Civil Engineering Study Structural Series 96-3

INRESB-3D-SUPII

User's Manual

GENERAL PURPOSE PROGRAM FOR INELASTIC ANALYSIS OF RC AND STEEL BUILDING SYSTEMS FOR 3D STATIC AND DYNAMIC LOADS AND SEISMIC EXCITATIONS (BASED ON SUPERCOMPUTER AND PC)

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ABSTRACT

This report was prepared as a user's guide to the computer program INRESB-3D-SUPII for analyzing elastic and inelastic building systems subject to static loading, multi-component earthquake motion, and pseudo-static cyclic loading. Additionally, the program is capable of calculating inelastic post-buckling behavior of steel members and systems, natural frequency, and response spectrum. A joint-based system is used to define the geometry of a structure. Structural members may be elastic 3D prismatic beams, nonlinear reinforced concrete shear walls, nonlinear springs, inelastic 3D-beam-column elements, finite-segment elements, and nonlinear bracing elements.

System formulation has the following attributes: 1) joint-based degrees of freedom, 2) rigid body and planar constraints, 3) incremental nonlinear static solution, 4) unbalanced load correction for overshooting, 5) incremental nonlinear dynamic solution, 6) mass and stiffness proportional damping, 7) condensation to reduce the size of a dynamic problem, 8) energy balance, 9) damage index, and 10) ductility and excursion ratio for various definitions of displacement, constant strain energy, and variable strain energy. This program has been developed for achieving efficiency in both computation and data preparation. Output solutions include static results of member forces and joint displacements as well as dynamic results of member forces, joint displacements, ductility factors, excursion ratios, damage indices, seismic input energies, and dissipated energies.

Major features of the report include a description of the program, instructions for data preparation, and a guide to modify the program's dynamic storage.

ACKNOWLEDGMENTS

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I. INTRODUCTION

INRESB-3D-SUPII is a general purpose computer program for elastic / inelastic analysis of reinforced concrete and steel structural systems under the action of static and dynamic loads. Such systems can be frame, truss, shear-wall or a combination of these. Material can be reinforced concrete, steel or both. The program has five main functions. They are

1. SOL01, elastic static analysis with multiple load cases.

2. SOL02, elastic or inelastic analysis of a structure subjected to multiple ground accelerations. The acting ground loading can be 3D ground motion.

3. SOL03, calculation of either natural frequencies and mode shape or buckling load and mode shape of an elastic structure.

4. SOL04, calculation of nonlinear static cyclic response for a given loading pattern that consists of joint loads, imposed displacements or element loads.

5. SOL05, calculation of maximum response of an elastic structure subject to pseudo-dynamic force obtained from the response spectrum.

Finite-segment element, provided by INRESB-3D-SUPII, uses either bilinear or Ramberg-Osgood stress-strain relationship. This element is applied only to steel material.

Calculation is not required for buckling loads and mode shapes of reinforced concrete structures, especially those with shear-walls. However, the program is capable of calculating these factors.

In this program, stress-strain relationships are obtained from experiments and research on steel or reinforced concrete. Nonlinear analysis is such applied only to these materials.

Floor-slab is rigid in its plane but flexible out of it's plane. Shear panels are available for elastic analysis only.

INRESB-3D-SUPII pertains to analysis of building systems above ground level supported by fix, hinge, or spring. The unit system can be international or English. Units for output are corresponding to those for input. If units of input loads and structural dimensions are kip and inch, the units of output forces, stresses and displacements are likewise kip, kip/in^2 and inch. The problem solving capacity of the program is restricted by computer memory. The program automatically checks the memory requirement of a problem, and gives the relevant information (refer section D of Chapter III).

This publication serves as the user's manual for computer program INRESB-3D-SUPII (INelastic Analysis of REinforced Concrete and Steel Building Systems for 3-Dimensional Ground Motions). Chapter II describes numerical procedures for the program. Chapter III discusses subroutines, program capacity, and the addition of materials, elements and solutions. Chapter IV contains detailed input instructions. Chapter V covers instructions for running the program under these environments: (1) CMS for IBM 4381 computer, (2) AIX/370 for IBM 3090S supercomputer, and (3) PC. Chapter VI uses four examples to illustrate the preparation of input data and the output of solutions for supercomputer. Chapter VII illustrate ten examples for PC applications. Ductility and excursion ratios are derived in Appendix A. An explanation of the damage index is given in Appendix B. The source codes of this program are in the report of UMR's Civil Engineering Study Series 96-32 on "INRESB-3D-SUPII —— Program Listing".

II. DESCRIPTION OF INRESB-3D-SUPII COMPUTER PROGRAM

INRESB-3D-SUPII is capable of analyzing elastic and nonlinear 3D structures subject to static and seismic loadings. It is a modular computer program consisting of six primary blocks. STRUCT, the first block, defines the structural model. SOL01, SOL02, SOL03, SOL04 and SOL05, the remaining blocks, are independent solutions for static loading, seismic loading, natural frequency or buckling load, static cyclic loading, and response spectrum analysis, respectively. Numerical procedures for each program block are presented in this chapter.

A. STRUCT - DEFINITION OF STRUCTURAL MODEL

A structural model consists of an assemblage of elements. The point where two or more elements connect is called a joint. To model a structure, the location and orientation of each joint are first defined. Materials that describe the behavior of elements, elements that connect the joints, and orientation of element are then defined. For dynamic analysis, the lumped mass at each joint is also defined. All these definitions are in the program block STRUCT. Figure 1 shows the flow chart for STRUCT.

Step 1. Define Joints and Determine DOF's Coordinates of the joints and their orientation are determined by the user. Coordinates are defined in the global coordinate system (GCS). The orientation of each joint gives its joint coordinate system (JCS). Each joint initially has six degrees of freedom (DOF) in the JCS. The user also determines for each joint the DOFs that are restrained, constrained and condensed out. The program generates the structural degrees of freedom (21).

Step 2. Define Material Properties Material properties are input and initialized. Twelve different materials constitute the materials library and are discussed below.

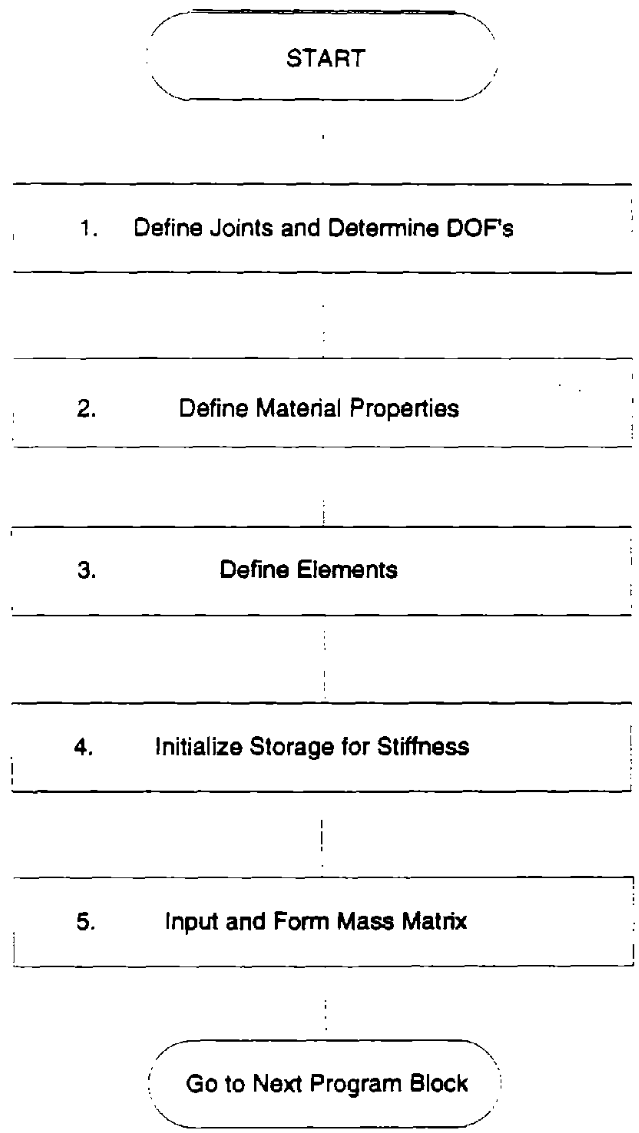


Figure 1. Bolck STRUCT - Definition of Structural Model

Step 3. Define Elements Element data is input. Transformation matrices, initial element structural stiffness and initial element geometric stiffness are calculated. Seven different elements constitute the elements library and are discussed later.

Step 4. Initialize Storage for Stiffness Storage for the structural stiffness and geometric matrices is initialized.

Step 5. Input and Store Mass The lumped mass at each joint is input, and the structures mass matrix is stored.

1. Materials Library

The library consists of twelve models as follows.

a. Elastic 3D Prismatic Beam Elastic section properties of a 3D prismatic beam, A_x, J, I_y, I_z, and the material's modula E and G.

b. R/C Axial Hysteresis Model An axial hysteresis model developed for the reinforced concrete boundary columns of a shear wall (20). This hysteresis model is sketched in Figures 2 and 3 and discussed in Reference 21.

c. Cheng-Mertz B1 Bending Hysteresis Model A bending hysteresis model developed for bending deformations in low-rise reinforced concrete shear walls (21). The hysteresis model is sketched in Figure 4 and uses the multiple segment backbone curve shown in Figure 5.

d. Cheng-Mertz S1 Shear Hysteresis Model A shear hysteresis model developed for the shear deformations in low-rise reinforced concrete shear walls (21). This hysteresis model is sketched in Figure 6. and uses the multiple segment backbone curve shown in Figure 5.

e. Takeda Hysteresis Model A bending hysteresis model developed for the bending

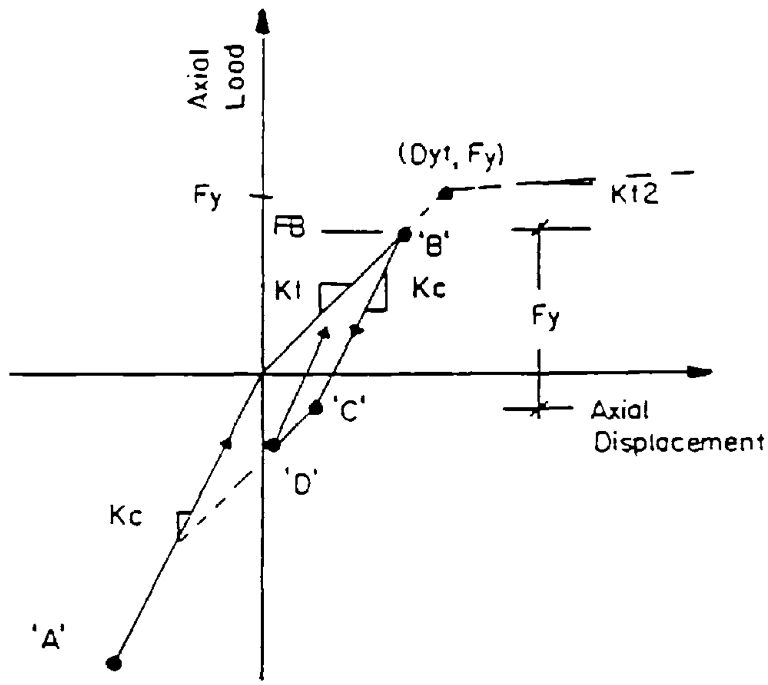


Figure 2. Axial Hysteresis Model Before Tensile Yield

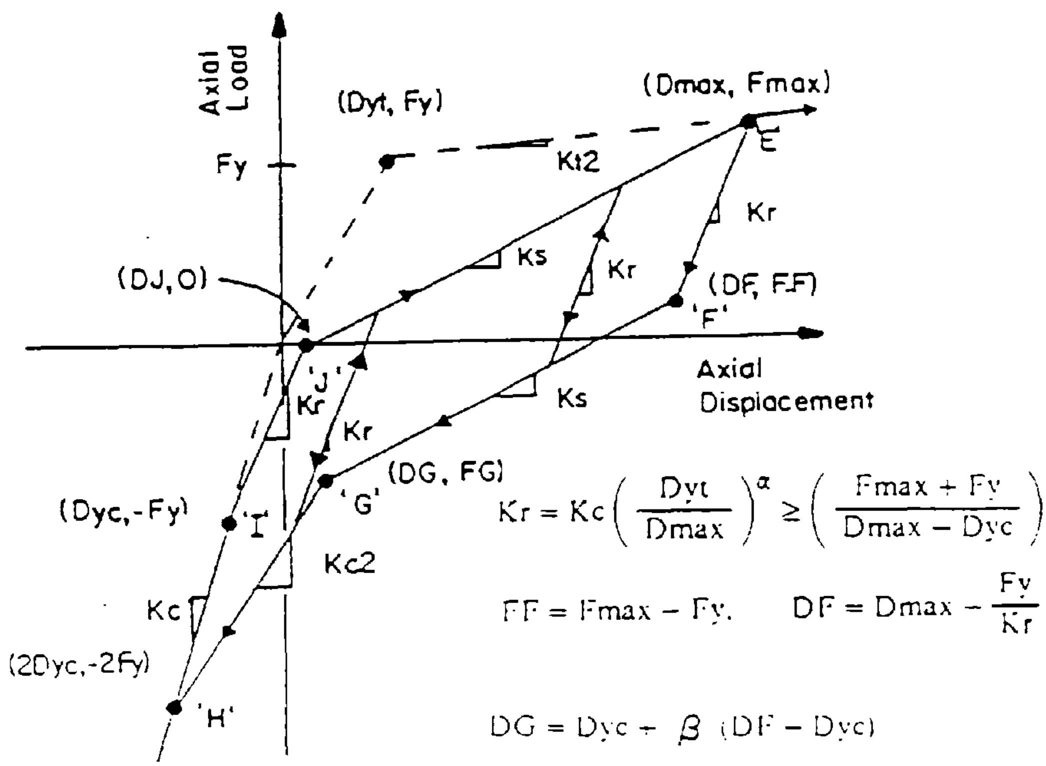


Figure 3. Axial Hysteresis Model After Tensile Yield

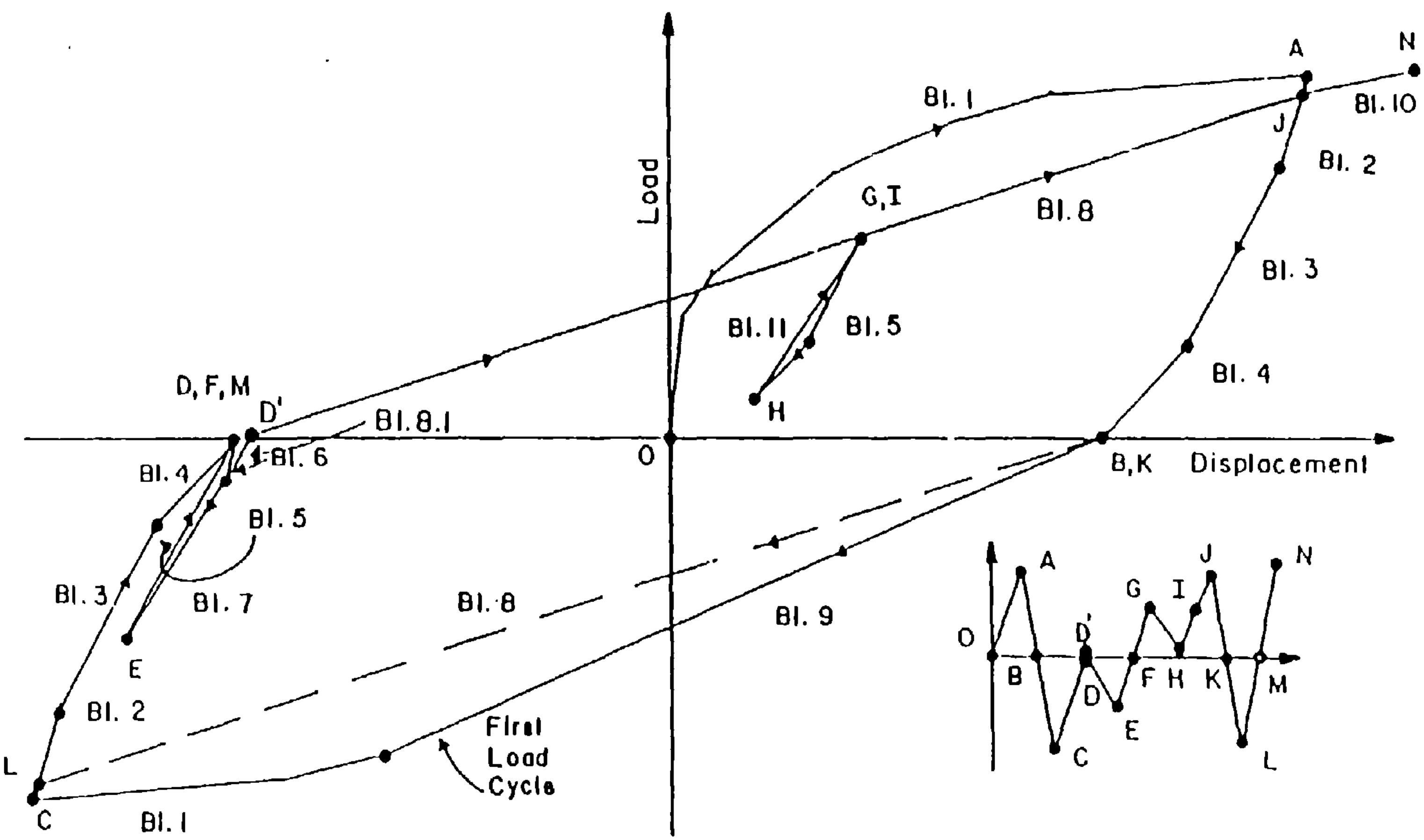


Figure 4. Low-Rise Shear Wall Cheng-Mertz Bending Hysteresis Model

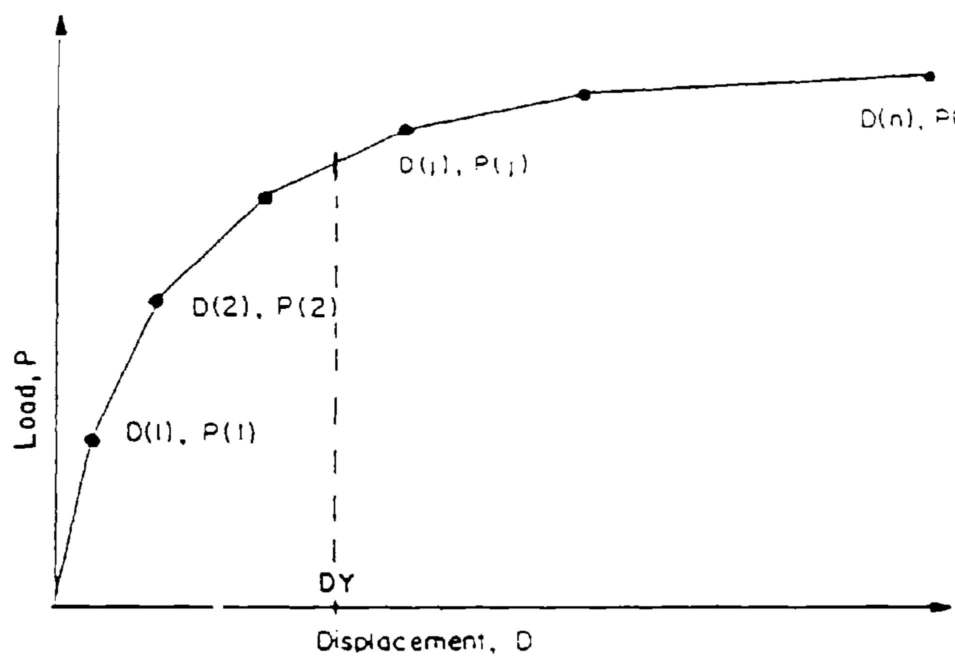


Figure 5. Multiple Segment Backbone Curve

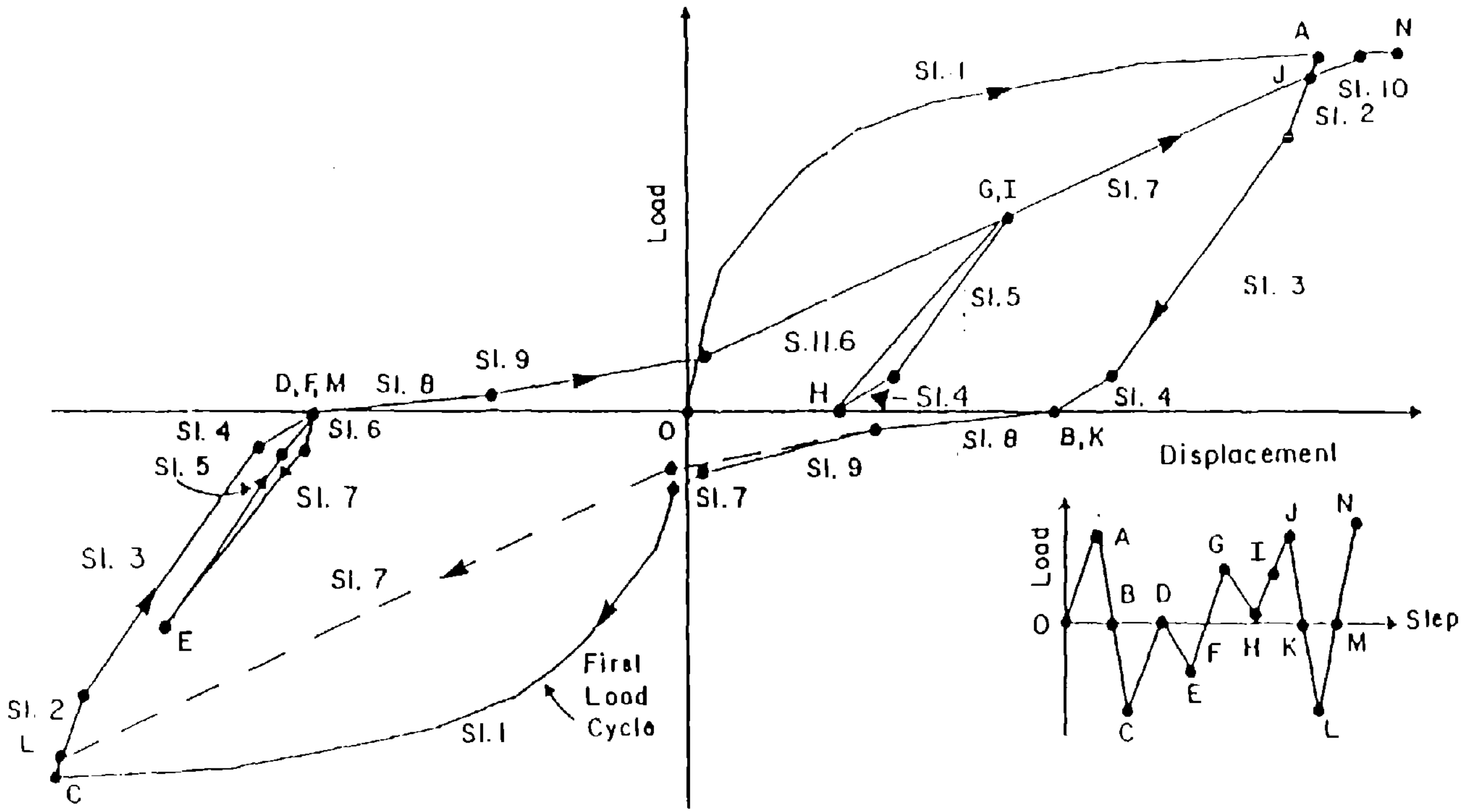


Figure 6. Low-Rise Shear Wall Cheng-Mertz Shear Hysteresis Model

deformations of reinforced concrete members (25). This hysteresis model is sketched in Figure 7.

f. Bilinear Hysteresis Model (BILINEAR) A hysteresis model with a bilinear backbone curve and an elastic unloading and reloading curve. The model may also represent the elasto-plastic model by setting the post-yielding stiffness to zero. This hysteresis model is sketched in Figure 8.

g. Bracing Member Hysteresis Model (BRACE) A hysteresis model developed for the strut hysteretic behavior. This model is based on the original Jain-Goel-Hanson's hysteresis model (19) and can be applied to the box, angle, and wide flange members. This hysteresis model is sketched in Figure 9.

h. Long-Direction Open-Web Joist Hysteresis Model (LONG-OWJG) A hysteresis model developed for the bending deformations in the long-direction open-web joist girder in a 22-story steel building called Pino Suarez Tower which collapsed in the 1985 Mexico earthquake. This hysteresis model (17, 16) is sketched in Figure 10.

i. Short-Direction Open-Web Joist Hysteresis Model (SHORT-OWJG) A hysteresis model developed to model the bending deformations in the short-direction open-web joist girder in the Pino Suarez Tower. This hysteresis model (17) is sketched in Figure 11.

j. Bilinear Hysteresis Model (IA-BILN) Used only for inelastic 3D-beam-column element described later in the elements library. This model has a bilinear backbone curve and an elastic unloading and reloading curve. It may also represent the elasto-plastic model by setting the post-yielding stiffness to zero.

k. Finite-Segment Stress-Strain Hysteresis Model (STABILITY) Can be either bilinear stress-strain relationship or Ramberg-Osgood stress-strain relationship. This model is used only for the finite-segment element described later in the elements library. The Ramberg-Osgood

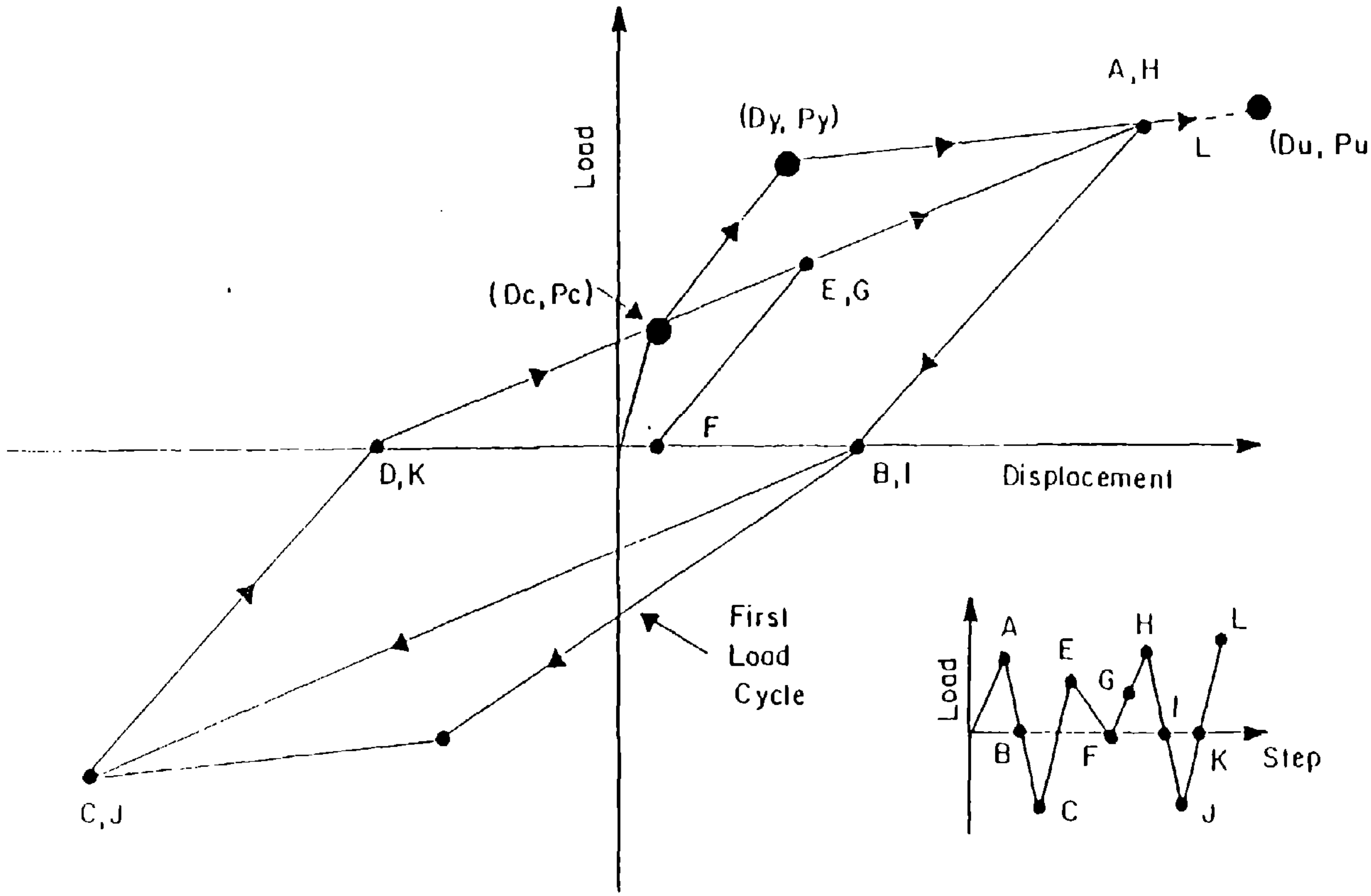


Figure 7. Takeda Hysteresis Model

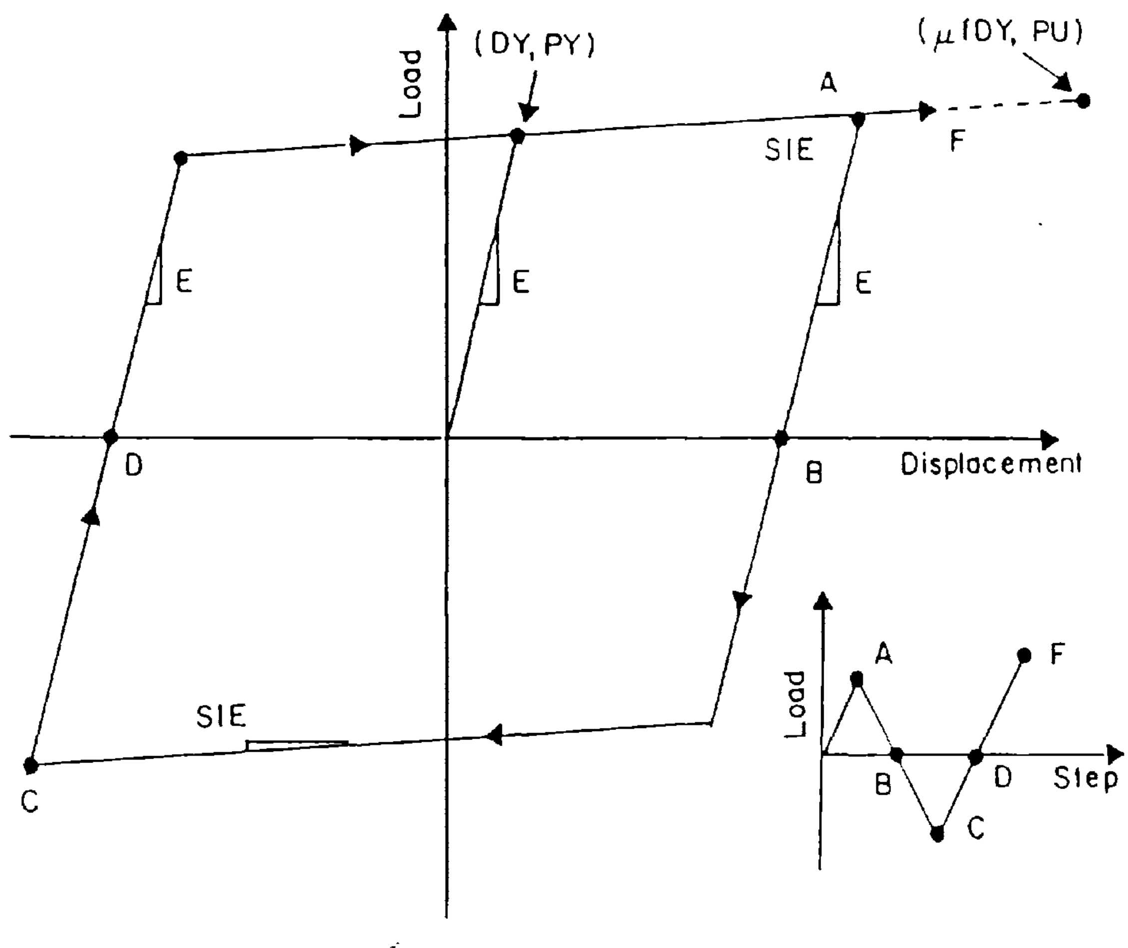


Figure 8. Bilinear Hysteresis Model

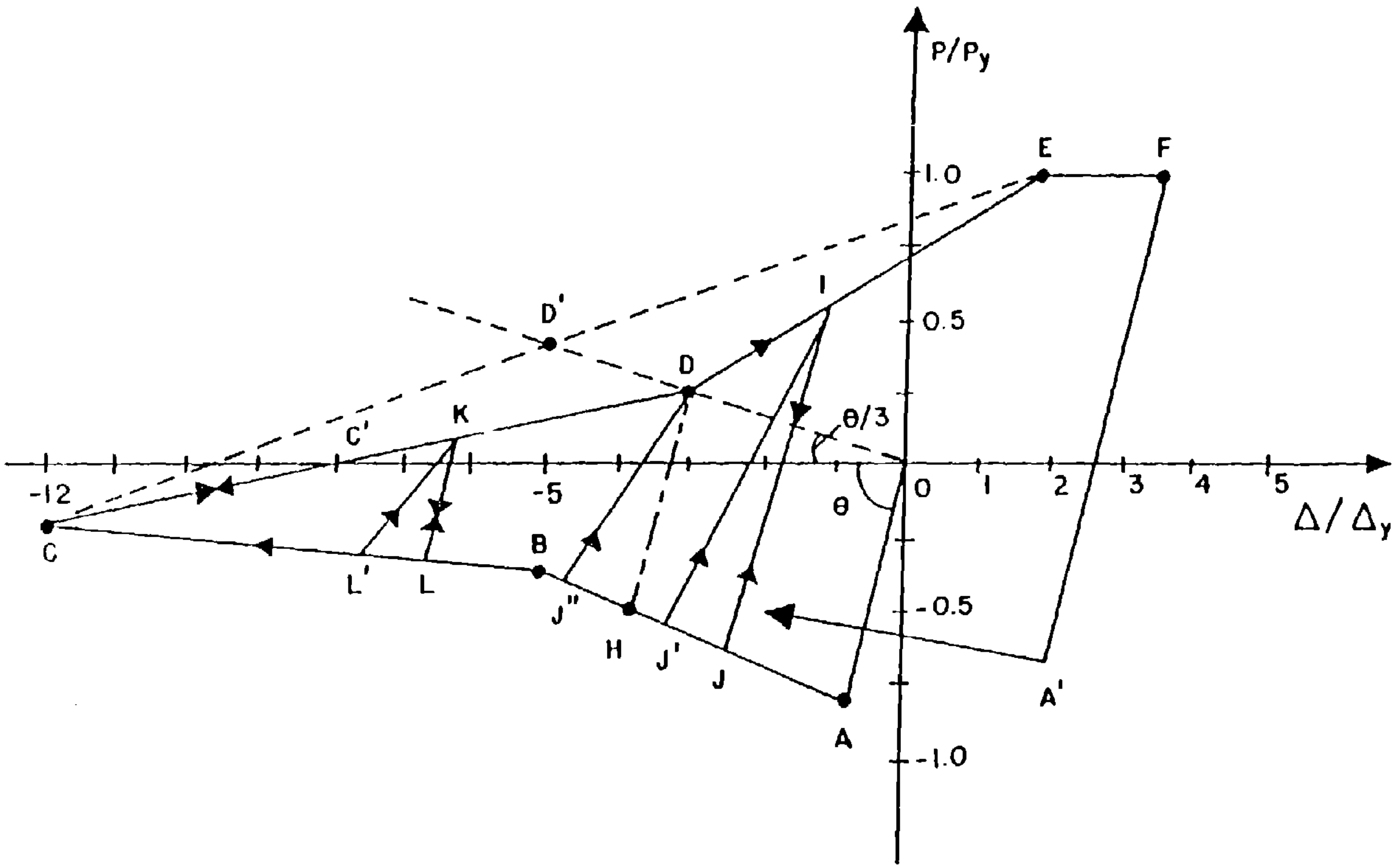
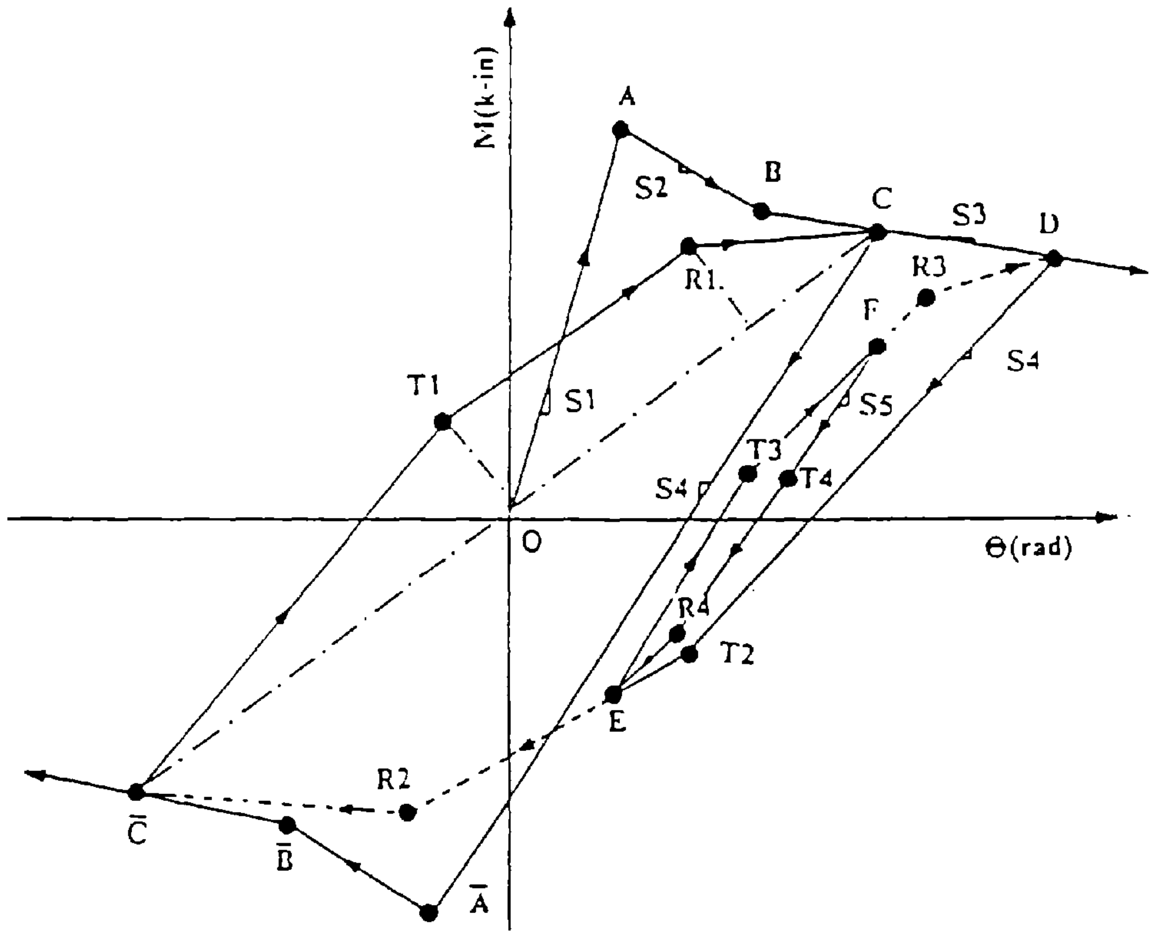


Figure 9. Bracing Member Hysteresis Model



FACH = HA/HA′ (ROTATION FACTOR)

FACV = VA/VA′ (LOAD FACTOR)

FAC = FACV/FACH

$HA, HB, \overline{HA}, \overline{HB}$ = FACH x (HA′,HB′,HA″,HB″)

$VA, VB, \overline{VA}, \overline{VB}$ = FACV x (VA′,VB′,VA″,VB″)

S1 = VA/HA

S2 = S2′ x FAC

S3 = S3′ x FAC

S4 = (-52030200|Θ/FACH| + 856000) x FAC IF |Θ| > HA

= S1 IF |Θ| ≤ HA

S5 = S5′ x FAC

Figure 10. Long-Direction Open-Web Joist Hysteresis Model

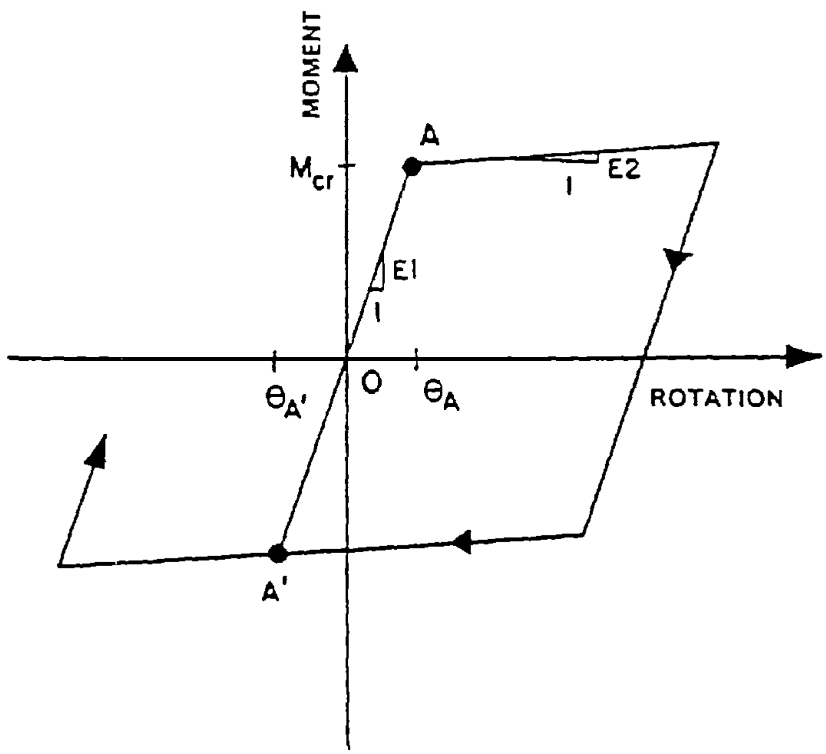


Figure 11. Short-Direction Open-Web Joist Hysteresis Model

stress-strain relationship is sketched in Figure 12. In the figure, parameter R controls the slope of stress-strain curves. If R approaches infinity, the stress-strain curve converges to the elasto-plastic stress-strain relationship.

L. Perforated Shear Wall Hysteresis Model A combined bending and shear hysteresis model developed for the hysteresis behavior of perforated shear walls. This model is sketched in Figure 13, and uses the multiple segment backbone curve shown in Figure 14.

2. Elements Library

This library consists of seven elements as follows.

a. Elastic 3D Prismatic Beam Element Figure 15 shows the elastic 3D prismatic beam element. This element connects the start and end joints. At the start end of the element, a rigid body of length XS is used to model the structural joint. A similar rigid body of length XE is used at the end joint. The beam's element coordinate system (ECS) X_e axis goes from end A toward end B. Orientation of the ECS Y_e axis is defined by a vector, $\overline{V}$, which lies on the ECS XY-plane. The ECS Z_e axis is perpendicular to the X_e and Y_e axes, right-hand rule. There are six internal forces F_X, F_Y, F_Z, M_X, M_Y and F_Z at end A in the ECS, and six at end B. All the internal forces are positive in the ECS direction.

The beam element considers axial, torsional, and bending deformations about the Y_e and Z_e axes. Warping torsion and shear deformation are not considered. Two formulations of geometric stiffness are also available. The 'lumped parameter' formulation only considers second order shears at the end of the beam while the 'consistent parameter' formulation considers second order moments and shears at the end of the beam. The 3D-beam material is used with the beam element.

b. Spring Element This element consist of an isolated spring that connects the start and end joints. At the start end of the spring, a rigid body of length XS is used to model the joint depth. A similar rigid body of length XE is used at the end joint. The spring element coordinate system (ECS) X_e axis goes from end A toward end B. Orientation of the ECS Y_e axis is defined by the

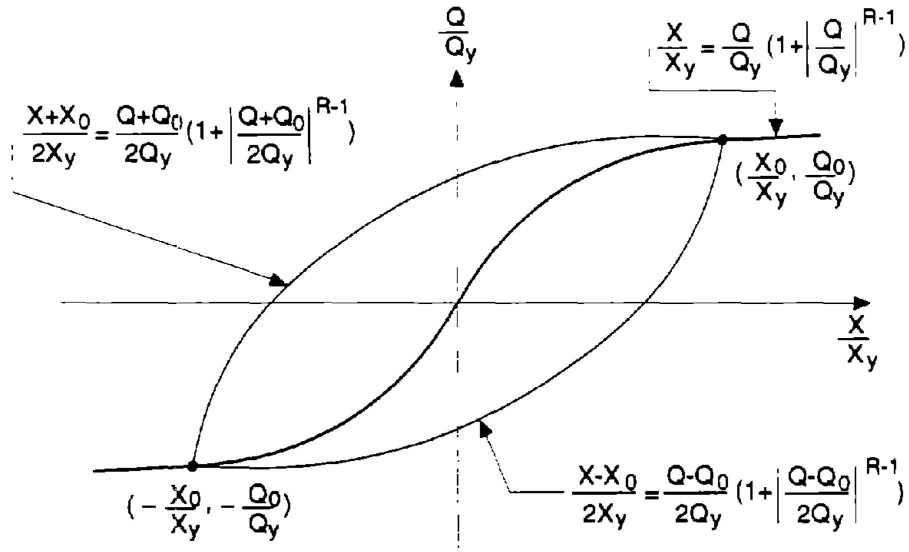


Figure 12. Ramberg-Osgood Stress-Strain Relationship

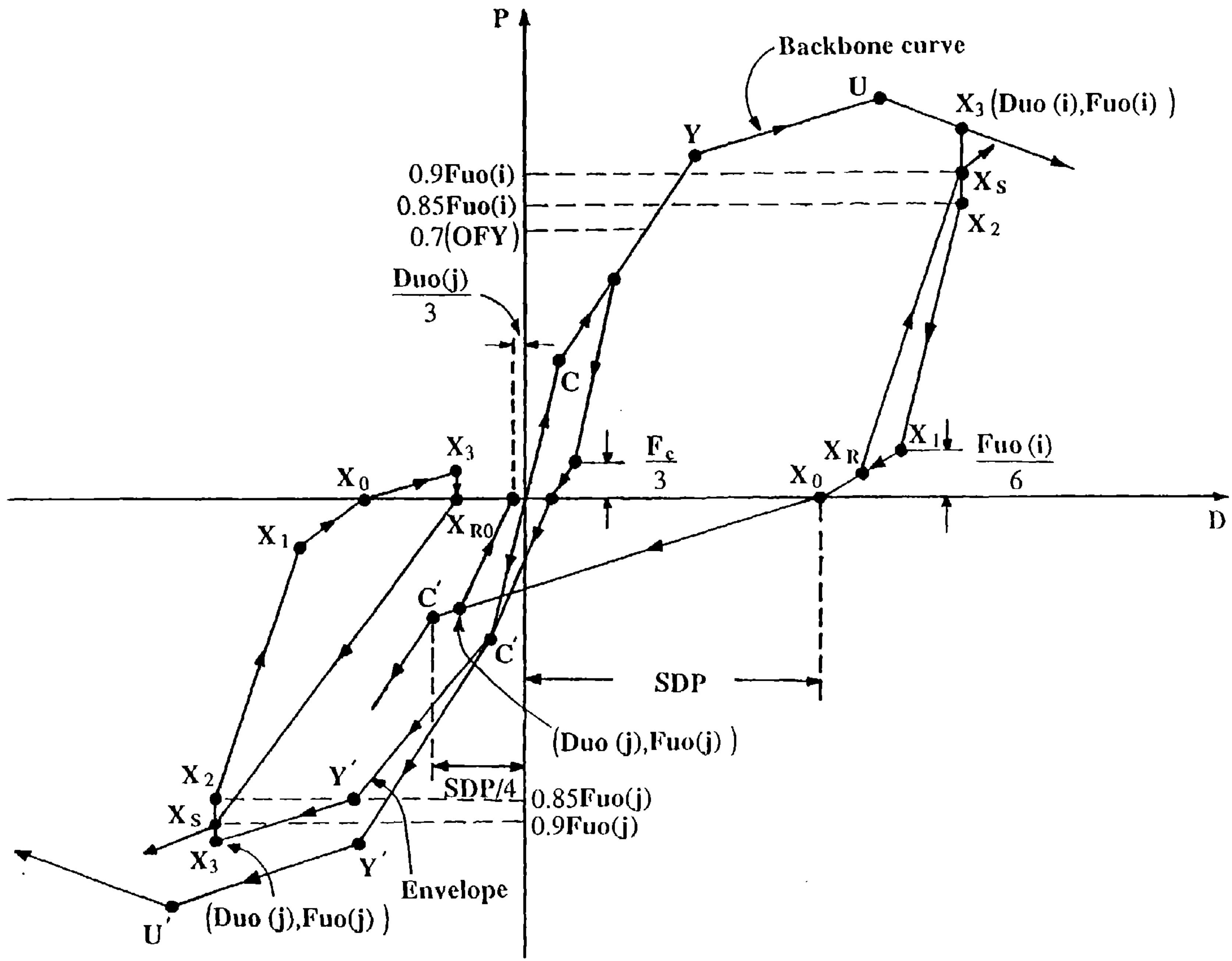


Figure 13. Perforated Shear Wall Hysteresis Model

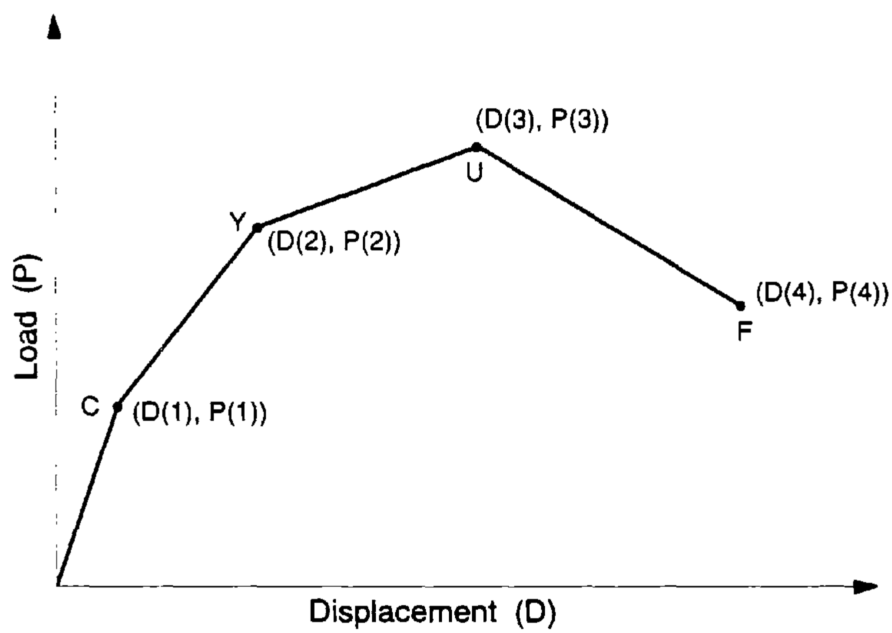


Figure 14. Backbone Curve of Perforated Shear Wall

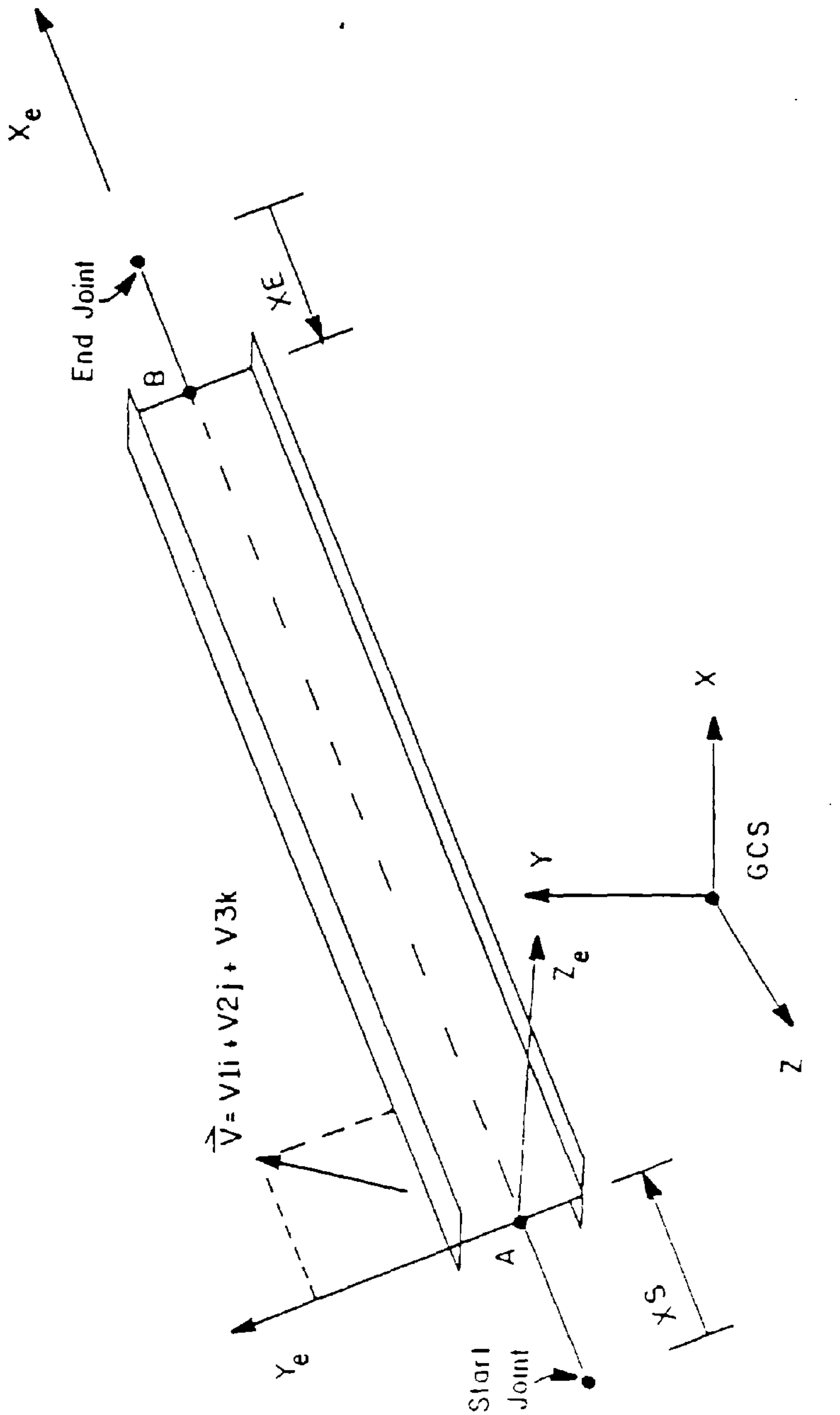


Figure 15. 3D Prismatic Beam Element

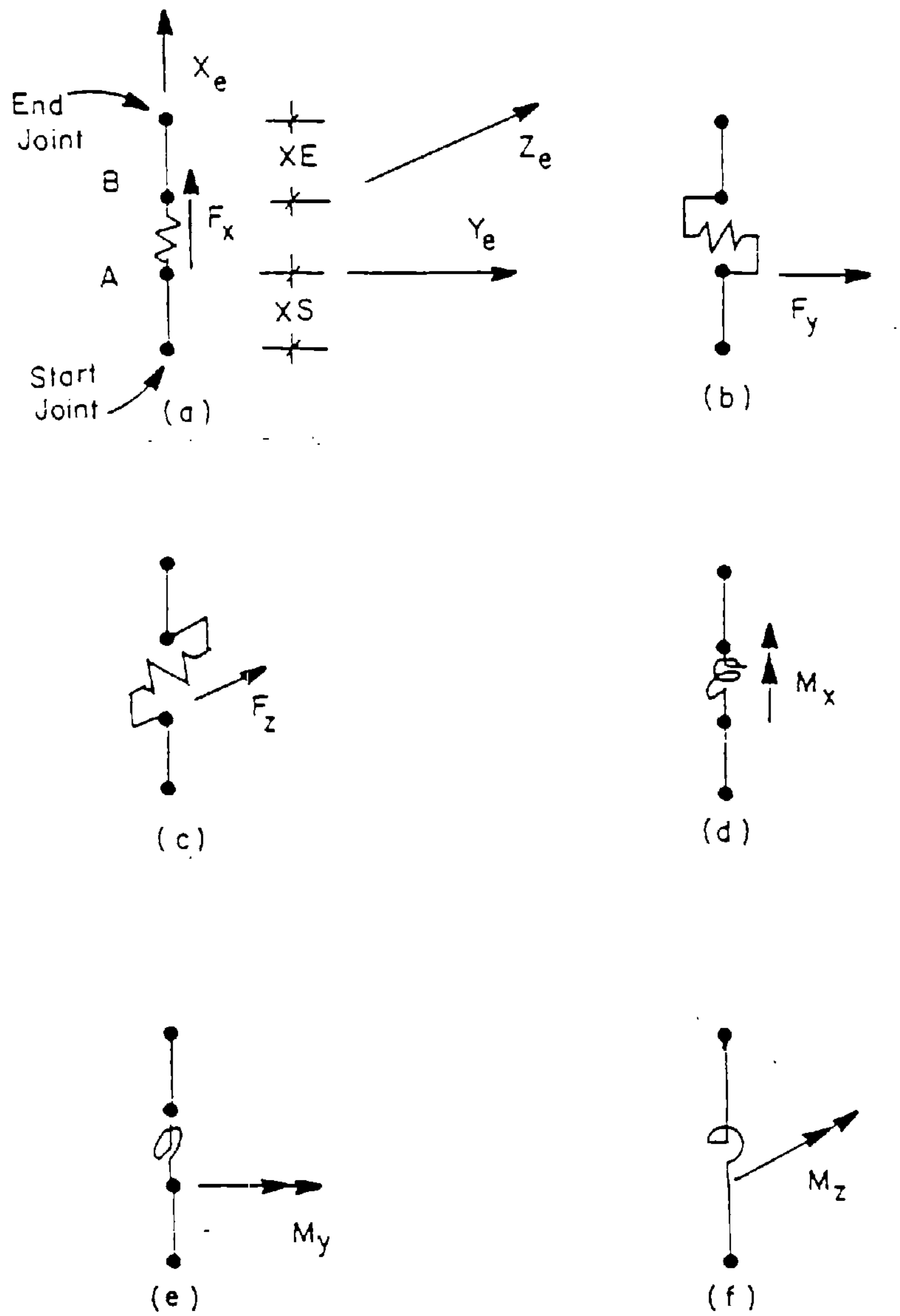


Figure 16. Spring Element: (a) Axial Spring and ECS, (b) Y-axis Shear Spring, (c) Z-axis Shear Spring, (d) Torsional Spring, (e) Y-axis Rotational Spring, (f) Z-axis Rotational Spring

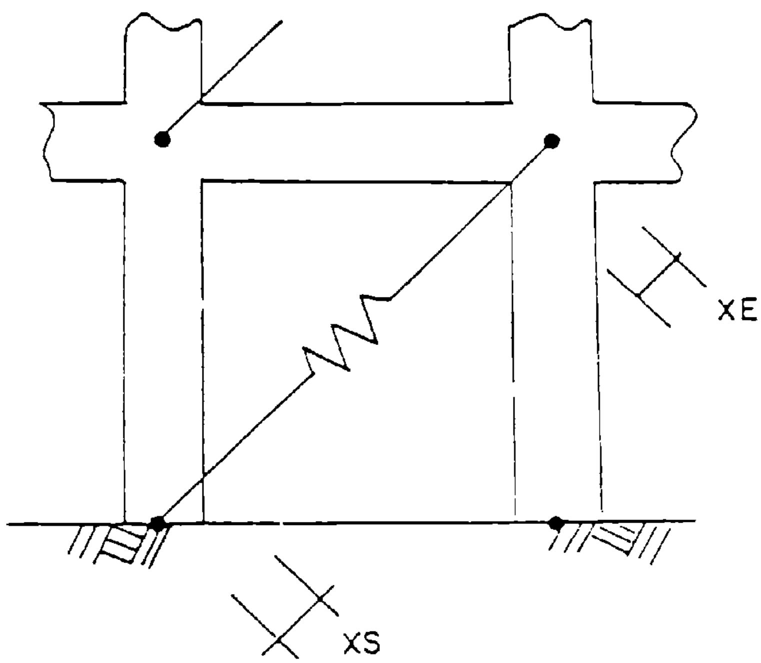


Figure 17. Diagonal Bracing Member Modeled with an Axial Spring

user. The ECS Z_e axis is perpendicular to the X_e and Y_e axes, right-hand rule. When the distance between the start and end joints is zero, orientation of the ECS is identical to the start joint's JCS. The distance between the start and end joints, less the length of the rigid bodies, is the length of the spring element. Optionally, the user may define the length of the spring element. Behavior of the spring element can be elastica or nonlinear, depending on the material properties used and the magnitude of forces acting on the spring. Second order P-Δ forces are not calculated for the spring element.

As shown in Figure 16, the spring may be orientated in one of six positions. Examples of axial, shear and rotational spring applications are shown in Figures 17, 18, and 19, respectively. The axial spring is parallel to the element's X_e axis. Rigid bodies at the ends of the spring reduce its length. The spring's axial force, F_X, at end A is positive in the X_e direction.

The Y-axis shear spring and Z-axis shear spring are oriented parallel to the axes of elements Y_e and Z_e, respectively. Rigid bodies at the ends of the spring reduce its length and induce moments at the joints. The spring's internal shears, F_Y and F_Z, at end A are positive in the Y_e and Z_e directions.

The torsional spring is parallel to the element's X_e axis. Rigid bodies at the end of the spring reduce its length. The spring's internal torsion, M_X, at end A is positive in the X_e direction.

The Y-axis and Z-axis rotational springs are about the Y_e and Z_e axes, respectively. Rigid bodies at the ends of the spring reduce its length. The spring's internal moments, M_Y and M_Z, at end A, are positive in the Y_e and Z_e directions.

c. <u>Reinforced Concrete Shear Wall Element</u> As shown in Figure 20, this element consists of a panel linking four joints. Bending and shear deformations in the plane of the wall are

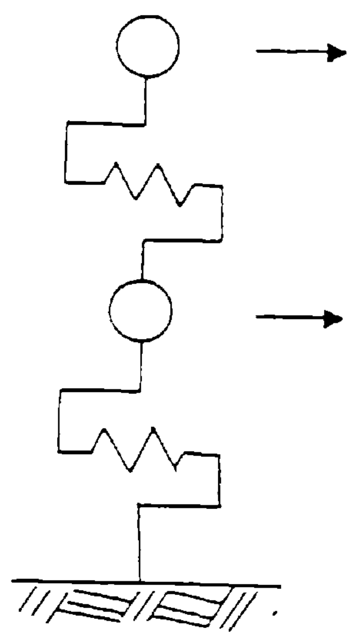


Figure 18. Two-DOF Model With Shear Springs

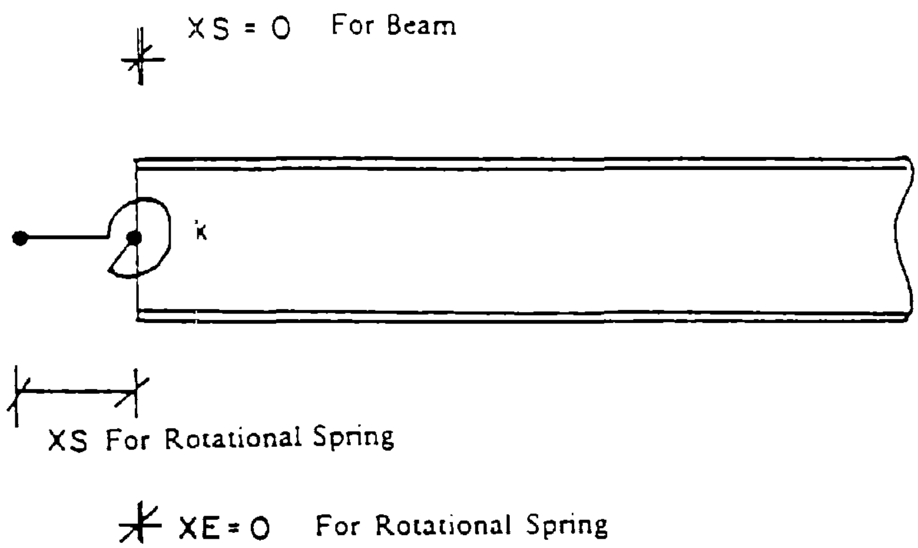


Figure 19. Member End Rotation of an Elastic 3D Prismatic Beam Modeled with Rotational Spring

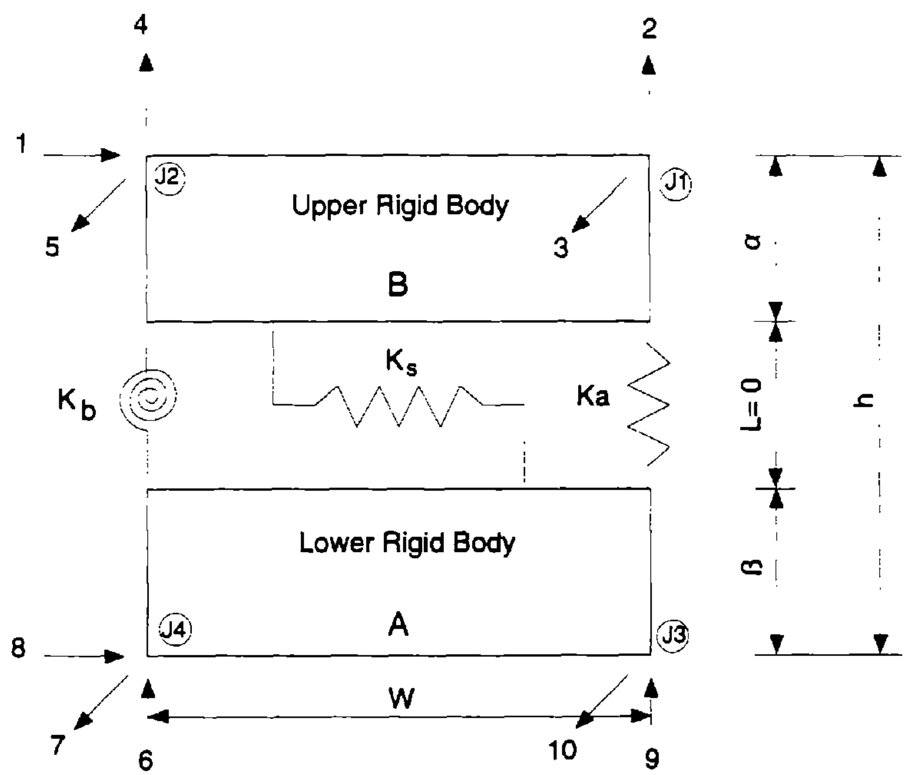


Figure 20. Shear Wall Element

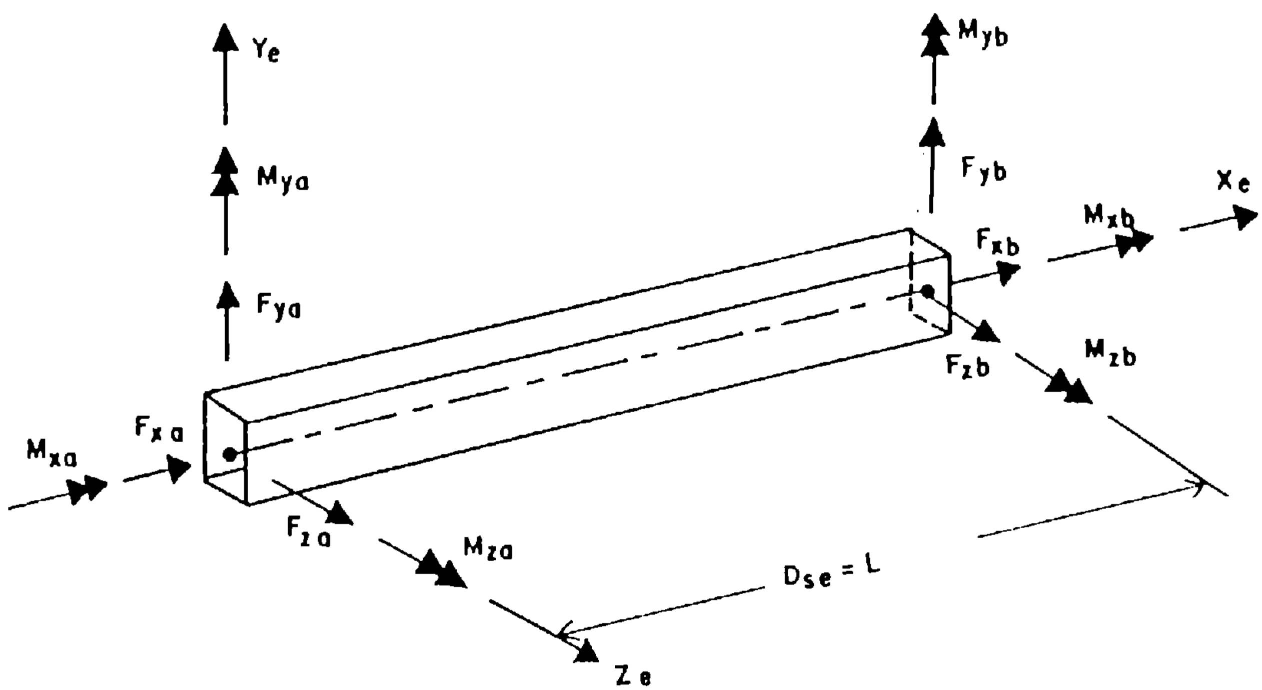


Figure 21. Inelastic 3D Beam-Column Element

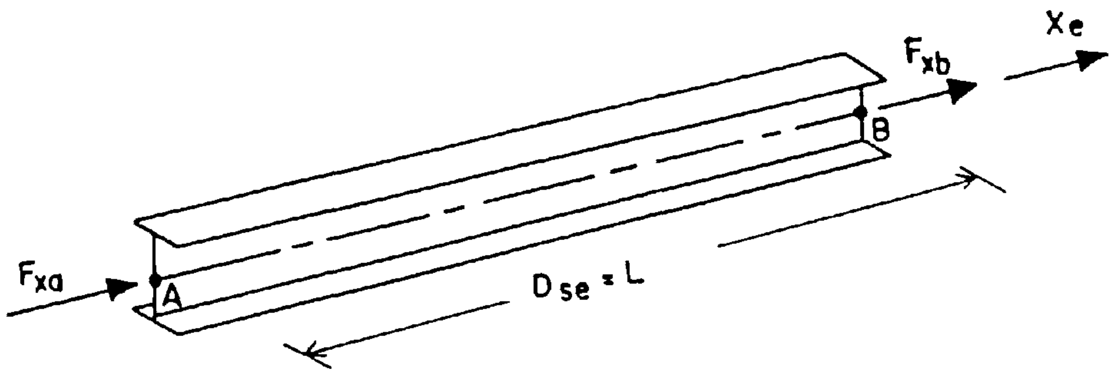


Figure 22. Bracing Element

considered, along with axial deformation. Bending, shear and axial deformations are lumped into three springs. A rigid body, of length α, connects the joints at the top of the wall with the springs while a second rigid body, of length β, connects the joints at the bottom of the wall with the springs. Bending and shear stiffness perpendicular to the plane of the wall are neglected. A 'lumped parameter' formulation of geometric stiffness considers both in-plane and out-of-plane P-Δ effects.

As shown in Figure 20, the wall has 10 dof at the corner joints. Fixing the bottom of the shear wall and applying a positive load to degree of freedom 1 yields a positive moment and shear at end A of the springs. Fixing the bottom of the shear wall and applying a positive load to degrees of freedom 2 and 4 yields a positive axial load at end A of the spring.

Different materials are used to describe the stiffness of the bending, shear and axial springs. Typically the bending stiffness is defined by the B1 bending hysteresis model, the shear stiffness by the S1 shear hysteresis model, and the axial stiffness by the axial hysteresis model.

d. <u>Inelastic 3D Beam-Column Element</u> This element (IE3DBC), which connects a start and end joint, is shown in Figure 21. At the start end of the element, a rigid body of length XS is used to model the structural joint. A similar rigid body of length XE is used at the end joint. The beam's element coordinate system (ECS) X_e axis goes from end A toward end B. Orientation of the ECS Y_e axis is defined by a vector, $\vec{V}$, which lies on the ECS XY-plane. The ECS Z_e axis is perpendicular to the X_e and Y_e axes, right-hand rule. There are six internal forces F_X, F_Y, F_Z, M_X, M_Y and M_Z at end A in the ECS. Similarly, six at end B. All the internal forces are positive in the direction of the ECS.

The beam element considers axial deformation, torsional deformation, and bending deformations about the Y_e and Z_e axes. Warping torsion and shear deformation are not considered. Two formulations of geometric stiffness are also available. The 'lumped parameter' formulation only considers the second order shears at the end of the beam, while the 'consistent parameter' formulation considers the second order moments and shears at the end of the beam.

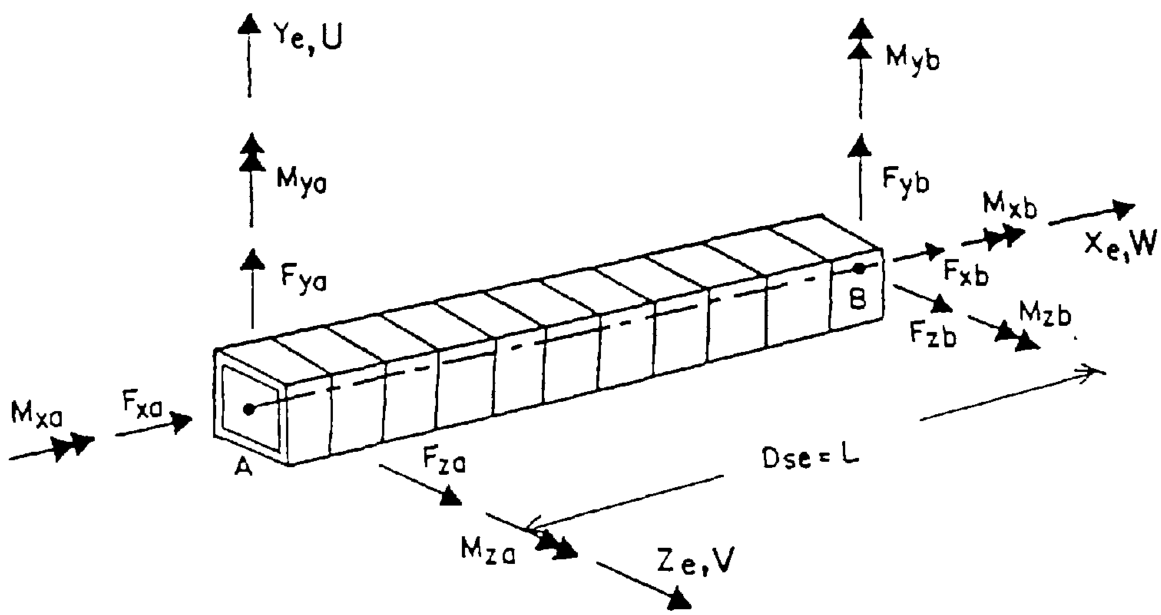


Figure 23. Finite-Segment Element

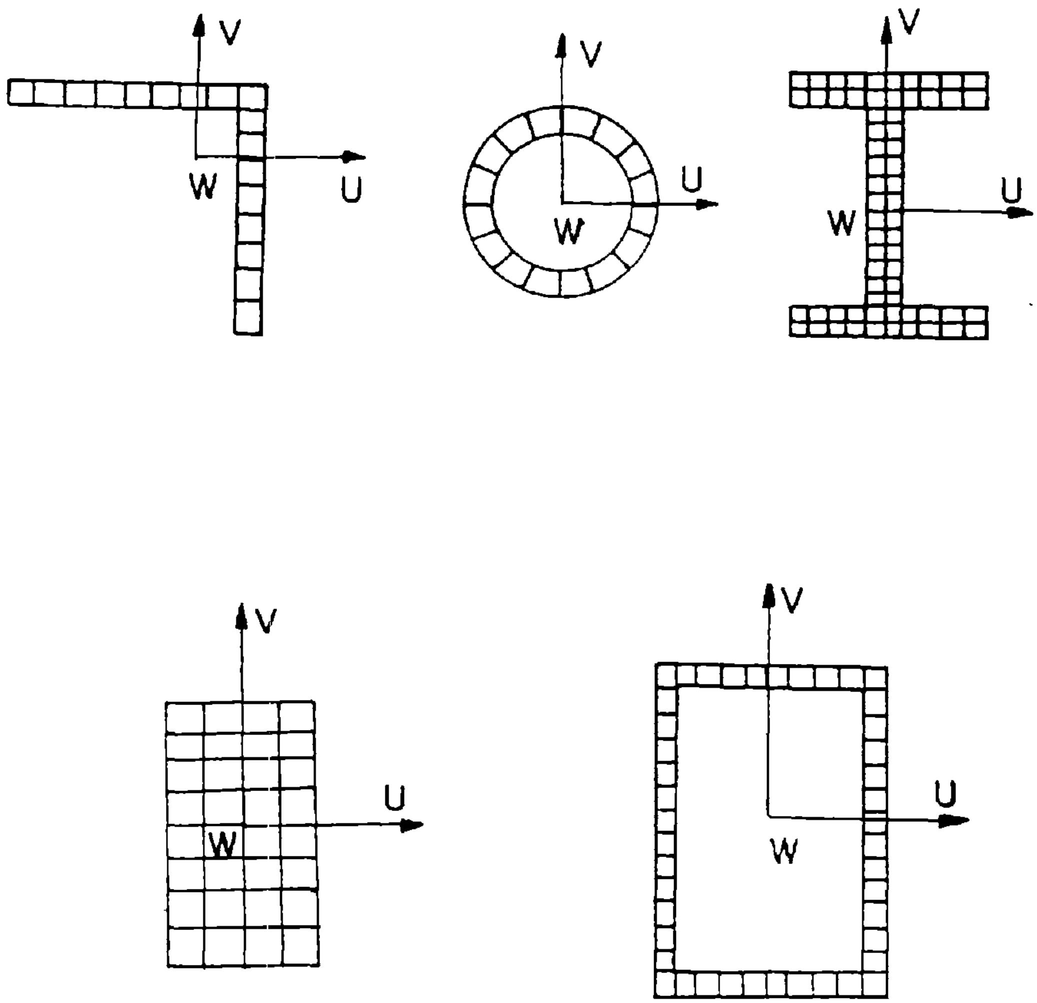
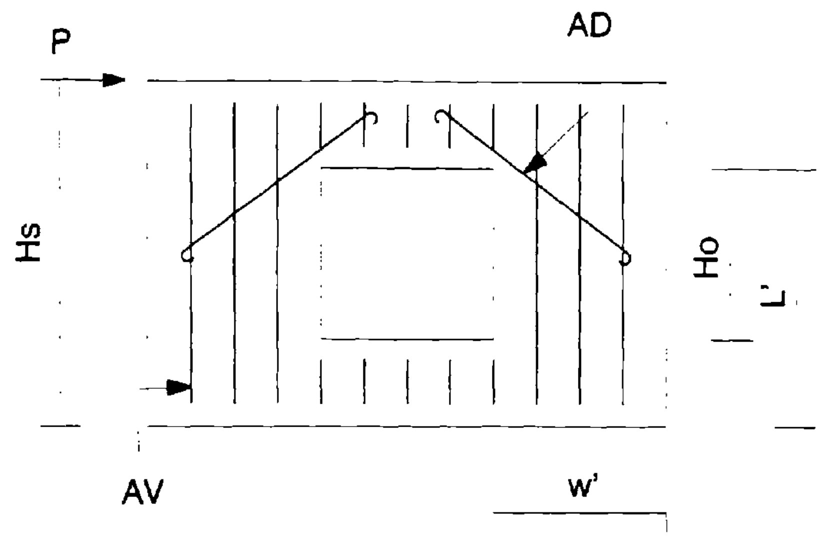
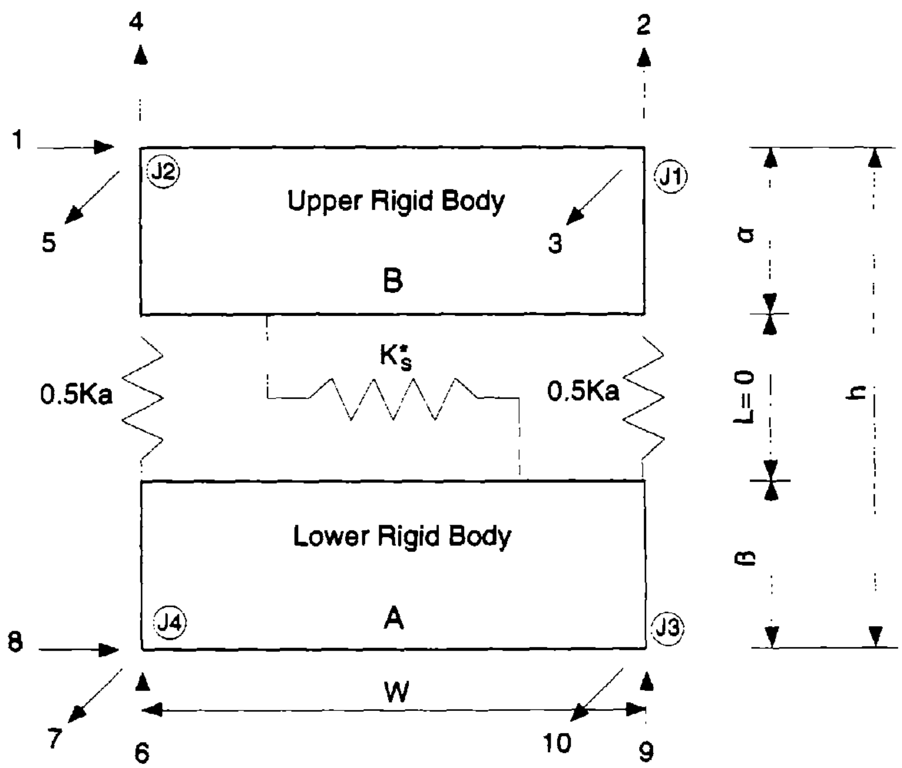


Figure 24. Sectional Reference Coordinates (U, V, W)



(a) Perforated Shear Wall



(b) Modeling of Perforated Shear Wall

Figure 25. Perorated Shear Wall Element

LONG-OWJG, SHORT-OWJG, IA-BILN, and TAKEDA material can be used for bending deformations. IA-BILN material is also used for torsion and axial deformations.

e. Bracing Element This element, which connects a start and end joint, is shown in Figure 22. At the start end of the element, a rigid body of length XS is used to model the structural joint. A similar rigid body of length XE is used at the end joint. There is only one internal force F_X, at end A in the ECS, and only one at end B. All the internal forces are positive in the direction of the ECS.

The bracing element considers axial deformation about the X_e axis. Bending, warping torsion and shear deformation are not considered. Behavior of the bracing element may be elastica or nonlinear, depending on the magnitude of axial deformation of the member. A hysteresis model of the bracing member is used to represent the hysteresis behavior of axially loaded box, angle, and wide flange members. Further investigation is needed for bracing members with different cross sections in order to check the applicability of this element. Since second order P-Δ forces are considered in the hysteresis model, formulation of geometric stiffness is not.

f. Finite-Segment Element This element (18), which connects a start and end joint, is shown in Figure 23. At the start end of the element, a rigid body of length XS is used to model the structural joint. A similar rigid body of length XE is used at the end joint. The element coordinate system (ECS) X_e axis goes from end A toward end B. Orientation of the ECS Y_e axis is defined by a vector, $\vec{V}$, which lies on the ECS XY-plane. The ECS Z_e axis is perpendicular to the X_e and Y_e axes, right-hand rule. There are six internal forces F_X, F_Y, F_Z, M_X, M_Y and M_Z at end A in the ECS, and six at end B. All the internal forces are positive in the direction of the ECS.

The element considers axial, torsional, and bending deformations about the Y_e and Z_e axes. Warping torsion and shear deformation are not considered. The member is divided into several segments; the cross section of each segment is further divided into many small elements, and U, V, and W represent the segment's sectional reference coordinates as shown in Figure 24.

In the analysis of a structural system, the degrees of freedom of an individual member should be reduced so that computational efficiency can be achieved. A substructural technique is applied to the finite segment element for which the internal degrees of freedom are condensed out by Gauss elimination. Only the degrees of freedom at both ends of the member are maintained. The STABILITY hysteresis material model is used for the finite segment element. Since second order P-Δ forces are considered in the hysteresis model, formulation of geometric stiffness is not considered.

g. Perforated Shear Wall Element This element consists of a panel linking four joints as shown in Figure 25(b). Bending and shear deformations in the plane of the wall are considered, along with axial deformation. Combined bending and shear deformations are lumped into one spring with stiffness K_s^*. Axial deformations are lumped into two springs at both sides of the wall. Bending and shear stiffness perpendicular to the plane of the wall are neglected. A 'lumped parameter' formulation of geometric stiffness considers both in-plane and out-of-plane P-Δ effects.

As shown in Figure 25(b), the wall has 10 dof at the corner joints. Combined bending and shear stiffness is defined by the perforated shear wall hysteresis model and axial stiffness is defined by the R/C axial hysteresis model.

B. SOL01 - ELASTIC STATIC ANALYSIS WITH MULTIPLE LOAD CASES

This block performs the elastic static analysis with multiple load cases. The flow chart for SOL01 is shown in Figure 26.

Step 1. Input Joint and Element Loadings Joint loads and imposed displacements are input for each load case. Uniform and concentrated element loadings are input for each load case on the 3D-beam element.

Step 2. Form Structural Stiffness and Load Matrices The structural stiffness matrix is formed. Optionally, the geometric stiffness matrix, based on the user's input axial loads, is subtracted from the structural stiffness matrix. Joint loadings are determined for the imposed displacements (support settlements) and combined with the input joint loadings and element loadings for each load case.

Step 3. Calculate Displacements Displacements for each load case are calculated by Gauss elimination.

Step 4. Calculate Reactions Reactions at restrained degrees of freedom and the summation of reactions are calculated for each load case.

Step 5. Calculate Element Forces Element forces are calculated for each load case.

C. SOL02 - ELASTIC / NONLINEAR SEISMIC TIME HISTORY RESPONSE

This block performs the elastic or nonlinear analysis of a structure subject to multiple ground accelerations. The flow chart for SOL02 is shown in Figure 27.

Step 1. Input Ground Motions Ground motions are input and stored. Transformation matrices to rotate the ground accelerations from the input coordinate system to the individual JCS are formed. The equation of motion for a dynamic loading is

$$M\ddot{X}+C\dot{X}+KX=F(t)=-M'\ddot{X}_g \tag{1}$$

For seismic analyses, $M=M'$. For nonseismic analyses the special mass matrix, M' and a pseudo-ground acceleration are input and stored. Thus the nonseismic forcing function is equal to

$$F(t)=-M'\ddot{X}_g \tag{2}$$

Step 2. Form Dynamic Loading The dynamic loading matrix is formed and added to the unbalanced force matrix.

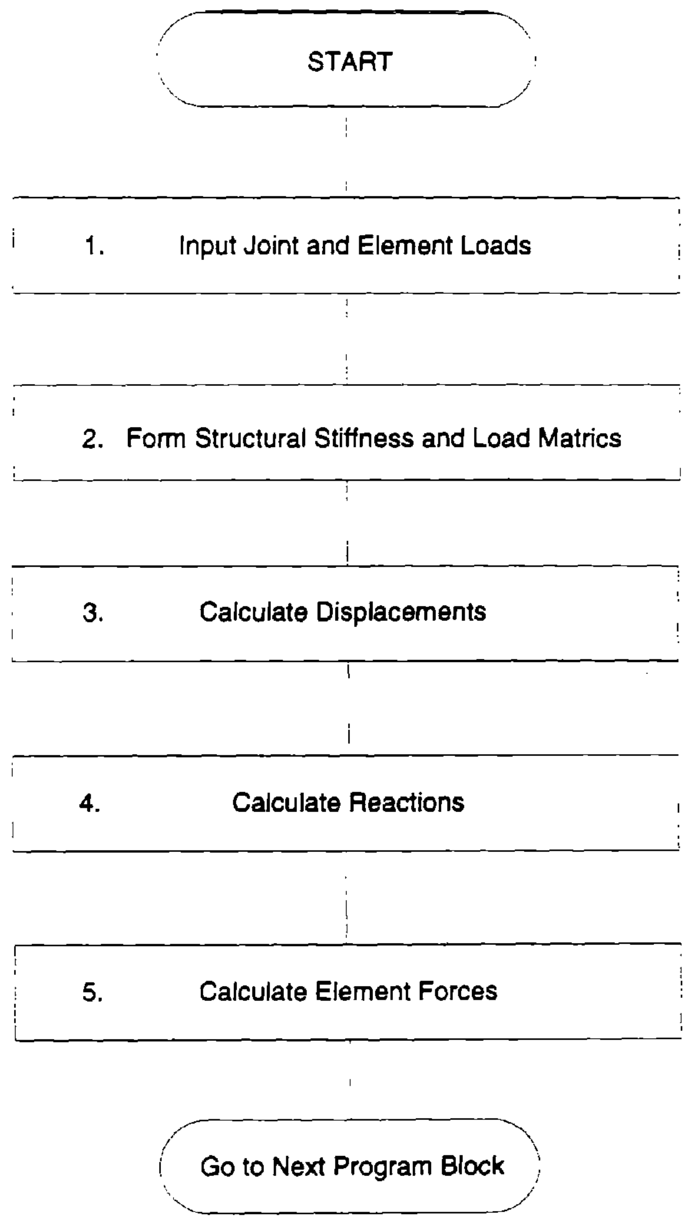


Figure 26. Block SOL01 - Static Analysis

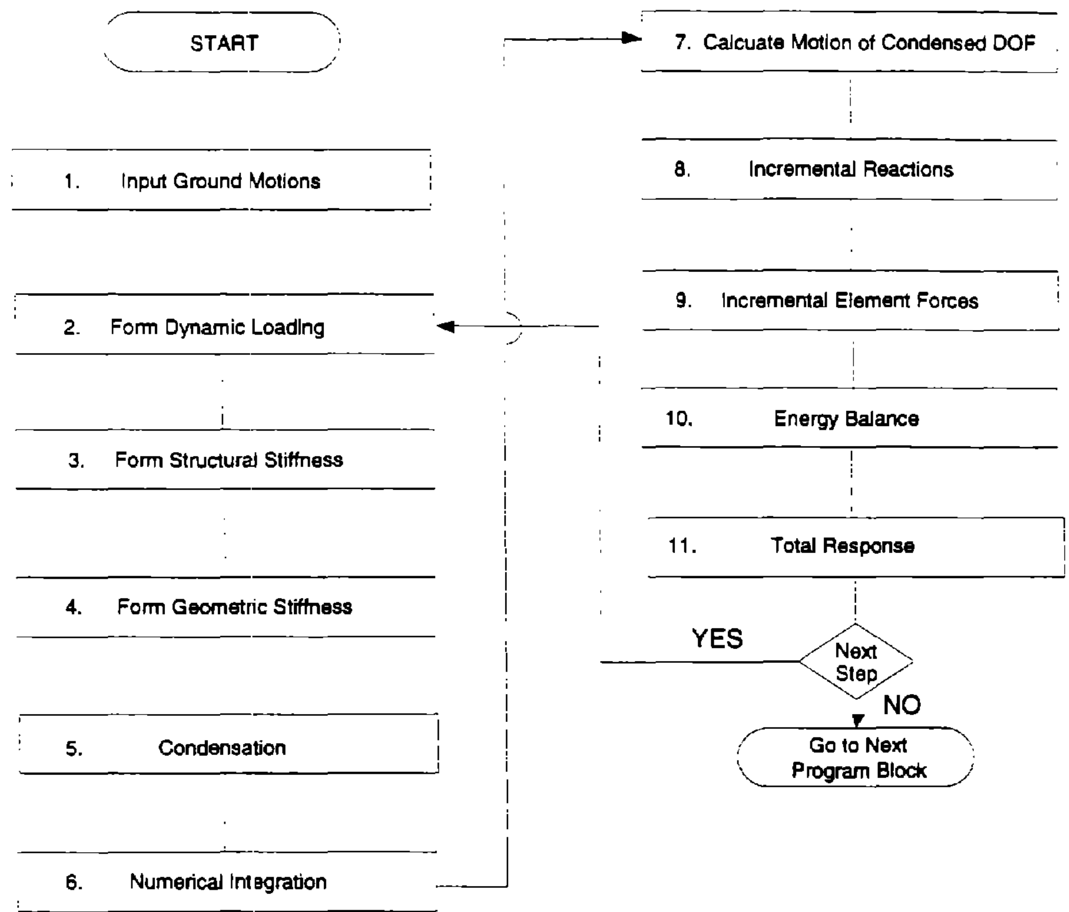


Figure 27. Block SOL02 - Elastic / Nonlinear Dynamic Analysis

Step 3. Form Structural Stiffness Structural stiffness is formed 1) for the first time step, 2) for every time step that an element's stiffness is modified, and 3) for every time step that the geometric stiffness is modified. The element's stiffness is only modified during nonlinear analysis.

Step 4. Form the Geometric Stiffness Geometric stiffness is formed 1) for the first time step, and 2) for every time step if the actual element axial loads are used to calculate the geometric stiffness.

Step 5. Condensation If condensed degrees of freedom exist, 1) the structural stiffness is condensed at each time step that is formed, 2) the geometric stiffness is condensed each time step that is formed, if condensation of the geometric stiffness is desired, 3) the mass matrix is condensed at the first time step, if needed, and 4) the dynamic loading matrix is condensed at each time step.

Step 6. Numerical Integration Incremental displacements, velocities and accelerations of free dof are calculated by either the linear or the average acceleration method.

Step 7. Calculate Motion of Condensed DOF Incremental displacements, velocities and accelerations of condensed dof are calculated.

Step 8. Incremental Reactions Incremental reactions are calculated.

Step 9. Incremental Element Forces Hysteresis models in the materials library are used to calculate the incremental element forces, given incremental displacements and previous loading history. For nonlinear analysis, if the element stiffness changes during incremental displacement, 1) the element's unbalanced forces are calculated, and 2) a flag to reform the structural stiffness in step 3 is put at the next time step. Elastic and plastic strain energies for each element are also calculated.

Step 10. Energy Balance Total input energy, kinetic energy, elastic strain energy, plastic strain energy and energy dissipated due to damping are calculated.

Step 11. Total Response Total displacements, velocities, accelerations, reactions, and element forces are calculated. The unbalanced force vector for nonlinear analysis is assembled from the element's unbalanced forces. If desired, selected results may be written to output files.

Go to step 2 for the next time step.

D. SOL03 - ELASTIC NATURAL FREQUENCY / ELASTIC BUCKLING LOAD

This block calculates either the natural frequencies and mode shape of an elastic structure or the buckling load and mode shape of that structure. Figure 28 shows the flow chart for SOL03.

Step 1. Form Structural Stiffness Matrix The structural stiffness matrix is formed.

Step 2. Form Mass Matrix or Geometric Stiffness Matrix For the buckling solution, the geometric stiffness matrix is formed. For the natural frequency solution, the mass matrix that was formed in block STRUCT is used.

Step 3. Condensation If condensed degrees of freedom exist, 1) the structural stiffness is condensed, 2) the geometric stiffness is condensed for buckling problems, if desired, and 3) the mass matrix is condensed for natural frequency problems, if needed.

Step 4. Calculate Eigenvalue and Eigenvector Eigenvalues and eigenvectors are calculated. Natural frequencies or buckling loads are extracted from the eigenvalues. The eigenvectors are normalized. Natural frequencies are printed along with each mode's shape, or buckling loads are printed along with the corresponding mode shape.

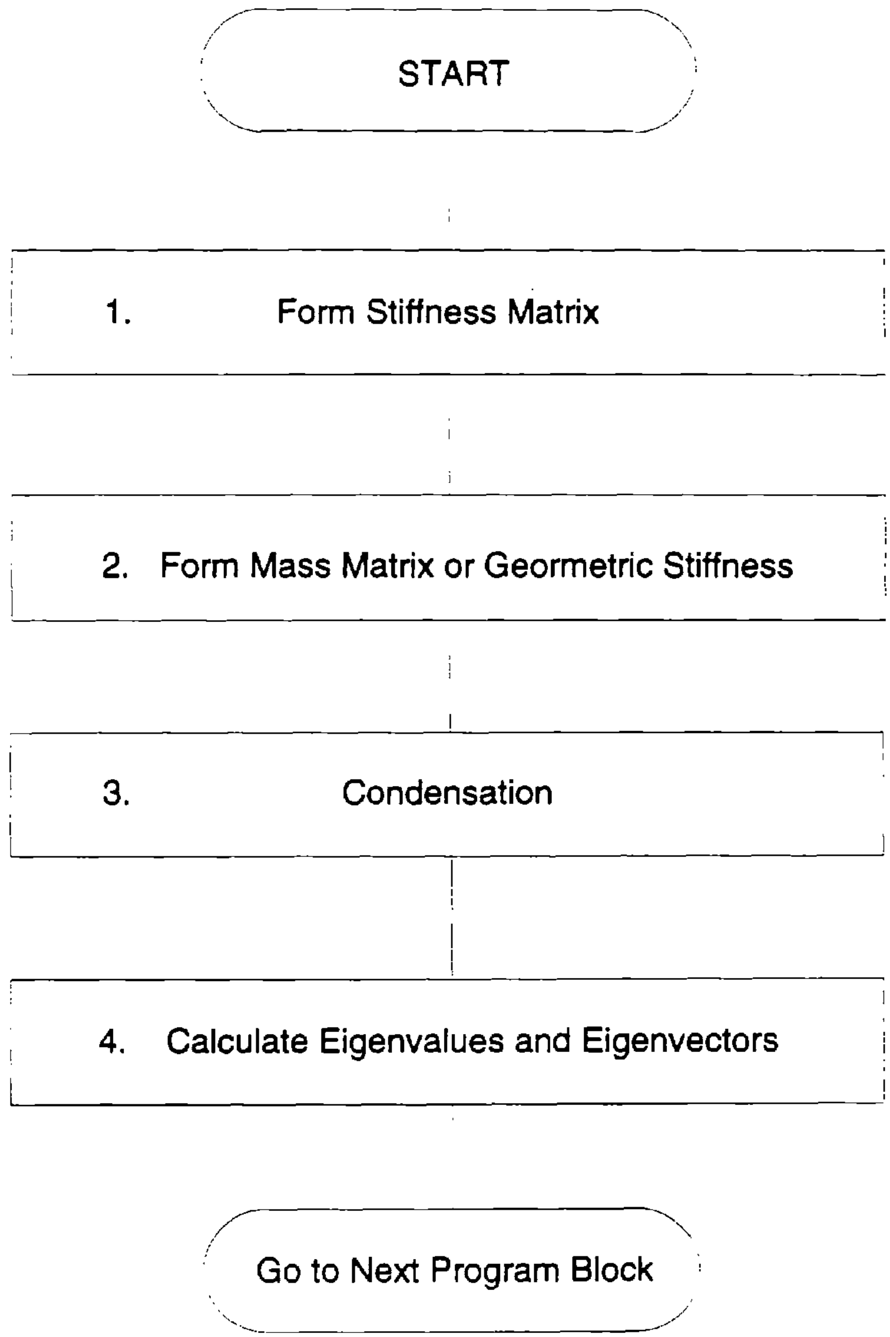


Figure 28. Block SOL03 - Natural Frequency / Elastic Buckling Load

E. SOL04 - NONLINEAR STATIC CYCLIC RESPONSE

This block calculates the nonlinear static cyclic response for a given loading pattern. A loading pattern consisting of joint loads, imposed displacements and element loads is defined and stored in the vector {Q}. The loading pattern, {Q}, is multiplied by positive and negative load factors to generate cyclic loading cycles. Define F_j as the loading factor for the current cycle and F_i as the loading factor for the previous cycle. Total loads on the structure for cycles i and j are $F_i\{Q\}$ and $F_j\{Q\}$, respectively. The loading from $F_i\{Q\}$ to $F_j\{Q\}$ is carried out in a series of steps. A variable number of steps, each one having incremental loads and displacements less than limiting values, may be used to load from $F_i\{Q\}$ to $F_j\{Q\}$ (loading option A). Alternately, a fixed number of equal load steps may be chosen to load from $F_i\{Q\}$ to $F_j\{Q\}$ (loading option B). Figure 29 shows the flow chart for SOL04.

Step 1. Input Joint and Element Loadings Joint loads and imposed displacements of the load pattern are input. Element loadings for the load pattern are input on the 3D-beam element.

Step 2. Input Load Factors For each loading cycle, a load factor and limits on the step size or the number of load steps are input.

Step 3. Form Load Matrix Loading matrix for option A is the difference between the load at the end of the cycle and the current load. Alternately, loading matrix for option B is the incremental load, $(F_j-F_i)*\{Q\}/N$, where N is the number of load steps.

Step 4. Form the Structural Stiffness Structural stiffness is formed 1) for the first load step, 2) for every load step that an element's stiffness is modified, and 3) for every load step that the geometric stiffness is modified.

Step 5. Form the Geometric Stiffness Geometric stiffness is formed 1) for the first load step, and 2) for every load step if the actual element axial loads are used to calculate the geometric stiffness.

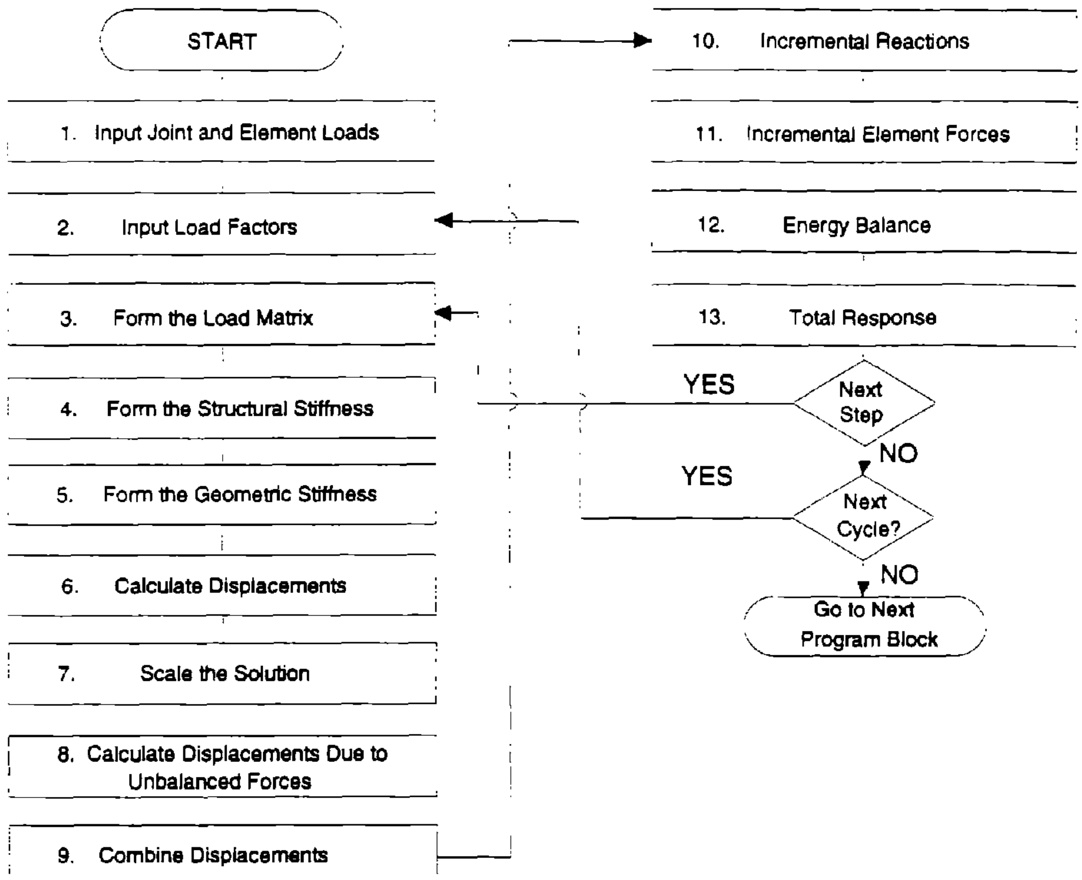


Figure 29. Block SOL04 - Nonlinear Static Cyclic Response

Step 6. Calculate Displacements Incremental displacements due to the applied loadings are calculated by Gauss elimination.

Step 7. Scale the Solution For loading option A, the response is scaled down such that the incremental loads and displacements for each step are less than the limiting values. This step is omitted for loading option B.

Step 8. Calculate Displacements due to Unbalanced Forces Incremental displacements due to unbalanced forces from the previous load step are calculated by Gauss elimination.

Step 9. Combine Displacements Scaled-down displacements due to the applied loadings and displacements due to the unbalanced loadings are added together.

Step 10. Incremental Reactions Incremental reactions are calculated.

Step 11. Incremental Element Forces Hysteresis models in the materials library are used to calculate the incremental element forces, given incremental displacements and previous loading history. For nonlinear analysis, if the element's stiffness changes during incremental displacement, 1) the element's unbalanced forces are calculated, and 2) a flag to reform the structural stiffness in step 4 is put at the next load step. Elastic and plastic strain energy for each element is also calculated.

Step 12. Energy Balance Total input energy, elastic strain energy and plastic strain energy are calculated.

Step 13. Total Response Total displacements, reactions, and element forces are calculated. The unbalanced force vector for nonlinear analysis is also calculated. If desired, selected results may be written to output files.

Go to step 3 for additional loading steps. Go to step 2 for the next loading cycle.

F. SOL05 - RESPONSE SPECTRUM ANALYSIS

This block calculates the maximum response of structure subject to dynamic force. Dynamic force is obtained from the response spectrum. Spectral values corresponding to structural natural frequencies represent the input forces. Equivalent earthquake forces and maximum member forces are also calculated. The modal combination in the analysis can be square-root-of-sum-of-square (SRSS) method or complete-quadratic-combination (CQC) method. Figure 30 shows the flow chart for SOL05.

Step 1. Input Modal Combination Method The modal combination method can be SRSS or CQC.

Step 2. Input Number of Modes Considered The more modes considered in the analysis, the more accurate the expected response.

Step 3. Form Structural Stiffness Structural stiffness is formed. Optionally, the geometric stiffness matrix, based on the user's input axial load, is subtracted from the structural stiffness matrix.

Step 4. Calculate Eigenvalue and Eigenvector Eigenvalues and eigenvectors are calculated. Optionally, they can be obtained from SOL03. Natural frequencies are extracted from the eigenvalues. The eigenvectors are normalized.

Step 5. Input Response Spectral Values The spectral value corresponding to each natural frequency is input. Input values can be accelerations or displacements.

Step 6. Calculate Effective Mass for Each Mode The effective mass for each mode is calculated. In general, to ensure solution accuracy, the summation of effective masses of total modes considered should be greater than 90% of the total structural mass. Effective masses of individual modes are also printed.

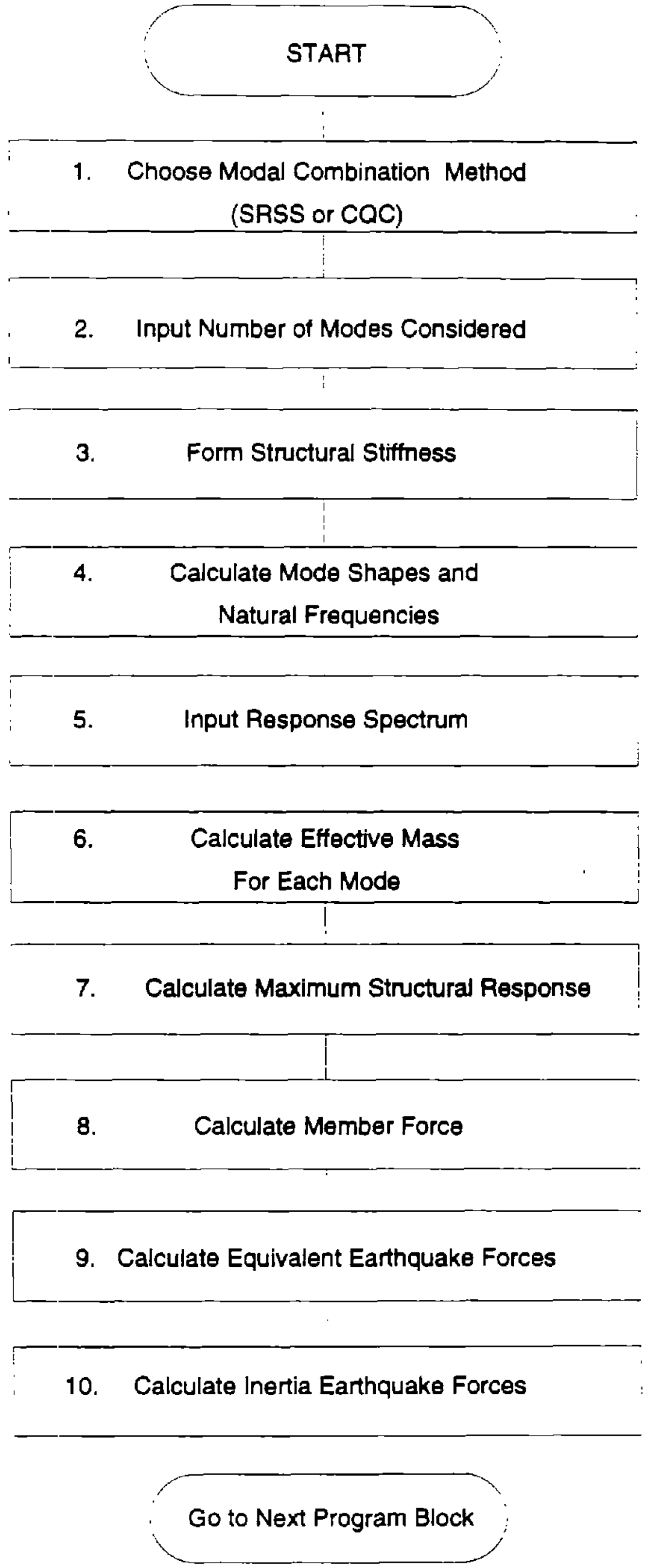


Figure 30. Block SOL05 - Response Spectrum Analysis

Step 7. Calculate Maximum Displacements Maximum structural displacements are calculated based on SRSS or CQC method.

Step 8. Calculate Maximum Member Forces Maximum member forces are calculated based on SRSS or CQC method.

Step 9. Calculate Equivalent Earthquake Forces Equivalent earthquake forces are calculated based on the maximum member forces.

Step 10. Calculate Inertia Earthquake Forces Maximum inertia earthquake forces are calculated.

III. DESCRIPTION OF PROGRAM

This chapter describes the computer program INRESB-3D-SUPII. A flow chart of the program is given in Figures 31 and 32.

A. MAIN PROGRAM AND COMMON BLOCKS

A brief description of the main program and three common blocks is presented below.

1. MAIN - Main Program This program 1) reads and echoes input data, 2) initializes data, 3) calls STRUCT to define the structural model, 4) calls SOLN to perform individual solutions, 5) calls COMDMP to dump contents of memory, 6) sets bug options to print stiffness matrices, etc., 7) releases memory from previous solutions, and 8) stops execution of the program.

2. Common Block DATA This block consists of a linear array that contains the program's dynamically allocated memory. A real array, Z, and an integer array, NZ comprise the linear array. Integer array and real array share the same storage location in memory[1]. Common block DATA is used by routines MAIN, CKSTOR, STRUCT, MATLIB, ELELIB, DMPDAT FORM, SOLN, SOL01, SOL02, SOL03, SOL04 and SOL05.

3. Common Block ZDATA This block contains flags which control the execution of the routines, the number of G-dof, joints, elements, etc. and the addresses of data in the Z array shared among different routines. ZDATA is used by routines MAIN, CKSTOR, STRUCT, MATLIB, ELELIB, DMPDAT, FORM, SOLN, SOL01, SOL02, SOL03, SOL04, SOL05, COMPT and COMDMP.

4. Common Block ZDATAP This block contains the title, bug options, and miscellaneous variables. ZDATAP is used by routines MAIN, CKSTOR, STRUCT, MATLIB, ELELIB, DMPDAT, FORM, SOLN, SOL01, SOL02, SOL03, SOL04, SOL05, COMPT and COMDMP.

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[1] This is accomplished by the FORTRAN EQUIVALENCE statement.

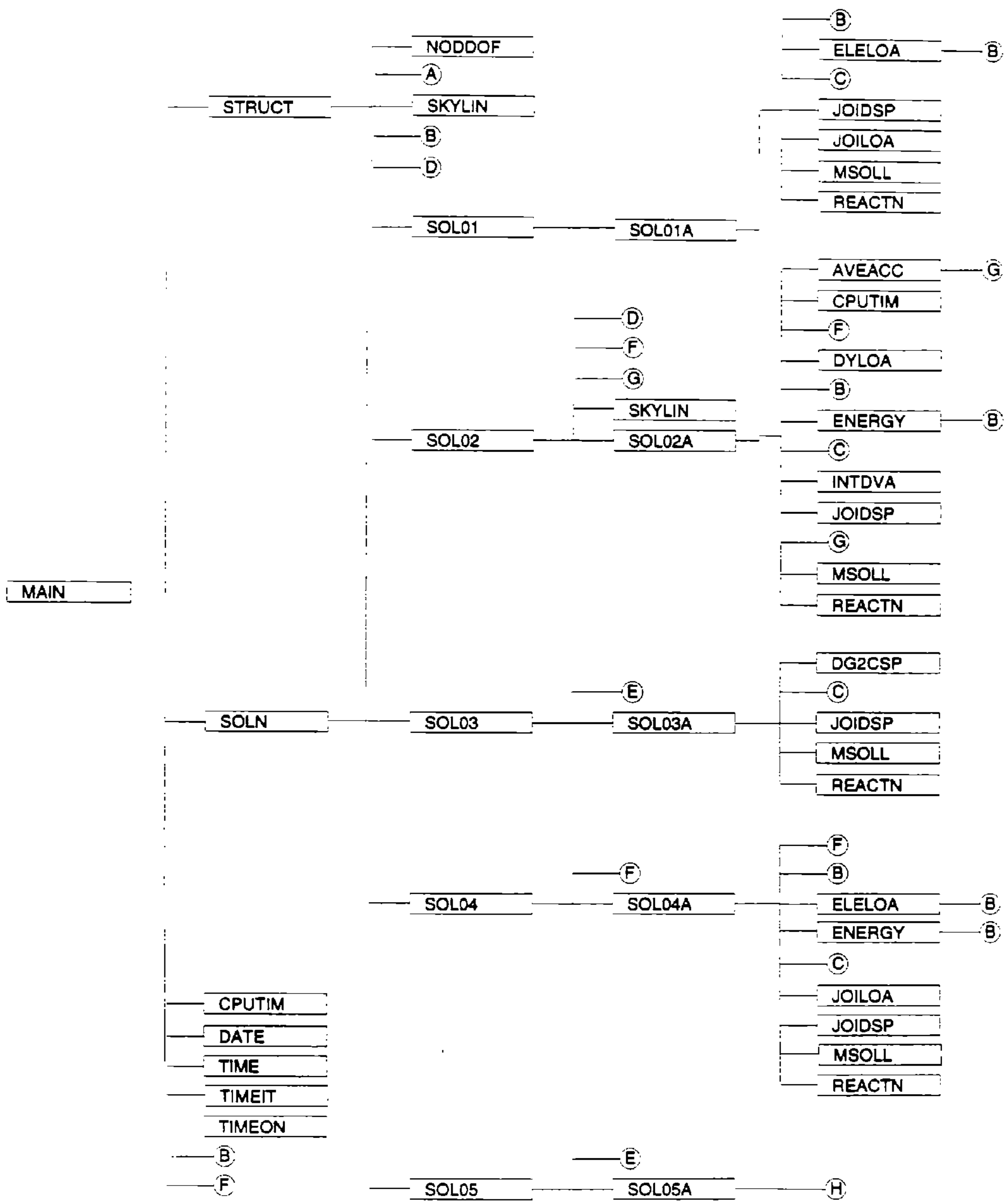


Figure 31. Flow Chart for Program INRESB-3D-SUPII: Part A

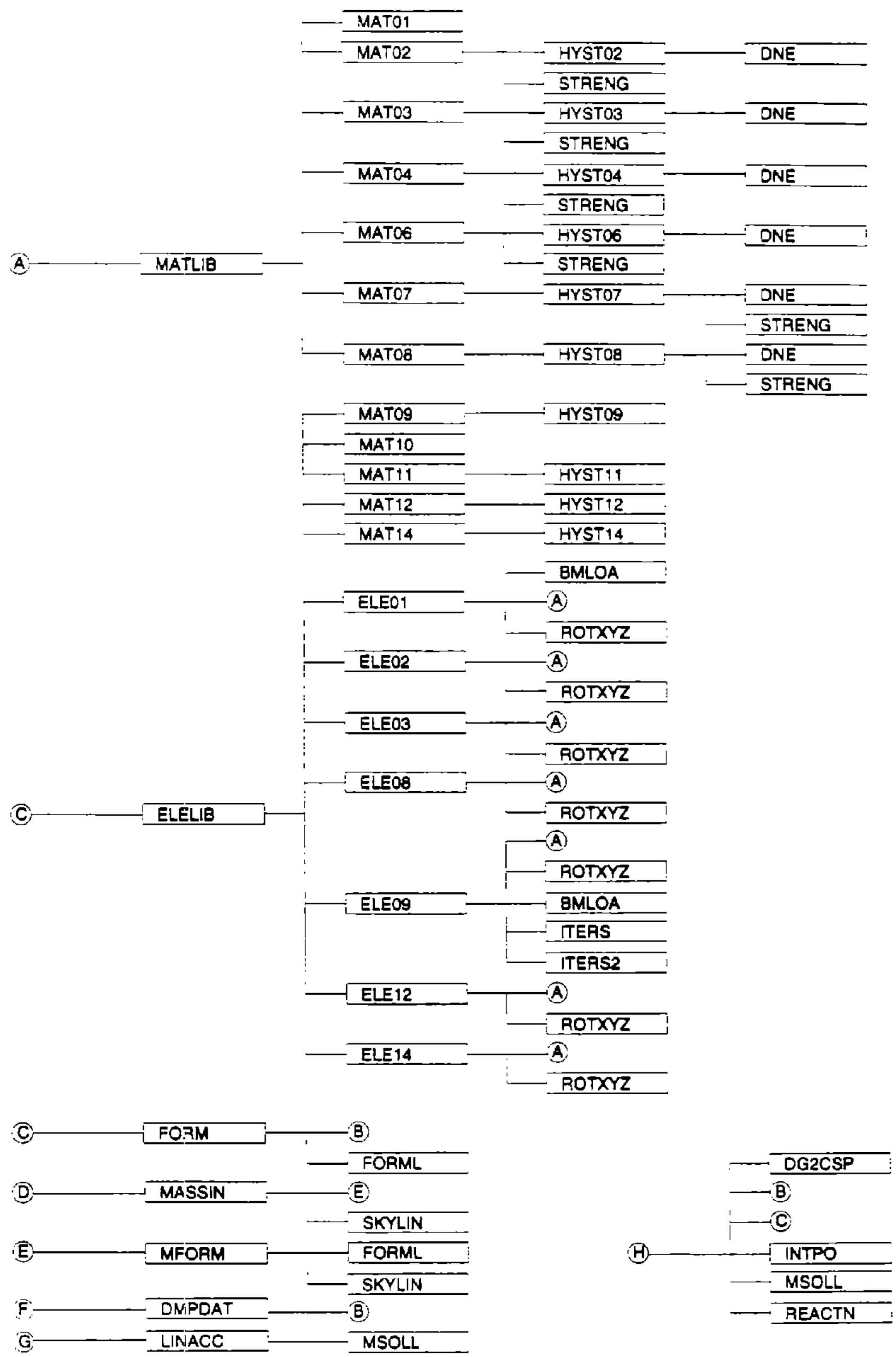


Figure 32. Flow Chart for Program INRESB-3D-SUPII: Part B

B. DESCRIPTION OF ROUTINES

INRESB-3D-SUPII includes 94 routines. They are presented below in alphabetical order with a brief description.

1. AVEACC Along with LINACC, calculates dynamic response by the average acceleration method. Called by SOL02A.

2. BMLOA Calculates the fixed end moments and shears of a prismatic beam element for uniform and concentrated element loadings. Called by ELE01.

3. CKRNG A utility routine called by ELELOA that checks the location of element loadings.

4. CKSTOR A utility routine that aborts the program if the problem requires more storage than is available. Called by SOL02, DMPDAT, SOL03, SOL04 and SOL05.

5. COMDMP A utility routine that prints the contents of the dynamic memory. Called by MAIN.

6. COMPT A utility routine that initializes the addresses of the dynamic memory. Called by MAIN.

7. CROSS Vector cross product. Called by DYLOA and NODDOF.

8. DIRECT A utility routine called by HYST03 and HYST04 to determine the current direction of loading.

9. DMPDAT 1) Writes the results for user-defined output files. 2) Reads the results from output files and prints data. Called by SOL02, SOL02A, SOL04, SOL04A, and MAIN.

10. DNE Calculates ductilities and excursion ratios for HYST02, HYST03, HYST04,

HYST06 and HYST07.

11. DYLOA Generates dynamic loadings due to base acceleration for multicomponent earthquakes. Called by SOL02A.

12. ELELIB - Element Library A controller that calls the members of the element library. All calls to the elements must pass through this subroutine. Called by MAIN, FORM, STRUCT, SOL01A, SOL02A. SOL04A SOL05A, ELELOA, ENERGY and DMPDAT.

13. ELELOA Calculates the element loads for the elastic 3D prismatic beam element. Called by SOL01A and SOL04A.

14. ELE01 - Elastic 3D Prismatic Beam Element Calculates the stiffness, geometric stiffness, element loads, displacements, forces, etc. for the elastic 3D prismatic beam element. Called by ELELIB.

15. ELE02 - Spring Element Calculates the stiffness, geometric stiffness, displacements, forces, unbalanced forces, etc. for the spring element. Called by ELELIB.

16. ELE03 - Shear Wall Stiffness Element Calculates the stiffness, geometric stiffness, displacements, forces, unbalanced forces, etc. for the shear wall stiffness element. Called by ELELIB.

17. ELE08 - Bracing Element Calculates stiffness, displacements, forces, unbalanced forces, etc. for the bracing element. Called by ELELIB.

18. ELE09 - Inelastic 3D-Beam-Column Element Calculates stiffness, geometric stiffness, displacements, forces, unbalanced forces, etc. for the inelastic 3D-beam-column element. Called by ELELIB.

19. ELE12 - Finite-Segment Element Calculates stiffness, displacements, forces, etc. for the

finite-segment element. Called by ELELIB.

20. ELE14 - Perforated Shear Wall Element Calculates stiffness, geometric stiffness, displacements, forces, unbalanced forces, etc. for the perforated shear wall element. Called by ELELIB.

21. ENERGY Calculates the energy balance. Called by SOL02A and SOL04A.

22. ETMPLY Performs multiplication, $\{\dot{x}\}^t[M]\{\dot{x}\}$, to calculate kinetic energy for an upper triangular mass matrix. Called by ENERGY.

23. FEMREL Modifies fixed end forces to account for end releases. Called by BMLOA.

24. FIRST Performs character manipulations. Called by GETCHR.

25. FORM Along with FORML, used to assemble structural and geometric stiffness matrices. Called by SOL01A, SOL02A, SOL03A , SOL04A, and SOL05A.

26. FORML 1) Adds element stiffness to global structural stiffness. 2) Adds element geometric stiffness to global geometric stiffness. 3) Adds joint mass to global mass matrix. Called by FORM and MFORM.

27. GETCHR A utility routine that extracts a character string from input. Called by MAIN.

28. GETINT A utility routine that extracts an integer from character input. Called by MAIN, LMATRX, SOLN, WMATRX and WMTRX2.

29. HYST02 - Axial Hysteresis Model Calculates axial stiffness of R/C elements based on current load and past loading history by the axial hysteresis model. Called by MAT02.

30. HYST03 - B1 Bending Hysteresis Model Calculates bending stiffness of R/C shear walls

based on current load and past loading history by the B1 bending hysteresis model. Called by MAT03.

31. HYST04 - S1 Shear Hysteresis Model Calculates shear stiffness of R/C shear walls based on current load and past loading history by the S1 shear hysteresis model. Called by MAT04.

32. HYST06 - Takeda Hysteresis Model Calculates bending stiffness of R/C elements based on current load and past loading history by the Takeda hysteresis model. Called by MAT06.

33. HYST07 - Bilinear Hysteresis Model Calculates stiffness based on current load and past loading history by the bilinear hysteresis model. This model is also capable of producing elasto-plastic behavior. Called by MAT06.

34. HYST08 - Bracing Member Hysteresis Model Calculates stiffness based on current load and past loading history by the bracing member hysteresis model. This model is also capable of producing post-buckling behavior. Called by MAT08.

35. HYST09 - Long-Direction Open-Web Joist Hysteresis Model Calculates stiffness based on current load and past loading history by the long-direction open-web joist hysteresis model. This model is also capable of producing post-buckling behavior. Called by MAT09.

36. HYST11 - Short-Direction Open-Web Joist Hysteresis Model Calculates stiffness based on current load and past loading history by the short-direction open-web joist hysteresis model. This model is also capable of producing post-buckling behavior. Called by MAT11.

37. HYST12 - Hysteresis Model for Finite-Segment Element Calculates stiffness based on current and past displacement history by the finite segment technique. This model is also capable of producing post-buckling behavior. Called by MAT12.

38. HYST14 - Hysteresis Model for Perforated Shear Wall Calculates the combined shear

and bending stiffness of R/C perforated shear walls based on current and past loading history. Called by MAT14.

39. IDRECT A utility routine that determines the current direction for HYST02 and HYST06.

40. INTDVA Reads and stores initial displacement, velocity and accelerations for dynamic solutions. Called by SOL02A.

41. INTPO Interpolates response spectral values for the response spectrum analysis. Called by SOL05A.

42. ITERS Checks local buckling of box column in Pino-Suarez Tower. Called by ELE09.

43. ITERS2 Checks strength criteria of box column in Pino-Suarez Tower. Called by ELE09.

44. INTSCT A utility routine that determines the intersection of two lines in point slope form. Called by HYST02, HYST03 and HYST04.

45. IQUICK A utility routine that finds the program's internal joint number, given the joint's ID number. Called by NODDOF, ELE01, ELE02, ELE03, ELE08, ELE09, ELE12, JOILOA, INTDVA, DMPDAT and MFORM.

46. ISORT A utility routine that sorts the joint input. Called by NODDOF.

47. JOIDSP Calculates and prints displacement, velocity, acceleration or eigenvector at each joint in the JCS and GCS. Called by SOL01A, SOL02A, SOL03A and SOL04A.

48. JOILOA Reads and calculates joint loads. Called by SOL01A and SOL04A.

49. KMIN A utility routine used by hysteresis models HYST03 and HYST04 to ensure that the stiffness is between zero and initial stiffness, SI.

50. LINACC Calculates dynamic response by linear acceleration method. Called by SOL02A and AVEACC.

51. LMATRX A utility routine that prints upper triangular mass, structural stiffness, element stiffness, geometric stiffness, etc. matrices. This routine is activated by user input bug options which are described later. Called by FORM, MFORM, ELE01, ELE02, ELE03, ELE08, ELE09, ELE12, SOL01A, SOL02A, SOL03A, SOL04A, SOL05A, MSOLL, TMPLY, ETMPLY, UTMPLY and MASSIN.

52. MASSIN Initializes storage for the mass matrix. Called by STRUCT and SOL02.

53. MATLIB - Materials Library. A subroutine serving as a controller that calls the members of the materials library. All calls to the materials and hysteresis models must pass through this subroutine. Called by STRUCT, ELE01, ELE02, ELE03, ELE08, ELE09, and ELE12.

54. MAT01 - Elastic 3D Prismatic Beam Stiffness A routine that reads and stores the stiffness of the elastic 3D prismatic beam element. Called by MATLIB.

55. MAT02 - Axial Stiffness for R/C Elements 1) Reads and stores axial input data. 2) Calculates axial stiffness with calls to the axial hysteresis model, HYST02. 3) Calculates strain energy with calls to STRENG. Called by MATLIB.

56. MAT03 - Bending Stiffness for R/S Shear Walls 1) Reads and stores bending input data. 2) Calculates bending stiffness with calls to the B1 bending hysteresis model, HYST03. 3) Calculates the strain energy with calls to STRENG. Called by MATLIB.

57. MAT04 - Shear Stiffness for R/C Shear Walls 1) Reads and stores shear input data. 2)

Calculates shear stiffness with calls to the S1 shear hysteresis model, HYST04. 3) Calculates strain energy with calls to STRENG. Called by MATLIB.

58. MAT06 - Bending Stiffness for R/C Elements 1) Reads and stores bending input data. 2) Calculates bending stiffness with calls to the Takeda hysteresis model, HYST06. 3) Calculates strain energy with calls to STRENG. Called by MATLIB.

59. MAT07 - Bilinear Material 1) Reads and stores input data. 2) Calculates stiffness with calls to the bilinear hysteresis model, HYST07. 3) Calculates the strain energy with calls to STRENG. Called by MATLIB.

60. MAT08 - Bracing Member Material 1) Reads and stores input data. 2) Calculates stiffness with calls to the bracing member hysteresis model, HYST08. 3) Calculates strain energy with calls to STRENG. Called by MATLIB.

61. MAT09 - Long-Direction Open-Web Joist Material 1) Reads and stores input data. 2) Calculates stiffness with calls to the long-direction open-web joist hysteresis model, HYST09. 3) Strain energy calculation not available. Called by MATLIB.

62. MAT10 - Bilinear Material 1) Reads and stores input data. 2) Calculates stiffness for ELE09 only. 3) The strain energy calculation not available. Called by MATLIB.

63. MAT11 - Short-Direction Open-Web Joist Material 1) Reads and stores input data. 2) Calculates stiffness with calls to the short-direction open-web joist hysteresis model, HYST11. 3) Strain energy calculation not available. Called by MATLIB.

64. MAT12 - Finite-Segment Element Material 1) Reads and stores input data. 2) Calculates stiffness with calls to the finite-segment hysteresis model, HYST12. 3) Strain energy calculation not available. Called by MATLIB.

65. MAT14 - Material for R/C Perforated Shear Wall 1) Reads and stores input data. 2)

Calculates stiffness with calls to the perforated shear wall hysteresis model, HYST14. 3) Calculates strain energy with calls to STRENG. Called by MATLIB.

66. MFORM Reads joint masses and forms mass matrix with calls to FORML. Called by MASSIN, SOL02, SOL03 and SOL05.

67. MSOLL 1) Performs Gauss elimination of the stiffness matrix. 2) Condenses the mass matrix while performing Gauss elimination. 3) Condenses the geometric stiffness while performing Gauss elimination. 4) Reduces the load matrix. 5) Performs back substitution. 6) Operations 1 through 5 may be performed on partitioned matrices. 7) Stiffness, geometric stiffness and mass matrices are upper triangular matrices with skyline storage. Called by SOL01A, SOL02A, SOL03A, SOL04A, SOL05A and LINACC.

68. NODDOF Reads joints, constraints, restraints and condensation information, calculates JCS cosine matrices, and determines global degrees of freedom. Called by STRUCT.

69. PBIT A utility routine that prints the joint restraint and constraint code for each joint. Called by NODDOF.

70. REACTN 1) Modifies loading to include restraint displacements. 2) Solves for reactions. 3) Prints reactions in the JCS and GCS coordinate systems. 4) Calculates summation of reactions. Called by SOL01A, SOL02A, SOL03A, SOL04A and SOL05A.

71. ROTXYZ 1) Calculates local element cosine matrix. 2) Calculates transformation from ECS to JCS. 3) Calculates constraint transformation. 4) Calculates transformation for a rigid body at the end of the beam element. Called by ELE01, ELE02 and ELE03.

72. SKYLIN Determines skyline of the structural stiffness, geometric stiffness and mass matrices. Called by STRUCT, MFORM and MASSIN.

73. SKYLN2 Determines skyline of the dynamic stiffness matrix. Called by SOL02.

74. SMAX A utility routine that determines and prints maximum and minimum input accelerations. Called by DYLOA.

75. SOLN - Solution Library A subroutine serving as a controller that calls the solution requested by the user. All calls to solutions must pass through this subroutine. Called by MAIN.

76. SOL01 - Elastic Static Analysis with Multiple Load Cases Initializes storage for elastic static analysis. Called by SOLN.

77. SOL01A Calculates elastic static response, as described in Section B of Chapter II. Called by SOL01.

78. SOL02 - Dynamic Time History Response Initializes storage for the dynamic time history response. Called by SOLN.

79. SOL02A Calculates dynamic time history response for both elastic and nonlinear structures, as described in Section C of Chapter II. Called by SOL02.

80. SOL03 - Elastic Natural Frequency / Buckling Load Initializes storage for elastic natural frequency or buckling load. Called by SOLN.

81. SOL03A Calls EIGZS to calculate elastic natural frequency or buckling load for elastic structures, as described in Section D of Chapter II. Called by SOL03.

82. SOL04 - Nonlinear Static Cyclic Response Initializes storage for static nonlinear analysis. Called by SOLN.

83. SOL04A Calculates static nonlinear response, as described in Section E of Chapter II. Called by SOL04.

84. SOL05 - Response Spectrum Analysis Initializes storage for response spectrum analysis.

85. SOL05A Calculates maximum structural response based on SRSS or CQC modal combination approach as described in Section F of Chapter II. Called by SOL05.

86. STRENG Calculates the elastic and plastic strain energy. Called by MAT02, MAT03, MAT04, MAT06, HYST07, and HYST08.

87. STRUCT - Structural Definition 1) Sets up storage for joints and calls NODDOF to input joint information and generate degrees of freedom. 2) Sets up storage for materials and calls MATLIB to input materials and initialize hysteresis models. 3) Sets up storage for elements and calls ELELIB to input elements and calculate initial element stiffness. 4) Calls SKYLIN to set up storage for the structural stiffness, geometric stiffness and mass matrices. 5) Reads and initializes mass matrix. These functions are described in greater detail in Section A of Chapter II. Called by MAIN.

88. TEST A utility routine that examines character input and sets a logical flag. Called by MAIN, STRUCT, SOL02, SOL03A, SOL04A, SOL05A, INTDVA and DMPDAT.

89. TMPLY A utility routine that performs multiplication for triangular matrices. Called by SOL02A, SOL04A and ETMPLY.

90. VCOS A utility subroutine that calculates the angle between two vectors. Called by ROTXYZ and ELE03.

91. VCROSS A utility subroutine that calculates the vector cross product. Called by ELE03.

92. WILSON Calculates dynamic response by the Wilson θ method. Called by SOL02A.

93. WMATRX A utility subroutine that prints a matrix. It is activated by user input bug options which are described later. Called by ELE01, ELE02, ELE03, ELE08, ELE09, ELE12, SOL01A, SOL04A, SOL05A, REACTN, MSOLL and DYLOA.

94. WMTRX2 A utility subroutine that prints a portion of a matrix. It is activated by user input bug options which are described later. Called by ELE02, ELE03, ELE08, ELE09, and ELE12.

C. DESCRIPTION OF MISCELLANEOUS ROUTINES

Other routines used by program INRESB-3D-SUPII are listed below.

1. DG2CSP An IMSL eigenvalue routine used to calculate natural frequency and buckling load. This routine is only required for SOL03 and SOL05. Its omission will not affect blocks STRUCT, SOL01, SOL02 or SOL04. Called by SOL03A or SOL05A.

2. SDUMP An IBM routine that prints contents of memory with bug option K. Called by COMDMP. Omission of this routine will only effect bug option K.

3. CPUTIM, TIMEON and TIMEIT Three routines on local UMR system used to print results of the analysis and abort SOL02 if the CPU time limit is close to being exceeded. Equivalent routines may be substituted on other systems, or these routines may be eliminated. Called by MAIN and SOL02A.

4. TIME and DATE Two routines on local UMR system used to print time and date of analysis on header. Equivalent routines may be substituted on other systems, or these routines may be eliminated. Called by MAIN.

D. DYNAMIC MEMORY MANAGEMENT

1. Dynamic Memory Allocation INRESB-3D-SUPII stores all joint, material, element, mass, stiffness, response, etc. data in a large linear array, Z, that resides in common block DATA. The Z array consists of real numbers. An integer array NZ is set equal to the Z array, by a Fortran EQUIVALENCE statement, to provide storage for integer variables. Index variables

beginning with IZ, such as IZxxxx, are used to store addresses of information in the Z array. A variable IZ is used to track the next available space in the Z array. The exact amount of space required to solve a specific problem is reserved in the Z array during execution of the program. This dynamic allocation of memory allows the program to use the computer's memory efficiently.

For example, assume that the Z array is empty and IZ=1. Joint ID numbers are integer variables stored in the NZ array. Thus the index for joint ID numbers is IZID=IZ=1, and NUMJOI joint numbers are stored in the NZ array. Once storage for the joint numbers is reserved, the next available storage location is IZ=IZ+NUMJOI. Then the joint coordinates are stored in the Z array, beginning at IZCORD=IZ. Joint coordinates require 3*NUMJOI storage locations. Once the storage for joint coordinates is reserved, the next available storage location is IZ=IZ+3*NUMJOI. Figure 33 shows the Z array with joint numbers and coordinates.

2. Compact Matrix Storage Mass, stiffness, geometric stiffness and dynamic stiffness matrices are sparse symmetric matrices. Because the matrices are symmetric, only half (the upper triangular matrix) of each matrix needs to be stored. Furthermore, many of the terms in the upper triangular matrix are zero. Nonzero terms, in a given column, are typically found near the main diagonal. The level of the upper nonzero term in each column is the skyline. Thus only the terms below the skyline of the upper triangular matrix are stored in the Z array. Additionally, the linear array addresses of main diagonal elements are stored in the array MD. For example, let matrix B be the 5x5 full symmetric matrix.

$$B = \begin{bmatrix} 1 & 3 & 0 & 0 & 12 \\ 3 & 2 & 5 & 0 & 11 \\ 0 & 5 & 4 & 7 & 10 \\ 0 & 0 & 7 & 6 & 9 \\ 12 & 11 & 10 & 9 & 8 \end{bmatrix} \tag{3}$$

where $B_{1,3}$, $B_{1,4}$ and $B_{2,4}$ are zero. Thus the terms in the upper triangular matrix below the skyline are

$$B_{upper\ triangular} = \begin{bmatrix} 1 & 3 & & & 12 \\ & 2 & 5 & & 11 \\ & & 4 & 7 & 10 \\ & & & 6 & 9 \\ & & & & 8 \end{bmatrix} \quad (4)$$

These elements are stored in the linear array by columns, beginning with the element on the main diagonal. Thus the B matrix in linear array form becomes.

$$\mathbf{A} = \begin{bmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \end{bmatrix} \quad (5)$$

and the array, MD, containing the addresses of the main diagonal elements, is

$$MD = \begin{bmatrix} 1 \\ 2 \\ 4 \\ 6 \\ 8 \\ 13 \end{bmatrix} \quad (6)$$

Last row of the array is a dummy element with the value N+1 where N is the number of elements in the linear array. The i,j element of the linear array is addressed with the algorithm

```
B(I,J)=A(MD(J)+J-I)  if J>I and (MD(J)+J-I)<MD(J+1)
      =0             if J>I and (MD(J)+J-I)≥MD(J+1)        (7)
```

This storage method was also presented by Bath and Wilson (2).

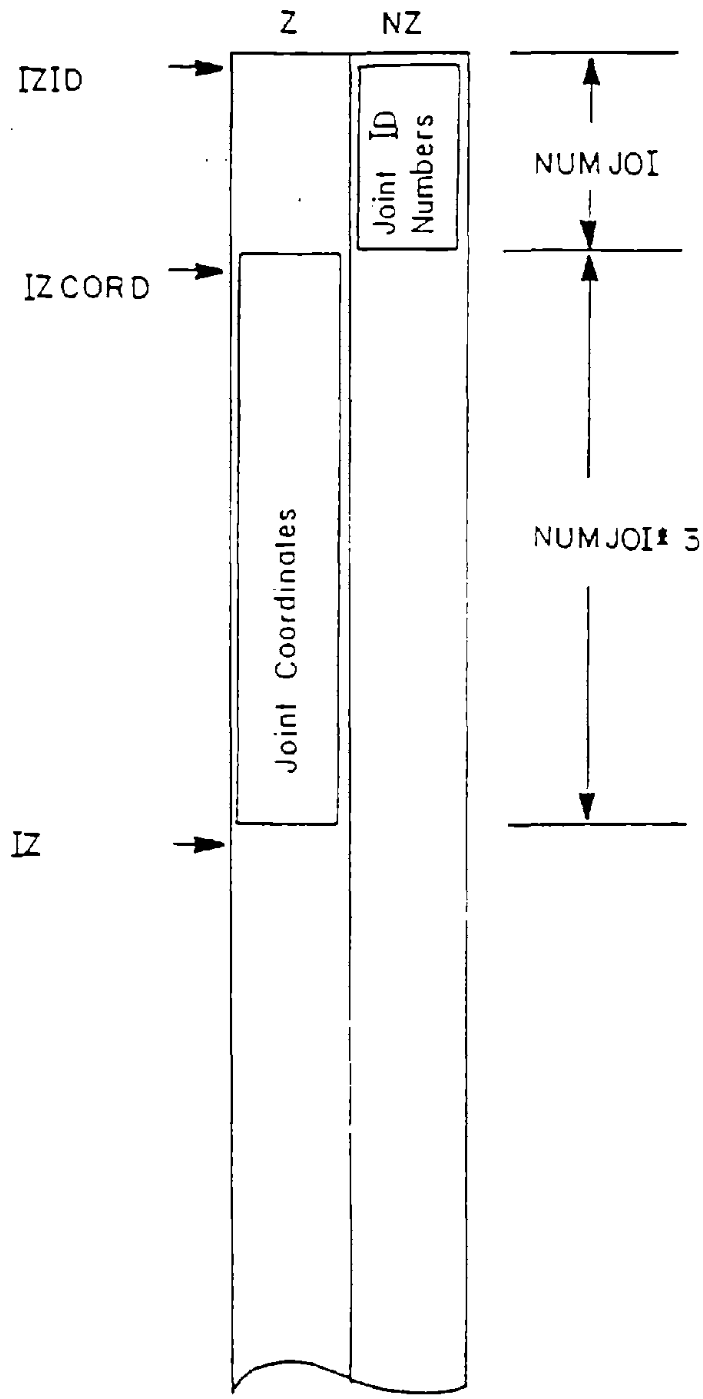


Figure 33. Dynamic Memory Example

3. Capacity of Dynamic Memory

The program's capacity is a function of the amount of memory available in the computer. Program instructions compiled in double precision on an IBM 4381 computer require about 0.8 megabytes of memory. Assuming 8 megabytes of total memory is available, the Z array may occupy 8-0.8=7.2 megabytes of memory. For double precision, on an IBM computer, each variable is 8 bytes long. Thus for 8 megabytes of memory, the Z array may contain up to $7.2*10^6/8=900,000$ variables.

The number of variables in the Z array required for a specific problem is a function of 1) number and orientation of the joints, 2) number of restraints, 3) the number of constraints, 4) number and types of material, 5) number and types of elements and the material each element uses, 6) number of joint masses, 7) amount of storage required by the structural stiffness, geometric stiffness, and mass matrices, which is a function of the band-width, 8) type of solution, 9) number of degrees of freedom, 10) number load cases for SOL01, 11) number of element loadings for SOL01 and SOL04, 12) number of free dof for SOL02 and SOL03, and 13) length of the ground acceleration record for SOL02. The actual number of variables used and the percentage of total memory used are printed out at the end of each block. For the example in Section C of Chapter V, the following message is printed in the output.

```
*--------------------------------------------------*
*--- MEMORY UTILIZATION ..........  ----*
*--- IZ=  21965,    MEM= 4.393%       ----*
*--------------------------------------------------*
```

This example required 21,965 variables. Four megabytes of memory are available for the Z array and the program is compiled in double precision on an IBM computer. Thus the Z array has a capacity of $4*10^6/8=500,000$ variables, and 21,965/500,000*100=4.393% of the available memory was used.

Capacity of the program is modified by changing the value of MAXZ in the PARAMETER statement

```
PARAMETER (MAXZ=500000, MAXDZ=MAXZ/2)
```

of file ZCOMN2 COPY. A macro library GEM3 is then regenerated and the program is recompiled.

E. ADDITION OF MATERIALS, ELEMENTS, AND SOLUTIONS

The modular form of INRESB-3D-SUPII allows for relatively easy addition of materials, elements and solutions. Changes necessary to add materials, elements and solutions are discussed below.

1. Addition of Material to Materials Library A subroutine with the name MATxx is written that contains additional material information. This subroutine must have the following options to be consistent with existing subroutines.

IOPT=0 Determines the number of storage spaces required for each element utilizing this material. Such storage is typically used by a hysteresis model called by routine MATxx.

IOPT=1 Inputs and stores data. Returns the amount of storage required for the material.

IOPT=2 Calculates initial stiffness and initializes the hysteresis model.

IOPT=3 Calculates current stiffness and load for an incremental displacement, given the previous loading history. Calculates strain energies, ductilities, and excursion ratios.

IOPT=4 Calculates strain energies, ductilities, and excursion ratios.

IOPT=5 Calculates damage index.

For nonlinear materials, the subroutine MATxx calls a companion hysteresis model, subroutine HYSTxx.

A call to MATxx is added in routine MATLIB. All communication with subroutine MATxx is through routine MATLIB. Names of the material and material number (MATTYP=xx) are added to routine STRUCT.

2. Addition of Element to Elements Library A subroutine with the name ELExx is written that contains the element information. The subroutine must have the following options to be consistent with existing subroutines.

IOPT=1	Interprets input data, calculates transformation matrices, initial structural stiffness and a unit load geometric stiffness. Determines actual amount of storage required.
IOPT=2	Determines axial load used for the geometric stiffness.
IOPT=3	Recalculates structural stiffness, if any of the components of stiffness has changed.
IOPT=4	Calculates incremental forces, unbalanced forces and new components of stiffness.
IOPT=5	Calculates total element forces and energies.
IOPT=6	Calculates fixed end forces due to element loads, if applicable.
IOPT=7	Writes element data to an output file.
IOPT=8	Reads and prints element data from an output file.
IOPT=9	Determines amount of storage required for the element's materials.

IOPT=10 Determines strain energy.

IOPT=11 Determines ductilities and excursion ratios.

IOPT=12 Prints out maximum forces and/or displacements that the element was subjected to.

IOPT=13 Sets internal forces and displacements equal to zero. Reinitializes the hysteresis models.

IOPT=14 Calculates and prints the damage index.

A call to ELExx is added in routine ELELIB. All communication with subroutine ELExx is through routine ELELIB. The name of the element, the element number (NELTYP=xx), the number of variables input for the element, and the maximum amount of storage required for the element are added to routine STRUCT.

3. <u>Addition of a Solution</u> A subroutine with the name SOLxx is written to reserve and initialize storage required by the solution. SOLxx also calls CKSTOR to ensure that the program has enough storage to execute the solution. A call to SOLxx is added to routine SOLN. All communication with subroutine SOLxx is through routine SOLN.

Subroutine SOLxx calls subroutine SOLxxA which performs the actual solution. Subroutine SOLxxA may call other subroutines such as FORM to establish the stiffness matrix, JOILOA to generate joint loadings, MSOLL to solve for displacements or ELELIB to calculate element forces. The function of these and other subroutines are described in the previous section.

IV. INPUT DATA FOR PROGRAM INRESB-3D-SUPII

The input for INRESB-3D-SUPII is divided into several blocks. Each block is briefly described below. These blocks may be executed in any order, unless otherwise noted. Multiple solutions for the same structure are possible by using multiple solution blocks. Multiple structures may be analyzed by redefining the structure with the STRUCT block.

BLOCK	DESCRIPTION
STRUCT	Definition of the structure to be analyzed. Joints, materials, elements, mass and damping are defined.
SOL01	Elastic static solution of the structure with multiple load cases. SOL01 must be preceded by the block STRUCT.
SOL02	Dynamic solution of linear and nonlinear structures subject to three-dimensional ground motion by numerical integration. SOL02 must be preceded by the block STRUCT.
SOL03	Eigenvalue solution for the natural frequency or buckling load of an elastic structure. SOL03 must be preceded by the block STRUCT.
SOL04	Incremental static solution of a nonlinear structure. SOL04 must be proceeded by the block STRUCT.
SOL05	Response spectrum analysis of linear structure. SOL05 must be proceeded by the block STRUCT.

Secondary Blocks

BUG	Sets flags to print out detailed information.
READ	Reads results written to an output file during SOL02 or SOL04 and prints these results.
NOECHO	Inhibits input echo.
DUMP	Prints out contents of memory.
RELEASE	Releases memory used for previous solution.
STOP	Terminates execution of program.

NOTES ON INPUT

1) Input is free format, unless otherwise noted.
2) Input variables beginning with I-N are integers and should not contain a decimal point.
3) Input variables beginning with A-H and O-Z are real and may contain a decimal point.
4) Logical variables are identified in the input description, and have the value .TRUE. or .FALSE.
5) Character variables are identified in the input description, and are enclosed in 'single quotes', except as noted.
6) Character and logical variables must be input in upper case.
7) Input data is read from unit 05, except as noted.
8) Output is printed on unit 06, except as noted.
9) Input cards are identified by a box. If that card is repeated, the entire box is repeated.

```
input card image........
```

Data for one card may be input on one or more lines in the data file, provided that all of the character variables are on the first line.

10) Consistent units are used throughout the program. Thus input in inches, kips, or seconds yields output in the same unit. Mixing units will yield unpredictable results. Units are indicated parenthetically where appropriate.

Example	Note
'BUG=K'	(1)
'STRUCT'	(2)
.	
. Structure input is omitted.	
.	
'SOL04'	(3)
.	
. Solution input is omitted.	
.	
'READ UNIT=21'	(4)
'STOP'	(5)

(1) Bug option is set, which prints out the hysteresis model data for each time step.

(2) Structure is defined.

(3) A cyclic static solution of the structure is performed.

(4) Data printed on unit 21 during SOL04 is read from the disk file and printed in a report.

(5) Program is terminated.

A. STRUCTURE - DEFINITION OF STRUCTURAL MODEL

These cards define the structural model to be analyzed. The following cards are each input once.

'STRUCT'
'TITLE'

STRUCT Signifies that the structural model is to be input. Character variable; enclose in single quotes.

TITLE User input title, 80 characters maximum. Character variable; enclose in single quotes.

1. Joints and Degrees of Freedom These cards are used to define the coordinates of the joints, joint restraints, constraints and degrees of freedom to be condensed. The degree of freedom numbers are assigned by the program and printed in the output. The following card is input once.

NJOINT	NCOS	NSUPT	NCOND	NCONST	SCALE

NJOINT Number of joints defined by joint coordinate cards.

NCOS Number of joint direction cosine cards input.

NSUPT Number of joint restraint cards input.

NCOND Number of joint condensation cards input.

NCONST Number of joint constraint cards input.

SCALE Scale factor that the joint coordinates are to be multiplied by. If SCALE=12, the user inputs the joint coordinates in feet, and the structure is defined in inches.

a. Joint Coordinates These cards are used to define the coordinates of the joints, in the global coordinate system, GCS, and identify the direction cosine of the joint. Total number of joints defined in this section is less than or equal to NJOINT. The second card is only used when the preceding card has a value of IGEN that is greater than zero. These cards are repeated until 1) NJOINT joints have been defined, or 2) an input or generated joint ID number is less than or equal to zero.

ID X Y Z ICOS IGEN
ΔID ΔX ΔY ΔZ

ID Joint identification number. ID numbers can be input in any convenient order and need not be consecutive. However, the band-width of the structural stiffness matrix is dependent on the joint ID numbers. An ID ≤ 0 terminates input of the joint coordinates.

X GCS X coordinate of the joint. (length)

Y GCS Y coordinate of the joint. (length)

Z GCS Z coordinate of the joint.(length)

ICOS Joint's direction cosine number.

IGEN Number of additional joints to be generated from this joint.

ΔID Increment between the generated ID number and the previous joint's ID number. A generated ID ≤ 0 terminates input of the joint coordinates.

ΔX Increment between the generated joint's GCS X coordinate and the previous joint's X coordinate. (length)

ΔY Increment between the generated joint's GCS Y coordinate and the previous joint's Y coordinate. (length)

ΔZ Increment between the generated joint's GCS Z coordinate and the previous joint's Z coordinate. (length)

Example NJOINT=7 Note

```
10  0. 0. 0.  1  2                                        (1,2)
10  0. 0. 3.                                              (2)
 1  4. 3. -1.  2  0                                       (3)
-1  0  0  0  0  0                                         (4)
```

(1) Joint 10 has the coordinates (0,0,0) and uses direction cosine #1.

(2) Two joints are generated from joint 10: joint 20 (0,0,3) and joint 30 (0,0,6).

(3) Joint 1 has the coordinates (4,3,-1) and uses direction cosine #2.

(4) Input of the joint coordinates is terminated.

b. Joint Direction Cosines These cards are used to input the joint direction cosines, which in turn define the joint coordinate system, JCS. Joint direction cosines are numbered from 1 to NCOS. This card is repeated NCOS times.

Vxi	Vxj	Vxk	Vyi	Vyj	Vyk

Vxi Projection on the GCS X axis of a unit vector parallel to the JCS X axis.

Vxj Projection on the GCS Y axis of a unit vector parallel to the JCS X axis.

Vxk Projection on the GCS Z axis of a unit vector parallel to the JCS X axis.

Vyi Projection on the GCS X axis of a unit vector parallel to the JCS Y axis.

Vyj Projection on the GCS Y axis of a unit vector parallel to the JCS Y axis.

Vyk Projection on the GCS Z axis of a unit vector parallel to the JCS Y axis.

c. Joint Restraints These cards are used to define the joint restraints. This card is repeated NSUPT times.

ID	ITX	ITY	ITZ	IRX	IRY	IRZ	IGEN	ΔID

ID Joint identification number. An ID of zero indicates that all the joints are restrained by this card.

ITX Restraint flag for translation in the JCS X direction.

ITY Restraint flag for translation in the JCS Y direction.

ITZ Restraint flag for translation in the JCS Z direction.

IRX Restraint flag for rotation about the JCS X axis.

IRY Restraint flag for rotation about the JCS Y axis.

IRZ Restraint flag for rotation about the JCS Z axis.

IGEN Number of additional joints, with the same restraints, to be generated from this joint.

ΔID Increment between the generated ID number and the last ID number.

Valid joint restraint flags are:

0 Free or unrestrained degree of freedom.

1 Restrained degree of freedom.

2 Restrained degree of freedom. A restraint flag of 2 forces the program to assign the dof a higher number. This option can be used to reduce the band-width of the stiffness matrix.

<u>Example</u> NSUPT=2 <u>Note</u>

```
0 0 0 0 0 0 1 0 0    (1)
1 1 1 1 1 1 1 0 0    (2)
```

(1) Rotation about the JCS Z axis of all joints is restrained.

(2) Joint 1 has all six dofs restrained.

d. <u>Joint Condensation</u> These cards are used to identify which dof are condensed. This card is repeated NCOND times and is omitted if NCOND equals zero.

```
ID  ITX  ITY  ITZ  IRX  IRY  IRZ  IGEN  ΔID
```

ID Joint identification number. An ID of zero indicates <u>that</u> all joints are affected by this card.

ITX Condensation flag for translation in the JCS X direction.

ITY Condensation flag for translation in the JCS Y direction.

ITZ Condensation flag for translation in the JCS Z direction.

IRX Condensation flag for rotation about the JCS X axis.

IRY Condensation flag for rotation about the JCS Y axis.

IRZ Condensation flag for rotation about the JCS Z axis.

IGEN Number of additional joints, with the same condensation, to be generated from this joint.

ΔID Increment between the generated ID number and the last ID number.

Valid condensation flags are:

0 Degree of freedom is not condensed.

1 Degree of freedom is condensed. Condensation of a restrained dof is ignored.

Example NCOND=1

30 0 0 0 1 1 1 0 0

Rotations of joint 30 are condensed. If the Z axis rotation had been previously restrained, only the X and Y axis rotations are condensed.

e. Joint Constraints These cards are used to identify which dof are constrained. This card is repeated NCONST times, and omitted if NCONST equals zero.

```
ITYPE  MASTER  ISLAVE  IGEN  ΔID
```

ITYPE Type of constraint.

0 Rigid body constraint. A rigid body constraint transfers all six joint dof from the slave to the master joint.

1 XY-planar constraint. An XY-planar constraint transfers the joint's JCS X and Y axes translational dof and the joint's JCS Z axis rotational dof from the slave to the master joint.

MASTER Joint identification number of the master joint.

ISLAVE Joint identification number of the slave joint.

IGEN Number of additional slave joints, constrained to the same master joint to be generated.

ΔID Increment between the generated ID number and the previous ID number.

Note Both the slave and master joint must have the same joint direction cosine number (ICOS).

Example NCONST=1

1 10 20 0 0

Joint 20 is constrained in the JCS XY-plane to joint 10.

2. Materials and Hysteresis Model Information These cards are used to input the material and hysteresis model information. The first card is input once. The second card is repeated NMAT times.

NMAT
TYPE VALUE1 VALUE2 ...

NMAT Number of materials input.

TYPE Material type. Valid types are discussed below. Character variable; enclose in single quotes.

VALUEi Input required by a given material type. The values for each TYPE are discussed below. (real or integer)

Notes on material - element compatibility

1) Individual elements may not use all the information provided by a given material.
2) A given material may not be compatible with all the elements. For example, the Takeda hysteresis model may not be used with the elastic prismatic beam element. Compatible materials for each element are specified under element input.

a. TYPE='3D-BEAM' Material data for an elastic 3D-beam.

'3D-BEAM' E G AX AY AZ J IY IZ

E Young's modulus. (force/length^2)

G Shear modulus. (force/length^2)

AX Cross sectional area. (length^2)

AY Y axis shear area. (length^2)

AZ Z axis shear area. (length^2)

J Torsional moment of inertia. (length^4)

IY Moment of inertia, about the Y axis. (length^4)

IZ Moment of inertia, about the Z axis. (length^4)

b. TYPE='AXLMOD' AXLMOD axial hysteresis model for reinforced concrete as shown in Figures 2 and 3.

'AXLMOD' Kc Kt Kt2 Fy α β μf βDI

Ks Compression stiffness of a unit length member (force/length).

Kt Pre-yielding tensile stiffness of a unit length member (force/length).

Kt2 Post-yielding tensile stiffness of a unit length member (force/length).

Fy Yield force (force).

α Unloading coefficient, usually 0.90.

β Pinching coefficient, usually 0.20.

μf Failure ductility.

βDI Parameter for Ang's damage index discussed in Appendix B (1).

Stiffness terms Kc, Kt, and Kt2 are real variables and may contain a decimal point.

c. TYPE='BEND1' Material data for the B1 hysteresis model. Figure 4 shows the B1 which was developed to model the bending behavior of reinforced concrete shear walls. Figure 5 shows the input for the backbone curve.

'BEND1' NSEG NI DY βDI
P(1) P(2) ... P(NSEG)
D(1) D(2) ... D(NSEG)

NSEG Number of points on the backbone curve.

NI Number of small amplitude loop reversal points that can be stored by the program at one time, usually 10.

DY Rotation of a unit length member, corresponding to the yield point. Used to define the ductility ratio. (radian/length)

βDI Parameter for Ang's damage index discussed in Appendix B (1).

P(i) Moment of a point on the backbone curve. (force*length)

D(i) Rotation of a point on the backbone curve, where the rotation is based on a unit length member. (radian/length)

d. TYPE='SHEAR1' Material data for the S1 hysteresis model. Figure 6 shows the S1 which was developed to model the shear deformation of reinforced concrete shear walls. Figure 5 shows the input for the backbone curve.

'SHEAR1'	NSEG	NI	DY	βDI
P(1)	P(2)	...	P(NSEG)	
D(1)	D(2)	...	D(NSEG)	

NSEG Number of points on the backbone curve.

NI Number of small amplitude loop reversal points that can be stored by the program at one time, usually 10.

DY Shear deformation of a unit length member, corresponding to the yield point. Used to define the ductility ratio. (length/length)

βDI Parameter for Ang's damage index discussed in Appendix B (1).

P(i) Shear of a point on the backbone curve. (force)

D(i) Shear deformation of a point on the backbone curve where shear deformation is based on a unit length member. (length/length)

e. TYPE='TAKEDA' Material data for the TAKEDA hysteresis model. Figure 7 shows the TAKEDA which was developed to model the bending deformations in reinforced concrete members.

'TAKEDA'	EI	PC	DC	PY	DY	PU	DU	βDI

EI Initial bending stiffness of the member (force/rad)

PC Cracking moment. (force*length)

DC	Cracking rotation for a unit length member. (radian/length)

PY	Yield moment. (force*length)

DY	Yield rotation for a unit length member. (radian/length)

PU	Ultimate moment. (force*length)

DU	Ultimate rotation, for a unit length member. (radian/length)

βDI	Parameter for Ang's damage index discussed in Appendix B (1).

f. <u>TYPE='BILINEAR'</u> Figure 8 shows the bilinear hysteresis model.

```
'BILINEAR'  E  PY  SIE  μf  βDI
```

E	Elastic stiffness. (force/length)

PY	Yield load. (force)

SIE	Inelastic stiffness. (force/length)

μf	Failure ductility.

βDI	Parameter for Ang's damage index discussed in Appendix B (1).

g. <u>TYPE='BRACE'</u> Figure 9 shows the bracing member hysteresis model.

```
'BRACE'  E  A  R  YS  SHAPE  μf  βDI
```

E	Elastic modulus. (force/length^2)

A	Section area. (length^2)

R	Ratio of gyration. (length^2)

YS	Yielding stress. (force/length^2)

SHAPE	Member cross section shape:

1 For box or equal-leg angle section

2 For I-shape section

μf	Failure ductility.

βDI	Parameter for Ang's damage index discussed in Appendix B (1).

h. <u>TYPE='LONG-OWJG'</u> Figure 10 shows Pino-Suarez Tower long-direction girder hysteresis model.

'LONG-OWJG' HA VA μf βDI

HA First buckling displacement. (radius)

VA First buckling load. (force*length)

μf Failure ductility (if $\mu f < 1$, then failure ductility is not considered).

βDI Parameter for Ang's damage index=0 (currently not available). Discussed in Appendix B (1).

i. TYPE='IA-BILN' Figure 8 shows this bilinear hysteresis model.

'IA-BILN' ELAS SP E TI TMP μf βDI
REDUCE

ELAS Index for elastic or nonlinear analysis:

- 0 For elastic material property.
- 1 For bilinear material property.
- 2 For box column with consideration of local buckling (18).
- 3 Same as ELAS=1, but strength criteria of box column is checked.

SP Strain hardening ratio.

E Elastic modulus.

TI Section area, torsional rigidity, or moment of inertia.

TMP Axial yielding load, torsional yielding load, or plastic moment.

μf Failure ductility (if $\mu f < 1$, then failure ductility is not considered).

βDI Parameter for Ang's damage index=0 (currently not available), discussed in Appendix B.

REDUCE Percentage of critical load, (if ELAS $\neq$ 2, then omit this data input).

j. TYPE='SHORT-OWJG' Figure 11 shows Pino-Suarez Tower short-direction girder hysteresis model.

```
'SHORT-OWJG'  HA  VA  RATIO  μf  βDI
```

HA — First buckling displacement. (radius)

VA — First buckling load. (force*length)

RATIO — Strain hardening ratio.

μf — Failure ductility (if $\mu f < 1$, then failure ductility is not considered).

βDI — Parameter for Ang's damage index=0 (currently not available), discussed in appendix B.

k. TYPE='STABILITY' Material properties for finite-segment element.

```
'STABILITY' NSEG YS EM LIBN HH UU WW ZZ INEB INEH ST IREV1
IREV2  IREV3 IREV4 IECOP SMALL  RATIX0  RATIY0  TOTA IAUTO
IMATER RATIO3 IR G QRNEE ISTIF
```

NSEG — Number of segments considered. Maximum number of NSEG is 32.

YS — Material yielding stress. (force/length^2)

EM — Elastic modulus.

LIBN — Cross section library number.

1 Box section.

2 Tube (one layer) section.

3 Rectangular section.

4 Wide-flange section.

6 Tube (two layer) section.

7 Equal leg angle section.

HH — Height for LIBN=1, 3, 4.

Radius of tube for LIBN=2, 6.

Angle leg length for LIBN=7.

UU — Width for LIBN=1, 3, 4.

Dummy variable for LIBN=2, 6.

Dummy variable for LIBN=7.

WW	U direction eccentricity from section reference coordinate origin to applied load location.
ZZ	V direction eccentricity from section reference coordinate origin to applied load location.
INEB	Total number of section elements in half width for LIBN=1, 3. Web thickness for LIBN=4. Total number of section elements in one quarter of a circle for LIBN=2, 6. Dummy variable for LIBN=7.
INEH	Total number of section elements in half height for LIBN=1, 3. Dummy variable for LIBN=2, 4, 6, and 7.
ST	Thickness for LIBN=1, 2, 6, and 7; flange thickness for LIBN=4 (length).
IREV1	IREV1 = 1 for LIBN=1. Dummy variable for LIBN=2, 3, and 6. Number of rows in flange's U direction for LIBN=4. Number of columns in segment U direction for LIBN=7.
IREV2	Dummy variable for LIBN=1, 2, 3, and 6. Number of columns in flange's U direction for LIBN=4. Number of rows in segment U direction for LIBN=7.
IREV3	Dummy variable for LIBN=1, 2, 3, and 6. Number of columns in web's V direction for LIBN=4. Number of rows in segment V direction for LIBN=7.
IREV4	Dummy variable for LIBN=1, 2, 3, and 6. Number of rows in web's V direction for LIBN=4. Number of columns in segment V direction for LIBN=7.
IECOP	0 Eccentricity is not considered. 1 Eccentricity is considered. Note If IECOP=0, WW and ZZ are ignored by program.
SMALL	Length of segments at two ends and center right and left sides.
RATIX0	Initial imperfection ratio in element coordinate X direction.
RATIY0	Initial imperfection ratio in element coordinate Y direction.
TOTA	Section gross area. ($length^2$)

IAUTO	1	Element stiffness parameter and displacement norm are calculated.
	0	Element stiffness parameter and displacement norm are not calculated.
IMATER	0	For bilinear stress-strain model shown in Figure 8.
	2	For Ramberg-Osgood stress-strain model.
	3	For elastic case.

RATIO3 Finite-segment element strain hardening ratio.

IR Parameter for Ramberg-Osgood stress-strain model.

G Shear modulus.

QRNEE Limitation of maximum displacement norm. (10^{-2} to 10^{-5})

ISTIF Segment stiffness formulation index:

- 0 Exact approach.
- 1 Approximated approach.

Note Failure ductility and parameter for Ang's damage index are not considered.

1. TYPE='SHEAR2' Material data for the perforated shear wall hysteresis model.

'SHEAR2' NSEG βDI
P(1) P(2) P(3) P(4)
D(1) D(2) D(3) D(4)
HO HS LWP AD AV

NSEG Number of points on the backbone curve.

βDI Parameter for Ang's damage index, discussed in Appendix B (1). βDI set to 0.4.

P(i) Total lateral force of a point on the backbone curve. (force*length)

D(i) Combined bending and shear deformation of a point on the backbone curve. (force*length)

HO Height of the opening. (see Figure 25(a))

HS Distance from the acting point to the bottom of the wall, usually called the shear span length. (see Figure 25(a))

LWP Ratio of the height of the opening to the width between the edge of the wall and the edge of the opening. LWP = L'/W'. (see Figure 25(a))

AD Cross-sectional area of the diagonal bar. (see Figure 25(a))

AV Cross-sectional area of the vertical bar. (see Figure 25(a))

3. Geometric Stiffness Data This card, used to determine the type of geometric stiffness in the analysis, is input once.

KGLOAD	KGTYPE	KGFORM	KGCOND

KGLOAD Type of axial force used to calculate the geometric stiffness.

0 Geometric stiffness is omitted.

1 Axial force is equal to input force, magnified by ground acceleration in the global Z direction, if applicable.

2 Internal element force of the previous load step, used to generate the geometric stiffness.

KGTYPE Type of geometric stiffness formulation.

0 Geometric stiffness is omitted.

1 A 'lumped parameter' formulation is used for the element geometric stiffness.

2 A 'consistent parameter' formulation is used for the element geometric stiffness. If a consistent parameter formulation for an individual element is not available, the lumped parameter formulation is used. Refer to individual element specifications for applicability.

KGFORM Form of the geometric stiffness used.

0 Geometric stiffness is omitted.

1 Geometric stiffness is subtracted from structural stiffness.

2 Separate structural stiffness and geometric stiffness matrices are formed.

Refer to individual solution for applicability.

KGCOND A logical flag. If KGCOND=.TRUE., the geometric stiffness matrix is condensed when applicable. Logical variable.

4. Element Data These cards are used to define the elements. Elements are numbered by the program in the order they are input from 1 to NELMT. Element numbers are used to identify elements in the output. The first card is input once. Second and third cards (if used) are

repeated until 1) NELMT elements are input, or 2) a TYPE='END' is encountered. The third card follows each second card with a value of IGEN > 1.

NELMT	
TYPE NAME VALUE1 VALUE2 ...	IGEN
ΔVALUE1 ΔVALUE2 ...	

NELMT Number of elements input.

TYPE Element type. Valid types are discussed below. Character variable; enclose in single quotes.

NAME A user defined name. Character variable; enclose in single quotes.

VALUEi Input required by a given element type. Values for each TYPE are discussed below. (real or integer)

IGEN Number of additional elements to be generated from this element.

ΔVALUEi Incremental value used to generate subsequent elements.

$$VALUEi_{generated} = VALUEi_{previous} + \Delta VALUEi$$

a. <u>TYPE='3D-BEAM'</u> This card is used to define element data for the elastic prismatic 3D-beam shown in Figure 15.

'3D-BEAM' NAME MAT JOINTI JOINTJ V1 V2 V3
XS XE PKG IRELT IGEN

NAME A user defined name. Character variable; enclose in single quotes.

MAT Material number. This number must correspond to the material type '3D-BEAM'. The terms EAX, GJ, EIY and EIZ from material '3D-BEAM' are used to generate the element stiffness.

JOINTI Start joint ID number.

JOINTJ End joint ID number.

V1 Projection on the GCS X axis of a vector in the element's local XY plane. This vector defines the orientation of the element's local Y axis.

V2 Projection on the GCS Y axis of a vector in the element's local XY plane.

V3 Projection on the GCS Z axis of a vector in the element's local XY plane.

XS Offset distance from the start joint to the beginning of the element. Positive in the direction of the element's local X axis. (length)

XE Offset distance from the end joint to the end of the element. Negative in the direction of the element's local X axis. (length)

PKG Axial load used to calculate the geometric stiffness, if KGLOAD=1. (force) Positive is compression.

IRELT A six-digit release code that is used to release the rotational dof at both ends of the element. A nonzero value of the i'th digit signifies a released dof.

<u>DIGIT</u>

1 Releases the moment about the element's X axis at the start joint.

2 Releases the moment about the element's Y axis at the start joint.

3 Releases the moment about the element's Z axis at the start joint.

4 Releases the moment about the element's X axis at the end joint.

5 Releases the moment about the element's Y axis at the end joint.

6 Releases the moment about the element's Z axis at the end joint.

IGEN Element generation parameter. See discussion under 'Element Data'.

b. <u>TYPE='SPRING'</u> This card is used to define element data for the one-dimensional spring shown in Figure 16.

'SPRING' NAME MAT JOINTI JOINTJ KTYPE XLEN V1 V2
V3 XS XE IGEN

NAME A user-defined name. Character variable; enclose in single quotes.

MAT Material number.

JOINTI Start joint ID number.

JOINTJ End joint ID number.

KTYPE Type of spring.

1 Axial spring.

2 Shear spring in the element's local Y axis.

3 Shear spring in the element's local Z axis.

4 Torsional spring.

5 Rotational spring about the element's local Y axis.

6 Rotational spring about the element's local Z axis.

XLEN Length of the spring used to calculate the stiffness. (length)

V1 Projection on the GCS X axis of a vector in the spring's local XY plane. This vector defines the orientation of the element's local Y axis.

V2 Projection on the GCS Y axis of a vector in the spring's local XY plane.

V3 Projection on the GCS Z axis of a vector in the spring's local XY plane.

XS Offset distance from the start joint to the beginning of the spring. Positive in the direction of the element's local X axis. (length)

XE Offset distance from the end joint to the end of the spring. Negative in the direction of the element's local X axis. (length)

IGEN Element generation parameter. See discussion under 'Element Data'.

Notes

1) Material specified for the spring element may consist of any of the following: 3D-BEAM, AXLMOD, BEND1, SHEAR1, TAKEDA, and ELSPLS.

2) Spring uses the axial stiffness from the 3D-BEAM material.

3) BEND1 and TAKEDA models are usually based on moment-rotation, (KTYPE=4 to KTYPE=6) but they can be used as translational springs (KTYPE=1 to KTYPE=3) by changing the material input from moment-rotation to force-translation.

4) AXLMOD and SHEAR1 models are usually based on force-translation, and are valid models for KTYPE=1 to KTYPE=3.

5) Program does not check the user's choice of model.

6) If the distance between the start and end joints is zero, the spring is oriented such that the ECS is parallel to the start joints JCS.

7) Spring stiffness is for axial (force/length), lateral (force/length), torsional (force-length/rad) and rotational (force-length/rad) springs. For a given spring stiffness a, we need input E, A and XLEN of which the numbers are arbitrary and mainly to have the equivalence of a=EA/XLEN. Normally use E and A the same as the member properties and adjust XLEN.

c. TYPE='SHEAR WALL' This card is used to define element data for the reinforced concrete shear wall shown in Figure 20.

```
'SHEAR WALL'  NAME  MATB  MATS  MATA  J1  J2  J3  J4  ALPHA
 PKG  IGEN
```

NAME A user-defined name. Character variable; enclose in single quotes.

MATB Bending hysteresis model material number.

MATS Shear hysteresis model material number.

MATA Axial hysteresis model material number.

J1 Joint at the upper right-hand corner of the element.

J2 Joint at the upper left-hand corner of the element.

J3 Joint at the lower left-hand corner of the element.

J4 Joint at the lower right-hand corner of the element.

ALPHA Fraction of the length from the top of the element to the internal springs.

PKG Axial load used to calculate the geometric stiffness, if KGLOAD=1. Positive is compression. (force)

IGEN Element generation parameter. See discussion under 'Element Data'.

Notes

1) Material specified for the shear wall element may consist of any of the following: 3D-BEAM, AXLMOD, BEND1, SHEAR1, TAKEDA, and ELSPLS.
2) BEND1 model is usually specified for the bending material.
3) SHEAR1 model is usually specified for the shear material.
4) AXLMOD model is usually specified for the axial material.
5) 3D-BEAM material's axial stiffness is used for the spring's stiffness if the 3D-BEAM material is specified.

Example	Note
5	(1)
'3D-BEAM' 'A1' 1 10 20 0. 0. 1. 0. 0. 0. 100000 2	(2, 3)
0 10 10 0. 0. 0. 0. 0. 0. 000000	(3)
'SPRING' 's1' 2 10 11 1 0. 0. 0. 1. 0. 0. 0	(4)
'SHEAR WALL' 'W1' 3 4 5 20 10 1 2 1. 35. 0	(5)

Notes

(1) Five elements are to be input.

(2) A 3D-beam is input between joints 10 and 20.

(3) Two more 3D-beams are generated from the first beam.

(4) An axial spring is input between joints 10 and 11.

(5) A shear wall element is input between joints 20, 10, 1 and 2.

d. TYPE='BRACE' This card is used to define element data for the bracing member.

```
'BRACE'  NAME  MAT  JOINTI  JOINTJ  KTYPE SLK V1 V2 V3 XS XE
IGEN
```

NAME A user-defined name. Character variable; enclose in single quotes.

MAT Modified Goel's hysteresis model number.

JOINTI Start joint ID number.

JOINTJ End joint ID number.

KTYPE Equal to 1.

SLK K factor for slenderness ratio.

V1 Projection on the GCS X axis of a vector in the member's XY plane. This vector defines the orientation of the element's local Y axis.

V2 Projection on the GCS Y axis of a vector in the member's XY plane.

V3 Projection on the GCS Z axis of a vector in the member's XY plane.

XS Offset distance from the start joint to the beginning of the strut. Positive in the direction of the element's local X axis. (length)

XE Offset distance from the end joint to the end of the strut. Negative in the direction of the element's local X axis. (length)

IGEN Element generation parameter. See discussion under 'Element Data'.

Notes

1) Stiffness of the bracing member is based on the 'BRACE' material only.

2) Cross section of the bracing member could be box, angle, or wide flange sections. The element may not be applied to other cross sections.

e. TYPE='IE3DBEAM' This card is used to define element data for the inelastic 3D-beam-column element.

```
'IE3DBEAM' NAME MATMYA MATMYB MATMZA MATMZB MATMXA MATFXA
JOINTI JOINTJ V1 V2 V3 XS XE PKG IGEN
```

NAME	A user-defined name. Character variable; enclose in single quotes.
MATMYA	Bending hysteresis material number at the start joint in element's local Y axis.
MATMYB	Bending hysteresis material number at the end joint in element's local Y axis.
MATMZA	Bending hysteresis material number at the start joint in element's local Z axis.
MATMZB	Bending hysteresis material number at the end joint in element's local Z axis.
MATMXA	Torsional hysteresis material number at the start joint in element's local X axis.
MATFXA	Element axial hysteresis material number.
JOINTI	Start joint ID number.
JOINTJ	End joint ID number.
V1	Projection on the GCS X axis of a vector in the member XY plane. This vector defines the orientation of the element's local Y axis.
V2	Projection on the GCS Y axis of a vector in the member's XY plane.
V3	Projection on the GCS Z axis of a vector in the member's XY plane.
XS	Offset distance from the start joint to the beginning of the element. Positive in the direction of the element's local X axis. (length)
XE	Offset distance from the end joint to the end of the element. Negative in the direction of the element's local X axis. (length)
PKG	Axial load used to calculate the geometric stiffness, if KGLOAD=1. (force) Positive is compression.
IGEN	Element generation parameter. See discussion under 'Element Data'.

Notes

1) Bending materials specified for inelastic 3D beam element may consist of any of the following: LONG-OWJG, IA-BILN, SHORT-OWJG, and TAKEDA.
2) Bending hysteresis material number at the start joint in the element's local Y axis should be same as that at the end joint in the element's local Y axis.
3) Bending hysteresis material number at the start joint in the element's local Z axis should be same as that at the end joint in the element's local Z axis.
4) IA-BILN model is specified for the torsional and axial materials.

f. <u>TYPE='STABILITY'</u> This card is used to define element data for the finite-segment element.

```
'STABILITY' NAME MAT JOINTI JOINTJ V1 V2 V3 XS XE IGEN
```

NAME	A user-defined name. Character variable; enclose in single quotes.
MAT	Material number.
JOINTI	Start joint ID number.
JOINTJ	End joint ID number.
V1	Projection on the GCS X axis of a vector in the member's XY plane. This vector defines the orientation of the element's local Y axis.
V2	Projection on the GCS Y axis of a vector in the member's XY plane.
V3	Projection on the GCS Z axis of a vector in the member's XY plane.
XS	Offset distance from the start joint to the beginning of the element. Positive in the direction of the element's local X axis. (length)
XE	Offset distance from the end joint to the end of the element. Negative in the direction of the element's local X axis. (length)
IGEN	Element generation parameter. See discussion under 'Element Data'.

<u>Note</u> STABILITY material model is specified for this element.

g. <u>TYPE='SHEAR-OPEN'</u> This card is used to define element data for the perforated reinforced concrete shear wall.

```
'SHEAR-OPEN' NAME MATS MATA1 MATA2 J1 J2 J3 J4 ALPHA
PKG IGEN
```

NAME	A user-defined name. Character variable; enclose in single quotes.
MATS	Perforated shear wall hysteresis model material number.
MATA1	Axial hysteresis model material number for left-side wall.
MATA2	Axial hysteresis model material number for right-side wall.
J1	Joint at the upper right-hand corner of the element.
J2	Joint at the upper left-hand corner of the element.
J3	Joint at the lower left-hand corner of the element.

J4 Joint at the lower right-hand corner of the element.

ALPHA Fraction of the length from the top of the element to the internal springs.

PKG Axial load used to calculate the geometric stiffness, if KGLOAD=1. Positive is compression. (force)

IGEN Element generation parameter. See discussion under 'Element Data'.

Notes

1) SHEAR2 model is usually specified for the combined bending and shear material.

2) AXLMOD is usually specified for the axial material.

5. Mass These cards are used to input lumped masses at the joints. The first card is input once. The second card is repeated INMASS times, or until a joint ID ≤ 0 is encountered. If INMASS is less than one, or FMASS is zero, omit the second card.

INMASS FMASS MCOND
ID PX PY PX RXX RYY RZZ RXY RXZ RYZ IGEN ΔID

INMASS Number of mass cards to be read.

FMASS Mass flag.

0 Mass matrix is omitted.

1 Mass matrix due to concentrated joint masses is formed.

MCOND A logical flag. If MCOND=.TRUE., the mass matrix is condensed when applicable. Logical variable.

ID Identification number of the joint.

PX Translational mass in the joint's JCS X direction. (mass)

PY Translational mass in the joint's JCS Y direction. (mass)

PZ Translational mass in the joint's JCS Z direction. (mass)

RXX Rotational mass moment of inertia about the joint's JCS X axis. (mass*length^2)

RYY Rotational mass moment of inertia about the joint's JCS Y axis. (mass*length^2)

RZZ Rotational mass moment of inertia about the joint's JCS Z axis. (mass*length^2)

RXY Rotational mass product of inertia about the joint's JCS XY axis. (mass*length^2)

RXZ Rotational mass product of inertia about the joint's JCS XZ axis. (mass*length^2)

RYZ Rotational mass product of inertia about the joint's JCS YZ axis. (mass*length^2)

IGEN	Number of joints with identical mass, to be generated.
ΔID	Increment of joint ID number for generated values.

Example INMASS=1, FMASS=1,

10 8. 8. 8. 0 0 0 0 0 0 0 0

Joint 10 has a translational mass of 8.0 in the X, Y and Z directions.

6. Damping This card is used to input proportional damping data.

ALPHA BETA

ALPHA	Proportional damping coefficient for mass.
BETA	Proportional damping coefficient for stiffness.

B. SOL01 - ELASTIC STATIC SOLUTION

This is an elastic solution with multiple load cases. The following cards are input once.

'SOL01'
TITLE
NLOAD MAXELD

SOL01	Signifies solution 1. Character variable; enclose in single quotes.
TITLE	User input title, 80 characters maximum. Character variable; enclose in single quotes.
NLOAD	Number of load cases.
MAXELD	Maximum number of element loads.

Notes

1) Condensation increases the band-width of the stiffness matrix for SOL01 without any other benefits. Condensation is not recommended for SOL01.

2) A separate geometric stiffness (KGFORM=2) is not used by SOL01. The geometric stiffness may be included by using KGFORM=1.

3) If the geometric stiffness is included, the element axial loads must be input (KGLOAD=1).

1. Joint Loads These cards are used to apply loads to joints. Loads applied to restrained joints are considered as displacements, yielding, support settlement or displacement control solutions. Loads applied to constrained joints are transferred to their 'master' joints. If the 'master' joint is restrained, loads transferred to restrained dof are considered as displacements. Joint loads are cumulative. Applying two loads to the same joint results in the sum of the joint loads being considered. The following card is repeated until the value of DIR is 'END'.

```
LOAD  ID  IGEN  ΔID  DIR  VALUE
```

LOAD Number of the load case that the load is applied to.

ID Joint ID number that the load is applied to.

IGEN Number of identical joint loads to be generated.

ΔID Increment of joint ID number for generated values.

DIR Direction of load in the joint coordinate system. Valid directions and the units of VALUE are given below. Character variable; enclose in single quotes.

- 'FX' Applied force in the joint's JCS X direction. (force)
- 'FY' Applied force in the joint's JCS Y direction. (force)
- 'FZ' Applied force in the joint's JCS Z direction. (force)
- 'MX' Applied moment about the joint's JCS X axis. (force*length)
- 'MY' Applied moment about the joint's JCS Y axis. (force*length)
- 'MZ' Applied moment about the joint's JCS Z axis. (force*length)
- 'END' Terminate the input of element loads.

VALUE Magnitude of the applied load.

Example	Note
1 2 2 1 'FZ' -3.00	(1)
2 7 0 0 'MX' 33.5	(2)
0 0 0 0 'END' 0	(3)

Notes

(1) Joints 2, 3, and 4 have an applied force of -3.00 in the Z direction for load case 1.

(2) Joints 7 has an applied moment of 33.50 in the X direction for load case 2.

(3) Joint loading input is terminated.

2. Element Loads Cards here are used to apply element loads to the '3D-BEAM' element at the portion of the beam between points A and B (see Figure 15 in the ECS). These loads are transferred by the program to the start and end joints. The card below is included only if MAXELD > 0. This card is repeated MAXELD times, or until the value of TYPE is 'END'.

```
LOAD  IELE  IGEN  ΔIELE TYPE  DIR  VALUE1,  VALUE2, ...
```

LOAD   Load case number.

IELE   Element number.

IGEN   Number of similar element loads to be generated.

ΔIELE   Increment of element number for generated values.

TYPE   Type of load. Valid types are described in detail below. Character variable; enclose in single quotes.

'CONC'   Concentrated load applied in direction DIR. VALUE1 is the magnitude of the load (force or force*length). VALUE2 is the ratio of the distance to the load, divided by the flexible length of the member. Distance is measured from the beginning of the flexible length at the member's start end. VALUE2 is between 0 and 1. Only two values are input.

'UNIF'   Uniform load applied in direction DIR. VALUE1 is the magnitude of the load. Only one value is input. (force/length)

'FEM'   Input the fixed end forces on the end of the member. DIR is not used and may be set to any value. VALUE1 to VALUE12 are required.

VALUE1   Fixed end axial force, at point A of Figure 15, in the ECS X direction. (force)

VALUE2   Fixed end shear, at point A of Figure 15, in the ECS Y direction. (force)

VALUE3   Fixed end shear, at point A of Figure 15, in the ECS Z direction. (force)

VALUE4 Fixed end torsion, at point A of Figure 15, about the ECS X axis. (force*length)

VALUES5 Fixed end moment, at point A of Figure 15, about the ECS Y axis. (force*length)

VALUE6 Fixed end moment, at point A of Figure 15, about the ECS Z axis. (force*length)

VALUE7 Fixed end axial force, at point B of Figure 15, in the ECS X direction. (force)

VALUE8 Fixed end shear, at point B of Figure 15, in the ECS Y direction. (force)

VALUE9 Fixed end shear, at point B of Figure 15, in the ECS Z direction. (force)

VALUE10 Fixed end torsion, at point B of Figure 15, about the ECS X axis. (force*length)

VALUE11 Fixed end moment, at point B of Figure 15, about the ECS Y axis. (force*length)

VALUE12 Fixed end moment, at point B of Figure 15, about the ECS Z axis. (force*length)

'END' Terminate the input of element loads.

DIR Direction of load in element coordinate system. Valid directions given below. Character variable; enclose in single quotes.

'FX' Axial load is applied.

'FY' Force is applied in the local element's Y direction.

'FZ' Force is applied in the local element's Z direction.

'MX' Torque is applied.

'MY' Moment is applied about the local element's Y axis.

'MZ' Moment is applied about the local element's Z axis.

VALUEi Values used to calculate the element loads.

Notes

1) Multiple loads may be put on a single element.

2) 'UNIF' 'MY' and 'UNIF' 'MZ' are not available.

3) Element load TYPE='FEM' is not modified to reflect member end releases.

Example   MAXELD=1,

1 13 0 0 'UNIF' 'FZ' -3.00

Element 13 has a uniform load of -3.00 applied in the element's local Z direction for load case 1.

C. SOL02 - DYNAMIC SOLUTION BY NUMERICAL INTEGRATION

This is a dynamic solution of the structure subject to ground accelerations. Both elastic and nonlinear behavior can be modeled. The following cards are input once.

'SOL02'
TITLE
INTEG THETA ELASTIC UNBAL
IPRINT IWRITE MAXACC SLMASS
TO ΔT TF GRAV

SOL02 Signifies solution 2. Character variable; enclose in single quotes.

TITLE User input title, 80 characters maximum. Character variable; enclose in single quotes.

INTEG Type of numerical integration used. Valid values of INTEG are given below. Character variable; enclose in single quotes.

- 'LINEAR' Linear acceleration method is used.
- 'AVERAGE' Average acceleration method is used.
- 'WILSON' Wilson theta method is used.

THETA Value of theta used by Wilson theta method. Set THETA=0 if the Wilson theta method is not used.

ELASTIC A logical flag. If ELASTIC=.TRUE., the structure is assumed to behave elastically. Logical variable.

UNBAL A logical flag. If UNBAL=.TRUE., the unbalanced loads from the preceding step are added to the current dynamic loads for nonlinear analysis. Logical variable.

IPRINT Step increment for printed output.

IWRITE Step increment for data written to output files.

MAXACC Maximum number of points in each ground acceleration record.

SLMASS A logical flag. If SLMASS=.TRUE., a special mass matrix is input. This matrix is used with ground acceleration to generate loads. Logical variable.

TO Initial time at the beginning of the solution. (time)

ΔT Time step. (time)

TF Final time at the end of the solution. (time)

GRAV Gravitational acceleration constant. (length/sec^2)

1. Special Loading Mass Cards here input the special loading mass matrix discussed in step 1 of Section C in Chapter II. If the special loading mass is input, the dynamic joint loads are ground acceleration times special loading mass. If the special loading mass is not input, the dynamic joint loads are ground acceleration times structural mass. The first card is input once. The second card is repeated INMASS times, or until an ID less than one is encountered. If INMASS is less than one, or FMASS is zero, omit the second card. Omit both cards if SLMASS=.FALSE..

```
INMASS  FMASS
ID  PX  PY  PX  RXX  RYY  RZZ  RXY  RXZ  RYZ  IGEN  ΔID
```

These cards are identical to the 'Mass' cards in the block STRUCT. Refer to STRUCT for a detailed description.

2. Output Data to Disk Files Cards control the data that is written to separate disk files. Such data is used to print reports and plot data. This card is repeated until the value of TYPE is 'END'.

```
TYPE  NUMB  IUNIT  IGEN ΔNUMB  ΔIUNIT
```

TYPE Type of data to be written to output file. Valid types are given below. Character variable; enclose in single quotes.

'DOF'	Data is printed for a degree of freedom. The degree of freedom ID number, as assigned by the program, is used.
'JOINT FX'	Data is printed for the degree of freedom corresponding to the joint's JCS X translation.
'JOINT FY'	Data is printed for the degree of freedom corresponding to the joint's JCS Y translation.
'JOINT FZ'	Data is printed for the degree of freedom corresponding to the joint's JCS Z translation.
'JOINT MX'	Data is printed for the degree of freedom corresponding to the joint's JCS X rotation.
'JOINT MY'	Data is printed for the degree of freedom corresponding to the joint's JCS Y rotation.
'JOINT MZ'	Data is printed for the degree of freedom corresponding to the joint's JCS Z rotation.
'ELE'	Element data is printed.
'ENERGY'	Structure's energy balance is printed.
'SUMRCT'	Structure's summation of reactions is printed.
'GROUND'	Ground response is printed.
'END'	Terminate the input of element loads.

NUMB Element, dof or joint number. Set NUMB=0 if TYPE='ENERGY'.

IUNIT Output file unit number.

IGEN Number of similar data groups to be printed.

ΔNUMB Incremental element dof or joint number for generation.

ΔIUNIT Incremental output file unit number for generation.

<u>Example</u> <u>Note</u>

```
'DOF'  5  10   0 0 0          (1)
'ELE' 32  11   1 1 1          (2)
'END'  0   0   0 0 0          (3)
```

Notes

(1) Degree of freedom #5 data is written to file 10.

(2) Element 32's data is written to file 11 and element 33's data is written to file 12.

(3) Output requests are terminated.

3. Initial Displacements, Velocities, Accelerations and Loads This card, used to define initial conditions for dynamic analysis, repeated until OPTION has a value of 'END'.

ISP1									
ID	IGEN	ΔID	OPTION	V1	V2	V3	V4	V5	V6

ISP1 0 Response due to static loads is not considered.

1 Response due to static loads is considered.

Note If ISP1 = 1, omit the second input line.

ID Joint ID number.

IGEN Number of joints with identical initial conditions.

ΔID Increment of the joint ID number for generation.

OPTION Type of initial condition. Valid options are listed below. Character variable; enclose in single quotes.

'DISPL' Initial displacements are given. V1, V2 and V3 are displacements (length) while V4, V5 and V6 are rotations (radians).

'VEL' Initial velocities are given. V1, V2 and V3 are translational velocities (length/time) while V4, V5 and V6 are rotational velocities (radians/time).

'ACC' Initial accelerations are given. V1, V2 and V3 are translational accelerations (length/time^2) while V4, V5 and V6 are rotational accelerations (radians/time^2).

'LOA' Initial loads are given. V1, V2 and V3 are loads (force) while V4, V5 and V6 are moments (force*length).

V1 Initial value of translation or force in the joint's JCS X direction.

V2 Initial value of translation or force in the joint's JCS Y direction.

V3 Initial value of translation or force in the joint's JCS Z direction.

V4 Initial value of rotation or moment about the joint's JCS X axis.

V5 Initial value of rotation or moment about the joint's JCS Y axis.

V6 Initial value of rotation or moment about the joint's JCS Z axis.

Notes

1) If the acceleration at time TO is nonzero, initial conditions must be specified to ensure equilibrium.

2) Initial acceleration may be set equal to zero by one of the following methods.

   a) Initial time at the beginning of the solution is equal to initial time of the acceleration record, (TO=TOG), set A(1) =0.

   b) Initial time at the beginning of the solution is less than initial time of the acceleration record, (TO <TOG), set A(1) ≠ 0.

3) If the dynamic solution, SOL02, follows a static solution, SOL01, then the resulting displacements and element forces are automatically included as initial conditions for the dynamic solution. Results from the static solution may be excluded from the dynamic solution by releasing the memory between solutions.

Example	Note
2 2 1 'ACC' 3. 0 0 0 0 0	(1)
0 0 0 'END' 0 0 0 0 0 0	(2)

Notes

(1) Joints 2, 3 and 4 have an initial acceleration of 3.0 in the X direction.

(2) Initial conditions are terminated.

4. Ground Acceleration Record. Cards here are used to input the ground acceleration record and its orientation. The cards below are input once.

NA	ASCALE	TOG	ΔTG	PRINT	
Vxi	Vzj	Vxk	Vyi	Vyj	Vyk

NA Number of components of ground acceleration input.

ASCALE Ground acceleration amplitude scale factor.

TOG Time at the first point of the ground acceleration. (time)

ΔTG Time increment for the input ground acceleration. (time)

PRINT A logical flag. If PRINT=.TRUE., then the 3D ground accelerations are printed.

Vxi GCS X axis projection of a unit vector defining the X' axis of the input ground acceleration.

Vxj GCS Y axis projection of a unit vector defining the X' axis of the input ground acceleration.

Vxk GCS Z axis projection of a unit vector defining the X' axis of the input ground acceleration.

Vyi GCS X axis projection of a unit vector defining the Y' axis of the input ground acceleration.

Vyj GCS Y axis projection of a unit vector defining the Y' axis of the input ground acceleration.

Vyk GCS Z axis projection of a unit vector defining the Y' axis of the input ground acceleration.

Below is a set of cards repeated NA times. The two FORMAT cards are used only if the value of FMT=.TRUE.. Both ATITLE cards and A( ) are input on unit=IN.

IN NPTS IDIR FMT ECHO REWIND
FORMAT1
FORMAT2
ATITLE2
ATITLE2
A(1) A(2) A(3) ... ... A(NPTS)

IN	Input unit number for acceleration record.
NPTS	Number of acceleration points to be read. NPTS $\leq$ MAXACC.
IDIR	Direction of acceleration being read. 1 Ground acceleration is in the X' direction. 2 Ground acceleration is in the Y' direction. 3 Ground acceleration is in the Z' direction.
FMT	A logical flag. If FMT=.TRUE., then the input acceleration is formatted and the corresponding Fortran format codes, FORMAT1 and FORMAT2, must be input. Logical variable.
ECHO	A logical flag. If ECHO=.TRUE., then the input acceleration is printed. Logical variable.
REWIND	A logical flag. If REWIND=.TRUE., then the acceleration input file is rewound before it is read. This allows the same acceleration input file to be read more than once. IF IN=5, then set REWIND=.FALSE.. Logical variable.
FORMAT1	Fortran format code capable of reading the two 80-character titles. (Character variable; do not enclose in single quote.)
FORMAT2	Fortran format code capable of reading the input ground accelerations. (Character variable; do not enclose in single quote.)
ATITLE1	Ground acceleration title. Read from unit IN. (Character variable; do not enclose in single quote.)
ATITLE2	Ground acceleration title. Read from unit IN. (Character variable; do not enclose in single quote.)
A( )	Input ground acceleration. If FMT=.FALSE., A( ) must be separated by blank spaces or commas. Otherwise, A( ) is input by the fixed format code FORMAT2. Read from unit IN. (g's)

Example	Note
2 1.0 0.0 0.01 .FALSE.	(1)
1 0 0 0 1 0	(2)
5 5 1 .TRUE. .FALSE.	(3)
(A/A)	(4)
(8F9.6)	(5)
ELCENTRO- 1940 EQ DATA FORMAT: (8F9.6)	(6)

```
DT=0.01 SEC    +++ E-W DIRECTION +++                    (6)
-0.011848-0.008267-0.004687-0.002477-0.004856           (7)
5 5 2 .FALSE. .FALSE.                                    (8)
ELCENTRO- 1940  EQ DATA                                  (9)
DT=0.01 SEC    +++ N-S DIRECTION +++                    (9)
0.010966       0.008610                                  (10)
0.006255                                                 (10)
0.003900        .001545                                  (10)
```

(1) Two ground motions are to be input.

(2) Vectors defining the X' and Y' axes are input.

(3) Input the first ground motion in fixed format from unit 5.

(4) Format code for titles.

(5) Format code for acceleration data.

(6) Titles.

(7) Acceleration data.

(8) Input the second ground motion in free format from unit 5.

(9) Titles.

(10) Acceleration data.

D. SOL03 - EIGENVALUE SOLUTION

This solution is used to calculate the elastic natural frequency and mode shape or the buckling load and mode shape. The cards below are input once.

'SOL03'
TITLE
OPTION IPRINT IPJT

SOL03 Signifies solution 3. Character variable; enclose in single quotes.

TITLE User input title, 80 characters maximum. Character variable; enclose in single quotes.

OPTION Choice of natural frequency or buckling load. Character variable; enclose in single quotes.

'FREQ'	Solves for the natural frequency and mode shapes of the structure.
'BUCK'	Solves for the buckling load and mode shapes of the structure.

IPRINT Number of modes to be printed.

IPJT Number of modes to be printed with detailed mode shape.

E. SOL04 - INCREMENTAL STATIC SOLUTION

This solution is used to calculate the static cyclic response of nonlinear structures. The cards below are input once.

```
'SOL04'
TITLE
MAXELD  IPRINT  IWRITE  UNBAL
```

SOL04 Signifies solution 4. Character variable; enclose in single quotes.

TITLE User input title, 80 characters maximum. Character variable; enclose in single quotes.

MAXELD Maximum number of element loads.

IPRINT Step increment for printed output.

IWRITE Step increment for data written to output files.

UNBAL A logical flag. If UNBAL=.TRUE., the unbalanced loads from the preceding step are added to the current load. Logical variable.

Note The load case for this solution is always input as one.

1. Output Data to Disk Files Cards here control the data that is written to separate disk files and are used to print reports or plot data. They are identical to the 'Output Data to Disk File' cards in block SOL02. Refer to SOL02 for a detailed description. These cards are repeated until the value of TYPE is 'END'.

```
TYPE   NUMB   IUNIT   IGEN ΔNUMB   ΔIUNIT
```

2. Joint Loads Cards here are used to apply loads to joints. These cards are identical to the 'Joint Load' cards in block SOL01. Refer to SOL01 for a detailed description. The card below is repeated until the value of DIR is 'END'.

```
LOAD   ID   IGEN   ΔID    DIR    VALUE
```

3. Element Loads Cards here are used to apply element loads to the '3D-BEAM' element. These cards are identical to the 'Element Load' cards in block SOL01. Refer to SOL01 for a detailed description. The card below is only included if MAXELD > 0. This card is repeated MAXELD times, or until the value of TYPE is 'END'.

```
LOAD   IELE   IGEN   ΔIELE   TYPE   DIR   VALUE1,   VALUE2, ...
```

4. Load Factors. Cards here contain the load factors used to generate incremental static loads. Two options are available to limit the size of the load step: 1) the results of each step are scaled such that joint loads and displacements on free dof are less than PMAX and DMAX; the step is repeated until the value of FACTOR is achieved (loading option A), or 2) each load step is subdivided into N steps (loading option B). This card is repeated until the value of STEP is 'END'.

```
STEP    FACTOR    PMAX    DMAX    N
```

STEP	User input step name, 80 characters maximum. Character variable; enclose in single quotes. If STEP is 'END', the current solution is terminated.
FACTOR	Load factor. The applied load at the end of the step is FACTOR. (applied joint and element loads).
PMAX	Maximum value for a free dof joint load per load step. (force or force*length)
DMAX	Maximum value for a free dof joint displacement per load step. (length or radians)
N	Number of load steps between the previous and current factor. N is only used if

both PMAX and DMAX are equal to zero.

Example | Note

'LOAD'	10.0	25.	.25	0	(1)
'UNLOAD'	0.0	0.	.0	20	(2)
'END'	0	0.	.0	0	(3)

Notes

(1) The structure is loaded to 10 times the joint and element loads in steps that do not have load increments greater than 25 or displacement increments greater than 0.25.

(2) The structure is then unloaded with 20 equal size load steps.

(3) SOL04 is terminated.

F. SOL05 - RESPONSE SPECTRUM ANALYSIS

This solution is used to calculate maximum structural response based on the response spectrum of
dynamic force. The cards below are input once.

'SOL05'
TITLE
ICOM NMODE DAMP NA NAP IPRT
NSTEP MEIG

SOL05 Signifies solution 5. Character variable; enclose in single quotes.

TITLE User input title, 80 characters maximum. Character variable; enclose in single quotes.

ICOM Modal combination method used. Character variable; enclose in single quotes.
'SRSS' Square-root-of-sum-of-square method is used.
'CQC' Complete quadratic combination method is used.

NMODE Number of modes considered.

DAMP Damping ratio for all modes.

NA Number of seismic components considered.

NAP Number of input points of response spectrum for individual seismic component.

IPRT Number of modes' for which information is to be printed.

NSTEP If NSTEP=1, calculate eigenpairs and store eigenpairs in the disk unit 'MEIG'. If NSTEP=2, read eigenpairs from the disk unit 'MEIG' and perform spectrum analysis. If NSTEP=3, calculate eigenpairs and perform spectrum analysis. Eigenpairs are not stored in the disk unit 'MEIG'.

MEIG Disk unit number for eigenpairs' solution.

1. Direction of Seismic Component Response spectral values corresponding to individual modes are read by the cards below. This set of cards can be omitted if NSTEP=1.

```
ASCALE   OPTION   PRINT
Vxi   Vzj   Vxk     Vyi   Vyj   Vyk
```

ASCALE Response spectral amplitude factor.

OPTION If OPTION='DISP', displacement spectral values are used. If OPTION='ACC', acceleration spectral values are used. Character variable; enclose in single quotes.

PRINT A logical flag. If PRINT=.TRUE. then the spectral information is printed.

Vxi GCS X axis projection of a unit vector defining the X' axis of the input ground component.

Vxj GCS Y axis projection of a unit vector defining the X' axis of the input ground component.

Vxk GCS Z axis projection of a unit vector defining the X' axis of the input ground component.

Vyi GCS X axis projection of a unit vector defining the Y' axis of the input ground component.

Vyj GCS Y axis projection of a unit vector defining the Y' axis of the input ground component.

Vyk GCS Z axis projection of a unit vector defining the Y' axis of the input ground component.

2. <u>Response Spectral Values.</u> The set of cards below is repeated NA times.

IDIR
RSNP1 RSNP2

IDIR Direction of ground component being read.

1 Ground spectrum is in the X' direction.

2 Ground spectrum is in the Y' direction.

3 Ground spectrum is in the Z' direction.

RSNP1 Period value of response spectrum curve.

RSNP2 Spectral value corresponding to period RSNP1.

<u>Note</u>

1) The spectral value corresponding to the structural natural period will be calculated by linear interpolation of two RSNP2 values in the response spectrum curve.
2) Repeat the second block NAP times.
3) RSNP1 should be input in increasing order.

3. <u>Effective Mass Limitation</u>

XLIM YLIM ZLIM

XLIM Effective mass limitation in GCS X direction.

YLIM Effective mass limitation in GCS Y direction.

ZLIM Effective mass limitation in GCS Z direction.

<u>Note</u>

1) If number of modes calculated based on XLIM, YLIM, or ZLIM is less than NMODE, the modes calculated based on XLIN, YLIM, or ZLIM are used for the modal combination in the response spectrum analysis.
2) If input value of XLIM, YLIM, or ZLIM is zero, NOMDE is used for the modal combination in the response spectrum analysis.

G. BUG - SET BUG OPTIONS

This card is used to set the bug options which print out the intermediate results listed below. Its entire statement is a character variable, and is enclosed in single quotes.

```
'BUG=options'
```

Option Description

A Print element displacements.

Print loads applied to degrees of freedom.

B Not used.

C Print plot data for program SEE to unit 07. SEE is a program that plots the structure on the UMR CALCOMP plotter. A listing of program SEE is given in Appendix C.

D Print joint, element, and dynamic loading data.

E Print numerical integration data for linear and average acceleration methods.

F Print the element's structural and geometric stiffness.

Print the global mass, structural stiffness, geometric stiffness, loads and displacements.

G Print the condensed global mass, structural stiffness and geometric stiffness matrices.

H Print the element transformations, structural and geometric stiffness, etc.

I Print contents of memory for elements.

J Print a skyline map for matrices.

K Print the material data for each load step.

L Print the energy balance.

M Print the skyline data for matrices.

N Print the contents of memory when DUMP is called.

Notes

1) Any number of options may be specified at one time.

2) Options specified with the last bug statement are the only options active.

H. READ - READ OUTPUT FILES

This card is used to read and print data written to output files during SOL02 and SOL04. The entire statement is a character variable and is enclosed in single quotes.

```
'READ  INC=I  UNIT=NO'
```

where NO is the unit number of the file that contains the data, and I is the increment of the steps printed out. Multiple UNIT=NO statements may exist on each read card.

I. NOECHO - INHIBIT INPUT ECHO

This card is used to inhibit the input echo. Character variable; enclose in single quotes.

```
'NOECHO'
```

J. DUMP - PRINT MEMORY

This card is used to print the addresses of the data in memory. If 'BUG=N' was previously specified, 'DUMP' also prints the nonzero values in the linear array. Character variable; enclose in single quotes.

```
'DUMP'
```

K. RELEASE - RELEASE MEMORY

This card is used to release or 'free up' memory used for previous solutions. Global displacements, velocities, etc. are reset to zero. Its entire statement is a character variable, and is enclosed in single quotes.

```
'RELEASE  OPTION'
```

If OPTION='ELEMENT', the element forces, displacements and hysteresis models are also reset to their initial values.

Example	Note
'STRUCT'	(1)
.	
. Structure input is omitted.	
.	
'SOL01'	(2)
.	
. Solution input is omitted.	
.	
'RELEASE'	(3)
'SOL03'	(4)
.	
. Solution input is omitted.	
.	
'STOP'	(5)

Notes

(1) Structure is defined.

(2) A static solution is performed.

(3) Static solution is released as is memory required for load, displacement, stiffness, etc. Element forces are not released because the ELEMENT statement was omitted from the RELEASE card.

(4) Natural frequencies or buckling loads are determined. For a buckling load solution, the geometric stiffness may be based on the axial load in the elements from SOL01. Releasing the memory after the static solution allows the same memory to be used for SOL03. If the memory is not released, then the total memory required would be the sum of the memory required for SOL01 and SOL03.

(5) Terminate the program.

L. STOP - TERMINATE EXECUTION

This card is used to terminate execution of the program. Its statement is a character variable and is enclosed in single quotes.

```
'STOP'
```

V. RUNNING PROGRAM INRESB-3D-SUPII

This chapter contains instructions for running program INRESB-3D-SUPII in the VM/SP CMS environment on an IBM 4381 computer, in the AIX/370 environment on an IBM 3090S supercomputer, or on a PC.

Several steps compose these instructions. First, a macro library is generated that contains the common blocks. Second, the main program and each subroutine are compiled. Text files are stored on a disk in the user's account. Third, the program is executed. The first and second steps are done only once to install the program.

A. GENERATING COMMON BLOCK MACRO LIBRARY

1. In the CMS Environment Here the common block macro library, GEM, is generated with the following CMS statements

```
MACLIB GEN ZCOMN  GEM
MACLIB ADD ZCOMN1 GEM
MACLIB ADD ZCOMN2 GEM
MACLIB ADD ZCOMN3 GEM
```

where ZCOMN COPY, ZCOMN1 COPY, ZCOMN2 COPY and ZCOMN3 COPY are four CMS files that contain the common blocks. These files are listed with the program.

2. In the AIX Environment Here the common block macro library does not need be generated. However, ZCOMN COPY, ZCOMN1 COPY, ZCOMN2 COPY and ZCOMN3 COPY should be renamed zcomn, zcomn1, zcomn2, and zcomn3, respectively.

B. COMPILING PROGRAM

1. In the CMS Environment Program and subroutines are compiled with the following CMS commands.

```
GLOBAL MACLIB GEM
FORTVS2  INRESB (OPT(2)  AUTODBL(DBLPAD4)
```

The GLOBAL MACLIB GEM statement lets the compiler know where to locate the common blocks. Common blocks are put into the program by the Fortran INCLUDE statement, which is in the source code. For example, INCLUDE (ZCOMN).

To reduce execution time, compiler option OPT(2) specifies code optimization. Vectorization may also be used to reduce execution time if hardware and software are available.

Computer accuracy differs according to respective word length. Hence the program is written in single precision, and compiler options are used to convert the program to double precision when required. The IBM compiler option AUTODBL(DBLPAD4) automatically converts the program to double precision. Integer and real variables in the program share the same storage location. Thus the compiler option which converts the program to double precision must pad the length of integer variables so that they have same length as real variables. Failure to use the DBLPAD4 compiler option and equivalent compiler option on other systems leads to unpredictable results.

2. In the AIX Environment Program and subroutines are compiled with the following AIX commands.

```
fvs inresb -f'opt(2) autodbl(dblpad4) il(dim) vector' -xa
-limslib -lesslv -faux -o exec
```

Compiler option il(dim) specifies that the code for adjustable-dimension array is to be placed inline. While this inline code may result in faster processing, it does not check for dimensioning errors. Compiler option -xa causes the supercomputer to generate an XA-mode module which gives maximum storage to run a program, about 800 megabytes. Option -o creates the execution file called 'exec'. Commands -limslib and -lesslv link the IMSL libraries. The -faux command loads the FORTRAN libraries needed to run the program. Common blocks are input into the program by the INCLUDE statement in the source code; for example, INCLUDE 'zcomn'.

C. RUNNING PROGRAM ON MAIN FRAME OR SUPERCOMPUTER

1. In the CMS Environment The program is run in the local CMS environment by the following commands.

```
GLOBAL TXTLIB VSF2LINK VSF2FORT CMSLIB IMSLDOUB UFORTLIB
FILEDEF  5  DISK   FN   FT05 A ( PERM LRECL  80  RECFM F
FILEDEF  6  DISK   FN   FT06 A ( PERM LRECL 132  RECFM F
FILEDEF 10  DISK   FN   FT10 A ( PERM LRECL  80  RECFM F
FILEDEF 11  DISK   FN   FT11 A ( PERM LRECL  80  RECFM F
      .
      .
      .
FILEDEF 92  DISK ELCENTRO EW    A
FILEDEF 93  DISK ELCENTRO NS    A
LOAD  INRESB ( CLEAR RESET  MAIN START  NOMAP
```

GLOBAL TXTLIB command loads the Fortran libraries needed to run the program. IMSL library is required to link IMSL subroutine DG2CSP. UFORTLIB library contains the local routines CPUTIM, TIMEON, TIMEIT, TIME and DATE. Input is contained in files FN FT05 A, ELCENTRO EW A and ELCENTRO NS A. Output is written to files FN FT06 A, FN FT10 A, FN FT11 A, etc.

2. In the AIX Environment The program is run in the AIX environment by the following commands.

```
setenv ft05001 fn.ft05
setenv ft06001 fn.ft06
setenv ft10001 fn.ft10
setenv ft11001 fn.ft11
      .
      .
      .
setenv ft92001 elcentro.ew
setenv ft93001 elcentro.ns
exec
```

Input is contained in files fn.ft05, elcentro.ew and elcentro.ns. Output is written to files fn.ft06, fn.ft10, fn.ft11, etc.

D. RUNNING PROGRAM ON PC

When running program INRESB-3D-SUPII on a PC, the program is divided into five independent programs, SOL01, SOL02, SOL03, SOL04, and SOL05, due to the limitation of PC memory. All five programs have the same function as explained in Chapter II. They can run independently on a PC.

Input and output files on a PC have the same form and contents as those used or produced on an IBM 4381 computer or a supercomputer. If an input data file can be executed on a supercomputer, it can usually work on a PC, and vice versa. However, when running program SOL02 (elastic / nonlinear seismic time history response analysis), ground acceleration data must be input in the same file with other data. Thus only one input file exists; the input unit number for acceleration record "IN" is always 5.

A user can define any combination of characters and numbers to name an input or output file. It is not necessary for a user to compile programs. Programs which a user needs are EXE files, there are five.

1. SOL01.EXE
2. SOL02.EXE
3. SOL03.EXE
4. SOL04.EXE
5. SOL05.EXE

When a user runs one of them, such as SOL02, only the following commands are needed.

>SOL02 (Enter)

>Name of Input File: Input File Name (Enter)

>Name of output File: Output File Name (Enter)

Note Contents underlined are input by a user. Enter stands for the "Enter" key.

Note also that the PC solution capacity is limited by its memory. For a large scale engineering problem, it is insufficient. Because it only runs one program at a time and uses one main function of INRESB-3D-SUPII, the option "RELEASE" is ignored.

VI. EXAMPLE PROBLEMS

A. ANGLE-SECTION MEMBER

1. Description of Input Information

A single angle L2 x 2 x 1/4 is subjected to an eccentric load with $e_x = -0.41$ in and $e_y = 0.804$ in (see Figure 34). The member is assumed to be a finite-segment element and is divided into 16 segments. It is restrained about X-axis at the support and has no initial imperfection.

Buckling capacity and post-buckling behavior of the member are determined by the displacement control at joint 1 in the X direction. The axial load-axial deformation relationship at joint 1 in the X direction is written in the file with unit 11 and plotted in Figure 35.

2. Input Data

```
ECHO OF INPUT DATA

LINE  ....:....10....:....20....:....30....:....40....:....50....:....60....:....70....:....80
 'STRUCTURE DEFINITION'
 'EXAMPLE 1. BUCKLING BEHAVIOR OF ANGLE-SECTION MEMBER'
  2  1 2 0 0  1.        NNODE,NCOS , NSUPT,NCOND,NCONST   SCALE
     1    0.00    0.00      00 1 0
     2   34.9     0.00      00 1 0
      1 0 0       0 1 0   DIRECTION COSINE
      1       1 1 1 1 0 1     0 0
      2       1 1 1 1 0 1     0 0
    1  !NMAT
'STABILITY        '  16  50.9  29400  7  2  0  -0.41 0.804  0  0  0.25
 21  2  20  2  1 2.  0  0  0.9375  0  0  0.003  0  11300 0.01 1
 0 0 0 .FALSE. KG: AXL. FORM. ASSY
1  NELEM     ELE MAT SJ EJ VYI,VYJ,VYK XS XE
'STABILITY' 'ANGLE SEC. ELE.'  1  1 2  0 1 0 0 0 0
  0 0 .FALSE.     MASS
  0 0  !  DAMP
'SOL04 SOLUTION'
'INCREMEMTAL DISPLACEMENT CONTROL'
 1 50000 1  .FALSE   !MAXELD IPRINT IWRITE UNBAL
 'JOINT FX'  1  11 0  0  0
 'END      '  2  16 0  0  0
 1  1  0  0 'FX'  0.2
 0  0  0  0 'END'  0       JOINT LOAD
 0  0  0  0 'END' 'FY'  0  0  ! ELEMENT LOAD
 'DISP. FROM  0    TO  0.2  '  1   0  0  100
 'END OF DISP. CONTROL      '  1   0  0  60
'READ UNIT=11'
 'STOP'
```

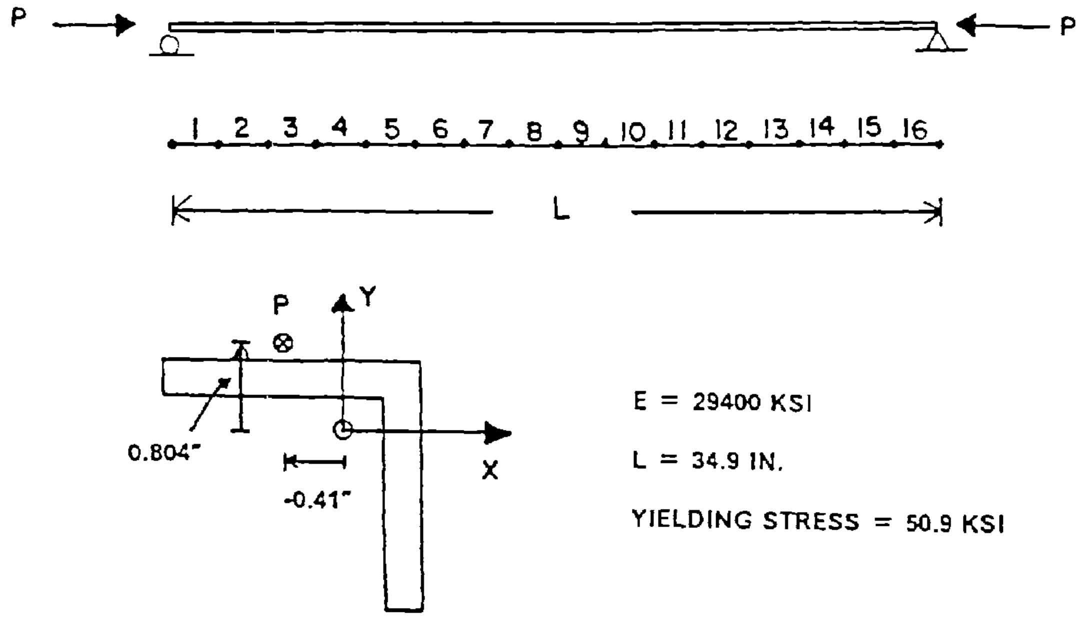


Figure 34. L2*2*1/4 Angle Section

3. Output

```
STRUCTURE.. .: [redacted]: BUCKLING BEHAVIOR OF ANGLE-SECTION MEMBER                          TIME. 23 37:38, DATE: 11/30/90
SOLUTION.....:

*** PROGRAM FEM ***          DOUBLE PRECISION VERSION


   NODE COORDINATES AND DEGREES OF FREEDOM

   TOTAL NUMBER OF DEGREES OF FREEDOM..........  ..     12
   NUMBER OF DEGREES OF FREEDOM CONDENSED OUT.. ..       0
   NUMBER OF FREE DEGREES OF FREEDOM..... . .....        2
   NUMBER OF RESTRAINED DEGREES OF FREEDOM.... . .      10

    NODE COS#    X-COORD        Y-COORD        Z-COORD        FX     FY     FZ     MX     MY     MZ
      1   1    0.00000E+00    0.00000E+00    0.00000E+00     3-R    4-R    5-R    6-R    1      7-R
      2   1    34.900         0.00000E+00    0.00000E+00     8-R    9-R   10-R   11-R    2     12-R
       NOTE: R - RESTRAINED DEGREE OF FREEDOM
             C - CONSTRAINED DEGREE OF FREEDOM


   DIRECTION COSINES ..

COS( 1)   VX:  1.00000 I +0.00000 J -0.00000 K   VY:  0.00000 I +1.00000 J +0.00000 K   VZ:  0.00000 I +0.00000 J +1.00000 K
 STRUCTURE..  : EXAMPLE 1: BUCKLING BEHAVIOR OF ANGLE-SECTION MEMBER                            TIME: 23:37:39, DATE: 11/30/90
 SOLUTION..  .:



STABILITY ELEMENT PARAMETERS (BOX,TUBE,OR ANGLE)
------------------------------------------------


MAT. NO.      =  1   ANGLE SECTION
NSEG          =      16           YS          =  50.9
EM            =  2.940E+04        LIBN        =          7
LAG LENGTH    =  2.00             DUMMY VAR.  =  0.000E+00
ECCXO         = -0.410            ECCYO       =  0.804
LAG SEC.NO.   =       0           DUMMY VAR.  =          0
THICKNESS     =  0.250            N.C.IN U DIR=         21
N.R.IN U DIR=         2           N.R.IN V DIR=         20
N.C.IN V DIR=         2           IECCP       =          1
NUMP          =      92           SMALL       =  2.00
RATIXO        =  0.000E+00        RATIYO      =  0.000E+00
TOTA          =  0.938            IAUTO       =          0
IMATER        =       0           RATIO3      =  3.000E-03
IR            =       0           G           =  1.130E+04
ORNEE         =  1.000E-02        ISTIF       =          1

 STRUCTURE....: EXAMPLE 1: BUCKLING BEHAVIOR OF ANGLE-SECTION MEMBER                            TIME: 23:37:38, DATE: 11/30/90
 SOLUTION.. ..:


ELEMENT 12,  STABILITY ELEMENT

                     #    MATL   START   END   LENGTH    ----------- Y-AXIS -----------  START DIST    END DIST
ANGLE SEC. ELE.      1     1      1       2    34.90     0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00


    ZERO MASS MATRIX
    ----------------


    PROPORTIONAL DAMPING COEFFICIENTS
    ---------------------------------
    ALPHA= 0.00000E+00   BETA=  0.00000E+00



*-------------------------------------*
*--- MEMORY UTILIZATION .. ...... ----*
*--- IZ=  60010,    MEM= 8.573%   ----*
*-------------------------------------*
*--- ELAPSED CPU TIME      0.59 SEC --*
*--- TOTAL CPU TIME        0.59 SEC --*
*-------------------------------------*

 STRUCTURE... : EXAMPLE 1: BUCKLING BEHAVIOR OF ANGLE-SECTION MEMBER                            TIME: 23:37:38, DATE: 11/30/90
 SOLUTION.. ..: INCREMEMTAL DISPLACEMENT CONTROL                                                TIME: 23:37:39, DATE: 11/30/90
 SOLUTION #4, STATIC NONLINEAR SOLUTION
 --------------------------------------
 INTERVAL FOR PRINTING DATA.............50000
 INTERVAL FOR WRITING DATA TO FILE .....    1

 UNBALANCED JOINT FORCES ARE NOT ADDED TO THE NEXT CYCLE

    DATA WRITTEN TO FILES
    ---------------------

    DEGREE OF FREEDOM  #    3 IS WRITTEN TO UNIT #   11  JOINT:      1   DIRECTION: FX
   APPLIED JOINT LOADS
   -------------------

LOAD CASE   1  JOINT     1  DIRECTION: FX   DOF(S)    3              MAGNITUDE   0.200000        ...JOINT DISPLACEMENT...
 STRUCTURE..... EXAMPLE 1  BUCKLING BEHAVIOR OF ANGLE-SECTION MEMBER                            TIME: 23:37.38, DATE. 11/30/90
 SOLUTION  ...  INCREMEMTAL DISPLACEMENT CONTROL                                                TIME: 23:37.39, DATE: 11/30/90

 . LOADING #    0     MAXIMUM DISPLACEMENTS


 GCS DISPLACEMENTS
 -----------------
                             NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

    NODE       DX               DY              DZ              RX              RY              RZ

      1   0.200000        0.000000E+00    0.000000E+00    0.000000E+00    6.812705E-02    0.000000E+00
      2   0.000000E+00    0.000000E+00    0.000000E+00    0.000000E+00   -6.812705E-02    0.000000E+00
```

STRUCTURE.....: [redacted] BUCKLING BEHAVIOR OF ANGLE-SECTION MEMBER — TIME 23:37:38, DATE: 11/30/90
SOLUTION. ...: INCREMEMTAL DISPLACEMENT CONTROL — TIME. 23:37:39, DATE: 11/30/90

, LOADING # 0 MAXIMUM REACTIONS

MAXIMUM GCS RESTRAINT REACTIONS   NOTE. MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

NODE	FX	FY	FZ	MX	MY	MZ
1	18.61292	-5.5900746E-12	2.8973464E-12	7.9987110E-02	0.0000000E+00	10.99620
2	18.61292	-5.9283047E-12	3.7769510E-12	7.9987110E-02	0.0000000E+00	-10.99620
MAX OF ALL--						
GCS SUMM	0.3090861E-12	-0.1151838E-10	0.6674297E-11	0.1599742	-0.1318156E-09	-0.2066221E-09

MAXIMUM RESULTANT OF REACTIONS, FORCE= 1.3315E-11 MOMENT= 0.1600

STRUCTURE. ...: EXAMPLE 1: BUCKLING BEHAVIOR OF ANGLE-SECTION MEMBER — TIME: 23:37:38, DATE: 11/30/90
SOLUTION.. ...: INCREMEMTAL DISPLACEMENT CONTROL — TIME. 23:37:39, DATE: 11/30/90

, LOADING # 0 PEAK ELEMENT FORCES
COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

STABILITY ELEMENT FORCES..
MAXIMUM VALUES FOR ALL STEPS   NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ	FLP.SP
1	1	FORCE	1	18.6129	-3.406563E-12	1.473807E-12	4.838568E-03	-1.444212E-14	4.57195	
		FORCE	2	-18.6129	-3.723633E-12	1.947044E-12	4.838568E-03	7.327472E-15	-4.57195	
1	2	FORCE	1	13.0752	-5.590075E-12	2.897346E-12	7.998711E-02	-1.785605E-14	10.9962	
		FORCE	2	-13.0752	-5.928305E-12	3.776951E-12	7.998711E-02	1.042222E-14	-10.9962	
1	3	FORCE	1	13.0752	-5.590075E-12	2.897346E-12	7.998711E-02	-1.785605E-14	10.9962	
		FORCE	2	-13.0752	-5.928305E-12	3.776951E-12	7.998711E-02	1.042222E-14	-10.9962	
1	4	FORCE	1	13.0752	-5.590075E-12	2.897346E-12	7.998711E-02	-1.785605E-14	10.9962	
		FORCE	2	-13.0752	-5.928305E-12	3.776951E-12	7.998711E-02	1.042222E-14	-10.9962	
1	5	FORCE	1	13.0752	-5.590075E-12	2.897346E-12	7.998711E-02	-1.785605E-14	10.9962	
		FORCE	2	-13.0752	-5.928305E-12	3.776951E-12	7.998711E-02	1.042222E-14	-10.9962	
1	6	FORCE	1	13.0752	-5.590075E-12	2.897346E-12	7.998711E-02	-1.785605E-14	10.9962	
		FORCE	2	-13.0752	-5.928305E-12	3.776951E-12	7.998711E-02	1.042222E-14	-10.9962	
1	7	FORCE	1	18.6129	-3.406563E-12	1.473807E-12	4.838568E-03	-1.444212E-14	4.57195	
		FORCE	2	-18.6129	-3.723633E-12	1.947044E-12	4.838568E-03	7.327472E-15	-4.57195	
1	8	FORCE	1	13.0752	-5.590075E-12	2.897346E-12	7.998711E-02	-1.785605E-14	10.9962	
		FORCE	2	-13.0752	-5.928305E-12	3.776951E-12	7.998711E-02	1.042222E-14	-10.9962	
1	9	FORCE	1	13.0752	-5.590075E-12	2.897346E-12	7.998711E-02	-1.785605E-14	10.9962	
		FORCE	2	-13.0752	-5.928305E-12	3.776951E-12	7.998711E-02	1.042222E-14	-10.9962	
1	10	FORCE	1	13.0752	-5.590075E-12	2.897346E-12	7.998711E-02	-1.785605E-14	10.9962	
		FORCE	2	-13.0752	-5.928305E-12	3.776951E-12	7.998711E-02	1.042222E-14	-10.9962	
1	11	FORCE	1	13.0752	-5.590075E-12	2.897346E-12	7.998711E-02	-1.785605E-14	10.9962	
		FORCE	2	-13.0752	-5.928305E-12	3.776951E-12	7.998711E-02	1.042222E-14	-10.9962	
1	12	FORCE	1	13.0752	-5.590075E-12	2.897346E-12	7.998711E-02	-1.785605E-14	10.9962	
		FORCE	2	-13.0752	-5.928305E-12	3.776951E-12	7.998711E-02	1.042222E-14	-10.9962	

STRUCTURE ...: EXAMPLE 1: BUCKLING BEHAVIOR OF ANGLE-SECTION MEMBER — TIME 23:37:38, DATE: 11/30/90
SOLUTION.....: INCREMEMTAL DISPLACEMENT CONTROL — TIME: 23:37:39, DATE: 11/30/90

, LOADING # 0 PEAK DUCTILITIES AND EXCURSION RATIO'S

STRUCTURE ...: EXAMPLE 1: BUCKLING BEHAVIOR OF ANGLE-SECTION MEMBER — TIME 23:37:38, DATE: 11/30/90
SOLUTION. ...: INCREMEMTAL DISPLACEMENT CONTROL — TIME. 23:37:39, DATE: 11/30/90

, LOADING # 0 DAMAGE INDEX

STRUCTURE DAMAGE INDEX= 0.00000E+00

```
*-----------------------------------------*
*--- MEMORY UTILIZATION .......... ----*
*--- IZ= 60235,    MEM= 8.605%    ----*
*-----------------------------------------*
*--- ELAPSED CPU TIME   101.45 SEC ----*
*--- TOTAL CPU TIME     102.04 SEC ----*
*-----------------------------------------*
```

STRUCTURE....: EXAMPLE 1: BUCKLING BEHAVIOR OF ANGLE-SECTION MEMBER — TIME: 23:37:38, DATE: 11/30/90
SOLUTION.. ...: INCREMEMTAL DISPLACEMENT CONTROL — TIME: 23:37:39, DATE: 11/30/90

DEGREE OF FREEDOM # 3 IS READ FROM UNIT # 11   JOINT # 1, DIRECTION: FX

STEP	TIME	LOAD	DISPLACEMENT	VELOCITY	ACCELERATION
0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
1	0.00000E+00	0.57476	2.00000E-03	0.00000E+00	0.00000E+00
2	0.00000E+00	1.1430	4.00000E-03	0.00000E+00	0.00000E+00
3	0.00000E+00	1.7047	6.00000E-03	0.00000E+00	0.00000E+00
4	0.00000E+00	2.2599	8.00000E-03	0.00000E+00	0.00000E+00
5	0.00000E+00	2.8086	1.00000E-02	0.00000E+00	0.00000E+00
6	0.00000E+00	3.3508	1.20000E-02	0.00000E+00	0.00000E+00
7	0.00000E+00	3.8965	1.40000E-02	0.00000E+00	0.00000E+00
8	0.00000E+00	4.4159	1.60000E-02	0.00000E+00	0.00000E+00
9	0.00000E+00	4.9388	1.80000E-02	0.00000E+00	0.00000E+00
10	0.00000E+00	5.4553	2.00000E-02	0.00000E+00	0.00000E+00
11	0.00000E+00	5.9655	2.20000E-02	0.00000E+00	0.00000E+00
12	0.00000E+00	6.4693	2.40000E-02	0.00000E+00	0.00000E+00
13	0.00000E+00	6.9669	2.60000E-02	0.00000E+00	0.00000E+00
14	0.00000E+00	7.4581	2.80000E-02	0.00000E+00	0.00000E+00
15	0.00000E+00	7.9432	3.00000E-02	0.00000E+00	0.00000E+00
16	0.00000E+00	8.4220	3.20000E-02	0.00000E+00	0.00000E+00
17	0.00000E+00	8.8947	3.40000E-02	0.00000E+00	0.00000E+00
18	0.00000E+00	9.3612	3.60000E-02	0.00000E+00	0.00000E+00
19	0.00000E+00	9.8217	3.80000E-02	0.00000E+00	0.00000E+00
20	0.00000E+00	10.276	4.00000E-02	0.00000E+00	0.00000E+00
21	0.00000E+00	10.725	4.20000E-02	0.00000E+00	0.00000E+00
22	0.00000E+00	11.167	4.40000E-02	0.00000E+00	0.00000E+00

23	0.00000E+00	11.604	4.60000E-02	0.00000E+00	0.00000E+00
24	0.00000E+00	12.034	4.80000E-02	0.00000E+00	0.00000E+00
25	0.00000E+00	12.459	5.00000E-02	0.00000E+00	0.00000E+00
26	0.00000E+00	12.878	5.20000E-02	0.00000E+00	0.00000E+00
27	0.00000E+00	13.292	5.40000E-02	0.00000E+00	0.00000E+00
28	0.00000E+00	13.699	5.60000E-02	0.00000E+00	0.00000E+00
29	0.00000E+00	14.101	5.80000E-02	0.00000E+00	0.00000E+00
30	0.00000E+00	14.498	6.00000E-02	0.00000E+00	0.00000E+00
31	0.00000E+00	14.889	6.20000E-02	0.00000E+00	0.00000E+00
32	0.00000E+00	15.274	6.40000E-02	0.00000E+00	0.00000E+00
33	0.00000E+00	15.655	6.60000E-02	0.00000E+00	0.00000E+00
34	0.00000E+00	16.029	6.80000E-02	0.00000E+00	0.00000E+00
35	0.00000E+00	16.386	7.00000E-02	0.00000E+00	0.00000E+00
36	0.00000E+00	16.725	7.20000E-02	0.00000E+00	0.00000E+00
37	0.00000E+00	17.055	7.40000E-02	0.00000E+00	0.00000E+00
38	0.00000E+00	17.356	7.60000E-02	0.00000E+00	0.00000E+00
39	0.00000E+00	17.636	7.80000E-02	0.00000E+00	0.00000E+00
40	0.00000E+00	17.879	8.00000E-02	0.00000E+00	0.00000E+00
41	0.00000E+00	18.089	8.20000E-02	0.00000E+00	0.00000E+00
42	0.00000E+00	18.267	8.40000E-02	0.00000E+00	0.00000E+00
43	0.00000E+00	18.411	8.60000E-02	0.00000E+00	0.00000E+00
44	0.00000E+00	18.514	8.80000E-02	0.00000E+00	0.00000E+00
45	0.00000E+00	18.575	9.00000E-02	0.00000E+00	0.00000E+00
46	0.00000E+00	18.613	9.20000E-02	0.00000E+00	0.00000E+00
47	0.00000E+00	18.605	9.40000E-02	0.00000E+00	0.00000E+00
48	0.00000E+00	18.568	9.60000E-02	0.00000E+00	0.00000E+00
49	0.00000E+00	18.510	9.80000E-02	0.00000E+00	0.00000E+00
50	0.00000E+00	18.432	0.10000	0.00000E+00	0.00000E+00
51	0.00000E+00	18.326	0.10200	0.00000E+00	0.00000E+00
52	0.00000E+00	18.205	0.10400	0.00000E+00	0.00000E+00
53	0.00000E+00	18.075	0.10600	0.00000E+00	0.00000E+00
54	0.00000E+00	17.930	0.10800	0.00000E+00	0.00000E+00
55	0.00000E+00	17.776	0.11000	0.00000E+00	0.00000E+00
56	0.00000E+00	17.636	0.11200	0.00000E+00	0.00000E+00
57	0.00000E+00	17.479	0.11400	0.00000E+00	0.00000E+00
58	0.00000E+00	17.331	0.11600	0.00000E+00	0.00000E+00
59	0.00000E+00	17.172	0.11800	0.00000E+00	0.00000E+00
60	0.00000E+00	17.021	0.12000	0.00000E+00	0.00000E+00
61	0.00000E+00	16.875	0.12200	0.00000E+00	0.00000E+00
62	0.00000E+00	16.722	0.12400	0.00000E+00	0.00000E+00
63	0.00000E+00	16.576	0.12600	0.00000E+00	0.00000E+00
64	0.00000E+00	16.436	0.12800	0.00000E+00	0.00000E+00
65	0.00000E+00	16.298	0.13000	0.00000E+00	0.00000E+00
66	0.00000E+00	16.164	0.13200	0.00000E+00	0.00000E+00
67	0.00000E+00	16.035	0.13400	0.00000E+00	0.00000E+00
68	0.00000E+00	15.906	0.13600	0.00000E+00	0.00000E+00
69	0.00000E+00	15.779	0.13800	0.00000E+00	0.00000E+00
70	0.00000E+00	15.655	0.14000	0.00000E+00	0.00000E+00
71	0.00000E+00	15.537	0.14200	0.00000E+00	0.00000E+00
72	0.00000E+00	15.423	0.14400	0.00000E+00	0.00000E+00
73	0.00000E+00	15.312	0.14600	0.00000E+00	0.00000E+00
74	0.00000E+00	15.204	0.14800	0.00000E+00	0.00000E+00
75	0.00000E+00	15.100	0.15000	0.00000E+00	0.00000E+00
76	0.00000E+00	14.999	0.15200	0.00000E+00	0.00000E+00
77	0.00000E+00	14.896	0.15400	0.00000E+00	0.00000E+00
78	0.00000E+00	14.796	0.15600	0.00000E+00	0.00000E+00
79	0.00000E+00	14.699	0.15800	0.00000E+00	0.00000E+00
80	0.00000E+00	14.605	0.16000	0.00000E+00	0.00000E+00
81	0.00000E+00	14.512	0.16200	0.00000E+00	0.00000E+00
82	0.00000E+00	14.422	0.16400	0.00000E+00	0.00000E+00
83	0.00000E+00	14.332	0.16600	0.00000E+00	0.00000E+00
84	0.00000E+00	14.247	0.16800	0.00000E+00	0.00000E+00
85	0.00000E+00	14.163	0.17000	0.00000E+00	0.00000E+00
86	0.00000E+00	14.080	0.17200	0.00000E+00	0.00000E+00
87	0.00000E+00	14.000	0.17400	0.00000E+00	0.00000E+00
88	0.00000E+00	13.921	0.17600	0.00000E+00	0.00000E+00
89	0.00000E+00	13.843	0.17800	0.00000E+00	0.00000E+00
90	0.00000E+00	13.766	0.18000	0.00000E+00	0.00000E+00
91	0.00000E+00	13.690	0.18200	0.00000E+00	0.00000E+00
92	0.00000E+00	13.615	0.18400	0.00000E+00	0.00000E+00
93	0.00000E+00	13.542	0.18600	0.00000E+00	0.00000E+00
94	0.00000E+00	13.470	0.18800	0.00000E+00	0.00000E+00
95	0.00000E+00	13.401	0.19000	0.00000E+00	0.00000E+00
96	0.00000E+00	13.334	0.19200	0.00000E+00	0.00000E+00
97	0.00000E+00	13.267	0.19400	0.00000E+00	0.00000E+00
98	0.00000E+00	13.202	0.19600	0.00000E+00	0.00000E+00
99	0.00000E+00	13.138	0.19800	0.00000E+00	0.00000E+00
100	0.00000E+00	13.075	0.20000	0.00000E+00	0.00000E+00

```
*-------------------------------------*
*--- MEMCRY UTILIZATION   ... ...  ---*
*--- IZ=  60235,    MEM= 8.605%   ----*
*-------------------------------------*
*--- ELAFSED CFU TIME    0.14 SEC ----*
*--- TOTAL CPU TIME    102.18 SEC ----*
*-------------------------------------*
```

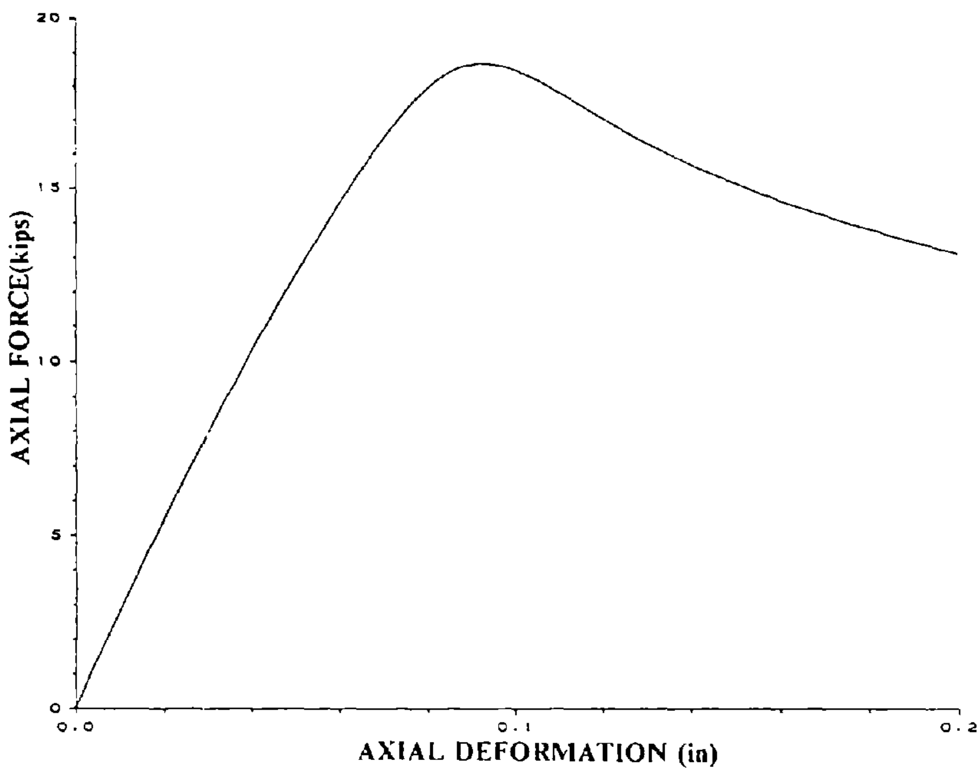


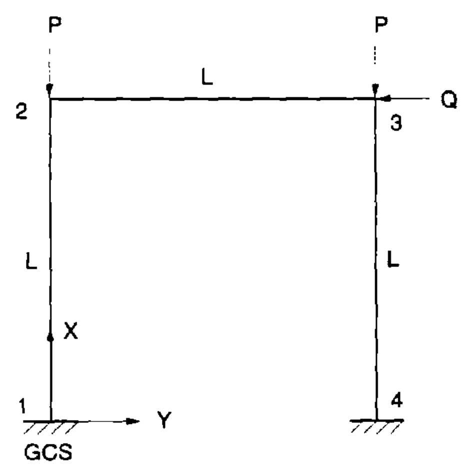
Figure 35. Axial Load-Axial Deformation Relationship

B. ONE-STORY STEEL BUILDING

1. Description of Input Information

Figure 36 shows a one-story steel building consisting of two columns and one beam. All members are tube-sections. Diameter, thickness, and length of each member are 24 in, 0.75 in, and 540 in, respectively. The material yielding stress is 36 ksi and the elastic modulus is assumed to be 29,000 ksi. Finite-segment elements are used for all members. Each member is divided into 16 segments and the initial inperfection is not considered in the calculation. Four joints are used to define the two-dimensional structural model. JCS for all the joints is parallel to the GCS.

At the base of the frame, joints 1 and 4 as well as all six degrees of freedom are restrained. Two constant axial loads with $P/P_y = 0.4$ are first applied to joints 2 and 3 in the negative X direction. Structural response due to constant axial loads is calculated by the elastic static solution.



$L = 540''$

$D = 24''$

$t = 0.75''$

$P_y = 1972$ kips

Figure 36. One-Story Steel Building

By using incremental displacement control, the lateral load-displacement relationship at joint 3 in the Y direction is determined for the second solution. Thus the structural response due to the first solution becomes the initial condition for the second solution. Figure 37 shows the result of load-displacement relation at joint 3 in the Y direction.

2. Input Data

```
ECHO OF INPUT DATA

LINE    ...:...10....:...20....:...30.......40....:..50.......60....:...70....:.. 80
   1:   'STRUCTURE DEFINITION'
   2:   '[redacted]: ONE-STORY BUILDING '
   3:    4  1 4 0 0  1.      NNODE,NCOS , NSUPT,NCOND,NCONST   SCALE
   4:      1   0.00    0.00     .00 1 0
   5:      2   540     0.00     .00 1 0
   6       3   540     540      00 1 0
   7.      4   0.00    540      00 1 0
   8:        1 0 0      0 1 0 ! DIRECTION COSINE
   9.       1       1 1 1 1 1 1    0 0
  10:       2       0 0 1 1 1 0    0 0
  11:       3       0 1 1 1 1 0    0 0
  12.       4       1 1 1 1 1 1    0 0
  13:     3   NMAT
  14:  'STABILITY MAT#1' 16 36 29000 2 11.6 0 0 0 10 10 0.75
  15:  0 0 0 0 0 30.  0 0 424 5  1 1 0 03 0 13000 0 01 1
  16:  'STABILITY MAT#2' 16 36 29000 2 11.6 0 0 0 10 10 0.75
  17   0 0 0 0 0 30.  0 0 424 5  1 1 0 03 0 13000 0 01 1
  18   'STABILITY MAT#3' 16 36 29000 2 11 6 0 0 0 10 10 0.75
  19   0 0 0 0 0 30.  0 0 424.5  1 1 0.03 0 13000 0.01 1
  20:   0 0 0 .FALSE.    !KG: AXL. FORM. ASSY
  21:  3  NELEM
  22:  'STABILITY' 'TUBE MEMBER 1 '  1 1 2                 0 0  1 0 0     0
  23:  'STABILITY' 'TUBE MEMBER 2 '  2 2 3                 0 0  1 0 0     0
  24:  'STABILITY' 'TUBE MEMBER 3 '  3 4 3                 0 0  1 0 0     0
  25:    0 0  FALSE  !  MASS
  26:    0 0  !  DAMP
  27:  'SOLC1  SOLUTION'
  28:  'APPLY AXIAL LOAD AT JOINT 2 AND JOINT 3'
  29:   1 1     . NLOAD MAXELD
  30    1  2  0  0 'FX'  -768.65 !JOINT LOAD FOR P/PY=0.4
  31    1  3  0  0 'FX'  -768.65 !JOINT LOAD FOR P/PY=0.4
  32    0  0  0  0 'END' 0
  33:  0  0  0  0  'END'  'FZ'      0     0.
  34:  'SOL04 SOLUTION'
  35:  'INCREMEMTAL DISPLACEMENT CONTROL AT JOINT 3'
  36:   1 50000 2   FALSE.   MAXELD IPRINT IWRITE UNBAL
  37:    'JOINT FY'  3  11 0  0  0
  38:    'END      '  2  13 0  0  0
  39:   1  3  0  0 'FY'  -20
  40:   0  0  0  0 'END'  0      !JOINT LOAD
  41:   0  0  0  0 'END' 'FY'  0  0  ! ELEMENT LOAD
  42:  'DISP. FROM  0    TO  -20   '  1   0  0  200
  43   'END OF DISP. CONTROL        '  0   0  0    0
  44   'READ UNIT=11'
  45:   'STOP'
```

3. Output

```
STRUCTURE.. ..: [redacted]2: ONE-STORY BUILDING                                          TIME: 23:41:09, DATE: 11/30/90
SOLUTION ....

*** PROGRAM FEM ***          DOUBLE PRECISION VERSION


  NODE COORDINATES AND DEGREES OF FREEDOM

  TOTAL NUMBER OF DEGREES OF FREEDOM.......  ....      24
  NUMBER OF DEGREES OF FREEDOM CONDENSED OUT.....       0
  NUMBER OF FREE DEGREES OF FREEDOM.  ..........        5
  NUMBER OF RESTRAINED DEGREES OF FREEDOM........      19

   NODE COS#    X-COORD       Y-COORD       Z-COORD       FX      FY      FZ      MX      MY      MZ
     1    1   0.00000E+00   0.00000E+00   0.00000E+00    6-R     7-R     8-R     9-R    10-R    11-R
     2    1    540.00       0.00000E+00   0.00000E+00    1       2      12-R    13-R    14-R     3
     3    1    540.00        540.00       0.00000E+00    4      15-R    16-R    17-R    18-R     5
     4    1   0.00000E+00    540.00       0.00000E+00   19-R    20-R    21-R    22-R    23-R    24-R
        NOTE. R - RESTRAINED DEGREE OF FREEDOM
              C - CONSTRAINED DEGREE OF FREEDOM


  DIRECTION COSINES  .

COS(  1)   VX:  1.00000 I -0.00000 J +0.00000 K   VY:  0.00000 I +1.00000 J +0.00000 K   VZ:  0.00000 I +0.00000 J +1.00000 K
 STRUCTURE....: EXAMPLE 2: ONE-STORY BUILDING                                            TIME: 23:41:09, DATE: 11/30/90
 SOLUTION.....:


STABILITY ELEMENT PARAMETERS (BOX,TUBE,OR ANGLE)
------------------------------------------------


MAT. NO.      =  1   TUBE SECTION
NSEG          =          16         YS             =  36 0
EM            = 2.900E+04           LIBN           =          2
RADIUS        =  11.6               DUMMY VAR.     = 0.000E+00
ECCX0         = 0.000E+00           ECCY0          = 0.000E+00
1/4.SEC.NO.   =          10         DUMMY VAR.     =         10
THICKNESS     = 0.750               IREV1          =          0
IREV2         =           0         IREV3          =          0
IREV4         =           0         IECOF          =          0
NUMP          =          40         SMALL          =  30.0
RATIX0        = 0.000E+00           RATIY0         = 0.000E+00
TOTA          =  425.               IAUTO          =          1
IMATER        =           1         RATIO3         = 3.000E-02
IR            =           0         G              = 1.300E+04
QRNEE         = 1.000E-02           ISTIF          =          1
```

```
MAT. NO.      =  2   TUBE SECTION
NSEG          =          16          YS            =  36.0
EM            = 2.900E+04            LIBN          =          2
RADIUS        =  11.6                DUMMY VAR.    = 0.000E+00
ECCX0         = 0.000E+00            ECCY0         = 0.000E+00
1/4 SEC.NO.   =          10          DUMMY VAR.    =         10
THICKNESS     = 0.750                IREV1         =          0
IREV2         =           0          IREV3         =          0
IREV4         =           0          IECOP         =          0
NUMP          =          40          SMALL         =  30.0
RATIX0        = 0.000E+00            RATIY0        = 0.000E+00
TOTA          =  425.                IAUTO         =          1
IMATER        =           1          RATIO3        = 3.000E-02
IR            =           0          G             = 1.300E+04
ORNEE         = 1.000E-02            ISTIF         =          1

MAT. NO       =  3   TUBE SECTION
NSEG          =          16          YS            =  36.0
EM            = 2.900E+04            LIBN          =          2
RADIUS        =  11.6                DUMMY VAR.    = 0.000E+00
ECCX0         = 0.000E+00            ECCY0         = 0.000E+00
1/4.SEC.NO.   =          10          DUMMY VAR.    =         10
THICKNESS     = 0.750                IREV1         =          0
IREV2         =           0          IREV3         =          0
IREV4         =           0          IECOP         =          0
NUMP          =          40          SMALL         =  30.0
RATIX0        = 0.000E+00            RATIY0        = 0.000E+00
TOTA          =  425.                IAUTO         =          1
IMATER        =           1          RATIO3        = 3.000E-02
IR            =           0          G             = 1.300E+04
ORNEE         = 1.000E-02            ISTIF         =          1

 STRUCTURE.....: EXAMPLE 2: ONE-STORY BUILDING                                                      TIME: 23:41:09, DATE: 11/30/90
 SOLUTION......:

ELEMENT 12,  STABILITY ELEMENT

                     #   MATL   START   END   LENGTH   ----------- Y-AXIS -----------          START DIST   END DIST
TUBE MEMBER 1        1     1      1      2    540.0    0.00000 I +0.00000 J +1.00000 K   0.0000E+00  0.0000E+00
TUBE MEMBER 2        2     2      2      3    540.0    0.00000 I +0.00000 J +1.00000 K   0.0000E+00  0.0000E+00
TUBE MEMBER 3        3     3      4      3    540.0    0.00000 I +0.00000 J +1.00000 K   0.0000E+00  0.0000E+00

    ZERO MASS MATRIX
   -----------------

    PROPORTIONAL DAMPING COEFFICIENTS
   ----------------------------------
   ALPHA=  0.00000E+00   BETA=  0.00000E+00


*-------------------------------------*
*--- MEMORY UTILIZATION .......... ----*
*--- IZ= 152898,     MEM=21.843%  ----*
*-------------------------------------*
*--- ELAPSED CPU TIME      1.44 SEC ----*
*--- TOTAL CPU TIME        1.44 SEC ----*
*-------------------------------------*

 STRUCTURE.....: EXAMPLE 2: ONE-STORY BUILDING                                                      TIME: 23:41:09, DATE: 11/30/90
 SOLUTION......: APPLY AXIAL LOAD AT JOINT 2 AND JOINT 3                                            TIME: 23:41:12, DATE: 11/30/90

 SOLUTION #1, STATIC - ELASTIC ANALYSIS
 ======================================

 NUMBER OF LOAD CASES ............   1
  APPLIED JOINT LOADS
  -------------------

LOAD CASE:  1  JOINT:    2  DIRECTION: FX   DOF(S)   1                MAGNITUDE:  -788.850
LOAD CASE:  1  JOINT:    3  DIRECTION: FX   DOF(S)   4                MAGNITUDE:  -788.850
 STRUCTURE.....: EXAMPLE 2: ONE-STORY BUILDING                                                      TIME: 23:41:09, DATE: 11/30/90
 SOLUTION......: APPLY AXIAL LOAD AT JOINT 2 AND JOINT 3                                            TIME: 23:41:12, DATE: 11/30/90

 GCS DISPLACEMENTS.  LOADING #    1
 ------------------

    NODE        DX              DY              DZ              RX              RY              RZ

      1  0.000000E+00   0.000000E+00   0.000000E+00   0.000000E+00   0.000000E+00   0.000000E+00
      2 -0.268714       3.976383E-16   0.000000E+00   0.000000E+00   0.000000E+00   5.333907E-16
      3 -0.268714       0.000000E+00   0.000000E+00   0.000000E+00   0.000000E+00  -5.613314E-15
      4  0.000000E+00   0.000000E+00   0.000000E+00   0.000000E+00   0.000000E+00   0.000000E+00
 STRUCTURE.....: EXAMPLE 2: ONE-STORY BUILDING                                                      TIME: 23:41:09, DATE: 11/30/90
 SOLUTION......: APPLY AXIAL LOAD AT JOINT 2 AND JOINT 3                                            TIME: 23:41:12, DATE: 11/30/90

 GCS RESTRAINT REACTIONS,   LOADING #    1
 ------------------------

    NODE        FX              FY              FZ              MX              MY              MZ

      1    788.8500      1.1673243E-12  0.0000000E+00  0.0000000E+00  0.0000000E+00  2.0982749E-10
      2  0.0000000E+00  0.0000000E+00  0.0000000E+00  0.0000000E+00  0.0000000E+00  0.0000000E+00
      3  0.0000000E+00  6.4549348E-14  0.0000000E+00  0.0000000E+00  0.0000000E+00  0.0000000E+00
      4    788.8500     -1.2318736E-12  0.0000000E+00  0.0000000E+00  0.0000000E+00 -2.2173725E-10
    ------------------------------------------------------------------------------------------------
SUMMATION   1577.700     -0.9814692E-25  0.0000000E+00  0.0000000E+00  0.0000000E+00  -425979.0
 STRUCTURE.....: EXAMPLE 2: ONE-STORY BUILDING                                                      TIME: 23:41:09, DATE: 11/30/90
 SOLUTION......: APPLY AXIAL LOAD AT JOINT 2 AND JOINT 3                                            TIME: 23:41:12, DATE: 11/30/90

   STABILITY ELEMENT  FORCES...

 ELEMENT LOAD        NODE      AXIAL           FY              FZ             TORSION          MY              MZ        FLP.SF

      1     1  DISPL   1   0.000000E+00   0.000000E+00   0.000000E+00   0.000000E+00   0.000000E+00   0.000000E+00
               DISPL   2  -0.268714       0.000000E+00  -3.976383E-16   0.000000E+00   5.333907E-16   0.000000E+00  0.00CE+00
```

```
    1    1  FORCE    1     788.850        0.000000E+00  -1.167324E-12   0.000000E+00   2.098275E-10   0.000000E+00
            FORCE    2    -788.850        0.000000E+00   1.167324E-12   0.000000E+00   4.205276E-10   0.000000E+00   0.000E+00

    2    1  DISPL    2    3.976383E-16    0.000000E+00  -0.268714       0.000000E+00   5.333907E-16   0.000000E+00
            DISPL    3    0.000000E+00    0.000000E+00  -0.268714       0.000000E+00  -5.613314E-16   0.000000E+00   0.000E+00

    2    1  FORCE    2    1.167324E-12    0.000000E+00   6.528746E-12   0.000000E+00  -4.205755E-10   0.000000E+00
            FORCE    3   -1.167324E-12    0.000000E+00   7.859743E-12   0.000000E+00   4.433965E-10   0.000000E+00   0.000E+00

    3    1  DISPL    4    0.000000E+00    0.000000E+00   0.000000E+00   0.000000E+00   0.000000E+00   0.000000E+00
            DISPL    3   -0.268714        0.000000E+00   0.000000E+00   0.000000E+00  -5.613314E-16   0.000000E+00   0.000E+00

    3    1  FORCE    4     786.850        0.000000E+00   1.231874E-12   0.000000E+00  -2.217372E-10   0.000000E+00
            FORCE    3    -786.850        0.000000E+00  -1.231874E-12   0.000000E+00  -4.434745E-10   0.000000E+00   0.000E+00

THE STATICS STRAIN ENERGY OF SYSTEM =   212.0

----------------------------------------


*---------------------------------------*
*--- MEMORY UTILIZATION ...   .    ----*
*--- IZ= 153035,    MEM=21.862%    ----*
*---------------------------------------*
*--- ELAPSED CPU TIME       2.95 SEC ----*
*--- TOTAL CPU TIME         4.39 SEC ----*
*---------------------------------------*

 STRUCTURE ...: EXAMPLE 2: ONE-STORY BUILDING                                               TIME: 23:41:09, DATE: 11/30/90
 SOLUTION. ...: INCREMEMTAL DISPLACEMENT CONTROL AT JOINT 3                                 TIME: 23:41:15, DATE: 11/30/90
 SOLUTION #4. STATIC NONLINEAR SOLUTION
----------------------------------------
 INTERVAL FOR PRINTING DATA......... ....5000C
 INTERVAL FOR WRITING DATA TO FILE. ...     2

 UNBALANCED JOINT FORCES ARE NOT ADDED TO THE NEXT CYCLE

    DATA WRITTEN TO FILES
   ----------------------

   DEGREE OF FREEDOM  #   15 IS WRITTEN TO UNIT #   11  JOINT:      3   DIRECTION: FY
  APPLIED JOINT LOADS
  --------------------

LOAD CASE:  1  JOINT.      3  DIRECTION: FY   DOF(S)   15            MAGNITUDE:  -20.0000       ...JOINT DISPLACEMENT...
 STRUCTURE.. .: EXAMPLE 2: ONE-STORY BUILDING                                               TIME  23.41:09, DATE: 11/30/90
 SOLUTION...  : INCREMEMTAL DISPLACEMENT CONTROL AT JOINT 3                                 TIME. 23.41.15, DATE: 11/30/90

 . LOADING #    0     MAXIMUM DISPLACEMENTS


 GCS DISPLACEMENTS
------------------
                          NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

    NODE        DX              DY              DZ              RX              RY              RZ

       1  0.000000E+00    0.000000E+00    0.000000E+00    0.000000E+00    0.000000E+00    0.000000E+00
       2 -0.689312       -19.9871         0.000000E+00    0.000000E+00    0.000000E+00   -1.171492E-02
       3 -0.646647       -20.0000         0.000000E+00    0.000000E+00    0.000000E+00   -1.304911E-02
       4  0.000000E+00    0.000000E+00    0.000000E+00    0.000000E+00    0.000000E+00    0.000000E+00
 STRUCTURE..  : EXAMPLE 2: ONE-STORY BUILDING                                               TIME: 23:41:09, DATE: 11/30/90
 SOLUTION.... : INCREMEMTAL DISPLACEMENT CONTROL AT JOINT 3                                 TIME: 23:41:15, DATE: 11/30/90

 . LOADING #    0     MAXIMUM REACTIONS


 MAXIMUM GCS RESTRAINT REACTIONS     NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY
--------------------------------

    NODE        FX              FY              FZ              MX              MY              MZ

       1   840.2106        24.60287       0.0000000E+00   0.0000000E+00   0.0000000E+00   14145.98
       2  0.0000000E+00   0.0000000E+00   0.0000000E+00   0.0000000E+00   0.0000000E+00   0.0000000E+00
       3  0.0000000E+00  -52.07221        0.0000000E+00   0.0000000E+00   0.0000000E+00   0.0000000E+00
       4   788.3674        27.53100       0.0000000E+00   0.0000000E+00   0.0000000E+00   14617.93
MAX OF ALL-------------------------------------------------------------------------------------------
GCS SUMM.    1577.700       0.3947502E-06  0.0000000E+00   0.0000000E+00   0.0000000E+00  -425600.4

  MAXIMUM RESULTANT OF REACTIONS,   FORCE=   1578.        MOMENT=  4.2580E+05
 STRUCTURE  ...: EXAMPLE 2: ONE-STORY BUILDING                                              TIME: 23:41.09, DATE  11/30/90
 SOLUTION.  ...: INCREMEMTAL DISPLACEMENT CONTROL AT JOINT 3                                TIME: 23:41.15, DATE  11/30/90

 . LOADING #    0     PEAK ELEMENT FORCES
     COLUMN ( LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

   STABILITY ELEMENT  FORCES ..
     MAXIMUM VALUES FOR ALL STEPS   NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME
 ELEMENT LOAD          NODE        AXIAL            FY            FZ             TORSION           MY              MZ       FLP.SP

       1    1  FORCE    1      840.211       0.000000E+00   -16.3832       0.000000E+00     14146.0        0.000000E+00
               FORCE    2     -840.211       0.000000E+00    16.3832       0.000000E+00     13673.5        0.000000E+00

       1    3  FORCE    1      829.882       0.000000E+00   -24.6029       0.000000E+00     12149.7        0.000000E+00
               FORCE    2     -829.882       0.000000E+00    24.6029       0.000000E+00     10965.0        0.000000E+00

       1    5  FORCE    1      840.211       0.000000E+00   -16.3832       0.000000E+00     14146.0        0.000000E+00
               FORCE    2     -840.211       0.000000E+00    16.3832       0.000000E+00     13673.5        0.000000E+00

       1    7  FORCE    1      840.211       0.000000E+00   -16.3832       0.000000E+00     14146.0        0.000000E+00
               FORCE    2     -840.211       0.000000E+00    16.3832       0.000000E+00     13673.5        0.000000E+00

       1    9  FORCE    1      829.882       0.000000E+00   -24.6029       0.000000E+00     12149.7        0.000000E+00
               FORCE    2      829.882       0.000000E+00    24.6029       0.000000E+00     10965.0        0.000000E+00

       1   11  FORCE    1      840.211       0.000000E+00   -16.3832       0.000000E+00     14146.0        0.000000E+00
               FORCE    2      840.211       0.000000E+00    16.3832       0.000000E+00     13673.5        0.000000E+00

       2    1  FORCE    2       24.6029      0.000000E+00    41.0321       0.000000E+00    -10965.0        0.000000E+00
               FORCE    3      -24.6029      0.000000E+00   -41.0321       0.000000E+00    -11191.3        0.000000E+00

       2    3  FORCE    2       16.3832      0.000000E+00    51.3606       0.000000E+00    -13673.5        0.000000E+00
               FORCE    3      -16.3832      0.000000E+00   -51.3606       0.000000E+00    -14059.9        0.000000E+00
```

```
  2    5  FORCE    2     16.3832      0.000000E+00     51.3606      0.000000E+00    -13673.5        0.000000E+00
          FORCE    3    -16.3832      0.000000E+00    -51.3606      0.000000E+00    -14059.9        0.000000E+00

  2    7  FORCE    2     24.6029      0.000000E+00     41.0321      0.000000E+00    -10965.0        0.000000E+00
          FORCE    3    -24.6029      0.000000E+00    -41.0321      0.000000E+00    -11191.3        0.000000E+00

  2    9  FORCE    2     16.3832      0.000000E+00     51.3606      0.000000E+00    -13673.5        0.000000E+00
          FORCE    3    -16.3832      0.000000E+00    -51.3606      0.000000E+00    -14059.9        0.000000E+00

  2   11  FORCE    2     16.3832      0.000000E+00     51.3606      0.000000E+00    -13673.5        0.000000E+00
          FORCE    3    -16.3832      0.000000E+00    -51.3606      0.000000E+00    -14059.9        0.000000E+00

  3    1  FORCE    4     788.850      0.000000E+00   1.231874E-12   0.000000E+00  -2.217372E-10    0.000000E+00
          FORCE    3    -788.850      0.000000E+00  -1.231874E-12   0.000000E+00  -4.434745E-10    0.000000E+00

  3    3  FORCE    4     747.061      0.000000E+00    -27.5310      0.000000E+00     12717.0        0.000000E+00
          FORCE    3    -747.061      0.000000E+00     27.5310      0.000000E+00     11402.4        0.000000E+00

  3    5  FORCE    4     737.489      0.000000E+00    -22.0832      0.000000E+00     14617.9        0.000000E+00
          FORCE    3    -737.489      0.000000E+00     22.0832      0.000000E+00     14059.9        0.000000E+00

  3    7  FORCE    4     788.850      0.000000E+00   1.231874E-12   0.000000E+00  -2.217372E-10    0.000000E+00
          FORCE    3    -788.850      0.000000E+00  -1.231874E-12   0.000000E+00  -4.434745E-10    0.000000E+00

  3    9  FORCE    4     747.061      0.000000E+00     27.5310      0.000000E+00     12717.0        0.000000E+00
          FORCE    3    -747.061      0.000000E+00     27.5310      0.000000E+00     11402.4        0.000000E+00

  3   11  FORCE    4     737.489      0.000000E+00    -22.0832      0.000000E+00     14617.9        0.000000E+00
          FORCE    3    -737.489      0.000000E+00     22.0832      0.000000E+00     14059.9        0.000000E+00
STRUCTURE.....: EXAMPLE 2: ONE-STORY BUILDING                                       TIME: 23:41:09, DATE: 11/30/90
SOLUTION......: INCREMENTAL DISPLACEMENT CONTROL AT JOINT 3                         TIME: 23:41:15, DATE: 11/30/90

. LOADING #     0      PEAK DUCTILITIES AND EXCURSION RATIO'S
STRUCTURE.....: EXAMPLE 2. ONE-STORY BUILDING                                       TIME: 23:41:09, DATE: 11/30/90
SOLUTION .....  INCREMENTAL DISPLACEMENT CONTROL AT JOINT 3                          TIME: 23:41:15, DATE: 11/30/90

. LOADING #     0      DAMAGE INDEX

      STRUCTURE DAMAGE INDEX=    0.00000E+00


*.......................................*
*--- MEMORY UTILIZATION .. .. .... ----*
*--- IZ= 153344,     MEM=21 906%   ----*
*.......................................*
*--- ELAPSED CPU TIME    625.60 SEC ----*
*--- TOTAL CPU TIME      629.99 SEC ----*
*.......................................*

STRUCTURE.....: EXAMPLE 2: ONE-STORY BUILDING                                       TIME: 23:41:09, DATE: 11/30/90
SOLUTION......: INCREMENTAL DISPLACEMENT CONTROL AT JOINT 3                         TIME: 23:41:15, DATE: 11/30/90

  DEGREE OF FREEDOM #   15 IS READ FROM UNIT #   11      JOINT #    3, DIRECTION: FY

    STEP     TIME          LOAD        DISPLACEMENT     VELOCITY      ACCELERATION
      0    0.00000E+00   6.454932E-14   0.00000E+00   0.00000E+00    0.00000E+00
      2    0.00000E+00   -1.5236       -0.20000       0.00000E+00    0.00000E+00
      4    0.00000E+00   -3.0472       -0.40000       0.00000E+00    0.00000E+00
      6    0.00000E+00   -4.5707       -0.60000       0.00000E+00    0.00000E+00
      8    0.00000E+00   -6.0941       -0.80000       0.00000E+00    0.00000E+00
     10    0.00000E+00   -7.6175       -1.0000        0.00000E+00    0.00000E+00
     12    0.00000E+00   -9.1408       -1.2000        0.00000E+00    0.00000E+00
     14    0.00000E+00   -10.664       -1.4000        0.00000E+00    0.00000E+00
     16    0.00000E+00   -12.187       -1.6000        0.00000E+00    0.00000E+00
     18    0.00000E+00   -13.711       -1.8000        0.00000E+00    0.00000E+00
     20    0.00000E+00   -15.234       -2.0000        0.00000E+00    0.00000E+00
     22    0.00000E+00   -16.757       -2.2000        0.00000E+00    0.00000E+00
     24    0.00000E+00   -18.280       -2.4000        0.00000E+00    0.00000E+00
     26    0.00000E+00   -19.803       -2.6000        0.00000E+00    0.00000E+00
     28    0.00000E+00   -21.326       -2.8000        0.00000E+00    0.00000E+00
     30    0.00000E+00   -22.849       -3.0000        0.00000E+00    0.00000E+00
     32    0.00000E+00   -24.372       -3.2000        0.00000E+00    0.00000E+00
     34    0.00000E+00   -25.895       -3.4000        0.00000E+00    0.00000E+00
     36    0.00000E+00   -27.417       -3.6000        0.00000E+00    0.00000E+00
     38    0.00000E+00   -28.940       -3.8000        0.00000E+00    0.00000E+00
     40    0.00000E+00   -30.463       -4.0000        0.00000E+00    0.00000E+00
     42    0.00000E+00   -31.986       -4.2000        0.00000E+00    0.00000E+00
     44    0.00000E+00   -33.501       -4.4000        0.00000E+00    0.00000E+00
     46    0.00000E+00   -34.962       -4.6000        0.00000E+00    0.00000E+00
     48    0.00000E+00   -36.369       -4.8000        0.00000E+00    0.00000E+00
     50    0.00000E+00   -37.704       -5.0000        0.00000E+00    0.00000E+00
     52    0.00000E+00   -38.951       -5.2000        0.00000E+00    0.00000E+00
     54    0.00000E+00   -40.132       -5.4000        0.00000E+00    0.00000E+00
     56    0.00000E+00   -41.260       -5.6000        0.00000E+00    0.00000E+00
     58    0.00000E+00   -42.294       -5.8000        0.00000E+00    0.00000E+00
     60    0.00000E+00   -43.274       -6.0000        0.00000E+00    0.00000E+00
     62    0.00000E+00   -44.165       -6.2000        0.00000E+00    0.00000E+00
     64    0.00000E+00   -44.969       -6.4000        0.00000E+00    0.00000E+00
     66    0.00000E+00   -45.753       -6.6000        0.00000E+00    0.00000E+00
     68    0.00000E+00   -46.461       -6.8000        0.00000E+00    0.00000E+00
     70    0.00000E+00   -47.100       -7.0000        0.00000E+00    0.00000E+00
     72    0.00000E+00   -47.692       -7.2000        0.00000E+00    0.00000E+00
     74    0.00000E+00   -48.243       -7.4000        0.00000E+00    0.00000E+00
     76    0.00000E+00   -48.742       -7.6000        0.00000E+00    0.00000E+00
     78    0.00000E+00   -49.212       -7.8000        0.00000E+00    0.00000E+00
     80    0.00000E+00   -49.606       -8.0000        0.00000E+00    0.00000E+00
     82    0.00000E+00   -49.967       -8.2000        0.00000E+00    0.00000E+00
     84    0.00000E+00   -50.309       -8.4000        0.00000E+00    0.00000E+00
     86    0.00000E+00   -50.632       -8.6000        0.00000E+00    0.00000E+00
     88    0.00000E+00    50.915       -8.8000        0.00000E+00    0.00000E+00
     90    0.00000E+00   -51.148       -9.0000        0.00000E+00    0.00000E+00
     92    0.00000E+00   -51.329       -9.2000        0.00000E+00    0.00000E+00
     94    0.00000E+00   -51.507       -9.4000        0.00000E+00    0.00000E+00
     96    0.00000E+00   -51.669       -9.6000        0.00000E+00    0.00000E+00
     98    0.00000E+00   -51.803       -9.8000        0.00000E+00    0.00000E+00
    100    0.00000E+00   -51.887       -10.000        0.00000E+00    0.00000E+00
    102    0.00000E+00   -51.961       -10.200        0.00000E+00    0.00000E+00
    104    0.00000E+00   -52.022       -10.400        0.00000E+00    0.00000E+00
    106    0.00000E+00   -52.067       -10.600        0.00000E+00    0.00000E+00
    108    0.00000E+00   -52.063       -10.800        0.00000E+00    0.00000E+00
    110    0.00000E+00   -52.029       -11.000        0.00000E+00    0.00000E+00
    112    0.00000E+00   -51.957       -11.200        0.00000E+00    0.00000E+00
    114    0.00000E+00   -51.876       -11.400        0.00000E+00    0.00000E+00
    116    0.00000E+00   -51.797       -11.600        0.00000E+00    0.00000E+00
    118    0.00000E+00   -51.695       -11.800        0.00000E+00    0.00000E+00
```

120	0.00000E+00	-51.591	-12.000	0.00000E+00	0.00000E+00
122	0.00000E+00	-51.463	-12.200	0.00000E+00	0.00000E+00
124	0.00000E+00	-51.116	-12.400	0.00000E+00	0.00000E+00
126	0.00000E+00	-51.149	-12.600	0.00000E+00	0.00000E+00
128	0.00000E+00	-50.975	-12.800	0.00000E+00	0.00000E+00
130	0.00000E+00	-50.798	-13.000	0.00000E+00	0.00000E+00
132	0.00000E+00	-50.616	-13.200	0.00000E+00	0.00000E+00
134	0.00000E+00	-50.418	-13.400	0.00000E+00	0.00000E+00
136	0.00000E+00	-50.204	-13.600	0.00000E+00	0.00000E+00
138	0.00000E+00	-49.967	13.800	0.00000E+00	0.00000E+00
140	0.00000E+00	-49.711	-14.000	0.00000E+00	0.00000E+00
142	0.00000E+00	-49.442	-14.200	0.00000E+00	0.00000E+00
144	0.00000E+00	-49.163	-14.400	0.00000E+00	0.00000E+00
146	0.00000E+00	-48.978	-14.600	0.00000E+00	0.00000E+00
148	0.00000E+00	-48.572	-14.800	0.00000E+00	0.00000E+00
150	0.00000E+00	-48.249	-15.000	0.00000E+00	0.00000E+00
152	0.00000E+00	-47.925	-15.200	0.00000E+00	0.00000E+00
154	0.00000E+00	-47.596	-15.400	0.00000E+00	0.00000E+00
156	0.00000E+00	-47.251	-15.600	0.00000E+00	0.00000E+00
158	0.00000E+00	-46.900	-15.800	0.00000E+00	0.00000E+00
160	0.00000E+00	-46.545	-16.000	0.00000E+00	0.00000E+00
162	0.00000E+00	-46.190	-16.200	0.00000E+00	0.00000E+00
164	0.00000E+00	-45.925	-16.400	0.00000E+00	0.00000E+00
166	0.00000E+00	-45.459	-16.600	0.00000E+00	0.00000E+00
168	0.00000E+00	-45.084	-16.800	0.00000E+00	0.00000E+00
170	0.00000E+00	-44.704	-17.000	0.00000E+00	0.00000E+00
172	0.00000E+00	-44.322	-17.200	0.00000E+00	0.00000E+00
174	0.00000E+00	-43.936	-17.400	0.00000E+00	0.00000E+00
176	0.00000E+00	-43.546	-17.600	0.00000E+00	0.00000E+00
178	0.00000E+00	-43.150	-17.800	0.00000E+00	0.00000E+00
180	0.00000E+00	-42.749	-18.000	0.00000E+00	0.00000E+00
182	0.00000E+00	-42.343	-18.200	0.00000E+00	0.00000E+00
184	0.00000E+00	-41.932	-18.400	0.00000E+00	0.00000E+00
186	0.00000E+00	-41.515	-18.600	0.00000E+00	0.00000E+00
188	0.00000E+00	-41.095	-18.800	0.00000E+00	0.00000E+00
190	0.00000E+00	-40.666	-19.000	0.00000E+00	0.00000E+00
192	0.00000E+00	-40.231	-19.200	0.00000E+00	0.00000E+00
194	0.00000E+00	-39.794	-19.400	0.00000E+00	0.00000E+00
196	0.00000E+00	-39.356	-19.600	0.00000E+00	0.00000E+00
198	0.00000E+00	-38.912	-19.800	0.00000E+00	0.00000E+00
200	0.00000E+00	-38.465	-20.000	0.00000E+00	0.00000E+00

```
*-------------------------------------*
*--- MEMORY UTILIZATION           ----*
*--- IZ= 153344,   MEM=21.906%    ----*
*-------------------------------------*
*--- ELAPSED CPU TIME      0.13 SEC ----*
*--- TOTAL CPU TIME      630.12 SEC ----*
*-------------------------------------*
```

Notes

(1) Results for an individual step are written to the output file every 50,000th step. The choice of a large increment (50,000) suppresses the output for individual steps.

(2) Ductility and excursion ratios are not available for finite-segment element.

(3) Damage index is not available for finite-segment element.

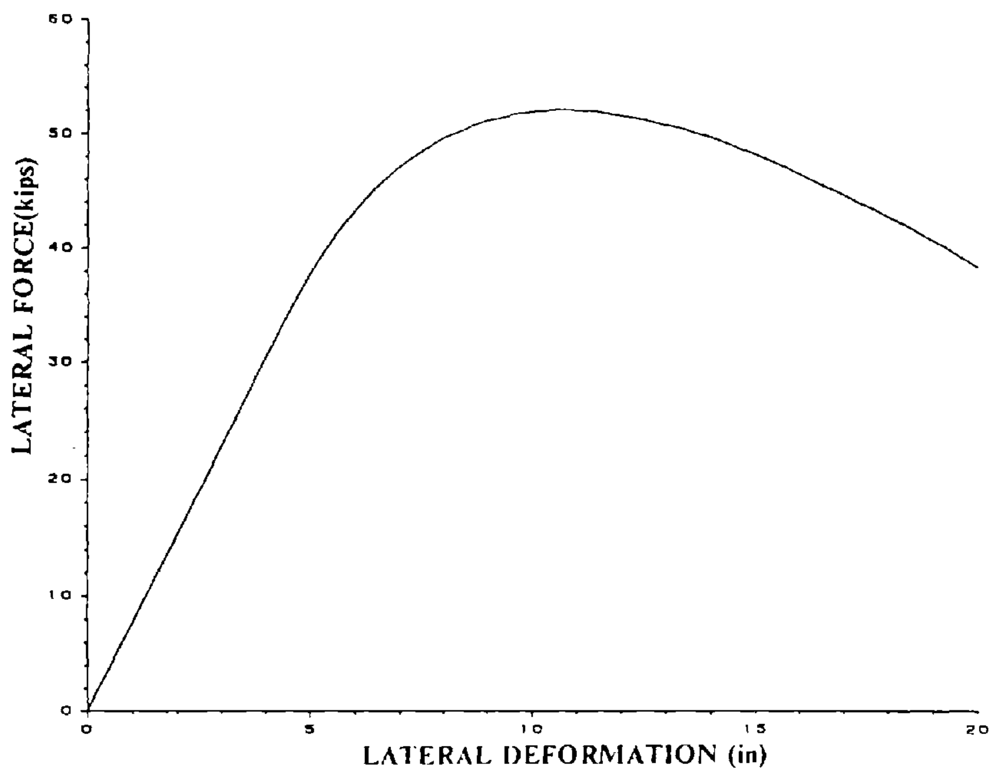


Figure 37. Lateral Load-Displacement Relationship

C. TWO-STORY TRUSS STRUCTURE

1. Description of Input Information

Figure 38 shows a two-story truss structure. In the structure, all members are box-shape struts. Table 1 gives and the material properties for two different size struts.

For all the members, the bracing member hysteresis model is used. Nonlinear response to the first 10 seconds of the 1940 El Centro earthquake, E-W component, is calculated. The east-west component of the El Centro earthquake is stored in the file accessed by unit 15. The hysteresis loops of member 8 are written in the file with unit 18 and plotted in Figure 39.

2. Input Data

```
ECHO OF INPUT DATA

LINE  ...!...10...!...20...!...30...!...40...!...50...!...60...!...70...!...80
  1:  'STRUCTURE DEFINATION'
  2:  'TWO-STORY TRUSS STRUCTURE'
  3:  6  1  4  0  0  1    !NNODE,NCOS,NSUPT,NCOND,NCCNST  SCALE
  4.     1   0      0     0     1 0
  5:     2   0     72     0     1 0
  6      3   0    144     0     1 0
  7.     4  72      0     0     1 0
  8:     5  72     72     0     1 0
  9:     6  72    144     0     1 0
 10:    1 0 0   0 1 0                DIRECTION COSINE
 11:    1  1 1 1 1 1 1    0 0      ! RESTRAINTS
 12:    4  1 1 1 1 1 1    0 0      ! RESTRAINTS
 13:    2  0 0 1 1 1 1    1 1      ! RESTRAINTS
 14:    5  0 0 1 1 1 1    1 1      ! RESTRAINTS
 15:   2  NMAT
 16: 'BRACE MAT#1' 29000 9       1.8   36  2  20 0 4
 17: 'BRACE MAT#2' 29000 7       1.39  36  2  20 0 4
 18    0  0  0  .FALSE.            !KGLOAD .....
 19       8          !NELEM
 20. 'BRACE' 'MEM. 1'  1  2  3  1 1    1 0 0    0 0     0
 21: 'BRACE' 'MEM. 2'  1  1  2  1 1    1 0 0    0 0     0
 22: 'BRACE' 'MEM. 3'  2  5  6  1 1    1 0 0    0 0     0
 23: 'BRACE' 'MEM. 4'  2  4  5  1 1    1 0 0    0 0     0
 24: 'BRACE' 'MEM. 5'  1  3  6  1 1    0 1 0    0 0     0
 25: 'BRACE' 'MEM  6'  1  2  5  1 1    0 1 0    0 0     0
 26: 'BRACE' 'MEM  7'  2  2  6  1 1    0 0 1    0 0     0
 27: 'BRACE' 'MEM. 8'  2  1  5  1 1    0 0 1    0 0     0
 28: 2    1 .FALSE. !  MASS
 29  2  0 3        0.3        0.3       0 0 0 0 0 0  1 1   ID PX PY PZ
 30  5  0 3        0 3        0 3       0 0 0 0 0 0  1 1   ID PX PY PZ
 31  1.306   0 00143  !DAMP
 32: 'SOL02  SOLUTION'
 33:  'STRUCTURAL RESPONSE DUE TO 1940 EL CENTRO E-W COMPONENT'
 34: 'WILSON'  1.4  .FALSE.  .TRUE.  ! INTEG THETA ELASTIC UNBAL
 35: 10000 50   2400   .FALSE.  ! IPRINT IWRITE MAXACC SLMASS
 36. 0  0.001 10    386       ! TO DT TF GRAV
 37: 'ELE' 8  18 0  0  0
 38  'JOINT FX' 6 27 0 0 0
 39. 'END' 0 0 0 0 0
 40: 0       ! ISP1
 41: 0  0  0  'END' 0 0 0 0 0 0
 42: 1   1   0.01  0.01     .FALSE.  !NA ASCALE TO DT PRINT
 43: 1 0 0  0 1 0  ! VXI VXJ VXZ...
 44: 15  2400  1   .TRUE.   .FALSE.  .FALSE. ! IN NPS IDIR FMT ECHO REWIND
 45: '(A/A)'
 46· '8F9 6'
 47  'READ UNIT-18'
 48  'READ UNIT-27'
 49· 'STOP'
```

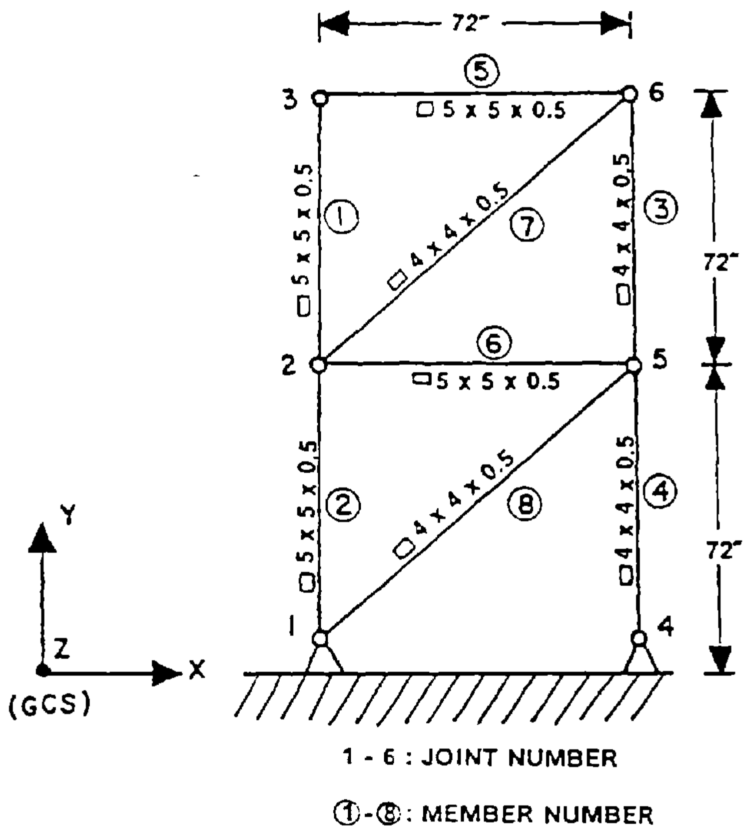


Figure 38. Two-Story Truss Structure

Table I. MATERIAL PROPERTIES OF STRUTS

Member Size	$A(in^2)$	E(ksi)	σ_y(ksi)	r (in)	L (in)	L/r	P_{max}(kips)
5x5x0.5	9	29000	36	1.8	72	40	307.8
4x4x0.5	7	29000	36	1.39	72	51.8	230.6
4x4x0.5	7	29000	36	1.39	101.82	73.2	209.47

3. Output

```
 STRUCTURE.....: TWO-STORY TRUSS STRUCTURE                                                              TIME: 13:49:05, DATE: 12/01/90
 SOLUTION.....:

*** PROGRAM FEM ***          DOUBLE PRECISION VERSION


    NODE COORDINATES AND DEGREES OF FREEDOM

   TOTAL NUMBER OF DEGREES OF FREEDOM...........         36
   NUMBER OF DEGREES OF FREEDOM CONDENSED OUT ....        0
   NUMBER OF FREE DEGREES OF FREEDOM...........           8
   NUMBER OF RESTRAINED DEGREES OF FREEDOM........       28

     NODE COS#    X-COORD        Y-COORD        Z-COORD        FX     FY     FZ     MX     MY     MZ
       1    1   0.00000E+00    0.00000E+00    0.00000E+00     9-R   10-R   11-R   12-R   13-R   14-R
       2    1   0.00000E+00     72.000        0.00000E+00     1      2     15-R   16-R   17-R   18-R
       3    1   0.00000E+00    144.00         0.00000E+00     3      4     19-R   20-R   21-R   22-R
       4    1    72.000        0.00000E+00    0.00000E+00    23-R   24-R   25-R   26-R   27-R   28-R
       5    1    72.000         72.000        0.00000E+00     5      6     29-R   30-R   31-R   32-R
       6    1    72.000        144.00         0.00000E+00     7      8     33-R   34-R   35-R   36-R
          NOTE. R - RESTRAINED DEGREE OF FREEDOM
                C - CONSTRAINED DEGREE OF FREEDOM


    DIRECTION COSINES ..

COS( 1)   VX: 1.00000 I -0.00000 J +0.00000 K   VY: 0.00000 I +1.00000 J +0.00000 K   VZ: 0.00000 I -0.00000 J +1.00000 K
 STRUCTURE.....: TWO-STORY TRUSS STRUCTURE                                                              TIME: 13:49:05, DATE: 12/01/90
 SOLUTION.....:


    BRACE HYSTERESIS MODEL PARAMETERS
    ---------------------------------

 MAT.      E          A          R          YS         SHAPE      MAX DUC    BETA
  1 29000.0      9.00000    1.60000    36.0000    2.00000    20.0000    0.400000

  2 29000.0      7.00000    1.39000    36.0000    2.00000    20.0000    0.400000

 STRUCTURE.....: TWO-STORY TRUSS STRUCTURE                                                              TIME: 13:49:05, DATE: 12/01/90
 SOLUTION.....:

ELEMENT 08, ONE (LOCAL) DOF STRUT ELEMENT

                      #  MATL START   END  --TYPE---    LENGTH     ----------- Y-AXIS -----------     START DIST    END DIST
MEM. 1                1    1     2     3     AXIAL       72.00     1.00000 I +0.00000 J -0.00000 K  0.0000E+00  0.0000E+00
MEM. 2                2    1     1     2     AXIAL       72.00     1.00000 I -0.00000 J +0.00000 K  0.0000E+00  0.0000E+00
MEM. 3                3    2     5     6     AXIAL       72.00     1.00000 I -0.00000 J +0.00000 K  0.0000E+00  0.0000E+00
MEM. 4                4    2     4     5     AXIAL       72.00     1.00000 I -0.00000 J +0.00000 K  0.0000E+00  0.0000E+00
MEM. 5                5    1     3     6     AXIAL       72.00     0.00000 I -1.00000 J +0.00000 K  0.0000E+00  0.0000E+00
MEM. 6                6    1     2     5     AXIAL       72.00     0.00000 I -1.00000 J +0.00000 K  0.0000E+00  0.0000E+00
MEM. 7                7    2     2     6     AXIAL      101.8      0.00000 I +0.00000 J +1.00000 K  0.0000E+00  0.0000E+00
MEM. 8                8    2     1     5     AXIAL      101.8      0.00000 I +0.00000 J +1.00000 K  0.0000E+00  0.0000E+00
 STRUCTURE.....: TWO-STORY TRUSS STRUCTURE                                                              TIME: 13:49:05, DATE: 12/01/90
 SOLUTION.....:

 LUMPED NODE MASSES
 ------------------

   NODE    MX          MY          MZ          IXX         IYY         IZZ         IXY         IYZ         IYZ       IGEN   INC
     2  0.3000      0.3000      0.3000      0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00    1     1
     5  0.3000      0.3000      0.3000      0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00    1     1

   - THE MASS MATRIX IS NOT CONDENSED WITH THE STRUCTURAL STIFFNESS MATRIX.


     PROPORTIONAL DAMPING COIEFICIENTS
     ---------------------------------
   ALPHA=   1.3060        BETA=  1.43000E-03


*--------------------------------------*
*--- MEMORY UTILIZATION ......... ----*
*--- IZ=   1527,     MEM= 0.218%   ----*
*--------------------------------------*
*--- ELAPSED CPU TIME      0.15 SEC ----*
*--- TOTAL CPU TIME        0.15 SEC ----*
*--------------------------------------*

 STRUCTURE..... TWO-STORY TRUSS STRUCTURE                                                               TIME: 13:49:05, DATE: 12/01/90
 SOLUTION ..... STRUCTURAL RESPONSE DUE TO 1940 EL CENTRO E-W COMPONENT                                  TIME: 13:49:05, DATE: 12/01/90

 SOLUTION #2, WILSON THETA METHOD OF NUMERICAL INTEGRATION
 ---------------------------------------------------------

 THETA.........................        1.40000
 INITIAL TIME ..................      0.000000E+00
 TIME STEP .....................      1.000000E-02
 FINAL TIME ....................       10.0000
 ACCELERATION DUE TO GRAVITY ...       386.000
 STEP INTERVAL FOR PRINTING ......10000

     DATA WRITTEN TO FILES
     ---------------------

    ELEMENT  #    8 IS WRITTEN TO UNIT #   18
    DEGREE OF FREEDOM  #    7 IS WRITTEN TO UNIT #   27   JOINT:     6   DIRECTION: FX

 NOT INCLUDE STATICS CASE EXTERNAL DEFORMATIONS
 ----------------------------------------------

     GROUND ACCELERATION RECORD
     --------------------------
```

INPUTING TRANSLATIONAL ACCELERATION RECORD # 1, FROM UNIT. 15
1940 EL CENTRO EQ DATA FORMAT:(8F9.6)
DT=0.01 SEC., E-W DIRECTION 2400 DATA
THE RECORD CONTAINS 2400 POINTS, BEGINING AT TIME 1.000000E-02 WITH A TIME INCREMENT OF: 1.000000E-02
DIRECTION OF ACCELERATION. 1.00000 I +0.00000 J +0.00000 K

	MAXIMUN	AT TIME	MINIMUN	AT TIME	AVERAGE	STANDARD DEV.	RMS
INPUT ACCELERATION	0.21490	1.8800	-0.16138	11.040	-8.84396E-05	5.46953E-02	5.46840E-02

	MAXIMUN	AT TIME	MINIMUN	AT TIME	AVERAGE	STANDARD DEV	RMS
X-AXIS ACCELERATION	0.21490	1.8800	-0.16138	11.040	-8.84396E-05	5.46953E-02	5.46840E-02
Y-AXIS ACCELERATION	0.00000E+00	2.00000E-02	0.00000E+00	2.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00
Z-AXIS ACCELERATION	0.00000E+00	2.00000E-02	0.00000E+00	2.00000E-02	0.00000E+00	0.00000E+00	0.00000E+00

STRUCTURE. . . : TWO-STORY TRUSS STRUCTURE TIME 13:49:05, DATE: 12/01/90
SOLUTION.... : STRUCTURAL RESPONSE DUE TO 1940 EL CENTRO E-W COMPONENT TIME 13:49:05, DATE: 12/01/90

SYSTEM DISPLACEMENT : FIRST ELEMENT REACH TO CRITICAL LOAD

** ELEMENT 8 FIRST REACH TO CRITICAL LOAD **

GCS DISPLACEMENTS, LOADING # 1 STEP- 4446, TIME: 4.4460

NODE	DX	DY	DZ	RX	RY	RZ
1	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
2	-0.252931	-1.816910E-02	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
3	0.423502	-1.856065E-02	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
4	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
5	-0.234845	5.587141E-02	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
6	-0.414675	8.105342E-02	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

STRUCTURE. . : TWO-STORY TRUSS STRUCTURE TIME: 13:49:05, DATE: 12/01/90
SOLUTION... : STRUCTURAL RESPONSE DUE TO 1940 EL CENTRO E-W COMPONENT TIME: 13:49:05, DATE: 12/01/90

MAXIMUN VALUES FOR ALL STEPS

GCS MAXIMUM DISPLACEMENTS

NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

NODE	DX	DY	DZ	RX	RY	RZ
1	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
2	-0.645847	-2.621933E-02	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
3	-0.713610	-2.830377E-02	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
4	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
5	-0.638099	8.594839E-02	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
6	-0.708948	0.117362	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

STRUCTURE ....: TWO-STORY TRUSS STRUCTURE TIME: 13:49:05, DATE: 12/01/90
SOLUTION. ....: STRUCTURAL RESPONSE DUE TO 1940 EL CENTRO E-W COMPONENT TIME: 13:49:05, DATE: 12/01/90

MAXIMUN VALUES FOR ALL STEPS

GCS MAXIMUM VELOCITIES

NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

NODE	DX	DY	DZ	RX	RY	RZ
1	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
2	4.77518	-0.666626	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
3	-9.26878	-0.619723	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
4	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
5	4.89796	1.43532	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
6	-8.03170	2.14507	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

STRUCTURE . .: TWO-STORY TRUSS STRUCTURE TIME: 13:49:05, DATE: 12/01/90
SOLUTION.....: STRUCTURAL RESPONSE DUE TO 1940 EL CENTRO E-W COMPONENT TIME: 13:49:05, DATE: 12/01/90

MAXIMUN VALUES FOR ALL STEPS

GCS MAXIMUM ACCELERATIONS

NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

NODE	DX	DY	DZ	RX	RY	RZ
1	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
2	119.187	28.7199	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
3	190.872	39.0954	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
4	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
5	118.098	-43.5181	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
6	192.681	-69.4972	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

STRUCTURE....: TWO-STORY TRUSS STRUCTURE TIME: 13:49.05, DATE: 12/01/90
SOLUTION.. ... STRUCTURAL RESPONSE DUE TO 1940 EL CENTRO E-W COMPONENT TIME: 13:49.05, DATE: 12/01/90

MAXIMUN VALUES FOR ALL STEPS

MAXIMUM GCS RESTRAINT REACTIONS NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

NODE	FX	FY	FZ	MX	MY	MZ
1	148.2414	234.7435	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
2	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
3	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
4	0.0000000E+00	-242.3267	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
5	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
6	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
MAX OF ALL GCS SUMM.	148.2414	-30.04625	0.0000000E+00	0.0000000E+00	0.0000000E+00	-17447.52

MAXIMUM RESULTANT OF REACTIONS, FORCE= 148.4 MOMENT= 1.7446E+04
STRUCTURE.... TWO-STORY TRUSS STRUCTURE TIME: 13:49:05, DATE: 12/01/90
SOLUTION. . .: STRUCTURAL RESPONSE DUE TO 1940 EL CENTRO E-W COMPONENT TIME 13:49:05, DATE: 12/01/90

MAXIMUN VALUES FOR ALL STEPS

BRACE FORCES... MAXIMUM LOAD AND DISPL AT MAXIMUM LOAD NOTE MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

ELEMENT	LOAD	TYPE	NODEI	NODEJ	FORCE	DISPLACMENT	STIFFNESS
1	0	AXIAL	2	3	-11.6577	-3.215921E-03	
2	0	AXIAL	1	2	-95.0451	-2.621933E-02	
3	0	AXIAL	5	6	101.791	3.610335E-02	
4	0	AXIAL	4	5	242.327	8.594839E-02	
5	0	AXIAL	3	6	-42.7626	-1.179658E-02	
6	0	AXIAL	2	5	117.778	3.249057E-02	
7	0	AXIAL	2	6	119.546	5.996358E-02	
8	0	AXIAL	1	5	-209.645	-0.440890	

STRUCTURE. ...: TWO-STORY TRUSS STRUCTURE TIME: 13:49:05, DATE: 12/01/90
SOLUTION. ....: STRUCTURAL RESPONSE DUE TO 1940 EL CENTRO E-W COMPONENT TIME: 13:49:05, DATE: 12/01/90

MAXIMUN VALUES FOR ALL STEPS

STRUT DUCTILITIES AND EXCURSION RATIOS. .
ELEMENT |- DUCTILITY DEFINATION #1 -|

ELEMENT	DUCTILITY	EXCURSION
1	0.000000E+00	0.000000E+00
2	0.000000E+00	0.000000E+00
3	0.000000E+00	0.000000E+00
4	0.000000E+00	0.000000E+00
5	0.000000E+00	0.000000E+00
6	0.000000E+00	0.000000E+00
7	0.000000E+00	0.000000E+00
8	3.48801	2.48801

STRUCTURE. ...: TWO-STORY TRUSS STRUCTURE TIME: 13:49:05, DATE: 12/01/90
SOLUTION. ...: STRUCTURAL RESPONSE DUE TO 1940 EL CENTRO E-W COMPONENT TIME: 13:49:05, DATE: 12/01/90

MAXIMUN VALUES FOR ALL STEPS

ELEMENT	DAMAGE INDEX	F MAX	D MAX	ESE	PSE
1	1.799030E-03	-11.6577	-3.215921E-03	8.920085E-03	0.000000E+00
2	1.466745E-02	95.0451	-2.621933E-02	4.859856E-04	0.000000E+00
3	2.019670E-02	101.791	3.610335E-02	3.561702E-02	0.000000E+00
4	4.808069E-02	242.327	8.594839E-02	1.10031	0.000000E+00
5	6.599166E-03	-42.7626	-1.179658E-02	7.320449E-03	0.000000E+00
6	1.817567E-02	117.778	3.249057E-02	0.217745	0.000000E+00
7	2.371950E-02	119.546	5.996358E-02	0.125229	0.000000E+00
8	0.243464	-59.0398	-0.440890	2.30551	109.995

STRUCTURE DAMAGE INDEX= 0.24080
STRUCTURE ....: TWO-STORY TRUSS STRUCTURE TIME: 13:49:05, DATE: 12/01/90
SOLUTION.....: STRUCTURAL RESPONSE DUE TO 1940 EL CENTRO E-W COMPONENT TIME: 13:49:05, DATE: 12/01/90

MAXIMUN VALUES FOR ALL STEPS

PEAK ENERGY VALUES
MAX INPUT ENERGY.............. 268.60
MAX ELASTIC STRAIN ENERGY...... 29.488
MAX PLASTIC STRAIN ENERGY...... 112.48
MAX KINETIC ENERGY 12.448
MAX DAMPING ENERGY 104.60

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*--------------------------------------*
*---- MEMORY UTILIZATION ......... ----*
*---- IZ= 12139,     MEM= 1.734%  ----*
*--------------------------------------*
*---- ELAPSED CPU TIME   218.32 SEC ----*
*---- TOTAL CPU TIME     216.47 SEC ----*
*--------------------------------------*
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STRUCTURE. ..: TWO-STORY TRUSS STRUCTURE TIME: 13:49:05, DATE: 12/01/90
SOLUTION.....: STRUCTURAL RESPONSE DUE TO 1940 EL CENTRO E-W COMPONENT TIME: 13:49:05, DATE: 12/01/90

ELEMENT # 8 IS READ FROM UNIT # 18

BRACE MEMBER FORCES. .
NODEI: 1 NODEJ: 5 BRACE"S TYPE: AXIAL

STEP	TIME	FORCE	DISPLACMENT	STIFFNESS	ESE	PSE
0	0.00000E+00	0.00000E+00	0.00000E+00	1994.0	0.00000E+00	0.00000E+00
50	5.00000E-02	1.8570	9.31360E-04	1994.0	8.64680E-04	3.79470E-19
100	1.00000E-01	4.4930	2.25390E-03	1994.0	5.06370E-03	0.00000E+00
150	0.15000	6.5870	3.30420E-03	1994.0	1.08830E-02	0.00000E+00
200	0.20000	8.4210	4.22400E-03	1994.0	1.77850E-02	0.00000E+00
250	0.25000	6.7020	3.36190E-03	1994.0	1.12660E-02	0.00000E+00
300	0.30000	6.3780	3.19930E-03	1994.0	1.02030E-02	0.00000E+00
350	0.35000	5.5890	2.80340E-03	1994.0	7.83390E-03	0.00000E+00
400	0.40000	11.940	5.99070E-03	1994.0	3.57740E-02	0.00000E+00
450	0.45000	5.2140	2.61530E-03	1994.0	6.81800E-03	0.00000E+00
500	0.50000	1.4350	7.19560E-04	1994.0	5.16120E-04	0.00000E+00
550	0.55000	-1.9670	-9.86840E-04	1994.0	9.70750E-04	0.00000E+00
600	0.60000	-4.2250	-2.11940E-03	1994.0	4.47740E-03	0.00000E+00
650	0.65000	7.6150	3.81960E-03	1994.0	1.45430E-02	0.00000E+00
700	0.70000	11.590	5.81330E-03	1994.0	3.36870E-02	0.00000E+00
750	0.75000	9.9530	4.99240E-03	1994.0	2.48450E-02	0.00000E+00
800	0.80000	-14.960	-7.50290E-03	1994.0	5.61150E-02	0.00000E+00
850	0.85000	-45.410	-2.27790E-02	1994.0	0.51720	0.00000E+00
900	0.90000	-65.270	-3.27410E-02	1994.0	1.0690	2.22040E-16
950	0.95000	-65.830	-3.30220E-02	1994.0	1.0870	0.00000E+00
1000	1.0000	-35.060	-1.75870E-02	1994.0	0.30830	0.00000E+00
1050	1.0500	-9.9060	-4.96990E-03	1994.0	2.46120E-02	0.00000E+00
1100	1.1000	20.820	1.04430E-02	1994.0	0.10870	0.00000E+00
1150	1.1500	41.590	2.08630E-02	1994.0	0.43390	0.00000E+00
1200	1.2000	39.030	1.95770E-02	1994.0	0.38200	0.00000E+00
1250	1.2500	2.4240	1.21610E-03	1994.0	1.47420E-03	0.00000E+00
1300	1.3000	-66.920	-3.35690E-02	1994.0	1.1230	0.00000E+00
1350	1.3500	-127.80	-6.41250E-02	1994.0	4.0990	0.00000E+00
1400	1.4000	-161.70	-8.11100E-02	1994.0	6.5580	0.00000E+00
1450	1.4500	-133.00	-6.67140E-02	1994.0	4.4370	0.00000E+00
1500	1.5000	-47.750	-2.39520E-02	1994.0	0.57190	0.00000E+00
1550	1.5500	58.110	2.91450E-02	1994.0	0.84670	0.00000E+00
1600	1.6000	166.30	8.34210E-02	1994.0	6.9370	0.00000E+00
1650	1.6500	186.60	9.35920E-02	1994.0	8.7320	0.00000E+00
1700	1.7000	136.00	6.82150E-02	1994.0	4.6390	0.00000E+00
1750	1.7500	13.240	6.64310E-03	1994.0	4.39910E-02	0.00000E+00
1800	1.8000	-117.00	-5.87060E-02	1994.0	3.4350	0.00000E+00

1850	1.8500	-191.70	-9.61690E-02	1994.0	9.2190	0.00000E+00
1900	1.9000	-207.60	-0.11110	1994.0	10.810	1.4400
1950	1.9500	-141.30	7.77680E-02	1994.0	5.0070	1.4400
2000	2.0000	-27.820	-2.08530E-02	1994.0	0.19410	1.4400
2050	2.0500	86.350	3.74190E-02	1994.0	1.9580	1.4400
2100	2.1000	156.50	9.34040E-02	629.20	6.1450	4.6320
2150	2.1500	166.40	0.11580	1994.0	6.9440	7.4990
2200	2.2000	45.580	5.53240E-02	1994.0	0.52780	7.4990
2250	2.2500	-83.420	-9.52920E-03	1994.0	1.7450	7.4990
2300	2.3000	-100.60	-5.04430E-02	-106.40	2.5370	10.900
2350	2.3500	-83.190	-6.13750E-02	1994.0	1.7360	12.760
2400	2.4000	71.670	1.63040E-02	1994.0	1.2880	12.760
2450	2.4500	91.690	2.63450E-02	1994.0	2.1080	12.760
2500	2.5000	63.140	1.20260E-02	1994.0	0.99990	12.760
2550	2.5500	34.270	-2.45850E-03	1994.0	0.29450	12.760
2600	2.6000	-49.390	-4.44220E-02	1994.0	0.61190	12.760
2650	2.6500	-10.850	-2.50860E-02	1994.0	2.95060E-02	12.760
2700	2.7000	10.470	-1.43930E-02	1994.0	2.75040E-02	12.760
2750	2.7500	87.680	2.43360E-02	1994.0	1.9280	12.760
2800	2.8000	131.10	4.61370E-02	1994.0	4.3140	12.760
2850	2.8500	97.280	2.91470E-02	1994.0	2.3730	12.760
2900	2.9000	36.890	-1.14300E-03	1994.0	0.34130	12.760
2950	2.9500	-64.430	-5.19650E-02	1994.0	1.0410	12.760
3000	3.0000	-57.240	-4.63580E-02	1994.0	0.82180	12.760
3050	3.0500	-31.360	-3.53780E-02	1994.0	0.24670	12.760
3100	3.1000	27.770	-5.71520E-03	1994.0	0.19340	12.760
3150	3.1500	69.990	2.54920E-02	1994.0	2.0310	12.760
3200	3.2000	80.890	2.09220E-02	1994.0	1.6410	12.760
3250	3.2500	65.200	1.30590E-02	1994.0	1.0660	12.760
3300	3.3000	29.780	-4.70950E-03	1994.0	0.22240	12.760
3350	3.3500	-1.5690	-2.04330E-02	1994.0	6.17190E-04	12.760
3400	3.4000	-22.870	-3.11190E-02	1994.0	0.13120	12.760
3450	3.4500	-55.480	-4.74730E-02	1994.0	0.77190	12.760
3500	3.5000	-77.720	-5.86290E-02	1994.0	1.5150	12.760
3550	3.5500	-66.600	-5.30540E-02	1994.0	1.1130	12.760
3600	3.6000	-16.550	-2.89500E-02	1994.0	8.62920E-02	12.760
3650	3.6500	37.650	-7.61440E-04	1994.0	0.35550	12.760
3700	3.7000	39.960	3.95830E-04	1994.0	0.40040	12.760
3750	3.7500	15.800	-1.17210E-02	1994.0	6.26100E-02	12.760
3800	3.8000	-44.180	4.18040E-02	1994.0	0.48940	12.760
3850	3.8500	-77.520	5.85320E-02	1994.0	1.5070	12.760
3900	3.9000	-34.580	-3.69900E-02	1994.0	0.29990	12.760
3950	3.9500	13.950	-1.26470E-02	1994.0	4.89290E-02	12.760
4000	4.0000	54.970	7.92810E-03	1994.0	0.75790	12.760
4050	4.0500	6.9570	1.61560E-02	1994.0	1.21400E-02	12.760
4100	4.1000	6.4160	1.64280E-02	1994.0	1.03250E-02	12.760
4150	4.1500	-7.7760	2.35460E-02	1994.0	1.51630E-02	12.760
4200	4.2000	52.400	6.63690E-03	1994.0	0.68860	12.760
4250	4.2500	107.60	3.43420E-02	1994.0	2.9050	12.760
4300	4.3000	84.190	2.25830E-02	1994.0	1.7780	12.760
4350	4.3500	43.480	2.16320E-03	1994.0	0.47410	12.760
4400	4.4000	-81.100	-6.03270E-02	1994.0	1.6500	12.760
4450	4.4500	-91.500	-0.13580	-106.40	2.1000	19.430
4500	4.5000	-76.080	-0.28070	-106.40	1.4520	32.230
4550	4.5500	-60.990	-0.42260	-106.40	0.93230	42.470
4600	4.6000	-31.170	0.42690	1994.0	0.24370	43.630
4650	4.6500	8.2940	0.40710	1994.0	1.72540E-02	43.630
4700	4.7000	24.050	0.38100	46.210	0.14500	44.060
4750	4.7500	30.560	-0.24000	46.210	0.23420	47.620
4800	4.8000	38.330	7.18620E-02	46.210	0.36850	53.480
4850	4.8500	61.290	2.37050E-03	318.00	0.94210	56.580
4900	4.9000	83.030	7.07270E-02	318.00	1.7290	60.720
4950	4.9500	103.40	0.13460	318.00	2.6820	65.740
5000	5.0000	72.080	0.12630	1994.0	1.3030	66.490
5050	5.0500	7.3030	9.37640E-02	1994.0	1.33750E-02	66.490
5100	5.1000	15.740	9.79970E-02	1994.0	6.21460E-02	66.490
5150	5.1500	-10.770	9.46960E-02	1994.0	2.91150E-02	66.490
5200	5.2000	38.050	0.10920	1994.0	0.36310	66.490
5250	5.2500	41.500	0.11090	1994.0	0.43190	65.490
5300	5.3000	-20.630	7.97540E-02	1994.0	0.10670	66.490
5350	5.3500	-68.270	5.58570E-02	1994.0	1.1690	66.490
5400	5.4000	-86.070	3.64550E-02	-70.630	1.8580	67.400
5450	5.4500	-19.190	7.00080E-02	1994.0	9.22150E-02	67.400
5500	5.5000	68.470	0.11400	1994.0	1.1760	67.400
5550	5.5500	95.520	0.12750	1994.0	2.2880	67.400
5600	5.6000	59.890	0.10970	1994.0	0.89940	67.400
5650	5.6500	-37.710	6.07120E-02	1994.0	0.35660	67.400
5700	5.7000	-85.450	2.22630E-02	-71.190	1.8310	68.540
5750	5.7500	-83.360	1.90910E-02	1994.0	1.7430	69.000
5800	5.8000	-31.580	4.50670E-02	1994.0	0.25010	69.000
5850	5.8500	60.720	9.13610E-02	1994.0	0.92460	69.000
5900	5.9000	94.700	0.10880	318.00	2.2490	69.040
5950	5.9500	81.370	0.10240	1994.0	1.6610	69.060
6000	6.0000	8.8640	6.59910E-02	1994.0	1.97060E-02	69.060
6050	6.0500	-36.620	4.31770E-02	1994.0	0.33610	69.060
6100	6.1000	-53.680	3.46210E-02	1994.0	0.72260	69.060
6150	6.1500	-26.430	4.82860E-02	1994.0	0.17520	69.060
6200	6.2000	4.6920	6.38990E-02	1994.0	5.52220E-03	69.060
6250	6.2500	24.110	7.36380E-02	1994.0	0.14580	69.060
6300	6.3000	40.910	8.20630E-02	1994.0	0.41970	69.060
6350	6.3500	43.790	8.35110E-02	1994.0	0.48100	69.060
6400	6.4000	26.750	7.49630E-02	1994.0	0.17950	69.060
6450	6.4500	-6.4470	5.83110E-02	1994.0	1.04240E-02	69.060
6500	6.5000	-33.350	4.48160E-02	1994.0	0.27900	69.060
6550	6.5500	-20.850	5.10880E-02	1994.0	0.10900	69.060
6600	6.6000	2.6840	6.28910E-02	1994.0	1.80740E-03	69.060
6650	6.6500	31.900	7.75440E-02	1994.0	0.25510	69.060
6700	6.7000	19.280	7.12160E-02	1994.0	9.32310E-02	69.060
6750	6.7500	-20.270	5.13790E-02	1994.0	0.10300	69.060
6800	6.8000	-9.9900	5.70360E-02	1994.0	2.02680E-02	69.060
6850	6.8500	2.9230	6.30110E-02	1994.0	2.14330E-03	69.060
6900	6.9000	26.790	7.59840E-02	1994.0	0.20780	69.060
6950	6.9500	14.970	6.90550E-02	1994.0	5.62250E-02	69.060
7000	7.0000	-32.630	4.51800E-02	1994.0	0.26690	69.060
7050	7.0500	-45.730	3.86070E-02	1994.0	0.52450	69.060
7100	7.1000	12.700	6.79130E-02	1994.0	4.04200E-02	69.060
7150	7.1500	79.590	0.10150	1994.0	1.5890	69.060
7200	7.2000	105.00	0.14030	318.00	2.7680	71.680
7250	7.2500	66.230	0.12680	1994.0	1.1000	72.300
7300	7.3000	-66.500	6.01950E-02	1994.0	1.1090	72.300
7350	7.3500	-84.500	2.56730E-02	-69.380	1.7910	74.480
7400	7.4000	-79.220	-5.05450E-02	-69.380	1.5740	80.940
7450	7.4500	-23.400	-4.34250E-02	1994.0	0.13730	92.580
7500	7.5000	72.710	3.55910E-02	318.00	1.3260	84.640
7550	7.5500	85.640	7.62750E-02	318.00	1.8400	87.340

7600	7.6000	101.10	0.12480	318.00	2.5620	91.150
7650	7.6500	43.820	9.88950E-02	1994.0	0.49160	91.440
7700	7.7000	-42.310	5.56940E-02	1994.0	0.44900	91.440
7750	7.7500	-68.080	4.27700E-02	1994.0	1.1620	91.440
7800	7.8000	-84.160	2.06800E-02	-69.360	2.0430	92.360
7850	7.8500	-46.410	4.22430E-02	1729.0	0.62290	92.380
7900	7.9000	10.550	7.52420E-02	1729.0	3.2798CE-02	92.380
7950	7.9500	11.650	7.58190E-02	1729.0	3.9229CE-02	92.380
8000	8.0000	38.340	9.12560E-02	1729.0	0.42510	92.380
8050	8.0500	0.57930	6.94180E-02	1729.0	9.7050CE-05	92.380
8100	8.1000	-15.860	5.99110E-02	1729.0	7.27380E-02	92.380
8150	8.1500	-1.4840	6.82250E-02	1729.0	6.36750E-04	92.380
8200	8.2000	-29.600	5.19680E-02	1729.0	0.25330	92.380
8250	8.2500	-23.900	5.52620E-02	1729.0	0.16520	92.380
8300	8.3000	-5.9540	6.56400E-02	1729.0	1.02500E-02	92.380
8350	8.3500	30.270	8.65910E-02	1729.0	0.26500	92.380
8400	8.4000	83.800	0.11750	1729.0	2.0310	92.380
8450	8.4500	98.930	0.13120	1994.0	2.4540	93.260
8500	8.5000	33.930	9.85990E-02	1994.0	0.26870	93.260
8550	8.5500	-9.6450	7.67440E-02	1994.0	2.33230E-02	93.260
8600	8.6000	-69.900	4.65210E-02	1994.0	1.2250	93.260
8650	8.6500	-49.070	5.66540E-02	1994.0	0.60470	93.270
8700	8.7000	49.800	0.10650	1994.0	0.62290	93.270
8750	8.7500	105.40	0.13590	318.00	2.7870	93.420
8800	8.8000	129.10	0.21030	318.00	4.1790	100.80
8850	8.8500	124.00	0.23820	1994.0	3.8590	104.90
8900	8.9000	1.9250	0.17690	1994.0	9.2969CE-04	104.90
8950	8.9500	-21.830	0.16500	1994.0	0.11950	104.90
9000	9.0000	-75.420	0.13810	1994.0	1.4260	104.90
9050	9.0500	-54.290	0.14970	1994.0	0.73910	104.90
9100	9.1000	10.990	0.18150	1994.0	3.03060E-02	104.90
9150	9.1500	16.730	0.18440	1994.0	7.01640E-02	104.90
9200	9.2000	20.450	0.18620	1994.0	0.10490	104.90
9250	9.2500	9.2560	0.18060	1994.0	2.14960E-02	104.90
9300	9.3000	-6.5100	0.17270	1994.0	1.06280E-02	104.90
9350	9.3500	-20.370	0.16580	1994.0	0.10410	104.90
9400	9.4000	-32.730	0.15960	1994.0	0.26870	104.90
9450	9.4500	-22.050	0.16490	1994.0	0.12190	104.90
9500	9.5000	7.4760	0.17970	1994.0	1.40190E-02	104.90
9550	9.5500	63.570	0.20790	1994.0	1.0130	104.90
9600	9.6000	56.350	0.20420	1994.0	0.79650	104.90
9650	9.6500	8.5780	0.18030	1994.0	1.84530E-02	104.90
9700	9.7000	-56.920	0.14740	1994.0	0.81240	104.90
9750	9.7500	-85.420	0.11260	-62.520	1.8300	106.60
9800	9.8000	-92.990	7.37730E-02	-62.520	1.7280	110.00
9850	9.8500	19.810	0.12530	1994.0	9.34400E-02	110.00
9900	9.9000	79.570	0.15530	1994.0	1.5880	110.00
9950	9.9500	95.170	0.16310	1994.0	2.2720	110.00

MAXIMUN DUCTILITIES AND EXCURSION RATIOS

DISPLACEMENT DEFINATION: J1= 3.488 E1= 2.488
ENERGY DEFINATION #1: J2= 36.31 E2= 36.25
ENERGY DEFINATION #2: J3= 2.938 E3= 2.409

```
*---------------------------------------*
*--- MEMORY UTILIZATION  ......... ----*
*--- IZ= 12139,    MEM= 1.734%    ----*
*---------------------------------------*
*--- ELAPSED CPU TIME      0.52 SEC ----*
*--- TOTAL CPU TIME      218.98 SEC ----*
*---------------------------------------*
```

STRUCTURE....: TWO-STORY TRUSS STRUCTURE
SOLUTION.... STRUCTURAL RESPONSE DUE TO 1940 EL CENTRO E-W COMPONENT

TIME: 13:49:05, DATE: 12/01/90
TIME: 13:49:05, DATE: 12/01/90

DEGREE OF FREEDOM # 7 IS READ FROM UNIT # 27 JOINT # 6, DIRECTION: FX

STEP	TIME	LOAD	DISPLACEMENT	VELOCITY	ACCELERATION
0	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
50	5.00000E-02	0.56232	2.31238E-03	8.86227E-02	1.4850
100	1.00000E-01	0.75374	9.31945E-03	0.17423	-0.23063
150	0.15000	0.92929	1.63405E-02	9.01561E-02	-1.8919
200	0.20000	0.48752	1.86368E-02	-2.30913E-02	-3.3528
250	0.25000	1.6917	1.53898E-02	-6.48114E-02	1.3683
300	0.30000	1.3193	1.28964E-02	-4.23889E-02	1.3112
350	0.35000	2.4767	1.19839E-02	4.34790E-02	4.9028
400	0.40000	0.94643	2.13993E-02	0.26888	-1.9134
450	0.45000	-1.6213	2.45666E-02	-0.27073	-14.642
500	0.50000	1.1052	-1.74359E-04	-0.54292	5.5928
550	0.55000	2.4684	-1.43560E-02	4.81462E-02	14.239
600	0.60000	0.28012	-3.44294E-03	0.26119	-8.89050E-02
650	0.65000	1.5196	1.06500E-02	0.33308	3.1335
700	0.70000	1.7250	2.89464E-02	0.32705	-3.5088
750	0.75000	-3.6530	3.19526E-02	-0.36374	-22.301
800	0.80000	-9.0514	-1.75993E-02	-1.6519	-25.740
850	0.85000	-4.6005	-0.10885	-1.6159	18.872
900	0.90000	-6.6275	-0.15943	-0.35225	25.373
950	0.95000	-5.5838	-0.14804	0.78305	20.282
1000	1.0000	-5.1116	-8.84156E-02	1.4931	7.2429
1050	1.0500	-1.3427	-1.21287E-02	1.4434	-6.4224
1100	1.1000	0.81396	4.71807E-02	0.87773	-11.339
1150	1.1500	5.7181	8.76209E-02	0.83119	-5.7713
1200	1.2000	-2.2650	0.10697	-0.35636	-40.184
1250	1.2500	-10.248	3.23713E-02	-2.6618	-44.272
1300	1.3000	-11.974	-0.14250	-3.9025	4.9703
1350	1.3500	-14.211	-0.30725	-2.3446	45.458
1400	1.4000	-19.136	-0.36874	-0.19660	39.203
1450	1.4500	-9.0979	-0.31995	2.3069	57.884
1500	1.5000	0.94041	-0.13478	4.9312	37.670
1550	1.5500	10.979	0.13740	5.5230	-13.057
1600	1.6000	14.530	0.37985	3.7538	-63.458
1650	1.6500	11.949	0.46769	-0.54452	-98.673
1700	1.7000	7.0062	0.32929	-4.7250	-62.915
1750	1.7500	-1.9799	5.67364E-02	-6.4658	-6.6994
1800	1.8000	-10.966	-0.27143	-5.3897	49.235
1850	1.8500	-19.952	-0.46332	-2.0909	71.961
1900	1.9000	-20.824	-0.48665	1.0467	61.597
1950	1.9500	-10.671	-0.35622	4.1465	58.314
2000	2.0000	-0.51820	-8.92228E-02	6.1489	12.873
2050	2.0500	9.6346	0.20773	5.2656	-41.702
2100	2.1000	13.904	0.40926	2.5393	-71.667
2150	2.1500	2.2579	0.43225	-1.8803	-97.873
2200	2.2000	-9.3683	0.21696	-6.6066	-81.274

2250	2.2500	1.3047	-0.16400	-7.1891	79.669
2300	2.3000	15.090	-0.36016	0.22650	177.36
2350	2.3500	5.0999	-0.17783	5.8375	36.950
2400	2.4000	-4.8895	0.11362	5.0543	-56.214
2450	2.4500	-12.250	0.25595	-7.70495E-02	-136.29
2500	2.5000	14.283	0.12653	-3.8594	9.9195
2550	2.5500	7.2526	-2.43282E-02	-1.8699	43.935
2600	2.6000	-0.95906	-8.58412E-02	-0.99368	-6.28871E-02
2650	2.6500	5.8256	-0.11789	0.29750	60.115
2700	2.7000	15.937	-2.17201E-02	3.4392	46.826
2750	2.7500	9.1392	0.17193	3.6619	-30.933
2800	2.8000	2.3417	0.29175	0.65513	-87.099
2850	2.8500	6.8564	0.22482	-2.9439	-49.223
2900	2.9000	-0.23693	3.59282E-02	-4.2343	-5.8080
2950	2.9500	3.5817	-0.16593	-3.3694	53.311
3000	3.0000	7.6104	-0.23634	1.0387	99.025
3050	3.0500	-2.5555	-9.34694E-02	3.8245	0.10624
3100	3.1000	0.32331	6.34996E-02	2.2008	-34.072
3150	3.1500	11.403	0.14540	1.3280	-5.2819
3200	3.2000	5.9270	0.16700	-4.44889E-02	-47.484
3250	3.2500	4.5398	0.12405	-2.2942	-23.267
3300	3.3000	11.224	1.21801E-02	-1.6426	34.590
3350	3.3500	0.76312	-3.59128E-02	-0.52099	6.3987
3400	3.4000	-9.6981	-6.79161E-02	-1.0009	-22.336
3450	3.4500	-9.9910	-0.14463	-1.8478	0.41577
3500	3.5000	5.6923	-0.22119	-0.88238	39.583
3550	3.5500	-0.66294	-0.20531	1.6186	48.784
3600	3.6000	1.3905	-7.81419E-02	3.2044	14.161
3650	3.6500	-4.8040	7.12429E-02	2.2298	-50.337
3700	3.7000	-7.5248	0.10219	-1.1873	67.595
3750	3.7500	0.10109	-6.00282E-03	-2.5019	1.7097
3800	3.8000	-9.8971	-0.12615	-2.3401	-2.0494
3850	3.8500	4.0078	-0.21860	-0.71232	69.718
3900	3.9000	5.3495	-0.16365	2.8511	63.667
3950	3.9500	-2.5170	2.71318E-02	3.8583	-37.455
4000	4.0000	-17.309	0.13620	-9.81423E-02	-110.06
4050	4.0500	5.6982	1.58764E-02	-3.6232	6.0270
4100	4.1000	12.791	-0.10058	-0.42695	83.807
4150	4.1500	7.6105	-3.65762E-02	2.4135	19.079
4200	4.2000	9.3803	8.57551E-02	2.3063	-2.4124
4250	4.2500	8.0796	0.19767	1.8701	-35.082
4300	4.3000	0.40854	0.22117	-1.3115	-78.627
4350	4.3500	-7.2625	6.82204E-02	-4.4752	-41.410
4400	4.4000	-14.513	-0.18993	-5.5128	0.86482
4450	4.4500	-10.515	-0.42889	-3.4097	73.300
4500	4.5000	-16.990	-0.52928	-1.3300	-4.4890
4550	4.5500	-4.0804	-0.61446	-2.1517	-11.610
4600	4.6000	8.8286	-0.70564	-0.73303	76.075
4650	4.6500	10.863	-0.62950	3.5980	57.419
4700	4.7000	7.3232	-0.42515	3.7505	-35.934
4750	4.7500	8.1110	-0.27829	2.4536	6.00513E-02
4800	4.8000	8.0649	-0.13402	3.6935	41.956
4850	4.8500	9.6174	9.22361E-02	4.9264	-12.005
4900	4.9000	-1.2022	0.27986	1.9324	-85.093
4950	4.9500	12.729	0.30471	-0.18886	1.7619
5000	5.0000	0.87823	0.28855	-0.83696	-40.652
5050	5.0500	3.1580	0.18347	-3.0917	-9.8051
5100	5.1000	12.717	6.78695E-02	-0.68403	81.585
5150	5.1500	5.8120	0.11405	1.9378	14.348
5200	5.2000	-1.0934	0.20572	1.4106	-25.460
5250	5.2500	-7.9988	0.23308	-0.60187	-58.570
5300	5.3000	-14.181	0.12315	-3.7289	-49.147
5350	5.3500	-3.0089	-7.58678E-02	-3.2794	62.447
5400	5.4000	8.1631	-0.13554	1.2332	103.59
5450	5.4500	3.9531	3.56998E-02	4.9626	31.204
5500	5.5000	-3.5423	0.28123	4.0118	-69.072
5550	5.5500	-5.9117	0.37231	-0.64153	-100.77
5600	5.6000	-1.0170	0.24322	-3.8940	-31.652
5650	5.6500	-8.3640	2.49593E-02	-4.5446	3.5766
5700	5.7000	5.1443	-0.16279	-2.0651	103.01
5750	5.7500	-2.9102	-0.14495	2.3957	57.957
5800	5.8000	-1.9848	1.54793E-02	3.5881	4.4007
5850	5.8500	4.0860	0.19274	3.3466	-15.290
5900	5.9000	1.2847	0.32216	1.3326	-69.976
5950	5.9500	-5.5402	0.29110	-2.6099	-74.971
6000	6.0000	4.2884	9.55096E-02	-4.3573	20.822
6050	6.0500	4.8074	-5.87240E-02	-1.4161	71.241
6100	6.1000	-2.9604	-5.23208E-02	1.2984	28.246
6150	6.1500	-8.5240	2.47599E-02	1.4019	-14.180
6200	6.2000	-1.7896	8.15612E-02	0.95899	-3.7766
6250	6.2500	3.1652	0.12812	0.94644	-0.96995
6300	6.3000	2.2796	0.16755	0.51169	-14.076
6350	6.3500	1.6600	0.17781	-0.14988	-18.926
6400	6.4000	-1.6947	0.14398	-1.2041	-19.658
6450	6.4500	-4.1419	6.43170E-02	-1.8470	-3.6964
6500	6.5000	2.3579	-1.65421E-02	-0.96477	43.001
6550	6.5500	1.5884	-2.62012E-03	1.4346	35.452
6600	6.6000	-2.1196	9.29831E-02	1.9708	-13.877
6650	6.6500	-5.5134	0.15973	0.48218	-40.217
6700	6.7000	-6.3982	0.13469	-1.4154	-34.241
6750	6.7500	1.8101	3.29826E-02	-2.1528	25.423
6800	6.8000	8.4790	-6.55243E-03	0.96400	67.055
6850	6.8500	-1.5828	9.63896E-02	2.4511	-14.617
6900	6.9000	-11.644	0.17092	9.29158E-02	-67.263
6950	6.9500	-2.6197	0.11229	-1.9188	-11.231
7000	7.0000	-9.0368	5.81651E-03	-2.2744	-3.3475
7050	7.0500	11.679	-6.76043E-02	0.18513	90.702
7100	7.1000	12.335	5.20344E-02	4.3191	56.094
7150	7.1500	4.1603	0.26853	4.1805	-56.446
7200	7.2000	4.0147	0.40035	-5.15942E-02	-97.561
7250	7.2500	-10.558	0.28319	-4.3965	-59.459
7300	7.3000	-5.4293	4.06128E-03	-5.9993	21.307
7350	7.3500	-1.8030	-0.21764	-2.0706	110.05
7400	7.4000	-1.8427	-0.20482	1.9278	41.291
7450	7.4500	7.5771	-7.24450E-02	3.1958	19.773
7500	7.5000	8.4921	0.11494	4.1733	1.7688
7550	7.5500	5.4955	0.29323	2.3561	-67.320
7600	7.6000	-1.1234	0.32288	-1.0915	-58.610
7650	7.6500	-1.3694	0.21423	-3.0474	-32.927
7700	7.7000	-2.5643	2.86043E-02	-3.9681	16.905
7750	7.7500	-3.0220	-0.11369	-1.2865	68.565
7800	7.8000	-6.8887	-0.10529	1.2559	26.709
7850	7.8500	-3.8740	-2.15781E-02	2.0181	16.966
7900	7.9000	-5.9262	9.45700E-02	2.3324	-17.517
7950	7.9500	-3.9902	0.16644	0.30372	-42.802

8000	8.0000	0.25244	0.14899	-0.61533	-2.6309
8050	8.0500	-3.3115	0.10906	-1.1449	-16.010
8100	8.1000	4.1308	4.57637E-02	-0.93072	31.548
8150	8.1500	-2.3843	4.36606E-02	0.73792	16.115
8200	8.2000	-11.636	7.16575E-02	-0.14451	-44.084
8250	8.2500	-1.1510	1.76869E-02	-1.3667	25.215
8300	8.3000	13.158	1.97387E-02	1.9391	73.918
8350	8.3500	1.6697	0.17164	3.3252	-21.533
8400	8.4000	9.9647	0.29800	1.7517	-24.273
8450	8.4500	-2.1992	0.33758	-0.53726	-67.522
8500	8.5000	-2.4225	0.22881	-3.5927	-42.635
8550	8.5500	4.6673	3.96079E-02	-3.0119	53.677
8600	8.6000	-5.3126	-5.20376E-02	-0.92739	30.627
8650	8.6500	13.007	-3.73509E-02	2.0264	69.494
8700	8.7000	10.522	0.16345	5.4900	25.918
8750	8.7500	8.6097	0.41716	3.7623	-75.616
8800	8.8000	10.817	0.50945	0.17972	-48.977
8850	8.8500	3.3905	0.47050	-1.6015	-34.707
8900	8.9000	-3.2619	0.33389	-4.0159	-47.082
8950	8.9500	4.4622	0.12310	-3.3621	73.610
9000	9.0000	0.54264	5.49165E-02	0.46609	57.477
9050	9.0500	-4.0157	0.12743	2.0841	15.744
9100	9.1000	-2.5324	0.24461	2.4492	-5.5542
9150	9.1500	-7.9523	0.33325	0.59812	-51.640
9200	9.2000	-7.79334E-02	0.29026	-1.8416	-7.2380
9250	9.2500	7.3034	0.22811	-0.21896	38.713
9300	9.3000	-4.5624	0.24401	0.37222	-17.626
9350	9.3500	-11.224	0.22257	-1.4170	-32.080
9400	9.4000	3.4640	0.14537	-0.99671	47.652
9450	9.4500	3.1749	0.16440	1.6299	37.957
9500	9.5000	3.3900	0.27181	2.3166	-1.7320
9550	9.5500	1.7582	0.37994	1.7247	-29.954
9600	9.6000	-4.6839	0.40976	-0.81513	-67.079
9650	9.6500	-9.3331	0.28734	-3.8605	-38.803
9700	9.7000	-3.7896	8.85879E-02	-3.3501	43.640
9750	9.7500	-11.301	-2.06917E-02	-1.0609	39.146
9800	9.8000	5.0730	-1.70479E-02	1.4219	61.590
9850	9.8500	8.2596	0.13738	4.5982	40.732
9900	9.9000	-4.3110	0.37230	3.7105	-85.982
9950	9.9500	2.6609	0.43025	-1.2557	-75.455

```
*-----------------------------------------*
*---- MEMORY UTILIZATION ...... ...  ----*
*---- IZ=  12139.    MEM= 1.734%     ----*
*-----------------------------------------*
*---- ELAPSED CPU TIME      0.31 SEC ----*
*---- TOTAL CPU TIME      219.29 SEC ----*
*-----------------------------------------*
```

Note   Gdof are printed for the six dof of each joint. Sffix -C denotes a constrained, 'slave' dof. Sffix -R denotes a restrained dof.

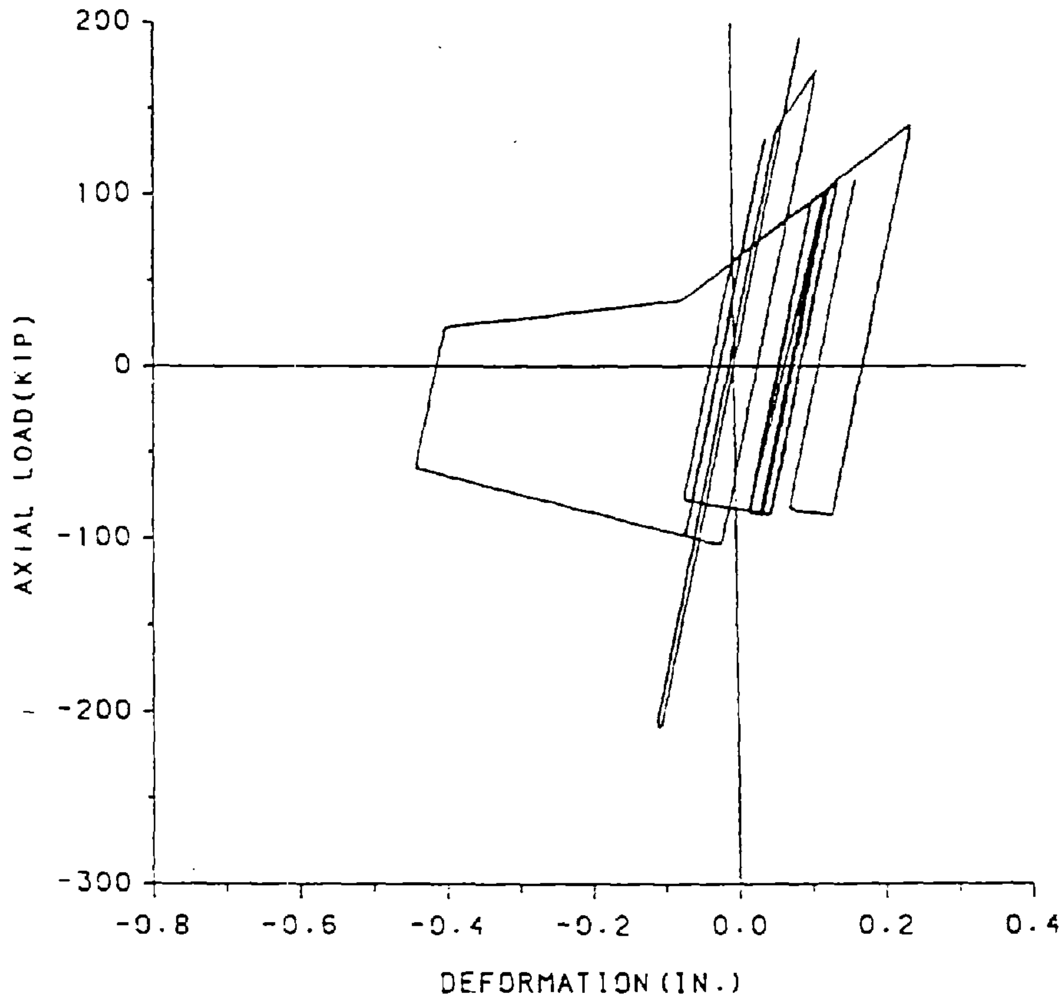


Figure 39. Hysteresis Loops of Member 8

D. FOUR-STORY SHEAR BUILDING

1. Description of Input Information

Figure 40 shows a four-story shear building. each column's moment of inertia of is 4838.85 in^4. Modulus of elasticity is E=3600 ksi. Masses of individual floors are 0.252, 0.288, 0.288, and 0.29 $k\text{-}sec^2/in.$ for the fourth, third, second, and first floors, respectively.

Response spectrum analysis is performed on the structure with consideration of all modes. The SRSS modal combination method is used in the analysis.

2. Input Data

```
ECHO OF INPUT DATA

LINE  ....... 10........20....... 30.    :  .40 ..  ...50. ..: ..60....:...70 ... ...80
  1:  'STRUCTURE DEFINATION'
  2:  '[redacted] FOUR STORY SHEAR BUILDING'
  3:  5 1  2 0 0   1.00  NNODE,NCOS,NSUPT,NCOND,NCONST  SCALE
  4:      1   0.00   0.00    0 00 1 0
  5:      2   0.00   0.00 144.00 1 0
  6:      3   0.00   0.00 270.00 1 0
  7:      4   0.00   0.00 396.00 1 0
  8:      5   0.00   0 00 522.00 1 0
  9:      1 0 0    0 1 0                COSINE
 10.      1 1 1 1 1 1 1    0 0       ! RESTRAINT
 11.      2 0 1 1 1 1 1    3 1       ! RESTRAINT
 12.    1  NMAT
 13: '3D-BEAM ' 3600 1400 11.8 0 0 0.95 9677 745  9677.745
 14: 0 0 0    FALSE.  KG : AXL, FORM, ASSY
 15: 4   NELEM
 16: '3D-BEAM' 'MEMBER  1' 1  1  2  0 1 0  0 0  1  000000            0
 17: '3D-BEAM' 'MEMBER  2' 1  2  3  0 1 0  0 0  1  000000            0
 18: '3D-BEAM' 'MEMBER  3' 1  3  4  0 1 0  0 0  1  000000            0
 19: '3D-BEAM' 'MEMBER  4' 1  4  5  0 1 0  0 0  1  000000            0
 20:  4  1  .FALSE. MASS
 21: 2  0.29    0.29    0.29    0 0 0 0 0 0   0 0
 22: 3  0.288   0.269   0.288   0 0 0 0 0 0   0 0
 23: 4  0.288   0.288   0.288   0 0 0 0 0 0   0 0
 24  5  0 252   0.252   0.252   0 0 0 0 0 0   0 0
 25  0 0   DAMPING
 26  'SCL05 - SOLUTION'
 27: 'RESPONSE SPECTRUM ANALYSIS'
 28: 'SRSS METHOD'  4   0.05  1  5  4   !ICOM NMODE DAMP NA NAF IPRT
 29: 3  10   NSTEP MEIG
 30: 1   'DISP' .TRUE.  !ASCALE,OPTION,PRINT
 31: 1 0 0    0 1 0
 32  1  !IDIR
 33: 0          0
 34: 0 124      0 039
 35: 0 154      0.062
 36: 0 244      0.155
 37: 0.723      1.19
 38: 0   0   0 .XLIM YLIM ZLIM
 39: 'STOP'
```

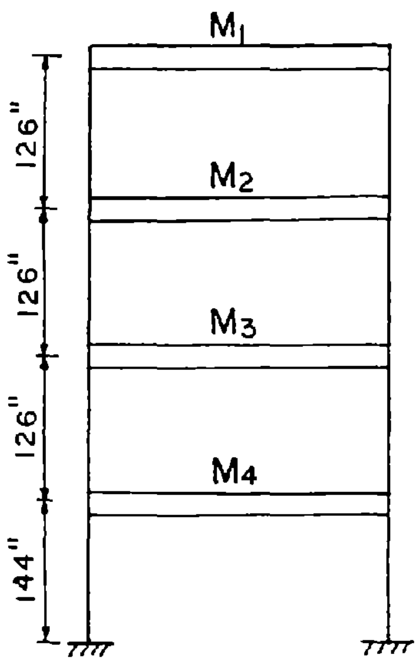


Figure 40. Four-Story Shear Building

3. Output

```
 STRUCTURE..... [redacted]: FOUR STORY SHEAR BUILDING                                          TIME: 11:22:40, DATE: 09/29/93
 SOLUTION. ...:

*** PROGRAM FEM ***         DOUBLE PRECISION VERSION


    NODE COORDINATES AND DEGREES OF FREEDOM

   TOTAL NUMBER OF DEGREES OF FREEDOM.. ...  .. ..     30
   NUMBER OF DEGREES OF FREEDOM CONDENSED OUT.. ..      0
   NUMBER OF FREE DEGREES OF FREEDOM... ... ... ..      4
   NUMBER OF RESTRAINED DEGREES OF FREEDOM.......      26

     NODE COS#     X-COORD        Y-COORD        Z-COORD        FX      FY      FZ      MX      MY      MZ
        1    1    0.00000E+00    0.00000E+00    0.00000E+00     5-R     6-R     7-R     8-R     9-R    10-R
        2    1    0.00000E+00    0.00000E+00    144.00          1      11-R    12-R    13-R    14-R    15-R
        3    1    0.00000E+00    0.00000E+00    270.00          2      16-R    17-R    18-R    19-R    20-R
        4    1    0.00000E+00    0.00000E+00    396.00          3      21-R    22-R    23-R    24-R    25-R
        5    1    0.00000E+00    0.00000E+00    522.00          4      26-R    27-R    28-R    29-R    30-R
         NOTE  R - RESTRAINED DEGREE OF FREEDOM
               C - CONSTRAINED DEGREE OF FREEDOM


    DIRECTION COSINES ..

COS( 1)   VX:  1.00000 I +0.00000 J +0.00000 K   VY:  0.00000 I -1.00000 J +0.00000 K   VZ.  0.00000 I +0.00000 J +1.00000 K
 STRUCTURE....: EXAMPLE 5: FOUR STORY SHEAR BUILDING                                          TIME: 11:22.40, DATE. 09/29/93
 SOLUTION...  :


    3-D ELASTIC BEAM ELEMENT
    ************************

   MATL.    E      GAMMA        AX        AY         AZ         IX         IY         IZ

      1 3.600E-03 1.400E-03  11.8      0.000E+00 0.000E+00 0.950      9.678E+03 9.678E+03

 STRUCTURE.. .. EXAMPLE 5: FOUR STORY SHEAR BUILDING                                          TIME: 11:22.40, DATE  09/29/93
 SOLUTION.... :


ELEMENT 08,  3D BEAM ELEMENT

                       #  MATL START   END  REL CD   LENGTH   ........... Y-AXIS ...........   START DIST    END DIST     PKG
MEMBER  1              1    1     1     2            144.0     0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00   1.000
MEMBER  2              2    1     2     3            126.0     0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00   1.000
MEMBER  3              3    1     3     4            126.0     0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00   1.000
MEMBER  4              4    1     4     5            126.0     0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00   1.000
 STRUCTURE... : EXAMPLE 5: FOUR STORY SHEAR BUILDING                                          TIME: 11:22:40, DATE. 09/29/93
 SOLUTION... .:

 LUMPED NODE MASSES
*******************

   NODE    MX         MY         MZ          IXX         IYY         IZZ         IXY         IYZ         IYZ       IGEN  INC
      2  0.2900     0.2900     0.2900     0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00    0     0
      3  0.2880     0.2880     0.2880     0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00    0     0
      4  0.2880     0.2880     0.2880     0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00    0     0
      5  0.2520     0.2520     0.2520     0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00    0     0

    - THE MASS MATRIX IS NOT CONDENSED WITH THE STRUCTURAL STIFFNESS MATRIX.


     PROPORTIONAL DAMPING COIEFICIENTS
    **********************************
    ALPHA=  0.00000E+00   BETA=  0.00000E+00



*.......................................*
*.... MEMORY UTILIZATION ..... .... ....*
*.... IZ=   2013,     MEM= 0.288%   ....*
*.......................................*
*.... ELAPSED CPU TIME      0.14 SEC ...*
*.... TOTAL CPU TIME        0.14 SEC ...*
*.......................................*

 STRUCTURE. ... EXAMPLE 5: FOUR STORY SHEAR BUILDING                                          TIME: 11:22:40, DATE: 09/29/93
 SOLUTION.  ..  RESPONSE SPECTRUM ANALYSIS                                                     TIME: 11:22:40, DATE: 09/29/93



                                   ** RESPONSE SPECTRUM ANALYSIS **

                                   NOTE: MODAL COMBINATION APPROACH CAN BE SRSS OR CQC
 STRUCTURE. .. EXAMPLE 5: FOUR STORY SHEAR BUILDING                                           TIME: 11:22 40, DATE. 09/29/93
 SOLUTION.. .  RESPONSE SPECTRUM ANALYSIS                                                     TIME: 11:22:40, DATE: 09/29/93

SOLUTION #5, SRSS MODAL COMBINATION METHOD
******************************************

 NUMBER OF MODES CONSIDERED ......  ..      4
 DAMPING RATIO FOR ALL MODES . ....... .    0.500E-01
 NO  OF SEISMIC COMPONENTS CONSIDERED  .    1
 NO. OF INPUT POINTS FOR SPECTRUM ......    5
         MODE:           1               2               3               4
FREQ (RAD/SEC):      8.6933          25.780          40.599          50.469
FREQUENCY (HZ):      1.3836          4.1030          6.4616          8.0324
  PERIOD (SEC):     0.72276         0.24372         0.15476         0.12450
  EIGENVECTORS:
    DOF(      1)    0.46203          1.0000          1.0000        -0.53637
```

DOF(	2)	0.72311	0.74774	-0.61721	1.0000
DOF(	3)	0.90868	-0.16932	-0.83252	-0.97358
DOF(	4)	1.0000	-0.95299	0.84311	0.47006

STRUCTURE.... EXAMPLE 5: FOUR STORY SHEAR BUILDING   TIME: 11:22:40, DATE: 09/29/93
SOLUTION .... RESPONSE SPECTRUM ANALYSIS   TIME: 11:22:40, DATE: 09/29/93

** DISPLACEMENT SPECTRUM VALUES :INPUTING TRANSLATIONAL # 1

DIRECTION OF COSINE: 1.00000 I +0.00000 J +0.00000 K

PERIOD	SPECTRUM VALUE
0.000000E+00	0.000000E+00
0.124000	0.390000E-01
0.154000	0.620000E-01
0.244000	0.155000
0.723000	1.19000

GLOBAL BASE ACCE.-SPECTRUM VALUES IN THE X DIRECTION

89.89 102.8 103.5 103.5

GLOBAL BASE ACCE.-SPECTRUM VALUES IN THE Y DIRECTION

0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00

GLOBAL BASE ACCE.-SPECTRUM VALUES IN THE Z DIRECTION

0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00

GLOBAL BASE DISP.-SPECTRUM VALUES IN THE X DIRECTION

1.189 0.1547 6.2766E-02 3.9360E-02

GLOBAL BASE DISP.-SPECTRUM VALUES IN THE Y DIRECTION

0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00

GLOBAL BASE DISP.-SPECTRUM VALUES IN THE Z DIRECTION

0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00

STRUCTURE... EXAMPLE 5: FOUR STORY SHEAR BUILDING   TIME: 11:22:40, DATE: 09/29/93
SOLUTION .... RESPONSE SPECTRUM ANALYSIS   TIME: 11:22:40, DATE: 09/29/93

EFFECTIVE MASS IN GCS" TRANSLATIONAL DIRECTIONS

EFFECTIVE MASS LIMIT IN GCS" X DIRECTION IS 0.000000E+00
EFFECTIVE MASS LIMIT IN GCS" Y DIRECTION IS 0.000000E+00
EFFECTIVE MASS LIMIT IN GCS" Z DIRECTION IS 0.000000E+00
NOTE: TOTAL STRUCTURAL MASS IN X DIRECTION IS 1.11800
NOTE: TOTAL STRUCTURAL MASS IN Y DIRECTION IS 0.000000E+00
NOTE. TOTAL STRUCTURAL MASS IN Z DIRECTION IS 0.000000E+00

MODE	GCS X-DIRECTION(%)	GCS Y-DIRECTION(%)	GCS Z-DIRECTION(%)
1	0.9331	0.0000E+00	0.0000E+00
2	0.5752E-01	0.0000E+00	0.0000E+00
3	0.8291E-02	0.0000E+00	0.0000E+00
4	0.1111E-02	0.0000E+00	0.0000E+00

STRUCTURE....: EXAMPLE 5: FOUR STORY SHEAR BUILDING   TIME: 11:22:40, DATE 09/29/93
SOLUTION...... RESPONSE SPECTRUM ANALYSIS   TIME: 11:22:40, DATE 09/29/93

TOTAL MAXIMUM STRUCTURAL RESPONSES

D.O.F.	DISPL	D.O.F.	DISPL	D.O.F.	DISPL
1	0.6715	2	1.049	3	1.318
4	1.450				

STRUCTURE.....: EXAMPLE 5: FOUR STORY SHEAR BUILDING   TIME: 11:22:40, DATE: 09/29/93
SOLUTION......: RESPONSE SPECTRUM ANALYSIS   TIME: 11:22:40, DATE: 09/29/93

TOTAL MAXIMUM EQUIVALENT EARTHQUAKE FORCES

D.O.F	FORCE	D.O.F.	FORCE	D.O.F	FORCE
1	58.45	2	84.66	3	29.16
4	162.9				

STRUCTURE.....: EXAMPLE 5: FOUR STORY SHEAR BUILDING   TIME: 11:22:40, DATE: 09/29/93
SOLUTION .....: RESPONSE SPECTRUM ANALYSIS   TIME: 11:22:40, DATE: 09/29/93

TOTAL MAXIMUM ELEMENT FORCES-

3D BEAM FORCES...

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ
1	1	FORCE	1	0.000000E+00	0.000000E+00	94.0134	0.000000E+00	6768.97	0.000000E+00
		FORCE	2	0.000000E+00	0.000000E+00	94.0134	0.000000E+00	6768.97	0.000000E+00
2	1	FORCE	2	0.000000E+00	0.000000E+00	79.1718	0.000000E+00	4987.83	0.000000E+00
		FORCE	3	0.000000E+00	0.000000E+00	79.1718	0.000000E+00	4987.83	0.000000E+00
3	1	FORCE	3	0.000000E+00	0.000000E+00	57.0422	0.000000E+00	3593.66	0.000000E+00
		FORCE	4	0.000000E+00	0.000000E+00	57.0422	0.000000E+00	3593.66	0.000000E+00
4	1	FORCE	4	0.000000E+00	0.000000E+00	28.7220	0.000000E+00	1809.49	0.000000E+00
		FORCE	5	0.000000E+00	0.000000E+00	28.7220	0.000000E+00	1809.49	0.000000E+00

STRUCTURE.....: EXAMPLE 5. FOUR STORY SHEAR BUILDING   TIME: 11:22:40, DATE: 09/29/93
SOLUTION.....: RESPONSE SPECTRUM ANALYSIS   TIME: 11:22:40, DATE: 09/29/93

TOTAL REACTIONS AT GCS" ORIGIN

	FX	FY	FZ	MX	MY	MZ
GCS SUMM	94.01341	0.0000000E+00	0.0000000E+00	0.0000000E+00	34072.17	0.0000000E+00

STRUCTURE.....: EXAMPLE 5: FOUR STORY SHEAR BUILDING   TIME: 11:22:40, DATE: 09/29/93

SOLUTION.....: RESPONSE SPECTRUM ANALYSIS   TIME: 11:22:40, DATE. 09/29/93

TOTAL MAXIMUM INERTIA FORCES

D.O.F.	FORCE	D.O.F.	FORCE	D.O.F.	FORCE
1	17.59	2	23.91	3	28.88
4	28.72				

```
*-------------------------------------*
*--- MEMORY UTILIZATION ........ ----*
*--- IZ=   2603,    MEM= 0.372%   ----*
*-------------------------------------*
*--- ELAPSED CPU TIME    0.12 SEC ----*
*--- TOTAL CPU TIME      0.26 SEC ----*
*-------------------------------------*
```

E. THREE-STORY FRAME-SHEAR WALL SPACE BUILDING

1. Structural Configuration For a three-story frame-shear wall space structure, Figure 41 shows the structural configuration.

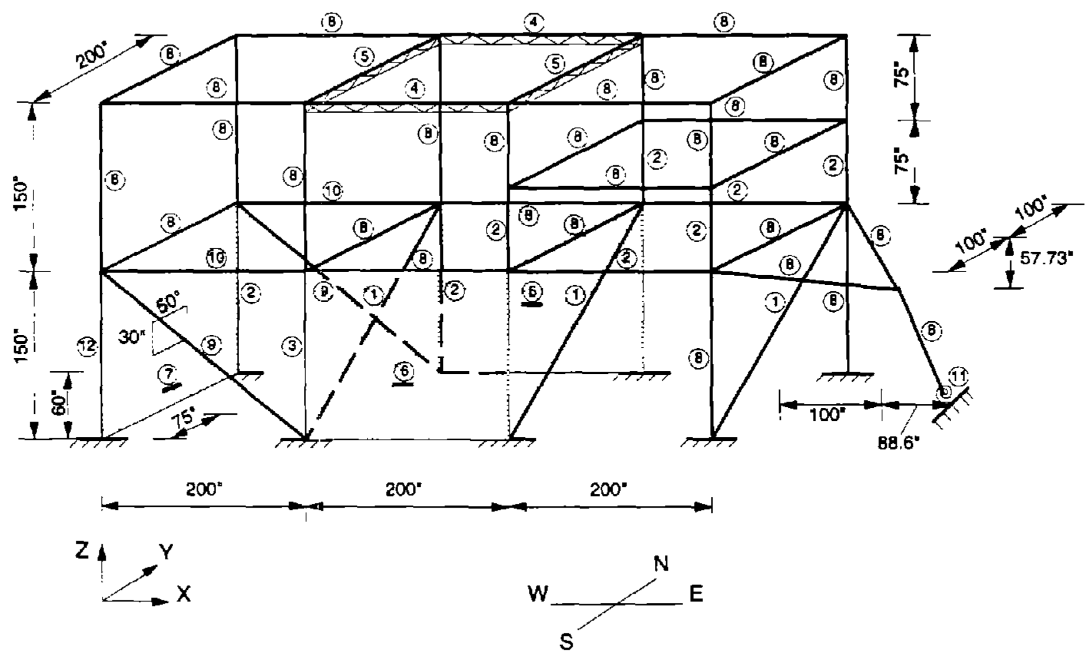


Figure 41. Structural Configuration

Note In Figure 41, the number in a circle stands for element type, where

1 Box bracing member

2 Inelastic-3D beam-column (bilinear hysteresis model)

3 Finite-segment element (box-section, bilinear stress-strain)

4 Long-direction girder

5 Short-direction girder

6 Shear wall

7 Perforated shear wall

8 Elastic-3D beam-column

9 I-shape bracing member

10 Inelastic 3D beam-column (Takeda hysteresis model)

11 Spring element (bilinear hysteresis model)

12 Finite-segment element (tube-section, Ramberg-Osgood stress-strain)

2. Member Sizes and Material Properties

1 Box bracing member

L(length) = 250 in, □ 12*6*5/16, A(area) = 10.6 in^2, r=2.5, L/r=99.6

2 Inelastic 3D beam-column (bilinear model)

W12*65, A = 19.1 in^2, I_y = 533 in^4, I_z = 174 in^4, Z_y = 96.8 in^3

Z_z = 44.1 in^3, J_x = 2.18 in^4, M_{py} = 3484.8 k-in, M_{pz} = 1587 k-in

3 Finite-segment element (box section)

□ 12*12*3/8. Bilinear stress-strain model with strain hardening of 3%.

4 Long-direction girder

First buckling displacement 0.004 rad

First buckling load 2000 k-in

5 Short-direction girder

First buckling displacement 0.005 rad

First buckling load 2000 k-in

Strain-hardening ratio 3%

6 RC shear wall

Axial stiffness

Compression k_s = 7000 k/in

Pre-yield tensile stiffness k_t = 6000 k/in

Post-yield tensile stiffness k_{t2} = 60 k/in

Yield force F_y = 2000 kips (for unit length)

Bending hysteresis curve

NSEG (number of points on backbone curve) = 4

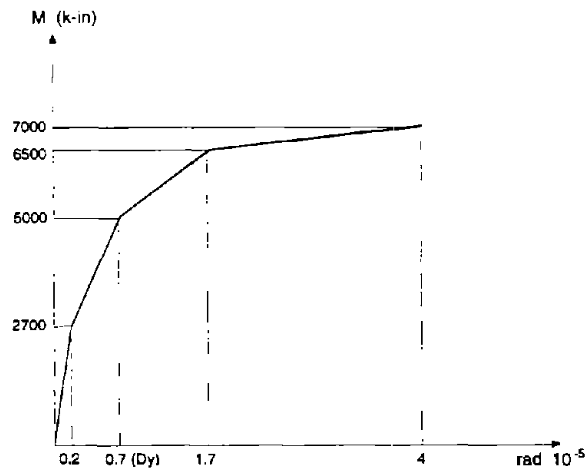


Figure 42. Bending Hysteresis Curve

k-in	rad
7000	$4.0*10^{-5}$
6500	$1.7*10^{-5}$
5000	$0.7*10^{-5}$
2700	$0.2*10^{-5}$

(for unit length)

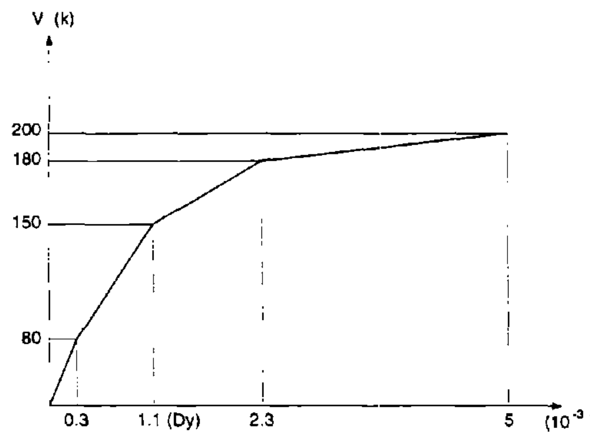


Figure 43. Shear Hysteresis Curve

k-in	in/in
200	$5.0*10^{-3}$
180	$2.3*10^{-3}$
150	$1.1*10^{-3}$
80	$0.3*10^{-3}$

(for unit length)

7 Perforated wall

<u>Axial stiffness</u>

Same as (6)

<u>Shear hysteresis curve</u>

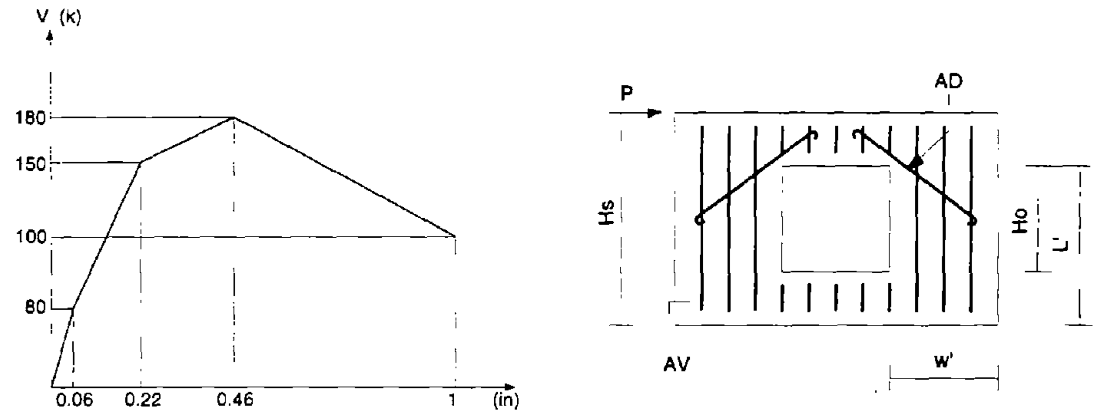


Figure 44. Shear Hysteresis Curve (for true width)

$L' = 90$ in, $w' = 75$ in, $AD = 0.2\ in^2$, $AV = 0.11\ in^2$, $LWP = L'/w'$

8 Elastic 3D-beam-column

W12*65, $A = 19.1\ in^2$, $I_y = 533\ in^4$, $I_z = 174\ in^4$, $J_x = 2.18\ in^4$

9 I-shape bracing member

W10*49, $L = 250\ in^2$, $A = 14.4\ in^2$, $r = 2.54$ in

10 Inelastic 3D beam-column (Takeda hysteresis model)

In Figure 45, PC is the cracking moment and DC is the cracking rotation. PY and DY are the yield moment and the yield rotation, respectively. PU is the ultimate moment and DU is the ultimate rotation.

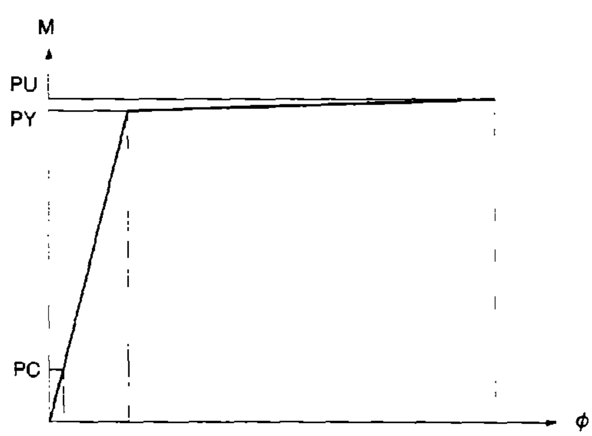


Figure 45. Bending Hysteresis Curve

PC= 250 k-in

DC= 0.00001 rad/length

PY= 1500 k-in

DY= 0.00015 rad/length

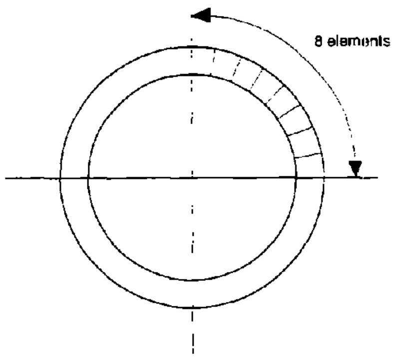
PU= 1550 k-in

DU= 0.00086 rad/length

11 Spring element (bilinear hysteresis model)

EI= 1,000,000 ksi, M_p= 1000 k-in,   Strain hardening ratio 3%

12 Finite-segment element (Ramberg-Osgood stress-strain model)



Tube section: 12*1/2

Figure 46. Finite-Segment Element

3. Masses, Static and Dynamic Loads

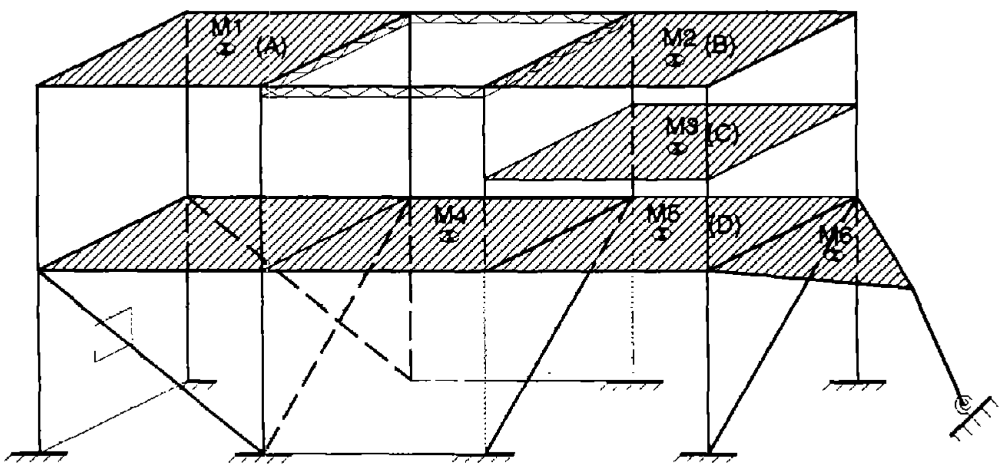


Figure 47. Structural Concentrate Masses

Static loads

Dead load (DL) for all floors = 80 psf, for roof = 60 psf

Live load (LL) for all floors = 90 psf, for roof = 20 psf

(a) First floor

DL+LL= 140 psf, slab area= 600*200= 120,000 in^2= 833.333 ft^2

Total load= 140*833.333= 116,666.67 lbs= 116.67 kips

Total beam number= 10

Uniform load for each beam= 116.67/(10*200)= 0.0583 k/in

Total mass M_4 = 116.67/386 = 0.302 k-sec^2/in

M_5 = 0.02 k-sec^2/in M_6 = 0.2 k-sec^2/in

(b) Second floor

DL+LL= 140 psf, slab area= 200*200= 40,000 in^2= 277.78 ft^2

Total load= 140*277.783= 38.89 kips

Total beam number= 4

Uniform load for each beam= 38.89/(4*200)= 0.0486 k/in

Total mass M_3= 38.89/386= 0.1 k-sec^2/in

(c) Roof

DL+LL= 80 psf, slab area= 200*200= 40,000 in^2= 277.78 ft^2

Total load= 80*277.783= 22.22 kips

Total beam number= 4

Uniform load for each beam= 22.22/(4*200)= 0.0278 k/in

Total mass M_1= M_2= 22.22/386= 0.0576 k-sec^2/in

Dynamic loads

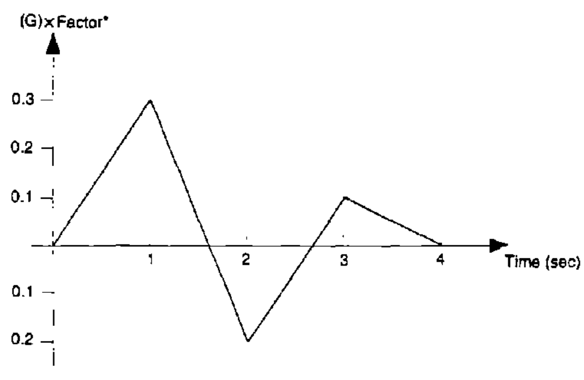


Figure 48. Dynamic Load History

Note *Factor can be adjustable.

Load conditions

Elastic (1) Static loads

(2) Static loads with P-Δ effect

(3) Dynamic loads only

(4) Dynamic loads and static loads

(5) Dynamic loads and static loads with P-Δ effect

(6) Eigenvalues, buckling

Inelastic (7) Static increment displacement

(8) Dynamic loads

4. Member and Joint Numbering

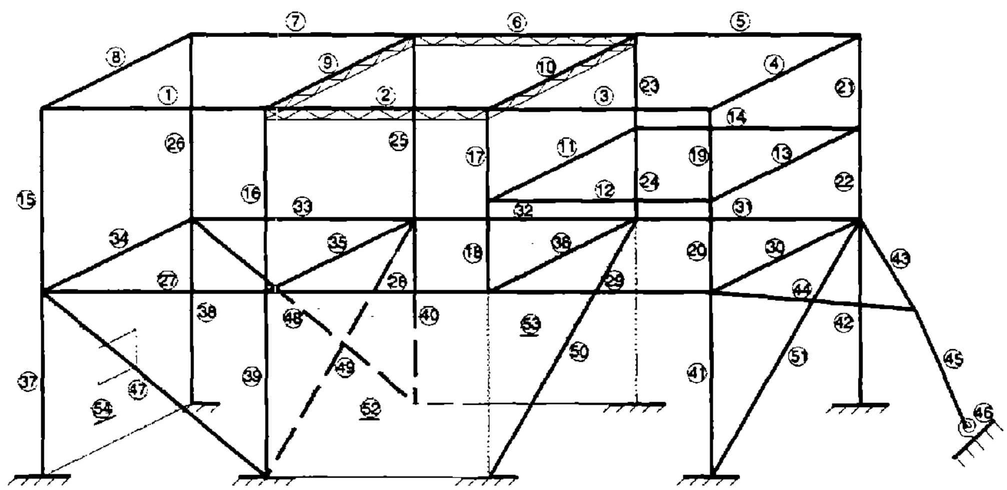


Figure 49. Member Numbering

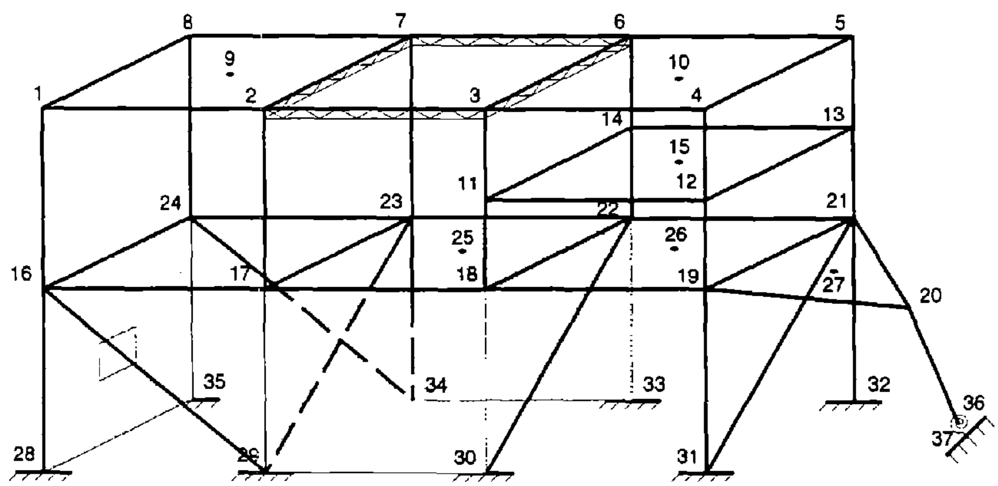


Figure 50. Joint Numbering

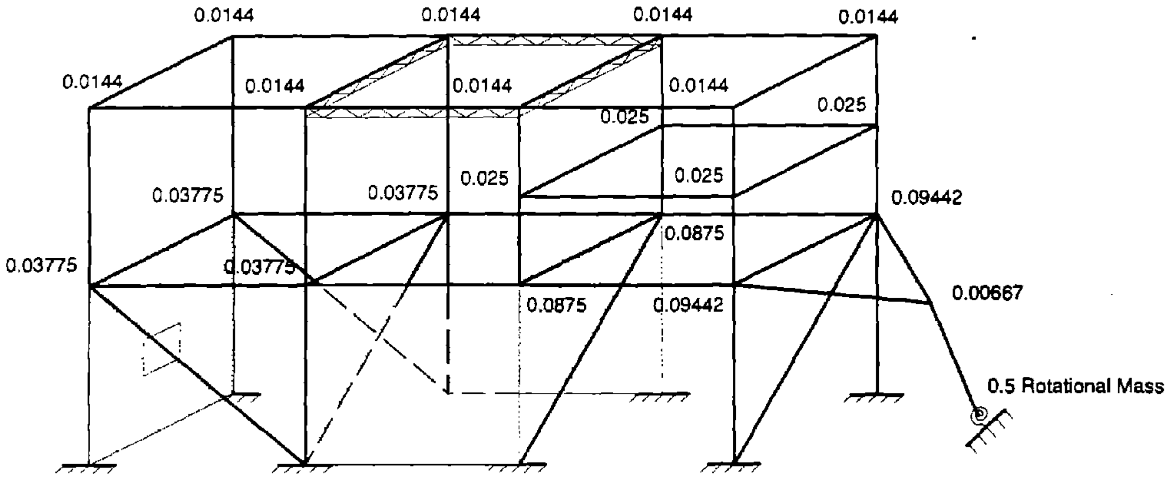


Figure 51. Joint Translational Mass

5. Initial Column Load for P-Δ Effects

Element No.	Accumulated Mass (k-sec^2/in)	Force (kip)
15	0.01440	5.5584
16	0.01440	5.5584
17	0.01440	5.5584
18	0.03940	15.2084
19	0.01440	5.5584
20	0.03940	15.2084
21	0.01440	5.5584
22	0.03940	15.2084
23	0.01440	5.5584
24	0.03940	15.2084
25	0.01440	5.5584
26	0.01440	5.5584
41	0.13382	51.6540
42	0.13382	51.6540
45	0.00578	2.2310
52	0.17930	69.2100
53	0.17930	69.2100
54	0.10430	40.2598

6. Input Data

```
'THREE-STORY BUILDING'
 37 1 8  2 8  1.                            : NNODE,NCOS,NSUPT,NCOND,NCONST SCALE
 1    0.00    0.00      300    1   3 : ID X Y Z ICOS IGEN
 1   200  0   0                      : DID DX DY DZ
 5    600     200       300    1   3 : ID X Y Z ICOS IGEN
 1  -200  0   0                      : DID DX DY DZ
 9    100     100       300    1   0 : ID X Y Z ICOS IGEN
10    500     100       300    1   0   ID X Y Z ICOS IGEN
11    400     0.00      225    1   0   ID X Y Z ICOS IGEN
12    600     0.00      225    1   0 : ID X Y Z ICOS IGEN
13    600     200       225    1   0 ' ID X Y Z ICOS IGEN
14    400     200       225    1   0 : ID X Y Z ICOS IGEN
15    500     100       225    1   0 ' ID X Y Z ICOS IGEN
16    0.00    0.00      150    1   3 : ID X Y Z ICOS IGEN
 1   200  0   0                      : DID DX DY DZ
20    700     100       92.27  1   0   ID X Y Z ICOS IGEN
21    600     200       150    1   3   ID X Y Z ICOS IGEN
 1  -200  0   0                      : DID DX DY DZ
25    300     100       150    1   1 : ID X Y Z ICOS IGEN
 1   200  0   0                      : DID DX DY DZ
27   633.33   100      130.63  1   0 : ID X Y Z ICOS IGEN
28    0.00    0.00      0.00   1   3 : ID X Y Z ICOS IGEN
 1   200  0   0                      : DID DX DY DZ
32    600     200       0.00   1   3 : ID X Y Z ICOS IGEN
 1  -200  0   0                      : DID DX DY DZ
36    788.6   100       0.00   1   0 ' ID X Y Z ICOS IGEN
37    788.6   100       0.00   1   0   ID X Y Z ICOS IGEN
 1 0 0      0 1 0                      VXI VXJ VXK VYI VYJ VYK
28   1 1 1 1 1 1    7 1              : JOINT RESTRAINT
 9   0 0 2 2 2 0    1 1              : JOINT RESTRAINT
15   0 0 2 2 2 0    0 0              : JOINT RESTRAINT
25   0 0 2 2 2 0    0 0              : JOINT RESTRAINT
26   0 0 1 1 1 0    0 0              : JOINT RESTRAINT
27   0 0 2 2 2 0    0 0              : JOINT RESTRAINT
36   1 1 1 1 0 1    0 0              ' JOINT RESTRAINT
37   1 1 1 1 1 1    0 0                JOINT RESTRAINT
 0   0 0 1 1 1 0    0 0                JOINT CONDENSATION
36   0 0 0 0 1 0    0 0              : JOINT CONDENSATION
 1   9  1   1 1                      : JOINT CONSTRAINT
 1   9  7   1 1                      : JOINT CONSTRAINT
 1  10  3   3 1                      : JOINT CONSTRAINT
 1  15 11   3 1                      : JOINT CONSTRAINT
 1  25 16   3 1                      : JOINT CONSTRAINT
 1  25 21   3 1                      : JOINT CONSTRAINT
 1  25 26   0 0                        JOINT CONSTRAINT
 0  27 19   2 1                        JOINT CONSTRAINT
  18          : NMAT
'BRACE  # 1'  29000  10 6  2.51  36  1  12  0.2
'IA_BILN MY # 2 '    1     0.03   29000  533    3464.8     -2    0
'IA_BILN MZ # 3 '    1     0.03   29000  174    1557.6     -2    0
'IA_BILN MX # 4 '    0     0.03   13000  2.18        0     -2    0
'IA_BILN FX # 5 '    0     0.03   29000  19.1        0     -2    0
'TAKEDA  MY # 6 ' 2.5E07  250  1.0E-5  1500 1.5E-4 1550  8.6E-4  0.2
'STABILITY BOX  # 7'  4   36    29000  1  12 12  0 0   0.0  4  4  0.375
 1  0  0  0  0  37.5  0  0  144  0  0  0.03  0  13000  0.01 1
'STABILITY TUBE # 8'  4 36 29000 2  5.5  0 0 0  8  0   0 5
0 0 0 0 0  37.5  0 0 95 03  1  2   0.03  20 13000 0.01 1
'3D-BEAM    # 9 '  29000 13000 19.1 19.1  19.1 2.18 533  174
'LONG_OWJG  # 10'   0.004   2000  -2  0.2
'SHORT_OWJG # 11'   0.005   2000  0.03   -2  0 2
'BRACE  # 12'  29000  14 4  2.54  36  2  12  0.2
'BILINEAR SPRING #13' 1000000 1000 0 03 12 0 2
'AXLMOD FOR WALL #14' 7000 6000 60  2000  0.9  0.2  15  0.2
'BEND1  FOR WALL #15' 4  10  0.7E-05   0.2
   2700      5000      6500      7000
   0.2E-05  0.7E-05  1.7E-05  4E-05
'SHEAR1 FOR WALL #16' 4  10  1.1E-03   0 2
    80       150       180       200
   0.3E-03  1.1E-03  2 3E-03  5E-03
'AXLMOD FOR OPEN-WALL #17' 7000 6000 60  2000  0 9  0.2  15  0.2
'SHEAR2 FOR OPEN-WALL #18' 4    0 4
    80       150      180       100
   0 06      0 22     0.46      1 0
   30    150  1.2 0.2  0.11  : HO HS LWP AD AV
 1 0   0 .TRUE              :  KG- AXL, FORM, ASSY
54          : NELMT
'3D-BEAM' 'MEMBER  1'  9  1  2   0   1   0  0 0  0   000000  0
'IE3DBEAM' 'MEMBER  2' 10 10  3  3  4  5    2  3  0 1 0   0 0  0  0
'3D-BEAM' 'MEMBER  3'  9  3  4   0   1   0  0 0  0   000000  0
'3D-BEAM' 'MEMBER  4'  9  4  5  -1   0   0  0 0  0   000000  0
'3D-BEAM' 'MEMBER  5'  9  6  5   0   1   0  0 0  0   000000  0
'IE3DBEAM' 'MEMBER  6' 10 10  3  3  4  5    7  6  0 1 0   0 0  0  0
'3D-BEAM' 'MEMBER  7'  9  8  7   0   1   0  0 0  0   000000  0
'3D-BEAM' 'MEMBER  8'  9  1  5  -1   0   0  0 0  0   000000  0
'IE3DBEAM' 'MEMBER  9' 11 11  3  3  4  5    2  7 -1 0 0   0 0  0  0
'IE3DBEAM' 'MEMBER 10' 11 11  3  3  4  5    3  6  1 0 0   0 0  0  0
'3D-BEAM' 'MEMBER 11'  9  11 14  -1   0   0  0 0  0   000000  0
'3D-BEAM' 'MEMBER 12'  9  11 12   0   1   0  0 0  0   000000  0
'3D-BEAM' 'MEMBER 13'  9  12 13  -1   0   0  0 0  0   000000  0
'3D-BEAM' 'MEMBER 14'  9  14 13   0   1   0  0 0  0   000000  0
'3D-BEAM' 'MEMBER 15'  9  16  1   1   0   0  0 0  5 558   000000  0
'3D-BEAM' 'MEMBER 16'  9  17  2   1   0   0  0 0  5 558   000000  0
'3D-BEAM' 'MEMBER 17'  9  11  3   1   0   0  0 0  5 558   000000  0
'IE3DBEAM' 'MEMBER 18'  2  2  3  3  4  5   16 11  1 0 0   0 0  15.208  0
'3D-BEAM' 'MEMBER 19'  9  12  4   1   0   0  0 0  5.558   000000  0
'IE3DBEAM' 'MEMBER 20'  2  2  3  3  4  5   19 12  1 0 0   0 0  15 205  0
'3D-BEAM' 'MEMBER 21'  9  13  5   1   0   0  0 0  5 556   000000  0
'IE3DBEAM' 'MEMBER 22'  2  2  3  3  4  5   21 13  1 0 0   0 0  15 208  0
'3D-BEAM' 'MEMBER 23'  9  14  6   1   0   0  0 0  5 558   000000  0
'IE3DBEAM' 'MEMBER 24'  2  2  3  3  4  5   22 14  1 0 0   0 0  15.208  0
'3D-BEAM' 'MEMBER 25'  9  23  7   1   0   0  0 0  5 558   000000  0
'3D-BEAM' 'MEMBER 26'  9  24  8   1   0   0  0 0  5.555   000000  0
'IE3DBEAM' 'MEMBER 27'  6  6  3  3  4  5   16 17  0 1 0   0 0  0  0
'3D-BEAM' 'MEMBER 28'  9  17 18   0   1   0  0 0  0   000000  0
'IE3DBEAM' 'MEMBER 29'  2  2  3  3  4  5   18 19  0 1 0   0 0  0  0
'3D-BEAM' 'MEMBER 30'  9  19 21  -1   0   0  0 0  0   000000  0
'IE3DBEAM' 'MEMBER 31'  2  2  3  3  4  5   22 21  0 1 0   0 0  0  0
'3D-BEAM' 'MEMBER 32'  9  23 22   0   1   0  0 0  0   000000  0
'IE3DBEAM' 'MEMBER 33'  6  6  3  3  4  5   24 23  0 1 0   0 0  0  0
'3D-BEAM' 'MEMBER 34'  9  16 24  -1   0   0  0 0  0   000000  0
'3D-BEAM' 'MEMBER 35'  9  17 23   1   0   0  0 0  0   000000  0
'3D-BEAM' 'MEMBER 36'  9  18 22  -1   0   0  0 0  0   000000  0
```

```
'STABILITY' 'MEMBER 37'  8  28 16  1   0    0  0 0     0
'IE3DBEAM' 'MEMBER 38'  2  2  3  3  4  5   35 24  1 0 0   0 0  0  0
'STABILITY' 'MEMBER 39'  7  29 17  1   0    0  0 0     0
'IE3DBEAM' 'MEMBER 40'  2  2  3  3  4  5   34 23  1 0 0   0 0  0  0
'3D-BEAM' 'MEMBER 41'  9  31 19  1   0   0  0 0  51.654   000000  0
'3D-BEAM' 'MEMBER 42'  9  32 21  1   0   0  0 0  51.654   000000  0
'3D-BEAM' 'MEMBER 43'  9  20 21   7071  7071  0  0 0  0   000000  0
'3D-BEAM' 'MEMBER 44'  9  20 19  -.7071 .7071  0  0 0  0   000000  0
'3D-BEAM' 'MEMBER 45'  9  36 20  0   1   0  0 0  2.231    000000  0
'SPRING' 'MEMBER 46'  13  37 36  5  0  0 1 0   0 0  0
'BRACE' 'MEMBER 47' 12  29 16  1  1   0 1 0  0 0  0
'BRACE' 'MEMBER 48' 12  34 24  1  1   0 1 0  0 0  0
'BRACE' 'MEMBER 49'  1  29 23  1  1   1 0 0  0 0  0
'BRACE' 'MEMBER 50'  1  30 22  1  1   1 0 0  0 0  0
'BRACE' 'MEMBER 51'  1  31 21  1  1   1 0 0  0 0  0
'SHEAR WALL' 'MEMBER 52' 15 16 14  16 17 29 30  1     69.21 0
 SHEAR WALL' 'MEMBER 53' 15 16 14  22 23 34 33  1     69.21 0
'SHEAR_OPEN' 'MEMBER 54' 18 17 17  16 24 35 28  1     40.26 0
  15    1   FALSE.    INMASS FMASS MCOND
1  0.0144  0.0144  0    0 0 0 0 0 0  7 1
11 0.025   0 025   0    0 0 0 0 0 0  3 1
16 0.03775 0.03775 0    0 0 0 0 0 0  1 1
18 0.08775 0 08775 0    0 0 0 0 0 0  0 0
19 0 09442 0 09442 0    0 0 0 0 0 0  0 0
20 0 00667 0.00667 0    0 0 0 0 0 0  0 0
21 0.09442 0 09442 0    0 0 0 0 0 0  0 0
22 0.08775 0.08775 0    0 0 0 0 0 0  0 0
23 0.03775 0.03775 0    0 0 0 0 0 0  1 1
26 0.2     0.2     0    0 0 0 0 0 0  0 0
27 0 0133  0.0133  0    0 0 0 0 0 0  0 0
36 0 0 0                0 0 5 0 0 0 0  0 0
 9 0 0 0                0 0 0 0 0 0  1 1
15 0 0 0                0 0 0 0 0 0  0 0
25 0 0 0                0 0 0 0 0 0  0 0
  0 0  !  DAMP
'SOL01  SOLUTION'
'ELASTIC STATIC ANALYSIS'
1  10     ' NLOAD  MAXELD
0 0 0 0  'END' 0    ! JOINT LOADS
1  1 3  2  'UNIF'  'FZ'  -0 0278
1  4 1  4  'UNIF'  'FZ'  -0 0278
1  9 1  1  'UNIF'  'FZ'  -0 0278
1 11 3  1  'UNIF'  'FZ'  -0.0486
1 27 1  1  'UNIF'  'FZ'  -0.0583
1 29 2  1  'UNIF'  'FZ'  -0.1548
1 32 3  1  'UNIF'  'FZ'  -0.0583
1 36 0  0   UNIF'  'FZ'  -0.1548
1 43 1  1  'UNIF'  'FZ'  -0 0253
0  0 0  0  'END'   'FZ'  -0 0253
'RELEASE'
'SOL02 - SOLUTION'
'LINEAR ACCELERATION METHOD - TRIANGULAR FORCING FUNCTIONS '
'LINEAR' 0  FALSE. .TRUE.            ! INTEG THETA ELAS? UNBAL?
 5000 1  5  .FALSE.                  ! IPRT IWRITE MAXACC SLMASS?
 0.00  1  4.0   386.4                ' TO DT TF GRAV
 'JOINT FX'  9  9           1 1 1      TYPE NUMB IUNIT...
 'JOINT FY'  9  11          1 1 1    ! TYPE NUMB IUNIT...
 'JOINT FX' 15  13          0 0 0    ! TYPE NUMB IUNIT..
 'JOINT FY' 15  14          0 0 0    ! TYPE NUMB IUNIT..
 'JOINT FX' 25  15          0 0 0    ! TYPE NUMB IUNIT  .
 'JOINT FY' 25  16          0 0 0    ! TYPE NUMB IUNIT  .
 'ELE'  2 17         0 0 0
 'ELE'  9 18         0 0 0
 'ELE' 37 19         1 2 1
 'ELE' 22 21         0 0 0
 'ELE' 27 22         0 0 0
 'ELE' 29 23         0 0 0
 'ELE' 38 24         0 0 0
 'ELE' 46 25         0 0 0
 'ELE' 47 26         0 0 0
 'ELE' 50 27         0 0 0
 'ELE' 52 28         0 0 0
 'ELE' 54 29         0 0 0
 'END'  0  0         0 0 0
 1   ! ISP1
  1   1  0.00  1 00  TRUE.     ! NA,ASCALE,TO,DT,PRINT
  1 0 0   0 1 0        V1, V2
  5  5  1  .FALSE.  TRUE.  FALSE  ! IN,NPTS,IDIR,FMT,ECHO.REWIND
TRIANGULAR FORCING FUNCTIONS
DURATION IS 4 SECONDS
0  0 3   0 2  0.1  0 0
'READ UNIT=9  UNIT=10 UNIT=11 UNIT=12 UNIT=13 UNIT=14'
'READ UNIT=15 UNIT=16 UNIT=17 UNIT=18 UNIT=19 UNIT=20'
'READ UNIT=21 UNIT=22 UNIT=23 UNIT=24 UNIT=25 UNIT=26'
'READ UNIT=27 UNIT=28 UNIT=29'
'RELEASE'
'SOL03   SOLUTION'
'NATURAL FREQUENCIES AND MODE SHAPES'
'BUCK'  5   5
'RELEASE'
'SOL04 - INCREMENTAL STATIC SOLUTION'
'NONLINEAR CYCLE ANALYSIS WITH UNBALANCED FORCES'
0   500   1     TRUE.! MAXELD IPRINT IWRITE UNBAL
 'ELE'  2 17         0 0 0
 'ELE'  9 18         0 0 0
 'ELE' 37 19         1 2 1
 'ELE  22 21         0 0 0
 'ELE' 27 22         0 0 0
 'ELE' 29 23         0 0 0
 'ELE' 38 24         0 0 0
 'ELE' 46 25         0 0 0
 'ELE' 47 26         0 0 0
 'ELE' 50 27         0 0 0
 'ELE' 52 28         0 0 0
 'ELE' 54 29         0 0 0
 'END'  0  0         0 0 0
1  1  7  1    'FX'  0.2222
0 0 0 0  'END'  0   ! JOINT LOADS
'LOAD'    200.0    0      0   20
'END'         0    0      0   0
'STOP'
```

7. Output

(Case: SOL04 -- Nonlinear Cycle Analysis With Unbalanced Forces)

```
1    ECHO OF INPUT DATA

 LINE   ....:....10...:....20....:....30....:....40....:....50....:....60....:....70....:....80
    1:  'STRUCTURE DEFINITION'
    2:  'THREE-STORY BUILDING'
    3:   37 1 8  2 8  1.                                 NNODE,NCOS,NSUPT,NCOND,NCONST SCALE
    4:   1   0.00    0.00     300     1  3 ! ID X Y Z ICOS IGEN
    5:   1  200  0   0                     ! DID DX DY DZ
    6:   5   600     200      300     1  3 ! ID X Y Z ICOS IGEN
    7:   1 -200  0   0                     ! DID DX DY DZ
    8:   9   100     100      300     1  0 ! ID X Y Z ICOS IGEN
    9:  10   500     100      300     1  0 ! ID X Y Z ICOS IGEN
   10:  11   400     0.00     225     1  0   ID X Y Z ICOS IGEN
   11:  12   600     0.00     225     1  0   ID X Y Z ICOS IGEN
   12:  13   600     200      225     1  0 ! ID X Y Z ICOS IGEN
   13:  14   400     200      225     1  0 ! ID X Y Z ICOS IGEN
   14:  15   500     100      225     1  0 ! ID X Y Z ICOS IGEN
   15:  16   0.00    0.00     150     1  3 ! ID X Y Z ICOS IGEN
   16:   1  200  0   0                     ! DID DX DY DZ
   17:  20   700     100      92.27 1  0 ! ID X Y Z ICOS IGEN
   18:  21   600     200      150     1  3   ID X Y Z ICOS IGEN
   19:   1 -200  0   0                     ! DID DX DY DZ
   20:  25   300     100      150     1  1 ! ID X Y Z ICOS IGEN
   21:   1  200  0   0                     ! DID DX DY DZ
   22:  27   633.33  100      130.83 1  0 ! ID X Y Z ICOS IGEN
   23:  28   0.00    0.00     0.00    1  3 ! ID X Y Z ICOS IGEN
   24:   1  200  0   0                     ! DID DX DY DZ
   25:  32   600     200      0.00    1  3 ! ID X Y Z ICOS IGEN
   26:   1 -200  0   0                       DID DX DY DZ
   27:  36   788.6   100      0.00    1  0 ! ID X Y Z ICOS IGEN
   28:  37   788.6   100      0.00    1  0 ! ID X Y Z ICOS IGEN
   29:   1 0 0       0 1 0                 ! VXI VXJ VXK VYI VYJ VYK
   30:  28   1 1 1 1 1 1     7 1           ! JOINT RESTRAINT
   31:   9   0 0 2 2 2 0     1 1           ! JOINT RESTRAINT
   32:  15   0 0 2 2 2 0     0 0           ! JOINT RESTRAINT
   33:  25   0 0 2 2 2 0     0 0           ! JOINT RESTRAINT
   34:  26   0 0 1 1 1 0     0 0             JOINT RESTRAINT
   35:  27   0 0 2 2 2 0     0 0           ! JOINT RESTRAINT
   36:  36   1 1 1 1 0 1     0 0           ! JOINT RESTRAINT
   37:  37   1 1 1 1 1 1     0 0           ! JOINT RESTRAINT
   38:  0    0 0 1 1 1 0     0 0           ! JOINT CONDENSATION
   39:  36   0 0 0 0 1 0     0 0           ! JOINT CONDENSATION
   40:  1    9  1   1 1                    ! JOINT CONSTRAINT
   41:  1    9  7   1 1                    ! JOINT CONSTRAINT
   42:  1   10  3   3 1                      JOINT CONSTRAINT
   43:  1   15 11   3 1                    ! JOINT CONSTRAINT
   44:  1   25 16   3 1                    ! JOINT CONSTRAINT
   45:  1   25 21   3 1                    ! JOINT CONSTRAINT
   46:  1   25 26   0 0                    ! JOINT CONSTRAINT
   47:  0   27 19   2 1                    ! JOINT CONSTRAINT
   48:   18          ! NMAT
   49: 'BRACE  # 1'  29000  10.6  2.51  36  1  12  0.2
   50: 'IA_BILN MY # 2 '   1     0.03    29000  533    3484.8     -2    0
   51: 'IA_BILN MZ # 3 '   1     0.03    29000  174    1587.6     -2    0
   52: 'IA_BILN MX # 4 '   0     0.03    13000  2.18        0     -2    0
   53: 'IA_BILN FX # 5 '   0     0.03    29000  19.1        0     -2    0
   54: 'TAKEDA  MY # 6 ' 2.5E07  250  1.0E-5  1500 1.5E-4 1550  8.6E-4  0.2
   55: 'STABILITY BOX  # 7'  4   36    29000  1  12 12  0.0   0.0  4  4  0.375
   56:  1  0  0  0  0  37.5  0  0  144  0  0  0.05  0  13000  0.01 1
1    ECHO OF INPUT DATA

 LINE   ....:....10...:....20....:....30....:....40....:....50....:....60....:....70....:....80
   57: 'STABILITY TUBE # 8'  4 36 29000 2  5.5  0 0 0  8  0   0 5
   58: 0 0 0 0 0  37.5  0 0 95.03  1  2   0.05  20 13000 0.01 1
   59: '3D-BEAM      # 9 '  29000 13000 19.1 19.1  19 1 2 18 533  174
   60: 'LONG_OWJG  # 10'   0.004    2000  -2  0.2
   61: 'SHORT_OWJG # 11'   0.005    2000  0.05   -2  0.2
   62: 'BRACE  # 12'  29000  14.4  2.54  36  2  12  0.2
   63: 'BILINEAR SPRING #13' 1000000 1000 0.03 12 0.2
   64: 'AXLMOD FOR WALL #14' 7000 6000 60  2000  0.9  0.2  15  0.2
   65: 'BEND1  FOR WALL #15' 4  10  0.7E-05   0.2
   66:     2700       5000       6500      7000
   67:    0.2E-05  0.7E-05  1.7E-05  4E-05
   68: 'SHEAR1 FOR WALL #16' 4  10  1.1E-03   0.2
   69:       80        150        180        200
   70:    0.3E-03  1.1E-03  2.3E-03  5E-03
   71: 'AXLMOD FOR OPEN-WALL #17' 7000 6000 60  2000  0.9  0.2  15  0.2
   72: 'SHEAR2 FOR OPEN-WALL #18' 4    0.4
   73:       80        150        180        100
   74:    0.06       0.22       0.46       1.0
   75:     30    150  1.2 0.2  0.11  ! HO HS LWF AD AV
   76:  1 0   0  TRUE.            !  KG: AXL, FORM, ASSY
   77: 54            ! NELMT
   78: '3D-BEAM' 'MEMBER  1'  9  1  2   0   1   0  0 0  0   000000  0
   79: 'IE3DBEAM' 'MEMBER  2' 10 10  3  3  4  5    2  3  0 1 0   0 0  0  0
   80: '3D-BEAM' 'MEMBER  3'  9  3  4   0   1   0  0 0  0   000000  0
   81: '3D-BEAM' 'MEMBER  4'  9  4  5  -1   0   0  0 0  0   000000  0
   82: '3D BEAM' 'MEMBER  5'  9  6  5   0   1   0  0 0  0   000000  0
   83: 'IE3DBEAM' 'MEMBER  6' 10 10  3  3  4  5    7  6  0 1 0   0 0  0  0
   84: '3D-BEAM' 'MEMBER  7'  9  8  7   0   1   0  0 0  0   000000  0
   85: '3D BEAM' 'MEMBER  8'  9  1  8  -1   0   0  0 0  0   000000  0
   86: 'IE3DBEAM' 'MEMBER  9' 11 11  3  3  4  5    2  7 -1 0 0   0 0  0  0
   87: 'IE3DBEAM' 'MEMBER 10' 11 11  3  3  4  5    3  6 -1 0 0   0 0  0  0
   88: '3D-BEAM' 'MEMBER 11'  9 11 14  -1   0   0  0 0  0   000000  0
   89: '3D-BEAM' 'MEMBER 12'  9 11 12   0   1   0  0 0  0   000000  0
   90: '3D-BEAM' 'MEMBER 13'  9 12 13  -1   0   0  0 0  0   000000  0
   91: '3D-BEAM' 'MEMBER 14'  9 14 13   0   1   0  0 0  0   000000  0
   92: '3D-BEAM' 'MEMBER 15'  9 16  1   1   0   0  0 0  5.558   000000  0
   93: '3D-BEAM' 'MEMBER 16'  9 17  2   1   0   0  0 0  5.558   000000  0
   94: '3D-BEAM' 'MEMBER 17'  9 11  3   1   0   0  0 0  5.555   000000  0
   95: 'IE3DBEAM' 'MEMBER 18'  2  2  3  3  4  5   18 11  1 0 0   0 0 15.208  0
   96: '3D-BEAM' 'MEMBER 19'  9 12  4   1   0   0  0 0  5.558   000000  0
   97: 'IE3DBEAM' 'MEMBER 20'  2  2  3  3  4  5   19 12  1 0 0   0 0 15.208  0
   98: '3D-BEAM' 'MEMBER 21'  9 13  5   1   0   0  0 0  5.558   000000  0
   99: 'IE3DBEAM' 'MEMBER 22'  2  2  3  3  4  5   21 13  1 0 0   0 0 15.208  0
  100: '3D-BEAM' 'MEMBER 23'  9 14  6   1   0   0  0 0  5.558   000000  0
  101: 'IE3DBEAM' 'MEMBER 24'  2  2  3  3  4  5   22 14  1 0 0   0 0 15.208  0
  102: '3D-BEAM' 'MEMBER 25'  9 23  7   1   0   0  0 0  5.558   000000  0
  103: '3D-BEAM' 'MEMBER 26'  9 24  8   1   0   0  0 0  5.558   000000  0
  104: 'IE3DBEAM' 'MEMBER 27'  6  6  3  3  4  5   16 17  0 1 0   0 0  0  0
  105: '3D-BEAM' 'MEMBER 28'  9 17 18   0   1   0  0 0  0   000000  0
  106: 'IE3DBEAM' 'MEMBER 29'  2  2  3  3  4  5   18 19  0 1 0   0 0  0  0
  107: '3D BEAM' 'MEMBER 30'  9 19 21  -1   0   0  0 0  0   000000  0
```

```
      108: 'IE3DBEAM' 'MEMBER 31'  2  2  3  3  4  5   22 21  0 1 0   0 0  0  0
      109: '3D-BEAM' 'MEMBER 32'  9  23 22  0   1   0  0 0  0   000000  0
      110: 'IE3DBEAM' 'MEMBER 33'  6  6  3  3  4  5   24 23  0 1 0   0 0  0  0
      111: '3D-BEAM' 'MEMBER 34'  9  16 24 -1   0   0  0 0  0   000000  0
      112  '3D-BEAM' 'MEMBER 35'  9  17 23 -1   0   0  0 0  0   000000  0
1     ECHO OF INPUT DATA

     LINE       |...10......20...|...30...|...40...|...50...|...60...|...70.......80
      113: '3D-BEAM' 'MEMBER 36'  9  16 22 -1   0   0  0 0  0   000000  0
      114: 'STABILITY' 'MEMBER 37'  8  28 16  1   0   0  0 0     0
      115: 'IE3DBEAM' 'MEMBER 38'  2  2  3  3  4  5   35 24  1 0 0   0 0  0  0
      116: 'STABILITY' 'MEMBER 39'  7  29 17  1   0   0  0 0     0
      117: 'IE3DBEAM' 'MEMBER 40'  2  2  3  3  4  5   34 23  1 0 0   0 0  0  0
      118  '3D-BEAM' 'MEMBER 41'  9  31 19  1   0   0  0 0  51.654   000000  0
      119  '3D-BEAM' 'MEMBER 42'  9  32 21  1   0   0  0 0  51.654   000000  0
      120  '3D-BEAM' 'MEMBER 43'  9  20 21  .7071 .7071  0  0 0  0   000000  0
      121: '3D-BEAM' 'MEMBER 44'  9  20 19  -.7071 .7071  0  0 0  0   000000  0
      122: '3D-BEAM' 'MEMBER 45'  9  36 20  0   1   0  0 0  2.231   000000  0
      123: 'SPRING' 'MEMBER 46'  13  37 36  5  0  0 1 0   0 0  0
      124: 'BRACE' 'MEMBER 47' 12  29 16  1  1   0 1 0  0 0  0
      125: 'BRACE' 'MEMBER 48' 12  34 24  1  1   0 1 0  0 0  0
      126: 'BRACE' 'MEMBER 49'  1  29 23  1  1   1 0 0  0 0  0
      127: 'BRACE' 'MEMBER 50'  1  30 22  1  1   1 0 0  0 0  0
      128: 'BRACE' 'MEMBER 51'  1  31 21  1  1   1 0 0  0 0  0
      129: 'SHEAR WALL' 'MEMBER 52' 15 16 14  18 17 29 30  1      69 21 0
      130  'SHEAR WALL' 'MEMBER 53' 15 16 14  22 23 34 33  1      69 21 0
      131  'SHEAR_OPEN' 'MEMBER 54' 18 17 17  16 24 35 28  1      40 26 0
      132    15    1  .FALSE  |  INMASS FMASS MCOND
      133: 1  0.0144  0.0144  0    0 0 0 0 0 0  7 1
      134: 11 0.025   0.025   0    0 0 0 0 0 0  3 1
      135: 16 0.03775 0.03775 0    0 0 0 0 0 0  1 1
      136: 18 0.08775 0.08775 0    0 0 0 0 0 0  0 0
      137: 19 0.09442 0.09442 0    0 0 0 0 0 0  0 0
      138. 20 0.00667 0.00667 0    0 0 0 0 0 0  0 0
      139  21 0.09442 0.09442 0    0 0 0 0 0 0  0 0
      140  22 0.08775 0.08775 0    0 0 0 0 0 0  0 0
      141: 23 0.03775 0.03775 0    0 0 0 0 0 0  1 1
      142: 26 0.2     0.2     0    0 0 0 0 0 0  0 0
      143: 27 0.0133  0.0133  0    0 0 0 0 0 0  0 0
      144: 36 0 0 0                0 0 5 0 0 0 0  0 0
      145:  9 0 0 0                0 0 0 0 0 0  1 1
      146: 15 0 0 0                0 0 0 0 0 0  0 0
      147  25 0 0 0                0 0 0 0 0 0  0 0
      148    0 0  |  DAMP
      149  'SOL04 - INCREMENTAL STATIC SOLUTION'
      150. 'NONLINEAR CYCLE ANALYSIS WITH UNBALANCED FORCES'
      151  0   500   1   .TRUE.| MAXELD IPRINT IWRITE UNBAL
      152.  'ELE'  2 17          0 0 0
      153:  'ELE'  9 18          0 0 0
      154:  'ELE' 37 19          1 2 1
      155:  'ELE' 22 21          0 0 0
      156:  'ELE' 27 22          0 0 0
      157   'ELE' 29 23          0 0 0
      158:  'ELE' 38 24          0 0 0
      159:  'ELE' 46 25          0 0 0
      160:  'ELE' 47 26          0 0 0
      161:  'ELE' 50 27          0 0 0
      162.  'ELE' 52 28          0 0 0
      163:  'ELE' 54 29          0 0 0
      164   'END'  0  0          0 0 0
      165  1  1  7  1    'FX'  0.2222
      166  0 0 0 0  'END'  0  , JOINT LOADS
      167: 'LOAD'   200.0    0      0   20
      168: 'END'        0    0      0   0
1     ECHO OF INPUT DATA

     LINE   . |...10...|...20...|...30...|...40.......50.......60.......70.......80
      169: 'STOP'
1 STRUCTURE...   THREE-STORY BUILDING                                                    TIME: 16 45:06, DATE: 07/27/94
  SOLUTION....

 *** PROGRAM FEM ***         DOUBLE PRECISION VERSION



       NODE CONSTRAINTS

    XY-PLANE        CONSTRAINT, MASTER:     9 SLAVE:     1
    XY-PLANE        CONSTRAINT, MASTER:     9 SLAVE:     2
    XY-PLANE        CONSTRAINT, MASTER:     9 SLAVE:     7
    XY-PLANE        CONSTRAINT, MASTER:     9 SLAVE:     8
    XY-PLANE        CONSTRAINT, MASTER:    10 SLAVE:     3
    XY-PLANE        CONSTRAINT, MASTER:    10 SLAVE:     4
    XY-PLANE        CONSTRAINT, MASTER:    10 SLAVE:     5
    XY-PLANE        CONSTRAINT, MASTER:    10 SLAVE:     6
    XY-PLANE        CONSTRAINT, MASTER:    15 SLAVE:    11
    XY-PLANE        CONSTRAINT, MASTER:    15 SLAVE:    12
    XY-PLANE        CONSTRAINT, MASTER:    15 SLAVE:    13
    XY-PLANE        CONSTRAINT, MASTER:    15 SLAVE:    14
    XY-PLANE        CONSTRAINT, MASTER:    25 SLAVE:    16
    XY-PLANE        CONSTRAINT, MASTER:    25 SLAVE:    17
    XY-PLANE        CONSTRAINT, MASTER:    25 SLAVE:    18
    XY-PLANE        CONSTRAINT, MASTER:    25 SLAVE:    19
    XY-PLANE        CONSTRAINT, MASTER:    25 SLAVE:    21
    XY-PLANE        CONSTRAINT, MASTER:    25 SLAVE:    22
    XY-PLANE        CONSTRAINT, MASTER:    25 SLAVE:    23
    XY-PLANE        CONSTRAINT, MASTER:    25 SLAVE:    24
    XY-PLANE        CONSTRAINT, MASTER:    25 SLAVE:    26
    3D-RIGID BODY   CONSTRAINT, MASTER:    27 SLAVE:    19
    3D-RIGID BODY   CONSTRAINT, MASTER:    27 SLAVE:    20
    3D-RIGID BODY   CONSTRAINT, MASTER:    27 SLAVE:    21


      NODE COORDINATES AND DEGREES OF FREEDOM

     TOTAL NUMBER OF DEGREES OF FREEDOM.... ....         147
     NUMBER OF DEGREES OF FREEDOM CONDENSED OUT..  .      55
     NUMBER OF FREE DEGREES OF FREEDOM ....  .... .       15
     NUMBER OF RESTRAINED DEGREES OF FREEDOM ....  .      77

       NODE COS#    X-COORD         Y-COORD        Z-COORD          FX      FY      FZ      MX      MY      MZ
         1    1    0.00000E+00     0.00000E+00     300.00          56-C    57-C     1       2       3      58-C
```

2	1	200.00	0.00000E+00	300.00	56-C	57-C	4	5	6	58-C
3	1	400.00	0.00000E+00	300.00	59-C	60-C	7	8	9	61-C
4	1	600.00	0.00000E+00	300.00	59-C	60-C	10	11	12	61-C
5	1	600.00	200.00	300.00	59-C	60-C	13	14	15	61-C
6	1	400.00	200.00	300.00	59-C	60-C	16	17	18	61-C
7	1	200.00	200.00	300.00	56-C	57-C	19	20	21	58-C
8	1	0.00000E+00	200.00	300.00	56-C	57-C	22	23	24	58-C
9	1	100.00	100.00	300.00	56	57	133-R	134-R	135-R	58
10	1	500.00	100.00	300.00	59	60	136-R	137-R	138-R	61
11	1	400.00	0.00000E+00	225.00	62-C	63-C	25	26	27	64-C
12	1	600.00	0.00000E+00	225.00	62-C	63-C	28	29	30	64-C
13	1	600.00	200.00	225.00	62-C	63-C	31	32	33	64-C
14	1	400.00	200.00	225.00	62-C	63-C	34	35	36	64-C
15	1	500.00	100.00	225.00	62	63	139-R	140-R	141-R	64
16	1	0.00000E+00	0.00000E+00	150.00	65-C	66-C	37	38	39	67-C
17	1	200.00	0.00000E+00	150.00	65-C	66-C	40	41	42	67-C
18	1	400.00	0.00000E+00	150.00	65-C	66-C	43	44	45	67-C
19	1	600.00	0.00000E+00	150.00	68-C	69-C	145-C	146-C	147-C	70-C
20	1	700.00	100.00	92.270	68-C	69-C	145-C	146-C	147-C	70-C
21	1	600.00	200.00	150.00	68-C	69-C	145-C	146-C	147-C	70-C
22	1	400.00	200.00	150.00	65-C	66-C	46	47	48	67-C
23	1	200.00	200.00	150.00	65-C	66-C	49	50	51	67-C
24	1	0.00000E+00	200.00	150.00	65-C	66-C	52	53	54	67-C
25	1	200.00	100.00	150.00	65	66	142-R	143-R	144-R	67
26	1	500.00	100.00	150.00	65-C	66-C	71-R	72-R	73-R	67-C
27	1	633.33	100.00	130.83	68	69	145-R	146-R	147-R	70
28	1	0.00000E+00	0.00000E+00	0.00000E+00	74-R	75-R	76-R	77-R	78-R	79-R
29	1	200.00	0.00000E+00	0.00000E+00	80-R	81-R	82-R	83-R	84-R	85-R
30	1	400.00	0.00000E+00	0.00000E+00	86-R	87-R	88-R	89-R	90-R	91-R
31	1	600.00	0.00000E+00	0.00000E+00	92-R	93-R	94-R	95-R	96-R	97-R
32	1	600.00	200.00	0.00000E+00	98-R	99-R	100-R	101-R	102-R	103-R
33	1	400.00	200.00	0.00000E+00	104-R	105-R	106-R	107-R	108-R	109-R
34	1	200.00	200.00	0.00000E+00	110-R	111-R	112-R	113-R	114-R	115-R
35	1	0.00000E+00	200.00	0.00000E+00	116-R	117-R	118-R	119-R	120-R	121-R
36	1	788.60	100.00	0.00000E+00	122-R	123-R	124-R	125-R	55	126-R
37	1	788.60	100.00	0.00000E+00	127-R	128-R	129-R	130-R	131-R	132-R

NOTE. R - RESTRAINED DEGREE OF FREEDOM
C - CONSTRAINED DEGREE OF FREEDOM

DIRECTION COSINES ..

COS- 1) VX: 1.00000 I +0.00000 J +0.00000 K VY: 0.00000 I +1.00000 J +0.00000 K VZ: 0.00000 I +0.00000 J -1.00000 K

1 STRUCTURE. . : THREE-STORY BUILDING TIME: 16:45.06, DATE 07/27/94
SOLUTION. . . . :

GOEL HYSTERESIS MODEL PARAMETERS

MAT.	E	A	R	YS	SHAPE	MAX DUC	BETA
1	29000.0	10.5000	2.51000	36.0000	1.00000	12.0000	0.200000

1 STRUCTURE....: THREE-STORY BUILDING TIME: 16:45:06, DATE: 07/27/94
SOLUTION.....

BILINEAR INTERACTIVE MATERIAL PROPERTIES

MAT	ELAS	SP	E	TI	MP	MAX DUC	BETA	REDU F
2	1.00000	0.300000E-01	29000.0	533.000	3484.80	-2.00000	0.000000E+00	0.000000E+00
3	1.00000	0.300000E-01	29000.0	174.000	1587.60	-2.00000	0.000000E+00	0.000000E+00
4	0.000000E+00	0.300000E-01	13000.0	2.18000	0.000000E+00	-2.00000	0.000000E+00	0.000000E+00
5	0.000000E+00	0.300000E-01	29000.0	19.1000	0.000000E+00	-2.00000	0.000000E+00	0.000000E+00

1 STRUCTURE... THREE-STORY BUILDING TIME: 16:45:06, DATE: 07/27/94
SOLUTION. ..

TAKEDA HYSTERESIS MODEL- FOR UNIT LENGTH MEMBER

MAT.	BETA	EI	CRACK	YEILD	ULTIMATE
6	0.200000	0.250000E+08	250.000	1500.00	1550.00
			0.100000E-04	0.150000E-03	0.960000E-03

1 STRUCTURE. . THREE-STORY BUILDING TIME: 16:45:06, DATE 07/27/94
SOLUTION . . :

STABILITY ELEMENT

MAT NO. = 7 BOX SECTION

NSEG	= 4	YS	= 36.0
EM	= 2.900E+04	LIBN	= 1
BOX HEIGTH	= 12.0	BOX WILTH	= 12.0
ECCX0	= 0.000E+00	ECCY0	= 0.000E+00
H W SEC NO	= 4.00	H H.SEC NO.	= 4.00
THICKNESS	= 0.375	L B. FLAG	= 1
IREV2	= 0	IREV3	= 0
IREV4	= 0	IECOF	= 0
NUMP	= 32	SMALL	= 37.5
RATIX0	= 0.000E+00	RATIY0	= 0.000E+00
TOTA	= 144	IAUTO	= 0
IMATER	= 0	RATIOJ	= 3.000E-02
IR	= 0	G	= 1.300E+04
QRNEE	= 1.000E-02	ISTIF	= 1

```
MAT  NO       =  5   TUBE SECTION
NSEG          =          4        YS          =  36.0
EM            = 2.900E+04         LIBN        =          2
RADIUS        =  5.50             DUMMY VAR.  = 0.000E+00
ECCXC         = 0.000E+00         ECCYC       = 0.000E+00
1/4 SEC.NO    =  9.00             DUMMY VAR   = 0.000E+00
THICKNESS     = 0.500             IREV1       =          0
IREV2         =          0        IREV3       =          0
IREV4         =          0        IECOP       =          0
NUMF          =         32        SMALL       =  37.5
RATIXO        = 0.000E+00         RATIYC      = 0.000E+00
TOTA          =  95.0             IAUTO       =          1
IMATER        =          2        RATIO3      = 3.000E-02
IF            =         20        G           = 1.300E-04
ORNEE         = 1.000E-02         ISTIF       =          1

1 STRUCTURE. .    THREE-STORY BUILDING                                    TIME: 16.45:06, DATE: 07/27/94
  SOLUTION....

    3-D ELASTIC BEAM ELEMENT
    ------------------------

   MATL.   E      GAMMA       AX       AY       AZ       IX       IY      IZ

     9 2.900E+04 1.300E-04  19.1     19.1     19.1     2.18     533.     174.

1 STRUCTURE...    THREE-STORY BUILDING                                    TIME: 16.45:06, DATE: 07/27/94
  SOLUTION....


 PINO-SUAREZ TOWER LONG DIR. HYST  MODEL PARAMETERS
 --------------------------------------------------

  MAT       HA          VA       MAX DUC        BETA
  10  0.400000E-02 2000.00     -2.00000     0.200000
1 STRUCTURE....: THREE-STORY BUILDING                                            TIME: 16:45 06. DATE:
07/27/94
  SOLUTION  ....:


 PINO-SUAREZ TOWER SHORT DIR. HYST  MODEL PARAMETERS
 ---------------------------------------------------

  MAT.      HA          VA        RATIO       MAX DUC       BETA
  11  0.500000E-02 2000.00     0.300000E-01-2.00000     0.200000
1 STRUCTURE....: THREE-STORY BUILDING                                            TIME: 16:45 06. DATE:
07/27/94
  SOLUTION  ....


    GOEL HYSTERESIS MODEL PARAMETERS
    --------------------------------

  MAT        E          A          R          YS       SHAPE     MAX DUC      BETA
   12 29000.0     14.4000    2.54000    36.0000    2.00000    12.0000    0.200000

1 STRUCTURE  ...: THREE-STORY BUILDING                                           TIME  16:45:06, DATE
07/27/94
  SOLUTION  ....


    BILINEAR HYSTERESIS MODEL PARAMETERS
    ------------------------------------

  MAT.         KE           PY          KIE       MAX DUCT        BETA
   13   0.100000E+07    1000.00    0.300000E-01   12.0000      0.200000
1 STRUCTURE.  ... THREE-STORY BUILDING                                           TIME: 16:45:06, DATE
07/27/94
  SOLUTION. ..


    AXLMOD HYSTERESIS MODEL- FOR UNIT LENGTH MEMBER
    -----------------------------------------------

  MAT       SC          ST1         ST2          PY        ALPHA       BETA     MAX DUCT.     BETA-DI
   14   7000.00     6500.00     60.0000     2000.00    0.900000    0.200000    15.0000     0.200000

1 STRUCTURE..   THREE-STORY BUILDING                                             TIME: 16.45 06. DATE:
07/27/94
  SOLUTION  ....:

    BEND1 HYSTERESIS MODEL DATA - UNIT LENGTH MEMBER
    ------------------------------------------------
    BACKBONE CURVE POINTS - MATL  NI     DY           BETA         MOMENT       ROTATION
                            15  10   0.700000E-05  0.200000      2700.00     0.200000E-05
                                                                 5000.00     0.700000E-05
                                                                 6500.00     0.170000E-04
                                                                 7000.00     0.400000E-04

1 STRUCTURE  ..  THREE-STORY BUILDING                                            TIME  16:45:06, DATE
07/27/94
  SOLUTION... ..:


    SHEAR1 HYSTERESIS MODEL DATA - UNIT LENGTH MEMBER
```

```
 ---------------------------------------------------
 BACKBONE CURVE POINTS - MAT   NI       DY          BETA         STRESS        STRAIN
                         16   10    0.110000E-02  0.200000       80.0000      0.300000E-03
                                                                150.000       0.110000E-02
                                                                180.000       0.230000E-02
                                                                200.000       0.500000E-02

1 STRUCTURE... - THREE-STORY BUILDING                                                    TIME: 16:45:06, DATE:
07/27/94
  SOLUTION....


   AXIMOD HYSTERESIS MODEL- FOR UNIT LENGTH MEMBER
   ---------------------------------------------------

 MAT       SC          ST1          ST2          PY         ALPHA        BETA     MAX DUCT.     BETA-DI
  17    7000.00     6000.00      60.0000     2000.00     0.900000     0.200000     15.0000     0.200000

1 STRUCTURE. .: THREE-STORY BUILDING                                                     TIME: 16:45:06, DATE:
07/27/94
  SOLUTION ....


 SHEAR2 HYSTERESIS MODEL DATA - FOR WHOLE LENGTH MEMBER
 ---------------------------------------------------
 BACKBONE CURVE POINTS - MAT         BETA         STRESS        STRAIN
                         18       0.400000       80.0000      0.600000E-01
                                                150.000       0.220000
                                                180.000       0.460000
                                                100.000       1.00000

1 STRUCTURE...   THREE-STORY BUILDING                                                    TIME: 16:45:06, DATE:
07/27/94
  SOLUTION.. ..

 ELEMENT 05,  3D BEAM ELEMENT

                   #  MATL START  END  REL CD   LENGTH   ----------- Y-AXIS -----------  START DIST   END DIST    PKG
 MEMBER  1         1    9     1     2            200.0     0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
1 STRUCTURE... - THREE-STORY BUILDING                                                    TIME: 16:45:06, DATE:
07/27/94
  SOLUTION.. ..

 ELEMENT 09,  IE3DBEAM ELEMENT

                   #   START   END   LENGTH   ----------- Y-AXIS -----------  START DIST   END DIST    PKG
 MEMBER  2         2     2      3  200.0     0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
               MATERIAL # - (FX )- 5 , (MX )- 4 ,(MY-A)-10 , (MY-B)-10 ,(MZ-A)- 3 , (MZ-B)- 3
1 STRUCTURE. .  THREE-STORY BUILDING                                                     TIME: 16:45:06, DATE:
07/27/94
  SOLUTION  ..

 ELEMENT 08,  3D BEAM ELEMENT

                   #  MATL START  END  REL CD   LENGTH   ----------- Y-AXIS -----------  START DIST   END DIST    PKG
 MEMBER  3         3    9     3     4            200.0     0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
 MEMBER  4         4    9     4     5            200.0    -1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
 MEMBER  5         5    9     6     5            200.0     0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
1 STRUCTURE .... THREE-STORY BUILDING                                                    TIME: 16:45:06, DATE
07/27/94
  SOLUTION......

 ELEMENT 09,  IE3DBEAM ELEMENT

                   #   START   END   LENGTH   ----------- Y-AXIS -----------  START DIST   END DIST    PKG
 MEMBER  6         6     7      6  200.0     0.00000 I -1.00000 J -0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
               MATERIAL # . (FX )- 5 , (MX )- 4 ,(MY-A)-10 , (MY-B)-10 ,(MZ-A)- 3 , (MZ-B)- 3
1 STRUCTURE ...: THREE-STORY BUILDING                                                    TIME: 16:45:06, DATE
07/27/94
  SOLUTION. ...:

 ELEMENT 08,  3D BEAM ELEMENT

                   #  MATL START  END  REL CD   LENGTH   ----------- Y-AXIS -----------  START DIST   END DIST    PKG
 MEMBER  7         7    9     8     7            200.0     0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
 MEMBER  8         8    9     1     8            200.0    -1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
1 STRUCTURE  .. THREE-STORY BUILDING                                                     TIME. 16:45:06, DATE
07/27/94
  SOLUTION. ...:

 ELEMENT 09,  IE3DBEAM ELEMENT

                   #   START   END   LENGTH   ----------- Y-AXIS -----------  START DIST   END DIST    PKG
 MEMBER  9         9     2      7  200.0    -1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
               MATERIAL # . (FX )- 5 , (MX )- 4 ,(MY-A)-11 , (MY-B)-11 ,(MZ-A)- 3 , (MZ-B)- 3
 MEMBER 10        10     3      6  200.0    -1.00000 I -0.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
               MATERIAL # . (FX )- 5 , (MX )- 4 ,(MY-A)-11 , (MY-B)-11 ,(MZ-A)- 3 , (MZ-B)- 3
1 STRUCTURE ...: THREE-STORY BUILDING                                                    TIME. 16:45:06, DATE:
07/27/94
  SOLUTION....

 ELEMENT 05,  3D BEAM ELEMENT

                   #  MATL START  END  REL CD   LENGTH   ----------- Y-AXIS -----------  START DIST   END DIST    PKG
 MEMBER 11        11    9    11    14            200.0    -1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
 MEMBER 12        12    9    11    12            200.0     0.00000 I -1.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
 MEMBER 13        13    9    12    13            200.0    -1.00000 I +0.00000 J -0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
 MEMBER 14        14    9    14    13            200.0     0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
 MEMBER 15        15    9    16     1            150.0     1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00  5.556
 MEMBER 16        16    9    17     2            150.0     1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00  5.556
```

```
 MEMBER 17          17    9    11    2          75.00      1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00   5.558
1 STRUCTURE ....: THREE-STORY BUILDING                                                         TIME: 16:45:06, DATE:
07/27/94
  SOLUTION .....

 ELEMENT 09,  IE3DBEAM ELEMENT

                    #   START   END   LENGTH   ........... Y-AXIS ...........  START DIST    END DIST     PKG
 MEMBER 18          18    18     11  75.00      1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00   15.21
                 MATERIAL # : (FX  ) - 5 , (MX  ) - 4 ,(MY-A) - 2 , (MY-B) - 2 ,(MZ-A) - 3 , (MZ-B) - 3
1 STRUCTURE ....: THREE-STORY BUILDING                                                         TIME: 16:45:06, DATE:
07/27/94
  SOLUTION .....

 ELEMENT 08,  3D BEAM ELEMENT

                    # MATL START   END  REL CD   LENGTH   ........... Y-AXIS ...........  START DIST    END DIST     PKG
 MEMBER 19          19    9    12     4          75.00      1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00   5.558
1 STRUCTURE ....: THREE-STORY BUILDING                                                         TIME: 16:45:06, DATE:
07/27/94
  SOLUTION .....

 ELEMENT 09,  IE3DBEAM ELEMENT

                    #   START   END   LENGTH   ........... Y-AXIS ...........  START DIST    END DIST     PKG
 MEMBER 20          20    19     12  75.00      1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00   15.21
                 MATERIAL # : (FX  ) - 5 , (MX  ) - 4 ,(MY-A) - 2 , (MY-B) - 2 ,(MZ-A) - 3 , (MZ-B) - 3
1 STRUCTURE....   THREE-STORY BUILDING                                                         TIME: 16:45:06, DATE
07/27/94
  SOLUTION......

 ELEMENT 08,  3D BEAM ELEMENT

                    # MATL START   END  REL CD   LENGTH   ........... Y-AXIS ...........  START DIST    END DIST     PKG
 MEMBER 21          21    9    13     5          75.00      1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00   5.558
1 STRUCTURE....   THREE-STORY BUILDING                                                         TIME: 16:45:06, DATE:
07/27/94
  SOLUTION......

 ELEMENT 09,  IE3DBEAM ELEMENT

                    #   START   END   LENGTH   ........... Y-AXIS ...........  START DIST    END DIST     PKG
 MEMBER 22          22    21     13  75.00      1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00   15.21
                 MATERIAL # : (FX  ) - 5 , (MX  ) - 4 ,(MY-A) - 2 , (MY-B) - 2 ,(MZ-A) - 3 , (MZ-B) - 3
1 STRUCTURE ....  THREE-STORY BUILDING                                                         TIME: 16:45:06, DATE.
07/27/94
  SOLUTION .....

 ELEMENT 08,  3D BEAM ELEMENT

                    # MATL START   END  REL CD   LENGTH   ........... Y-AXIS ...........  START DIST    END DIST     PKG
 MEMBER 23          23    9    14     6          75.00      1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00   5.558
1 STRUCTURE....   THREE-STORY BUILDING                                                         TIME: 16:45:06, DATE
07/27/94
  SOLUTION....

 ELEMENT 09,  IE3DBEAM ELEMENT

                    #   START   END   LENGTH   ........... Y-AXIS ...........  START DIST    END DIST     PKG
 MEMBER 24          24    22     14  75.00      1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00   15.21
                 MATERIAL # : (FX  ) - 5 , (MX  ) - 4 ,(MY-A) - 2 , (MY-B) - 2 ,(MZ-A) - 3 , (MZ-B) - 3
1 STRUCTURE. ...  THREE-STORY BUILDING                                                         TIME: 16:45:06, DATE:
07/27/94
  SOLUTION ...

 ELEMENT 08,  3D BEAM ELEMENT

                    # MATL START   END  REL CD   LENGTH   ........... Y-AXIS ...........  START DIST    END DIST     PKG
 MEMBER 25          25    9    23     7          150.0      1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00   5.558
 MEMBER 26          26    9    24     8          150.0      1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00   5.558
1 STRUCTURE. ...: THREE-STORY BUILDING                                                         TIME: 16:45:06, DATE:
07/27/94
  SOLUTION...

 ELEMENT 09,  IE3DBEAM ELEMENT

                    #   START   END   LENGTH   ........... Y-AXIS ...........  START DIST    END DIST     PKG
 MEMBER 27          27    16     17  200.0      0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
                 MATERIAL # : (FX  ) - 5 , (MX  ) - 4 ,(MY-A) - 6 , (MY-B) - 6 ,(MZ-A) - 3 , (MZ-B) - 3
1 STRUCTURE. ...: THREE-STORY BUILDING                                                         TIME: 16:45:06, DATE
07/27/94
  SOLUTION .....

 ELEMENT 08,  3D BEAM ELEMENT

                    # MATL START   END  REL CD   LENGTH   ........... Y-AXIS ...........  START DIST    END DIST     PKG
 MEMBER 28          28    9    17     18         200.0      0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
1 STRUCTURE.....  THREE-STORY BUILDING                                                         TIME: 16:45:06, DATE
07/27/94
  SOLUTION  ..

 ELEMENT 09,  IE3DBEAM ELEMENT

                    #   START   END   LENGTH   ........... Y-AXIS ...........  START DIST    END DIST     PKG
 MEMBER 29          29    18     19  200.0      0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
                 MATERIAL # : (FX  ) - 5 , (MX  ) - 4 ,(MY-A) - 2 , (MY-B) - 2 ,(MZ-A) - 3 , (MZ-B) - 3
1 STRUCTURE....   THREE-STORY BUILDING                                                         TIME: 16:45:06, DATE:
07/27/94
  SOLUTION
```

```
ELEMENT 08,  3D BEAM ELEMENT

                     #  MATL START   END  REL CD   LENGTH   ........... Y-AXIS ............ START DIST    END DIST     PKG
MEMBER 30           30     9    19    21            200.0     -1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
1 STRUCTURE..... THREE-STORY BUILDING                                                                  TIME 16:45:06, DATE
07/27/94
  SOLUTION....


ELEMENT 09,  IE3DBEAM ELEMENT

                     #   START   END   LENGTH   ........... Y-AXIS ............ START DIST    END DIST     PKG
MEMBER 31           31    22     21  200.0      0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
                MATERIAL # : (FX ) - 5 , (MX ) - 4 ,(MY-A)- 2 , (MY-B)- 2 ,(MZ-A)- 3 , (MZ-B)- 3
1 STRUCTURE...   THREE-STORY BUILDING                                                                  TIME: 16:45:06, DATE
07/27/94
  SOLUTION.. ..


ELEMENT 08,  3D BEAM ELEMENT

                     #  MATL START   END  REL CD   LENGTH   ........... Y-AXIS ............ START DIST    END DIST     PKG
MEMBER 32           32     9    23    22            200.0      0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
1 STRUCTURE.     THREE-STORY BUILDING                                                                  TIME: 16:45:06, DATE.
07/27/94
  SOLUTION  . .


ELEMENT 09,  IE3DBEAM ELEMENT

                     #   START   END   LENGTH   ........... Y-AXIS ............ START DIST    END DIST     PKG
MEMBER 33           33    24     23  200.0      0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
                MATERIAL #   (FX ) - 5 , (MX ) - 4 ,(MY-A)- 6 , (MY-B)- 6 ,(MZ-A)- 3 , (MZ-B)- 3
1 STRUCTURE. .: THREE-STORY BUILDING                                                                   TIME: 16:45:06, DATE:
07/27/94
  SOLUTION.. .:


ELEMENT 06,  3D BEAM ELEMENT

                     #  MATL START   END  REL CD   LENGTH   ........... Y-AXIS ............ START DIST    END DIST     PKG
MEMBER 34           34     9    16    24            200.0     -1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
MEMBER 35           35     9    17    23            200.0     -1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
MEMBER 36           36     9    18    22            200.0     -1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
1 STRUCTURE . .: THREE-STORY BUILDING                                                                  TIME: 16:45:06, DATE.
07/27/94
  SOLUTION .....


ELEMENT 12,  STABILITY ELEMENT

                     #    MATL   START   END   LENGTH   ........... Y-AXIS ............ START DIST    END DIST
MEMBER 37           37     8     26     16   150.0      1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00
1 STRUCTURE....: THREE-STORY BUILDING                                                                  TIME. 16:45:06, DATE
07/27/94
  SOLUTION. ..


ELEMENT 09,  IE3DBEAM ELEMENT

                     #   START   END   LENGTH   ........... Y-AXIS ............ START DIST    END DIST     PKG
MEMBER 38           38    35     24  150.0      1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
                MATERIAL # : (FX ) - 5 , (MX ) - 4 ,(MY-A)- 2 , (MY-B)- 2 ,(MZ-A)- 3 , (MZ-B)- 3
1 STRUCTURE ..   THREE-STORY BUILDING                                                                  TIME: 16:45:06, DATE
07/27/94
  SOLUTION.. .:


ELEMENT 12,  STABILITY ELEMENT

                     #    MATL   START   END   LENGTH   ........... Y-AXIS ............ START DIST    END DIST
MEMBER 39           39     7     29     17   150.0      1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00
1 STRUCTURE. ..  THREE-STORY BUILDING                                                                  TIME: 16:45:06, DATE:
07/27/94
  SOLUTION . .:


ELEMENT 09,  IE3DBEAM ELEMENT

                     #   START   END   LENGTH   ........... Y-AXIS ............ START DIST    END DIST     PKG
MEMBER 40           40    34     23  150.0      1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
                MATERIAL #   (FX ) - 5 , (MX ) - 4 ,(MY-A)- 2 , (MY-B)- 2 ,(MZ-A)- 3 , (MZ-B)- 3
1 STRUCTURE      THREE-STORY BUILDING                                                                  TIME. 16:45:06, DATE:
07/27/94
  SOLUTION..


ELEMENT 08,  3D BEAM ELEMENT

                     #  MATL START   END  REL CD   LENGTH   ........... Y-AXIS ............ START DIST    END DIST     PKG
MEMBER 41           41     9    31    19            150.0      1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00   51.65
MEMBER 42           42     9    32    21            150.0      1.00000 I +0.00000 J +0.00000 K  0.0000E+00  0.0000E+00   51.65
MEMBER 43           43     9    20    21            152.6      0.70711 I +0.70711 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
MEMBER 44           44     9    20    19            152.6     -0.70711 I +0.70711 J +0.00000 K  0.0000E+00  0.0000E+00  0.0000E+00
MEMBER 45           45     9    36    20            127.9      0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00    2.231
1 STRUCTURE ....: THREE-STORY BUILDING                                                                 TIME 16:45:06, DATE:
07/27/94
  SOLUTION  ...


ELEMENT 02, ONE (LOCAL) DOF SPRING ELEMENT

                     #  MATL START   END  --TYPE---        LENGTH   ........... Y-AXIS ............ START DIST    END DIST
MEMBER 46           46    13    37    36  BENDING-Y        1.000      0.00000 I +1.00000 J +0.00000 K  0.0000E+00  0.0000E+00
1 STRUCTURE... : THREE-STORY BUILDING                                                                  TIME: 16:45:06, DATE:
07/27/94
  SOLUTION   .


ELEMENT 05, ONE (LOCAL) DOF STRUT ELEMENT
```

	#	MATL	START	END	--TYPE--	LENGTH	---------- Y-AXIS ----------	START DIST	END DIST
MEMBER 47	47	12	29	16	AXIAL	250.0	0.00000 I +1.00000 J +0.00000 K	0.0000E+00	0.0000E+00
MEMBER 48	48	12	34	24	AXIAL	250.0	0.00000 I +1.00000 J +0.00000 K	0.0000E+00	0.0000E+00
MEMBER 49	49	1	29	23	AXIAL	250.0	1.00000 I +0.00000 J +0.00000 K	0.0000E+00	0.0000E+00
MEMBER 50	50	1	30	22	AXIAL	250.0	1.00000 I +0.00000 J +0.00000 K	0.0000E+00	0.0000E+00
MEMBER 51	51	1	31	21	AXIAL	250.0	1.00000 I +0.00000 J +0.00000 K	0.0000E+00	0.0000E+00

1 STRUCTURE... THREE-STORY BUILDING TIME: 16:45:06, DATE: 07/27/94
SOLUTION....

ELEMENT 03. R/C SHEAR WALL ELEMENT

	ELEM #	BEND MATL	SHEAR MATL	AXIAL MATL	JOINT #1	JOINT #2	JOINT #3	JOINT #4	LENGTH	WIDTH	ALPHA	PKG
MEMBER 52	52	15	16	14	19	17	29	30	150.0	200.0	1.000	69.21
MEMBER 53	53	15	16	14	22	23	34	33	150.0	200.0	1.000	69.21

1 STRUCTURE... THREE-STORY BUILDING TIME: 16:45:06, DATE: 07/27/94
SOLUTION....

ELEMENT 14. R/C SHEAR WALL ELEMENT(SHEAR SPAN LENGTH RATIO= 0.0000E+00)

	ELEM #	SHEAR MATL	AXIAL1 MATL	AXIAL2 MATL	JOINT #1	JOINT #2	JOINT #3	JOINT #4	LENGTH	WIDTH	ALPHA	PKG
MEMBER 54	54	18	17	17	16	24	35	28	150.0	200.0	1.000	40.26

1 STRUCTURE... THREE-STORY BUILDING TIME 16:45:06, DATE 07/27/94
SOLUTION....

LUMPED NODE MASSES

NODE	MX	MY	MZ	IXX	IYY	IZZ	IXY	IYZ	IYZ	IGEN	INC
1	1.4400E-02	1.4400E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	7	1
11	2.5000E-02	2.5000E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	3	1
16	3.7750E-02	3.7750E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1	1
18	8.7750E-02	8.7750E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0	0
19	9.4420E-02	9.4420E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0	0
20	6.6700E-03	6.6700E-03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0	0
21	9.4420E-02	9.4420E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0	0
22	8.7750E-02	8.7750E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0	0
23	3.7750E-02	3.7750E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1	1
26	0.2000	0.2000	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0	0
27	1.3300E-02	1.3300E-02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0	0
35	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.5000	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0	0
9	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1	1
15	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0	0
25	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0	0

- THE MASS MATRIX IS NOT CONDENSED WITH THE STRUCTURAL STIFFNESS MATRIX

PROPORTIONAL DAMPING COEFFICIENTS

ALPHA= 0.00000E+00 BETA= 0.00000E+00

```
*-------------------------------------*
*--- MEMORY UTILIZATION ...  . ..  ---*
*--  IZ= 43934,    MEM= 6.276%    -- *
*-------------------------------------*
*--- ELAPSED CPU TIME     1.39 SEC ---*
*--- TOTAL CPU TIME       1.39 SEC ---*
*-------------------------------------*
```

1 STRUCTURE... THREE-STORY BUILDING TIME 16:45:06, DATE. 07/27/94
SOLUTION ... NONLINEAR CYCLE ANALYSIS WITH UNBALANCED FORCES TIME 16:45:08, DATE: 07/27/94
SOLUTION #4. STATIC NONLINEAR SOLUTION

INTERVAL FOR PRINTING DATA 500
INTERVAL FOR WRITING DATA TO FILE . .. 1

UNBALANCED JOINT FORCES ARE ADDED TO THE NEXT CYCLE

DATA WRITTEN TO FILES

ELEMENT # 2 IS WRITTEN TO UNIT # 17
ELEMENT # 9 IS WRITTEN TO UNIT # 18
ELEMENT # 37 IS WRITTEN TO UNIT # 19
ELEMENT # 39 IS WRITTEN TO UNIT # 20
ELEMENT # 22 IS WRITTEN TO UNIT # 21
ELEMENT # 27 IS WRITTEN TO UNIT # 22
ELEMENT # 29 IS WRITTEN TO UNIT # 23
ELEMENT # 38 IS WRITTEN TO UNIT # 24
ELEMENT # 46 IS WRITTEN TO UNIT # 25
ELEMENT # 47 IS WRITTEN TO UNIT # 26
ELEMENT # 50 IS WRITTEN TO UNIT # 27
ELEMENT # 52 IS WRITTEN TO UNIT # 28
ELEMENT # 54 IS WRITTEN TO UNIT # 29

APPLIED JOINT LOADS

LOAD CASE 1 JOINT: 1 DIRECTION: FX DOF(S) 56, 3, 58 MAGNITUDE: 0.22220
LOAD CASE 1 JOINT: 2 DIRECTION: FX DOF(S) 56, 6, 58 MAGNITUDE: 0.22220
LOAD CASE 1 JOINT: 3 DIRECTION: FX DOF(S) 59, 9, 61 MAGNITUDE: 0.22220
LOAD CASE 1 JOINT: 4 DIRECTION: FX DOF(S) 59, 12, 61 MAGNITUDE: 0.22220
LOAD CASE 1 JOINT: 5 DIRECTION: FX DOF(S) 59, 15, 61 MAGNITUDE: 0.22220
LOAD CASE 1 JOINT: 6 DIRECTION: FX DOF(S) 59, 18, 61 MAGNITUDE: 0.22220
LOAD CASE 1 JOINT: 7 DIRECTION: FX DOF(S) 56, 21, 58 MAGNITUDE: 0.22220
LOAD CASE 1 JOINT: 8 DIRECTION: FX DOF(S) 56, 24, 58 MAGNITUDE: 0.22220

1 STRUCTURE ...: THREE-STORY BUILDING TIME: 16:45:06, DATE: 07/27/94
SOLUTION ... NONLINEAR CYCLE ANALYSIS WITH UNBALANCED FORCES TIME: 16:45:08, DATE 07/27/94

1 STRUCTURE.. .. THREE-STORY BUILDING TIME: 16:45:06, DATE:

07/27/94
SOLUTION.... : NONLINEAR CYCLE ANALYSIS WITH UNBALANCED FORCES TIME: 16:45:08, DATE: 07/27/94

1 STRUCTURE... : THREE-STORY BUILDING TIME: 16:45:06, DATE:
07/27/94
SOLUTION.... : NONLINEAR CYCLE ANALYSIS WITH UNBALANCED FORCES TIME: 16:45:08, DATE: 07/27/94

1 STRUCTURE... : THREE-STORY BUILDING TIME: 16:45:06, DATE:
07/27/94
SOLUTION.... : NONLINEAR CYCLE ANALYSIS WITH UNBALANCED FORCES TIME: 16:45:08, DATE: 07/27/94

1 STRUCTURE ...: THREE-STORY BUILDING TIME: 16:45:06, DATE:
07/27/94
SOLUTION ...: NONLINEAR CYCLE ANALYSIS WITH UNBALANCED FORCES TIME: 16:45:08, DATE: 07/27/94

1 STRUCTURE ...: THREE-STORY BUILDING TIME: 16:45:06, DATE:
07/27/94
SOLUTION. ...: NONLINEAR CYCLE ANALYSIS WITH UNBALANCED FORCES TIME: 16:45:08, DATE: 07/27/94

1 STRUCTURE ...: THREE-STORY BUILDING TIME: 16:45:06, DATE:
07/27/94
SOLUTION.....: NONLINEAR CYCLE ANALYSIS WITH UNBALANCED FORCES TIME: 16:45:08, DATE: 07/27/94

MORE THAN 5 CYCLES IN MAT06, IELNO: 27
MORE THAN 5 CYCLES IN MAT06, IELNO: 33
MORE THAN 5 CYCLES IN MAT06, IELNO: 27
MORE THAN 5 CYCLES IN MAT06, IELNO: 33

1 STRUCTURE... THREE-STORY BUILDING TIME: 16:45:06, DATE:
07/27/94
SOLUTION.... NONLINEAR CYCLE ANALYSIS WITH UNBALANCED FORCES TIME: 16:45:08, DATE: 07/27/94

, LOADING # 0 MAXIMUM DISPLACEMENTS

GCS DISPLACEMENTS

NOTE MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

NODE	DX	DY	DZ	RX	RY	RZ
1	3.21269	-3.182326E-02	3.039812E-02	9.923894E-05	7.365519E-03	5.407635E-05
2	3.21269	-2.100799E-02	8.390620E-03	-4.599072E-05	2.840130E-03	5.407635E-05
3	3.20987	-2.600029E-02	0.130509	-1.097744E-04	1.993621E-03	6.110213E-05
4	3.20987	-1.377986E-02	-8.475560E-03	6.603351E-05	5.548780E-03	6.110213E-05
5	3.19765	-1.377986E-02	-8.416801E-03	6.603351E-05	5.663967E-03	6.110213E-05
6	3.19765	-2.600029E-02	0.124515	-1.097754E-04	2.030924E-03	6.110213E-05
7	3.20188	-2.100799E-02	5.646703E-03	-5.439597E-05	2.821374E-03	5.407635E-05
8	3.20188	-3.182326E-02	3.483453E-02	1.018036E-04	6.978863E-03	5.407635E-05
9	3.20729	-2.641562E-02	0.000000E+00	0.000000E+00	0.000000E+00	5.407635E-05
10	3.20376	-1.989007E-02	0.000000E+00	0.000000E+00	0.000000E+00	6.110213E-05
11	2.43197	-3.352056E-02	0.130599	-1.645726E-04	8.489481E-03	1.176206E-04
12	2.43197	-9.996444E-03	-6.544751E-03	1.060958E-04	7.368210E-03	1.176206E-04
13	2.40845	-9.996444E-03	-6.490015E-03	1.060958E-04	7.457012E-03	1.176206E-04
14	2.40845	-3.352056E-02	0.124622	-1.645732E-04	8.601118E-03	1.176206E-04
15	2.42021	-2.175850E-02	0.000000E+00	0.000000E+00	0.000000E+00	1.176206E-04
16	9.131998E-02	-8.434568E-03	2.423024E-02	9.155180E-05	8.159407E-03	-9.763047E-05
17	9.131998E-02	-2.796066E-02	6.554087E-03	1.043290E-04	4.189095E-03	-9.763047E-05
18	9.131998E-02	-4.748675E-02	0.126057	-1.535780E-04	2.453625E-03	-9.763047E-05
19	7.637754E-02	-3.885899E-03	0.000000E+00	0.000000E+00	0.000000E+00	-9.366243E-05
20	8.574379E-02	-1.325214E-02	0.000000E+00	0.000000E+00	0.000000E+00	-9.366243E-05
21	9.511003E-02	-3.885899E-03	0.000000E+00	0.000000E+00	0.000000E+00	-9.366243E-05
22	0.110846	-4.748675E-02	0.120183	-1.535743E-04	2.625858E-03	-9.763047E-05
23	0.110846	2.796066E-02	5.587034E-03	1.280743E-04	5.098853E-03	-9.763047E-05
24	0.110846	-8.434568E-03	2.983227E-02	8.577719E-05	1.063002E-02	-9.763047E-05
25	0.101083	-3.772371E-02	0.000000E+00	0.000000E+00	0.000000E+00	-9.763047E-05
26	0.101083	-5.724980E-02	0.000000E+00	0.000000E+00	0.000000E+00	-9.763047E-05
27	8.574379E-02	-7.007668E-03	0.000000E+00	0.000000E+00	0.000000E+00	-9.366243E-05
28	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
29	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
30	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
31	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
32	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
33	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
34	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
35	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
36	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	2.363083E-04	0.000000E+00
37	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

1 STRUCTURE. ...: THREE-STORY BUILDING TIME: 16:45:06, DATE:
07/27/94
SOLUTION. .. NONLINEAR CYCLE ANALYSIS WITH UNBALANCED FORCES TIME: 16:45:08, DATE: 07/27/94

, LOADING # 0 MAXIMUM REACTIONS

MAXIMUM GCS RESTRAINT REACTIONS NOTE. MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

NODE	FX	FY	FZ	MX	MY	MZ
9	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
10	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
15	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
25	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
26	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00
27	0.0000000E+00	0.0000000E+00	-85.68833	-557.3136	886.6435	0.0000000E+00
28	16.46656	6.731974	-83.09603	-9.724447	702.0929	4.443795
29	69.20426	21.69853	73.48646	-68.74381	357.1609	5.750468
30	11.68215	-31.56377	-44.65764	0.0000000E+00	0.0000000E+00	0.0000000E+00
31	-1.370315	3.271547	2.293489	-16.01716	-102.7736	1.7695955E-02
32	1.706401	0.2135621	0.0000000E+00	-16.01716	-127.9801	1.7695955E-02
33	39.34437	0.0000000E+00	-19.18904	0.0000000E+00	0.0000000E+00	0.0000000E+00
34	-90.51088	1.008763	81.28026	-68.85456	193.8964	1.8445649E-02
35	12.31503	0.1360138	-106.4690	-18.38941	566.0335	1.8445649E-02
36	-181.0930	0.5033726	182.6154	-21.38766	0.0000000E+00	-20.51623
37	0.0000000E+00	0.0000000E+00	0.0000000E+00	0.0000000E+00	-236.3083	0.0000000E+00
MAX OF ALL						
GCS SUMM.	355.5200	0.1283001E-12	3.5766454	-63.54447	-94520.63	35552.35

MAXIMUM RESULTANT OF REACTIONS. FORCE= 355.5 MOMENT= 1.0099E+05

1 STRUCTURE ... THREE-STORY BUILDING TIME: 16:45:06, DATE
07/27/94
SOLUTION.. . NONLINEAR CYCLE ANALYSIS WITH UNBALANCED FORCES TIME: 16:45:08, DATE: 07/27/94

. LOADING # 0 PEAK ELEMENT FORCES
COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

3D BEAM FORCES.
MAXIMUM VALUES FOR ALL STEPS NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ
1	2	FORCE	1	0.000000E+00	4.607859E-18	-9.25142	2.052586E-02	1107.10	6.930220E-16
		FORCE	2	0.000000E+00	-4.607859E-18	9.25142	-2.052586E-02	743.182	7.199102E-16
1	3	FORCE	1	0.000000E+00	-1.138412E-18	-23.0257	1.620256E-02	2652.32	1.379105E-16
		FORCE	2	0.000000E+00	1.138412E-18	23.0257	-1.620256E-02	1952.83	3.989864E-17
1	4	FORCE	1	0.000000E+00	4.607859E-18	-9.25142	2.052586E-02	1107.10	6.930220E-16
		FORCE	2	0.000000E+00	-4.607859E-18	9.25142	-2.052586E-02	743.182	7.199102E-16
1	5	FORCE	1	0.000000E+00	-1.138412E-18	-23.0257	1.620256E-02	2652.32	1.379105E-16
		FORCE	2	0.000000E+00	1.138412E-18	23.0257	-1.620256E-02	1952.83	3.989864E-17
1	6	FORCE	1	0.000000E+00	4.607859E-18	-9.25142	2.052586E-02	1107.10	6.930220E-16
		FORCE	2	0.000000E+00	-4.607859E-18	9.25142	-2.052586E-02	743.182	7.199102E-16
1	8	FORCE	1	0.000000E+00	4.607859E-18	-9.25142	2.052586E-02	1107.10	6.930220E-16
		FORCE	2	0.000000E+00	-4.607859E-18	9.25142	-2.052586E-02	743.182	7.199102E-16
1	9	FORCE	1	0.000000E+00	-1.138412E-18	-23.0257	1.620256E-02	2652.32	1.379105E-16
		FORCE	2	0.000000E+00	1.138412E-18	23.0257	-1.620256E-02	1952.83	3.989864E-17
1	10	FORCE	1	0.000000E+00	4.607859E-18	-9.25142	2.052586E-02	1107.10	6.930220E-16
		FORCE	2	0.000000E+00	-4.607859E-18	9.25142	-2.052586E-02	743.182	7.199102E-16
1	11	FORCE	1	0.000000E+00	-1.138412E-18	-23.0257	1.620256E-02	2652.32	1.379105E-16
		FORCE	2	0.000000E+00	1.138412E-18	23.0257	-1.620256E-02	1952.83	3.989864E-17
1	12	FORCE	1	0.000000E+00	4.607859E-18	-9.25142	2.052586E-02	1107.10	6.930220E-16
		FORCE	2	0.000000E+00	-4.607859E-18	9.25142	-2.052586E-02	743.182	7.199102E-16

COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

IE3D BEAM FORCES..
MAXIMUM VALUES FOR ALL STEPS NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ	STBFAG
2	1	FORCE	2	21.7547	3.940799E-02	-9.90774	3.072046E-03	908.296	3.78268	
		FORCE	3	-21.7547	-3.940799E-02	9.90774	-3.072046E-03	1073.25	4.09891	0
2	2	FORCE	2	21.2635	0.120466	-9.05748	2.153567E-03	820.179	11.8693	
		FORCE	3	-21.2635	-0.120466	9.05748	-2.153567E-03	991.317	12.2239	0
2	3	FORCE	2	6.82003	-4.235813E-02	-14.9391	1.008987E-02	1575.60	-4.50469	
		FORCE	3	-6.82003	4.235813E-02	14.9391	-1.008987E-02	1412.22	-3.96693	0
2	4	FORCE	2	6.82003	-4.235813E-02	-14.9391	1.008987E-02	1575.60	-4.50469	
		FORCE	3	-6.82003	4.235813E-02	14.9391	-1.008987E-02	1412.22	-3.96693	0
2	5	FORCE	2	6.82003	-4.235813E-02	-14.9391	1.008987E-02	1575.60	-4.50469	
		FORCE	3	-6.82003	4.235813E-02	14.9391	-1.008987E-02	1412.22	-3.96693	0
2	6	FORCE	2	21.2635	0.120466	-9.05748	2.153567E-03	820.179	11.8693	
		FORCE	3	-21.2635	-0.120466	9.05748	-2.153567E-03	991.317	12.2239	0
2	7	FORCE	2	21.7547	3.940799E-02	-9.90774	3.072046E-03	908.296	3.78268	
		FORCE	3	-21.7547	-3.940799E-02	9.90774	-3.072046E-03	1073.25	4.09891	0
2	8	FORCE	2	21.2635	0.120466	-9.05748	2.153567E-03	820.179	11.8693	
		FORCE	3	-21.2635	-0.120466	9.05748	-2.153567E-03	991.317	12.2239	0
2	9	FORCE	2	6.82003	-4.235813E-02	-14.9391	1.008987E-02	1575.60	-4.50469	
		FORCE	3	-6.82003	4.235813E-02	14.9391	-1.008987E-02	1412.22	-3.96693	0
2	10	FORCE	2	6.82003	-4.235813E-02	-14.9391	1.008987E-02	1575.60	-4.50469	
		FORCE	3	-6.82003	4.235813E-02	14.9391	-1.008987E-02	1412.22	-3.96693	0
2	11	FORCE	2	6.82003	-4.235813E-02	-14.9391	1.008987E-02	1575.60	-4.50469	
		FORCE	3	-6.82003	4.235813E-02	14.9391	-1.008987E-02	1412.22	-3.96693	0
2	12	FORCE	2	21.2635	0.120466	-9.05748	2.153567E-03	820.179	11.8693	
		FORCE	3	-21.2635	-0.120466	9.05748	-2.153567E-03	991.317	12.2239	0

COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

3D BEAM FORCES..
MAXIMUM VALUES FOR ALL STEPS NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ
3	2	FORCE	3	0.000000E+00	2.084040E-17	-12.0994	-1.386010E-02	1018.64	2.278451E-15
		FORCE	4	0.000000E+00	-2.084040E-17	12.0994	1.386010E-02	1401.24	2.313254E-15
3	3	FORCE	3	0.000000E+00	1.422677E-17	-13.9548	-2.491198E-02	1110.38	1.154350E-15
		FORCE	4	0.000000E+00	-1.422677E-17	13.9548	2.491198E-02	1680.58	1.161397E-15
3	4	FORCE	3	0.000000E+00	1.422677E-17	-13.9548	-2.491198E-02	1110.38	1.154350E-15
		FORCE	4	0.000000E+00	-1.422677E-17	13.9548	2.491198E-02	1680.58	1.161397E-15
3	5	FORCE	3	0.000000E+00	1.563623E-17	-13.5250	-1.750634E-02	1112.50	1.751095E-15
		FORCE	4	0.000000E+00	-1.563623E-17	13.5250	1.750634E-02	1592.49	1.785898E-15
3	6	FORCE	3	0.000000E+00	2.084040E-17	-12.0994	-1.386010E-02	1018.64	2.278451E-15
		FORCE	4	0.000000E+00	-2.084040E-17	12.0994	1.386010E-02	1401.24	2.313254E-15
3	8	FORCE	3	0.000000E+00	2.084040E-17	-12.0994	-1.386010E-02	1018.64	2.278451E-15
		FORCE	4	0.000000E+00	-2.084040E-17	12.0994	1.386010E-02	1401.24	2.313254E-15
3	9	FORCE	3	0.000000E+00	1.422677E-17	-13.9548	-2.491198E-02	1110.38	1.154350E-15
		FORCE	4	0.000000E+00	-1.422677E-17	13.9548	2.491198E-02	1680.58	1.161397E-15
3	10	FORCE	3	0.000000E+00	1.422677E-17	-13.9548	-2.491198E-02	1110.38	1.154350E-15
		FORCE	4	0.000000E+00	-1.422677E-17	13.9548	2.491198E-02	1680.58	1.161397E-15
3	11	FORCE	3	0.000000E+00	1.422677E-17	-13.9548	-2.491198E-02	1110.38	1.154350E-15
		FORCE	4	0.000000E+00	-1.422677E-17	13.9548	2.491198E-02	1680.58	1.161397E-15
3	12	FORCE	3	0.000000E+00	2.084040E-17	-12.0994	-1.386010E-02	1018.64	2.278451E-15
		FORCE	4	0.000000E+00	-2.084040E-17	12.0994	1.386010E-02	1401.24	2.313254E-15
4	2	FORCE	4	0.000000E+00	2.367186E-16	0.148118	-1.683860E-02	-14.8118	2.268574E-14
		FORCE	5	0.000000E+00	-2.367186E-16	-0.148118	1.683860E-02	-14.8118	2.272054E-14
4	3	FORCE	4	0.000000E+00	1.425014E-16	0.304842	-1.632201E-02	-30.4842	1.313782E-14
		FORCE	5	0.000000E+00	-1.425014E-16	-0.304842	1.632201E-02	-30.4842	1.314487E-14
4	4	FORCE	4	0.000000E+00	2.341165E-16	0.169479	-1.814149E-02	-16.9479	2.268574E-14
		FORCE	5	0.000000E+00	-2.341165E-16	-0.169479	1.814149E-02	-16.9479	2.272054E-14
4	5	FORCE	4	0.000000E+00	1.425014E-16	0.304842	-1.632201E-02	-30.4842	-1.313782E-14
		FORCE	5	0.000000E+00	-1.425014E-16	-0.304842	1.632201E-02	-30.4842	1.314487E-14
4	6	FORCE	4	0.000000E+00	2.341165E-16	0.169479	-1.814149E-02	-16.9479	2.268574E-14
		FORCE	5	0.000000E+00	-2.341165E-16	-0.169479	1.814149E-02	-16.9479	2.272054E-14
4	8	FORCE	4	0.000000E+00	2.367186E-16	0.148118	-1.683860E-02	-14.8118	2.268574E-14
		FORCE	5	0.000000E+00	-2.367186E-16	-0.148118	1.683860E-02	-14.8118	2.272054E-14
4	9	FORCE	4	0.000000E+00	1.425014E-16	0.304842	-1.632201E-02	-30.4842	1.313782E-14
		FORCE	5	0.000000E+00	-1.425014E-16	-0.304842	1.632201E-02	-30.4842	1.314487E-14
4	10	FORCE	4	0.000000E+00	2.341165E-16	0.169479	-1.814149E-02	-16.9479	2.268574E-14
		FORCE	5	0.000000E+00	-2.341165E-16	-0.169479	1.814149E-02	-16.9479	2.272054E-14
4	11	FORCE	4	0.000000E+00	1.425014E-16	0.304842	-1.632201E-02	-30.4842	1.313782E-14
		FORCE	5	0.000000E+00	-1.425014E-16	-0.304842	1.632201E-02	-30.4842	1.314487E-14
4	12	FORCE	4	0.000000E+00	2.341165E-16	0.169479	-1.814149E-02	-16.9479	2.268574E-14
		FORCE	5	0.000000E+00	-2.341165E-16	-0.169479	1.814149E-02	-16.9479	2.272054E-14

5	2	FORCE	6	0.000000E+00	2.084040E-17	-12.4826	-1.386023E-02	1049.76	2.278451E-15
		FORCE	5	0.000000E+00	2.084040E-17	12.4826	1.386023E-02	1446.77	2.313254E-15
5	3	FORCE	6	0.000000E+00	1.422677E-17	-14.5348	-2.491213E-02	1165.23	1.154350E-15
		FORCE	5	0.000000E+00	-1.422677E-17	14.5348	2.491213E-02	1741.73	1.161397E-15
5	4	FORCE	6	0.000000E+00	1.422677E-17	-14.5348	-2.491213E-02	1165.23	1.154350E-15
		FORCE	5	0.000000E+00	-1.422677E-17	14.5348	2.491213E-02	1741.73	1.161397E-15
5	5	FORCE	6	0.000000E+00	1.422677E-17	-14.5348	-2.491213E-02	1165.23	1.154350E-15
		FORCE	5	0.000000E+00	-1.422677E-17	14.5348	2.491213E-02	1741.73	1.161397E-15
5	6	FORCE	6	0.000000E+00	2.084040E-17	-12.4826	-1.386023E-02	1049.76	2.278451E-15
		FORCE	5	0.000000E+00	-2.084040E-17	12.4826	1.386023E-02	1446.77	2.313254E-15
5	8	FORCE	6	0.000000E+00	2.084040E-17	-12.4826	-1.386023E-02	1049.76	2.278451E-15
		FORCE	5	0.000000E+00	-2.084040E-17	12.4826	1.386023E-02	1446.77	2.313254E-15
5	9	FORCE	6	0.000000E+00	1.422677E-17	-14.5348	-2.491213E-02	1165.23	1.154350E-15
		FORCE	5	0.000000E+00	-1.422677E-17	14.5348	2.491213E-02	1741.73	1.161397E-15
5	10	FORCE	6	0.000000E+00	1.422677E-17	-14.5348	-2.491213E-02	1165.23	1.154350E-15
		FORCE	5	0.000000E+00	-1.422677E-17	14.5348	2.491213E-02	1741.73	1.161397E-15
5	11	FORCE	6	0.000000E+00	1.422677E-17	-14.5348	-2.491213E-02	1165.23	1.154350E-15
		FORCE	5	0.000000E+00	-1.422677E-17	14.5348	2.491213E-02	1741.73	1.161397E-15
5	12	FORCE	6	0.000000E+00	2.084040E-17	-12.4826	-1.386023E-02	1049.76	2.278451E-15
		FORCE	5	0.000000E+00	-2.084040E-17	12.4826	1.386023E-02	1446.77	2.313254E-15

COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

IE3D BEAM FORCES . .

MAXIMUM VALUES FOR ALL STEPS   NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ	STBFAG
6	1	FORCE	7	25.2260	3.940799E-02	-9.94631	1.992666E-03	907.334	3.78268	
		FORCE	6	-25.2260	-3.940799E-02	9.94631	-1.992666E-03	1081.93	4.09891	0
6	2	FORCE	7	25.1551	0.120466	-9.13764	1.100529E-03	823.212	11.8693	
		FORCE	6	-25.1551	-0.120466	9.13764	-1.100529E-03	1004.32	12.2239	0
6	3	FORCE	7	12.7230	-4.235813E-02	-15.0021	8.819539E-03	1574.14	-4.50469	
		FORCE	6	-12.7230	4.235813E-02	15.0021	-8.819539E-03	1426.29	-3.96693	0
6	4	FORCE	7	12.7230	-4.235813E-02	-15.0021	8.819539E-03	1574.14	-4.50469	
		FORCE	6	-12.7230	4.235813E-02	15.0021	-8.819539E-03	1426.29	-3.96693	0
6	5	FORCE	7	12.7230	-4.235813E-02	-15.0021	8.819539E-03	1574.14	-4.50469	
		FORCE	6	-12.7230	4.235813E-02	15.0021	-8.819539E-03	1426.29	-3.96693	0
6	6	FORCE	7	25.1551	0.120466	-9.13764	1.100529E-03	823.212	11.8693	
		FORCE	6	-25.1551	-0.120466	9.13764	-1.100529E-03	1004.32	12.2239	0
6	7	FORCE	7	25.2260	3.940799E-02	-9.94631	1.992666E-03	907.334	3.78268	
		FORCE	6	-25.2260	-3.940799E-02	9.94631	-1.992666E-03	1081.93	4.09891	0
6	8	FORCE	7	25.1551	0.120466	-9.13764	1.100529E-03	823.212	11.8693	
		FORCE	6	-25.1551	-0.120466	9.13764	-1.100529E-03	1004.32	12.2239	0
6	9	FORCE	7	12.7230	-4.235813E-02	-15.0021	8.819539E-03	1574.14	-4.50469	
		FORCE	6	-12.7230	4.235813E-02	15.0021	-8.819539E-03	1426.29	-3.96693	0
6	10	FORCE	7	12.7230	-4.235813E-02	-15.0021	8.819539E-03	1574.14	-4.50469	
		FORCE	6	-12.7230	4.235813E-02	15.0021	-8.819539E-03	1426.29	-3.96693	0
6	11	FORCE	7	12.7230	-4.235813E-02	-15.0021	8.819539E-03	1574.14	-4.50469	
		FORCE	6	-12.7230	4.235813E-02	15.0021	-8.819539E-03	1426.29	-3.96693	0
6	12	FORCE	7	25.1551	0.120466	-9.13764	1.100529E-03	823.212	11.8693	
		FORCE	6	-25.1551	-0.120466	9.13764	-1.100529E-03	1004.32	12.2239	0

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3D BEAM FORCES...

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ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ
7	2	FORCE	8	0.000000E+00	4.607859E-18	-8.76772	2.194247E-02	1051.32	6.930220E-16
		FORCE	7	0.000000E+00	-4.607859E-18	8.76772	-2.194247E-02	702.224	7.199102E-16
7	3	FORCE	8	0.000000E+00	-1.138412E-18	-21.9145	1.755101E-02	2512.77	1.379105E-16
		FORCE	7	0.000000E+00	1.138412E-18	21.9145	-1.755101E-02	1870.14	3.989864E-17
7	4	FORCE	8	0.000000E+00	4.607859E-15	-8.76772	2.194247E-02	1051.32	6.930220E-16
		FORCE	7	0.000000E+00	-4.607859E-16	8.76772	-2.194247E-02	702.224	7.199102E-16
7	5	FORCE	8	0.000000E+00	-1.138412E-18	-21.9145	1.755101E-02	2512.77	1.379105E-16
		FORCE	7	0.000000E+00	1.138412E-18	21.9145	-1.755101E-02	1870.14	3.989864E-17
7	6	FORCE	8	0.000000E+00	4.607859E-15	-8.76772	2.194247E-02	1051.32	6.930220E-16
		FORCE	7	0.000000E+00	-4.607859E-16	8.76772	-2.194247E-02	702.224	7.199102E-16
7	8	FORCE	8	0.000000E+00	4.607859E-18	-8.76772	2.194247E-02	1051.32	6.930220E-16
		FORCE	7	0.000000E+00	4.607859E-18	8.76772	-2.194247E-02	702.224	7.199102E-16
7	9	FORCE	8	0.000000E+00	-1.138412E-16	-21.9145	1.755101E-02	2512.77	1.379105E-16
		FORCE	7	0.000000E+00	1.138412E-16	21.9145	-1.755101E-02	1870.14	3.989864E-17
7	10	FORCE	8	0.000000E+00	4.607859E-18	-8.76772	2.194247E-02	1051.32	6.930220E-16
		FORCE	7	0.000000E+00	-4.607859E-16	8.76772	-2.194247E-02	702.224	7.199102E-16
7	11	FORCE	8	0.000000E+00	-1.138412E-18	-21.9145	1.755101E-02	2512.77	1.379105E-16
		FORCE	7	0.000000E+00	1.138412E-18	21.9145	-1.755101E-02	1870.14	3.989864E-17
7	12	FORCE	8	0.000000E+00	4.607859E-18	-8.76772	2.194247E-02	1051.32	6.930220E-16
		FORCE	7	0.000000E+00	-4.607859E-18	8.76772	-2.194247E-02	702.224	7.199102E-16
8	2	FORCE	1	0.000000E+00	-1.540109E-16	0.296090	1.698218E-02	-29.5324	-1.502617E-14
		FORCE	8	0.000000E+00	1.540109E-16	-0.296090	-1.698218E-02	-29.6857	-1.499929E-14
8	3	FORCE	1	0.000000E+00	-9.242824E-17	0.376077	1.713242E-02	-37.4095	-8.808926E-15
		FORCE	8	0.000000E+00	9.242824E-17	-0.376077	-1.713242E-02	-37.8059	-8.782038E-15
8	4	FORCE	1	0.000000E+00	-6.694948E-17	0.249794	5.478925E-02	-24.9369	-6.130513E-15
		FORCE	8	0.000000E+00	6.694948E-17	-0.249794	-5.478925E-02	-25.0220	-6.228525E-15
8	5	FORCE	1	0.000000E+00	-9.242824E-17	0.376077	1.713242E-02	-37.4095	-8.808926E-15
		FORCE	8	0.000000E+00	9.242824E-17	-0.376077	-1.713242E-02	-37.8059	-8.782038E-15
8	6	FORCE	1	0.000000E+00	-1.540109E-16	0.296090	1.698218E-02	-29.5324	-1.502617E-14
		FORCE	8	0.000000E+00	1.540109E-16	-0.296090	-1.698218E-02	-29.6857	-1.499929E-14
8	8	FORCE	1	0.000000E+00	-1.540109E-16	0.296090	1.698218E-02	-29.5324	-1.502617E-14
		FORCE	8	0.000000E+00	1.540109E-16	-0.296090	-1.698218E-02	-29.6857	-1.499929E-14
8	9	FORCE	1	0.000000E+00	-9.242824E-17	0.376077	1.713242E-02	-37.4095	-8.808926E-15
		FORCE	8	0.000000E+00	9.242824E-17	-0.376077	-1.713242E-02	-37.8059	-8.782038E-15
8	10	FORCE	1	0.000000E+00	-6.694948E-17	0.249794	5.478925E-02	-24.9369	-6.130513E-15
		FORCE	8	0.000000E+00	6.694948E-17	-0.249794	-5.478925E-02	-25.0220	-6.228525E-15
8	11	FORCE	1	0.000000E+00	9.242824E-17	0.376077	1.713242E-02	-37.4095	-8.808926E-15
		FORCE	8	0.000000E+00	9.242824E-17	-0.376077	-1.713242E-02	-37.8059	-8.782038E-15
8	12	FORCE	1	0.000000E+00	-1.540109E-16	0.296090	1.698218E-02	-29.5324	-1.502617E-14
		FORCE	8	0.000000E+00	1.540109E-16	-0.296090	-1.698218E-02	-29.6857	-1.499929E-14

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ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ	STBFAG
9	2	FORCE	2	0.000000E+00	-1.540109E-16	-0.121452	3.150259E-03	11.6373	-1.502617E-14	

		FORCE	7	0.000000E+00	1.540109E-16	0.121452	-3.150259E-03	12.6531	-1.499929E-14	0
9	3	FORCE	2	0.000000E+00	-9.242824E-17	0.149581	3.542979E-03	14.4626	-8.808926E-15	
		FORCE	7	0.000000E+00	9.242824E-17	0.149581	-3.542979E-03	15.4535	-8.782038E-15	0
9	4	FORCE	2	0.000000E+00	-5.274644E-17	-0.137186	5.779339E-03	13.1619	-4.576201E-15	
		FORCE	7	0.000000E+00	5.274644E-17	0.137186	-5.779339E-03	14.2753	-4.549312E-15	0
9	5	FORCE	2	0.000000E+00	-9.242824E-17	-0.149581	3.542979E-03	14.4626	-8.808926E-15	
		FORCE	7	0.000000E+00	9.242824E-17	0.149581	-3.542979E-03	15.4535	-8.782038E-15	0
9	6	FORCE	2	0.000000E+00	-1.540109E-16	-0.121452	3.150259E-03	11.6373	-1.502617E-14	
		FORCE	7	0.000000E+00	1.540109E-16	0.121452	-3.150259E-03	12.6531	-1.499929E-14	0
9	8	FORCE	2	0.000000E+00	-1.540109E-16	-0.121452	3.150259E-03	11.6373	1.502617E-14	
		FORCE	7	0.000000E+00	1.540109E-16	0.121452	-3.150259E-03	12.6531	-1.499929E-14	0
9	9	FORCE	2	0.000000E+00	-9.242824E-17	-0.149581	3.542979E-03	14.4626	-8.808926E-15	
		FORCE	7	0.000000E+00	9.242824E-17	0.149581	-3.542979E-03	15.4535	-8.782038E-15	0
9	10	FORCE	2	0.000000E+00	-5.274644E-17	-0.137186	5.779339E-03	13.1619	-4.576201E-15	
		FORCE	7	0.000000E+00	5.274644E-17	0.137186	-5.779339E-03	14.2753	-4.549312E-15	0
9	11	FORCE	2	0.000000E+00	-9.242824E-17	-0.149581	3.542979E-03	14.4626	-8.808926E-15	
		FORCE	7	0.000000E+00	9.242824E-17	0.149581	-3.542979E-03	15.4535	-8.782038E-15	0
9	12	FORCE	2	0.000000E+00	-1.540109E-16	-0.121452	3.150259E-03	11.6373	-1.502617E-14	
		FORCE	7	0.000000E+00	1.540109E-16	0.121452	-3.150259E-03	12.6531	-1.499929E-14	0
10	2	FORCE	3	0.000000E+00	2.367186E-16	-0.197071	-5.043353E-03	19.7071	2.268574E-14	
		FORCE	6	0.000000E+00	-2.367186E-16	0.197071	5.043353E-03	19.7072	2.272054E-14	0
10	3	FORCE	3	0.000000E+00	1.425014E-16	-0.319232	-1.054729E-02	31.9231	1.313782E-14	
		FORCE	6	0.000000E+00	-1.425014E-16	0.319232	1.054729E-02	31.9233	1.314487E-14	0
10	4	FORCE	3	0.000000E+00	1.425014E-16	-0.319232	-1.054729E-02	31.9231	1.313782E-14	
		FORCE	6	0.000000E+00	-1.425014E-16	0.319232	1.054729E-02	31.9233	1.314487E-14	0
10	5	FORCE	3	0.000000E+00	1.425014E-16	-0.319232	-1.054729E-02	31.9231	1.313782E-14	
		FORCE	6	0.000000E+00	-1.425014E-16	0.319232	1.054729E-02	31.9233	1.314487E-14	0
10	6	FORCE	3	0.000000E+00	2.341165E-16	-0.240074	-4.928993E-03	24.0074	2.268574E-14	
		FORCE	6	0.000000E+00	-2.341165E-16	0.240074	4.928993E-03	24.0075	2.272054E-14	0
10	8	FORCE	3	0.000000E+00	2.367186E-16	-0.197071	-5.043353E-03	19.7071	2.268574E-14	
		FORCE	6	0.000000E+00	-2.367186E-16	0.197071	5.043353E-03	19.7072	2.272054E-14	0
10	9	FORCE	3	0.000000E+00	1.425014E-16	-0.319232	-1.054729E-02	31.9231	1.313782E-14	
		FORCE	6	0.000000E+00	-1.425014E-16	0.319232	1.054729E-02	31.9233	1.314487E-14	0
10	10	FORCE	3	0.000000E+00	1.425014E-16	-0.319232	-1.054729E-02	31.9231	1.313782E-14	
		FORCE	6	0.000000E+00	-1.425014E-16	0.319232	1.054729E-02	31.9233	1.314487E-14	0
10	11	FORCE	3	0.000000E+00	1.425014E-16	-0.319232	-1.054729E-02	31.9231	1.313782E-14	
		FORCE	6	0.000000E+00	-1.425014E-16	0.319232	1.054729E-02	31.9233	1.314487E-14	0
10	12	FORCE	3	0.000000E+00	2.341165E-16	-0.240074	-4.928993E-03	24.0074	2.268574E-14	
		FORCE	6	0.000000E+00	-2.341165E-16	0.240074	4.928993E-03	24.0075	2.272054E-14	0

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ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ
11	2	FORCE	11	0.000000E+00	2.370439E-16	-0.624563	-1.596062E-02	62.4563	2.366770E-14
		FORCE	14	0.000000E+00	-2.370439E-16	0.624563	1.596062E-02	62.4563	2.371154E-14
11	3	FORCE	11	0.000000E+00	2.370439E-16	-0.624563	-1.596062E-02	62.4563	2.366770E-14
		FORCE	14	0.000000E+00	-2.370439E-16	0.624563	1.596062E-02	62.4563	2.371194E-14
11	4	FORCE	11	0.000000E+00	2.370439E-16	-0.624563	-1.596062E-02	62.4563	2.366770E-14
		FORCE	14	0.000000E+00	-2.370439E-16	0.624563	1.596062E-02	62.4563	2.371194E-14
11	5	FORCE	11	0.000000E+00	2.370439E-16	-0.624563	-1.596062E-02	62.4563	2.366770E-14
		FORCE	14	0.000000E+00	-2.370439E-16	0.624563	1.596062E-02	62.4563	2.371194E-14
11	6	FORCE	11	0.000000E+00	2.370439E-16	-0.624563	-1.596062E-02	62.4563	2.366770E-14
		FORCE	14	0.000000E+00	-2.370439E-16	0.624563	1.596062E-02	62.4563	2.371194E-14
11	8	FORCE	11	0.000000E+00	2.370439E-16	-0.624563	-1.596062E-02	62.4563	2.366770E-14
		FORCE	14	0.000000E+00	-2.370439E-16	0.624563	1.596062E-02	62.4563	2.371194E-14
11	9	FORCE	11	0.000000E+00	2.370439E-16	-0.624563	-1.596062E-02	62.4563	2.366770E-14
		FORCE	14	0.000000E+00	-2.370439E-16	0.624563	1.596062E-02	62.4563	2.371194E-14
11	10	FORCE	11	0.000000E+00	2.370439E-16	0.624563	-1.596062E-02	62.4563	2.366770E-14
		FORCE	14	0.000000E+00	-2.370439E-16	0.624563	1.596062E-02	62.4563	2.371194E-14
11	11	FORCE	11	0.000000E+00	2.370439E-16	-0.624563	-1.596062E-02	62.4563	2.366770E-14
		FORCE	14	0.000000E+00	-2.370439E-16	0.624563	1.596062E-02	62.4563	2.371194E-14
11	12	FORCE	11	0.000000E+00	2.370439E-16	-0.624563	-1.596062E-02	62.4563	2.366770E-14
		FORCE	14	0.000000E+00	-2.370439E-16	0.624563	1.596062E-02	62.4563	2.371194E-14
12	2	FORCE	11	0.000000E+00	3.095736E-17	-32.1602	-3.456892E-02	3295.26	2.469379E-15
		FORCE	12	0.000000E+00	-3.095736E-17	32.1602	3.456892E-02	3136.78	2.513614E-15
12	3	FORCE	11	0.000000E+00	2.958855E-17	-33.5848	-3.835371E-02	3445.06	2.364428E-15
		FORCE	12	0.000000E+00	-2.958855E-17	33.5848	3.835371E-02	3271.90	2.408664E-15
12	4	FORCE	11	0.000000E+00	2.958855E-17	-33.5848	-3.835371E-02	3445.06	2.364428E-15
		FORCE	12	0.000000E+00	-2.958855E-17	33.5848	3.835371E-02	3271.90	2.408664E-15
12	5	FORCE	11	0.000000E+00	2.958855E-17	-33.5848	-3.835371E-02	3445.06	2.364428E-15
		FORCE	12	0.000000E+00	-2.958855E-17	33.5848	3.835371E-02	3271.90	2.408664E-15
12	6	FORCE	11	0.000000E+00	2.905662E-17	-26.8857	-2.225936E-02	2721.53	2.539635E-15
		FORCE	12	0.000000E+00	-2.905662E-17	26.8857	2.225936E-02	2655.60	2.581269E-15
12	8	FORCE	11	0.000000E+00	3.095736E-17	-32.1602	-3.456892E-02	3295.26	2.469379E-15
		FORCE	12	0.000000E+00	-3.095736E-17	32.1602	3.456892E-02	3136.78	2.513614E-15
12	9	FORCE	11	0.000000E+00	2.958855E-17	-33.5848	-3.835371E-02	3445.06	2.364428E-15
		FORCE	12	0.000000E+00	-2.958855E-17	33.5848	3.835371E-02	3271.90	-2.408664E-15
12	10	FORCE	11	0.000000E+00	2.958855E-17	-33.5848	-3.835371E-02	3445.06	2.364428E-15
		FORCE	12	0.000000E+00	-2.958855E-17	33.5848	3.835371E-02	3271.90	2.408664E-15
12	11	FORCE	11	0.000000E+00	2.958855E-17	-33.5848	-3.835371E-02	3445.06	2.364428E-15
		FORCE	12	0.000000E+00	-2.958855E-17	33.5848	3.835371E-02	3271.90	2.408664E-15
12	12	FORCE	11	0.000000E+00	2.905662E-17	-26.8857	-2.225936E-02	2721.53	2.539635E-15
		FORCE	12	0.000000E+00	-2.905662E-17	26.8857	2.225936E-02	2655.60	2.581269E-15
13	2	FORCE	12	0.000000E+00	2.370439E-16	0.490708	-1.258311E-02	-49.0708	2.366770E-14
		FORCE	13	0.000000E+00	-2.370439E-16	-0.490708	1.258311E-02	-49.0708	2.371194E-14
13	3	FORCE	12	0.000000E+00	2.370439E-16	0.490708	-1.258311E-02	-49.0708	2.366770E-14
		FORCE	13	0.000000E+00	-2.370439E-16	-0.490708	1.258311E-02	-49.0708	2.371194E-14
13	4	FORCE	12	0.000000E+00	7.676151E-17	0.278155	2.020101E-02	-27.8155	8.174017E-15
		FORCE	13	0.000000E+00	-7.676151E-17	-0.278155	-2.020101E-02	-27.8155	8.215650E-15
13	5	FORCE	12	0.000000E+00	2.370439E-16	0.490708	-1.258311E-02	-49.0708	2.366770E-14

		FORCE	13	0.000000E+00	-2.370439E-16	-0.490708	1.258311E-02	-49.0708	2.371194E-14
13	6	FORCE	12	0.000000E+00	2.370439E-16	0.490708	-1.258311E-02	-49.0708	2.366770E-14
		FORCE	13	0.000000E+00	-2.370439E-16	-0.490708	1.258311E-02	-49.0708	2.371194E-14
13	8	FORCE	12	0.000000E+00	2.370439E-16	0.490708	-1.258311E-02	-49.0708	2.366770E-14
		FORCE	13	0.000000E+00	-2.370439E-16	-0.490708	1.258311E-02	-49.0708	2.371194E-14
13	9	FORCE	12	0.000000E+00	2.370439E-16	0.490708	-1.258311E-02	-49.0708	2.366770E-14
		FORCE	13	0.000000E+00	-2.370439E-16	-0.490708	1.258311E-02	-49.0708	2.371194E-14
13	10	FORCE	12	0.000000E+00	7.676151E-17	0.278155	2.020101E-02	-27.8155	6.174017E-15
		FORCE	13	0.000000E+00	-7.676151E-17	-0.278155	2.020101E-02	-27.8155	6.215650E-15
13	11	FORCE	12	0.000000E+00	2.370439E-16	0.490708	-1.258311E-02	-49.0708	2.366770E-14
		FORCE	13	0.000000E+00	-2.370439E-16	-0.490708	1.258311E-02	-49.0708	2.371194E-14
13	12	FORCE	12	0.000000E+00	2.370439E-16	0.490708	-1.258311E-02	-49.0708	2.366770E-14
		FORCE	13	0.000000E+00	-2.370439E-16	-0.490708	1.258311E-02	-49.0708	2.371194E-14
14	2	FORCE	14	0.000000E+00	3.095736E-17	-32.6960	3.456900E-02	3350.66	2.469379E-15
		FORCE	13	0.000000E+00	-3.095736E-17	32.6960	3.456900E-02	3188.54	2.513614E-15
14	3	FORCE	14	0.000000E+00	2.958855E-17	-34.1917	-3.835380E-02	3507.59	2.364428E-15
		FORCE	13	0.000000E+00	-2.958855E-17	34.1917	3.835380E-02	3330.75	2.408664E-15
14	4	FORCE	14	0.000000E+00	2.958855E-17	-34.1917	-3.835380E-02	3507.59	2.364428E-15
		FORCE	13	0.000000E+00	-2.958855E-17	34.1917	3.835380E-02	3330.75	2.408664E-15
14	5	FORCE	14	0.000000E+00	2.958855E-17	-34.1917	-3.835380E-02	3507.59	2.364428E-15
		FORCE	13	0.000000E+00	-2.958855E-17	34.1917	3.835380E-02	3330.75	2.408664E-15
14	6	FORCE	14	0.000000E+00	2.905662E-17	-26.6872	-2.225943E-02	2716.92	2.539635E-15
		FORCE	13	0.000000E+00	-2.905662E-17	26.6872	2.225943E-02	2620.51	2.581269E-15
14	8	FORCE	14	0.000000E+00	3.095736E-17	-32.6960	-3.456900E-02	3350.66	2.469379E-15
		FORCE	13	0.000000E+00	-3.095736E-17	32.6960	3.456900E-02	3188.54	2.513614E-15
14	9	FORCE	14	0.000000E+00	2.958855E-17	-34.1917	-3.835380E-02	3507.59	2.364428E-15
		FORCE	13	0.000000E+00	-2.958855E-17	34.1917	3.835380E-02	3330.75	2.408664E-15
14	10	FORCE	14	0.000000E+00	2.958855E-17	-34.1917	-3.835380E-02	3507.59	2.364428E-15
		FORCE	13	0.000000E+00	-2.958855E-17	34.1917	3.835380E-02	3330.75	2.408664E-15
14	11	FORCE	14	0.000000E+00	2.958855E-17	-34.1917	-3.835380E-02	3507.59	2.364428E-15
		FORCE	13	0.000000E+00	-2.958855E-17	34.1917	3.835380E-02	3330.75	2.408664E-15
14	12	FORCE	14	0.000000E+00	2.905662E-17	-26.6872	-2.225943E-02	2716.92	2.539635E-15
		FORCE	13	0.000000E+00	-2.905662E-17	26.6872	2.225943E-02	2620.51	2.581269E-15
15	1	FORCE	16	-22.7759	-35.0089	0.325554	1.787783E-02	-23.8800	-2598.96
		FORCE	1	22.7759	35.0089	-0.325554	1.787783E-02	-24.9531	-2652.37
15	2	FORCE	16	-22.7759	-35.0089	0.325554	-1.787783E-02	-23.8800	-2598.96
		FORCE	1	22.7759	35.0089	-0.325554	1.787783E-02	-24.9531	-2652.37
15	3	FORCE	16	-8.87534	-14.6978	0.509175	-2.589984E-02	-38.9463	-1097.55
		FORCE	1	8.87534	14.6978	-0.509175	2.589984E-02	-37.4300	-1107.12
15	4	FORCE	16	-8.87534	-14.6978	0.509175	-2.589984E-02	-38.9463	1097.55
		FORCE	1	8.87534	14.6978	-0.509175	2.589984E-02	-37.4300	-1107.12
15	5	FORCE	16	-8.87534	-14.6978	0.509175	-2.589984E-02	-38.9463	-1097.55
		FORCE	1	8.87534	14.6978	-0.509175	2.589984E-02	-37.4300	-1107.12
15	6	FORCE	16	-22.7759	-35.0089	0.325554	-1.787783E-02	-23.8800	-2598.96
		FORCE	1	22.7759	35.0089	-0.325554	1.787783E-02	-24.9531	-2652.37
15	7	FORCE	16	-22.7759	-35.0089	0.325554	-1.787783E-02	-23.8800	-2598.96
		FORCE	1	22.7759	35.0089	-0.325554	1.787783E-02	-24.9531	-2652.37
15	8	FORCE	16	-22.7759	-35.0089	0.325554	-1.787783E-02	-23.8800	-2598.96
		FORCE	1	22.7759	35.0089	-0.325554	1.787783E-02	-24.9531	-2652.37
15	9	FORCE	16	-8.87534	14.6978	0.509175	-2.589984E-02	-38.9463	-1097.55
		FORCE	1	8.87534	14.6978	-0.509175	2.589984E-02	-37.4300	-1107.12
15	10	FORCE	16	-8.87534	-14.6978	0.509175	-2.589984E-02	-38.9463	-1097.55
		FORCE	1	8.87534	14.6978	-0.509175	2.589984E-02	-37.4300	-1107.12
15	11	FORCE	16	-8.87534	-14.6978	0.509175	-2.589984E-02	-38.9463	-1097.55
		FORCE	1	8.87534	14.6978	-0.509175	2.589984E-02	-37.4300	-1107.12
15	12	FORCE	16	-22.7759	-35.0089	0.325554	-1.787783E-02	-23.8800	-2598.96
		FORCE	1	22.7759	35.0089	-0.325554	1.787783E-02	-24.9531	-2652.37
16	1	FORCE	17	7.97337	-46.4407	-0.339451	-1.787783E-02	40.1840	-3437.67
		FORCE	2	-7.97337	46.4407	0.339451	1.787783E-02	10.7337	3528.43
16	2	FORCE	17	7.97337	-46.4407	-0.339451	-1.787783E-02	40.1840	-3437.67
		FORCE	2	-7.97337	46.4407	0.339451	1.787783E-02	10.7337	-3528.43
16	3	FORCE	17	4.436127E-02	-20.6546	-0.372722	-2.589984E-02	41.4273	-1534.83
		FORCE	2	-4.436127E-02	20.6546	0.372722	2.589984E-02	14.4809	-1563.36
16	4	FORCE	17	4.436127E-02	-20.6546	-0.372722	-2.589984E-02	41.4273	-1534.83
		FORCE	2	-4.436127E-02	20.6546	0.372722	2.589984E-02	14.4809	-1563.36
16	5	FORCE	17	1.25822	-26.0286	-0.371436	-2.398597E-02	42.1898	-1930.15
		FORCE	2	-1.25822	26.0286	0.371436	2.398597E-02	13.5256	-1974.14
16	6	FORCE	17	7.97337	-46.4407	-0.339451	-1.787783E-02	40.1840	-3437.67
		FORCE	2	-7.97337	46.4407	0.339451	1.787783E-02	10.7337	-3528.43
16	7	FORCE	17	7.97337	-46.4407	-0.339451	-1.787783E-02	40.1840	-3437.67
		FORCE	2	-7.97337	46.4407	0.339451	1.787783E-02	10.7337	-3528.43
16	8	FORCE	17	7.97337	-46.4407	-0.339451	-1.787783E-02	40.1840	3437.67
		FORCE	2	-7.97337	46.4407	0.339451	1.787783E-02	10.7337	-3528.43
16	9	FORCE	17	4.436127E-02	20.6546	-0.372722	-2.589984E-02	41.4273	-1534.83
		FORCE	2	-4.436127E-02	20.6546	0.372722	2.589984E-02	14.4809	-1563.36
16	10	FORCE	17	4.436127E-02	-20.6546	-0.372722	-2.589984E-02	41.4273	-1534.83
		FORCE	2	-4.436127E-02	20.6546	0.372722	2.589984E-02	14.4809	-1563.36
16	11	FORCE	17	4.436127E-02	-20.6546	-0.372722	-2.589984E-02	41.4273	-1534.83
		FORCE	2	-4.436127E-02	20.6546	0.372722	2.589984E-02	14.4809	-1563.36
16	12	FORCE	17	7.97337	-46.4407	-0.339451	-1.787783E-02	40.1840	-3437.67
		FORCE	2	-7.97337	46.4407	0.339451	1.787783E-02	10.7337	-3528.43
17	1	FORCE	11	-3.28197	-45.2936	-0.443825	2.135643E-02	9.26348	1387.07
		FORCE	3	3.28197	45.2936	0.443825	-2.135643E-02	24.0234	-2009.95
17	2	FORCE	11	0.665033	-55.3764	-0.551056	3.655080E-02	9.37104	1630.64
		FORCE	3	-0.665033	55.3764	0.551056	-3.655080E-02	31.9581	-2522.59
17	3	FORCE	11	0.665033	-55.3764	-0.551056	3.655080E-02	9.37104	-1630.64
		FORCE	3	-0.665033	55.3764	0.551056	-3.655080E-02	31.9581	-2522.59
17	4	FORCE	11	0.665033	-55.3764	-0.551056	3.655080E-02	9.37104	-1630.64
		FORCE	3	-0.665033	55.3764	0.551056	-3.655080E-02	31.9581	-2522.59
17	5	FORCE	11	-2.72421	-36.2957	0.140163	1.202479E-02	-17.0213	-1149.68
		FORCE	3	2.72421	36.2957	-0.140163	-1.202479E-02	6.50902	-1572.50
17	6	FORCE	11	0.665033	55.3764	-0.551056	3.655080E-02	9.37104	-1630.64
		FORCE	3	-0.665033	55.3764	0.551056	-3.655080E-02	31.9581	-2522.59
17	7	FORCE	11	-3.28197	-45.2936	-0.443825	2.135643E-02	9.26348	-1387.07
		FORCE	3	3.28197	45.2936	0.443825	-2.135643E-02	24.0234	2009.95
17	8	FORCE	11	0.665033	-55.3764	0.551056	3.655080E-02	9.37104	-1630.64
		FORCE	3	-0.665033	55.3764	0.551056	-3.655080E-02	31.9581	2522.59
17	9	FORCE	11	0.665033	-55.3764	-0.551056	3.655080E-02	9.37104	-1630.64
		FORCE	3	-0.665033	55.3764	0.551056	-3.655080E-02	31.9581	-2522.59
17	10	FORCE	11	0.665033	-55.3764	-0.551056	3.655080E-02	9.37104	-1630.64
		FORCE	3	-0.665033	55.3764	0.551056	-3.655080E-02	31.9581	-2522.59
17	11	FORCE	11	0.665033	-55.3764	-0.551056	3.655080E-02	9.37104	-1630.64
		FORCE	3	-0.665033	55.3764	0.551056	-3.655080E-02	31.9581	-2522.59
17	12	FORCE	11	0.665033	-55.3764	-0.551056	3.655080E-02	9.37104	-1630.64
		FORCE	3	-0.665033	55.3764	0.551056	-3.655080E-02	31.9581	-2522.59

COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

IE3D BEAM FORCES ..

MAXIMUM VALUES FOR ALL STEPS NOTE MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ	STBFAG
18	1	FORCE	18	34.9689	-43.1929	-1.31719	-7.778064E-02	50.9914	-1644.86	
		FORCE	11	34.9689	43.1929	1.31719	7.778064E-02	47.7976	-1594.60	1

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ	STBFAG
18	2	FORCE	18	-33.5443	-49.0901	-1.47705	-7.633347E-02	57.6554	-1867.36	
		FORCE	11	33.5443	49.0901	1.47705	7.633347E-02	53.1236	-1814.40	1
18	3	FORCE	18	-33.5443	-49.0901	-1.47705	-7.633347E-02	57.6554	-1867.36	
		FORCE	11	33.5443	49.0901	1.47705	7.633347E-02	53.1236	-1814.40	1
18	4	FORCE	18	-33.2762	-44.7909	-1.25087	-7.808934E-02	49.3653	-1704.16	
		FORCE	11	33.2762	44.7909	1.25087	7.808934E-02	44.4297	-1655.15	1
18	5	FORCE	18	-33.5443	-49.0901	-1.47705	-7.633347E-02	57.6554	-1867.36	
		FORCE	11	33.5443	49.0901	1.47705	7.633347E-02	53.1236	-1814.40	1
18	6	FORCE	18	-33.5443	-49.0901	1.47705	-7.633347E-02	57.6554	-1867.36	
		FORCE	11	33.5443	49.0901	1.47705	7.633347E-02	53.1236	-1814.40	1
18	7	FORCE	18	-34.9689	-43.1929	-1.31719	-7.778064E-02	50.9914	-1644.80	
		FORCE	11	34.9689	43.1929	1.31719	7.778064E-02	47.7978	-1594.60	1
18	8	FORCE	18	-33.5443	-49.0901	-1.47705	-7.633347E-02	57.6554	-1867.36	
		FORCE	11	33.5443	49.0901	1.47705	7.633347E-02	53.1236	-1814.40	1
18	9	FORCE	18	-33.5443	-49.0901	1.47705	-7.633347E-02	57.6554	-1867.36	
		FORCE	11	33.5443	49.0901	1.47705	7.633347E-02	53.1236	-1814.40	1
18	10	FORCE	18	-33.2762	44.7909	-1.25087	-7.808934E-02	49.3653	-1704.16	
		FORCE	11	33.2762	44.7909	1.25087	7.808934E-02	44.4297	-1655.15	1
18	11	FORCE	18	-28.0586	-57.0330	-1.44182	-4.672836E-02	50.3859	-1589.74	
		FORCE	11	28.0586	57.0330	1.44182	4.672836E-02	57.7502	-1187.73	1
18	12	FORCE	18	-33.5443	-49.0901	-1.47705	-7.633347E-02	57.6554	-1867.36	
		FORCE	11	33.5443	49.0901	1.47705	7.633347E-02	53.1236	-1814.40	1

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3D BEAM FORCES .

MAXIMUM VALUES FOR ALL STEPS NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ
19	1	FORCE	12	14.2597	-41.5508	0.593400	3.655080E-02	-13.9959	-1435.74
		FORCE	4	-14.2597	41.5508	-0.593400	-3.655080E-02	-30.5091	-1680.57
19	2	FORCE	12	14.2597	-41.5508	0.593400	3.655080E-02	-13.9959	-1435.74
		FORCE	4	-14.2597	41.5508	-0.593400	-3.655080E-02	-30.5091	-1680.57
19	3	FORCE	12	14.2597	-41.5508	0.593400	3.655080E-02	-13.9959	-1435.74
		FORCE	4	-14.2597	41.5508	-0.593400	-3.655080E-02	-30.5091	-1680.57
19	4	FORCE	12	14.2597	41.5508	0.593400	3.655080E-02	-13.9959	-1435.74
		FORCE	4	14.2597	41.5508	-0.593400	-3.655080E-02	-30.5091	-1680.57
19	5	FORCE	12	14.2597	-41.5508	0.593400	3.655080E-02	-13.9959	-1435.74
		FORCE	4	-14.2597	41.5508	-0.593400	-3.655080E-02	-30.5091	-1680.57
19	6	FORCE	12	14.2597	-41.5508	0.593400	3.655080E-02	-13.9959	-1435.74
		FORCE	4	-14.2597	41.5508	-0.593400	-3.655080E-02	-30.5091	-1680.57
19	7	FORCE	12	14.2597	-41.5508	0.593400	3.655080E-02	-13.9959	-1435.74
		FORCE	4	14.2597	41.5508	-0.593400	-3.655080E-02	-30.5091	-1680.57
19	8	FORCE	12	14.2597	-41.5508	0.593400	3.65508CE-02	-13.9959	-1435.74
		FORCE	4	-14.2597	41.5508	-0.593400	-3.65508CE-02	-30.5091	-1680.57
19	9	FORCE	12	14.2597	-41.5508	0.593400	3.65508CE-02	-13.9959	-1435.74
		FORCE	4	-14.2597	41.5508	-0.593400	-3.65508CE-02	-30.5091	-1680.57
19	10	FORCE	12	14.2597	-41.5508	0.593400	3.655080E-02	-13.9959	1435.74
		FORCE	4	-14.2597	41.5508	-0.593400	-3.655080E-02	-30.5091	-1680.57
19	11	FORCE	12	14.2597	-41.5508	0.593400	3.655080E-02	-13.9959	-1435.74
		FORCE	4	-14.2597	41.5508	-0.593400	-3.655080E-02	-30.5091	-1680.57
19	12	FORCE	12	14.2597	-41.5508	0.593400	3.655080E-02	-13.9959	-1435.74
		FORCE	4	-14.2597	41.5508	-0.593400	-3.655080E-02	-30.5091	-1680.57

COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

IE3D BEAM FORCES.

MAXIMUM VALUES FOR ALL STEPS NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ	STBFAG
20	1	FORCE	19	48.3352	-49.6869	1.51944	-7.483408E-02	-78.8445	-1890.38	
		FORCE	12	-48.3352	49.6869	-1.51944	7.483408E-02	-35.1132	-1836.14	1
20	2	FORCE	19	48.3352	-49.6869	1.51944	-7.483408E-02	-78.8445	-1890.38	
		FORCE	12	-48.3352	49.6869	-1.51944	7.483408E-02	-35.1132	-1836.14	1
20	3	FORCE	19	48.3352	-49.6869	1.51944	-7.483408E-02	-78.8445	-1890.38	
		FORCE	12	-48.3352	49.6869	-1.51944	7.483408E-02	-35.1132	-1836.14	1
20	4	FORCE	19	44.6430	-45.3670	1.19971	-7.668332E-02	-62.2979	-1727.15	
		FORCE	12	-44.6430	45.3670	-1.19971	7.668332E-02	-27.6805	-1675.37	1
20	5	FORCE	19	48.3352	-49.6869	1.51944	-7.483408E-02	-78.8445	-1890.38	
		FORCE	12	-48.3352	49.6869	-1.51944	7.483408E-02	-35.1132	-1836.14	1
20	6	FORCE	19	48.3352	-49.6869	1.51944	-7.483408E-02	-78.8445	-1890.38	
		FORCE	12	-48.3352	49.6869	-1.51944	7.483408E-02	-35.1132	-1836.14	1
20	7	FORCE	19	48.3352	-49.6869	1.51944	-7.483408E-02	-78.8445	-1890.38	
		FORCE	12	-48.3352	49.6869	-1.51944	7.483408E-02	-35.1132	-1836.14	1
20	8	FORCE	19	48.3352	-49.6869	1.51944	-7.483408E-02	-78.8445	-1890.38	
		FORCE	12	-48.3352	49.6869	-1.51944	7.483408E-02	-35.1132	-1836.14	1
20	9	FORCE	19	48.3352	-49.6869	1.51944	-7.483408E-02	-78.8445	-1890.38	
		FORCE	12	-48.3352	49.6869	-1.51944	7.483408E-02	-35.1132	-1836.14	1
20	10	FORCE	19	44.6430	-45.3670	1.19971	-7.668332E-02	-62.2979	1727.15	
		FORCE	12	-44.6430	45.3670	-1.19971	7.668332E-02	-27.6805	-1675.37	1
20	11	FORCE	19	36.1892	-39.2257	1.44699	-4.495410E-02	-67.2193	-1612.08	
		FORCE	12	-36.1892	39.2257	-1.44699	4.495410E-02	-41.3046	-1330.07	1
20	12	FORCE	19	48.3352	-49.6869	1.51944	-7.483408E-02	-78.8445	-1890.38	
		FORCE	12	-48.3352	49.6869	-1.51944	7.483408E-02	-35.1132	-1836.14	1

COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

3D BEAM FORCES...

MAXIMUM VALUES FOR ALL STEPS NOTE MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ
21	1	FORCE	13	14.2300	-43.2296	0.593400	3.65508CE-02	-13.9959	-1500.47
		FORCE	5	-14.2300	43.2296	-0.593400	3.65508CE-02	-30.5091	1741.75
21	2	FORCE	13	14.2300	-43.2296	0.593400	3.65508CE-02	-13.9959	-1500.47
		FORCE	5	14.2300	43.2296	-0.593400	-3.655080E-02	-30.5091	-1741.75
21	3	FORCE	13	14.2300	-43.2296	0.593400	3.655080E-02	-13.9959	-1500.47

		FORCE	5	-14.2300	43.2296	-0.593400	-3.655080E-02	-30.5091	-1741.75	
21	4	FORCE	13	14.2300	-43.2296	0.593400	3.655080E-02	-13.9959	-1500.47	
		FORCE	5	-14.2300	43.2296	-0.593400	-3.655080E-02	-30.5091	-1741.75	
21	5	FORCE	13	14.2300	-43.2296	0.593400	3.655080E-02	-13.9959	-1500.47	
		FORCE	5	-14.2300	43.2296	-0.593400	-3.655080E-02	-30.5091	-1741.75	
21	6	FORCE	13	14.2300	-43.2296	0.593400	3.655080E-02	-13.9959	-1500.47	
		FORCE	5	-14.2300	43.2296	-0.593400	-3.655080E-02	-30.5091	-1741.75	
21	7	FORCE	13	14.2300	-43.2296	0.593400	3.655080E-02	13.9959	-1500.47	
		FORCE	5	-14.2300	43.2296	-0.593400	-3.655080E-02	-30.5091	-1741.75	
21	8	FORCE	13	14.2300	-43.2296	0.593400	3.655080E-02	-13.9959	-1500.47	
		FORCE	5	-14.2300	43.2296	-0.593400	-3.655080E-02	-30.5091	-1741.75	
21	9	FORCE	13	14.2300	-43.2296	0.593400	3.655080E-02	-13.9959	-1500.47	
		FORCE	5	-14.2300	43.2296	-0.593400	-3.655080E-02	-30.5091	-1741.75	
21	10	FORCE	13	14.2300	-43.2296	0.593400	3.655080E-02	-13.9959	-1500.47	
		FORCE	5	-14.2300	43.2296	-0.593400	-3.655080E-02	-30.5091	-1741.75	
21	11	FORCE	13	14.2300	-43.2296	0.593400	3.655080E-02	-13.9959	-1500.47	
		FORCE	5	-14.2300	43.2296	-0.593400	-3.655080E-02	-30.5091	-1741.75	
21	12	FORCE	13	14.2300	-43.2296	0.593400	3.655080E-02	-13.9959	-1500.47	
		FORCE	5	-14.2300	43.2296	-0.593400	-3.655080E-02	-30.5091	-1741.75	

COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

IE3D BEAM FORCES...

MAXIMUM VALUES FOR ALL STEPS NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ	STBFAG
22	1	FORCE	21	47.9309	-49.5188	1.51944	-7.483408E-02	-78.8445	-1883.62	
		FORCE	13	-47.9309	49.5188	-1.51944	7.483408E-02	-35.1132	-1830.28	1
22	2	FORCE	21	47.9309	-49.5188	1.51944	-7.483408E-02	-78.8445	-1883.62	
		FORCE	13	-47.9309	49.5188	-1.51944	7.483408E-02	-35.1132	-1830.28	1
22	3	FORCE	21	47.9309	-49.5188	1.51944	-7.483408E-02	-78.8445	-1883.62	
		FORCE	13	-47.9309	49.5188	-1.51944	7.483408E-02	-35.1132	-1830.28	1
22	4	FORCE	21	44.2620	-45.1970	1.19971	-7.668332E-02	-62.2979	-1720.30	
		FORCE	13	-44.2620	45.1970	-1.19971	7.668332E-02	-27.6805	-1669.47	1
22	5	FORCE	21	47.9309	-49.5188	1.51944	-7.483408E-02	-78.8445	-1883.62	
		FORCE	13	-47.9309	49.5188	-1.51944	7.483408E-02	-35.1132	-1830.28	1
22	6	FORCE	21	47.9309	-49.5188	1.51944	-7.483408E-02	-78.8445	-1883.62	
		FORCE	13	-47.9309	49.5188	-1.51944	7.483408E-02	-35.1132	-1830.28	1
22	7	FORCE	21	47.9309	-49.5188	1.51944	-7.483408E-02	-78.8445	-1883.62	
		FORCE	13	-47.9309	49.5188	-1.51944	7.483408E-02	-35.1132	-1830.28	1
22	8	FORCE	21	47.9309	-49.5188	1.51944	-7.483408E-02	-78.8445	-1883.62	
		FORCE	13	-47.9309	49.5188	-1.51944	7.483408E-02	-35.1132	-1830.28	1
22	9	FORCE	21	47.9309	-49.5188	1.51944	-7.483408E-02	-78.8445	-1883.62	
		FORCE	13	-47.9309	49.5188	-1.51944	7.483408E-02	-35.1132	-1830.28	1
22	10	FORCE	21	44.2620	-45.1970	1.19971	-7.668332E-02	-62.2979	-1720.30	
		FORCE	13	-44.2620	45.1970	-1.19971	7.668332E-02	-27.6805	-1669.47	1
22	11	FORCE	21	35.5352	-38.0196	1.44699	-4.495410E-02	-67.2193	-1608.56	
		FORCE	13	-35.5352	38.0196	-1.44699	4.495410E-02	-41.3046	-1242.89	1
22	12	FORCE	21	47.9309	-49.5188	1.51944	-7.483408E-02	-78.8445	-1883.62	
		FORCE	13	-47.9309	49.5188	-1.51944	7.483408E-02	-35.1132	-1830.28	1

COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

3D BEAM FORCES...

MAXIMUM VALUES FOR ALL STEPS NOTE MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ
23	1	FORCE	14	-3.16284	-43.5553	7.452197E-02	1.582773E-02	-15.9965	-1359.42
		FORCE	6	3.16284	43.5553	-7.452197E-02	-1.582773E-02	10.4073	-1907.23
23	2	FORCE	14	0.786579	-57.1463	-0.551028	3.655080E-02	9.37010	-1694.44
		FORCE	6	-0.786579	57.1463	0.551028	-3.655080E-02	31.9570	-2591.53
23	3	FORCE	14	0.786579	-57.1463	-0.551028	3.655080E-02	9.37010	-1694.44
		FORCE	6	-0.786579	57.1463	0.551028	-3.655080E-02	31.9570	-2591.53
23	4	FORCE	14	0.786579	-57.1463	-0.551028	3.655080E-02	9.37010	-1694.44
		FORCE	6	-0.786579	57.1463	0.551028	-3.655080E-02	31.9570	-2591.53
23	5	FORCE	14	-2.83147	-37.3219	0.140176	1.202479E-02	-17.0217	-1193.80
		FORCE	6	2.83147	37.3219	-0.140176	-1.202479E-02	6.50646	-1605.34
23	6	FORCE	14	0.786579	-57.1463	-0.551028	3.655080E-02	9.37010	-1694.44
		FORCE	6	-0.786579	57.1463	0.551028	-3.655080E-02	31.9570	-2591.53
23	7	FORCE	14	-3.16284	-43.5553	7.452197E-02	1.582773E-02	-15.9965	-1359.42
		FORCE	6	3.16284	43.5553	-7.452197E-02	-1.582773E-02	10.4073	-1907.23
23	8	FORCE	14	0.786579	-57.1463	-0.551028	3.655080E-02	9.37010	-1694.44
		FORCE	6	-0.786579	57.1463	0.551028	-3.655080E-02	31.9570	2591.53
23	9	FORCE	14	0.786579	-57.1463	-0.551028	3.655080E-02	9.37010	-1694.44
		FORCE	6	-0.786579	57.1463	0.551028	-3.655080E-02	31.9570	-2591.53
23	10	FORCE	14	0.786579	-57.1463	-0.551028	3.655080E-02	9.37010	-1694.44
		FORCE	6	-0.786579	57.1463	0.551028	-3.655080E-02	31.9570	-2591.53
23	11	FORCE	14	0.786579	-57.1463	-0.551028	3.655080E-02	9.37010	-1694.44
		FORCE	6	-0.786579	57.1463	0.551028	-3.655080E-02	31.9570	-2591.53
23	12	FORCE	14	0.786579	-57.1463	-0.551028	3.655080E-02	9.37010	-1694.44
		FORCE	6	-0.786579	57.1463	0.551028	-3.655080E-02	31.9570	-2591.53

COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

IE3D BEAM FORCES...

MAXIMUM VALUES FOR ALL STEPS NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ	STBFAG
24	1	FORCE	22	-33.9483	43.0981	-1.31724	-7.778064E-02	50.3541	-1638.94	
		FORCE	14	33.9483	43.0981	1.31724	7.778064E-02	47.7986	-1593.42	1
24	2	FORCE	22	-32.7805	-49.0073	-1.47710	-7.633347E-02	57.6582	-1862.38	
		FORCE	14	32.7805	49.0073	1.47710	7.633347E-02	53.1246	-1813.17	1
24	3	FORCE	22	-32.7805	-49.0073	-1.47710	-7.633347E-02	57.6582	-1862.38	
		FORCE	14	32.7805	49.0073	1.47710	7.633347E-02	53.1246	-1813.17	1
24	4	FORCE	22	-32.4247	-44.6885	-1.25091	-7.608934E-02	49.3879	-1696.19	
		FORCE	14	32.4247	44.6885	1.25091	7.608934E-02	44.4306	1653.44	1
24	5	FORCE	22	-32.7805	-49.0073	-1.47710	-7.633347E-02	57.6582	-1862.38	
		FORCE	14	32.7805	49.0073	1.47710	7.633347E-02	53.1246	-1813.17	1
24	6	FORCE	22	-32.7805	-49.0073	-1.47710	-7.633347E-02	57.6582	-1862.38	
		FORCE	14	32.7805	49.0073	1.47710	7.633347E-02	53.1246	-1813.17	1

24	7	FORCE	22	-33.9483	-43.0981	-1.31724	-7.778064E-02	50.9941	1636.94	
		FORCE	14	33.9483	43.0981	1.31724	7.778064E-02	47.7988	-1593.42	1
24	8	FORCE	22	-32.7805	49.0073	-1.47710	-7.633347E-02	57.6562	-1862.38	
		FORCE	14	32.7805	49.0073	1.47710	7.633347E-02	53.1246	-1913.17	1
24	9	FORCE	22	-32.7805	-49.0073	-1.47710	-7.633347E-02	57.6562	-1662.38	
		FORCE	14	32.7805	49.0073	1.47710	7.633347E-02	53.1246	-1813.17	1
24	10	FORCE	22	-32.4247	-44.6885	-1.25091	-7.808934E-02	49.3879	-1698.19	
		FORCE	14	32.4247	44.6885	1.25091	7.808934E-02	44.4306	-1653.44	1
24	11	FORCE	22	-27.0274	-25.7645	-1.44185	-4.672836E-02	50.3877	-1583.21	
		FORCE	14	27.0274	35.7645	1.44185	4.672836E-02	57.7509	-1099.13	1
24	12	FORCE	22	32.7805	-49.0073	-1.47710	-7.633347E-02	57.6582	-1862.38	
		FORCE	14	32.7805	49.0073	1.47710	7.633347E-02	53.1246	-1613.17	1

COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

3D BEAM FORCES ..
MAXIMUM VALUES FOR ALL STEPS NOTE MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ
25	1	FORCE	23	7.02566	-44.9022	-0.400369	-1.787783E-02	48.1236	-3291.05
		FORCE	7	-7.02566	44.9022	0.400369	1.787783E-02	11.9318	-3444.28
25	2	FORCE	23	7.02566	-44.9022	-0.400369	-1.787783E-02	48.1236	-3291.05
		FORCE	7	-7.02566	44.9022	0.400369	1.787783E-02	11.9318	-3444.28
25	3	FORCE	23	0.858594	-25.2072	-0.428548	-2.398597E-02	49.6332	-1856.82
		FORCE	7	-0.858594	25.2072	0.428548	2.398597E-02	14.6489	-1924.26
25	4	FORCE	23	-0.220337	-20.1083	-0.423226	-2.589984E-02	48.0095	-1490.81
		FORCE	7	0.220337	20.1083	0.423226	2.589984E-02	15.4744	-1525.43
25	5	FORCE	23	0.858594	-25.2072	0.428548	-2.398597E-02	49.6332	-1856.82
		FORCE	7	-0.858594	25.2072	0.428548	2.398597E-02	14.6489	-1924.26
25	6	FORCE	23	7.02566	-44.9022	-0.400369	-1.787783E-02	48.1236	-3291.05
		FORCE	7	-7.02566	44.9022	0.400369	1.787783E-02	11.9318	-3444.28
25	7	FORCE	23	7.02566	-44.9022	-0.400369	-1.787783E-02	48.1236	-3291.05
		FORCE	7	-7.02566	44.9022	0.400369	1.787783E-02	11.9318	-3444.28
25	8	FORCE	23	7.02566	-44.9022	-0.400369	-1.787783E-02	48.1236	-3291.05
		FORCE	7	-7.02566	44.9022	0.400369	1.787783E-02	11.9318	-3444.28
25	9	FORCE	23	0.858594	-25.2072	-0.428548	-2.398597E-02	49.6332	-1856.82
		FORCE	7	-0.858594	25.2072	0.428548	2.398597E-02	14.6489	-1924.26
25	10	FORCE	23	-0.220337	-20.1083	-0.423226	-2.589984E-02	48.0095	-1490.81
		FORCE	7	0.220337	20.1083	0.423226	2.589984E-02	15.4744	-1525.43
25	11	FORCE	23	-0.220337	-20.1083	-0.423226	-2.589984E-02	48.0095	-1490.81
		FORCE	7	0.220337	20.1083	0.423226	2.589984E-02	15.4744	-1525.43
25	12	FORCE	23	7.02566	-44.9022	-0.400369	-1.787783E-02	48.1236	-3291.05
		FORCE	7	-7.02566	44.9022	0.400369	1.787783E-02	11.9318	-3444.28
26	1	FORCE	24	-22.1643	-31.8652	0.329550	-1.787783E-02	-24.3930	-2267.06
		FORCE	8	22.1643	31.8652	-0.329550	1.787783E-02	-25.0395	-2512.71
26	2	FORCE	24	22.1643	-31.8652	0.329550	-1.787783E-02	-24.3930	-2267.06
		FORCE	8	22.1643	31.8652	-0.329550	1.787783E-02	-25.0395	-2512.71
26	3	FORCE	24	-9.14380	-13.6647	0.527705	-2.589984E-02	-41.3278	-998.405
		FORCE	8	9.14380	13.6647	-0.527705	2.589984E-02	-37.8279	-1051.30
26	4	FORCE	24	-9.14380	-13.6647	0.527705	-2.589984E-02	-41.3278	-998.405
		FORCE	8	9.14380	13.6647	-0.527705	2.589984E-02	-37.8279	-1051.30
26	5	FORCE	24	-9.14380	-13.6647	0.527705	-2.589984E-02	-41.3278	-998.405
		FORCE	8	9.14380	13.6647	-0.527705	2.589984E-02	-37.8279	-1051.30
26	6	FORCE	24	-22.1643	-31.8652	0.329550	-1.787783E-02	-24.3930	-2267.06
		FORCE	5	22.1643	31.8652	-0.329550	1.787783E-02	-25.0395	-2512.71
26	7	FORCE	24	-22.1643	-31.8652	0.329550	-1.787783E-02	-24.3930	-2267.06
		FORCE	5	22.1643	31.8652	-0.329550	1.787783E-02	-25.0395	2512.71
26	8	FORCE	24	-22.1643	-31.8652	0.329550	1.787783E-02	-24.3930	-2267.06
		FORCE	5	22.1643	31.8652	-0.329550	1.787783E-02	-25.0395	-2512.71
26	9	FORCE	24	-9.14380	-13.6647	0.527705	-2.589984E-02	-41.3278	-998.405
		FORCE	8	9.14380	13.6647	-0.527705	2.589984E-02	-37.8279	-1051.30
26	10	FORCE	24	-9.14380	-13.6647	0.527705	-2.589984E-02	-41.3278	-998.405
		FORCE	5	9.14380	13.6647	-0.527705	2.589984E-02	-37.8279	-1051.30
26	11	FORCE	24	-9.14380	-13.6647	0.527705	-2.589984E-02	-41.3278	958.405
		FORCE	8	9.14380	13.6647	-0.527705	2.589984E-02	-37.8279	1051.30
26	12	FORCE	24	-22.1643	31.8652	0.329550	-1.787783E-02	-24.3930	-2267.06
		FORCE	5	22.1643	31.8652	-0.329550	1.787783E-02	-25.0395	-2512.71

COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

IE3D BEAM FORCES ..
MAXIMUM VALUES FOR ALL STEPS NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ	STBFAG
27	2	FORCE	16	0.000000E+00	-3.408461E-18	-6.25565	-2.517562E-03	741.859	-1.136244E-15	
		FORCE	17	0.000000E+00	3.408461E-18	6.25565	2.517562E-03	509.272	-1.229052E-15	0
27	3	FORCE	16	0.000000E+00	-3.408461E-18	-6.56661	-3.308198E-03	776.469	-1.150122E-15	
		FORCE	17	0.000000E+00	3.408461E-18	6.56661	3.308198E-03	536.852	-1.242929E-15	0
27	4	FORCE	16	0.000000E+00	6.673617E-19	-3.08651	-4.814824E-03	337.113	-1.804112E-16	
		FORCE	17	0.000000E+00	-6.673617E-19	3.08651	4.814824E-03	280.189	-1.804112E-16	0
27	5	FORCE	16	0.000000E+00	-3.408461E-18	-6.56661	-3.308198E-03	776.469	-1.150122E-15	
		FORCE	17	0.000000E+00	3.408461E-18	6.56661	3.308198E-03	536.852	-1.242929E-15	0
27	6	FORCE	16	0.000000E+00	-3.408461E-18	-6.56661	-3.308198E-03	776.469	-1.150122E-15	
		FORCE	17	0.000000E+00	3.408461E-18	6.56661	3.308198E-03	536.852	-1.242929E-15	0
27	8	FORCE	16	0.000000E+00	-3.408461E-18	-6.25565	2.517562E-03	741.859	-1.136244E-15	
		FORCE	17	0.000000E+00	3.408461E-18	6.25565	2.517562E-03	509.272	-1.229052E-15	0
27	9	FORCE	16	0.000000E+00	-3.408461E-18	-6.56661	-3.308198E-03	776.469	1.150122E-15	
		FORCE	17	0.000000E+00	3.408461E-18	6.56661	3.308198E-03	536.852	-1.242929E-15	0
27	10	FORCE	16	0.000000E+00	6.673617E-19	-3.08651	-4.814824E-03	337.113	-1.804112E-16	
		FORCE	17	0.000000E+00	-6.673617E-19	3.08651	4.814824E-03	280.189	-1.804112E-16	0
27	11	FORCE	16	0.000000E+00	-3.408461E-18	-6.56661	-3.308198E-03	776.469	-1.150122E-15	
		FORCE	17	0.000000E+00	3.408461E-18	6.56661	3.308198E-03	536.852	-1.242929E-15	0
27	12	FORCE	16	0.000000E+00	-3.408461E-18	-6.56661	-3.308198E-03	776.469	-1.150122E-15	
		FORCE	17	0.000000E+00	3.408461E-18	6.56661	3.308198E-03	536.852	-1.242929E-15	0

COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

3D BEAM FORCES .
MAXIMUM VALUES FOR ALL STEPS NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ
28	2	FORCE	17	0.000000E+00	-8.890456E-18	-10.2452	2.418967E-02	945.665	-1.706968E-15

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              FORCE    18   0.000000E+00   8.890458E-18    10.2452     -2.418967E-02   1103.37     -1.790235E-15
   28      3  FORCE    17   0.000000E+00  -8.666841E-18   -17.1357      3.654542E-02   1883.37     -1.982789E-15
              FORCE    18   0.000000E+00   8.666841E-18    17.1357     -3.654542E-02   1543.77     -2.075597E-15
   28      4  FORCE    17   0.000000E+00  -8.666841E-18   -17.1357      3.654542E-02   1883.37     -1.982789E-15
              FORCE    18   0.000000E+00   8.666841E-18    17.1357     -3.654542E-02   1543.77     -2.075597E-15
   28      5  FORCE    17   0.000000E+00  -8.666841E-18   -17.1357      3.654542E-02   1883.37     -1.982789E-15
              FORCE    18   0.000000E+00   8.666841E-18    17.1357     -3.654542E-02   1543.77     -2.075597E-15
   28      6  FORCE    17   0.000000E+00  -8.666841E-18   -17.1357      3.654542E-02   1883.37     -1.982789E-15
              FORCE    18   0.000000E+00   8.666841E-18    17.1357     -3.654542E-02   1543.77     -2.075597E-15
   28      8  FORCE    17   0.000000E+00  -8.890458E-18   -10.2452      2.418967E-02   945.665     -1.706968E-15
              FORCE    18   0.000000E+00   8.890458E-18    10.2452     -2.418967E-02   1103.37      1.790235E-15
   28      9  FORCE    17   0.000000E+00  -8.666841E-18   -17.1357      3.654542E-02   1883.37     -1.982789E-15
              FORCE    18   0.000000E+00   8.666841E-18    17.1357     -3.654542E-02   1543.77      2.075597E-15
   28     10  FORCE    17   0.000000E+00  -8.666841E-18   -17.1357      3.654542E-02   1883.37     -1.982789E-15
              FORCE    18   0.000000E+00   8.666841E-18    17.1357     -3.654542E-02   1543.77     -2.075597E-15
   28     11  FORCE    17   0.000000E+00  -8.666841E-18   -17.1357      3.654542E-02   1883.37     -1.982789E-15
              FORCE    18   0.000000E+00   8.666841E-18    17.1357     -3.654542E-02   1543.77     -2.075597E-15
   28     12  FORCE    17   0.000000E+00  -8.666841E-18   -17.1357      3.654542E-02   1883.37     -1.982789E-15
              FORCE    18   0.000000E+00   8.666841E-18    17.1357     -3.654542E-02   1543.77     -2.075597E-15
   COLUMN ( LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

 IE3D BEAM FORCES.
   MAXIMUM VALUES FOR ALL STEPS   NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME
ELEMENT LOAD          NODE       AXIAL          FY              FZ            TORSION         MY              MZ    STBFAG

   29      1  FORCE    18    41.3831      -0.474804       -1.69597       2.176200E-02    323.552      -47.5806
              FORCE    19   -41.3831       0.474804        1.69597       2.176200E-02    15.6414      -47.3803       0

   29      2  FORCE    18    41.3831      -0.474804       -1.69597      -2.176200E-02    323.552      -47.5806
              FORCE    19   -41.3831       0.474804        1.69597       2.176200E-02    15.6414      -47.3803       0

   29      3  FORCE    18    16.4993      -0.318074       -3.73880      -1.795247E-02    563.508      -31.9259
              FORCE    19   -16.4993       0.318074        3.73880       1.795247E-02    184.252      -31.6890       0

   29      4  FORCE    18    41.3831      -0.474804       -1.69597      -2.176200E-02    323.552      -47.5806
              FORCE    19   -41.3831       0.474804        1.69597       2.176200E-02    15.6414      -47.3803       0

   29      5  FORCE    18    16.4993      -0.318074        3.73880      -1.795247E-02    563.508      -31.9259
              FORCE    19   -16.4993       0.318074        3.73880       1.795247E-02    184.252      -31.6890       0

   29      6  FORCE    18    41.3831      -0.474804       -1.69597      -2.176200E-02    323.552      -47.5806
              FORCE    19   -41.3831       0.474804        1.69597       2.176200E-02    15.6414      -47.3803       0

   29      7  FORCE    18    41.3831      -0.474804       -1.69597      -2.176200E-02    323.552      -47.5806
              FORCE    19   -41.3831       0.474804        1.69597       2.176200E-02    15.6414      -47.3803       0

   29      8  FORCE    18    41.3831      -0.474804       -1.69597      -2.176200E-02    323.552      -47.5806
              FORCE    19   -41.3831       0.474804        1.69597       2.176200E-02    15.6414      -47.3803       0

   29      9  FORCE    18    16.4993      -0.318074       -3.73880      -1.795247E-02    563.508      -31.9259
              FORCE    19   -16.4993       0.318074        3.73880       1.795247E-02    184.252      -31.6890       0

   29     10  FORCE    18    41.3831      -0.474804       -1.69597      -2.176200E-02    323.552      -47.5806
              FORCE    19   -41.3831       0.474804        1.69597       2.176200E-02    15.6414      -47.3803       0

   29     11  FORCE    18    16.4993      -0.318074       -3.73880      -1.795247E-02    563.508      -31.9259
              FORCE    19   -16.4993       0.318074        3.73880       1.795247E-02    184.252      -31.6890       0

   29     12  FORCE    18    41.3831      -0.474804       -1.69597      -2.176200E-02    323.552      -47.5806
              FORCE    19   -41.3831       0.474804        1.69597       2.176200E-02    15.6414      -47.3803       0
   COLUMN ( LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

  3D BEAM FORCES...
   MAXIMUM VALUES FOR ALL STEPS   NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME
ELEMENT LOAD          NODE       AXIAL          FY              FZ            TORSION         MY              MZ
   30      2  FORCE    19   0.000000E+00  -4.225339E-17   0.000000E+00   0.000000E+00   0.000000E+00  -4.596150E-15
              FORCE    21   0.000000E+00   4.225339E-17   0.000000E+00   0.000000E+00   0.000000E+00  -4.695029E-15
   30      6  FORCE    19   0.000000E+00  -4.225339E-17   0.000000E+00   0.000000E+00   0.000000E+00  -4.596150E-15
              FORCE    21   0.000000E+00   4.225339E-17   0.000000E+00   0.000000E+00   0.000000E+00  -4.695029E-15
   30      8  FORCE    19   0.000000E+00  -4.225339E-17   0.000000E+00   0.000000E+00   0.000000E+00  -4.596150E-15
              FORCE    21   0.000000E+00   4.225339E-17   0.000000E+00   0.000000E+00   0.000000E+00  -4.695029E-15
   30     12  FORCE    19   0.000000E+00  -4.225339E-17   0.000000E+00   0.000000E+00   0.000000E+00  -4.596150E-15
              FORCE    21   0.000000E+00   4.225339E-17   0.000000E+00   0.000000E+00   0.000000E+00  -4.695029E-15
   COLUMN ( LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

 IE3D BEAM FORCES...
   MAXIMUM VALUES FOR ALL STEPS   NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME
ELEMENT LOAD          NODE       AXIAL          FY              FZ            TORSION         MY              MZ    STBFAG

   31      1  FORCE    22    43.5810      -0.474804       -1.25854       2.176148E-02    260.689      -47.5806
              FORCE    21   -43.5810       0.474804        1.25854       2.176148E-02   -8.98101      -47.3803       0

   31      2  FORCE    22    43.5810      -0.474804       -1.25854      -2.176148E-02    260.689      -47.5806
              FORCE    21   -43.5810       0.474804        1.25854       2.176148E-02   -8.98101      -47.3803       0

   31      3  FORCE    22    22.5748      -0.400470       -3.97158      -1.212588E-02    600.097      -40.1970
              FORCE    21   -22.5748       0.400470        3.97158       1.212588E-02    194.218      -39.8970       0

   31      4  FORCE    22    43.5810      -0.474804       -1.25854      -2.176148E-02    260.689      -47.5806
              FORCE    21   -43.5810       0.474804        1.25854       2.176148E-02   -8.98101      -47.3803       0

   31      5  FORCE    22    22.5748      -0.400470       -3.97158      -1.212588E-02    600.097      -40.1970
              FORCE    21   -22.5748       0.400470        3.97158       1.212588E-02    194.218      -39.8970       0

   31      6  FORCE    22    43.5810      -0.474804       -1.25854      -2.176148E-02    260.689      -47.5806
              FORCE    21   -43.5810       0.474804        1.25854       2.176148E-02   -8.98101      -47.3803       0

   31      7  FORCE    22    43.5810      -0.474804       -1.25854      -2.176148E-02    260.689       47.5806
              FORCE    21   -43.5810       0.474804        1.25854       2.176148E-02   -8.98101      -47.3803       0

   31      8  FORCE    22    43.5810      -0.474804       -1.25854      -2.176148E-02    260.689      -47.5806
              FORCE    21   -43.5810       0.474804        1.25854       2.176148E-02   -8.98101      -47.3803       0

   31      9  FORCE    22    22.5748      -0.400470       -3.97158      -1.212588E-02    600.097      -40.1970
              FORCE    21   -22.5748       0.400470        3.97158       1.212588E-02    194.218      -39.8970       0

   31     10  FORCE    22    43.5810      -0.474804       -1.25854      -2.176148E-02    260.689      -47.5806
              FORCE    21    43.5810       0.474804        1.25854       2.176148E-02   -8.98101      -47.3803       0

   31     11  FORCE    22    22.5748      -0.400470       -3.97158      -1.212588E-02    600.097      -40.1970
              FORCE    21   -22.5748       0.400470        3.97158       1.212588E-02    194.218      -39.8970       0

   31     12  FORCE    22    43.5810      -0.474804       -1.25854      -2.176148E-02    260.689      -47.5806
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FORCE	21	-43.5810	0.474804	1.25854	2.176148E-02	-8.98101	-47.3803	0

COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

3D BEAM FORCES..

MAXIMUM VALUES FOR ALL STEPS NOTE MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ
32	2	FORCE	23	0.000000E+00	-8.890458E-18	-11.2022	2.697862E-02	1021.51	-1.706969E-15
		FORCE	22	0.000000E+00	8.890458E-18	11.2022	-2.697862E-02	1218.93	-1.790235E-15
32	3	FORCE	23	0.000000E+00	-8.666841E-18	-18.6095	3.990961E-02	2120.18	-1.982789E-15
		FORCE	22	0.000000E+00	8.666841E-18	18.6095	-3.990961E-02	1601.72	-2.075597E-15
32	4	FORCE	23	0.000000E+00	-8.666841E-18	-18.6095	3.990961E-02	2120.18	-1.982789E-15
		FORCE	22	0.000000E+00	8.666841E-18	18.6095	-3.990961E-02	1601.72	-2.075597E-15
32	5	FORCE	23	0.000000E+00	-8.666841E-18	-18.6095	3.990961E-02	2120.18	-1.982789E-15
		FORCE	22	0.000000E+00	8.666841E-18	18.6095	-3.990961E-02	1601.72	-2.075597E-15
32	6	FORCE	23	0.000000E+00	-8.666841E-18	-18.6095	3.990961E-02	2120.18	-1.982789E-15
		FORCE	22	0.000000E+00	8.666841E-18	18.6095	-3.990961E-02	1601.72	-2.075597E-15
32	8	FORCE	23	0.000000E+00	-8.890458E-18	-11.2022	2.697862E-02	1021.51	-1.706968E-15
		FORCE	22	0.000000E+00	8.890458E-18	11.2022	-2.697862E-02	1218.93	-1.790235E-15
32	9	FORCE	23	0.000000E+00	-8.666841E-18	-18.6095	3.990961E-02	2120.18	-1.982789E-15
		FORCE	22	0.000000E+00	8.666841E-18	18.6095	-3.990961E-02	1601.72	-2.075597E-15
32	10	FORCE	23	0.000000E+00	-8.666841E-18	-18.6095	3.990961E-02	2120.18	-1.982789E-15
		FORCE	22	0.000000E+00	8.666841E-18	18.6095	-3.990961E-02	1601.72	-2.075597E-15
32	11	FORCE	23	0.000000E+00	-8.666841E-18	-18.6095	3.990961E-02	2120.18	-1.982789E-15
		FORCE	22	0.000000E+00	8.666841E-18	18.6095	-3.990961E-02	1601.72	-2.075597E-15
32	12	FORCE	23	0.000000E+00	-8.666841E-18	-18.6095	3.990961E-02	2120.18	-1.982789E-15
		FORCE	22	0.000000E+00	8.666841E-18	18.6095	-3.990961E-02	1601.72	-2.075597E-15

COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

IE3D BEAM FORCES..

MAXIMUM VALUES FOR ALL STEPS NOTE MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ	STEPFAG
33	2	FORCE	24	0.000000E+00	-3.408461E-18	-7.23308	-6.211496E-03	875.060	-1.136244E-15	
		FORCE	23	0.000000E+00	3.408461E-18	7.23308	6.211496E-03	571.555	-1.229052E-15	0
33	3	FORCE	24	0.000000E+00	-3.408461E-18	-7.71998	-6.888248E-03	936.256	-1.150122E-15	
		FORCE	23	0.000000E+00	3.408461E-18	7.71998	6.888248E-03	607.740	-1.242929E-15	0
33	4	FORCE	24	0.000000E+00	-3.408461E-18	-7.71998	-6.888248E-03	936.256	-1.150122E-15	
		FORCE	23	0.000000E+00	3.408461E-18	7.71998	6.888248E-03	607.740	-1.242929E-15	0
33	5	FORCE	24	0.000000E+00	-3.408461E-18	-7.71998	-6.888248E-03	936.256	-1.150122E-15	
		FORCE	23	0.000000E+00	3.408461E-18	7.71998	6.888248E-03	607.740	-1.242929E-15	0
33	6	FORCE	24	0.000000E+00	-3.408461E-18	-7.71998	-6.888248E-03	936.256	-1.150122E-15	
		FORCE	23	0.000000E+00	3.408461E-18	7.71998	6.888248E-03	607.740	-1.242929E-15	0
33	8	FORCE	24	0.000000E+00	-3.408461E-18	-7.23308	-6.211496E-03	875.060	-1.136244E-15	
		FORCE	23	0.000000E+00	3.408461E-18	7.23308	6.211496E-03	571.555	-1.229052E-15	0
33	9	FORCE	24	0.000000E+00	-3.408461E-18	-7.71998	-6.888248E-03	936.256	-1.150122E-15	
		FORCE	23	0.000000E+00	3.408461E-18	7.71998	6.888248E-03	607.740	-1.242929E-15	0
33	10	FORCE	24	0.000000E+00	-3.408461E-18	-7.71998	-6.888248E-03	936.256	-1.150122E-15	
		FORCE	23	0.000000E+00	3.408461E-18	7.71998	6.888248E-03	607.740	-1.242929E-15	0
33	11	FORCE	24	0.000000E+00	-3.408461E-18	-7.71998	-6.888248E-03	936.256	-1.150122E-15	
		FORCE	23	0.000000E+00	3.408461E-18	7.71998	6.888248E-03	607.740	-1.242929E-15	0
33	12	FORCE	24	0.000000E+00	-3.408461E-18	-7.71998	-6.888248E-03	936.256	-1.150122E-15	
		FORCE	23	0.000000E+00	3.408461E-18	7.71998	6.888248E-03	607.740	-1.242929E-15	0

COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

3D BEAM FORCES...

MAXIMUM VALUES FOR ALL STEPS NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ
34	2	FORCE	16	0.000000E+00	5.854692E-18	0.186497	-5.615024E-02	-18.6601	3.469447E-16
		FORCE	24	0.000000E+00	-5.854692E-18	-0.186497	5.615024E-02	-18.6393	3.469447E-16
34	3	FORCE	16	0.000000E+00	-4.553649E-18	0.321330	-7.412100E-02	-32.6787	-1.276756E-15
		FORCE	24	0.000000E+00	4.553649E-18	-0.321330	7.412100E-02	-31.5874	-1.360023E-15
34	4	FORCE	16	0.000000E+00	-2.222614E-18	0.265300	-0.350086	-26.6475	-1.215174E-15
		FORCE	24	0.000000E+00	2.222614E-18	-0.265300	0.350086	-26.4126	-1.307982E-15
34	5	FORCE	16	0.000000E+00	-4.553649E-18	0.321330	-7.412100E-02	-32.6787	-1.276756E-15
		FORCE	24	0.000000E+00	4.553649E-18	-0.321330	7.412100E-02	-31.5874	-1.360023E-15
34	6	FORCE	16	0.000000E+00	-4.770490E-18	0.274560	-9.130834E-02	-27.6672	-1.308849E-15
		FORCE	24	0.000000E+00	4.770490E-18	-0.274560	9.130834E-02	-27.2448	-1.401657E-15
34	8	FORCE	16	0.000000E+00	5.854692E-18	0.186497	-5.615024E-02	-18.6601	3.469447E-16
		FORCE	24	0.000000E+00	-5.854692E-18	-0.186497	5.615024E-02	-18.6393	3.469447E-16
34	9	FORCE	16	0.000000E+00	-4.553649E-18	0.321330	-7.412100E-02	-32.6787	-1.276756E-15
		FORCE	24	0.000000E+00	4.553649E-18	-0.321330	7.412100E-02	-31.5874	-1.360023E-15
34	10	FORCE	16	0.000000E+00	-2.222614E-18	0.265300	-0.350086	-26.6475	-1.215174E-15
		FORCE	24	0.000000E+00	2.222614E-18	-0.265300	0.350086	-26.4126	-1.307982E-15
34	11	FORCE	16	0.000000E+00	-4.553649E-18	0.321330	-7.412100E-02	-32.6787	-1.276756E-15
		FORCE	24	0.000000E+00	4.553649E-18	-0.321330	7.412100E-02	-31.5874	-1.360023E-15
34	12	FORCE	16	0.000000E+00	-4.770490E-18	0.274560	-9.130834E-02	-27.6672	-1.308849E-15
		FORCE	24	0.000000E+00	4.770490E-18	-0.274560	9.130834E-02	-27.2448	-1.401657E-15
35	2	FORCE	17	0.000000E+00	5.854692E-18	0.459117	-1.964595E-02	-44.8681	3.469447E-16
		FORCE	23	0.000000E+00	-5.854692E-18	-0.459117	1.964595E-02	-46.9553	3.469447E-16
35	3	FORCE	17	0.000000E+00	-2.222614E-18	0.613131	-0.128913	-59.4780	-1.215174E-15
		FORCE	23	0.000000E+00	2.222614E-18	-0.613131	0.128913	-63.1483	-1.307982E-15
35	4	FORCE	17	0.000000E+00	-2.222614E-18	0.613131	-0.128913	-59.4780	-1.215174E-15
		FORCE	23	0.000000E+00	2.222614E-18	-0.613131	0.128913	-63.1483	-1.307982E-15
35	5	FORCE	17	0.000000E+00	-2.222614E-18	0.613131	-0.128913	-59.4780	-1.215174E-15
		FORCE	23	0.000000E+00	2.222614E-18	-0.613131	0.128913	-63.1483	-1.307982E-15
35	6	FORCE	17	0.000000E+00	-4.770490E-18	0.536155	-3.383434E-02	-52.0561	-1.308849E-15
		FORCE	23	0.000000E+00	4.770490E-18	-0.536155	3.383434E-02	-55.1748	-1.401657E-15
35	8	FORCE	17	0.000000E+00	5.854692E-18	0.459117	-1.964595E-02	-44.8681	3.469447E-16
		FORCE	23	0.000000E+00	-5.854692E-18	-0.459117	1.964595E-02	-46.9553	3.469447E-16
35	9	FORCE	17	0.000000E+00	-2.222614E-18	0.613131	-0.128913	-59.4780	-1.215174E-15
		FORCE	23	0.000000E+00	2.222614E-18	-0.613131	0.128913	-63.1483	-1.307982E-15
35	10	FORCE	17	0.000000E+00	-2.222614E-18	0.613131	-0.128913	-59.4780	-1.215174E-15
		FORCE	23	0.000000E+00	2.222614E-18	-0.613131	0.128913	-63.1483	-1.307982E-15
35	11	FORCE	17	0.000000E+00	-2.222614E-18	0.613131	-0.128913	-59.4780	-1.215174E-15
		FORCE	23	0.000000E+00	2.222614E-18	-0.613131	0.128913	-63.1483	-1.307982E-15
35	12	FORCE	17	0.000000E+00	-4.770490E-18	0.536155	3.383434E-02	-52.0561	-1.308849E-15
		FORCE	23	0.000000E+00	4.770490E-18	0.536155	3.383434E-02	-55.1749	-1.401657E-15
36	2	FORCE	18	0.000000E+00	5.854692E-18	-0.435063	2.138706E-02	43.5064	3.469447E-16
		FORCE	22	0.000000E+00	-5.854692E-18	0.435063	-2.138706E-02	43.5061	3.469447E-16
36	3	FORCE	18	0.000000E+00	-2.222614E-18	-0.575966	3.505638E-02	57.5971	-1.215174E-15
		FORCE	22	0.000000E+00	2.222614E-18	0.575966	-3.505638E-02	57.5965	-1.307982E-15
36	4	FORCE	18	0.000000E+00	-4.553649E-18	-0.397664	-4.567978E-02	39.7666	-1.276756E-15
		FORCE	22	0.000000E+00	4.553649E-18	0.397664	4.567978E-02	39.7662	-1.360023E-15
36	5	FORCE	18	0.000000E+00	-2.222614E-18	-0.575966	3.505636E-02	57.5971	-1.215174E-15

		FORCE	22	0.000000E+00	2.222614E-18	0.575968	-3.505638E-02	57.5965	-1.307962E-15
36	6	FORCE	18	0.000000E+00	-4.770490E-18	-0.524469	1.132785E-02	52.4471	-1.308849E-15
		FORCE	22	0.000000E+00	4.770490E-18	0.524469	-1.132785E-02	52.4466	-1.401657E-15
36	8	FORCE	18	0.000000E+00	5.854692E-18	-0.435063	2.138706E-02	43.5064	3.469447E-16
		FORCE	22	0.000000E+00	-5.854692E-18	0.435063	-2.138706E-02	43.5061	3.469447E-16
36	9	FORCE	18	0.000000E+00	-2.222614E-18	-0.575968	3.505638E-02	57.5971	-1.215174E-15
		FORCE	22	0.000000E+00	2.222614E-18	0.575968	-3.505638E-02	57.5965	-1.307982E-15
36	10	FORCE	18	0.000000E+00	-4.553649E-18	-0.397664	-4.567978E-02	39.7666	-1.276756E-15
		FORCE	22	0.000000E+00	4.553649E-18	0.397664	4.567978E-02	39.7662	-1.360023E-15
36	11	FORCE	18	0.000000E+00	2.222614E-18	-0.575968	3.505638E-02	57.5971	-1.215174E-15
		FORCE	22	0.000000E+00	2.222614E-18	0.575968	-3.505638E-02	57.5965	-1.307982E-15
36	12	FORCE	18	0.000000E+00	-4.770490E-18	-0.524469	1.132785E-02	52.4471	-1.308849E-15
		FORCE	22	0.000000E+00	4.770490E-18	0.524469	-1.132785E-02	52.4466	1.401657E-15

COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

STABILITY ELEMENT FORCES...
MAXIMUM VALUES FOR ALL STEPS NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ	FLF,SP
37	1	FORCE	28	-82.6114	16.4666	8.791081E-02	4.44379	-9.72445	702.093	
		FORCE	16	82.6114	-16.4666	-8.791081E-02	-4.33578	-2.76415	1775.73	
37	2	FORCE	28	-82.6114	16.4666	8.791081E-02	4.44379	-9.72445	702.093	
		FORCE	16	82.6114	16.4666	-8.791081E-02	-4.33578	-2.76415	1775.73	
37	3	FORCE	28	-82.6114	16.4666	8.791081E-02	4.44379	-9.72445	702.093	
		FORCE	16	82.6114	-16.4666	-8.791081E-02	-4.33578	-2.76415	1775.73	
37	4	FORCE	28	-82.6114	16.4666	8.791081E-02	4.44379	-9.72445	702.093	
		FORCE	16	82.6114	-16.4666	-8.791081E-02	-4.33578	-2.76415	1775.73	
37	5	FORCE	28	-82.6114	16.4666	8.791081E-02	4.44379	-9.72445	702.093	
		FORCE	16	82.6114	-16.4666	8.791081E-02	-4.33578	-2.76415	1775.73	
37	6	FORCE	28	-82.6114	16.4666	8.791081E-02	4.44379	-9.72445	702.093	
		FORCE	16	82.6114	-16.4666	-8.791081E-02	-4.33578	-2.76415	1775.73	
37	7	FORCE	28	-82.6114	16.4666	8.791081E-02	4.44379	-9.72445	702.093	
		FORCE	16	82.6114	-16.4666	-8.791081E-02	-4.33578	-2.76415	1775.73	
37	8	FORCE	28	-82.6114	16.4666	8.791081E-02	4.44379	-9.72445	702.093	
		FORCE	16	82.6114	-16.4666	-8.791081E-02	-4.33578	-2.76415	1775.73	
37	9	FORCE	28	-82.6114	16.4666	8.791081E-02	4.44379	-9.72445	702.093	
		FORCE	16	82.6114	-16.4666	-8.791081E-02	-4.33578	-2.76415	1775.73	
37	10	FORCE	28	-82.6114	16.4666	8.791081E-02	4.44379	-9.72445	702.093	
		FORCE	16	82.6114	-16.4666	-8.791081E-02	-4.33578	-2.76415	1775.73	
37	11	FORCE	28	-46.5893	5.24866	-1.909424E-02	3.76748	-3.12123	223.554	
		FORCE	16	46.5893	-5.24866	1.909424E-02	-3.74988	6.26663	566.390	
37	12	FORCE	28	-82.6114	16.4666	8.791081E-02	4.44379	-9.72445	702.093	
		FORCE	16	82.6114	-16.4666	-8.791081E-02	-4.33578	-2.76415	1775.73	

COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

IE3D BEAM FORCES...
MAXIMUM VALUES FOR ALL STEPS NOTE MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ	STBFAG
38	1	FORCE	35	-106.468	12.3150	0.136014	1.844565E-02	-18.3894	566.033	
		FORCE	24	106.468	-12.3150	-0.136014	-1.844565E-02	-2.01266	1281.22	0
38	2	FORCE	35	-106.468	12.3150	0.136014	1.844565E-02	-18.3894	566.033	
		FORCE	24	106.468	-12.3150	-0.136014	-1.844565E-02	-2.01266	1281.22	0
38	3	FORCE	35	-106.468	12.3150	0.136014	1.844565E-02	-18.3894	566.033	
		FORCE	24	106.468	-12.3150	-0.136014	-1.844565E-02	-2.01266	1281.22	0
38	4	FORCE	35	-106.468	12.3150	0.136014	1.844565E-02	-18.3894	566.033	
		FORCE	24	106.468	-12.3150	-0.136014	-1.844565E-02	-2.01266	1281.22	0
38	5	FORCE	35	-106.468	12.3150	0.136014	1.844565E-02	-18.3894	566.033	
		FORCE	24	106.468	-12.3150	-0.136014	-1.844565E-02	-2.01266	1281.22	0
38	6	FORCE	35	-106.468	12.3150	0.136014	1.844565E-02	-18.3894	566.033	
		FORCE	24	106.468	-12.3150	-0.136014	-1.844565E-02	-2.01266	1281.22	0
38	7	FORCE	35	-106.468	12.3150	0.136014	1.844565E-02	-18.3894	566.033	
		FORCE	24	106.468	-12.3150	-0.136014	-1.844565E-02	2.01266	1281.22	0
38	8	FORCE	35	106.468	12.3150	0.136014	1.844565E-02	-18.3894	566.033	
		FORCE	24	106.468	-12.3150	-0.136014	-1.844565E-02	-2.01266	1281.22	0
38	9	FORCE	35	-106.468	12.3150	0.136014	1.844565E-02	-18.3894	566.033	
		FORCE	24	106.468	-12.3150	-0.136014	-1.844565E-02	-2.01266	1281.22	0
38	10	FORCE	35	106.468	12.3150	0.136014	1.844565E-02	-18.3894	566.033	
		FORCE	24	106.468	-12.3150	-0.136014	-1.844565E-02	-2.01266	1281.22	0
38	11	FORCE	35	-65.2558	3.90563	-1.336999E-02	1.568301E-02	-7.73782	162.440	
		FORCE	24	65.2558	-3.90563	1.336999E-02	-1.568301E-02	9.74332	423.404	0
38	12	FORCE	35	-106.468	12.3150	0.136014	1.844565E-02	-18.3894	566.033	
		FORCE	24	106.468	-12.3150	-0.136014	-1.844565E-02	-2.01266	1281.22	0

COLUMN (LOAD) REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

STABILITY ELEMENT FORCES...
MAXIMUM VALUES FOR ALL STEPS NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ	FLP,SP
39	1	FORCE	29	-28.9636	2.96574	0.756225	5.37682	-63.4069	80.4578	
		FORCE	17	28.9636	-2.96574	-0.756225	-5.29350	-49.2834	366.368	
39	2	FORCE	29	-17.6871	8.99430	0.814613	5.75047	-68.7438	357.181	
		FORCE	17	17.6871	-8.99430	-0.814613	5.50409	-52.9415	993.755	
39	3	FORCE	29	-17.6871	8.99430	0.814613	5.75047	-68.7438	357.181	
		FORCE	17	17.6871	-8.99430	-0.814613	-5.50409	-52.9415	993.755	
39	4	FORCE	29	17.6871	8.99430	0.814613	5.75047	-68.7438	357.181	
		FORCE	17	17.6871	-8.99430	-0.814613	-5.50409	-52.9415	993.755	

39	5	FORCE	29	-17.6871	8.99430	0.814613	5.75047	-68.7438	357.191
		FORCE	17	17.6871	-8.99430	-0.814613	-5.50409	-52.9415	993.755
39	6	FORCE	29	-17.6871	8.99430	0.814613	5.75047	-68.7438	357.181
		FORCE	17	17.6871	-8.99430	-0.814613	-5.50409	-52.9415	993.755
39	7	FORCE	29	-28.9636	2.96574	0.756225	5.37662	-63.4069	80.4578
		FORCE	17	28.9636	-2.96574	-0.756225	-5.29250	-49.2834	366.368
39	8	FORCE	29	-17.6871	8.99430	0.814613	5.75047	-68.7438	357.181
		FORCE	17	17.6871	-8.99430	-0.814613	-5.50409	-52.9415	993.755
39	9	FORCE	29	-17.6871	8.99430	0.814613	5.75047	-68.7438	357.181
		FORCE	17	17.6871	-8.99430	-0.814613	-5.50409	-52.9415	993.755
39	10	FORCE	29	-17.6871	8.99430	0.814613	5.75047	-68.7438	357.181
		FORCE	17	17.6871	-8.99430	0.814613	-5.50409	-52.9415	993.755
39	11	FORCE	29	-17.6871	8.99430	0.814613	5.75047	-68.7438	357.181
		FORCE	17	17.6871	-8.99430	-0.814613	-5.50409	-52.9415	993.755
39	12	FORCE	29	-17.6871	8.99430	0.814613	5.75047	-68.7438	357.181
		FORCE	17	17.6871	-8.99430	-0.814613	-5.50409	-52.9415	993.755

COLUMN ' LOAD' REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

IE3D BEAM FORCES ...

MAXIMUM VALUES FOR ALL STEPS NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ	STBFAG
40	1	FORCE	34	-20.6311	0.501121	0.816602	1.568301E-02	-72.0463	-7.78522	
		FORCE	23	20.6311	-0.501121	-0.816602	-1.568301E-02	-50.4440	82.9534	0
40	2	FORCE	34	-7.00455	4.87229	1.00876	1.844565E-02	-88.8549	193.896	
		FORCE	23	7.00455	-4.87229	-1.00876	-1.844565E-02	-62.4596	536.947	0
40	3	FORCE	34	-7.00455	4.87229	1.00876	1.844565E-02	-88.8549	193.896	
		FORCE	23	7.00455	-4.87229	-1.00876	-1.844565E-02	-62.4596	536.947	0
40	4	FORCE	34	-7.00455	4.87229	1.00876	1.844565E-02	-88.8549	193.896	
		FORCE	23	7.00455	-4.87229	-1.00876	-1.844565E-02	-62.4596	536.947	0
40	5	FORCE	34	-7.00455	4.87229	1.00876	1.844565E-02	-88.8549	193.896	
		FORCE	23	7.00455	-4.87229	-1.00876	-1.844565E-02	-62.4596	536.947	0
40	6	FORCE	34	-7.00455	4.87229	1.00876	1.844565E-02	-88.8549	193.896	
		FORCE	23	7.00455	-4.87229	-1.00876	-1.844565E-02	-62.4596	536.947	0
40	7	FORCE	34	-20.6311	0.501121	0.816602	1.568301E-02	-72.0463	-7.78522	
		FORCE	23	20.6311	-0.501121	-0.816602	-1.568301E-02	-50.4440	82.9534	0
40	8	FORCE	34	-7.00455	4.87229	1.00876	1.844565E-02	-88.8549	193.896	
		FORCE	23	7.00455	-4.87229	-1.00876	-1.844565E-02	-62.4596	536.947	0
40	9	FORCE	34	-7.00455	4.87229	1.00876	1.844565E-02	-88.8549	193.896	
		FORCE	23	7.00455	-4.87229	-1.00876	-1.844565E-02	-62.4596	536.947	0
40	10	FORCE	34	-7.00455	4.87229	1.00876	1.844565E-02	-88.8549	193.896	
		FORCE	23	7.00455	-4.87229	-1.00876	-1.844565E-02	-62.4596	536.947	0
40	11	FORCE	34	-7.00455	4.87229	1.00876	1.844565E-02	-88.8549	193.896	
		FORCE	23	7.00455	-4.87229	-1.00876	-1.844565E-02	-62.4596	536.947	0
40	12	FORCE	34	-7.00455	4.87229	1.00876	1.844565E-02	-88.8549	193.896	
		FORCE	23	7.00455	-4.87229	-1.00876	-1.844565E-02	-62.4596	536.947	0

COLUMN ' LOAD' REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

3D BEAM FORCES.

MAXIMUM VALUES FOR ALL STEPS NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ
41	2	FORCE	31	0.000000E+00	-1.37031	0.213562	1.769595E-02	-16.0172	-102.774
		FORCE	19	0.000000E+00	1.37031	-0.213562	-1.769595E-02	-16.0172	-102.774
41	3	FORCE	31	0.000000E+00	-1.37031	0.213562	1.769595E-02	-16.0172	-102.774
		FORCE	19	0.000000E+00	1.37031	-0.213562	-1.769595E-02	-16.0172	-102.774
41	4	FORCE	31	0.000000E+00	-1.37031	0.213562	1.769595E-02	-16.0172	-102.774
		FORCE	19	0.000000E+00	1.37031	-0.213562	-1.769595E-02	-16.0172	-102.774
41	5	FORCE	31	0.000000E+00	-1.37031	0.213562	1.769595E-02	-16.0172	-102.774
		FORCE	19	0.000000E+00	1.37031	-0.213562	-1.769595E-02	-16.0172	-102.774
41	6	FORCE	31	0.000000E+00	-1.37031	0.213562	1.769595E-02	-16.0172	-102.774
		FORCE	19	0.000000E+00	1.37031	-0.213562	-1.769595E-02	-16.0172	-102.774
41	8	FORCE	31	0.000000E+00	-1.37031	0.213562	1.769595E-02	-16.0172	-102.774
		FORCE	19	0.000000E+00	1.37031	-0.213562	-1.769595E-02	-16.0172	-102.774
41	9	FORCE	31	0.000000E+00	-1.37031	0.213562	1.769595E-02	-16.0172	-102.774
		FORCE	19	0.000000E+00	1.37031	-0.213562	-1.769595E-02	-16.0172	-102.774
41	10	FORCE	31	0.000000E+00	-1.37031	0.213562	1.769595E-02	-16.0172	-102.774
		FORCE	19	0.000000E+00	1.37031	-0.213562	-1.769595E-02	-16.0172	-102.774
41	11	FORCE	31	0.000000E+00	-1.37031	0.213562	1.769595E-02	-16.0172	-102.774
		FORCE	19	0.000000E+00	1.37031	-0.213562	-1.769595E-02	-16.0172	-102.774
41	12	FORCE	31	0.000000E+00	-1.37031	0.213562	1.769595E-02	-16.0172	-102.774
		FORCE	19	0.000000E+00	1.37031	-0.213562	-1.769595E-02	-16.0172	-102.774
42	2	FORCE	32	0.000000E+00	-1.70640	0.213562	1.769595E-02	-16.0172	-127.980
		FORCE	21	0.000000E+00	1.70640	-0.213562	-1.769595E-02	-16.0172	-127.980
42	3	FORCE	32	0.000000E+00	-1.70640	0.213562	1.769595E-02	-16.0172	-127.980
		FORCE	21	0.000000E+00	1.70640	-0.213562	-1.769595E-02	-16.0172	-127.980
42	4	FORCE	32	0.000000E+00	-1.70640	0.213562	1.769595E-02	-16.0172	-127.980
		FORCE	21	0.000000E+00	1.70640	0.213562	1.769595E-02	-16.0172	127.980
42	5	FORCE	32	0.000000E+00	-1.70640	0.213562	1.769595E-02	-16.0172	-127.980
		FORCE	21	0.000000E+00	1.70640	-0.213562	1.769595E-02	16.0172	-127.980
42	6	FORCE	32	0.000000E+00	-1.70640	0.213562	1.769595E-02	-16.0172	-127.980
		FORCE	21	0.000000E+00	1.70640	-0.213562	-1.769595E-02	-16.0172	-127.980
42	8	FORCE	32	0.000000E+00	-1.70640	0.213562	1.769595E-02	16.0172	-127.980
		FORCE	21	0.000000E+00	1.70640	-0.213562	-1.769595E-02	-16.0172	-127.980
42	9	FORCE	32	0.000000E+00	-1.70640	0.213562	1.769595E-02	-16.0172	-127.980
		FORCE	21	0.000000E+00	1.70640	-0.213562	-1.769595E-02	-16.0172	-127.980
42	10	FORCE	32	0.000000E+00	-1.70640	0.213562	1.769595E-02	-16.0172	-127.980
		FORCE	21	0.000000E+00	1.70640	-0.213562	-1.769595E-02	-16.0172	-127.980
42	11	FORCE	32	0.000000E+00	-1.70640	0.213562	1.769595E-02	-16.0172	-127.980
		FORCE	21	0.000000E+00	1.70640	-0.213562	1.769595E-02	-16.0172	-127.980
42	12	FORCE	32	0.000000E+00	-1.70640	0.213562	1.769595E-02	-16.0172	-127.980
		FORCE	21	0.000000E+00	1.70640	-0.213562	-1.769595E-02	-16.0172	-127.980
43	1	FORCE	20	5.504105E-15	5.801498E-17	3.949715E-17	0.000000E+00	-3.016607E-15	3.948231E-15
		FORCE	21	-5.504105E-15	-5.801498E-17	-3.949715E-17	0.000000E+00	-3.016607E-15	4.252675E-15
43	2	FORCE	20	5.504105E-15	5.801498E-17	3.949715E-17	0.000000E+00	-3.016607E-15	3.948231E-15
		FORCE	21	-5.504105E-15	-5.801498E-17	-3.949715E-17	0.000000E+00	-3.016607E-15	4.252675E-15

```
 43    3  FORCE    20    5.504105E-15    5.801498E-17    3.949715E-17    0.000000E+00   -3.016607E-15    3.948231E-15
          FORCE    21   -5.504105E-15   -5.801498E-17   -3.949715E-17    0.000000E+00   -3.016607E-15    4.252675E-15
 43    5  FORCE    20    5.504105E-15    5.801498E-17    3.949715E-17    0.000000E+00   -3.016607E-15    3.948231E-15
          FORCE    21   -5.504105E-15   -5.801498E-17   -3.949715E-17    0.000000E+00   -3.016607E-15    4.252675E-15
 43    6  FORCE    20    5.504105E-15    5.801498E-17    3.949715E-17    0.000000E+00   -3.016607E-15    3.948231E-15
          FORCE    21   -5.504105E-15   -5.801498E-17    3.949715E-17    0.000000E+00   -3.016607E-15    4.252675E-15
 43    7  FORCE    20    5.504105E-15    5.801498E-17    3.949715E-17    0.000000E+00   -3.016607E-15    3.948231E-15
          FORCE    21   -5.504105E-15   -5.801498E-17   -3.949715E-17    0.000000E+00   -3.016607E-15    4.252675E-15
 43    8  FORCE    20    5.504105E-15    5.801498E-17    3.949715E-17    0.000000E+00   -3.016607E-15    3.948231E-15
          FORCE    21   -5.504105E-15   -5.801498E-17   -3.949715E-17    0.000000E+00   -3.016607E-15    4.252675E-15
 43    9  FORCE    20    5.504105E-15    5.801498E-17    3.949715E-17    0.000000E+00   -3.016607E-15    3.948231E-15
          FORCE    21   -5.504105E-15   -5.801498E-17   -3.949715E-17    0.000000E+00   -3.016607E-15    4.252675E-15
 43   11  FORCE    20    5.504105E-15    5.801498E-17    3.949715E-17    0.000000E+00   -3.016607E-15    3.948231E-15
          FORCE    21   -5.504105E-15   -5.801498E-17    3.949715E-17    0.000000E+00   -3.016607E-15    4.252675E-15
 43   12  FORCE    20    5.504105E-15    5.801498E-17    3.949715E-17    0.000000E+00   -3.016607E-15    3.948231E-15
          FORCE    21    5.504105E-15   -5.801498E-17   -3.949715E-17    0.000000E+00   -3.016607E-15    4.252675E-15
 44    1  FORCE    20    3.145203E-15   -6.332418E-18    7.335186E-17    0.000000E+00   -5.602271E-15   -9.263423E-16
          FORCE    19   -3.145203E-15    6.332418E-18   -7.335186E-17    0.000000E+00   -5.602271E-15   -6.218984E-16
 44    2  FORCE    20    1.769176E-15   -9.540979E-18    4.231838E-17    0.000000E+00   -3.232079E-15   -9.436896E-16
          FORCE    19   -1.769176E-15    9.540979E-18   -4.231838E-17    0.000000E+00   -3.232079E-15   -9.436896E-16
 44    3  FORCE    20    3.145203E-15   -6.332418E-18    7.335186E-17    0.000000E+00   -5.602271E-15   -9.263423E-16
          FORCE    19   -3.145203E-15    6.332418E-18   -7.335186E-17    0.000000E+00   -5.602271E-15   -6.218984E-16
 44    5  FORCE    20    3.145203E-15   -6.332418E-18    7.335186E-17    0.000000E+00   -5.602271E-15   -9.263423E-16
          FORCE    19   -3.145203E-15    6.332418E-18   -7.335186E-17    0.000000E+00   -5.602271E-15   -6.218984E-16
 44    6  FORCE    20    1.769176E-15   -9.540979E-18    4.231838E-17    0.000000E+00   -3.232079E-15   -9.436896E-16
          FORCE    19   -1.769176E-15    9.540979E-18   -4.231838E-17    0.000000E+00   -3.232079E-15   -9.436896E-16
 44    7  FORCE    20    3.145203E-15   -6.332418E-18    7.335186E-17    0.000000E+00   -5.602271E-15   -9.263423E-16
          FORCE    19   -3.145203E-15    6.332418E-18   -7.335186E-17    0.000000E+00   -5.602271E-15   -6.218984E-16
 44    8  FORCE    20    1.769176E-15   -9.540979E-18    4.231838E-17    0.000000E+00   -3.232079E-15   -9.436896E-16
          FORCE    19   -1.769176E-15    9.540979E-18   -4.231838E-17    0.000000E+00   -3.232079E-15   -9.436896E-16
 44    9  FORCE    20    3.145203E-15   -6.332418E-18    7.335186E-17    0.000000E+00   -5.602271E-15   -9.263423E-16
          FORCE    19   -3.145203E-15    6.332418E-18   -7.335186E-17    0.000000E+00   -5.602271E-15   -6.218984E-16
 44   11  FORCE    20    3.145203E-15   -6.332418E-18    7.335186E-17    0.000000E+00   -5.602271E-15   -9.263423E-16
          FORCE    19   -3.145203E-15    6.332418E-19   -7.335186E-17    0.000000E+00   -5.602271E-15   -6.218984E-16
 44   12  FORCE    20    1.769176E-15   -9.540979E-18    4.231838E-17    0.000000E+00   -3.232079E-15   -9.436896E-16
          FORCE    19   -1.769176E-15    9.540979E-18   -4.231838E-17    0.000000E+00   -3.232079E-15   -9.436896E-16
 45    1  FORCE    36     257.150         0.503373         4.14103        1.496732E-02   -236.308          29.6369
          FORCE    20    -257.150        -0.503373        -4.14103       -1.496732E-02   -293.416          34.7549
 45    2  FORCE    30     257.150         0.503373         4.14103        1.496732E-02   -236.308          29.6369
          FORCE    20    -257.150        -0.503373        -4.14103       -1.496732E-02   -293.416          34.7549
 45    3  FORCE    36     257.150         0.503373         4.14103        1.496732E-02   -236.308          29.6369
          FORCE    20    -257.150        -0.503373        -4.14103       -1.496732E-02   -293.416          34.7549
 45    4  FORCE    36     257.150         0.503373         4.14103        1.496732E-02   -236.308          29.6369
          FORCE    20    -257.150        -0.503373        -4.14103        1.496732E-02   -293.416          34.7549
 45    5  FORCE    36     257.150         0.503373         4.14103        1.496732E-02   -236.308          29.6369
          FORCE    20    -257.150        -0.503373        -4.14103       -1.496732E-02   -293.416          34.7549
 45    6  FORCE    36     257.150         0.503373         4.14103        1.496732E-02   -236.308          29.6369
          FORCE    20    -257.150        -0.503373        -4.14103       -1.496732E-02   -293.416          34.7549
 45    7  FORCE    36     257.150         0.503373         4.14103        1.496732E-02   -236.308          29.6369
          FORCE    20    -257.150        -0.503373        -4.14103       -1.496732E-02   -293.416          34.7549
 45    8  FORCE    36     257.150         0.503373         4.14103        1.496732E-02   -236.308          29.6369
          FORCE    20    -257.150        -0.503373        -4.14103       -1.496732E-02   -293.416          34.7549
 45    9  FORCE    36     257.150         0.503373         4.14103        1.496732E-02   -236.308          29.6369
          FORCE    20    -257.150        -0.503373        -4.14103       -1.496732E-02   -293.416          34.7549
 45   10  FORCE    36     257.150         0.503373         4.14103        1.496732E-02   -236.308          29.6369
          FORCE    20    -257.150        -0.503373        -4.14103       -1.496732E-02   -293.416          34.7549
 45   11  FORCE    36     257.150         0.503373         4.14103        1.496732E-02   -236.308          29.6369
          FORCE    20    -257.150        -0.503373        -4.14103       -1.496732E-02   -293.416          34.7549
 45   12  FORCE    36     257.150         0.503373         4.14103        1.496732E-02   -236.308          29.6369
          FORCE    20    -257.150        -0.503373        -4.14103       -1.496732E-02   -293.416          34.7549

   SPRING FORCES  .     MAXIMUM LOAD AND DISPL AT MAXIMUM LOAD  NOTE  MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY
ELEMENT LOAD        TYPE NODEI NODEJ       FORCE      DISPLACMENT       STIFFNESS
   46     0  BENDING-Y    37    36     236.308      2.363083E-04

   GOEL FORCES  .     MAXIMUM LOAD AND DISPL AT MAXIMUM LOAD  NOTE. MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY
ELEMENT LOAD        TYPE NODEI NODEJ       FORCE      DISPLACMENT       STIFFNESS
   47     0        AXIAL   29    16     -97.7482     -5.851784E-02
   48     0        AXIAL   34    24    -119.229      -7.137750E-02
   49     0        AXIAL   29    23     -26.1049     -2.123040E-02
   50     0        AXIAL   30    22      41.9547      3.412061E-02
   51     0        AXIAL   31    21     -3.82248     -3.108719E-03

 R/C SHEAR WALL FORCES...     MAXIMUM LOADS AND DISPL AT MAXIMUM LOADS  NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY
ELEMENT LOAD  JNT-1 JNT-2 JNT-3 JNT-4    MOMENT        ROTATION          SHEAR      SHEAR DISPL        AXIAL      AXIAL DISPL

   52     2     18    17    29    30   -3634.65     -6.047785E-04    11.6821     6.571208E-03    2.62316     6.557901E-02
   53     2     22    23    34    33   -3593.65     -5.914324E-04   -39.3444    -2.213121E-02    2.44160     6.104012E-02

 R/C SHEAR WALL FORCES ..     MAXIMUM LOADS AND DISPL AT MAXIMUM LOADS  NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY
ELEMENT LOAD  JNT-1 JNT-2 JNT-3 JNT-4     SHEAR       SHEAR DISPL        AXIAL1      AXIAL DISPL 1      AXIAL2     AXIAL DISPL 2

   54     2     16    24    35    28    6.64406     4.983048E-03   0.484605     2.423024E-02   0.576645     2.883227E-02
1 STRUCTURE..  · THREE-STORY BUILDING                                                              TIME 16:45:06, DATE.
07/27/94
 SOLUTION ....  NONLINEAR CYCLE ANALYSIS WITH UNBALANCED FORCES                             TIME 16.45 08, DATE 07/27/94

 , LOADING #    0     PEAK DUCTILITIES AND EXCURSION RATIO'S

   IE3DBEAM  DUCTILITY(BASED ON DEFINITION 1):
      ELEM#      |MYA|      |MYB|      |MZA|      |MZB|      |MX|       |FX|
        2       0.00000    0.00000    0.00000    0.00000    0.00000    0.00000

   IE3DBEAM  DUCTILITY(BASED ON DEFINITION 1)
      ELEM#      |MYA|      |MYB|      |MZA|      |MZB|      |MX|       |FX|
        6       0.00000    0.00000    0.00000    0.00000    0.00000    0.00000

   IE3DBEAM  DUCTILITY(BASED ON DEFINITION 1)
      ELEM#      |MYA|      |MYB|      |MZA|      |MZB|      |MX|       |FX|
        9       0.00000    0.00000    0.00000    0.00000    0.00000    0.00000
       10       0.00000    0.00000    0.00000    0.00000    0.00000    0.00000

   IE3DBEAM  DUCTILITY(BASED ON DEFINITION 1.)
      ELEM#      |MYA|      |MYB|      |MZA|      |MZB|      |MX|       |FX|
       18       0.00000    0.00000    7.42444    5.77259    0.00000    0.00000

   IE3DBEAM  DUCTILITY(BASED ON DEFINITION 1):
      ELEM#      |MYA|      |MYB|      |MZA|      |MZB|      |MX|       |FX|
       20       0.00000    0.00000    7.98162    6.10615    0.00000    0.00000

   IE3DBEAM  DUCTILITY(BASED ON DEFINITION 1):
      ELEM#      |MYA|      |MYB|      |MZA|      |MZB|      |MX|       |FX|
       22       0.00000    0.00000    7.84733    4.07904    0.00000    0.00000
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IE3DBEAM  DUCTILITY(BASED ON DEFINITION 1):
   ELEM#      |MYA       MYB|       MZA|       |MZB|       |MX |       |FX |
    24      0.00000    0.00000    7.35037    5.60697    0.00000    0.00000

IE3DBEAM  DUCTILITY(BASED ON DEFINITION 1)
   ELEM#      |MYA.      |MYB|      |MZA|       |MZB|       |MX |       |FX |
    27      0.00000    0.00000    0.00000    0.00000    0.00000    0.00000

IE3DBEAM  DUCTILITY(BASED ON DEFINITION 1):
   ELEM#       MYA|      |MYB|      |MZA|       |MZB        |MX '       |FX |
    29      0.00000    0.00000    0.00000    0.00000    0.00000    0.00000

IE3DBEAM  DUCTILITY(BASED ON DEFINITION 1):
   ELEM#      .MYA|      |MYB       |MZA        |MZB        .MX |       |FX |
    32      0.00000    0.00000    0.00000    0.00000    0.00000    0.00000

IE3DBEAM  DUCTILITY(BASED ON DEFINITION 1):
   ELEM#      |MYA|      |MYB       |MZA        MZB|        |MX         |FX
    33      0.00000    0.00000    0.00000    0.00000    0.00000    0.00000

IE3DBEAM  DUCTILITY(BASED ON DEFINITION 1):
   ELEM#      |MYA|      |MYB|      |MZA|       |MZB|       |MX         |FX
    38      0.00000    0.00000    0.00000    0.00000    0.00000    0.00000

IE3DBEAM  DUCTILITY(BASED ON DEFINITION 1)
   ELEM#      |MYA|      |MYB|      |MZA|       |MZB|       'MX         |FX
    40      0.00000    0.00000    0.00000    0.00000    0.00000    0.00000

SPRING DUCTILITIES AND EXCURSION RATIOS ...
 ELEMENT |- DUCTILITY DEFINATION #1 -|  - DUCTILITY DEFINATION #2 -| |- DUCTILITY DEFINATION #3 -|
         DUCTILITY    EXCURSION        DUCTILITY    EXCURSION        DUCTILITY    EXCURSION
     46  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00  0.000000E+00

STRUT DUCTILITIES AND EXCURSION RATIOS ...
 ELEMENT  - DUCTILITY DEFINATION #1 -|
         DUCTILITY    EXCURSION
     47  0.000000E+00  0.000000E+00
     48  0.000000E+00  0.000000E+00
     49  0.000000E+00  0.000000E+00
     50  0.000000E+00  0.000000E+00
     51  0.000000E+00  0.000000E+00

  R/C SHEAR WALL DUCTILITY AND EXCURSION RATIOS
      |------ -- BENDING COMPONENT ------------|  --------- SHEAR COMPONENT ------------|  ---------- AXIAL COMPONENT ------------|
ELEM#  |-- DEFN 1--- --- DEFN 2--- --- DEFN 3--|  -- DEFN 1--- --- DEFN 2--- --- DEFN 3--|  -- DEFN 1--- --- DEFN 2--- --- DEFN 3--|
       DUCT   EXCR   DUCT.  EXCR.  DUCT.  EXCR.  DUCT   EXCR.  DUCT.  EXCR   DUCT.  EXCR.  DUCT   EXCR.  DUCT   EXCR.  DUCT.  EXCR.
  52   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   1.17   0.00   1.00   0.00
  53   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   1.17   0.00   1.00   0.00

  R/C SHEAR WALL DUCTILITY AND EXCURSION RATIOS
      |---------- SHEAR COMPONENT ------- ----| |---------- AXIAL COMPONENT 1-----------| |---------- AXIAL COMPONENT 2-----------|
ELEM# |-- DEFN 1--- --- DEFN 2--- --- DEFN 3--| |-- DEFN 1--- --- DEFN 2--- --- DEFN 3--| |-- DEFN 1--- --- DEFN 2--- --- DEFN 3--|
       DUCT   EXCR.  DUCT   EXCR.  DUCT.  EXCR.  DUCT   EXCR   DUCT.  EXCR.  DUCT.  EXCR.  DUCT.  EXCR.  DUCT.  EXCR   DUCT.  EXCR.
  54   0.02   0.00   1.00   0.00   1.00   0.00   0.00   0.00   1.17   0.00   1.00   0.00   0.00   0.00   1.17   0.00   1.00   0.00
1 STRUCTURE.  .- THREE-STORY BUILDING                                                              TIME: 16:45.06, DATE.
07/27/94
 SOLUTION    .: NONLINEAR CYCLE ANALYSIS WITH UNBALANCED FORCES                              TIME: 16:45:08. DATE: 07/27/94

 , LOADING #    0     DAMAGE INDEX

  ELEMENT  DAMAGE INDEX       F MAX          D MAX          ESE            PSE
      45   1.963236E-02     236.308      2.363083E-04   2.792080E 02   0.000000E+00

  ELEMENT  DAMAGE INDEX       F MAX          D MAX          ESE            PSE
      47   1.571312E-02    -97.7482      5.951784E-02   2.86001        0.000000E+00
      48   1.916615E-02    -119.229      7.137750E-02   4.25513        0.000000E+00
      49   5.700756E-03    -26.1049      2.123040E-02   0.277109       1.526557E-16
      50   9.162017E-03     41.9547      3.412061E-02   0.715760       4.024558E-16
      51   8.347466E-04    -3.82248     -3.105719E-03   5.941510E-03   8.673617E-19

      |-------- BENDING COMPONENT ------- ----  |---------- SHEAR COMPONENT ------------| |---------- AXIAL COMPONENT ------------|
ELEM# |-- DAMAGE -- ---- ESE ---- ---- PSE ---- |-- DAMAGE -- ---- ESE ---- ---- PSE ---| |-- DAMAGE -- ---- ESE ---- ---- PSE ---|
  52         1.03604   6.12814E-03   3.00740E-03      0.08762   2.15614E-06   0.00000E+00      0.00087   4.91498E-04   8.19163E-05
  53         1.01429   5.95730E-03   2.85661E-03      0.29506   2.90246E-03   1.24683E-18      0.00061   4.25817E-04   7.09695E-05

      '------ --- SHEAR COMPONENT ------- ----| |---------- AXIAL COMPONENT -----------|
ELEM# .-- DAMAGE -- ---- ESE ---- ---- PSE ---| |-- DAMAGE -- ---- ESE ---- ---- PSE --|
  54         0.04983   1.65536E-02   0.00000E+00      0.00032   6.70977E-05   1.11829E-05      0.00038   9.50057E-05   1.58343E-05

       STRUCTURE DAMAGE INDEX=    5.30610E-04


*--------------------- ------------ -*
*-- MEMORY UTILIZATION        . . ----*
*-- IZ= 46473.    MEM= 6.639%    ----*
*------------------------------------*
*-- ELAPSED CPU TIME    17.19 SEC ----*
*--- TOTAL CPU TIME     16.56 SEC ----*
*------------------------------------*
```
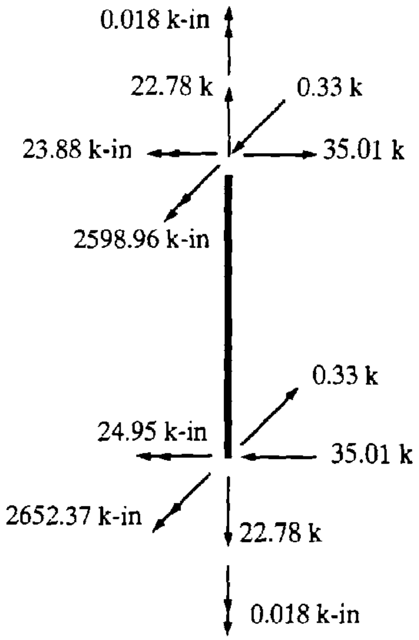
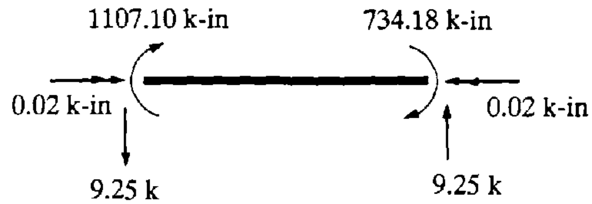
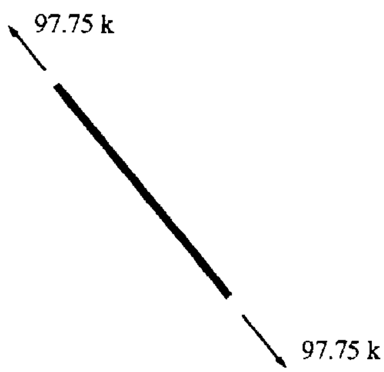

8. Drawing of Internal Forces



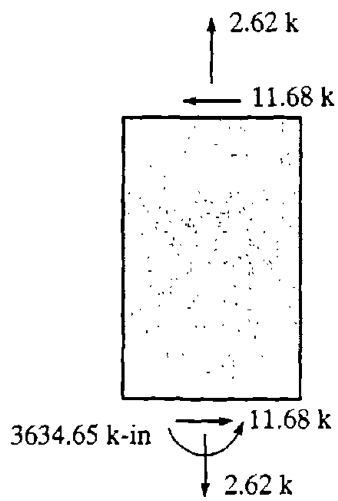
a. Member 15 (Column)



b. Member 1 (Beam)



c. Member 47 (Brace)



d. Member 52 (Shear Wall)

Figure 52. Drawing of Internal Forces

VII. EXAMPLE PROBLEMS (For PC)

A. ELASTIC STATIC SOLUTION

Description of Input Information

Find the structural displacements and internal forces of the space frame (Fig. 53), which is subjected to vertical load. Structural members have the same cross-section area and material properties. Cross-sectional area is $A=4.59$ in^2; torsional moment of inertia is $J=24.5$ in^4; moments of inertia about bending are $I_Y=11.7$ in^4 and $I_Z=22.1$ in^4; Young's modulus is $E=30000$ ksi; and shear modulus is $G=12000$ ksi.

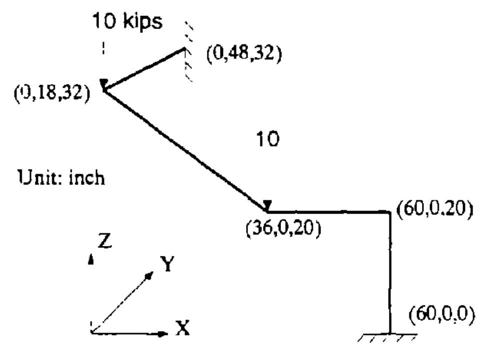


Figure 53. Space Frame Subjected to Vertical Loads

Input and Output

Input

```
:    ECHO OF INPUT DATA

   LINE    ......10... :   20.  .' ..30..  :  .40 ..   .. 50 .. :.. 60. .   .. 70  .  ...80
     1     'STRUCTURE DEFINATION'
     2     '3-D FRAME , WITH CONDENSATION'
     3        5 1  2 1 0           1.00  NNODE,NCCS,NSUPT,NCCND,NCONST    SCALE
     4        1       0.00  48.00  32.00 1  0      : NODES
     5        2       0.00  18.00  32.00 1  0      :
     6        3  36.00   0.00  20.00 1  0
     7        4  60.00   0.00  20.00 1  0
     8        5  60.00   0.00   0.00 1  0
     9         1 0 0    0 1 0                  : DIRECTION COSINE
    10               1 1 1 1 1 1 1             0 1        : RESTRAINTS
    11               5 1 1 1 1 1 1             0 1        :
    12               0 0 0 0 1 1 1             0 0        : CONDENSE
    13       1  NMAT
    14:  '3D-BEAM 4X4X 25 TUBE' 30000 12000 4 59 0 0 24 5 11.7 22.1  4 4 2  4 4 2
    15    0 0 0 .FALSE              KG
    16       4  NELEM ELE MAT SJ EJ VYI,VYJ,VYK XS XE PKG KODE
    17   '3D-BEAM' 'MEMBER  1' 1  1  2  0 0 1  0 0 0 000000 000
    18:  '3D-BEAM' 'MEMBER  2' 1  2  3  0 0 1  0 0 0 000000 000
    19   '3D-BEAM' 'MEMBER  3' 1  3  4  0 0 1  0 0 0 000000 000
    20.  '3D-BEAM' 'MEMBER  4' 1  4  5  1 0 0  0 0 0 000000 000
    21-    0 0 .FALSE    :  MASS
    22:    0 0              :  DAMP
    23:  'SOL01  SOLUTION
    24:  'STATIC LOADING CASES ONE AND TWO - WITH CONDENSATION'
    25.    2  0
```

```
26: 1 2 0 0  'FZ' -10
27: 2 3 0 0  'FZ' -10
28: 0 0 0 0  'END'  0
29: 'STOP'
```

Output

```
1 STRUCTURE. . . : 3-D FRAME , WITH CONDENSATION                                   TIME  9: 2 58, DATE   5/24/96
  SOLUTION. . . :

 *** PROGRAM FEM ***         DOUBLE PRECISION VERSION



     NODE COORDINATES AND DEGREES OF FREEDOM

    TOTAL NUMBER OF DEGREES OF FREEDOM . . . . .          30
    NUMBER OF DEGREES OF FREEDOM CONDENSED OUT. . .        9
    NUMBER OF FREE DEGREES OF FREEDOM. . . . . . . .       9
    NUMBER OF RESTRAINED DEGREES OF FREEDOM. . . .        12

     NODE COS#    X-COORD       Y-COORD        Z-COORD       FX     FY     FZ     MX     MY     MZ
       1    1     .00000        48.000         32.000        19-R   20-R   21-R   22-R   23-R   24-R
       2    1     .00000        18.000         32.000        10     11     12     1      2      3
       3    1     36.000        .00000         20.000        13     14     15     4      5      6
       4    1     60.000        .00000         20.000        16     17     18     7      8      9
       5    1     60.000        .00000         .00000        25-R   26-R   27-R   28-R   29-R   30-R
        NOTE  R - RESTRAINED DEGREE OF FREEDOM
              C   CONSTRAINED DEGREE OF FREEDOM

     DIRECTION COSINES ..

 COS( 1)   VX   1.00000 I + .00000 J +.00000 K   VY:   .00000 I +1.00000 J +.00000 K   VZ:   .00000 I +.00000 J +1.00000 K
1 STRUCTURE. . .: 3-D FRAME , WITH CONDENSATION                                    TIME: 9: 2:58, DATE:  5/24/96
  SOLUTION. . . :


     3-D ELASTIC BEAM ELEMENT
     ------------------------

    MATL.    E      GAMMA        AX        AY        AZ        IX        IY        IZ

      1 3.000E+04 1.200E+04  4.59      .000      .000      24.5      11.7      22.1

1 STRUCTURE . . . : 3-D FRAME , WITH CONDENSATION                                  TIME: 9: 2:58, DATE   5/24/96
  SOLUTION . . . .


 ELEMENT 06,  3D BEAM ELEMENT

                      #  MATL START  END  REL CD   LENGTH   ----------- Y-AXIS -----------  START DIST   END DIST    PKG
 MEMBER  1            1    1    1     2            30.00      .00000 I +.00000 J +1.00000 K  .0000       .0000      .0000
 MEMBER  2            2    1    2     3            42.00      .25555 I -.12778 J +.95831 K  .0000       .0000      .0000
 MEMBER  3            3    1    3     4            24.00      .00000 I +.00000 J +1.00000 K  .0000       .0000      .0000
 MEMBER  4            4    1    4     5            20.00     1.00000 I +.00000 J +.00000 K   .0000       .0000      .0000


      ZERO MASS MATRIX
      ----------------


      PROPORTIONAL DAMPING COEFFICIENTS
      ---------------------------------
     ALPHA=   .00000       BETA=   .00000

1 STRUCTURE. . .: 3-D FRAME , WITH CONDENSATION                                    TIME  9: 2:58, DATE   5/24/96
  SOLUTION. . . : STATIC LOADING CASES ONE AND TWO - WITH CONDENSATION             TIME. 9: 2 58, DATE   5/24/96

   SOLUTION #1, STATIC - ELASTIC ANALYSIS
  ---------------------------------------

   NUMBER OF LOAD CASES . . . . . . .       2
     APPLIED JOINT LOADS
    --------------------

 LOAD CASE:  1  JOINT     2  DIRECTION. FZ   DOF'S    12              MAGNITUDE:  -10.0000
 LOAD CASE:  2  JOINT.    3  DIRECTION. FZ   DOF'S.   15              MAGNITUDE.  -10.0000
1 STRUCTURE . . 3-D FRAME , WITH CONDENSATION                                      TIME:  9: 2 58, DATE   5/24/96
  SOLUTION . . .  STATIC LOADING CASES ONE AND TWO - WITH CONDENSATION             TIME   9: 2:58, DATE:  5/24/96

   GCS DISPLACEMENTS,  LOADING #    1
  ------------------

      NODE       DX              DY              DZ              RX              RY              RZ

        1    .000000         .000000         .000000         .000000         .000000         .000000
        2 -2.544955E-02   6.332357E-05   -9.289331E-02    4.264072E-03   -2.636739E-03   -1.253013E-03
        3 -1.077555E-02  -1.042561E-03   -4.567984E-02    1.633369E-03   -2.375254E-03   -5.326993E-04
        4 -1.095648E-02  -5.241764E-03   -2.141821E-04    7.689711E-04   -1.200627E-03   -1.467299E-04
        5    .000000         .000000         .000000         .000000         .000000         .000000
1 STRUCTURE. . : 3-D FRAME , WITH CONDENSATION                                     TIME: 9: 2:58, DATE:  5/24/96
  SOLUTION . . .  STATIC LOADING CASES ONE AND TWO - WITH CONDENSATION             TIME  9: 2:58, DATE:  5/24/96

   GCS DISPLACEMENTS,  LOADING #    2
  ------------------

      NODE       DX              DY              DZ              RX              RY              RZ

        1    .000000         .000000         .000000         .000000         .000000         .000000
        2 -1.632222E-02  -9.153944E-06   -4.567983E-02    2.494263E-03    4.608209E-04   -8.977455E-04
        3 -2.619243E-02   2.499981E-03   -7.934558E-02    3.406416E-03   -2.753468E-03   -6.838654E-04
```

```
     4 -2.627011E-02  -1.378137E-02  -1.098668E-03   1.386143E-03  -2.671822E-03  -4.580517E-04
     5  .000000        .000000        .000000        .000000        .000000        .000000
1 STRUCTURE. . 3-D FRAME , WITH CONDENSATION                                          TIME  9  2:58, DATE:  5/24/96
  SOLUTION . : STATIC LOADING CASES ONE AND TWO  WITH CONDENSATION                    TIME  9  2:58, DATE:  5/24/96


  GCS RESTRAINT REACTIONS,   LOADING #    1
 ************************

    NODE      FX             FY             FZ             MX             MY             MZ

     1   1.038081       .2906552       8.525362      -222.1165       25.86023       30.23147
     5  -1.038051       .2906559       1.474644      -16.40200       29.40039       2.156929
      ---------------------------------------------------------------------------------------
 SUMMATION  .3004074E-04  .6954534E-06  10.00001     179.9999       .5950925E-03  -.1292828E-03
1 STRUCTURE.. : 3-D FRAME , WITH CONDENSATION                                         TIME:  9: 2:58, DATE:  5/24/96
  SOLUTION    : STATIC LOADING CASES ONE AND TWO - WITH CONDENSATION                  TIME.  9: 2:58, DATE.  5/24/96


  GCS RESTRAINT REACTIONS,   LOADING #    2
 ************************

    NODE      FX             FY             FZ             MX             MY             MZ

     1   .4456985       4.215430E-02   2.435681      -91.65842      -4.516044       17.18910
     5  -.4456500       4.215216E-02   7.564327      -23.90530       84.11436       6.733359
      ---------------------------------------------------------------------------------------
 SUMMATION  .4848838E-04  .2138317E-05  10.00001     .2288815E-04  -359.9999      -.2014786E-03
1 STRUCTURE . . 3-D FRAME . WITH CONDENSATION                                         TIME  9  2:58, DATE.  5/24/96
  SOLUTION ... STATIC LOADING CASES ONE AND TWO - WITH CONDENSATION                   TIME  9  2:58, DATE:  5/24/96


      3D BEAM FORCES...

  ELEMENT LOAD        NODE     AXIAL          FY             FZ             TORSION        MY             MZ
     1     1  FORCE    1     .290655        8.52536       -1.03806       -25.8602        30.2315        222.116
              FORCE    2     .290655       -8.52536        1.03806        25.8602        .910964        33.6445
     1     2  FORCE    1   -4.215430E-02    2.43569       -.445698        4.51604        17.1991        91.6584
              FORCE    2    4.215430E-02   -2.43569        .445698       -4.51604       -3.81815       -18.5880
     2     1  FORCE    2     1.43566       -1.11075       -.204270        18.0155        4.42059       -38.1764
              FORCE    3     1.43566        1.11075        .204270       -18.0155        4.15876       -8.47513
     2     2  FORCE    2    -.331961        2.44266       -.237020       -15.0880       -.514146        12.3521
              FORCE    3     .331961       -2.44266        .237020        15.0880        10.4690        90.2394
     3     1  FORCE    3     1.03806       -1.47454        .290656        10.5889       -9.13268        14.7699
              FORCE    4    -1.03806        1.47454       -.290656       -10.5889        2.15693       -50.1614
     3     2  FORCE    3     .445656       -7.56432      -4.215300E-02    24.7483       -5.72169       -86.5164
              FORCE    4    -.445656        7.56432       4.215300E-02   -24.7483        6.73336       -93.0273
     4     1  FORCE    4     1.47464        1.03805        .290656        2.15693        10.5889        50.1614
              FORCE    5    -1.47464       -1.03805       -.290656       -2.15693       -15.4020       -29.4004
     4     2  FORCE    4     7.56433        .445651      -4.215232E-02    6.73336        24.7483        93.0274
              FORCE    5    -7.56433       -.445651       4.215232E-02   -6.73336       -23.9053       -94.1144

 THE STATICS STRAIN ENERGY OF SYSTEM =     [illegible]967

 ************************************************
1 STRUCTURE    : 3-D FRAME , WITH CONDENSATION                                        TIME:  9. 2:58, DATE.  5/24/96
  SOLUTION.. ... STATIC LOADING CASES ONE AND TWO - WITH CONDENSATION                 TIME:  9: 2:58, DATE:  5/24/96

  MAXIMUN VALUES FOR ALL LOAD CASES
 ***********************************


  GCS MAXIMUM DISPLACEMENTS
 **************************
                        NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

    NODE      DX             DY             DZ             RX             RY             RZ

     1   .000000        .000000        .000000        .000000        .000000        .000000
     2  -2.544356E-02   6.332357E-05  -9.289331E-02   4.264072E-03  -2.638799E-03  -1.253013E-03
     3   2.619243E-02   2.459981E-03  -7.934558E-02   3.406416E-03  -2.753466E-03   8.838654E-04
     4  -2.627011E-02  -1.378137E-02  -1.098668E-03   1.386143E-03  -2.671822E-03  -4.580517E-04
     5   .000000        .000000        .000000        .000000        .000000        .000000
1 STRUCTURE ... 3-D FRAME , WITH CONDENSATION                                         TIME:  9: 2:58, DATE  5/24/96
  SOLUTION. . . STATIC LOADING CASES ONE AND TWO - WITH CONDENSATION                  TIME:  9: 2:58, DATE  5/24/96

  MAXIMUN VALUES FOR ALL LOAD CASES
 ***********************************


  MAXIMUM GCS RESTRAINT REACTIONS     NOTE  MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY
 *********************************

    NODE      FX             FY             FZ             MX             MY             MZ

     1   1.039081       .2906552       8.525362      -222.1165       25.86023       30.23147
     5  -1.038051       .2906559       7.564327      -22.90530       84.11438       6.733359
 MAX OF ALL-------------------------------------------------------------------------------
 GCS SUMM   .0000000       .0000000       .0000000       .0000000       .0000000       .0000000
1 STRUCTURE.    3-D FRAME , WITH CONDENSATION                                         TIME:  9: 2:58, DATE:  5/24/96
  SOLUTION    - STATIC LOADING CASES ONE AND TWO - WITH CONDENSATION                  TIME   9: 2:58, DATE:  5/24/96

  MAXIMUN VALUES FOR ALL LOAD CASES
 ***********************************
       COLUMN ( LOAD) REPRESENTS THE
      DOF WHICH HAS MAXIMUM VALUE

      3D BEAM FORCES
       MAXIMUM VALUES FOR ALL STEPS   NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME
  ELEMENT LOAD        NODE     AXIAL          FY             FZ             TORSION        MY             MZ
     1     1  FORCE    1     .290655        8.52536       -1.03808       -25.8602        30.2315        222.116
              FORCE    2    -.290655       -8.52536        1.03808        25.8602        .910964        33.6445
     1     2  FORCE    1     .290655        8.52536       -1.03808       -25.8602        30.2315        222.116
              FORCE    2     .290655       -8.52536        1.03808        25.8602        .910964        33.6445
     1     3  FORCE    1     .290655        8.52536       -1.03808       -25.8602        30.2315        222.116
              FORCE    2    -.290655       -8.52536        1.03808        25.8602        .910964        33.6445
     1     4  FORCE    1     .290655        8.52536       -1.03808       -25.8602        30.2315        222.116
              FORCE    2     .290655       -8.52536        1.03808        25.8602        .910964        33.6445
     1     5  FORCE    1     .290655        8.52536       -1.03808       -25.8602        30.2315        222.116
```

		FORCE	2	-.290655	-8.52536	1.03808	25.8602	.910964	33.6445
1	6	FORCE	1	.290655	8.52536	-1.03808	-25.8602	30.2315	222.116
		FORCE	2	-.290655	-8.52536	1.03808	25.8602	.910964	33.6445
1	7	FORCE	1	.290655	8.52536	-1.03808	-25.8602	30.2315	222.116
		FORCE	2	-.290655	-8.52536	1.03808	25.8602	.910964	33.6445
1	8	FORCE	1	.290655	8.52536	-1.03808	-25.8602	30.2315	222.116
		FORCE	2	-.290655	-8.52536	1.03808	25.8602	.910964	33.6445
1	9	FORCE	1	.290655	8.52536	-1.03808	-25.8602	30.2315	222.116
		FORCE	2	-.290655	-8.52536	1.03808	25.8602	.910964	33.6445
1	10	FORCE	1	.290655	8.52536	-1.03808	-25.8602	30.2315	222.116
		FORCE	2	-.290655	-8.52536	1.03808	25.8602	.910964	33.6445
1	11	FORCE	1	-4.215430E-02	2.43568	-.445699	4.51604	17.1891	93.6584
		FORCE	2	4.215430E-02	-2.43568	.445699	-4.51604	-3.81815	18.5580
1	12	FORCE	1	.290655	8.52536	-1.03808	-25.8602	30.2315	222.116
		FORCE	2	-.290655	-8.52536	1.03808	25.8602	.910964	33.6445
2	1	FORCE	2	1.43566	-1.11075	-.204270	18.0155	4.42059	-38.1764
		FORCE	3	-1.43566	1.11075	.204270	-18.0155	4.15876	-8.47513
2	2	FORCE	2	-.331961	2.44266	-.237020	-15.0880	-.514146	12.3521
		FORCE	3	.331961	-2.44266	.237020	15.0880	10.4690	90.2394
2	3	FORCE	2	-.331961	2.44266	-.237020	-15.0880	-.514146	12.3521
		FORCE	3	.331961	-2.44266	.237020	15.0880	10.4690	90.2394
2	4	FORCE	2	1.43566	-1.11075	-.204270	18.0155	4.42059	-38.1764
		FORCE	3	-1.43566	1.11075	.204270	-18.0155	4.15876	-8.47513
2	5	FORCE	2	1.43566	-1.11075	-.204270	18.0155	4.42059	-38.1764
		FORCE	3	-1.43566	1.11075	.204270	-18.0155	4.15876	-8.47513
2	6	FORCE	2	1.43566	-1.11075	-.204270	18.0155	4.42059	-38.1764
		FORCE	3	-1.43566	1.11075	.204270	-18.0155	4.15876	-8.47513
2	7	FORCE	2	1.43566	-1.11075	-.204270	18.0155	4.42059	-38.1764
		FORCE	3	-1.43566	1.11075	.204270	-18.0155	4.15876	-8.47513
2	8	FORCE	2	-.331961	2.44266	-.237020	-15.0880	-.514146	12.3521
		FORCE	3	.331961	-2.44266	.237020	15.0880	10.4690	90.2394
2	9	FORCE	2	-.331961	2.44266	-.237020	-15.0880	-.514146	12.3521
		FORCE	3	.331961	-2.44266	.237020	15.0880	10.4690	90.2394
2	10	FORCE	2	1.43566	-1.11075	-.204270	18.0155	4.42059	-38.1764
		FORCE	3	-1.43566	1.11075	.204270	-18.0155	4.15876	-8.47513
2	11	FORCE	2	-.331961	2.44266	-.237020	-15.0880	-.514146	12.3521
		FORCE	3	.331961	-2.44266	.237020	15.0880	10.4690	90.2394
2	12	FORCE	2	-.331961	2.44266	-.237020	-15.0880	-.514146	12.3521
		FORCE	3	.331961	-2.44266	.237020	15.0880	10.4690	90.2394
3	1	FORCE	3	1.03806	-1.47464	.290656	10.5889	-9.13268	14.7699
		FORCE	4	-1.03806	1.47464	-.290656	-10.5889	2.15693	-50.1614
3	2	FORCE	3	.445656	-7.56432	-4.215300E-02	24.7483	-5.72169	-88.5164
		FORCE	4	-.445656	7.56432	4.215300E-02	-24.7483	6.73336	-93.0273
3	3	FORCE	3	1.03806	-1.47464	.290656	10.5889	-9.13268	14.7699
		FORCE	4	-1.03806	1.47464	-.290656	-10.5889	2.15693	-50.1614
3	4	FORCE	3	.445656	-7.56432	-4.215300E-02	24.7483	-5.72169	-88.5164
		FORCE	4	-.445656	7.56432	4.215300E-02	-24.7483	6.73336	-93.0273
3	5	FORCE	3	1.03806	-1.47464	.290656	10.5889	-9.13268	14.7699
		FORCE	4	-1.03806	1.47464	-.290656	-10.5889	2.15693	-50.1614
3	6	FORCE	3	.445656	-7.56432	-4.215300E-02	24.7483	-5.72169	-88.5164
		FORCE	4	-.445656	7.56432	4.215300E-02	-24.7483	6.73336	-93.0273
3	7	FORCE	3	1.03806	-1.47464	.290656	10.5889	-9.13268	14.7699
		FORCE	4	-1.03806	1.47464	-.290656	-10.5889	2.15693	-50.1614
3	8	FORCE	3	.445656	-7.56432	-4.215300E-02	24.7483	-5.72169	-88.5164
		FORCE	4	-.445656	7.56432	4.215300E-02	-24.7483	6.73336	-93.0273
3	9	FORCE	3	1.03806	-1.47464	.290656	10.5889	-9.13268	14.7699
		FORCE	4	-1.03806	1.47464	-.290656	-10.5889	2.15693	-50.1614
3	10	FORCE	3	.445656	-7.56432	-4.215300E-02	24.7483	-5.72169	-88.5164
		FORCE	4	-.445656	7.56432	4.215300E-02	-24.7483	6.73336	-93.0273
3	11	FORCE	3	.445656	-7.56432	-4.215300E-02	24.7483	-5.72169	-88.5164
		FORCE	4	-.445656	7.56432	4.215300E-02	-24.7483	6.73336	-93.0273
3	12	FORCE	3	.445656	-7.56432	-4.215300E-02	24.7483	-5.72169	-88.5164
		FORCE	4	-.445656	7.56432	4.215300E-02	-24.7483	6.73336	-93.0273
4	1	FORCE	4	7.56433	.445651	-4.215232E-02	6.73336	24.7483	93.0274
		FORCE	5	-7.56433	.445651	4.215232E-02	-6.73336	-23.9053	-84.1144
4	2	FORCE	4	1.47464	1.03805	.290656	2.15693	10.5889	50.1614
		FORCE	5	-1.47464	-1.03805	-.290656	-2.15693	-16.4020	-29.4004
4	3	FORCE	4	1.47464	1.03805	.290656	2.15693	10.5889	50.1614
		FORCE	5	-1.47464	-1.03805	-.290656	-2.15693	16.4020	-29.4004
4	4	FORCE	4	7.56433	.445651	-4.215232E-02	6.73336	24.7483	93.0274
		FORCE	5	-7.56433	-.445651	4.215232E-02	-6.73336	-23.9053	-84.1144
4	5	FORCE	4	7.56433	.445651	-4.215232E-02	6.73336	24.7483	93.0274
		FORCE	5	-7.56433	-.445651	4.215232E-02	-6.73336	-23.9053	-84.1144
4	6	FORCE	4	7.56433	.445651	-4.215232E-02	6.73336	24.7483	93.0274
		FORCE	5	-7.56433	-.445651	4.215232E-02	-6.73336	-23.9053	-84.1144
4	7	FORCE	4	7.56433	.445651	-4.215232E-02	6.73336	24.7483	93.0274
		FORCE	5	-7.56433	-.445651	4.215232E-02	-6.73336	-23.9053	-84.1144
4	8	FORCE	4	1.47464	1.03805	.290656	2.15693	10.5889	50.1614
		FORCE	5	-1.47464	-1.03805	-.290656	-2.15693	-16.4020	-29.4004
4	9	FORCE	4	1.47464	1.03805	.290656	2.15693	10.5889	50.1614
		FORCE	5	-1.47464	-1.03805	-.290656	-2.15693	-16.4020	-29.4004
4	10	FORCE	4	7.56433	.445651	-4.215232E-02	6.73336	24.7483	93.0274
		FORCE	5	7.56433	-.445651	4.215232E-02	-6.73336	-23.9053	-84.1144
4	11	FORCE	4	7.56433	.445651	-4.215232E-02	6.73336	24.7483	93.0274
		FORCE	5	7.56433	-.445651	4.215232E-02	-6.73336	-23.9053	-84.1144
4	12	FORCE	4	7.56433	.445651	-4.215232E-02	6.73336	24.7483	93.0274
		FORCE	5	-7.56433	-.445651	4.215232E-02	-6.73336	-23.9053	-84.1144

B. BUCKLING ANALYSIS

Description of Input Information

Perform the buckling analysis of a four-element column (Fig. 54), and find the buckling loads. Cross-sectional area of the element is A = 11.8 in^2; torsional moment of inertia is J = 0.95 in^4; moments of inertia about bending are I_Y = 44.1 in^4 and I_Z = 310.0 in^4; Young's modulus is E = 29000 ksi; and shear modulus G = 11600 ksi.

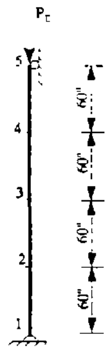


Figure 54. Buckling Analysis of Four-Element Column

Input and Output

Input

```
1     ECHO OF INPUT DATA

    LINE     .!...10...!...20.....  .30 ..!.. 40  .  .. 50.  . ...60. ..!.. 70.  .!  .80
       1:   'STRUCTURE DEFINATION'
       2:   'FOUR ELEMENT COLUMN W/ PKG =1.0 '
       3.   5 1  2 1 0   1.00  NNODE,NCOS,NSUPT,NCOND.NCONST  SCALE
       4:      1       0.00   0.00   0 00 1 4
       5.      1       0.00   0.00  60 00
       6:      1 0 0     0 1 0          ! COSINE
       7:
       8.      1 1 1 1 0 0 1    0 0        RESTRAINT
       9:      5 1 1 0 0 0 0    0 0
      10.      0 0 0 1 0 0 1    0 0        CONDENSE OUT FZ AND MZ (AXIAL AND TORSION
      11
      12:    1  NMAT
      13:  '3D-BEAM W12X40 ' 29000 11600 11 8 0 0 0.95 44.1 310.  4 4 2  4 4 2
      14
      15:    1 2 2   .FALSE   KG : AXL. FORM. ASSY
      16:
      17:    4   NELEM
      18:  '3D-BEAM' 'MEMBER  1' 1  1  2  0 1 0  0 0  1  000000            0
      19:  '3D-BEAM' 'MEMBER  2' 1  2  3  0 1 0  0 0  1  000000            0
      20   '3D-BEAM' 'MEMBER  3' 1  3  4  0 1 0  0 0  1  000000            0
      21   '3D-BEAM' 'MEMBER  4' 1  4  5  0 1 0  0 0  1  000000            0
      22
      23: 0 0     FALSE. MASS
      24. 0 0   DAMPING
      25   'SOL03 - SOLUTION'
      26:  'BUCKLING ANALYSIS'
      27.  'BUCKLE'      2   0
      28   'STOP'
```

Output

```
1 STRUCTURE..  .                     FOUR ELEMENT COLUMN W/ PKG =1 0                 TIME:  9. 4 54. DATE   5/24/96
  SOLUTION ..  .

 *** PROGRAM FEM ***        DOUBLE PRECISION VERSION
```

```
NODE COORDINATES AND DEGREES OF FREEDOM

TOTAL NUMBER OF DEGREES OF FREEDOM. .....              30
NUMBER OF DEGREES OF FREEDOM CONDENSED OUT ..           8
NUMBER OF FREE DEGREES OF FREEDOM  . ... ....          16
NUMBER OF RESTRAINED DEGREES OF FREEDOM  ... ..         6

 NODE COS#    X COORD        Y-COORD        Z-COORD        FX     FY     FZ     MX     MY     MZ
   1    1     .00000         .00000         .00000         25-R   26-R   27-R    9     10     28-R
   2    1     .00000         .00000        60.000          11     12      1     13     14      2
   3    1     .00000         .00000       120.00           15     16      3     17     18      4
   4    1     .00000         .00000       180.00           19     20      5     21     22      6
   5    1     .00000         .00000       240.00           29-R   30-R    7     23     24      8
      NOTE. R - RESTRAINED DEGREE OF FREEDOM
            C - CONSTRAINED DEGREE OF FREEDOM


DIRECTION COSINES . .

COS( 1)   VX- 1.00000 I +.00000 J +.00000 K   VY   .00000 I +1.00000 J +.00000 K   VZ   .00000 I +.00000 J +1.00000 K
1 STRUCTURE.... FOUR ELEMENT COLUMN W/ PKG =1.0                                     TIME- 9. 4 54, DATE  5/24/96
  SOLUTION ... :


3-D ELASTIC BEAM ELEMENT
************************

MATL    E      GAMMA        AX        AY        AZ        IX        IY        IZ

   1 2.900E+04 1.160E+04  11.8      .005      .005      .950      44.1      310.

1 STRUCTURE..   FOUR ELEMENT COLUMN W/ PKG =1.0                                     TIME. 9: 4.54, DATE: 5/24/96
  SOLUTION... :

   GEOMETRIC STIFFNESS DATA
   ************************

  KGDATA(1)= 1, LOAD= F(INPUT)*(1.00+ACCEL)
                F(INPUT) IS POSITIVE IN COMPRESSION
                ACCEL IS POSITIVE GLOBAL Z-AXIS ACCELERATION
  KGDATA(2)= 2, CONSISTENT FORMULATION
  KGDATA(3)= 2, SEPERATE GLOBAL KG IS FORMED

  - THE GEOMETRIC STIFFNESS MATRIX IS NOT CONDENSED WITH THE STRUCTURAL STIFFNESS MATRIX
1 STRUCTURE..  : FOUR ELEMENT COLUMN W/ PKG =1.0                                    TIME  9 4:54, DATE: 5/24/96
  SOLUTION  ..:


ELEMENT 09,  3D BEAM ELEMENT

                  #  MATL START  END  REL CD  LENGTH   ........... Y-AXIS ...........  START DIST   END DIST   PKG
MEMBER  1         1    1    1     2           60.00    .00000 I +1.00000 J + .00000 K   .0000       .0000     1.000
MEMBER  2         2    1    2     3           60.00    .00000 I +1.00000 J + .00000 K   .0000       .0000     1.000
MEMBER  3         3    1    3     4           60.00    .00000 I +1.00000 J + .00000 K   .0000       .0000     1.000
MEMBER  4         4    1    4     5           60.00    .00000 I +1.00000 J + .00000 K   .0000       .0000     1.000


   ZERO MASS MATRIX
   ****************


   PROPORTIONAL DAMPING COEFFICIENTS
   *********************************
  ALPHA=   .00000      BETA=   .00000

1 STRUCTURE  . . FOUR ELEMENT COLUMN W/ PKG =1.0                                    TIME: 9- 4-54, DATE. 5/24/96
  SOLUTION.. ..: BUCKLING ANALYSIS                                                  TIME  9 4:54, DATE- 5/24/96

  SOLUTION #3, DETERMINE EIGENVALUES AND EIGENVECTORS
  ***************************************************

  OPTION... .... . .. ..ELASTIC BUCKLING LOAD
  NUMBER OF EIGENVALUES: ..   16
        MODE:         1              2              3              4              5              6              7
    EIGENVALUE    219.25         583.14         1541.2         2037.9         4263.0         6208.0         6844.2
  EIGENVECTORS
    DOF(   9)     .00000         .00000        1.30896E-02     .00000         .00000        2.61294E-02     .00000
    DOF(  10)    1.30896E-02    2.61294E-02     .00000        3.79368E-02    1.0000          .00000        -.10983
    DOF(  11)     .70711        -1.0000         .00000         .70711       -5.37679E-06     .00000         .70711
    DOF(  12)     .00000         .00000         .70711         .00000         .00000       -1.0000          .00000
    DOF(  13)     .00000         .00000       -9.25577E-03     .00000         .00000       -5.88447E-09     .00000
    DOF(  14)    9.25577E-03    5.34140E-09     .00000       -2.68253E-02   -1.0000          .00000        7.76629E-02
    DOF(  15)    1.0000         3.10089E-07     .00000       -1.0000        -1.03210E-06     .00000       -1.0000
    DOF(  16)     .00000         .00000        1.0000          .00000         .00000        8.94547E-07     .00000
    DOF(  17)     .00000         .00000        3.02756E-09     .00000         .00000       -2.61294E-02     .00000
    DOF(  18)   -7.41558E-10    2.61294E-02     .00000        1.34253E-08    1.0000          .00000        3.54819E-08
    DOF(  19)     .70711        1.0000          .00000         .70711       -9.45618E-06     .00000         .70711
    DOF(  20)     .00000         .00000         .70711         .00000         .00000        1.0000          .00000
    DOF(  21)     .00000         .00000        9.25577E-03     .00000         .00000        9.59503E-09     .00000
    DOF(  22)   -9.25577E-03   -6.35625E-09     .00000        2.68253E-02   -1.0000          .00000       -7.76629E-02
    DOF(  23)     .00000         .00000        1.30896E-02     .00000         .00000        2.61294E-02     .00000
    DOF(  24)   -1.30896E-02   -2.61294E-02     .00000       -3.79368E-02    1.0000          .00000         .10983
1 STRUCTURE.. . FOUR ELEMENT COLUMN W/ PKG =1.0                                     TIME: 9: 4-54, DATE- 5/24/96
  SOLUTION .      BUCKLING ANALYSIS                                                 TIME- 9. 4-54, DATE- 5/24/96

  SOLUTION #3, DETERMINE EIGENVALUES AND EIGENVECTORS
  ***************************************************

  OPTION. .. . . ..... .ELASTIC BUCKLING LOAD
  NUMBER OF EIGENVALUES.. .  16
        MODE          8              9              10             11             12             13             14
    EIGENVALUE-   11432          14325          17647          21315          29967          46111          80362.
  EIGENVECTORS
    DOF(   9)     .00000       -3.79368E-02     .00000         .00000        1.0000         -.10983        -.15946
    DOF(  10)    -.15946         .00000        -.31632        1.0000          .00000         .00000         .00000
    DOF(  11)    1.0000          .00000         .70711        5.65586E-07     .00000         .00000         .00000
```

DOF(	12)	.00000	.70711	.00000	.00000	-2.03558E-07	-.70711	-1.0000
DOF(	13)	.00000	2.68253E-02	.00000	.00000	-1.0000	7.76629E-02	-1.39478E-08
DOF(	14)	-2.92245E-09	.00000	-.22508	1.0000	.00000	.00000	.00000
DOF(	15)	2.42153E-07	.00000	1.0000	7.36960E-07	.00000	.00000	.00000
DOF(	16)	.00000	-1.0000	.00000	.00000	-9.25975E-06	1.0000	4.91211E-07
DOF(	17)	.00000	6.45645E-10	.00000	.00000	1.0000	3.63759E-08	.15946
DOF(	18)	.15946	.00000	4.79983E-09	1.0000	.00000	.00000	.00000
DOF(	19)	-1.0000	.00000	.70711	1.95446E-07	.00000	.00000	.00000
DOF(	20)	.00000	.70711	.00000	.00000	1.93115E-06	-.70711	1.0000
DOF(	21)	.00000	-2.68253E-02	.00000	.00000	-1.0000	-7.76629E-02	-3.08918E-09
DOF(	22)	4.18450E-06	.00000	.22509	1.0000	.00000	.00000	.00000
DOF(	23)	.00000	3.79266E-02	.00000	.00000	1.0000	.10953	.15946
DOF(	24)	-.15946	.00000	.31832	1.0000	.00000	.00000	.00000

1 STRUCTURE . . : FOUR ELEMENT COLUMN W/ PKG =1.0 TIME: 9: 4 54. DATE 5/24/96

SOLUTION . . . BUCKLING ANALYSIS TIME: 9. 4 54. DATE 5/24/96

SOLUTION #3. DETERMINE EIGENVALUES AND EIGENVECTORS
****

OPTION:...... ... . .ELASTIC BUCKLING LOAD

NUMBER OF EIGENVALUES 16

MODE		15	16
EIGENVALUE		1.24049E-05	1.49833E-05
EIGENVECTORS			
DOF(	9)	-.31832	1.0000
DOF(	10)	.00000	.00000
DOF(	11)	.00000	.00000
DOF(	12)	.70711	-4.41371E-08
DOF(	13)	-.22509	1.0000
DOF(	14)	.00000	.00000
DOF(	15)	.00000	.00000
DOF(	16)	-1.0000	9.44156E-07
DOF(	17)	-5.94418E-08	1.0000
DOF(	18)	.00000	.00000
DOF(	19)	.00000	.00000
DOF(	20)	-.70711	3.62855E-07
DOF(	21)	.22509	1.0000
DOF(	22)	.00000	.00000
DOF(	23)	.31832	1.0000
DOF(	24)	.00000	.00000

C. NATURAL FREQUENCY AND MODE SHAPE ANALYSIS

Description of Input Information

Find the natural frequencies and mode shapes of the elastic plane shear frame (Fig. 55). Cross-sectional area of the column is A=6 in^2; moment of inertia is I=166.66 in^4; Young's modulus is E=30000 ksi. Structural transnational mass is M=0.01294 k-sec^2/in; rotational mass moment of inertia is RXY=62.1118 k-sec^2-in.

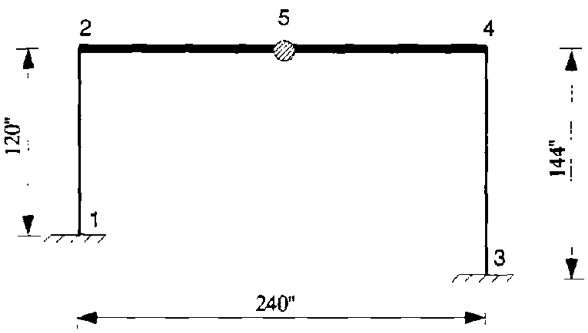


Figure 55. Plane Shear Frame

Input and Output

Input

```
1    ECHO OF INPUT DATA

  LINE  ... : .10.... ...20..  .. .30 ...  ..40. ..:.  50. ..: ..60.. .:.  70..  :.. 80
     1:  'STRUCTURE DEFINATION'
     2:  ' ONE STORY - PLANE FRAME (GLOBAL XY PLANE)
     3   5 1  5 0 2   1 00  NNODE,NCOS,NSUPT,NCOND,NCONST  SCALE
     4      1     0.00     0.00   0.00 1  0
     5      2     0.00   120.00   0.00 1  0
     6      3   240.00   -24.00   0.00 1  0
     7      4   240.00   120.00   0.00 1  0
     8      5   120.00   120.00   0.00 1  0
     9      1 0 0    0 1 0                  ! DIRECTION COSINE
    10:     1 1 1 1 1 1 1    0 0            !  RESTRAINT
    11:     2 0 0 1 1 1 0    0 0            !  RESTRAINT
    12:     3 1 1 1 1 1 1    0 0            !  RESTRAINT
    13:     4 0 0 1 1 1 0    0 0               RESTRAINT
    14:     5 0 0 1 1 1 0    0 0               RESTRAINT
    15     1  5  2 0 0                        CONSTRAINTS
    16     1  5  4 0 0                      ! CONSTRAINTS
    17
    18:    1  NMAT
    19: '3D-BEAM'  30000.0   6.0 0  0.0 166.66   4 4 2  4 4 2
    20:
    21.    0 0 0  FALSE   KG  AXL. FORM. ASSY
    22:
    23:    2   NELEM
    24: '3D-BEAM' 'MEMBER  1' 1  1  2   1 0 0   0 0 0  000000        0
    25: '3D-BEAM' 'MEMBER  2' 1  3  4   1 0 0   0 0 0  000000        0
    26
    27  10 1 .FALSE   MASS
    28   5     .01294 .01294 0      0 0 62.1118      0 0 0   0 0
    29.  0 0 0 0  0 0 0  0 0 0   0 0
    30: 0 0   DAMPING
    31. 'SOL03 - SOLUTION'
    32: 'NATURAL FREQUENCIES AND MODE SHAPES'
    33: 'FREQUENCY'  0   3
    34: 'STOP'
```

Output

```
1 STRUCTURE. ... ONE STORY - PLANE FRAME (GLOBAL XY PLANE)                                       TIME:  9: 5 45, DATE  5/24/96
  SOLUTION.. ..:

 *** PROGRAM FEM ***          DOUBLE PRECISION VERSION



      NODE CONSTRAINTS

   XY-PLANE        CONSTRAINT, MASTER      5 SLAVE.     2
   XY-PLANE        CONSTRAINT, MASTER      5 SLAVE:     4


     NODE COORDINATES AND DEGREES OF FREEDOM

    TOTAL NUMBER OF DEGREES OF FREEDOM.. ... .....       24
    NUMBER OF DEGREES OF FREEDOM CONDENSED OUT   .        0
    NUMBER OF FREE DEGREES OF FREEDOM... . . .....        3
    NUMBER OF RESTRAINED DEGREES OF FREEDOM     ...      21

      NODE COS#    X-COORD        Y COORD        Z-COORD         FX      FY      FZ      MX      MY      MZ
         1    1     .00000         .00000         .00000         4-R     5-R     6-R     7-R     8-R     9-R
         2    1     .00000        120.00          .00000         1-C     2-C    10-R    11-R    12-R     3-C
         3    1    240.00         -24.000         .00000        13-R    14-R    15-R    16-R    17-R    18-R
         4    1    240 00         120 00          .00000         1-C     2-C    19-R    20-R    21-R     3-C
         5    1    120 00         120.00          .00000         1       2      22-R    23-R    24-R     3
         NOTE: R - RESTRAINED DEGREE OF FREEDOM
               C - CONSTRAINED DEGREE OF FREEDOM


     DIRECTION COSINES ...

 COS( 1)   VX:  1 00000 I  +.00000 J  -.00000 K   VY.   .00000 I +1 00000 J  +.00000 K   VZ:   .00000 I  -.00000 J +1.00000 K
1 STRUCTURE  ...: ONE STORY   PLANE FRAME (GLOBAL XY PLANE)                                      TIME:  9. 5:45, DATE:  5/24/96
  SOLUTION.  ...


     3-D ELASTIC BEAM ELEMENT
     ------------------------

   MATL    E     GAMMA       AX        AY        AZ        IX        IY        IZ

      1 3.000E-04  .000      5 00      .000      000       .000      .000      167

1 STRUCTURE....  ONE STORY - PLANE FRAME (GLOBAL XY PLANE)                                       TIME   9  5:45, DATE:  5/24/96
  SOLUTION . .

 ELEMENT 05,  3D BEAM ELEMENT

                      #  MATL START   END  REL CD   LENGTH   ----------- Y-AXIS -----------  START DIST    END DIST     PKG
 MEMBER  1            1    1     1     2            120.0    1.00000 I  + 00000 J  -.00000 K  .0000        0000        .0000
 MEMBER  2            2    1     3     4            144.0    1 00000 I  - 00000 J  -.00000 K  0000        .0000        .0000
1 STRUCTURE .   : ONE STORY - PLANE FRAME (GLOBAL XY PLANE)                                      TIME:  9: 5:45, DATE:  5/24/96
  SOLUTION..  .:

  LUMPED NODE MASSES
 -------------------

    NODE     MX          MY          MZ          IXX         IYY         IZZ         IXY         IYZ         IYZ       IGEN   INC
      5  1.2940E-02  1.2940E-02   .0000       .0000       0000       52.11        0000       .0000        0000         0      0

     - THE MASS MATRIX IS NOT CONDENSED WITH THE STRUCTURAL STIFFNESS MATRIX


      PROPORTIONAL DAMPING COIEFICIENTS
     ----------------------------------
     ALPHA=    00000       BETA=   .00000

1 STRUCTURE ...  ONE STORY - PLANE FRAME (GLOBAL XY PLANE)                                       TIME   9  5:45, DATE   5/24/96
  SOLUTION. ...  NATURAL FREQUENCIES AND MODE SHAPES                                             TIME   9  5:45, DATE   5/24/96

  SOLUTION #3, DETERMINE EIGENVALUES AND EIGENVECTORS
 ----------------------------------------------------

  OPTION:.. ... ... ... ..  NATURAL FREQUENCIES
  NUMBER OF EIGENVALUES: ..      3
          MODE             1              2              3
 FREQ (RAD/SEC)        64.896         458.18         803 18
 FREQUENCY (HZ)        10.329         72.922         127 83
   PERIOD (SEC)     9 68191E-02    1.37133E-02    7.82252E-03
   EIGENVECTORS
     DOF(     1)       1.0000       1 48063E-03    7.94230E-02
     DOF(     2)   -9 99416E-04      1.0000        -1 0000
     DOF(     3)   -5 97976E-05    1 11644E-03      18656
1 STRUCTURE  ..  ONE STORY - PLANE FRAME (GLOBAL XY PLANE)                                       TIME:  9: 5 45, DATE   5/24/96
  SOLUTION. ..   NATURAL FREQUENCIES AND MODE SHAPES                                             TIME:  9: 5 45, DATE   5/24/96

  GCS EIGENVECTORS,  LOADING #    1     MODE #  1   FREQUENCY:    10 3255
 ------------------

     NODE       DX            DY             DZ            RX            RY             RZ

        1    .000000       .000000        000000        000000        000000        000000
        2   1.00000       9.776299E-03    000000       .000000       .000000      -8 979763E-05
        3    .000000       .000000       .000000        000000        000000        000000
        4   1 00000      -1.177513E-02   .000000       .000000        000000      -8 979763E-05
        5   1 00000      -9.994161E-04   .000000       .000000        000000      -8 979763E-05
1 STRUCTURE..  . ONE STORY - PLANE FRAME (GLOBAL XY PLANE)                                      TIME:  9: 5:45, DATE:  5/24/96
  SOLUTION  .   : NATURAL FREQUENCIES AND MODE SHAPES                                           TIME:  9  5 45, DATE:  5/24/96
```

GCS EIGENVECTORS, LOADING # 1 MODE # 2 FREQUENCY 72.9220

NODE	DX	DY	DZ	RX	RY	RZ
1	.000000	.000000	.000000	.000000	.000000	.000000
2	1.480634E-03	.866027	.000000	.000000	.000000	1.116444E-03
3	.000000	.000000	.000000	.000000	.000000	.000000
4	1.480634E-03	1.13397	.000000	.000000	.000000	1.116444E-03
5	1.480634E-03	1.00000	.000000	.000000	.000000	1.116444E-03

GCS EIGENVECTORS, LOADING # 1 MODE # 3 FREQUENCY 127.829

NODE	DX	DY	DZ	RX	RY	RZ
1	.000000	.000000	.000000	.000000	.000000	.000000
2	-7.942297E-02	23.3900	.000000	.000000	.000000	-.186583
3	.000000	.000000	.000000	.000000	.000000	.000000
4	-7.942297E-02	-21.3900	.000000	.000000	.000000	-.186583
5	-7.942297E-02	1.00000	.000000	.000000	.000000	-.186583

D. TWO-STORY PLANE SHEAR FRAME DYNAMIC ANALYSIS

Description of Input Information

A two-story plane shear frame (Fig. a) is subjected to triangular dynamic loading shown in (b) and (c) applied at mass m_1 and m_2, respectively. Moment of inertia of the structural member is $I=107$ in^4; the elastic modulus is $E=30000$ ksi; and structural masses are $m_1=m_2=0.414$ k-sec^2/in. For the dynamic loading input, special loading mass concept given in Chapter II (pg. 35) and Chapter IV (pg. 97) is used. Let $F_1(t)=30k=m_1'g$ and $F_2(t)=20k=m_2'g$, then the $m_1'=0.07763975$ k-sec^2/in and $m_2'=0.05175983$ k-sec^2/in. Before applying the triangular load, assume that the structure is in vibration with initial accelerations $a_1=72.4638$ in/s^2 at m_1 and $a_2=48.3092$ in/s^2 at m_2. Time increment is DT=0.01 second for 25 time steps (TF=0.25 second).

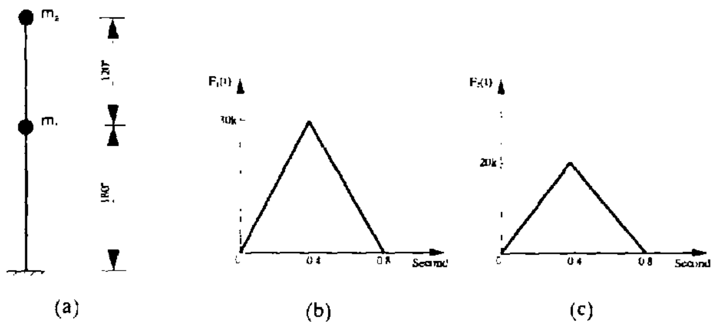


Figure 56. Two-Story Shear Frame Subjected to Triangular Loading

Input and Output

Input

```
1    ECHO OF INPUT DATA

   LINE . . . . 10. . . . 20. . . . 30 . . . .40 . . . .50 . . . 60. . . .70. . . . .80
     1.  'STRUCTURE DEFINATION'
     2   'TWO STORY PLANE SHEAR FRAME'
     3.  3 1  3 0 0   1.00  NNODE,NCOS,NSUPT,NCOND,NCONST  SCALE
     4.      1       0.00   0.00    0.00 1  0
     5       2       0.00   0.00 150.00 1  0
     6       3       0.00   0.00 300.00 1  0
     7       1 0 0    0 1 0               : DIRECTION COSINE
     8:      1  1 2 2 2 1 2    0 0          RESTRAINTS
     9.      2  0 2 2 2 1 2    0 0        '
    10       3  0 2 2 2 1 2    0 0
    11        1  NMAT
    12.  '3D-BEAM I=5 ' 30E3  0    0  0  0    0. 107 0    4 4 2  4 4 2
    13:   0 0 0  FALSE  KGDATA
    14:     2   NELEM
    15:  '3D-BEAM' 'MEMBER  1' 1  1  2  0 1 0  0 0 0  000000            0
    16   '3D-BEAM  'MEMBER  2  1  2  3  0 1 0  0 0 0  000000            0
    17    2 1 .FALSE   MASS
    18:   2 .414    0 0  0 0 0  0 0 0   0 0
    19:   3  414    0 0  0 0 0  0 0 0   0 0
    20.   .0            0    . DAMPING
```

```
'SOL02 - SOLUTION'
'AVERAGE ACCELERATION METHOD - TRIANGULAR FORCING FUNCTION '
'AVERAGE' 0 TRUE. TRUE            : INTEG THETA ELAS? UNBAL?
 5000 1  20 .TRUE.                : IPRT IWRITE MAXACC SLMASS?
 0 00  010 .25 386.4               TO DT TF GRAV
 2 1 .FALSE.  MASS
 2 .07763975            0 0  0 0 0  0 0 0   0 0
 3 .05175983            0 0  0 0 0  0 0 0   0 0
 'DOF' 1  13             0 0 0
 'END' 0  0              0 0 0
 0    ISP1
  2 0 0 'ACCELERATION' 72.4638 0 0   0 0 0
  3 0 0 'ACCELERATION' 48 3092 0 0   0 0 0
  0 0 0 'END'               0 0 0   0 0 0
  1   -1 0.00 .4  TRUE   NA,ASCALE,TO,DT,PRINT
  1 0 0   0 1 0     V1, V2
105 10 1  FALSE. .TRUE. .FALSE.  IN,NPTS,IDIR,FMT,ECHO,REWIND
TRIANGULAR FORCING FUNCTION
PEAK VALUE OF ONE
1.00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
'READ UNIT=13'
'STOP'
```

Output

```
1 STRUCTURE . . TWO STORY PLANE SHEAR FRAME                                   TIME: 11:42  1. DATE  5/24/96
  SOLUTION .. .

 *** PROGRAM FEM ***        DOUBLE PRECISION VERSION


    NODE COORDINATES AND DEGREES OF FREEDOM

    TOTAL NUMBER OF DEGREES OF FREEDOM. ......  ..         18
    NUMBER OF DEGREES OF FREEDOM CONDENSED OUT...           0
    NUMBER OF FREE DEGREES OF FREEDOM.. ......  ..          2
    NUMBER OF RESTRAINED DEGREES OF FREEDOM.    .          16

     NODE COS#    X-COORD      Y-COORD      Z-COORD      FX     FY     FZ     MX     MY     MZ
       1    1     .00000       00000        00000        3-R    7-R    8-R    9-R    4-R   10-R
       2    1     .00000       00000       180 00        1     11-R   12-R   13-R    5-R   14-R
       3    1     .00000       00000       300 00        2     15-R   16-R   17-R    6-R   18-R
        NOTE  R - RESTRAINED DEGREE OF FREEDOM
              C - CONSTRAINED DEGREE OF FREEDOM


    DIRECTION COSINES  ..

 COS( 1)   VX   1.00000 I  +.00000 J  +.00000 K   VY   .00000 I +1.00000 J  +.00000 K   VZ:   00000 I  +.00000 J +1 00000 K
1 STRUCTURE..  . TWO STORY PLANE SHEAR FRAME                                  TIME: 11:42  1. DATE  5/24/96
  SOLUTION .. ..


    3-D ELASTIC BEAM ELEMENT
    ------------------------

   MATL.   E      GAMMA       AX        AY        AZ        IX        IY        IZ

     1 3 000E+04  .000       .000      .000      000       000      107.      .000

1 STRUCTURE..  : TWO STORY PLANE SHEAR FRAME                                  TIME: 11:42  1. DATE  5/24/96
  SOLUTION .. ..


 ELEMENT 06,  3D BEAM ELEMENT

                      #  MATL START  END  REL CD  LENGTH    .. ...... Y-AXIS ..........  START DIST   END DIST    PKG
 MEMBER  1            1    1    1     2           180 0     00000 I +1.00000 J  + 00000 K   0000       0000      .0000
 MEMBER  2            2    1    2     3           120 0    .00000 I +1 00000 J  + 00000 K   0000      .0000      .0000
1 STRUCTURE  ..  TWO STORY PLANE SHEAR FRAME                                  TIME: 11.42: 1. DATE  5/24/96
  SOLUTION.....

  LUMPED NODE MASSES
 -------------------

   NODE    MX        MY        MZ        IXX       IYY       IZZ       IXY       IYZ       IYZ     IGEN  INC
     2    4140      0000     .0000      0000     .0000      0000     .0000     .0000     .0000      0    0
     3    4140      0000     .0000      0000     .0000      0000     .0000     .0000     .0000      0    0

   - THE MASS MATRIX IS NOT CONDENSED WITH THE STRUCTURAL STIFFNESS MATRIX.


    PROPORTIONAL DAMPING COEFFICIENTS
    ---------------------------------
    ALPHA=   .00000        BETA=   .00000

1 STRUCTURE      TWO STORY PLANE SHEAR FRAME,                                 TIME  11 42: 1, DATE:  5/24/96
  SOLUTION .. .  AVERAGE ACCELERATION METHOD - TRIANGULAR FORCING FUNCTION    TIME  11 42: 1, DATE:  5/24/96

  SOLUTION #2, AVERAGE ACCELERATION METHOD OF NUMERICAL INTEGRATION
 ******************************************************************

  INITIAL TIME  .  ... ...  .. ..    .000000
  TIME STEP ..     . ... .   . ..   1.000000E-02
  FINAL TIME ...... . ...... ... .    250000
  ACCELERATION DUE TO GRAVITY ....   386.400
  STEP INTERVAL FOR PRINTING ...... 5000
  THE STRUCTURE IS ASSUMED TO BEHAVE ELASTICALLY
1 STRUCTURE  . : TWO STORY PLANE SHEAR FRAME                                  TIME. 11.42: 1, DATE  5/24/96
  SOLUTION.  ..  AVERAGE ACCELERATION METHOD - TRIANGULAR FORCING FUNCTION    TIME. 11.42: 1, DATE:  5/24/96

  LUMPED NODE MASSES
 -------------------
```

```
NODE    MX            MY       MZ       IXX      IYY      IZZ      IXY      IYZ      IYZ      IGEN  INC
  2  7.7640E-02   .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000      0     0
  3  5.1760E-02   .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000      0     0

 DATA WRITTEN TO FILES
 ---------------------

 DEGREE OF FREEDOM #   1 IS WRITTEN TO UNIT #  13

NOT INCLUDE STATICS CASE EXTERNAL DEFORMATIONS
----------------------------------------------
1 STRUCTURE      TWO STORY PLANE SHEAR FRAME                                  TIME 11:42: 1, DATE: 5/24/96
SOLUTION. .... AVERAGE ACCELERATION METHOD - TRIANGULAR FORCING FUNCTION       TIME 11:42: 1, DATE: 5/24/96

INITIAL ACCELERATIONS, VELOCITIES DISPLACEMENTS AND LOADS
--------------------------------------------------------

 NODE  IGEN  INC COMPONENT        TX        TY       TZ       RX       RY       RZ
  2     0     0 ACCELERATION     72.46     .0000    .0000    .0000    .0000    .0000
  3     0     0 ACCELERATION     48.31     .0000    .0000    .0000    .0000    .0000


 INITIAL, NON-ZERO VALUES
  DOF      FORCE        DISP        VEL         ACC
   1      .000000     .000000     .000000    72.4635
   2      .000000     .000000     .000000    48.3092

 GROUND ACCELERATION RECORD
 --------------------------

 INPUTING TRANSLATIONAL ACCELERATION RECORD # 1, FROM UNIT. 105
 TRIANGULAR FORCING FUNCTION
 PEAK VALUE OF ONE
 THE RECORD CONTAINS     10 POINTS, BEGINING AT TIME:   .000000    WITH A TIME INCREMENT OF.   .400000
 DIRECTION OF ACCELERATION:     1.00000 I  +.00000 J  +.00000 K

 INPUT ACCELERATION:                 (g's)
1.000     .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000

                      MAXIMUM   AT   TIME       MINIMUM   AT   TIME       AVERAGE    STANDARD DEV.    RMS
INPUT ACCELERATION    1.0000        .00000       .00000       .40000      .10000       .31623       .31623


 GLOBAL BASE ACCELERATION IN THE X DIRECTION (g's)
-1.000    .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000
 .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000


 GLOBAL BASE ACCELERATION IN THE Y DIRECTION (g's)
 .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000
 .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000


 GLOBAL BASE ACCELERATION IN THE Z DIRECTION (g's)
 .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000
 .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000    .0000

                      MAXIMUM   AT   TIME       MINIMUM   AT   TIME       AVERAGE      STANDARD DEV.    RMS
 X-AXIS ACCELERATION   .00000        .40000     -1.0000        .40000   -5.00000E-02      .22361       .22361
 Y-AXIS ACCELERATION   .00000        .40000      .00000        .40000     .00000          .00000       .00000
 Z-AXIS ACCELERATION   .00000        .40000      .00000        .40000     .00000          .00000       .00000
1 STRUCTURE..  - TWO STORY PLANE SHEAR FRAME                                  TIME: 11:42: 1, DATE  5/24/96
 SOLUTION ..  : AVERAGE ACCELERATION METHOD - TRIANGULAR FORCING FUNCTION      TIME: 11:42: 1, DATE  5/24/96

 MAXIMUM VALUES FOR ALL STEPS
 ----------------------------


 GCS MAXIMUM DISPLACEMENTS
 -------------------------
                       NOTE  MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

    NODE      DX          DY          DZ          RX          RY          RZ

      1    .000000     .000000     .000000     .000000     .000000     .000000
      2   1.49603      .000000     .000000     .000000     .000000     .000000
      3   1.32781      .000000     .000000     .000000     .000000     .000000
1 STRUCTURE.  - TWO STORY PLANE SHEAR FRAME                                   TIME 11:42: 1, DATE. 5/24/96
 SOLUTION.. ..: AVERAGE ACCELERATION METHOD - TRIANGULAR FORCING FUNCTION      TIME 11:42: 1, DATE: 5/24/96

 MAXIMUM VALUES FOR ALL STEPS
 ----------------------------


 GCS MAXIMUM VELOCITIES
 ----------------------
                       NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

    NODE      DX          DY          DZ          RX          RY          RZ

      1    .000000     .000000     .000000     .000000     .000000     .000000
      2   8.55098      .000000     .000000     .000000     .000000     .000000
      3   9.88436      .000000     .000000     .000000     .000000     .000000
1 STRUCTURE..   TWO STORY PLANE SHEAR FRAME                                   TIME: 11:42  1, DATE: 5/24/96
 SOLUTION  .    AVERAGE ACCELERATION METHOD - TRIANGULAR FORCING FUNCTION      TIME: 11:42  1. DATE: 5/24/96

 MAXIMUM VALUES FOR ALL STEPS
 ----------------------------


 GCS MAXIMUM ACCELERATIONS
 -------------------------
                       NOTE  MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

    NODE      DX          DY          DZ          RX          RY          RZ

      1    .000000     .000000     .000000     .000000     .000000     .000000
      2   70.4121      .000000     .000000     .000000     .000000     .000000
      3   47.2280      .000000     .000000     .000000     .000000     .000000
```

1 STRUCTURE ... TWO STORY PLANE SHEAR FRAME — TIME: 11:42: 1. DATE. 5/24/96

SOLUTION . . : AVERAGE ACCELERATION METHOD · TRIANGULAR FORCING FUNCTION — TIME: 11:42 1. DATE 5/24/96

MAXIMUN VALUES FOR ALL STEPS

MAXIMUM GCS RESTRAINT REACTIONS   NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

NODE	FX	FY	FZ	MX	MY	MZ
1	-9.881194	.0000000	.0000000	.0000000	-889.3073	.0000000
2	.0000000	.0000000	.0000000	.0000000	-664.3168	.0000000
3	.0000000	.0000000	.0000000	.0000000	266.2274	.0000000
MAX OF ALL-						
GCS SUMM.	-9.881194	.0000000	.0000000	.0000000	-1328.634	.0000000

MAXIMUM RESULTANT OF REACTIONS, FORCE= 9.881 MOMENT= 1329.

1 STRUCTURE ... TWO STORY PLANE SHEAR FRAME — TIME: 11:42: 1, DATE: 5/24/96.

SOLUTION.. .. AVERAGE ACCELERATION METHOD · TRIANGULAR FORCING FUNCTION — TIME: 11 42: 1, DATE: 5/24/96

MAXIMUN VALUES FOR ALL STEPS

COLUMN (LOAD) REPRESENTS THE
DOF WHICH HAS MAXIMUM VALUE

3D BEAM FORCES..

MAXIMUM VALUES FOR ALL STEPS   NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ
1	3	FORCE	1	.000000	.000000	9.88119	.000000	-889.307	.000000
		FORCE	2	.000000	.000000	-9.88119	.000000	-889.307	.000000
1	5	FORCE	1	.000000	.000000	9.88119	.000000	-889.307	.000000
		FORCE	2	.000000	.000000	-9.88119	.000000	-889.307	.000000
1	9	FORCE	1	.000000	.000000	9.88119	.000000	-889.307	.000000
		FORCE	2	.000000	.000000	-9.88119	.000000	-889.307	.000000
1	11	FORCE	1	.000000	.000000	9.88119	.000000	-889.307	.000000
		FORCE	2	.000000	.000000	-9.88119	.000000	-889.307	.000000
2	3	FORCE	2	.000000	.000000	-4.43712	.000000	266.227	.000000
		FORCE	3	.000000	.000000	4.43712	.000000	266.227	.000000
2	5	FORCE	2	.000000	.000000	-4.43712	.000000	266.227	.000000
		FORCE	3	.000000	.000000	4.43712	.000000	266.227	.000000
2	9	FORCE	2	.000000	.000000	-4.43712	.000000	266.227	.000000
		FORCE	3	.000000	.000000	4.43712	.000000	266.227	.000000
2	11	FORCE	2	.000000	.000000	-4.43712	.000000	266.227	.000000
		FORCE	3	.000000	.000000	4.43712	.000000	266.227	.000000

1 STRUCTURE. ... TWO STORY PLANE SHEAR FRAME — TIME: 11.42: 1, DATE: 5/24/96

SOLUTION. . . AVERAGE ACCELERATION METHOD · TRIANGULAR FORCING FUNCTION — TIME 11 42: 1, DATE: 5/24/96

MAXIMUN VALUES FOR ALL STEPS

PEAK ENERGY VALUES
MAX INPUT ENERGY.... . ... 43.197
MAX ELASTIC STRAIN ENERGY .. . 7.7067
MAX PLASTIC STRAIN ENERGY 00000
MAX KINETIC ENERGY 35.112
MAX DAMPING ENERGY 00000

1 STRUCTURE ..: TWO STORY PLANE SHEAR FRAME — TIME: 11:42: 1, DATE: 5/24/96

SOLUTION. . : AVERAGE ACCELERATION METHOD · TRIANGULAR FORCING FUNCTION — TIME 11:42: 1, DATE: 5/24/96

DEGREE OF FREEDOM # 1 IS READ FROM UNIT # 13 JOINT # 0, DIRECTION:

STEP	TIME	LOAD	DISPLACEMENT	VELOCITY	ACCELERATION
0	.00000	30.000	.00000	.00000	72.464
1	1.00000E-02	29.250	3.58900E-03	.71438	70.412
2	2.00000E-02	28.500	1.42154E-02	1.4071	68.129
3	3.00000E-02	27.750	3.16510E-02	2.0759	65.627
4	4.00000E-02	27.000	5.56458E-02	2.7186	62.918
5	5.00000E-02	26.250	8.59293E-02	3.3333	60.020
6	6.00000E-02	25.500	.12221	3.9181	56.949
7	7.00000E-02	24.750	.16419	4.4715	53.725
8	8.00000E-02	24.000	.21153	4.9920	50.365
9	9.00000E-02	23.250	.26391	5.4783	46.899
10	1.00000E-01	22.500	.32098	5.9295	43.341
11	.11000	21.750	.38238	6.3448	39.716
12	.12000	21.000	.44776	6.7236	36.048
13	.13000	20.250	.51673	7.0657	32.360
14	.14000	19.500	.58895	7.3708	28.674
15	.15000	18.750	.66403	7.6393	25.014
16	.16000	18.000	.74161	7.8713	21.402
17	.17000	17.250	.82133	8.0677	17.859
18	.18000	16.500	.90285	8.2290	14.404
19	.19000	15.750	.98587	8.3563	11.056
20	.20000	15.000	1.0699	8.4507	7.8336
21	.21000	14.250	1.1547	8.5136	4.7505
22	.22000	13.500	1.2400	8.5455	1.8209
23	.23000	12.750	1.3255	8.5509	-.94376
24	.24000	12.000	1.4110	8.5295	-3.5339
25	.25000	11.250	1.4960	8.4811	-5.9420

E. NONLINEAR CYCLIC ANALYSIS WITH UNBALANCED FORCES AND ENERGY BALANCE

Description of Input Information

An axial spring (Fig. 57-a) is analyzed to calculate the static cyclic response of a nonlinear element. A bilinear hysteresis model is assumed for this spring with elastic stiffness E=5 kips/in, yield load PY=20 kips, inelastic stiffness SIE=0.05 kips/in, failure ductility $\mu f = 15$, and damage index DI=0.2. Length of the spring used to calculate the stiffness is XLEN=1 in. Loading condition is shown in Fig. 57-b.

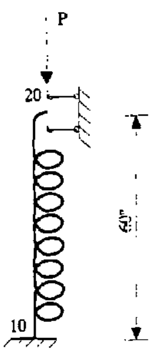


Figure 57-a. Axial Bilinear Spring

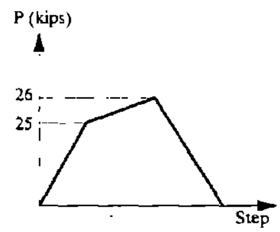


Figure 57-b. Loading Conditions

Input and Output

Input

```
1    ECHO OF INPUT DATA

   LINE  .. .:. .10 ... ...20 .  :   30 ...:.  40. ..: ..50.  .:   60.. .: ..70... :. .80
      1   'STRUCTURE DEFINATION'
      2   'BILINEAR SPRING MODEL '
      3:   2 1 2 0 C   1.00  NNODE,NCOS,NSLPT,NCOND,NCONST  SCALE
      4·     10        C.00   0.00   0 00 1 C
      5·     20        C.00   0.00  60 00 1 C
      6          1 0 0     0 1 0   0 0 1
      7      10  1 1 1 1 1 1     0 C        FESTRAINTS
      8·     20  1 1 0 1 1 1     0 0      . FESTRAINTS
      9:     1  NMAT
     10:  'ELSPLS '  5  20  05   15  0 2
     11.     0 0 0  FALSE.  KG· AXL. FORM  ASSY
     12      1   NELEM
     13   'SPRING-3' 'FX   1 10 20 1 1.00    1 0 0   0.  0.  0
     14    0 C .FALSE.  MASS
     15·   C 0   DAMPING
     16·  'SOL04 '
     17:  'NONLINEAR CYCLIC ANALYSIS W/O UNBALANCED FORCES, WITH ENERGY BALANCE'
     18:     C 50 1 .FALSE     NELOA, IPRINT, IWRITE. UNBAL
     19      'ELE' 1 21             C 0 C
     20      'JOINT FZ' 10 23       0 0 0
     21      'END' 0  C             0 C 0
     22:    1 20 0 C 'FZ'   1.C
     23:    0  C 0 C 'END'  0
     24:     'LOAD-A'  25.00 9999  9999  5
     25.     'LOAD-A'  26.00 9999  9999  5
     26·     'LOAD-A'    .00 9999  9999  5
     27      'END'     0     C     0    0
     28.     'READ UNIT=21 UNIT=23'
```

29 'STOP'

Output

```
1 STRUCTURE. ... BILINEAR SPRING MODEL                                                              TIME. 9:10:57, DATE: 5/24/96
  SOLUTION. . .

*** PROGRAM FEM ***          DOUBLE PRECISION VERSION


    NODE COORDINATES AND DEGREES OF FREEDOM

   TOTAL NUMBER OF DEGREES OF FREEDOM. ..........      12
   NUMBER OF DEGREES OF FREEDOM CONDENSED OUT ..        0
   NUMBER OF FREE DEGREES OF FREEDOM  .. ..  ... .      1
   NUMBER OF RESTRAINED DEGREES OF FREEDOM..  ....     11

     NODE COS#    X-COORD         Y-COORD        Z-COORD        FX     FY     FZ     MX     MY     MZ
      10    1      .00000          .00000         .00000        2-R    3-R    4-R    5-R    6-R    7-R
      20    1      .00000          .00000       60.00000        8-R    9-R    1     10-R   11-R   12-R
        NOTE. R - RESTRAINED DEGREE OF FREEDOM
              C - CONSTRAINED DEGREE OF FREEDOM

    DIRECTION COSINES ..

COS# 1)  VX   1.00000 I  +.00000 J  + 00000 K   VY:   00000 I +1 00000 J  + 00000 K   VZ:   .00000 I  +.00000 J +1.00000 K
1 STRUCTURE ...  BILINEAR SPRING MODEL                                                              TIME. 9:10:57, DATE  5/24/96
  SOLUTION . ..



    BILINEAR HYSTERESIS MODEL PARAMETERS
    ************************************

  MAT         KE            PY           KIE        MAX DUCT        BETA
   1    5.00000       20.0000      .500000E-01    15.0000         200000
1 STRUCTURE... : BILINEAR SPRING MODEL                                                              TIME: 9:10:57, DATE: 5/24/96
  SOLUTION.. ...

ELEMENT 02, ONE (LOCAL) DOF SPRING ELEMENT

                      #  MATL START  END  --TYPE--     LENGTH   ........... Y-AXIS ............  START DIST    END DIST
FX                    1    1    10    20     AXIAL      1.000    1.00000 I  +.00000 J  + 00000 K  .0000         .0000

     ZERO MASS MATRIX
    *****************

     PROPORTIONAL DAMPING COEFFICIENTS
    ***********************************
    ALPHA=  .00000       BETA=  .00000

1 STRUCTURE.. : BILINEAR SPRING MODEL                                                               TIME: 9:10:57, DATE: 5/24/96
  SOLUTION. . : NONLINEAR CYCLIC ANALYSIS W/O UNBALANCED FORCES, WITH ENERGY BALANCE                TIME. 9:10:57, DATE: 5/24/96
  SOLUTION #4, STATIC NONLINEAR SOLUTION
 ***************************************
  INTERVAL FOR PRINTING DATA .. . ....    50
  INTERVAL FOR WRITING DATA TO FILE . . .  1

  UNBALANCED JOINT FORCES ARE NOT ADDED TO THE NEXT CYCLE

     DATA WRITTEN TO FILES
    **********************

    ELEMENT  #    1 IS WRITTEN TO UNIT #   21
    DEGREE OF FREEDOM  #    4 IS WRITTEN TO UNIT #  22  JOINT-    10   DIRECTION. FZ
   APPLIED JOINT LOADS
   ********************

LOAD CASE:  1  JOINT.    20  DIRECTION: FZ   DOF:S    1                MAGNITUDE-   1 00000
1 STRUCTURE. ... BILINEAR SPRING MODEL                                                              TIME: 9:10 57, DATE. 5/24/96
  SOLUTION.  ... NONLINEAR CYCLIC ANALYSIS W/O UNBALANCED FORCES, WITH ENERGY BALANCE               TIME: 9:10 57, DATE: 5/24/96

1 STRUCTURE .   BILINEAR SPRING MODEL                                                               TIME. 9 10:57, DATE: 5/24/96
  SOLUTION .. : NONLINEAR CYCLIC ANALYSIS W/O UNBALANCED FORCES. WITH ENERGY BALANCE                TIME  9 10:57, DATE: 5/24/96

  . LOADING #    0     MAXIMUM DISPLACEMENTS

  GCS DISPLACEMENTS
 ******************
                         NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

     NODE       DX            DY            DZ             RX             RY             RZ

       10    000000        .000000       .000000        000000         .000000         000000
       20    .000000       .000000       25 0000        .000000        .000000         000000
1 STRUCTURE  ..  BILINEAR SPRING MODEL                                                              TIME- 9 10:57, DATE. 5/24/96
  SOLUTION. .  . NONLINEAR CYCLIC ANALYSIS W/O UNBALANCED FORCES. WITH ENERGY BALANCE               TIME- 9:10:57, DATE: 5/24/96

  . LOADING #    0    MAXIMUM REACTIONS

  MAXIMUM GCS RESTRAINT REACTIONS     NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY
 ********************************

     NODE       FX            FY            FZ             MX             MY             MZ
```

```
       10   .0000000       .0000000      -26.00000      .0000000       .0000000       .0000000
       20   .0000000       .0000000       .0000000      .0000000       .0000000       .0000000
 MAX OF ALL----------------------------------------------------------------------------------------
 GCS SUMM   .0000000       .0000000      -26.00000      .0000000       .0000000       .0000000

   MAXIMUM RESULTANT OF REACTIONS,   FORCE=   26.00      MOMENT=    .0000
1 STRUCTURE..  : BILINEAR SPRING MODEL                                                TIME:  9:10:57, DATE:  5/24/96
  SOLUTION ..  : NONLINEAR CYCLIC ANALYSIS W/O UNBALANCED FORCES, WITH ENERGY BALANCE  TIME:  9:10:57, DATE:  5/24/96

  , LOADING #     0     PEAK ELEMENT FORCES

     SPRING FORCES..     MAXIMUM LOAD AND DISPL AT MAXIMUM LOAD NOTE  MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY
   ELEMENT LOAD        TYPE NODEI NODEJ      FORCE     DISPLACMENT      STIFFNESS
        1    0       AXIAL    10    20    21.0500       25.0000
1 STRUCTURE. ...: BILINEAR SPRING MODEL                                               TIME   9:10:57, DATE:  5/24/96
  SOLUTION. . .  NONLINEAR CYCLIC ANALYSIS W/O UNBALANCED FORCES, WITH ENERGY BALANCE  TIME   9:10:57, DATE:  5/24/96

  . LOADING #     0     PEAK DUCTILITIES AND EXCURSION RATIO'S

  SPRING DUCTILITIES AND EXCURSION RATIOS...
   ELEMENT |- DUCTILITY DEFINATION #1 -| |- DUCTILITY DEFINATION #2 -| |- DUCTILITY DEFINATION #3 -
             DUCTILITY     EXCURSION        DUCTILITY     EXCURSION        DUCTILITY    EXCURSION
        1    6.25000       .000000          10.6302       .000000          11.6679      .000000
1 STRUCTURE.     BILINEAR SPRING MODEL                                                TIME:  9:10:57, DATE   5/24/96
  SOLUTION  ...  NONLINEAR CYCLIC ANALYSIS W/O UNBALANCED FORCES, WITH ENERGY BALANCE  TIME:  9:10:57, DATE   5/24/96

  , LOADING #     0     DAMAGE INDEX

   ELEMENT  DAMAGE INDEX       F MAX          D MAX          ESE            PSE
        1     .487786        21.0500        25.0000        2.45025        426.715

         STRUCTURE DAMAGE INDEX=      .48779
1 STRUCTURE..  . BILINEAR SPRING MODEL                                                TIME:  9:10:57, DATE:  5/24/96
  SOLUTION ..  : NONLINEAR CYCLIC ANALYSIS W/O UNBALANCED FORCES, WITH ENERGY BALANCE  TIME:  9:10:57, DATE:  5/24/96

    ELEMENT #    1 IS READ FROM UNIT #   21

     SPRING FORCES.
    NODEI-    10     NODEJ.    20     SPRING TYPE     AXIAL

     STEP    TIME          FORCE     DISPLACMENT  STIFFNESS     ESE          PSE
       0     .00000        .00000      .00000     5.0000        .00000       .00000
       1     .00000       20.050      5.0000      5.0000       40.200       19.620
       2     .00000       21.050     25.000      5.00000E-02   44.310      426.70
       3     .00000       -4.9500    19.800      5.0000        2.4500      426.70

         MAXIMUN DUCTILITIES AND EXCURSION RATIOS
        ----------------------------------------
             DISPLACEMENT DEFINATION  U1=    6.250          E1=   .0000
             ENERGY DEFINATION #1     U2=   10.63           E2=   .0000
             ENERGY DEFINATION #2.    U3=   11.67           E3=   .0000
1 STRUCTURE ...  BILINEAR SPRING MODEL                                                TIME:  9:10:57, DATE.  5/24/96
  SOLUTION. ...  NONLINEAR CYCLIC ANALYSIS W/O UNBALANCED FORCES, WITH ENERGY BALANCE  TIME:  9:10:57, DATE.  5/24/96

    DEGREE OF FREEDOM #    4 IS READ FROM UNIT #   25     JOINT #   10, DIRECTION- FZ

     STEP      TIME          LOAD        DISPLACEMENT      VELOCITY      ACCELERATION
       0      .00000        .00000         .00000          .00000          .00000
       1      .00000       -25.000         .00000          .00000          .00000
       2      .00000       -26.000         .00000          .00000          .00000
       3      .00000        .00000         .00000          .00000          .00000
```

F. NONLINEAR HYSTERESIS MODEL

Description of Input Information

An axial spring system (Fig. 58-a) is analyzed to calculate the static cyclic response of the nonlinear element. TAKEDA, AXLMODA, BEND1, SHEAR1 and BILINEAR hysteresis models are assumed for this system. Length of the spring used to calculate the stiffness is XLEN=1. Loading condition is shown in Fig. 58-b with displacement control and consideration of unbalanced forces. Material properties are

AXLMOD: Ks=111.1 kips/in, Kt=33.3 kips/in , Kt2=0.01111 kips/in, Fy=5 kips, α=0.9, β=0.2, μf=20., DI=0.2.

BEND1: NSEG=8, NI=10, DY=0.16 1/in, DI=0.2. (Fig. 58-c)

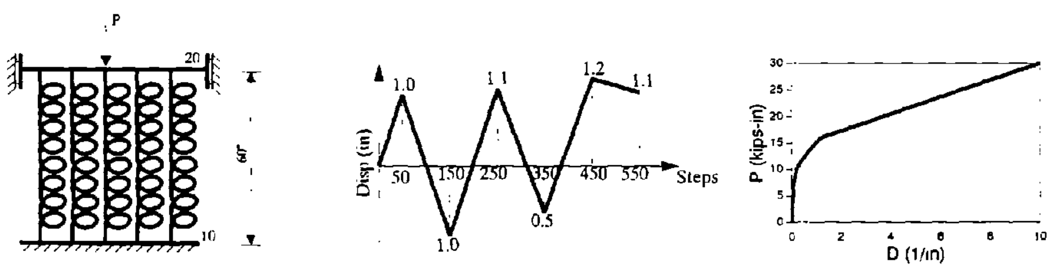
P (kips-in):	6.12	8.080	9.950	12.01	13.67	15.49	15.91	30.0
D (1/in):	0.065	0.120	0.181	0.485	0.731	1.069	1.155	10.0

SHEAR1: NSEG=8, NI=10, DY=0.16 1/in, DI=0.2. (Fig. 58-c)

P (kips-in):	6.12	8.080	9.950	12.01	13.67	15.49	15.91	30.0
D (1/in):	0.065	0.120	0.181	0.485	0.731	1.069	1.155	10.0

TAKEDA: EI=2.5E7 kips, PC=6 kips-in, DC=0.1 1/in, PY=15 kips-in, DY=0.5 1/in, PU=30 kips-in, DU=10 1/in, DI=0.2.

BILINEAR: E=50 kips/in, PY=15 kips, SIE=0.5 kips/in, μF=10, DI=0.2.



a. Axial Spring System   b. Cyclic Displacement Control   c. Bend and Shear Hystersis Curve

Figure 58. Axial Spring System

Input and Output

Input

```
1    ECHO OF INPUT DATA

  LINE  ....:...10  ..:..20...:...30.  :  .40...:..50...:..60...  ..70.......80
    1: ' STRUCTURE DEFINATION
    2: 'NONLINEAR HYSTERESIS MODELS
    3: 2 1 1 0 0   1.00  NNODE,NCOS,NSUPT,NCOND,NCONST  SCALE
    4.       10   0.00   0.00             0.00 1 0
    5:       20   0.00   0.00            60.00 1 0
    6:           1 0 0        0 1 0   0 0 1
    7:       10  2 2 1 2 2 2            . 10        : RESTRAINTS
    8  5  NMAT
    9:       'AXLMOD'  111.1 33.3 .01111  5.00  9  2   20  0.2
   10:       'BEND1  '  5 10  .160      0.20
   11:                6 120 8 080 9.950 12 010 13.670 15.490 15.910 30.
   12:                0 065 0.120 0 181  0.485  0.731  1.069  1.155 10.
   13.       'SHEAR1  '  5 10   160      0 20
   14:                6 120 8.080 9 950 12.010 13.670 15.490 15.910 30
   15                 0 065 0 120 0.181  0 485  0.731  1.069  1 155 10
   16        'TAKEDA'   2 5E7  6   .1     15  .5      30 10  0 20
   17        'ELSPLS '  50 15 .5    10   0.20
   18: 0 0 0  FALSE.  KG  AXL. FORM. ASSY
   19: 5   NELEM
   20:       'SPRING-1' 'FX'  1 10 20 1 1.00    1 0 0   0.  0   0
   21:       'SPRING-2' 'FX'  2 10 20 1 1.00    1 0 0   0.  0   0
   22:       'SPRING-3' 'FX'  3 10 20 1 1.00    1 0 0   0   0   0
   23.       'SPRING-4' 'FX'  4 10 20 1 1.00    1 0 0   0   0   0
   24        'SPRING-5' 'FX'  5 10 20 1 1.00    1 0 0   0   0.  0
   25   0 0  FALSE.  MASS
   26   0 0   DAMPING
   27. 'SOL04 '
   28: 'CYCLIC DISPL CONTROLL  WITH UNBALANCED FORCES & ENERGY BALANCE'
   29:    0 2500 10   TRUE. /           NELCA. IPRINT. IWRITE. UNBAL
   30:    'ELE'      1 21    0  0 0
   31:    'ENERGY'  20 33    0  0 0
   32:    'END' 0  0          0  0 0
   33    1 20 0 0 'FZ'   1.0
   34    0  0 0 0 'END'  0
   35:   'LOAD-A'   1.00  0 0    50
   36:   'LOAD-A'  -1.00  0 0   100
   37:   'LOAD-A'   1.10  0 0   100
   38.   'LOAD-A'   - 50  0 0   100
   39:   'LOAD-A'   1 20  0 0   100
   40:   'LOAD-A'   1.10  0 0    10
   41:   'END'      0     0     0    0
   42.   'READ UNIT=21  UNIT=33'
   43: 'STOP'
```

Output

```
1 STRUCTURE...  NONLINEAR HYSTERESIS MODELS                                                     TIME:  9:11:37, DATE   5/24/96
  SOLUTION .

 *** PROGRAM FEM ***         DOUBLE PRECISION VERSION



     NODE COORDINATES AND DEGREES OF FREEDOM

    TOTAL NUMBER OF DEGREES OF FREEDOM. . ......       12
    NUMBER OF DEGREES OF FREEDOM CONDENSED OUT. ...     0
    NUMBER OF FREE DEGREES OF FREEDOM.. ......          0
    NUMBER OF RESTRAINED DEGREES OF FREEDOM . .        12

      NODE COS#    X-COORD        Y-COORD        Z-COORD          FX      FY      FZ      MX      MY      MZ
       10    1     .00000         .00000         .00000          3-R     4-R     1-R     5-R     6-R     7-R
       20    1     .00000         .00000        60 000           8-R     9-R     2-R    10-R    11-R    12-R
         NOTE. R - RESTRAINED DEGREE OF FREEDOM
               C - CONSTRAINED DEGREE OF FREEDOM

     DIRECTION COSINES  ..

 COS'  1-  VX   1.00000 I  +.00000 J  -.00000 K   VY    .00000 I +1.00000 J  -.00000 K   VZ    00000 I  +.00000 J +1.00000 K
1 STRUCTURE.. . NONLINEAR HYSTERESIS MODELS                                                     TIME:  9:11 37, DATE:  5/24/96
  SOLUTION ..  .



     AXLMOD HYSTERESIS MODEL- FOR UNIT LENGTH MEMBER
     ***********************************************

 MAT        SC          ST1          ST2           FY          ALPHA         BETA     MAX DUCT.     BETA-DI
   1     111.100      33 3000      111100E-01    5.00000      .900000       200000     20.0000      .200000

1 STRUCTURE ... NONLINEAR HYSTERESIS MODELS                                                     TIME:  9 11:37, DATE:  5/24/96
  SOLUTION...  :

     BEND1 HYSTERESIS MODEL DATA - UNIT LENGTH MEMBER
     ************************************************
     BACKBONE CURVE POINTS - MATL  NI      DF          BETA            MOMENT      ROTATION
                             2   10     .150000       200000          6 12000     .650000E-01
                                                                      8.08000     .120000
                                                                      9.95000     .181000
                                                                     12.0100      .485000
                                                                     13 6700      .731000
                                                                     15 4900      1 06900
                                                                     15 9100      1 15500
                                                                     30 0000      10.0000
1 STRUCTURE. ...: NONLINEAR HYSTERESIS MODELS                                                   TIME:  9:11:37, DATE:  5/24/96
  SOLUTION.. ...
```

```
    SHEAR1 HYSTERESIS MODEL DATA - UNIT LENGTH MEMBER
    -------------------------------------------------
    BACKBONE CURVE POINTS - MAT.  NI        DY           BETA          STRESS        STRAIN
                              3   10      .150000      .200000         5.12000      .650000E-01
                                                                       8.08000       .120000
                                                                       9.95000       .181000
                                                                       12.0100       .485000
                                                                       13.6700       .731000
                                                                       15.4900       1.06900
                                                                       15.9100       1.15500
                                                                       30.0000       10.0000
1 STRUCTURE.     NONLINEAR HYSTERESIS MODELS                                                    TIME:  9:11:37, DATE:  5/24/96
  SOLUTION.  ...:


    TAKEDA HYSTERESIS MODEL- FOR UNIT LENGTH MEMBER
    -----------------------------------------------

  MAT.    BETA           EI                  CRACK         YEILD        ULTIMATE

   4     200000       .250000E+05          6.00000       15.0000        30.0000
                                            100000       .500000        10.0000
1 STRUCTURE. . : NONLINEAR HYSTERESIS MODELS                                                    TIME:  9:11:37, DATE:  5/24/96
  SOLUTION  .  :


    BILINEAR HYSTERESIS MODEL PARAMETERS
    ------------------------------------

  MAT.          KE            PY             KIE         MAX DUCT          BETA
   5     50.0000        25.0000        500000       10.0000          .200000
1 STRUCTURE ...: NONLINEAR HYSTERESIS MODELS                                                    TIME.  9.11:37, DATE:  5/24/96
  SOLUTION. . .:

 ELEMENT 02, ONE (LOCAL) DOF SPRING ELEMENT

                      #  MATL START  END  --TYPE---     LENGTH   ----------- Y-AXIS -----------  START DIST    END DIST
 FX                   1     1    10   20     AXIAL       1.000    1.00000 I  +.00000 J  +.00000 K   .0000        .0000
 FX                   2     2    10   20     AXIAL       1.000    1.00000 I  -.00000 J  -.00000 K   .0000        .0000
 FX                   3     3    10   20     AXIAL       1.000    1.00000 I  +.00000 J  +.00000 K   .0000        .0000
 FX                   4     4    10   20     AXIAL       1.000    1.00000 I  +.00000 J  +.00000 K   .0000        .0000
 FX                   5     5    10   20     AXIAL       1.000    1.00000 I  +.00000 J  +.00000 K   .0000        .0000

     ZERO MASS MATRIX
     ----------------


     PROPORTIONAL DAMPING COIEFICIENTS
     ---------------------------------
    ALPHA=  .00000        BETA=  .00000

1 STRUCTURE ...: NONLINEAR HYSTERESIS MODELS                                                    TIME.  9:11:37, DATE:  5/24/96
  SOLUTION ...   CYCLIC DISPL CONTROLL  WITH UNBALANCED FORCES & ENERGY BALANCE                 TIME:  9:11:37, DATE   5/24/96
  SOLUTION #4, STATIC NONLINEAR SOLUTION
 ----------------------------------------
  INTERVAL FOR PRINTING DATA  ...  ..  .. 2500
  INTERVAL FOR WRITING DATA TO FILE..   .   10

  UNBALANCED JOINT FORCES ARE ADDED TO THE NEXT CYCLE

     DATA WRITTEN TO FILES
    ---------------------

    ELEMENT  #    1 IS WRITTEN TO UNIT #   21
    ENERGY BALANCE IS WRITTEN TO UNIT #   33
   APPLIED JOINT LOADS
   -------------------

 LOAD CASE   1  JOINT:    20  DIRECTION. FZ   DOF(S)    2             MAGNITUDE    1.00000     ...JOINT DISPLACEMENT .
1 STRUCTURE..  : NONLINEAR HYSTERESIS MODELS                                                    TIME:  9:11.37, DATE:  5/24/96
  SOLUTION ..  : CYCLIC DISPL CONTROLL  WITH UNBALANCED FORCES & ENERGY BALANCE                 TIME.  9:11:37, DATE.  5/24/96

 MORE THAN 5 CYCLES IN MAT06,  IELNO:          4
 MORE THAN 5 CYCLES IN MAT06,  IELNO           4
 MORE THAN 5 CYCLES IN MAT06,  IELNO           4
 MORE THAN 5 CYCLES IN MAT06,  IELNO.          4
1 STRUCTURE. .   NONLINEAR HYSTERESIS MODELS                                                    TIME.  9:11.37, DATE:  5/24/96
  SOLUTION ..  . CYCLIC DISPL CONTROLL  WITH UNBALANCED FORCES & ENERGY BALANCE                 TIME.  9:11:37, DATE:  5/24/96

  , LOADING #    0      MAXIMUM DISPLACEMENTS


  GCS DISPLACEMENTS
 -----------------
                         NOTE. MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

     NODE        DX             DY             DZ             RX             RY             RZ

       10    .000000        .000000        .000000        .000000        .000000        .000000
       20    .000000        .000000        1.20000        .000000        .000000        .000000
1 STRUCTURE ...  NONLINEAR HYSTERESIS MODELS                                                    TIME:  9.11 37, DATE   5/24/96
  SOLUTION  ... . CYCLIC DISPL CONTROLL  WITH UNBALANCED FORCES & ENERGY BALANCE                TIME:  9:11 37, DATE   5/24/96

  , LOADING #    0      MAXIMUM REACTIONS


  MAXIMUM GCS RESTRAINT REACTIONS     NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY
 ---------------------------------
```

NODE	FX	FY	FZ	MX	MY	MZ
10	.0000000	.0000000	171.8458	.0000000	.0000000	.0000000
20	.0000000	.0000000	-171.8459	.0000000	.0000000	.0000000
MAX OF ALL						
GCS SUMM	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000

MAXIMUM RESULTANT OF REACTIONS. FORCE= .0000 MOMENT= .0000

1 STRUCTURE. : NONLINEAR HYSTERESIS MODELS TIME 9 11:37, DATE: 5/24/96

SOLUTION.. . . CYCLIC DISPL CONTROLL WITH UNBALANCED FORCES & ENERGY BALANCE TIME: 9.11:37, DATE: 5/24/96

. LOADING # 0 PEAK ELEMENT FORCES

SPRING FORCES.. MAXIMUM LOAD AND DISPL AT MAXIMUM LOAD NOTE MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

ELEMENT	LOAD	TYPE	NODEI	NODEJ	FORCE	DISPLACMENT	STIFFNESS
1	0	AXIAL	10	20	111.100	-1.00000	
2	0	AXIAL	10	20	15.6414	1.10000	
3	0	AXIAL	10	20	15.9817	1.20000	
4	0	AXIAL	10	20	16.7882	1.20000	
5	0	AXIAL	10	20	15.4500	1.20000	

1 STRUCTURE. : NONLINEAR HYSTERESIS MODELS TIME: 9:11.37, DATE: 5/24/96

SOLUTION. . CYCLIC DISPL CONTROLL WITH UNBALANCED FORCES & ENERGY BALANCE TIME. 9:11:37, DATE: 5/24/96

. LOADING # 0 PEAK DUCTILITIES AND EXCURSION RATIO'S

SPRING DUCTILITIES AND EXCURSION RATIOS ..

ELEMENT	DUCTILITY DEFINATION #1		DUCTILITY DEFINATION #2		DUCTILITY DEFINATION #3	
	DUCTILITY	EXCURSION	DUCTILITY	EXCURSION	DUCTILITY	EXCURSION
1	7.99200	11.9860	7.56746	9.31306	11.6905	15.5663
2	7.50000	18.5000	2.84045	5.15953	9.74521	25.0207
3	7.50000	19.5000	4.07364	9.26980	10.2654	28.8766
4	2.40000	3.20000	3.36601	6.04265	3.16726	6.15131
5	4.00000	8.00000	10.4060	28.5342	10.9165	30.3645

1 STRUCTURE.... NONLINEAR HYSTERESIS MODELS TIME 9 11:37, DATE: 5/24/96

SOLUTION .. . CYCLIC DISPL CONTROLL WITH UNBALANCED FORCES & ENERGY BALANCE TIME: 9:11:37, DATE 5/24/96

. LOADING # 0 DAMAGE INDEX

ELEMENT	DAMAGE INDEX	F MAX	D MAX	ESE	PSE
1	.552130	5.01166	1.20000	.318252	11.4512
2	.180685	15.4372	1.20000	2.74459	28.2375
3	.188672	15.9817	1.20000	1.59328	31.9541
4	.160857	16.7882	1.20000	4.67172	30.6430
5	.777092	15.4500	1.20000	1.09202	84.8456

STRUCTURE DAMAGE INDEX= .46007

1 STRUCTURE. : NONLINEAR HYSTERESIS MODELS TIME: 9:11:37, DATE: 5/24/96

SOLUTION.. ..: CYCLIC DISPL CONTROLL WITH UNBALANCED FORCES & ENERGY BALANCE TIME: 9:11:37, DATE: 5/24/96

ELEMENT # 1 IS READ FROM UNIT # 21

SPRING FORCES.

NODEI: 10 NODEJ: 20 SPRING TYPE: AXIAL

STEP	TIME	FORCE	DISPLACMENT	STIFFNESS	ESE	PSE
0	.00000	.00000	.00000	111.10	.00000	.00000
10	.00000	5.0010	.20000	1.11100E-02	.13250	.49220
20	.00000	5.0030	.40000	1.11100E-02	.25980	1.3650
30	.00000	5.0050	.60000	1.11100E-02	.38040	2.2450
40	.00000	5.0070	.80000	1.11100E-02	.49710	3.1300
50	.00000	5.0090	1.0000	1.11100E-02	.61100	4.0180
60	.00000	.97650	.80000	20.160	2.36470E-02	4.0060
70	.00000	-.94610	.60000	6.2850	2.21960E-02	4.0550
80	.00000	-2.2030	.40000	6.2850	.12040	4.2720
90	.00000	-3.4600	.20000	6.2850	.29690	4.6620
100	.00000	7.3570	2.55180E-07	29.360	1.3420	4.5850
110	.00000	-22.220	-.20000	111.10	4.7290	3.7530
120	.00000	-44.440	-.40000	111.10	11.140	4.0100
130	.00000	-66.660	-.60000	111.10	22.170	4.0870
140	.00000	-88.880	-.80000	111.10	37.690	4.1240
150	.00000	-111.10	-1.0000	111.10	57.660	4.1450
160	.00000	-87.770	-.79000	111.10	36.590	4.3330
170	.00000	-64.440	-.58000	111.10	20.580	4.3680
180	.00000	-41.110	-.37000	111.10	9.4220	4.4410
190	.00000	-17.780	-.16000	111.10	3.0080	4.6730
200	.00000	-3.0640	5.00000E-02	20.160	.23590	5.7510
210	.00000	.35850	.26000	6.2850	3.18720E-03	5.7580
220	.00000	1.6780	.47000	6.2850	6.98490E-02	5.9050
230	.00000	2.9980	.68000	6.2850	.22250	6.2430
240	.00000	4.3180	.89000	6.2850	.46230	6.7720
250	.00000	5.0110	1.1000	1.11100E-02	.66660	7.5820
260	.00000	2.0490	.94000	18.510	.11350	7.5700
270	.00000	-.27480	.78000	5.7270	2.04090E-03	7.5750
280	.00000	-1.3510	.62000	5.7270	3.83380E-02	7.6560
290	.00000	-2.1080	.46000	5.7270	.12000	7.8380
300	.00000	-3.0240	.30000	5.7270	.24710	8.1220
310	.00000	-3.9400	.14000	5.7270	.41950	8.5060
320	.00000	-5.0900	-2.00000E-02	27.290	1.7680	8.1040
330	.00000	20.000	-.18000	111.10	4.5120	7.3430
340	.00000	-37.770	-.34000	111.10	5.9010	7.5760
350	.00000	-55.550	-.50000	111.10	16.290	7.6520
360	.00000	-36.660	-.33000	111.10	8.0860	8.0190
370	.00000	-17.780	-.16000	111.10	3.2620	8.2150
380	.00000	-3.9320	9.99990E-03	18.510	.42840	9.4920
390	.00000	.53590	.18000	18.510	1.68760E-02	9.4920
400	.00000	.71500	.35000	5.7270	1.36110E-02	9.5230
410	.00000	1.6890	.52000	5.7270	7.70400E-02	9.6640
420	.00000	2.6620	.69000	5.7270	.19150	9.9200
430	.00000	3.6360	.86000	5.7270	.35720	10.290
440	.00000	4.6100	1.0300	5.7270	.57410	10.770
450	.00000	5.0120	1.2000	1.11100E-02	.72450	11.460
460	.00000	3.3000	1.1000	17.110	.31930	11.450

MAXIMUN DUCTILITIES AND EXCURSION RATIOS

DISPLACEMENT DEFINATION U1= 7.992 E1= 11.99

ENERGY DEFINATION #1. U2= 7.567 E2= 9.313

ENERGY DEFINATION #2: U3= 11.69 E3= 15.57

1 STRUCTURE. ..: NONLINEAR HYSTERESIS MODELS TIME 9 11:37, DATE: 5/24/96

SOLUTION .. : CYCLIC DISPL CONTROLL WITH UNBALANCED FORCES & ENERGY BALANCE TIME: 9:11 37, DATE 5/24/96

ENERGY DATA IS READ FROM UNIT # 33

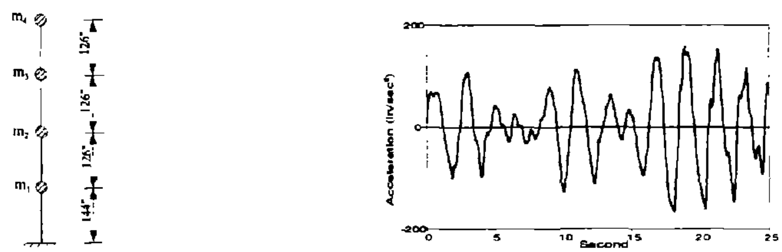
STEP	TIME	INPUT	ELASTIC STRAIN	KINETIC	PLASTIC STRAIN	DAMPINED	RELATIVE ERROR %
0	.00000	.00000	.00000	.00000	.00000	.00000	.0000
10	.00000	5.4580	3.1748	.00000	2.0569	.00000	4.1466
20	.00000	15.792	6.6545	.00000	8.8825	.00000	1.6160
30	.00000	27.665	10.168	.00000	17.032	.00000	1.6829
40	.00000	40.214	12.058	.00000	27.690	.00000	1.1587
50	.00000	53.300	13.858	.00000	38.976	.00000	.8742
60	.00000	43.532	4.9307	.00000	38.164	.00000	1.0045
70	.00000	39.654	1.5260	.00000	37.685	.00000	1.1172
80	.00000	40.442	2.3609	.00000	37.637	.00000	1.0994
90	.00000	44.385	2.8411	.00000	41.082	.00000	1.0399
100	.00000	50.832	5.6115	.00000	44.764	.00000	.8983
110	.00000	60.992	11.839	.00000	48.700	.00000	.7417
120	.00000	76.854	20.666	.00000	55.732	.00000	.5923
130	.00000	98.336	33.768	.00000	64.113	.00000	.4629
140	.00000	125.04	50.696	.00000	73.887	.00000	.3642
150	.00000	156.86	72.356	.00000	84.049	.00000	.2876
160	.00000	126.59	41.076	.00000	85.064	.00000	.3575
170	.00000	106.92	21.903	.00000	84.566	.00000	.4248
180	.00000	96.919	11.613	.00000	84.842	.00000	.4785
190	.00000	94.366	5.3922	.00000	88.507	.00000	.4950
200	.00000	97.701	3.3736	.00000	93.844	.00000	.4944
210	.00000	103.90	4.4911	.00000	98.927	.00000	.4680
220	.00000	112.03	6.5835	.00000	105.02	.00000	.4336
230	.00000	122.14	9.3963	.00000	112.25	.00000	.3961
240	.00000	134.04	12.929	.00000	120.62	.00000	.3628
250	.00000	147.74	16.556	.00000	130.43	.00000	.5111
260	.00000	139.13	7.1144	.00000	131.27	.00000	.5299
270	.00000	134.40	2.8730	.00000	130.79	.00000	.5487
280	.00000	132.90	1.6571	.00000	130.51	.00000	.5545
290	.00000	134.16	2.3603	.00000	131.06	.00000	.5552
300	.00000	136.98	2.4613	.00000	133.77	.00000	.5450
310	.00000	140.71	2.9526	.00000	137.01	.00000	.5304
320	.00000	145.60	4.9194	.00000	139.93	.00000	.5116
330	.00000	152.28	8.5844	.00000	142.96	.00000	.4819
340	.00000	162.43	14.290	.00000	147.41	.00000	.4515
350	.00000	176.31	23.343	.00000	152.23	.00000	.4160
360	.00000	162.97	10.124	.00000	152.13	.00000	.4451
370	.00000	156.21	3.5582	.00000	151.92	.00000	.4658
380	.00000	155.39	1.5460	.00000	153.11	.00000	.4733
390	.00000	158.02	2.6158	.00000	154.66	.00000	.4708
400	.00000	162.30	3.5001	.00000	158.06	.00000	.4584
410	.00000	167.84	4.9843	.00000	162.11	.00000	.4433
420	.00000	174.72	7.3052	.00000	166.67	.00000	.4258
430	.00000	183.15	10.475	.00000	171.93	.00000	.4062
440	.00000	193.15	14.456	.00000	177.95	.00000	.3852
450	.00000	204.51	17.386	.00000	186.13	.00000	.4882
460	.00000	198.54	10.420	.00000	187.13	.00000	.4985
MAXIMUN		204.51	72.356	.00000	187.13	.00000	

GROSS RE· .51038

G. FOUR-STORY SHEAR BUILDING DYNAMIC ANALYSIS USING MEXICO EARTHQUAKE ACCELERATION DATA (E-W)

Description of Input Information

A four-story shear building (Fig. 59-a) is subjected to the 1985 Mexico earthquake loading (Fig. 59-b). Masses of the structure are $m_1 = .29$ k-sec^2/in, $m_2 = .288$ k-sec^2/in, $m_3 = .288$ k-sec^2/in, and $m_4 = .252$ k-sec^2/in. Young's modulus and shear modulus are 3600 ksi and 1400 ksi, respectively. Cross-sectional area, torsional moment and moment of inertia are 11.8 in^2, .95 in^4, and 14000 in^4, respectively. Find the dynamic response of the structure assuming the time increment is 0.02 second for time duration of 24.98 seconds with linear acceleration method.



a. Four-Story Shear Building

b. 1985 Mexico Earthquake Acceleration Records (E-W)

Figure 59. Four-Story Shear Building

Input and Output

Input

```
.    ECHO OF INPUT DATA

LINE  .....:. 10   .:  .20   .:. .30 .. '...40....: ..50.  .: ..60.  .: ..70.  .:  .80
  1.  'STRUCTURE DEFINATION'
  2   'FOUR STORY SHEAR BUILDING'
  3.  5 1  2 1 0   1 0C  NNODE.NCOS.NSCPT.NCOND.NCONST  SCALE
  4.     1       0.00   0.00   0.00 1 0
  5.     2       0.00   0.00 144.00 1 0
  6.     3       0.00   0.00 270.00 1 0
  7.     4       0.00   0.00 396.00 1 0
  8.     5       0.00   0.00 522.00 1 0
  9.     1 0 0     0 1 0              COSINE
 10.     1 1 1 1 1 1 1    0 0       : RESTRAINT
 11.     2 0 1 1 1 0 1    3 1       : RESTRAINT
 12.     2 0 0 0 0 1 0    3 1         CONDENSATION
 13.      1  NMAT
 14. '3D-BEAM ' 3600 1400 11.8 0 0 0.95 14000  14000
 15  0 0 0        FALSE   KG   AXL. FORM, ASSY
 16  4   NELEM
 17  '3D-BEAM' 'MEMBER  1' 1  1  2  0 1 0  0 0  1  000000          0
 18. '3D BEAM  'MEMBER  2' 1  2  3  0 1 0  0 0  1  000000          0
 19. '3D-BEAM' 'MEMBER  3' 1  3  4  0 1 0  0 0  1  000000          0
 20.  3D BEAM' 'MEMBER  4' 1  4  5  0 1 0  0 0  1  000000          0
 21:  4  1    FALSE. MASS
 22  2  0 29   0 29         0 29      0 0 0 0 0 0  0 0
 23. 3  0.286  0 288  0.258           0 0 0 0 0 0  0 0
 24. 4  0.288  0.288  0.288           0 0 0 0 0 0  0 0
```

```
25: 5  0.252  0.252  0.252          0 0 0 0 0 0  0 0
26: 0 0   DAMPING
27. 'SOL02 - SOLUTION'
28  'DYNAMIC ANALYSIS  USE SCT1 E-W COMPONENT(40-60SEC )'
29. 'LINEAR' 0  TRUE.  FALSE  !INTEG THETA ELASTIC UNBAL
30: 100000 100000 1250  .FALSE.  IPRINT IWRITE MAXACC SLMASS
31: 0   0.02 24.98 385.825 !TO DT TF GRAV
32: 'END'  0 0 0 0 0    !OUTPUT UNIT
33: 0   ISP1
34  0 0 0 'END' 0 0 0 0 0 0 'INITIAL DISP,VELO, AND ACCEL
35: 1 0.00102  0  0.02   .FALSE  !NA ASCALE TO DT PRINT
36: 1 0 0 0 1 0   !VXI VXJ VXK ..
37. 105  1250  1   .FALSE            .FALSE.   FALSE. ! IN NFS IDIR FMT ECHO REWIND
38: 1985 SEP  19 MEXICO EARTHQUAKE ACCELERATION DATA, SCT1 RECORDS
39  DT=0.02 SEC , E-W DIRECTION, 1250 DATA(40 TO 64.98 SEC. UNIT=IN/SEC**2)
40          7.346      13.541        21.661       29.614       36.779
41:        44.409      50.065        54.546       58.457       60.183
42         63.467      61.961        62.956       64.717       65.851
43:        66.581      66.737        66.242       64.891       64.386
44         63.405      61.600        60.738       60.611       60.322
45.        59.003      59.771        60.557       61.529       64.069
46:        64.295      65.642        66.047       64.157       64.452
47:        64.564      63.508        62.990       63.506       63.918
48         64.778      65.377        64.863       63.961       61.887
49         59.953      57.503        53.934       50.344       46.022
50.        42.668      39.493        34.669       31.362       29.016
51:        25.233      21.139        17.015       12.022        7.283
52:         2.328      -4.613        -9.471      -12.250      -16.648
53        -20.706     -23.672       -26.963      -30.337      -32.901
54.       -35.601     -38.761       -41.648      -44.930      -48.573
55:       -51.743     -54.686       -57.702      -60.687      -63.710
56.       -66.279     -67.752       -69.462      -71.977      -74.321
1   ECHO OF INPUT DATA

LINE  .. . ...10. .! .20 .... .30 ...!...40....!...50. ..! .60... !. .70 .. !.. 80
 57       -76.978     -79.249       -82.614      -87.096      -91.623
 58:      -95.547     -97.518      -100.083     -102.245     -100.367
 59.      -95.958     -89.509       -80.157      -75.804      -79.248
 60:      -79.963     -80.341       -82.265      -80.160      -77.044
 61:      -73.847     -71.324       -69.642      -71.443      -69.233
 62       -58.967     -54.141       -46.598      -39.326      -37.562
 63:      -29.104     -24.236       -19.167      -12.151      -11.357
 64:       -6.033      -6.063        -5.730       -1.782        2.329
 65:        9.032      17.530        26.509       35.520       45.871
 66:       55.943      65.692        76.248       81.727       91.094
 67        69.976      65.373        94.829       91.837       91.654
 68:       96.826      96.837       102.445      104.506      102.719
 69:       99.646      99.309       101.242      103.074      106.159
 70:      106.014     105.381       105.897      103.126       99.337
 71.       92.920      87.229        69.053       83.734       74.051
 72:       69.305      63.943        59.608       56.091       51.466
 73.       44.226      36.569        25.996       20.668       13.337
 74:        6.848       1.335        -3.982       -8.581      -13.045
 75       -17.191     -20.076       -23.230      -25.481      -26.193
 76       -26.421     -26.255       -26.564      -27.344      -28.843
 77       -31.347     -33.775       -36.768      -40.715      -44.922
 78:      -49.796     -54.860       -60.179      -67.019      -73.814
 79:      -80.189     -86.796       -92.595      -96.246      -97.465
 80       -98.495     -95.940       -98.404      -96.322      -92.455
 81       -88.059     -82.040       -75.208      -67.627      -59.298
 82.      -50.616     -42.885       -36.614      -30.919      -26.178
 83:      -23.054     -21.248       -18.673      -16.952      -14.659
 84:      -11.711      -9.905       -10.191      -10.962       -9.993
 85.      -12.657     -14.584       -15.619      -16.087      -12.920
 86       -10.377      -7.911        -6.133       -2.805       -1.438
 87:       -1.378       1.275         4.296       10.001       12.434
 88:       11.665      16.498        23.506       26.795       29.880
 89:       33.739      36.127        38.561       40.225       42.178
 90        42.541      42.291        42.709       41.683       41.398
 91        39.293      37.095        36.306       36.317       36.987
 92        36.379      35.919        35.590       35.560       34.051
 93:       30.628      27.197        23.367       19.147       14.646
 94:       11.540       9.124         5.752        3.847        3.594
 95         3.749       3.453         3.077        3.471        3.793
 96.        3.653       3.903         4.581        4.504        3.172
 97:       -0.665      -3.780        -5.502       -8.493      -10.174
 98:      -12.126     -14.641       -15.993      -16.638      -17.465
 99:      -19.489     -21.613       -24.555      -27.157      -28.665
100       -30.029     -30.409       -29.877      -28.432      -26.934
101.      -25.219     -23.249       -22.232      -20.609      -17.106
102.      -12.727      -7.959        -2.641        2.936        8.214
103:       12.882      17.130        20.807       23.848       25.518
104:       25.964      26.591        26.521       25.909       25.224
105        24.089      23.151        21.940       20.095       17.869
106:       15.010      11.953         9.005        6.100        4.276
107:        2.641       0.703        -0.201       -0.141        0.755
108:        1.803       2.784         3.620        3.747        3.713
109:        3.545       2.660         1.837        1.466        0.692
110        -6.555      -2.571        -5.666       -9.547      -13.593
111       -17.758     -22.458       -26.240      -28.523      -30.219
112:      -31.244     -31.275       -31.498      -31.922      -31.483
1   ECHO OF INPUT DATA

LINE  . . . .10. .! .20.  .. 30. ..!...40.. .! ..50. .! .60.. .! ..70... !...80
113.      -31.219     -31.291       -31.271      -31.270      -31.290
114       -31.075     -30.262       -29.995      -27.186      -24.930
115:      -22.038     -19.055       -15.858      -12.408      -10.011
116:       -8.369      -7.096        -6.275       -5.304       -5.455
117        -5.892      -5.845        -7.290       -9.404      -11.262
118       -12.319     -13.773       -15.760      -16.833      -17.970
119:      -18.982     -20.906       -22.504      -23.064      -23.205
120:      -21.975     -20.235       -18.059      -16.552      -15.770
121:      -14.619     -13.952       -13.464      -12.820      -11.239
122        -9.093      -6.972        -3.902       -0.035        4.011
123         8.001      11.833        14.612       15.531       14.918
124:       14.890      15.416        15.099       15.750       16.790
125:       18.012      19.456        20.159       21.604       22.858
126.       24.166      26.547        29.798       31.678       33.629
127.       37.832      43.162        47.427       50.439       53.653
```

128	57.060	59.862	62.995	65.540	67.442
129	70.346	71.748	72.322	74.294	74.866
130	75.107	76.444	76.666	75.531	73.706
131	71.772	70.886	70.141	68.096	66.397
132	64.555	61.744	59.654	57.249	53.816
133	50.518	47.794	45.410	42.825	40.594
134	38.490	35.614	32.609	29.052	23.556
135	17.400	11.292	4.364	-2.564	-9.663
136	-17.215	-24.060	-31.181	-37.864	-44.541
137	-51.271	-56.769	-62.463	-66.289	-72.572
138	-77.953	-84.017	-90.768	-99.194	-105.560
139	-111.656	-116.529	-119.830	-124.997	-127.186
140	-125.221	-125.356	-128.224	-129.377	-127.209
141	-122.557	-117.490	-112.791	-109.496	-106.247
142	-101.467	-96.072	-89.419	-82.090	-76.429
143	70.825	-65.501	56.919	-55.268	-49.976
144	-44.906	-41.449	-35.451	-30.634	-24.764
145	-17.960	-10.839	-4.422	0.627	6.655
146	12.802	20.176	25.917	32.205	38.550
147	47.706	59.092	65.791	75.456	92.827
148	91.062	95.162	95.819	107.051	108.515
149	108.034	112.042	110.722	110.881	111.038
150	111.077	111.181	111.819	110.359	108.378
151	106.652	104.674	102.031	97.599	95.180
152	92.801	89.149	83.994	80.150	77.683
153	73.931	71.392	67.467	63.062	59.182
154	55.486	52.966	50.618	48.961	47.525
155	45.806	43.706	41.939	40.537	38.639
156	35.272	30.892	26.280	20.527	15.620
157	10.420	4.684	-1.622	-8.019	-13.629
158	-18.857	-22.699	-27.704	-33.894	-40.094
159	-46.150	-50.518	-55.184	-59.137	-62.717
160	-66.678	-70.144	-74.411	-77.724	-79.882
161	-83.325	-88.320	-92.985	-96.525	-100.253
162	-104.144	-107.115	-109.127	-109.865	-109.753
163	-111.244	-113.406	-111.593	-106.303	-100.969
164	-95.972	-90.884	-84.597	-77.247	-69.626
165	-61.719	-51.657	-42.121	-35.863	-29.107
166	-25.694	-26.961	-29.633	-32.087	-31.249
167	-27.703	-23.441	-19.856	-15.628	-11.419
168	-10.647	-11.651	-7.200	-3.326	-5.139

1 ECHO OF INPUT DATA

LINE .. .:. .10 ... ...20....:...30 ...:.. 40. ..:...50. .:...60....: ..70. .: .80

169	-1.511	2.582	1.911	1.186	2.842
170	7.551	9.761	11.999	17.253	22.286
171	26.751	31.032	34.599	37.018	38.555
172	39.125	39.670	40.075	41.009	42.721
173	43.895	45.452	48.412	51.126	52.908
174	56.102	58.046	59.236	61.526	62.608
175	61.325	57.791	58.171	59.449	58.023
176	54.554	48.755	46.697	45.419	43.354
177	40.610	36.508	34.503	33.094	31.423
178	28.792	24.631	20.498	18.722	17.135
179	13.210	6.477	4.958	3.861	2.275
180	-0.287	-1.759	-2.554	-3.906	-5.636
181	-9.604	-15.398	-19.376	-21.299	-21.127
182	-22.790	-24.176	-22.475	-23.669	-25.987
183	-26.160	-26.456	-27.224	-24.766	-19.809
184	-16.730	-14.445	-12.335	-8.204	-3.513
185	-0.968	0.960	2.869	5.181	7.936
186	12.410	17.363	22.275	24.383	24.086
187	25.837	25.776	28.793	31.383	32.639
188	33.665	33.317	33.625	34.184	34.140
189	31.961	28.162	26.026	24.817	24.087
190	23.700	22.927	21.320	20.716	19.127
191	17.835	16.770	14.586	10.989	5.858
192	2.907	-1.139	-4.925	-8.338	-11.713
193	-14.543	-17.961	-22.324	-27.011	-32.182
194	-37.199	-42.989	-47.587	-50.936	-55.072
195	-57.824	-60.782	-64.141	-67.427	-71.336
196	-73.616	75.785	-76.021	-79.364	-82.051
197	-84.555	-85.973	-88.739	-91.799	-93.330
198	-94.689	-95.175	-95.206	-95.721	-94.976
199	-93.267	-91.541	-86.334	-85.029	-81.561
200	-76.510	-71.651	-66.124	-60.569	-56.723
201	-53.322	-49.621	-45.364	-40.771	-36.191
202	-30.343	-22.771	-15.729	-9.286	-2.851
203	4.067	11.391	17.257	23.026	30.077
204	37.873	45.938	54.096	62.872	71.627
205	78.994	86.112	93.547	100.024	105.456
206	109.373	114.136	120.003	123.361	125.857
207	129.135	132.547	134.884	135.992	136.777
208	136.544	133.909	131.016	131.806	134.771
209	136.463	136.112	135.115	134.912	134.971
210	134.620	132.930	129.514	124.173	118.442
211	115.056	112.251	107.232	100.645	92.946
212	83.091	74.203	69.491	64.961	54.716
213	40.606	27.000	14.558	4.108	-5.326
214	-15.330	-24.427	-34.123	-45.690	-56.291
215	-64.319	-72.182	-81.541	-90.157	-99.058
216	108.061	-114.506	-121.025	128.221	-133.366
217	-137.839	-142.749	-145.536	-147.552	-149.127
218	-150.132	-152.010	-153.597	-154.564	155.088
219	-155.252	-156.162	-156.875	160.567	162.042
220	-164.349	164.274	-164.604	-165.296	-167.916
221	-164.572	-158.510	-151.841	-139.259	-126.904
222	-115.515	-106.442	101.777	-97.473	-93.142
223	-86.467	-76.475	-62.022	-48.582	-36.989
224	-22.228	-8.135	4.825	18.417	35.393

1 ECHO OF INPUT DATA

LINE ...'. 10 .. : ..20 . .: 30 .. ...40....: ..50. ... .60 . .:. .70. :. .80

225	50.839	60.936	71.482	78.727	81.133
226	78.204	71.277	70.011	75.597	84.579
227	96.016	106.764	115.991	125.906	136.365
228	145.002	145.985	151.524	155.061	157.517
229	158.398	154.561	148.441	144.442	143.535
230	144.612	142.772	140.204	140.272	141.644

```
231.     143.226    144.852    146.678    146.750    144.841
232:     141.199    137.064    133.166    128.847    122.690
233      114.632    103.332     92.685     83.834     73.373
234.      59.977     49.230     39.086     30.435     23.623
235:      17.869     14.947     11.278      7.756      2.598
236:      -5.057    -12.482    -19.899    -26.917    -34.874
237      -43.549    -51.930    -63.870    -70.312    -78.566
238      -84.743    -89.577    -92.558    -93.251    -94.421
239       97.528    101.149   -104.779   -109.362   -114.765
240:    -117.720   -119.315   -122.757    126.700   -129.957
241:    -132.871   -135.923   -138.860   -141.925   -144.866
242:    -147.535   -149.211   -150.844   -151.764   -149.617
243      154.621   -162.771   -161.414   -155.475   -150.982
244     -149.232   -141.149   -125.951    113.826   -101.518
245.     -79.334    -52.997    -36.241    -25.897     -9.445
246:      -1.030      3.606      9.449     13.216     19.230
247:      30.019     39.799     45.494     49.996     52.795
248       52.164     51.546     46.795     39.022     38.770
249.      42.083     44.205     49.209     54.626     62.269
250:      72.772     83.929     91.144     97.693    104.550
251:     111.159    117.762    122.530    126.276    130.593
252      134.534    137.849    142.943    147.923    150.549
253:     151.990    151.247    147.666    143.102    139.057
254:     133.525    124.233    110.851     93.556     77.663
255:      67.186     60.263     56.624     54.084     50.062
256       45.014     37.965     28.771     19.527     11.478
257.       4.298     -2.971    -11.459    -20.280    -27.595
258.     -33.614    -36.492    -41.946    -44.542    -47.839
259:     -50.999     54.434    -56.709     55.760    -54.915
260      -51.537    -49.474    -49.600    -50.967    -55.360
261:     -61.573    -66.614    -71.293    -77.046    -81.770
262.     -85.650    -92.006    -98.676   -103.731   -108.634
263:    -113.080   -118.914   -126.157   -133.225   -140.351
264     -144.046   -145.474   -147.980   -148.957   -146.234
265:    -139.919   -131.515   -120.618   -106.369    -90.046
266:     -73.071    -57.055    -42.553    -27.639    -12.413
267:       1.658     14.116     23.445     32.153     41.117
268.      48.000     54.091     58.696     60.498     60.129
269       58.116     56.611     56.184     54.985     54.896
270:      56.693     58.461     61.603     65.521     68.104
271:      70.619     73.223     73.869     75.626     78.397
272:      79.311     80.176     82.751     85.955     89.890
273:      94.494     99.420    106.170    113.210    116.891
274      114.521    105.963     95.222     83.549     70.103
275:      56.902     45.416     37.628     23.244     30.437
276:      29.108     28.962     26.565     26.350     23.189
277:      19.910     15.416     10.472      5.915      0.347
278       -6.504    -13.685    -21.730    -31.096    -40.190
279:     -47.360    -52.642    -56.485    -58.976    -60.718
280.     -61.636    -61.913    -60.954     59.061    -56.223
1    ECHO OF INPUT DATA

LINE .....10.......20.......30.......40.......50.......60.......70.......80
281      -53.376    -50.767    -47.549    -44.273    -42.252
282      -40.575    -38.156    -37.917    -39.651    -41.421
283      -44.531    -49.011    -54.421    -60.435    -65.645
284:     -70.930     77.045    -82.887    -88.172    -92.253
285:     -92.906    -91.423    -89.177    -83.747    -75.427
286      -65.635    -53.697    -39.377    -24.563    -10.821
287.       2.565     15.970     28.305     38.580     47.935
288:      57.116     65.223     72.263     78.542     83.874
289:      86.640     85.670     81.264     74.431     70.103
290   'STOP'
```

Output

```
1 STRUCTURE ...  FOUR STORY SHEAR BUILDING                                    TIME. 11:42:40. DATE   5/24/96
  SOLUTION ...

*** PROGRAM FEM ***          DOUBLE PRECISION VERSION


   NODE COORDINATES AND DEGREES OF FREEDOM

   TOTAL NUMBER OF DEGREES OF FREEDOM .. .. .. ..          30
   NUMBER OF DEGREES OF FREEDOM CONDENSED OUT.. ..          4
   NUMBER OF FREE DEGREES OF FREEDOM. .  ....               4
   NUMBER OF RESTRAINED DEGREES OF FREEDOM .. ..           22

    NODE CCS#    X-COORD       Y-COORD      Z-COORD      FX     FY     FZ     MX     MY     MZ
      1    1      .00000        .00000       .00000     9-R   10-R   11-R   12-R   13-R   14-R
      2    1      .00000        .00000      144.00       5    15-R   16-R   17-R    1     18-R
      3    1      .00000        .00000      270.00       6    19-R   20-R   21-R    2     22-R
      4    1      .00000        .00000      396.00       7    23-R   24-R   25-R    3     26-R
      5    1      .00000        .00000      522.00       8    27-R   28-R   29-R    4     30-R
       NOTE: R - RESTRAINED DEGREE OF FREEDOM
             C - CONSTRAINED DEGREE OF FREEDOM


   DIRECTION COSINES ...

CCS:  1:  VX: 1.00000 I + .00000 J +.00000 K   VY: .00000 I +1.00000 J + .00000 K   VZ: .00000 I +.00000 J +1.00000 K
1 STRUCTURE... : FOUR STORY SHEAR BUILDING                                    TIME. 11:42.40. DATE   5/24/96
  SOLUTION.. . :

   3-D ELASTIC BEAM ELEMENT
   ------------------------

   MATL    E     GAMMA      AX       AY       AZ       IX       IY       IZ
```

```
     1 3.600E-03 1.400E+03  11.8       .000       .000       .950     1.400E+04 1.400E-04

1 STRUCTURE  ... FOUR STORY SHEAR BUILDING                                              TIME. 11:42:40, DATE:  5/24/96
  SOLUTION.  . .


 ELEMENT 08.   3D BEAM ELEMENT

                          #  MATL START   END  REL CD   LENGTH   ----------- Y-AXIS -----------  START DIST    END DIST     PKG
 MEMBER  1                1    1     1     2            144.0     .00000 I +1.00000 J  +.00000 K   .0000         .0000      1.000
 MEMBER  2                2    1     2     3            126.0     .00000 I +1.00000 J  +.00000 K   .0000         .0000      1.000
 MEMBER  3                3    1     3     4            126.0     .00000 I +1.00000 J  +.00000 K   .0000         .0000      1.000
 MEMBER  4                4    1     4     5            126.0     .00000 I +1.00000 J  +.00000 K   .0000         .0000      1.000
1 STRUCTURE      FOUR STORY SHEAR BUILDING                                              TIME  11 42.40, DATE   5/24/96
  SOLUTION

 LUMPED NODE MASSES
 ------------------

   NODE     MX          MY          MZ          IXX         IYY         IZZ         IXY         IYZ         IYZ       IGEN  INC
     2    .2900       .2900       .2900       .0000       .0000       .0000       .0000       .0000       .0000         0    0
     3    .2880       .2880       .2880       .0000       .0000       .0000       .0000       .0000       .0000         0    0
     4    .2880       .2880       .2880       .0000       .0000       .0000       .0000       .0000       .0000         0    0
     5    .2520       .2520       .2520       .0000       .0000       .0000       .0000       .0000       .0000         0    0

    - THE MASS MATRIX IS NOT CONDENSED WITH THE STRUCTURAL STIFFNESS MATRIX.


     PROPORTIONAL DAMPING COEFFICIENTS
     ---------------------------------
   ALPHA=    .0000C        BETA=   .00000

1 STRUCTURE..  : FOUR STORY SHEAR BUILDING                                              TIME: 11:42:40, DATE:  5/24/96
  SOLUTION ..  : DYNAMIC ANALYSIS. USE SCT1 E-W COMPONENT(40-60SEC.)                    TIME: 11:42:40, DATE:  5/24/96

  SOLUTION #2, LINEAR ACCELERATION METHOD OF NUMERICAL INTEGRATION
 ------------------------------------------------------------------

  INITIAL TIME ..... . ...... .. ..      .000000
  TIME STEP ....  .. ... ..... . .     2.000000E-02
  FINAL TIME ... ... ..... .. ... ..     24.9800
  ACCELERATION DUE TO GRAVITY .. .      385.926
  STEP INTERVAL FOR PRINTING .... . *****
  THE STRUCTURE IS ASSUMED TO BEHAVE ELASTICALLY

     DATA WRITTEN TO FILES
     ---------------------


  NOT INCLUDE STATICS CASE EXTERNAL DEFORMATIONS
  ----------------------------------------------

     GROUND ACCELERATION RECORD
     --------------------------

     INPUTING TRANSLATIONAL ACCELERATION RECORD # 1. FROM UNIT. 105
     1985 SEP  19 MEXICO EARTHQUAKE ACCELERATION DATA, SCT1 RECORDS
     DT=0 02 SEC., E-W DIRECTION. 1250 DATA(40 TO 64.98 SEC. UNIT=CM/SEC**2)
     THE RECORD CONTAINS   1250 POINTS, BEGINING AT TIME:      .000000     WITH A TIME INCREMENT OF.   2.000000E-02
     DIRECTION OF ACCELERATION        1.00000 I  +.00000 J  +.00000 K

                             MAXIMUN   AT    TIME         MINIMUN   AT    TIME          AVERAGE     STANDARD DEV        RMS
   INPUT ACCELERATION        158.40          15.900       -167.92         16.080         .80496        71.189          71.165

                             MAXIMUN   AT    TIME         MINIMUN   AT    TIME          AVERAGE     STANDARD DEV.       RMS
   X-AXIS ACCELERATION       .16157          16.900       -.17126         16.080        8.21078E-04   7.26128E-02    7.25884E-02
   Y-AXIS ACCELERATION       .00000       2.00000E-02     .00000       2.00000E-02      .00000        .00000         .00000
   Z-AXIS ACCELERATION       .00000       2.00000E-02     .00000       2.00000E-02      .00000        .00000         .00000
1 STRUCTURE. ... FOUR STORY SHEAR BUILDING                                              TIME  11.42:40, DATE.  5/24/96
  SOLUTION.. ... DYNAMIC ANALYSIS  USE SCT1 E-W COMPONENT(40-60SEC )                    TIME  11 42:40, DATE:  5/24/96

  MAXIMUN VALUES FOR ALL STEPS
 -----------------------------


  GCS MAXIMUM DISPLACEMENTS
 --------------------------
                             NOTE. MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

     NODE       DX             DY             DZ             RX              RY              RZ

        1    .000000        .000000        .000000        .000000        .000000         .000000
        2    3.28925        .000000        .000000        .000000        4.276008E-02    .000000
        3    10 3397        .000000        .000000        .000000        6.995825E-02    .000000
        4    20 2743        .000000        .000000        .000000        8.751189E-02    .000000
        5    31 6544        .000000        .000000        .000000        9 325309E-02    .000000
1 STRUCTURE  .   FOUR STORY SHEAR BUILDING                                              TIME  11.42 40  DATE:  5/24/96
  SOLUTION.....  DYNAMIC ANALYSIS  USE SCT1 E-W COMPONENT(40-60SEC )                    TIME: 11.42.40, DATE:  5/24/96

  MAXIMUN VALUES FOR ALL STEPS
 -----------------------------


  GCS MAXIMUM VELOCITIES
 -----------------------
                             NOTE  MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

     NODE       DX             DY             DZ             RX              RY              RZ

        1    .000000        .000000        .000000        .000000         .000000        .000000
        2   -9.62952        .000000        .000000        .000000        -.114641        .000000
        3   -26.4033        .000000        .000000        .000000        -.151512        .000000
        4   -45.3156        .000000        .000000        .000000        -.207110        .000000
        5   -67 5249        .000000        .000000        .000000         .234099        .000000
1 STRUCTURE..    FOUR STORY SHEAR BUILDING                                              TIME  11 42.40, DATE.  5/24/96
  SOLUTION .   : DYNAMIC ANALYSIS. USE SCT1 E-W COMPONENT(40-60SEC )                    TIME  11 42:40, DATE:  5/24/96

  MAXIMUN VALUES FOR ALL STEPS
 -----------------------------
```

GCS MAXIMUM ACCELERATIONS

NOTE MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

NODE	DX	DY	DZ	RX	RY	RZ
1	000000	.000000	.000000	.000000	000000	000000
2	-70.2211	.000000	.000000	000000	-.609117	.000000
3	120.910	000000	000000	000000	.452265	000000
4	125.862	.000000	000000	.000000	.945054	000000
5	-150.336	.000000	.000000	.000000	1.35486	000000

1 STRUCTURE... FOUR STORY SHEAR BUILDING TIME 11:42:40, DATE 5/24/96
SOLUTION...... DYNAMIC ANALYSIS USE SCT1 E-W COMPONENT(40-60SEC.) TIME 11:42:40, DATE: 5/24/96

MAXIMUN VALUES FOR ALL STEPS

MAXIMUM GCS RESTRAINT REACTIONS NOTE. MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

NODE	FX	FY	FZ	MX	MY	MZ
1	-66.85920	.0000000	0000000	.0000000	-18246.34	0000000
2	0000000	.0000000	.0000000	0000000	0000000	0000000
3	0000000	.0000000	.0000000	.0000000	.0000000	.0000000
4	.0000000	0000000	0000000	0000000	.0000000	.0000000
5	.0000000	0000000	0000000	0000000	.0000000	.0000000
MAX OF ALL						
GCS SUMM	-66.85920	.0000000	.0000000	.0000000	-18246.34	.0000000

MAXIMUM RESULTANT OF REACTIONS. FORCE= 66.86 MOMENT= 1.8246E+04
1 STRUCTURE .... FOUR STORY SHEAR BUILDING TIME: 11:42:40, DATE 5/24/96
SOLUTION. ... DYNAMIC ANALYSIS. USE SCT1 E-W COMPONENT(40-60SEC.) TIME: 11:42:40, DATE: 5/24/96

MAXIMUN VALUES FOR ALL STEPS

COLUMN (LOAD) REPRESENTS THE
DOF WHICH HAS MAXIMUM VALUE

3D BEAM FORCES. .
MAXIMUM VALUES FOR ALL STEPS NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ
1	3	FORCE	1	.000000	.000000	66.8592	.000000	-11560.0	000000
		FORCE	2	.000000	.000000	-66.8592	.000000	1932.29	.000000
1	5	FORCE	1	000000	000000	49.0992	.000000	-18246.3	000000
		FORCE	2	.000000	000000	-49.0952	000000	11176.0	.000000
1	9	FORCE	1	000000	.000000	66.8592	000000	-11560.0	000000
		FORCE	2	.000000	.000000	-66.8592	.000000	1932.29	.000000
1	11	FORCE	1	000000	.000000	20.8950	.000000	-16293.1	.000000
		FORCE	2	000000	000000	-20.8950	.000000	13284.2	.000000
2	3	FORCE	2	.000000	000000	45.5442	.000000	-10726.9	000000
		FORCE	3	.000000	000000	-45.5442	.000000	4988.36	000000
2	5	FORCE	2	.000000	.000000	35.2140	.000000	-13284.2	.000000
		FORCE	3	.000000	000000	-35.2140	000000	8847.28	.000000
2	9	FORCE	2	000000	000000	45.5442	.000000	-10726.9	.000000
		FORCE	3	.000000	.000000	-45.5442	.000000	4988.36	.000000
2	11	FORCE	2	.000000	.000000	27.8678	.000000	-13238.4	.000000
		FORCE	3	.000000	.000000	-27.8678	.000000	9727.11	.000000
3	3	FORCE	3	000000	.000000	41.6176	.000000	-9481.45	.000000
		FORCE	4	000000	000000	-41.6176	000000	4237.64	.000000
3	5	FORCE	3	.000000	.000000	41.0687	000000	-9727.11	000000
		FORCE	4	.000000	.000000	-41.0687	.000000	4552.47	.000000
3	9	FORCE	3	000000	000000	41.6176	.000000	-9481.45	.000000
		FORCE	4	000000	000000	-41.6176	.000000	4237.64	.000000
3	11	FORCE	3	.000000	000000	40.7677	000000	-9713.65	.000000
		FORCE	4	.000000	.000000	-40.7677	000000	4576.94	000000
4	3	FORCE	4	.000000	000000	36.3248	.000000	-4576.92	.000000
		FORCE	5	000000	000000	-36.3248	.000000	1.451425E-02	.000000
4	5	FORCE	4	000000	000000	36.3248	000000	-4576.92	.000000
		FORCE	5	.000000	.000000	-36.3248	.000000	1.451425E-02	000000
4	9	FORCE	4	.000000	.000000	36.3248	.000000	-4576.92	.000000
		FORCE	5	.000000	.000000	-36.3249	.000000	1.451425E-02	.000000
4	11	FORCE	4	000000	000000	28.8041	000000	-3629.32	000000
		FORCE	5	.000000	000000	-28.8041	000000	1.976073E-02	.000000

1 STRUCTURE ... FOUR STORY SHEAR BUILDING TIME. 11:42:40, DATE. 5/24/96
SOLUTION . . DYNAMIC ANALYSIS USE SCT1 E-W COMPONENT(40-60SEC.) TIME 11:42:40, DATE: 5/24/96

MAXIMUN VALUES FOR ALL STEPS

PEAK ENERGY VALUES
MAX INPUT ENERGY 466.11
MAX ELASTIC STRAIN ENERGY. .. 535.73
MAX PLASTIC STRAIN ENERGY .... .00000
MAX KINETIC ENERGY.. ... . 545.31
MAX DAMPING ENERGY. 00000

H. INELASTIC DYNAMIC ANALYSIS

Description of Input Information

A one-bay frame (Fig. 60) is subjected to inelastic dynamic analysis with linear acceleration method. Input force is $F(t)=0.02\sin(\pi t)$ kips. Structural mass is equal to 0.0002 k-sec^2/in at joint 3. Time increment is 0.01 second with time duration of 1.5 seconds. Gravitational acceleration constant is assumed as 1 in/s^2. Time increment for the input acceleration is 0.1 second. The element is IE3DBEAM. Its hysteresis material properties are bilinear hysteresis models (IA BILN) as follows.

Bending in element's local Y axis:	ELAS=1	SP=0.05	E=25000 ksi;
	TI=0.04 in^4	TMP=0.2	μF=0.2
Bending in element's local Z axis:	ELAS=1	SP=0.05	E=25000 ksi
	TI=0.04 in^4	TMP=0.2	μF=0.2
Torsional in element's local X axis:	ELAS=0	SP=0.05	E=11150 ksi
	TI=1 in^4	TMP=1	μF=0.2
Axial material:	ELAS=0	SP=0.05	E=1 ksi
	TI=1 in^2	TMP=1	μF=0.2

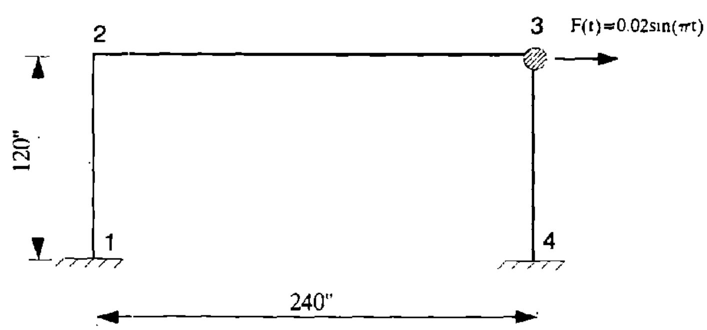


Figure 60. Inelastic Dynamic Analysis of One-Bay Frame

Input and Output

Input

```
1    ECHO OF INPUT DATA

    LINE   .. .. 10. .' .20   .  .30  .. ...40.  .:...50... :. .60.. .: ..70 .. :...80
       1:  'STRUCTURE DEFINATION - ONE STORY BUILDING'
       2:  'INELASTIC DYNAMIC ANALYSIS'
       3   4 1  2 1 1   1.00  NNODE,NCOS,NSUPT,NCOND,NCONST  SCALE
```

```
     1       0.00    0.00    0.00 1 0
     2       0.00    0.00    120  1 0
     3       240     0.00    120  1 0
     4       240     0.00    0.00 1 0
   1 0 0   0 1 0                DIRECTION COSINE
   1  1 1 1 1 1 1     0 0      ! RESTRAINTS
   4  1 1 1 1 1 1     0 0      ! RESTRAINTS
   2  0 1 0 1 0 1     1 1      ! RESTRAINTS
  2   0 0 0 0 1 0     1 1        CONDENSATION
  1   3 2        0 0      ' CONSTRAINT
  5   !NMAT
'3D-BEAM ELEMENT' 25000 1115C  1     1     1    1      0.04  0.04
'IA_BILN MY' 1 0.05          25000 0.04    0.2  0.2  0
'IA_BILN MZ' 1 0.05          25000 0.04    0.2  0 2  0
'IA_BILN MX' 0 0.05          11150 1       1    0 2  0
'IA_BILN FX' 0 0 05          1      1      1    0.2  0
  0  0      0  .TRUE.  !KGLOAD KGTYPE KGFORM KGCOND
   3   !NELEM
'IE3DBEAM ' 'MEM. 1' 2 2 3 3 4 5 1 2 1 0 0 0 0 0    0
'IE3DBEAM ' 'MEM. 2' 2 2 3 3 4 5 2 3 0 0 1 0 0 0    0
'IE3DBEAM ' 'MEM  3' 2 2 3 3 4 5 4 3 1 0 0 0 0 0    0
1  1    FALSE. !  MASS  FMASS MCOND
3  0.0002 0.0002  0 0002     0 0 0 0 0 0  0 0  !ID PX PY PZ
  0         0         !  DAMP
'SOL02  SOLUTION'
'INELASTIC DYNAMIC ANALYSIS'
'LINEAR'  0      FALSE.   TRUE    . INTEG THETA ELASTIC UNBAL
100  1       16     .FALSE.         ! IPRINT IWRITE MAXACC SLMASS
0  0.01  1.5  1            ! TO DT TF GRAV
'END' 0 0 0 0 0
 0         ISP1
0 0 0 'END' 0 0 0 0 0 0  ! ID IGEN DID OPTION..
1  -1            0  0 1  .TRUE   !NA ASCALE TO DT PRINT
1 0 0  0 1 0  ! VXI VXJ VXZ....
105 16       1 .FALSE     .TRUE    FALSE   !IN NPTS IDIR FMT ECHO REWIND
USE F(T)=0.02*SIN(PI*T) AS THE EXTERNAL FORCE
THEREFORE ACCELERATION A(T)=F(T)/MASS = 100*SIN(PI*T)
              0 000    30.902           58.779              80.902              95.106
            100 000    95.106           80.902              56.779              30.902
              0 000        -30 902                -58 779             -80 902             -95.106
        -100 000
'STOP'
```

Output

```
1 STRUCTURE.    : INELASTIC DYNAMIC ANALYSIS                                          TIME  11 57: 5, DATE:  5/24/96
  SOLUTION.. ..:

 *** PROGRAM FEM ***          DOUBLE PRECISION VERSION



     NODE CONSTRAINTS

 NODE:      2 IS RESTRAINED, CONSTRAINT 2 IS IGNORED..
 NODE:      2 IS RESTRAINED, CONSTRAINT 6 IS IGNORED...
  XY-PLANE        CONSTRAINT, MASTER       3 SLAVE:      2

    NODE COORDINATES AND DEGREES OF FREEDOM

   TOTAL NUMBER OF DEGREES OF FREEDOM. . . . ....       23
   NUMBER OF DEGREES OF FREEDOM CONDENSED OUT. ...       2
   NUMBER OF FREE DEGREES OF FREEDOM.   .      ..        1
   NUMBER OF RESTRAINED DEGREES OF FREEDOM..  ...       20

     NODE COS#     X COORD          Y-COORD          Z-COORD         FX     FY     FZ     MX     MY     MZ
        1    1      00000            00000           .00000          4-R    5-R    6-R    7-R    8-R    9-R
        2    1     .00000            00000          120 00           3-C   10-R   11-R   12-R    1     13-R
        3    1     240.00           .00000          120.00           3     14-R   15-R   16-R    2     17-R
        4    1     240.00            00000           .00000         18-R   19-R   20-R   21-R   22-R   23-R
          NOTE. R - RESTRAINED DEGREE OF FREEDOM
                C - CONSTRAINED DEGREE OF FREEDOM

    DIRECTION COSINES ..

 COS! 1.   VX.  1.00000 I  -.00000 J  + 00000 K   VY    .00000 I +1.00000 J  -.00000 K   VZ    .00000 I  + 00000 J -1.00000 K
1 STRUCTURE  .   INELASTIC DYNAMIC ANALYSIS                                           TIME: 11:57  5, DATE:  5/24/96
  SOLUTION ..


    3-D ELASTIC BEAM ELEMENT
    ************************

   MATL     E     GAMMA        AX         AY         AZ         IX         IY         IZ

      1 2 500E+04 1 115E-04  1.00       1.00       1 00       1.00     4.000E-02 4 000E-02

1 STRUCTURE..  . INELASTIC DYNAMIC ANALYSIS                                          TIME. 11:57  5, DATE:  5/24/96
  SOLUTION ..  :



 BILINEAR INTERACTIVE MATERIAL PROPERTIES
 ****************************************

 MAT     ELAS         SP           E          TI          MP       MAX DUC       BETA      REDU F

    2 1 00000     .500000E-01 25000.0     400000E-01  200000     200000     .000000     000000

    3 1 00000     .500000E-01 25000 0    .400000E-01  200000     200000      000000    .000000
```

```
   4  .000000     .500000E-01 11150.0     1.00000     1.00000      200000     .000000      000000

   5  000000      500000E-01 1 00000      1 00000     1.00000     .200000      000000      .000000

1 STRUCTURE . .. INELASTIC DYNAMIC ANALYSIS                                                    TIME. 11:57: 5, DATE:  5/24/96
  SOLUTION. ....

 ELEMENT 09.  IE3DBEAM ELEMENT

                    #   START   END   LENGTH   - -------   Y-AXIS  -----------  START DIST    END DIST     PKG
 MEM. 1             1     1      2  120.0      1.00000 I  +.00000 J  + 00000 K    0000         .0000        .0000
               MATERIAL #    (FX  )- 5 , (MX  )- 4 ,(MY-A)- 2 , (MY-B)- 2 ,(MZ-A)- 3 , (MZ-B)- 3
 MEM. 2             2     2      3  240 0       .00000 I  + 00000 J +1.00000 K   .0000        0000         0000
               MATERIAL # : (FX  )- 5 , (MX  )- 4 ,(MY-A)  2 , (MY-B)- 2 ,(MZ-A)- 3 , (MZ-B)- 3
 MEM. 3             3     4      3  120 0      1.00000 I  -.00000 J  +.00000 K   .0000        0000         0000
               MATERIAL # - (FX  )- 5 , (MX  )- 4 ,(MY-A)- 2 , (MY-B)- 2 ,(MZ-A)- 3 , (MZ-B)- 3
1 STRUCTURE. .  INELASTIC DYNAMIC ANALYSIS                                                     TIME: 11:57: 5, DATE:  5/24/96
  SOLUTION  .  :

  LUMPED NODE MASSES
 -------------------

    NODE    MX          MY           MZ          IXX         IYY          IZZ         IXY          IYZ          IYZ        IGEN   INC
      3  2.0000E-04  2.0000E-04  2 0000E-04     0000        .0000        .0000        .0000        0000        .0000         0      0

    - THE MASS MATRIX IS NOT CONDENSED WITH THE STRUCTURAL STIFFNESS MATRIX


     PROPORTIONAL DAMPING COEFFICIENTS
    ----------------------------------
    ALPHA=   .00000       BETA=   .00000

1 STRUCTURE ...  INELASTIC DYNAMIC ANALYSIS                                                    TIME: 11:57  5, DATE   5/24/96
  SOLUTION. ....  INELASTIC DYNAMIC ANALYSIS                                                   TIME: 11.57  5, DATE   5/24/96

  SOLUTION #2, LINEAR ACCELERATION METHOD OF NUMERICAL INTEGRATION
 -----------------------------------------------------------------

  INITIAL TIME ..  ..   .   .  ..  ..         000000
  TIME STEP .   ..   .  ..  ..  ..  ...     1.000000E-02
  FINAL TIME   . .   ..  ..  ..  ..  ..      1.50000
  ACCELERATION DUE TO GRAVITY ....           1.00000
  STEP INTERVAL FOR PRINTING .....        100

     DATA WRITTEN TO FILES
    ----------------------


  NOT INCLUDE STATICS CASE EXTERNAL DEFORMATIONS
  ----------------------------------------------

     GROUND ACCELERATION RECORD
    ---------------------------

    INPUTING TRANSLATIONAL ACCELERATION RECORD # 1, FROM UNIT: 105
    USE F(T)=0.02*SIN(PI*T) AS THE EXTERNAL FORCE
    THEREFORE ACCELERATION A(T)=F(T)/MASS = 100*SIN(PI*T)
    THE RECORD CONTAINS     16 POINTS,  BEGINING AT TIME-      .000000      WITH A TIME INCREMENT OF:      100000
    DIRECTION OF ACCELERATION:       1.00000 I  + 00000 J  +.00000 K

    INPUT ACCELERATION.                    (g's)
   .0000       30.90       58.78       80 90       95.11       100.0       95.11        80 90       58 78      30 90
   .0000      -30.90      -58 78      -80.90      -95.11      -100.0

                              MAXIMUM    AT    TIME         MINIMUM   AT    TIME         AVERAGE      STANDARD DEV.       RMS
  INPUT ACCELERATION          100.00           50000        -100 00         1.5000       16.606         70 988          70 711

    GLOBAL BASE ACCELERATION IN THE X DIRECTION (g's)
   .0000      -30 90      -58.78      -80.90      -95 11      -100 0      -95 11       -80.90      -58.78     -30.90
   0000        30.90       58.78       80.90       95 11       100 0

    GLOBAL BASE ACCELERATION IN THE Y DIRECTION (g's)
   0000        0000        .0000       0000        .0000       .0000        0000        .0000       .0000       .0000
   0000        0000        .0000       0000        0000        .0000

    GLOBAL BASE ACCELERATION IN THE Z DIRECTION (g's)
   .0000       .0000       .0000       .0000       .0000       .0000        .0000       .0000       .0000       .0000
   .0000       .0000       .0000       0000        .0000       .0000

                              MAXIMUM    AT    TIME         MINIMUM   AT    TIME         AVERAGE      STANDARD DEV        RMS
  X-AXIS ACCELERATION         100.00          1 5000        -100 00         .50000       -16.606         70.988          70.711
  Y AXIS ACCELERATION         00000           10000         .00000          .10000        .00000          00000           00000
  Z-AXIS ACCELERATION         .00000          10000         .00000          .10000        .00000          .00000          00000
 SYSTEM DISPLACEMENT ' FIRST ELEMENT REACH TO CRITICAL LOAD
 ----------------------------------------------------------
 ** ELEMENT     1 FIRST REACH TO CRITICAL LOAD **


  GCS DISPLACEMENTS.  LOADING #     1      STEP.    25,  TIME-    .25000
 ------------------

     NODE        DX            DY             DZ             RX             RY             RZ

       1      000000        000000        .000000        .000000         000000         000000
       2     .692969        .000000        .000000        .000000       4.949776E-03    .000000
       3      692969        .000000        .000000        .000000       4.949776E-03    .000000
       4      000000        .000000        .000000        000000         .000000        .000000
1 STRUCTURE..  : INELASTIC DYNAMIC ANALYSIS                                                     TIME. 11:57: 5, DATE.  5/24/96
  SOLUTION      - INELASTIC DYNAMIC ANALYSIS                                                    TIME: 11:57: 5, DATE:  5/24/96

  . LOADING #  100      STEP     100,  TIME.    1.0000

       ENERGY BALANCE
      ----------------
                                   INCREMENTAL        TOTAL
          INPUT ENERGY             6 70922E-03       .33019
```

```
          ELASTIC STRAIN ENERGY      5.24288E-03      .24866
          KINETIC ENERGY             5.22898E-03      .14599
          PLASTIC STRAIN ENERGY        .00000          .00000
          DAMPING ENERGY               .00000          .00000
          RELATIVE ERROR                             -19.523    *

       GROUND RESPONSE
       ----------------
       INCREMENTAL VALUES                     DISPLACEMENT     VELOCITY      ACCELERATION
            GLOBAL X AXIS TRANSLATION .          -.63133      -1.54514E-02     3.0902
            GLOBAL Y AXIS TRANSLATION..           .00000        .00000          .00000
            GLOBAL Z AXIS TRANSLATION             .00000        .00000          .00000
       TOTAL VALUES
            GLOBAL X AXIS TRANSLATION. .         31.569        -63.138        -3.31402E-05
            GLOBAL Y AXIS TRANSLATION..           .00000        .00000          .00000
            GLOBAL Z AXIS TRANSLATION ..          .00000        .00000          .00000
1 STRUCTURE.. : INELASTIC DYNAMIC ANALYSIS                                        TIME: 11:57: 5, DATE:  5/24/96
  SOLUTION .. . INELASTIC DYNAMIC ANALYSIS                                        TIME: 11:57: 5, DATE:  5/24/96

  GCS DISPLACEMENTS,  LOADING #    1     STEP:   100,  TIME:   1.0000
 ------------------

     NODE        DX             DY             DZ             RX             RY             RZ

        1     .000000        .000000        .000000        .000000        .000000        .000000
        2    18.3064         .000000        .000000        .000000        .128686        .000000
        3    18.3064         .000000        .000000        .000000        .128686        .000000
        4     .000000        .000000        .000000        .000000        .000000        .000000
1 STRUCTURE ...  INELASTIC DYNAMIC ANALYSIS                                       TIME: 11:57: 5, DATE:  5/24/96
  SOLUTION ....  INELASTIC DYNAMIC ANALYSIS                                       TIME: 11:57: 5, DATE   5/24/96

  GCS VELOCITIES,  LOADING #    1     STEP   100,  TIME:   1.0000
 ---------------

     NODE        DX             DY             DZ             RX             RY             RZ

        1     .000000        .000000        .000000        .000000        .000000        .000000
        2    24.9295         .000000        .000000        .000000        .167600        .000000
        3    24.9295         .000000        .000000        .000000        .167600        .000000
        4     .000000        .000000        .000000        .000000        .000000        .000000
1 STRUCTURE... : INELASTIC DYNAMIC ANALYSIS                                       TIME: 11:57: 5, DATE:  5/24/96
  SOLUTION.. .. INELASTIC DYNAMIC ANALYSIS                                        TIME  11:57: 5, DATE.  5/24/96

  GCS ACCELERATIONS,  LOADING #    1     STEP.   100,  TIME   1.0000
 ------------------

     NODE        DX             DY             DZ             RX             RY             RZ

        1     .000000        .000000        .000000        .000000        .000000        .000000
        2   -69.3017         .000000        .000000        .000000       -.514871        .000000
        3   -69.3017         .000000        .000000        .000000       -.514871        .000000
        4     .000000        .000000        .000000        .000000        .000000        .000000
1 STRUCTURE.. : INELASTIC DYNAMIC ANALYSIS                                        TIME: 11:57: 5, DATE:  5/24/96
  SOLUTION...   INELASTIC DYNAMIC ANALYSIS                                        TIME: 11:57: 5, DATE:  5/24/96

  GCS RESTRAINT REACTIONS,   LOADING #    1     STEP:   100,  TIME:   1.0000
 -------------------------

     NODE        FX             FY             FZ             MX             MY             MZ

        1 -6.8724840E-03  .0000000       .0000000       .0000000      -.4700736       .0000000
        2    .0000000     .0000000     -2.9552080E-03   .0000000       .0000000       .0000000
        3    .0000000     .0000000      2.9552080E-03   .0000000       .0000000       .0000000
        4 -6.8724840E-03  .0000000       .0000000       .0000000      -.4700736       .0000000
          ..............................................................................
 SUMMATION -.1374497E-01  .0000000       .0000000       .0000000     -1.649397        .0000000

    RESULTANT OF REACTIONS,   FORCE=  1.3745E-02   MOMENT=   1.649
1 STRUCTURE  . : INELASTIC DYNAMIC ANALYSIS                                       TIME  11:57: 5, DATE:  5/24/96
  SOLUTION.. . : INELASTIC DYNAMIC ANALYSIS                                       TIME  11:57: 5, DATE   5/24/96

     IE3D BEAM FORCES.
       STEP   100,  TIME:   1.0000
   ELEMENT LOAD        NODE      AXIAL          FY            FZ            TORSION        MY          MZ   STBFAG

        1    1  DISPL    1     .000000       .000000       .000000       .000000       .000000     -.152553
                DISPL    2     .000000      18.3064        .000000       .000000       .000000    -2.386707E-02

        1    1  FORCE    1     .000000     -6.791689E-03   .000000       .000000       .000000     -.464145
                FORCE    2     .000000      6.791689E-03   .000000       .000000       .000000     -.350858     1

        2    1  DISPL    2    18.3064       .000000       .000000       .000000       .000000     -.128686
                DISPL    3    18.3064       .000000       .000000       .000000       .000000     -.128686

        2    1  FORCE    2     .000000     -2.923817E-03   .000000       .000000       .000000     -.350858
                FORCE    3     .000000      2.923817E-03   .000000       .000000       .000000     -.350858     1

        3    1  DISPL    4     .000000       .000000       .000000       .000000       .000000     -.152553
                DISPL    3     .000000      18.3064        .000000       .000000       .000000    -2.386707E-02

        3    1  FORCE    4     .000000     -6.791689E-03   .000000       .000000       .000000     -.464145
                FORCE    3     .000000      6.791689E-03   .000000       .000000       .000000     -.350855     1
1 STRUCTURE. ...: INELASTIC DYNAMIC ANALYSIS                                      TIME  11:57: 5, DATE   5/24/96
  SOLUTION..   : INELASTIC DYNAMIC ANALYSIS                                       TIME. 11:57  5, DATE   5/24/96

    IE3DBEAM  DUCTILITY BASED ON DEFINITION 1.
      ELEM#     |MYA|     |MYB|     |MZA       |MZB|      |MX |     FX |
        1       .00000    .00000   38.13834    5.88313    .00000    .00000
        2       .00000    .00000   16.08579   16.08579    .00000    .00000
        3       .00000    .00000   38.13834    5.88313    .00000    .00000
1 STRUCTURE ...  INELASTIC DYNAMIC ANALYSIS                                       TIME: 11:57: 5, DATE   5/24/96
  SOLUTION. ...  INELASTIC DYNAMIC ANALYSIS                                       TIME: 11:57  5, DATE   5/24/96
```

MAXIMUN VALUES FOR ALL STEPS

GCS MAXIMUM DISPLACEMENTS

NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

NODE	DX	DY	DZ	RX	RY	RZ
1	.000000	.000000	.000000	.000000	.000000	.000000
2	21.5113	.000000	.000000	.000000	.151578	.000000
3	21.5113	.000000	.000000	.000000	.151578	.000000
4	.000000	.000000	.000000	.000000	.000000	.000000

1 STRUCTURE..... INELASTIC DYNAMIC ANALYSIS TIME: 11:57 5, DATE: 5/24/96
SOLUTION..... INELASTIC DYNAMIC ANALYSIS TIME: 11:57 5, DATE: 5/24/96

MAXIMUN VALUES FOR ALL STEPS

GCS MAXIMUM VELOCITIES

NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

NODE	DX	DY	DZ	RX	RY	RZ
1	.000000	.000000	.000000	.000000	.000000	.000000
2	-32.6556	.000000	.000000	.000000	-.222574	.000000
3	-32.6556	.000000	.000000	.000000	-.222574	.000000
4	.000000	.000000	.000000	.000000	.000000	.000000

1 STRUCTURE ...: INELASTIC DYNAMIC ANALYSIS TIME 11:57: 5, DATE: 5/24/96
SOLUTION...... INELASTIC DYNAMIC ANALYSIS TIME 11:57 5, DATE: 5/24/96

MAXIMUN VALUES FOR ALL STEPS

GCS MAXIMUM ACCELERATIONS

NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

NODE	DX	DY	DZ	RX	RY	RZ
1	.000000	.000000	.000000	.000000	.000000	.000000
2	-145.965	.000000	.000000	.000000	-1.06247	.000000
3	-145.965	.000000	.000000	.000000	-1.06247	.000000
4	.000000	.000000	.000000	.000000	.000000	.000000

1 STRUCTURE ... INELASTIC DYNAMIC ANALYSIS TIME: 11:57 5, DATE 5/24/96
SOLUTION. ... INELASTIC DYNAMIC ANALYSIS TIME: 11:57 5, DATE 5/24/96

MAXIMUN VALUES FOR ALL STEPS

MAXIMUM GCS RESTRAINT REACTIONS NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

NODE	FX	FY	FZ	MX	MY	MZ
1	-7.5053740E-03	.0000000	.0000000	.0000000	-.5177653	.0000000
2	.0000000	.0000000	-3.1936660E-05	.0000000	.0000000	.0000000
3	.0000000	.0000000	3.1936660E-05	.0000000	.0000000	.0000000
4	-7.5053740E-03	.0000000	.0000000	.0000000	-.5177653	.0000000
MAX OF ALL						
GCS SUMM.	.1501675E-01	.0000000	.0000000	.0000000	-1.802010	.0000000

MAXIMUM RESULTANT OF REACTIONS. FORCE= 1.5017E-02 MOMENT= 1.802
1 STRUCTURE. : INELASTIC DYNAMIC ANALYSIS TIME 11:57: 5, DATE. 5/24/96
SOLUTION.... : INELASTIC DYNAMIC ANALYSIS TIME: 11:57: 5, DATE: 5/24/96

MAXIMUN VALUES FOR ALL STEPS

COLUMN : LOAD: REPRESENTS THE DOF WHICH HAS MAXIMUM VALUE

IE3D BEAM FORCES.
MAXIMUM VALUES FOR ALL STEPS NOTE. MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ	STEPAG
1	2	FORCE	1	.000000	-7.427579E-03	.000000	.000000	.000000	-.511837	
		FORCE	2	.000000	7.427579E-03	.000000	.000000	.000000	-.379473	1
1	6	FORCE	1	.000000	-7.427579E-03	.000000	.000000	.000000	-.511837	
		FORCE	2	.000000	7.427579E-03	.000000	.000000	.000000	-.379473	1
1	8	FORCE	1	.000000	-7.427579E-03	.000000	.000000	.000000	-.511837	
		FORCE	2	.000000	7.427579E-03	.000000	.000000	.000000	-.379473	1
1	12	FORCE	1	.000000	-7.427579E-03	.000000	.000000	.000000	.511837	
		FORCE	2	.000000	7.427579E-03	.000000	.000000	.000000	.379473	1
2	2	FORCE	2	.000000	-3.162276E-03	.000000	.000000	.000000	.379473	
		FORCE	3	.000000	3.162276E-03	.000000	.000000	.000000	.379473	1
2	6	FORCE	2	.000000	-3.162276E-03	.000000	.000000	.000000	-.379473	
		FORCE	3	.000000	3.162276E-03	.000000	.000000	.000000	-.379473	1
2	8	FORCE	2	.000000	-3.162276E-03	.000000	.000000	.000000	-.379473	
		FORCE	3	.000000	3.162276E-03	.000000	.000000	.000000	-.379473	1
2	12	FORCE	2	.000000	-3.162276E-03	.000000	.000000	.000000	-.379473	
		FORCE	3	.000000	3.162276E-03	.000000	.000000	.000000	-.379473	1
3	2	FORCE	4	.000000	-7.427579E-03	.000000	.000000	.000000	-.511837	
		FORCE	3	.000000	7.427579E-03	.000000	.000000	.000000	-.379473	1
3	6	FORCE	4	.000000	-7.427579E-03	.000000	.000000	.000000	-.511837	
		FORCE	3	.000000	7.427579E-03	.000000	.000000	.000000	-.379473	1

```
     3   6  FORCE    4      .000000      -7.427579E-03    .000000       .000000       .000000       -.511837
            FORCE    3      .000000       7.427579E-03    .000000       .000000       .000000       -.379473      1

     3  12  FORCE    4      .000000       7.427579E-03    .000000       .000000       .000000       -.511837
            FORCE    3      .000000       7.427579E-03    .000000       .000000       .000000       -.379473      1
1 STRUCTURE. ...: INELASTIC DYNAMIC ANALYSIS                                                  TIME  11:57: 5, DATE:  5/24/96
  SOLUTION. ....: INELASTIC DYNAMIC ANALYSIS                                                  TIME: 11:57: 5, DATE   5/24/96

  MAXIMUN VALUES FOR ALL STEPS
 -----------------------------

   IE3DBEAM  DUCTILITY(BASED ON DEFINITION 1):
     ELEM#       (MYA)       MYB.       MZA.       MZB)       .MX )      (FX )
       1        .00000     .00000    44.81517    6.82360     .00000     .00000
       2        .00000     .00000    18.94728   18.94726     .00000     .00000
       3        .00000     .00000    44.81517    6.82360     .00000     .00000
1 STRUCTURE   .: INELASTIC DYNAMIC ANALYSIS                                                   TIME: 11:57: 5, DATE:  5/24/96
  SOLUTION.. ...: INELASTIC DYNAMIC ANALYSIS                                                  TIME: 11:57: 5, DATE:  5/24/96

  MAXIMUN VALUES FOR ALL STEPS
 -----------------------------

         STRUCTURE DAMAGE INDEX=      .00000
1 STRUCTURE   .: INELASTIC DYNAMIC ANALYSIS                                                   TIME: 11:57: 5, DATE:  5/24/96
  SOLUTION..  .: INELASTIC DYNAMIC ANALYSIS                                                   TIME: 11:57: 5, DATE:  5/24/96

  MAXIMUN VALUES FOR ALL STEPS
 -----------------------------
   PEAK ENERGY VALUES
   MAX INPUT ENERGY.. .. ... ...       .61633
   MAX ELASTIC STRAIN ENERGY. ..       .31955
   MAX PLASTIC STRAIN ENERGY.. .       .00000
   MAX KINETIC ENERGY... ... .. .      .41248
   MAX DAMPING ENERGY.. ... . . ..     .00000
```

I. ONE-BAY FRAME OF TUBE SECTION ELEMENT INCREMENT DISPLACEMENT CONTROL

Description of Input Information

Find the structural member internal force of a one-bay frame (Fig. 61), which is subjected to displacement change. The structural member is modeled as a stability element of tube section, for which the finite-segment (STABILITY) has the following properties NSEG=1, YS=36 ksi, EM=29000 ksi, HH=11.6 in, INEB=10, INEH=10, ST=0.75 in, SMALL=30 in, TOTA=424.5 in^2, RATIO3=0.03, G=13000 ksi, and QRNEE=0.01.

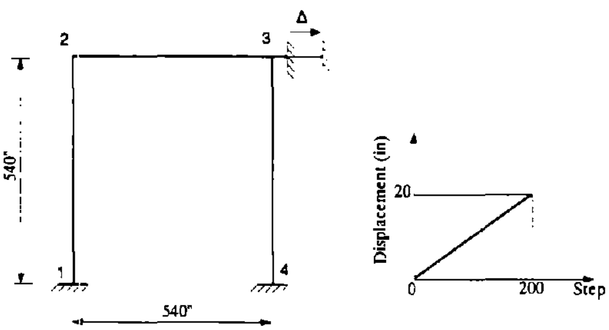


Figure 61. One-Bay Frame of Tube Section Element

Input and Output

Input

```
:    ECHO OF INPUT DATA

LINE  .. .:. .10 ... ...20.. ...  30    :.. 40. ..:.. 50.  .: ..60. ..: ..70.. .:  .80
   1:  'STRUCTURE DEFINITION'
   2:  'EXAMPLE I: ONE-STORY BUILDING '
   3    4  1 4 0 0  1.        NNODE,NCOS , NSUPT,NCOND,NCONST   SCALE
   4:     1       0.00    0 00     .00 1 0
   5:     2       540     0 00      00 1 0
   6:     3       540     540      .00 1 0
   7.     4       0.00    540      00 1 0
   8:       1 0 0             0 1 0 : DIRECTION COSINE
   9:      1          1 1 1 1 1 1          0 0
  10:      2          0 0 1 1 1 0          0 0
  11:      3          0 1 1 1 1 0          0 0
  12       4          1 1 1 1 1 1          0 0
  13:    3  :NMAT
  14: 'STABILITY MAT#1' 1 36 29000 2 11.6 0 0 0 10 10 0.75
  15. 0 0 0 0 0 30 0 0 424.5              1 1 0.03 0 13000 0 01 1
  16: 'STABILITY MAT#2' 1 36 29000 2 11 6 0 0 0 10 10 0.75
  17  0 0 0 0 0 30 0 0 424.5              1 1 0.03 0 13000 0 01 1
  18: 'STABILITY MAT#3' 1 36 29000 2 11.6 0 0 0 10 10 0.75
  19: 0 0 0 0 0 30 0 0 424.5              1 1 0.03 0 13000 0 01 1
  20:  0 0 0  FALSE.           :KG: AXL, FORM, ASSY
  21. 3  NELEM
  22: 'STABILITY' 'TUBE MEMBER 1 '  1 1 2                  0 0 1  0 0    0
  23: 'STABILITY' 'TUBE MEMBER 2 '  2 2 3                  0 0 1  0 0    0
  24: 'STABILITY' 'TUBE MEMBER 3 '  3 4 3                  0 0 1  0 0    0
  25:   0 0  FALSE. :  MASS
  26:   0 0  :  DAMP
  27: 'SOL04 SOLUTION'
  28: 'INCREMENTAL DISPLACEMENT CONTROL AT JOINT 3'
  29:  1 50000 2  .FALSE    MAXELD IPRINT IWRITE UNBAL
  30:  'ELE'        2  10 0  0  0
```

```
'JOINT FY'  3  11 0  0  0
'END       '  2  13 0  0  0
1  2  0  0 'FY'  -20
0  0  0  0 'END'  0        !JOINT LOAD
0  0  0  0 'END' 'FY'  0  0  ' ELEMENT LOAD
'DISP  FROM  0     TO  -20     '  1    0  0  200
'END OF DISP. CONTROL          '  0    0  0    0
'READ UNIT=10 UNIT=11'
'STOP'
```

Output

```
1 STRUCTURE ...  EXAMPLE I: ONE-STORY BUILDING                                    TIME  9:18:33, DATE:  5/24/96
  SOLUTION ... .

 *** PROGRAM FEM ***        DOUBLE PRECISION VERSION


    NODE COORDINATES AND DEGREES OF FREEDOM

   TOTAL NUMBER OF DEGREES OF FREEDOM.. .. .. ...       24
   NUMBER OF DEGREES OF FREEDOM CONDENSED OUT.. ..       0
   NUMBER OF FREE DEGREES OF FREEDOM... ... .....        5
   NUMBER OF RESTRAINED DEGREES OF FREEDOM.... ...      19

     NODE COS#    X-COORD      Y-COORD      Z-COORD      FX     FY     FZ     MX     MY     MZ
        1    1     .00000       .00000       .00000      6-R    7-R    8-R    9-R   10-R   11-R
        2    1    540.00        .00000       .00000      1      2     12-R   13-R   14-R    3
        3    1    540.00       540.00        .00000      4     15-R   16-R   17-R   18-R    5
        4    1     00000       540.00        00000      19-R   20-R   21-R   22-R   23-R   24-R
         NOTE: R - RESTRAINED DEGREE OF FREEDOM
               C - CONSTRAINED DEGREE OF FREEDOM

    DIRECTION COSINES . .

 COS#  1:   VX: 1.00000 I  + 00000 J  +.00000 K   VY:  .00000 I +1.00000 J  +.00000 K   VZ:  .00000 I  + 0000C J +1.00000 K
1 STRUCTURE.. .: EXAMPLE I  ONE-STORY BUILDING                                    TIME  9:18:33, DATE:  5/24/96
  SOLUTION.. ...


 STABILITY ELEMENT
 -----------------

 MAT  NO     =  1   TUBE SECTION
 NSEG        =          1          YS           =  36.0
 EM          =  2.900E+04          LIBN         =          2
 RADIUS      =  11.6               DUMMY VAR    =  .000
 ECCXO       =  .000               ECCYO        =  .000
 1/4.SEC.NO  =  10.0               DUMMY VAR.   =  10.0
 THICKNESS   =  .750               IREV1        =          0
 IREV2       =          0          IREV3        =          0
 IREV4       =          0          IECOP        =          0
 NUMP        =         40          SMALL        =  30.0
 RATIXO      =  .000               RATIYO       =  .000
 TOTA        =  425.               IAUTO        =          1
 IMATER      =          1          RATIO3       =  3.000E-02
 IR          =          0          G            =  1.300E+04
 ORNEE       =  1.000E-02          ISTIF        =          1

 MAT. NO.    =  2   TUBE SECTION
 NSEG        =          1          YS           =  36.0
 EM          =  2.900E+04          LIBN         =          2
 RADIUS      =  11.6               DUMMY VAR.   =  .000
 ECCXO       =  .000               ECCYO        =  .000
 1/4.SEC.NO. =  10.0               DUMMY VAR    =  10.0
 THICKNESS   =  .750               IREV1        =          0
 IREV2       =          0          IREV3        =          0
 IREV4       =          0          IECOP        =          0
 NUMP        =         40          SMALL        =  30.0
 RATIXO      =  .000               RATIYO       =  .000
 TOTA        =  425.               IAUTO        =          1
 IMATER      =          1          RATIO3       =  3.000E-02
 IR          =          0          G            =  1.300E+04
 ORNEE       =  1.000E-02          ISTIF        =          1

 MAT. NO.    =  3   TUBE SECTION
 NSEG        =          1          YS           =  36.0
 EM          =  2.900E+04          LIBN         =          2
 RADIUS      =  11.6               DUMMY VAR.   =  .000
 ECCXO       =  .000               ECCYO        =  .000
 1/4.SEC.NO  =  10.0               DUMMY VAR    =  10.0
 THICKNESS   =  .750               IREV1        =          0
 IREV2       =          0          IREV3        =          0
 IREV4       =          0          IECOP        =          0
 NUMP        =         40          SMALL        =  30.0
 RATIXO      =  .000               RATIYO       =  .000
 TOTA        =  425.               IAUTO        =          1
 IMATER      =          1          RATIO3       =  3.000E-02
 IR          =          0          G            =  1.300E+04
 ORNEE       =  1.000E-02          ISTIF        =          1

1 STRUCTURE ...  EXAMPLE I: ONE-STORY BUILDING                                    TIME  9.18:33, DATE:  5/24/96
  SOLUTION ..


 ELEMENT 12,  STABILITY ELEMENT
```

```
                    #   MATL   START   END   LENGTH    ........... Y-AXIS ............   START DIST    END DIST
TUBE MEMBER 1       1    1      1       2    540.0     .00000 I  -.00000 J +1 00000 K    0000          0000
TUBE MEMBER 2       2    2      2       3    540.0     .00000 I  - 00000 J +1 00000 K   .0000          0000
TUBE MEMBER 3       3    3      4       3    540.0     .00000 I  - 00000 J +1 00000 K   .0000         .0000

     ZERO MASS MATRIX
    ------------------

     PROPORTIONAL DAMPING COIEFICIENTS
    -----------------------------------
    ALPHA=    00000       BETA=    00000

1 STRUCTURE ...  EXAMPLE 1: ONE-STORY BUILDING                                          TIME  9 18:33, DATE   5/24/96
  SOLUTION...   - INCREMEMTAL DISPLACEMENT CONTROL AT JOINT 3                           TIME. 9 18:34, DATE.  5/24/96
  SOLUTION #4. STATIC NONLINEAR SOLUTION
 ----------------------------------------
  INTERVAL FOR PRINTING DATA.  ...   ... 50000
  INTERVAL FOR WRITING DATA TO FILE. ...      2

  UNBALANCED JOINT FORCES ARE NOT ADDED TO THE NEXT CYCLE

     DATA WRITTEN TO FILES
    -----------------------

    ELEMENT  #    2 IS WRITTEN TO UNIT #   10
    DEGREE OF FREEDOM  #   15 IS WRITTEN TO UNIT #   11  JOINT:     3   DIRECTION  FY
   APPLIED JOINT LOADS
   ---------------------

 LOAD CASE:  1  JOINT      3  DIRECTION. FY   DOF(S)   15             MAGNITUDE:  -20 C000      ...JOINT DISPLACEMENT...
1 STRUCTURE.   . EXAMPLE 1  ONE-STORY BUILDING                                       TIME:  9:18:33, DATE:  5/24/96
  SOLUTION.....: INCREMEMTAL DISPLACEMENT CONTROL AT JOINT 3                          TIME:  9:18:34, DATE:  5/24/96

1 STRUCTURE  ... EXAMPLE 1: ONE-STORY BUILDING                                       TIME-  9:18:33, DATE:  5/24/96
  SOLUTION.. ..- INCREMEMTAL DISPLACEMENT CONTROL AT JOINT 3                          TIME   9.18:34, DATE:  5/24/96

  . LOADING #    0     MAXIMUM DISPLACEMENTS


  GCS DISPLACEMENTS
 -------------------
                         NOTE  MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY

     NODE       DX            DY            DZ            RX            RY            RZ

        1   .000000       000000       .000000       .000000       .000000        000000
        2  -.399738     -19.9627       000000       .000000       .000000     -2.228548E-02
        3  -.334750      20 0000       000000       000000       .000000     -2.238449E-02
        4   .000000      .000000      .000000       000000       .000000       .000000
1 STRUCTURE ..   EXAMPLE 1. ONE-STORY BUILDING                                       TIME.  9 18:33, DATE:  5/24/96
  SOLUTION.....  INCREMEMTAL DISPLACEMENT CONTROL AT JOINT 3                          TIME-  9-18.34, DATE   5/24/96

  , LOADING #    0     MAXIMUM REACTIONS


  MAXIMUM GCS RESTRAINT REACTIONS     NOTE: MAXIMUM VALUES MAY NOT OCCUR SIMULTANEOUSLY
 ----------------------------------

     NODE       FX            FY            FZ            MX            MY            MZ

        1   97 27026      109 6446     1 3355900E-06 2 1285850E-05 1.3935460E-03   34942 20
        2    0000000      .0000000     2 9292250E-06 1 5323840E-03 9.5943700E-04   .0000000
        3    0000000     -227.0349    -3 8636130E-06 1.5481910E-03 9 9929110E-04    0000000
        4  -97.27023      117.3995     3.7081510E 07 2.1646040E-05 1 2957070E-03   35136.98
MAX OF ALL-------------------------------------------------------------------------------------
GCS SUMM.   .3051756E-04  - 1007080E-02  4629527E-06  .1075247E-02   5149832E-02   15.64099

   MAXIMUM RESULTANT OF REACTIONS,   FORCE= 1.0071E-03   MOMENT=   15.64
1 STRUCTURE ....  EXAMPLE 1: ONE-STORY BUILDING                                      TIME:  9-18:33, DATE:  5/24/96
  SOLUTION. .. : INCREMEMTAL DISPLACEMENT CONTROL AT JOINT 3                          TIME   9.18:34, DATE:  5/24/96

  , LOADING #    0     PEAK ELEMENT FORCES
      COLUMN ( LOAD) REPRESENTS THE DOF WHICH HAS
      MAXIMUM VALUE

    STABILITY ELEMENT  FORCES .
      MAXIMUM VALUES FOR ALL STEPS   NOTE: MAXIMUM VALUES WITH THE OTHER DOFS FORCES ARE PRINT OUT AT THE SAME TIME
 ELEMENT LOAD         NODE       AXIAL          FY            FZ            TORSION         MY            MZ        FLP,SF

       1     1  FORCE    1     97 2702      1.335590E-06   -109.645      2.059007E-05    34942.2      -1 393546E-03
                FORCE    2    -97.2702     -1.335590E-06    109 645      1.410933E-05    26195 6      -9 594870E-04

       1     2  FORCE    1     97.2702      1 335590E-06   -109 645      2.059007E-05    34942 2      -1.393546E-03
                FORCE    2    -97.2702     -1 335590E-06    109 645      1.410933E-05    26195.6      -9.594870E-04

       1     3  FORCE    1     97 2702      1 335590E-06   -109.645      2 059007E-05    34942 2      -1.393546E-03
                FORCE    2    -97.2702     -1.335590E-06    109.645      1 410933E-05    26195.6      -9.594870E-04

       1     4  FORCE    1     95 8102      1.294674E-06   -108.055      2 126585E-05    34419.1      -1.372644E-03
                FORCE    2    -95 8102     -1.294674E-06    108.055      1 446854E-05    25803.2      -9.337699E-04

       1     5  FORCE    1     97 2702      1.335590E-06   -109.645      2.059007E-05    34942.2      -1 393546E-03
                FORCE    2    -97 2702     -1.335590E-06    109.645      1.410933E-05    26195.6      -9.594870E-04

       1     6  FORCE    1     97.2702      1 335590E-06   -109.645      2.059007E-05    34942 2      -1 393546E-03
                FORCE    2    -97.2702     -1.335590E 06    109 645      1.410933E-05    26195.6      -9 594870E-04

       1     7  FORCE    1     97.2702      1 335590E-06   -109 645      2.059007E-05    34942 2      -1.393546E-03
                FORCE    2    -97 2702     -1 335590E-06    109.645      1.410933E-05    26195 6      -9.594870E-04

       1     8  FORCE    1     97.2702      1 335590E-06   -109.645      2.059007E-05    34942.2      -1.393546E-03
                FORCE    2    -97 2702     -1.335590E-06    109.645      1.410933E-05    26195.6      -9.594870E-04

       1     9  FORCE    1     97 2702      1.335590E-06   -109.645      2 059007E-05    34942.2      -1.393546E-03
                FORCE    2    -97 2702     -1.335590E-06    109.645      1.410933E-05    26195.6      -9.594870E-04

       1    10  FORCE    1     96.2969      1 305979E-06   -106 585      2.122178E-05    34593.5      -1.376825E-03
```

		FORCE	2	-96.2969	-1.306979E-06	108.585	1.471980E-05	25934.0	-9.427321E-04
1	11	FORCE	1	97.2702	1.335590E-06	-109.645	2.059007E-05	34942.2	-1.393546E-03
		FORCE	2	-97.2702	-1.335590E-06	109.645	1.410933E-05	26195.6	-9.594870E-04
1	12	FORCE	1	97.2702	1.335590E-06	-109.645	2.059007E-05	34942.2	-1.393546E-03
		FORCE	2	-97.2702	-1.335590E-06	109.645	1.410933E-05	26195.6	-9.594870E-04
2	1	FORCE	2	109.645	4.263814E-06	97.2702	-4.997152E-08	-26195.6	1.518275E-03
		FORCE	3	-109.645	-3.800821E-06	-97.2702	-5.109543E-08	-26234.4	1.526956E-03
2	2	FORCE	2	109.645	4.263814E-06	97.2702	-4.997152E-08	-26195.6	1.518275E-03
		FORCE	3	-109.645	-3.800821E-06	-97.2702	-5.109543E-08	-26234.4	1.526956E-03
2	3	FORCE	2	109.645	4.263814E-06	97.2702	-4.997152E-08	-26195.6	1.518275E-03
		FORCE	3	-109.645	-3.800821E-06	-97.2702	-5.109543E-08	-26234.4	1.526956E-03
2	4	FORCE	2	109.115	4.232787E-06	96.7836	-5.016296E-08	-26064.8	1.514204E-03
		FORCE	3	-109.115	-3.777460E-06	-96.7836	-5.094365E-08	-26103.3	1.522618E-03
2	5	FORCE	2	109.645	4.263814E-06	97.2702	-4.997152E-08	-26195.6	1.518275E-03
		FORCE	3	-109.645	-3.800821E-06	-97.2702	-5.109543E-08	-26234.4	1.526956E-03
2	6	FORCE	2	109.645	4.263814E-06	97.2702	-4.997152E-08	-26195.6	1.518275E-03
		FORCE	3	109.645	-3.800821E-06	97.2702	-5.109543E-08	-26234.4	1.526956E-03
2	7	FORCE	2	109.645	4.263814E-06	97.2702	-4.997152E-08	-26195.6	1.518275E-03
		FORCE	3	-109.645	-3.800821E-06	-97.2702	-5.109543E-08	-26234.4	1.526956E-03
2	8	FORCE	2	109.645	4.263814E-06	97.2702	-4.997152E-08	-26195.6	1.518275E-03
		FORCE	3	-109.645	-3.800821E-06	-97.2702	-5.109543E-08	-26234.4	1.526956E-03
2	9	FORCE	2	109.645	4.263814E-06	97.2702	-4.997152E-08	-26195.6	1.518275E-03
		FORCE	3	-109.645	-3.800821E-06	-97.2702	-5.109543E-08	-26234.4	1.526956E-03
2	10	FORCE	2	109.645	4.263814E-06	97.2702	-4.997152E-08	-26195.6	1.518275E-03
		FORCE	3	-109.645	-3.800821E-06	-97.2702	-5.109543E-08	-26234.4	1.526956E-03
2	11	FORCE	2	109.645	4.263814E-06	97.2702	-4.997152E-08	-26195.6	1.518275E-03
		FORCE	3	109.645	-3.800821E-06	-97.2702	-5.109543E-08	-26234.4	1.526956E-03
2	12	FORCE	2	109.645	4.263814E-06	97.2702	-4.997152E-08	-26195.6	1.518275E-03
		FORCE	3	-109.645	-3.800821E-06	-97.2702	-5.109543E-08	-26234.4	1.526956E-03
3	1	FORCE	4	-97.2702	6.279098E-08	-117.389	2.184803E-05	35137.0	-1.295707E-03
		FORCE	3	97.2702	-6.279098E-08	117.389	2.123584E-05	26234.4	-9.960829E-04
3	2	FORCE	4	-71.9684	3.708151E-07	-86.1183	1.279061E-05	25988.5	-9.521103E-04
		FORCE	3	71.9684	-3.708151E-07	86.1183	1.207246E-05	19418.4	-7.393577E-04
3	3	FORCE	4	-97.2702	6.279098E-08	-117.389	2.184803E-05	35137.0	-1.295707E-03
		FORCE	3	97.2702	-6.279098E-08	117.389	2.123584E-05	26234.4	-9.960829E-04
3	4	FORCE	4	-97.2702	6.279098E-08	-117.389	2.184803E-05	35137.0	-1.295707E-03
		FORCE	3	97.2702	-6.279098E-08	117.389	2.123584E-05	26234.4	-9.960829E-04
3	5	FORCE	4	-97.2702	6.279098E-08	-117.389	2.184803E-05	35137.0	-1.295707E-03
		FORCE	3	97.2702	-6.279098E-08	117.389	2.123584E-05	26234.4	-9.960829E-04
3	6	FORCE	4	-97.2702	6.279098E-08	-117.389	2.184803E-05	35137.0	-1.295707E-03
		FORCE	3	97.2702	-6.279098E-08	117.389	2.123584E-05	26234.4	-9.960829E-04
3	7	FORCE	4	-97.2702	6.279098E-08	-117.389	2.184803E-05	35137.0	-1.295707E-03
		FORCE	3	97.2702	-6.279098E-08	117.389	2.123584E-05	26234.4	-9.960829E-04
3	8	FORCE	4	-71.9684	3.708151E-07	-86.1183	1.279061E-05	25988.5	-9.521103E-04
		FORCE	3	71.9684	-3.708151E-07	86.1183	1.207246E-05	19418.4	-7.393577E-04
3	9	FORCE	4	97.2702	6.279098E-08	-117.389	2.184803E-05	35137.0	1.295707E-03
		FORCE	3	97.2702	-6.279098E-08	117.389	2.123584E-05	26234.4	-9.960829E-04
3	10	FORCE	4	-97.2702	6.279098E-08	-117.389	2.184803E-05	35137.0	1.295707E-03
		FORCE	3	97.2702	-6.279098E-08	117.389	2.123584E-05	26234.4	-9.960829E-04
3	11	FORCE	4	-97.2702	6.279098E-08	-117.389	2.184803E-05	35137.0	-1.295707E-03
		FORCE	3	97.2702	-6.279098E-08	117.389	2.123584E-05	26234.4	-9.960829E-04
3	12	FORCE	4	-96.7836	5.600937E-08	-116.783	2.180644E-05	34961.0	-1.294534E-03
		FORCE	3	96.7836	-5.600937E-08	116.783	2.122793E-05	26103.3	-9.993421E-04

```
1 STRUCTURE. .. EXAMPLE I  ONE-STORY BUILDING                                  TIME: 9:18:33, DATE:  5/24/96
  SOLUTION.. .. INCREMENTAL DISPLACEMENT CONTROL AT JOINT 3                    TIME. 9:18:34, DATE:  5/24/96

  . LOADING #    0     PEAK DUCTILITIES AND EXCURSION RATIO'S
1 STRUCTURE  . . EXAMPLE I  ONE-STORY BUILDING                                 TIME  9:18:33, DATE.  5/24/96
  SOLUTION   . . INCREMENTAL DISPLACEMENT CONTROL AT JOINT 3                   TIME  9:18:34, DATE.  5/24/96

  . LOADING #    0     DAMAGE INDEX

        STRUCTURE DAMAGE INDEX=       .00000
1 STRUCTURE ..   EXAMPLE I. ONE-STORY BUILDING                                 TIME:  9:18:33, DATE   5/24/96
  SOLUTION  .    INCREMENTAL DISPLACEMENT CONTROL AT JOINT 3                   TIME:  9:18:34, DATE   5/24/96

     ELEMENT #    2 IS READ FROM UNIT #   10

     STABILITY ELEMENT FORCES  .
```

STEP	TIME	NODE	AXIAL	FY	FZ	TORSION	MY	MZ	FLP.SP
0	.00000	2	.000000	.000000	.000000	.000000	.000000	.000000	
		3	.000000	.000000	.000000	.000000	.000000	.000000	.000
		DISP	.000000	.000000	.000000	.000000	.000000	.000000	
			.000000	.000000	.000000	.000000	.000000	.000000	.000
2	.00000	2	1.13420	5.865950E-08	.972260	.000000	-262.370	1.235410E-05	
		3	-1.13420	-4.643750E-06	-.972260	.000000	-262.650	1.234160E-05	1.00
		DISP	-.199610	.000000	-3.496040E-04	.000000	-2.223880E-04	.000000	
			-.200000	.000000	3.127100E-04	.000000	-2.231050E-04	.000000	.000
4	.00000	2	2.26770	6.709840E-08	1.94450	.000000	-524.720	3.650350E-05	
		3	-2.26770	-4.645090E-08	-1.94450	.000000	-525.290	3.651660E-05	.251

		DISP	-.399230	.000000	-7.728550E-04	.000000	-4.447840E-04	.000000	
			-.400000	.000000	5.514910E-04	.000000	-4.462240E-04	.000000	.000
6	.00000	2	3.40040	1.062920E-07	2.91680	.000000	-787.070	5.117180E-05	
		3	-3.40040	-7.928690E-08	-2.91680	.000000	-787.930	5.119920E-05	.112
		DISP	-.598840	.000000	-1.269750E-03	.000000	-6.671890E-04	.000000	
			-.600000	.000000	7.163430E-04	.000000	-6.693570E-04	.000000	.000
8	.00000	2	4.53230	1.379840E-07	3.88910	.000000	-1049.40	6.554350E-05	
		3	-4.53230	-1.025130E-07	-3.88910	.000000	-1050.60	6.557160E-05	6.316E-02
		DISP	-.798460	.000000	1.840300E-03	.000000	-8.896030E-04	.000000	
			-.800000	.000000	8.072670E-04	.000000	-8.925040E-04	.000000	.000
10	.00000	2	5.66330	1.781050E-07	4.86140	.000000	-1311.70	8.011820E-05	
		3	5.66330	-1.353540E-07	-4.86140	.000000	-1313.20	8.017410E-05	4.058E-02
		DISP	-.998070	.000000	-2.484500E-03	.000000	-1.112020E-03	.000000	
			-1.00000	.000000	5.242620E-04	.000000	-1.115670E-03	.000000	.000
12	.00000	2	6.79370	2.196890E-07	5.83370	.000000	-1574.10	1.073940E-04	
		3	-6.79370	-1.585980E-07	-5.83370	.000000	-1575.80	1.075000E-04	2.828E-02
		DISP	-1.19770	.000000	-3.202350E-03	.000000	-1.334460E-03	.000000	
			-1.20000	.000000	7.673300E-04	.000000	-1.339840E-03	.000000	.000
14	.00000	2	7.92330	2.677040E-07	6.80590	.000000	-1836.40	1.164870E-04	
		3	-7.92330	2.146350E-07	-6.80590	.000000	-1838.40	1.166020E-04	2.085E-02
		DISP	1.39730	.000000	-3.993840E-03	.000000	-1.556900E-03	.000000	
			-1.40000	.000000	6.364690E-04	.000000	-1.562030E-03	.000000	.000
16	.00000	2	9.05210	2.674490E-07	7.77820	.000000	-2098.70	1.302030E-04	
		3	-9.05210	-2.146340E-07	-7.77820	.000000	-2101.00	1.303370E-04	1.603E-02
		DISP	1.59690	.000000	-4.858990E-03	.000000	-1.779340E-03	.000000	
			-1.60000	.000000	4.316810E-04	.000000	-1.785240E-03	.000000	.000
18	.00000	2	10.1800	3.379940E-07	8.75050	.000000	-2361.00	1.358770E-04	
		3	-10.1800	-2.707130E-07	-8.75050	.000000	-2363.60	1.360320E-04	1.271E-02
		DISP	-1.79650	.000000	-5.797790E-03	.000000	-2.001800E-03	.000000	
			-1.80000	.000000	1.529650E-04	.000000	-2.008450E-03	.000000	.000
20	.00000	2	11.3070	4.057040E-07	9.72290	.000000	-2623.20	1.556750E-04	
		3	-11.3070	-3.403680E-07	-9.72290	.000000	-2626.20	1.558480E-04	1.033E-02
		DISP	-1.99610	.000000	-6.810250E-03	.000000	-2.224270E-03	.000000	
			-2.00000	.000000	-1.996780E-04	.000000	-2.231690E-03	.000000	.000
22	.00000	2	12.4340	4.752460E-07	10.6950	.000000	-2885.50	1.635670E-04	
		3	-12.4340	-3.964500E-07	-10.6950	.000000	-2888.70	1.637680E-04	8.564E-03
		DISP	-2.19580	.000000	-7.896360E-03	.000000	-2.446740E-03	.000000	
			-2.20000	.000000	-6.262490E-04	.000000	-2.454930E-03	.000000	.000
24	.00000	2	13.5590	5.386520E-07	11.6670	.000000	-3147.80	1.805950E-04	
		3	-13.5590	-4.525260E-07	-11.6670	.000000	-3151.30	1.808470E-04	7.226E-03
		DISP	-2.39540	.000000	-9.056120E-03	.000000	-2.669220E-03	.000000	
			-2.40000	.000000	-1.126750E-03	.000000	-2.678200E-03	.000000	.000
26	.00000	2	14.6640	5.846520E-07	12.6400	.000000	-3410.00	1.943110E-04	
		3	-14.6640	-4.949930E-07	-12.6400	.000000	-3413.90	1.945900E-04	6.178E-03
		DISP	-2.59500	.000000	-1.028950E-02	.000000	-2.891720E-03	.000000	
			-2.60000	.000000	-1.701170E-03	.000000	-2.901470E-03	.000000	.000
28	.00000	2	15.8080	6.212130E-07	13.6120	.000000	-3672.30	2.165490E-04	
		3	-15.8080	-5.182410E-07	-13.6120	.000000	-3676.40	2.168830E-04	5.349E-03
		DISP	-2.79460	.000000	-1.159660E-02	.000000	-3.114220E-03	.000000	
			-2.80000	.000000	-2.349530E-03	.000000	-3.124760E-03	.000000	.000
30	.00000	2	16.9320	6.370630E-07	14.5840	.000000	-3934.50	2.248290E-04	
		3	-16.9320	-5.162690E-07	-14.5840	.000000	-3939.00	2.252280E-04	4.675E-03
		DISP	-2.99420	.000000	-1.297740E-02	.000000	-3.336730E-03	.000000	
			-3.00000	.000000	-3.071610E-03	.000000	-3.348070E-03	.000000	.000
32	.00000	2	18.0540	6.706850E-07	15.5570	.000000	-4196.70	2.422600E-04	
		3	-18.0540	-5.647000E-07	-15.5570	.000000	-4201.50	2.426330E-04	4.123E-03
		DISP	-3.19380	.000000	-1.443180E-02	.000000	3.559250E-03	.000000	
			-3.20000	.000000	-3.868010E-03	.000000	-3.571380E-03	.000000	.000
34	.00000	2	19.1760	6.915640E-07	16.5290	.000000	-4459.00	2.576500E-04	
		3	19.1760	-5.743420E-07	-16.5290	.000000	-4464.10	2.581010E-04	3.668E-03
		DISP	-3.39350	.000000	-1.595980E-02	.000000	-3.781770E-03	.000000	
			-3.40000	.000000	-4.738150E-03	.000000	-3.794720E-03	.000000	.000
36	.00000	2	20.2970	7.461580E-07	17.5020	-1.885280E-10	-4721.20	2.730940E-04	
		3	-20.2970	-6.206150E-07	17.5020	-1.892150E-10	-4726.60	2.735810E-04	3.283E-03
		DISP	-3.59310	.000000	-1.756150E-02	.000000	-4.004310E-03	.000000	
			-3.60000	.000000	-5.682210E-03	.000000	-4.018070E-03	.000000	.000
38	.00000	2	21.4170	7.647060E-07	18.4740	-1.885280E-10	-4983.40	2.787070E-04	
		3	-21.4170	-6.440730E-07	-18.4740	-1.892150E-10	-4989.10	2.792510E-04	2.959E-03
		DISP	-3.79270	.000000	-1.923690E-02	.000000	-4.226560E-03	.000000	
			-3.80000	.000000	-6.700210E-03	.000000	-4.241430E-03	.000000	.000
40	.00000	2	22.5370	8.377290E-07	19.4460	-1.885280E-10	-5245.60	3.035070E-04	
		3	-22.5370	-6.905450E-07	-19.4460	-1.892150E-10	-5251.60	3.041020E-04	2.679E-03
		DISP	-3.99230	.000000	-2.098600E-02	.000000	-4.449410E-03	.000000	
			-4.00000	.000000	7.792130E-03	.000000	-4.464610E-03	.000000	.000
42	.00000	2	23.6550	8.747050E-07	20.4190	-1.885280E-10	-5507.70	3.165980E-04	
		3	-23.6550	-7.234120E-07	-20.4190	-1.892150E-10	-5514.10	3.172320E-04	2.439E-03
		DISP	-4.19190	.000000	-2.280870E-02	.000000	-4.671980E-03	.000000	
			-4.20000	.000000	-8.957980E-03	.000000	-4.688200E-03	.000000	.000
44	.00000	2	24.7730	9.195510E-07	21.3910	1.885280E-10	-5769.90	3.319500E-04	
		3	-24.7730	-7.562920E-07	-21.3910	-1.892150E-10	-5776.60	3.326620E-04	2.232E-03
		DISP	4.39160	.000000	-2.470500E-02	.000000	-4.894550E-03	.000000	
			-4.40000	.000000	-1.019780E-02	.000000	-4.911600E-03	.000000	.000
46	.00000	2	25.8900	9.563230E-07	22.3630	-3.385530E-10	-6032.10	3.559080E-04	
		3	-25.8900	-7.891600E-07	-22.3630	-3.398040E-10	-6039.10	3.566790E-04	2.051E-03
		DISP	4.59120	.000000	-2.667510E-02	.000000	-5.117130E-03	.000000	
			-4.60000	.000000	-1.151150E-02	.000000	-5.135030E-03	.000000	.000
48	.00000	2	27.0070	1.000960E-06	23.3360	-4.630720E-10	-6294.20	3.678980E-04	

		3	-27.0070	-8.220430E-07	-23.3260	-4.647940E-10	-6301.60	3.587480E-04	1.889E-03
		DISP	-4.79080	.000000	-2.871860E-02	.000000	-5.339720E-03	.000000	
			-4.80000	.000000	-1.289910E-02	.000000	-5.358460E-03	.000000	.000
50	.00000	2	28.1220	1.034230E-06	24.3080	-4.630720E-10	-6556.40	3.751440E-04	
		3	-28.1220	-8.549070E-07	-24.3080	-4.647940E-10	-6564.10	3.760040E-04	1.748E-03
		DISP	4.99040	.000000	-3.083620E-02	.000000	-5.562320E-03	.000000	
			5.00000	.000000	-1.436070E-02	.000000	-5.581910E-03	.000000	.000
52	.00000	2	29.2370	1.044830E-06	25.2810	-5.475470E-10	-6819.50	3.878720E-04	
		3	-29.2370	-8.645350E-07	-25.2810	-6.499780E-10	-6826.60	3.887420E-04	1.623E-03
		DISP	-5.19000	.000000	-3.302720E-02	.000000	-5.784930E-03	.000000	
			-5.20000	.000000	-1.589620E-02	.000000	-5.805360E-03	.000000	.000
54	.00000	2	30.3510	1.090540E-06	26.2530	-8.585200E-10	-7080.60	4.170460E-04	
		3	-30.3510	-9.110140E-07	26.2530	-8.918830E-10	-7089.00	4.179510E-04	1.511E-03
		DISP	-5.38970	.000000	-3.529190E-02	.000000	-6.007550E-03	.000000	
			-5.40000	.000000	-1.750560E-02	.000000	-6.028860E-03	.000000	.000
56	.00000	2	31.4650	1.132830E-06	27.2260	-9.999400E-10	-7342.90	4.474640E-04	
		3	-31.4650	-9.535100E-07	-27.2260	-1.003740E-09	-7351.50	4.484100E-04	1.409E-03
		DISP	-5.58930	.000000	-3.763030E-02	.000000	-6.230180E-03	.000000	
			-5.60000	.000000	-1.918900E-02	.000000	-6.252350E-03	.000000	.000
58	.00000	2	32.5770	1.149170E-06	28.1980	-9.999400E-10	-7604.90	4.541210E-04	
		3	-32.5770	-9.631500E-07	-28.1980	-1.003740E-09	-7614.00	4.551470E-04	1.319E-03
		DISP	-5.78890	.000000	-4.004240E-02	.000000	-6.452820E-03	.000000	
			-5.80000	.000000	-2.094620E-02	.000000	-6.475650E-03	.000000	.000
60	.00000	2	33.6890	1.205280E-06	29.1700	-1.304020E-09	-7867.00	4.775740E-04	
		3	-33.6890	-1.009660E-06	-29.1700	1.309020E-09	-7876.40	4.787020E-04	1.238E-03
		DISP	-5.98850	.000000	-4.252620E-02	.000000	-6.675460E-03	.000000	
			-6.00000	.000000	-2.277750E-02	.000000	-6.699390E-03	.000000	.000
62	.00000	2	34.8000	1.243400E-06	30.1430	-1.625950E-09	-8129.10	4.908040E-04	
		3	34.8000	-1.042540E-06	-30.1430	-1.632220E-09	-8138.80	4.919940E-04	1.165E-03
		DISP	-6.18810	.000000	-4.508760E-02	.000000	-6.898120E-03	.000000	
			-6.20000	.000000	-2.468260E-02	.000000	-6.922920E-03	.000000	.000
64	.00000	2	35.9100	1.236110E-06	31.1150	-1.950730E-09	-8391.20	5.032370E-04	
		3	-35.9100	-1.042530E-06	-31.1150	-1.958300E-09	-8401.30	5.043790E-04	1.096E-03
		DISP	-6.38760	.000000	-4.772070E-02	.000000	-7.120780E-03	.000000	
			-6.40000	.000000	-2.666170E-02	.000000	-7.146460E-03	.000000	.000
66	.00000	2	37.0200	1.273460E-06	32.0880	-2.094870E-09	-8653.20	5.064910E-04	
		3	-37.0200	-1.075410E-06	-32.0880	-2.103010E-09	-8663.70	5.076700E-04	1.035E-03
		DISP	-6.58740	.000000	-5.042750E-02	.000000	-7.343460E-03	.000000	
			-6.60000	.000000	-2.871470E-02	.000000	-7.370050E-03	.000000	.000
68	.00000	2	38.1280	1.292820E-06	33.0600	-2.436300E-09	-8915.30	5.119600E-04	
		3	-38.1280	-1.094670E-06	-33.0600	-2.572820E-09	-8926.10	5.131440E-04	9.793E-04
		DISP	-6.78700	.000000	-5.320800E-02	.000000	-7.566140E-03	.000000	
			-6.80000	.000000	-3.084170E-02	.000000	-7.593630E-03	.000000	.000
70	.00000	2	39.2360	1.329390E-06	34.0330	-3.024640E-09	-9177.40	5.337930E-04	
		3	-39.2360	-1.127560E-06	-34.0330	-3.039260E-09	-9188.50	5.350220E-04	9.266E-04
		DISP	-6.98660	.000000	-5.606210E-02	.000000	-7.788840E-03	.000000	
			-7.00000	.000000	-3.304260E-02	.000000	-7.817230E-03	.000000	.000
72	.00000	2	40.3440	1.360630E-06	35.0050	-3.327120E-09	-9439.40	5.438630E-04	
		3	-40.3440	-1.174040E-06	-35.0050	-3.301870E-09	-9451.00	5.449330E-04	8.797E-04
		DISP	-7.18630	.000000	-5.899000E-02	.000000	-8.011540E-03	.000000	
			-7.20000	.000000	-3.531740E-02	.000000	-8.040840E-03	.000000	.000
74	.00000	2	41.4500	1.413760E-06	35.9780	-3.595210E-09	-9701.50	5.634670E-04	
		3	-41.4500	-1.220560E-06	-35.9780	-3.571070E-09	-9713.40	5.646350E-04	8.365E-04
		DISP	-7.38590	.000000	-6.199150E-02	.000000	-8.234250E-03	.000000	
			-7.40000	.000000	-3.766620E-02	.000000	-8.264470E-03	.000000	.000
76	.00000	2	42.5560	1.480610E-06	36.9500	-3.775340E-09	-9963.50	5.881660E-04	
		3	-42.5560	-1.276720E-06	-36.9500	-3.751930E-09	-9975.80	5.895040E-04	7.966E-04
		DISP	-7.58550	.000000	-6.506670E-02	.000000	-8.456970E-03	.000000	
			-7.60000	.000000	-4.008890E-02	.000000	-8.485120E-03	.000000	.000
78	.00000	2	43.6610	1.531230E-06	37.9230	-4.390960E-09	-10226.0	5.967530E-04	
		3	-43.6610	-1.332650E-06	-37.9230	-4.343640E-09	-10238.0	5.980280E-04	7.584E-04
		DISP	-7.78510	.000000	-6.821560E-02	.000000	-8.679700E-03	.000000	
			-7.80000	.000000	-4.258550E-02	.000000	-8.711770E-03	.000000	.000
80	.00000	2	44.7650	1.592270E-06	38.8950	-4.918920E-09	-10488.0	6.239570E-04	
		3	-44.7650	-1.399010E-06	-38.8950	-4.745750E-09	-10501.0	6.253320E-04	7.242E-04
		DISP	-7.98480	.000000	-7.143820E-02	.000000	-8.902440E-03	.000000	
			-8.00000	.000000	-4.515610E-02	.000000	-8.935450E-03	.000000	.000
82	.00000	2	45.8680	1.636690E-06	39.8680	-5.547220E-09	-10750.0	6.531580E-04	
		3	-45.8680	-1.431540E-06	-39.8680	5.235510E-09	-10763.0	6.545980E-04	6.925E-04
		DISP	-8.18440	.000000	-7.473450E-02	.000000	-9.125200E-03	.000000	
			-8.20000	.000000	-4.780060E-02	.000000	-9.159140E-03	.000000	.000
84	.00000	2	46.9710	1.649970E-06	40.8410	-6.003460E-09	-11012.0	6.706860E-04	
		3	-46.9710	-1.431560E-06	-40.8410	-5.645940E-09	-11025.0	6.723080E-04	6.629E-04
		DISP	-8.38400	.000000	-7.810450E-02	.000000	-9.347960E-03	.000000	
			-8.40000	.000000	-5.051910E-02	.000000	-9.382840E-03	.000000	.000
86	.00000	2	48.0730	1.700930E-06	41.8130	-6.229870E-09	-11274.0	6.864140E-04	
		3	-48.0730	-1.479100E-06	-41.8130	-5.990000E-09	-11288.0	6.881120E-04	6.352E-04
		DISP	-8.58360	.000000	-8.154820E-02	.000000	-9.570730E-03	.000000	
			-8.60000	.000000	-5.331150E-02	.000000	-9.606560E-03	.000000	.000
88	.00000	2	49.1740	1.770560E-06	42.7860	-6.646050E-09	-11536.0	6.917440E-04	
		3	-49.1740	-1.534260E-06	-42.7860	-6.316040E-09	-11550.0	6.935980E-04	6.034E-04
		DISP	-8.78330	.000000	-8.506560E-02	.000000	-9.793510E-03	.000000	
			-8.80000	.000000	-5.617790E-02	.000000	-9.830290E-03	.000000	.000
90	.00000	2	50.2740	1.804330E-06	43.7580	-6.990660E-09	-11798.0	7.010860E-04	
		3	-50.2740	-1.567180E-06	43.7580	-6.690000E-09	-11812.0	7.029490E-04	5.653E-04
		DISP	-8.98290	.000000	-8.865670E-02	.000000	-1.001830E-02	.000000	
			-9.00000	.000000	-5.911820E-02	.000000	-1.005400E-02	.000000	.000

92	.00000		2	51.3740	1.875960E-06	44.7310	-7.321720E-09	12060.0	7.116830E-04	
			3	-51.3740	-1.636980E-06	-44.7310	-7.022080E-09	-12075.0	7.135960E-04	5.626E-04
		DISP		-9.18250	.000000	-9.232150E-02	.000000	-1.023910E-02	.000000	
				-9.20000	.000000	-6.213240E-02	.000000	-1.027780E-02	.000000	.000
94	.00000		2	52.4720	1.881110E-06	45.7030	-7.530760E-09	-12321.0	7.242540E-04	
			3	-52.4720	-1.636990E-06	-45.7030	-7.232030E-09	-12337.0	7.262920E-04	5.413E-04
		DISP		-9.38210	.000000	-9.606000E-02	.000000	-1.046190E-02	.000000	
				-9.40000	.000000	-6.522060E-02	.000000	-1.050160E-02	.000000	.000
96	.00000		2	53.5710	1.896680E-06	46.6760	-7.754100E-09	-12581.0	7.358590E-04	
			3	-53.5710	-1.660240E-06	-46.6760	-7.581190E-09	-12599.0	7.378420E-04	5.195E-04
		DISP		-9.58190	.000000	-9.987230E-02	.000000	-1.068470E-02	.000000	
				-9.60000	.000000	-6.538270E-02	.000000	1.072540E-02	.000000	.000
98	.00000		2	54.6680	1.952470E-06	47.6490	-6.616970E-09	-12845.0	7.419330E-04	
			3	-54.6680	-1.739700E-06	-47.6490	-6.096010E-09	-12862.0	7.439900E-04	5.008E-04
		DISP		-9.78140	.000000	-.103760	.000000	-1.090750E-02	.000000	
				-9.80000	.000000	-7.161880E-02	.000000	-1.094920E-02	.000000	.000
100	.00000		2	55.7650	2.014240E-06	48.6210	-9.457380E-09	-13107.0	7.506440E-04	
			3	-55.7650	-1.786210E-06	-48.6210	-8.878080E-09	-13124.0	7.524820E-04	4.833E-04
		DISP		9.96100	.000000	-.107720	.000000	-1.113040E-02	.000000	
				10.0000	.000000	-7.492880E-02	.000000	-1.117300E-02	.000000	.000
102	.00000		2	56.8600	2.058000E-06	49.5940	-9.794690E-09	-13369.0	7.631010E-04	
			3	-56.8600	-1.828760E-06	-49.5940	-9.422560E-09	-13386.0	7.649630E-04	4.666E-04
		DISP		-10.1810	.000000	-.111750	.000000	-1.135320E-02	.000000	
				-10.2000	.000000	-7.531280E-02	.000000	-1.139690E-02	.000000	.000
104	.00000		2	57.9550	2.067210E-06	50.5670	-1.018480E-08	-13631.0	7.829680E-04	
			3	57.9550	-1.838400E-06	-50.5670	-9.953610E-09	-13649.0	7.846770E-04	4.509E-04
		DISP		-10.3800	.000000	-.115860	.000000	-1.157610E-02	.000000	
				-10.4000	.000000	-8.177070E-02	.000000	-1.162070E-02	.000000	.000
106	.00000		2	59.0500	2.134970E-06	51.5390	-1.058270E-08	-13893.0	7.984850E-04	
			3	-59.0500	-1.894610E-06	-51.5390	-1.048040E-08	-13911.0	8.005780E-04	4.360E-04
		DISP		-10.5800	.000000	-.120340	.000000	-1.179900E-02	.000000	
				-10.6000	.000000	-8.530260E-02	.000000	-1.184460E-02	.000000	.000
108	.00000		2	60.1430	2.164860E-06	52.5120	-1.141310E-08	-14155.0	8.090920E-04	
			3	-60.1430	-1.917900E-06	-52.5120	-1.135590E-08	-14173.0	8.113120E-04	4.220E-04
		DISP		-10.7800	.000000	-.124290	.000000	-1.202180E-02	.000000	
				-10.8000	.000000	-8.890840E-02	.000000	-1.206850E-02	.000000	.000
110	.00000		2	61.2360	2.237320E-06	53.4850	-1.213690E-08	-14417.0	8.343900E-04	
			3	-61.2360	-1.983750E-06	-53.4850	-1.205720E-08	-14436.0	8.367790E-04	4.087E-04
		DISP		-10.9790	.000000	-.128620	.000000	-1.224470E-02	.000000	
				-11.0000	.000000	-9.258820E-02	.000000	-1.229240E-02	.000000	.000
112	.00000		2	62.3280	2.244650E-06	54.4570	-1.280900E-08	-14679.0	8.548550E-04	
			3	-62.3280	-2.007000E-06	-54.4570	-1.285760E-08	-14698.0	8.570040E-04	3.947E-04
		DISP		-11.1790	.000000	-.133020	.000000	-1.246760E-02	.000000	
				-11.2000	.000000	-9.634200E-02	.000000	-1.251630E-02	.000000	.000
114	.00000		2	63.4190	2.319880E-06	55.4300	-1.312660E-08	-14941.0	8.584260E-04	
			3	-63.4190	-2.076850E-06	-55.4300	-1.346690E-08	-14960.0	8.606780E-04	3.827E-04
		DISP		-11.3780	.000000	-.137500	.000000	-1.269050E-02	.000000	
				-11.4000	.000000	-.100170	.000000	-1.274020E-02	.000000	.000
116	.00000		2	64.5100	2.353940E-06	56.4030	-1.374280E-08	-15203.0	8.804010E-04	
			3	-64.5100	-2.100150E-06	-56.4030	-1.446650E-08	-15223.0	8.829000E-04	3.714E-04
		DISP		-11.5780	.000000	.142050	.000000	-1.291350E-02	.000000	
				-11.6000	.000000	-.104070	.000000	-1.296420E-02	.000000	.000
118	.00000		2	65.6000	2.428650E-06	57.3760	-1.428290E-08	-15464.0	8.822140E-04	
			3	-65.6000	-2.170010E-06	-57.3760	-1.500500E-08	-15485.0	8.847950E-04	3.606E-04
		DISP		-11.7780	.000000	-.146670	.000000	-1.313640E-02	.000000	
				-11.8000	.000000	-.108050	.000000	-1.318820E-02	.000000	.000
120	.00000		2	66.6890	2.508740E-06	58.3480	-1.527140E-08	-15726.0	9.078990E-04	
			3	-66.6890	-2.249500E-06	-58.3480	-1.573320E-08	-15747.0	9.105350E-04	3.504E-04
		DISP		-11.9770	.000000	-.151370	.000000	-1.335930E-02	.000000	
				-12.0000	.000000	-.112100	.000000	-1.341210E-02	.000000	.000
122	.00000		2	67.7770	2.563620E-06	59.3210	-1.625970E-08	-15988.0	9.190980E-04	
			3	-67.7770	-2.296090E-06	-59.3210	-1.649180E-08	-16009.0	9.218900E-04	3.406E-04
		DISP		-12.1770	.000000	-.156140	.000000	-1.358230E-02	.000000	
				-12.2000	.000000	-.116220	.000000	-1.363610E-02	.000000	.000
124	.00000		2	68.8650	2.623880E-06	60.2940	-1.677100E-08	-16250.0	9.365920E-04	
			3	-68.8650	-2.352320E-06	-60.2940	-1.729520E-08	-16272.0	9.395040E-04	3.312E-04
		DISP		-12.3770	.000000	-.160980	.000000	-1.380520E-02	.000000	
				-12.4000	.000000	-.120420	.000000	-1.386010E-02	.000000	.000
126	.00000		2	69.9520	2.705510E-06	61.2670	-1.714070E-08	-16512.0	9.486800E-04	
			3	-69.9520	-2.431830E-06	-61.2670	-1.779940E-08	-16534.0	9.516490E-04	3.212E-04
		DISP		-12.5760	.000000	-.165900	.000000	-1.402520E-02	.000000	
				12.6000	.000000	-.124690	.000000	-1.408420E-02	.000000	.000
128	.00000		2	71.0380	2.782590E-06	62.2400	-1.794200E-08	-16774.0	9.527900E-04	
			3	-71.0380	-2.497730E-06	-62.2400	-1.861440E-08	-16796.0	9.559560E-04	3.128E-04
		DISP		-12.7760	.000000	-.170890	.000000	-1.425120E-02	.000000	
				-12.8000	.000000	.129030	.000000	-1.430820E-02	.000000	.000
130	.00000		2	72.1230	2.847140E-06	63.2120	1.874450E-08	-17036.0	9.671140E-04	
			3	-72.1230	-2.544350E-06	-63.2120	-1.936900E-08	-17058.0	9.706770E-04	3.047E-04
		DISP		-12.9750	.000000	-.175960	.000000	1.447420E-02	.000000	
				-13.0000	.000000	-.133450	.000000	-1.453230E-02	.000000	.000
132	.00000		2	73.2080	2.871860E-06	64.1850	-1.959930E-08	-17297.0	9.869540E-04	
			3	-73.2080	-2.567640E-06	-64.1850	-2.014340E-08	-17321.0	9.905690E-04	2.970E-04
		DISP		-13.1750	.000000	-.181100	.000000	-1.469720E-02	.000000	
				-13.2000	.000000	-.137950	.000000	-1.475640E-02	.000000	.000
134	.00000		2	74.2910	2.903320E-06	65.1580	-2.053580E-08	-17559.0	1.012250E-03	
			3	-74.2910	2.600580E-06	-65.1580	-2.116860E-08	-17583.0	1.015900E-03	2.896E-04
		DISP		-13.3750	.000000	-.185310	.000000	-1.492020E-02	.000000	
				-13.4000	.000000	-.142510	.000000	-1.498040E-02	.000000	.000

136	.00000	2	75.3750	2.922250E-06	66.1310	-2.132220E-08	-17821.0	1.020810E-03	
		3	-75.3750	-2.610250E-06	-66.1310	-2.189770E-08	-17845.0	1.024650E-03	2.825E-04
		DISP	-13.5740	.000000	-.191600	.000000	-1.514320E-02	.000000	
			-13.6000	.000000	-.147160	.000000	-1.520450E-02	.000000	.000
138	.00000	2	76.4570	2.955920E-06	67.1040	-2.216080E-08	-18083.0	1.034650E-03	
		3	-76.4570	-2.643200E-06	-67.1040	-2.273080E-08	-18107.0	1.038520E-03	2.757E-04
		DISP	-13.7740	.000000	-.196960	.000000	-1.536620E 02	.000000	
			13.8000	.000000	-.151870	.000000	-1.542870E-02	.000000	.000
140	.00000	2	77.5380	2.985050E-06	68.0770	-2.305610E-08	18345.0	1.049700E-03	
		3	-77.5380	-2.666510E-06	-68.0770	-2.379830E-08	-18370.0	1.053730E-03	2.682E-04
		DISP	-13.9740	.000000	-.202390	.000000	-1.558930E-02	.000000	
			-14.0000	.000000	-.156660	.000000	-1.565290E-02	.000000	.000
142	.00000	2	78.6190	3.060900E-06	69.0500	-2.344520E-08	-18606.0	1.065410E-03	
		3	-78.6190	-2.732430E-06	-69.0500	-2.467230E-08	-18632.0	1.069680E-03	2.621E-04
		DISP	-14.1730	.000000	-.207900	.000000	-1.581230E-02	.000000	
			-14.2000	.000000	-.161520	.000000	-1.587700E-02	.000000	.000
144	.00000	2	79.6990	3.098280E-06	70.0220	-2.402530E-08	-18866.0	1.084650E-03	
		3	-79.6990	-2.755770E-06	-70.0220	-2.527650E-08	-18894.0	1.089270E-03	2.561E-04
		DISP	-14.3730	.000000	-.213480	.000000	-1.603540E-02	.000000	
			-14.4000	.000000	-.166460	.000000	-1.610110E-02	.000000	.000
146	.00000	2	80.7790	3.132490E-06	70.9950	-2.509160E-08	-19130.0	1.096260E-03	
		3	-80.7790	-2.788720E-06	-70.9950	-2.619010E-08	-19156.0	1.100910E-03	2.504E-04
		DISP	-14.5720	.000000	-.219140	.000000	-1.625850E-02	.000000	
			-14.6000	.000000	-.171470	.000000	-1.632530E-02	.000000	.000
148	.00000	2	81.8570	3.166130E-06	71.9680	-2.559230E-08	-19392.0	1.119990E-03	
		3	-81.8570	-2.835340E-06	-71.9680	-2.669330E-08	-19418.0	1.124870E-03	2.449E-04
		DISP	-14.7720	.000000	-.224870	.000000	-1.648150E-02	.000000	
			-14.8000	.000000	-.176560	.000000	-1.654950E-02	.000000	.000
150	.00000	2	82.9350	3.181990E-06	72.9410	-2.660460E-08	-19654.0	1.129690E-03	
		3	-82.9350	-2.844960E-06	-72.9410	-2.780360E-08	-19681.0	1.134260E-03	2.396E-04
		DISP	-14.9720	.000000	-.230670	.000000	-1.670460E-02	.000000	
			-15.0000	.000000	-.181720	.000000	-1.677370E-02	.000000	.000
152	.00000	2	84.0130	3.251890E-06	73.9140	-2.641720E-08	-19915.0	1.140080E-03	
		3	-84.0130	-2.914890E-06	-73.9140	-2.761530E-08	-19943.0	1.144650E-03	2.345E-04
		DISP	-15.1710	.000000	-.236550	.000000	-1.692770E-02	.000000	
			-15.2000	.000000	-.186950	.000000	-1.699800E-02	.000000	.000
154	.00000	2	85.0890	3.252700E-06	74.8870	-2.687820E-08	-20177.0	1.140990E-03	
		3	-85.0890	-2.914880E-06	-74.8870	-2.776360E-08	-20205.0	1.145580E-03	2.288E-04
		DISP	-15.3710	.000000	-.242500	.000000	-1.715080E-02	.000000	
			-15.4000	.000000	-.192260	.000000	-1.722220E-02	.000000	.000
156	.00000	2	86.1650	3.309620E-06	75.8600	-2.779270E-08	-20439.0	1.149590E-03	
		3	-86.1650	-2.961520E-06	-75.8600	-2.848520E-08	-20467.0	1.154420E-03	2.241E-04
		DISP	-15.5710	.000000	-.248520	.000000	-1.737400E-02	.000000	
			-15.6000	.000000	-.197640	.000000	-1.744650E-02	.000000	.000
158	.00000	2	87.2400	3.387360E-06	76.8330	-2.800320E-08	-20701.0	1.171650E-03	
		3	-87.2400	-3.041100E-06	-76.8330	-2.899380E-08	-20729.0	1.176500E-03	2.196E-04
		DISP	-15.7700	.000000	-.254620	.000000	-1.759710E-02	.000000	
			-15.8000	.000000	-.203090	.000000	-1.767080E-02	.000000	.000
160	.00000	2	88.3140	3.408670E-06	77.8060	-2.879790E-08	-20962.0	1.181290E-03	
		3	-88.3140	-3.041150E-06	-77.8060	-2.982910E-08	-20992.0	1.186670E-03	2.153E-04
		DISP	-15.9700	.000000	-.260790	.000000	-1.782030E-02	.000000	
			-16.0000	.000000	-.208620	.000000	-1.789510E-02	.000000	.000
162	.00000	2	89.3870	3.470110E-06	78.7790	-2.989610E-08	-21224.0	1.201000E-03	
		3	-89.3870	-3.097440E-06	-78.7790	-3.108140E-08	-21254.0	1.206550E-03	2.110E-04
		DISP	-16.1700	.000000	-.267040	.000000	-1.804340E-02	.000000	
			-16.2000	.000000	-.214230	.000000	-1.811940E-02	.000000	.000
164	.00000	2	90.4600	3.541060E-06	79.7520	-3.104990E-08	-21486.0	1.223940E-03	
		3	-90.4600	-3.152770E-06	-79.7520	-3.200070E-08	-21516.0	1.229680E-03	2.070E-04
		DISP	-16.3690	.000000	-.273360	.000000	-1.826660E-02	.000000	
			-16.4000	.000000	-.219900	.000000	-1.834370E 02	.000000	.000
166	.00000	2	91.5320	3.555570E-06	80.7250	-3.236000E-08	21747.0	1.237280E-03	
		3	-91.5320	-3.163440E-06	-80.7250	-3.326860E-08	-21778.0	1.243390E-03	2.031E-04
		DISP	-16.5690	.000000	-.279750	.000000	-1.848960E-02	.000000	
			-16.6000	.000000	-.225650	.000000	-1.856810E-02	.000000	.000
168	.00000	2	92.6030	3.590900E-06	81.6990	-3.297610E-08	-22009.0	1.261130E-03	
		3	-92.6030	-3.196420E-06	-81.6990	-3.354290E-08	-22040.0	1.267350E-03	1.993E-04
		DISP	-16.7680	.000000	-.286220	.000000	-1.871290E-02	.000000	
			-16.8000	.000000	-.231480	.000000	-1.879240E-02	.000000	.000
170	.00000	2	93.6740	3.627730E-06	82.6720	-3.301210E-08	-22271.0	1.273700E-03	
		3	-93.6740	-3.229400E-06	-82.6720	-3.387910E-08	-22302.0	1.280050E-03	1.956E-04
		DISP	-16.9680	.000000	-.292760	.000000	-1.893610E-02	.000000	
			-17.0000	.000000	-.237390	.000000	-1.901680E-02	.000000	.000
172	.00000	2	94.7440	3.654760E-06	83.6450	-3.368000E-08	-22532.0	1.291090E-03	
		3	-94.7440	3.252730E-06	-83.6450	-3.487530E-08	-22565.0	1.297580E-03	1.921E-04
		DISP	-17.1680	.000000	-.299380	.000000	-1.915940E-02	.000000	
			-17.2000	.000000	.243350	.000000	-1.924120E-02	.000000	.000
174	.00000	2	95.8130	3.660480E-06	84.6160	-3.460730E-08	-22794.0	1.312610E-03	
		3	-95.8130	-3.252750E-06	-84.6160	-3.588950E-08	-22827.0	1.319280E-03	1.874E-04
		DISP	-17.3670	.000000	-.306070	.000000	1.938260E 02	.000000	
			-17.4000	.000000	.249400	.000000	-1.946560E-02	.000000	.000
176	.00000	2	96.8810	3.697950E-06	85.5910	-3.559700E-08	-23050.0	1.324730E-03	
		3	-96.8810	-3.285740E-06	-85.5910	-3.673670E-08	-23089.0	1.331530E-03	1.841E-04
		DISP	-17.5670	.000000	-.312830	.000000	-1.960580E-02	.000000	
			-17.6000	.000000	-.255520	.000000	-1.969010E-02	.000000	.000
178	.00000	2	97.9490	3.751000E-06	86.5640	-3.666140E-08	-23318.0	1.331740E-03	
		3	-97.9490	-3.342040E-06	-86.5640	-3.792770E-08	-23351.0	1.338460E-03	1.810E-04
		DISP	-17.7670	.000000	-.319670	.000000	-1.982910E-02	.000000	
			-17.8000	.000000	261720	.000000	1.991450E-02	.000000	.000

180	.00000		2	99.0160	3.788970E-06	87.5370	-3.887050E-08	-23579.0	1.344310E-03	
			3	-99.0160	3.365400E-06	-87.5370	-3.985590E-08	-23613.0	1.351460E-03	1.779E-04
		DISP		-17.9660	.000000	-.326580	.000000	-2.005230E-02	.000000	
				-18.0000	.000000	-.267990	.000000	-2.013900E-02	.000000	.000
182	.00000		2	100.080	3.823190E-06	88.5110	-3.983930E-08	-23841.0	1.365310E-03	
			3	-100.080	-3.412020E-06	-88.5110	-4.077770E-08	-23875.0	1.372140E-03	1.750E-04
		DISP		-18.1660	.000000	-.333560	.000000	-2.027560E-02	.000000	
				-18.2000	.000000	-.274330	.000000	-2.036340E-02	.000000	.000
184	.00000		2	101.150	3.880990E-06	89.4840	-4.098730E-08	-24103.0	1.382910E-03	
			3	-101.150	-3.455710E-06	-89.4840	-4.193200E-08	-24137.0	1.390090E-03	1.721E-04
		DISP		-18.3660	.000000	-.340620	.000000	-2.049890E-02	.000000	
				-18.4000	.000000	-.280750	.000000	-2.058790E-02	.000000	.000
186	.00000		2	102.210	3.962370E-06	90.4570	-4.176330E-08	-24364.0	1.389190E-03	
			3	-102.210	-3.538360E-06	-90.4570	-4.296540E-08	-24400.0	1.396420E-03	1.693E-04
		DISP		-18.5650	.000000	-.347750	.000000	-2.072210E-02	.000000	
				-18.6000	.000000	-.287240	.000000	-2.081250E-02	.000000	.000
188	.00000		2	103.280	3.974010E-06	91.4300	-4.362170E-08	-24626.0	1.418770E-03	
			3	-103.280	-3.528390E-06	-91.4300	-4.460140E-08	-24662.0	1.426410E-03	1.667E-04
		DISP		-18.7650	.000000	-.354930	.000000	-2.094540E-02	.000000	
				-18.8000	.000000	-.293800	.000000	-2.103700E-02	.000000	.000
190	.00000		2	104.340	4.036570E-06	92.4040	-4.452780E-08	-24887.0	1.435140E-03	
			3	-104.340	3.594740E-06	-92.4040	-4.592130E-08	-24924.0	1.443000E-03	1.641E-04
		DISP		-18.9640	.000000	-.362230	.000000	-2.116880E-02	.000000	
				-19.0000	.000000	-.300440	.000000	-2.126150E-02	.000000	.000
192	.00000		2	105.400	4.076050E-06	93.3770	-4.571440E-08	-25149.0	1.445640E-03	
			3	-105.400	-3.627750E-06	-93.3770	-4.709130E-08	-25186.0	1.453710E-03	1.615E-04
		DISP		-19.1640	.000000	-.369590	.000000	-2.139210E-02	.000000	
				-19.2000	.000000	-.307160	.000000	-2.148610E-02	.000000	.000
194	.00000		2	106.460	4.119780E-06	94.3500	-4.666040E-08	-25411.0	1.456790E-03	
			3	-106.460	-3.674410E-06	-94.3500	-4.764650E-08	-25448.0	1.464780E-03	1.591E-04
		DISP		-19.3640	.000000	-.377010	.000000	-2.161540E-02	.000000	
				-19.4000	.000000	-.313940	.000000	-2.171070E-02	.000000	.000
196	.00000		2	107.530	4.140430E-06	95.3240	-4.777290E-08	-25672.0	1.468650E-03	
			3	-107.530	-3.684110E-06	-95.3240	-4.873330E-08	-25710.0	1.476990E-03	1.567E-04
		DISP		-19.5630	.000000	-.384510	.000000	-2.183880E-02	.000000	
				-19.6000	.000000	-.320600	.000000	-2.193530E-02	.000000	.000
198	.00000		2	108.590	4.204000E-06	96.2970	-4.924080E-08	-25934.0	1.493580E-03	
			3	-108.590	-3.754110E-06	-96.2970	-5.030160E-08	-25972.0	1.501780E-03	1.544E-04
		DISP		-19.7630	.000000	-.392090	.000000	-2.206210E-02	.000000	
				-19.8000	.000000	-.327740	.000000	-2.215990E-02	.000000	.000
200	.00000		2	109.650	4.263510E-06	97.2700	-4.997150E-08	-26196.0	1.519270E-03	
			3	-109.650	-3.800820E-06	-97.2700	-5.109540E-08	-26234.0	1.526960E-03	1.522E-04
		DISP		-19.9630	.000000	-.399740	.000000	-2.228550E-02	.000000	
				-20.0000	.000000	-.334750	.000000	-2.238450E-02	.000000	.000

1 STRUCTURE . . : EXAMPLE I: ONE-STORY BUILDING — TIME: 9:18:33, DATE 5/24/96
SOLUTION... : INCREMENTAL DISPLACEMENT CONTROL AT JOINT 3 — TIME: 9:18:34, DATE 5/24/96

DEGREE OF FREEDOM # 15 IS READ FROM UNIT # 11 JOINT # 3, DIRECTION: FY

STEP	TIME	LOAD	DISPLACEMENT	VELOCITY	ACCELERATION
0	.00000	.00000	.00000	.00000	.00000
2	.00000	-2.2704	-.20000	.00000	.00000
4	.00000	-4.5408	-.40000	.00000	.00000
6	.00000	-6.8112	-.60000	.00000	.00000
8	.00000	-9.0814	-.80000	.00000	.00000
10	.00000	-11.352	-1.0000	.00000	.00000
12	.00000	-13.622	-1.2000	.00000	.00000
14	.00000	-15.892	-1.4000	.00000	.00000
16	.00000	-18.162	-1.6000	.00000	.00000
18	.00000	-20.432	-1.8000	.00000	.00000
20	.00000	-22.702	-2.0000	.00000	.00000
22	.00000	-24.972	-2.2000	.00000	.00000
24	.00000	-27.242	-2.4000	.00000	.00000
26	.00000	-29.512	-2.6000	.00000	.00000
28	.00000	-31.782	-2.8000	.00000	.00000
30	.00000	-34.052	-3.0000	.00000	.00000
32	.00000	-36.322	-3.2000	.00000	.00000
34	.00000	-38.592	-3.4000	.00000	.00000
36	.00000	-40.862	-3.6000	.00000	.00000
38	.00000	-43.132	-3.8000	.00000	.00000
40	.00000	-45.401	-4.0000	.00000	.00000
42	.00000	-47.671	-4.2000	.00000	.00000
44	.00000	-49.941	-4.4000	.00000	.00000
46	.00000	-52.211	-4.6000	.00000	.00000
48	.00000	-54.480	-4.8000	.00000	.00000
50	.00000	-56.750	-5.0000	.00000	.00000
52	.00000	-59.020	-5.2000	.00000	.00000
54	.00000	-61.289	-5.4000	.00000	.00000
56	.00000	-63.559	-5.6000	.00000	.00000
58	.00000	-65.829	-5.8000	.00000	.00000
60	.00000	-68.098	-6.0000	.00000	.00000
62	.00000	-70.368	-6.2000	.00000	.00000
64	.00000	-72.638	-6.4000	.00000	.00000
66	.00000	-74.907	-6.6000	.00000	.00000
68	.00000	-77.177	-6.8000	.00000	.00000
70	.00000	-79.446	-7.0000	.00000	.00000
72	.00000	-81.716	-7.2000	.00000	.00000
74	.00000	-83.986	-7.4000	.00000	.00000
76	.00000	-86.255	-7.6000	.00000	.00000
78	.00000	-88.525	-7.8000	.00000	.00000
80	.00000	-90.795	-8.0000	.00000	.00000
82	.00000	-93.064	-8.2000	.00000	.00000
84	.00000	-95.334	-8.4000	.00000	.00000
86	.00000	-97.604	-8.6000	.00000	.00000
88	.00000	-99.873	-8.8000	.00000	.00000
90	.00000	-102.14	-9.0000	.00000	.00000
92	.00000	-104.41	-9.2000	.00000	.00000
94	.00000	-106.68	-9.4000	.00000	.00000
96	.00000	-108.95	-9.6000	.00000	.00000

98	.00000	-111.22	-9.8000	.00000	.00000
100	00000	-113.49	-10.000	.00000	00000
102	00000	-115.76	-10.200	.00000	00000
104	00000	-118.03	-10.400	.00000	00000
106	00000	-120.30	-10.600	.00000	.00000
108	00000	-122.57	-10.800	.00000	00000
110	00000	-124.84	-11.000	.00000	00000
112	00000	-127.11	-11.200	.00000	00000
114	00000	-129.38	-11.400	.00000	.00000
116	00000	-131.65	-11.600	.00000	.00000
118	00000	-133.92	-11.800	.00000	.00000
120	00000	-136.19	-12.000	.00000	.00000
122	00000	-138.46	-12.200	.00000	.00000
124	.00000	-140.73	-12.400	.00000	.00000
126	00000	-143.00	12.600	.00000	00000
128	00000	-145.27	-12.800	.00000	.00000
130	00000	-147.54	-13.000	.00000	.00000
132	.00000	-149.81	-13.200	00000	.00000
134	.00000	-152.08	-13.400	.00000	.00000
136	.00000	-154.35	-13.600	.00000	.00000
138	.00000	-156.62	-13.800	.00000	.00000
140	.00000	-158.89	-14.000	.00000	.00000
142	.00000	-161.16	-14.200	.00000	.00000
144	.00000	-163.43	-14.400	.00000	.00000
146	.00000	-165.71	14.600	.00000	00000
148	.00000	-167.98	-14.800	.00000	.00000
150	.00000	-170.25	-15.000	.00000	.00000
152	.00000	-172.52	15.200	.00000	.00000
154	.00000	-174.79	-15.400	.00000	.00000
156	.00000	-177.06	15.600	.00000	.00000
158	.00000	-179.33	-15.800	.00000	.00000
160	.00000	-181.60	-16.000	.00000	.00000
162	.00000	-183.87	-16.200	.00000	.00000
164	.00000	-186.14	16.400	.00000	.00000
166	.00000	-188.41	-16.600	.00000	.00000
168	.00000	-190.69	-16.800	.00000	.00000
170	.00000	-192.96	-17.000	.00000	.00000
172	.00000	-195.23	-17.200	.00000	.00000
174	.00000	-197.50	-17.400	.00000	.00000
176	.00000	-199.77	-17.600	.00000	.00000
178	.00000	-202.04	-17.800	.00000	.00000
180	.00000	-204.31	-18.000	00000	.00000
182	.00000	206.59	-18.200	.00000	.00000
184	00000	-208.86	-18.400	.00000	.00000
186	00000	-211.13	-18.600	.00000	.00000
188	.00000	-213.40	-18.800	.00000	.00000
190	00000	-215.67	-19.000	00000	.00000
192	00000	-217.95	-19.200	00000	00000
194	.00000	-220.22	-19.400	.00000	.00000
196	.00000	-222.49	-19.600	00000	.00000
198	00000	-224.76	-19.800	00000	.00000
200	00000	-227.03	-20.000	00000	.00000

J. SHEAR WALL STATIC ANALYSIS

Description of Input Information

A shear wall structure (Fig. 62) is subjected to static loads. One shear wall and two 3DBEAM elements comprise the structural system. For 3DBEAM, elastic modulus is E=29000 ksi and shear modulus is G=13000 ksi. Cross-sectional area, torsional moment of inertia, and moment of inertia are $A=19.1$ in^2, $J=2.18$ in^4, $I_Y=533$ in^4, and $I_Z=174$ in^4, respectively. For shear wall, bending, shear, and axial material properties are BEND1, SHEAR1, and AXLMOD, respectively. Fraction of the length from the top to the internal springs is 1.0, and the axial load used to calculate the geometric stiffness is 69.21.

AXLMOD:	Ks=7000 kips/in	Kt=6000 kips/in	Kt2=60 kips/in		Fy=2000 kips
	$\alpha=0.9$	$\beta=0.2$ $\mu f=15$	βDI=0.2		
BEND1:	NSEG=4	NI=10	DY=0.7E-5 1/in	βDI=0.2	
P (kips-in):	2700	5000	6500	7000	
D (1/in):	0.2E-5	0.7E-5	1.7E-5	4E-5	
SHEAR1:	NSEG=4	NI=10	DY=1.0E-3 1/in	βDI=0.2	
P (kips-in):	80	150	180	200	
D (1/in):	0.3E-3	1.1E-2	2.3E-3	5E-3	

Note: While the input data can be used for inelastic analysis, only the elastic properties of the materials are used in this example.

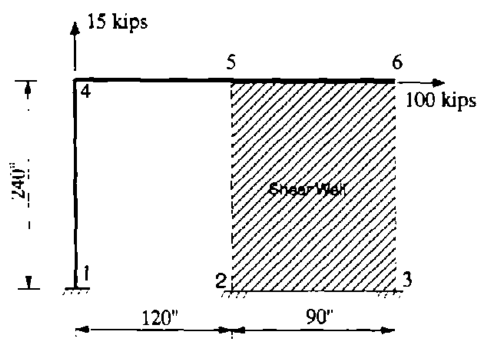


Figure 62. Shear Wall Static Analysis

Input and Output

Input

```
1    ECHO OF INPUT DATA

   LINE  .  ...10 ...:  .20 ..  .. 30.  .:  40   ... 50. . .  60  . .  70.  :.  80
     1:  'STRUCTURE DEFINATION'
     2:  'SHEAR WALL STATIC ANALYSIS'
     3:  6 1  6 0 1   1 00  NNODE,NCOS,NSUPT,NCOND,NCONST  SCALE
     4      1  0.00            0.00   0.00 1 0
     5      2  120.            0.00   0.00 1 0
     6      3  210.            0.00   0.00 1 0
     7      4  0.00            240.   0.00 1 0
     8.     5  120.            240.   0.00 1 0
     9.     6  210             240    0.00 1 0
    10.       1 0 0    0 1 0          ; DIRECTION COSINE
    11.     1  1 1 1 1 1 1    0 0       RESTRAINTS
    12:     2  1 1 1 1 1 1    0 0     ; RESTRAINTS
    13:     3  1 1 1 1 1 1    0 0     ; RESTRAINTS
    14.     4  0 0 1 1 1 0    0 0     ; RESTRAINTS
    15      5  0 0 1 1 1 0    0 0     ; RESTRAINTS
    16      6  0 0 1 1 1 0    0 0     ; RESTRAINTS
    17.     0  6  5  0          0
    18:    4  NMAT
    19: '3D-BEAM     # 1 '  29000 13000 19 1 19.1  19 1 2 18 533  174
    20: 'AXLMOD FOR WALL #2' 7000 6000 60  2000  0.9  0 2  15  0.2
    21  'BEND1  FOR WALL #3' 4  10  0.7E-05   0 2
    22     2700      5000      6500      7000
    23.    0.2E-05  0.7E-05  1.7E-05  4E-05
    24: 'SHEAR1 FOR WALL #4' 4  10  1.1E-03   0.2
    25:      90        150        160        200
    26.    0.3E-03  1.1E-03  2.3E-03  5E-03
    27:    1 1 1  FALSE.  KG
    28.    3   NELEM
    29  '3D-BEAM' 'SCO'  1  1  4   1   0   0  0 0  0   000000  0
    30  '3D-BEAM' 'SBE'  1  4  5   0   1   0  0 0  0   000000  0
    31. 'SHEAR WALL' 'SW1' 3 4 2  6 5 2 3  1  69.21  0
    32:  0 0 .FALSE.  MASS
    33:  0 0   DAMPING
    34: 'SOL01 '
    35: 'STATIC LOADING'
    36.    1  0          NLOADS, NMEMB
    37.   1  4 0 0 'FY'   15.00
    38    1  6 0 0 'FX'   100.0
    39:   0  0 0 0 'END'  0.
    40: 'STOP '
```

Output

```
1 STRUCTURE ...  SHEAR WALL STATIC ANALYSIS                                              TIME: 17:29  1, DATE   5/29/96
  SOLUTION  ...

 *** PROGRAM FEM ***        DOUBLE PRECISION VERSION


     NODE CONSTRAINTS

  NODE:      5 IS RESTRAINED, CONSTRAINT 3 IS IGNORED...
  NODE:      5 IS RESTRAINED, CONSTRAINT 4 IS IGNORED..
  NODE:      5 IS RESTRAINED, CONSTRAINT 5 IS IGNORED ..
   3D-RIGID BODY  CONSTRAINT, MASTER:      6 SLAVE:     5

    NODE COORDINATES AND DEGREES OF FREEDOM

    TOTAL NUMBER OF DEGREES OF FREEDOM ... .. ..       33
    NUMBER OF DEGREES OF FREEDOM CONDENSED OUT ...      0
    NUMBER OF FREE DEGREES OF FREEDOM ... .. ... ..     6
    NUMBER OF RESTRAINED DEGREES OF FREEDOM. ... ..    27

     NODE COS#    X-COORD       Y-COORD       Z-COORD        FX     FY     FZ     MX     MY     MZ
       1    1     .00000        .00000        .00000        7-R    8-R    9-R   10-R   11-R   12-R
       2    1     120.00        .00000        .00000       13-R   14-R   15-R   16-R   17-R   18-R
       3    1     210.00        .00000        .00000       19-R   20-R   21-R   22-R   23-R   24-R
       4    1     .00000        240.00        .00000        1      2     25-R   26-R   27-R    3
       5    1     120.00        240.00        .00000        4-C    5-C   28-R   29-R   30-R    6-C
       6    1     210.00        240.00        .00000        4      5     31-R   32-R   33-R    6
       NOTE: R - RESTRAINED DEGREE OF FREEDOM
             C - CONSTRAINED DEGREE OF FREEDOM

    DIRECTION COSINES ...

 COS( 1)   VX.  1.00000 I  + 00000 J  + 00000 K   VY.  .00000 I -1 00000 J  +.00000 K   VZ:   .00000 I  - 00000 J -1.00000 K
1 STRUCTURE .. . SHEAR WALL STATIC ANALYSIS                                            TIME. 17:29: 1, DATE.  5/29/96
  SOLUTION. ..

    3-D ELASTIC BEAM ELEMENT
    ************************

   MATL     E        GAMMA         AX         AY         AZ         IX         IY         IZ

     1 2.900E+04 1 300E+04  19 1       19 1       19.1       2.18       533        174

1 STRUCTURE  . : SHEAR WALL STATIC ANALYSIS                                            TIME: 17.29: 1, DATE.  5/29/96
  SOLUTION.. ..:
```

AXLMOD HYSTERESIS MODEL- FOR UNIT LENGTH MEMBER

MAT	SC	ST1	ST2	FY	ALPHA	BETA	MAX DUCT.	BETA-DI
2	7000.00	6000.00	60.0000	2000.00	.900000	.200000	15.0000	.200000

1 STRUCTURE ... SHEAR WALL STATIC ANALYSIS TIME: 17:29 1, DATE. 5/29/96
SOLUTION......

BEND1 HYSTERESIS MODEL DATA - UNIT LENGTH MEMBER

BACKBONE CURVE POINTS - MATL	NI	DY	BETA	MOMENT	ROTATION
3	10	.700000E 05	200000	2700.00	.200000E-05
				5000.00	.700000E-05
				6500.00	.170000E-04
				7000.00	.400000E-04

1 STRUCTURE. ...: SHEAR WALL STATIC ANALYSIS TIME: 17:29: 1, DATE: 5/29/96
SOLUTION.. . :

SHEAR1 HYSTERESIS MODEL DATA - UNIT LENGTH MEMBER

BACKBONE CURVE POINTS - MAT	NI	DY	BETA	STRESS	STRAIN
4	10	.10000E-02	.200000	80.0000	.300000E-03
				150.000	.110000E-02
				180.000	.230000E-02
				200.000	.500000E-02

1 STRUCTURE ... SHEAR WALL STATIC ANALYSIS TIME: 17.29 1 DATE: 5/29/96
SOLUTION. ....

GEOMETRIC STIFFNESS DATA

KGDATA(1)= 1, LOAD= F(INPUT)*(1.00+ACCEL)
F(INPUT) IS POSITIVE IN COMPRESSION
ACCEL IS POSITIVE GLOBAL Z-AXIS ACCELERATION
KGDATA(2)= 1, LUMPED FORMULATION
KGDATA(3)= 1, KG IS SUBTRACTED FROM ELEMENT STIFFNESS

- THE GEOMETRIC STIFFNESS MATRIX IS NOT CONDENSED WITH THE STRUCTURAL STIFFNESS MATRIX.
1 STRUCTURE. ...: SHEAR WALL STATIC ANALYSIS TIME. 17:29: 1, DATE: 5/29/96
SOLUTION.. ...:

ELEMENT 08, 3D BEAM ELEMENT

	#	MATL	START	END	REL CD	LENGTH	Y-AXIS	START DIST	END DIST	PKG
SCC	1	1	1	4		240.0	1.00000 I - 00000 J -.00000 K	0000	0000	.0000
SBE	2	1	4	5		120.0	.00000 I +1.00000 J -.00000 K	0000	.0000	.0000

1 STRUCTURE.. .. SHEAR WALL STATIC ANALYSIS TIME. 17.29. 1, DATE 5/29/96
SOLUTION .. .

ELEMENT 03, R/C SHEAR WALL ELEMENT

	ELEM #	BEND MATL	SHEAR MATL	AXIAL MATL	JOINT #1	JOINT #2	JOINT #3	JOINT #4	LENGTH	WIDTH	ALPHA	PKG
SW1	3	3	4	2	6	5	2	3	240.0	90.00	1.000	69.21

ZERO MASS MATRIX

PROPORTIONAL DAMPING COEFICIENTS

ALPHA= .00000 BETA= .00000

1 STRUCTURE ... SHEAR WALL STATIC ANALYSIS TIME 17:29: 1, DATE: 5/29/96
SOLUTION.... . STATIC LOADING TIME 17:29: 1, DATE: 5/29/96

SOLUTION #1, STATIC - ELASTIC ANALYSIS

NUMBER OF LOAD CASES . . 1
APPLIED JOINT LOADS

LOAD CASE 1 JOINT 4 DIRECTION. FY DOF(S) 2 MAGNITUDE 15.0000
LOAD CASE: 1 JOINT. 6 DIRECTION FX DOF(S) 4 MAGNITUDE 100.000
1 STRUCTURE ... SHEAR WALL STATIC ANALYSIS TIME 17 29. 1, DATE 5/29/9?
SOLUTION...... STATIC LOADING TIME 17 29. 1, DATE 5/29/96

GCS DISPLACEMENTS. LOADING # 1

NODE	DX	DY	DZ	RX	RY	RZ
1	.000000	.000000	.000000	.000000	.000000	.000000
2	.000000	.000000	.000000	.000000	.000000	.000000
3	.000000	.000000	.000000	.000000	.000000	.000000
4	1.06331	5.324801E-03	.000000	.000000	.000000	-4.364681E-03
5	1.06382	5.999706E-02	.000000	.000000	.000000	4.065306E-03
6	1.06382	.275861	.000000	.000000	.000000	4.065306E-03

1 STRUCTURE. .. SHEAR WALL STATIC ANALYSIS TIME. 17 29: 1, DATE: 5/29/96
SOLUTION .. STATIC LOADING TIME. 17:29: 1, DATE: 5/29/96

GCS RESTRAINT REACTIONS. LOADING # I

NODE	FX	FY	FZ	MX	MY	MZ

1	-2.363337	-12.28920	.0000000	.0000000	.0000000	375.3679
2	.0000000	252.7263	.0000000	.0000000	.0000000	.0000000
3	-97.94371	-255.4370	.0000000	.0000000	.0000000	.0000000
4	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
5	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
6	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
SUMMATION	-100.3070	-14.59998	.0000000	.0000000	.0000000	-22939.26

1 STRUCTURE.. : SHEAR WALL STATIC ANALYSIS TIME 17:29: 1, DATE. 5/29/96
SOLUTION. . : STATIC LOADING TIME. 17:29: 1, DATE 5/29/96

3D BEAM FORCES

ELEMENT	LOAD		NODE	AXIAL	FY	FZ	TORSION	MY	MZ
1	1	FORCE	1	-12.2892	2.36334	.000000	.000000	.000000	-375.368
		FORCE	4	12.2892	2.36334	.000000	.000000	.000000	-191.833
2	1	FORCE	4	-2.36387	2.71080	.000000	.000000	.000000	-191.833
		FORCE	5	2.36367	-2.71080	.000000	.000000	.000000	517.129

1 STRUCTURE ...: SHEAR WALL STATIC ANALYSIS TIME: 17:29 1, DATE: 5/29/96
SOLUTION.. ...: STATIC LOADING TIME: 17.29 1, DATE. 5/29/96

R/C SHEAR WALL FORCES...

ELEMENT	LOAD	JNT-1	JNT-2	JNT-3	JNT-4	MOMENT	ROTATION	SHEAR	SHEAR DISPL.	AXIAL	AXIAL DISPL
3	1	6	5	2	3	-22867.3	-4.065306E-03	-97.9437	-8.814933E-02	2.71080	9.294173E-02

THE STATICS STRAIN ENERGY OF SYSTEM = 53.39

Drawing of Internal Forces

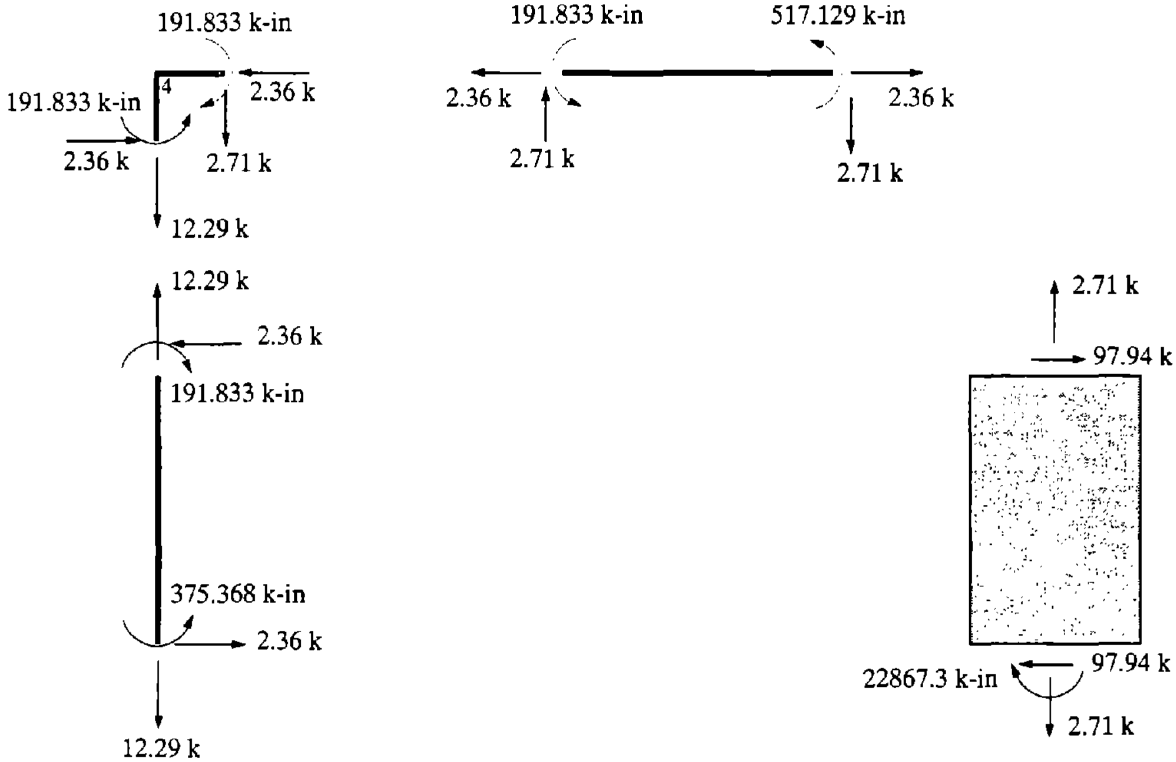


Figure 63. Drawing of Internal Forces

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APPENDIX A

DUCTILITY AND EXCURSION RATIO

Three definitions of ductility are considered in this study. First and most common is the displacement definition shown in Figure A1. Let displacement ductility be defined as

$$\mu_1 = \frac{|\Delta_{max}|}{\Delta_y} \qquad \text{(A-1)}$$

when Δ_{max} represents maximum displacement, rotation or strain in the structure or element, and Δ_y is yield displacement, rotation or strain. Ductility for the elastic 3D prismatic beam element is not calculated. For the reinforced concrete shear wall element, ductility is calculated for the bending, shear and axial components of deformation. The type of spring element determines if ductility is calculated for axial, shear, torsional or rotational deformation.

Cheng et al. (14, 9) have proposed several energy-based ductility definitions. Both variable strain energy and constant strain energy formulations are used in this study. Figure A2 shows the variable strain energy definition of ductility which is defined as

$$\mu_2 = 1 + \frac{PSE}{ESE} \qquad \text{(A-2)}$$

where PSE corresponds to the plastic strain energy for the current half cycle. The constant strain energy definition of ductility is shown in Figure A3 and defined as

$$\mu_3 = 1 + \frac{PSE}{CSE} \qquad \text{(A-3)}$$

where CSE is the constant strain energy corresponding to displacement at yield.

For each ductility ratio, a corresponding excursion ratio exists; this ratio is given by

$$\varepsilon = \sum (\mu - 1) \qquad \text{(A-4)}$$

and the summation is carried out for each half cycle.

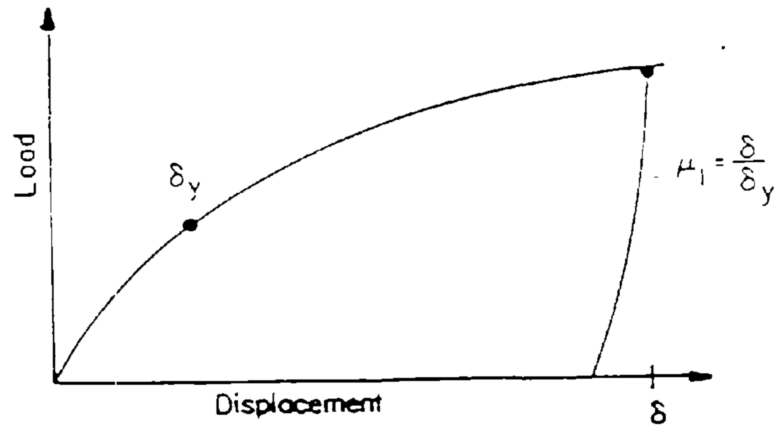

Figure A1. Displacement Definition of Ductility

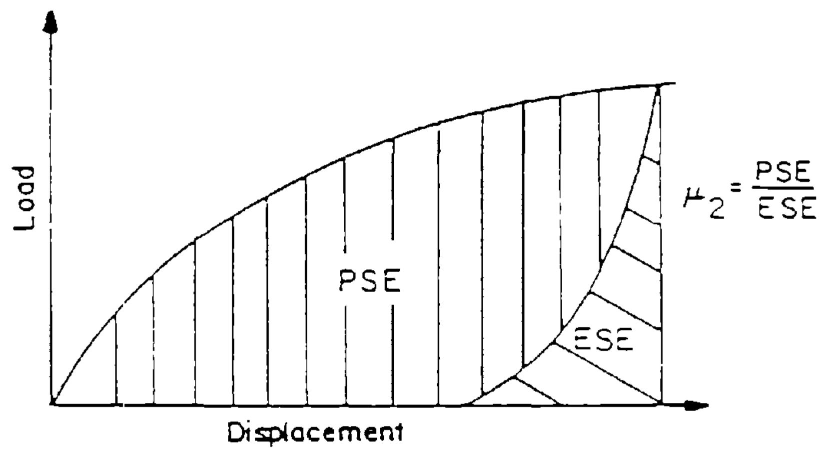

Figure A2. Variable Strain Energy Definition of Ductility

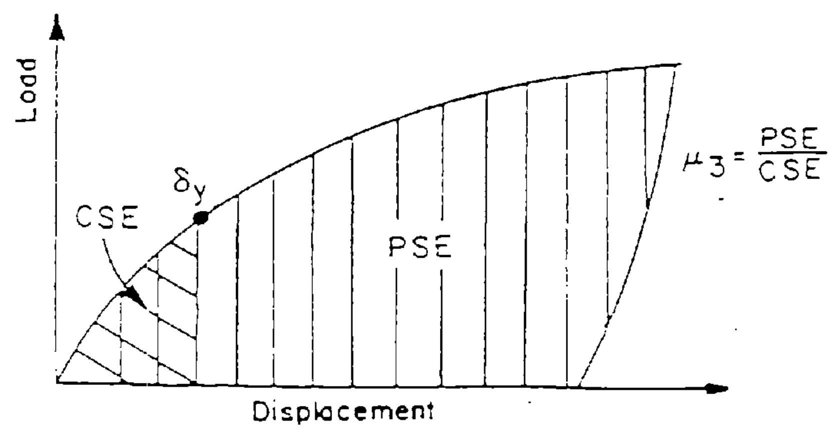

Figure A3. Constant Strain Energy Definition of Ductility

APPENDIX B

DAMAGE INDEX

Damage index is a parameter developed by Ang et al. to assess the damage in a structure (22, 23, 1). Total damage or collapse is indicated by a damage index greater than 1.0. Let damage index be defined as

$$DI = \frac{\Delta_{max}}{\Delta_{ult}} + \frac{\beta}{F_y \Delta_{ult}} \int_0^t d(PSE) \qquad \text{(A-5)}$$

where Δ_{max} is maximum displacement, Δ_{ult} is failure displacement under monotonic loading, F_y is yield force, and β is a hysteretic energy coefficient. For RC shear walls, Sheu (24) determined β=0.20, based on NCKU walls SW1a through SW6.

For the elastic 3D prismatic beam element, the damage index is not calculated. For the reinforced concrete shear wall element, the damage index is calculated independently for the bending, shear and axial components of deformation. The type of spring element determines if damage index is calculated for axial, shear, torsional or rotational deformation. For each of the shear wall element's components and for the spring element, a damage index is printed in the output. For the entire structure, the damage index is calculated by taking a weighted average of each individual component's damage index where total strain energy, SE_i, for each component is used as the weighting factor. Thus

$$DI = \frac{\sum SE_i DI_i}{\sum SE_I} \qquad \text{(A-6)}$$

where the summation is carried out for all members. A sample calculation of the damage index is included in Section B.1 of Chapter VI.

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13. ABSTRACT *(Maximum 200 words)*

This report serves as a user's guide to the computer program INSRED-3D-SUPII for analyzing elastic and inelastic building systems subject to static loading, dynamic forces, multi-component earthquake motion, and pseudo-static cyclic loading. The program is also capable of calculating inelastic post-buckling behavior of steel members and systems as well as free vibration. A joint-based system is used to define the geometry of a structure. Structural members may be elastic 3D prismatic beams, nonlinear RC shear walls, nonlinear springs, inelastic 3D-beam-column elements, finite-segment elements, and nonlinear bracing elements. System formulation has the following attributes: 1) joint-based degrees of freedom, 2) rigid body and planar constraints, 3) incremental nonlinear static solution, 4) unbalanced load correction for overshooting, 5) incremental nonlinear dynamic solution, 6) mass and stiffness proportional damping, 7) condensation to reduce the size of a dynamic problem, 8) energy balance, 9) damage index, and 10) ductility and excursion ratio for various definitions of displacement, constant strain energy, and variable strain energy. This program allows efficiency in both computation and data preparation. Output solutions include static results of member forces and joint displacements as well as dynamic results of member forces, joint displacements, ductility factors, excursion ratios, damage indices, seismic input energy, and dissipated energy. Major features of the report include a description of the program, instructions for data preparation, and a guide to modify the program's dynamic storage.

14. SUBJECT TERMS

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