-01	6.75E-02	1.16E-01	1.46E-01
$20Mj_1$	1.28E+00	2.62E-01	5.24E-01	1.19E+00	3.05E-01	4.12E-01	6.79E-01	2.90E+00	1.24E+00	2.09E+00	4.44E+00	1.08E+00	1.65E+00	2.01E+00
$20Mj_2$	2.30E+00	4.46E-01	1.04E+00	3.02E+00	3.59E-01	5.34E-01	1.28E+00	1.86E+01	1.26E+01	1.84E+01	3.19E+01	7.49E+00	1.03E+01	1.11E+01
$20M_{j3}$	1.05E+01	3.44E+00	6.61E+00	1.95E+01	4.63E+00	5.98E+00	9.34E+00	5.72E+01	3.11E+01	4.51E+01	8.17E+01	1.75E+01	2.47E+01	4.15E+01

Table 3.4.5 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$21R_{i1}$	2.42E-01	2.77E-02	5.88E-02	9.54E-02	2.57E-02	5.31E-02	4.26E-02	4.01E+00	2.65E+00	3.68E+00	6.43E+00	2.03E+00	2.04E+00	2.53E+00
$21R_{i2}$	1.11E-01	4.51E-02	8.01E-02	2.43E-01	6.51E-02	4.72E-02	9.46E-02	6.43E-01	2.89E-01	4.48E-01	9.29E-01	1.63E-01	2.15E-01	3.54E-01
$21R_{i3}$	1.79E-02	3.70E-03	7.37E-03	1.66E-02	3.97E-03	5.45E-03	9.11E-03	1.67E-01	1.10E-01	1.74E-01	3.22E-01	6.97E-02	7.55E-02	1.06E-01
$21M_{i1}$	1.28E+00	2.62E-01	5.24E-01	1.19E+00	3.05E-01	4.12E-01	6.79E-01	2.90E+00	1.24E+00	2.09E+00	4.44E+00	1.08E+00	1.65E+00	2.01E+00
$21M_{i2}$	2.30E+00	4.46E-01	1.04E+00	3.02E+00	3.59E-01	5.34E-01	1.28E+00	1.86E+01	1.26E+01	1.84E+01	3.19E+01	7.49E+00	1.03E+01	1.11E+01
$21M_{i3}$	1.05E+01	3.44E+00	6.61E+00	1.95E+01	4.63E+00	5.98E+00	9.34E+00	5.72E+01	3.11E+01	4.51E+01	8.17E+01	1.75E+01	2.47E+01	4.15E+01
$21R_{j1}$	2.42E-01	2.77E-02	5.88E-02	9.54E-02	2.57E-02	5.31E-02	4.26E-02	4.01E+00	2.65E+00	3.68E+00	6.43E+00	2.03E+00	2.04E+00	2.53E+00
$21R_{j2}$	1.11E-01	4.51E-02	8.01E-02	2.43E-01	6.51E-02	4.72E-02	9.46E-02	6.43E-01	2.89E-01	4.48E-01	9.29E-01	1.63E-01	2.15E-01	3.54E-01
$21R_{j3}$	1.79E-02	3.70E-03	7.37E-03	1.66E-02	3.97E-03	5.45E-03	9.11E-03	1.67E-01	1.10E-01	1.74E-01	3.22E-01	6.97E-02	7.55E-02	1.06E-01
$21M_{j1}$	1.28E+00	2.62E-01	5.24E-01	1.19E+00	3.05E-01	4.12E-01	6.79E-01	2.90E+00	1.24E+00	2.09E+00	4.44E+00	1.08E+00	1.65E+00	2.01E+00
$21M_{j2}$	3.34E+00	6.08E-01	1.33E+00	3.76E+00	5.25E-01	6.87E-01	1.65E+00	1.57E+01	6.41E+00	9.24E+00	2.38E+01	3.56E+00	7.29E+00	8.87E+00
$21M_{j3}$	1.40E+01	4.49E+00	7.69E+00	1.99E+01	7.18E+00	6.95E+00	8.17E+00	6.42E+01	1.54E+01	2.53E+01	7.61E+01	8.22E+00	1.61E+01	4.23E+01
$22R_{i1}$	2.46E-01	2.80E-02	5.95E-02	9.60E-02	2.58E-02	5.39E-02	4.28E-02	4.67E+00	2.92E+00	3.93E+00	7.25E+00	2.39E+00	2.31E+00	2.80E+00
$22R_{i2}$	2.02E-01	5.81E-02	1.11E-01	3.03E-01	9.22E-02	1.01E-01	1.34E-01	1.04E+00	3.40E-01	5.14E-01	1.30E+00	1.83E-01	2.98E-01	7.21E-01
$22R_{i3}$	4.90E-02	8.74E-03	1.92E-02	5.44E-02	7.13E-03	9.75E-03	2.39E-02	2.79E-01	1.37E-01	1.96E-01	4.38E-01	7.92E-02	1.26E-01	1.58E-01
$22M_{i1}$	1.28E+00	2.62E-01	5.24E-01	1.19E+00	3.05E-01	4.12E-01	6.79E-01	2.90E+00	1.24E+00	2.09E+00	4.44E+00	1.08E+00	1.65E+00	2.01E+00
$22M_{i2}$	3.34E+00	6.08E-01	1.33E+00	3.76E+00	5.25E-01	6.87E-01	1.65E+00	1.57E+01	6.41E+00	9.24E+00	2.38E+01	3.56E+00	7.29E+00	8.87E+00
$22M_{i3}$	1.40E+01	4.49E+00	7.69E+00	1.99E+01	7.18E+00	6.95E+00	8.17E+00	6.42E+01	1.54E+01	2.53E+01	7.61E+01	8.22E+00	1.61E+01	4.23E+01
$22R_{j1}$	2.46E-01	2.80E-02	5.95E-02	9.60E-02	2.58E-02	5.39E-02	4.28E-02	4.67E+00	2.92E+00	3.93E+00	7.25E+00	2.39E+00	2.31E+00	2.80E+00
$22R_{j2}$	2.02E-01	5.81E-02	1.11E-01	3.03E-01	9.22E-02	1.01E-01	1.34E-01	1.04E+00	3.40E-01	5.14E-01	1.30E+00	1.83E-01	2.98E-01	7.21E-01
$22R_{j3}$	4.90E-02	8.74E-03	1.92E-02	5.44E-02	7.13E-03	9.75E-03	2.39E-02	2.79E-01	1.37E-01	1.96E-01	4.38E-01	7.92E-02	1.26E-01	1.58E-01
$22M_{j1}$	1.28E+00	2.62E-01	5.24E-01	1.19E+00	3.05E-01	4.12E-01	6.79E-01	2.90E+00	1.24E+00	2.09E+00	4.44E+00	1.08E+00	1.65E+00	2.01E+00
$22M_{j2}$	4.55E-01	1.14E-01	2.34E-01	6.02E-01	1.22E-01	1.56E-01	3.07E-01	2.95E+00	2.20E+00	3.58E+00	6.19E+00	1.52E+00	1.86E+00	2.00E+00
$22M_{j3}$	2.53E+00	1.30E+00	2.28E+00	6.46E+00	1.98E+00	1.23E+00	2.20E+00	1.08E+01	5.63E+00	8.58E+00	1.69E+01	3.18E+00	4.09E+00	6.24E+00
$23R_{i1}$	2.48E-01	2.81E-02	5.98E-02	9.64E-02	2.59E-02	5.43E-02	4.28E-02	5.31E+00	3.18E+00	4.19E+00	8.33E+00	2.77E+00	2.57E+00	3.07E+00
$23R_{i2}$	4.04E-01	1.47E-01	2.34E-01	6.08E-01	2.30E-01	2.13E-01	2.39E-01	1.67E+00	3.84E-01	6.47E-01	1.96E+00	2.03E-01	4.12E-01	1.09E+00
$23R_{i3}$	9.54E-02	1.81E-02	4.06E-02	1.14E-01	1.65E-02	2.09E-02	4.93E-02	4.10E-01	1.69E-01	2.45E-01	6.36E-01	1.11E-01	2.21E-01	2.41E-01
$23M_{i1}$	1.28E+00	2.62E-01	5.24E-01	1.19E+00	3.05E-01	4.12E-01	6.79E-01	2.90E+00	1.24E+00	2.09E+00	4.44E+00	1.08E+00	1.65E+00	2.01E+00
$23M_{i2}$	4.55E-01	1.14E-01	2.34E-01	6.02E-01	1.22E-01	1.56E-01	3.07E-01	2.95E+00	2.20E+00	3.58E+00	6.19E+00	1.52E+00	1.86E+00	2.00E+00
$23M_{i3}$	2.53E+00	1.30E+00	2.28E+00	6.46E+00	1.98E+00	1.23E+00	2.20E+00	1.08E+01	5.63E+00	8.58E+00	1.69E+01	3.18E+00	4.09E+00	6.24E+00
$23R_{j1}$	2.48E-01	2.81E-02	5.98E-02	9.64E-02	2.59E-02	5.43E-02	4.28E-02	5.31E+00	3.18E+00	4.19E+00	8.33E+00	2.77E+00	2.57E+00	3.07E+00
$23R_{j2}$	4.04E-01	1.47E-01	2.34E-01	6.08E-01	2.30E-01	2.13E-01	2.39E-01	1.67E+00	3.84E-01	6.47E-01	1.96E+00	2.03E-01	4.12E-01	1.09E+00
$23R_{j3}$	9.54E-02	1.81E-02	4.06E-02	1.14E-01	1.65E-02	2.09E-02	4.93E-02	4.10E-01	1.69E-01	2.45E-01	6.36E-01	1.11E-01	2.21E-01	2.41E-01
$23M_{j1}$	1.28E+00	2.62E-01	5.24E-01	1.19E+00	3.05E-01	4.12E-01	6.79E-01	2.90E+00	1.24E+00	2.09E+00	4.44E+00	1.08E+00	1.65E+00	2.01E+00
$23M_{j2}$	5.32E+00	1.00E+00	2.24E+00	6.35E+00	8.81E-01	1.13E+00	2.74E+00	2.56E+01	1.19E+01	1.69E+01	4.05E+01	6.66E+00	1.35E+01	1.51E+01
$23M_{j3}$	2.26E+01	7.51E+00	1.30E+01	3.45E+01	1.22E+01	1.19E+01	1.42E+01	9.72E+01	2.78E+01	4.31E+01	1.20E+02	1.47E+01	2.61E+01	6.64E+01

Results from Response Spectrum Method (I):

Table 3.4.6 Maximum nodal displacements for benchmark problem #4a & 4b.

Nodes	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
2Ux	3.95E-07	1.22E-07	3.91E-07	8.58E-07	1.26E-07	2.51E-07	3.65E-07	3.91E-02	2.31E-02	3.42E-02	9.76E-02	3.24E-02	2.30E-02	3.11E-02
2Uy	1.19E-02	4.51E-03	8.38E-03	2.11E-02	6.61E-03	6.50E-03	9.28E-03	1.23E-05	2.13E-06	4.44E-06	1.73E-05	1.45E-06	2.67E-06	7.18E-06
2Uz	1.80E-07	2.74E-08	5.71E-08	2.65E-07	1.93E-08	3.96E-08	1.03E-07	1.20E-06	5.29E-07	8.86E-07	2.37E-06	3.78E-07	6.13E-07	9.00E-07
2Θx	3.22E-05	1.15E-05	2.24E-05	5.71E-05	1.64E-05	1.77E-05	2.59E-05	6.15E-09	4.47E-09	8.32E-09	1.13E-08	3.91E-09	4.67E-09	3.99E-09
2Θy	1.14E-09	3.58E-10	1.14E-09	2.50E-09	3.66E-10	7.31E-10	1.06E-09	1.07E-04	6.39E-05	9.52E-05	2.74E-04	8.64E-05	6.58E-05	8.58E-05
2Θz	7.38E-10	2.77E-10	5.11E-10	1.38E-09	4.04E-10	3.90E-10	5.94E-10	6.24E-09	4.50E-09	6.05E-09	1.62E-08	4.01E-09	3.80E-09	4.81E-09
3Ux	1.00E-06	3.12E-07	9.99E-07	2.19E-06	3.21E-07	6.41E-07	9.32E-07	9.70E-02	5.76E-02	8.55E-02	0.245	7.95E-02	5.83E-02	7.75E-02
3Uy	2.93E-02	1.08E-02	2.05E-02	5.19E-02	1.57E-02	1.61E-02	2.32E-02	2.11E-05	4.54E-06	9.12E-06	2.99E-05	3.47E-06	5.38E-06	1.24E-05
3Uz	3.47E-07	5.34E-08	1.12E-07	5.21E-07	3.78E-08	7.79E-08	2.02E-07	2.34E-06	1.05E-06	1.76E-06	4.66E-06	7.50E-07	1.21E-06	1.77E-06
3Θx	5.58E-05	1.98E-05	3.88E-05	9.93E-05	2.82E-05	3.08E-05	4.51E-05	1.06E-08	8.00E-09	1.48E-08	1.97E-08	6.99E-09	8.25E-09	6.90E-09
3Θy	2.00E-09	6.31E-10	2.02E-09	4.41E-09	6.45E-10	1.29E-09	1.88E-09	1.87E-04	1.12E-04	1.67E-04	4.80E-04	1.50E-04	1.16E-04	1.50E-04
3Θz	1.48E-09	5.54E-10	1.02E-09	2.75E-09	8.07E-10	7.79E-10	1.19E-09	1.25E-08	9.00E-09	1.21E-08	3.23E-08	8.02E-09	7.59E-09	9.62E-09
4Ux	1.61E-06	5.05E-07	1.62E-06	3.56E-06	5.19E-07	1.04E-06	1.51E-06	0.155	9.24E-02	0.137	0.395	0.126	9.42E-02	0.124
4Uy	4.67E-02	1.70E-02	3.26E-02	8.26E-02	2.45E-02	2.56E-02	3.72E-02	2.28E-05	6.72E-06	1.30E-05	3.32E-05	5.52E-06	7.50E-06	1.35E-05
4Uz	4.45E-07	7.94E-08	1.75E-07	7.76E-07	6.28E-08	1.10E-07	3.02E-07	3.20E-06	1.36E-06	2.29E-06	6.29E-06	9.71E-07	1.60E-06	2.39E-06
4Θx	6.98E-05	2.46E-05	4.85E-05	1.24E-04	3.48E-05	3.85E-05	5.66E-05	2.04E-08	1.04E-08	1.93E-08	3.27E-08	8.94E-09	1.08E-08	1.25E-08
4Θy	2.53E-09	7.96E-10	2.56E-09	5.57E-09	8.15E-10	1.61E-09	2.37E-09	2.34E-04	1.40E-04	2.09E-04	6.03E-04	1.87E-04	1.45E-04	1.88E-04
4Θz	1.81E-09	6.62E-10	1.26E-09	3.49E-09	9.41E-10	9.55E-10	1.52E-09	1.87E-08	1.45E-08	1.92E-08	4.99E-08	1.33E-08	1.19E-08	1.47E-08
5Ux	2.39E-06	7.50E-07	2.41E-06	5.28E-06	7.70E-07	1.53E-06	2.24E-06	0.227	0.135	0.201	0.58	0.184	0.139	0.182
5Uy	6.78E-02	2.44E-02	4.72E-02	0.12	3.49E-02	3.73E-02	5.44E-02	1.84E-05	9.36E-06	1.76E-05	2.97E-05	8.12E-06	9.99E-06	1.13E-05
5Uz	5.42E-07	1.10E-07	2.58E-07	1.06E-06	9.44E-08	1.49E-07	4.17E-07	4.05E-06	1.68E-06	2.85E-06	7.93E-06	1.21E-06	2.00E-06	3.01E-06
5Θx	7.98E-05	2.80E-05	5.54E-05	1.42E-04	3.95E-05	4.42E-05	6.50E-05	3.33E-08	1.25E-08	2.35E-08	4.97E-08	1.05E-08	1.33E-08	1.98E-08
5Θy	2.92E-09	9.20E-10	2.97E-09	6.45E-09	9.42E-10	1.85E-09	2.74E-09	2.68E-04	1.61E-04	2.41E-04	6.94E-04	2.15E-04	1.68E-04	2.16E-04
5Θz	2.33E-09	8.24E-10	1.59E-09	4.43E-09	1.16E-09	1.24E-09	1.95E-09	2.34E-08	1.76E-08	2.33E-08	6.30E-08	1.71E-08	1.49E-08	1.85E-08
6Ux	3.19E-06	1.00E-06	3.24E-06	7.05E-06	1.03E-06	2.04E-06	2.99E-06	0.3	0.179	0.267	0.77	0.242	0.185	0.241
6Uy	8.95E-02	3.19E-02	6.23E-02	0.159	4.55E-02	4.93E-02	7.21E-02	1.50E-05	1.24E-05	2.30E-05	2.91E-05	1.09E-05	1.29E-05	1.00E-05
6Uz	6.23E-07	1.41E-07	3.42E-07	1.33E-06	1.26E-07	1.87E-07	5.27E-07	4.72E-06	1.99E-06	3.36E-06	9.32E-06	1.42E-06	2.34E-06	3.53E-06
6Θx	8.50E-05	2.97E-05	5.90E-05	1.52E-04	4.19E-05	4.70E-05	6.93E-05	4.28E-08	1.39E-08	2.63E-08	6.23E-08	1.15E-08	1.50E-08	2.52E-08
6Θy	3.13E-09	9.86E-10	3.19E-09	6.91E-09	1.01E-09	1.97E-09	2.93E-09	2.86E-04	1.72E-04	2.57E-04	7.41E-04	2.29E-04	1.79E-04	2.30E-04
6Θz	2.85E-09	9.88E-10	1.92E-09	5.39E-09	1.38E-09	1.53E-09	2.39E-09	2.82E-08	2.09E-08	2.76E-08	7.63E-08	2.10E-08	1.80E-08	2.23E-08
7Ux	3.69E-06	1.16E-06	3.75E-06	8.17E-06	1.19E-06	2.35E-06	3.47E-06	0.346	0.207	0.308	0.889	0.278	0.214	0.278
7Uy	0.103	3.66E-02	7.16E-02	0.183	5.21E-02	5.68E-02	8.31E-02	1.91E-05	1.45E-05	2.69E-05	3.54E-05	1.27E-05	1.51E-05	1.24E-05
7Uz	6.64E-07	1.59E-07	3.95E-07	1.49E-06	1.46E-07	2.12E-07	5.94E-07	5.02E-06	2.16E-06	3.64E-06	1.00E-05	1.55E-06	2.53E-06	3.79E-06
7Θx	8.63E-05	3.01E-05	5.99E-05	1.54E-04	4.25E-05	4.78E-05	7.04E-05	4.59E-08	1.43E-08	2.73E-08	6.65E-08	1.17E-08	1.55E-08	2.70E-08
7Θy	3.18E-09	1.00E-09	3.25E-09	7.03E-09	1.03E-09	1.99E-09	2.98E-09	2.91E-04	1.74E-04	2.61E-04	7.53E-04	2.32E-04	1.82E-04	2.34E-04
7Θz	3.31E-09	1.13E-09	2.22E-09	6.18E-09	1.58E-09	1.78E-09	2.75E-09	2.93E-08	2.10E-08	2.79E-08	7.94E-08	2.18E-08	1.86E-08	2.32E-08

Table 3.4.6 (Cont'd)

Nodes	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
8Ux	4.16E-06	1.31E-06	4.24E-06	9.21E-06	1.35E-06	2.65E-06	3.91E-06	0.388	0.232	0.347	1	0.312	0.241	0.312
8Uy	0.116	4.10E-02	8.04E-02	0.206	5.82E-02	6.38E-02	9.35E-02	2.57E-05	1.65E-05	3.07E-05	4.43E-05	1.44E-05	1.73E-05	1.62E-05
8Uz	6.97E-07	1.77E-07	4.46E-07	1.63E-06	1.65E-07	2.35E-07	6.55E-07	5.19E-06	2.31E-06	3.89E-06	1.05E-05	1.66E-06	2.67E-06	3.97E-06
8Θx	8.66E-05	3.02E-05	6.01E-05	1.54E-04	4.26E-05	4.79E-05	7.07E-05	4.69E-08	1.45E-08	2.77E-08	6.78E-08	1.19E-08	1.57E-08	2.75E-08
8Θy	3.20E-09	1.01E-09	3.27E-09	7.06E-09	1.03E-09	1.99E-09	2.99E-09	2.92E-04	1.75E-04	2.62E-04	7.56E-04	2.33E-04	1.83E-04	2.35E-04
8Θz	3.76E-09	1.27E-09	2.52E-09	6.99E-09	1.77E-09	2.04E-09	3.12E-09	3.04E-08	2.13E-08	2.85E-08	8.27E-08	2.28E-08	1.94E-08	2.42E-08
9Ux	4.16E-06	1.31E-06	4.14E-06	9.09E-06	1.37E-06	2.73E-06	3.91E-06	0.388	0.232	0.347	1	0.312	0.241	0.312
9Uy	0.116	4.10E-02	8.04E-02	0.206	5.82E-02	6.38E-02	9.35E-02	2.75E-05	1.90E-05	3.28E-05	5.25E-05	1.55E-05	1.71E-05	1.78E-05
9Uz	6.76E-03	2.36E-03	4.69E-03	1.21E-02	3.32E-03	3.74E-03	5.51E-03	7.00E-02	4.20E-02	6.28E-02	0.181	5.59E-02	4.38E-02	5.63E-02
9Θx	8.66E-05	3.02E-05	6.01E-05	1.54E-04	4.26E-05	4.79E-05	7.07E-05	4.69E-08	1.45E-08	2.77E-08	6.78E-08	1.19E-08	1.57E-08	2.75E-08
9Θy	3.20E-09	1.01E-09	3.27E-09	7.06E-09	1.03E-09	1.99E-09	2.99E-09	2.92E-04	1.75E-04	2.62E-04	7.56E-04	2.33E-04	1.83E-04	2.35E-04
9Θz	3.76E-09	1.27E-09	2.52E-09	6.99E-09	1.77E-09	2.04E-09	3.12E-09	3.04E-08	2.13E-08	2.85E-08	8.27E-08	2.28E-08	1.94E-08	2.42E-08
10Ux	8.83E-06	2.38E-06	6.91E-06	1.79E-05	2.54E-06	3.80E-06	8.18E-06	0.39	0.233	0.348	1	0.313	0.241	0.313
10Uy	0.124	4.36E-02	8.64E-02	0.221	6.18E-02	6.86E-02	0.1	4.57E-03	4.22E-03	6.28E-03	1.04E-02	2.68E-03	3.09E-03	3.92E-03
10Uz	7.21E-03	2.50E-03	5.11E-03	1.27E-02	3.51E-03	3.98E-03	5.81E-03	4.70E-02	3.24E-02	4.33E-02	0.126	3.79E-02	2.92E-02	3.80E-02
10Θx	1.98E-04	7.09E-05	2.13E-04	4.65E-04	8.39E-05	1.01E-04	2.14E-04	5.22E-05	4.27E-05	7.22E-05	1.09E-04	3.34E-05	4.63E-05	4.68E-05
10Θy	1.93E-05	4.33E-06	1.16E-05	2.74E-05	4.59E-06	5.94E-06	1.27E-05	4.49E-04	3.29E-04	5.47E-04	1.03E-03	3.09E-04	3.12E-04	3.60E-04
10Θz	1.22E-04	3.79E-05	9.03E-05	2.18E-04	5.09E-05	6.71E-05	1.02E-04	7.77E-05	7.38E-05	1.10E-04	1.78E-04	4.70E-05	5.35E-05	6.55E-05
11Ux	1.61E-05	3.92E-06	1.09E-05	3.15E-05	4.17E-06	5.86E-06	1.45E-05	0.391	0.234	0.349	1.01	0.314	0.242	0.314
11Uy	0.127	4.44E-02	8.86E-02	0.225	6.30E-02	7.02E-02	0.103	8.40E-03	8.07E-03	1.20E-02	1.93E-02	5.13E-03	5.82E-03	7.04E-03
11Uz	7.46E-03	2.57E-03	5.35E-03	1.30E-02	3.63E-03	4.08E-03	5.95E-03	3.53E-02	3.31E-02	4.55E-02	8.92E-02	2.54E-02	2.41E-02	2.87E-02
11Θx	3.55E-04	1.31E-04	4.01E-04	8.93E-04	1.49E-04	1.76E-04	4.07E-04	1.04E-04	8.55E-05	1.44E-04	2.18E-04	6.67E-05	9.27E-05	9.36E-05
11Θy	1.12E-05	1.65E-06	3.78E-06	7.21E-06	1.36E-06	2.60E-06	3.79E-06	3.04E-04	1.86E-04	2.70E-04	8.02E-04	2.41E-04	1.91E-04	2.45E-04
11Θz	6.83E-05	2.16E-05	4.70E-05	1.24E-04	2.90E-05	3.79E-05	5.70E-05	1.51E-05	6.76E-06	1.16E-05	3.25E-05	4.40E-06	7.39E-06	1.50E-05
12Ux	2.35E-05	5.55E-06	1.52E-05	4.58E-05	5.88E-06	8.18E-06	2.10E-05	0.391	0.234	0.35	1.01	0.314	0.243	0.314
12Uy	0.116	4.10E-02	8.04E-02	0.206	5.82E-02	6.38E-02	9.35E-02	2.57E-05	1.65E-05	3.07E-05	4.43E-05	1.44E-05	1.73E-05	1.62E-05
12Uz	6.76E-03	2.36E-03	4.69E-03	1.20E-02	3.32E-03	3.74E-03	5.51E-03	6.10E-06	3.10E-06	5.40E-06	1.20E-05	2.34E-06	3.23E-06	4.44E-06
12Θx	5.19E-04	1.93E-04	5.91E-04	1.33E-03	2.17E-04	2.53E-04	6.03E-04	1.56E-04	1.28E-04	2.17E-04	3.27E-04	1.00E-04	1.39E-04	1.40E-04
12Θy	3.48E-05	1.08E-05	2.97E-05	7.69E-05	1.17E-05	1.39E-05	3.46E-05	8.27E-04	8.32E-04	1.21E-03	1.95E-03	5.50E-04	6.10E-04	6.72E-04
12Θz	1.84E-04	5.78E-05	1.54E-04	3.44E-04	7.53E-05	9.91E-05	1.62E-04	2.19E-04	2.19E-04	3.23E-04	5.05E-04	1.39E-04	1.55E-04	1.78E-04
13Ux	8.79E-04	2.75E-04	6.74E-04	2.00E-03	2.75E-04	3.58E-04	9.11E-04	0.399	0.238	0.372	1.01	0.316	0.253	0.321
13Uy	0.111	4.01E-02	7.64E-02	0.204	5.68E-02	6.10E-02	9.16E-02	9.16E-03	9.24E-03	1.36E-02	2.08E-02	5.71E-03	6.17E-03	6.96E-03
13Uz	6.67E-03	2.32E-03	4.58E-03	1.24E-02	3.21E-03	3.72E-03	5.66E-03	3.41E-02	3.42E-02	5.13E-02	7.77E-02	2.20E-02	2.58E-02	2.76E-02
13Θx	6.69E-04	2.48E-04	7.61E-04	1.71E-03	2.79E-04	3.28E-04	7.74E-04	1.45E-04	1.16E-04	1.98E-04	2.74E-04	8.14E-05	1.13E-04	1.05E-04
13Θy	3.11E-05	8.84E-06	1.63E-05	6.16E-05	8.24E-06	1.24E-05	2.94E-05	3.04E-03	3.06E-03	4.60E-03	6.91E-03	1.97E-03	2.31E-03	2.45E-03
13Θz	2.83E-04	1.01E-04	3.07E-04	6.77E-04	1.16E-04	1.41E-04	3.10E-04	6.73E-04	6.88E-04	1.01E-03	1.55E-03	4.38E-04	4.84E-04	5.36E-04

Table 3.4.6 (Cont'd)

Nodes	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
14Ux	2.51E-03	7.23E-04	1.25E-03	4.86E-03	6.73E-04	1.03E-03	2.35E-03	0.488	0.352	0.589	1.15	0.351	0.343	0.392
14Uy	0.109	4.18E-02	8.74E-02	0.239	5.55E-02	5.65E-02	0.105	1.67E-02	1.53E-02	2.40E-02	3.41E-02	9.74E-03	1.18E-02	1.16E-02
14Uz	6.67E-03	2.33E-03	4.58E-03	1.25E-02	3.21E-03	3.72E-03	5.68E-03	3.43E-02	3.44E-02	5.16E-02	7.82E-02	2.21E-02	2.60E-02	2.78E-02
14Θx	4.43E-04	1.57E-04	4.73E-04	1.02E-03	1.87E-04	2.29E-04	4.73E-04	7.15E-05	5.26E-05	9.94E-05	1.17E-04	4.35E-05	6.62E-05	5.20E-05
14Θy	1.17E-05	4.17E-06	1.05E-05	2.64E-05	4.50E-06	5.95E-06	1.21E-05	1.88E-03	1.92E-03	2.78E-03	4.44E-03	1.27E-03	1.39E-03	1.51E-03
14Θz	2.57E-04	9.15E-05	2.77E-04	6.11E-04	1.05E-04	1.28E-04	2.80E-04	1.01E-03	1.04E-03	1.53E-03	2.35E-03	6.64E-04	7.38E-04	8.11E-04
15Ux	2.00E-03	6.63E-04	1.17E-03	3.85E-03	6.43E-04	9.65E-04	1.91E-03	0.461	0.355	0.59	1.06	0.324	0.331	0.37
15Uy	9.75E-02	3.80E-02	8.36E-02	0.224	4.95E-02	4.92E-02	9.80E-02	1.49E-02	1.31E-02	2.16E-02	2.79E-02	8.78E-03	1.14E-02	9.59E-03
15Uz	6.67E-03	2.33E-03	4.58E-03	1.25E-02	3.20E-03	3.72E-03	5.69E-03	3.45E-02	3.45E-02	5.19E-02	7.86E-02	2.22E-02	2.61E-02	2.80E-02
15Θx	3.50E-04	1.36E-04	3.82E-04	9.39E-04	1.53E-04	1.65E-04	4.17E-04	1.05E-04	9.27E-05	1.45E-04	2.24E-04	5.86E-05	7.03E-05	8.01E-05
15Θy	1.93E-05	4.83E-06	9.46E-06	3.78E-05	4.48E-06	6.77E-06	1.77E-05	1.73E-03	1.55E-03	2.48E-03	3.89E-03	1.12E-03	1.31E-03	1.40E-03
15Θz	2.30E-04	8.20E-05	2.47E-04	5.45E-04	9.42E-05	1.15E-04	2.51E-04	1.36E-03	1.39E-03	2.05E-03	3.14E-03	8.90E-04	9.92E-04	1.09E-03
16Ux	3.18E-06	9.99E-07	3.16E-06	6.95E-06	1.05E-06	2.10E-06	2.99E-06	0.3	0.179	0.267	0.77	0.242	0.185	0.241
16Uy	8.95E-02	3.19E-02	6.23E-02	0.159	4.55E-02	4.93E-02	7.21E-02	1.49E-05	1.22E-05	2.28E-05	2.87E-05	1.09E-05	1.30E-05	9.94E-06
16Uz	6.66E-03	2.33E-03	4.58E-03	1.26E-02	3.20E-03	3.72E-03	5.71E-03	3.47E-02	3.47E-02	5.21E-02	7.90E-02	2.23E-02	2.62E-02	2.81E-02
16Θx	1.34E-03	4.84E-04	1.48E-03	3.23E-03	5.58E-04	6.77E-04	1.48E-03	2.56E-04	2.18E-04	3.68E-04	4.36E-04	1.52E-04	2.07E-04	1.50E-04
16Θy	2.79E-05	1.21E-05	2.59E-05	6.16E-05	1.26E-05	1.75E-05	3.06E-05	5.80E-03	5.91E-03	8.71E-03	1.34E-02	3.84E-03	4.34E-03	4.62E-03
16Θz	2.04E-04	7.25E-05	2.17E-04	4.80E-04	8.33E-05	1.02E-04	2.21E-04	1.70E-03	1.74E-03	2.57E-03	3.93E-03	1.12E-03	1.25E-03	1.37E-03
17Ux	2.80E-03	1.28E-03	3.05E-03	6.74E-03	1.37E-03	1.81E-03	3.23E-03	0.703	0.664	0.905	1.78	0.522	0.48	0.56
17Uy	0.206	7.04E-02	0.191	0.413	9.11E-02	0.112	0.193	2.49E-02	2.07E-02	3.56E-02	4.06E-02	1.48E-02	2.06E-02	1.42E-02
17Uz	6.66E-03	2.33E-03	4.57E-03	1.26E-02	3.19E-03	3.71E-03	5.72E-03	3.48E-02	3.47E-02	5.22E-02	7.93E-02	2.24E-02	2.63E-02	2.82E-02
17Θx	1.72E-03	6.04E-04	1.82E-03	3.92E-03	7.17E-04	8.93E-04	1.82E-03	2.82E-04	2.35E-04	4.08E-04	4.54E-04	1.70E-04	2.40E-04	1.62E-04
17Θy	3.53E-05	1.57E-05	3.95E-05	8.78E-05	1.71E-05	2.21E-05	4.11E-05	7.13E-03	7.28E-03	1.05E-02	1.69E-02	4.85E-03	5.25E-03	5.65E-03
17Θz	1.77E-04	6.31E-05	1.87E-04	4.14E-04	7.25E-05	8.87E-05	1.91E-04	2.04E-03	2.09E-03	3.08E-03	4.72E-03	1.34E-03	1.50E-03	1.64E-03
18Ux	5.12E-03	2.31E-03	5.75E-03	1.27E-02	2.51E-03	3.26E-03	5.99E-03	1.14	1.13	1.57	2.82	0.818	0.806	0.907
18Uy	0.31	0.107	0.303	0.652	0.134	0.167	0.304	4.19E-02	3.51E-02	6.08E-02	6.76E-02	2.53E-02	3.56E-02	2.39E-02
18Uz	6.65E-03	2.33E-03	4.57E-03	1.26E-02	3.19E-03	3.70E-03	5.72E-03	3.49E-02	3.48E-02	5.23E-02	7.94E-02	2.24E-02	2.64E-02	2.83E-02
18Θx	6.52E-04	2.30E-04	6.95E-04	1.49E-03	2.71E-04	3.39E-04	6.92E-04	1.31E-04	8.64E-05	1.55E-04	2.19E-04	6.49E-05	9.45E-05	8.54E-05
18Θy	1.98E-05	7.37E-06	2.02E-05	4.81E-05	8.16E-06	1.02E-05	2.16E-05	3.01E-03	3.07E-03	4.44E-03	7.09E-03	2.03E-03	2.21E-03	2.38E-03
18Θz	1.51E-04	5.38E-05	1.58E-04	3.49E-04	6.17E-05	7.58E-05	1.61E-04	2.39E-03	2.44E-03	3.60E-03	5.52E-03	1.57E-03	1.76E-03	1.92E-03
19Ux	5.29E-03	2.34E-03	5.98E-03	1.33E-02	2.57E-03	3.29E-03	6.19E-03	1.13	1.12	1.56	2.78	0.804	0.798	0.894
19Uy	0.298	0.103	0.292	0.628	0.128	0.16	0.293	4.05E-02	3.35E-02	5.85E-02	6.52E-02	2.44E-02	3.44E-02	2.33E-02
19Uz	6.63E-03	2.32E-03	4.56E-03	1.26E-02	3.18E-03	3.70E-03	5.73E-03	3.49E-02	3.48E-02	5.24E-02	7.95E-02	2.25E-02	2.64E-02	2.83E-02
19Θx	9.13E-04	3.17E-04	9.35E-04	2.01E-03	3.86E-04	4.82E-04	9.33E-04	1.47E-04	1.18E-04	2.03E-04	2.41E-04	8.41E-05	1.19E-04	9.01E-05
19Θy	1.64E-05	6.69E-06	1.53E-05	3.45E-05	7.06E-06	9.54E-06	1.70E-05	3.26E-03	3.27E-03	4.63E-03	7.92E-03	2.28E-03	2.35E-03	2.59E-03
19Θz	1.25E-04	4.45E-05	1.28E-04	2.84E-04	5.11E-05	6.30E-05	1.32E-04	2.73E-03	2.79E-03	4.12E-03	6.31E-03	1.80E-03	2.01E-03	2.20E-03

Table 3.4.6 (Cont'd)

Nodes	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
20Ux	3.10E-03	1.34E-03	3.49E-03	7.83E-03	1.48E-03	1.86E-03	3.59E-03	0.655	0.636	0.876	1.64	0.477	0.456	0.521
20Uy	0.175	5.99E-02	0.165	0.356	7.68E-02	9.49E-02	0.166	2.17E-02	1.77E-02	3.10E-02	3.49E-02	1.30E-02	1.82E-02	1.28E-02
20Uz	6.62E-03	2.32E-03	4.55E-03	1.26E-02	3.17E-03	3.68E-03	5.73E-03	3.49E-02	3.48E-02	5.24E-02	7.96E-02	2.24E-02	2.64E-02	2.83E-02
20Θx	1.82E-03	6.33E-04	1.87E-03	4.02E-03	7.67E-04	9.61E-04	1.87E-03	2.81E-04	2.30E-04	4.01E-04	4.53E-04	1.67E-04	2.36E-04	1.62E-04
20Θy	3.59E-05	1.58E-05	4.02E-05	8.99E-05	1.73E-05	2.22E-05	4.18E-05	7.26E-03	7.35E-03	1.05E-02	1.75E-02	5.03E-03	5.27E-03	5.76E-03
20Θz	1.00E-04	3.54E-05	9.84E-05	2.20E-04	4.07E-05	5.03E-05	1.03E-04	3.07E-03	3.14E-03	4.64E-03	7.11E-03	2.02E-03	2.27E-03	2.48E-03
21Ux	1.60E-06	5.01E-07	1.58E-06	3.49E-06	5.34E-07	1.07E-06	1.50E-06	0.155	9.24E-02	0.137	0.395	0.126	9.42E-02	0.124
21Uy	4.67E-02	1.70E-02	3.26E-02	8.26E-02	2.45E-02	2.56E-02	3.72E-02	2.28E-05	6.60E-06	1.29E-05	3.31E-05	5.48E-06	7.52E-06	1.34E-05
21Uz	6.60E-03	2.32E-03	4.54E-03	1.27E-02	3.16E-03	3.67E-03	5.72E-03	3.49E-02	3.48E-02	5.23E-02	7.95E-02	2.24E-02	2.64E-02	2.83E-02
21Θx	1.17E-03	4.05E-04	1.20E-03	2.57E-03	4.89E-04	6.17E-04	1.20E-03	1.92E-04	1.47E-04	2.59E-04	3.24E-04	1.09E-04	1.52E-04	1.21E-04
21Θy	3.15E-05	1.33E-05	3.59E-05	8.09E-05	1.50E-05	1.81E-05	3.65E-05	5.64E-03	5.75E-03	8.22E-03	1.35E-02	3.88E-03	4.11E-03	4.48E-03
21Θz	7.57E-05	2.67E-05	6.94E-05	1.58E-04	3.09E-05	3.80E-05	7.44E-05	3.42E-03	3.49E-03	5.16E-03	7.90E-03	2.25E-03	2.52E-03	2.75E-03
22Ux	1.95E-03	7.66E-04	2.16E-03	4.98E-03	9.07E-04	9.90E-04	2.20E-03	0.299	0.288	0.447	0.659	0.197	0.222	0.238
22Uy	3.63E-02	1.50E-02	3.61E-02	8.84E-02	1.95E-02	1.72E-02	3.86E-02	1.11E-02	5.18E-03	9.54E-03	2.03E-02	4.28E-03	5.96E-03	7.73E-03
22Uz	6.57E-03	2.31E-03	4.53E-03	1.26E-02	3.16E-03	3.65E-03	5.71E-03	3.48E-02	3.47E-02	5.22E-02	7.94E-02	2.24E-02	2.63E-02	2.82E-02
22Θx	5.74E-05	2.17E-05	5.61E-05	1.46E-04	2.49E-05	2.77E-05	6.47E-05	8.70E-05	5.25E-05	7.54E-05	1.68E-04	3.76E-05	4.14E-05	6.37E-05
22Θy	1.81E-05	6.17E-06	1.70E-05	4.18E-05	7.97E-06	7.12E-06	1.86E-05	1.51E-03	1.54E-03	2.23E-03	3.60E-03	1.01E-03	1.10E-03	1.23E-03
22Θz	5.38E-05	1.88E-05	4.22E-05	1.01E-04	2.21E-05	2.66E-05	4.86E-05	3.76E-03	3.84E-03	5.68E-03	8.69E-03	2.48E-03	2.78E-03	3.03E-03
23Ux	3.02E-03	1.09E-03	3.04E-03	7.25E-03	1.39E-03	1.29E-03	3.20E-03	0.319	0.31	0.478	0.705	0.209	0.236	0.257
23Uy	2.90E-02	1.14E-02	2.06E-02	5.44E-02	1.66E-02	1.54E-02	2.35E-02	1.26E-02	9.03E-03	1.33E-02	2.61E-02	6.62E-03	7.48E-03	1.02E-02
23Uz	6.55E-03	2.31E-03	4.52E-03	1.26E-02	3.15E-03	3.64E-03	5.70E-03	3.47E-02	3.46E-02	5.21E-02	7.91E-02	2.23E-02	2.63E-02	2.81E-02
23Θx	3.95E-04	1.43E-04	4.42E-04	9.60E-04	1.64E-04	1.99E-04	4.41E-04	1.90E-04	1.85E-04	2.74E-04	4.24E-04	1.13E-04	1.22E-04	1.30E-04
23Θy	1.50E-05	4.86E-06	9.17E-06	2.57E-05	6.74E-06	5.23E-06	1.23E-05	5.62E-04	4.80E-04	7.20E-04	1.25E-03	3.23E-04	3.94E-04	4.67E-04
23Θz	3.87E-05	1.33E-05	2.36E-05	6.63E-05	1.65E-05	1.77E-05	3.18E-05	4.11E-03	4.19E-03	6.20E-03	9.49E-03	2.70E-03	3.03E-03	3.31E-03
24Ux	2.53E-03	9.15E-04	2.60E-03	6.12E-03	1.18E-03	1.06E-03	2.70E-03	0.233	0.218	0.341	0.51	0.155	0.171	0.188
24Uy	2.95E-02	1.12E-02	2.04E-02	5.26E-02	1.64E-02	1.59E-02	2.31E-02	1.61E-02	1.44E-02	2.11E-02	3.55E-02	9.70E-03	1.09E-02	1.30E-02
24Uz	6.73E-03	2.22E-03	5.19E-03	1.24E-02	2.98E-03	3.82E-03	5.81E-03	2.74E-02	2.72E-02	4.09E-02	6.25E-02	1.76E-02	2.08E-02	2.23E-02
24Θx	9.30E-05	3.18E-05	6.44E-05	1.73E-04	4.35E-05	5.23E-05	7.93E-05	4.94E-04	4.85E-04	7.40E-04	1.12E-03	3.15E-04	3.76E-04	4.01E-04
24Θy	1.80E-05	6.22E-06	1.67E-05	3.90E-05	8.46E-06	8.56E-06	1.70E-05	9.69E-04	9.52E-04	1.42E-03	2.18E-03	6.17E-04	7.12E-04	7.63E-04
24Θz	4.13E-05	1.46E-05	3.96E-05	9.62E-05	1.87E-05	1.70E-05	4.26E-05	3.97E-03	4.05E-03	6.00E-03	9.18E-03	2.61E-03	2.94E-03	3.21E-03
25Ux	1.00E-06	3.12E-07	9.99E-07	2.19E-06	3.21E-07	6.41E-07	9.32E-07	9.70E-02	5.76E-02	8.55E-02	0.245	7.95E-02	5.83E-02	7.75E-02
25Uy	2.95E-02	1.12E-02	2.05E-02	5.26E-02	1.64E-02	1.60E-02	2.31E-02	1.61E-02	1.44E-02	2.11E-02	3.55E-02	9.69E-03	1.09E-02	1.30E-02
25Uz	3.50E-07	5.47E-08	1.10E-07	5.24E-07	3.79E-08	8.75E-08	2.05E-07	3.36E-03	2.01E-03	3.00E-03	8.64E-03	2.70E-03	2.08E-03	2.70E-03
25Θx	1.09E-04	3.58E-05	8.57E-05	2.00E-04	4.78E-05	6.14E-05	9.40E-05	3.66E-04	3.56E-04	5.44E-04	8.25E-04	2.32E-04	2.79E-04	2.99E-04
25Θy	1.68E-05	5.88E-06	1.59E-05	3.66E-05	7.92E-06	8.02E-06	1.60E-05	8.39E-04	8.21E-04	1.23E-03	1.88E-03	5.33E-04	6.19E-04	6.61E-04
25Θz	4.11E-05	1.55E-05	4.45E-05	1.02E-04	2.01E-05	1.75E-05	4.47E-05	2.62E-03	2.67E-03	3.93E-03	6.08E-03	1.72E-03	1.94E-03	2.13E-03

Table 3.4.6 (Cont'd)

Nodes	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
26Ux	3.10E-03	1.24E-03	3.47E-03	7.69E-03	1.62E-03	1.37E-03	3.37E-03	0.146	0.119	0.158	0.371	0.112	9.06E-02	0.116
26Uy	2.95E-02	1.12E-02	2.04E-02	5.26E-02	1.63E-02	1.60E-02	2.31E-02	1.59E-02	1.44E-02	2.10E-02	3.52E-02	9.66E-03	1.08E-02	1.29E-02
26Uz	7.73E-03	2.62E-03	5.71E-03	1.39E-02	3.59E-03	4.34E-03	6.42E-03	1.80E-02	1.56E-02	2.45E-02	3.84E-02	1.06E-02	1.28E-02	1.42E-02
26Θx	5.12E-05	1.86E-05	3.53E-05	9.15E-05	2.66E-05	2.80E-05	4.10E-05	2.60E-05	1.38E-05	2.26E-05	4.72E-05	1.02E-05	1.29E-05	1.79E-05
26Θy	1.57E-05	5.36E-06	1.47E-05	3.30E-05	7.06E-06	7.20E-06	1.46E-05	6.28E-04	6.05E-04	9.25E-04	1.39E-03	3.97E-04	4.68E-04	4.97E-04
26Θz	1.31E-05	5.47E-06	1.38E-05	3.03E-05	7.00E-06	6.19E-06	1.35E-05	3.75E-04	3.77E-04	5.62E-04	8.49E-04	2.44E-04	2.72E-04	2.99E-04
27Ux	1.96E-03	8.08E-04	2.20E-03	4.81E-03	1.05E-03	8.97E-04	2.12E-03	0.103	6.48E-02	8.94E-02	0.264	8.52E-02	6.05E-02	8.22E-02
27Uy	2.94E-02	1.11E-02	2.04E-02	5.24E-02	1.62E-02	1.59E-02	2.31E-02	1.57E-02	1.43E-02	2.10E-02	3.50E-02	9.63E-03	1.08E-02	1.28E-02
27Uz	1.06E-02	3.74E-03	7.47E-03	1.89E-02	5.29E-03	5.88E-03	8.60E-03	9.25E-03	7.96E-03	1.27E-02	2.00E-02	5.68E-03	6.71E-03	7.32E-03
27Θx	4.24E-05	1.42E-05	2.56E-05	6.54E-05	2.10E-05	1.75E-05	2.90E-05	1.73E-04	1.42E-04	2.19E-04	3.54E-04	9.30E-05	1.14E-04	1.32E-04
27Θy	1.59E-05	5.00E-06	1.38E-05	3.04E-05	6.39E-06	6.63E-06	1.39E-05	4.72E-04	4.37E-04	6.84E-04	1.03E-03	2.98E-04	3.53E-04	3.75E-04
27Θz	4.57E-05	1.87E-05	5.09E-05	1.13E-04	2.46E-05	2.03E-05	4.93E-05	1.28E-03	1.20E-03	1.76E-03	2.87E-03	7.91E-04	8.85E-04	1.02E-03
28Ux	2.20E-05	9.21E-06	1.93E-05	4.56E-05	1.26E-05	9.61E-06	1.98E-05	9.80E-02	5.83E-02	8.61E-02	0.248	8.06E-02	5.86E-02	7.83E-02
28Uy	2.93E-02	1.08E-02	2.05E-02	5.19E-02	1.57E-02	1.61E-02	2.32E-02	2.11E-05	4.54E-06	9.12E-06	2.99E-05	3.47E-06	5.38E-06	1.24E-05
28Uz	1.11E-02	3.92E-03	7.69E-03	1.97E-02	5.57E-03	6.10E-03	8.94E-03	2.93E-06	1.27E-06	2.29E-06	5.42E-06	1.11E-06	1.68E-06	2.13E-06
28Θx	4.40E-05	1.49E-05	2.62E-05	6.76E-05	2.22E-05	1.91E-05	3.00E-05	1.05E-04	4.60E-05	7.96E-05	2.01E-04	4.19E-05	5.00E-05	7.76E-05
28Θy	1.42E-05	2.97E-06	6.77E-06	2.12E-05	2.61E-06	4.63E-06	1.04E-05	2.57E-04	1.81E-04	3.05E-04	6.02E-04	1.77E-04	1.81E-04	2.07E-04
28Θz	8.86E-05	3.08E-05	9.20E-05	1.98E-04	3.71E-05	4.58E-05	9.20E-05	4.03E-04	3.46E-04	5.11E-04	8.98E-04	2.35E-04	2.68E-04	3.52E-04
29Ux	1.64E-05	6.87E-06	1.44E-05	3.40E-05	9.40E-06	7.14E-06	1.48E-05	9.79E-02	5.82E-02	8.60E-02	0.247	8.04E-02	5.86E-02	7.82E-02
29Uy	3.32E-02	1.23E-02	2.37E-02	5.83E-02	1.80E-02	1.82E-02	2.61E-02	2.02E-02	1.21E-02	1.83E-02	3.85E-02	8.20E-03	9.98E-03	1.61E-02
29Uz	1.14E-02	4.00E-03	7.97E-03	2.06E-02	5.61E-03	6.39E-03	9.41E-03	1.40E-02	8.64E-03	1.45E-02	3.38E-02	9.96E-03	9.31E-03	1.11E-02
29Θx	4.52E-05	1.59E-05	2.82E-05	7.36E-05	2.34E-05	2.17E-05	3.28E-05	7.89E-05	3.45E-05	5.97E-05	1.51E-04	3.14E-05	3.75E-05	5.82E-05
29Θy	1.16E-05	2.44E-06	5.83E-06	1.71E-05	2.18E-06	4.60E-06	8.29E-06	2.14E-04	1.24E-04	1.97E-04	5.36E-04	1.60E-04	1.36E-04	1.70E-04
29Θz	5.53E-05	2.33E-05	4.29E-05	9.99E-05	3.51E-05	2.87E-05	4.16E-05	2.55E-04	8.27E-05	1.35E-04	4.10E-04	5.43E-05	8.19E-05	1.79E-04
30Ux	1.09E-05	4.52E-06	9.58E-06	2.25E-05	6.23E-06	4.67E-06	9.77E-06	9.76E-02	5.80E-02	8.59E-02	0.247	8.02E-02	5.85E-02	7.80E-02
30Uy	3.45E-02	1.30E-02	2.46E-02	6.06E-02	1.90E-02	1.89E-02	2.69E-02	2.57E-02	1.14E-02	1.77E-02	4.43E-02	7.63E-03	1.01E-02	1.90E-02
30Uz	1.16E-02	4.04E-03	8.09E-03	2.10E-02	5.65E-03	6.50E-03	9.59E-03	2.52E-02	1.48E-02	2.38E-02	6.32E-02	1.90E-02	1.62E-02	2.01E-02
30Θx	4.77E-05	1.70E-05	3.11E-05	8.11E-05	2.49E-05	2.46E-05	3.64E-05	5.26E-05	2.30E-05	3.98E-05	1.00E-04	2.09E-05	2.50E-05	3.88E-05
30Θy	3.58E-06	7.14E-07	1.64E-06	5.06E-06	6.12E-07	1.12E-06	2.52E-06	1.86E-04	1.18E-04	1.64E-04	4.88E-04	1.53E-04	1.13E-04	1.50E-04
30Θz	2.10E-05	7.29E-06	2.18E-05	4.69E-05	8.77E-06	1.08E-05	2.18E-05	9.82E-05	8.21E-05	1.21E-04	2.17E-04	5.56E-05	6.40E-05	8.60E-05
31Ux	5.32E-06	2.19E-06	4.76E-06	1.10E-05	3.06E-06	2.21E-06	4.79E-06	9.73E-02	5.78E-02	8.57E-02	0.246	7.99E-02	5.84E-02	7.78E-02
31Uy	3.20E-02	1.19E-02	2.26E-02	5.63E-02	1.75E-02	1.75E-02	2.50E-02	1.26E-02	4.57E-03	7.31E-03	2.06E-02	3.02E-03	4.31E-03	8.92E-03
31Uz	1.13E-02	3.98E-03	7.90E-03	2.04E-02	5.62E-03	6.31E-03	9.27E-03	3.48E-02	2.06E-02	3.15E-02	8.91E-02	2.75E-02	2.18E-02	2.79E-02
31Θx	5.13E-05	1.83E-05	3.47E-05	8.98E-05	2.65E-05	2.76E-05	4.06E-05	2.63E-05	1.15E-05	1.99E-05	5.02E-05	1.05E-05	1.25E-05	1.94E-05
31Θy	1.28E-05	2.70E-06	6.41E-06	1.91E-05	2.39E-06	5.03E-06	9.25E-06	1.76E-04	1.14E-04	1.54E-04	4.50E-04	1.45E-04	1.03E-04	1.42E-04
31Θz	6.23E-05	2.54E-05	5.00E-05	1.15E-04	3.77E-05	3.25E-05	4.90E-05	2.82E-04	1.16E-04	1.82E-04	4.77E-04	7.75E-05	1.05E-04	2.05E-04

Table 3.4.6 (Cont'd)

Nodes	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
32Ux	1.07E-06	3.41E-07	1.11E-06	2.41E-06	3.36E-07	5.88E-07	9.73E-07	9.70E-02	5.76E-02	8.55E-02	0.245	7.95E-02	5.83E-02	7.75E-02
32Uy	2.93E-02	1.08E-02	2.05E-02	5.19E-02	1.57E-02	1.61E-02	2.32E-02	2.12E-05	5.77E-06	1.03E-05	3.17E-05	4.31E-06	5.55E-06	1.26E-05
32Uz	1.11E-02	3.92E-03	7.69E-03	1.97E-02	5.57E-03	6.10E-03	8.94E-03	4.48E-02	2.68E-02	4.00E-02	0.115	3.60E-02	2.77E-02	3.60E-02
32Θx	5.58E-05	1.98E-05	3.88E-05	9.93E-05	2.82E-05	3.08E-05	4.51E-05	1.06E-08	8.00E-09	1.48E-08	1.97E-08	6.99E-09	8.25E-09	6.90E-09
32Θy	2.00E-09	6.31E-10	2.02E-09	4.41E-09	6.45E-10	1.29E-09	1.88E-09	1.87E-04	1.12E-04	1.67E-04	4.80E-04	1.50E-04	1.16E-04	1.50E-04
32Θz	1.48E-09	5.54E-10	1.02E-09	2.75E-09	8.07E-10	7.79E-10	1.19E-09	1.25E-08	9.00E-09	1.21E-08	3.23E-08	8.02E-09	7.59E-09	9.62E-09

Table 3.4.7 Maximum element forces and moments for P-components (group#1) of benchmark problem #4a and #4b.

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$1R_{i1}$	7.39E-01	1.13E-01	2.35E-01	1.09E+00	7.94E-02	1.63E-01	4.23E-01	4.93E+00	2.18E+00	3.65E+00	9.75E+00	1.56E+00	2.52E+00	3.70E+00
$1R_{i2}$	4.58E-01	1.39E-01	4.44E-01	9.76E-01	1.43E-01	2.86E-01	4.16E-01	4.59E+04	2.70E+04	3.98E+04	1.13E+05	3.84E+04	2.65E+04	3.64E+04
$1R_{i3}$	1.41E+04	5.44E+03	9.93E+03	2.48E+04	8.05E+03	7.62E+03	1.08E+04	2.00E+01	3.04E+00	6.51E+00	2.79E+01	1.82E+00	3.96E+00	1.17E+01
$1M_{i1}$	1.66E+02	6.24E+01	1.15E+02	3.10E+02	9.09E+01	8.77E+01	1.34E+02	1.41E+03	1.01E+03	1.36E+03	3.64E+03	9.03E+02	8.55E+02	1.08E+03
$1M_{i2}$	1.29E+07	4.64E+06	8.96E+06	2.28E+07	6.67E+06	7.07E+06	1.03E+07	3.89E+03	1.78E+03	3.36E+03	6.13E+03	1.54E+03	1.91E+03	2.37E+03
$1M_{i3}$	4.56E+02	1.43E+02	4.59E+02	1.00E+03	1.47E+02	2.93E+02	4.27E+02	4.33E+07	2.58E+07	3.85E+07	1.11E+08	3.52E+07	2.65E+07	3.47E+07
$1R_{j1}$	7.39E-01	1.13E-01	2.35E-01	1.09E+00	7.94E-02	1.63E-01	4.23E-01	4.93E+00	2.18E+00	3.65E+00	9.75E+00	1.56E+00	2.52E+00	3.70E+00
$1R_{j2}$	4.58E-01	1.39E-01	4.44E-01	9.76E-01	1.43E-01	2.86E-01	4.16E-01	4.59E+04	2.70E+04	3.98E+04	1.13E+05	3.84E+04	2.65E+04	3.64E+04
$1R_{j3}$	1.41E+04	5.44E+03	9.93E+03	2.48E+04	8.05E+03	7.62E+03	1.08E+04	2.00E+01	3.04E+00	6.51E+00	2.79E+01	1.82E+00	3.96E+00	1.17E+01
$1M_{j1}$	1.66E+02	6.24E+01	1.15E+02	3.10E+02	9.09E+01	8.77E+01	1.34E+02	1.41E+03	1.01E+03	1.36E+03	3.64E+03	9.03E+02	8.55E+02	1.08E+03
$1M_{j2}$	9.74E+06	3.44E+06	6.77E+06	1.73E+07	4.89E+06	5.38E+06	7.89E+06	2.01E+03	1.41E+03	2.60E+03	3.62E+03	1.23E+03	1.45E+03	1.29E+03
$1M_{j3}$	3.58E+02	1.13E+02	3.61E+02	7.89E+02	1.15E+02	2.30E+02	3.35E+02	3.32E+07	1.99E+07	2.97E+07	8.57E+07	2.67E+07	2.06E+07	2.67E+07
$2R_{i1}$	6.89E-01	1.07E-01	2.24E-01	1.05E+00	7.62E-02	1.57E-01	4.09E-01	4.71E+00	2.14E+00	3.58E+00	9.42E+00	1.53E+00	2.46E+00	3.57E+00
$2R_{i2}$	4.41E-01	1.35E-01	4.34E-01	9.54E-01	1.39E-01	2.79E-01	4.06E-01	4.27E+04	2.53E+04	3.75E+04	1.07E+05	3.51E+04	2.55E+04	3.42E+04
$2R_{i3}$	1.29E+04	4.78E+03	9.01E+03	2.27E+04	6.97E+03	7.03E+03	1.01E+04	1.46E+01	2.39E+00	5.06E+00	2.04E+01	1.60E+00	3.04E+00	8.54E+00
$2M_{i1}$	1.66E+02	6.24E+01	1.15E+02	3.10E+02	9.09E+01	8.77E+01	1.34E+02	1.41E+03	1.01E+03	1.36E+03	3.64E+03	9.03E+02	8.55E+02	1.08E+03
$2M_{i2}$	9.74E+06	3.44E+06	6.77E+06	1.73E+07	4.89E+06	5.38E+06	7.89E+06	2.01E+03	1.41E+03	2.60E+03	3.62E+03	1.23E+03	1.45E+03	1.29E+03
$2M_{i3}$	3.58E+02	1.13E+02	3.61E+02	7.89E+02	1.15E+02	2.30E+02	3.35E+02	3.32E+07	1.99E+07	2.97E+07	8.57E+07	2.67E+07	2.06E+07	2.67E+07
$2R_{j1}$	6.89E-01	1.07E-01	2.24E-01	1.05E+00	7.62E-02	1.57E-01	4.09E-01	4.71E+00	2.14E+00	3.58E+00	9.42E+00	1.53E+00	2.46E+00	3.57E+00
$2R_{j2}$	4.41E-01	1.35E-01	4.34E-01	9.54E-01	1.39E-01	2.79E-01	4.06E-01	4.27E+04	2.53E+04	3.75E+04	1.07E+05	3.51E+04	2.55E+04	3.42E+04
$2R_{j3}$	1.29E+04	4.78E+03	9.01E+03	2.27E+04	6.97E+03	7.03E+03	1.01E+04	1.46E+01	2.39E+00	5.06E+00	2.04E+01	1.60E+00	3.04E+00	8.54E+00
$2M_{j1}$	1.66E+02	6.24E+01	1.15E+02	3.10E+02	9.09E+01	8.77E+01	1.34E+02	1.41E+03	1.01E+03	1.36E+03	3.64E+03	9.03E+02	8.55E+02	1.08E+03
$2M_{j2}$	6.90E+06	2.39E+06	4.78E+06	1.23E+07	3.34E+06	3.83E+06	5.66E+06	4.53E+03	1.22E+03	2.33E+03	6.51E+03	9.71E+02	1.32E+03	2.67E+03
$2M_{j3}$	2.65E+02	8.31E+01	2.65E+02	5.78E+02	8.46E+01	1.68E+02	2.46E+02	2.38E+07	1.43E+07	2.14E+07	6.19E+07	1.89E+07	1.50E+07	1.92E+07

Table 3.4.7 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$3R_{i1}$	5.83E-01	1.58E-01	4.13E-01	1.39E+00	1.54E-01	2.00E-01	5.63E-01	4.39E+00	1.54E+00	2.65E+00	8.20E+00	1.10E+00	1.94E+00	3.13E+00
$3R_{i2}$	4.00E-01	1.23E-01	4.03E-01	8.84E-01	1.27E-01	2.57E-01	3.70E-01	3.86E+04	2.31E+04	3.44E+04	9.89E+04	3.13E+04	2.37E+04	3.11E+04
$3R_{i3}$	1.14E+04	4.10E+03	7.96E+03	2.03E+04	5.87E+03	6.29E+03	9.17E+03	6.66E+00	1.78E+00	3.40E+00	9.43E+00	1.39E+00	1.98E+00	3.83E+00
$3M_{i1}$	9.84E+01	3.23E+01	7.21E+01	2.17E+02	3.86E+01	4.99E+01	9.68E+01	1.86E+03	1.50E+03	1.95E+03	4.94E+03	1.46E+03	1.19E+03	1.48E+03
$3M_{i2}$	6.90E+06	2.39E+06	4.78E+06	1.23E+07	3.34E+06	3.83E+06	5.66E+06	4.57E+03	1.19E+03	2.31E+03	6.52E+03	9.59E+02	1.33E+03	2.68E+03
$3M_{i3}$	2.62E+02	8.21E+01	2.70E+02	5.79E+02	8.42E+01	1.62E+02	2.45E+02	2.38E+07	1.43E+07	2.14E+07	6.19E+07	1.89E+07	1.50E+07	1.92E+07
$3Rj_1$	5.83E-01	1.58E-01	4.13E-01	1.39E+00	1.54E-01	2.00E-01	5.63E-01	4.39E+00	1.54E+00	2.65E+00	8.20E+00	1.10E+00	1.94E+00	3.13E+00
$3Rj_2$	4.00E-01	1.23E-01	4.03E-01	8.84E-01	1.27E-01	2.57E-01	3.70E-01	3.86E+04	2.31E+04	3.44E+04	9.89E+04	3.13E+04	2.37E+04	3.11E+04
$3Rj_3$	1.14E+04	4.10E+03	7.96E+03	2.03E+04	5.87E+03	6.29E+03	9.17E+03	6.66E+00	1.78E+00	3.40E+00	9.43E+00	1.39E+00	1.98E+00	3.83E+00
$3Mj_1$	9.84E+01	3.23E+01	7.21E+01	2.17E+02	3.86E+01	4.99E+01	9.68E+01	1.86E+03	1.50E+03	1.95E+03	4.94E+03	1.46E+03	1.19E+03	1.48E+03
$3Mj_2$	4.78E+06	1.63E+06	3.31E+06	8.57E+06	2.25E+06	2.66E+06	3.96E+06	5.56E+03	1.07E+03	2.15E+03	7.73E+03	7.59E+02	1.27E+03	3.22E+03
$3Mj_3$	1.91E+02	5.97E+01	1.96E+02	4.17E+02	6.12E+01	1.15E+02	1.77E+02	1.67E+07	1.00E+07	1.50E+07	4.36E+07	1.31E+07	1.06E+07	1.34E+07
$3R_{i1}$	5.26E-01	1.53E-01	4.06E-01	1.32E+00	1.50E-01	1.95E-01	5.41E-01	3.76E+00	1.43E+00	2.45E+00	7.27E+00	1.03E+00	1.75E+00	2.76E+00
$4R_{i2}$	3.71E-01	1.17E-01	3.76E-01	8.17E-01	1.20E-01	2.34E-01	3.48E-01	3.36E+04	2.01E+04	3.02E+04	8.71E+04	2.67E+04	2.11E+04	2.70E+04
$4R_{i3}$	9.75E+03	3.39E+03	6.76E+03	1.74E+04	4.76E+03	5.40E+03	7.98E+03	4.25E+00	1.48E+00	2.82E+00	6.30E+00	1.26E+00	1.63E+00	2.55E+00
$4M_{i1}$	1.27E+02	4.01E+01	8.39E+01	2.35E+02	5.38E+01	6.91E+01	1.07E+02	1.20E+03	8.01E+02	1.09E+03	3.24E+03	9.41E+02	7.58E+02	9.60E+02
$4M_{i2}$	4.78E+06	1.63E+06	3.31E+06	8.57E+06	2.25E+06	2.66E+06	3.96E+06	5.56E+03	1.07E+03	2.15E+03	7.73E+03	7.59E+02	1.27E+03	3.22E+03
$4M_{i3}$	1.91E+02	5.97E+01	1.96E+02	4.17E+02	6.12E+01	1.15E+02	1.77E+02	1.67E+07	1.00E+07	1.50E+07	4.36E+07	1.31E+07	1.06E+07	1.34E+07
$4Rj_1$	5.26E-01	1.53E-01	4.06E-01	1.32E+00	1.50E-01	1.95E-01	5.41E-01	3.76E+00	1.43E+00	2.45E+00	7.27E+00	1.03E+00	1.75E+00	2.76E+00
$4Rj_2$	3.71E-01	1.17E-01	3.76E-01	8.17E-01	1.20E-01	2.34E-01	3.48E-01	3.36E+04	2.01E+04	3.02E+04	8.71E+04	2.67E+04	2.11E+04	2.70E+04
$4Rj_3$	9.75E+03	3.39E+03	6.76E+03	1.74E+04	4.76E+03	5.40E+03	7.98E+03	4.25E+00	1.48E+00	2.82E+00	6.30E+00	1.26E+00	1.63E+00	2.55E+00
$4Mj_1$	1.27E+02	4.01E+01	8.39E+01	2.35E+02	5.38E+01	6.91E+01	1.07E+02	1.20E+03	8.01E+02	1.09E+03	3.24E+03	9.41E+02	7.58E+02	9.60E+02
$4Mj_2$	2.73E+06	9.16E+05	1.89E+06	4.92E+06	1.26E+06	1.52E+06	2.28E+06	4.77E+03	8.07E+02	1.66E+03	6.59E+03	5.13E+02	9.94E+02	2.75E+03
$4Mj_3$	1.16E+02	3.54E+01	1.17E+02	2.47E+02	3.63E+01	6.59E+01	1.05E+02	9.62E+06	5.79E+06	8.71E+06	2.53E+07	7.50E+06	6.17E+06	7.75E+06
$4R_{i1}$	4.87E-01	1.47E-01	3.97E-01	1.24E+00	1.46E-01	1.90E-01	5.15E-01	3.00E+00	1.31E+00	2.22E+00	6.14E+00	9.46E-01	1.52E+00	2.32E+00
$5R_{i2}$	3.08E-01	9.66E-02	3.10E-01	6.74E-01	9.83E-02	1.92E-01	2.85E-01	2.71E+04	1.63E+04	2.45E+04	7.10E+04	2.13E+04	1.73E+04	2.18E+04
$5R_{i3}$	7.75E+03	2.62E+03	5.36E+03	1.39E+04	3.62E+03	4.31E+03	6.43E+03	1.03E+01	1.79E+00	3.68E+00	1.44E+01	1.21E+00	2.21E+00	5.97E+00
$5M_{i1}$	1.27E+02	4.01E+01	8.39E+01	2.35E+02	5.38E+01	6.91E+01	1.07E+02	1.20E+03	8.01E+02	1.09E+03	3.24E+03	9.41E+02	7.58E+02	9.60E+02
$5M_{i2}$	2.73E+06	9.16E+05	1.89E+06	4.92E+06	1.26E+06	1.52E+06	2.28E+06	4.77E+03	8.07E+02	1.66E+03	6.59E+03	5.13E+02	9.94E+02	2.75E+03
$5M_{i3}$	1.16E+02	3.54E+01	1.17E+02	2.47E+02	3.63E+01	6.59E+01	1.05E+02	9.62E+06	5.79E+06	8.71E+06	2.53E+07	7.50E+06	6.17E+06	7.75E+06
$5Rj_1$	4.87E-01	1.47E-01	3.97E-01	1.24E+00	1.46E-01	1.90E-01	5.15E-01	3.00E+00	1.31E+00	2.22E+00	6.14E+00	9.46E-01	1.52E+00	2.32E+00
$5Rj_2$	3.08E-01	9.66E-02	3.10E-01	6.74E-01	9.83E-02	1.92E-01	2.85E-01	2.71E+04	1.63E+04	2.45E+04	7.10E+04	2.13E+04	1.73E+04	2.18E+04
$5Rj_3$	7.75E+03	2.62E+03	5.36E+03	1.39E+04	3.62E+03	4.31E+03	6.43E+03	1.03E+01	1.79E+00	3.68E+00	1.44E+01	1.21E+00	2.21E+00	5.97E+00
$5Mj_1$	1.27E+02	4.01E+01	8.39E+01	2.35E+02	5.38E+01	6.91E+01	1.07E+02	1.20E+03	8.01E+02	1.09E+03	3.24E+03	9.41E+02	7.58E+02	9.60E+02
$5Mj_2$	1.11E+06	3.66E+05	7.64E+05	2.00E+06	4.96E+05	6.17E+05	9.30E+05	2.61E+03	4.36E+02	8.92E+02	3.58E+03	2.63E+02	5.34E+02	1.50E+03
$5Mj_3$	5.64E+01	1.60E+01	5.44E+01	1.11E+02	1.67E+01	2.65E+01	4.76E+01	3.93E+06	2.37E+06	3.57E+06	1.04E+07	3.04E+06	2.54E+06	3.17E+06

Table 3.4.7 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$6R_{i1}$	4.76E-01	1.42E-01	3.88E-01	1.15E+00	1.41E-01	1.85E-01	4.87E-01	2.25E+00	1.19E+00	1.99E+00	4.98E+00	8.60E-01	1.30E+00	1.89E+00
$6R_{i2}$	2.39E-01	7.52E-02	2.39E-01	5.10E-01	7.73E-02	1.40E-01	2.22E-01	1.91E+04	1.15E+04	1.73E+04	5.03E+04	1.48E+04	1.23E+04	1.54E+04
$6R_{i3}$	5.39E+03	1.79E+03	3.72E+03	9.72E+03	2.44E+03	3.01E+03	4.52E+03	1.11E+01	1.78E+00	3.70E+00	1.54E+01	1.05E+00	2.28E+00	6.41E+00
$6M_{i1}$	1.75E+02	5.60E+01	1.23E+02	3.17E+02	7.55E+01	9.79E+01	1.47E+02	6.79E+02	4.54E+02	7.65E+02	1.67E+03	4.82E+02	4.77E+02	5.49E+02
$6M_{i2}$	1.11E+06	3.66E+05	7.64E+05	2.00E+06	4.96E+05	6.17E+05	9.30E+05	2.61E+03	4.36E+02	8.92E+02	3.58E+03	2.63E+02	5.34E+02	1.50E+03
$6M_{i3}$	5.64E+01	1.60E+01	5.44E+01	1.11E+02	1.67E+01	2.65E+01	4.76E+01	3.93E+06	2.37E+06	3.57E+06	1.04E+07	3.04E+06	2.54E+06	3.17E+06
$6R_{j1}$	4.76E-01	1.42E-01	3.88E-01	1.15E+00	1.41E-01	1.85E-01	4.87E-01	2.25E+00	1.19E+00	1.99E+00	4.98E+00	8.60E-01	1.30E+00	1.89E+00
$6R_{j2}$	2.39E-01	7.52E-02	2.39E-01	5.10E-01	7.73E-02	1.40E-01	2.22E-01	1.91E+04	1.15E+04	1.73E+04	5.03E+04	1.48E+04	1.23E+04	1.54E+04
$6R_{j3}$	5.39E+03	1.79E+03	3.72E+03	9.72E+03	2.44E+03	3.01E+03	4.52E+03	1.11E+01	1.78E+00	3.70E+00	1.54E+01	1.05E+00	2.28E+00	6.41E+00
$6M_{j1}$	1.75E+02	5.60E+01	1.23E+02	3.17E+02	7.55E+01	9.79E+01	1.47E+02	6.79E+02	4.54E+02	7.65E+02	1.67E+03	4.82E+02	4.77E+02	5.49E+02
$6M_{j2}$	3.79E+05	1.24E+05	2.61E+05	6.86E+05	1.67E+05	2.12E+05	3.20E+05	1.11E+03	2.03E+02	4.00E+02	1.52E+03	1.26E+02	2.34E+02	6.39E+02
$6M_{j3}$	2.83E+01	6.58E+00	2.32E+01	4.48E+01	6.97E+00	8.83E+00	1.93E+01	1.35E+06	8.15E+05	1.23E+06	3.59E+06	1.04E+06	8.79E+05	1.09E+06
$7R_{i1}$	4.96E-01	1.39E-01	3.80E-01	1.07E+00	1.36E-01	1.81E-01	4.61E-01	1.81E+00	1.09E+00	1.80E+00	4.09E+00	7.83E-01	1.12E+00	1.58E+00
$7R_{i2}$	1.29E-01	4.21E-02	1.33E-01	2.79E-01	4.37E-02	7.59E-02	1.23E-01	1.00E+04	6.04E+03	9.13E+03	2.66E+04	7.70E+03	6.51E+03	8.09E+03
$7R_{i3}$	2.80E+03	9.18E+02	1.93E+03	5.08E+03	1.23E+03	1.57E+03	2.37E+03	7.52E+00	1.16E+00	2.43E+00	1.04E+01	6.42E-01	1.50E+00	4.32E+00
$7M_{i1}$	1.75E+02	5.60E+01	1.23E+02	3.17E+02	7.55E+01	9.79E+01	1.47E+02	6.79E+02	4.54E+02	7.65E+02	1.67E+03	4.82E+02	4.77E+02	5.49E+02
$7M_{i2}$	3.79E+05	1.24E+05	2.61E+05	6.86E+05	1.67E+05	2.12E+05	3.20E+05	1.11E+03	2.03E+02	4.00E+02	1.52E+03	1.26E+02	2.34E+02	6.39E+02
$7M_{i3}$	2.83E+01	6.58E+00	2.32E+01	4.48E+01	6.97E+00	8.83E+00	1.93E+01	1.35E+06	8.15E+05	1.23E+06	3.59E+06	1.04E+06	8.79E+05	1.09E+06
$7R_{j1}$	4.96E-01	1.39E-01	3.80E-01	1.07E+00	1.36E-01	1.81E-01	4.61E-01	1.81E+00	1.09E+00	1.80E+00	4.09E+00	7.83E-01	1.12E+00	1.58E+00
$7R_{j2}$	1.29E-01	4.21E-02	1.33E-01	2.79E-01	4.37E-02	7.59E-02	1.23E-01	1.00E+04	6.04E+03	9.13E+03	2.66E+04	7.70E+03	6.51E+03	8.09E+03
$7R_{j3}$	2.80E+03	9.18E+02	1.93E+03	5.08E+03	1.23E+03	1.57E+03	2.37E+03	7.52E+00	1.16E+00	2.43E+00	1.04E+01	6.42E-01	1.50E+00	4.32E+00
$7M_{j1}$	1.75E+02	5.60E+01	1.23E+02	3.17E+02	7.55E+01	9.79E+01	1.47E+02	6.79E+02	4.54E+02	7.65E+02	1.67E+03	4.82E+02	4.77E+02	5.49E+02
$7M_{j2}$	3.58E+01	6.82E+00	1.62E+01	4.82E+01	5.85E+00	9.72E+00	2.12E+01	1.53E+02	8.10E+01	1.35E+02	2.95E+02	5.78E+01	8.27E+01	1.19E+02
$7M_{j3}$	1.92E+01	3.52E+00	9.09E+00	1.94E+01	3.51E+00	5.81E+00	9.63E+00	1.54E+02	1.35E+02	1.94E+02	3.53E+02	8.93E+01	9.74E+01	1.21E+02

Table 3.4.8 Maximum element forces and moments for joint elements (group#2) of benchmark problem #4a and #4b.

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$1R_{i1}$	2.79E-01	8.84E-02	2.02E-01	5.08E-01	1.21E-01	1.57E-01	2.37E-01	8.06E+00	5.24E+00	8.83E+00	2.00E+01	5.77E+00	5.64E+00	6.51E+00
$1R_{i2}$	8.48E-01	2.70E-01	5.97E-01	1.53E+00	3.64E-01	4.74E-01	7.09E-01	2.72E+00	1.84E+00	3.10E+00	6.65E+00	1.92E+00	1.92E+00	2.20E+00
$1R_{i3}$	1.05E-01	1.93E-02	4.99E-02	1.06E-01	1.94E-02	3.08E-02	5.24E-02	9.03E-01	8.12E-01	1.18E+00	2.04E+00	5.29E-01	5.88E-01	7.11E-01
$1M_{i1}$	1.36E+01	5.09E+00	1.54E+01	3.54E+01	5.63E+00	6.47E+00	1.60E+01	1.80E+01	1.63E+01	2.45E+01	3.97E+01	1.03E+01	1.17E+01	1.39E+01
$1M_{i2}$	5.69E+00	1.16E+00	3.02E+00	7.34E+00	1.19E+00	1.48E+00	3.33E+00	6.32E+01	5.86E+01	8.82E+01	1.40E+02	3.80E+01	4.45E+01	5.07E+01
$1M_{i3}$	3.91E+01	1.22E+01	2.81E+01	6.99E+01	1.65E+01	2.17E+01	3.25E+01	1.80E+01	1.62E+01	2.42E+01	4.08E+01	1.03E+01	1.20E+01	1.56E+01
$1R_{j1}$	2.79E-01	8.84E-02	2.02E-01	5.08E-01	1.21E-01	1.57E-01	2.37E-01	8.06E+00	5.24E+00	8.83E+00	2.00E+01	5.77E+00	5.64E+00	6.51E+00
$1R_{j2}$	8.48E-01	2.70E-01	5.97E-01	1.53E+00	3.64E-01	4.74E-01	7.09E-01	2.72E+00	1.84E+00	3.10E+00	6.65E+00	1.92E+00	1.92E+00	2.20E+00
$1R_{j3}$	1.05E-01	1.93E-02	4.99E-02	1.06E-01	1.94E-02	3.08E-02	5.24E-02	9.03E-01	8.12E-01	1.18E+00	2.04E+00	5.29E-01	5.88E-01	7.11E-01
$1M_{j1}$	1.36E+01	5.09E+00	1.54E+01	3.54E+01	5.63E+00	6.47E+00	1.60E+01	1.80E+01	1.63E+01	2.45E+01	3.97E+01	1.03E+01	1.17E+01	1.39E+01
$1M_{j2}$	2.23E+01	4.83E+00	1.36E+01	2.85E+01	5.12E+00	7.49E+00	1.38E+01	1.68E+02	1.47E+02	2.11E+02	3.83E+02	9.70E+01	1.06E+02	1.31E+02
$1M_{j3}$	1.75E+02	5.60E+01	1.23E+02	3.17E+02	7.55E+01	9.79E+01	1.47E+02	6.79E+02	4.54E+02	7.65E+02	1.67E+03	4.82E+02	4.77E+02	5.49E+02
$2R_{i1}$	2.91E-01	1.34E-01	2.20E-01	5.29E-01	2.07E-01	1.48E-01	2.00E-01	3.43E+00	2.44E+00	3.28E+00	7.79E+00	2.71E+00	1.88E+00	2.74E+00
$2R_{i2}$	3.42E-01	1.47E-01	2.57E-01	6.07E-01	2.24E-01	1.76E-01	2.46E-01	3.38E+00	1.71E+00	2.35E+00	6.57E+00	2.04E+00	1.37E+00	2.43E+00
$2R_{i3}$	7.82E-02	1.89E-02	4.60E-02	1.36E-01	1.78E-02	3.64E-02	6.38E-02	3.68E-01	1.87E-01	3.26E-01	7.83E-01	1.63E-01	2.24E-01	2.75E-01
$2M_{i1}$	2.01E+00	4.28E-01	9.83E-01	3.10E+00	3.70E-01	7.43E-01	1.50E+00	1.28E+01	8.17E+00	1.36E+01	2.68E+01	6.03E+00	8.24E+00	9.91E+00
$2M_{i2}$	3.37E+00	7.47E-01	1.84E+00	5.19E+00	7.03E-01	1.44E+00	2.48E+00	1.49E+01	8.19E+00	1.36E+01	2.81E+01	5.83E+00	8.29E+00	1.07E+01
$2M_{i3}$	1.91E+01	8.08E+00	1.48E+01	3.45E+01	1.22E+01	9.91E+00	1.43E+01	8.26E+01	2.76E+01	4.48E+01	1.33E+02	1.81E+01	2.69E+01	5.78E+01
$2R_{j1}$	2.91E-01	1.34E-01	2.20E-01	5.29E-01	2.07E-01	1.48E-01	2.00E-01	3.43E+00	2.44E+00	3.28E+00	7.79E+00	2.71E+00	1.88E+00	2.74E+00
$2R_{j2}$	3.42E-01	1.47E-01	2.57E-01	6.07E-01	2.24E-01	1.76E-01	2.46E-01	3.38E+00	1.71E+00	2.35E+00	6.57E+00	2.04E+00	1.37E+00	2.43E+00
$2R_{j3}$	7.82E-02	1.89E-02	4.60E-02	1.36E-01	1.78E-02	3.64E-02	6.38E-02	3.68E-01	1.87E-01	3.26E-01	7.83E-01	1.63E-01	2.24E-01	2.75E-01
$2M_{j1}$	2.01E+00	4.28E-01	9.83E-01	3.10E+00	3.70E-01	7.43E-01	1.50E+00	1.28E+01	8.17E+00	1.36E+01	2.68E+01	6.03E+00	8.24E+00	9.91E+00
$2M_{j2}$	2.10E+01	5.15E+00	1.25E+01	3.70E+01	4.85E+00	9.88E+00	1.74E+01	1.00E+02	5.09E+01	8.87E+01	2.18E+02	4.56E+01	6.20E+01	7.54E+01
$2M_{j3}$	8.75E+01	3.77E+01	6.54E+01	1.55E+02	5.75E+01	4.49E+01	6.25E+01	1.01E+03	5.48E+02	7.49E+02	2.02E+03	6.45E+02	4.34E+02	7.40E+02

Table 3.4.8 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$3R_{i1}$	1.24E+00	4.48E-01	1.02E+00	2.90E+00	5.45E-01	6.43E-01	1.28E+00	2.94E-01	2.61E-01	3.99E-01	6.52E-01	1.62E-01	1.86E-01	2.24E-01
$3R_{i2}$	4.16E-06	1.48E-06	2.90E-06	7.37E-06	2.11E-06	2.29E-06	3.35E-06	1.32E-04	7.88E-05	1.18E-04	3.40E-04	1.05E-04	8.24E-05	1.06E-04
$3R_{i3}$	4.92E-01	1.42E-01	3.95E-01	1.05E+00	1.43E-01	1.80E-01	4.59E-01	2.32E+00	1.74E+00	2.73E+00	4.93E+00	1.15E+00	1.49E+00	1.91E+00
$3M_{i1}$	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$3M_{i2}$	1.01E-03	2.98E-04	6.94E-04	1.91E-03	3.52E-04	5.68E-04	9.04E-04	1.93E-04	9.67E-05	1.40E-04	3.81E-04	1.56E-04	7.83E-05	1.45E-04
$3M_{i3}$	1.62E-04	5.77E-05	1.13E-04	2.87E-04	8.22E-05	8.94E-05	1.30E-04	5.13E-03	3.07E-03	4.61E-03	1.32E-02	4.09E-03	3.21E-03	4.12E-03
$3Rj_1$	1.24E+00	4.48E-01	1.02E+00	2.90E+00	5.45E-01	6.43E-01	1.28E+00	2.94E-01	2.61E-01	3.99E-01	6.52E-01	1.62E-01	1.86E-01	2.24E-01
$3Rj_2$	4.16E-06	1.48E-06	2.90E-06	7.37E-06	2.11E-06	2.29E-06	3.35E-06	1.32E-04	7.88E-05	1.18E-04	3.40E-04	1.05E-04	8.24E-05	1.06E-04
$3Rj_3$	4.92E-01	1.42E-01	3.95E-01	1.05E+00	1.43E-01	1.80E-01	4.59E-01	2.32E+00	1.74E+00	2.73E+00	4.93E+00	1.15E+00	1.49E+00	1.91E+00
$3Mj_1$	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$3Mj_2$	3.83E+01	1.10E+01	3.08E+01	8.16E+01	1.11E+01	1.40E+01	3.58E+01	1.81E+02	1.36E+02	2.13E+02	3.85E+02	8.95E+01	1.16E+02	1.49E+02
$3Mj_3$	1.63E-04	5.79E-05	1.13E-04	2.88E-04	8.25E-05	8.97E-05	1.31E-04	5.14E-03	3.08E-03	4.62E-03	1.33E-02	4.10E-03	3.22E-03	4.14E-03
$3R_{i1}$	3.13E+00	1.05E+00	2.77E+00	6.06E+00	1.37E+00	1.73E+00	2.86E+00	2.48E+00	2.16E+00	2.95E+00	6.41E+00	1.86E+00	1.65E+00	1.97E+00
$4R_{i2}$	7.00E-01	2.33E-01	5.93E-01	1.32E+00	3.01E-01	3.92E-01	6.29E-01	1.05E+01	9.40E+00	1.25E+01	2.73E+01	7.91E+00	6.97E+00	8.27E+00
$4R_{i3}$	2.73E-05	9.37E-06	1.89E-05	4.89E-05	1.31E-05	1.52E-05	2.25E-05	2.13E-05	1.27E-05	1.90E-05	5.46E-05	1.71E-05	1.31E-05	1.71E-05
$4M_{i1}$	5.41E-04	1.89E-04	3.76E-04	9.65E-04	2.67E-04	2.99E-04	4.41E-04	1.30E-05	7.92E-06	1.14E-05	3.38E-05	1.06E-05	8.00E-06	1.05E-05
$4M_{i2}$	7.20E-04	2.81E-04	5.09E-04	1.27E-03	4.17E-04	3.89E-04	5.48E-04	4.30E-03	2.57E-03	3.84E-03	1.11E-02	3.45E-03	2.67E-03	3.45E-03
$4M_{i3}$	8.64E-05	3.11E-05	5.92E-05	1.55E-04	4.41E-05	4.75E-05	7.00E-05	5.66E-02	3.38E-02	5.06E-02	1.45E-01	4.56E-02	3.49E-02	4.54E-02
$4Rj_1$	3.13E+00	1.05E+00	2.77E+00	6.06E+00	1.37E+00	1.73E+00	2.86E+00	2.48E+00	2.16E+00	2.95E+00	6.41E+00	1.86E+00	1.65E+00	1.97E+00
$4Rj_2$	7.00E-01	2.33E-01	5.93E-01	1.32E+00	3.01E-01	3.92E-01	6.29E-01	1.05E+01	9.40E+00	1.25E+01	2.73E+01	7.91E+00	6.97E+00	8.27E+00
$4Rj_3$	2.73E-05	9.37E-06	1.89E-05	4.89E-05	1.31E-05	1.52E-05	2.25E-05	2.13E-05	1.27E-05	1.90E-05	5.46E-05	1.71E-05	1.31E-05	1.71E-05
$4Mj_1$	5.41E-04	1.89E-04	3.76E-04	9.65E-04	2.67E-04	2.99E-04	4.41E-04	1.30E-05	7.92E-06	1.14E-05	3.38E-05	1.06E-05	8.00E-06	1.05E-05
$4Mj_2$	7.09E-04	2.77E-04	5.01E-04	1.25E-03	4.12E-04	3.82E-04	5.39E-04	3.32E-03	1.98E-03	2.95E-03	8.46E-03	2.69E-03	2.03E-03	2.66E-03
$4Mj_3$	5.61E+01	1.86E+01	4.75E+01	1.06E+02	2.41E+01	3.14E+01	5.03E+01	8.39E+02	7.52E+02	1.00E+03	2.19E+03	6.33E+02	5.58E+02	6.62E+02
$4R_{i1}$	3.31E+00	1.16E+00	3.27E+00	7.06E+00	1.48E+00	1.77E+00	3.26E+00	2.53E+00	2.27E+00	3.23E+00	6.10E+00	1.77E+00	1.78E+00	2.04E+00
$5R_{i2}$	7.47E-01	2.65E-01	7.22E-01	1.56E+00	3.32E-01	4.02E-01	7.28E-01	1.07E+01	1.02E+01	1.41E+01	2.60E+01	7.67E+00	7.36E+00	8.42E+00
$5R_{i3}$	9.63E-06	3.43E-06	6.70E-06	1.71E-05	4.90E-06	5.31E-06	7.76E-06	6.20E-06	3.69E-06	5.56E-06	1.59E-05	4.99E-06	3.84E-06	4.98E-06
$5M_{i1}$	8.20E-04	2.89E-04	5.70E-04	1.46E-03	4.09E-04	4.53E-04	6.65E-04	4.09E-03	2.46E-03	3.64E-03	1.06E-02	3.30E-03	2.53E-03	3.29E-03
$5M_{i2}$	4.92E-03	1.75E-03	3.43E-03	8.75E-03	2.49E-03	2.72E-03	3.97E-03	1.95E-03	1.17E-03	1.75E-03	5.07E-03	1.55E-03	1.23E-03	1.57E-03
$5M_{i3}$	8.83E-04	3.17E-04	6.16E-04	1.57E-03	4.55E-04	4.86E-04	7.08E-04	2.46E-03	1.42E-03	2.13E-03	5.88E-03	2.07E-03	1.37E-03	1.94E-03
$5Rj_1$	3.31E+00	1.16E+00	3.27E+00	7.06E+00	1.48E+00	1.77E+00	3.26E+00	2.53E+00	2.27E+00	3.23E+00	6.10E+00	1.77E+00	1.78E+00	2.04E+00
$5Rj_2$	7.47E-01	2.65E-01	7.22E-01	1.56E+00	3.32E-01	4.02E-01	7.28E-01	1.07E+01	1.02E+01	1.41E+01	2.60E+01	7.67E+00	7.36E+00	8.42E+00
$5Rj_3$	9.63E-06	3.43E-06	6.70E-06	1.71E-05	4.90E-06	5.31E-06	7.76E-06	6.20E-06	3.69E-06	5.56E-06	1.59E-05	4.99E-06	3.84E-06	4.98E-06
$5Mj_1$	8.20E-04	2.89E-04	5.70E-04	1.46E-03	4.09E-04	4.53E-04	6.65E-04	4.09E-03	2.46E-03	3.64E-03	1.06E-02	3.30E-03	2.53E-03	3.29E-03
$5Mj_2$	2.52E-03	9.03E-04	1.75E-03	4.48E-03	1.29E-03	1.39E-03	2.03E-03	1.80E-03	1.08E-03	1.62E-03	4.66E-03	1.44E-03	1.13E-03	1.45E-03
$5Mj_3$	5.98E+01	2.12E+01	5.78E+01	1.25E+02	2.66E+01	3.22E+01	5.83E+01	8.58E+02	8.14E+02	1.13E+03	2.08E+03	6.14E+02	5.89E+02	6.74E+02

Table 3.4.8 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$6R_{i1}$	6.14E-02	2.23E-02	4.09E-02	1.06E-01	2.75E-02	2.80E-02	5.14E-02	7.17E+00	6.56E+00	9.99E+00	1.50E+01	4.43E+00	4.77E+00	5.49E+00
$6R_{i2}$	1.21E-04	4.21E-05	8.43E-05	2.17E-04	5.91E-05	6.73E-05	9.93E-05	2.93E-05	1.35E-05	2.10E-05	5.64E-05	2.02E-05	1.19E-05	2.15E-05
$6R_{i3}$	3.99E-01	1.33E-01	4.07E-01	8.66E-01	1.56E-01	2.03E-01	4.06E-01	1.11E+00	8.58E-01	1.32E+00	2.19E+00	5.64E-01	7.02E-01	8.15E-01
$6M_{i1}$	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$6M_{i2}$	3.27E-05	1.17E-05	2.32E-05	5.64E-05	1.61E-05	1.84E-05	2.65E-05	3.17E-03	2.13E-03	2.89E-03	8.50E-03	2.51E-03	1.98E-03	2.55E-03
$6M_{i3}$	7.53E-04	3.02E-04	5.35E-04	1.32E-03	4.53E-04	4.02E-04	5.62E-04	2.68E-04	1.25E-04	1.92E-04	5.12E-04	1.93E-04	1.06E-04	1.97E-04
$6Rj_1$	6.14E-02	2.23E-02	4.09E-02	1.06E-01	2.75E-02	2.80E-02	5.14E-02	7.17E+00	6.56E+00	9.99E+00	1.50E+01	4.43E+00	4.77E+00	5.49E+00
$6Rj_2$	1.21E-04	4.21E-05	8.43E-05	2.17E-04	5.91E-05	6.73E-05	9.93E-05	2.93E-05	1.35E-05	2.10E-05	5.64E-05	2.02E-05	1.19E-05	2.15E-05
$6Rj_3$	3.99E-01	1.33E-01	4.07E-01	8.66E-01	1.56E-01	2.03E-01	4.06E-01	1.11E+00	8.58E-01	1.32E+00	2.19E+00	5.64E-01	7.02E-01	8.15E-01
$6Mj_1$	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$6Mj_2$	7.18E+00	2.40E+00	7.33E+00	1.56E+01	2.82E+00	3.66E+00	7.30E+00	1.99E+01	1.54E+01	2.38E+01	3.95E+01	1.01E+01	1.26E+01	1.47E+01
$6Mj_3$	2.92E-03	1.05E-03	2.04E-03	5.18E-03	1.51E-03	1.61E-03	2.34E-03	2.57E-04	1.18E-04	1.86E-04	5.00E-04	1.72E-04	1.08E-04	1.89E-04
$7R_{i1}$	1.48E+00	7.10E-01	1.43E+00	3.26E+00	1.04E+00	6.66E-01	1.30E+00	3.46E+00	7.24E-01	1.31E+00	4.97E+00	4.30E-01	8.98E-01	2.01E+00
$7R_{i2}$	8.33E-08	2.96E-08	5.83E-08	1.47E-07	4.22E-08	4.60E-08	6.70E-08	1.26E-06	5.85E-07	9.91E-07	2.87E-06	6.11E-07	7.13E-07	9.90E-07
$7R_{i3}$	1.50E-01	3.61E-02	9.67E-02	2.38E-01	3.78E-02	6.90E-02	1.12E-01	6.32E-01	3.67E-01	5.62E-01	1.08E+00	2.38E-01	2.93E-01	4.10E-01
$7M_{i1}$	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$7M_{i2}$	4.92E-03	1.75E-03	3.42E-03	8.73E-03	2.49E-03	2.71E-03	3.96E-03	4.15E-06	3.09E-06	4.46E-06	9.64E-06	2.48E-06	2.24E-06	3.00E-06
$7M_{i3}$	8.28E-06	2.95E-06	5.76E-06	1.46E-05	4.20E-06	4.59E-06	6.66E-06	6.04E-03	3.58E-03	5.30E-03	1.52E-02	4.97E-03	3.60E-03	4.82E-03
$7Rj_1$	1.48E+00	7.10E-01	1.43E+00	3.26E+00	1.04E+00	6.66E-01	1.30E+00	3.46E+00	7.24E-01	1.31E+00	4.97E+00	4.30E-01	8.98E-01	2.01E+00
$7Rj_2$	8.33E-08	2.96E-08	5.83E-08	1.47E-07	4.22E-08	4.60E-08	6.70E-08	1.26E-06	5.85E-07	9.91E-07	2.87E-06	6.11E-07	7.13E-07	9.90E-07
$7Rj_3$	1.50E-01	3.61E-02	9.67E-02	2.38E-01	3.78E-02	6.90E-02	1.12E-01	6.32E-01	3.67E-01	5.62E-01	1.08E+00	2.38E-01	2.93E-01	4.10E-01
$7Mj_1$	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$7Mj_2$	2.97E+01	7.14E+00	1.91E+01	4.71E+01	7.48E+00	1.37E+01	2.22E+01	1.25E+02	7.27E+01	1.11E+02	2.15E+02	4.71E+01	5.80E+01	8.11E+01
$7Mj_3$	8.22E-06	2.92E-06	5.78E-06	1.46E-05	4.15E-06	4.51E-06	6.61E-06	6.09E-03	3.62E-03	5.39E-03	1.55E-02	4.97E-03	3.69E-03	4.87E-03

Table 3.4.9 Maximum element forces and moments for S-component (group#3) of benchmark problem #4a and #4b.

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$1R_{i1}$	4.24E-02	9.31E-03	2.48E-02	8.11E-02	9.75E-03	1.39E-02	3.69E-02	7.73E+00	5.16E+00	8.72E+00	1.90E+01	5.48E+00	5.46E+00	6.25E+00
$1R_{i2}$	6.60E-01	2.07E-01	4.68E-01	1.18E+00	2.79E-01	3.66E-01	5.49E-01	2.48E-01	2.12E-01	3.19E-01	5.60E-01	1.35E-01	1.60E-01	2.20E-01
$1R_{i3}$	1.01E-01	1.77E-02	4.46E-02	9.37E-02	1.73E-02	2.63E-02	4.60E-02	8.94E-01	7.96E-01	1.19E+00	1.96E+00	5.14E-01	5.95E-01	7.06E-01
$1M_{i1}$	1.34E+01	5.10E+00	1.54E+01	3.55E+01	5.64E+00	6.43E+00	1.60E+01	4.20E+00	3.44E+00	5.82E+00	8.78E+00	2.69E+00	3.73E+00	3.77E+00
$1M_{i2}$	6.01E+00	1.14E+00	2.96E+00	6.53E+00	1.17E+00	1.65E+00	3.13E+00	6.55E+01	6.07E+01	9.13E+01	1.45E+02	3.92E+01	4.58E+01	5.24E+01
$1M_{i3}$	3.91E+01	1.22E+01	2.81E+01	6.99E+01	1.65E+01	2.17E+01	3.25E+01	1.80E+01	1.62E+01	2.42E+01	4.08E+01	1.03E+01	1.20E+01	1.56E+01
$1Rj_1$	4.24E-02	9.31E-03	2.48E-02	8.11E-02	9.75E-03	1.39E-02	3.69E-02	7.73E+00	5.16E+00	8.72E+00	1.90E+01	5.48E+00	5.46E+00	6.25E+00
$1Rj_2$	6.60E-01	2.07E-01	4.68E-01	1.18E+00	2.79E-01	3.66E-01	5.49E-01	2.48E-01	2.12E-01	3.19E-01	5.60E-01	1.35E-01	1.60E-01	2.20E-01
$1Rj_3$	1.01E-01	1.77E-02	4.46E-02	9.37E-02	1.73E-02	2.63E-02	4.60E-02	8.94E-01	7.96E-01	1.19E+00	1.96E+00	5.14E-01	5.95E-01	7.06E-01
$1Mj_1$	1.34E+01	5.10E+00	1.54E+01	3.55E+01	5.64E+00	6.43E+00	1.60E+01	4.20E+00	3.44E+00	5.82E+00	8.78E+00	2.69E+00	3.73E+00	3.77E+00
$1Mj_2$	2.16E+00	3.18E-01	7.25E-01	1.41E+00	2.57E-01	5.11E-01	7.37E-01	1.03E+01	4.10E+00	5.88E+00	2.04E+01	3.37E+00	4.11E+00	7.35E+00
$1Mj_3$	1.38E+01	4.39E+00	9.50E+00	2.52E+01	5.90E+00	7.69E+00	1.16E+01	2.52E+00	8.16E-01	1.60E+00	5.40E+00	5.44E-01	1.14E+00	2.55E+00
$2R_{i1}$	4.22E-02	9.30E-03	2.47E-02	8.09E-02	9.73E-03	1.39E-02	3.68E-02	6.25E+00	4.46E+00	7.52E+00	1.50E+01	4.32E+00	4.51E+00	5.05E+00
$2R_{i2}$	1.63E-01	5.04E-02	1.35E-01	3.01E-01	6.56E-02	8.67E-02	1.42E-01	1.94E-01	1.92E-01	2.83E-01	4.47E-01	1.22E-01	1.37E-01	1.60E-01
$2R_{i3}$	3.29E-02	9.62E-03	2.62E-02	6.87E-02	1.03E-02	1.23E-02	3.09E-02	7.53E-01	7.20E-01	1.11E+00	1.69E+00	4.72E-01	5.67E-01	6.12E-01
$2M_{i1}$	1.34E+01	5.10E+00	1.54E+01	3.55E+01	5.64E+00	6.43E+00	1.60E+01	4.20E+00	3.44E+00	5.82E+00	8.78E+00	2.69E+00	3.73E+00	3.77E+00
$2M_{i2}$	2.16E+00	3.18E-01	7.25E-01	1.41E+00	2.57E-01	5.11E-01	7.37E-01	1.03E+01	4.10E+00	5.88E+00	2.04E+01	3.37E+00	4.11E+00	7.35E+00
$2M_{i3}$	1.38E+01	4.39E+00	9.50E+00	2.52E+01	5.90E+00	7.69E+00	1.16E+01	2.52E+00	8.16E-01	1.60E+00	5.40E+00	5.44E-01	1.14E+00	2.55E+00
$2Rj_1$	4.22E-02	9.30E-03	2.47E-02	8.09E-02	9.73E-03	1.39E-02	3.68E-02	6.25E+00	4.46E+00	7.52E+00	1.50E+01	4.32E+00	4.51E+00	5.05E+00
$2Rj_2$	1.63E-01	5.04E-02	1.35E-01	3.01E-01	6.56E-02	8.67E-02	1.42E-01	1.94E-01	1.92E-01	2.83E-01	4.47E-01	1.22E-01	1.37E-01	1.60E-01
$2Rj_3$	3.29E-02	9.62E-03	2.62E-02	6.87E-02	1.03E-02	1.23E-02	3.09E-02	7.53E-01	7.20E-01	1.11E+00	1.69E+00	4.72E-01	5.67E-01	6.12E-01
$2Mj_1$	1.34E+01	5.10E+00	1.54E+01	3.55E+01	5.64E+00	6.43E+00	1.60E+01	4.20E+00	3.44E+00	5.82E+00	8.78E+00	2.69E+00	3.73E+00	3.77E+00
$2Mj_2$	4.26E+00	9.45E-01	2.52E+00	6.01E+00	1.00E+00	1.29E+00	2.79E+00	6.35E+01	6.02E+01	9.17E+01	1.42E+02	3.91E+01	4.65E+01	5.13E+01
$2Mj_3$	2.61E+01	8.08E+00	1.93E+01	4.65E+01	1.09E+01	1.43E+01	2.17E+01	1.70E+01	1.61E+01	2.39E+01	3.89E+01	1.02E+01	1.17E+01	1.44E+01
$3R_{i1}$	4.19E-02	9.26E-03	2.47E-02	8.05E-02	9.71E-03	1.38E-02	3.66E-02	4.91E+00	3.91E+00	6.47E+00	1.14E+01	3.27E+00	3.65E+00	3.98E+00
$3R_{i2}$	3.90E-01	1.26E-01	2.63E-01	7.44E-01	1.67E-01	2.15E-01	3.37E-01	1.66E-01	1.55E-01	2.29E-01	3.78E-01	9.85E-02	1.11E-01	1.37E-01
$3R_{i3}$	8.14E-02	1.28E-02	2.91E-02	7.12E-02	9.21E-03	1.90E-02	3.39E-02	7.04E-01	5.91E-01	9.31E-01	1.50E+00	3.96E-01	4.92E-01	5.51E-01
$3M_{i1}$	1.34E+01	5.10E+00	1.54E+01	3.55E+01	5.64E+00	6.43E+00	1.60E+01	4.20E+00	3.44E+00	5.82E+00	8.78E+00	2.69E+00	3.73E+00	3.77E+00
$3M_{i2}$	4.26E+00	9.45E-01	2.52E+00	6.01E+00	1.00E+00	1.29E+00	2.79E+00	6.35E+01	6.02E+01	9.17E+01	1.42E+02	3.91E+01	4.65E+01	5.13E+01
$3M_{i3}$	2.61E+01	8.08E+00	1.93E+01	4.65E+01	1.09E+01	1.43E+01	2.17E+01	1.70E+01	1.61E+01	2.39E+01	3.89E+01	1.02E+01	1.17E+01	1.44E+01
$3Rj_1$	4.19E-02	9.26E-03	2.47E-02	8.05E-02	9.71E-03	1.38E-02	3.66E-02	4.91E+00	3.91E+00	6.47E+00	1.14E+01	3.27E+00	3.65E+00	3.98E+00
$3Rj_2$	3.90E-01	1.26E-01	2.63E-01	7.44E-01	1.67E-01	2.15E-01	3.37E-01	1.66E-01	1.55E-01	2.29E-01	3.78E-01	9.85E-02	1.11E-01	1.37E-01
$3Rj_3$	8.14E-02	1.28E-02	2.91E-02	7.12E-02	9.21E-03	1.90E-02	3.39E-02	7.04E-01	5.91E-01	9.31E-01	1.50E+00	3.96E-01	4.92E-01	5.51E-01
$3Mj_1$	1.34E+01	5.10E+00	1.54E+01	3.55E+01	5.64E+00	6.43E+00	1.60E+01	4.20E+00	3.44E+00	5.82E+00	8.78E+00	2.69E+00	3.73E+00	3.77E+00
$3Mj_2$	4.85E+00	1.38E+00	3.67E+00	1.01E+01	1.36E+00	1.77E+00	4.48E+00	1.11E+02	1.07E+02	1.65E+02	2.49E+02	7.03E+01	8.46E+01	9.00E+01
$3Mj_3$	1.23E+01	4.71E+00	1.25E+01	3.25E+01	5.30E+00	5.98E+00	1.44E+01	2.77E+01	2.84E+01	4.18E+01	6.40E+01	1.81E+01	1.99E+01	2.20E+01

Table 3.4.9 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$4R_{i1}$	4.15E-02	9.23E-03	2.46E-02	8.00E-02	9.69E-03	1.37E-02	3.64E-02	4.17E+00	3.65E+00	5.89E+00	9.42E+00	2.69E+00	3.16E+00	3.38E+00
$4R_{i2}$	4.30E-01	1.32E-01	3.76E-01	9.76E-01	1.37E-01	1.66E-01	4.29E-01	1.79E+00	1.17E+00	1.84E+00	3.81E+00	7.71E-01	1.05E+00	1.53E+00
$4R_{i3}$	7.63E-01	2.93E-01	8.05E-01	2.04E+00	3.27E-01	3.64E-01	9.05E-01	2.04E-01	1.36E-01	2.36E-01	4.23E-01	9.53E-02	1.34E-01	1.75E-01
$4M_{i1}$	1.34E+01	5.10E+00	1.54E+01	3.55E+01	5.64E+00	6.43E+00	1.60E+01	4.20E+00	3.44E+00	5.82E+00	8.78E+00	2.69E+00	3.73E+00	3.77E+00
$4M_{i2}$	1.23E+01	4.71E+00	1.25E+01	3.25E+01	5.30E+00	5.98E+00	1.44E+01	2.77E+01	2.84E+01	4.18E+01	6.40E+01	1.81E+01	1.99E+01	2.20E+01
$4M_{i3}$	4.85E+00	1.38E+00	3.67E+00	1.01E+01	1.36E+00	1.77E+00	4.48E+00	1.11E+02	1.07E+02	1.65E+02	2.49E+02	7.03E+01	8.46E+01	9.00E+01
$4R_{C1}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$4R_{C2}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$4R_{C3}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$4M_{C1}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$4M_{C2}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$4M_{C3}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$4R_{j1}$	4.30E-01	1.32E-01	3.76E-01	9.76E-01	1.37E-01	1.66E-01	4.29E-01	1.79E+00	1.17E+00	1.84E+00	3.81E+00	7.71E-01	1.05E+00	1.53E+00
$4R_{j2}$	4.15E-02	9.23E-03	2.46E-02	8.00E-02	9.69E-03	1.37E-02	3.64E-02	4.17E+00	3.65E+00	5.89E+00	9.42E+00	2.69E+00	3.16E+00	3.38E+00
$4R_{j3}$	7.63E-01	2.93E-01	8.05E-01	2.04E+00	3.27E-01	3.64E-01	9.05E-01	2.04E-01	1.36E-01	2.36E-01	4.23E-01	9.53E-02	1.34E-01	1.75E-01
$4M_{j1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$4M_{j2}$	6.74E+00	2.19E+00	4.80E+00	1.22E+01	2.91E+00	3.80E+00	5.77E+00	4.35E+00	4.25E+00	6.33E+00	1.01E+01	2.76E+00	3.16E+00	3.67E+00
$4M_{j3}$	2.84E+00	9.46E-01	2.79E+00	7.11E+00	1.02E+00	1.18E+00	3.11E+00	2.99E+01	2.63E+01	3.61E+01	7.44E+01	2.03E+01	1.94E+01	2.43E+01
$5R_{i1}$	4.23E-01	1.31E-01	3.74E-01	9.56E-01	1.37E-01	1.64E-01	4.21E-01	1.67E+00	1.06E+00	1.66E+00	3.53E+00	6.96E-01	9.59E-01	1.42E+00
$5R_{i2}$	6.67E-01	2.54E-01	7.66E-01	1.78E+00	2.80E-01	3.17E-01	8.01E-01	1.61E-01	1.12E-01	2.00E-01	3.16E-01	8.25E-02	1.20E-01	1.31E-01
$5R_{i3}$	3.87E-02	9.26E-03	2.61E-02	7.51E-02	9.90E-03	1.33E-02	3.36E-02	3.48E+00	3.36E+00	5.20E+00	7.78E+00	2.22E+00	2.65E+00	2.81E+00
$5M_{i1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$5M_{i2}$	2.84E+00	9.46E-01	2.79E+00	7.11E+00	1.02E+00	1.18E+00	3.11E+00	2.99E+01	2.63E+01	3.61E+01	7.44E+01	2.03E+01	1.94E+01	2.43E+01
$5M_{i3}$	6.74E+00	2.19E+00	4.80E+00	1.22E+01	2.91E+00	3.80E+00	5.77E+00	4.35E+00	4.25E+00	6.33E+00	1.01E+01	2.76E+00	3.16E+00	3.67E+00
$5R_{j1}$	4.23E-01	1.31E-01	3.74E-01	9.56E-01	1.37E-01	1.64E-01	4.21E-01	1.67E+00	1.06E+00	1.66E+00	3.53E+00	6.96E-01	9.59E-01	1.42E+00
$5R_{j2}$	6.67E-01	2.54E-01	7.66E-01	1.78E+00	2.80E-01	3.17E-01	8.01E-01	1.61E-01	1.12E-01	2.00E-01	3.16E-01	8.25E-02	1.20E-01	1.31E-01
$5R_{j3}$	3.87E-02	9.26E-03	2.61E-02	7.51E-02	9.90E-03	1.33E-02	3.36E-02	3.48E+00	3.36E+00	5.20E+00	7.78E+00	2.22E+00	2.65E+00	2.81E+00
$5M_{j1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$5M_{j2}$	3.39E+00	7.85E-01	1.49E+00	6.44E+00	7.15E-01	1.12E+00	3.01E+00	2.75E+02	2.60E+02	4.07E+02	6.17E+02	1.75E+02	2.11E+02	2.24E+02
$5M_{j3}$	5.54E+01	2.13E+01	6.30E+01	1.50E+02	2.34E+01	2.61E+01	6.70E+01	1.55E+01	1.19E+01	1.97E+01	3.22E+01	7.93E+00	1.05E+01	1.24E+01

Table 3.4.9 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$6R_{i1}$	4.12E-01	1.29E-01	3.73E-01	9.28E-01	1.37E-01	1.62E-01	4.11E-01	1.47E+00	8.87E-01	1.40E+00	3.09E+00	5.85E-01	8.21E-01	1.26E+00
$6R_{i2}$	5.79E-01	1.93E-01	5.46E-01	1.17E+00	2.42E-01	3.16E-01	5.54E-01	1.25E-01	5.46E-02	1.05E-01	2.31E-01	4.51E-02	7.41E-02	9.57E-02
$6R_{i3}$	2.80E-02	8.46E-03	2.65E-02	6.86E-02	9.50E-03	1.10E-02	2.98E-02	2.17E+00	2.09E+00	2.87E+00	5.47E+00	1.56E+00	1.50E+00	1.70E+00
$6M_{i1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$6M_{i2}$	3.39E+00	7.85E-01	1.49E+00	6.44E+00	7.15E-01	1.12E+00	3.01E+00	2.75E+02	2.60E+02	4.07E+02	6.17E+02	1.75E+02	2.11E+02	2.24E+02
$6M_{i3}$	5.54E+01	2.13E+01	6.30E+01	1.50E+02	2.34E+01	2.61E+01	6.70E+01	1.55E+01	1.19E+01	1.97E+01	3.22E+01	7.93E+00	1.05E+01	1.24E+01
$6R_{j1}$	4.12E-01	1.29E-01	3.73E-01	9.28E-01	1.37E-01	1.62E-01	4.11E-01	1.47E+00	8.87E-01	1.40E+00	3.09E+00	5.85E-01	8.21E-01	1.26E+00
$6R_{j2}$	5.79E-01	1.93E-01	5.46E-01	1.17E+00	2.42E-01	3.16E-01	5.54E-01	1.25E-01	5.46E-02	1.05E-01	2.31E-01	4.51E-02	7.41E-02	9.57E-02
$6R_{j3}$	2.80E-02	8.46E-03	2.65E-02	6.86E-02	9.50E-03	1.10E-02	2.98E-02	2.17E+00	2.09E+00	2.87E+00	5.47E+00	1.56E+00	1.50E+00	1.70E+00
$6M_{j1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$6M_{j2}$	2.48E+00	8.79E-01	1.94E+00	5.20E+00	9.13E-01	1.27E+00	2.47E+00	4.14E+02	4.20E+02	6.25E+02	9.47E+02	2.71E+02	3.12E+02	3.31E+02
$6M_{j3}$	9.17E+01	3.36E+01	1.03E+02	2.27E+02	3.83E+01	4.57E+01	1.04E+02	1.77E+01	1.45E+01	2.52E+01	3.07E+01	1.04E+01	1.47E+01	1.14E+01
$7R_{i1}$	4.01E-01	1.27E-01	3.72E-01	9.02E-01	1.37E-01	1.61E-01	4.02E-01	1.27E+00	7.17E-01	1.14E+00	2.64E+00	4.74E-01	6.83E-01	1.09E+00
$7R_{i2}$	8.25E-01	2.74E-01	5.82E-01	1.53E+00	3.68E-01	4.66E-01	7.08E-01	1.60E-01	6.99E-02	1.21E-01	3.93E-01	4.75E-02	7.52E-02	1.74E-01
$7R_{i3}$	5.62E-02	9.74E-03	2.72E-02	1.05E-01	9.37E-03	1.36E-02	4.68E-02	2.93E+00	1.83E+00	2.60E+00	7.90E+00	2.26E+00	1.87E+00	2.35E+00
$7M_{i1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$7M_{i2}$	2.48E+00	8.79E-01	1.94E+00	5.20E+00	9.13E-01	1.27E+00	2.47E+00	4.14E+02	4.20E+02	6.25E+02	9.47E+02	2.71E+02	3.12E+02	3.31E+02
$7M_{i3}$	9.17E+01	3.36E+01	1.03E+02	2.27E+02	3.83E+01	4.57E+01	1.04E+02	1.77E+01	1.45E+01	2.52E+01	3.07E+01	1.04E+01	1.47E+01	1.14E+01
$7R_{j1}$	4.01E-01	1.27E-01	3.72E-01	9.02E-01	1.37E-01	1.61E-01	4.02E-01	1.27E+00	7.17E-01	1.14E+00	2.64E+00	4.74E-01	6.83E-01	1.09E+00
$7R_{j2}$	8.25E-01	2.74E-01	5.82E-01	1.53E+00	3.68E-01	4.66E-01	7.08E-01	1.60E-01	6.99E-02	1.21E-01	3.93E-01	4.75E-02	7.52E-02	1.74E-01
$7R_{j3}$	5.62E-02	9.74E-03	2.72E-02	1.05E-01	9.37E-03	1.36E-02	4.68E-02	2.93E+00	1.83E+00	2.60E+00	7.90E+00	2.26E+00	1.87E+00	2.35E+00
$7M_{j1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$7M_{j2}$	4.07E+00	1.25E+00	3.63E+00	9.21E+00	1.39E+00	1.71E+00	4.10E+00	5.00E+02	4.88E+02	6.73E+02	1.26E+03	3.61E+02	3.50E+02	3.94E+02
$7M_{j3}$	1.35E+02	4.58E+01	1.30E+02	2.79E+02	5.74E+01	7.35E+01	1.31E+02	2.05E+01	1.32E+01	2.43E+01	3.51E+01	1.03E+01	1.58E+01	1.47E+01
$8R_{i1}$	3.90E-01	1.25E-01	3.71E-01	8.78E-01	1.37E-01	1.61E-01	3.93E-01	1.07E+00	5.48E-01	8.81E-01	2.20E+00	3.65E-01	5.47E-01	9.19E-01
$8R_{i2}$	2.21E+00	7.59E-01	2.21E+00	4.75E+00	9.32E-01	1.18E+00	2.21E+00	4.23E-01	2.56E-01	4.56E-01	6.94E-01	1.89E-01	2.82E-01	2.66E-01
$8R_{i3}$	5.28E-02	1.84E-02	4.93E-02	1.13E-01	2.02E-02	2.56E-02	5.26E-02	8.24E+00	8.19E+00	1.15E+01	2.02E+01	5.79E+00	5.87E+00	6.50E+00
$8M_{i1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$8M_{i2}$	4.07E+00	1.25E+00	3.63E+00	9.21E+00	1.39E+00	1.71E+00	4.10E+00	5.00E+02	4.88E+02	6.73E+02	1.26E+03	3.61E+02	3.50E+02	3.94E+02
$8M_{i3}$	1.35E+02	4.58E+01	1.30E+02	2.79E+02	5.74E+01	7.35E+01	1.31E+02	2.05E+01	1.32E+01	2.43E+01	3.51E+01	1.03E+01	1.58E+01	1.47E+01
$8R_{j1}$	3.90E-01	1.25E-01	3.71E-01	8.78E-01	1.37E-01	1.61E-01	3.93E-01	1.07E+00	5.48E-01	8.81E-01	2.20E+00	3.65E-01	5.47E-01	9.19E-01
$8R_{j2}$	2.21E+00	7.59E-01	2.21E+00	4.75E+00	9.32E-01	1.18E+00	2.21E+00	4.23E-01	2.56E-01	4.56E-01	6.94E-01	1.89E-01	2.82E-01	2.66E-01
$8R_{j3}$	5.28E-02	1.84E-02	4.93E-02	1.13E-01	2.02E-02	2.56E-02	5.26E-02	8.24E+00	8.19E+00	1.15E+01	2.02E+01	5.79E+00	5.87E+00	6.50E+00
$8M_{j1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$8M_{j2}$	1.71E+00	4.46E-01	8.25E-01	2.97E+00	4.18E-01	6.59E-01	1.44E+00	2.03E+02	2.05E+02	2.99E+02	4.70E+02	1.34E+02	1.50E+02	1.62E+02
$8M_{j3}$	5.28E+01	1.89E+01	5.76E+01	1.26E+02	2.21E+01	2.68E+01	5.78E+01	1.70E+01	9.23E+00	1.55E+01	3.08E+01	6.17E+00	8.84E+00	1.14E+01

Table 3.4.9 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$9R_{i1}$	3.79E-01	1.24E-01	3.70E-01	8.56E-01	1.37E-01	1.62E-01	3.86E-01	8.77E-01	3.82E-01	6.27E-01	1.77E+00	2.58E-01	4.16E-01	7.52E-01
$9R_{i2}$	1.29E+00	4.45E-01	1.32E+00	2.82E+00	5.40E-01	6.86E-01	1.31E+00	2.13E-01	1.52E-01	2.72E-01	3.76E-01	1.14E-01	1.68E-01	1.39E-01
$9R_{i3}$	3.37E-02	1.21E-02	3.33E-02	8.18E-02	1.34E-02	1.69E-02	3.67E-02	5.10E+00	5.15E+00	7.29E+00	1.24E+01	3.55E+00	3.68E+00	4.03E+00
$9M_{i1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$9M_{i2}$	1.71E+00	4.46E-01	8.25E-01	2.97E+00	4.18E-01	6.59E-01	1.44E+00	2.03E+02	2.05E+02	2.99E+02	4.70E+02	1.34E+02	1.50E+02	1.62E+02
$9M_{i3}$	5.28E+01	1.89E+01	5.76E+01	1.26E+02	2.21E+01	2.68E+01	5.78E+01	1.70E+01	9.23E+00	1.55E+01	3.08E+01	6.17E+00	8.84E+00	1.14E+01
$9Rj_1$	3.79E-01	1.24E-01	3.70E-01	8.56E-01	1.37E-01	1.62E-01	3.86E-01	8.77E-01	3.82E-01	6.27E-01	1.77E+00	2.58E-01	4.16E-01	7.52E-01
$9Rj_2$	1.29E+00	4.45E-01	1.32E+00	2.82E+00	5.40E-01	6.86E-01	1.31E+00	2.13E-01	1.52E-01	2.72E-01	3.76E-01	1.14E-01	1.68E-01	1.39E-01
$9Rj_3$	3.37E-02	1.21E-02	3.33E-02	8.18E-02	1.34E-02	1.69E-02	3.67E-02	5.10E+00	5.15E+00	7.29E+00	1.24E+01	3.55E+00	3.68E+00	4.03E+00
$9Mj_1$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$9Mj_2$	3.22E+00	1.35E+00	3.35E+00	7.46E+00	1.46E+00	1.91E+00	3.54E+00	6.26E+02	6.36E+02	9.09E+02	1.50E+03	4.30E+02	4.57E+02	4.96E+02
$9Mj_3$	1.60E+02	5.60E+01	1.68E+02	3.60E+02	6.71E+01	8.40E+01	1.67E+02	2.64E+01	2.13E+01	3.69E+01	4.24E+01	1.53E+01	2.18E+01	1.56E+01
$10R_{i1}$	3.70E-01	1.23E-01	3.70E-01	8.38E-01	1.38E-01	1.63E-01	3.80E-01	6.90E-01	2.27E-01	3.94E-01	1.36E+00	1.59E-01	2.98E-01	5.95E-01
$10R_{i2}$	1.23E-01	4.27E-02	1.30E-01	2.96E-01	4.77E-02	5.66E-02	1.36E-01	2.41E-01	4.70E-02	9.16E-02	4.04E-01	2.65E-02	6.51E-02	1.64E-01
$10R_{i3}$	2.51E-02	3.66E-03	8.09E-03	2.69E-02	2.92E-03	5.19E-03	1.49E-02	5.86E-01	1.46E-01	2.70E-01	1.05E+00	1.08E-01	1.97E-01	4.11E-01
$10M_{i1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$10M_{i2}$	3.22E+00	1.35E+00	3.35E+00	7.46E+00	1.46E+00	1.91E+00	3.54E+00	6.26E+02	6.36E+02	9.09E+02	1.50E+03	4.30E+02	4.57E+02	4.96E+02
$10M_{i3}$	1.60E+02	5.60E+01	1.68E+02	3.60E+02	6.71E+01	8.40E+01	1.67E+02	2.64E+01	2.13E+01	3.69E+01	4.24E+01	1.53E+01	2.18E+01	1.56E+01
$10Rj_1$	3.70E-01	1.23E-01	3.70E-01	8.38E-01	1.38E-01	1.63E-01	3.80E-01	6.90E-01	2.27E-01	3.94E-01	1.36E+00	1.59E-01	2.98E-01	5.95E-01
$10Rj_2$	1.23E-01	4.27E-02	1.30E-01	2.96E-01	4.77E-02	5.66E-02	1.36E-01	2.41E-01	4.70E-02	9.16E-02	4.04E-01	2.65E-02	6.51E-02	1.64E-01
$10Rj_3$	2.51E-02	3.66E-03	8.09E-03	2.69E-02	2.92E-03	5.19E-03	1.49E-02	5.86E-01	1.46E-01	2.70E-01	1.05E+00	1.08E-01	1.97E-01	4.11E-01
$10Mj_1$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$10Mj_2$	3.42E+00	1.40E+00	3.64E+00	8.37E+00	1.53E+00	1.97E+00	3.86E+00	6.20E+02	6.29E+02	8.97E+02	1.49E+03	4.26E+02	4.51E+02	4.91E+02
$10M_{j3}$	1.51E+02	5.28E+01	1.57E+02	3.37E+02	6.35E+01	7.97E+01	1.57E+02	2.70E+01	1.93E+01	3.39E+01	4.47E+01	1.42E+01	2.03E+01	1.63E+01
$11R_{i1}$	3.62E-01	1.22E-01	3.70E-01	8.23E-01	1.39E-01	1.66E-01	3.76E-01	5.32E-01	1.30E-01	2.46E-01	1.02E+00	1.00E-01	2.17E-01	4.59E-01
$11R_{i2}$	1.45E+00	5.07E-01	1.52E+00	3.26E+00	6.07E-01	7.62E-01	1.51E+00	2.66E-01	1.91E-01	3.32E-01	4.71E-01	1.38E-01	1.99E-01	1.64E-01
$11R_{i3}$	2.76E-02	1.12E-02	2.68E-02	6.21E-02	1.21E-02	1.60E-02	3.00E-02	5.22E+00	5.28E+00	7.52E+00	1.25E+01	3.60E+00	3.80E+00	4.13E+00
$11M_{i1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$11M_{i2}$	3.42E+00	1.40E+00	3.64E+00	8.37E+00	1.53E+00	1.97E+00	3.86E+00	6.20E+02	6.29E+02	8.97E+02	1.49E+03	4.26E+02	4.51E+02	4.91E+02
$11M_{i3}$	1.51E+02	5.28E+01	1.57E+02	3.37E+02	6.35E+01	7.97E+01	1.57E+02	2.70E+01	1.93E+01	3.39E+01	4.47E+01	1.42E+01	2.03E+01	1.63E+01
$11Rj_1$	3.62E-01	1.22E-01	3.70E-01	8.23E-01	1.39E-01	1.66E-01	3.76E-01	5.32E-01	1.30E-01	2.46E-01	1.02E+00	1.00E-01	2.17E-01	4.59E-01
$11Rj_2$	1.45E+00	5.07E-01	1.52E+00	3.26E+00	6.07E-01	7.62E-01	1.51E+00	2.66E-01	1.91E-01	3.32E-01	4.71E-01	1.38E-01	1.99E-01	1.64E-01
$11Rj_3$	2.76E-02	1.12E-02	2.68E-02	6.21E-02	1.21E-02	1.60E-02	3.00E-02	5.22E+00	5.28E+00	7.52E+00	1.25E+01	3.60E+00	3.80E+00	4.13E+00
$11Mj_1$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$11Mj_2$	1.90E+00	5.38E-01	1.49E+00	3.60E+00	6.02E-01	7.12E-01	1.66E+00	1.84E+02	1.85E+02	2.66E+02	4.39E+02	1.25E+02	1.33E+02	1.47E+02
$11M_{j3}$	2.96E+01	1.02E+01	2.98E+01	6.40E+01	1.26E+01	1.58E+01	2.98E+01	9.12E+00	3.71E+00	7.20E+00	1.63E+01	3.05E+00	4.75E+00	8.21E+00

Table 3.4.9 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$12R_{i1}$	3.57E-01	1.22E-01	3.71E-01	8.11E-01	1.40E-01	1.70E-01	3.73E-01	4.41E-01	2.03E-01	3.30E-01	8.53E-01	1.43E-01	2.20E-01	3.73E-01
$12R_{i2}$	2.25E+00	7.85E-01	2.30E+00	4.95E+00	9.58E-01	1.19E+00	2.30E+00	4.60E-01	2.81E-01	4.94E-01	7.36E-01	2.04E-01	2.98E-01	2.77E-01
$12R_{i3}$	5.02E-02	1.81E-02	4.46E-02	1.05E-01	1.93E-02	2.60E-02	5.04E-02	8.23E+00	8.22E+00	1.16E+01	1.98E+01	5.72E+00	5.90E+00	6.50E+00
$12M_{i1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$12M_{i2}$	1.90E+00	5.38E-01	1.49E+00	3.60E+00	6.02E-01	7.12E-01	1.66E+00	1.84E+02	1.85E+02	2.66E+02	4.39E+02	1.25E+02	1.33E+02	1.47E+02
$12M_{i3}$	2.96E+01	1.02E+01	2.98E+01	6.40E+01	1.26E+01	1.58E+01	2.98E+01	9.12E+00	3.71E+00	7.20E+00	1.63E+01	3.05E+00	4.75E+00	8.21E+00
$12R_{j1}$	3.57E-01	1.22E-01	3.71E-01	8.11E-01	1.40E-01	1.70E-01	3.73E-01	4.41E-01	2.03E-01	3.30E-01	8.53E-01	1.43E-01	2.20E-01	3.73E-01
$12R_{j2}$	2.25E+00	7.85E-01	2.30E+00	4.95E+00	9.58E-01	1.19E+00	2.30E+00	4.60E-01	2.81E-01	4.94E-01	7.36E-01	2.04E-01	2.98E-01	2.77E-01
$12R_{j3}$	5.02E-02	1.81E-02	4.46E-02	1.05E-01	1.93E-02	2.60E-02	5.04E-02	8.23E+00	8.22E+00	1.16E+01	1.98E+01	5.72E+00	5.90E+00	6.50E+00
$12M_{j1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$12M_{j2}$	2.82E+00	1.07E+00	2.38E+00	5.82E+00	1.14E+00	1.56E+00	2.92E+00	5.11E+02	5.06E+02	7.12E+02	1.23E+03	3.58E+02	3.65E+02	4.04E+02
$12M_{j3}$	1.60E+02	5.57E+01	1.64E+02	3.52E+02	6.79E+01	8.43E+01	1.63E+02	3.31E+01	2.04E+01	3.54E+01	5.55E+01	1.47E+01	2.14E+01	1.97E+01
$13R_{i1}$	3.55E-01	1.22E-01	3.72E-01	8.04E-01	1.41E-01	1.75E-01	3.72E-01	4.64E-01	3.53E-01	5.48E-01	9.46E-01	2.37E-01	3.06E-01	3.77E-01
$13R_{i2}$	9.97E-01	3.52E-01	9.63E-01	2.09E+00	4.55E-01	5.34E-01	9.62E-01	5.35E-01	1.20E-01	2.37E-01	1.03E+00	9.05E-02	1.77E-01	3.45E-01
$13R_{i3}$	1.94E-02	4.67E-03	8.61E-03	3.26E-02	4.53E-03	7.05E-03	1.78E-02	2.57E+00	2.09E+00	2.82E+00	6.00E+00	1.81E+00	1.59E+00	1.99E+00
$13M_{i1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$13M_{i2}$	2.82E+00	1.07E+00	2.38E+00	5.82E+00	1.14E+00	1.56E+00	2.92E+00	5.11E+02	5.06E+02	7.12E+02	1.23E+03	3.58E+02	3.65E+02	4.04E+02
$13M_{i3}$	1.60E+02	5.57E+01	1.64E+02	3.52E+02	6.79E+01	8.43E+01	1.63E+02	3.31E+01	2.04E+01	3.54E+01	5.55E+01	1.47E+01	2.14E+01	1.97E+01
$13R_{j1}$	3.55E-01	1.22E-01	3.72E-01	8.04E-01	1.41E-01	1.75E-01	3.72E-01	4.64E-01	3.53E-01	5.48E-01	9.46E-01	2.37E-01	3.06E-01	3.77E-01
$13R_{j2}$	9.97E-01	3.52E-01	9.63E-01	2.09E+00	4.55E-01	5.34E-01	9.62E-01	5.35E-01	1.20E-01	2.37E-01	1.03E+00	9.05E-02	1.77E-01	3.45E-01
$13R_{j3}$	1.94E-02	4.67E-03	8.61E-03	3.26E-02	4.53E-03	7.05E-03	1.78E-02	2.57E+00	2.09E+00	2.82E+00	6.00E+00	1.81E+00	1.59E+00	1.99E+00
$13M_{j1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$13M_{j2}$	1.88E+00	7.35E-01	1.82E+00	4.17E+00	7.97E-01	1.05E+00	1.96E+00	3.31E+02	3.38E+02	4.89E+02	7.81E+02	2.22E+02	2.42E+02	2.62E+02
$13M_{j3}$	7.79E+01	2.75E+01	8.42E+01	1.81E+02	3.20E+01	4.03E+01	8.37E+01	2.70E+01	1.59E+01	2.57E+01	5.48E+01	1.01E+01	1.30E+01	1.73E+01
$14R_{i1}$	3.55E-01	1.22E-01	3.74E-01	8.01E-01	1.43E-01	1.81E-01	3.72E-01	5.88E-01	5.16E-01	7.96E-01	1.25E+00	3.43E-01	4.27E-01	4.69E-01
$14R_{i2}$	9.91E-01	3.48E-01	1.06E+00	2.28E+00	4.08E-01	5.15E-01	1.06E+00	2.69E-01	1.17E-01	2.28E-01	5.52E-01	9.95E-02	1.69E-01	1.97E-01
$14R_{i3}$	2.00E-02	7.19E-03	1.71E-02	3.97E-02	7.70E-03	1.04E-02	1.94E-02	3.23E+00	3.28E+00	4.73E+00	7.67E+00	2.19E+00	2.36E+00	2.56E+00
$14M_{i1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$14M_{i2}$	1.88E+00	7.35E-01	1.82E+00	4.17E+00	7.97E-01	1.05E+00	1.96E+00	3.31E+02	3.38E+02	4.89E+02	7.81E+02	2.22E+02	2.42E+02	2.62E+02
$14M_{i3}$	7.79E+01	2.75E+01	8.42E+01	1.81E+02	3.20E+01	4.03E+01	8.37E+01	2.70E+01	1.59E+01	2.57E+01	5.48E+01	1.01E+01	1.30E+01	1.73E+01
$14R_{j1}$	3.55E-01	1.22E-01	3.74E-01	8.01E-01	1.43E-01	1.81E-01	3.72E-01	5.88E-01	5.16E-01	7.96E-01	1.25E+00	3.43E-01	4.27E-01	4.69E-01
$14R_{j2}$	9.91E-01	3.48E-01	1.06E+00	2.28E+00	4.08E-01	5.15E-01	1.06E+00	2.69E-01	1.17E-01	2.28E-01	5.52E-01	9.95E-02	1.69E-01	1.97E-01
$14R_{j3}$	2.00E-02	7.19E-03	1.71E-02	3.97E-02	7.70E-03	1.04E-02	1.94E-02	3.23E+00	3.28E+00	4.73E+00	7.67E+00	2.19E+00	2.36E+00	2.56E+00
$14M_{j1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$14M_{j2}$	4.92E-01	1.47E-01	4.15E-01	1.10E+00	1.61E-01	2.09E-01	5.04E-01	6.26E+01	6.27E+01	9.32E+01	1.42E+02	4.04E+01	4.54E+01	5.00E+01
$14M_{j3}$	5.83E+00	2.07E+00	5.39E+00	1.18E+01	2.77E+00	3.16E+00	5.41E+00	1.46E+01	1.35E+01	2.08E+01	3.20E+01	8.92E+00	1.10E+01	1.20E+01

Table 3.4.9 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$15R_{i1}$	3.58E-01	1.23E-01	3.76E-01	8.01E-01	1.44E-01	1.86E-01	3.74E-01	7.03E-01	6.27E-01	9.67E-01	1.51E+00	4.15E-01	5.15E-01	5.61E-01
$15R_{i2}$	9.56E-01	3.45E-01	1.07E+00	2.28E+00	3.98E-01	4.84E-01	1.05E+00	6.40E-01	1.55E-01	3.05E-01	1.12E+00	1.16E-01	2.29E-01	4.10E-01
$15R_{i3}$	2.93E-02	9.89E-03	2.72E-02	6.70E-02	1.11E-02	1.42E-02	3.04E-02	4.24E+00	4.26E+00	6.29E+00	9.67E+00	2.75E+00	3.07E+00	3.35E+00
$15M_{i1}$	2.06E+00	7.36E-01	2.31E+00	5.09E+00	8.49E-01	1.01E+00	2.31E+00	2.64E+01	2.69E+01	3.98E+01	6.10E+01	1.74E+01	1.96E+01	2.13E+01
$15M_{i2}$	4.92E-01	1.47E-01	4.15E-01	1.10E+00	1.61E-01	2.09E-01	5.04E-01	6.26E+01	6.27E+01	9.32E+01	1.42E+02	4.04E+01	4.54E+01	5.00E+01
$15M_{i3}$	5.83E+00	2.07E+00	5.39E+00	1.18E+01	2.77E+00	3.16E+00	5.41E+00	1.46E+01	1.35E+01	2.08E+01	3.20E+01	8.92E+00	1.10E+01	1.20E+01
$15R_{C1}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$15R_{C2}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$15R_{C3}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$15M_{C1}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$15M_{C2}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$15M_{C3}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$15R_{j1}$	9.56E-01	3.45E-01	1.07E+00	2.28E+00	3.98E-01	4.84E-01	1.05E+00	6.40E-01	1.55E-01	3.05E-01	1.12E+00	1.16E-01	2.29E-01	4.10E-01
$15R_{j2}$	3.58E-01	1.23E-01	3.76E-01	8.01E-01	1.44E-01	1.86E-01	3.74E-01	7.03E-01	6.27E-01	9.67E-01	1.51E+00	4.15E-01	5.15E-01	5.61E-01
$15R_{j3}$	2.93E-02	9.89E-03	2.72E-02	6.70E-02	1.11E-02	1.42E-02	3.04E-02	4.24E+00	4.26E+00	6.29E+00	9.67E+00	2.75E+00	3.07E+00	3.35E+00
$15M_{j1}$	3.02E-01	5.19E-02	1.11E-01	3.32E-01	6.38E-02	7.90E-02	1.86E-01	1.47E+01	1.43E+01	2.04E+01	3.46E+01	9.66E+00	1.03E+01	1.15E+01
$15M_{j2}$	1.82E+00	6.66E-01	1.94E+00	4.24E+00	7.38E-01	9.17E-01	1.98E+00	5.04E+01	4.98E+01	7.35E+01	1.14E+02	3.21E+01	3.58E+01	3.93E+01
$15M_{j3}$	1.60E+01	5.64E+00	1.74E+01	3.72E+01	6.54E+00	8.23E+00	1.73E+01	6.18E+00	3.42E+00	6.06E+00	1.30E+01	2.76E+00	4.39E+00	5.21E+00
$16R_{i1}$	9.39E-01	3.53E-01	1.07E+00	2.29E+00	4.16E-01	4.63E-01	1.05E+00	9.16E-01	1.96E-01	3.85E-01	1.49E+00	1.36E-01	2.88E-01	5.72E-01
$16R_{i2}$	4.09E-02	1.20E-02	3.44E-02	8.98E-02	1.36E-02	1.73E-02	4.11E-02	4.84E+00	4.81E+00	7.19E+00	1.09E+01	3.11E+00	3.49E+00	3.85E+00
$16R_{i3}$	3.67E-01	1.26E-01	3.85E-01	8.21E-01	1.48E-01	1.92E-01	3.84E-01	7.87E-01	6.96E-01	1.07E+00	1.70E+00	4.61E-01	5.73E-01	6.28E-01
$16M_{i1}$	3.02E-01	5.19E-02	1.11E-01	3.32E-01	6.38E-02	7.90E-02	1.86E-01	1.47E+01	1.43E+01	2.04E+01	3.46E+01	9.66E+00	1.03E+01	1.15E+01
$16M_{i2}$	1.60E+01	5.64E+00	1.74E+01	3.72E+01	6.54E+00	8.23E+00	1.73E+01	6.18E+00	3.42E+00	6.06E+00	1.30E+01	2.76E+00	4.39E+00	5.21E+00
$16M_{i3}$	1.82E+00	6.66E-01	1.94E+00	4.24E+00	7.38E-01	9.17E-01	1.98E+00	5.04E+01	4.98E+01	7.35E+01	1.14E+02	3.21E+01	3.58E+01	3.93E+01
$16R_{j1}$	9.39E-01	3.53E-01	1.07E+00	2.29E+00	4.16E-01	4.63E-01	1.05E+00	9.16E-01	1.96E-01	3.85E-01	1.49E+00	1.36E-01	2.88E-01	5.72E-01
$16R_{j2}$	4.09E-02	1.20E-02	3.44E-02	8.98E-02	1.36E-02	1.73E-02	4.11E-02	4.84E+00	4.81E+00	7.19E+00	1.09E+01	3.11E+00	3.49E+00	3.85E+00
$16R_{j3}$	3.67E-01	1.26E-01	3.85E-01	8.21E-01	1.48E-01	1.92E-01	3.84E-01	7.87E-01	6.96E-01	1.07E+00	1.70E+00	4.61E-01	5.73E-01	6.28E-01
$16M_{j1}$	3.02E-01	5.19E-02	1.11E-01	3.32E-01	6.38E-02	7.90E-02	1.86E-01	1.47E+01	1.43E+01	2.04E+01	3.46E+01	9.66E+00	1.03E+01	1.15E+01
$16M_{j2}$	6.83E+00	2.06E+00	5.94E+00	1.28E+01	2.53E+00	3.51E+00	6.15E+00	4.33E+01	3.89E+01	5.95E+01	9.25E+01	2.53E+01	3.07E+01	3.37E+01
$16M_{j3}$	2.52E+00	7.90E-01	1.46E+00	4.38E+00	7.66E-01	1.16E+00	2.24E+00	3.40E+02	3.39E+02	5.05E+02	7.65E+02	2.19E+02	2.45E+02	2.70E+02

Table 3.4.9 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$17R_{i1}$	9.67E-01	3.98E-01	1.09E+00	2.37E+00	5.06E-01	4.55E-01	1.06E+00	1.42E+00	2.84E-01	5.51E-01	2.19E+00	1.80E-01	4.05E-01	8.71E-01
$17R_{i2}$	5.31E-02	2.14E-02	5.51E-02	1.21E-01	2.67E-02	2.49E-02	5.50E-02	2.43E+00	1.72E+00	2.65E+00	4.40E+00	1.19E+00	1.27E+00	1.69E+00
$17R_{i3}$	6.88E-02	1.04E-02	2.65E-02	4.69E-02	9.18E-03	1.49E-02	2.56E-02	4.02E-01	1.64E-01	2.59E-01	6.09E-01	1.06E-01	1.46E-01	2.39E-01
$17M_{i1}$	3.02E-01	5.19E-02	1.11E-01	3.32E-01	6.38E-02	7.90E-02	1.86E-01	1.47E+01	1.43E+01	2.04E+01	3.46E+01	9.66E+00	1.03E+01	1.15E+01
$17M_{i2}$	6.83E+00	2.06E+00	5.94E+00	1.28E+01	2.53E+00	3.51E+00	6.15E+00	4.33E+01	3.89E+01	5.95E+01	9.25E+01	2.53E+01	3.07E+01	3.37E+01
$17M_{i3}$	2.52E+00	7.90E-01	1.46E+00	4.38E+00	7.66E-01	1.16E+00	2.24E+00	3.40E+02	3.39E+02	5.05E+02	7.65E+02	2.19E+02	2.45E+02	2.70E+02
$17Rj_1$	9.67E-01	3.98E-01	1.09E+00	2.37E+00	5.06E-01	4.55E-01	1.06E+00	1.42E+00	2.84E-01	5.51E-01	2.19E+00	1.80E-01	4.05E-01	8.71E-01
$17Rj_2$	5.31E-02	2.14E-02	5.51E-02	1.21E-01	2.67E-02	2.49E-02	5.50E-02	2.43E+00	1.72E+00	2.65E+00	4.40E+00	1.19E+00	1.27E+00	1.69E+00
$17Rj_3$	6.88E-02	1.04E-02	2.65E-02	4.69E-02	9.18E-03	1.49E-02	2.56E-02	4.02E-01	1.64E-01	2.59E-01	6.09E-01	1.06E-01	1.46E-01	2.39E-01
$17Mj_1$	3.02E-01	5.19E-02	1.11E-01	3.32E-01	6.38E-02	7.90E-02	1.86E-01	1.47E+01	1.43E+01	2.04E+01	3.46E+01	9.66E+00	1.03E+01	1.15E+01
$17Mj_2$	5.98E+00	1.50E+00	4.09E+00	8.94E+00	1.73E+00	2.61E+00	4.21E+00	3.09E+01	2.31E+01	3.59E+01	6.02E+01	1.52E+01	1.87E+01	2.26E+01
$17M_{j3}$	4.78E+00	1.85E+00	5.25E+00	1.18E+01	2.39E+00	2.07E+00	5.19E+00	1.99E+02	1.73E+02	2.52E+02	4.29E+02	1.16E+02	1.29E+02	1.54E+02
$18R_{i1}$	1.08E+00	4.81E-01	1.16E+00	2.57E+00	6.61E-01	4.89E-01	1.10E+00	1.96E+00	3.88E-01	7.44E-01	2.95E+00	2.36E-01	5.40E-01	1.20E+00
$18R_{i2}$	4.33E-02	1.82E-02	4.06E-02	9.33E-02	2.41E-02	1.99E-02	4.10E-02	2.39E+00	2.16E+00	3.15E+00	5.25E+00	1.42E+00	1.59E+00	1.87E+00
$18R_{i3}$	6.43E-02	1.65E-02	4.50E-02	9.78E-02	1.92E-02	2.83E-02	4.60E-02	3.20E-01	2.41E-01	3.76E-01	6.30E-01	1.59E-01	1.97E-01	2.38E-01
$18M_{i1}$	3.02E-01	5.19E-02	1.11E-01	3.32E-01	6.38E-02	7.90E-02	1.86E-01	1.47E+01	1.43E+01	2.04E+01	3.46E+01	9.66E+00	1.03E+01	1.15E+01
$18M_{i2}$	5.98E+00	1.50E+00	4.09E+00	8.94E+00	1.73E+00	2.61E+00	4.21E+00	3.09E+01	2.31E+01	3.59E+01	6.02E+01	1.52E+01	1.87E+01	2.26E+01
$18M_{i3}$	4.78E+00	1.85E+00	5.25E+00	1.18E+01	2.39E+00	2.07E+00	5.19E+00	1.99E+02	1.73E+02	2.52E+02	4.29E+02	1.16E+02	1.29E+02	1.54E+02
$18Rj_1$	1.08E+00	4.81E-01	1.16E+00	2.57E+00	6.61E-01	4.89E-01	1.10E+00	1.96E+00	3.88E-01	7.44E-01	2.95E+00	2.36E-01	5.40E-01	1.20E+00
$18Rj_2$	4.33E-02	1.82E-02	4.06E-02	9.33E-02	2.41E-02	1.99E-02	4.10E-02	2.39E+00	2.16E+00	3.15E+00	5.25E+00	1.42E+00	1.59E+00	1.87E+00
$18Rj_3$	6.43E-02	1.65E-02	4.50E-02	9.78E-02	1.92E-02	2.83E-02	4.60E-02	3.20E-01	2.41E-01	3.76E-01	6.30E-01	1.59E-01	1.97E-01	2.38E-01
$18Mj_1$	3.02E-01	5.19E-02	1.11E-01	3.32E-01	6.38E-02	7.90E-02	1.86E-01	1.47E+01	1.43E+01	2.04E+01	3.46E+01	9.66E+00	1.03E+01	1.15E+01
$18Mj_2$	8.54E-01	1.90E-01	5.03E-01	1.18E+00	2.01E-01	3.53E-01	5.63E-01	5.50E+00	3.85E+00	5.83E+00	1.03E+01	2.50E+00	3.01E+00	3.77E+00
$18M_{j3}$	7.50E+00	3.20E+00	8.29E+00	1.81E+01	4.22E+00	3.45E+00	7.93E+00	1.72E+01	4.89E+00	8.32E+00	2.74E+01	6.72E+00	5.57E+00	1.25E+01

Table 3.4.9 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$19R_{i1}$	1.17E+00	5.43E-01	1.22E+00	2.73E+00	7.68E-01	5.28E-01	1.14E+00	2.27E+00	4.50E-01	8.59E-01	3.38E+00	2.70E-01	6.18E-01	1.39E+00
$19R_{i2}$	4.04E-02	1.71E-02	3.55E-02	8.43E-02	2.31E-02	1.80E-02	3.64E-02	2.84E+00	2.28E+00	3.26E+00	6.02E+00	1.64E+00	1.70E+00	2.16E+00
$19R_{i3}$	9.43E-02	2.27E-02	6.15E-02	1.40E-01	2.52E-02	4.14E-02	6.67E-02	4.38E-01	2.69E-01	4.25E-01	7.82E-01	1.78E-01	2.27E-01	3.01E-01
$19M_{i1}$	3.02E-01	5.19E-02	1.11E-01	3.32E-01	6.38E-02	7.90E-02	1.86E-01	1.47E+01	1.43E+01	2.04E+01	3.46E+01	9.66E+00	1.03E+01	1.15E+01
$19M_{i2}$	8.54E-01	1.90E-01	5.03E-01	1.18E+00	2.01E-01	3.53E-01	5.63E-01	5.50E+00	3.85E+00	5.83E+00	1.03E+01	2.50E+00	3.01E+00	3.77E+00
$19M_{i3}$	7.50E+00	3.20E+00	8.29E+00	1.81E+01	4.22E+00	3.45E+00	7.93E+00	1.72E+01	4.89E+00	8.32E+00	2.74E+01	6.72E+00	5.57E+00	1.25E+01
$19RC_1$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$19RC_2$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$19RC_3$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$19MC_1$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$19MC_2$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$19M_{C3}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$19Rj_1$	4.04E-02	1.71E-02	3.55E-02	8.43E-02	2.31E-02	1.80E-02	3.64E-02	2.84E+00	2.28E+00	3.26E+00	6.02E+00	1.64E+00	1.70E+00	2.16E+00
$19Rj_2$	1.17E+00	5.43E-01	1.22E+00	2.73E+00	7.68E-01	5.28E-01	1.14E+00	2.27E+00	4.50E-01	8.59E-01	3.38E+00	2.70E-01	6.18E-01	1.39E+00
$19Rj_3$	9.43E-02	2.27E-02	6.15E-02	1.40E-01	2.52E-02	4.14E-02	6.67E-02	4.38E-01	2.69E-01	4.25E-01	7.82E-01	1.78E-01	2.27E-01	3.01E-01
$19Mj_1$	8.54E-01	2.22E-01	6.10E-01	1.36E+00	2.55E-01	3.96E-01	6.47E-01	2.83E+00	1.24E+00	2.14E+00	5.39E+00	1.13E+00	1.34E+00	2.08E+00
$19Mj_2$	1.65E+00	4.22E-01	1.16E+00	2.62E+00	4.92E-01	7.74E-01	1.24E+00	2.04E+01	1.89E+01	2.76E+01	4.50E+01	1.24E+01	1.39E+01	1.55E+01
$19M_{j3}$	1.36E+01	6.43E+00	1.34E+01	3.04E+01	9.36E+00	6.07E+00	1.23E+01	6.96E+01	4.55E+01	6.70E+01	1.29E+02	3.04E+01	3.55E+01	4.85E+01
$20R_{i1}$	4.05E-02	1.71E-02	3.55E-02	8.44E-02	2.31E-02	1.81E-02	3.65E-02	3.06E+00	2.35E+00	3.30E+00	6.54E+00	1.87E+00	1.76E+00	2.34E+00
$20R_{i2}$	2.74E-01	1.30E-01	2.10E-01	5.06E-01	2.02E-01	1.32E-01	1.88E-01	1.30E+00	2.99E-01	5.11E-01	1.92E+00	1.79E-01	3.35E-01	8.13E-01
$20R_{i3}$	5.19E-02	1.15E-02	2.92E-02	7.80E-02	1.14E-02	2.25E-02	3.75E-02	2.43E-01	1.13E-01	1.63E-01	4.43E-01	8.49E-02	9.67E-02	1.57E-01
$20M_{i1}$	8.54E-01	2.22E-01	6.10E-01	1.36E+00	2.55E-01	3.96E-01	6.47E-01	2.83E+00	1.24E+00	2.14E+00	5.39E+00	1.13E+00	1.34E+00	2.08E+00
$20M_{i2}$	1.65E+00	4.22E-01	1.16E+00	2.62E+00	4.92E-01	7.74E-01	1.24E+00	2.04E+01	1.89E+01	2.76E+01	4.50E+01	1.24E+01	1.39E+01	1.55E+01
$20M_{i3}$	1.36E+01	6.43E+00	1.34E+01	3.04E+01	9.36E+00	6.07E+00	1.23E+01	6.96E+01	4.55E+01	6.70E+01	1.29E+02	3.04E+01	3.55E+01	4.85E+01
$20Rj_1$	4.05E-02	1.71E-02	3.55E-02	8.44E-02	2.31E-02	1.81E-02	3.65E-02	3.06E+00	2.35E+00	3.30E+00	6.54E+00	1.87E+00	1.76E+00	2.34E+00
$20Rj_2$	2.74E-01	1.30E-01	2.10E-01	5.06E-01	2.02E-01	1.32E-01	1.88E-01	1.30E+00	2.99E-01	5.11E-01	1.92E+00	1.79E-01	3.35E-01	8.13E-01
$20Rj_3$	5.19E-02	1.15E-02	2.92E-02	7.80E-02	1.14E-02	2.25E-02	3.75E-02	2.43E-01	1.13E-01	1.63E-01	4.43E-01	8.49E-02	9.67E-02	1.57E-01
$20Mj_1$	8.54E-01	2.22E-01	6.10E-01	1.36E+00	2.55E-01	3.96E-01	6.47E-01	2.83E+00	1.24E+00	2.14E+00	5.39E+00	1.13E+00	1.34E+00	2.08E+00
$20Mj_2$	1.80E+00	3.73E-01	8.59E-01	2.67E+00	3.20E-01	6.45E-01	1.31E+00	1.43E+01	1.28E+01	1.96E+01	3.11E+01	8.35E+00	1.03E+01	1.15E+01
$20M_{j3}$	9.66E+00	3.50E+00	9.08E+00	1.99E+01	4.67E+00	5.08E+00	9.10E+00	4.21E+01	3.07E+01	4.58E+01	8.73E+01	2.08E+01	2.44E+01	3.56E+01

Table 3.4.9 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$21R_{i1}$	4.06E-02	1.71E-02	3.56E-02	8.46E-02	2.31E-02	1.81E-02	3.66E-02	3.43E+00	2.48E+00	3.43E+00	7.39E+00	2.25E+00	1.88E+00	2.63E+00
$21R_{i2}$	8.93E-02	4.26E-02	8.61E-02	1.97E-01	6.26E-02	4.01E-02	7.93E-02	5.49E-01	2.89E-01	4.31E-01	9.28E-01	1.91E-01	2.34E-01	3.58E-01
$21R_{i3}$	1.29E-02	3.03E-03	8.12E-03	1.85E-02	3.42E-03	5.58E-03	8.72E-03	1.41E-01	1.21E-01	1.74E-01	3.06E-01	8.10E-02	8.79E-02	1.03E-01
$21M_{i1}$	8.54E-01	2.22E-01	6.10E-01	1.36E+00	2.55E-01	3.96E-01	6.47E-01	2.83E+00	1.24E+00	2.14E+00	5.39E+00	1.13E+00	1.34E+00	2.08E+00
$21M_{i2}$	1.80E+00	3.73E-01	8.59E-01	2.67E+00	3.20E-01	6.45E-01	1.31E+00	1.43E+01	1.28E+01	1.96E+01	3.11E+01	8.35E+00	1.03E+01	1.15E+01
$21M_{i3}$	9.66E+00	3.50E+00	9.08E+00	1.99E+01	4.67E+00	5.08E+00	9.10E+00	4.21E+01	3.07E+01	4.58E+01	8.73E+01	2.08E+01	2.44E+01	3.56E+01
$21R_{j1}$	4.06E-02	1.71E-02	3.56E-02	8.46E-02	2.31E-02	1.81E-02	3.66E-02	3.43E+00	2.48E+00	3.43E+00	7.39E+00	2.25E+00	1.88E+00	2.63E+00
$21R_{j2}$	8.93E-02	4.26E-02	8.61E-02	1.97E-01	6.26E-02	4.01E-02	7.93E-02	5.49E-01	2.89E-01	4.31E-01	9.28E-01	1.91E-01	2.34E-01	3.58E-01
$21R_{j3}$	1.29E-02	3.03E-03	8.12E-03	1.85E-02	3.42E-03	5.58E-03	8.72E-03	1.41E-01	1.21E-01	1.74E-01	3.06E-01	8.10E-02	8.79E-02	1.03E-01
$21M_{j1}$	8.54E-01	2.22E-01	6.10E-01	1.36E+00	2.55E-01	3.96E-01	6.47E-01	2.83E+00	1.24E+00	2.14E+00	5.39E+00	1.13E+00	1.34E+00	2.08E+00
$21M_{j2}$	2.41E+00	4.98E-01	1.20E+00	3.47E+00	4.47E-01	9.43E-01	1.69E+00	1.18E+01	6.21E+00	1.04E+01	2.23E+01	4.48E+00	6.40E+00	8.53E+00
$21M_{j3}$	1.12E+01	4.75E+00	8.57E+00	2.00E+01	7.20E+00	5.77E+00	8.27E+00	5.51E+01	1.54E+01	2.60E+01	8.64E+01	9.95E+00	1.63E+01	3.77E+01
$22R_{i1}$	4.07E-02	1.71E-02	3.56E-02	8.47E-02	2.31E-02	1.81E-02	3.66E-02	3.87E+00	2.65E+00	3.61E+00	8.35E+00	2.68E+00	2.02E+00	2.97E+00
$22R_{i2}$	1.58E-01	6.28E-02	1.30E-01	2.94E-01	9.20E-02	8.26E-02	1.28E-01	8.50E-01	3.35E-01	5.30E-01	1.42E+00	2.23E-01	3.08E-01	6.17E-01
$22R_{i3}$	3.63E-02	7.03E-03	1.66E-02	4.86E-02	6.03E-03	1.29E-02	2.42E-02	2.00E-01	1.37E-01	2.16E-01	3.94E-01	9.08E-02	1.21E-01	1.51E-01
$22M_{i1}$	8.54E-01	2.22E-01	6.10E-01	1.36E+00	2.55E-01	3.96E-01	6.47E-01	2.83E+00	1.24E+00	2.14E+00	5.39E+00	1.13E+00	1.34E+00	2.08E+00
$22M_{i2}$	2.41E+00	4.98E-01	1.20E+00	3.47E+00	4.47E-01	9.43E-01	1.69E+00	1.18E+01	6.21E+00	1.04E+01	2.23E+01	4.48E+00	6.40E+00	8.53E+00
$22M_{i3}$	1.12E+01	4.75E+00	8.57E+00	2.00E+01	7.20E+00	5.77E+00	8.27E+00	5.51E+01	1.54E+01	2.60E+01	8.64E+01	9.95E+00	1.63E+01	3.77E+01
$22R_{j1}$	4.07E-02	1.71E-02	3.56E-02	8.47E-02	2.31E-02	1.81E-02	3.66E-02	3.87E+00	2.65E+00	3.61E+00	8.35E+00	2.68E+00	2.02E+00	2.97E+00
$22R_{j2}$	1.58E-01	6.28E-02	1.30E-01	2.94E-01	9.20E-02	8.26E-02	1.28E-01	8.50E-01	3.35E-01	5.30E-01	1.42E+00	2.23E-01	3.08E-01	6.17E-01
$22R_{j3}$	3.63E-02	7.03E-03	1.66E-02	4.86E-02	6.03E-03	1.29E-02	2.42E-02	2.00E-01	1.37E-01	2.16E-01	3.94E-01	9.08E-02	1.21E-01	1.51E-01
$22M_{j1}$	8.54E-01	2.22E-01	6.10E-01	1.36E+00	2.55E-01	3.96E-01	6.47E-01	2.83E+00	1.24E+00	2.14E+00	5.39E+00	1.13E+00	1.34E+00	2.08E+00
$22M_{j2}$	3.36E-01	9.16E-02	2.47E-01	6.29E-01	9.86E-02	1.79E-01	2.97E-01	2.86E+00	2.54E+00	3.53E+00	7.00E+00	1.83E+00	1.85E+00	2.19E+00
$22M_{j3}$	2.62E+00	1.27E+00	2.23E+00	5.29E+00	1.94E+00	1.21E+00	1.99E+00	9.02E+00	5.59E+00	8.28E+00	1.63E+01	3.74E+00	4.43E+00	6.19E+00
$23R_{i1}$	4.08E-02	1.71E-02	3.56E-02	8.47E-02	2.32E-02	1.81E-02	3.67E-02	4.35E+00	2.85E+00	3.85E+00	9.39E+00	3.14E+00	2.20E+00	3.34E+00
$23R_{i2}$	3.50E-01	1.52E-01	2.65E-01	6.27E-01	2.33E-01	1.80E-01	2.52E-01	1.45E+00	3.85E-01	6.57E-01	2.25E+00	2.46E-01	4.16E-01	9.81E-01
$23R_{i3}$	6.81E-02	1.52E-02	3.68E-02	1.08E-01	1.40E-02	2.91E-02	5.14E-02	3.26E-01	1.64E-01	2.82E-01	6.44E-01	1.30E-01	1.85E-01	2.38E-01
$23M_{i1}$	8.54E-01	2.22E-01	6.10E-01	1.36E+00	2.55E-01	3.96E-01	6.47E-01	2.83E+00	1.24E+00	2.14E+00	5.39E+00	1.13E+00	1.34E+00	2.08E+00
$23M_{i2}$	3.36E-01	9.16E-02	2.47E-01	6.29E-01	9.86E-02	1.79E-01	2.97E-01	2.86E+00	2.54E+00	3.53E+00	7.00E+00	1.83E+00	1.85E+00	2.19E+00
$23M_{i3}$	2.62E+00	1.27E+00	2.23E+00	5.29E+00	1.94E+00	1.21E+00	1.99E+00	9.02E+00	5.59E+00	8.28E+00	1.63E+01	3.74E+00	4.43E+00	6.19E+00
$23R_{j1}$	4.08E-02	1.71E-02	3.56E-02	8.47E-02	2.32E-02	1.81E-02	3.67E-02	4.35E+00	2.85E+00	3.85E+00	9.39E+00	3.14E+00	2.20E+00	3.34E+00
$23R_{j2}$	3.50E-01	1.52E-01	2.65E-01	6.27E-01	2.33E-01	1.80E-01	2.52E-01	1.45E+00	3.85E-01	6.57E-01	2.25E+00	2.46E-01	4.16E-01	9.81E-01
$23R_{j3}$	6.81E-02	1.52E-02	3.68E-02	1.08E-01	1.40E-02	2.91E-02	5.14E-02	3.26E-01	1.64E-01	2.82E-01	6.44E-01	1.30E-01	1.85E-01	2.38E-01
$23M_{j1}$	8.54E-01	2.22E-01	6.10E-01	1.36E+00	2.55E-01	3.96E-01	6.47E-01	2.83E+00	1.24E+00	2.14E+00	5.39E+00	1.13E+00	1.34E+00	2.08E+00
$23M_{j2}$	3.83E+00	8.32E-01	2.00E+00	5.89E+00	7.52E-01	1.57E+00	2.83E+00	1.94E+01	1.15E+01	1.91E+01	3.85E+01	8.31E+00	1.16E+01	1.45E+01
$23M_{j3}$	1.91E+01	8.08E+00	1.48E+01	3.45E+01	1.22E+01	9.91E+00	1.43E+01	8.26E+01	2.76E+01	4.48E+01	1.33E+02	1.81E+01	2.69E+01	5.78E+01

Results from Response Spectrum Method (II):

Table 3.4.10 Maximum nodal displacements for benchmark problem #4a & 4b.

Nodes	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
2Ux	8.91E-07	3.45E-07	7.20E-07	1.81E-06	4.37E-07	4.97E-07	7.99E-07	3.71E-02	2.21E-02	3.30E-02	9.49E-02	2.99E-02	2.28E-02	2.97E-02
2Uy	1.10E-02	3.96E-03	7.68E-03	1.96E-02	5.67E-03	6.05E-03	8.84E-03	2.79E-05	1.24E-05	1.90E-05	5.18E-05	1.90E-05	1.08E-05	2.03E-05
2Uz	4.33E-07	2.02E-07	3.09E-07	7.97E-07	3.15E-07	1.80E-07	2.70E-07	1.62E-06	6.81E-07	1.05E-06	3.11E-06	8.55E-07	7.08E-07	1.27E-06
2Θx	3.20E-05	1.14E-05	2.23E-05	5.69E-05	1.63E-05	1.77E-05	2.58E-05	1.16E-08	8.01E-09	1.30E-08	2.51E-08	9.00E-09	9.05E-09	1.01E-08
2Θy	2.52E-09	9.65E-10	2.05E-09	5.14E-09	1.20E-09	1.42E-09	2.29E-09	1.07E-04	6.37E-05	9.51E-05	2.74E-04	8.60E-05	6.58E-05	8.56E-05
2Θz	7.98E-10	2.99E-10	5.89E-10	1.50E-09	4.21E-10	4.14E-10	6.53E-10	7.51E-09	5.24E-09	7.65E-09	1.80E-08	5.91E-09	4.42E-09	6.20E-09
3Ux	2.24E-06	8.62E-07	1.82E-06	4.56E-06	1.08E-06	1.26E-06	2.02E-06	9.41E-02	5.62E-02	8.39E-02	0.241	7.59E-02	5.80E-02	7.55E-02
3Uy	2.80E-02	1.00E-02	1.95E-02	4.98E-02	1.43E-02	1.54E-02	2.25E-02	4.77E-05	2.17E-05	3.33E-05	8.90E-05	3.27E-05	1.92E-05	3.49E-05
3Uz	8.32E-07	3.87E-07	5.93E-07	1.53E-06	6.03E-07	3.46E-07	5.19E-07	3.15E-06	1.34E-06	2.05E-06	6.09E-06	1.67E-06	1.39E-06	2.47E-06
3Θx	5.63E-05	2.01E-05	3.92E-05	1.00E-04	2.86E-05	3.10E-05	4.54E-05	2.01E-08	1.40E-08	2.28E-08	4.36E-08	1.56E-08	1.59E-08	1.75E-08
3Θy	4.44E-09	1.70E-09	3.61E-09	9.05E-09	2.11E-09	2.51E-09	4.04E-09	1.87E-04	1.12E-04	1.67E-04	4.81E-04	1.51E-04	1.16E-04	1.51E-04
3Θz	1.60E-09	5.99E-10	1.18E-09	3.00E-09	8.42E-10	8.28E-10	1.31E-09	1.50E-08	1.05E-08	1.53E-08	3.59E-08	1.18E-08	8.85E-09	1.24E-08
4Ux	3.61E-06	1.38E-06	2.93E-06	7.35E-06	1.73E-06	2.03E-06	3.28E-06	0.152	9.11E-02	0.136	0.391	0.123	9.40E-02	0.122
4Uy	4.54E-02	1.62E-02	3.16E-02	8.07E-02	2.31E-02	2.50E-02	3.66E-02	5.03E-05	2.37E-05	3.68E-05	9.48E-05	3.47E-05	2.19E-05	3.73E-05
4Uz	1.02E-06	4.72E-07	7.35E-07	1.91E-06	7.33E-07	4.28E-07	6.59E-07	4.33E-06	1.78E-06	2.75E-06	8.25E-06	2.27E-06	1.87E-06	3.38E-06
4Θx	7.09E-05	2.53E-05	4.94E-05	1.26E-04	3.61E-05	3.91E-05	5.72E-05	4.31E-08	2.34E-08	3.71E-08	8.49E-08	3.08E-08	2.40E-08	3.36E-08
4Θy	5.61E-09	2.14E-09	4.55E-09	1.14E-08	2.67E-09	3.15E-09	5.09E-09	2.36E-04	1.41E-04	2.11E-04	6.06E-04	1.91E-04	1.46E-04	1.90E-04
4Θz	2.13E-09	8.02E-10	1.59E-09	4.06E-09	1.12E-09	1.09E-09	1.76E-09	2.14E-08	1.61E-08	2.33E-08	5.33E-08	1.72E-08	1.34E-08	1.81E-08
5Ux	5.32E-06	2.03E-06	4.32E-06	1.08E-05	2.53E-06	3.00E-06	4.83E-06	0.225	0.134	0.201	0.577	0.181	0.139	0.181
5Uy	6.71E-02	2.39E-02	4.67E-02	0.119	3.41E-02	3.70E-02	5.40E-02	3.79E-05	2.10E-05	3.35E-05	7.51E-05	2.72E-05	2.18E-05	2.98E-05
5Uz	1.19E-06	5.41E-07	8.62E-07	2.26E-06	8.33E-07	4.99E-07	7.93E-07	5.47E-06	2.23E-06	3.45E-06	1.04E-05	2.87E-06	2.35E-06	4.26E-06
5Θx	8.18E-05	2.92E-05	5.69E-05	1.45E-04	4.16E-05	4.51E-05	6.59E-05	7.22E-08	3.55E-08	5.54E-08	1.38E-07	5.03E-08	3.40E-08	5.42E-08
5Θy	6.48E-09	2.48E-09	5.27E-09	1.32E-08	3.10E-09	3.63E-09	5.87E-09	2.72E-04	1.63E-04	2.43E-04	6.99E-04	2.20E-04	1.68E-04	2.19E-04
5Θz	2.78E-09	1.05E-09	2.05E-09	5.23E-09	1.48E-09	1.44E-09	2.28E-09	2.64E-08	1.95E-08	2.83E-08	6.63E-08	2.13E-08	1.66E-08	2.23E-08
6Ux	7.09E-06	2.71E-06	5.76E-06	1.45E-05	3.37E-06	3.99E-06	6.44E-06	0.3	0.179	0.267	0.77	0.242	0.185	0.241
6Uy	8.95E-02	3.19E-02	6.23E-02	0.159	4.55E-02	4.93E-02	7.21E-02	2.66E-05	2.08E-05	3.42E-05	6.11E-05	2.17E-05	2.43E-05	2.46E-05
6Uz	1.29E-06	5.82E-07	9.53E-07	2.51E-06	8.88E-07	5.48E-07	9.01E-07	6.36E-06	2.61E-06	4.03E-06	1.21E-05	3.34E-06	2.75E-06	4.97E-06
6Θx	8.75E-05	3.12E-05	6.09E-05	1.55E-04	4.45E-05	4.82E-05	7.05E-05	9.29E-08	4.42E-08	6.86E-08	1.76E-07	6.43E-08	4.12E-08	6.91E-08
6Θy	6.95E-09	2.66E-09	5.65E-09	1.42E-08	3.34E-09	3.89E-09	6.29E-09	2.91E-04	1.74E-04	2.60E-04	7.47E-04	2.35E-04	1.80E-04	2.34E-04
6Θz	3.45E-09	1.30E-09	2.52E-09	6.42E-09	1.84E-09	1.78E-09	2.80E-09	3.16E-08	2.29E-08	3.34E-08	7.96E-08	2.55E-08	1.99E-08	2.65E-08
7Ux	8.20E-06	3.13E-06	6.67E-06	1.67E-05	3.90E-06	4.61E-06	7.45E-06	0.347	0.207	0.309	0.89	0.28	0.214	0.278
7Uy	0.103	3.69E-02	7.20E-02	0.184	5.26E-02	5.71E-02	8.34E-02	3.57E-05	2.54E-05	4.15E-05	7.82E-05	2.80E-05	2.90E-05	3.14E-05
7Uz	1.33E-06	5.92E-07	9.90E-07	2.62E-06	8.95E-07	5.68E-07	9.54E-07	6.72E-06	2.80E-06	4.32E-06	1.30E-05	3.55E-06	2.93E-06	5.30E-06
7Θx	8.89E-05	3.17E-05	6.19E-05	1.58E-04	4.52E-05	4.90E-05	7.16E-05	9.94E-08	4.69E-08	7.28E-08	1.87E-07	6.86E-08	4.35E-08	7.37E-08
7Θy	7.08E-09	2.72E-09	5.75E-09	1.44E-08	3.40E-09	3.95E-09	6.40E-09	2.96E-04	1.77E-04	2.64E-04	7.59E-04	2.39E-04	1.82E-04	2.38E-04
7Θz	3.96E-09	1.49E-09	2.87E-09	7.30E-09	2.11E-09	2.07E-09	3.20E-09	3.28E-08	2.32E-08	3.38E-08	8.27E-08	2.64E-08	2.05E-08	2.74E-08

Table 3.4.10 (Cont'd)

Nodes	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
8Ux	9.25E-06	3.53E-06	7.52E-06	1.89E-05	4.40E-06	5.20E-06	8.40E-06	0.39	0.233	0.348	1	0.315	0.241	0.314
8Uy	0.117	4.16E-02	8.12E-02	0.207	5.93E-02	6.43E-02	9.40E-02	5.08E-05	3.17E-05	5.12E-05	1.05E-04	3.79E-05	3.48E-05	4.19E-05
8Uz	1.34E-06	5.87E-07	1.01E-06	2.68E-06	8.78E-07	5.77E-07	9.93E-07	6.89E-06	2.94E-06	4.52E-06	1.35E-05	3.67E-06	3.05E-06	5.49E-06
8Θx	8.92E-05	3.18E-05	6.21E-05	1.59E-04	4.54E-05	4.92E-05	7.19E-05	1.01E-07	4.77E-08	7.39E-08	1.91E-07	6.98E-08	4.42E-08	7.50E-08
8Θy	7.12E-09	2.73E-09	5.79E-09	1.45E-08	3.43E-09	3.97E-09	6.43E-09	2.97E-04	1.78E-04	2.65E-04	7.63E-04	2.40E-04	1.83E-04	2.39E-04
8Θz	4.48E-09	1.68E-09	3.22E-09	8.20E-09	2.39E-09	2.35E-09	3.61E-09	3.41E-08	2.35E-08	3.44E-08	8.59E-08	2.74E-08	2.12E-08	2.83E-08
9Ux	9.32E-06	3.56E-06	7.54E-06	1.89E-05	4.44E-06	5.27E-06	8.45E-06	0.39	0.233	0.348	1	0.315	0.241	0.314
9Uy	0.117	4.16E-02	8.12E-02	0.207	5.93E-02	6.43E-02	9.40E-02	5.14E-05	3.26E-05	5.14E-05	1.08E-04	3.84E-05	3.43E-05	4.24E-05
9Uz	6.96E-03	2.48E-03	4.85E-03	1.24E-02	3.54E-03	3.84E-03	5.61E-03	7.13E-02	4.26E-02	6.36E-02	0.183	5.75E-02	4.40E-02	5.73E-02
9Θx	8.92E-05	3.18E-05	6.21E-05	1.59E-04	4.54E-05	4.92E-05	7.19E-05	1.01E-07	4.77E-08	7.39E-08	1.91E-07	6.98E-08	4.42E-08	7.50E-08
9Θy	7.12E-09	2.73E-09	5.79E-09	1.45E-08	3.43E-09	3.97E-09	6.43E-09	2.97E-04	1.78E-04	2.65E-04	7.63E-04	2.40E-04	1.83E-04	2.39E-04
9Θz	4.48E-09	1.68E-09	3.22E-09	8.20E-09	2.39E-09	2.35E-09	3.61E-09	3.41E-08	2.35E-08	3.44E-08	8.59E-08	2.74E-08	2.12E-08	2.83E-08
10Ux	1.79E-05	7.27E-06	1.34E-05	3.52E-05	1.03E-05	8.54E-06	1.43E-05	0.392	0.234	0.349	1.01	0.316	0.242	0.315
10Uy	0.126	4.48E-02	8.73E-02	0.223	6.40E-02	6.94E-02	0.101	5.30E-03	4.58E-03	6.57E-03	1.27E-02	4.04E-03	3.44E-03	4.98E-03
10Uz	7.86E-03	2.94E-03	5.43E-03	1.38E-02	4.30E-03	4.20E-03	6.08E-03	4.92E-02	3.39E-02	4.97E-02	0.126	3.97E-02	3.12E-02	4.11E-02
10Θx	2.46E-04	9.33E-05	2.14E-04	5.41E-04	1.17E-04	1.21E-04	2.27E-04	4.66E-05	3.78E-05	6.33E-05	1.06E-04	3.61E-05	4.11E-05	4.45E-05
10Θy	4.27E-05	1.95E-05	3.05E-05	7.77E-05	3.02E-05	1.77E-05	2.69E-05	4.55E-04	3.31E-04	4.79E-04	1.16E-03	3.62E-04	2.85E-04	3.81E-04
10Θz	1.48E-04	5.70E-05	1.02E-04	2.59E-04	8.42E-05	7.78E-05	1.13E-04	8.85E-05	7.94E-05	1.13E-04	2.16E-04	6.87E-05	5.87E-05	8.32E-05
11Ux	3.17E-05	1.31E-05	2.30E-05	6.13E-05	1.90E-05	1.43E-05	2.43E-05	0.393	0.235	0.35	1.01	0.317	0.242	0.315
11Uy	0.128	4.58E-02	8.90E-02	0.227	6.55E-02	7.10E-02	0.103	9.51E-03	8.67E-03	1.24E-02	2.34E-02	7.44E-03	6.37E-03	8.95E-03
11Uz	8.17E-03	3.11E-03	5.63E-03	1.44E-02	4.60E-03	4.30E-03	6.20E-03	3.75E-02	3.49E-02	4.98E-02	9.54E-02	3.02E-02	2.54E-02	3.46E-02
11Θx	4.82E-04	1.85E-04	4.29E-04	1.08E-03	2.28E-04	2.33E-04	4.52E-04	9.31E-05	7.55E-05	1.27E-04	2.13E-04	7.22E-05	8.21E-05	8.91E-05
11Θy	2.88E-05	1.35E-05	2.05E-05	5.14E-05	2.11E-05	1.20E-05	1.72E-05	3.20E-04	1.93E-04	2.88E-04	8.14E-04	2.56E-04	1.96E-04	2.58E-04
11Θz	8.41E-05	3.19E-05	5.84E-05	1.48E-04	4.65E-05	4.45E-05	6.55E-05	2.08E-05	9.89E-06	1.56E-05	4.27E-05	1.31E-05	1.06E-05	1.93E-05
12Ux	4.62E-05	1.91E-05	3.31E-05	8.87E-05	2.80E-05	2.06E-05	3.49E-05	0.393	0.235	0.351	1.01	0.317	0.243	0.316
12Uy	0.117	4.16E-02	8.12E-02	0.207	5.93E-02	6.43E-02	9.40E-02	5.08E-05	3.17E-05	5.12E-05	1.05E-04	3.79E-05	3.48E-05	4.19E-05
12Uz	6.96E-03	2.48E-03	4.85E-03	1.24E-02	3.54E-03	3.84E-03	5.61E-03	1.09E-05	4.86E-06	7.56E-06	2.05E-05	6.85E-06	4.82E-06	8.25E-06
12Θx	7.24E-04	2.78E-04	6.48E-04	1.63E-03	3.42E-04	3.48E-04	6.81E-04	1.40E-04	1.13E-04	1.90E-04	3.19E-04	1.08E-04	1.23E-04	1.34E-04
12Θy	5.52E-05	2.25E-05	4.19E-05	1.10E-04	3.27E-05	2.30E-05	4.26E-05	8.55E-04	8.66E-04	1.23E-03	2.20E-03	7.01E-04	6.01E-04	8.12E-04
12Θz	2.25E-04	8.81E-05	1.63E-04	4.12E-04	1.28E-04	1.16E-04	1.77E-04	2.42E-04	2.33E-04	3.30E-04	6.08E-04	1.94E-04	1.67E-04	2.27E-04
13Ux	1.15E-03	4.14E-04	8.43E-04	2.33E-03	5.65E-04	4.65E-04	9.54E-04	0.402	0.237	0.354	1.03	0.324	0.247	0.321
13Uy	0.118	4.26E-02	8.50E-02	0.217	5.97E-02	6.43E-02	9.72E-02	1.13E-02	1.06E-02	1.51E-02	2.82E-02	9.10E-03	8.13E-03	1.06E-02
13Uz	7.47E-03	2.67E-03	5.30E-03	1.35E-02	3.78E-03	4.05E-03	6.08E-03	3.47E-02	3.53E-02	4.99E-02	8.98E-02	2.88E-02	2.45E-02	3.27E-02
13Θx	9.26E-04	3.55E-04	8.28E-04	2.09E-03	4.38E-04	4.46E-04	8.70E-04	2.03E-04	1.58E-04	2.53E-04	4.74E-04	1.60E-04	1.72E-04	1.92E-04
13Θy	4.24E-05	1.48E-05	2.51E-05	7.61E-05	2.12E-05	1.73E-05	3.20E-05	3.08E-03	3.16E-03	4.46E-03	7.98E-03	2.57E-03	2.18E-03	2.90E-03
13Θz	3.82E-04	1.48E-04	3.28E-04	8.28E-04	1.91E-04	1.86E-04	3.46E-04	7.30E-04	7.28E-04	1.03E-03	1.87E-03	5.99E-04	5.14E-04	6.87E-04

Table 3.4.10 (Cont'd)

Nodes	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
14Ux	3.57E-03	1.27E-03	2.11E-03	6.34E-03	1.82E-03	1.52E-03	2.69E-03	0.492	0.351	0.51	1.26	0.399	0.311	0.407
14Uy	0.144	5.36E-02	1.17E-01	0.296	6.99E-02	7.28E-02	0.127	2.36E-02	1.99E-02	3.02E-02	5.67E-02	1.88E-02	1.90E-02	2.22E-02
14Uz	7.52E-03	2.69E-03	5.35E-03	1.37E-02	3.80E-03	4.07E-03	6.13E-03	3.49E-02	3.55E-02	5.02E-02	9.04E-02	2.89E-02	2.46E-02	3.29E-02
14Θx	5.46E-04	2.06E-04	4.70E-04	1.18E-03	2.63E-04	2.74E-04	4.99E-04	9.02E-05	6.71E-05	1.17E-04	2.02E-04	7.26E-05	8.66E-05	8.55E-05
14Θy	2.44E-05	9.74E-06	1.87E-05	4.82E-05	1.30E-05	1.26E-05	2.07E-05	1.92E-03	1.99E-03	2.81E-03	4.98E-03	1.61E-03	1.37E-03	1.81E-03
14Θz	3.43E-04	1.33E-04	2.94E-04	7.44E-04	1.72E-04	1.67E-04	3.11E-04	1.08E-03	1.09E-03	1.54E-03	2.77E-03	8.90E-04	7.62E-04	1.02E-03
15Ux	3.28E-03	1.21E-03	2.13E-03	5.93E-03	1.65E-03	1.62E-03	2.63E-03	0.465	0.356	0.513	1.2	0.378	0.299	0.391
15Uy	1.34E-01	5.02E-02	1.11E-01	0.282	6.44E-02	6.67E-02	1.20E-01	2.13E-02	1.76E-02	2.75E-02	5.05E-02	1.72E-02	1.81E-02	2.00E-02
15Uz	7.58E-03	2.72E-03	5.40E-03	1.38E-02	3.83E-03	4.09E-03	6.18E-03	3.52E-02	3.57E-02	5.05E-02	9.09E-02	2.91E-02	2.48E-02	3.31E-02
15Θx	5.41E-04	2.07E-04	4.81E-04	1.21E-03	2.55E-04	2.57E-04	5.08E-04	1.46E-04	1.20E-04	1.81E-04	3.50E-04	1.14E-04	1.12E-04	1.38E-04
15Θy	2.78E-05	1.01E-05	1.67E-05	5.04E-05	1.50E-05	1.07E-05	2.02E-05	1.76E-03	1.58E-03	2.26E-03	4.53E-03	1.44E-03	1.18E-03	1.57E-03
15Θz	3.04E-04	1.17E-04	2.61E-04	6.59E-04	1.52E-04	1.48E-04	2.75E-04	1.43E-03	1.45E-03	2.05E-03	3.68E-03	1.18E-03	1.01E-03	1.35E-03
16Ux	7.14E-06	2.73E-06	5.78E-06	1.45E-05	3.40E-06	4.05E-06	6.48E-06	0.3	0.179	0.267	0.77	0.242	0.185	0.241
16Uy	8.95E-02	3.19E-02	6.23E-02	0.159	4.55E-02	4.93E-02	7.21E-02	2.66E-05	2.08E-05	3.43E-05	6.09E-05	2.17E-05	2.44E-05	2.46E-05
16Uz	7.62E-03	2.74E-03	5.44E-03	1.39E-02	3.86E-03	4.11E-03	6.22E-03	3.53E-02	3.58E-02	5.07E-02	9.13E-02	2.92E-02	2.49E-02	3.33E-02
16Θx	1.76E-03	6.67E-04	1.53E-03	3.87E-03	8.40E-04	8.72E-04	1.62E-03	3.66E-04	2.97E-04	4.73E-04	8.52E-04	2.97E-04	3.21E-04	3.40E-04
16Θy	5.66E-05	2.19E-05	4.33E-05	1.10E-04	2.69E-05	3.22E-05	5.06E-05	5.94E-03	6.11E-03	8.64E-03	1.54E-02	4.96E-03	4.21E-03	5.57E-03
16Θz	2.66E-04	1.02E-04	2.27E-04	5.75E-04	1.33E-04	1.29E-04	2.40E-04	1.79E-03	1.81E-03	2.56E-03	4.59E-03	1.47E-03	1.26E-03	1.68E-03
17Ux	6.21E-03	2.46E-03	5.01E-03	1.25E-02	3.01E-03	3.54E-03	5.66E-03	0.722	0.694	0.986	1.87	0.601	0.503	0.664
17Uy	0.219	8.02E-02	0.171	0.434	1.09E-01	0.117	0.188	3.54E-02	2.84E-02	4.56E-02	8.15E-02	2.88E-02	3.14E-02	3.28E-02
17Uz	7.66E-03	2.75E-03	5.48E-03	1.40E-02	3.88E-03	4.13E-03	6.26E-03	3.55E-02	3.59E-02	5.08E-02	9.17E-02	2.93E-02	2.49E-02	3.34E-02
17Θx	2.13E-03	8.00E-04	1.81E-03	4.56E-03	1.03E-03	1.08E-03	1.93E-03	3.98E-04	3.20E-04	5.19E-04	9.18E-04	3.25E-04	3.61E-04	3.71E-04
17Θy	7.80E-05	3.07E-05	6.37E-05	1.59E-04	3.71E-05	4.40E-05	7.14E-05	7.36E-03	7.55E-03	1.07E-02	1.91E-02	6.15E-03	5.22E-03	6.90E-03
17Θz	2.27E-04	8.74E-05	1.94E-04	4.90E-04	1.14E-04	1.10E-04	2.05E-04	2.14E-03	2.17E-03	3.07E-03	5.50E-03	1.77E-03	1.51E-03	2.01E-03
18Ux	1.13E-02	4.43E-03	9.23E-03	2.30E-02	5.31E-03	6.43E-03	1.04E-02	1.18	1.17	1.66	3.05	0.983	0.828	1.1
18Uy	0.348	0.129	0.281	0.712	0.171	0.183	0.305	5.91E-02	4.79E-02	7.74E-02	1.37E-01	4.85E-02	5.37E-02	5.51E-02
18Uz	7.70E-03	2.77E-03	5.52E-03	1.41E-02	3.90E-03	4.14E-03	6.30E-03	3.56E-02	3.60E-02	5.09E-02	9.19E-02	2.94E-02	2.50E-02	3.35E-02
18Θx	8.19E-04	3.08E-04	6.93E-04	1.75E-03	3.97E-04	4.17E-04	7.40E-04	1.87E-04	1.25E-04	2.04E-04	4.03E-04	1.40E-04	1.42E-04	1.63E-04
18Θy	4.24E-05	1.72E-05	3.41E-05	8.65E-05	2.25E-05	2.22E-05	3.70E-05	3.12E-03	3.18E-03	4.50E-03	8.06E-03	2.60E-03	2.20E-03	2.92E-03
18Θz	1.89E-04	7.24E-05	1.60E-04	4.07E-04	9.44E-05	9.16E-05	1.70E-04	2.50E-03	2.53E-03	3.58E-03	6.41E-03	2.06E-03	1.76E-03	2.35E-03
19Ux	1.16E-02	4.54E-03	9.52E-03	2.38E-02	5.43E-03	6.56E-03	1.07E-02	1.16	1.16	1.65	3.01	0.971	0.819	1.08
19Uy	0.335	0.124	0.272	0.687	0.165	0.176	0.295	5.69E-02	4.57E-02	7.42E-02	1.31E-01	4.65E-02	5.16E-02	5.30E-02
19Uz	7.73E-03	2.79E-03	5.56E-03	1.42E-02	3.91E-03	4.15E-03	6.33E-03	3.56E-02	3.60E-02	5.10E-02	9.20E-02	2.94E-02	2.50E-02	3.36E-02
19Θx	1.08E-03	4.03E-04	8.98E-04	2.27E-03	5.27E-04	5.57E-04	9.64E-04	2.10E-04	1.64E-04	2.64E-04	4.77E-04	1.68E-04	1.81E-04	1.94E-04
19Θy	3.76E-05	1.62E-05	2.97E-05	7.41E-05	2.22E-05	2.03E-05	3.16E-05	3.37E-03	3.41E-03	4.83E-03	8.71E-03	2.81E-03	2.38E-03	3.15E-03
19Θz	1.51E-04	5.77E-05	1.27E-04	3.23E-04	7.54E-05	7.32E-05	1.35E-04	2.85E-03	2.89E-03	4.09E-03	7.32E-03	2.35E-03	2.01E-03	2.68E-03

Table 3.4.10 (Cont'd)

Nodes	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f.	g
20Ux	6.84E-03	2.71E-03	5.61E-03	1.40E-02	3.32E-03	3.80E-03	6.24E-03	0.675	0.663	0.941	1.75	0.563	0.473	0.625
20Uy	0.189	6.95E-02	0.149	0.378	9.40E-02	1.01E-01	0.164	3.02E-02	2.40E-02	3.90E-02	6.95E-02	2.46E-02	2.73E-02	2.81E-02
20Uz	7.75E-03	2.80E-03	5.59E-03	1.43E-02	3.93E-03	4.15E-03	6.35E-03	3.57E-02	3.60E-02	5.10E-02	9.21E-02	2.94E-02	2.50E-02	3.36E-02
20Θx	2.17E-03	8.09E-04	1.80E-03	4.56E-03	1.06E-03	1.12E-03	1.94E-03	3.97E-04	3.15E-04	5.11E-04	9.10E-04	3.22E-04	3.55E-04	3.67E-04
20Θy	7.88E-05	3.08E-05	6.43E-05	1.61E-04	3.71E-05	4.43E-05	7.23E-05	7.51E-03	7.64E-03	1.08E-02	1.94E-02	6.27E-03	5.31E-03	7.03E-03
20Θz	1.14E-04	4.33E-05	9.46E-05	2.42E-04	5.69E-05	5.52E-05	1.02E-04	3.21E-03	3.25E-03	4.60E-03	8.23E-03	2.64E-03	2.26E-03	3.01E-03
21Ux	3.64E-06	1.39E-06	2.94E-06	7.39E-06	1.75E-06	2.07E-06	3.30E-06	0.152	9.11E-02	0.136	0.391	0.123	9.40E-02	0.122
21Uy	4.54E-02	1.62E-02	3.16E-02	8.07E-02	2.31E-02	2.50E-02	3.66E-02	5.03E-05	2.37E-05	3.68E-05	9.47E-05	3.47E-05	2.19E-05	3.73E-05
21Uz	7.76E-03	2.81E-03	5.61E-03	1.43E-02	3.93E-03	4.15E-03	6.37E-03	3.56E-02	3.60E-02	5.10E-02	9.20E-02	2.94E-02	2.50E-02	3.36E-02
21Θx	1.39E-03	5.19E-04	1.16E-03	2.92E-03	6.79E-04	7.18E-04	1.24E-03	2.70E-04	1.99E-04	3.24E-04	6.06E-04	2.12E-04	2.27E-04	2.45E-04
21Θy	6.85E-05	2.71E-05	5.66E-05	1.42E-04	3.33E-05	3.76E-05	6.26E-05	5.85E-03	5.97E-03	8.45E-03	1.51E-02	4.88E-03	4.14E-03	5.48E-03
21Θz	7.92E-05	2.97E-05	6.32E-05	1.64E-04	3.96E-05	3.82E-05	6.93E-05	3.56E-03	3.61E-03	5.11E-03	9.14E-03	2.94E-03	2.51E-03	3.34E-03
22Ux	3.91E-03	1.52E-03	3.23E-03	8.19E-03	1.87E-03	2.07E-03	3.57E-03	0.304	0.294	0.416	0.782	0.251	0.209	0.277
22Uy	5.08E-02	1.94E-02	4.42E-02	1.12E-01	2.43E-02	2.48E-02	4.69E-02	1.68E-02	8.47E-03	1.36E-02	3.34E-02	1.14E-02	9.22E-03	1.33E-02
22Uz	7.77E-03	2.81E-03	5.63E-03	1.44E-02	3.94E-03	4.15E-03	6.39E-03	3.56E-02	3.59E-02	5.09E-02	9.19E-02	2.93E-02	2.50E-02	3.36E-02
22Θx	9.14E-05	3.50E-05	7.81E-05	1.97E-04	4.46E-05	4.49E-05	8.31E-05	1.23E-04	7.22E-05	1.06E-04	2.49E-04	8.39E-05	6.03E-05	9.84E-05
22Θy	3.07E-05	1.21E-05	2.44E-05	6.45E-05	1.61E-05	1.46E-05	2.66E-05	1.59E-03	1.60E-03	2.26E-03	4.06E-03	1.30E-03	1.12E-03	1.50E-03
22Θz	5.13E-05	1.89E-05	3.61E-05	9.89E-05	2.60E-05	2.48E-05	4.26E-05	3.91E-03	3.97E-03	5.62E-03	1.00E-02	3.23E-03	2.76E-03	3.68E-03
23Ux	5.34E-03	2.08E-03	4.34E-03	1.13E-02	2.67E-03	2.65E-03	4.76E-03	0.324	0.315	0.447	0.833	0.266	0.225	0.298
23Uy	2.98E-02	1.10E-02	2.24E-02	5.70E-02	1.50E-02	1.58E-02	2.51E-02	1.54E-02	1.01E-02	1.48E-02	3.22E-02	1.07E-02	8.05E-03	1.28E-02
23Uz	7.77E-03	2.81E-03	5.64E-03	1.44E-02	3.94E-03	4.14E-03	6.39E-03	3.55E-02	3.58E-02	5.07E-02	9.17E-02	2.93E-02	2.49E-02	3.35E-02
23Θx	5.30E-04	2.01E-04	4.61E-04	1.16E-03	2.54E-04	2.64E-04	4.88E-04	2.59E-04	2.23E-04	3.20E-04	6.25E-04	2.06E-04	1.75E-04	2.30E-04
23Θy	2.16E-05	9.56E-06	1.54E-05	4.20E-05	1.46E-05	8.85E-06	1.52E-05	6.01E-04	5.10E-04	7.32E-04	1.43E-03	4.51E-04	3.85E-04	5.46E-04
23Θz	4.53E-05	1.72E-05	2.98E-05	8.49E-05	2.35E-05	2.23E-05	3.68E-05	4.27E-03	4.33E-03	6.13E-03	1.10E-02	3.52E-03	3.01E-03	4.01E-03
24Ux	4.35E-03	1.69E-03	3.56E-03	9.24E-03	2.19E-03	2.13E-03	3.87E-03	0.235	0.22	0.313	0.601	0.192	0.16	0.213
24Uy	2.82E-02	1.02E-02	2.01E-02	5.12E-02	1.44E-02	1.53E-02	2.30E-02	1.80E-02	1.53E-02	2.19E-02	4.19E-02	1.37E-02	1.11E-02	1.59E-02
24Uz	7.28E-03	2.60E-03	5.02E-03	1.28E-02	3.76E-03	4.03E-03	5.79E-03	2.77E-02	2.80E-02	3.97E-02	7.15E-02	2.28E-02	1.95E-02	2.62E-02
24Θx	1.05E-04	3.74E-05	7.33E-05	1.88E-04	5.33E-05	5.71E-05	8.45E-05	5.04E-04	5.00E-04	7.08E-04	1.30E-03	4.14E-04	3.51E-04	4.71E-04
24Θy	2.55E-05	1.00E-05	2.06E-05	5.28E-05	1.34E-05	1.25E-05	2.21E-05	1.01E-03	9.89E-04	1.40E-03	2.56E-03	8.27E-04	6.90E-04	9.28E-04
24Θz	7.18E-05	2.82E-05	5.75E-05	1.51E-04	3.68E-05	3.51E-05	6.29E-05	4.13E-03	4.18E-03	5.92E-03	1.06E-02	3.40E-03	2.91E-03	3.88E-03
25Ux	2.24E-06	8.62E-07	1.82E-06	4.56E-06	1.08E-06	1.26E-06	2.02E-06	9.41E-02	5.62E-02	8.39E-02	0.241	7.59E-02	5.80E-02	7.55E-02
25Uy	2.82E-02	1.02E-02	2.01E-02	5.12E-02	1.44E-02	1.54E-02	2.30E-02	1.79E-02	1.53E-02	2.19E-02	4.17E-02	1.36E-02	1.10E-02	1.58E-02
25Uz	8.42E-07	3.90E-07	5.99E-07	1.55E-06	6.07E-07	3.55E-07	5.29E-07	3.37E-03	2.02E-03	3.01E-03	8.66E-03	2.72E-03	2.08E-03	2.71E-03
25Θx	1.20E-04	4.41E-05	8.38E-05	2.14E-04	6.43E-05	6.58E-05	9.48E-05	3.74E-04	3.65E-04	5.19E-04	9.54E-04	3.04E-04	2.57E-04	3.48E-04
25Θy	2.37E-05	9.30E-06	1.92E-05	4.92E-05	1.24E-05	1.16E-05	2.06E-05	8.73E-04	8.52E-04	1.21E-03	2.21E-03	7.14E-04	5.95E-04	8.00E-04
25Θz	6.67E-05	2.57E-05	5.61E-05	1.44E-04	3.25E-05	3.27E-05	6.05E-05	2.73E-03	2.75E-03	3.90E-03	6.99E-03	2.24E-03	1.92E-03	2.57E-03

Table 3.4.10 (Cont'd)

Nodes	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
26Ux	4.53E-03	1.74E-03	3.92E-03	9.95E-03	2.19E-03	2.22E-03	4.16E-03	0.15	0.125	0.18	0.376	0.121	9.78E-02	0.132
26Uy	2.82E-02	1.02E-02	2.00E-02	5.10E-02	1.44E-02	1.54E-02	2.29E-02	1.76E-02	1.52E-02	2.18E-02	4.13E-02	1.35E-02	1.10E-02	1.57E-02
26Uz	8.93E-03	3.41E-03	6.19E-03	1.57E-02	5.05E-03	4.75E-03	6.80E-03	2.05E-02	1.63E-02	2.34E-02	4.66E-02	1.50E-02	1.21E-02	1.73E-02
26Θx	5.20E-05	1.87E-05	3.67E-05	9.35E-05	2.65E-05	2.84E-05	4.21E-05	3.57E-05	1.77E-05	2.63E-05	6.31E-05	2.14E-05	1.47E-05	2.60E-05
26Θy	2.38E-05	9.71E-06	1.89E-05	4.75E-05	1.35E-05	1.10E-05	1.94E-05	6.50E-04	6.25E-04	8.86E-04	1.64E-03	5.30E-04	4.41E-04	5.92E-04
26Θz	1.85E-05	8.06E-06	1.55E-05	3.90E-05	1.15E-05	8.79E-06	1.52E-05	3.95E-04	3.90E-04	5.53E-04	9.98E-04	3.22E-04	2.72E-04	3.66E-04
27Ux	2.76E-03	1.09E-03	2.40E-03	6.04E-03	1.43E-03	1.35E-03	2.49E-03	0.1	6.44E-02	9.52E-02	0.256	8.10E-02	6.24E-02	8.20E-02
27Uy	2.81E-02	1.01E-02	1.99E-02	5.08E-02	1.44E-02	1.53E-02	2.28E-02	1.73E-02	1.51E-02	2.16E-02	4.09E-02	1.33E-02	1.09E-02	1.55E-02
27Uz	1.08E-02	3.85E-03	7.45E-03	1.90E-02	5.53E-03	5.94E-03	8.61E-03	1.00E-02	8.24E-03	1.18E-02	2.39E-02	7.68E-03	6.21E-03	8.57E-03
27Θx	6.56E-05	2.95E-05	4.87E-05	1.22E-04	4.49E-05	2.94E-05	4.48E-05	2.18E-04	1.54E-04	2.22E-04	4.48E-04	1.47E-04	1.14E-04	1.75E-04
27Θy	2.66E-05	1.13E-05	2.02E-05	5.05E-05	1.64E-05	1.16E-05	2.00E-05	4.86E-04	4.49E-04	6.37E-04	1.23E-03	3.94E-04	3.25E-04	4.35E-04
27Θz	6.54E-05	2.52E-05	5.67E-05	1.44E-04	3.19E-05	3.19E-05	6.00E-05	1.39E-08	1.27E-03	1.81E-03	3.36E-03	1.10E-03	9.01E-04	1.25E-03
28Ux	4.00E-05	1.93E-05	3.10E-05	7.98E-05	2.96E-05	1.81E-05	2.76E-05	9.49E-02	5.68E-02	8.48E-02	0.243	7.65E-02	5.85E-02	7.62E-02
28Uy	2.80E-02	1.00E-02	1.95E-02	4.98E-02	1.43E-02	1.54E-02	2.25E-02	4.77E-05	2.17E-05	3.33E-05	8.90E-05	3.27E-05	1.92E-05	3.49E-05
28Uz	1.11E-02	3.97E-03	7.76E-03	1.98E-02	5.67E-03	6.15E-03	8.98E-03	4.97E-06	3.11E-06	4.94E-06	1.05E-05	3.41E-06	3.32E-06	4.21E-06
28Θx	6.39E-05	2.85E-05	4.69E-05	1.18E-04	4.34E-05	2.89E-05	4.36E-05	1.68E-04	6.93E-05	1.06E-04	2.91E-04	9.61E-05	6.53E-05	1.21E-04
28Θy	2.89E-05	1.26E-05	2.06E-05	5.09E-05	1.90E-05	1.22E-05	1.97E-05	2.65E-04	1.84E-04	2.68E-04	6.71E-04	2.11E-04	1.65E-04	2.19E-04
28Θz	1.13E-04	4.37E-05	9.44E-05	2.38E-04	5.81E-05	5.70E-05	1.00E-04	4.45E-04	3.69E-04	5.31E-04	1.03E-03	3.35E-04	2.74E-04	4.07E-04
29Ux	3.01E-05	1.45E-05	2.33E-05	6.01E-05	2.22E-05	1.36E-05	2.08E-05	9.48E-02	5.67E-02	8.46E-02	0.243	7.64E-02	5.84E-02	7.61E-02
29Uy	3.04E-02	1.09E-02	2.10E-02	5.36E-02	1.56E-02	1.69E-02	2.43E-02	2.45E-02	1.51E-02	2.22E-02	4.96E-02	1.71E-02	1.20E-02	2.01E-02
29Uz	1.21E-02	4.35E-03	8.45E-03	2.16E-02	6.21E-03	6.65E-03	9.74E-03	1.45E-02	8.86E-03	1.31E-02	3.64E-02	1.14E-02	8.73E-03	1.16E-02
29Θx	5.61E-05	2.38E-05	4.08E-05	1.03E-04	3.57E-05	2.69E-05	4.05E-05	1.26E-04	5.20E-05	7.96E-05	2.18E-04	7.21E-05	4.90E-05	9.08E-05
29Θy	2.37E-05	1.05E-05	1.67E-05	4.18E-05	1.60E-05	1.05E-05	1.57E-05	2.22E-04	1.28E-04	1.91E-04	5.56E-04	1.75E-04	1.33E-04	1.76E-04
29Θz	4.31E-05	1.71E-05	3.15E-05	7.94E-05	2.51E-05	2.22E-05	3.37E-05	3.30E-04	1.57E-04	2.36E-04	6.15E-04	2.20E-04	1.33E-04	2.49E-04
30Ux	2.01E-05	9.71E-06	1.57E-05	4.03E-05	1.49E-05	9.09E-06	1.40E-05	9.46E-02	5.66E-02	8.44E-02	0.242	7.63E-02	5.83E-02	7.60E-02
30Uy	3.12E-02	1.12E-02	2.15E-02	5.49E-02	1.61E-02	1.73E-02	2.49E-02	3.24E-02	1.71E-02	2.54E-02	6.23E-02	2.20E-02	1.41E-02	2.53E-02
30Uz	1.25E-02	4.49E-03	8.70E-03	2.22E-02	6.42E-03	6.82E-03	1.00E-02	2.60E-02	1.51E-02	2.26E-02	6.56E-02	2.06E-02	1.57E-02	2.07E-02
30Θx	5.18E-05	2.04E-05	3.72E-05	9.44E-05	3.00E-05	2.66E-05	3.97E-05	8.42E-05	3.47E-05	5.31E-05	1.45E-04	4.81E-05	3.27E-05	6.05E-05
30Θy	7.45E-06	3.28E-06	5.30E-06	1.31E-05	4.96E-06	3.13E-06	5.00E-06	1.88E-04	1.20E-04	1.78E-04	4.82E-04	1.52E-04	1.17E-04	1.54E-04
30Θz	2.71E-05	1.05E-05	2.25E-05	5.68E-05	1.40E-05	1.36E-05	2.38E-05	1.10E-04	8.86E-05	1.28E-04	2.50E-04	8.20E-05	6.63E-05	9.99E-05
31Ux	1.02E-05	4.90E-06	8.00E-06	2.06E-05	7.47E-06	4.62E-06	7.22E-06	9.44E-02	5.64E-02	8.41E-02	0.242	7.61E-02	5.81E-02	7.58E-02
31Uy	2.96E-02	1.06E-02	2.05E-02	5.23E-02	1.52E-02	1.63E-02	2.37E-02	1.61E-02	7.90E-03	1.19E-02	3.03E-02	1.08E-02	6.65E-03	1.23E-02
31Uz	1.18E-02	4.21E-03	8.20E-03	2.09E-02	6.01E-03	6.48E-03	9.48E-03	3.52E-02	2.08E-02	3.11E-02	9.02E-02	2.83E-02	2.16E-02	2.82E-02
31Θx	5.19E-05	1.90E-05	3.66E-05	9.32E-05	2.73E-05	2.80E-05	4.14E-05	4.21E-05	1.73E-05	2.65E-05	7.27E-05	2.40E-05	1.63E-05	3.03E-05
31Θy	2.63E-05	1.16E-05	1.86E-05	4.63E-05	1.77E-05	1.16E-05	1.75E-05	1.80E-04	1.16E-04	1.71E-04	4.46E-04	1.41E-04	1.09E-04	1.47E-04
31Θz	5.22E-05	2.04E-05	3.90E-05	9.84E-05	2.92E-05	2.69E-05	4.20E-05	3.58E-04	1.83E-04	2.74E-04	6.82E-04	2.41E-04	1.52E-04	2.76E-04

Table 3.4.10 (Cont'd)

Nodes	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
32Ux	2.21E-06	8.54E-07	1.82E-06	4.56E-06	1.07E-06	1.21E-06	2.00E-06	9.41E-02	5.62E-02	8.39E-02	0.241	7.59E-02	5.80E-02	7.55E-02
32Uy	2.80E-02	1.00E-02	1.95E-02	4.98E-02	1.43E-02	1.54E-02	2.25E-02	4.81E-05	2.20E-05	3.37E-05	9.03E-05	3.31E-05	1.93E-05	3.53E-05
32Uz	1.11E-02	3.97E-03	7.76E-03	1.98E-02	5.67E-03	6.15E-03	8.98E-03	4.50E-02	2.69E-02	4.01E-02	0.115	3.63E-02	2.78E-02	3.61E-02
32Θx	5.63E-05	2.01E-05	3.92E-05	1.00E-04	2.86E-05	3.10E-05	4.54E-05	2.01E-08	1.40E-08	2.28E-08	4.36E-08	1.56E-08	1.59E-08	1.75E-08
32Θy	4.44E-09	1.70E-09	3.61E-09	9.05E-09	2.11E-09	2.51E-09	4.04E-09	1.87E-04	1.12E-04	1.67E-04	4.81E-04	1.51E-04	1.16E-04	1.51E-04
32Θz	1.60E-09	5.99E-10	1.18E-09	3.00E-09	8.42E-10	8.28E-10	1.31E-09	1.50E-08	1.05E-08	1.53E-08	3.59E-08	1.18E-08	8.85E-09	1.24E-08

Table 3.4.11 Maximum element forces and moments for P-components (group#1) of benchmark problem #4a and #4b.

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$1R_{i1}$	1.78E+00	8.31E-01	1.27E+00	3.28E+00	1.30E+00	7.42E-01	1.11E+00	5.39E+00	2.63E+00	3.80E+00	8.82E+00	1.32E+00	2.81E+00	4.21E+00
$1R_{i2}$	1.04E+00	4.08E-01	8.37E-01	2.10E+00	5.27E-01	5.74E-01	9.22E-01	4.61E+04	2.62E+04	3.99E+04	1.14E+05	3.80E+04	2.69E+04	3.78E+04
$1R_{i3}$	1.26E+04	4.58E+03	8.81E+03	2.25E+04	6.58E+03	6.90E+03	1.01E+04	2.02E+01	2.82E+00	6.25E+00	2.05E+01	1.37E+00	3.32E+00	1.03E+01
$1M_{i1}$	1.80E+02	6.74E+01	1.33E+02	3.38E+02	9.48E+01	9.32E+01	1.47E+02	1.67E+03	9.23E+02	1.35E+03	3.20E+03	6.70E+02	1.05E+03	1.08E+03
$1M_{i2}$	1.26E+07	4.50E+06	8.79E+06	2.24E+07	6.42E+06	6.96E+06	1.02E+07	4.28E+03	1.35E+03	2.39E+03	4.54E+03	8.90E+02	1.52E+03	2.30E+03
$1M_{i3}$	1.01E+03	3.88E+02	8.24E+02	2.07E+03	4.83E+02	5.72E+02	9.21E+02	4.34E+07	2.57E+07	3.85E+07	1.11E+08	3.51E+07	2.65E+07	3.50E+07
$1R_{j1}$	1.78E+00	8.31E-01	1.27E+00	3.28E+00	1.30E+00	7.42E-01	1.11E+00	5.39E+00	2.63E+00	3.80E+00	8.82E+00	1.32E+00	2.81E+00	4.21E+00
$1R_{j2}$	1.04E+00	4.08E-01	8.37E-01	2.10E+00	5.27E-01	5.74E-01	9.22E-01	4.61E+04	2.62E+04	3.99E+04	1.14E+05	3.80E+04	2.69E+04	3.78E+04
$1R_{j3}$	1.26E+04	4.58E+03	8.81E+03	2.25E+04	6.58E+03	6.90E+03	1.01E+04	2.02E+01	2.82E+00	6.25E+00	2.05E+01	1.37E+00	3.32E+00	1.03E+01
$1M_{j1}$	1.80E+02	6.74E+01	1.33E+02	3.38E+02	9.48E+01	9.32E+01	1.47E+02	1.67E+03	9.23E+02	1.35E+03	3.20E+03	6.70E+02	1.05E+03	1.08E+03
$1M_{j2}$	9.87E+06	3.52E+06	6.87E+06	1.75E+07	5.02E+06	5.44E+06	7.96E+06	2.04E+03	9.77E+02	1.66E+03	2.34E+03	7.16E+02	1.08E+03	1.19E+03
$1M_{j3}$	7.94E+02	3.03E+02	6.45E+02	1.62E+03	3.78E+02	4.48E+02	7.21E+02	3.32E+07	1.99E+07	2.97E+07	8.55E+07	2.67E+07	2.07E+07	2.66E+07
$2R_{i1}$	1.64E+00	7.62E-01	1.17E+00	3.02E+00	1.19E+00	6.83E-01	1.03E+00	5.15E+00	2.56E+00	3.73E+00	8.57E+00	1.30E+00	2.76E+00	4.04E+00
$2R_{i2}$	9.99E-01	3.88E-01	8.06E-01	2.02E+00	4.95E-01	5.55E-01	8.92E-01	4.34E+04	2.50E+04	3.76E+04	1.08E+05	3.50E+04	2.57E+04	3.49E+04
$2R_{i3}$	1.21E+04	4.34E+03	8.45E+03	2.16E+04	6.21E+03	6.68E+03	9.76E+03	1.52E+01	2.22E+00	4.64E+00	1.47E+01	1.16E+00	2.51E+00	7.70E+00
$2M_{i1}$	1.80E+02	6.74E+01	1.33E+02	3.38E+02	9.48E+01	9.32E+01	1.47E+02	1.67E+03	9.23E+02	1.35E+03	3.20E+03	6.70E+02	1.05E+03	1.08E+03
$2M_{i2}$	9.87E+06	3.52E+06	6.87E+06	1.75E+07	5.02E+06	5.44E+06	7.96E+06	2.04E+03	9.77E+02	1.66E+03	2.34E+03	7.16E+02	1.08E+03	1.19E+03
$2M_{i3}$	7.94E+02	3.03E+02	6.45E+02	1.62E+03	3.78E+02	4.48E+02	7.21E+02	3.32E+07	1.99E+07	2.97E+07	8.55E+07	2.67E+07	2.07E+07	2.66E+07
$2R_{j1}$	1.64E+00	7.62E-01	1.17E+00	3.02E+00	1.19E+00	6.83E-01	1.03E+00	5.15E+00	2.56E+00	3.73E+00	8.57E+00	1.30E+00	2.76E+00	4.04E+00
$2R_{j2}$	9.99E-01	3.88E-01	8.06E-01	2.02E+00	4.95E-01	5.55E-01	8.92E-01	4.34E+04	2.50E+04	3.76E+04	1.08E+05	3.50E+04	2.57E+04	3.49E+04
$2R_{j3}$	1.21E+04	4.34E+03	8.45E+03	2.16E+04	6.21E+03	6.68E+03	9.76E+03	1.52E+01	2.22E+00	4.64E+00	1.47E+01	1.16E+00	2.51E+00	7.70E+00
$2M_{j1}$	1.80E+02	6.74E+01	1.33E+02	3.38E+02	9.48E+01	9.32E+01	1.47E+02	1.67E+03	9.23E+02	1.35E+03	3.20E+03	6.70E+02	1.05E+03	1.08E+03
$2M_{j2}$	7.20E+06	2.57E+06	5.01E+06	1.28E+07	3.67E+06	3.97E+06	5.80E+06	4.77E+03	1.00E+03	1.82E+03	4.81E+03	6.05E+02	1.08E+03	2.55E+03
$2M_{j3}$	5.86E+02	2.25E+02	4.74E+02	1.19E+03	2.82E+02	3.29E+02	5.29E+02	2.37E+07	1.44E+07	2.13E+07	6.16E+07	1.89E+07	1.53E+07	1.88E+07

Table 3.4.11 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$3R_{i1}$	1.11E+00	4.88E-01	8.53E-01	2.25E+00	7.24E-01	4.80E-01	8.38E-01	5.47E+00	2.04E+00	2.95E+00	7.77E+00	9.60E-01	1.96E+00	4.21E+00
$3R_{i2}$	9.11E-01	3.50E-01	7.39E-01	1.85E+00	4.37E-01	5.14E-01	8.25E-01	3.90E+04	2.30E+04	3.44E+04	9.87E+04	3.12E+04	2.38E+04	3.12E+04
$3R_{i3}$	1.13E+04	4.04E+03	7.88E+03	2.01E+04	5.76E+03	6.24E+03	9.13E+03	6.76E+00	1.45E+00	2.60E+00	7.21E+00	8.29E-01	1.53E+00	3.59E+00
$3M_{i1}$	1.49E+02	5.73E+01	1.16E+02	2.94E+02	7.86E+01	7.32E+01	1.26E+02	1.62E+03	1.39E+03	2.03E+03	4.41E+03	1.21E+03	1.29E+03	1.33E+03
$3M_{i2}$	7.20E+06	2.57E+06	5.01E+06	1.28E+07	3.67E+06	3.97E+06	5.80E+06	4.81E+03	1.00E+03	1.80E+03	4.77E+03	6.16E+02	1.07E+03	2.58E+03
$3M_{i3}$	5.84E+02	2.24E+02	4.75E+02	1.19E+03	2.82E+02	3.25E+02	5.28E+02	2.37E+07	1.44E+07	2.13E+07	6.16E+07	1.89E+07	1.53E+07	1.88E+07
$3R_{j1}$	1.11E+00	4.88E-01	8.53E-01	2.25E+00	7.24E-01	4.80E-01	8.38E-01	5.47E+00	2.04E+00	2.95E+00	7.77E+00	9.60E-01	1.96E+00	4.21E+00
$3R_{j2}$	9.11E-01	3.50E-01	7.39E-01	1.85E+00	4.37E-01	5.14E-01	8.25E-01	3.90E+04	2.30E+04	3.44E+04	9.87E+04	3.12E+04	2.38E+04	3.12E+04
$3R_{j3}$	1.13E+04	4.04E+03	7.88E+03	2.01E+04	5.76E+03	6.24E+03	9.13E+03	6.76E+00	1.45E+00	2.60E+00	7.21E+00	8.29E-01	1.53E+00	3.59E+00
$3M_{j1}$	1.49E+02	5.73E+01	1.16E+02	2.94E+02	7.86E+01	7.32E+01	1.26E+02	1.62E+03	1.39E+03	2.03E+03	4.41E+03	1.21E+03	1.29E+03	1.33E+03
$3M_{j2}$	5.10E+06	1.83E+06	3.56E+06	9.07E+06	2.61E+06	2.81E+06	4.11E+06	5.56E+03	9.57E+02	1.95E+03	5.76E+03	5.37E+02	9.86E+02	2.96E+03
$3M_{j3}$	4.24E+02	1.64E+02	3.44E+02	8.63E+02	2.10E+02	2.32E+02	3.79E+02	1.65E+07	1.01E+07	1.49E+07	4.33E+07	1.31E+07	1.10E+07	1.30E+07
$3R_{i1}$	9.29E-01	3.98E-01	7.37E-01	1.95E+00	5.76E-01	4.11E-01	7.46E-01	4.71E+00	1.86E+00	2.72E+00	7.05E+00	8.91E-01	1.80E+00	3.71E+00
$4R_{i2}$	8.14E-01	3.12E-01	6.62E-01	1.66E+00	3.90E-01	4.56E-01	7.38E-01	3.35E+04	2.02E+04	3.01E+04	8.66E+04	2.67E+04	2.14E+04	2.66E+04
$4R_{i3}$	1.01E+04	3.61E+03	7.04E+03	1.80E+04	5.15E+03	5.57E+03	8.15E+03	5.07E+00	1.15E+00	2.12E+00	4.72E+00	7.53E-01	1.31E+00	2.54E+00
$4M_{i1}$	1.60E+02	6.05E+01	1.14E+02	2.89E+02	8.72E+01	8.39E+01	1.27E+02	1.23E+03	7.82E+02	9.25E+02	3.08E+03	8.72E+02	8.17E+02	8.75E+02
$4M_{i2}$	5.10E+06	1.83E+06	3.56E+06	9.07E+06	2.61E+06	2.81E+06	4.11E+06	5.56E+03	9.57E+02	1.95E+03	5.76E+03	5.37E+02	9.86E+02	2.96E+03
$4M_{i3}$	4.24E+02	1.64E+02	3.44E+02	8.63E+02	2.10E+02	2.32E+02	3.79E+02	1.65E+07	1.01E+07	1.49E+07	4.33E+07	1.31E+07	1.10E+07	1.30E+07
$4R_{j1}$	9.29E-01	3.98E-01	7.37E-01	1.95E+00	5.76E-01	4.11E-01	7.46E-01	4.71E+00	1.86E+00	2.72E+00	7.05E+00	8.91E-01	1.80E+00	3.71E+00
$4R_{j2}$	8.14E-01	3.12E-01	6.62E-01	1.66E+00	3.90E-01	4.56E-01	7.38E-01	3.35E+04	2.02E+04	3.01E+04	8.66E+04	2.67E+04	2.14E+04	2.66E+04
$4R_{j3}$	1.01E+04	3.61E+03	7.04E+03	1.80E+04	5.15E+03	5.57E+03	8.15E+03	5.07E+00	1.15E+00	2.12E+00	4.72E+00	7.53E-01	1.31E+00	2.54E+00
$4M_{j1}$	1.60E+02	6.05E+01	1.14E+02	2.89E+02	8.72E+01	8.39E+01	1.27E+02	1.23E+03	7.82E+02	9.25E+02	3.08E+03	8.72E+02	8.17E+02	8.75E+02
$4M_{j2}$	2.98E+06	1.07E+06	2.08E+06	5.31E+06	1.53E+06	1.64E+06	2.40E+06	4.64E+03	7.22E+02	1.56E+03	4.97E+03	3.81E+02	7.92E+02	2.51E+03
$4M_{j3}$	2.61E+02	1.03E+02	2.10E+02	5.26E+02	1.35E+02	1.39E+02	2.27E+02	9.56E+06	5.86E+06	8.64E+06	2.51E+07	7.52E+06	6.48E+06	7.42E+06
$4R_{i1}$	8.33E-01	3.52E-01	6.76E-01	1.77E+00	4.99E-01	3.75E-01	6.91E-01	3.68E+00	1.63E+00	2.43E+00	6.11E+00	8.03E-01	1.66E+00	3.05E+00
$5R_{i2}$	6.78E-01	2.62E-01	5.49E-01	1.38E+00	3.32E-01	3.78E-01	6.09E-01	2.69E+04	1.65E+04	2.43E+04	7.05E+04	2.13E+04	1.80E+04	2.11E+04
$5R_{i3}$	8.34E+03	2.99E+03	5.81E+03	1.48E+04	4.27E+03	4.59E+03	6.71E+03	1.02E+01	1.58E+00	3.51E+00	1.09E+01	8.60E-01	1.76E+00	5.34E+00
$5M_{i1}$	1.60E+02	6.05E+01	1.14E+02	2.89E+02	8.72E+01	8.39E+01	1.27E+02	1.23E+03	7.82E+02	9.25E+02	3.08E+03	8.72E+02	8.17E+02	8.75E+02
$5M_{i2}$	2.98E+06	1.07E+06	2.08E+06	5.31E+06	1.53E+06	1.64E+06	2.40E+06	4.64E+03	7.22E+02	1.56E+03	4.97E+03	3.81E+02	7.92E+02	2.51E+03
$5M_{i3}$	2.61E+02	1.03E+02	2.10E+02	5.26E+02	1.35E+02	1.39E+02	2.27E+02	9.56E+06	5.86E+06	8.64E+06	2.51E+07	7.52E+06	6.48E+06	7.42E+06
$5R_{j1}$	8.33E-01	3.52E-01	6.76E-01	1.77E+00	4.99E-01	3.75E-01	6.91E-01	3.68E+00	1.63E+00	2.43E+00	6.11E+00	8.03E-01	1.66E+00	3.05E+00
$5R_{j2}$	6.78E-01	2.62E-01	5.49E-01	1.38E+00	3.32E-01	3.78E-01	6.09E-01	2.69E+04	1.65E+04	2.43E+04	7.05E+04	2.13E+04	1.80E+04	2.11E+04
$5R_{j3}$	8.34E+03	2.99E+03	5.81E+03	1.48E+04	4.27E+03	4.59E+03	6.71E+03	1.02E+01	1.58E+00	3.51E+00	1.09E+01	8.60E-01	1.76E+00	5.34E+00
$5M_{j1}$	1.60E+02	6.05E+01	1.14E+02	2.89E+02	8.72E+01	8.39E+01	1.27E+02	1.23E+03	7.82E+02	9.25E+02	3.08E+03	8.72E+02	8.17E+02	8.75E+02
$5M_{j2}$	1.23E+06	4.43E+05	8.59E+05	2.19E+06	6.35E+05	6.76E+05	9.88E+05	2.51E+03	3.91E+02	8.74E+02	2.68E+03	2.00E+02	4.31E+02	1.39E+03
$5M_{j3}$	1.31E+02	5.44E+01	1.03E+02	2.59E+02	7.62E+01	6.48E+01	1.06E+02	3.92E+06	2.40E+06	3.53E+06	1.03E+07	3.05E+06	2.69E+06	3.00E+06

Table 3.4.11 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$6R_{i1}$	8.68E-01	3.74E-01	6.97E-01	1.79E+00	5.40E-01	3.90E-01	6.90E-01	2.66E+00	1.37E+00	2.09E+00	5.09E+00	7.23E-01	1.50E+00	2.30E+00
$6R_{i2}$	5.25E-01	2.06E-01	4.23E-01	1.06E+00	2.67E-01	2.84E-01	4.62E-01	1.90E+04	1.17E+04	1.71E+04	4.99E+04	1.48E+04	1.30E+04	1.46E+04
$6R_{i3}$	5.95E+03	2.14E+03	4.15E+03	1.06E+04	3.06E+03	3.27E+03	4.78E+03	1.08E+01	1.54E+00	3.51E+00	1.19E+01	7.98E-01	1.81E+00	5.81E+00
$6M_{i1}$	2.02E+02	7.40E+01	1.39E+02	3.55E+02	1.07E+02	1.10E+02	1.60E+02	6.23E+02	4.54E+02	7.76E+02	1.51E+03	4.89E+02	5.96E+02	5.13E+02
$6M_{i2}$	1.23E+06	4.43E+05	8.59E+05	2.19E+06	6.35E+05	6.76E+05	9.88E+05	2.51E+03	3.91E+02	8.74E+02	2.68E+03	2.00E+02	4.31E+02	1.39E+03
$6M_{i3}$	1.31E+02	5.44E+01	1.03E+02	2.59E+02	7.62E+01	6.48E+01	1.06E+02	3.92E+06	2.40E+06	3.53E+06	1.03E+07	3.05E+06	2.69E+06	3.00E+06
$6Rj_1$	8.68E-01	3.74E-01	6.97E-01	1.79E+00	5.40E-01	3.90E-01	6.90E-01	2.66E+00	1.37E+00	2.09E+00	5.09E+00	7.23E-01	1.50E+00	2.30E+00
$6Rj_2$	5.25E-01	2.06E-01	4.23E-01	1.06E+00	2.67E-01	2.84E-01	4.62E-01	1.90E+04	1.17E+04	1.71E+04	4.99E+04	1.48E+04	1.30E+04	1.46E+04
$6Rj_3$	5.95E+03	2.14E+03	4.15E+03	1.06E+04	3.06E+03	3.27E+03	4.78E+03	1.08E+01	1.54E+00	3.51E+00	1.19E+01	7.98E-01	1.81E+00	5.81E+00
$6Mj_1$	2.02E+02	7.40E+01	1.39E+02	3.55E+02	1.07E+02	1.10E+02	1.60E+02	6.23E+02	4.54E+02	7.76E+02	1.51E+03	4.89E+02	5.96E+02	5.13E+02
$6Mj_2$	4.27E+05	1.54E+05	2.98E+05	7.61E+05	2.21E+05	2.35E+05	3.43E+05	1.07E+03	1.87E+02	4.00E+02	1.16E+03	9.23E+01	1.98E+02	6.06E+02
$6Mj_3$	6.85E+01	3.03E+01	5.15E+01	1.29E+02	4.54E+01	3.05E+01	4.84E+01	1.36E+06	8.31E+05	1.21E+06	3.55E+06	1.04E+06	9.41E+05	1.02E+06
$7R_{i1}$	1.01E+00	4.49E-01	7.85E-01	1.99E+00	6.67E-01	4.44E-01	7.40E-01	2.03E+00	1.12E+00	1.73E+00	4.20E+00	6.74E-01	1.34E+00	1.78E+00
$7R_{i2}$	2.86E-01	1.13E-01	2.32E-01	5.82E-01	1.47E-01	1.54E-01	2.52E-01	1.01E+04	6.15E+03	8.99E+03	2.63E+04	7.73E+03	6.97E+03	7.59E+03
$7R_{i3}$	3.16E+03	1.14E+03	2.21E+03	5.64E+03	1.64E+03	1.74E+03	2.54E+03	7.24E+00	1.01E+00	2.31E+00	8.06E+00	4.96E-01	1.21E+00	3.89E+00
$7M_{i1}$	2.02E+02	7.40E+01	1.39E+02	3.55E+02	1.07E+02	1.10E+02	1.60E+02	6.23E+02	4.54E+02	7.76E+02	1.51E+03	4.89E+02	5.96E+02	5.13E+02
$7M_{i2}$	4.27E+05	1.54E+05	2.98E+05	7.61E+05	2.21E+05	2.35E+05	3.43E+05	1.07E+03	1.87E+02	4.00E+02	1.16E+03	9.23E+01	1.98E+02	6.06E+02
$7M_{i3}$	6.85E+01	3.03E+01	5.15E+01	1.29E+02	4.54E+01	3.05E+01	4.84E+01	1.36E+06	8.31E+05	1.21E+06	3.55E+06	1.04E+06	9.41E+05	1.02E+06
$7Rj_1$	1.01E+00	4.49E-01	7.85E-01	1.99E+00	6.67E-01	4.44E-01	7.40E-01	2.03E+00	1.12E+00	1.73E+00	4.20E+00	6.74E-01	1.34E+00	1.78E+00
$7Rj_2$	2.86E-01	1.13E-01	2.32E-01	5.82E-01	1.47E-01	1.54E-01	2.52E-01	1.01E+04	6.15E+03	8.99E+03	2.63E+04	7.73E+03	6.97E+03	7.59E+03
$7Rj_3$	3.16E+03	1.14E+03	2.21E+03	5.64E+03	1.64E+03	1.74E+03	2.54E+03	7.24E+00	1.01E+00	2.31E+00	8.06E+00	4.96E-01	1.21E+00	3.89E+00
$7Mj_1$	2.02E+02	7.40E+01	1.39E+02	3.55E+02	1.07E+02	1.10E+02	1.60E+02	6.23E+02	4.54E+02	7.76E+02	1.51E+03	4.89E+02	5.96E+02	5.13E+02
$7Mj_2$	8.59E+01	3.98E+01	6.27E+01	1.57E+02	6.16E+01	3.66E+01	5.44E+01	1.67E+02	7.76E+01	1.16E+02	2.85E+02	4.99E+01	9.59E+01	1.33E+02
$7M_{j3}$	4.53E+01	2.09E+01	3.20E+01	8.06E+01	3.26E+01	1.90E+01	2.75E+01	1.81E+02	1.23E+02	1.96E+02	3.10E+02	7.64E+01	8.15E+01	1.08E+02

Table 3.4.12 Maximum element forces and moments for joint elements (group#2) of bench-mark problem #4a and #4b.

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$1R_{i1}$	3.27E-01	1.20E-01	2.23E-01	5.70E-01	1.75E-01	1.76E-01	2.55E-01	7.14E+00	5.24E+00	9.14E+00	1.83E+01	5.92E+00	7.10E+00	6.00E+00
$1R_{i2}$	9.84E-01	3.62E-01	6.78E-01	1.72E+00	5.26E-01	5.32E-01	7.74E-01	2.52E+00	1.84E+00	3.12E+00	5.99E+00	1.94E+00	2.39E+00	2.06E+00
$1R_{i3}$	2.48E-01	1.15E-01	1.75E-01	4.42E-01	1.79E-01	1.04E-01	1.51E-01	1.08E+00	7.45E-01	1.17E+00	1.77E+00	4.49E-01	5.27E-01	6.68E-01
$1M_{i1}$	2.00E+01	7.74E+00	1.77E+01	4.48E+01	9.69E+00	9.45E+00	1.85E+01	2.18E+01	1.49E+01	2.30E+01	3.48E+01	8.99E+00	1.17E+01	1.35E+01
$1M_{i2}$	1.40E+01	6.42E+00	1.01E+01	2.55E+01	9.93E+00	5.86E+00	8.84E+00	7.45E+01	5.66E+01	8.23E+01	1.26E+02	3.24E+01	4.46E+01	5.05E+01
$1M_{i3}$	4.72E+01	1.80E+01	3.25E+01	8.24E+01	2.65E+01	2.50E+01	3.64E+01	2.09E+01	1.48E+01	2.31E+01	3.21E+01	9.40E+00	1.13E+01	1.35E+01
$1R_{j1}$	3.27E-01	1.20E-01	2.23E-01	5.70E-01	1.75E-01	1.76E-01	2.55E-01	7.14E+00	5.24E+00	9.14E+00	1.83E+01	5.92E+00	7.10E+00	6.00E+00
$1R_{j2}$	9.84E-01	3.62E-01	6.78E-01	1.72E+00	5.26E-01	5.32E-01	7.74E-01	2.52E+00	1.84E+00	3.12E+00	5.99E+00	1.94E+00	2.39E+00	2.06E+00
$1R_{j3}$	2.48E-01	1.15E-01	1.75E-01	4.42E-01	1.79E-01	1.04E-01	1.51E-01	1.08E+00	7.45E-01	1.17E+00	1.77E+00	4.49E-01	5.27E-01	6.68E-01
$1M_{j1}$	2.00E+01	7.74E+00	1.77E+01	4.48E+01	9.69E+00	9.45E+00	1.85E+01	2.18E+01	1.49E+01	2.30E+01	3.48E+01	8.99E+00	1.17E+01	1.35E+01
$1M_{j2}$	5.00E+01	2.29E+01	3.57E+01	8.99E+01	3.56E+01	2.11E+01	3.11E+01	1.98E+02	1.33E+02	2.13E+02	3.35E+02	8.29E+01	8.92E+01	1.18E+02
$1M_{j3}$	2.02E+02	7.40E+01	1.39E+02	3.55E+02	1.07E+02	1.10E+02	1.60E+02	6.23E+02	4.54E+02	7.76E+02	1.51E+03	4.89E+02	5.96E+02	5.13E+02
$2R_{i1}$	2.24E-01	1.01E-01	1.66E-01	4.18E-01	1.54E-01	1.11E-01	1.58E-01	3.45E+00	2.75E+00	3.52E+00	6.90E+00	2.41E+00	2.15E+00	2.32E+00
$2R_{i2}$	2.39E-01	9.56E-02	1.72E-01	4.34E-01	1.42E-01	1.26E-01	1.83E-01	4.66E+00	1.87E+00	2.53E+00	5.71E+00	1.87E+00	1.64E+00	2.45E+00
$2R_{i3}$	1.45E-01	6.10E-02	1.01E-01	2.54E-01	9.24E-02	6.74E-02	1.00E-01	4.17E-01	1.82E-01	3.04E-01	6.67E-01	1.40E-01	2.75E-01	2.67E-01
$2M_{i1}$	4.05E+00	1.75E+00	2.86E+00	7.10E+00	2.65E+00	1.75E+00	2.75E+00	1.66E+01	8.43E+00	1.18E+01	2.60E+01	4.96E+00	9.83E+00	9.92E+00
$2M_{i2}$	6.75E+00	2.97E+00	4.76E+00	1.19E+01	4.55E+00	3.04E+00	4.48E+00	1.95E+01	8.47E+00	1.22E+01	3.10E+01	4.77E+00	9.42E+00	1.13E+01
$2M_{i3}$	1.47E+01	5.87E+00	1.08E+01	2.71E+01	8.61E+00	7.61E+00	1.15E+01	9.72E+01	2.78E+01	4.31E+01	1.20E+02	1.47E+01	2.61E+01	6.64E+01
$2R_{j1}$	2.24E-01	1.01E-01	1.66E-01	4.18E-01	1.54E-01	1.11E-01	1.58E-01	3.45E+00	2.75E+00	3.52E+00	6.90E+00	2.41E+00	2.15E+00	2.32E+00
$2R_{j2}$	2.39E-01	9.56E-02	1.72E-01	4.34E-01	1.42E-01	1.26E-01	1.83E-01	4.66E+00	1.87E+00	2.53E+00	5.71E+00	1.87E+00	1.64E+00	2.45E+00
$2R_{j3}$	1.45E-01	6.10E-02	1.01E-01	2.54E-01	9.24E-02	6.74E-02	1.00E-01	4.17E-01	1.82E-01	3.04E-01	6.67E-01	1.40E-01	2.75E-01	2.67E-01
$2M_{j1}$	4.05E+00	1.75E+00	2.86E+00	7.10E+00	2.65E+00	1.75E+00	2.75E+00	1.66E+01	8.43E+00	1.18E+01	2.60E+01	4.96E+00	9.83E+00	9.92E+00
$2M_{j2}$	3.85E+01	1.61E+01	2.69E+01	6.74E+01	2.43E+01	1.80E+01	2.69E+01	1.10E+02	4.82E+01	8.40E+01	1.91E+02	4.03E+01	7.65E+01	7.16E+01
$2M_{j3}$	6.02E+01	2.41E+01	4.30E+01	1.09E+02	3.57E+01	3.17E+01	4.59E+01	1.37E+03	6.06E+02	8.13E+02	1.78E+03	5.85E+02	5.20E+02	7.35E+02

Table 3.4.12 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$3R_{i1}$	1.81E+00	6.78E-01	1.48E+00	3.75E+00	8.79E-01	9.05E-01	1.61E+00	2.97E-01	2.36E-01	3.83E-01	5.45E-01	1.43E-01	1.61E-01	2.11E-01
$3R_{i2}$	4.15E-06	1.48E-06	2.88E-06	7.36E-06	2.11E-06	2.29E-06	3.34E-06	5.27E-04	3.13E-04	4.73E-04	1.35E-03	4.26E-04	3.26E-04	4.24E-04
$3R_{i3}$	1.00E+00	4.44E-01	7.78E-01	1.96E+00	6.60E-01	4.36E-01	7.30E-01	2.34E+00	1.68E+00	2.56E+00	5.04E+00	1.05E+00	1.60E+00	2.15E+00
$3M_{i1}$	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$3M_{i2}$	1.33E-03	5.03E-04	9.44E-04	2.40E-03	7.30E-04	7.23E-04	1.05E-03	3.87E-04	1.90E-04	2.40E-04	7.89E-04	3.11E-04	1.52E-04	2.68E-04
$3M_{i3}$	1.62E-04	5.76E-05	1.12E-04	2.87E-04	8.21E-05	8.92E-05	1.30E-04	2.05E-02	1.22E-02	1.85E-02	5.26E-02	1.66E-02	1.27E-02	1.65E-02
$3R_{j1}$	1.81E+00	6.78E-01	1.48E+00	3.75E+00	8.79E-01	9.05E-01	1.61E+00	2.97E-01	2.36E-01	3.83E-01	5.45E-01	1.43E-01	1.61E-01	2.11E-01
$3R_{j2}$	4.15E-06	1.48E-06	2.88E-06	7.36E-06	2.11E-06	2.29E-06	3.34E-06	5.27E-04	3.13E-04	4.73E-04	1.35E-03	4.26E-04	3.26E-04	4.24E-04
$3R_{j3}$	1.00E+00	4.44E-01	7.78E-01	1.96E+00	6.60E-01	4.36E-01	7.30E-01	2.34E+00	1.68E+00	2.56E+00	5.04E+00	1.05E+00	1.60E+00	2.15E+00
$3M_{j1}$	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$3M_{j2}$	7.80E+01	3.46E+01	6.07E+01	1.53E+02	5.15E+01	3.40E+01	5.70E+01	1.83E+02	1.31E+02	2.00E+02	3.93E+02	8.18E+01	1.25E+02	1.68E+02
$3M_{j3}$	1.62E-04	5.78E-05	1.13E-04	2.88E-04	8.23E-05	8.95E-05	1.31E-04	2.05E-02	1.22E-02	1.85E-02	5.26E-02	1.66E-02	1.27E-02	1.65E-02
$3R_{i1}$	3.35E+00	1.21E+00	2.49E+00	6.33E+00	1.69E+00	1.83E+00	2.79E+00	2.26E+00	2.15E+00	3.05E+00	5.00E+00	1.58E+00	1.57E+00	1.80E+00
$4R_{i2}$	7.41E-01	2.70E-01	5.32E-01	1.36E+00	3.85E-01	4.05E-01	6.01E-01	9.55E+00	8.89E+00	1.32E+01	2.18E+01	6.55E+00	7.02E+00	7.48E+00
$4R_{i3}$	2.88E-05	1.03E-05	2.01E-05	5.12E-05	1.47E-05	1.59E-05	2.32E-05	2.22E-05	1.31E-05	1.98E-05	5.66E-05	1.80E-05	1.36E-05	1.80E-05
$4M_{i1}$	5.56E-04	1.98E-04	3.87E-04	9.87E-04	2.83E-04	3.06E-04	4.48E-04	9.17E-05	4.49E-05	6.44E-05	1.72E-04	7.05E-05	3.67E-05	6.84E-05
$4M_{i2}$	6.34E-04	2.32E-04	4.44E-04	1.13E-03	3.34E-04	3.47E-04	5.06E-04	3.81E-03	2.25E-03	3.39E-03	9.68E-03	3.10E-03	2.32E-03	3.08E-03
$4M_{i3}$	8.99E-05	3.24E-05	6.40E-05	1.63E-04	4.53E-05	4.93E-05	7.37E-05	5.19E-03	3.11E-03	4.56E-03	1.33E-02	4.19E-03	3.14E-03	4.17E-03
$4R_{j1}$	3.35E+00	1.21E+00	2.49E+00	6.33E+00	1.69E+00	1.83E+00	2.79E+00	2.26E+00	2.15E+00	3.05E+00	5.00E+00	1.58E+00	1.57E+00	1.80E+00
$4R_{j2}$	7.41E-01	2.70E-01	5.32E-01	1.36E+00	3.85E-01	4.05E-01	6.01E-01	9.55E+00	8.89E+00	1.32E+01	2.18E+01	6.55E+00	7.02E+00	7.48E+00
$4R_{j3}$	2.88E-05	1.03E-05	2.01E-05	5.12E-05	1.47E-05	1.59E-05	2.32E-05	2.22E-05	1.31E-05	1.98E-05	5.66E-05	1.80E-05	1.36E-05	1.80E-05
$4M_{j1}$	5.56E-04	1.98E-04	3.87E-04	9.87E-04	2.83E-04	3.06E-04	4.48E-04	9.17E-05	4.49E-05	6.44E-05	1.72E-04	7.05E-05	3.67E-05	6.84E-05
$4M_{j2}$	6.23E-04	2.28E-04	4.36E-04	1.11E-03	3.28E-04	3.41E-04	4.97E-04	3.85E-03	2.27E-03	3.42E-03	9.78E-03	3.13E-03	2.34E-03	3.11E-03
$4M_{j3}$	5.93E+01	2.16E+01	4.26E+01	1.09E+02	3.09E+01	3.24E+01	4.81E+01	7.64E+02	7.12E+02	1.06E+03	1.75E+03	5.25E+02	5.62E+02	5.99E+02
$4R_{i1}$	3.74E+00	1.39E+00	3.07E+00	7.75E+00	1.84E+00	1.95E+00	3.30E+00	2.82E+00	2.29E+00	3.30E+00	5.78E+00	1.66E+00	1.61E+00	1.99E+00
$5R_{i2}$	8.05E-01	3.03E-01	6.54E-01	1.65E+00	4.06E-01	4.19E-01	7.04E-01	1.06E+01	9.79E+00	1.50E+01	2.26E+01	6.70E+00	6.36E+00	7.78E+00
$5R_{i3}$	9.63E-06	3.43E-06	6.70E-06	1.71E-05	4.89E-06	5.31E-06	7.76E-06	6.26E-06	3.71E-06	5.71E-06	1.60E-05	5.11E-06	3.92E-06	5.07E-06
$5M_{i1}$	8.34E-04	2.98E-04	5.81E-04	1.48E-03	4.24E-04	4.60E-04	6.72E-04	3.62E-03	2.18E-03	3.22E-03	9.32E-03	2.91E-03	2.24E-03	2.89E-03
$5M_{i2}$	4.94E-03	1.76E-03	3.44E-03	8.77E-03	2.51E-03	2.72E-03	3.98E-03	2.76E-03	1.59E-03	2.43E-03	6.89E-03	2.24E-03	1.66E-03	2.23E-03
$5M_{i3}$	8.70E-04	3.10E-04	6.05E-04	1.54E-03	4.43E-04	4.80E-04	7.00E-04	1.51E-02	8.96E-03	1.36E-02	3.86E-02	1.22E-02	9.41E-03	1.21E-02
$5R_{j1}$	3.74E+00	1.39E+00	3.07E+00	7.75E+00	1.84E+00	1.95E+00	3.30E+00	2.82E+00	2.29E+00	3.30E+00	5.78E+00	1.66E+00	1.61E+00	1.99E+00
$5R_{j2}$	8.05E-01	3.03E-01	6.54E-01	1.65E+00	4.06E-01	4.19E-01	7.04E-01	1.06E+01	9.79E+00	1.50E+01	2.26E+01	6.70E+00	6.36E+00	7.78E+00
$5R_{j3}$	9.63E-06	3.43E-06	6.70E-06	1.71E-05	4.89E-06	5.31E-06	7.76E-06	6.26E-06	3.71E-06	5.71E-06	1.60E-05	5.11E-06	3.92E-06	5.07E-06
$5M_{j1}$	8.34E-04	2.98E-04	5.81E-04	1.48E-03	4.24E-04	4.60E-04	6.72E-04	3.62E-03	2.18E-03	3.22E-03	9.32E-03	2.91E-03	2.24E-03	2.89E-03
$5M_{j2}$	2.51E-03	8.95E-04	1.75E-03	4.46E-03	1.28E-03	1.38E-03	2.02E-03	2.77E-03	1.63E-03	2.47E-03	7.02E-03	2.24E-03	1.69E-03	2.23E-03
$5M_{j3}$	6.45E+01	2.42E+01	5.23E+01	1.32E+02	3.25E+01	3.35E+01	5.64E+01	8.48E+02	7.84E+02	1.20E+03	1.81E+03	5.37E+02	5.09E+02	6.23E+02

Table 3.4.12 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$6R_{i1}$	1.14E-01	5.36E-02	8.32E-02	2.13E-01	8.15E-02	5.14E-02	7.87E-02	8.49E+00	5.99E+00	9.38E+00	1.41E+01	4.11E+00	4.75E+00	4.68E+00
$6R_{i2}$	1.26E-04	4.49E-05	8.76E-05	2.24E-04	6.41E-05	6.94E-05	1.01E-04	5.93E-05	2.95E-05	4.31E-05	1.12E-04	4.60E-05	2.44E-05	4.52E-05
$6R_{i3}$	5.46E-01	2.20E-01	4.43E-01	1.12E+00	3.08E-01	2.71E-01	4.56E-01	1.24E+00	8.44E-01	1.21E+00	2.43E+00	4.77E-01	7.36E-01	8.27E-01
$6M_{i1}$	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$6M_{i2}$	3.13E-05	1.13E-05	2.16E-05	5.48E-05	1.58E-05	1.80E-05	2.56E-05	7.08E-03	4.48E-03	5.46E-03	1.84E-02	5.51E-03	4.43E-03	5.60E-03
$6M_{i3}$	6.41E-04	2.39E-04	4.52E-04	1.15E-03	3.47E-04	3.48E-04	5.08E-04	5.39E-04	2.68E-04	3.90E-04	1.02E-03	4.18E-04	2.22E-04	4.10E-04
$6Rj_1$	1.14E-01	5.36E-02	8.32E-02	2.13E-01	8.15E-02	5.14E-02	7.87E-02	8.49E+00	5.99E+00	9.38E+00	1.41E+01	4.11E+00	4.75E+00	4.68E+00
$6Rj_2$	1.26E-04	4.49E-05	8.76E-05	2.24E-04	6.41E-05	6.94E-05	1.01E-04	5.93E-05	2.95E-05	4.31E-05	1.12E-04	4.60E-05	2.44E-05	4.52E-05
$6Rj_3$	5.46E-01	2.20E-01	4.43E-01	1.12E+00	3.08E-01	2.71E-01	4.56E-01	1.24E+00	8.44E-01	1.21E+00	2.43E+00	4.77E-01	7.36E-01	8.27E-01
$6Mj_1$	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$6Mj_2$	9.82E+00	3.96E+00	7.97E+00	2.01E+01	5.54E+00	4.87E+00	8.20E+00	2.24E+01	1.52E+01	2.18E+01	4.37E+01	8.59E+00	1.33E+01	1.49E+01
$6Mj_3$	2.88E-03	1.03E-03	2.00E-03	5.11E-03	1.46E-03	1.59E-03	2.32E-03	5.29E-04	2.62E-04	3.83E-04	9.92E-04	4.09E-04	2.18E-04	4.02E-04
$7R_{i1}$	1.69E+00	7.29E-01	1.45E+00	3.65E+00	1.02E+00	8.02E-01	1.44E+00	3.46E+00	7.04E-01	1.41E+00	4.46E+00	3.76E-01	7.85E-01	1.88E+00
$7R_{i2}$	8.27E-08	2.95E-08	5.75E-08	1.47E-07	4.20E-08	4.57E-08	6.67E-08	5.88E-05	3.52E-05	5.32E-05	1.51E-04	4.73E-05	3.72E-05	4.70E-05
$7R_{i3}$	2.93E-01	1.29E-01	2.06E-01	5.19E-01	2.00E-01	1.34E-01	1.91E-01	6.82E-01	3.60E-01	5.70E-01	1.20E+00	2.07E-01	2.88E-01	4.27E-01
$7M_{i1}$	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$7M_{i2}$	4.92E-03	1.75E-03	3.43E-03	8.75E-03	2.50E-03	2.71E-03	3.97E-03	2.43E-05	1.61E-05	1.97E-05	6.21E-05	1.79E-05	1.61E-05	1.88E-05
$7M_{i3}$	8.24E-06	2.94E-06	5.71E-06	1.46E-05	4.19E-06	4.57E-06	6.64E-06	5.73E-04	2.87E-04	4.21E-04	1.06E-03	4.29E-04	2.43E-04	4.18E-04
$7Rj_1$	1.69E+00	7.29E-01	1.45E+00	3.65E+00	1.02E+00	8.02E-01	1.44E+00	3.46E+00	7.04E-01	1.41E+00	4.46E+00	3.76E-01	7.85E-01	1.88E+00
$7Rj_2$	8.27E-08	2.95E-08	5.75E-08	1.47E-07	4.20E-08	4.57E-08	6.67E-08	5.88E-05	3.52E-05	5.32E-05	1.51E-04	4.73E-05	3.72E-05	4.70E-05
$7Rj_3$	2.93E-01	1.29E-01	2.06E-01	5.19E-01	2.00E-01	1.34E-01	1.91E-01	6.82E-01	3.60E-01	5.70E-01	1.20E+00	2.07E-01	2.88E-01	4.27E-01
$7Mj_1$	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$7Mj_2$	5.80E+01	2.56E+01	4.09E+01	1.03E+02	3.95E+01	2.66E+01	3.79E+01	1.35E+02	7.14E+01	1.13E+02	2.38E+02	4.10E+01	5.71E+01	8.45E+01
$7M_{j3}$	8.13E-06	2.90E-06	5.67E-06	1.45E-05	4.13E-06	4.48E-06	6.56E-06	1.19E-02	7.05E-03	1.06E-02	3.03E-02	9.63E-03	7.30E-03	9.58E-03

Table 3.4.13 Maximum element forces and moments for S-component (group#3) of benchmark problem #4a and #4b.

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$1R_{i1}$	8.30E-02	3.45E-02	5.84E-02	1.57E-01	5.10E-02	3.64E-02	6.14E-02	7.09E+00	5.19E+00	8.92E+00	1.71E+01	5.57E+00	6.92E+00	5.74E+00
$1R_{i2}$	7.96E-01	3.02E-01	5.49E-01	1.39E+00	4.43E-01	4.23E-01	6.16E-01	2.91E-01	1.97E-01	3.02E-01	4.24E-01	1.23E-01	1.52E-01	1.98E-01
$1R_{i3}$	2.47E-01	1.15E-01	1.76E-01	4.43E-01	1.80E-01	1.03E-01	1.49E-01	1.11E+00	7.57E-01	1.12E+00	1.75E+00	4.38E-01	5.81E-01	7.04E-01
$1M_{i1}$	1.97E+01	7.57E+00	1.77E+01	4.46E+01	9.27E+00	9.39E+00	1.86E+01	4.90E+00	3.67E+00	4.77E+00	9.36E+00	2.41E+00	3.66E+00	4.01E+00
$1M_{i2}$	1.43E+01	6.63E+00	1.02E+01	2.57E+01	1.03E+01	5.95E+00	8.73E+00	7.76E+01	5.84E+01	8.54E+01	1.30E+02	3.35E+01	4.60E+01	5.22E+01
$1M_{i3}$	4.72E+01	1.80E+01	3.25E+01	8.24E+01	2.65E+01	2.50E+01	3.64E+01	2.09E+01	1.48E+01	2.31E+01	3.21E+01	9.39E+00	1.13E+01	1.35E+01
$1Rj_1$	8.30E-02	3.45E-02	5.84E-02	1.57E-01	5.10E-02	3.64E-02	6.14E-02	7.09E+00	5.19E+00	8.92E+00	1.71E+01	5.57E+00	6.92E+00	5.74E+00
$1Rj_2$	7.96E-01	3.02E-01	5.49E-01	1.39E+00	4.43E-01	4.23E-01	6.16E-01	2.91E-01	1.97E-01	3.02E-01	4.24E-01	1.23E-01	1.52E-01	1.98E-01
$1Rj_3$	2.47E-01	1.15E-01	1.76E-01	4.43E-01	1.80E-01	1.03E-01	1.49E-01	1.11E+00	7.57E-01	1.12E+00	1.75E+00	4.38E-01	5.81E-01	7.04E-01
$1Mj_1$	1.97E+01	7.57E+00	1.77E+01	4.46E+01	9.27E+00	9.39E+00	1.86E+01	4.90E+00	3.67E+00	4.77E+00	9.36E+00	2.41E+00	3.66E+00	4.01E+00
$1Mj_2$	5.54E+00	2.60E+00	3.95E+00	9.91E+00	4.06E+00	2.32E+00	3.32E+00	1.13E+01	3.92E+00	6.33E+00	1.85E+01	2.87E+00	3.89E+00	7.83E+00
$1Mj_3$	1.67E+01	6.26E+00	1.16E+01	2.95E+01	9.08E+00	8.92E+00	1.31E+01	2.77E+00	9.13E-01	1.28E+00	4.32E+00	4.95E-01	1.04E+00	2.34E+00
$2R_{i1}$	8.25E-02	3.42E-02	5.80E-02	1.57E-01	5.06E-02	3.62E-02	6.11E-02	6.03E+00	4.45E+00	7.39E+00	1.27E+01	4.25E+00	5.76E+00	4.49E+00
$2R_{i2}$	2.13E-01	8.60E-02	1.54E-01	3.87E-01	1.27E-01	1.08E-01	1.63E-01	2.14E-01	1.74E-01	2.72E-01	3.75E-01	1.10E-01	1.28E-01	1.37E-01
$2R_{i3}$	5.71E-02	2.41E-02	4.24E-02	1.11E-01	3.59E-02	2.36E-02	4.16E-02	8.42E-01	7.08E-01	1.00E+00	1.54E+00	4.03E-01	6.21E-01	5.91E-01
$2M_{i1}$	1.97E+01	7.57E+00	1.77E+01	4.46E+01	9.27E+00	9.39E+00	1.86E+01	4.90E+00	3.67E+00	4.77E+00	9.36E+00	2.41E+00	3.66E+00	4.01E+00
$2M_{i2}$	5.54E+00	2.60E+00	3.95E+00	9.91E+00	4.06E+00	2.32E+00	3.32E+00	1.13E+01	3.92E+00	6.33E+00	1.85E+01	2.87E+00	3.89E+00	7.83E+00
$2M_{i3}$	1.67E+01	6.26E+00	1.16E+01	2.95E+01	9.08E+00	8.92E+00	1.31E+01	2.77E+00	9.13E-01	1.28E+00	4.32E+00	4.95E-01	1.04E+00	2.34E+00
$2Rj_1$	8.25E-02	3.42E-02	5.80E-02	1.57E-01	5.06E-02	3.62E-02	6.11E-02	6.03E+00	4.45E+00	7.39E+00	1.27E+01	4.25E+00	5.76E+00	4.49E+00
$2Rj_2$	2.13E-01	8.60E-02	1.54E-01	3.87E-01	1.27E-01	1.08E-01	1.63E-01	2.14E-01	1.74E-01	2.72E-01	3.75E-01	1.10E-01	1.28E-01	1.37E-01
$2Rj_3$	5.71E-02	2.41E-02	4.24E-02	1.11E-01	3.59E-02	2.36E-02	4.16E-02	8.42E-01	7.08E-01	1.00E+00	1.54E+00	4.03E-01	6.21E-01	5.91E-01
$2Mj_1$	1.97E+01	7.57E+00	1.77E+01	4.46E+01	9.27E+00	9.39E+00	1.86E+01	4.90E+00	3.67E+00	4.77E+00	9.36E+00	2.41E+00	3.66E+00	4.01E+00
$2Mj_2$	9.45E+00	4.32E+00	6.76E+00	1.72E+01	6.69E+00	3.92E+00	5.95E+00	7.26E+01	5.88E+01	8.43E+01	1.28E+02	3.35E+01	4.91E+01	5.07E+01
$2Mj_3$	3.21E+01	1.25E+01	2.22E+01	5.62E+01	1.84E+01	1.68E+01	2.45E+01	1.95E+01	1.46E+01	2.29E+01	3.17E+01	9.29E+00	1.10E+01	1.25E+01
$3R_{i1}$	8.15E-02	3.37E-02	5.72E-02	1.55E-01	4.97E-02	3.58E-02	6.05E-02	5.00E+00	3.78E+00	5.86E+00	8.52E+00	3.01E+00	4.59E+00	3.53E+00
$3R_{i2}$	5.09E-01	1.94E-01	3.67E-01	9.29E-01	2.77E-01	2.65E-01	4.07E-01	1.79E-01	1.43E-01	2.18E-01	3.48E-01	8.60E-02	1.04E-01	1.43E-01
$3R_{i3}$	2.08E-01	9.76E-02	1.50E-01	3.76E-01	1.52E-01	8.77E-02	1.27E-01	8.52E-01	5.77E-01	8.22E-01	1.46E+00	3.26E-01	5.33E-01	5.49E-01
$3M_{i1}$	1.97E+01	7.57E+00	1.77E+01	4.46E+01	9.27E+00	9.39E+00	1.86E+01	4.90E+00	3.67E+00	4.77E+00	9.36E+00	2.41E+00	3.66E+00	4.01E+00
$3M_{i2}$	9.45E+00	4.32E+00	6.76E+00	1.72E+01	6.69E+00	3.92E+00	5.95E+00	7.26E+01	5.88E+01	8.43E+01	1.28E+02	3.35E+01	4.91E+01	5.07E+01
$3M_{i3}$	3.21E+01	1.25E+01	2.22E+01	5.62E+01	1.84E+01	1.68E+01	2.45E+01	1.95E+01	1.46E+01	2.29E+01	3.17E+01	9.29E+00	1.10E+01	1.25E+01
$3Rj_1$	8.15E-02	3.37E-02	5.72E-02	1.55E-01	4.97E-02	3.58E-02	6.05E-02	5.00E+00	3.78E+00	5.86E+00	8.52E+00	3.01E+00	4.59E+00	3.53E+00
$3Rj_2$	5.09E-01	1.94E-01	3.67E-01	9.29E-01	2.77E-01	2.65E-01	4.07E-01	1.79E-01	1.43E-01	2.18E-01	3.48E-01	8.60E-02	1.04E-01	1.43E-01
$3Rj_3$	2.08E-01	9.76E-02	1.50E-01	3.76E-01	1.52E-01	8.77E-02	1.27E-01	8.52E-01	5.77E-01	8.22E-01	1.46E+00	3.26E-01	5.33E-01	5.49E-01
$3Mj_1$	1.97E+01	7.57E+00	1.77E+01	4.46E+01	9.27E+00	9.39E+00	1.86E+01	4.90E+00	3.67E+00	4.77E+00	9.36E+00	2.41E+00	3.66E+00	4.01E+00
$3Mj_2$	9.40E+00	4.15E+00	7.18E+00	1.83E+01	6.20E+00	4.03E+00	6.76E+00	1.14E+02	1.05E+02	1.47E+02	2.38E+02	5.95E+01	9.12E+01	8.76E+01
$3Mj_3$	1.93E+01	7.34E+00	1.67E+01	4.23E+01	9.14E+00	9.25E+00	1.78E+01	2.90E+01	2.57E+01	4.01E+01	5.61E+01	1.62E+01	1.85E+01	1.85E+01

Table 3.4.13 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$4R_{i1}$	8.05E-02	3.32E-02	5.65E-02	1.53E-01	4.89E-02	3.54E-02	5.99E-02	4.31E+00	3.59E+00	5.17E+00	7.77E+00	2.36E+00	3.80E+00	3.05E+00
$4R_{i2}$	8.19E-01	3.58E-01	6.52E-01	1.65E+00	5.22E-01	3.61E-01	6.27E-01	2.05E+00	1.11E+00	1.78E+00	4.06E+00	7.24E-01	1.07E+00	1.66E+00
$4R_{i3}$	1.20E+00	4.59E-01	1.05E+00	2.66E+00	5.68E-01	5.73E-01	1.12E+00	2.23E-01	1.28E-01	2.16E-01	3.27E-01	7.34E-02	1.13E-01	2.09E-01
$4M_{i1}$	1.97E+01	7.57E+00	1.77E+01	4.46E+01	9.27E+00	9.39E+00	1.86E+01	4.90E+00	3.67E+00	4.77E+00	9.36E+00	2.41E+00	3.66E+00	4.01E+00
$4M_{i2}$	1.93E+01	7.34E+00	1.67E+01	4.23E+01	9.14E+00	9.25E+00	1.78E+01	2.90E+01	2.57E+01	4.01E+01	5.61E+01	1.62E+01	1.85E+01	1.85E+01
$4M_{i3}$	9.40E+00	4.15E+00	7.18E+00	1.83E+01	6.20E+00	4.03E+00	6.76E+00	1.14E+02	1.05E+02	1.47E+02	2.38E+02	5.95E+01	9.12E+01	8.76E+01
$4R_{C1}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$4R_{C2}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$4R_{C3}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$4M_{C1}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$4M_{C2}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$4M_{C3}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$4R_{j1}$	8.19E-01	3.58E-01	6.52E-01	1.65E+00	5.22E-01	3.61E-01	6.27E-01	2.05E+00	1.11E+00	1.78E+00	4.06E+00	7.24E-01	1.07E+00	1.66E+00
$4R_{j2}$	8.05E-02	3.32E-02	5.65E-02	1.53E-01	4.89E-02	3.54E-02	5.99E-02	4.31E+00	3.59E+00	5.17E+00	7.77E+00	2.36E+00	3.80E+00	3.05E+00
$4R_{j3}$	1.20E+00	4.59E-01	1.05E+00	2.66E+00	5.68E-01	5.73E-01	1.12E+00	2.23E-01	1.28E-01	2.16E-01	3.27E-01	7.34E-02	1.13E-01	2.09E-01
$4M_{j1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$4M_{j2}$	7.59E+00	2.74E+00	5.23E+00	1.34E+01	3.95E+00	4.18E+00	6.04E+00	5.18E+00	3.97E+00	6.10E+00	9.11E+00	2.46E+00	3.08E+00	3.06E+00
$4M_{j3}$	4.89E+00	2.03E+00	4.07E+00	1.04E+01	2.80E+00	2.21E+00	4.12E+00	2.80E+01	2.66E+01	3.64E+01	6.59E+01	1.66E+01	1.90E+01	2.19E+01
$5R_{i1}$	8.03E-01	3.51E-01	6.40E-01	1.62E+00	5.13E-01	3.54E-01	6.14E-01	1.93E+00	9.94E-01	1.62E+00	3.77E+00	6.57E-01	9.69E-01	1.56E+00
$5R_{i2}$	9.88E-01	3.81E-01	8.90E-01	2.25E+00	4.64E-01	4.67E-01	9.35E-01	1.75E-01	1.01E-01	1.70E-01	2.39E-01	6.37E-02	1.04E-01	1.54E-01
$5R_{i3}$	8.25E-02	3.59E-02	6.08E-02	1.59E-01	5.32E-02	3.70E-02	6.08E-02	3.48E+00	3.29E+00	4.60E+00	7.15E+00	1.83E+00	2.85E+00	2.50E+00
$5M_{i1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$5M_{i2}$	4.89E+00	2.03E+00	4.07E+00	1.04E+01	2.80E+00	2.21E+00	4.12E+00	2.80E+01	2.66E+01	3.64E+01	6.59E+01	1.66E+01	1.90E+01	2.19E+01
$5M_{i3}$	7.59E+00	2.74E+00	5.23E+00	1.34E+01	3.95E+00	4.18E+00	6.04E+00	5.18E+00	3.97E+00	6.10E+00	9.11E+00	2.46E+00	3.08E+00	3.06E+00
$5R_{j1}$	8.03E-01	3.51E-01	6.40E-01	1.62E+00	5.13E-01	3.54E-01	6.14E-01	1.93E+00	9.94E-01	1.62E+00	3.77E+00	6.57E-01	9.69E-01	1.56E+00
$5R_{j2}$	9.88E-01	3.81E-01	8.90E-01	2.25E+00	4.64E-01	4.67E-01	9.35E-01	1.75E-01	1.01E-01	1.70E-01	2.39E-01	6.37E-02	1.04E-01	1.54E-01
$5R_{j3}$	8.25E-02	3.59E-02	6.08E-02	1.59E-01	5.32E-02	3.70E-02	6.08E-02	3.48E+00	3.29E+00	4.60E+00	7.15E+00	1.83E+00	2.85E+00	2.50E+00
$5M_{j1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$5M_{j2}$	5.12E+00	1.93E+00	3.10E+00	9.25E+00	2.90E+00	1.98E+00	3.64E+00	2.82E+02	2.56E+02	3.60E+02	5.61E+02	1.41E+02	2.36E+02	1.98E+02
$5M_{j3}$	8.42E+01	3.24E+01	7.56E+01	1.91E+02	3.95E+01	3.97E+01	7.96E+01	1.47E+01	1.10E+01	1.84E+01	2.53E+01	6.55E+00	8.11E+00	1.42E+01

Table 3.4.13 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$6R_{i1}$	7.73E-01	3.39E-01	6.19E-01	1.56E+00	4.95E-01	3.41E-01	5.92E-01	1.75E+00	8.39E-01	1.38E+00	3.30E+00	5.56E-01	8.13E-01	1.41E+00
$6R_{i2}$	6.53E-01	2.38E-01	5.04E-01	1.28E+00	3.27E-01	3.51E-01	5.56E-01	1.46E-01	5.17E-02	9.06E-02	2.03E-01	3.98E-02	6.63E-02	1.11E-01
$6R_{i3}$	5.00E-02	1.95E-02	4.02E-02	1.04E-01	2.57E-02	2.33E-02	4.33E-02	2.16E+00	2.00E+00	2.98E+00	4.67E+00	1.29E+00	1.34E+00	1.58E+00
$6M_{i1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$6M_{i2}$	5.12E+00	1.93E+00	3.10E+00	9.25E+00	2.90E+00	1.98E+00	3.64E+00	2.82E+02	2.56E+02	3.60E+02	5.61E+02	1.41E+02	2.36E+02	1.98E+02
$6M_{i3}$	8.42E+01	3.24E+01	7.56E+01	1.91E+02	3.95E+01	3.97E+01	7.96E+01	1.47E+01	1.10E+01	1.84E+01	2.53E+01	6.55E+00	8.11E+00	1.42E+01
$6R_{j1}$	7.73E-01	3.39E-01	6.19E-01	1.56E+00	4.95E-01	3.41E-01	5.92E-01	1.75E+00	8.39E-01	1.38E+00	3.30E+00	5.56E-01	8.13E-01	1.41E+00
$6R_{j2}$	6.53E-01	2.38E-01	5.04E-01	1.28E+00	3.27E-01	3.51E-01	5.56E-01	1.46E-01	5.17E-02	9.06E-02	2.03E-01	3.98E-02	6.63E-02	1.11E-01
$6R_{j3}$	5.00E-02	1.95E-02	4.02E-02	1.04E-01	2.57E-02	2.33E-02	4.33E-02	2.16E+00	2.00E+00	2.98E+00	4.67E+00	1.29E+00	1.34E+00	1.58E+00
$6M_{j1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$6M_{j2}$	4.86E+00	1.90E+00	3.55E+00	9.31E+00	2.55E+00	2.51E+00	4.06E+00	4.18E+02	4.01E+02	5.88E+02	8.54E+02	2.36E+02	2.95E+02	3.09E+02
$6M_{j3}$	1.23E+02	4.71E+01	1.09E+02	2.75E+02	5.87E+01	6.04E+01	1.15E+02	1.41E+01	1.21E+01	2.06E+01	2.30E+01	7.95E+00	1.15E+01	1.26E+01
$7R_{i1}$	7.38E-01	3.24E-01	5.94E-01	1.50E+00	4.72E-01	3.27E-01	5.69E-01	1.56E+00	6.96E-01	1.16E+00	2.83E+00	4.53E-01	6.57E-01	1.24E+00
$7R_{i2}$	9.38E-01	3.34E-01	6.45E-01	1.66E+00	4.80E-01	5.13E-01	7.53E-01	1.87E-01	7.23E-02	1.46E-01	3.51E-01	4.66E-02	6.69E-02	1.89E-01
$7R_{i3}$	1.02E-01	4.29E-02	6.97E-02	1.92E-01	6.55E-02	4.00E-02	7.07E-02	3.34E+00	1.86E+00	2.22E+00	7.44E+00	2.19E+00	1.82E+00	2.07E+00
$7M_{i1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$7M_{i2}$	4.86E+00	1.90E+00	3.55E+00	9.31E+00	2.55E+00	2.51E+00	4.06E+00	4.18E+02	4.01E+02	5.88E+02	8.54E+02	2.36E+02	2.95E+02	3.09E+02
$7M_{i3}$	1.23E+02	4.71E+01	1.09E+02	2.75E+02	5.87E+01	6.04E+01	1.15E+02	1.41E+01	1.21E+01	2.06E+01	2.30E+01	7.95E+00	1.15E+01	1.26E+01
$7R_{j1}$	7.38E-01	3.24E-01	5.94E-01	1.50E+00	4.72E-01	3.27E-01	5.69E-01	1.56E+00	6.96E-01	1.16E+00	2.83E+00	4.53E-01	6.57E-01	1.24E+00
$7R_{j2}$	9.38E-01	3.34E-01	6.45E-01	1.66E+00	4.80E-01	5.13E-01	7.53E-01	1.87E-01	7.23E-02	1.46E-01	3.51E-01	4.66E-02	6.69E-02	1.89E-01
$7R_{j3}$	1.02E-01	4.29E-02	6.97E-02	1.92E-01	6.55E-02	4.00E-02	7.07E-02	3.34E+00	1.86E+00	2.22E+00	7.44E+00	2.19E+00	1.82E+00	2.07E+00
$7M_{j1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$7M_{j2}$	8.32E+00	3.45E+00	6.53E+00	1.68E+01	4.78E+00	4.03E+00	6.87E+00	4.95E+02	4.64E+02	6.93E+02	1.06E+03	2.99E+02	3.02E+02	3.61E+02
$7M_{j3}$	1.53E+02	5.61E+01	1.20E+02	3.05E+02	7.61E+01	8.15E+01	1.32E+02	2.16E+01	1.10E+01	1.87E+01	2.66E+01	7.94E+00	1.32E+01	1.60E+01
$8R_{i1}$	7.00E-01	3.07E-01	5.67E-01	1.43E+00	4.45E-01	3.12E-01	5.44E-01	1.35E+00	5.51E-01	9.30E-01	2.34E+00	3.50E-01	5.00E-01	1.07E+00
$8R_{i2}$	2.57E+00	9.54E-01	2.10E+00	5.31E+00	1.26E+00	1.34E+00	2.27E+00	4.19E-01	2.07E-01	3.47E-01	4.81E-01	1.42E-01	2.31E-01	2.72E-01
$8R_{i3}$	1.25E-01	5.54E-02	9.97E-02	2.49E-01	7.85E-02	6.31E-02	1.00E-01	8.34E+00	7.75E+00	1.17E+01	1.76E+01	4.91E+00	4.85E+00	5.82E+00
$8M_{i1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$8M_{i2}$	8.32E+00	3.45E+00	6.53E+00	1.68E+01	4.78E+00	4.03E+00	6.87E+00	4.95E+02	4.64E+02	6.93E+02	1.06E+03	2.99E+02	3.02E+02	3.61E+02
$8M_{i3}$	1.53E+02	5.61E+01	1.20E+02	3.05E+02	7.61E+01	8.15E+01	1.32E+02	2.16E+01	1.10E+01	1.87E+01	2.66E+01	7.94E+00	1.32E+01	1.60E+01
$8R_{j1}$	7.00E-01	3.07E-01	5.67E-01	1.43E+00	4.45E-01	3.12E-01	5.44E-01	1.35E+00	5.51E-01	9.30E-01	2.34E+00	3.50E-01	5.00E-01	1.07E+00
$8R_{j2}$	2.57E+00	9.54E-01	2.10E+00	5.31E+00	1.26E+00	1.34E+00	2.27E+00	4.19E-01	2.07E-01	3.47E-01	4.81E-01	1.42E-01	2.31E-01	2.72E-01
$8R_{j3}$	1.25E-01	5.54E-02	9.97E-02	2.49E-01	7.85E-02	6.31E-02	1.00E-01	8.34E+00	7.75E+00	1.17E+01	1.76E+01	4.91E+00	4.85E+00	5.82E+00
$8M_{j1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$8M_{j2}$	3.52E+00	1.59E+00	2.53E+00	6.65E+00	2.40E+00	1.62E+00	2.52E+00	2.08E+02	1.94E+02	2.93E+02	4.21E+02	1.17E+02	1.37E+02	1.62E+02
$8M_{j3}$	6.78E+01	2.57E+01	5.89E+01	1.49E+02	3.25E+01	3.36E+01	6.24E+01	1.97E+01	8.10E+00	1.51E+01	2.18E+01	5.01E+00	7.08E+00	1.55E+01

Table 3.4.13 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$9R_{i1}$	6.59E-01	2.87E-01	5.37E-01	1.35E+00	4.14E-01	2.96E-01	5.18E-01	1.14E+00	4.04E-01	7.02E-01	1.85E+00	2.61E-01	3.54E-01	8.88E-01
$9R_{i2}$	1.54E+00	5.72E-01	1.26E+00	3.20E+00	7.55E-01	8.01E-01	1.36E+00	1.89E-01	1.23E-01	2.05E-01	2.71E-01	8.33E-02	1.34E-01	1.64E-01
$9R_{i3}$	6.73E-02	2.57E-02	5.33E-02	1.37E-01	3.21E-02	3.49E-02	5.99E-02	5.20E+00	4.89E+00	7.32E+00	1.08E+01	3.00E+00	2.98E+00	3.70E+00
$9M_{i1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$9M_{i2}$	3.52E+00	1.59E+00	2.53E+00	6.65E+00	2.40E+00	1.62E+00	2.52E+00	2.08E+02	1.94E+02	2.93E+02	4.21E+02	1.17E+02	1.37E+02	1.62E+02
$9M_{i3}$	6.78E+01	2.57E+01	5.89E+01	1.49E+02	3.25E+01	3.36E+01	6.24E+01	1.97E+01	8.10E+00	1.51E+01	2.18E+01	5.01E+00	7.08E+00	1.55E+01
$9Rj_1$	6.59E-01	2.87E-01	5.37E-01	1.35E+00	4.14E-01	2.96E-01	5.18E-01	1.14E+00	4.04E-01	7.02E-01	1.85E+00	2.61E-01	3.54E-01	8.88E-01
$9Rj_2$	1.54E+00	5.72E-01	1.26E+00	3.20E+00	7.55E-01	8.01E-01	1.36E+00	1.89E-01	1.23E-01	2.05E-01	2.71E-01	8.33E-02	1.34E-01	1.64E-01
$9Rj_3$	6.73E-02	2.57E-02	5.33E-02	1.37E-01	3.21E-02	3.49E-02	5.99E-02	5.20E+00	4.89E+00	7.32E+00	1.08E+01	3.00E+00	2.98E+00	3.70E+00
$9Mj_1$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$9Mj_2$	7.31E+00	3.03E+00	5.89E+00	1.47E+01	3.97E+00	4.00E+00	6.39E+00	6.43E+02	6.00E+02	9.07E+02	1.32E+03	3.67E+02	3.82E+02	4.45E+02
$9Mj_3$	1.95E+02	7.31E+01	1.64E+02	4.14E+02	9.49E+01	1.00E+02	1.76E+02	2.21E+01	1.68E+01	2.75E+01	2.61E+01	1.18E+01	1.68E+01	1.53E+01
$10R_{i1}$	6.16E-01	2.66E-01	5.06E-01	1.27E+00	3.81E-01	2.80E-01	4.92E-01	9.11E-01	2.57E-01	4.74E-01	1.34E+00	1.85E-01	2.33E-01	7.01E-01
$10R_{i2}$	1.82E-01	7.17E-02	1.52E-01	3.88E-01	9.52E-02	8.47E-02	1.61E-01	2.69E-01	4.97E-02	8.53E-02	3.68E-01	2.86E-02	6.38E-02	1.86E-01
$10R_{i3}$	6.74E-02	3.39E-02	5.17E-02	1.30E-01	5.26E-02	3.01E-02	4.36E-02	6.66E-01	1.53E-01	3.15E-01	9.62E-01	1.20E-01	2.08E-01	4.78E-01
$10M_{i1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$10M_{i2}$	7.31E+00	3.03E+00	5.89E+00	1.47E+01	3.97E+00	4.00E+00	6.39E+00	6.43E+02	6.00E+02	9.07E+02	1.32E+03	3.67E+02	3.82E+02	4.45E+02
$10M_{i3}$	1.95E+02	7.31E+01	1.64E+02	4.14E+02	9.49E+01	1.00E+02	1.76E+02	2.21E+01	1.68E+01	2.75E+01	2.61E+01	1.18E+01	1.68E+01	1.53E+01
$10Rj_1$	6.16E-01	2.66E-01	5.06E-01	1.27E+00	3.81E-01	2.80E-01	4.92E-01	9.11E-01	2.57E-01	4.74E-01	1.34E+00	1.85E-01	2.33E-01	7.01E-01
$10Rj_2$	1.82E-01	7.17E-02	1.52E-01	3.88E-01	9.52E-02	8.47E-02	1.61E-01	2.69E-01	4.97E-02	8.53E-02	3.68E-01	2.86E-02	6.38E-02	1.86E-01
$10Rj_3$	6.74E-02	3.39E-02	5.17E-02	1.30E-01	5.26E-02	3.01E-02	4.36E-02	6.66E-01	1.53E-01	3.15E-01	9.62E-01	1.20E-01	2.08E-01	4.78E-01
$10Mj_1$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$10Mj_2$	7.49E+00	3.00E+00	6.06E+00	1.52E+01	3.80E+00	4.07E+00	6.69E+00	6.36E+02	5.96E+02	8.91E+02	1.30E+03	3.61E+02	3.68E+02	4.51E+02
$10Mj_3$	1.83E+02	6.83E+01	1.53E+02	3.86E+02	8.90E+01	9.40E+01	1.64E+02	2.65E+01	1.54E+01	2.63E+01	3.42E+01	1.06E+01	1.57E+01	1.78E+01
$11R_{i1}$	5.73E-01	2.44E-01	4.74E-01	1.19E+00	3.46E-01	2.65E-01	4.67E-01	6.81E-01	1.59E-01	3.10E-01	9.73E-01	1.14E-01	1.94E-01	5.08E-01
$11R_{i2}$	1.77E+00	6.62E-01	1.48E+00	3.75E+00	8.60E-01	9.07E-01	1.59E+00	2.53E-01	1.53E-01	2.56E-01	3.55E-01	1.08E-01	1.50E-01	1.79E-01
$11R_{i3}$	5.82E-02	2.31E-02	4.59E-02	1.16E-01	2.93E-02	3.18E-02	5.15E-02	5.30E+00	4.99E+00	7.58E+00	1.11E+01	3.08E+00	3.17E+00	3.74E+00
$11M_{i1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$11M_{i2}$	7.49E+00	3.00E+00	6.06E+00	1.52E+01	3.80E+00	4.07E+00	6.69E+00	6.36E+02	5.96E+02	8.91E+02	1.30E+03	3.61E+02	3.68E+02	4.51E+02
$11M_{i3}$	1.83E+02	6.83E+01	1.53E+02	3.86E+02	8.90E+01	9.40E+01	1.64E+02	2.65E+01	1.54E+01	2.63E+01	3.42E+01	1.06E+01	1.57E+01	1.78E+01
$11Rj_1$	5.73E-01	2.44E-01	4.74E-01	1.19E+00	3.46E-01	2.65E-01	4.67E-01	6.81E-01	1.59E-01	3.10E-01	9.73E-01	1.14E-01	1.94E-01	5.08E-01
$11Rj_2$	1.77E+00	6.62E-01	1.48E+00	3.75E+00	8.60E-01	9.07E-01	1.59E+00	2.53E-01	1.53E-01	2.56E-01	3.55E-01	1.08E-01	1.50E-01	1.79E-01
$11Rj_3$	5.82E-02	2.31E-02	4.59E-02	1.16E-01	2.93E-02	3.18E-02	5.15E-02	5.30E+00	4.99E+00	7.58E+00	1.11E+01	3.08E+00	3.17E+00	3.74E+00
$11Mj_1$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$11Mj_2$	4.57E+00	2.14E+00	3.59E+00	9.02E+00	3.18E+00	2.17E+00	3.40E+00	1.98E+02	1.77E+02	2.59E+02	3.73E+02	1.05E+02	1.09E+02	1.37E+02
$11Mj_3$	3.47E+01	1.29E+01	2.84E+01	7.19E+01	1.71E+01	1.80E+01	3.06E+01	8.99E+00	3.81E+00	6.44E+00	1.44E+01	2.55E+00	3.93E+00	1.01E+01

Table 3.4.13 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$12R_{i1}$	5.33E-01	2.22E-01	4.44E-01	1.12E+00	3.11E-01	2.52E-01	4.45E-01	4.66E-01	2.39E-01	3.53E-01	9.06E-01	1.36E-01	2.22E-01	3.70E-01
$12R_{i2}$	2.66E+00	9.94E-01	2.21E+00	5.59E+00	1.30E+00	1.37E+00	2.38E+00	4.87E-01	2.25E-01	3.97E-01	6.22E-01	1.54E-01	2.32E-01	3.10E-01
$12R_{i3}$	1.17E-01	5.15E-02	9.23E-02	2.33E-01	7.26E-02	6.01E-02	9.48E-02	8.34E+00	7.84E+00	1.18E+01	1.75E+01	4.84E+00	4.85E+00	6.05E+00
$12M_{i1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$12M_{i2}$	4.57E+00	2.14E+00	3.59E+00	9.02E+00	3.18E+00	2.17E+00	3.40E+00	1.98E+02	1.77E+02	2.59E+02	3.73E+02	1.05E+02	1.09E+02	1.37E+02
$12M_{i3}$	3.47E+01	1.29E+01	2.84E+01	7.19E+01	1.71E+01	1.80E+01	3.06E+01	8.99E+00	3.81E+00	6.44E+00	1.44E+01	2.55E+00	3.93E+00	1.01E+01
$12R_{j1}$	5.33E-01	2.22E-01	4.44E-01	1.12E+00	3.11E-01	2.52E-01	4.45E-01	4.66E-01	2.39E-01	3.53E-01	9.06E-01	1.36E-01	2.22E-01	3.70E-01
$12R_{j2}$	2.66E+00	9.94E-01	2.21E+00	5.59E+00	1.30E+00	1.37E+00	2.38E+00	4.87E-01	2.25E-01	3.97E-01	6.22E-01	1.54E-01	2.32E-01	3.10E-01
$12R_{j3}$	1.17E-01	5.15E-02	9.23E-02	2.33E-01	7.26E-02	6.01E-02	9.48E-02	8.34E+00	7.84E+00	1.18E+01	1.75E+01	4.84E+00	4.85E+00	6.05E+00
$12M_{j1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$12M_{j2}$	5.89E+00	2.43E+00	4.52E+00	1.16E+01	3.27E+00	3.12E+00	4.96E+00	5.09E+02	4.82E+02	7.33E+02	1.10E+03	3.06E+02	3.06E+02	3.71E+02
$12M_{j3}$	1.89E+02	7.07E+01	1.58E+02	3.98E+02	9.23E+01	9.75E+01	1.69E+02	3.43E+01	1.70E+01	2.86E+01	4.37E+01	1.15E+01	1.63E+01	2.28E+01
$13R_{i1}$	4.97E-01	2.02E-01	4.16E-01	1.05E+00	2.78E-01	2.41E-01	4.25E-01	4.97E-01	3.60E-01	5.12E-01	9.15E-01	2.17E-01	3.13E-01	3.96E-01
$13R_{i2}$	1.10E+00	4.08E-01	8.90E-01	2.25E+00	5.43E-01	5.73E-01	9.62E-01	5.28E-01	1.14E-01	2.53E-01	7.96E-01	7.96E-02	1.63E-01	3.95E-01
$13R_{i3}$	3.46E-02	1.42E-02	2.29E-02	6.47E-02	2.10E-02	1.50E-02	2.54E-02	2.65E+00	2.00E+00	3.21E+00	5.15E+00	1.61E+00	1.51E+00	1.83E+00
$13M_{i1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$13M_{i2}$	5.89E+00	2.43E+00	4.52E+00	1.16E+01	3.27E+00	3.12E+00	4.96E+00	5.09E+02	4.82E+02	7.33E+02	1.10E+03	3.06E+02	3.06E+02	3.71E+02
$13M_{i3}$	1.89E+02	7.07E+01	1.58E+02	3.98E+02	9.23E+01	9.75E+01	1.69E+02	3.43E+01	1.70E+01	2.86E+01	4.37E+01	1.15E+01	1.63E+01	2.28E+01
$13R_{j1}$	4.97E-01	2.02E-01	4.16E-01	1.05E+00	2.78E-01	2.41E-01	4.25E-01	4.97E-01	3.60E-01	5.12E-01	9.15E-01	2.17E-01	3.13E-01	3.96E-01
$13R_{j2}$	1.10E+00	4.08E-01	8.90E-01	2.25E+00	5.43E-01	5.73E-01	9.62E-01	5.28E-01	1.14E-01	2.53E-01	7.96E-01	7.96E-02	1.63E-01	3.95E-01
$13R_{j3}$	3.46E-02	1.42E-02	2.29E-02	6.47E-02	2.10E-02	1.50E-02	2.54E-02	2.65E+00	2.00E+00	3.21E+00	5.15E+00	1.61E+00	1.51E+00	1.83E+00
$13M_{j1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$13M_{j2}$	4.17E+00	1.75E+00	3.33E+00	8.30E+00	2.34E+00	2.22E+00	3.57E+00	3.45E+02	3.17E+02	4.72E+02	6.97E+02	1.89E+02	2.02E+02	2.41E+02
$13M_{j3}$	9.88E+01	3.72E+01	8.41E+01	2.12E+02	4.79E+01	5.01E+01	8.96E+01	2.71E+01	1.41E+01	2.32E+01	3.89E+01	8.62E+00	1.03E+01	1.81E+01
$14R_{i1}$	4.71E-01	1.85E-01	3.93E-01	9.91E-01	2.50E-01	2.35E-01	4.10E-01	6.47E-01	5.18E-01	7.16E-01	1.32E+00	2.98E-01	4.47E-01	4.84E-01
$14R_{i2}$	1.25E+00	4.68E-01	1.06E+00	2.66E+00	6.04E-01	6.33E-01	1.13E+00	2.99E-01	1.06E-01	1.95E-01	4.47E-01	8.76E-02	1.44E-01	2.32E-01
$14R_{i3}$	4.55E-02	1.99E-02	3.55E-02	8.91E-02	2.80E-02	2.34E-02	3.67E-02	3.35E+00	3.09E+00	4.62E+00	6.95E+00	1.85E+00	1.96E+00	2.35E+00
$14M_{i1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$14M_{i2}$	4.17E+00	1.75E+00	3.33E+00	8.30E+00	2.34E+00	2.22E+00	3.57E+00	3.45E+02	3.17E+02	4.72E+02	6.97E+02	1.89E+02	2.02E+02	2.41E+02
$14M_{i3}$	9.88E+01	3.72E+01	8.41E+01	2.12E+02	4.79E+01	5.01E+01	8.96E+01	2.71E+01	1.41E+01	2.32E+01	3.89E+01	8.62E+00	1.03E+01	1.81E+01
$14R_{j1}$	4.71E-01	1.85E-01	3.93E-01	9.91E-01	2.50E-01	2.35E-01	4.10E-01	6.47E-01	5.18E-01	7.16E-01	1.32E+00	2.98E-01	4.47E-01	4.84E-01
$14R_{j2}$	1.25E+00	4.68E-01	1.06E+00	2.66E+00	6.04E-01	6.33E-01	1.13E+00	2.99E-01	1.06E-01	1.95E-01	4.47E-01	8.76E-02	1.44E-01	2.32E-01
$14R_{j3}$	4.55E-02	1.99E-02	3.55E-02	8.91E-02	2.80E-02	2.34E-02	3.67E-02	3.35E+00	3.09E+00	4.62E+00	6.95E+00	1.85E+00	1.96E+00	2.35E+00
$14M_{j1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$14M_{j2}$	1.03E+00	4.37E-01	7.95E-01	2.09E+00	6.17E-01	4.91E-01	8.33E-01	6.77E+01	5.77E+01	8.88E+01	1.25E+02	3.65E+01	4.41E+01	4.34E+01
$14M_{j3}$	6.19E+00	2.30E+00	4.88E+00	1.24E+01	3.14E+00	3.27E+00	5.31E+00	1.59E+01	1.34E+01	1.90E+01	2.99E+01	7.68E+00	1.18E+01	1.21E+01

Table 3.4.13 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$15R_{i1}$	4.59E-01	1.77E-01	3.81E-01	9.62E-01	2.36E-01	2.33E-01	4.03E-01	7.67E-01	6.29E-01	8.66E-01	1.60E+00	3.52E-01	5.51E-01	5.53E-01
$15R_{i2}$	1.27E+00	4.82E-01	1.09E+00	2.74E+00	6.19E-01	6.37E-01	1.15E+00	6.81E-01	1.37E-01	2.92E-01	8.93E-01	1.05E-01	1.88E-01	4.47E-01
$15R_{i3}$	6.30E-02	2.63E-02	4.93E-02	1.26E-01	3.60E-02	3.13E-02	5.27E-02	4.55E+00	3.94E+00	5.93E+00	8.39E+00	2.43E+00	2.85E+00	3.02E+00
$15M_{i1}$	3.01E+00	1.17E+00	2.59E+00	6.54E+00	1.51E+00	1.47E+00	2.73E+00	2.76E+01	2.52E+01	3.77E+01	5.30E+01	1.55E+01	1.86E+01	1.83E+01
$15M_{i2}$	1.03E+00	4.37E-01	7.95E-01	2.09E+00	6.17E-01	4.91E-01	8.33E-01	6.77E+01	5.77E+01	8.88E+01	1.25E+02	3.65E+01	4.41E+01	4.34E+01
$15M_{i3}$	6.19E+00	2.30E+00	4.88E+00	1.24E+01	3.14E+00	3.27E+00	5.31E+00	1.59E+01	1.34E+01	1.90E+01	2.99E+01	7.68E+00	1.18E+01	1.21E+01
$15R_{C1}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$15R_{C2}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$15R_{C3}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$15M_{C1}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$15M_{C2}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$15M_{C3}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$15R_{j1}$	1.27E+00	4.82E-01	1.09E+00	2.74E+00	6.19E-01	6.37E-01	1.15E+00	6.81E-01	1.37E-01	2.92E-01	8.93E-01	1.05E-01	1.88E-01	4.47E-01
$15R_{j2}$	4.59E-01	1.77E-01	3.81E-01	9.62E-01	2.36E-01	2.33E-01	4.03E-01	7.67E-01	6.29E-01	8.66E-01	1.60E+00	3.52E-01	5.51E-01	5.53E-01
$15R_{j3}$	6.30E-02	2.63E-02	4.93E-02	1.26E-01	3.60E-02	3.13E-02	5.27E-02	4.55E+00	3.94E+00	5.93E+00	8.39E+00	2.43E+00	2.85E+00	3.02E+00
$15M_{j1}$	6.30E-01	2.81E-01	4.36E-01	1.10E+00	4.28E-01	2.56E-01	4.11E-01	1.71E+01	1.33E+01	2.05E+01	3.36E+01	8.30E+00	8.86E+00	1.09E+01
$15M_{j2}$	2.22E+00	8.48E-01	1.91E+00	4.83E+00	1.09E+00	1.09E+00	2.03E+00	5.60E+01	4.58E+01	6.90E+01	9.93E+01	2.84E+01	3.27E+01	3.66E+01
$15M_{j3}$	2.06E+01	7.74E+00	1.75E+01	4.41E+01	9.98E+00	1.04E+01	1.86E+01	6.69E+00	3.92E+00	5.90E+00	1.28E+01	2.49E+00	4.64E+00	5.33E+00
$16R_{i1}$	1.28E+00	4.93E-01	1.11E+00	2.79E+00	6.36E-01	6.37E-01	1.16E+00	9.48E-01	1.83E-01	3.80E-01	1.30E+00	1.25E-01	2.37E-01	5.89E-01
$16R_{i2}$	9.14E-02	4.01E-02	7.06E-02	1.83E-01	5.79E-02	4.29E-02	7.17E-02	5.25E+00	4.40E+00	6.85E+00	9.56E+00	2.86E+00	3.42E+00	3.26E+00
$16R_{i3}$	4.62E-01	1.75E-01	3.83E-01	9.67E-01	2.32E-01	2.37E-01	4.08E-01	8.70E-01	6.98E-01	9.69E-01	1.78E+00	3.91E-01	6.13E-01	6.10E-01
$16M_{i1}$	6.30E-01	2.81E-01	4.36E-01	1.10E+00	4.28E-01	2.56E-01	4.11E-01	1.71E+01	1.33E+01	2.05E+01	3.36E+01	8.30E+00	8.86E+00	1.09E+01
$16M_{i2}$	2.06E+01	7.74E+00	1.75E+01	4.41E+01	9.98E+00	1.04E+01	1.86E+01	6.69E+00	3.92E+00	5.90E+00	1.28E+01	2.49E+00	4.64E+00	5.33E+00
$16M_{i3}$	2.22E+00	8.48E-01	1.91E+00	4.83E+00	1.09E+00	1.09E+00	2.03E+00	5.60E+01	4.58E+01	6.90E+01	9.93E+01	2.84E+01	3.27E+01	3.66E+01
$16R_{j1}$	1.28E+00	4.93E-01	1.11E+00	2.79E+00	6.36E-01	6.37E-01	1.16E+00	9.48E-01	1.83E-01	3.80E-01	1.30E+00	1.25E-01	2.37E-01	5.89E-01
$16R_{j2}$	9.14E-02	4.01E-02	7.06E-02	1.83E-01	5.79E-02	4.29E-02	7.17E-02	5.25E+00	4.40E+00	6.85E+00	9.56E+00	2.86E+00	3.42E+00	3.26E+00
$16R_{j3}$	4.62E-01	1.75E-01	3.83E-01	9.67E-01	2.32E-01	2.37E-01	4.08E-01	8.70E-01	6.98E-01	9.69E-01	1.78E+00	3.91E-01	6.13E-01	6.10E-01
$16M_{j1}$	6.30E-01	2.81E-01	4.36E-01	1.10E+00	4.28E-01	2.56E-01	4.11E-01	1.71E+01	1.33E+01	2.05E+01	3.36E+01	8.30E+00	8.86E+00	1.09E+01
$16M_{j2}$	9.76E+00	4.10E+00	7.31E+00	1.85E+01	6.11E+00	4.80E+00	7.29E+00	4.65E+01	3.80E+01	5.42E+01	9.80E+01	2.17E+01	3.24E+01	3.22E+01
$16M_{j3}$	4.78E+00	2.14E+00	3.43E+00	9.07E+00	3.17E+00	2.24E+00	3.51E+00	3.71E+02	3.10E+02	4.80E+02	6.70E+02	2.00E+02	2.38E+02	2.32E+02

Table 3.4.13 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$17R_{i1}$	1.33E+00	5.28E-01	1.15E+00	2.91E+00	6.93E-01	6.51E-01	1.20E+00	1.42E+00	2.80E-01	5.59E-01	2.06E+00	1.62E-01	3.26E-01	8.62E-01
$17R_{i2}$	7.17E-02	2.99E-02	5.96E-02	1.50E-01	4.17E-02	3.36E-02	6.04E-02	2.94E+00	1.61E+00	2.53E+00	4.43E+00	1.08E+00	1.27E+00	1.63E+00
$17R_{i3}$	1.78E-01	8.52E-02	1.30E-01	3.26E-01	1.33E-01	7.53E-02	1.08E-01	4.22E-01	1.58E-01	2.58E-01	6.57E-01	8.97E-02	1.37E-01	2.46E-01
$17M_{i1}$	6.30E-01	2.81E-01	4.36E-01	1.10E+00	4.28E-01	2.56E-01	4.11E-01	1.71E+01	1.33E+01	2.05E+01	3.36E+01	8.30E+00	8.86E+00	1.09E+01
$17M_{i2}$	9.76E+00	4.10E+00	7.31E+00	1.85E+01	6.11E+00	4.80E+00	7.29E+00	4.65E+01	3.80E+01	5.42E+01	9.80E+01	2.17E+01	3.24E+01	3.22E+01
$17M_{i3}$	4.78E+00	2.14E+00	3.43E+00	9.07E+00	3.17E+00	2.24E+00	3.51E+00	3.71E+02	3.10E+02	4.80E+02	6.70E+02	2.00E+02	2.38E+02	2.32E+02
$17Rj_1$	1.33E+00	5.28E-01	1.15E+00	2.91E+00	6.93E-01	6.51E-01	1.20E+00	1.42E+00	2.80E-01	5.59E-01	2.06E+00	1.62E-01	3.26E-01	8.62E-01
$17Rj_2$	7.17E-02	2.99E-02	5.96E-02	1.50E-01	4.17E-02	3.36E-02	6.04E-02	2.94E+00	1.61E+00	2.53E+00	4.43E+00	1.08E+00	1.27E+00	1.63E+00
$17Rj_3$	1.78E-01	8.52E-02	1.30E-01	3.26E-01	1.33E-01	7.53E-02	1.08E-01	4.22E-01	1.58E-01	2.58E-01	6.57E-01	8.97E-02	1.37E-01	2.46E-01
$17Mj_1$	6.30E-01	2.81E-01	4.36E-01	1.10E+00	4.28E-01	2.56E-01	4.11E-01	1.71E+01	1.33E+01	2.05E+01	3.36E+01	8.30E+00	8.86E+00	1.09E+01
$17Mj_2$	1.24E+01	5.68E+00	8.95E+00	2.25E+01	8.80E+00	5.53E+00	7.94E+00	3.52E+01	2.32E+01	3.40E+01	6.07E+01	1.31E+01	2.01E+01	2.44E+01
$17M_{j3}$	7.22E+00	2.79E+00	6.17E+00	1.57E+01	3.55E+00	3.49E+00	6.56E+00	2.31E+02	1.70E+02	2.54E+02	4.30E+02	9.96E+01	1.16E+02	1.48E+02
$18R_{i1}$	1.42E+00	5.84E-01	1.23E+00	3.10E+00	7.87E-01	6.84E-01	1.25E+00	1.93E+00	4.02E-01	7.57E-01	2.88E+00	2.21E-01	4.66E-01	1.17E+00
$18R_{i2}$	7.39E-02	3.53E-02	5.84E-02	1.49E-01	5.36E-02	3.40E-02	5.28E-02	2.79E+00	2.09E+00	3.12E+00	5.24E+00	1.23E+00	1.44E+00	1.76E+00
$18R_{i3}$	1.32E-01	6.09E-02	9.61E-02	2.41E-01	9.42E-02	5.93E-02	8.52E-02	3.60E-01	2.43E-01	3.53E-01	6.30E-01	1.36E-01	2.16E-01	2.53E-01
$18M_{i1}$	6.30E-01	2.81E-01	4.36E-01	1.10E+00	4.28E-01	2.56E-01	4.11E-01	1.71E+01	1.33E+01	2.05E+01	3.36E+01	8.30E+00	8.86E+00	1.09E+01
$18M_{i2}$	1.24E+01	5.68E+00	8.95E+00	2.25E+01	8.80E+00	5.53E+00	7.94E+00	3.52E+01	2.32E+01	3.40E+01	6.07E+01	1.31E+01	2.01E+01	2.44E+01
$18M_{i3}$	7.22E+00	2.79E+00	6.17E+00	1.57E+01	3.55E+00	3.49E+00	6.56E+00	2.31E+02	1.70E+02	2.54E+02	4.30E+02	9.96E+01	1.16E+02	1.48E+02
$18Rj_1$	1.42E+00	5.84E-01	1.23E+00	3.10E+00	7.87E-01	6.84E-01	1.25E+00	1.93E+00	4.02E-01	7.57E-01	2.88E+00	2.21E-01	4.66E-01	1.17E+00
$18Rj_2$	7.39E-02	3.53E-02	5.84E-02	1.49E-01	5.36E-02	3.40E-02	5.28E-02	2.79E+00	2.09E+00	3.12E+00	5.24E+00	1.23E+00	1.44E+00	1.76E+00
$18Rj_3$	1.32E-01	6.09E-02	9.61E-02	2.41E-01	9.42E-02	5.93E-02	8.52E-02	3.60E-01	2.43E-01	3.53E-01	6.30E-01	1.36E-01	2.16E-01	2.53E-01
$18Mj_1$	6.30E-01	2.81E-01	4.36E-01	1.10E+00	4.28E-01	2.56E-01	4.11E-01	1.71E+01	1.33E+01	2.05E+01	3.36E+01	8.30E+00	8.86E+00	1.09E+01
$18Mj_2$	1.83E+00	8.28E-01	1.29E+00	3.25E+00	1.29E+00	8.07E-01	1.15E+00	6.45E+00	3.76E+00	5.76E+00	1.12E+01	2.22E+00	2.85E+00	4.20E+00
$18M_{j3}$	1.04E+01	4.27E+00	9.01E+00	2.27E+01	5.76E+00	5.04E+00	9.18E+00	1.85E+01	4.60E+00	9.74E+00	3.18E+01	6.58E+00	7.07E+00	1.47E+01

Table 3.4.13 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$19R_{i1}$	1.49E+00	6.26E-01	1.29E+00	3.24E+00	8.56E-01	7.13E-01	1.29E+00	2.22E+00	4.72E-01	8.71E-01	3.34E+00	2.62E-01	5.53E-01	1.35E+00
$19R_{i2}$	7.18E-02	3.46E-02	5.55E-02	1.43E-01	5.31E-02	3.26E-02	4.96E-02	3.21E+00	2.28E+00	3.37E+00	5.86E+00	1.43E+00	1.60E+00	2.11E+00
$19R_{i3}$	1.92E-01	8.69E-02	1.37E-01	3.44E-01	1.35E-01	8.60E-02	1.23E-01	5.04E-01	2.71E-01	4.10E-01	8.04E-01	1.52E-01	2.50E-01	3.18E-01
$19M_{i1}$	6.30E-01	2.81E-01	4.36E-01	1.10E+00	4.28E-01	2.56E-01	4.11E-01	1.71E+01	1.33E+01	2.05E+01	3.36E+01	8.30E+00	8.86E+00	1.09E+01
$19M_{i2}$	1.83E+00	8.28E-01	1.29E+00	3.25E+00	1.29E+00	8.07E-01	1.15E+00	6.45E+00	3.76E+00	5.76E+00	1.12E+01	2.22E+00	2.85E+00	4.20E+00
$19M_{i3}$	1.04E+01	4.27E+00	9.01E+00	2.27E+01	5.76E+00	5.04E+00	9.18E+00	1.85E+01	4.60E+00	9.74E+00	3.18E+01	6.58E+00	7.07E+00	1.47E+01
$19RC_1$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$19RC_2$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$19RC_3$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$19MC_1$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$19MC_2$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$19M_{C3}$	-	-	-	-	-	-	-	-	-	-	-	-	-	-
$19Rj_1$	7.18E-02	3.46E-02	5.55E-02	1.43E-01	5.31E-02	3.26E-02	4.96E-02	3.21E+00	2.28E+00	3.37E+00	5.86E+00	1.43E+00	1.60E+00	2.11E+00
$19Rj_2$	1.49E+00	6.26E-01	1.29E+00	3.24E+00	8.56E-01	7.13E-01	1.29E+00	2.22E+00	4.72E-01	8.71E-01	3.34E+00	2.62E-01	5.53E-01	1.35E+00
$19Rj_3$	1.92E-01	8.69E-02	1.37E-01	3.44E-01	1.35E-01	8.60E-02	1.23E-01	5.04E-01	2.71E-01	4.10E-01	8.04E-01	1.52E-01	2.50E-01	3.18E-01
$19Mj_1$	1.65E+00	7.40E-01	1.18E+00	2.97E+00	1.14E+00	7.48E-01	1.08E+00	2.90E+00	1.24E+00	2.09E+00	4.44E+00	1.08E+00	1.65E+00	2.01E+00
$19Mj_2$	3.18E+00	1.42E+00	2.27E+00	5.70E+00	2.19E+00	1.45E+00	2.08E+00	2.41E+01	1.78E+01	2.72E+01	4.70E+01	1.08E+01	1.25E+01	1.67E+01
$19M_{j3}$	1.58E+01	6.63E+00	1.36E+01	3.43E+01	9.06E+00	7.51E+00	1.37E+01	8.32E+01	4.55E+01	6.91E+01	1.32E+02	2.60E+01	3.21E+01	4.88E+01
$20R_{i1}$	7.22E-02	3.49E-02	5.59E-02	1.44E-01	5.35E-02	3.28E-02	4.99E-02	3.34E+00	2.38E+00	3.45E+00	6.11E+00	1.68E+00	1.79E+00	2.25E+00
$20R_{i2}$	2.02E-01	8.94E-02	1.57E-01	3.94E-01	1.32E-01	9.71E-02	1.53E-01	1.44E+00	3.08E-01	5.37E-01	1.54E+00	1.46E-01	3.27E-01	7.67E-01
$20R_{i3}$	1.05E-01	4.64E-02	7.39E-02	1.85E-01	7.14E-02	4.71E-02	6.87E-02	2.77E-01	1.09E-01	1.79E-01	4.62E-01	6.75E-02	1.16E-01	1.46E-01
$20M_{i1}$	1.65E+00	7.40E-01	1.18E+00	2.97E+00	1.14E+00	7.48E-01	1.08E+00	2.90E+00	1.24E+00	2.09E+00	4.44E+00	1.08E+00	1.65E+00	2.01E+00
$20M_{i2}$	3.18E+00	1.42E+00	2.27E+00	5.70E+00	2.19E+00	1.45E+00	2.08E+00	2.41E+01	1.78E+01	2.72E+01	4.70E+01	1.08E+01	1.25E+01	1.67E+01
$20M_{i3}$	1.58E+01	6.63E+00	1.36E+01	3.43E+01	9.06E+00	7.51E+00	1.37E+01	8.32E+01	4.55E+01	6.91E+01	1.32E+02	2.60E+01	3.21E+01	4.88E+01
$20Rj_1$	7.22E-02	3.49E-02	5.59E-02	1.44E-01	5.35E-02	3.28E-02	4.99E-02	3.34E+00	2.38E+00	3.45E+00	6.11E+00	1.68E+00	1.79E+00	2.25E+00
$20Rj_2$	2.02E-01	8.94E-02	1.57E-01	3.94E-01	1.32E-01	9.71E-02	1.53E-01	1.44E+00	3.08E-01	5.37E-01	1.54E+00	1.46E-01	3.27E-01	7.67E-01
$20Rj_3$	1.05E-01	4.64E-02	7.39E-02	1.85E-01	7.14E-02	4.71E-02	6.87E-02	2.77E-01	1.09E-01	1.79E-01	4.62E-01	6.75E-02	1.16E-01	1.46E-01
$20Mj_1$	1.65E+00	7.40E-01	1.18E+00	2.97E+00	1.14E+00	7.48E-01	1.08E+00	2.90E+00	1.24E+00	2.09E+00	4.44E+00	1.08E+00	1.65E+00	2.01E+00
$20Mj_2$	3.68E+00	1.61E+00	2.60E+00	6.47E+00	2.44E+00	1.59E+00	2.48E+00	1.86E+01	1.26E+01	1.84E+01	3.19E+01	7.49E+00	1.03E+01	1.11E+01
$20M_{j3}$	1.07E+01	4.09E+00	8.63E+00	2.18E+01	5.55E+00	5.45E+00	9.24E+00	5.72E+01	3.11E+01	4.51E+01	8.17E+01	1.75E+01	2.47E+01	4.15E+01

Table 3.4.13 (Cont'd)

Elem.	4a Load Cases							4b Load Cases						
	a	b	c	d	e	f	g	a	b	c	d	e	f	g
$21R_{i1}$	7.27E-02	3.51E-02	5.63E-02	1.45E-01	5.39E-02	3.30E-02	5.02E-02	4.01E+00	2.65E+00	3.68E+00	6.43E+00	2.03E+00	2.04E+00	2.53E+00
$21R_{i2}$	9.99E-02	4.20E-02	8.63E-02	2.17E-01	5.74E-02	4.75E-02	8.67E-02	6.43E-01	2.89E-01	4.48E-01	9.29E-01	1.63E-01	2.15E-01	3.54E-01
$21R_{i3}$	2.72E-02	1.24E-02	1.95E-02	4.90E-02	1.93E-02	1.22E-02	1.73E-02	1.67E-01	1.10E-01	1.74E-01	3.22E-01	6.97E-02	7.55E-02	1.06E-01
$21M_{i1}$	1.65E+00	7.40E-01	1.18E+00	2.97E+00	1.14E+00	7.48E-01	1.08E+00	2.90E+00	1.24E+00	2.09E+00	4.44E+00	1.08E+00	1.65E+00	2.01E+00
$21M_{i2}$	3.68E+00	1.61E+00	2.60E+00	6.47E+00	2.44E+00	1.59E+00	2.48E+00	1.86E+01	1.26E+01	1.84E+01	3.19E+01	7.49E+00	1.03E+01	1.11E+01
$21M_{i3}$	1.07E+01	4.09E+00	8.63E+00	2.18E+01	5.55E+00	5.45E+00	9.24E+00	5.72E+01	3.11E+01	4.51E+01	8.17E+01	1.75E+01	2.47E+01	4.15E+01
$21Rj_{1}$	7.27E-02	3.51E-02	5.63E-02	1.45E-01	5.39E-02	3.30E-02	5.02E-02	4.01E+00	2.65E+00	3.68E+00	6.43E+00	2.03E+00	2.04E+00	2.53E+00
$21Rj_{2}$	9.99E-02	4.20E-02	8.63E-02	2.17E-01	5.74E-02	4.75E-02	8.67E-02	6.43E-01	2.89E-01	4.48E-01	9.29E-01	1.63E-01	2.15E-01	3.54E-01
$21Rj_{3}$	2.72E-02	1.24E-02	1.95E-02	4.90E-02	1.93E-02	1.22E-02	1.73E-02	1.67E-01	1.10E-01	1.74E-01	3.22E-01	6.97E-02	7.55E-02	1.06E-01
$21Mj_{1}$	1.65E+00	7.40E-01	1.18E+00	2.97E+00	1.14E+00	7.48E-01	1.08E+00	2.90E+00	1.24E+00	2.09E+00	4.44E+00	1.08E+00	1.65E+00	2.01E+00
$21Mj_{2}$	5.00E+00	2.22E+00	3.54E+00	8.82E+00	3.40E+00	2.20E+00	3.29E+00	1.57E+01	6.41E+00	9.24E+00	2.38E+01	3.56E+00	7.29E+00	8.87E+00
$21M_{j3}$	8.52E+00	3.41E+00	6.17E+00	1.55E+01	5.02E+00	4.38E+00	6.58E+00	6.42E+01	1.54E+01	2.53E+01	7.61E+01	8.22E+00	1.61E+01	4.23E+01
$22R_{i1}$	7.31E-02	3.53E-02	5.66E-02	1.46E-01	5.42E-02	3.32E-02	5.04E-02	4.67E+00	2.92E+00	3.93E+00	7.25E+00	2.39E+00	2.31E+00	2.80E+00
$22R_{i2}$	1.42E-01	5.51E-02	1.07E-01	2.69E-01	7.85E-02	7.24E-02	1.15E-01	1.04E+00	3.40E-01	5.14E-01	1.30E+00	1.83E-01	2.98E-01	7.21E-01
$22R_{i3}$	7.77E-02	3.49E-02	5.52E-02	1.37E-01	5.35E-02	3.36E-02	5.06E-02	2.79E-01	1.37E-01	1.96E-01	4.38E-01	7.92E-02	1.26E-01	1.58E-01
$22M_{i1}$	1.65E+00	7.40E-01	1.18E+00	2.97E+00	1.14E+00	7.48E-01	1.08E+00	2.90E+00	1.24E+00	2.09E+00	4.44E+00	1.08E+00	1.65E+00	2.01E+00
$22M_{i2}$	5.00E+00	2.22E+00	3.54E+00	8.82E+00	3.40E+00	2.20E+00	3.29E+00	1.57E+01	6.41E+00	9.24E+00	2.38E+01	3.56E+00	7.29E+00	8.87E+00
$22M_{i3}$	8.52E+00	3.41E+00	6.17E+00	1.55E+01	5.02E+00	4.38E+00	6.58E+00	6.42E+01	1.54E+01	2.53E+01	7.61E+01	8.22E+00	1.61E+01	4.23E+01
$22Rj_{1}$	7.31E-02	3.53E-02	5.66E-02	1.46E-01	5.42E-02	3.32E-02	5.04E-02	4.67E+00	2.92E+00	3.93E+00	7.25E+00	2.39E+00	2.31E+00	2.80E+00
$22Rj_{2}$	1.42E-01	5.51E-02	1.07E-01	2.69E-01	7.85E-02	7.24E-02	1.15E-01	1.04E+00	3.40E-01	5.14E-01	1.30E+00	1.83E-01	2.98E-01	7.21E-01
$22Rj_{3}$	7.77E-02	3.49E-02	5.52E-02	1.37E-01	5.35E-02	3.36E-02	5.06E-02	2.79E-01	1.37E-01	1.96E-01	4.38E-01	7.92E-02	1.26E-01	1.58E-01
$22Mj_{1}$	1.65E+00	7.40E-01	1.18E+00	2.97E+00	1.14E+00	7.48E-01	1.08E+00	2.90E+00	1.24E+00	2.09E+00	4.44E+00	1.08E+00	1.65E+00	2.01E+00
$22Mj_{2}$	5.28E-01	2.11E-01	3.64E-01	9.23E-01	3.18E-01	2.65E-01	3.80E-01	2.95E+00	2.20E+00	3.58E+00	6.19E+00	1.52E+00	1.86E+00	2.00E+00
$22M_{j3}$	2.56E+00	1.15E+00	2.14E+00	5.37E+00	1.66E+00	1.21E+00	2.05E+00	1.08E+01	5.63E+00	8.58E+00	1.69E+01	3.18E+00	4.09E+00	6.24E+00
$23R_{i1}$	7.32E-02	3.54E-02	5.67E-02	1.46E-01	5.43E-02	3.32E-02	5.05E-02	5.31E+00	3.18E+00	4.19E+00	8.33E+00	2.77E+00	2.57E+00	3.07E+00
$23R_{i2}$	2.55E-01	1.04E-01	1.84E-01	4.64E-01	1.55E-01	1.31E-01	1.93E-01	1.67E+00	3.84E-01	6.47E-01	1.96E+00	2.03E-01	4.12E-01	1.09E+00
$23R_{i3}$	1.35E-01	5.85E-02	9.46E-02	2.36E-01	8.92E-02	6.05E-02	9.03E-02	4.10E-01	1.69E-01	2.45E-01	6.36E-01	1.11E-01	2.21E-01	2.41E-01
$23M_{i1}$	1.65E+00	7.40E-01	1.18E+00	2.97E+00	1.14E+00	7.48E-01	1.08E+00	2.90E+00	1.24E+00	2.09E+00	4.44E+00	1.08E+00	1.65E+00	2.01E+00
$23M_{i2}$	5.28E-01	2.11E-01	3.64E-01	9.23E-01	3.18E-01	2.65E-01	3.80E-01	2.95E+00	2.20E+00	3.58E+00	6.19E+00	1.52E+00	1.86E+00	2.00E+00
$23M_{i3}$	2.56E+00	1.15E+00	2.14E+00	5.37E+00	1.66E+00	1.21E+00	2.05E+00	1.08E+01	5.63E+00	8.58E+00	1.69E+01	3.18E+00	4.09E+00	6.24E+00
$23Rj_{1}$	7.32E-02	3.54E-02	5.67E-02	1.46E-01	5.43E-02	3.32E-02	5.05E-02	5.31E+00	3.18E+00	4.19E+00	8.33E+00	2.77E+00	2.57E+00	3.07E+00
$23Rj_{2}$	2.55E-01	1.04E-01	1.84E-01	4.64E-01	1.55E-01	1.31E-01	1.93E-01	1.67E+00	3.84E-01	6.47E-01	1.96E+00	2.03E-01	4.12E-01	1.09E+00
$23Rj_{3}$	1.35E-01	5.85E-02	9.46E-02	2.36E-01	8.92E-02	6.05E-02	9.03E-02	4.10E-01	1.69E-01	2.45E-01	6.36E-01	1.11E-01	2.21E-01	2.41E-01
$23Mj_{1}$	1.65E+00	7.40E-01	1.18E+00	2.97E+00	1.14E+00	7.48E-01	1.08E+00	2.90E+00	1.24E+00	2.09E+00	4.44E+00	1.08E+00	1.65E+00	2.01E+00
$23Mj_{2}$	7.70E+00	3.37E+00	5.42E+00	1.35E+01	5.14E+00	3.42E+00	5.14E+00	2.56E+01	1.19E+01	1.69E+01	4.05E+01	6.66E+00	1.35E+01	1.51E+01
$23M_{j3}$	1.47E+01	5.87E+00	1.08E+01	2.71E+01	8.61E+00	7.61E+00	1.15E+01	9.72E+01	2.78E+01	4.31E+01	1.20E+02	1.47E+01	2.61E+01	6.64E+01

6. CONCLUSIONS

This report presents a developed in the scope of the Benchmark Program analytical method for analyzing of non-classically damped structures. On the basis of obtained results the following preliminary notes and some conclusions may be stated:

1. Proposed Response Spectrum Method (RSM-II) can be easily implemented in engineering practice from point of view of traditionally available information for purposes of analysis:
   - modal properties of primary system or its simplified (stick) model ;
   - full information for secondary system;
   - set of Response Spectra for different damping ratios.
2. High Frequency modes can be correctly taken into account for realized approach.
3. Preliminary comparison of RSM results versus THA results have shown that RSM-I method leads to more accurate solution. It means that additional improvement of proposed method may be obtained using more sophisticated procedure for cross-correlation coefficient calculation.
4. RSM results for benchmark problems #1, #2, #3 for the case M show the great deviation versus THA. It has to be discussed on the next stages of this Benchmark Program.
5. During actual investigation it was founded that for primary-secondary systems with closely spaced frequencies use of the absolute sign in front of the double summation recommended US NRC shows an essential error even for classically damped systems.
6. The simplified analysis of the Equation (11) with diagonal components of damping matrix only, which is often used in engineering practice, has been carried out additionally. This analysis was performed for the Problem #4. Appendix C contains the comparative data of resulting moments for all elements of the coupled model. Obviously, that this method leads to essential errors not only versus accurate solution, but also versus other proposed methods and can't be recommended.
7. On the basis of obtained results it seems to be necessary and very important to investigate extra case in the frame of this Benchmark Program the phenomena of local damping according to our preliminary proposals. We are ready to prepare the necessary documentation and data for BNL and participants.

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[3] Computer Software Code For Piping Dynamic Analysis dPIPE, Program Manual, Report No. 07-96-01, St. Petersburg, 1996

[4] Computer Software Code For Piping Dynamic Analysis dPIPE, Verification Manual Report No. co06-96x.vvk-01, St. Petersburg, 1997

APPENDIX A

GENERAL DESCRIPTION OF THE dPIPE SYSTEM, VERSION 2.2.

dPIPE is the finite-element computer program for piping dynamic analysis with the following main capabilities:

static analysis:
- solution is obtained from distributed and concentrated gravity loads and internal pressure;

thermal expansion analysis:
- solution is obtained with option accounting of friction support;

dynamic analysis:
- free vibration analysis. Eigenvalue solution is carried out by the high efficient Lanczos method;
- response spectrum analysis. For this type of analysis the following options can be used: Square Root Sum of Squares (SRSS) or Complete Quadratic Combination (CQC) rule for summation of mode shapes and spatial components of response, correction for missing mass effect. This type of analysis is applicable for uniform as well as independent support motioned piping systems.
- time history analysis. This type of analysis can provide not only linear solution, but also take into account local non-linear effects. Usually these effects should be consider for correct dynamic analysis of piping systems with such types of devices as: viscoelastic dampers (non-proportional damping may be modeled not only with simplified models (elastic or viscous), but also by means of precise 4-parametrical Maxwell model. The last one provides characteristics of these devices in the full frequency range), *limit stops* (these piping supports are modeled by special elements with gaps); *mechanical and hydraulic snubbers,* etc.

The program uses a friendly "piping" language to input geometry and properties of piping system. Extensive graphical display of the piping model is available with abilities to rotate, zoom, pan the image and view it from different points. There is a comprehensive diagnostic system to check out the piping input.

The postprocessing for results of analyses includes the following options:

- checking for code compliance (ASME BPVC, Class 1, 2, 3 and Russian PNAE Code);
- specific output for Seismic Margin Assessment with calculation of HCLPF values;
- graphic output of maximal displacements and stresses due to various cases of loading;
- graphic output and animation of mode shapes;
- animation of Time History motion of pipeline;
- summary tables of result stresses and internal forces for all pipe elements including the corresponding scale factors;
- summary tables of seismic displacements and accelerations;
- summary tables of pipe support reactions (hangers, nozzles, dampers, etc.).

During its development the dPIPE program was successfully compared with such well known computer codes as SAP-IV, COSMOS-M, ANSYS, PD-STRUDL, SOLVIA. Results of analysis with viscoelastic dampers were compared with experimental results obtained from the pipeline model on the IHI shaking table (Japan, June 1989).

APPENDIX B

BENCHMARK PROBLEM #4.
CAEPIPE MODAL ANALYSIS.

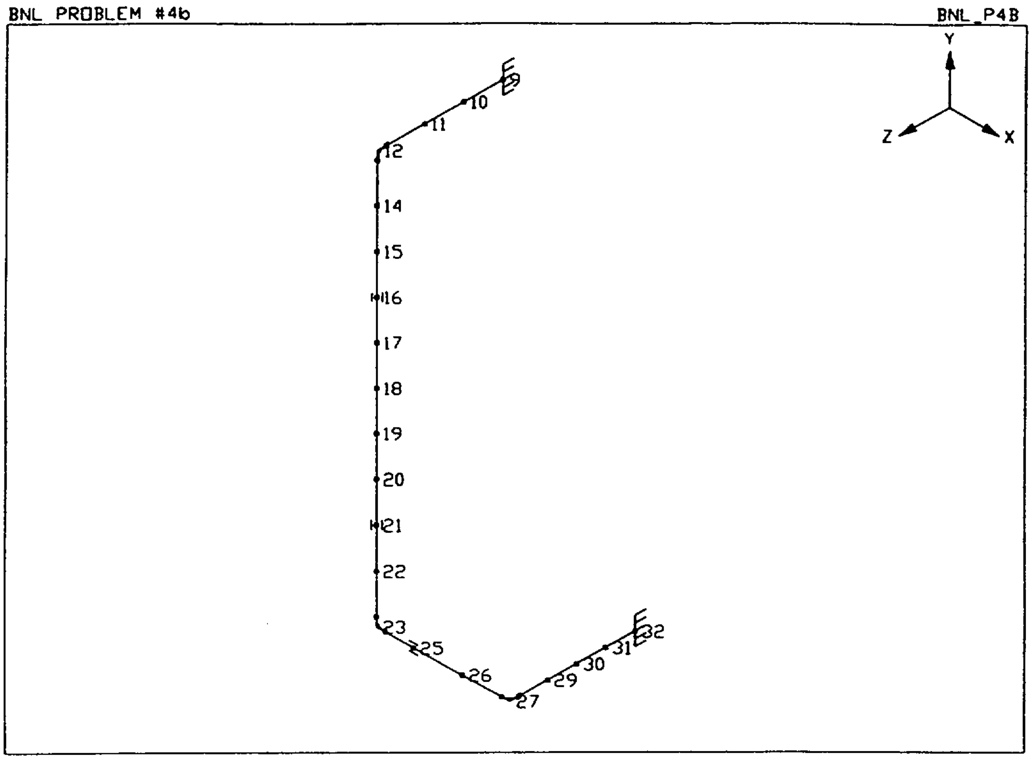

Figure B1. CAEPIPE Calculation Model

Options

Piping code = None
Reference temperature = 70 (F)
Number of thermal cycles = 7000
Use modulus at reference temperature
Include hanger stiffness
Do not include Bourdon effect
Use pressure correction for bends
Pressure stress = PD / 4t
Peak pressure factor = 1.00
Cut off frequency = 800 Hz
Number of modes = 56
Do not use friction in dynamic analysis
Vertical direction = Y

Coordinates

Node	X (ft'in")	Y (ft'in")	Z (ft'in")
9	0'0"	0'0"	0'0"
10	0'0"	0'0"	6'8"
11	0'0"	0'0"	13'4"
12A	0'0"	0'0"	20'0"
12	0'0"	0'0"	21'6"
12B	0'0"	-1'6"	21'6"
14	0'0"	-8'6"	21'6"
15	0'0"	-15'6"	21'6"
16	0'0"	-22'6"	21'6"
17	0'0"	-29'6"	21'6"
18	0'0"	-36'6"	21'6"
19	0'0"	-43'6"	21'6"
20	0'0"	-50'6"	21'6"
21	0'0"	-57'6"	21'6"
22	0'0"	-64'6"	21'6"
23A	0'0"	-71'6"	21'6"
23	0'0"	-73'0"	21'6"
23B	1'6"	-73'0"	21'6"
25	6'6"	-73'0"	21'6"
26	14'10"	-73'0"	21'6"
27A	21'6"	-73'0"	21'6"
27	23'0"	-73'0"	21'6"
27B	23'0"	-73'0"	20'0"
29	23'0"	-73'0"	15'0"
30	23'0"	-73'0"	10'0"
31	23'0"	-73'0"	5'0"
32	23'0"	-73'0"	0'0"

Pipe material 2: A53 Grade A

Density = 0.0000 (lb/in3), Nu = 0.300, Joint factor = 1.00, Type = CS

Temp (F)	E (psi)	Alpha (in/in/F)	Allowable (psi)
-100	30.2E+6	5.65E-6	12000
70	29.5E+6	6.07E-6	12000
200	28.8E+6	6.38E-6	12000
300	28.3E+6	6.60E-6	12000
400	27.7E+6	6.82E-6	12000
500	27.3E+6	7.02E-6	12000
600	26.7E+6	7.23E-6	12000
650	26.1E+6	7.34E-6	12000
700	25.5E+6	7.44E-6	11700
750	24.9E+6	7.55E-6	10700
800	24.2E+6	7.65E-6	9000

Pipe material 1: mn,mn

Density = 0.0000 (lb/in3), Nu = 0.300, Joint factor = 1.00

Temp (F)	E (psi)	Alpha (in/in/F)	Allowable (psi)
70	30.0E+3		

Pipe Sections

Name	Nominal Dia.	Sch	O.D. (inch)	Thk (inch)	Cor.Al (inch)	M.Tol (%)	Ins.Dens (lb/ft3)	Ins.Th (inch)	Lin.Dens (lb/ft3)	Lin.Th (inch)
2	Non Std		12.75	0.375	0.0	0.0				
3	12"	40S	12.75	0.375	0.0	0.0				

Mode	Frequency (Hz)	Period (sec)	Participation factors X	Participation factors Y	Participation factors Z	Modal mass / Total mass X	Modal mass / Total mass Y	Modal mass / Total mass Z
1	8.232	0.1215	0.0023	-0.0072	0.0513	0.0001	0.0015	0.0753
2	8.535	0.1172	-0.0573	0.0011	0.0021	0.0939	0.0000	0.0001
3	14.908	0.0671	-0.0020	-0.0204	0.0190	0.0001	0.0119	0.0104
4	16.851	0.0593	-0.0043	-0.0547	-0.0746	0.0005	0.0855	0.1591
5	17.296	0.0578	-0.0666	0.0043	0.0084	0.1268	0.0005	0.0020
6	22.688	0.0441	0.0073	0.0511	-0.0272	0.0015	0.0746	0.0212
7	24.890	0.0402	-0.0021	-0.0061	0.0361	0.0001	0.0011	0.0372
8	25.866	0.0387	-0.0211	-0.0204	-0.0179	0.0127	0.0119	0.0092
9	26.056	0.0384	-0.0313	0.0232	-0.0040	0.0280	0.0154	0.0005
10	27.371	0.0365	-0.0663	-0.0067	0.0091	0.1255	0.0013	0.0024
11	28.226	0.0354	0.0138	0.0059	0.0293	0.0054	0.0010	0.0246
12	31.131	0.0321	-0.0037	0.0386	-0.0111	0.0004	0.0427	0.0036
13	33.559	0.0298	-0.0012	-0.1347	0.0167	0.0000	0.5185	0.0079
14	34.126	0.0293	0.0568	0.0118	0.0517	0.0923	0.0040	0.0763
15	39.282	0.0255	-0.0439	0.0282	0.0204	0.0551	0.0227	0.0119
16	44.792	0.0223	-0.0212	0.0030	-0.0149	0.0128	0.0003	0.0063
17	51.191	0.0195	-0.0676	-0.0002	0.0180	0.1308	0.0000	0.0093

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Mode	Frequency (Hz)	Period (sec)	Participation factors X	Y	Z	Modal mass / Total mass X	Y	Z
18	53.610	0.0187	0.0283	0.0079	-0.0276	0.0229	0.0018	0.0218
19	54.712	0.0183	0.0253	-0.0077	0.0173	0.0183	0.0017	0.0086
20	59.095	0.0169	-0.0111	0.0016	-0.0021	0.0035	0.0001	0.0001
21	62.679	0.0160	-0.0007	-0.0112	-0.0161	0.0000	0.0036	0.0074
22	72.811	0.0137	0.0219	0.0001	-0.0006	0.0137	0.0000	0.0000
23	74.916	0.0133	-0.0001	0.0001	0.0016	0.0000	0.0000	0.0001
24	75.948	0.0132	0.0003	0.0179	0.0014	0.0000	0.0092	0.0001
25	79.969	0.0125	-0.0017	0.0004	0.0002	0.0001	0.0000	0.0000
26	80.112	0.0125	0.0001	0.0002	0.0011	0.0000	0.0000	0.0000
27	83.820	0.0119	0.0074	-0.0004	0.0017	0.0016	0.0000	0.0001
28	88.020	0.0114	-0.0013	0.0110	0.0127	0.0000	0.0034	0.0046
29	89.613	0.0112	0.0278	0.0004	-0.0007	0.0221	0.0000	0.0000
30	93.343	0.0107	0.0001	-0.0170	-0.0047	0.0000	0.0083	0.0006
31	114.277	0.0088	-0.0058	-0.0044	0.0839	0.0009	0.0006	0.2013
32	115.641	0.0086	-0.0075	0.0108	-0.0080	0.0016	0.0033	0.0018
33	125.569	0.0080	-0.0096	-0.0118	0.0416	0.0026	0.0040	0.0495
34	127.797	0.0078	-0.0017	0.0008	-0.0029	0.0001	0.0000	0.0002
35	141.341	0.0071	-0.0012	-0.0174	0.0000	0.0000	0.0087	0.0000
36	141.607	0.0071	-0.0191	0.0003	0.0043	0.0104	0.0000	0.0005
37	161.173	0.0062	-0.0022	0.0032	-0.0103	0.0001	0.0003	0.0030
38	210.015	0.0048	-0.0050	-0.0051	-0.0232	0.0007	0.0007	0.0154
39	226.764	0.0044	0.0065	-0.0068	-0.0006	0.0012	0.0013	0.0000
40	261.708	0.0038	0.0063	0.0116	0.0201	0.0011	0.0038	0.0115
41	288.059	0.0035	-0.0129	0.0070	-0.0068	0.0047	0.0014	0.0013
42	315.678	0.0032	0.0059	0.0061	0.0123	0.0010	0.0011	0.0043
43	357.314	0.0028	0.0024	-0.0021	-0.0018	0.0002	0.0001	0.0001
44	393.710	0.0025	0.0007	0.0002	0.0117	0.0000	0.0000	0.0039
45	417.364	0.0024	-0.0011	0.0054	-0.0029	0.0000	0.0008	0.0002
46	427.530	0.0023	-0.0044	-0.0031	0.0176	0.0005	0.0003	0.0088
47	450.618	0.0022	0.0020	-0.0039	0.0013	0.0001	0.0004	0.0000
48	484.442	0.0021	-0.0022	-0.0033	0.0043	0.0001	0.0003	0.0005
49	505.187	0.0020	-0.0055	0.0014	0.0029	0.0009	0.0001	0.0002
50	515.824	0.0019	0.0030	0.0011	-0.0041	0.0003	0.0000	0.0005
51	530.961	0.0019	-0.0010	0.0004	-0.0014	0.0000	0.0000	0.0001
52	540.266	0.0019	-0.0005	0.0008	0.0017	0.0000	0.0000	0.0001
53	553.906	0.0018	0.0000	0.0052	0.0033	0.0000	0.0008	0.0003
54	620.675	0.0016	-0.0035	0.0001	-0.0082	0.0003	0.0000	0.0019
55	630.904	0.0016	0.0006	0.0005	0.0011	0.0000	0.0000	0.0000
56	729.137	0.0014	0.0016	0.0000	-0.0033	0.0001	0.0000	0.0003
					Total	0.7956	0.8491	0.8067

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Mode	Frequency (Hz)	Period (sec)	Participation factors X	Participation factors Y	Participation factors Z	Modal mass / Total mass X	Modal mass / Total mass Y	Modal mass / Total mass Z
1	4.591	0.2178	0.0041	-0.0129	0.0920	0.0001	0.0015	0.0753
2	4.760	0.2101	-0.1028	0.0020	0.0037	0.0939	0.0000	0.0001
3	8.314	0.1203	-0.0036	-0.0366	0.0341	0.0001	0.0119	0.0104
4	9.398	0.1064	-0.0077	-0.0981	-0.1338	0.0005	0.0855	0.1591
5	9.646	0.1037	-0.1195	0.0077	0.0151	0.1268	0.0005	0.0020
6	12.653	0.0790	0.0132	0.0916	-0.0488	0.0015	0.0746	0.0212
7	13.881	0.0720	-0.0037	-0.0109	0.0647	0.0001	0.0011	0.0372
8	14.425	0.0693	-0.0378	-0.0366	-0.0322	0.0127	0.0119	0.0092
9	14.531	0.0688	-0.0561	0.0417	-0.0072	0.0280	0.0154	0.0005
10	15.265	0.0655	-0.1188	-0.0120	0.0163	0.1255	0.0013	0.0024
11	15.741	0.0635	0.0247	0.0106	0.0526	0.0054	0.0010	0.0246
12	17.361	0.0576	-0.0066	0.0693	-0.0200	0.0004	0.0427	0.0036
13	18.715	0.0534	-0.0021	-0.2415	0.0299	0.0000	0.5185	0.0079
14	19.032	0.0525	0.1019	0.0212	0.0926	0.0923	0.0040	0.0763
15	21.907	0.0456	-0.0787	0.0505	0.0365	0.0551	0.0227	0.0119
16	24.980	0.0400	-0.0379	0.0055	-0.0267	0.0128	0.0003	0.0063
17	28.549	0.0350	-0.1213	-0.0003	0.0323	0.1308	0.0000	0.0093
18	29.898	0.0334	0.0508	0.0142	-0.0495	0.0229	0.0018	0.0218
19	30.513	0.0328	0.0453	-0.0138	0.0310	0.0183	0.0017	0.0086
20	32.957	0.0303	-0.0198	0.0029	-0.0038	0.0035	0.0001	0.0001
21	34.956	0.0286	-0.0013	-0.0201	-0.0289	0.0000	0.0036	0.0074
22	40.606	0.0246	0.0393	0.0002	-0.0010	0.0137	0.0000	0.0000
23	41.780	0.0239	-0.0002	0.0002	0.0029	0.0000	0.0000	0.0001
24	42.356	0.0236	0.0006	0.0321	0.0026	0.0000	0.0092	0.0001
25	44.598	0.0224	-0.0031	0.0007	0.0003	0.0001	0.0000	0.0000
26	44.678	0.0224	0.0002	0.0003	0.0019	0.0000	0.0000	0.0000
27	46.746	0.0214	0.0132	-0.0007	0.0031	0.0016	0.0000	0.0001
28	49.088	0.0204	-0.0023	0.0196	0.0227	0.0000	0.0034	0.0046
29	49.976	0.0200	0.0499	0.0007	-0.0013	0.0221	0.0000	0.0000
30	52.056	0.0192	0.0003	-0.0305	-0.0084	0.0000	0.0083	0.0006
31	63.732	0.0157	-0.0103	-0.0079	0.1505	0.0009	0.0006	0.2013
32	64.492	0.0155	-0.0134	0.0193	-0.0144	0.0016	0.0033	0.0018
33	70.029	0.0143	-0.0172	-0.0212	0.0746	0.0026	0.0040	0.0495
34	71.272	0.0140	-0.0031	0.0015	-0.0051	0.0001	0.0000	0.0002
35	78.825	0.0127	-0.0022	-0.0312	0.0001	0.0000	0.0087	0.0000
36	78.973	0.0127	-0.0343	0.0005	0.0078	0.0104	0.0000	0.0005
37	89.885	0.0111	-0.0040	0.0058	-0.0185	0.0001	0.0003	0.0030
38	117.123	0.0085	-0.0089	-0.0091	-0.0417	0.0007	0.0007	0.0154
39	126.464	0.0079	0.0117	-0.0123	-0.0010	0.0012	0.0013	0.0000
40	145.952	0.0069	0.0113	0.0207	0.0360	0.0011	0.0038	0.0115
41	160.648	0.0062	-0.0231	0.0126	-0.0122	0.0047	0.0014	0.0013
42	176.051	0.0057	0.0106	0.0110	0.0221	0.0010	0.0011	0.0043
43	199.271	0.0050	0.0043	-0.0037	-0.0032	0.0002	0.0001	0.0001
44	219.569	0.0046	0.0013	0.0004	0.0210	0.0000	0.0000	0.0039
45	232.760	0.0043	-0.0020	0.0098	-0.0053	0.0000	0.0008	0.0002
46	238.430	0.0042	-0.0078	-0.0056	0.0315	0.0005	0.0003	0.0088
47	251.306	0.0040	0.0036	-0.0070	0.0023	0.0001	0.0004	0.0000
48	270.169	0.0037	-0.0039	-0.0060	0.0077	0.0001	0.0003	0.0005
49	281.739	0.0035	-0.0099	0.0024	0.0052	0.0009	0.0001	0.0002
50	287.671	0.0035	0.0053	0.0019	-0.0074	0.0003	0.0000	0.0005
51	296.113	0.0034	-0.0017	0.0008	-0.0025	0.0000	0.0000	0.0001
52	301.302	0.0033	-0.0009	0.0014	0.0030	0.0000	0.0000	0.0001
53	308.909	0.0032	0.0000	0.0093	0.0060	0.0000	0.0008	0.0003

CAEPIPE	BNL_P4B	Page 2
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Mode	Frequency (Hz)	Period (sec)	Participation factors X	Y	Z	Modal mass / Total mass X	Y	Z
54	346.145	0.0029	-0.0062	0.0001	-0.0148	0.0003	0.0000	0.0019
55	351.850	0.0028	0.0011	0.0009	0.0019	0.0000	0.0000	0.0000
56	406.634	0.0025	0.0028	0.0000	-0.0059	0.0001	0.0000	0.0003
					Total	0.7956	0.8491	0.8067

Table A1. Comparison of Frequencies for Benchmark Problem #4a.

Mode	BNL	dPIPE	CAEPIPE	ERROR		
				BNL/dPIPE	BNL/CAEPIPE	dPIPE/CAEPIPE
1	8.25	8.23	8.23	0.24%	0.22%	-0.02%
2	8.56	8.54	8.54	0.23%	0.29%	0.06%
3	14.95	14.91	14.91	0.27%	0.28%	0.01%
4	16.67	16.85	16.85	-1.08%	-1.09%	-0.01%
5	17.35	17.30	17.30	0.29%	0.31%	0.02%
6	24.57	22.69	22.69	**7.65%**	**7.66%**	0.01%
7	25.56	24.89	24.89	**2.62%**	**2.62%**	0.00%
8	26.09	25.87	25.87	0.84%	0.86%	0.02%
9	26.25	26.06	26.06	0.72%	0.74%	0.02%
10	27.48	27.37	27.37	0.40%	0.40%	0.00%
11	28.55	28.23	28.23	1.12%	1.13%	0.01%
12	30.21	31.13	31.13	**-3.05%**	**-3.05%**	0.00%
13	33.48	33.56	33.56	-0.24%	-0.24%	0.00%
14	33.70	34.13	34.13	-1.28%	-1.26%	0.01%
15	41.20	39.28	39.28	**4.66%**	**4.66%**	-0.01%
16	44.78	44.79	44.79	-0.02%	-0.03%	0.00%
17	52.49	51.19	51.19	**2.48%**	**2.47%**	0.00%
18	54.69	53.61	53.61	1.97%	1.97%	0.00%
19	57.59	54.71	54.71	**5.00%**	**5.00%**	0.00%
20	60.39	59.09	59.10	**2.15%**	**2.14%**	-0.01%
21	63.97	62.68	62.68	**2.02%**	**2.02%**	0.00%
22	73.12	72.81	72.81	0.42%	0.42%	0.00%
23	74.39	74.92	74.92	-0.71%	-0.71%	0.01%
24	77.40	75.95	75.95	1.87%	1.88%	0.00%
25	80.08	79.97	79.97	0.14%	0.14%	0.00%
26	80.14	80.11	80.11	0.04%	0.03%	0.00%
27	81.34	83.82	83.82	**-3.05%**	**-3.05%**	0.00%
28	88.18	88.02	88.02	0.18%	0.18%	0.00%
29	107.97	89.61	89.61	**17.00%**	**17.00%**	0.00%
30	110.17	93.34	93.34	**15.28%**	**15.27%**	0.00%
31	111.09	114.28	114.28	-2.87%	-2.87%	0.00%
32	112.42	115.64	115.64	-2.86%	-2.87%	0.00%
33	125.75	125.57	125.57	0.14%	0.14%	0.00%
34	140.88	127.80	127.80	9.28%	9.29%	0.00%
35	143.25	141.34	141.34	1.33%	1.33%	0.00%
36	159.39	141.61	141.61	11.16%	11.16%	0.00%
37	160.81	161.17	161.17	-0.22%	-0.23%	0.00%
38	203.12	210.01	210.02	-3.39%	-3.39%	0.00%
39	222.87	226.76	226.76	-1.75%	-1.75%	0.00%
40	253.03	261.71	261.71	-3.43%	-3.43%	0.00%

Table A1. (Cont'd)

Mode	BNL	dPIPE	CAEPIPE	ERROR		
				BNL/dPIPE	BNL/CAEPIPE	dPIPE/CAEPIPE
41	278.63	288.06	288.06	-3.38%	-3.38%	0.00%
42	312.82	315.68	315.68	-0.91%	-0.91%	0.00%
43	349.87	357.31	357.31	-2.13%	-2.13%	0.00%
44	389.02	393.71	393.71	-1.21%	-1.21%	0.00%
45	414.87	417.36	417.36	-0.60%	-0.60%	0.00%
46	426.30	427.53	427.53	-0.29%	-0.29%	0.00%
47	447.23	450.62	450.62	-0.76%	-0.76%	0.00%
48	482.75	484.44	484.44	-0.35%	-0.35%	0.00%
49	503.37	505.19	505.19	-0.36%	-0.36%	0.00%
50	513.97	515.82	515.82	-0.36%	-0.36%	0.00%
51	530.18	530.96	530.96	-0.15%	-0.15%	0.00%
52	539.88	540.27	540.27	-0.07%	-0.07%	0.00%
53	552.58	553.91	553.91	-0.24%	-0.24%	0.00%
54	620.30	620.67	620.68	-0.06%	-0.06%	0.00%
55	627.06	630.90	630.90	-0.61%	-0.61%	0.00%
56	729.17	729.14	729.14	0.00%	0.00%	0.00%

Table A2. Comparison of Frequencies for Benchmark Problem #4b

Mode	BNL	dPIPE	CAEPIPE	ERROR		
				BNL/dPIPE	BNL/CAEPIPE	dPIPE/CAEPIPE
1	4.60	4.59	4.59	0.22%	0.20%	-0.02%
2	4.77	4.76	4.76	0.21%	0.21%	0.00%
3	8.34	8.31	8.31	0.36%	0.31%	-0.05%
4	9.29	9.40	9.40	-1.18%	-1.16%	0.02%
5	9.67	9.64	9.65	0.31%	0.25%	-0.06%
6	13.59	12.65	12.65	**6.92%**	**6.89%**	-0.02%
7	14.25	13.88	13.88	**2.60%**	**2.59%**	-0.01%
8	14.55	14.42	14.43	0.89%	0.86%	-0.03%
9	14.64	14.53	14.53	0.75%	0.74%	-0.01%
10	15.32	15.26	15.27	0.39%	0.36%	-0.03%
11	15.92	15.74	15.74	1.13%	1.12%	-0.01%
12	16.84	17.36	17.36	**-3.09%**	**-3.09%**	-0.01%
13	18.67	18.71	18.72	-0.21%	-0.24%	-0.03%
14	18.79	19.03	19.03	-1.28%	-1.29%	-0.01%
15	22.97	21.90	21.91	**4.66%**	**4.63%**	-0.03%
16	24.97	24.98	24.98	-0.04%	-0.04%	0.00%
17	29.27	28.54	28.55	**2.49%**	**2.46%**	-0.03%
18	30.49	29.89	29.90	1.97%	1.94%	-0.03%
19	32.11	30.51	30.51	**4.98%**	**4.97%**	-0.01%
20	33.67	32.95	32.96	**2.14%**	**2.12%**	-0.02%

Table A2. (Cont'd)

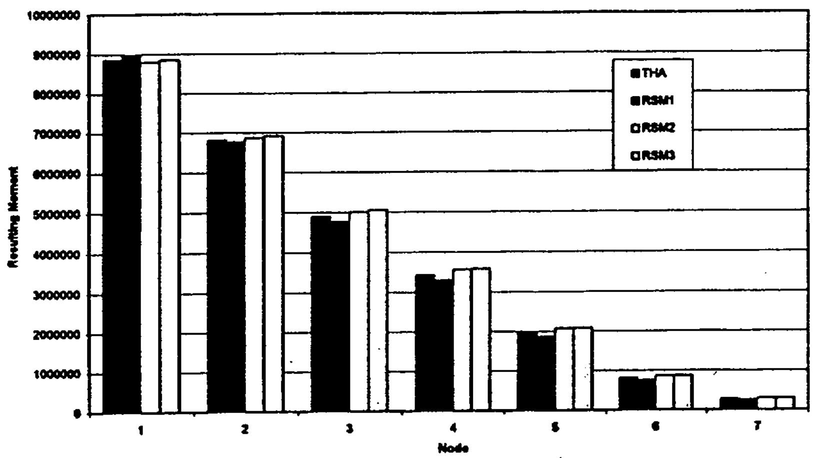
Mode	BNL	dPIPE	CAEPIPE	ERROR		
				BNL/dPIPE	BNL/CAEPIPE	dPIPE/CAEPIPE
21	35.67	34.95	34.96	**2.02%**	**2.00%**	-0.02%
22	40.77	40.60	40.61	0.42%	0.40%	-0.01%
23	41.48	41.77	41.78	-0.70%	-0.72%	-0.02%
24	43.16	42.35	42.36	1.88%	1.86%	-0.01%
25	44.65	44.59	44.60	0.13%	0.12%	-0.02%
26	44.68	44.67	44.68	0.02%	0.00%	-0.02%
27	45.35	46.74	46.75	**-3.07%**	**-3.08%**	-0.01%
28	49.17	49.08	49.09	0.18%	0.17%	-0.02%
29	60.20	49.97	49.98	**16.99%**	**16.98%**	-0.01%
30	61.43	52.05	52.06	**15.27%**	**15.26%**	-0.01%
31	61.94	63.72	63.73	-2.87%	-2.89%	-0.02%
32	62.68	64.48	64.49	-2.87%	-2.89%	-0.02%
33	70.12	70.01	70.03	0.16%	0.13%	-0.03%
34	78.55	71.26	71.27	9.28%	9.27%	-0.02%
35	79.87	78.81	78.83	1.33%	1.31%	-0.02%
36	88.87	78.96	78.97	11.15%	11.14%	-0.02%
37	89.66	89.87	89.89	-0.23%	-0.25%	-0.02%
38	113.26	117.10	117.12	-3.39%	-3.41%	-0.02%
39	124.27	126.44	126.46	-1.75%	-1.77%	-0.02%
40	141.09	145.92	145.95	-3.42%	-3.45%	-0.02%
41	155.36	160.61	160.65	-3.38%	-3.40%	-0.02%
42	174.42	176.01	176.05	-0.91%	-0.94%	-0.02%
43	195.08	199.23	199.27	-2.13%	-2.15%	-0.02%
44	216.91	219.52	219.57	-1.20%	-1.23%	-0.02%
45	231.32	232.71	232.76	-0.60%	-0.62%	-0.02%
46	237.69	238.38	238.43	-0.29%	-0.31%	-0.02%
47	249.36	251.25	251.31	-0.76%	-0.78%	-0.02%
48	269.17	270.11	270.17	-0.35%	-0.37%	-0.02%
49	280.67	281.68	281.74	-0.36%	-0.38%	-0.02%
50	286.58	287.61	287.67	-0.36%	-0.38%	-0.02%
51	295.62	296.05	296.11	-0.15%	-0.17%	-0.02%
52	301.02	301.24	301.30	-0.07%	-0.09%	-0.02%
53	308.10	308.85	308.91	-0.24%	-0.26%	-0.02%
54	345.87	346.07	346.15	-0.06%	-0.08%	-0.02%
55	349.63	351.78	351.85	-0.61%	-0.63%	-0.02%
56	406.57	406.55	406.63	0.00%	-0.02%	-0.02%

APPENDIX C

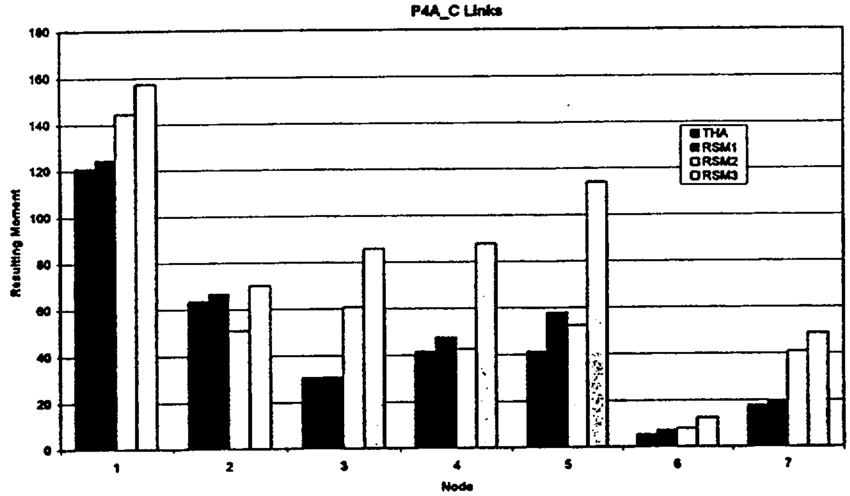
COMPARATIVE RESULTS FOR PROBLEM #4*)

*) The following designation is used on the figures of this Appendix: P4A_A - Results for Benchmark Problem #4a, Load Case - a.

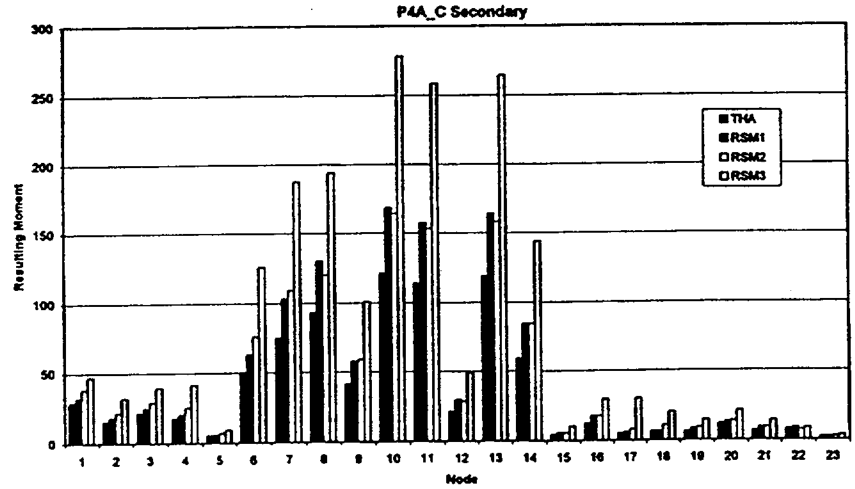
P4A_C Primary System



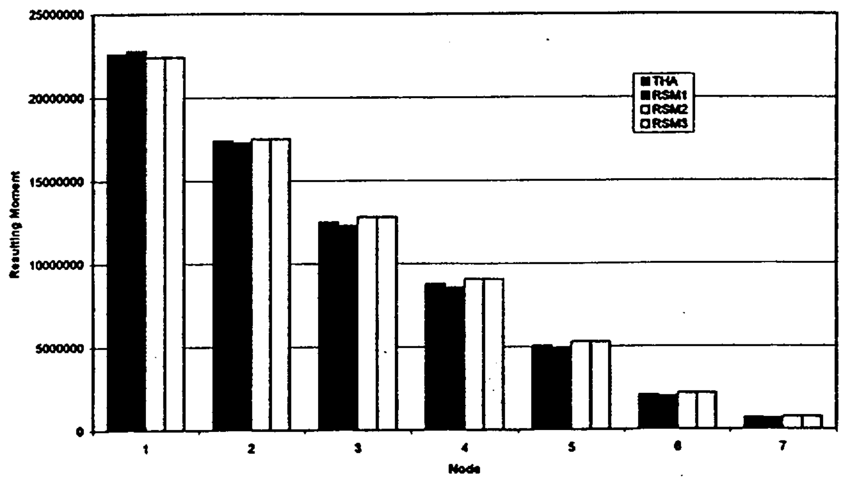
P4A_C Links



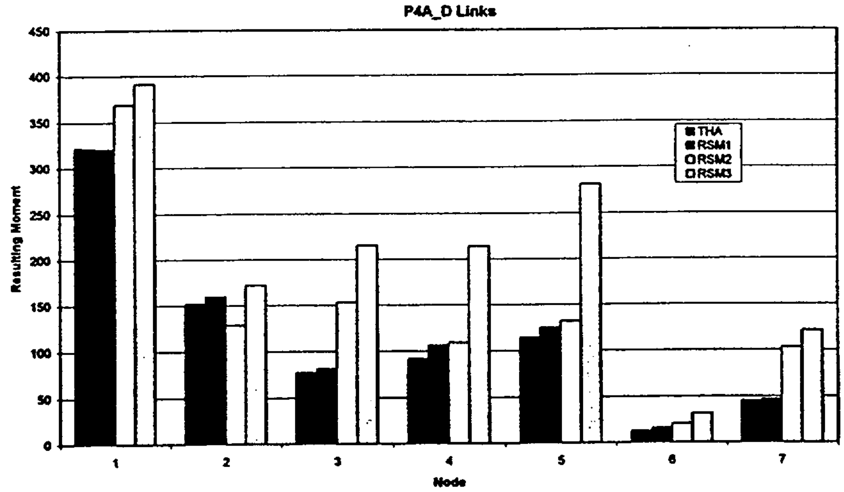
P4A_C Secondary



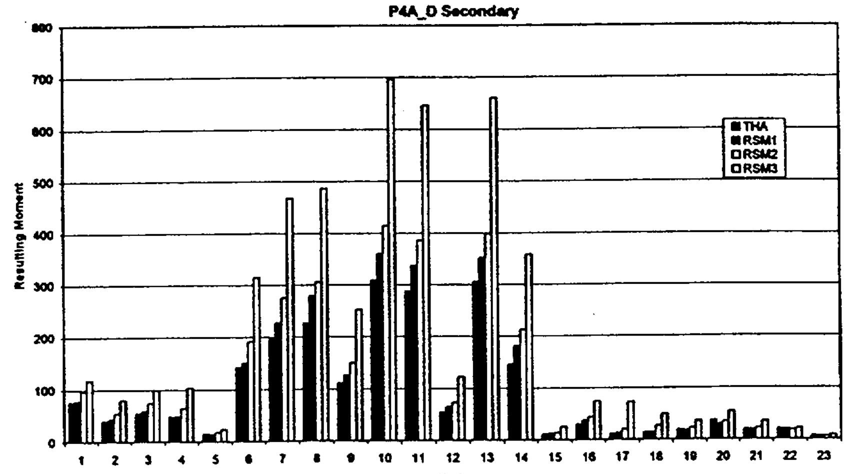
P4A_D Primary System



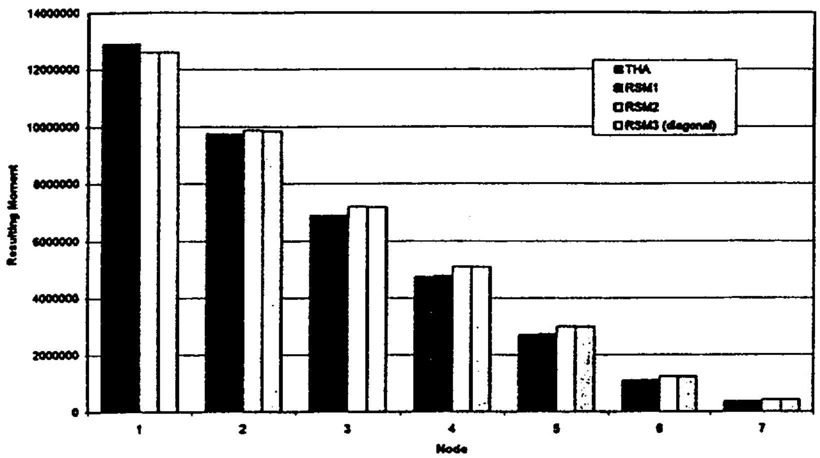
P4A_D Links



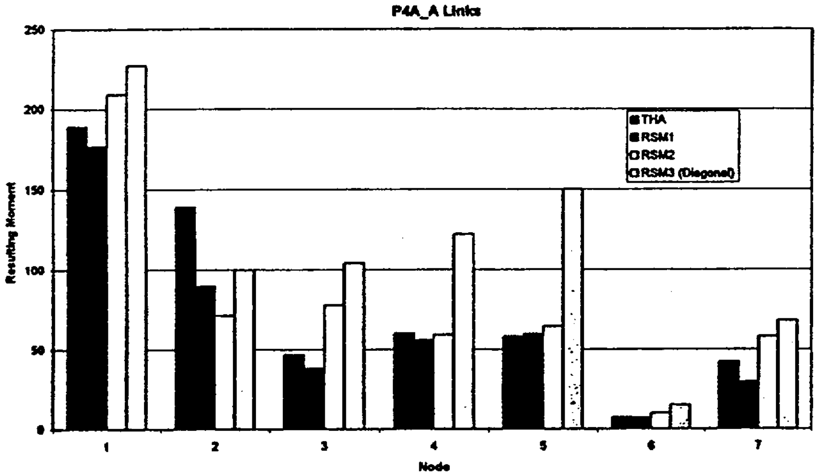
P4A_D Secondary



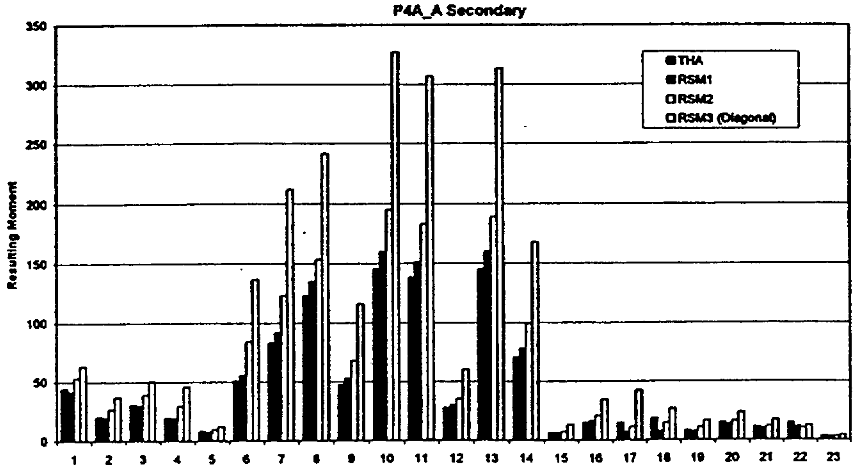
P4A_A Primary System

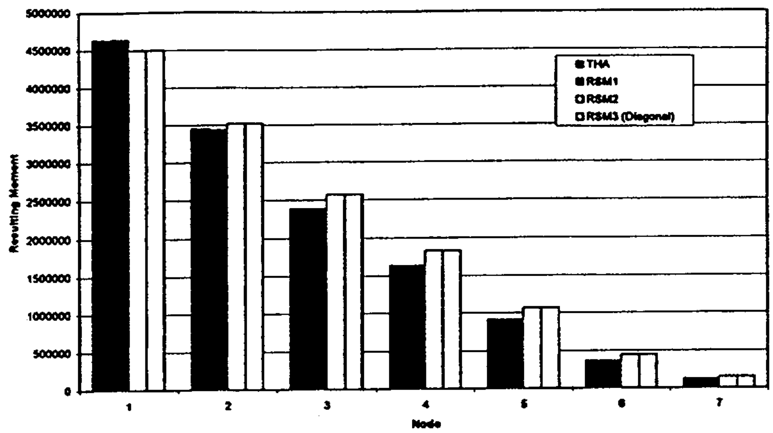


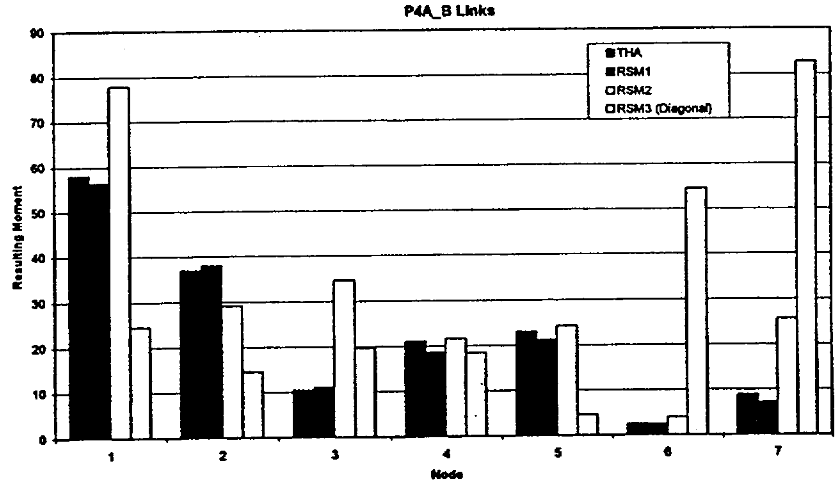
P4A_A Links

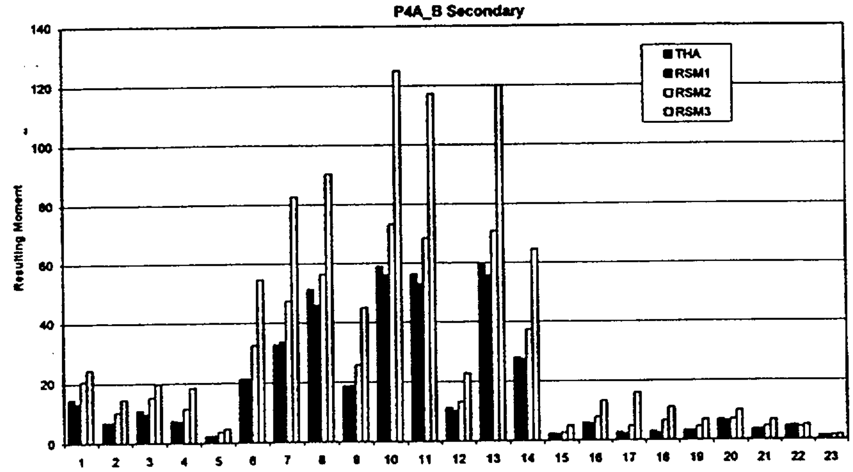


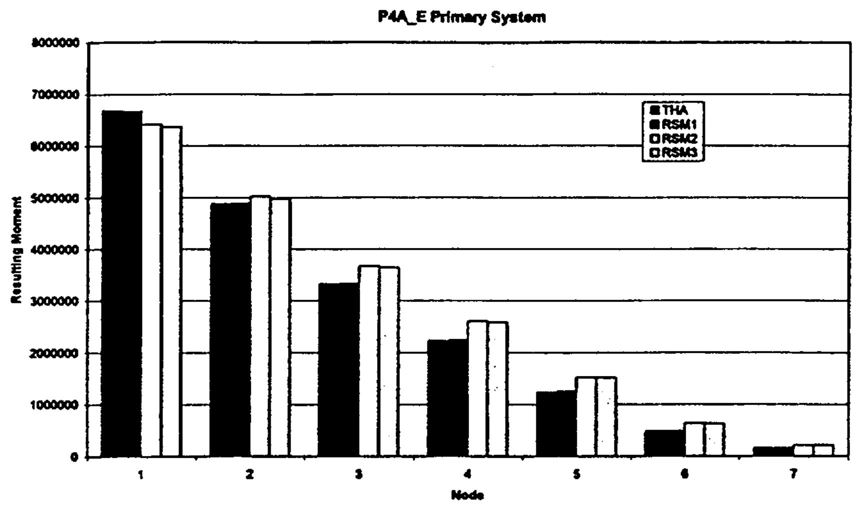
P4A_A Secondary

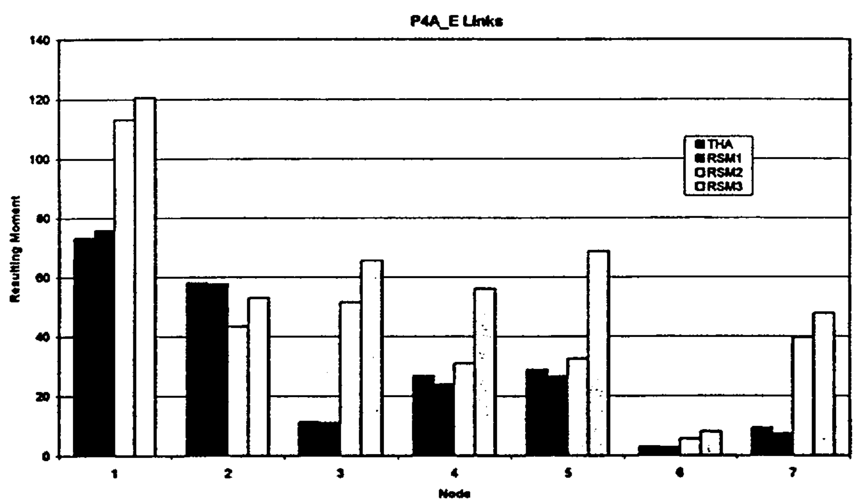


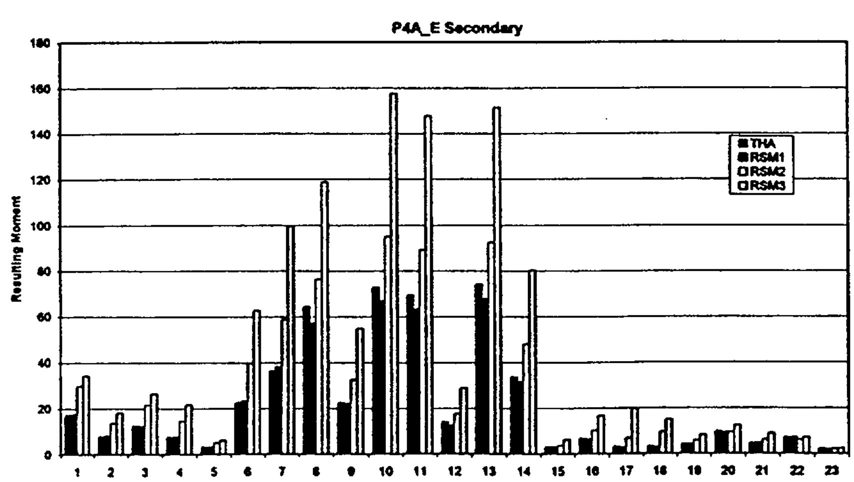

P4A_B Primary System
Resulting Moment
0
500000
1000000
1500000
2000000
2500000
3000000
3500000
4000000
4500000
5000000
THA
RSM1
RSM2
RSM3 (Diagonal)
1
2
3
4
5
6
7
Node

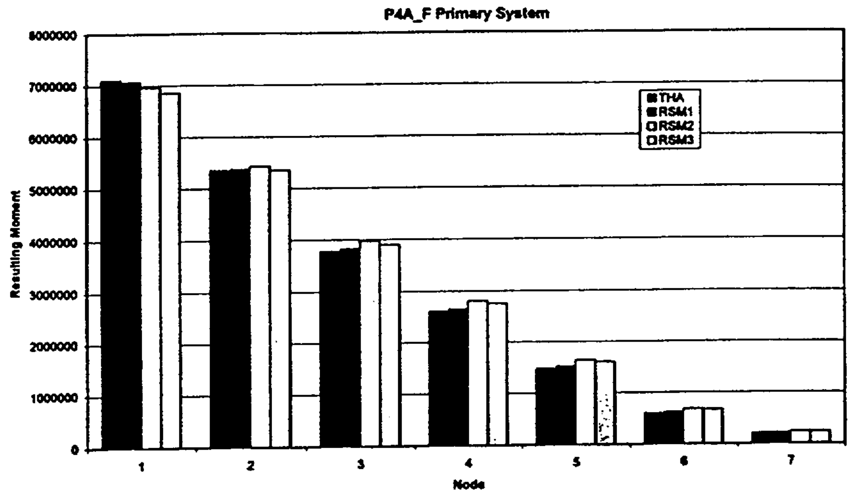

P4A_B Links
Resulting Moment
0
10
20
30
40
50
60
70
80
90
THA
RSM1
RSM2
RSM3 (Diagonal)
1
2
3
4
5
6
7
Node

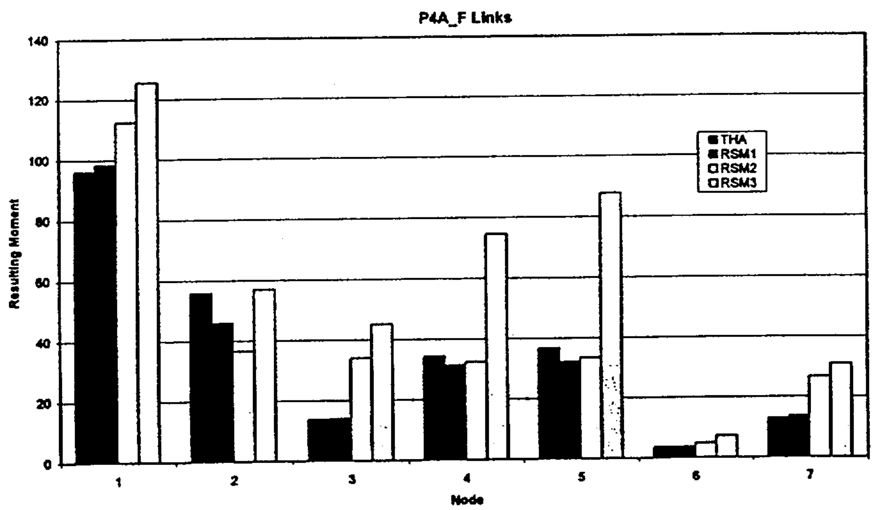

P4A_B Secondary
Resulting Moment
0
20
40
60
80
100
120
140
THA
RSM1
RSM2
RSM3
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
Node

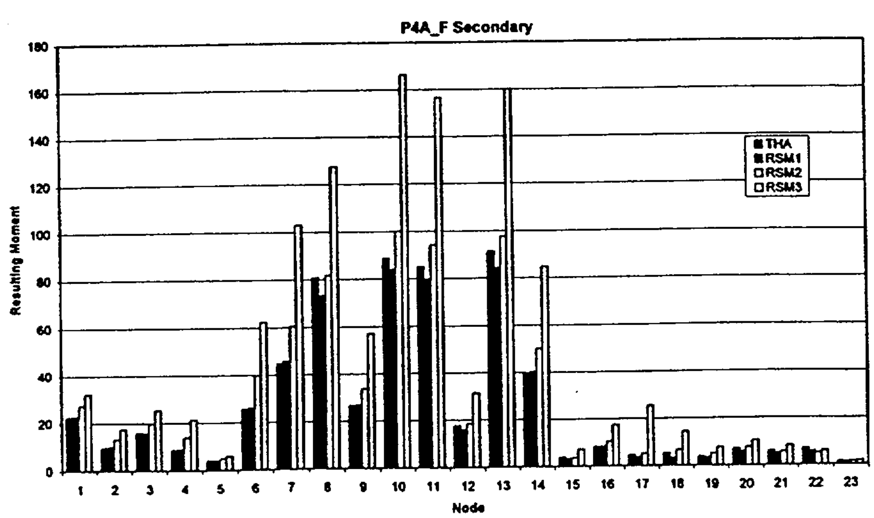

P4A_E Primary System
Resulting Moment
Node
THA
RSM1
RSM2
RSM3

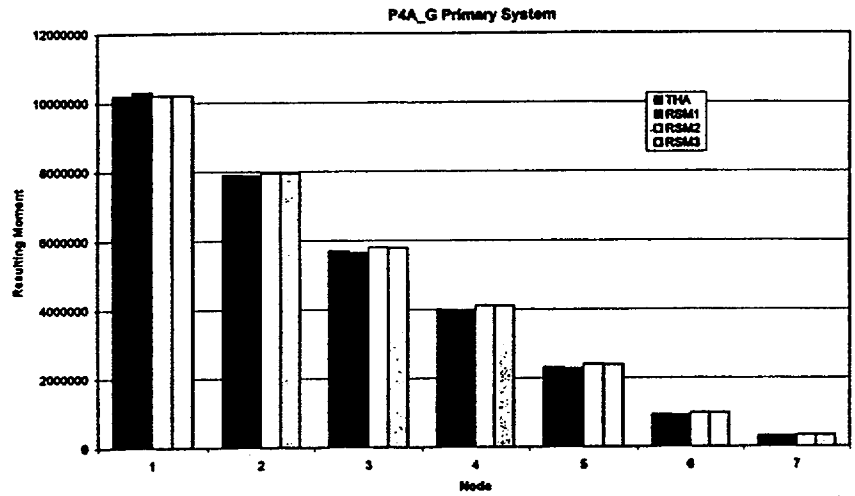

P4A_E Links
Resulting Moment
Node
THA
RSM1
RSM2
RSM3

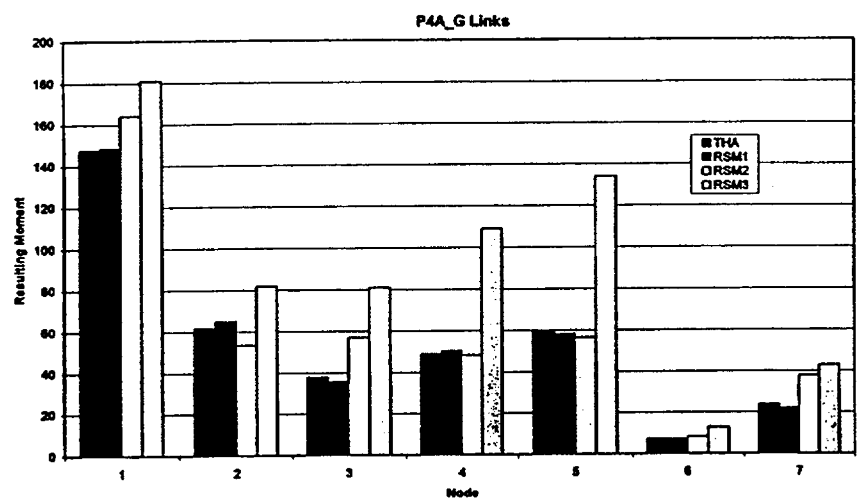

P4A_E Secondary
Resulting Moment
Node
THA
RSM1
RSM2
RSM3

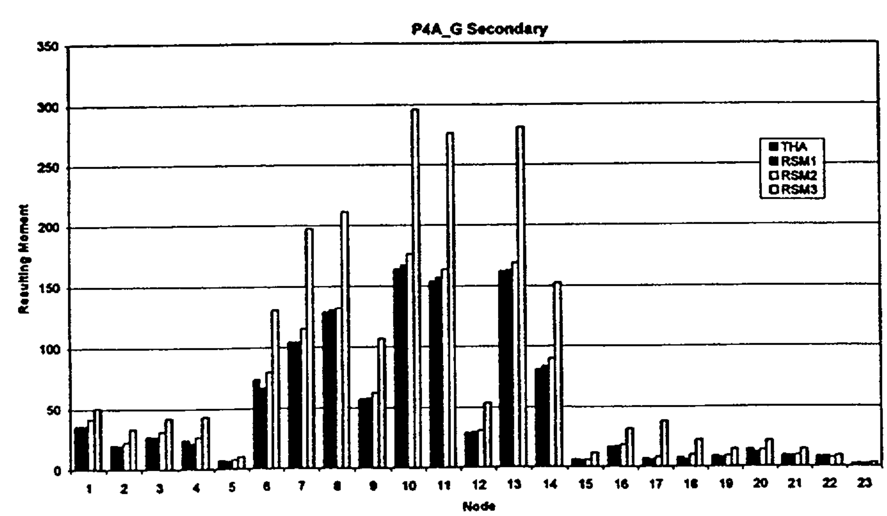

P4A_F Primary System
Resulting Moment
Node
THA
RSM1
RSM2
RSM3
0
1000000
2000000
3000000
4000000
5000000
6000000
7000000
8000000
1
2
3
4
5
6
7

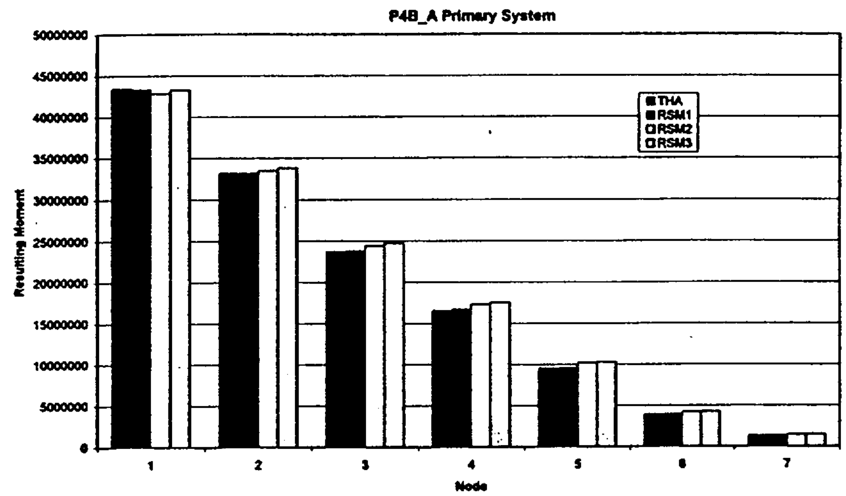

P4A_F Links
Resulting Moment
Node
THA
RSM1
RSM2
RSM3
0
20
40
60
80
100
120
140
1
2
3
4
5
6
7

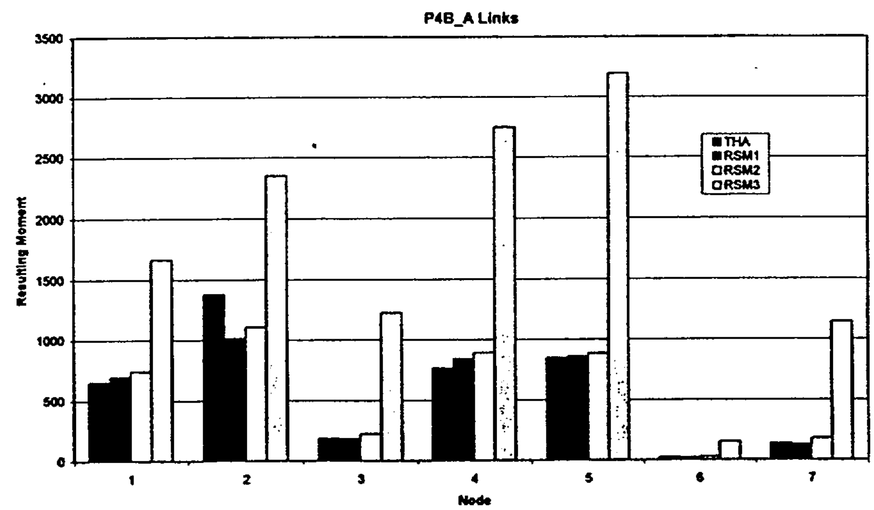

P4A_F Secondary
Resulting Moment
Node
THA
RSM1
RSM2
RSM3
0
20
40
60
80
100
120
140
160
180
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23

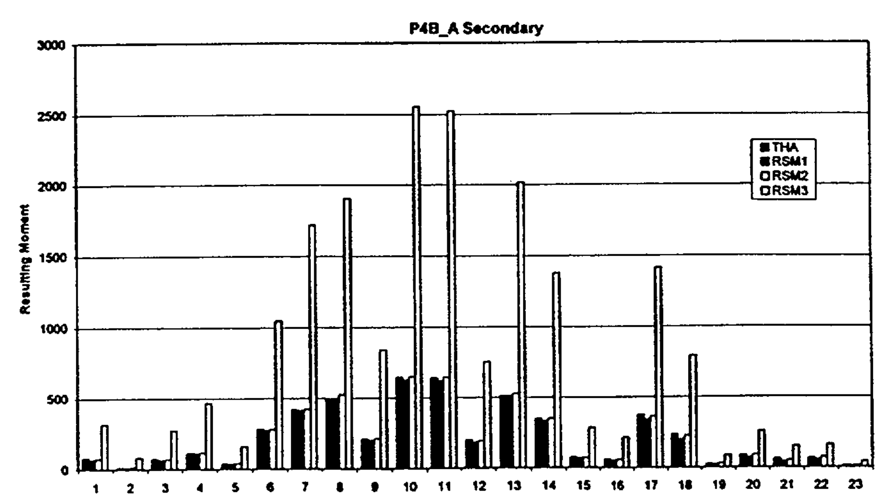

P4A_G Primary System
Resulting Moment
12000000
10000000
8000000
6000000
4000000
2000000
0
THA
RSM1
RSM2
RSM3
1
2
3
4
5
6
7
Node

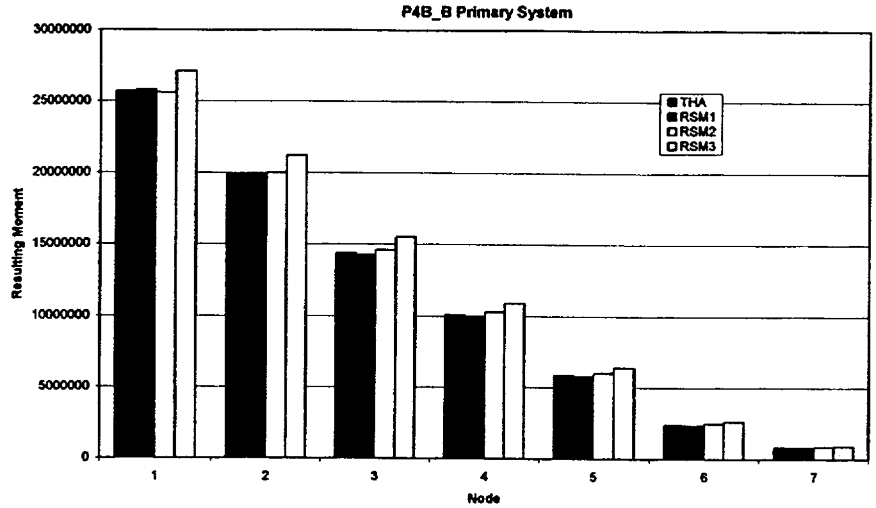

P4A_G Links
Resulting Moment
200
180
160
140
120
100
80
60
40
20
0
THA
RSM1
RSM2
RSM3
1
2
3
4
5
6
7
Node

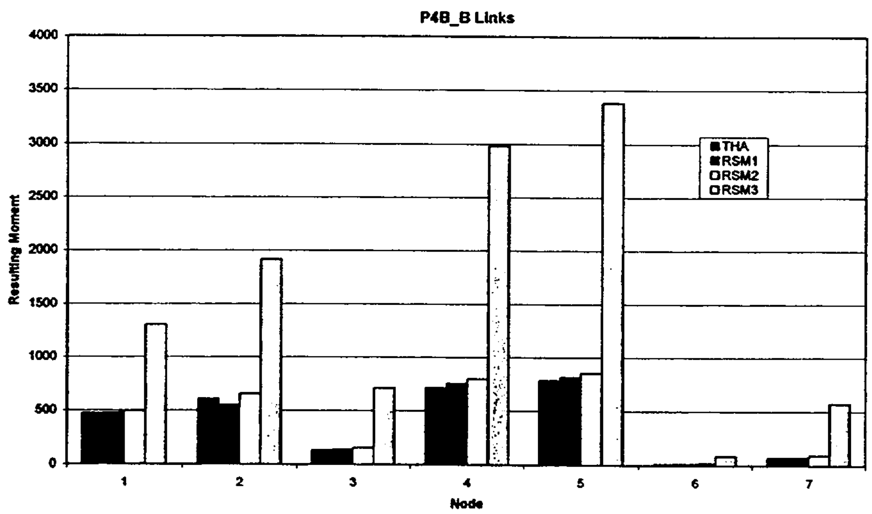

P4A_G Secondary
Resulting Moment
350
300
250
200
150
100
50
0
THA
RSM1
RSM2
RSM3
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Node


P4B_A Primary System
THA
RSM1
RSM2
RSM3
Resulting Moment
Node
50000000
45000000
40000000
35000000
30000000
25000000
20000000
15000000
10000000
5000000
0
1
2
3
4
5
6
7


P4B_A Links
THA
RSM1
RSM2
RSM3
Resulting Moment
Node
3500
3000
2500
2000
1500
1000
500
0
1
2
3
4
5
6
7


P4B_A Secondary
THA
RSM1
RSM2
RSM3
Resulting Moment
Node
3000
2500
2000
1500
1000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23


P4B_B Primary System
30000000
25000000
20000000
15000000
10000000
5000000
0
Resulting Moment
THA
RSM1
RSM2
RSM3
1
2
3
4
5
6
7
Node


P4B_B Links
4000
3500
3000
2500
2000
1500
1000
500
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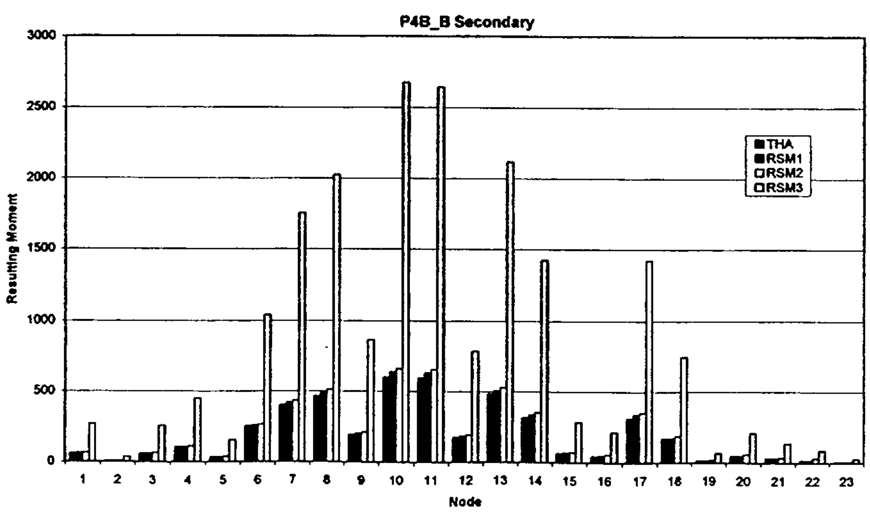
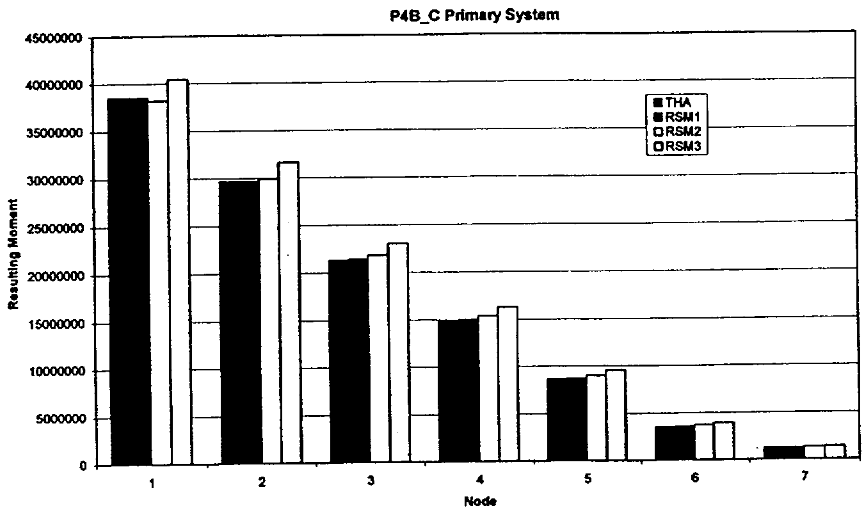
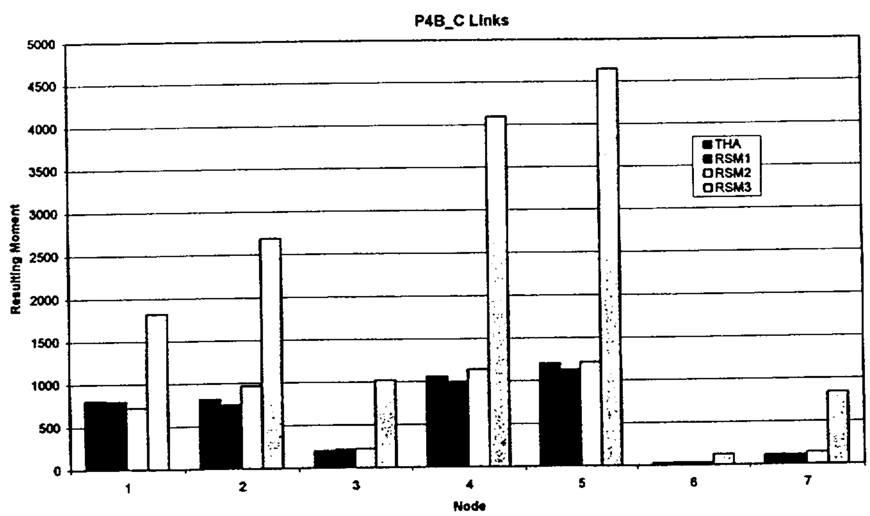
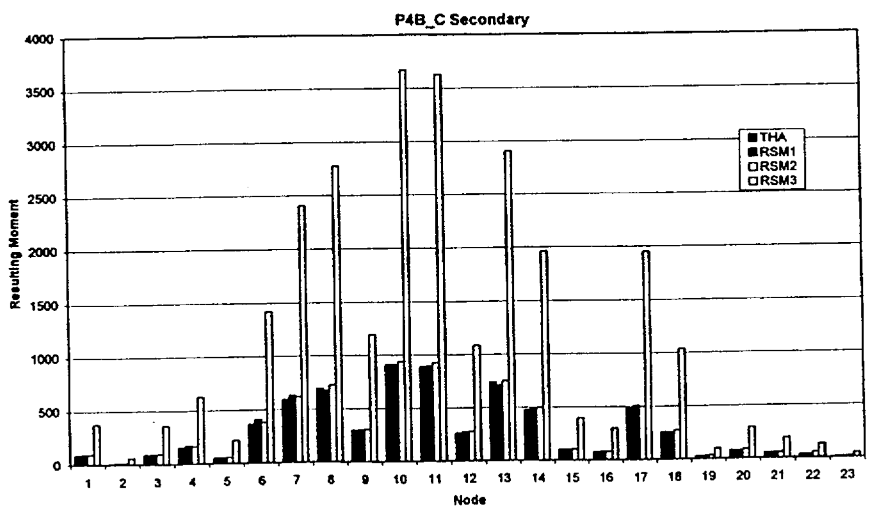
Resulting Moment
THA
RSM1
RSM2
RSM3
1
2
3
4
5
6
7
Node

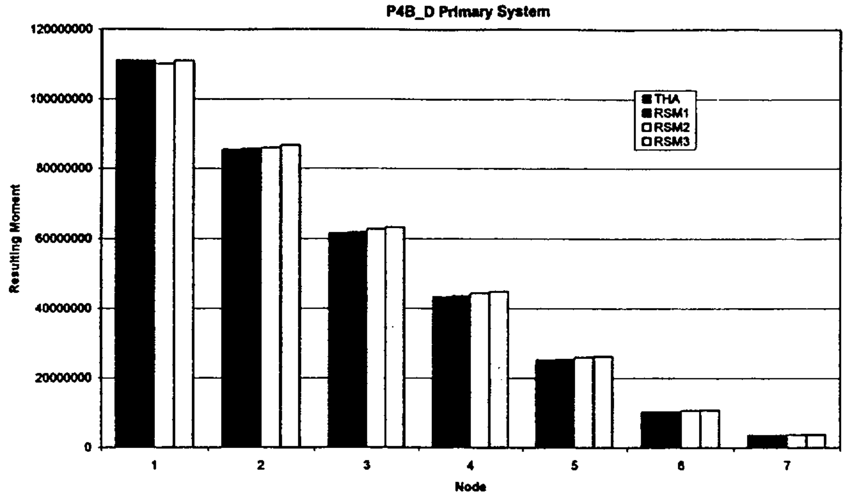

P4B_B Secondary
3000
2500
2000
1500
1000
500
0
Resulting Moment
THA
RSM1
RSM2
RSM3
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Node


P4B_C Primary System
Resulting Moment
Node
THA
RSM1
RSM2
RSM3

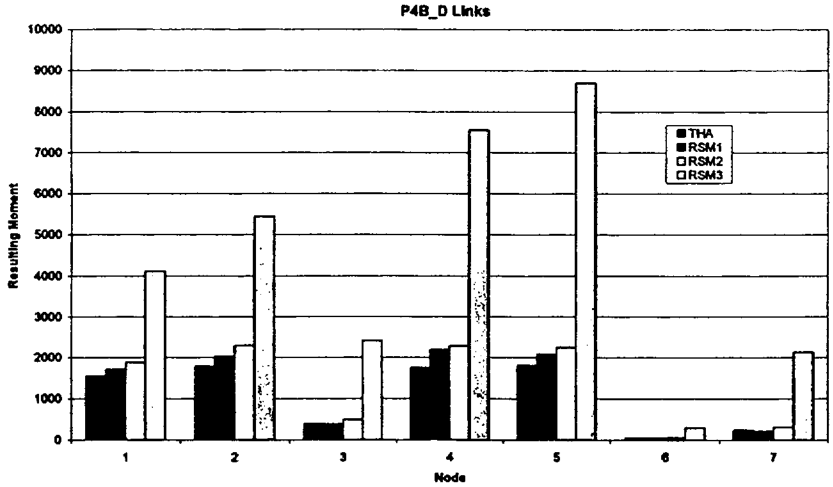

P4B_C Links
Resulting Moment
Node
THA
RSM1
RSM2
RSM3


P4B_C Secondary
Resulting Moment
Node
THA
RSM1
RSM2
RSM3

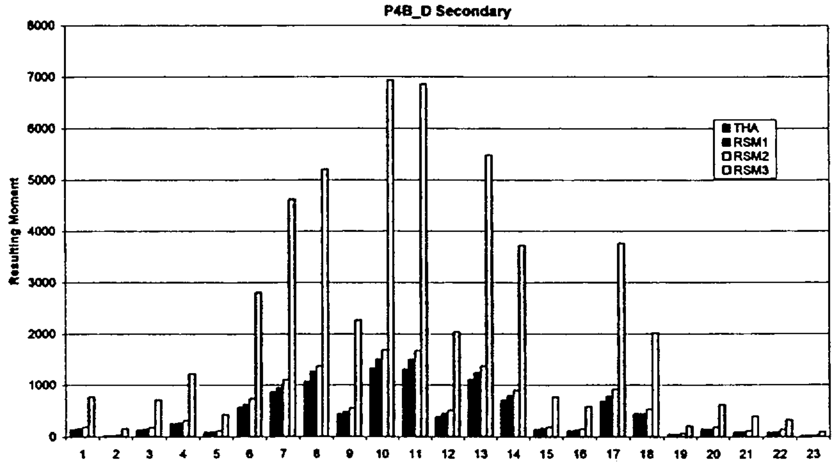
P4B_D Primary System

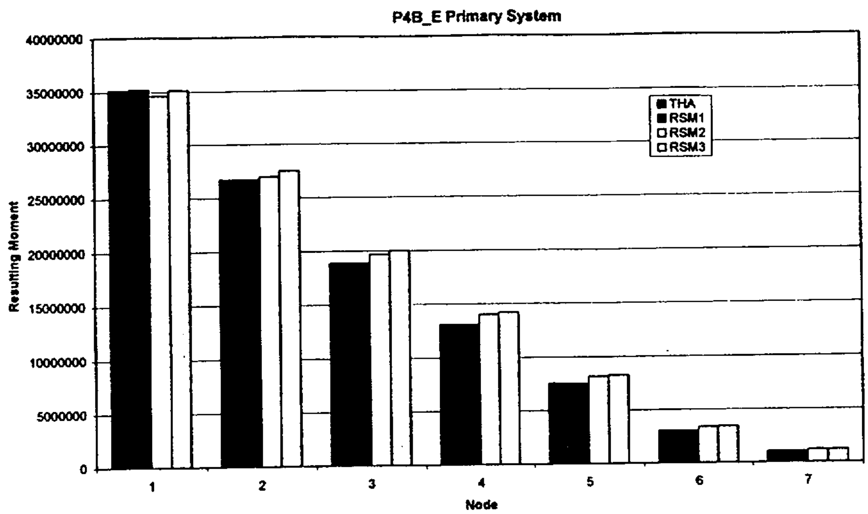


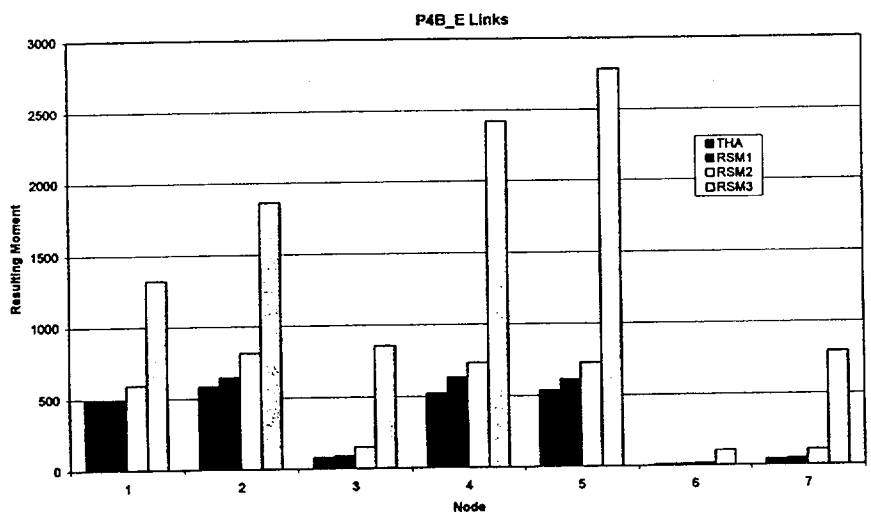
P4B_D Links

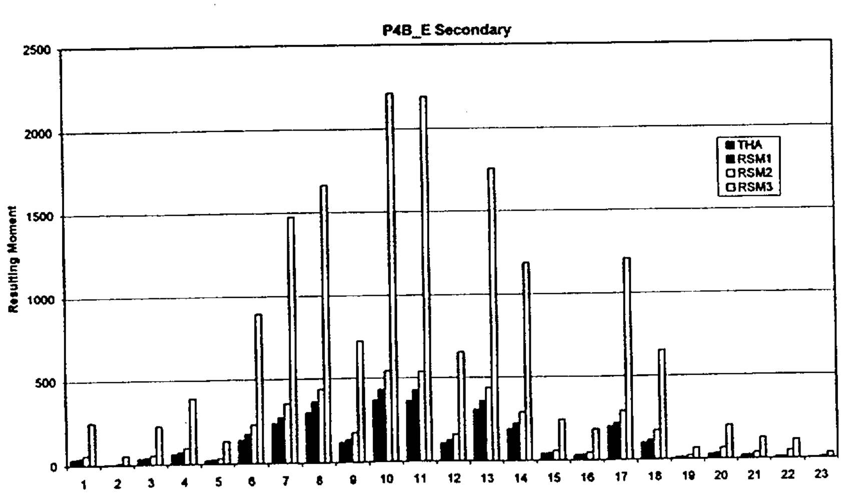


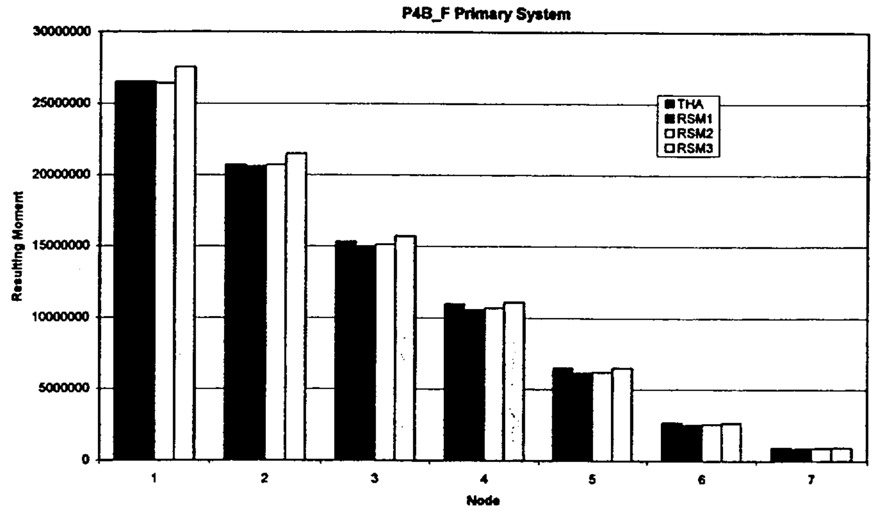
P4B_D Secondary

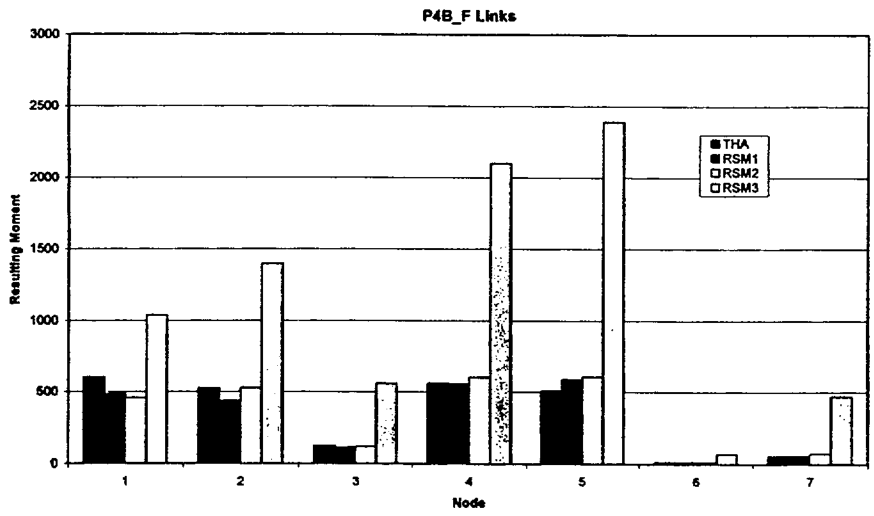


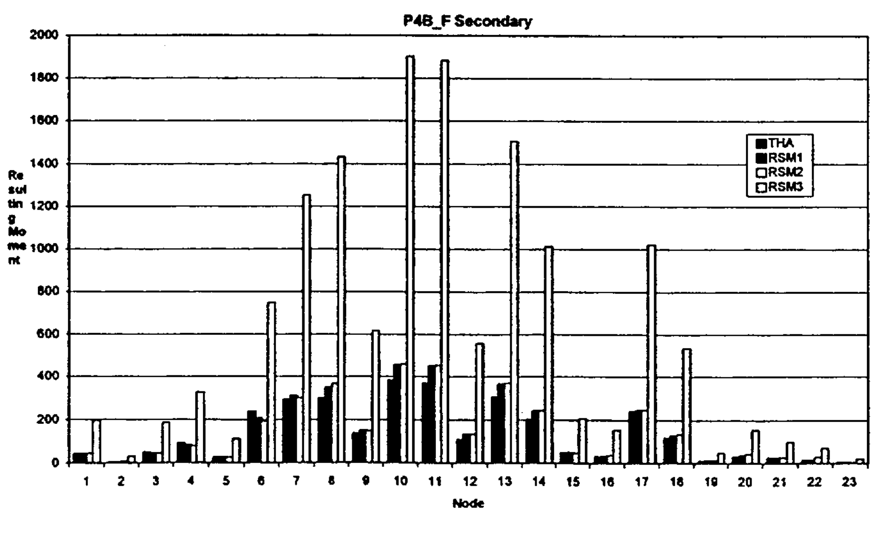

P4B_E Primary System
Resulting Moment
40000000
35000000
30000000
25000000
20000000
15000000
10000000
5000000
0
THA
RSM1
RSM2
RSM3
1
2
3
4
5
6
7
Node

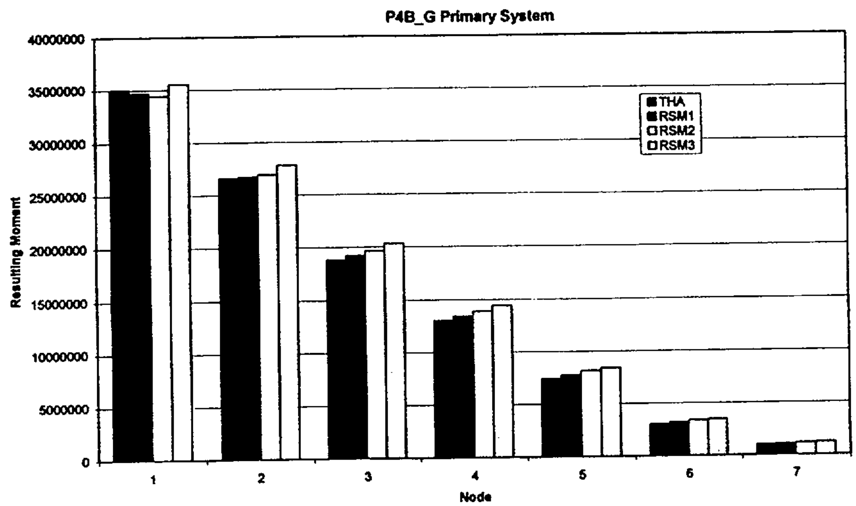

P4B_E Links
Resulting Moment
3000
2500
2000
1500
1000
500
0
THA
RSM1
RSM2
RSM3
1
2
3
4
5
6
7
Node

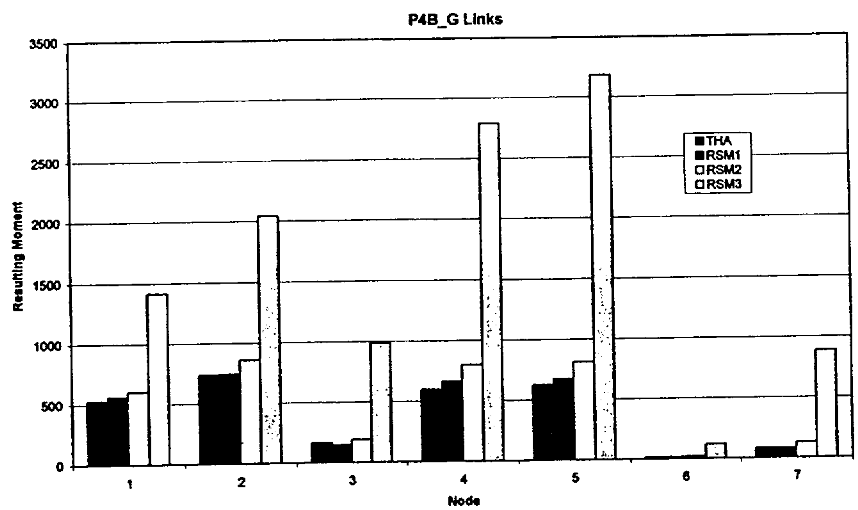

P4B_E Secondary
Resulting Moment
2500
2000
1500
1000
500
0
THA
RSM1
RSM2
RSM3
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Node


P4B_F Primary System
Resulting Moment
Node
THA
RSM1
RSM2
RSM3


P4B_F Links
Resulting Moment
Node
THA
RSM1
RSM2
RSM3


P4B_F Secondary
Resulting Moment
Node
THA
RSM1
RSM2
RSM3


P4B_G Primary System
Resulting Moment
40000000
35000000
30000000
25000000
20000000
15000000
10000000
5000000
0
THA
RSM1
RSM2
RSM3
1
2
3
4
5
6
7
Node


P4B_G Links
Resulting Moment
3500
3000
2500
2000
1500
1000
500
0
THA
RSM1
RSM2
RSM3
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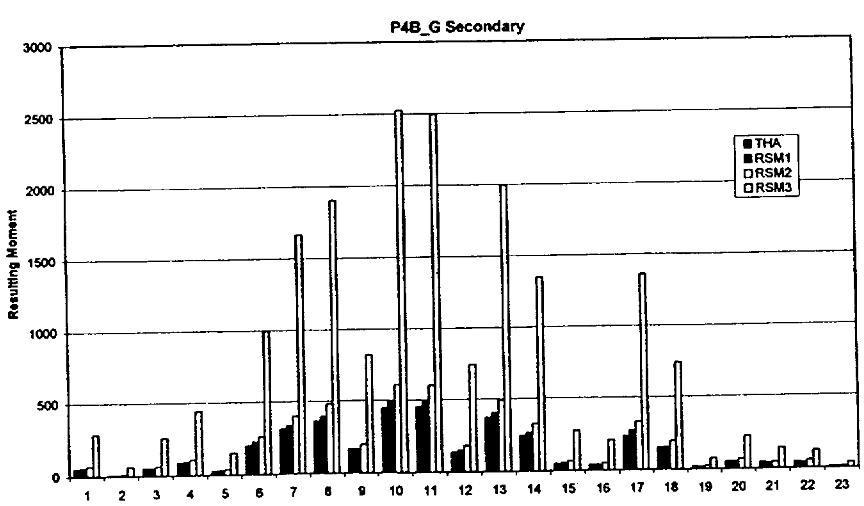
4
5
6
7
Node


P4B_G Secondary
Resulting Moment
3000
2500
2000
1500
1000
500
0
THA
RSM1
RSM2
RSM3
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Node

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Washington, DC 20555-0001

10. SUPPLEMENTARY NOTES

N. Chokshi, Project Manager

11. ABSTRACT *(200 words or less)*

Under the auspices of the US Nuclear Regulatory Commission (NRC), Office of Nuclear Regulatory Research, Brookhaven National Laboratory (BNL) developed a two-phase benchmark program to evaluate state-of-the-art methods for performing seismic analysis of coupled nuclear power plant (NPP) structures with non-classical damping. A Preliminary Report was issued for Phase I of the program, in which a series of benchmark problems were established and "exact" solutions were developed by BNL. The Preliminary Report, which included the detailed descriptions of the benchmark problems, the BNL analysis method, and the necessary inputs, was distributed to the program participants who applied alternate state-of-the-art analysis methods for their independent analyses.

In Phase II, the analysis results that were submitted to BNL by the participating organizations and individuals were compared to and evaluated against the BNL "exact" solutions. This report describes the results and evaluations of the participant analyses of the benchmark problems.

2 KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*

Coupled systems, non-classical damping, seismic analysis, complex modes, response spectrum methods, direct integration, time history solutions.

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