MODERN STEEL CONSTRUCTION

July 1993 $3.00

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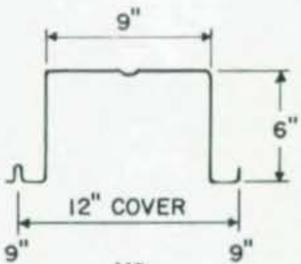
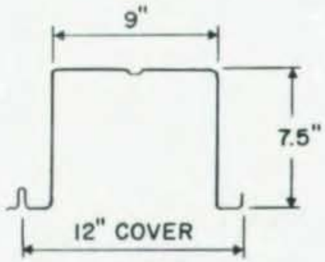
DECK DESIGN DATA SHEET

No. 19

DEEP DECK – 6" and 7.5" H



H6



H7.5

32' Maximum piece length.

Profile	Gage	Wt., psf	Section Properties			Allowable End Reaction, lbs. Bearing Width		
			Ip	Sp	Sn	3"	4"	5"
H6	18	4.5	7.28	2.24	2.36	690	780	870
	16	5.5	9.79	2.90	2.99	1210	1350	1480
H7.5	18	5	12.17	3.02	3.15	640	720	810
	16	6	16.22	3.92	4.04	1140	1270	1400

SINGLE SPAN TOTAL LOADS, PSF

Profile	Gage	Span														
		18'	19'	20'	21'	22'	23'	24'	25'	26'	27'	28'	29'	30'	31'	32'
H6	18	77	73	69	*62*	*55*	*49*	*45*	*41*	*37*	*34*	*32*	*30*	*28*	*26*	*25*
	16	119	107	*95*	*84*	*75*	*68*	*61*	*56*	*51*	*47*	*44*	*41*	*39*	*36*	*34*
H7.5	18	71	67	64	61	58	56	53	51	49	47	46	44	43	41	39
	16	127	120	114	109	104	99	91	*83*	*76*	*69*	*64*	*59*	*54*	*51*	*48*

Notes: Loads controlled by 3" end bearing are underlined.
Loads controlled by deflection (L/240) are shown in *italics*.
All other loads are controlled by bending. 10 psf has been added to deflection loads to account for roofing dead load. The designer is urged to check the fastener uplift resistance.

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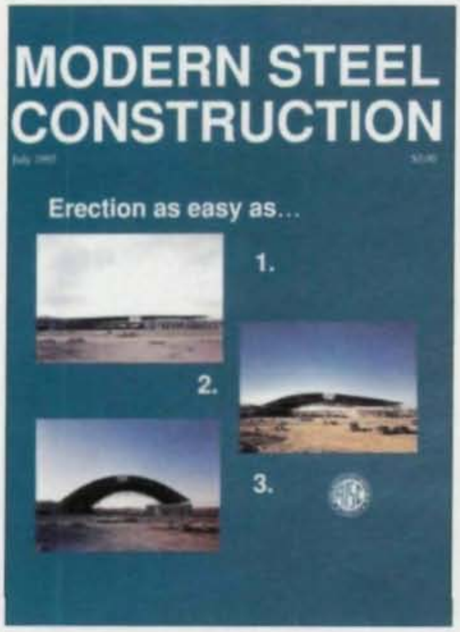
MODERN STEEL CONSTRUCTION

Volume 33, Number 7 July 1993



Using the STRARCH system, a 320'-wide hangar begins as a flat truss of nearly 400'. Tension is applied to prestressing strands, which forces the truss-frames to begin arching. One end of the truss is fixed, while the other slides nearly 70' while the arch rises 72'. The story behind the unique building system begins on page 32.

FEATURES

NEWS AND DEPARTMENTS

Modern Steel Construction (Volume 33, Number 7). ISSN 0026-8445. Published monthly by the American Institute of Steel Construction, Inc. (AISC), One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001.

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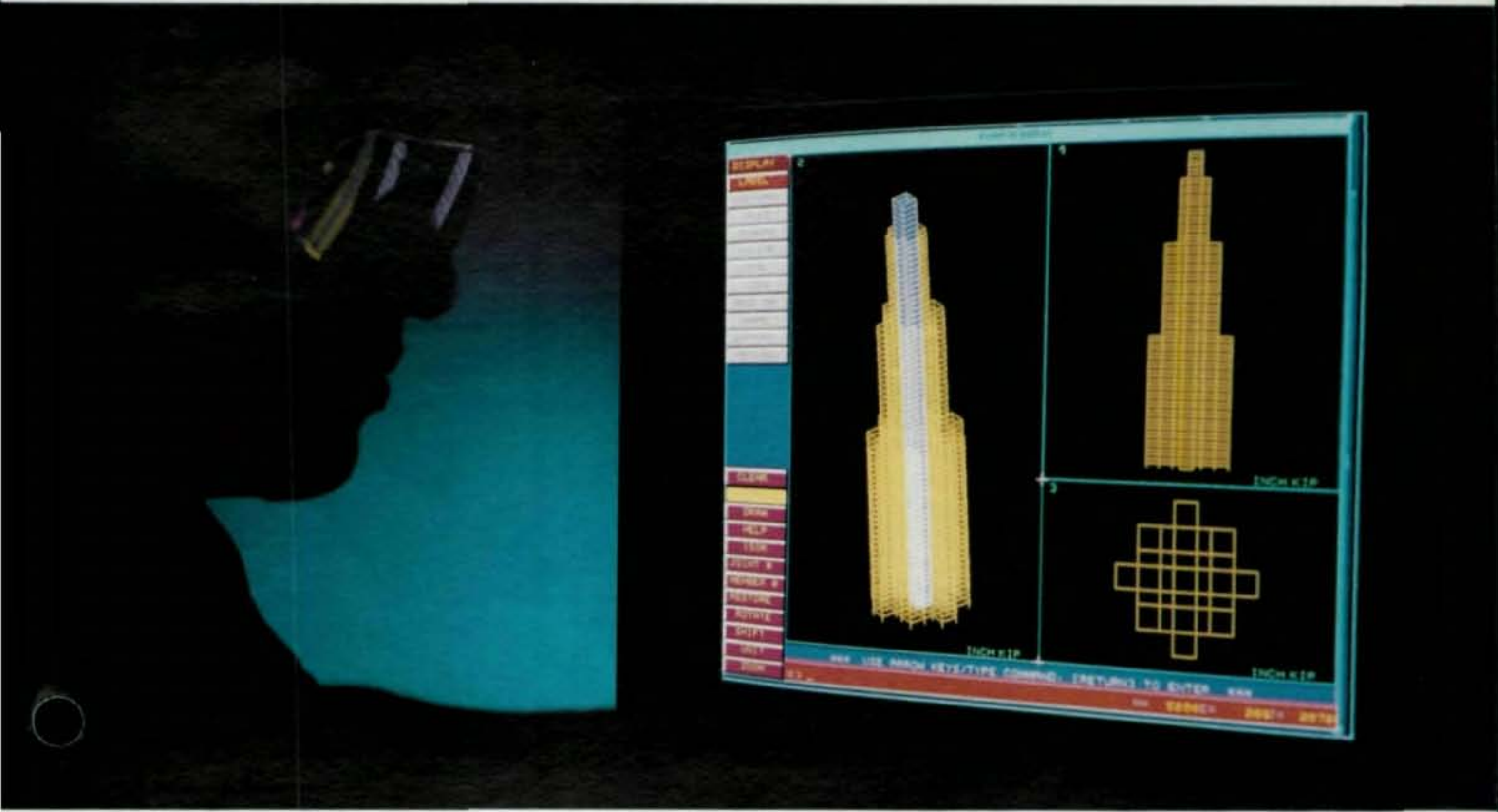

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Computers Can't Replace Innovative Design

Friday afternoons often seem the time to wax philosophical. The work week is winding down, and I'm always trying (and usually failing) to clear off my desk so I can have a fresh start on Monday. It's also a time to chat with the AISC engineers down the hall.

The topic last Friday was professionalism, and the question came up whether the increased use of new software programs was changing the structural engineers role from that of designer to that of merely a technician. The discussion was of particular interest to me, given this issue's product emphasis on engineering software. But while it's true that engineers today can rely on their computers for the nitty-gritty calculation work, I see too many examples of innovative design to believe that engineers are simply becoming sophisticated technicians.

And this month's feature stories provide vivid examples of the type of innovation and creativity that make structural engineering such an exciting profession. This issue features three stories about airport hangar design. While the owner's needs for all three structures are similar, the engineers designing the buildings took three very different approaches to these long-span structures.

We kick off with James O'Kon's story about a re-thinking of the very shape required for a hangar. Rather than design a standard rectangular building, his firm considered the shape of an airplane itself, and then designed a structure around that shape, with the goal to minimize wasted space. The result, a trapezoid, initially reduces cladding needs and in the long-run cuts cooling and heating costs.

Our second story, by Anne Anderson, describes the use of an Australian system designed to minimize construction time. Using the STRARCH system, a large truss was constructed near ground level. Then, using prestressing cables, the truss was forced into a 72'-high arch shape. The contractor estimated that this innovative system cut construction time by 30%.

The third story, by W. Scott Wilhoite and Steven Fenner, features a fairly conventional hangar design—with one twist: the need to meet extensive seismic requirements. And while the engineers did make substantial use of computer technology, the project complexity belies any thought of relegating the engineer to mere technician status.

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Steel Interchange

Steel Interchange is an open forum for *Modern Steel Construction* readers to exchange useful and practical professional ideas and information on all phases of steel building and bridge construction. Opinions and suggestions are welcome on any subject covered in this magazine. If you have a question or problem that your fellow readers might help to solve, please forward it to *Modern Steel Construction*. At the same time feel free to respond to any of the questions that you have read here. Please send them to:

Steel Interchange
Modern Steel Construction
1 East Wacker Dr.
Suite 3100
Chicago, IL 60601

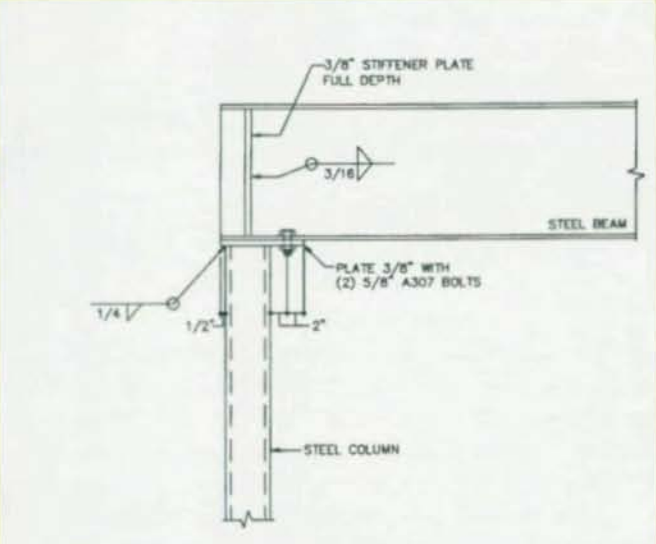
Answers and/or questions should be typewritten and double spaced. Submittals that have been prepared by word-processing are appreciated on computer diskette (either as a Wordperfect file or in ASCII format).

The opinions expressed in *Steel Interchange* do not necessarily represent an official position of the American Institute of Steel Construction, Inc. and have not been reviewed. It is recognized that the design of structures is within the scope and expertise of a competent licensed structural engineer, architect or other licensed professional for the application of principles to a particular structure.

Information on ordering AISC publications mentioned in this article can be obtained by calling AISC at 312/670-2400 ext. 433.

The following responses to questions from previous Steel Interchange columns have been received:

When designing a horizontal beam resting on columns with an unbraced compression top flange, may full-height web stiffeners at the bearing ends provide bracing to the compression flange without any intersecting beams? (See Detail)



COLUMN TO BEAM CONNECTION

The purpose of bracing the compression flange of a beam in bending is that this flange acts as a column and so is predisposed to buckle. The beam's web prevents buckling in the flange's weak direction; so it buckles sideways —about its strong axis (the beam's weak axis). (This is called "lateral torsional buckling" because the beam will twist as it buckles in this manner.) To prevent this, the compression flange must be braced.

However, the flange at the end of a simply supported beam is not in compression and doesn't need to be braced for this purpose. The web stiffener could help prevent web buckling if shear were high, but based on the very light connection detail shown, it's obvious that this is not a consideration.

Normally, the bracing utilized for situations where it is necessary is another compression member (i.e. a brace, not a stiffener) that is capable of resisting a small fraction of the flange compression force in the lateral direction. The actual design of such bracing is beyond the scope of this letter, but is described in books on structural steel design.

Mark W. Cunningham
Worcester, MA

Is it permissible to weld nuts to bolts to prevent them from backing off? Are any special welding procedures required? Is the bolt/nut strength affected?

There are countless thousands of examples where all kinds of bolts and/or nuts have been successfully welded to each other and/or to the connected parts: to preventing the nut from backing off; for holding the bolt in place during erection; for holding the fastener when there is no access to the far side of the assembled member; or, for sealing the fastener to make it air or water tight.

However, it is not recommended that welding be added to supplement the strength of a threaded fastener, for instance, where bolt threads are required, but fail, to engage the full threading of the nut.

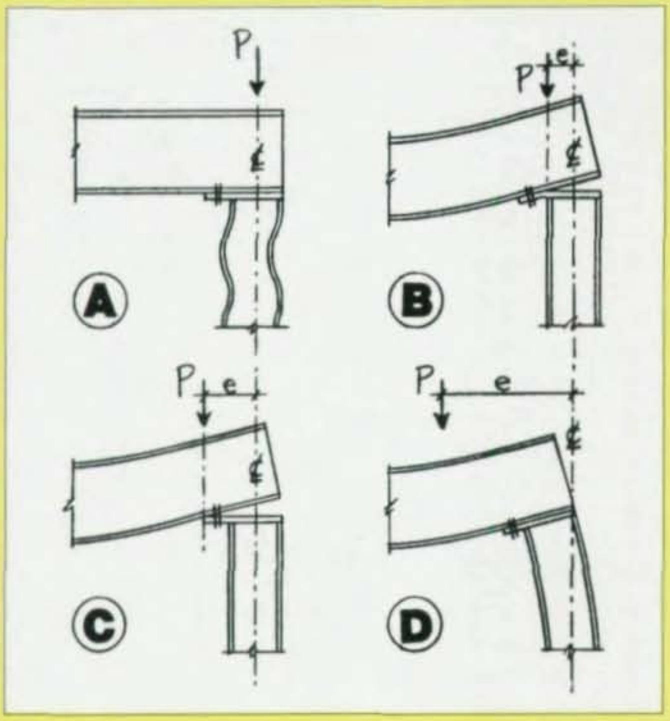
Column anchor bolts, not subject to significant uplift, have been successfully welded to column base plates via heavy washers to prevent shifting of the base, but this is a special case requiring engineering judgement. A column anchor bolt can be extended utilizing a properly executed groove weld.

David T. Ricker
Payson, AZ

Consider eccentricity and what has to be done to accommodate it in various connections.

The determination of eccentricity and its importance require value judgements on the part of the designer. Even the most ordinary connection details

Steel Interchange



provide a system complex enough for illustrative purposes. In the hypothetical detail shown, the eccentricity is a function of the designed relative stiffness of the various components.

In Figure A, the load is applied near the column centerline when the beam stiffness is high and the column stiffness is low. The column cap plate stiffness is inconsequential.

In Figure B, the load is applied out near the column face when the beam stiffness is low, the column stiffness is high and the cap plate stiffness is low, causing yielding of the cap plate at the column face.

In Figure C, the load is applied further out, near the outer edge of the cap plate when the beam stiffness is low and the column and cap plate stiffnesses are high. The bolt stiffness is assumed to be low for the sake of the discussion.

In Figure D, the load is applied theoretically further out still, potentially beyond the connection itself when the beam and column stiffness are low. In this case, the eccentricity is the bending moment transferred to the column divided by the load magnitude. The cap plate stiffness is inconsequential.

More variations on this theme are possible in this detail but unnecessary to the discussion. Other apparently ordinary details can be subjected to this type of examination. Often, however, they are not. This examination is usually reserved for those classic details in which eccentricity of load application is an obvious and routine part of the detail design. It is nevertheless the responsibility of the designer to determine when this is necessary.

The AISC Specification provides guidelines for classifying connection details according to the degree with which eccentricity is involved. The reader is referred to the Types of Construction section in the General Provisions of the Specification in both the ninth edition of the Allowable Stress Design Manual and the first edition of the Load and Resistance Factor Design Manual. A comparison of the two is interesting. In the ASD Specification, connections are classified as either rigid, semi-rigid, or simple. In the LRFD Specification, connections are classified as fully restrained or partially restrained, with simple connections being a special case of partial restraint. The evolution of the terminology is also interesting, with emphasis moving away from the classification of simple vs. fixed to a desire to identify the degree of partial restraint involved.

As more precise determinations of partial restraint become common place in the design office, it will increasingly be the responsibility of the designer to make value judgements about how eccentricity of load application is involved, when it is to be considered to be critical and to design the connection components accordingly.

David B. Morris, P.E.
St. Paul MN

New Question

Listed below is a question we would like the readers to answer or discuss. If you have an answer or suggestion please send it to the Steel Interchange Editor, Modern Steel Construction, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001.

Questions and responses will be printed in future editions of Steel Interchange. Also, if you have a question or problem that readers might help solve, send these to the Steel Interchange Editor.

There is a dearth of information related to the preparation of a pin hole in a lifting lug. We would like an opinion and sources of information that would answer the following question:

If a pin hole in a lifting lug is flame-cut, should the net section be reduced to compute the capacity of the lug?

Thank you very much for making available to the profession a wide variety of opinions in this matter.

Richard W. Frazee, P.E.
Dossett Engineering Co.
Maryland Heights, MO

Note: Maximum lenghts of shapes obtained vary with producer, but typically range from 60' to 75'. Please consult individual producers for unusual lengths.

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Y. Bayou Steel Corp.

Section Weight Per Ft.	Producer Code
W44x335*	T
W44x290*	T
W44x262*	T
W44x230*	T
W44x198-285	T***
W40x297-655	T***
W40x294-561	T***
W40x192-328	T***
W40x321,372,431,503*, 593	T
W40x278,331,392,466*	T
W40x297	N**, T***
W40x277	N**, T
W40x264*	B, T
W40x249	N**, T
W40x235*	B, T
W40x215	N**, T
W40x211*	B, T
W40x199	N**, T
W40x174*	T
W40x149-183	B, I, N**, T
W36x798-848	T
W36x720	T***
W36x650	T
W36x588	T***
W36x527	T
W36x485	T***
W36x439	T
W36x393	B, T
W36x328-359	B, I, T
W36x260-300	B, I, N**, T
W36x232, 256	B, I, T***
W36x135-230, 245	B, I, N**, T
W33x387-619	T***
W33X263-354	B, T
W33x201-241	B, N**, T
W33x169	B, T
W33x118-152	B, I, N**, T
W30x581,526	T***
W30x477	T
W30x433	T***
W30x391	T
W30x357	T***
W30x261, 292, 326	B, T
W30x284*	I
W30x173-235	B, I, N**, T
W30x165*	T***
W30x148	B, I, T
W30x99-132	B, I, N**, T
W30x90	B, N**, T***
W27x539	T
W27x494	T***
W27x448	T
W27x407	T***
W27x368	T
W27x336	T***
W27x307	T
W27x281	T***
W27x258	N**, T
W27x235	N**, T***
W27x146-217	B, N**, T
W27x132*	I
W27x129	B, I, T, W
W27x84-114	B, I, N**, T, W
W24x492	T
W24x450	T***
W24x408	T
W24x370	T***
W24x335	T
W24x306	T***
W24x279	T
W24x250	N**, T***, W
W24x229	N**, T, W
W24x207	N**, T***, W
W24x192	I, N**, T, W
W24x176	B, I, N**, T, W
W24x104-162	B, I, N, T, W
W24x103	B, T***, W
W24x84-94	B, I, N, W
W24x55-76	B, C, I, N, W
W21x182-201	I, W
W21x166	B, I, W
W21x83-147	B, I, N, W
W21x44-73	B, C, I, N, W
W18x258-311	B
W18x175-234	B, W
W18x130-158	B, N**, W
W18x76-119	B, N, W
W18x65-71	B, I, N, W
W18x35-60	B, C, I, N, W
W16x67-100	B, N, W
W16x57	B, I, N, W
W16x26-50	B, C, I, N, W
W14x808*	B
W14x342-730	B, I, T
W14x311	B, I, T, W
W14x145-283	B, I, N**, T, W
W14x90-132	B, I, N, T, W
W14x82	B, N, W
W14x74	B, C, I, N, W
W14x61-68	B, C, N, W
W14x43-53	B, C, I, N, W
W14x38	B, I, N, W
W14x22-34	B, C, I, N, W
W12x252-336	B, T***
W12x210-230	B, T
W12x170-190	B, I, T, W
W12x136-152	B, I, N**, T, W
W12x65-120	B, I, N, T, W

Notes: * Shapes not currenlty listed in Manual of Steel Construction
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S. North Star Steel
T. TradeARBED
U. Nucor Steel
W. Northwestern Steel & Wire
Y. Bayou Steel Corp.

Section Weight Per Ft.	Producer Code
W12x50-58	B, C, I, N, W
W12x16-45	B, C, N, W
W12x14	B, C, W
W10x88-112	B, I, N, W
W10x49-77	B, C, I, N, W
W10x33-45	B, C, N, W
W10x22-30	B, C, I, N, W
W10x15-19	B, C, I, W
W10x12	B, C, W
W8x31-67	B, C, I, N, W
W8x18-28	B, C, N, W
W8x15	B, C, W, Y
W8x10-13	B, C, M, W, Y
W6x15-25	B, C, I, N, W
W6x12-16	B, C, W, Y
W6x9	B, C, M, W, Y
W6x8.5*	C, M, Y
W5x16-19	B
W4x13	B, C, M, Y
S 24x80-121	B, W
S 20x66-96	B, W
S 18x54.7-70	B, W
S 15x42.9-50	B, W
S 12x31.8-50	B, W
S 10x25.4-35	B, S,
S 8x18.4-23	B, C, S
S 6x12.5-17.25	C, S, Y
S 5x10	C, Y
S 4x9.5	C
S 4x7.7	C, Y
S 3x7.5	C
S 3x5.7	C, M, Y
M 12x10.8-11.8	C
M 10x8-9	C
M 8x6.5	C
M 5x18.9	B
HP14x73-117	B, I, N, W
HP 12x53-84	B, I, N, W
HP 10x42-57	B, I, C, N, W
HP 8x36	B, I, C, N, W
C 15x33.9-50	B, N**, W
C 12x30	B, W
C 12x20.7-25	B, C, S, W
C 10x25-30	B, S. W
C 10x15.3-20	B, C, S, W
C 9x20	B
C 9x13.4-15	B, S
C 8x18.75	S, W, Y
C 8x11.5-13.75	C, M, S, U, W, Y
C 7x12.25	S, U, W
C 7x9.8	M, S, U, W
C 6x13	M, S, U, W, Y
C 6x10.5	C, M, S, U, W, Y
C 6x8.2	C, F, M, U, W, Y
C 5x9	M, U, W, Y
C 5x6.7	F, M, U, W, Y
C 4x5.4-7.25	F, U, M, W, Y
C 3x6	M, W, U, Y
C 3x4.1-5	F, M, R, U, W, Y
MC 18x42.7-58	B, N**
MC 13x31.8-50	B, N**
MC 12x31-50	B, N**
MC 12x10.6	S
MC 10x22-41.1	B
MC 10x8.4	S
MC 9x23.9-25.4	B
MC 8x18.7-22.8	B, S
MC 8x8.5	M
MC 7x19.1-22.7	B
MC 6x18	B
MC 6x12-16.3	B, S
MC 4x13.8*	S
MC 3x7.1*	S

Section By Leg Length & Thickness		Producer Code
L8x8x	1⅛	B
	1	B, S
	⅞	B, S
	¾	B, S
	⅝	B, S
	9/16	B, S
	½	B, S
L6x6x	1	B, U, Y
	⅞	B, U, Y
	¾	B, M, U, Y
	⅝	B, M, U, Y
	9/16	B, M, U, Y
	½	B, M, S, U, Y
	7/16	B, M, U, Y
	⅜	B, M, S, U, Y
	5/16	M, U, Y
L5x5x	⅞	B, U, Y
	¾	B, M, U, Y
	⅝	B, M, U, Y
	½	B, M, U, W, Y
	7/16	B, M, U, Y
	⅜	B, M, U, W, Y
	5/16	B, M, U, W, Y
L4x4x	¾	M, U, Y
	⅝	M, U, Y
	½	F, M, R, U, W, Y

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F. Florida Steel Corp.	N. Nucor-Yamato Steel	T. TradeARBED	Y. Bayou Steel Corp.

Section By Leg Length & Thickness		Producer Code
	7/16	F, M, U, Y
	3/8	F, M, R, U, W, Y
	5/16	F, M, R, U, W, Y
	1/4	F, M, R, U, W, Y
L3½x3½x	1/2	F, M, R, U, W, Y
	7/16	U, Y
	3/8	F, M, R, U, W, Y
	5/16	F, M, R, U, W, Y
	1/4	F, M, R, U, W, Y
L3x3x	1/2	F, M, U, W, Y
	7/16	U, Y
	3/8	F, M, R, S, U, W, Y
	5/16	F, M, R, S, U, W, Y
	1/4	F, M, R, S, U, W, Y
	3/16	F, M, R, U, W, Y
L2½x2½x	1/2	F, U
	3/8	F, S, U
	5/16	F, S, U
	1/4	F, S, U
	3/16	F, U
L2x2x	3/8	F, S, U
	5/16	F, S, U
	1/4	F, S, U
	3/16	F, S, U
	1/8	F, S, U
L8x6x	1	B, S
	7/8	B
	3/4	B, S
	5/8	B
	9/16	B, S
	1/2	B, S
	7/16	B, S
L8x4x	1	B, S
	7/8*	B, S
	3/4	B, S
	5/8*	B, S
	9/16	B, S
	1/2	B, S
	7/16*	B, S
L7x4x	3/4	B, Y
	5/8	B, Y
	1/2	B, S, Y
	7/16*	B, Y
	3/8	B, S, Y
L6x4x	7/8	B
	3/4	B, M, S, U, W, Y
	5/8	B, M, S, U, W, Y
	9/16	B, M, U, Y
	1/2	B, M, S, U, W, Y
	7/16	B, U, Y
	3/8	B, M, S, U, W, Y
	5/16	B, M, S, U, W, Y
L6x3½x	1/2	M, U, W, Y
	3/8	B, M, U, W, Y
	5/16	B, M, U, W, Y
L5x3½x	3/4	M, U, Y
	5/8	M, U, Y
	1/2	M, U, W, Y
	3/8	M, U, W, Y
	5/16	M, U, W, Y
	1/4	M, U, W, Y
L5x3x	1/2	F, M, U, W, Y
	7/16	F, Y
	3/8	F, M, U, W, Y
	5/16	F, M, U, W, Y
	1/4	F, M, U, W, Y
L4x3½x	1/2	F, M, U, W
	3/8	F, M, R, U, W
	5/16	F, M, R, U, W
	1/4	F, M, R, U, W
L4x3x	5/8	M, U, Y
	1/2	F, M, U, W, Y
	7/16	U, Y
	3/8	F, M, R, U, W, Y
	5/16	F, M, R, U, W, Y
	1/4	F, M, R, U, W, Y
L3½x3x	1/2	U, W
	3/8	M, U, W
	5/16	M, U, W
	1/4	M, U, W
L3½x2½x	1/2	U
	3/8	U
	1/4	U
L3x2½x	1/2	U
	3/8	U, W
	5/16	U, W, Y
	1/4	R, U, W
	3/16	U
L3x2x	1/2	F, U
	3/8	F, S, U
	5/16	F, S, U
	1/4	F, R, S, U
	3/16	F, R, U
L2½x2x	3/8	R, S, U
	5/16	S, U
	1/4	R, S, U
	3/16	R, S, U

Notes: * Shapes not currenlty listed in Manual of Steel Construction
** Mill is scheduled to begin rolling these shapes in 1993
*** Only available through the end of 1993

Principal Producers Of Structural Tubing (TS)

A. Acme Roll Forming
B. Bull Moose
C. Copperweld Corp.
D. Dallas Tube & Rollform
E. Eugene Welding Co.
H. Hanna Steel Corp.
I. Independence Tube Corp.
P. IPSCO Steel
U. UNR-Leavitt, Div. of UNR Inc.
V. Valmont Industries Inc.
W. Welded Tube Co. of America
X. EXLTUBE

Size	Producers
30x30x⅝	V*
28x28x⅝	V*
26x26x⅝	V*
24x24x⅝, ½, ⅜	V*
22x22x⅝, ½, ⅜	V*
20x20x⅝, ½, ⅜	V*
18x18x⅝, ½, ⅜	V*
16x16x⅝	V*
16x16x½, ⅜, 5/16	V*, W
14x14x⅝	V*
14x14x½, ⅜	V*, W
14x14x5/16	W
12x12x⅝	B
12x12x½, ⅜	B, V*, W
12x12x5/16, ¼	B, W
10x10x⅝	B,C
10x10x½, ⅜, 5/16, ¼	B, C, P, U, W
10x10x3/16	B, C, P, W
8x8x⅝	B, C
8x8x½	B, C, P, U, W
8x8x⅜, 5/16, ¼, 3/16	B, C, D, P, U, W
7x7x⅝	B
7x7x½	B, C, P, U, W
7x7x⅜, 5/16, ¼, 3/16	B, C, D, P, U, W
6x6x⅝	B
6x6x½	B, C, P, U, W
6x6x⅜, 5/16	B, C, D, I, P, U, W
6x6x¼, 3/16	A, B, C, D, I, P, U, W, X
6x6x⅛	A, B, C, I, P
5½x5½x⅜, 5/16, ¼, 3/16, ⅛	B, I
5x5x½	B, C, P, U, W
5x5x⅜, 5/16	B, C, D, I, P, U, W
5x5x¼	A, B, C, D, I, P, U, W, X
5x5x3/16	A, B, C, D, I, P, U, V, W, X
5x5x⅛	A, B, C, I, P, V, W
4½x4½x⅜, 5/16	I, P, W
4½x4½x¼, 3/16	A, B, C, D, I, P, W, X
4½x4½x⅛	A, B, C, P, I, W
4x4x½	B, C, P, U, W
4x4x⅜, 5/16	A, B, C, D, E, I, P, U, W
4x4x¼, 3/16, ⅛	A, B, C, D, E, I, P, U, V, W, X
3½x3½x5/16	A, B, C, E, I, P, U, W
3½x3½x¼, 3/16	D, P, X
3x3x5/16	I, P, W
3x3x¼, 3/16	A, B, C, D, E, I, P, U, W, X
3x 3x⅛	A, B, C, D, E, I, P, U, W
2½x2½x5/16	I
2½x2½x¼, 3/16	A, B, C, D, E, I, P, U, V, W, X
2½x2½x⅛	A, B, C, D, E, I, P, U, V, W
2x2x5/16	I, V
2x2x¼	A, B, C, D, I, U, V, W, X
2x2x3/16	A, B, C, D, E, I, P, U, V, W, X
2x2x⅛	A, B, C, D, E, I, P, U, V, W, X
1½x1½x3/16	B, E, P, U, V
30x24x½, ⅜, 5/16	V*
28x24x½, ⅜, 5/16	V*
26x24x½, ⅜, 5/16	V*
24x22x½, ⅜, 5/16	V*
22x20x½, ⅜, 5/16	V*
20x18x½, ⅜, 5/16	W
20x12x½, ⅜, 5/16	W
20x8x½, ⅜, 5/16	W
20x4x½, ⅜, 5/16	W
18x12x½, ⅜, 5/16	V*
18x6x½, ⅜, 5/16	B, W
18x6x¼	B
16x12x½, ⅜, 5/16	V*, W
16x8x½, ⅜, 5/16	B, W

Notes: *Size is manufactured by Submerged Arc Welding (SAW) process and are not stocked by steel service centers (contact producer for specific requirements. All other sizes are manufactured by Electric Resistance Welding and most are available from steel service centers.

Principal Producers Of Structural Tubing (TS)

A. Acme Roll Forming
B. Bull Moose
C. Copperweld Corp.
D. Dallas Tube & Rollform
E. Eugene Welding Co.
H. Hanna Steel Corp.
I. Independence Tube Corp.
P. IPSCO Steel
U. UNR-Leavitt, Div. of UNR Inc.
V. Valmont Industries Inc.
W. Welded Tube Co. of America
X. EXLTUBE

16x4x1/2, 3/8, 5/16	B, W
14x12x1/2, 3/8	V*
14x10x1/2, 3/8, 5/16	B, W
14x6x5/8	B
14x6x1/2, 3/8, 5/16, 1/4	B, W
14x4x5/8	B
14x4x1/2, 3/8, 5/16, 1/4	B, W
14x4x3/16	B
12x10x1/2, 3/8, 5/16, 1/4	B
12x8x5/8	B
12x8x1/2, 3/8, 5/16, 1/4	B, C, U, W
12x8x3/16	B, C, W
12x6x5/8	B
12x6x1/2, 3/8, 5/16, 1/4	B, C, U, W
12x6x3/16	B, C, W
12x4x5/8	B
12x4x1/2, 3/8, 5/16, 1/4, 3/16	B, U, W
12x3x5/16, 1/4, 3/16	B
12x2x1/4, 3/16	B, U
10x8x1/2, 3/8, 5/16, 1/4, 3/16	B, C, U, W
10x6x1/2,	
10x6x3/8, 5/16, 1/4, 3/16	B, C, D, P, U, W
10x5x3/8, 5/16, 1/4, 3/16	B, C, D
10x4x1/2	B, C, P, U, W
10x4x3/8, 5/16, 1/4, 3/16	B, C, D, P, U, W
10x2x3/8, 5/16	D
10x3x1/4, 3/16	B, D
10x2x5/16	P, W
10x2x1/4, 3/16	B, D, P, U, W
8x6x1/2	B, C, P, U, W
8x6x3/8, 5/16, 1/4, 3/16	B, C, D, P, U, W
8x4x5/8	B
8x4x1/2	B, C, P, U, W
8x4x3/8, 5/16	B, C, D, H, I, P, U, W
8x4x1/4, 3/16	A, B, C, D, H, I, P, U, W, X
8x4x1/8	A, B, D, I, P
8x3x1/2	C, P, U
8x3x3/8, 5/16	B, C, D, H, I, P, U, W
8x3x1/4, 3/16	A, B, C, D, H, I, P, U, W
8x3x1/8	A, B, C, D, I, P
8.x2x3/8	H
8x2x5/16	H, I, P, W
8x2x1/4, 3/16	A, B, D, H, I, P, U, W
8x2x1/8	A, B, D, I, P
7x5x1/2	B, C, P, U, W
7x5x3/8, 5/16	B, C, I, P, U, W
7x5x1/4, 3/16	A, B, C, H, I, P, U, W
7x5x1/8	A, B, C, I, P
7x4x3/8, 5/16	B, C, D, H, I, P, U, W
7x4x1/4, 3/16	A, B, C, D, H, I, P, U, W, I
7x4x5/16	A, B, C, H, I, P
7x3x3/8, 5/16	B, C, D, H, I, P, W
7x3x1/4, 3/16	A, B, C, H, I, P, W, X
7x3x1/8	A, B, C, D, H, I, P
6x4x1/2	B, C, P, U, W
6x4x3/8, 5/16	B, C, D, H, I, P, U, W
6x4x1/4	A, B, C, D, H, I, P, U, W, X
6x4x3/16	A, B, C, D, H, I, P, U, V, W, X
6x4x1/8	A, B, C, D, H, I, P, V, W
6x3x1/2	P, U
6x3x3/8, 5/16	B, D, H, I, P, U
6x3x1/4	A, B, C, D, H, I, P, U, X
6x3x3/16	A, B, C, D, H, I, P, U, W, X
6x3x1/8	A, B, C, D, H, I, P, W
6x2x3/8	H
6x2x5/16	H, I, P, W
6x2x1/4, 3/16	A, B, C, D, E, H, I, P, U, W, X
6x2x1/8	A, B, C, D, E, H, I, P, U, W
5x4x3/8, 5/16	I, P, W
5x4x1/4, 3/16	B, C, D, I, P, U, W
5x3x1/2	C, P, U
5x3x3/8, 5/16	B, C, D, H, I, P, U, W
5x3x1/4, 3/16	A, B, C, D, E, H, I, P, U, W, X
5x3x1/8	A, B, C, D, E, H, I, P, U, W
5x2x5/16	I, P, W
5x2x1/4, 3/16	A, B, C, D, E, H, I, P, U, W, X
5x2x1/8	A, B, C, D, E, H, I, P, U, W
4x3x5/16	B, I, P, W
4x3x1/4, 3/16	A, B, C, D, E, H, I, P, U, W, X
4x3x1/8	A, B, C, D, E, H, I, P, U, W
4x2x3/8	H
4x2x5/16	H, I, P, W
4x2x1/4, 3/16	A, B, C, D, E, H, I, P, U, W, X
4x2x1/8	A, B, C, D, E, H, I, P, U, W
3x2x5/16	I
3x2x1/4, 3/16	A, B, C, D, E, H, I, P, U, V, W, X
3x2x1/8	A, B, C, D, E, H, I, P, U, V, W
2 1/2x1 1/2x1/4, 3/16	H, X

Principal Producers Of Steel Tubing (Round)

C. Copperweld Corp.
P. IPSCO Steel
U. UNR-Leavitt, Div. of UNR Corp.
V. Valmont Industries, Inc.
W. Welded Tube Co. Of America
X. EXLTUBE

Size	Producers
20.000x.500, .375, .250	P*, W
18.000x.500, .375, .250	P*, W
16.000x.500	P*, W
16.000x.375, .250	P, W
16.000x.188	P, V*
16.000x.125	V*
14.000x.500, .438, .375, .250	P, W
14.000x.188	P, V*
14.000x.125	V*
12.750x.500, .406, .375	P, W
12.750x.188, .125	P, V*
10.750x.500, .365, .250	P, W
10.000x.625, .500, .375, .312	C
10.000x.250, .188	C, V
10.000x.125	V
9.625x.500	C, U
9.625x..375, .312, .250, .188	P, U
8.625x.500	C, P, U
8.625x.375, .322	C, P, U, W
8.625x.250, .188	C, P, U, V, W
8.625x.125	P, V, W
7.000x.500	C, P, U
7.000x.375, .312, .250	C, P, U, W
7.000x.188	C, P, U, V, W
7.000x.125	C, P, V, W
6.625x.500, .432	P, U
6.625x.375, .312, .280	P, U, W
6.626x.250, .188	P, U, V, W
6.625x.125	P, V, W
6.000x.500, .375, .312	W
6.000x.280	X
6.000x.250, .188, .125	V, W
5.563x.375	P, U
5.563x.258	P, U, V, W
5.563x.134	P, V, W
5.000x.500, .375, .312	P, C, W
5.000x.258	P, X
5.000x.250, .188	C, P, U, V, W
5.000x.125	P, U, V, W
4.500x.237, .188, .125	P, U, V, W
4.000x.250, .266, .188, .125	U, V, W
4.000x.237, .337	
3.500x.318	X
3.500x.300	P, W
3.500x.250, .203, .188, .125	P, U, V, W
3.500x.216	P, X
3.000x.300, .216	X
2.875x.276	W
2.875x.250, .203, .188, .125	P, U, V, W
2.375x.250, .218, .188	P, V, W
2.375x.154, .125	P, U, V, W

Notes: *Indicates size is manufactured by Submerged Arc Welding (SAW) Process and is typically not stocked by steel service centers. Other sizes are manufactured by Electric Resistance Welding and typically are available from steel service centers. For more information contact the manufacturer or the American Institute for Hollow Structural Sections (412) 221-8880.

Also, other sizes and wall thicknesses may be available. Contact an individual manufacturer for more details.

Structural Steel Shape Producers

Bayou Steel Corp.
P.O. Box 5000
Laplace, LA 70068
(800) 535-7692

Bethlehem Steel Corp.
301 East Third St.
Bethlehem, PA 18016-7699
(800) 633-0482

British Steel Inc.
475 N. Martingale Road #400
Schaumburg, IL 60173
(800) 542-6244

Chaparral Steel Co.
300 Ward Road
Midlothian, TX 76065-9501
(800) 529-7979

Florida Steel Corp.
P.O. Box 31328
Tampa, FL 33631
(800) 237-0230

Northwestern Steel & Wire Co.
121 Wallace St.
P.O. Box 618
Sterling, IL 61081-0618
(800) 793-2200

North Star Steel Co.
1380 Corporate Center Curve
Suite 215
P.O. Box 21620
Eagan, MNB 55121-0620
(800) 328-1944

Nucor Steel
P.O. Box 126
Jewett, TX 75846
(800) 527-6445

Nucor-Yamato Steel
P.O. Box 1228
Blytheville, AR 72316
(800) 289-6977

Roanoke Electric Steel Corp.
P.O. Box 13948
Roanoke, VA 24038
(800) 753-3532

SMI Steel, Inc.
101 South 50th St.
Birmingham, AL 35232
(800) 621-0262

TradeARBED
825 Third Ave.
New York, NY 10022
(212) 486-9890

Structural Tube Producers

American Institute for
Hollow Structural Sections
929 McLaughlin Run Road, Suite 8
Pittsburgh, PA 15017
(412) 221-8880

Acme Roll Forming Co.
812 North Beck St.
Sebewaing, MI 48759-0706
(800) 937-8823

Bull Moose
57540 SR 19 S
P.O. Box B-1027
Elkhart, IN 46515
(800) 348-7460

Copperweld Corp.
7401 South Linder Ave.
Chicago, IL 60638
(800) 327-8823

Dallas Tube & Rollform
P.O. Box 540873
Dallas, TX 75354-0873
(214) 556-0234

Eugene Welding Co.
P.O. Box 249
Marysville, MI 48040
(313) 364-7421

EXLTUBE, Inc.
905 Atlantic
North Kansas City, MO 64116
(800) 892-8823

Hanna Steel Corp.
3812 Commerce Ave.
P.O. Box 558
Fairfield, AL 35064
(800) 633-8252

Independence Tube Corp.
6226 west 74th St.
Chicago, IL 60638
(708) 496-0380

IPSCO Steel, Inc.
P.O. Box 1670, Armour Road
Regina, Saskatchewan S4P 3C7
CANADA
(416) 271-2312

UNR-Leavitt, Div. of UNR Inc.
1717 West 115th St.
Chicago, IL 60643
(800) 532-8488

Valmont Industries, Inc.
P.O. Box 358
Valley, NE 68064
(800) 8250-6668

Welded Tube Co. of America
1855 East 122nd St.
Chicago, IL 60633
(800) 733-5683

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For structural applications that demand greater strength, closer tolerances and ease of fabrication.

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Measures the strength of finished tubing. These exact properties are reported on our certifications.

the Tube People . . . Know that there is no substitute for experience. Our average employees service time is 20 years "plus". This kind of dedication assures you consistent, high quality tubing every time you order from Leavitt. Our staff of professionals offer you technical support and assistance in order to fulfill any of your special requirements. You'll get instant answers over the phone or in person from our inside or outside sales representatives — individuals who understand tubing from the manufacturing process through the end use application. Quality tubing products can only be produced through years of experience — with UNR-Leavitt you'll recognize the difference our experience makes.

ASTM A513 TYPES I & II MECHANICAL TUBING • ASTM A500 GRADES A, B AND C STRUCTURAL TUBING • HI-Y 50 STRUCTURAL PIPE • HSLA STRUCTURAL TUBING • ROPS • RACK TUBING • OCTG CASING (UNTESTED) • SIZES: SQUARES AND EQUIVALENT RECTANGLES: 1/2" x 1/2" TO 10" x 10"; ROUNDS: 3/8" TO 12¾" • WALL THICKNESSES: .018" (26 ga) TO .500" (1/2").

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GENERAL OFFICES
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1-800-L-E-A-V-I-T-T
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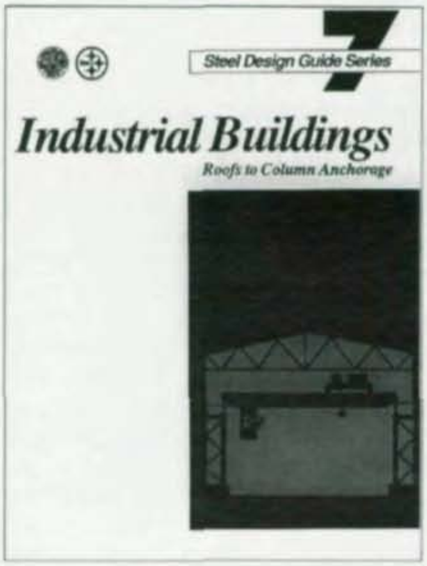
1
ABC 2
DEF 3
GHI 4
JKL 5
MNO 6

S T E E L   N E W S

New Guide Aids Design Of Industrial Buildings

A new 103-page publication from the American Institute of Steel Construction provides engineers, architects and fabricators with general guidelines and criteria for the design of industrial buildings. The new Guide is an upgrade and improvement of AISC's publication: *Light and Heavy Industrial Buildings.*

"It is essential to realize that most industrial buildings involve much more than structural design," according to the Guide's introduction. "The designer may assume an expanded role and may be responsible for site planning, establishing grades, handling surface drainage, parking, on-site traffic, building aesthetics, and, perhaps, landscaping. Access to rail and the establishment of proper floor elevations (depending on whether direct fork truck entry to rail cars is required) are important considerations. Proper clearances to sidings and special attention to curved siding and truck grade limitations are also essential."



Design Guide #7 will be available later this month for $16.

The *Steel Design Guide #7: Industrial Buildings (Roofs to Column Anchorage)* covers both industrial buildings without cranes and industrial buildings with light-to-medium duty cycle cranes. The Guide's authors are James M. Fisher, Ph.D., president of Computerized Structural Design, Milwaukee, and Donald R. Buettner, Ph.D., also of Computerized Structural Design.

For industrial buildings without cranes, the topics include: loading conditions and loading combinations; owner established criteria; roof systems; roof trusses; wall systems; framing schemes; bracing systems; column anchorage; and servicability criteria. For industrial buildings with cranes, the topics include: fatigue; rane induced loads and load combinations; roof systems; wall systems; bracing systems; crane runway design; crane runway fabrication and erection tolerances; column design; outside cranes; underhung crane systems; maintenance and repair; and design procedures.

Appendix A in the Guide includes detailed information on beam sections and channel sections, including axis X-X, axis X-Y, composite section data, and maximum spans. Appendix B is an article detailing the calculation of effective lengths of stepped columns.

"It's an important book for enveryone involved in industrial building design," according Patrick M. Newman, P.E., an AISC Senior Staff Engineer. "The Guide includes some new information on column anchorage design that isn't readily available elsewhere. Also, it includes information not only on strength, but also on serviceability. It's a one stop book for those involved in the structural design of industrial buildings."

Design Guide #7 is available for $16. For more information, call: AISC Publications at (312) 670-2400 extension 433.

After a short summer vacation, the **AISC Lecture Series** is scheduled to resume in September. During the first six months, the seminars have been an overwhelming success, often attracting more than 100 participants and very positive reactions.

"I was surprised that so many people wanted to here about such advanced subjects, but the response has been very positive," according to Charles Carter, an AISC Staff Engineer.

The seminars present information on eccentrically braced frames, partially restrained connections, low-rise buildings, and connection design. Registration is only $60 ($45 for AISC members). Included as part of the registration fee is a meal and more than a dozen handouts and publications, including: AISC Design Guide 5: Low & Medium Rise Buildings (a $16 value); ASD Simple Shear Connections (a $16 value); LRFD Simple Shear Connections (a $16 value); Seismic Provisions for Structural Steel (a $5 value). And pre-registrants also receive the other five AISC design guides (an $80 value).

Seminars are scheduled for:

Birmingham, AL	9/9
Miami	9/14
Orlando	9/16
Rochestor, NY	9/22
Albany, NY	9/23
Atlanta	9/28
Richmond, VA	9/30
Cleveland	10/19
Columbus, OH	10/20
Cincinnati	10/21

For more information, contact: Colleen Hays, American Institute of Steel Construction, Inc., One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001 (312) 670-2400; fax: 312/670-5403.

Steel Design Seminar Series—design of Steel Connections (conducted by the Steel Structures Technology Center). The one-day, professional level program will discuss joint analysis methods, design criteria and methods, constructability and economical design. Seminars are scheduled for:

Detroit	9/13
Chicago	9/15
Minneapolis	9/16
New York	10/4
North Haven, CT	10/5
Boston	10/6
Portland, ME	10/7
Portland, OR	10/25
Seattle	10/26
Kansas City	11/4
Costa Mesa, CA	11/29
Los Angeles	11/30
San Francisco	12/2
Sacramento	12/3

The fee for the seven-hour seminar is $145. For more information, contact: Steel Structures Technology Center, 40612 Village Oaks Dr., Novi, MI 48375 (313) 344-2910; fax: 313/344-2911.

Steel Bridge Forum (July 21 in Albany, NY). Seminar featuring information on: seismic retrofit of steel bridges; jointless bridges; NCHRP & FHWA curved girder steel bridge research; cost-effective design of girder bridges; bridge paint containment; and Albany County short span bridges. For more information, contact: Camille Rubeiz, American Iron and Steel Institute, 1101 17 Street, NW, Suite 1300, Washington, DC 20036-4700 (202) 452-7100; fax: 202/463-6573.

Amoco Building Recladding—*Lessons Learned* (November 11 in Chicago). All-day seminar discussing entire renovation project from design to the final recladding. Sponsored by Chicago Committee on High-Rise Buildings. For more information, contact: Ian Chin (312) 372-0555; fax: 312/372-0873.

Development & Design of Colorado Rockies Ballpark (November 5 in Westminster, CO). Breakfast seminar features both the structural engineer and a member of the Denver Ballpark Commission. For more information, contact: Jim Anders at (214) 369-0664.

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Fortuitous Location Wins An Unusual Job

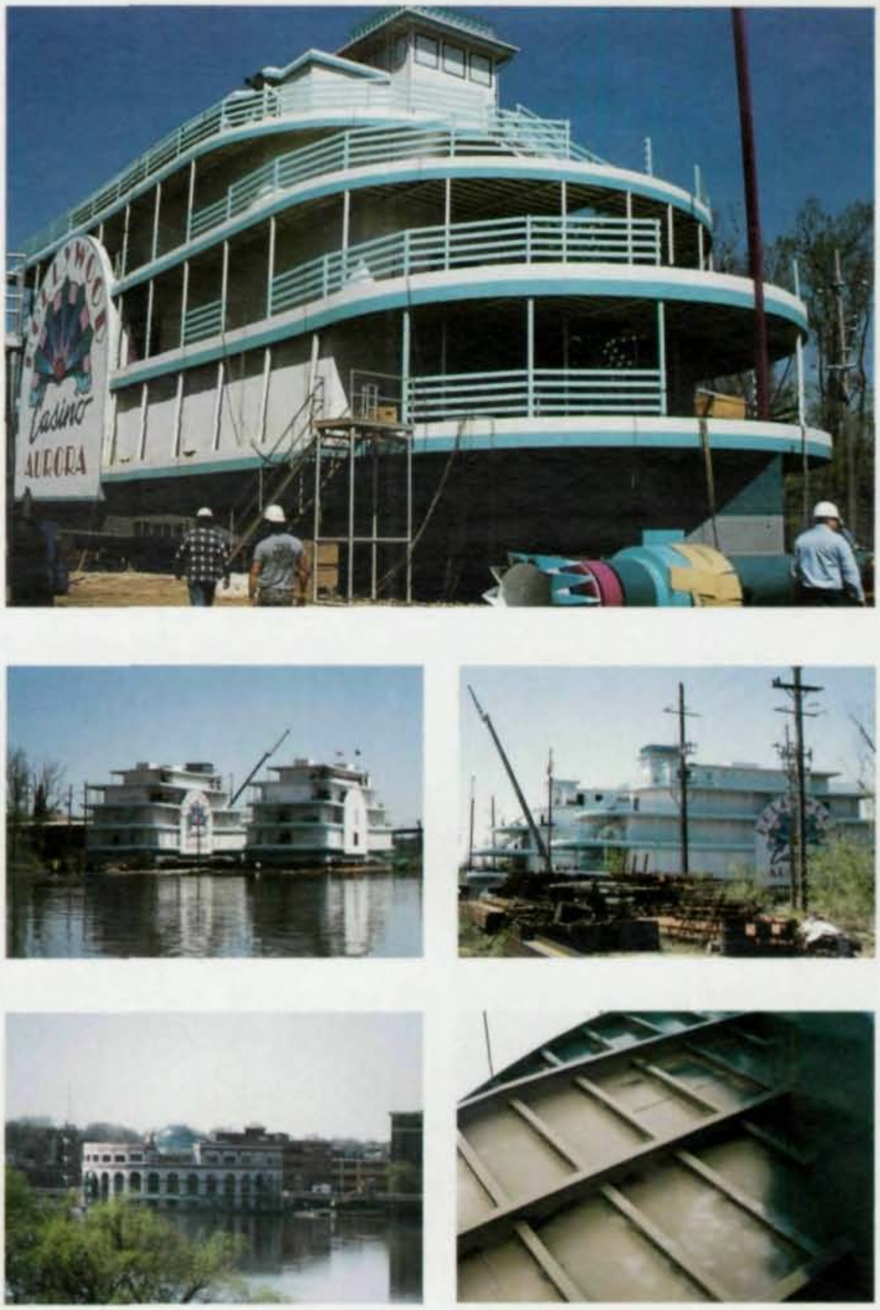
While Chicago may never rival Las Vegas as a gambling mecca, the advent of riverboat gambling is making it a lot easier for midwesterners to place a wager. The latest port of call for highroller-wannabes is Aurora, a quiet town on the Fox River about a 50-minute drive from downtown Chicago.

The two recently launched ships are closer in construction to land-based casinos than to the Queen Elizabeth II, which isn't surprising since they're only designed to sail between two fixed river bridges—a distance of less than a mile. And fittingly, the ships were built by a steel fabricator rather than in a shipyard.

"We were chosen for the job primarily because of our location," explained Bill Dyker, engineering manager with AISC-member Garbe Iron Works, Inc. The fabricator's shop is fortuitously located right on the banks of the river between the two bridges. The ships were constructed on top of flat rail trucks. Once construction was complete, rail track was layed from the ships down into the water. Finally, the blocks holding the cars in place were removed, and the ships slid into the river.

Each four-story-tall ship measures 145' in length with a maximum width of 45'. The bottom portion of the hull is stainless steel, while the upper portion of the hull plate is carbon steel. All of the hull plate is 3/16" thick. The plate was welded to panels in the shop and then brought outside to be erected. The main deck is 10 gauge plate, with 11 gauge plate stiffeners and 14 gauge reinforcement throughout. "It's very light construction," Dyker said.

"We used orthotropic construction, with tube columns, a central I-beam, and j-beams," he added. The majority of the framing is 3$\frac{5}{14}$" lightweight metal studs. Almost all of the connections are welded—a challenge for Garbe Iron, which more often than not uses fasteners for their building work.



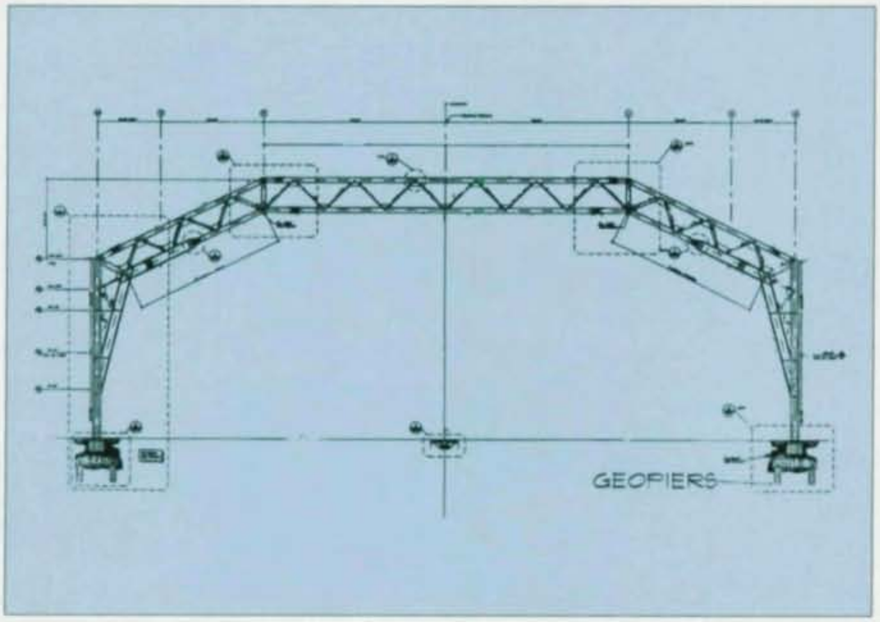
Shown above are various views of the riverboats and support building.

Another challenge was ensuring that the ships weight was kept to a minimum. "The ships are designed to weigh 385 tons without the gaming equipment," Dyker said. "When we suggested any changes, we had to be very conscious of that weight limit." For example, during construction Garbe wanted to reinforce the elevator shaft. "But it would have added more than 1,000 lbs. and we couldn't do it. What would have been a minor change on a building became a difficult challenge on a ship."

In addition to the two ships, Garbe also fabricated the steel for the casino support building, a much more conventional project.

A New Shape For Hangar Design

A trapezoidal design minimizes both exterior cladding needs and interior heating and cooling requirements



James A. O'Kon, P.E.

Although developments in aerospace design have produced remarkable advances in the aircraft capabilities, the design of maintenance facilities is only beginning to catch up.

Hangars today cannot simply be large, column-free spaces. Instead, they must be carefully designed to handle a wide variety of advanced systems, including: laminar flow HVAC systems to protect sensitive avionics, as well as the health of workers; AFFF pre-action fire protection systems; specialized 400 Hz and 28 volt electrical generating systems; and radio-controlled, full coverage, overhead lifting systems.

A prototype hangar is now under construction for a KC-135 aircraft that will not only provide all of this technology, but also will house it in a trapezoidal geometric configuration designed to minimize spatial requirements. Rather than the nearly 30,000 sq. ft. required for a rectangular box hangar, the trapezoidal hangar encapsulates only 17,600 sq. ft. As a result, both construction costs and heating/cooling costs are reduced.

The prototype was developed as part of a Fuel Cell Maintenance Facility for KC-135 Tanker Aircraft and was commissioned by the Mississippi Air National Guard at Meridian, MS.

Designing a trapezoidal hangar required new approaches in order to satisfy the dynamic loadings on the structural space frame, maintain quality assurance and control, and keep within a tight budget. It also required close cooperation between the architect, engineer and fabricator.

Structural Design

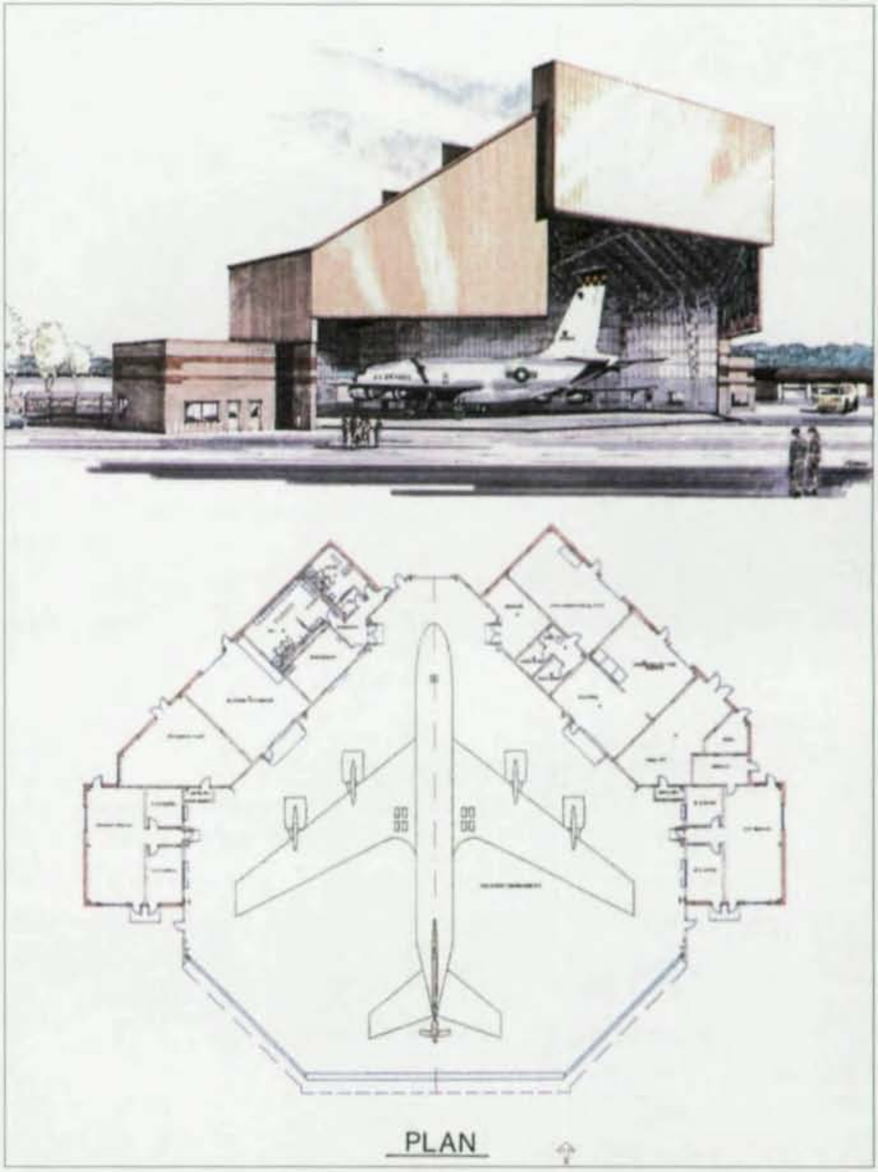
The structural steel superstructure with its trapezoidal cantilever configuration must resist a large range of loadings including the dynamic loads from the door systems, gravity loadings attendant to dead and live loading, horizontal seismic and wind forces, plus the large internal uplift forces generated by hurricane force winds with speeds up to 125 mph.

Interior dimensions of the hangar are determined by minimum clearance requirements required by aviation standards that require a 15′ clearance between the aircraft and the enclosure. This encapsulate criteria formula dictates both the size of the hangar and its truncated shape. For this project, however, the dimensions were increased due to the USAF requirement that the hangar be large enough to handle the larger KC-10 aircraft in the future. Therefore, the dimensions for this hangar were 161′-3″ wide by 159′-6″ long.

An important part of the design of the structure is the recognition that an aircraft hangar does not have to be a rectangular box. Once the size of the interior envelope was determined, the exterior configuration skin was fine-tuned to include roof slopes, openings and wall finishes. The structural skeleton of the hangar was then configured to follow the vertical and horizontal geometry established by the building envelope. To achieve the goal of optimum space utilization, the configuration was translated into a low-profile, three-dimensional space frame.

The principal members of this space frame are:

- Transverse Bent Truss. This 7′ deep truss with W14 chords and double angles spans across the width of the hangar and extends down to the foundation. This member is the principal resisting element for gravity, horizontal and uplift forces.
- Longitudinal Trusses. These paired 7′ deep trusses with W14 chords and double angles occupy the same plane as the transverse truss and cantilever 60′ across the



The trapezoidal design of this hangar in Meridien, MS, reflects the natrual dimensions of an airplane and therefore reduces the needed size of the building. As a result, in the short run exterior cladding needs are reduced and in the long run heating and cooling requirments are minimized.

transverse truss to support the door system. In the event that the facility is converted to accommodate larger aircraft, this member was designed to be expandable.

- Perimeter Trusses/Tension Trusses. A series of 7′ deep perimeter trusses with WT7 chords and double angles were established along door lines, and tension trusses were introduced to resist horizontal forces.
- Lateral Bracing Trusses. Trussed bracing were introduced into the side walls to resist lateral forces.

Another factor in the structural design criteria was the desire to minimize the height of the structure. A low profile reduces the cost of cladding, reduces wind forces, and reduces the interior volume that needs to be heated or cooled.

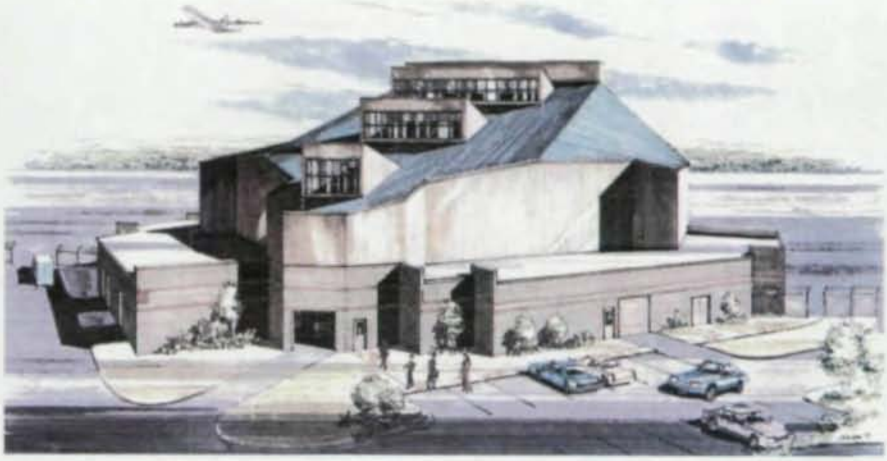
The components of the space frame were analyzed using various structural depths in combination with hybrid structural steel members. The structural components were analyzed using a combination of 36 ksi, 50 ksi and 70 ksi yield strength steel sections to develop the optimum configuration for both economy and deflection control. A reiteration process was implemented by inserting high strength steel members in areas of high strength in order to reduce the total required tonnage. The majority of the truss was 50 ksi steel with 70 ksi steel used for the largest members, which represented about 25% of the member.

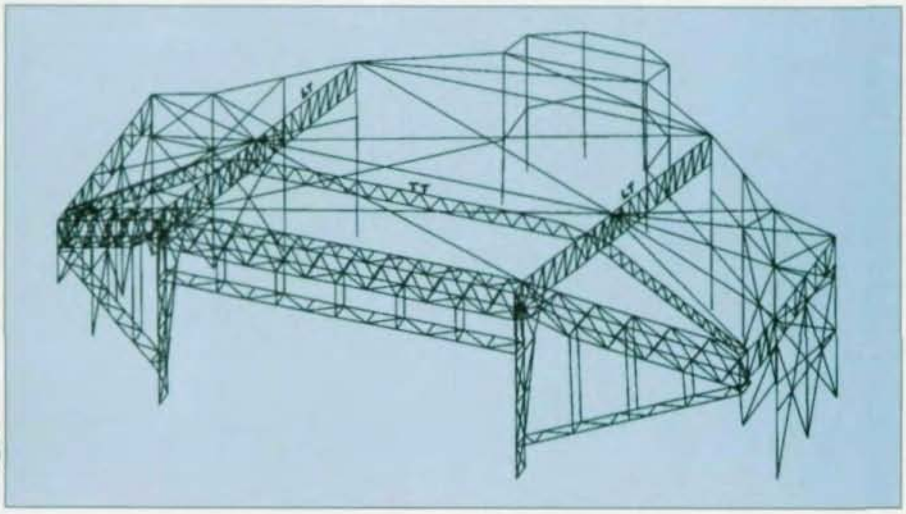
Also, the structural space frame was configured and splice points designed to produce a self-erecting structure. This was done to minimize the use of erection cranes and to expedite the erection process.

Computer Analysis

The structural system geometry was translated into a three dimensional model using a combination of computer software, including Research Engineer's STAAD-III and AutoCAD Version 11.0. Likewise, the STAAD-III software was used for code check verification.

Due to the hangars location in a region subject to both hurricane force winds and seismic risk, the structure was analyzed using 18





The three dimensional space frame pictured above shows the various elements needed in the design, including the transverse bent truss, longitudinal trusses, perimeter trusses, and lateral bracing trusses. The 7'-deep transverse bent truss spans the length of the hangar. It is the principal resisting element for gravity, horizontal and uplift forces. The space frame's geometry was calculated using the STAAD-III computer program.

separate load cases with a combination of dead load, live load, seismic and wind forces. The critical loading case involved uplift forces acting on the superstructure with the hangar doors open to the wind. Also, hurricane force winds were shown to produce a more critical loading situation than seismic force requirements.

Foundation Economics

After selecting a steel superstructure system that satisfied geometry, economy and deflection criteria, the question of minimizing the cost of the foundation remained. The foundation represented a significant cost factor because of the large uplift forces generated by the transverse bent supports. These forces produced a net uplift of 300,000 lbs. (67,400 newtons) on each side.

Traditional resistance methods such as massive concrete foundations would require 113 cubic yards of concrete on each side, This would require a 10' x 10' footing 30" in depth, with a cost of more than $200,000.

Two alternate uplift resisting systems were investigated to reduce cost and time.

- Drilled in helical anchors. These steel anchors are drilled to depths of 20' into virgin soil. The shafts are then cast integrally into the foundations. Each anchor would resist 20,000 lbs. of uplift and 15 anchors were required per foundation for a cost of $85,000.
- GEOPIER. The GEOPIER foundation soil reinforcement system utilizes a column of compacted crushed stone extending downward approximately 8' into the soil under the foundations. The GEOPIERS are constructed by the densification of crushed stone in a pre-drilled pit. A high-energy tamper results in a high density matrix and each GEOPIER develops 20,000 lbs. of uplift resistance. The 15 required GEOPIERS per foundation cost $32,000 and so this system was chosen.

Quality Control & Fabrication

The use of hybrid materials of construction for the space frame required a high level of quality control during preparation and review of the shop drawings. O'Kon & Company developed a color-coded system for the shop drawings that permitted easy identification of the various steel strengths. Also, mill tests verifying the grade of steel were required.

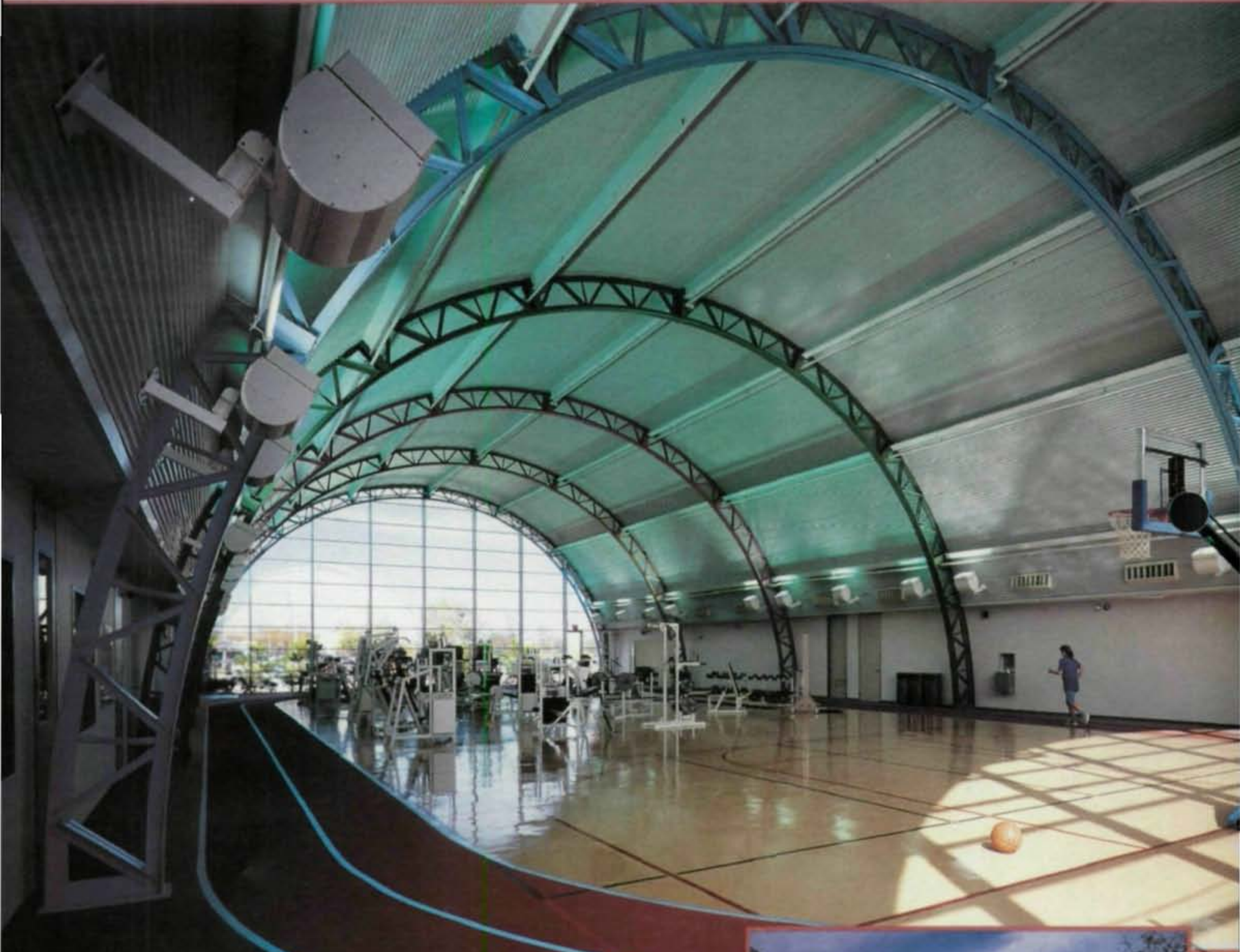
Erection procedures for the steel space frame were carefully reviewed and assessed. Many of the connections required full penetration welds and all of these were done in the shop, while all field connections were slip critical type bolted assemblies. To assure that proper tension was applied to the connection bolts, ASTM F959 direct tension indicator washers were specified.

The structural steel space frame was designed to be "self-erecting" with a minimum of guying supports. Camber was fabricated into the frame in the fabrication shop. Steel fabricator was AISC-member Gipson Steel, Inc.

Construction began in June 1992 and is expected to be completed in mid-September 1993. The general contractor is Tilley Constructors and Engineers of Gulfport, MS. Construction budget for the project is $4,145,000, including all sitework.

James A. O'Kon, P.E., is president of O'Kon & Company, an engineer/design firm headquartered in Atlanta.

SUPPORT CAN



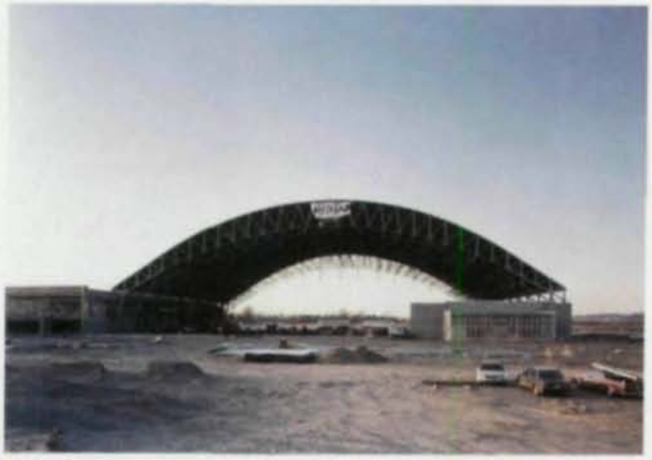
Arched chord joists, Brown & Root employee center, Houston.

Raising An Arch

An arched roof was created by applying stress to a flat truss

The 320'-wide hangar begins as a flat truss of nearly 400'...

...tension is applied to prestressing strands, forcing the truss-frames to begin arching...



...each end column travels about 70' and the center of the arch rises 72'.

By Anne M. Anderson, P.E.

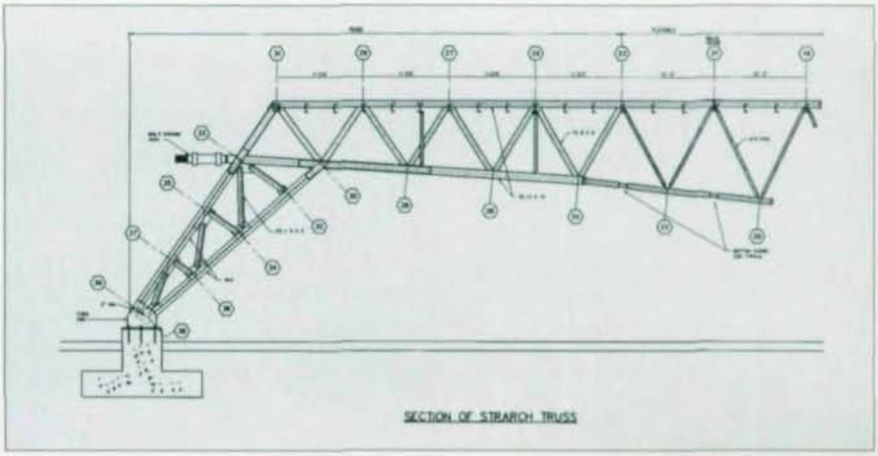
From a structural engineer's standpoint, an arch is a wonderfully stable shape. Unfortunately, from an erectors standpoint, an arch—especially one that soars 100' off the ground—can create all sorts of problems. The solution, according to its creators and designers who have used it, is an innovative stressed arch (STRARCH) system.

The STRARCH system is a technology developed eight years ago by Lewis Harding in Perth, Australia. STRARCH International Limited purchased the patent in 1985 and started to market this construction system. Since that time, more than 50 STRARCH buildings have been built in Australia, Malaysia, Japan, Canada, and most recently, the United States.

The first use of the STRARCH system in the U.S.—and the largest world-wide to date—is for twin hangars for the Pacific Aircraft Maintenance Corporation (PAMCORP), a privately owned company based in Portland. Each hangar is 320'-wide by 350'-long and capable of housing one B747 and two B727s. The project also includes 66,000 sq. ft. of shops and offices between the hangars.

The site is located within Air-Trans Center, an aviation business park at Portland International Airport. PAMCORP plans on performing a variety of services, including FAA required inspection and maintenance checks, repair and replacement of faulty equipment, major structural modifications, powerplant replacement, interior renovation, and paint stripping and repainting. The facility is expected to be completed in August 1993 and will employ a workforce of approximately 1,300 people by its fifth year of operation.

From the time Ken Kelly, founder of PAMCORP, conceived his idea of building a third-party maintenance facility, he had planned on using the innovative STRARCH system. Kelly first heard of STRARCH International in 1988. He was impressed with the uniqueness and simplicity of the design and was convinced it would be ideally suited for the PAMCORP project. At that time, STRARCH was owned by New Zealand's Fletcher Construction Group, which also owned Howard S. Wright Construction Company of Seattle. Kelly enlisted Howard S. Wright to be the project's prime design/build contractor, with design by Portland-based Moffatt Nichol & Bonney, Inc.



The STRARCH System

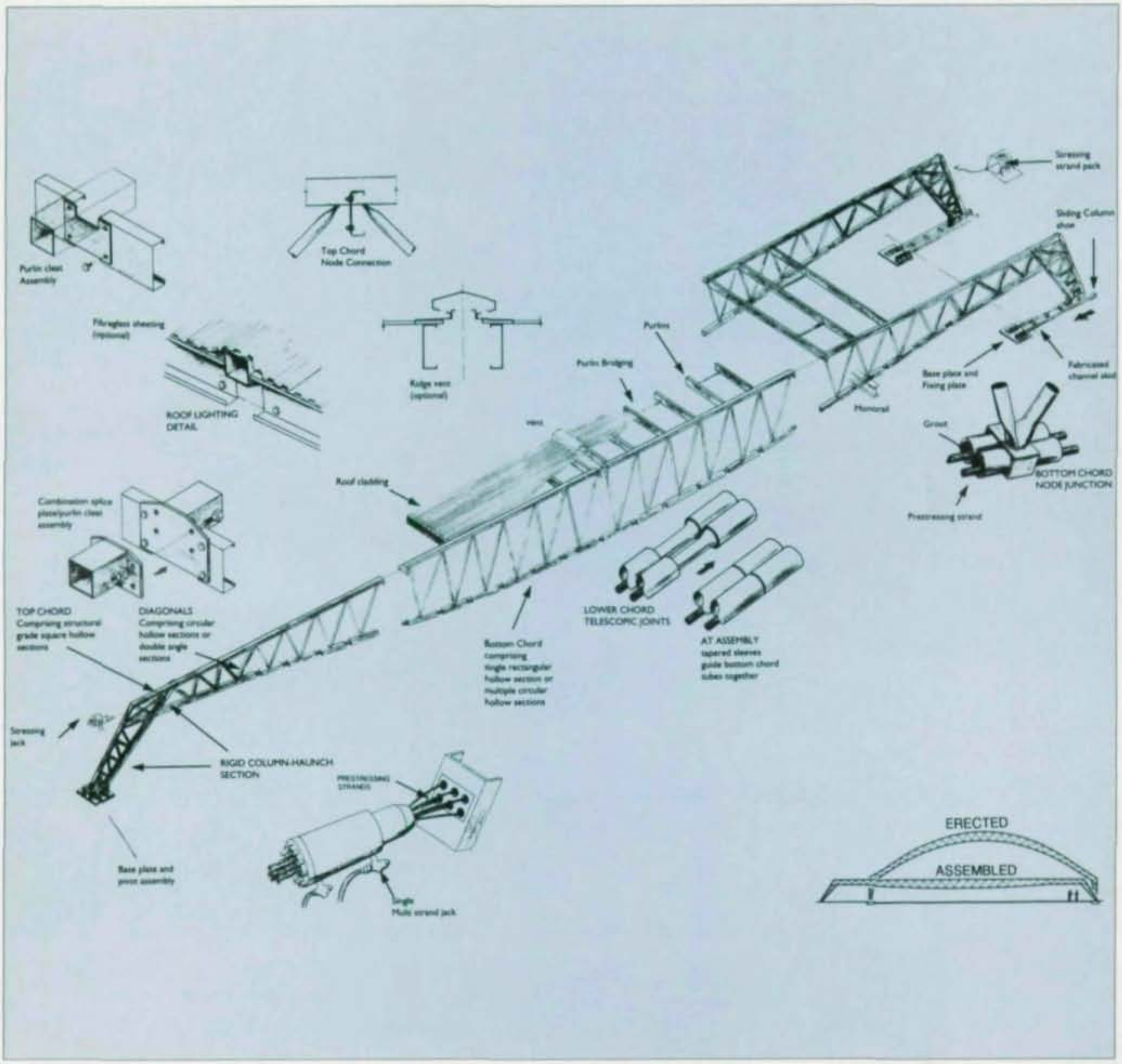
Essentially, the STRARCH system involves the construction of a large flat truss. Prestressing strands are then used to force the truss into an arched shape.

The STRARCH trusses are made up of standard steel shapes, mainly tubes and pipes. The steel fabrication was done locally by AISC-member Canron Western of Portland. The erector was The Erection Company of Seattle and the stressing contractor was DYWIDAG Systems International, with on-site consultation provided by STRARCH International.

The roof framing process involves two stages: Assembly and Stress-Erection.

During the assembly, the trusses are erected and placed on temporary scaffolding towers with the top chord member, which is a 12" x 12" x ⅝" tube, in a horizontal position approximately 28' off the ground. Each hangar is composed of 12 trusses spaced at 30' on center. The depth of the truss is 18' at the center, tapering to 9' at the ends. The 12" "C" purlins that span between the trusses are placed at the assembly stage, as well as the metal deck, insulation and membrane roofing material. Also during this time, utilities are installed beneath the roof, including lighting, electrical wiring, sprinkler pipes and mechanical duct work.

Prestressing cables are jacked through the trusses to force them into an arch (above). As the arch is formed, the base of one end of the truss slides along the ground until it is in the correct position (left). At the same time, the base of the truss pivots more than 30 degrees.



This work is all accomplished using low-rise scissor lifts.

The trusses are more precisely truss-frames with incorporated columns. At assembly, the columns are at a 35 degree slope. Each column is supported on a 3"-diameter steel pin, which allows rotation when the structure is stressed into place. One column is fixed and bolted down to its base plate, while the other column is supported on temporary skids that rest on greased channels.

Once the roof is complete, prestressing cables are pushed through the bottom chord of the trusses, which have a catenary curved shape at assembly. The bottom chord is composed of two 6"-diameter pipes with telescoping joints in between each panel point. Each pipe contains six ⅝" diameter 270 ksi prestressing strands, or twelve strands per truss. The cables emerge at both ends of the truss. At one side the cables are anchored off, and at the other, they are attached to a large multistrand hydraulic jack. There is one jack provided at each truss.

Once the cables are installed and the jacks are in place, the roof is ready to go up. To raise the roof, tension is applied to the cables, simultaneously at each truss. As the cables start to straighten, the roof begins to rise and the columns begin to slide in. As soon as the trusses are up off the scaffolding towers, the towers are dismantled and taken off the site.

Columns Travel 70'

With each stroke of the hydraulic jack, approximately 9" of cable is pulled out. As the cable is pulled, the gaps in the bottom chord telescoping joints begin to close. It is the size of the gaps that determine the final shape of the truss. The stress-erection process continues until all the gaps are closed and the sliding column has traveled approximately 70′ to its final position over its footing. Both columns rotate 35 degrees to a near vertical position and the apex of the roof rises 72′. The entire stress-erection process for each PAMCORP hangar took approximately five hours.

Once the structure obtains its final configuration, the sliding columns are bolted down to their foundation. The prestressing strands are locked off at the required force at the stressing end, and then the jacks are relocated to the opposite side of the truss where the strands are again stressed and locked off to ensure that the same force is at each end. Also at this time, the bottom chords of the trusses are filled with grout, which prevents corrosion of the strands and bonds them to the bottom chord pipes.

After the stress-erection process is concluded, the rest of the hangar is then ready to be finished. The erection crew started framing the endwalls on the very same day. This was followed by the installation of the wall girts, siding, framing above the hangar doors, and the assembly and installation of the hangar doors themselves. Each hangar has one set of doors consisting of six 50′ x 50′ leaves that provide a 50′ x 300′ opening with a 20′ high tail door at the center.

To determine the accuracy of the final geometry of the PAMCORP hangars, surveyors located a few points on the trusses and determined that no point in the 320′ span was off by more than 1″.

Construction Advantages

From a construction standpoint, the principal advantage to the STRARCH system is that the roof is assembled closer to the ground and on a flat surface. All roof mounted electrical and plumbing systems are substantially completed before the roof is raised. The contractor stated that using this method reduced construction time by as much as 30% compared with conventional construction on a building of this size. For the PAMCORP hangars, this translated into a savings of nearly six months.

From a structural engineer's

One of the major advantages of the STRARCH system is that the truss is erected close to the ground by workers on scaffolding (left). The hangar is designed not only to provide a large open area, but also to support several girder cranes for airplane maintenance work (opposite–above). After the arches are erected, a standard front wall is installed and the structure is roofed (opposite—below).

point of view, there are many advantages to using the STRARCH system. The biggest advantage is being able to utilize an arched truss to span the 320′. An arch is the most efficient shape in structural design and the STRARCH process provided an easy way to achieve this shape without complicated fabrication and erection. Because of the inherent stiffness of the arch, combined with added strength due to the prestressing forces, the trusses were designed on the basis of strength, not deflection control. The PAMCORP trusses are designed for a roof snow load of 25 psf as well as three roof supported 10 ton cranes. The deflection caused by the three cranes (truck weight plus hook load) acting simultaneously at one truss is only 3½" at the center, or L/1100. Other design loads include an average wind uplift of 34 psf due to 80 mph winds acting on an open structure.

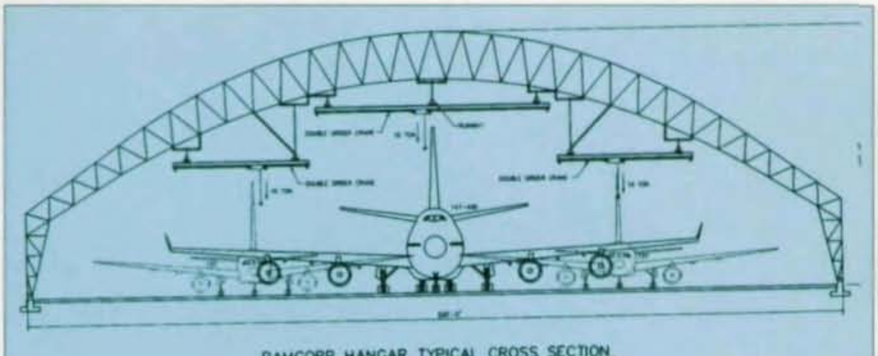
No Bottom Chord Member

Another steel saving advantage is that the trusses do not need bottom chord bracing. The bottom chord is prevented from laterally buckling due to the highly tensioned prestressing strands running through the member. The weight of the structural steel in the STRARCH trusses is 9.7 psf. The purlins bridging the metal deck weigh 4.2 psf. By keeping the steel weight down, the STRARCH method provided a very efficient solution to clear spanning 320′.

The structural analysis is done using microSTRARCH, which was developed by Engineering Systems of Australia, the same company that wrote microSTRAN, a popular structural analysis program in Australia. The microSTRARCH program allows the easy generation of the truss geometry, both in the assembled stage and erected stage, by inputting only a few key dimensions, as well as doing standard linearly elastic structural analysis. The structure is analyzed at three stages:

- The assembled truss, one end pinned, the other on rollers with dead loads and prestressing only;
- Erected truss, one end pinned, the other on rollers with dead loads and prestressing only;
- Erected truss, both ends pinned, with all required dead and live load combinations.

The most innovative part of the analysis is the design of the top chord. During stress-erection, the top chord undergoes significant bending. Depending on the radius of curvature, the outer fibers of the tube may be stressed beyond the elastic limit. In order to determine the allowable axial load in the tube a column design curve was used, which accounts for the radius of curvature as well as the unsup-



PAMCORP HANGAR TYPICAL CROSS SECTION

ported length (KL/R). The curve, which is based on a finite element nonlinear analysis, was developed at the University of Sydney to simulate the geometric nonlinear behavior and plasticity in the stressed-arch, particularly the top chord. Numerous tests on full-scale panels also were conducted. The experimental results showed excellent agreement with the vigorous theoretical investigation.

Another interesting design feature is the lateral force resisting system. Instead of roof bracing, a stressed skin diaphragm is used. The diaphragm consists of 1½" ASC Pacific HR 36 metal deck screwed down to the purlins with #14 self tapping tek screws. The thickness of the deck ranges from 24 gauge at the center to 18 gauge at the sides. In order to install the metal deck at the assembly stage, it is placed at the neutral axis or centerline of the top chord member (after which the rigid insulation and flexible membrane is placed). This ensures that during stress-erection the roof material does not undergo any stretching or compressing. The roof of each hangar has approximately 2.9 acres of metal deck and 130,000 screws.

The design of the PAMCORP hangar facility began in 1991 with construction starting in June 1992. Steel fabrication began in July 1992 and completion of construction was expected in June 1993. The facility will be open for business in August 1993.

Anne M. Anderson, P.E., is a structural engineer with Moffatt Nichol & Bonney, Inc., Consulting Engineers in Portland.

Winging It

High-bay steel moment frames clear-spanning 200' were required to meet seismic design criteria for an airplane wing fabrication and assembly building

By W. Scott Wilhoite, P.E., and Steven F. Fenner, P.E.

Construction is now underway in Everett, WA, for a new fabrication and assembly complex to support the production of Boeing Commercial Airplane Group's new Boeing 777 aircraft. At their peak capacity, the new facilities will handle the production of seven planes per month, with first delivery scheduled for mid-1995.

Completing the facility under a very tight design and construction schedule is critical to the overall success of the 777 Program. As such, high quality design that expedited fabrication and erection while minimizing capital costs was a top priority.

One of the most interesting structures constructed as part of the new program is the Wing Spar Assembly Building, in which the structural components of the wings are fabricated and assembled. This long-span, high-bay building is 650'-long by 250'-wide with a 65' eave height. It features a 200' assembly bay with full crane coverage and a 50'-wide multistory bay for support operations. The facility houses a 290'-long automated spar assembly tool that drills and installs fasteners for the wing spars and clean, seal and paint facility for coating operations.

Design Criteria

Lockwood Greene Engineers worked closely on site with Boeing engineers from Maintenance, Manufacturing, Construction Services and Airplane Design for two weeks following project kickoff to define the functional requirements, configuration limitations, and loading criteria for the new facility.

A comprehensive Design Criteria was developed for use as the project design basis for the team. The Design Criteria defined: the applicable codes; general building configuration including bay sizes and schematic floor plans; and the operational criteria including crane capacity, coverage requirements, and hook heights.

A significant limitation on the structural assembly system for the Spar Assembly Building was the operational requirement to keep all bays in the longitudinal direction free for material flow and potential future expansion.

Many existing assembly buildings at the Everett site were built in the mid-1960s and used a 300' assembly bay with full height mezzanine bays on both sides for support functions. On these buildings, the mezzanine bays are braced above the second level in both directions with a soft story at grade.

However, to avoid designing to the more stringent code requirements associated with a soft story structure, upper level bracing was not included in the lateral force resisting system for the new Spar Assembly Building. Instead, a moment resisting frame system was chosen for the transverse direction to improve ductility and result in a more uniform deformation profile. The long-span, high-bay moment frames have only three columns in the transverse direction, resulting in a relatively flexible structure.

Conventional X-bracing was utilized on the exterior walls in the longitudinal bracing.

Structural Design Decisions

The 200′ assembly area span was designed to support two rotating, 20 ton capacity, four-block cranes on runways spaced 25′ on center. The maximum truss panel point design load induced by the cranes was 60 kips. Crane coverage was required for the full 650′ length of the building. Engineered steel trusses were chosen to support these heavy loads.

A nominal truss depth of 16′ was identified as the most economic design based on simple-span gravity load analyses. The magnitude of the loads resulted in chord forces as large as 1,635 kips. W14 shapes with a yield strength of 50 ksi were selected as optimum for the high axial loads in the truss chords. The W14 shapes provided adequate strength and allowed connection designs that were easy to fabricate and erect.

A double column row and expansion joint within the 650′-long building was incorporated to accommodate thermal movement.

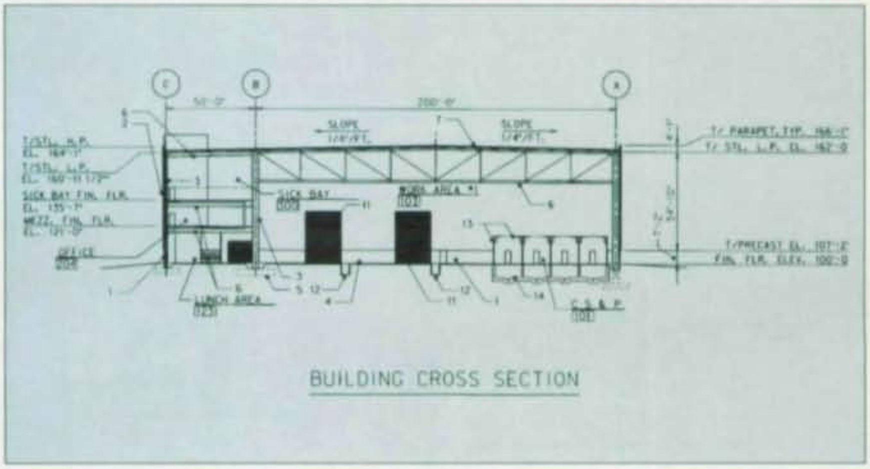
The structure was designed in compliance with the 1988 Uniform Building Code. The Everett complex is located in a seismic zone 3; therefore, seismic design considerations included the type of trussed moment frame to use (Special vs. Ordinary), drift control, P-delta effects due to heavy column loads, and connection design.

Frame Analysis & Design

Preliminary frame analysis using Research Engineer's STAAD-III software showed that meeting the lateral drift limits would control the columns sizing. It was clear the column bases and foundations had to be fixed against rotation to maintain a cost-effective design.

Axial column loads due to dead and live load cases are as large as 600 kips. The columns are unbraced on the strong axis from the foundation to the bottom chord of the truss, approximately 46′.

Built-up columns using two W14 shapes were considered, but



Boeing's' new Wing Spar Assembly building is 650′ long by 250′ wide with a 65′ eave height. It features a 200′ assembly bay with full crane coverage and a 50′-wide multi-story bay for full support operations.

The magnitude of the loads resulted in chord forces as large as 1,635 kips. After analysis, W14 shapes with a yield strength of 50 ksi were selected as optimum for the high axial loads in the truss chords. For the top chord, a 1⅞" cap plate was welded to the column and a specially fabricated piece of the W14 column sits on the cap plate.

were not used because of the difficulty in detailing connections to assure continuity with the truss. Rather, W40x531 50 ksi steel columns were selected for the bents.

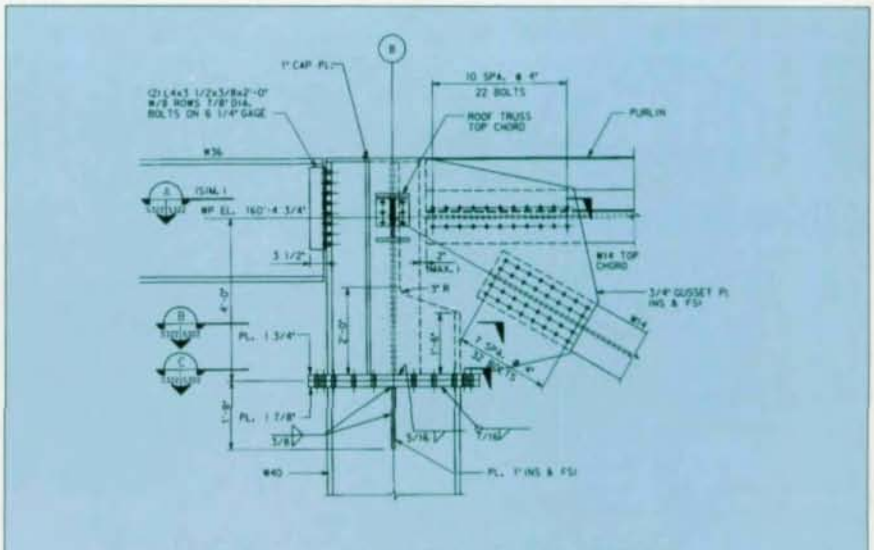
The W40 columns provided a cap plate seat large enough to get an adequate number of bolts in to develop the top chord forces of the truss, simplified construction by allowing the truss to bear on the cap plate during erection, and provided the stiffness needed to control lateral drift.

The site is founded on fill and the geotechnical investigation determined that spread footings could be utilized with an allowable bearing pressure of 3000 psf. Also, it was desirable to keep the vertical and lateral loads on the foundations as low as possible.

One way to minimize lateral loads and drift was to use a Special Moment Resisting Frame where the code prescribed seismic loads would be 50% lower than for an Ordinary Moment Frame. However, connections of the truss chords to the columns would be required to develop the strength of the chords or 125% of the flexural strength of the columns.

Structural studies addressing the cost implications of Special Moment Frames versus Ordinary Moment Frames for this long-span, high-bay, heavily-loaded structure indicated that an Ordinary Moment Frame was the most economical choice despite the higher lateral forces for this type of system.

The building is tall and heavy resulting in a relatively long period and low lateral loads. Calculations showed that the lateral load moments were a small portion of the stress interaction formula for the columns compared with the heavy dead and live loads. The stiff W40 columns have a very high moment of inertia.


COLUMN - TOP CHORD CONNECTION DETAIL

Because the column sizing was based on drift control and not strength, increasing the lateral loads due to system type was accommodated with reserve strength inherent in the deep columns. Further, because the drift limit of 0.005 times story height equates to an $R_w = 8$, (0.04/0.005), the potential economic savings of an $R_w = 12$ system cannot be fully realized when drift controls over strength.

The costs of the connections are a direct function of the forces to be transferred that do vary by system

A nominal truss depth of 16′ was identified as the most economic design based on simple-span gravity load analysis. Axial column loads due to dead and live loads are as large as 600 kips, while the gravity loads can reach 1,635 kips.

type. For the Wing Spar Assembly Building, it was determined that designing to the full elastic forces, $3R_w/8$ times the member forces based on the calculated base shear, was still much lower than developing the full plastic capacity of the deep truss/heavy column frames.

While the increased lateral forces for an Ordinary Moment Resisting Frame did not influence the framing costs significantly, the connection strength requirements for a Special Moment Resisting Frame greatly increased the cost. Ordinary Moment Resisting Frames were used for the final design. Where the detailing provisions of Special Moment Resisting Frames could be easily achieved, they were included as well.

Connection Details

The top chord to column connection proved to be the most critical and challenging to design. A 1⅞" cap plate was welded to the column and a specially fabricated piece of the W40 column sits on the cap plate.

The flange of the W40 piece was coped to allow the gusset on each side of the W14 top chord to be welded to the outstanding flange of a split W14x257 on each side of the W40 web. This was done to ensure that vertical loads were applied at the center of the W40 columns and to provide an adequate weld length for the applied loads.

The gusset was then field bolted to the chord and diagonal members using 1⅛"-diameter ASTM A490 bolts with oversize holes for slip-critical bolts. The column cap plate, the W40 connection piece, and the top chord connection were all designed to fully develop the strength of the top chord.

All connections for the 200′ span trusses were designed as slip critical using 1⅛"-diameter ASTM A490 bolts to avoid potential problems associated with welding heavy sections. Oversized holes were used in the members for field fit-up. All W14 truss members wre oriented so the flanges were parallel to the plane of the truss. This allowed the gusset plates to be bolted to the flanges of the members on each side of the truss. Web splice plates were added on the chord members to help transfer the large axial forces.

The column bases were designed as moment resisting by using six 3"-diameter ASTM A36 threaded rods for anchor bolts. The base plate has a thickness of 5¼" with 1¼" stiffeners.

Fabrication & Erection

Due to their 200' length and 90-ton weight, the trusses were field bolted and assembled on site as close to the erected location was possible. The trusses were then lifted into position by two Manitowac cranes. Steel fabricator was AISC-member Canron Construction Corporation.

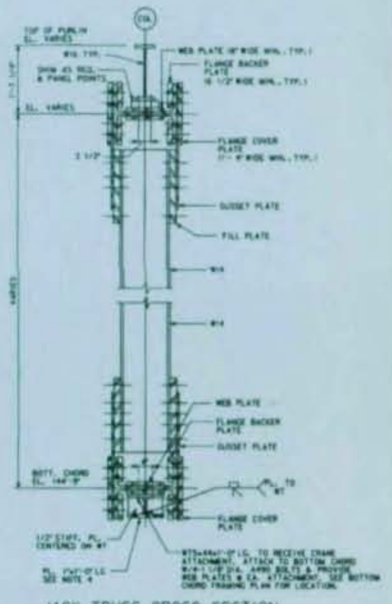
The top and bottom chord/collumn connection bolts were fully pretensioned prior to release by the cranes. Pretensioning was required because the final design took advantage of the truss/frame continuity for all load cases including dead.

This design approach took advantage of the column stiffness required to control lateral drift and allowed these span trusses to be designed with some fixity at the ends, thus reducing truss weight and saving considerable steel cost on the project.

The top chord bearing connections greatly simplified the truss erection, but caused some difficulty in erecting the W36 mezzanine girders below.

A solution was to field weld some column cap plates after erection of the mezzanine girders. All these welds were inspected and defects repaired to the satisfaction of the independent welding inspectors.

Steven F. Fenner, P.E., is Civil/Structural Division Manager and W. Scott Wilhoite, P.E., is Assistant Structural Department Manager with Lockwood Greene Engineers, Oak Ridge, TN.

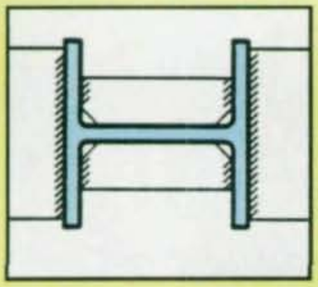


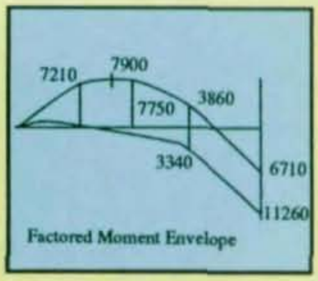
JACK TRUSS CROSS SECTION

STRUCTURAL STEEL DESIGN

SOFTWARE

FROM AISC





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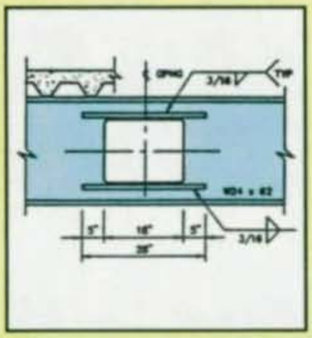

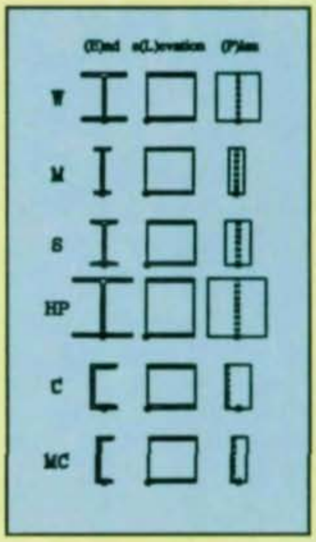

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CAD Takes On Structural Engineering

Pre-processors are beginning to provide design engineers with the graphical advantages of advanced CAD systems

By James Lord and Mark Middlebrook

A computer aided drafting program has become one of the "tools of the trade" in most engineering firms, in part because many projects now require construction documents produced with CAD. Also, the quality and sophistication of structural drafting applications that run inside of general-purpose CAD programs such as AutoCAD or MicroStation has improved to the point where CAD can be an efficient tool, even on small or unrepetitive projects. Until recently, though, CAD software was relegated to the drafting department. Engineers continued to ply their trade with calculator and spreadsheet, text editor and finite element analysis software, while casting envious glances at the high resolution graphics and high performance computers available to drafters.

That distinction is beginning to blur as structural software developers release CAD-based graphical preprocessors for analysis programs. The concept on which this new breed of software is based is simple and appealing: engineers should be able to "draw" their analysis models interactively in a CAD program, rather than have to type line after line of arcane code into text input files. The three-dimensional CAD model can then serve not only as the source of analysis input, but also as the basis for two-dimensional framing plans and elevations.

The details of implementing this simple idea turn out to be surprisingly complicated. While today's CAD programs are powerful tools for creating and manipulating the graphical geometry of a structure, they aren't especially well-tuned for managing all the non-graphical data that defines a structural model. As a result, programmers have to develop methods for attaching member sizes, materials, and other data to the graphical CAD entities. In addition, graphical preprocessors have to contend with the imprecision of a CAD model. In finite element analysis, everything is tied to nodes (or "joints"). Nodes are the first data that the engineer specifies in traditional input methods, and they define precisely where members can connect. Most preprocessors, on the other hand, let the engineer simply draw structural members. Then during translation, the preprocessor infers node locations from member intersections, using a small "slop factor" to account for drawing inaccuracies and CAD coordinate round-off error. This approach seems more direct for the engineer, but the trade-off is a loss of control. Now the preprocessor rather than the engineer decides how to organize the analysis input, including the node and element numbers.

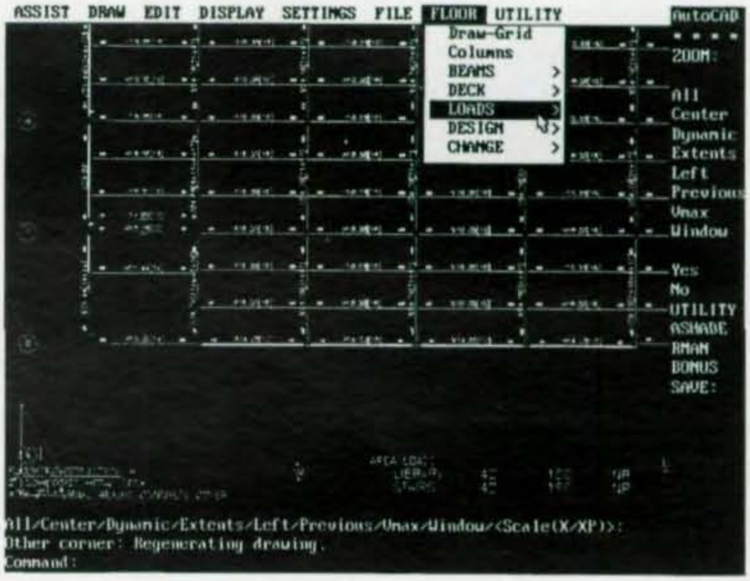
The venerable ASCII text file input method used by almost all current structural analysis programs seems crude by today's software standards, but text input offers a number of advantages to the engineer (and to the programmer). First, text input is unambiguous; it ensures that node and element locations are specified precisely. Second, text input gives the engineer a high degree of control over node and element numbering. With an efficiently numbered structural model, it is much easier to check and get results. Finally, most analysis programs include node and element generation options that can make short work of modeling large structures that exhibit symmetry or regularity.

Why should you even consider a CAD-based graphical preprocessor, then? First, because the geometry of some structures is easier to model in a CAD program. This is especially true for geometrically complex structures in which locating the nodes is tricky. Second, because a good graphical preprocessor does more than prepare analysis input. Most of them can generate drafted plans and frame elevations automatically from the same 3D model. The quality and degree of completion of these generated drawings varies, but it's possible to save a significant amount of the time that drafters normally would spend laying out plans and elevations. Some preprocessors also can create material reports and true-size "extruded" members that can be rendered by the CAD program for presentation purposes. And finally, other parts of the design process, such as calculating gravity loads and designing floor framing, can be automated and linked to analysis preprocessing through CAD.

A crucial question for any firm considering implementing a CAD-based graphical preprocessors is "who will use it?" Few engineers are completely comfortable with CAD software, while drafters usually don't understand finite element analysis. Using these packages effectively really requires both skills. A drafter who doesn't grasp analysis modeling concepts is a menace to life safety. On the other hand, an engineer who stumbles around in the CAD program will become frustrated with it as a modeling environment. Most structural software developers recognize this problem and try to provide a graphical modeling environment that's less daunting than the one offered by the "raw" CAD package.

For these reviews, we looked at three CAD-based structural applications. AutoFLOOR and AutoETABS are companion programs from Computers and Structures, Inc. (CSI), and they run inside of Autodesk's AutoCAD. FrameWorks, from Intergraph's AEC Group, runs inside of Intergraph MicroStation and produces input files for AutoSTEEL, GTSTRUDL, STAAD-III, and MicasPlus. Other available graphical preprocessors that work with AutoCAD include AutoSTAAD STAADInput from Research Engineers, Inc. and Structural Modeler from Softdesk. A recent version of STAADInput was reviewed in the March 1993 issue of CE Computing Review, and older versions of both packages were reviewed in the August issue of CADalyst magazine. Both sets of reviews were conducted by James Lord and Mark Middlebrook. Research Engineers and Softdesk chose not to have their products included in these reviews.

To test the programs, we experimented with them on a schematic study recently completed by James Lord at Rutherford and Chekene. The structure is a 250'x175' three-story steel moment frame building, with a mostly rectangular configuration. Our testing was conducted on two 33 MHz 486 computers, each having 8 megabytes of RAM. We used the current version of each CAD program: AutoCAD Release 12 and MicroStation version 4.0.



AutoFLOOR 2.0 and AutoETABS 3.0

AutoFLOOR and AutoETABS are AutoCAD-based structural programs from Computers and Structures Incorporated (CSI) that can be used separately or together. AutoFLOOR designs floor and roof steel framing systems and creates drafted framing plans. AutoETABS is an input file generator for CSI's ETABS building analysis program, and it also creates drafted elevations of the lateral building frames. The output from AutoFLOOR can be imported into AutoETABS to reduce the work of building a structural model.

AutoFLOOR 2.0 was developed for AutoCAD Release 11, but works with Release 12 also. AutoETABS 3.0 requires Release 12 and takes advantage of dialogue boxes and other improvements to the Release 12 interface. Both programs use a single pull-down menu (which replaces the AutoCAD solid modeling menu) as the primary means of accessing structural commands, such as those for grid layout and model translation. In addition, the other menus are slightly rearranged to include a few custom commands.

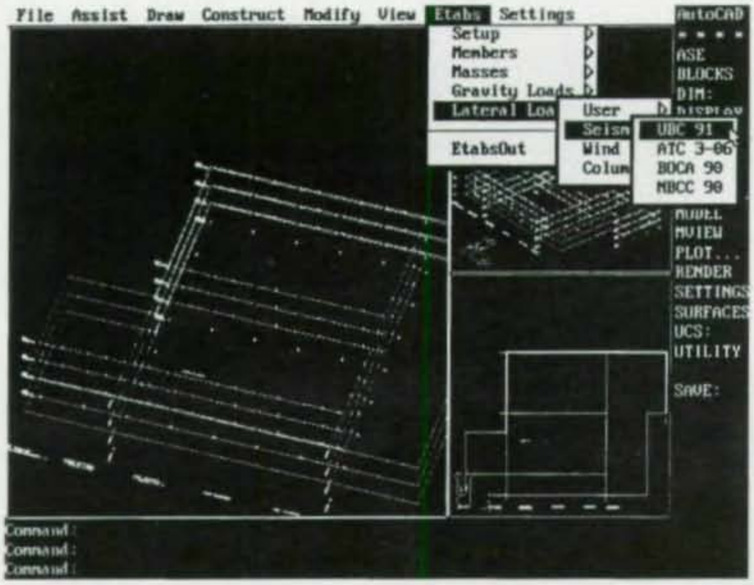
Each program comes with its own reference manual which consists of an extended tutorial. Extensive appendices in the AutoFLOOR documentation describe the different layers and ways of representing elements of the model in the drawing. AutoETABS is not copy protected; AutoFLOOR uses a parallel port hardware lock.

AutoFLOOR

AutoFLOOR provides commands for drawing the framing of a steel floor plan and specifying loads in an AutoCAD drawing. It will then design and label all the framing members using either the ASD or LRFD code. No other CSI products are required to use AutoFLOOR.

In AutoFLOOR, each floor or roof level resides in a separate 2D AutoCAD drawing. You begin a model by starting a new drawing based on one of two prototype drawings-one for 1/8" scale and one for 1/16" scale-supplied with the program. The scale is used to size entities such as text, symbols, and the gap between the end of a member and its support. You first draw a grid system using a custom AutoFLOOR command that supports orthogonal, oblique, and radial grid lines. You then add structural columns, girders, and beams using AutoFLOOR commands provided for each type of member. With the framing in place, you define the deck edge and global direction and type. You must also include any openings or local deck types and directions.

The last piece of information to



add to the model is the dead and live loading. AutoFLOOR automatically includes the slab and member weight in dead load calculations, so you only need to define additional dead loads. AutoFLOOR uses both dead and live load cases when designing for strength and deflections, but it doesn't support a seismic load case. Once the loads are defined, you use selections on the DESIGN menu to tell AutoFLOOR to design all or part of the framing. AutoFLOOR then designs and labels each member. If you want to interactively design individual members, AutoFLOOR will present you with the set of beams which meet the constraints. You can select whichever size best meets your requirements.

AutoFLOOR computes the load on a member based on an area bounded by half the distance to the adjacent beam. Any additional area, line, or point loads are also included. The program selects members on the basis of these loads using a simple economic analysis; the least cost beam which meets all the constraints is the one selected. You can change any of the economic parameters, and you can globally or individually constrain the member designs for deflections and/or girder depth. The program can handle cantilevers and trapezoidal or other odd-shaped bays.

AutoFLOOR labels each member with its size, number of shear studs, and end reactions. You can add other annotations to the drawing as required for the project, and still use the drawing to redesign all or a portion of the floor. AutoFLOOR also can be used to provide input to its sister program, AutoETABS. The grid lines, beam sizes, column locations, and gravity loads can all be imported into AutoETABS. AutoFLOOR also generates steel take-offs, backup calculations, and column gravity loads.

I was able to evaluate AutoFLOOR on a schematic level job in a design office. The initial layout and design of the floor was very quick; within a few hours I had most of the structure done. Unfortunately, finishing the structure took the rest of the week. Some of the delay was caused by my unfamiliarity with producing presentation quality floor plans and by the bugs mentioned below. The level of detail required to develop a AutoFLOOR model was also a contributing factor. In a manual schematic design, you often make gross assumptions and ignore many special conditions in order to speed the process. To get a realistic design from AutoFLOOR, though, you must specify every load, slab condition, etc. Because of this, I believe that you can save more time producing construction documents than schematic documents.

Floor still has a few problems. Additional drafting functions for tasks such as creating a moment connection symbol would be useful. A feature to constrain a group of beams to be designed together would improve AutoFLOOR's use for schematic design. When generating the model, I found two bugs. The first was an obvious problem labeling the number of studs on a beam. The second was more severe; AutoFLOOR neglected some loads when analyzing highly irregular framing. I called CSI and received a fixed version two weeks later.

AutoETABS

AutoETABS uses AutoCAD as a three-dimensional modeling environment within which you build an ETABS structural model. It also lays out frame and wall elevation views where you can add and manipulate structural entities. These views can be used as the basis of drafted elevations for the project construction documents.

AutoETABS divides the AutoCAD screen into three views for easier 3D manipulation. You start the model by drawing grid lines in a plan view, or by importing them from a AutoFLOOR drawing. You then set up the heights and names of each building level. Once you've indicated frame elevation locations by picking grid lines, AutoETABS lays out each elevation side-by-side using AutoCAD's paper space feature. You can switch between the full model view and frame elevation view as often as you wish; working on the frame elevations is often much easier than using the 3D views.

Once the grid and views are in place, you define columns, girders, diaphragm edges, diaphragm masses, and building loads. You can do this from scratch using commands on the AutoETABS menu, or you can import much of the data from AutoFLOOR drawings. The model is then ready for translation to an ETABS text input file. During the translation process, a dialogue box queries you for two title lines, rigid end offsets, p-delta multiplier, and type of analysis.

AutoETABS then reads information from the AutoCAD drawing and writes out an ETABS text input file.

AutoETABS provides support of most of ETABS' features, including UBC, BOCA, NBCC and other seismic and wind codes. The standard ETABS load cases are supported, but the load combinations must be added manually. The only unexpected behavior I encountered is that the program lumps all the members into one frame and does not use the substructuring feature of ETABS. I was told that this is to ensure compatibility with the next major revision of ETABS, where such substructuring will be performed automatically within ETABS.

The most glaring missing feature is control over the column, bay, brace, and wall numbering. When translating a model, AutoETABS assigns these numbers sequentially but provides no way to change, or even view, the default numbering. You can change the numbering in the translated text file, but the changes will not be reflected in the model or in subsequent translations; translation is strictly a one-way process. To be fair, though, this limitation applies to all the CAD-based graphical preprocessors we've looked at.

While working with the program, I found one minor but annoying bug while assigning rectangular concrete beams; the program incorrectly reads previously entered section data and will not allow you to assign beams with the same property number again. Also, selecting elevations can be problematic when using portions of the same grid line. My last complaint is more of a wish-grid line labeling similar to AutoFLOOR's would make navigation in the elevation views much easier.

AutoFLOOR is a very usable program for designing and producing presentation quality steel floor plans. AutoETABS is also helpful for generating ETABS input files if you can accept losing control of the node and member numbering. The two programs work well together. If you use CSI analysis programs and design steel buildings, these two programs deserve a look.

FrameWorks 1.4

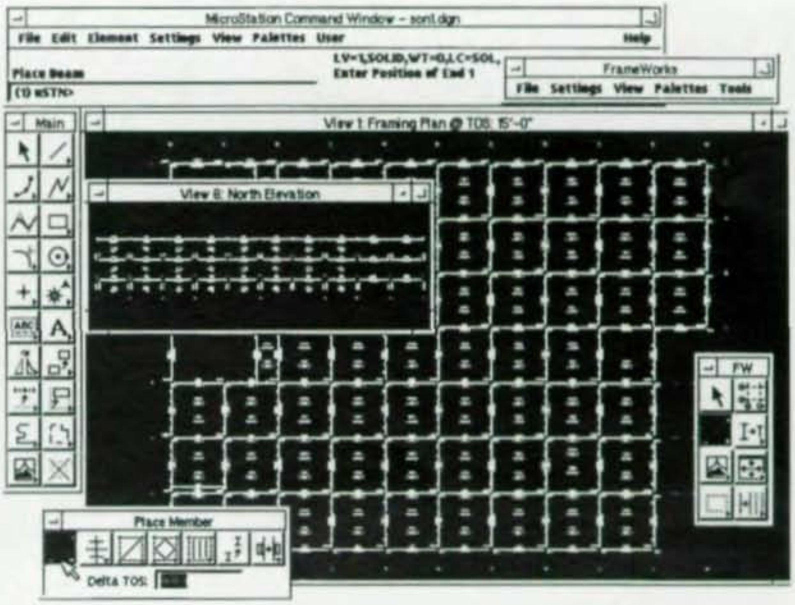
Intergraph developed a series of structural analysis preprocessors for their UNIX and mainframe CAD systems beginning in the early 1980s, but until a year and a half ago, there weren't any such programs available for MicroStation (Intergraph's PC-based CAD package). The AEC Group, formerly a developer of third party applications for MicroStation and now a division of Intergraph, changed that with their release of FrameWorks, a structural application for creating analysis input, 2D plans and elevations, material reports, and 3D renderings from a single three-dimensional stick model. FrameWorks will create analysis input files for AutoSTEEL, GTSTRUDL, and STAAD-III, as well as for programs that can accept Intergraph's CSD (Common Structural Database) file format. FrameWorks requires a parallel port hardware lock.

FrameWorks uses MicroStation's graphical user interface to good advantage, and is well-integrated with it. The motif-style interface features multiple graphics windows, dialogue boxes, icon palette menus, and pull-down command menus. FrameWorks leaves the standard MicroStation palette and command menus on screen and adds its own command menu window and palette menu containing the application-specific functions. You can open, move, and resize windows to your heart's content, but as with most windowed graphical user interfaces, the result will be a pretty cramped screen unless you have a high-resolution monitor.

You begin a FrameWorks model by defining a plan view and then specifying a column grid. The grid is optional, but very helpful, since FrameWorks commands will automatically snap to grid line intersections. Unfortunately the grid placement dialog only handles rectangular grids. With the grid in place, you use the palette menu to place columns and beams and to modify their section properties, orientations, and other characteristics. FrameWorks stores these data in external databases that the MicroStation design file is linked to, but it also displays the information next to each member, which helps in checking the model. Once you've drawn some of the structural geometry, you can use custom FrameWorks editing commands to copy or modify it (ordinary MicroStation editing commands aren't allowed, because they don't know how to update the external databases). To complete the model, you define additional plan levels (and elevations, if necessary) and copy or draw the members at those locations.

Creating the framing for our sample structure was, for the most part, straightforward and efficient. The automatic grid intersection snap made quick work of laying out most of the members, and MicroStation's snap lock and precision input handled the rest of the cases. One operational limitation that became apparent was the lack of an undo capability. FrameWorks prevents you from using MicroStation's undo feature because, once again, it doesn't know how to handle the structural database files. As a result, recovering from mistakes that involved copying or modifying a large number of members sometimes was time-consuming.

More serious are the functional limitations in the current version of FrameWorks. Although it does a good job with structural geometry, it doesn't currently address loads, supports, planar elements, or member-specific end releases. These limitations place fairly severe constraints on the types of structural analysis models that could be modeled efficiently with FrameWorks. Of course you can add loads, supports, and the rest to the input file by hand after FrameWorks has created it, but that would be a tedious job for all but the smallest of structures. Also, you would lose the associativity of the input file with the FrameWorks model, so any changes would have to be made in two places. On the



positive side, FrameWorks is able to read member size changes resulting from redesign back into the MicroStation design file.

Fortunately FrameWorks does a lot more than create analysis input files. You can extract 2D framing plans and elevations from the structural models, and then update them when the model changes. The levels and symbology (color, line style, and weight) assigned to each type of object in the design files are configurable, which makes it easy to accommodate the CAD standards of different offices. FrameWorks also includes a sophisticated and highly configurable report generator with which you can create material reports. Finally, the program will "extrude" the single-line members into surface representations which MicroStation can render. All of these features worked well when we tested them, although the surface models for moderately large structures can bog down even a fast computer.

The FrameWorks documentation comprises a tutorial guide and reference manual, both of which are well-designed and a pleasure to use. A few important details about installation are missing, but otherwise the manuals seem quite complete. The conceptual information presented at the beginning of the reference manual is especially helpful in becoming acquainted with this new method of modeling structures.

The functional shortcomings of FrameWorks will limit its range of application as an analysis preprocessor, but the program is worth considering for its drawing and report generation capabilities. Although this version of FrameWorks is far from complete as a structural modeler, the features it does offer are well-thought-out and well-implemented. If Intergraph's AEC Group builds on this strength, then FrameWorks could become a versatile CAD-based preprocessor.

Companies:

Intergraph Corporation/AEC Group contact: Stuart Obermann, 205/730-8677 Huntsville, AL 35894 phone: 205/730-2000 fax: 205/730-2461

Computers & Structures, Inc. contact: Randall Corson, 1995 University Avenue Berkeley, CA 94704 phone: 510/845-2177 fax: 510/845-4096

James Lord is a registered civil engineer specializing in structures at Rutherford & Chekene in San Francisco, California. Mark Middlebrook is president of Daedalus Consulting, a structural CAD and computer consulting firm in Oakland, California. He is co-author of the forthcoming book AutoCAD Power Tools.

Steel Girder Bridge Design

Version 5.0 of Merlin-Dash, a PC-based computer program for the design and analysis of straight steel girder bridge systems, has been released by the Bridge Engineering Software Center (BEST). The new rolled beam design feature allows user defined nominal depth and material. The steel material is arbitrary with the optimal nominal depth up to 40". The change of section can be user-defined or default by the program. In the new pouring sequence feature, pouring numbers and days are defined on screen and it is allowed to have either DL stage analysis or DL stage + LL analysis. The program is widely used by the FHWA, state/county/city agencies and private consultants.

For more information, contact: Pat Johnson at The BEST Center, Department of Civil Engineering, University of Maryland, College Park, MD 20742 (301) 405-2011; fax 301/314-9129.

80 Mhz Workstation

The Performance Logic Predator Series from MC² Computer Systems is an Intel 486DX2-based graphic station running at 80 Mhz. The system is targeted toward the rapidly developing market of MicroStation PC users. To speed MicroStation's continual reads and writes to the hard drive, the computer is equipped with a Maxtor FAST SCSI-2 disk drive with an 8.5 millisecond access time. The system comes with 256K of Static RAM and from 16 to 128 Mb of 60 nanosecond RAM and have a price range beginning at $5,500.

For more information, call: MC² Computer Systems at (800) 377-2087.

Ink-Jet Plotter Supplies

Dietzgen Corporation has introduced a new line of ink-jet plotter medium. Although ink-jet plotters are designed to print on most papers, their performance can be enhanced by choosing a material optimized for ink-jet plotting. The company is offering a wide variety of materials, including: three types of bond; vellum; and polyester film.

For more information, call: Dietzgen Corporation at (800) 473-1200.

Integrated Structural Analysis and Design

Metrosoft, Inc. has introduced Version 1.2 of ROBOT V6, a new generation of integrated structural analysis and design software. Completely rewritten in C++, state-of-the-art programming techniques are used to all but eliminate limits on problem size (maximums are 32,500 nodes, 32,500 elements, 32,500 loads and combinations, and 1,000 mode shapes). Despite its power, the program is very easy to use and features full graphical input and result processing. Rapid input creation is possible using powerful CAD-like generating and editing commands. The program is menu-driven. Also, member optimization can be performed according to minimum weight, a range of maximum and minimum depths, or both. The program is geared for structural engineers and supports the latest U.S. codes (various foreign code supplements are available).

For more information, contact: Metrosoft, Inc, 332 Paterson Ave., East Rutherford, NJ 07073 (201) 438-4915; fax 201/438-7058.

CAD Steel Design Utility Programs

A new package of AutoLISP utility programs is now available for users of AutoCAD 12. These programs were written and tested by a structural engineer with extensive experience in steel design and fabrication to meet the needs of designers and detailers. Among the utilities available are: cross sections with side view options for structural shapes make use of a dialogue box control with unique input options to quickly assemble plan views and elevations of steel framing; programs to interactively create welding symbols, section arrows and item balloons; and calculator programs to report item weights and drawing border/scale options from selected geometry.

For more information, contact: R. Larsen, P.E., 4640 Windemere Dr., Sturgeon Bay, WI 54235 (414) 746-0521.

Inexpensive 3D CAD

Release 2 of Generic 3D, Autodesk's inexpensive DOS-based CAD program, is now available. Despite its $399 price tag, the program includes: cursor alignment/tracking; sculpt modes; AutoCAD compatibility; linear dimensioning and text lines; nested commands; "bite-sized" exercises and tutorials; and a large library of sample symbols. Minimum system requirements include a PC AT or higher, 1 MB of RAM; MS-DOS 3.0 or higher; a hard drive with 7 MB of free space; an EGA or better graphics card and a Microsoft mouse or compatible.

For more information, contact: Retail Products Division, Autodesk, 11911 North Creek Parkway South, Bothel, WA 98011 (800) 228-3601; fax 206/483-6989.

Analysis, Design & Drafting

Research Engineer's Auto-STAAD/MAX software offers: model generation; analysis; design; drafting; and detailing—all entirely within AutoCAD. Analysis facilities include 2D/3D static/dynamic/seismic/P-Delta analysis, frame/plate/shell elements, and all possible loading and support conditions. The program designs for both current American and International codes. Extensive load generation facilities are available, including moving loads (AASHTO and user provided), UBC seismic loads, wind loads, floor loads, response spectrum and time history loads. Graphics facilities include interactive model generation and elaborate verification capabilities—plotting of structural geometry, deflected shapes, bending moment, shear force diagrams, stress contours, etc. Structural drafting facilities include generation of framing plans/sections/elevations, foundation plans, and details.

For more information, contact: John Putnam, Research Engineers, Inc., 1570 N. Batavia, Orange, CA 92667 (714) 974-2500; fax 714/974-4771.

Dimensional Calculations

Jobber Instruments, the producer of the Jobber II and III Dimensional Calculators has added a software/mathematical program to its line. The program works with the user's CAD system and works in three-dimensional formats with instant conversion between different measurement systems—feet, inches and fractions; decimals of a foot; and metric. It has a scrolling tape on the screen for displaying all dimensions, calculations and solutions. And it comes with special graphics for working with items such as right triangles, oblique triangles, circles, off-set bracing, and stairs. Calculating roof slopes, stairs, rails, bracing, beams, columns, frames, hoppers, and hips and valleys is greatly simplified.

For more information, contact: Jobber Instruments, P.O. Box 4112, Sevierville, TN 32864 (800) 635-1339.

High-Speed Plotters

Xerox Corporation has introduced a new digital writing technology which allows for faster, higher resolution raster plotting. Based on the electrostatic writing process, the ASI imaging process allows for significantly enhanced line quality and solid fill areas. Prices for the 8770 series begin at $25,900. The plotters can draw on five types of media, including opaque, vellum and translucent paper and clear and matte-black film.

For more information, contact: Xerox Engineering Systems, P.O. Box 92718, Rochester, NY 14692-8818 (800) XES-TALK, ext. 7067.

Plant Design

Applications Development, Inc., has introduced a new software module to supplement its PRO-SERIES family of software for AutoCAD-based plant design. This new release speeds drafting and generation of reports for plant and equipment arrangements, as well as for intelligent 2D or 3D background steel. PRO-PLANT/STEEL takes advantage of AutoCAD's extensive entity data programming feature so that all of the steel component intelligence—including height, width, length, paint area, etc.—are easily available for automatic notation and bill of material generation. Also, when a steel beam is trimmed or stretched, all of the information is updated. The program also readily converts back and forth from 2D to 3D and features automatic generation of sections.

For more information, call (504) 835-1627 or fax 504/835-4867.

Ink Jet Plotter

CADVisions has announced a new, lower price on NovaJET II, an A-E size inkjet plotter. The $7,995 plotter features improved monochrome line drawings, better color images, and is easier to use. To improve monochrome line drawings, a new linear encoder tracks the position of each inkjet cartridge and places the ink in precise location, eliminating banding and overspraying. Also, banding, bleeding and buckling are virtually eliminated in color plotting.

For more information, call: Roy B. Burchfield of CADVisions at (214) 720-2023 or fax 214/720-0617.

3D Analysis & Design

Computers and Structures, Inc., has released the latest versions of ETABS and AutoETABS, state-of-the-art software applications for building analysis and design. The ETABS system is a series of large capacity programs specifically developed for three-dimensional analysis and design of building structures. ETABS can analyze moment frame, braced framed or shear wall buildings, or combinations of these. Dead, live, wind, static seismic and/or dynamic earthquake load analysis (including time history) are all possible. TIMER, an interactive time history display processor, generates time history traces of displacements, velocities, accelerations, as well as element forces. STEELER V5.4, a design post-processor for ETABS, supports LRFD and ASD according to the latest AISC Specs. Version 3.0 of AutoETABS, the AutoCAD-based structural modeler program for the ETABS building design system, fully supports AutoCAD 12's new user interface. New dialogue boxes have been added throughout, making it easier to define, assign and review story heights, sections properties and materials, loads and AutoFLOOR references. It also now supports metric units.

For more information, contact: Computers and Structures, Inc., 1995 University Ave., Berkeley, CA 94704 (510) 845-2177; fax 510/845-4096.

Integrated Design & Detailing

The SDS/2 Software from Design Data saves time and money by eliminating the duplication of information between engineers and detailers. Users of SDS/2 create a three dimensional model only once, which is then used for all phases of design and fabrication. The same model is used to analyze and design the structure, design connections, add connection material and automatically produce shop drawings. Design Data also has developed an interface to other third party engineering software products. DesignLINK provides a means of data transfer between different engineering and detailing software packages.

For more information or to schedule a free demonstration, call: Design Data at (800) 443-0782 or fax 402/476-8354.

DOS Engineering Calculations

ENERCALC Engineering Software has introduced their first "DOS" only software system. The program is designed to perform most of an engineer's typical building structural calculations without the need for a separate spreadsheet program, such as Lotus 1-2-3. Beams, columns, foundations, walls, diaphragms and 2D frames can be designed using the program. Also, seismic & wind analysis can be performed.

For more information on the $945 program, call: Beverly Kibler at (800) 424-2252 or fax 714/557-9957,

Bridge Design

Version 5.0 of MERLIN DASH (Design Analysis of Straight Highway Bridge Systems) is now available from Opti-Mate. The program is fast running and features an extremely user-friendly menu-driven input system. An AASHTO Code check is performed for LFD and WSD. New features include: design capability for rolled beams with 40" sections; pouring sequence where curing rates are considered; and special boundary conditions, such as partially or fully fixed supports as well as support settlements and frame simulation.

For more information, contact: Ollie Weber, OPTI-MATE, Inc., P.O. Box 9097, Dept. A1, Bethlehem, PA 18018 (215) 867-4077.

Angle Strut Design

Formal Software Publishing has released a new software program for the design of Single Equal Leg Angle Struts. ANGLE-1 eliminates the need for tedious and labor intensive compression member calculations. Based on AISC Specifications, the program offers the structural engineer a point-and-shoot approach to solving problems. The program works with both ASD and LRFD methods. It has fully configurable design parameters, a database of AISC equal leg angle sizes, and four calculation modes.

For more information on the $125 program, contact: Formal Software Publishing, 2120 Market Street, Suite 209, Camp Hill, PA 17001 (717) 763-5772.

Macintosh Structural Software

Multiframe is a structural analysis and design software system for the Macintosh. Featuring fast interactive graphics, the program delivers ease of use with powerful 3D analysis and design. Integrated CAD and spreadsheet tools allows fast data editing and allows the user to make incremental changes interactively and to re-analyze without having to restart from scratch. Advanced visualization capabilities, including color stress contours, rendering and animation allow the user to quickly identify problem areas. Code checking and customizable libraries are included. Multiframe 3D sells for $1,495. The company also offers a Steel Designer program for $695, a Section Maker program for $395, and a bundle of all three programs for $1,995.

For more information, contact: Graphic Magic, 180 Seventh St., Suite 201, Santa Cruz, CA 95602 (408) 464-1949; fax 408/464-0731.

Low-Cost Scanner

An inexpensive system to quickly scan A to D size drawings into a PC for archiving or CAD conversion is now available from IDEAL Scanners & Systems. The IDEAL I/Brush combines a portable scanner with calibration software and board to seamlessly scan any document up to 24" x 34". Complete tools for image cleanup, format conversion, viewing and plotting provide bridges to most raster operations. Resolution is selectable up to 300 dpi and prices for the scanner start at $2,595.

For more information, contact: IDEAL Scanners & Systems, 11810 Parklawn Dr., Rockville, MD 20852 (310) 468-0123; fax 301/230-0813.

Bridge Grid Analysis & Steel Girder Design

An integrated bridge grid analysis and steel girder design package from MDX Software is designed to save time and reduce material costs. The scope of application includes plate girders and box girders, including web haunches, rolled shapes, skewed abutments and piers, and variable horizontal curvature. The program features a highly advanced girder design processor that performs sophisticated mathematical searches for optimal designs conforming to both the 1992 AASHTO Specification and the engineer's preferences. The grid program generates the geometry and influences surfaces, calculates the live load envelope from rigorous lane loading or wheel load distribution, and closely interacts with the girder program.

For more information, contact: MDX Software, 1412 Ridgemont Court, Columbia, MO 65203 (314) 446-3221; fax 314/446-3278.

Column Design

Ram Analysis has released RAMSTEEL Column Module Version 1.0, a program that seamlessly integrates with the RAMSTEEL Floor Framing Module. The user of the Floor Framing Module graphically and interactively specifies several new parameters for the Column Module, which then design all the columns and base plates for the entire building. Columns may be designed as wide flange, tube or pipe, and the program can design to both the ASD 8th or 9th editions and LRFD. For column design, the user may consider the effects of "unbalance moments" due to skipped live loads on eccentric "pinned" beam-to-column connections, and corresponding axial load. The program checks for the worst possible condition of loading. Up to three different column trial designs can be automatically calculated. The user specifies where column splices occur, thereby grouping columns where the same column extends for two or more levels.

For more information, contact: Gus Bergsma, Ram Analysis, 5315 Avenida Encinas, Suite M, Carlsbad, CA 92008 (619) 431-3610; 619/431-5124.

2D Structural Design

The RISA-2D program provides a fast, truly interactive environment for the solution of a wide range of structural design problems. RISA-2D can easily handle frames, trusses, shear walls, continuous beams and much more. Static, dynamic and P-Delta capabilities are included, with full steel design (including member selection). Powerful data generation functions combined with spreadsheet editing and extensive graphics make the $495 program easy to learn and use.

For more information and a free demo disk, contact: RISA Technologies, 25212 Dimension Dr., Suite 200, Lake Forest, CA 92630 (800) 332-7472; fax 714/951-5848.

Partially Restrained Connections

A new program from RMR Design Group, PRCONN V2.0, supports the analysis of noncomposite and shored and unshored composite beams having typical PR connections (double web angles, single plates, header plates, top and seat angles, and combinations of these). Unshored composite beam analysis is a two-stage structure and loading procedure. Stage one is the analysis of the noncomposite beam with the beam, decking, and wet concrete loads. Stage two is the analysis of the composite beam with the superimposed dead and live loads. PRCONN also provides the horizontal components of the connection forces (bolts, reinforcement and seat) that result from the connection moment. The designer can use these forces to determine if the supporting structure (e.g. a column) will require stiffening and/or strengthening to prevent local yielding.

For more information, contact: RMR Design Group, Inc., 4421 E. Coronado Dr., Tucson, AZ 85718 (602) 577-2191.

Structural Analysis Tool Box

A powerful collection of 60 of SAI's most useful structural analysis and design programs is now available for only $650. The package provides complete steel design capability as per ASD 9th Edition. The package analyzes and designs simple span and continuous span beams (20 spans), composite beams and column stacks (unlimited number of floors), as well as frames and trusses (400 joints, 600 members). Wide flange, tube and pipe shapes are all stored on disk files to facilitate final shape selection. Beam and column programs store and recall beam reactions, and allow multiple member designs in a single run.

For more information or a free catalogue, contact: Structural Analysis Inc., 555 South Federal Highway, Suite 210, Boca Raton, FL 33432 (407) 394-4257.

Bridge Girder Design

A new 3D model and moving load generator for the design of open girder bridge models is now available from SC Solutions. SC-Bridge features: variable girder depths; variable spacing; variable number of girders; cross-bracing definition; automatic seismic models; input generation; and multiple horizontal & vertical curves. The program also includes a moving load generator module that supports standard truck databases, lane load generation and user selected load combinations.

For more information, contact: Greg Loy, SC Solutions, 1933 Landings Dr., Mountain View, CA 94043-0810 (415) 903-5050; 415/691-9452.

3D Bridge Analysis

A full-featured, 3D bridge analysis and design system for straight or curved girder bridges is now available from Telos Technologies. CBRIDGE also now allows for the simultaneous placement of multiple vehicle types. Specialized vehicles may be positioned in critical lanes while standard vehicles occupy additional lanes. User defined vehicles up to 30 axles are automatically positioned on an influence surface. Flexible options for both live and dead loads provide a wide variety of loading conditions. Mouse-driven graphical interface allows rapid building and editing of design model. AASHTO code check is performed during design sequence.

For more information or a free demo disk, contact: Telos Technologies, Inc., 1201 E. Fayette St., Syracuse, NY 13210 (315) 471-0113.

Structural FEM Design & Analysis

StruCAD*3D is a powerful 3D graphics-oriented suite of programs for structural FEM design and analysis. The program, from Zentech, performs stress calculations and code checks in accordance with the latest AISC ASD and LRFD specs. Included are full AISC section libraries. Analysis includes static, eigen, seismic, P-Delta, wind and gravity load generation, fatigue, steady-state analysis, and 3D nonlinear soil pile interaction. A total graphics environment allows model generation, analysis, design, review of results, and interactive redesign, with menu-driven features and options, which allow the user to design with ease and speed. The program has a capacity of 6,000 nodes, 12,000 elements, 200 load cases, and 200 load combinations, and is available in DOS and UNIX models. A special purchase price of $2,500 is available until 10/31/93, or a competitive upgrade is available for $995.

For more information, contact: Randy Parikh, P.E., Zentech, Inc, 8582 Katy Freeway, Suite 205, Houston, TX 77024 (713) 984-9171; fax 713/984-9175.

3D Rendering

Visual Software has begun shipping Version 2.0 of Renderize for Windows, a photorealistic 3D image rendering utility for Microsoft Windows. The program allows designers to quickly convert a wireframe model into a full-color, photorealistic image for hardcopy output.

For more information, contact: Visual Software, Inc., 21731 Ventura Blvd., Suite 310, Woodland Hills, CA 91364 (800) 669-7318; fax 818/593-3750.

Inkjet Plotter

Pacific Data Products has announced a new C-size inkjet plotter for only $1,499. The ProTracer can be used to produce both C-size drawings and regular office documents. Both HP-GL and PostScript emulation cards are available. Output is 360x360 dpi and area fills are solid with no banding or streaking.

For more information, contact: Pacific Data Products, 9125 Rehco Road, San Diego, CA 92121 (619) 552-0880; fax (619) 552-0889.

Structural Analysis & Design

A general purpose structural analysis and design program, M-STRUDL from CAST, is designed to perform static, dynamic, and UBC analysis for 2D/3D frame/truss/plate problems. It designs steel structures according to both ASD and LRFD specs. Prices for the program start at $340.

For more information, contact: CAST, P.O. Box 14676, Fremont, CA 94539-4676 (510) 226-8857.

Masonry-To-Steel Connections

The MTD System 1 is a third-party software system that eliminates the need to assemble masonry and structural steel component details from scratch. Sixty complete state-of-the-art details are provided in plan, section, and isometric form. All details have been carefully researched and formulated to meet current standards and code requirements. Engineers and fabricators can use the details as shown or make modifications to meet specific project requirements. This system is ideal for architects and engineers involved in designing low-rise steel structures clad with masonry. The MTD System operates on DOS version of AutoCAD Release 11 and 12. All details are derived from the technical publication "Masonry and Steel Detailing Handbook." Cost is $225.

For more information or to receive a free demonstration disk, contact: Masonry Technologies Inc., 2000 Aldrich Place, Downers Grove, IL 60516 (708) 852-9122.

Connection Design

Dogwood Technologies has introduced an engineering software module for structural steel connections. Included are: framed beam connections with bolted or welded clip angles including cope checks; moment connections with beam flanges bolted or welded to column flange or web including column stiffener design; end plate moment connections; single plate shear connections; vertical and horizontal bracing connections; truss end connections; welded truss interior panel joints; column splices; column base plates; USD eccentric weld analysis; USD eccentric bolt analysis; and bolt prying checks.

For more information, contact: Dogwood Technologies, Inc., P.O. Box 52831, Knoxville, TN 37950-2831 (800) 467-0096.

Project Management Software

Designed by engineers for engineers, BeInformed from Saga Solutions provides a tightly controlled project management environment that coordinates project contacts, documents, employee hours, appointments and task skills. Features include: detailed, on-line time cards; work assignment lists; pop-up notepads; and multi-level security.

For more information, contact: Saga Solutions, 160 E. Virginia St., Suite 280, San Jose, CA 95112 (408) 293-7110; fax 408/293-0890.

AISC Software

AISC offers six software packages for structural engineers.

CONXPRT is a knowledge-based, menu-driven PC software system for the design of connections in steel framed buildings. All strength limit states are checked and expert advice from long-time fabricators and engineers is used to augment the design rules. The program generates cope sizes, allows bolt stagger and permits different bolt diameters for shop and field use. CONXPRT costs $300 for the LRFD version and $400 for the ASD version. Also available is a moment connection module for $400 (ASD only).

STEMFIRE determines safe and economical fire protection for steel beams, columns and trusses. It is based on rational procedures developed by AISI. STEMFIRE costs $96.

WEBOPEN is designed to enable engineers to quickly and economically design beam web openings. It uses state-of-the-art criteria and a clear, logical data entry system with easy-to-use color coded input windows. WEBOPEN sells for $495.

AISC FOR AUTOCAD is designed to reduce the time it takes to draw structural steel details. It contains data from both the ASD and LRFD manuals. The program sells for $120.

ELRFD is a sophisticated new program for interactively checking structural steel building components for compliance with AISC Specification. It checks whether the member satisfies all limit states and limitation requirements set by the LRFD Specification. ELRFD costs $495.

AISC DATABASE contains the properties and dimensions of structural steel shapes, corresponding to data published in the most recent ASD and LRFD manuals. It is presented in ASCII format. The database costs $60.

For more information, contact: AISC Software, P.O. Box 806276, Chicago, IL 60680-4124 (312) 670-2400; fax 312/670-5403.

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