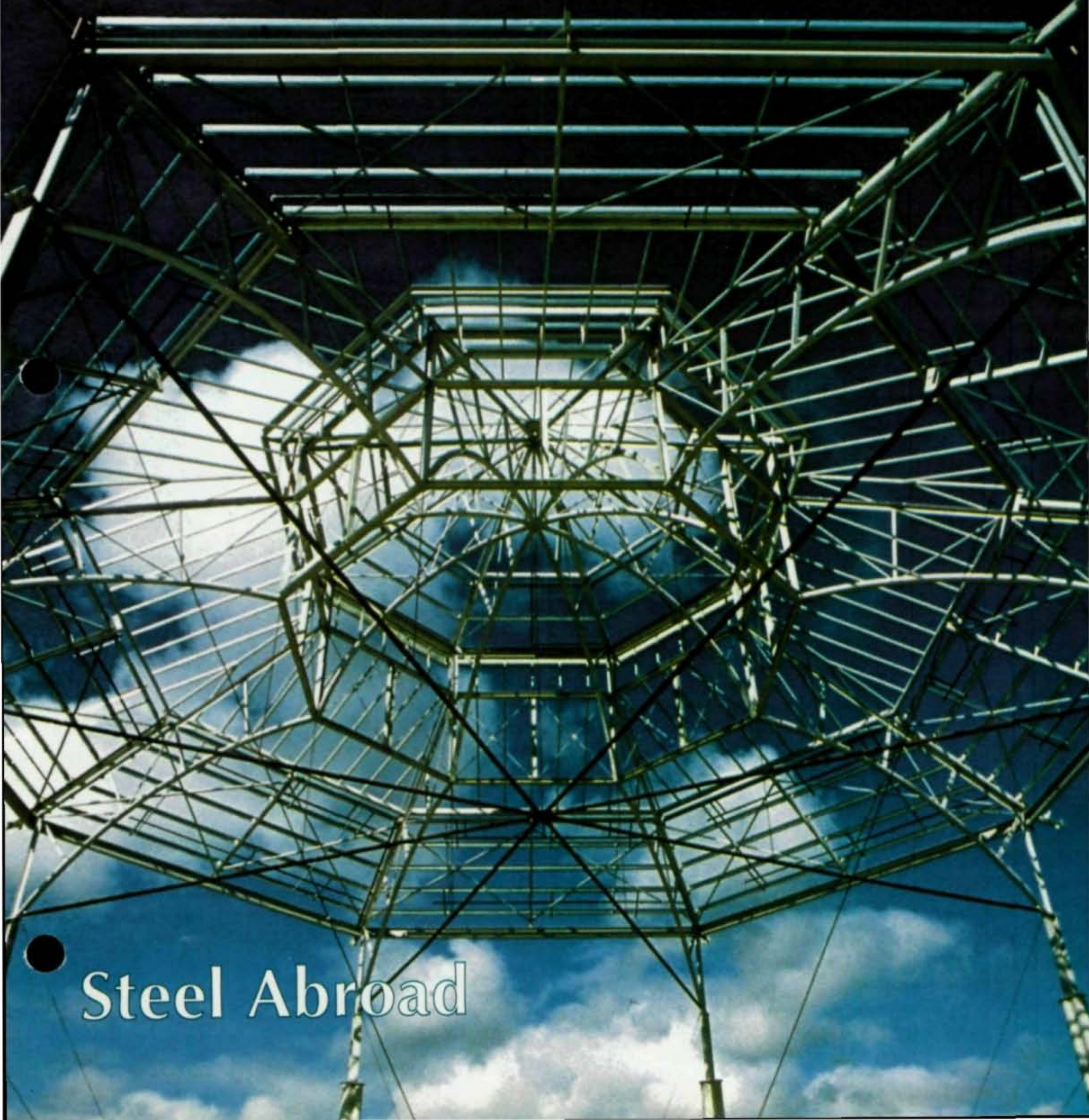
MODERN STEEL CONSTRUCTION

July 1995

$3.00



UNITED STEEL DECK, INC.

deck design data sheet

#22

Uplift Values for SCREWED DECK

Deck can be screwed to structural steel, bar joists, or light gage steel framing. The lowest strength was used to produce the tabulated values. For bar joists and structural steel, a tensile strength (F_u) of 58 ksi was used which is the lowest value for A36 steel. For gage supports, F_u = 45 ksi was used which is the lowest provided in ASTM A653 Structural Quality grade 33. Deck materials furnished in gages 24, 26 and 28 are usually grade 80 steels which use a tensile strength (F_u) of 60 ksi as limited by the AISI specifications. Either pull out of the screw or pullover of the deck will normally control. The values are based on the equations provided by the AISI Specifications (1986 with addenda). These specifications call for a safety factor of 3 to be applied to the table values. However, for temporary wind loads, a one third load increase is appropriate. If it is known that the tensile strength of the support steel or the sheet steel is greater than the values used for the tables, the tabulated ultimate strengths may be increased by a straight line ratio.

Screw Size	d dia.	d_w nom. head dia.	Average tested tensile strength, kips
#10	0.190	0.415 or 0.400	2.56
#12	0.210	0.430 or 0.400	3.62
1/4	0.250	0.480 or 0.520	4.81

Pull Over Strength, kips = $P_{nov} = 1.5\, t_1 d_w F_u$; $d_w < 0.50"$.

Washer or head, d_w	16 ga.	18 ga.	20 ga.	22 ga.	24 ga.	26 ga.	28 ga.
0.400	1.61	1.28	0.97	0.80	0.86	0.64	0.54
0.415	1.68	1.33	1.00	0.83	0.89	0.67	0.56
0.430	1.74	1.38	1.04	0.86	0.92	0.69	0.58
0.480	1.94	1.54	1.16	0.96	1.03	0.77	0.64
0.520(0.500)	2.02	1.60	1.20	1.00	1.08	0.81	0.67

Key
Fu = 60 ksi
Fu = 45 ksi
Fu = 58 ksi

Pull Out Strength, kips = $P_{not} = 0.85 t_2 d F_u$; Metal thickness = t_2

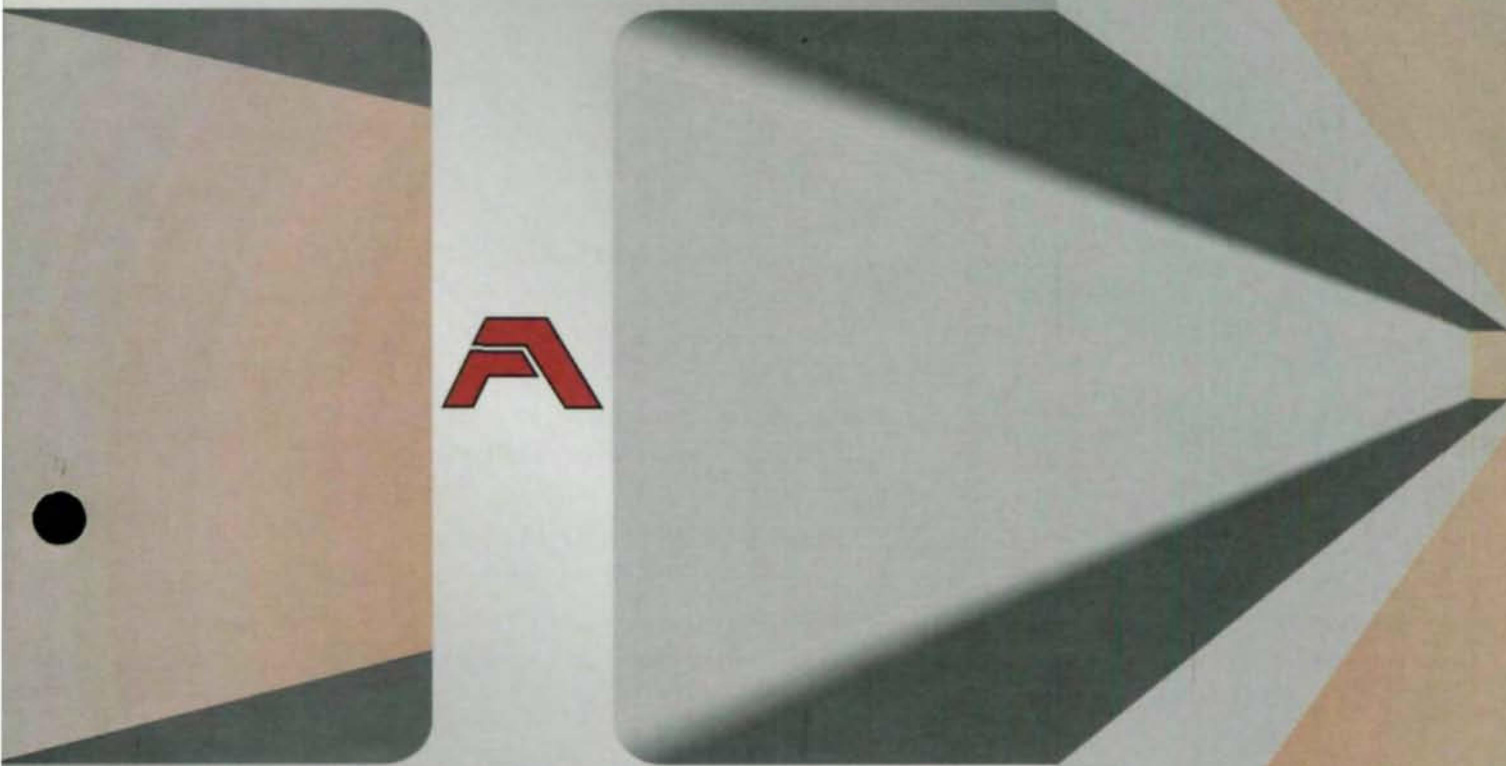
Screw	1/4"	3/16"	10 ga. (0.135)	1/8"	12 ga. (0.105)	14 ga. (0.075)	16 ga. (0.060)	18 ga. (0.047)	20 ga. (0.036)	22 ga (0.030)
#10	2.34	1.76	0.98	1.17	0.76	0.55	0.44	0.35	0.26	0.22
#12	2.66	2.00	1.12	1.33	0.87	0.62	0.50	0.38	0.29	0.24
1/4	3.08	2.31	1.29	1.54	1.00	0.72	0.57	0.45	0.34	0.28

Note: In our Metric catalog "Steel Decks for Floors and Roofs", the tables on pages 33 and 35 are in the wrong place. Contact us for the needed corrections or contact us for a copy of the corrected publication.

NICHOLAS J. BOURAS, INC.
P.O. BOX 662, 475 SPRINGFIELD AVE.
SUMMIT, NEW JERSEY 07902-0662
(908) 277-1617

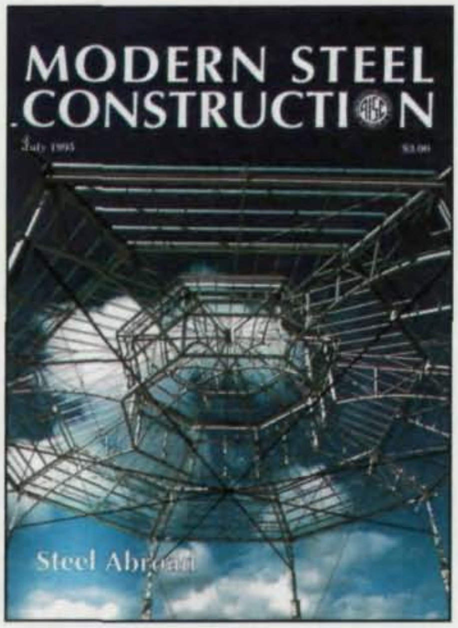
MEMBER sdi

ASSOCIATE MEMBER



MODERN STEEL CONSTRUCTION

Volume 35, Number 7 **July 1995**



A new retail center in Australia features a huge central skylight supported by a spiderweb of steel members. The story behind this fascinating project begins on page 32.

FEATURES

Modern Steel Construction (Volume 35, 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.

Advertising office: Facinelli Media Sales, O'Hare Lake Office Plaza, 2400 E. Devon Ave., Des Plaines, IL 60618 (708) 699-6049.

Subscription price:
Within the U.S.—single issues $3; 3 years $85.
Outside the U.S.—single issues $5; 1 year $36; 3 years $100.

Please fax any addresses changes to 312/670-5403 or to the address below.

Postmaster: Please send address changes to Modern Steel Construction, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001.

Second class postage paid at Chicago, IL and at additional mailing offices.

DEPARTMENTS

Editorial Staff
Scott Melnick,
Editor and Publisher
Patrick M. Newman, P.E.
Senior Technical Advisor
Charlie Carter,
Senior Technical Advisor
Jacques Cattan,
Technical Advisor

Editorial Offices
Modern Steel Construction
One East Wacker Dr.,
Suite 3100
Chicago, IL 60601-2001
(312) 670-5407
Fax 312/670-5403

Advertising Sales
Facinelli Media Sales
2400 E. Devon Ave.,
Suite 267
Des Plaines, IL 60018
(708) 699-6049
Fax 708/699-8681

AISC Officers
Frank B. Wylie, III,
Chairman
Robert E. Owen,
First Vice Chairman
H. Louis Gurthet,
Second Vice Chairman
Robert D. Freeland,
Treasurer
Neil W. Zundel,
President
David Ratterman,
Secretary &
General Counsel
Morris Caminer,
Vice President,
Finance/Administration

Next Year In...

MORE THAN 1,100 ENGINEERS, FABRICATORS, EDUCATORS AND CONTRACTORS GATHERED IN SAN ANTONIO in Mid-May for the National Steel Construction Conference. While the food was surprisingly mild, the seminars were anything but. It's hard to summarize the more than 20 sessions over a three-day period, but if I had to choose one recurring theme, it was that least weight does not necessarily produce the lowest cost steel structure (anyway, I heard it in three separate seminars). Or perhaps a more accurate theme was simply how to do the best job at designing and fabricating steel structures.

In addition to the seminars ranging from industrial building design to advances in fabricating tubular sections, there also were a number of new products premiered at the show, including Chaparral Steel's Castelite beams and MNH-SMRF's new seismic connections (these will be covered in depth in next months new products section). I could regale you with stories from the conference (crossing the spectrum from a hilarious five-minute video on painting one speaker used as an introduction to the very detailed and thorough presentation on welding inspection offered by Bob Shaw), but if you missed it, nothing short of reading the entire Proceedings would provide you with even an inkling of the valuable material presented there. Instead, I'll let you know what's coming in the future.

Next year's NSCC, to be held March 27-29 in Phoenix will offer the usual array of technical engineering and fabrication seminars, as well as the engineering management and construction management tracks offered in San Antonio. And, as was done this year, many of the sessions will be translated into Spanish for our attendees from south of the border. But next year also will see the introduction of two completely new tracks: Erection and Computers.

Complete information will appear in a future issue of Modern Steel Construction. In the meantime, be sure to mark March 27-29 on your calendar (and if you see any good air fares, book early). **SM**

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 you 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
One East Wacker Dr., Suite 3100
Chicago, IL 60601-2001

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 principals to a particular structure.

Information on ordering AISC publications mentioned in this article can be obtained by calling AISC at 800/644-2400.

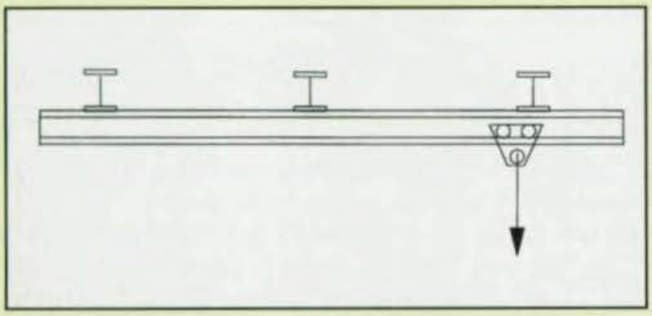
The following responses from previous Steel Interchange columns have been received:

Are there any limitations on the span to depth ratio of beams required by AISC Specification for Structural Steel Buildings?

In the Commentary on the AISC Specification (9 edition) chapter L, section L3 the following rule was suggested: "The depth of fully stressed beams and girders in floors should, if practicable, be not less than (F_y/800) times the span. If members of less depth are used, the unit stress in bending should be decreased from than recommended above."

Alex Krasilovsky, P.E.
Ridgefield Park, NJ

For a continuous trolley beam with multiple spans and cantilevered ends what is the lateral unbraced length for the bottom flange?



The lateral unbraced length of a cantilever trolley beam is approximately half[1] of the cantilever span, provided the support is braced against twist. The AISC code[2] states that L shall conservatively be taken as a unity, if the support is braced against twist. ANSI[3] Monorail Specifications specify L to be 2 times the length of cantilever, since the cantilever is not fully stayed at its outer end. The ANSI method is the most logical, L unbraced equals 2 times the actual length. If the cantilever is braced, the brace should connect to the top tension flange at the end, to offset twist[4].

The interior unbraced length, should be the distance between supports, per ANSI specifications on Monorail Systems[3].

Often the size of the trolley beam is controlled by the flange width, to be wide enough for the bolted gage plus 2 proper edge distances. Also the beam depth must be deep enough for the trolley wheel diameter. Flange bending strength under the wheels is important also.

[1] Timoshenko, S., "Theory of Elastic Stability", p. 260 & 269, 1961.
[2] AISC, "Manual of Steel Construction, Allowable Stress Design", p. 5-47, Ninth Edition.
[3] ANSI, "American National Standard Specifications for Underhung Cranes and Monorail Systems", p. 7, MH 27.1-1981.
[4] AISC, "Steel Design Current Practice, Bending Members - Buckling and Bracing", p.27.

Claude R. Krout, P.E.
Birmingham, AL

Can an existing steel beam and concrete slab be made to work together in composite action by adding studs to the steel through cored holes?

This question was previously responded to and it was the author's opinion that the existing loads presently on the beam should act on the bare steel. However, utilizing the Load & Resistance Factor Design code (LRFD) and assuming plastic stress distribution for positive moment, the composite section can carry all the load if the following requirements are met:

1. $\phi M_n \geq M_u$ for the composite section.
2. Yielding of the beam does not occur at the

maximum possible service load.

3.Composite action between the grouted holes and existing concrete occurs.

4.The deflection of the member is acceptable.

Using load factor design, the nominal moment of the section is developed when the entire section is fully plastic. When this occurs, the relationship between stress and strain is non-linear. Therefore, the existing dead load can be assumed to be carried by the composite section. Reference should be made to Chapter I of the LRFD code under Sections I1. and I3. By utilizing this type of analysis, significant load increase may be permitted under the provisions of the LRFD code.

Kurt Seidler, P.E.
Canfield, OH

Can you provide some information on eccentric effects on single angle bending members?

The specifications for LRFD design of single angle members is valid for angles loaded eccentric to the neutral axis and to the shear center; however, the effects of these eccentric loadings must be considered in combination with stresses form all other load effects if the provision of sect. 5.2.1a are not met. That is, if the brick wall does not have the stiffness or connectivity to the angle to prevent lateral torsional buckling or if the angle is not independently restrained then the effects of this eccentricity must be considered. Furthermore, the location of the restraint with respect to the vertical leg of the angle (i.e. the extreme fiber of the compression portion of the angle) should be considered when determining restraint.

The location of the load with respect to the shear center will cause a torsional eccentricity. This eccentricity will increase the shear and normal stress in the angle requiring an increase in the strength of the angle. The effect of the load eccentricity to the shear center will induce torsional stresses in the member. These stresses can be categorized into two types, pure torsion (St. Venant's torsion) and warping torsion. Pure torsion causes pure shear stress only $\tau_t = Gt(d\phi/dz)$, warping torsion causes warping shear stress $\tau_w = ES_w(d^3\phi/dz3)$ and warping longitudinal stress $\sigma_w = E\omega_n(d^2\phi/dz^2)$. Under the loading conditions shown all three of these stresses can be present. Their magnitude will depend on the magnitude and location of the loads and the boundary conditions of the angle. For design purposes these stresses should be considered as acting in combination with the normal and shear stress due to bending.

In addition, deflection and rotation due to these torsional stresses should be added to the deflection due to bending when considering the serviceability requirements of this angle.

A very good source which outlines the calculation of the torsional stresses indicated above is found in "Cold Formed Steel Design 2nd edition appendix B", Wei-Wen Yu. Additional information on torsional stresses and their effects can be found in "Steel Structures design and behavior", Salmon & Johnson and in the AISC publication "Torsional Analysis of steel members".

The commentary to the specification for single angle members section C6 states "... the applied moments should be resolved about the principal axes for the interaction check." If Mn is determined about the principal axis then Mu must be converted from geometric axis loading to equivalent principal axis loading. Hence, Mnx = Mn(sin) and Muy = Mn (cos).

The resolution of loading and stresses about the principal axes may be neglected if the provision of sect. 5.2.1a is met. That is, as stated in the commentary to this section, if the angle is restrained against lateral torsional buckling along its length then bending occurs without any torsional rotation or lateral deflection. Therefore, only bending about the geometric x axis and shear in the geometric y axis need be considered.

Thomas M. Vossmeyer, P.E.
Salina, KS

New Question

In field bolted connections for galvanized members, are bolt holes enlarged to account for the layer of zinc which will be deposited? If so, by how much and is it possible to treat the resulting hole as a standard hole in design?

How do you calculate the moment capacity of a double angle shear connection?


We designed our mill with the same convenience in mind.
When you're in the market for steel, and you need it fast, you know there's nothing convenient about waiting for a rolling schedule. Maybe it's time you switched from a rolling mill to a stocking mill: Chaparral.
Our $50-million on-site steel inventory is one of the largest in the world. It's so large, in fact, that we can fill over 80% of our steel orders from stock — in two weeks or less. Special orders? Fast track jobs? We'll process those within 72 hours. Even if your order changes, we'll work with you to fill it as quickly as possible.
So what are you waiting for? Next time you're shopping for steel, call Chaparral. You'll always get the right steel…right away.
CHAPARRAL STEEL.
Toll Free (800) 527-7979 U.S. and Canada • Local (214) 775-8241
Fax (214) 775-6120 • 300 Ward Road, Midlothian, Texas 76065-9651
Please circle # 43

Steel Seminars Continue

FROM DISCUSSIONS OF BOLT INSTALLATION TO THE DEVELOPMENT OF A NEW HIGH-STRENGTH STEEL, AISC's 1995 Seminar Series is designed to provide practical information for structural engineers, fabricators, and others involved in the steel construction industry. As an added bonus, the seminar will offer a session on "Answers to the Most Commonly Asked Questions" of AISC staff engineers.

Each seminar begins at 2:00 p.m. and ends at 8:15 p.m. Cost for the seminar, which has a CEU value of 0.45, is $120 ($90 for AISC members). The fee includes the lectures, numerous handouts, LRFD educational software, and dinner.

For more information, call AISC at 312/670-5422.

1995 Steel Seminar Schedule

Date	City
July 20	Omaha
July 25	Minneapolis
July 27	St. Louis
August 8	Rochester, NY
August 9	Albany
August 10	Portland, ME
August 15	Washington, DC
August 17	Philadelphia
August 22	Chicago
August 24	Milwaukee
September 7	New York City
September 12	Meriden
September 14	Boston
September 19	Dallas
September 21	Houston
September 26	Denver
September 28	*Kansas City*
October 3	Birmingham, AL
October 5	Atlanta
October 10	Detroit
October 12	Indianapolis
October 17	Cleveland
October 18	Columbus
October 19	Cincinnati
October 24	Memphis
October 26	Nashville
October 31	Pittsburgh
November 2	Edison
November 7	New Orleans
November 9	Albuquerque
November 28	Miami
November 30	Orlando

For more information, call 312/670-5422 or FAX 312/670-5403

National Steel Bridge-Building Competition

Civil engineering students from 31 universities met at the University of Florida in May to compete in the Fourth Annual National Steel Bridge-Building Competition. The students were finalists in regional competitions, where they had previously erected their scale bridges. The 18-ft.-long structures are judged on stiffness (won by State University of New York—Buffalo); lightness (University of Alaska at Fairbanks); construction speed (Louisiana Technical University); efficiency (San Diego State University); economy (North Dakota State University); and aesthetics (New Mexico State University). This year's overall winner was North Dakota State University.

The regional competitions, which will actually finish up this fall, are expected to attract 170 schools from all 20 ASCE student Chapter regions.

For more information about the 1996 National Steel Bridge-Building Competition, contact Fromy Rosenberg, AISC Assistant Director of Education, at 312/670-5408.

Answers To Frequently Asked Questions

Two recent articles in *Modern Steel Construction* have generated a lot of attention.

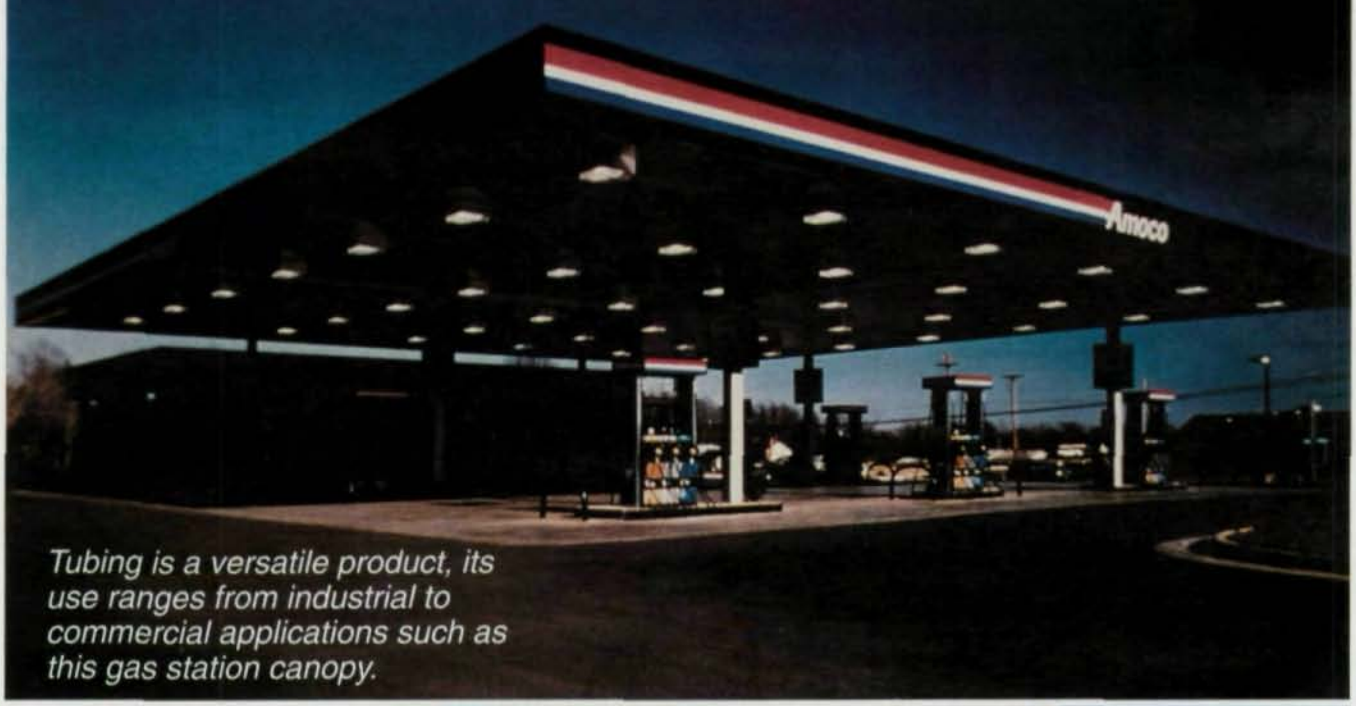
Most recently, the cover of the May issue featured a picture of an ironworker atop two girders. But what pricked peoples interest was the innovative tie-off system. The system, called the "SINCO Beam Walker," is a fall protection product that provides an easy to install tie-off point for ironworkers who must work at heights before flooring or other fall protection is available. According to the manufacturer, the system is economical and easy to install—it simply attaches to the beam with two structural bolts and safety strap using a standard wrench. Further, it mounts at a 19 degree angle from the base, so it does not impede worker movement. For more information, contact: SINCO Products, Inc., One SINCO Place, P.O. Box 3651, East Hampton, CT 06424-0361; ph: 800/243-6753; fax: 203/267-4976; or **CIRCLE #106** on the reader service card near the back of this magazine.

Another question that has frequently arisen concerns the publisher of a book mentioned in an article on Mathcad in the April issue. The book, *Building Structural Design: Reinforced Concrete and Structural Steel Applications*, is by Thomas Magner and provides information on automated structural design calculations using Mathcad. For information on the book, call 800/628-4223.

New Guide For Welding Of Open Web Steel Joists

THE STEEL JOIST INSTITUTE HAS ISSUED ITS TECHNICAL DIGEST #8 to aid design and construction professionals in selecting and working with steel joists. The publication includes criteria for inspecting joist welds, a method for determining weld strengths, and graphs and tables correlating material sizes with weld capacities. Cost of the publication, including shipping and handling, is $12.50. For more information, contact the Steel Joist Institute, Suite A, 1205 48th Ave. N., Myrtle Beach, SC 29577; 803/449-0487 or **CIRCLE #54**.

TUBING VERSATILITY.



Tubing is a versatile product, its use ranges from industrial to commercial applications such as this gas station canopy.

Bicycle Racks
and other recreational products may be fabricated from mechanical tubing.

Outdoor Furniture
a popular end-use application for mechanical tubing.

Exercise Equipment
tubing is an integral part of this product's framework.

Transmission Towers
assembled with UNR-Leavitt HI-Y 50 structural pipe.

Products Made From Tubing are Unlimited...

From agricultural equipment to commercial construction, the end use applications for structural and mechanical tubing are dramatically increasing. Our large size range...variety of products...sales and technical support, make UNR-Leavitt, the "Tube People", the preferred "one-stop" supplier for a growing number of companies. Add to that, the convenience of buying any UNR-Leavitt product through your local steel service center and you'll know why we're an Industry Leader...At UNR-Leavitt we put our customers first.

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 12 3/4" • WALL THICKNESSES: .018" (26 ga.) TO .500" (1/2").

UNR Leavitt
A Division of UNR Industries, Inc.

GENERAL OFFICES
1717 W. 115th. ST., CHICAGO, IL 60643
PHONE: 312-239-7700 OR
1-800-L-E-A-V-I-T-T
FAX: 312-239-1023

Associate Member
Steel Service
Center Institute

Our people make the difference

the TUBE PEOPLE
Committed to Excellence
WHERE SERVICE IS OUR OBSESSION

UNR-LEAVITT CHICAGO, ILLINOIS

UNR-LEAVITT BLUE ISLAND, ILLINOIS

UNR-LEAVITT HAMMOND, INDIANA

UNR-LEAVITT MADISON, MISSISSIPPI

Please circle # 79

Principal Producers Of Structural Shapes

B. Bethlehem Struct. Prod.
C. Chaparral Steel
F. Florida Steel Corp.
G. British Steel
J. J&L Structural Inc.
M. SMI Steel Inc.
N. Nucor-Yamato Steel
R. Roanoke Steel
S. North Star Steel
T. TradeARBED
U. Nucor Steel
W. Northwestern Steel & Wire
Y. Bayou Steel Corp.

Section Weight Per Ft.	Nominal b_f	Producer Code
W44 x 230, 262, 290 335	16	T
W40 x 593, 503, 431	16	T
362*, 397*	16	N, T
327*	16	N
297, 324*	16	N, T
294*	16	N
199, 215, 249, 277	16	N, T
174	16	T
W40 x 392	12	T
278, 331	12	T, G
211, 235, 264	12	B**, G, T
183	12	B**, G, N, T
149, 167	12	B**, G, N, T
W36 x 439, 527, 650, 798	16.5	T
393	16.5	B**, N, T
230, 245, 260, 280, 300, 328,359	16.5	B**, G, N, T
W36 x 256	12	B**, G, N
232	12	B**, G, N
135, 150, 160, 170, 182, 194, 210	12	B**, G, N, T
W33 x 387*	15.75	N
201, 221, 241, 263, 291, 318, 354	15.75	B**, N, T
W33 x 118, 130, 141, 152, 169	11.5	B**, G, N, T
W30 x 357*, 391	15	N, T
261, 292, 326	15	B**, G, N, T
284*	15	G
173, 191, 211, 235	15	B**, G, N, T
W30 x 99, 108, 116, 124, 132, 148	10.5	B**, G, N, T
W30 x 90	10.5	B**, N
W27 x 539	14	G
368	14	G, N, T
336*	14	N, T
307	14	G, N, T
281*	14	N
258	14	G, N, T
235	14	G, N
146, 161, 178, 194, 217	14	B**, G, N, T
W27 x 132*	10	G
84, 94, 102, 114, 129	10	B**, G, N, T, W
W24 x 335, 370	12.75	T
306	12.75	N, T
279	12.75	G, N, T
250	12.75	G, N
229	12.75	B**, G, N, T, W
207	12.75	B**, N, W
104, 117, 131, 146, 162, 176, 192	12.75	B**, G, N, T, W
W24 x 100*, 120*, 160*	12	N
W24 x 103	9	B**, N, W
84, 94	9	B**, G, N, W
68, 76	9	B**, C, G, N, W
56*, 61*	9	N
W24 x 55, 62	7	B, C, G, N, W
W21 x 182, 201	12.25	G
101, 111, 122, 132, 147, 166	12.25	B**, G, N, W
W21 x 83, 93	8.25	B, G, N, W
62, 68, 73	8.25	B, C, G, N, W
48*, 55*	8.25	N
W21 x 44, 50, 57	6.5	B, C, G, N, W
W18 x 258, 283, 311	11	B**
192, 211, 234	11	B**
175	11	B**, W
130, 143, 158	11	B, N, W
W18 x 130*	11	N
76, 86, 97, 106, 119	11	B**, N, W
W18 x 65, 71	7.5	B, G, N, W
50, 65, 60	7.5	B, C, G, N, W
W18 x 35, 40, 46	6	B, C, G, N, W
W16 x 67, 77, 89, 100	10.25	B**, N, W
W16 x 57	7	B, G, N, W
36, 40, 45, 50	7	B, C, G, N, W
W16 x 26, 31	5.5	B, C, G, N, W

Notes: Maximum lengths of shapes obtained vary with producer, but typically range from 60 ft to 75 ft. Lengths up to 100 ft are available for certain shapes. Please consult individual producers for length requirements.
* Shapes not currently listed in *Manual of Steel Construction*
**Mill scheduled to cease rolling these shapes in late 1995

Principal Producers Of Structural Shapes

B. Bethlehem Struct. Prod.
C. Chaparral Steel
F. Florida Steel Corp.
G. British Steel
J. J&L Structural Inc.
M. SMI Steel Inc.
N. Nucor-Yamato Steel
R. Roanoke Steel
S. North Star Steel
T. TradeARBED
U. Nucor Steel
W. Northwestern Steel & Wire
Y. Bayou Steel Corp.

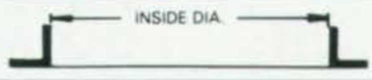
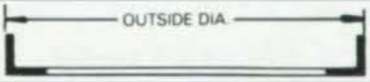
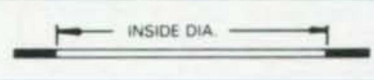
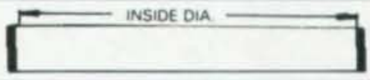
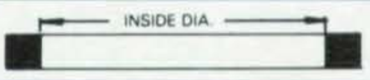
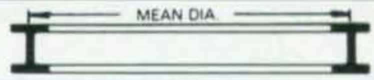
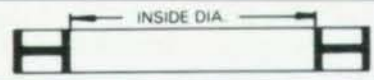
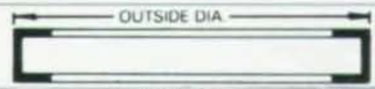
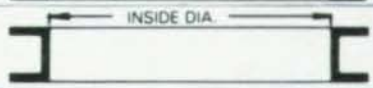
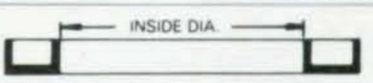
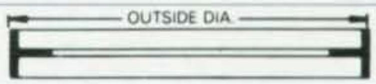
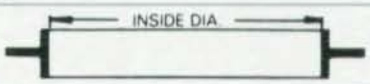
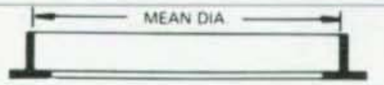
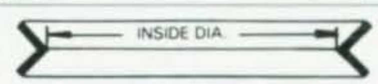
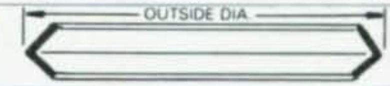
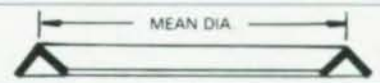
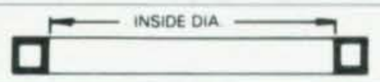
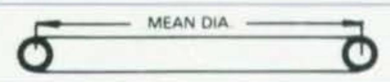
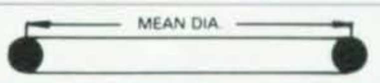
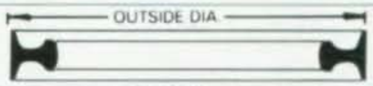
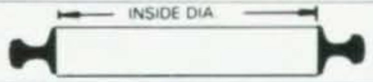
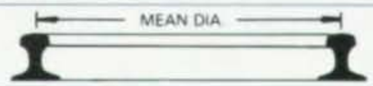
Section Weight Per Ft.	Nominal b_f	Producer Code
W14 x 808	16	B**
455, 500, 550, 605, 665, 730	16	B**, G, T
426	16	B**, G, T
398	16	B**, G, N, T
370	16	B**, G, N, T
311, 342	16	B**, G, N, T, W
145, 159, 176, 193, 211, 233, 257, 283	16	B**, G, N, T, W
W14 x 90, 99, 109, 120, 132	14.5	B**, G, N, T, W
W14 x 82	10	B, N, W
74	10	B, C, N, W
61, 68	10	B, C, N, W
W14 x 43, 48, 53	8	B, C, N, W
W14 x 38	6.75	B, C, G, N, W
30, 34	*6.75*	*B, C, G, N, W*
W14 x 22, 26	5	B, C, G, N, W
W12 x 252, 279, 305, 336	12	B**, G, N
210, 230	12	B**, G, N, T
170, 190	12	B**, G, N, T, W
65, 72, 79, 87, 96, 106, 120, 136, 152	12	B**, G, N, T, W
W12 x 53, 58	10	B, C, N, W
W12 x 50	8	B, C, N, W
40, 45	8	B, C, N, W
W12 x 26, 30, 35	6.5	B, C, G, N, W
W12 x 16, 19, 22	4	B, C, G, N, W
14	4	B, C, W
W10 x 88, 100, 112	10	B, G, N, W
49, 54, 60, 68, 77	10	B, C, G, N, W
W10 x 33, 39, 45	8	B, C, N, W
W10 x 22, 26, 30	5.75	B, C, G, N, W
W10 x 15, 17, 19	4	B, C, G, U, W
12	4	B, C, U, W
W8 x 31, 35, 40, 48, 58, 67	8	B, C, G, N, W
W8 x 24, 28	6.5	B, C, N, W
W8 x 18, 21	5.25	B, C, G, N, U, W, Y
W8 x 15	4	B, C, U, W, Y
10, 13	4	B, C, M, U, W, Y
W6 x 15, 20, 25	6	B, C, G, N, U, W
W6 x 12, 16	4	B, C, U, W, Y
9	4	B, C, J, M, U, W, Y
8.5*	4	C, J, M, U, Y
W5 x 16, 19	5	B, U
W4 x 13	4	B, C, M, U, Y

Section Weight Per Ft.	Producer Code
M12 x 10.8, 11.8	C, J
*M12 x 10.0**	*J*
M10 x 8, 9	C, J, U
M10 x 7.5*	J
M8 x 6.2*	J
M8 x 6.5	C, J, U
M6 x 3.7*, 4.4	J
M5 x 18.9	B
M4 x 6*	C, U
S24 x 106, 121	B**, W
S24 x 80-100	B**, W
S20 x 86, 96	B**, W
S20x 66, 75	B**, W
S18 x 54.7, 70	B**, W
S15 x 42.9, 50	B, W
S12 x 40.8, 50	B, W
S12 x 35	B, W
S12 x 31.8	B, C, W
S10 x 35	B, S
S10 x 25.4	B, C, S
S8 x 18.4, 23	C, S
S6 x 17.25	C, S
S6 x 12.5	C, S, Y
S5 x 10	C, Y
S4 x 9.5	C, M
S4 x 7.7	C, M,Y
S3 x 7.5, 5.7	C, J, M, Y

Notes: Maximum lengths of shapes obtained vary with producer, but typically range from 60 ft to 75 ft. Lengths up to 100 ft are available for certain shapes. Please consult individual producers for length requirements.
* Shapes not currently listed in *Manual of Steel Construction*
**Mill scheduled to cease rolling these shapes in late 1995


Big
Bend
36"

STANDARD MILL SHAPES Rolled or Bent to Order – FAST!

SECTION		TYPE	We bend ALL sizes up to:
ANGLE RINGS LEG OUT		1	**10″×10″×1″ Angle**
ANGLE RINGS LEG IN		2	**10″×10″×1″ Angle**
FLAT BAR RINGS THE HARD WAY		3	**12″×2¾″ Flat**
FLAT BAR RINGS THE EASY WAY		4	**14″×4″ Flat**
SQUARE BAR RINGS		5	**8″×8″ Square**
BEAM RINGS THE EASY WAY (Y-Y Axis)		6	**36″×210 lb./ft. Beam**
BEAM RINGS THE HARD WAY (X-X Axis)		7	**18″×50 lb./ft. Beam**
CHANNEL RINGS FLANGES IN		8	**18″×58 lb./ft. Channel**
CHANNEL RINGS FLANGES OUT		9	**18″×58 lb./ft. Channel**
CHANNEL RINGS THE HARD WAY (X-X Axis)		10	**13″×50 lb./ft. Channel**
TEE RINGS STEM IN		11	**12″×81 lb./ft. Tee**
TEE RINGS STEM OUT		12	**12″×81 lb./ft. Tee**
TEE RINGS STEM UP		13	**10.5″×83 lb./ft. Tee**
ANGLE RINGS HEEL IN		14	**8″×8″×1″ Angle**
ANGLE RINGS HEEL OUT		15	**8″×8″×1″ Angle**
ANGLE RINGS HEEL UP		16	**8″×8″×1″ Angle**
SQUARE & RECTANGULAR TUBE RINGS		17	**16″ Square Tube** **20″×8″ Rectangular Tube**
ROUND TUBE & PIPE RINGS		18	**14″ Pipe**
ROUND BAR RINGS		19	**9″ Round Bar**
RAIL RINGS BALL IN		20	**ASCE 100# Rail** **Bethlehem 175# Rail**
RAIL RINGS BALL OUT		21	**ASCE 100# Rail** **Bethlehem 175# Rail**
RAIL RINGS BALL UP		22	**ASCE 100# Rail** **Bethlehem 175# Rail**

WE ALSO ROLL SPECIAL FORMED SHAPES AND EXTRUSIONS AND HAVE IN STOCK LEG OUT ANGLE RINGS FROM 3" TO 72" INSIDE DIAMETER.

Principal Producers Of Structural Shapes

B. Bethlehem Struct. Prod.
C. Chaparral Steel
F. Florida Steel Corp.
G. British Steel
J. J&L Structural Gnc.
M. SMI Steel Inc.
N. Nucor-Yamato Steel
R. Roanoke Steel
S. North Star Steel
T. TradeARBED
U. Nucor Steel
W. Northwestern Steel & Wire
Y. Bayou Steel Corp.

Section Weight Per Ft.	Producer Code
HP14 x 73, 89, 102, 117	B**, G, N, W
HP12 x 53, 63, 74, 84	B**, G, N, W
HP10 x 42, 57	B, C, G, N, W
HP8 x 36	B, C, G, N, W
C15 x 33.9, 40, 50	B, N, W
C12 x 30	B, S, W
C12 x 20.7, 25	B, C, S, W
C10 x 25, 30	B, S, W
C10 x 15.3, 20	B, C, S, U, W
C9 x 20	B
C9 x 13.4, 15	B, S
C8 x 18.75	S, W, Y
C8 x 11.5, 13.75	C, M, S, U, W, Y
C7 x 12.25	S, U, W
C7 x 9.8	M, S, U, W
C6 x 13	M, S, U, W, Y
C6 x 10.5	C, M, S, U, W, Y
C6 x 8.2	C, F, M, S, U, W, Y,
C5 x 9	C, M, U, W, Y
C5 x 6.7	C, F, M, U, W, Y
C4 x 5.4, 7.25	C, F, M, U, W, Y
C4 x 4.5*	M, U
C3 x 6	M, U, W, Y
C3 x 4.1, 5	C, F, M, R, U, W, Y
C3 x 3.5*	M, R, U
MC18 x 42.7, 45.8, 51.9, 58	B, N
MC13 x 31.8, 35, 40, 50	B, N
MC12 x 31, 35, 40, 45, 50	B, N
MC12 x 10.6	J, S
MC10 x 28.5, 33.6, 41.1	B
MC10 x 22, 25	B
MC10 x 8.4	J, S
MC10 x 6.5	J
MC9 x 23.9, 25.4	B
MC8 x 21.4, 22.8	B, S
MC8 x 18.7, 20	B, S
MC8 x 8.5	J, M
MC8 x 6.6*	J
MC7 x 19.1, 22.7	B
MC6 x 18	B
MC6 x 16.3	B,S
MC6 x 15.3*	B
MC6 x 15.1	B, S
MC6 x 12	B, S
MC6 x 6.5*, 7.0	J
MC4 x 13.8*	S
MC 3 x 7.1*	S

Section by Leg Lengths & Thickness		Producer Code
L8 x 8 x	$1\frac{1}{8}$	B, T
	1	B, T
	$\frac{7}{8}$	B, T
	$\frac{3}{4}$	B, S, T
	$\frac{5}{8}$	B, T
	$\frac{1}{2}$	B, S
L6 x 6 x	1	B, U, Y
	$\frac{7}{8}$	B, U, Y
	$\frac{3}{4}$	B, M, U, Y
	$\frac{5}{8}$	B, M, U, Y
	$\frac{9}{16}$	M, U, Y
	$\frac{1}{2}$	B, M, S, U, Y
	$\frac{7}{16}$	B, M, U, Y
	$\frac{3}{8}$	B, M, S, U, Y
	$\frac{5}{16}$	M, U, Y
	$\frac{1}{4}$*	U
L5 x 5 x	$\frac{7}{8}$	U, Y
	$\frac{3}{4}$	M, U, Y
	$\frac{5}{8}$	M, U, Y
	$\frac{1}{2}$	M, U, W, Y
	$\frac{7}{16}$	M, U, Y
	$\frac{3}{8}$	M, U, W, Y
	$\frac{5}{16}$	M, U, W, Y
	$\frac{1}{4}$*	U
L4 x 4 x	$\frac{3}{4}$	M, U, Y
	$\frac{5}{8}$	M, U, Y
	$\frac{1}{2}$	F, M, R, U, W, Y
	$\frac{7}{16}$	F, M, R, U, Y
	$\frac{3}{8}$	F, M, R, U, W, Y
	$\frac{5}{16}$	F, M, R, U, W, Y
	$\frac{1}{4}$	F, M, R, U, W, Y
L$3\frac{1}{2}$ x $3\frac{1}{2}$ x	$\frac{1}{2}$	F, M, U, W, Y
	$\frac{7}{16}$	U, Y
	$\frac{3}{8}$	F, M, R, U, W, Y
	$\frac{5}{16}$	F, M, R, U, W, Y
	$\frac{1}{4}$	F, M, R, U, W, Y
L3 x 3 x	$\frac{1}{2}$	F, M, U, W, Y
	$\frac{7}{16}$	U, Y
	$\frac{3}{8}$	F, M, R, S, U, W, Y
	$\frac{5}{16}$	F, M, R, S, U, W, Y
	$\frac{1}{4}$	F, M, R, S, U, W, Y
	$\frac{3}{16}$	F, M, R, S, U, W, Y

Notes: Maximum lengths of shapes obtained vary with producer, but typically range from 60 ft to 75 ft. Lengths up to 100 ft are available for certain shapes. Please consult individual producers for length requirements.

* Shapes not currently listed in *Manual of Steel Construction*

**Mill scheduled to cease rolling these shapes in late 1995

Principal Producers Of Structural Shapes

B. Bethlehem Struct. Prod.
C. Chaparral Steel
F. Florida Steel Corp.
G. British Steel
J. J&L Structural Inc.
M. SMI Steel Inc.
N. Nucor-Yamato Steel
R. Roanoke Steel
S. North Star Steel
T. TradeARBED
U. Nucor Steel
W. Northwestern Steel & Wire
Y. Bayou Steel Corp.

Section by Leg Lengths & Thickness		Producer Code
L$2\frac{1}{2}$ x $2\frac{1}{2}$ x	$\frac{1}{2}$	F, U, Y
	$\frac{3}{8}$	F, R, S, U, Y
	$\frac{5}{16}$	F, R, S, U, Y
	$\frac{1}{4}$	F, R, S, U, Y
	$\frac{3}{16}$	F, R, U, Y
L2 x 2 x	$\frac{3}{8}$	F, R, S, U, Y
	$\frac{5}{16}$	F, R, S, U, Y
	$\frac{1}{4}$	F, R, S, U, Y
	$\frac{3}{16}$	F, R, S, U, Y
	$\frac{1}{8}$	F, R, S, U, Y
L8 x 6 x	1	B
	$\frac{3}{4}$	B, S
	$\frac{1}{2}$	B, S
	$\frac{7}{16}$	B
L8 x 4 x	1	B
	$\frac{3}{4}$	B, S
	$\frac{1}{2}$	B, S
L7 x 4 x	$\frac{3}{4}$	B, Y
	$\frac{5}{8}$	B, Y
	$\frac{1}{2}$	B, S, Y
	$\frac{7}{16}$	Y
	$\frac{3}{8}$	B, S, Y
L6 x 4 x	$\frac{7}{8}$	B
	$\frac{3}{4}$	B, M, S, U, W, Y
	$\frac{5}{8}$	B, M, U, W, Y
	$\frac{9}{16}$	M, U, Y
	$\frac{1}{2}$	B, M, S, U, W, Y
	$\frac{7}{16}$	U, Y
	$\frac{3}{8}$	M, S, U, W, Y
	$\frac{5}{16}$	M, S, U, W, Y
L6 x $3\frac{1}{2}$ x	$\frac{1}{2}$	M, U, W, Y
	$\frac{3}{8}$	M, U, W, Y
	$\frac{5}{16}$	M, U, W, Y
L5 x $3\frac{1}{2}$ x	$\frac{3}{4}$	M, U, Y
	$\frac{5}{8}$	M, U, W, Y
	$\frac{1}{2}$	M, U, W, Y
	$\frac{3}{8}$	M, U, W, Y
	$\frac{5}{16}$	M, U, W, Y
	$\frac{1}{4}$	M, U, W, Y

Section by Leg Lengths & Thickness		Producer Code
L5 x 3 x	$\frac{1}{2}$	F, M, U, W, Y
	$\frac{7}{16}$	F, U, Y
	$\frac{3}{8}$	F, M, U, W, Y
	$\frac{5}{16}$	F, M, U, W, Y
	$\frac{1}{4}$	F, M, U, W, Y
L4 x $3\frac{1}{2}$ x	$\frac{1}{2}$	F, M, U, W
	$\frac{3}{8}$	F, M, U, W
	$\frac{5}{16}$	F, M, R, U, W
	$\frac{1}{4}$	F, M, R, U, W
L4 x 3 x	$\frac{5}{8}$	U, Y
	$\frac{1}{2}$	F, M, U, W, Y
	$\frac{7}{16}$	U, Y
	$\frac{3}{8}$	F, M, R, U, W, Y
	$\frac{5}{16}$	F, M, R, U, W, Y
	$\frac{1}{4}$	F, M, R, U, W, Y
L$3\frac{1}{2}$ x 3 x	$\frac{1}{2}$	U, W
	$\frac{3}{8}$	M, U, W
	$\frac{5}{16}$	M, U, W
	$\frac{1}{4}$	M, U, W
L$3\frac{1}{2}$ x $2\frac{1}{2}$ x	$\frac{1}{2}$	U
	$\frac{3}{8}$	U, W
	$\frac{5}{16}$ *	U, W
	$\frac{1}{4}$	U, W
L3 x $2\frac{1}{2}$ x	$\frac{1}{2}$	U, W
	$\frac{3}{8}$	U, W
	$\frac{5}{16}$	U, W, Y
	$\frac{1}{4}$	R, U, W
	$\frac{3}{16}$	U
L3 x 2 x	$\frac{1}{2}$	F, U
	$\frac{3}{8}$	F, U
	$\frac{5}{16}$	F, U
	$\frac{1}{4}$	F, R, U
	$\frac{3}{16}$	F, R, U
L$2\frac{1}{2}$ x 2 x	$\frac{3}{8}$	R, S, U
	$\frac{5}{16}$	S, U
	$\frac{1}{4}$	R, S, U
	$\frac{3}{16}$	R, S, U

Notes: Maximum lengths of shapes obtained vary with producer, but typically range from 60 ft to 75 ft. Lengths up to 100 ft are available for certain shapes. Please consult individual producers for length requirements.

* Shapes not currently listed in *Manual of Steel Construction*

**Mill scheduled to cease rolling these shapes in late 1995

Principal Producers Of Structural Tubing (TS)

A. Acme Roll Forming Co.
B. Bull Moose Tube Co.
C. Copperweld Corp.
D. Dallas Tube & Rollform
E. Eugene Welding Co.
G. British Steel**
H. Hanna Steel Corp.
I. Independence Tube Corp.
J. Vest Inc.
K. Maverick Tube
L. Laclede Steel Co.
M. Maruichi American Corp.
N. Hannibal Industries, Inc.
P. IPSCO Inc.
R. Standard Tube Co.
S. Sonco Steel Tube
T. Atlas Tube
U. UNR- Leavitt, Div. of UNR Inc.
V. Valmont Industries
W. Welded Tube Co. of America
X. EXLTUBE
Y. James Steel & Tube Co.
Z. Welded Tube of Canada Ltd.

Nominal Size and Thickness	Producer Code
32x32x5/8, 1/2, 3/8	V*
30x30x5/8, 1/2, 3/8	V*
28x28x5/8, 1/2, 3/8	V*
26x26x5/8, 1/2, 3/8	V*
24x24x5/8, 1/2, 3/8	V*
22x22x5/8, 1/2, 3/8	V*
20x20x5/8, 1/2, 3/8	V*
18x18x5/8, 1/2, 3/8	V*
16x16x5/8, 1/2, 3/8	G, V*, W
16x16x5/16	W
14x14x5/8	G, V*,W
14x14x1/2,3/8	G, V*,W
14x14x5/16	G, W
12x12x5/8	B,G,S,W
12x12x1/2,3/8,5/16,1/4	B,G,S,T,W
10x10x5/8	B,C,G,S,W
10x10x1/2,3/8,5/16,1/4	B,C,G,P,S,T,U,W
10x10x3/16	B,C,G,P,S,U,W
8x8x5/8	B,C,G,S,W
8x8x1/2,3/8,5/16	B,C,D,G,K,P,S,T,U,W,Z
8x8x1/4	B,C,G,K,P,S,T,U,W,Z
8x8x3/16	B,C,G,K,P,S,U,W,Z
7x7x5/8	B,C,G,S
7x7x1/2,3/8,5/16,1/4, 3/16	B,C,G,K,P,S,T,U,W,Z
6x6x5/8	B,G,S
6x6x1/2	B,C,G,K,P,S,T,U,W,Z
6x6x3/8, 5/16	B,C,D,G,K,P,R,S,H,I,J,T,U,W,Z
6x6x1/4, 3/16	B,C,D,G,K,P,R,S,H,I,J,T,U,W,X,Z
6x6x1/8	B,C,D,G,S,T,H,I,J,Z
5 1/2x5 1/2x3/8,5/16,1/4,3/16,1/8	B,D,G,S,H,I,Z
5 1/2x5 1/2x1/8	B,G,S,I,Z
5x5x1/2	B,C,G,K,P,R,S,T,U,W,Z
5x5x3/8, 5/16	B,C,D,G,H,I,J,K,P,R,S,T,U,W,Z
5x5x1/4, 3/16	B,C,D,G,H,I,J,K,M,P,R,S,T,X,U,W,Y,Z
5x5x1/8	B,C,G,H,I,J,M,P,S,T,Y,Z
4 1/2x4 1/2x1/2	C,K,T,Z
4 1/2x4 1/2x3/8	T,H,I,K,P,S,W,Z
4 1/2x4 1/2x5/16	T,H,I,K,P,W,Z
4 1/2x4 1/2x1/4, 3/16	B,C,D,H,I,K,P,S,T,W,Y,Z
4 1/2x4 1/2x1/8	B,C,H,I,K,P,S,T,Y,Z
4x4x1/2	B,C,K,P,R,S,T,U,W,Z
4x4x3/8, 5/16	B,C,D,H,I,J,K,R,S,T,D,P,U,W,Z
4x4x1/4, 3/16, 1/8	B,C,D,E,H,I,J,K,M,N,P,R,S,T,X,U,W,Y,Z
3 1/2x3 1/2x3/8	C, T
3 1/2x3 1/2x5/16	C,I,J,P,S,T,U,W,Z
3 1/2x3 1/2x1/4, 3/16, 1/8	B,C,D,E,H,I,J,K,I,M,N,P,R,S,T,U,W,X,Y,Z
3 1/2x3 1/2x3/8	C, T
3x3x3/8	C, H, T
3x3x5/16	C,H,I,J,P,S,T,U,W,Z
3x3x1/4, 3/16	A,B,C,D,E,H,I,J,K,L,M,N,P,R,S,T,U,W,X,Y,Z

Nominal Size and Thickness	Producer Code
3x3x1/8	A,B,C,D,E,H,I,J,K,L,M,N,P,R,S,T,
	U,W,X,Y,Z
2 1/2x2 1/2x5/16	I,S,T
2 1/2x2 1/2x1/4, 3/16	A,B,C,D,E,H,I,J,K,L,M,N,P,R,S,T,
	U,W,X,Y,Z
2 1/2x2 1/2x1/8	A,B,C,D,E,H,I,J,K,L,M,N,P,R,S,
	T,U,X,W,Y,Z
2x2x5/16	I,S
2x2x1/4	B,C,D,H,I,J,K,M,N,R,S,T,U,W,X,Y,Z
2x2x3/16,1/8	A,B,C,D,E,H.I,J,K,M,N,P,R,S,
	T,U,W,X,Y,Z
1 3/4x1 3/4x1/4	H
1 3/4x1 3/4x3/16	H,Y,Z
1 1/2x1 1/2x3/16	B,E,H,L,N,P,R,S,T,U,W,Y,Z
32x24x5/8, 1/2, 3/8	V*
30x24x5/8, 1/2, 3/8	V*
28x24x5/8, 1/2, 3/8	V*
26x24x5/8, 1/2, 3/8	V*
24x22x5/8, 1/2, 3/8	V*
22x20x5/8, 1/2, 3/8	V*
20x18x5/8, 1/2, 3/8	V*
20x12x1/2, 3/8, 5/16	G,V*,W
20x12x5/8	G
20x8x5/8, 1/2, 3/8	V*,W
20x8x5/8	G
18x12x1/2, 3/8	V*
18x6x5/8	G
18x6x1/2, 3/8, 5/16	B,G,W
18x6x1/4	B,G
16x12x1/2, 3/8, 5/16	G,V*,W
16x12x5/8	G
16x8x1/2, 3/8, 5/16	B,G,W
16x8x5/8	G
16x4x1/2, 3/8, 5/16	B,G,W
16x4x5/8	G
14x12x1/2, 3/8	V*
14x10x1/2, 3/8	B,G,S,W
14x10x5/8	G
14x10x 5/16	W
14x6x5/8	B,G
14x6x1/2, 3/8, 5/16, 1/4	B,G,W
14x4x5/8	B,S
14x4x1/2, 3/8, 5/16, 1/4	B,S,W
14x4x3/16	B,S
12x10x1/2, 3/8, 1/4	B, S, U
12x8x5/8	B, C, G, S,W
12x8x1/2, 3/8, 5/16, 1/4	B, C, G, S, T, W
12x8x3/16	B, C, G, S, U
12x6x5/8	B, S
12x6x1/2, 3/8, 5/16, 1/4	B, C, S,U,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.
**British Steel also produces a full range of metric
Some manufactures produce a .120 size instead of a 1/8; please check with individual manufacturers

Principal Producers Of Structural Tubing (TS)

A. Acme Roll Forming Co.
B. Bull Moose Tube Co.
C. Copperweld Corp.
D. Dallas Tube & Rollform
E. Eugene Welding Co.
G. British Steel**
H. Hanna Steel Corp.
I. Independence Tube Corp.
J. Vest Inc.
K. Maverick Tube
L. Laclede Steel Co.
M. Maruichi American Corp.
N. Hannibal Industries, Inc.
P. IPSCO Inc.
R. Standard Tube Co.
S. Sonco Steel Tube
T. Atlas Tube
U. UNR- Leavitt, Div. of UNR Inc.
V. Valmont Industries
W. Welded Tube Co. of America
X. EXLTUBE
Y. James Steel & Tube Co.
Z. Welded Tube of Canada Ltd.

Nominal Size and Thickness	Producer Code
12x6x3/16	B, C, S, U
12x4x5/8	C, G, S
12x4x1/2, 3/8, 5/16, 1/4, 3/16	B, C, G, K, S, U, W, Z
12x3 1/2x3/8, 5/16	Z
12x3x5/16, 1/4, 3/16	C, B, K, Z
12x2x1/4, 3/16	B, K, S, U, Z
10x8x1/2, 3/8, 5/16, 1/4, 3/16	B, C, S, U, W
10x6x5/8	G, K
10x6x1/2	B, C, G, K, S, T, U, W, Z
10x6x3/8, 5/16, 1/4	B, C, D, G, K, P, S, T, U, W, Z
10x6x3/16	B, C, D, K, P, S, U, W, Z
10x5x3/8, 5/16, 1/4, 3/16	B, C, D, K, S
10x4x5/8	G
10x4x1/2	B, C, G, K, P, S, T, U, W, Z
10x4x3/8, 5/16, 1/4, 3/16	B, C, D, G, K, P, S, T, U, W, Z
10x3 1/2x3/16	K, Z
10x3x3/8, 5/16, 1/4	B, D, K, T
10x3x3/16	B, D, K, T, Z
10x2x3/8	T, Z
10x2x5/16	D, P, S, T, U, W, Z
10x2x1/4, 3/16	B, D, P, S, T, U, W, Z
9x7x1/2, 3/8, 5/16, 1/4, 3/16	B, C, W, Z
9x5x1/2, 3/8, 5/16, 1/4, 3/16	B, C, W, Z
9x3x1/2	C
9x3/8, 5/16	C, Z
9x3x1/4, 3/16	B, C, Z
8x6x5/8	G
8x6x1/2	B, C, G, K, P, S, T, U, W, Z
8x6x3/8, 5/16, 1/4, 3/16	B, C, D, G, K, P, S, T, U, W, Z
8x4x5/8	B, G, S
8x4x1/2	B, C, G, K, P, S, T, U, W, Z
8x4x3/8, 5/16	B,C,D,G,H, I,J,K,P,R,S,T,U,W,Z
8x4x1/4, 3/16	B, C, D, G, H, I, J, K, P, R, S, T, W, X, Z
8x4x1/8	B, C, D, G, I, J, K, P, S, T, Z
8x3x1/2	C, P, U
8x3x3/8, 5/16	C, D, H, I, P, T, U, W, Z
8x3x1/4, 3/16	B, C, D, H, I, P, S, T, U, W, Z
8x3x1/8	B, C, D, I, P, S, Z
8x2x3/8	H, J, K, S, T, U, Z
8x2x5/16	H, I, J, K, P, S, T, U, W, Z
8x2x1/4, 3/16	B, D, H, I, J, K, P, S, T, U, W, Z
8x2x1/8	B, D, I, J, K, P, S, T, Z
7x5x1/2	B, C, K, P, S, T, U, W, Z
7x5x3/8, 5/16, 1/4, 3/16	B, C, D, H, I, K, P, R, S, T, U, W, Z
7x5x1/8	B, C, I, K, P, S, T, Z
7x4x1/2	Z
7x4x3/8, 5/16, 1/4, 3/16	B, C, D, H, I, P, S, U, W, Z
7x4x1/8	C, I, P, S, Z
7x3x1/2	Z
7x3x3/8, 5/16	B, C, D, H, I, K, P, S, W, Z
7x3x1/4, 3/16	B, C, D, H, I, K, P, S, W, X, Z
7x3x1/8	C, D, H, I, K, P, S, Z
6x4x1/2	B, C, K, P, S, T, U, W, Z
6x4x3/8, 5/16	B, C, D, H, I, J, K, P, R, S, T, U, W, Z

Nominal Size and Thickness	Producer Code
6x4x1/4, 3/16	B,C,D,H,I,J,K,M,P,R,S,T,U,W,X,Y,Z
6x4x1/8	B, C, D, I, J, K, P, S, T, V, X, Y, Z
6x3x1/2	C, K, P, S, U, Z
6x3x3/8, 5/16	B, C, D, H, I, J, K, P, S, T, U, W, Z
6x3x1/4, 3/16	B,C,D,H,I,J,K,P,R,S,T,U,W,X,Y,Z
6x3x1/8	B, C, D, H, I, J, K, P, R, S, T, U, X, Y, Z
6x2x3/8	H, K, S, T, U, W, Z
6x2x5/16	B, H, I, J, K, P, S, T, U, W, Z
6x2x1/4, 3/16	B, C, D, E, H, I, J, K, M,
	N, P, R, S, T, U, W, X, Y, Z
6x2x1/8	B,C,D,E,H,I,J,K,M,N,P,R,S,T,U,W,X,Y,Z
5x4x1/2	T
5x4x3/8, 5/16	B, C, I, K, P, T, W, Z
5x4x1/4, 3/16	B, C, D, I, K, P, T, W, Y, Z
5x3x1/2	C, K, P, S, U, Z
5x3x3/8, 5/16	C, D, H, I, J, K, P, R, S, T, U, W, Z
5x3x1/4, 3/16	B,C,D, E,H,I,J,K,M,N,P,R,S,T,U,W,X,Z
5x3x1/8	B, C, D, E, H, I, J, K, M, N,
	P, R, S, T, U, W, X, Y, Z
5x2 1/2x1/4, 3/16	J, K, Y, Z
5x2x3/8	C, K, T
5x2x5/16	C, I, J, P, R, S, T, W
5x2x1/4, 3/16, 1/8	B,C,D,E,H,I,J,K,M,N,P,R,S,T,U,W,X,Z
4x3x3/8	B, J, S, T
4x3x5/16	B, I, J, P, S, T, U, W, Z
4x3x1/4, 3/16	B, C, D, E, H, I, J, K, L, M, N, P,
	R, S, T, U, W, X, Y, Z
4x3x1/8	B, C, D, E, H, I, J, K, L, M, N, P, R, S,
	T, U, W, X, Y, Z
4x2 1/2x1/4, 3/16, 5/16	Y, Z
4x2x3/8	C, H, S, T, Y
4x2x5/16	C, H, I, J, P, S, T, U, W, Z
4x2x1/4	B, C, D, E, H, I, J, K, L, M, N, P, R, S,
	T, U, W, X, Y, Z
4x2x3/16	A, B, C, D, E, I, J, K, L, M, P, R, S, T,
	U, W, X, Y, Z
4x2x1/8	A,B,C,E,H,I,J,K,L,M,N,P,R,S,T,U,W,X,Y,Z
3 1/2x2 1/2x1/4	I, R, Y, Z
3x2 1/2x1/4	Y, Z
3x2x5/16	I, S, T
3x2x1/4	B, C, D, E, H, I, J, K, L,M, N, P, R, S,
	T, U, W, X, Y, Z
3x2x3/16	A, B,C, D, E, I, J, K, M, P, R,
	S, T, U, W, X, Y, Z
3x2x1/8	A, B, C, D, E, H, I, J, K, L, M, N, P, R,
	S, T, U, W, X, Y, Z
3x1 1/2x3/16, 1/8	C, E, I, U, W, Y, Z
3x1 1/2 x1/4	I, Y
2 1/2 x1 1/2 x1/4	A, B, C, E, I, S, U, Y
2 1/2 x1 1/2 x3/16	B, C, E, H, I, R, S, U, Y, Z
2x1 1/2 x3/16	Y, Z
2x1x3/16	Y, Z
1 1/2 x1 1/2 x1/4	H,
1 1/2 x1 1/2 x3/16, 1/8	Z

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.
**British Steel also produces a full range of metric
Some manufactures produce a .120 size instead of a 1/8; please check with individual manufacturers

Principal Producers Of Steel Pipe (P)

A. Acme Roll Forming Co.
B. Bull Moose Tube Co.
C. Copperweld Corp.
D. Dallas Tube & Rollform
E. Eugene Welding Co.
G. British Steel**
H. Hanna Steel Corp.
I. Independence Tube Corp.
J. Vest Inc.
K. Maverick Tube
L. Laclede Steel Co.
M. Maruichi American Corp.
N. Hannibal Industries, Inc.
P. IPSCO Inc.
R. Standard Tube Co.
S. Sonco Steel Tube
T. Atlas Tube
U. UNR- Leavitt, Div. of UNR Inc.
V. Valmont Industries
W. Welded Tube Co. of America
X. EXLTUBE
Y. James Steel & Tube Co.
Z. Welded Tube of Canada Ltd.

Nominal Size and Thickness	Producer Code
20x.500, .375	P*, W
20x.250	P*
18x.500, .375	P*, W
18x.250	P*
16x.500	P*, W
16x.375	P*, W
16x.250	P
16x.188	P
14x.500	P, W
14x.438	P
14x.375	P, W
14x.250, .188	P
12.75x.500	P, W
12.75x.406	P
12.75x.375	P, W
12.75x.188, .125	P
12.5x .625, .500, .375, .312, .250, .188	C
11.25x.625, .500, .375, .312, .250, .188	C
10.75x.500, .365, .250	P, W, Z
10x.625	C
10x.500, .375, .312	C, Z
10x.250, .188	C, Z
10x.125	V
9.625x.500, .375, .312, .250, .188	C, P, U, Z
8.75x.500, .375, .312, .250, .188	C, Z
8.625x.500	K, P, U, Z
8.625x.375	K, P, U, Z
8.625x.322	K, P, U, W, Z
8.625x.250, .188	K, P, U, Z
8.625x.125	P,
7.625x.125	Z
7.5x.500, .375, .312, .250, .188	C, R, Z
7x.500	C, P, U, Z
7x.375, .312, .250	C, H, P, R, U, Z
7x.188	C, H, P, R, U, Z
7x.125	C, P, Z
6.875x.500, .375, .312, .250, .188	C
6.625x.500, .432	K, P, U, Z
6.625..375, .312	H, K, P, R, U, Z
6.625x.280	H,K,P,R,U,W, X, Z
6.625x.250, .188	H,K,P,R,U,W,X,Z
6.625x.125	P, Z
6.125x.500, .375, .312, .250, .188	C
6x.500	Z
6x.375, .312	H, R, Z
6x.280	H, R, Z
6x.250, .188	H, R, Z
6x .125	H, Z

Nominal Size and Thickness	Producer Code
5.563x.375	P, U
5.563x.258	P, R, W, X, Z
5.563x.188	P, Z
5.563x.134	P, R, Z
5.5x.500	Z
5.5x.375, .258	K, P, Z
5x.500, .375, .312	C, K, P, R, T, Z
5x.258	C, K, P, R, T, U, Z
5x.250, .188	C, H, K, L, P, R, T, U, Y, Z
5x.125	C, H, L, P, R T, U, Y, Z
4.5x.337	L***, P, Z
4.5x.237	C, H, K, L***, P, R, U, W, X, Z
4.5x.188	C, H, K, P, R, U, W, X, Z
4.5x.125	C, H, L, P, R, U, Z
4x.337	H, R
4x.318	L***
4x.313	Z
4x.250, .188	C, H, R, U, Y, Z
4x.237	C, H, R, Y, Z
4x.226	L***
4x.125	C, H, R, U, Y, Z
3.5x.313	Z
3.5x.300	H, L***, P, X, Z
3.5x.250, .203, .188, .125	H, K, P, R, U, Y, Z
3.5x.216	H, L***, P, R, U, X, Y, Z
3x.250, .203, .188, .152	H, R, U, Z
3x.300	Z
3x.216	R, U, Y, Z
3x.120, .134	R, Y, Z
2.875x.276	L***
2.875x.250	K, P, U, Z
2.875x.203	L***, P, U, W, Z
2.875x.188, .125	K, P, U, Y, Z
2.375x.250	H, L***, P, Y, Z
2.375x.218, .188	H, P, Y, Z
2.375x.154	H, L***, P, U, W, X, Y, Z
2.375x.125	K, H, P, R, U, Y, Z
1.900x.145	Z
1.660x.140	Z

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.
**British Steel also produces a full range of metric
***Size produced by Continuous But Welding

Structural Steel Shape Producers

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

Bethlehem Struc. Prod. Corp.
501 East Third St.
Bethlehem, PA 18016-7699
800/633-0482

British Steel Inc.
475 N. Martingale Rd., #400
Schaumburg, IL 60173
800/542-6244

Chaparral Steel Co.
300 Ward Road
Midlothian, TX 76065-9501
800/542-6244

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

J&L Structural Inc.
111 Station St.
Aliquippa, PA 15001
800/451-7469

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

North Star Steel Co.
1380 Corp. Center Curve
P.O. Box 21620
Eagan, MN 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

ACME Roll Forming Co.*
812 North Beck St.
Sebewaing, MI 48759-1120
800/937-8823

Atlas Tube*
200 Clark St.
Harrow, Ontario, NOR 1G0
CANADA
519/738-3541

British Steel Inc.
475 N. Martingale Rd., #400
Schaumburg, IL 60173
800/542-6244

Bull Moose Tube Co.*
1819 Clarkson Rd., Ste 100
Chesterfield, MO
63017-5040
800/325-4467

Copperweld Corp.*
4 Gateway Center, Ste. 2200
Pittsburgh, PA 15522
412/263-3200

Dallas Tube & Rollform
P.O. Box 540873
Dallas, TX 75354-0873
214/445-0234

Eugene Welding Co.*
P.O. Box 249
Marysville, MI 48040
800/336-3926

EXLTUBE
905 Atlantic
N. Kansas City, MO 64116
800/892-8823

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

Hannibal Industries, Inc.*
P.O. Box 558
Los Angeles, CA 90058
213/588-4261

Independence Tube Corp.
6226 W. 74th St.
Chicago, IL 60638-6196
708/496-0380

IPSCO Steel, Inc.
P.O. Box 1670, Armour Rd.
Regina, Saskatchewan
S4P 3C7
CANADA
306/934-7700

James Steel & Tube Co.
29774 Stepheson Hwy.
Madison Heights, MI 48071
800/521-2539

Laclede Steel Co.*
One Metropolitan Square
St. Louis, MO 63102-2739
314/425-1461

Maruichi American Corp.*
11529 S. Greenstone Ave.
Santa Fe Springs, CA 90670
310/946-1881

Maverick Tube Corp.*
400 Chesterfield Center,
Second Floor
Chesterfield, MO 63017
800/840-8823

Sonco Steel Tube*
14 Holtby Ave.
Brampton, Ontario
L6S 2M3
CANADA
800/268-3005

Standard Tube Co.*
P.O. Box 430
Woodstock, Ontario
N4S 7Y6
CANADA
519/537-6671

UNR-Leavitt
Div. of UNR Industries, Inc.*
1717 West 115th St.
Chicago, IL 60643-4399
800/532-8488

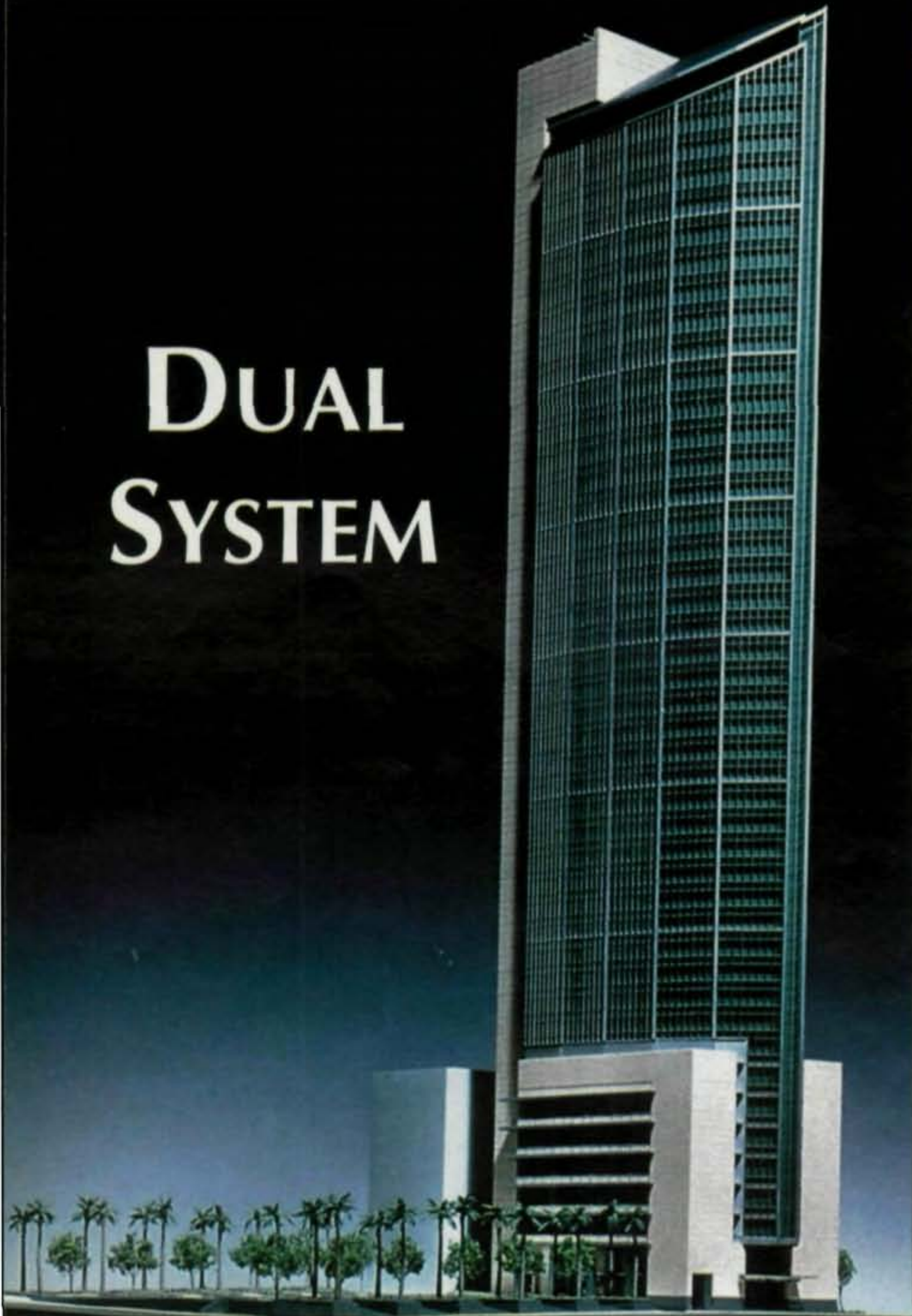
Valmont Industries, Inc.*
(Structural Tube Division)
801 North Xanthus
P.O. Box 2620
Tulsa, OK 74101
800/331-3002

Vest Incorporated*
6023 Alcoa Ave.
Los Angeles, CA 90058
213/581-8823

Welded Tube Co. of
America
1855 E. 122nd St.
Chicago, IL 60633
800/733-5683

Welded Tube of Canada,
Ltd.
111 Rayette Road
Concord, Ontario L4K 2E9
CANADA
800/565-8823

*Member of the Steel Tube Institute of North America, 8500 Station St., Ste. 270, Mentor, OH 44060 216/974-6990



DUAL SYSTEM

A new 47-story building in Taichung, Taiwan, will utilize a combination of moment and braced frames to resist both high wind loads and stringent seismic requirements

By Leo E. Argiris, P.E.

WHERE SOME SEE A FISH, OTHERS SEE AN IRON. Its owners and designers, though, see an elegant solution that turned a complicated program into a signature tower for the city of Taichung, Taiwan.

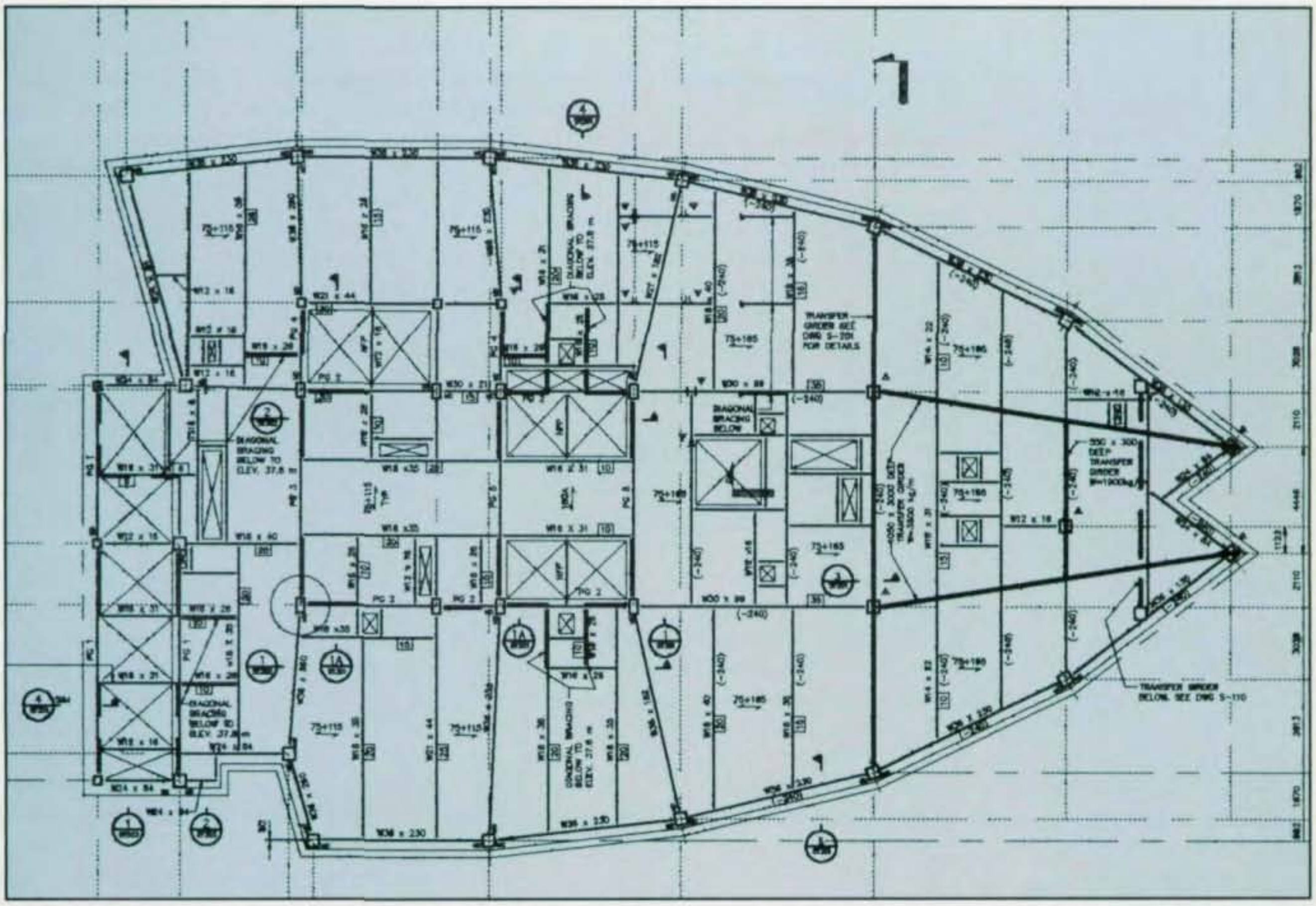
The Tzung Tang Development Group commissioned Kohn Pedersen Fox Associates, Architects and Weiskopf & Pickworth Consulting Engineers, both of New York City, to create a new focal point for this city in central Taiwan. Within this tower, the developers needed a range of uses, including an office block, a 350-room hotel with ballroom, a private club with workout equipment and swimming pool, retail levels and extensive parking facilities.

The solution is a 47-story, 184-meter-tall tower whose fish-like shape was considered a favorable symbol for the developers. The 47 tower floors house the office, hotel, and club facilities while six below grade floors house two retail levels and four parking levels.

During the 1950s, Taiwan built a large ship building industry which in turn created a highly-developed steel industry, which remains today. In fact steel is promoted so vehemently that proposals for concrete towers rising more than 20 stories will likely not be accepted by Taiwan's Structural Review Committees. The Committees, made up of a combination of university professors and practitioners, study each proposed structural design carefully before allowing a building permit to be issued. The Committees are uncomfortable with the quality of concrete produced in Taiwan and they see structural steel as cost competitive, accessible and the smart solution for seismic and wind forces.

A DUAL SYSTEM SOLUTION

While the use of structural steel for this tower was a forgone conclusion, the structural system for the tower's unique layout and complicated program required a



good bit of ingenuity.

Taichung is located in a high seismic zone roughly equivalent to UBC s Zone 3. In addition, the entire island of Taiwan is subject to typhoons and their resulting high wind forces.

Responding to the developer's desire for wide clear spans in the office floors, the designers pulled the core off to one side of the building. To maximize window space, perimeter column sizes needed to be minimized and columns needed to be placed no closer than eight meters on center.

Weiskopf & Pickworth's (W&P's) structural solution uses a dual system consisting of an eccentric braced frame core working in combination with a special moment-resisting steel frame to provide lateral resistance. Floor framing uses steel beams acting compositely with the floor slab.

Because the core and plan were irregular, the structural designers were faced with the challenge of minimizing the eccentricity of the lateral load resisting system. The design was a balancing act between the stiffness of the moment frames and the eccentric braced frames.

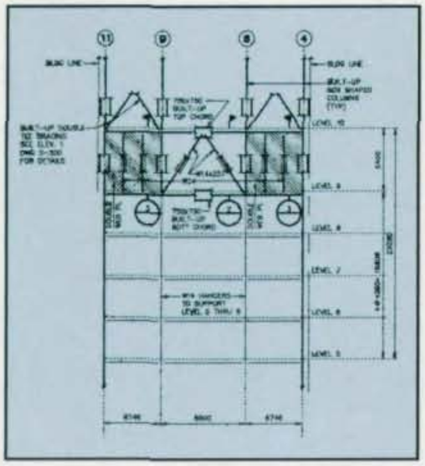
While maintaining wide column-free spaces in the office floors, the nature of hotel floors allowed the designers to stiffen some of the moment frames by adding diagonal bracing within the partitions between guest rooms.

Taiwan's steel mills generally fabricate structural steel members by welding steel plates instead of rolled I-sections. Columns are traditionally made by welding four plates in the shape of a box . For this project, a variety of rectangular column sizes were designed to accommodate the multiple floor plan and core layouts required in a mixed-use tower. Local mills can roll up to 50mm thick plates while local welding techniques can weld up to 70mm thick plates. The tower's design uses these local plates in all but a few isolated columns for which 95mm thick plates needed to be imported.

The seismic code in Taiwan requires that the column splices develop the full capacity of all columns in tension. This requirement, coupled with the box shape columns, results in extensive full penetration field welds for column splices. Beam-to-column moment connections also are commonly field welded with full penetration welds.

SCULPTING THE SYSTEM AROUND AMENITIES

The health club and ballroom are situated in the low-rise podium (called the plinth) on the third above grade level. These spaces called for column-free spans approaching 30 meters, thus very deep transfer trusses were required. Since these transfers could not be accommodated in the floor above the health club/ballroom (the fourth floor), they were introduced at the ninth floor mechanical level and



floors eight down to four were hung from the trusses.

The floor plan illustrates how the depth of the mechanical floor between levels nine and ten was used to transfer two interior columns that would have run through the ballroom and two columns at the mouth of the fish that would block the main entrance to the hotel. The latter columns were picked up on plate girders cantilevering over the plate girder at the H.4 line. This arrangement of plate girders allowed the cantilever without requiring heavy splices in the girders.

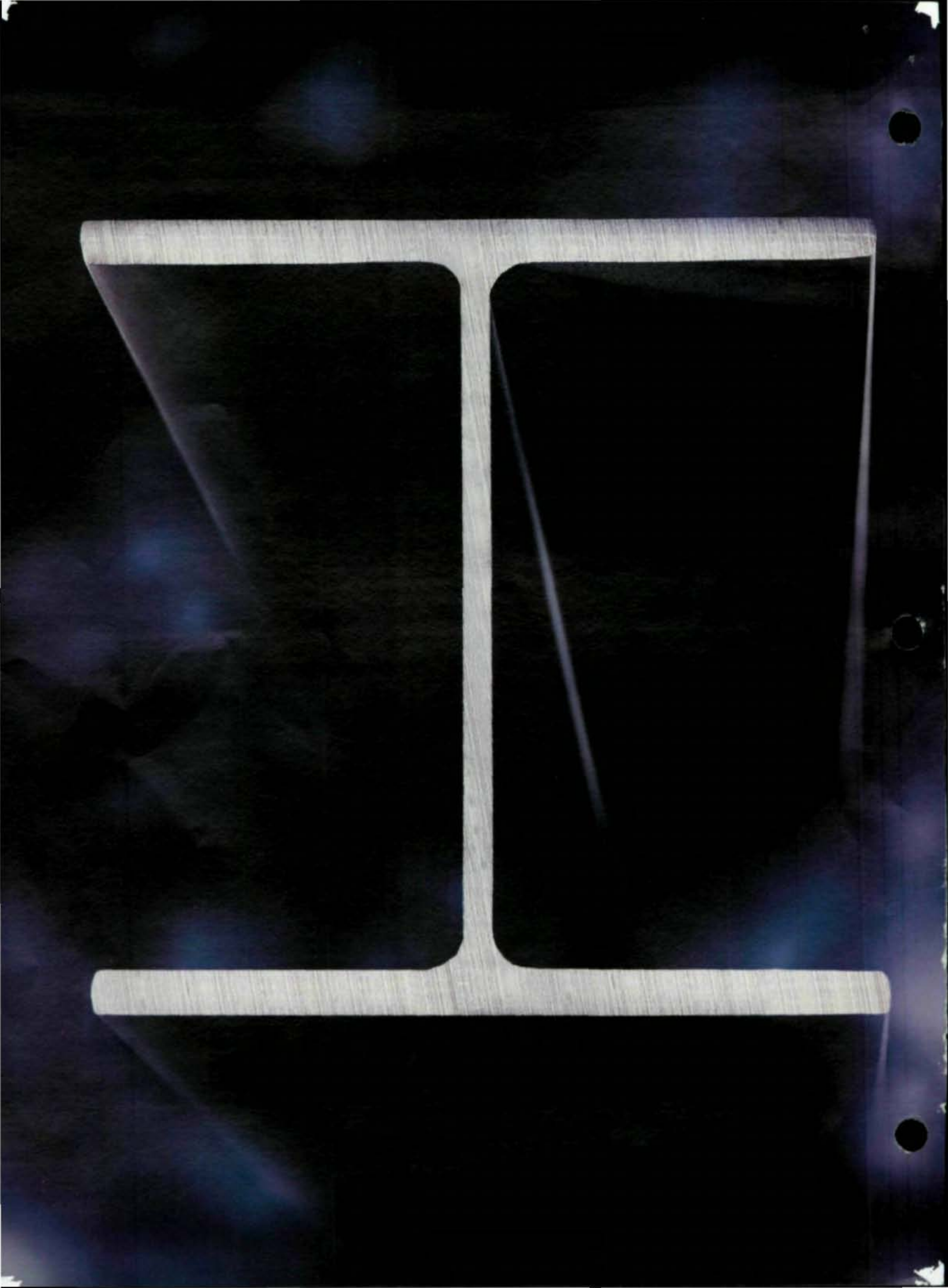
The transfer at the G line was accomplished with a combination truss/transfer girder. The girder was divided into three panels. The center panel includes truss diagonals to allow for passage within the mechanical spaces. The two outer panels use 50mm-thick web plates to transfer the column shear applied at the third points.

Taichung's prevalent soil conditions are a combination of clay soil with a dense matrix of boulders. Combined with a high water table this stiff soil system offers a unique excavation challenge. Traditionally, hand dug piles are used to provide a perimeter wall on the site prior to excavation.

This tower is designed for seven basements; the three lowest provide additional headroom to accommodate mechanical stacked parking. The foundation is a mat with voids carved into it for fuel storage tanks. Reaching down some 32 meters, these foundations are the deepest in the city of Taichung. To save construction time, the basements will be constructed using a top-down construction; excavation will start at the same time as the superstructure begins to rise.

Taichung's signature tower totals 61,100 square meters (700,000 square feet). Its site is at the north end of a three-mile-long landscaped mall and promises to be a premier destination for this city of one million people. Construction is to begin in 1995 with completion in 1997.

Leo Argiris, P.E., is a Partner in Weiskopf & Pickworth, a New York City-based structural engineering firm.



ANYTHING BUT INDUSTRIAL

A new retail center in Australia disproves that country's notion that exposed steel can only create a "warehouse" appearance

By Norman M. Garden, AIA, and Michael Connolly, ARAIA

THOUGH A COMMON STRUCTURAL MATERIAL IN AUSTRALIA, steel is seldom left exposed on high-end projects because most developers in that country think of it as creating an industrial feel. The designers of the new \$220 million Galleria Morley in Perth quickly put that image to rest.

Long before its September 1994 opening, the Galleria Morley created a stir. When the joint venture of Colonial Mutual and Coles Myer Properties Ltd. announced the project, they promised it would be the largest retail facility in Western Australia. And at 700,000 sq. ft., they delivered on that promise. But even more importantly, they promised a world class facility incorporating the latest international design concepts. This promise was crucial, since the developers hoped to attract a large number of major retailers who had not previously entered the western Australia market. The design, developed by the Los Angeles office of RTKL Associates Inc., in conjunction with The Buckan Group of Brisbane and Perth, was so well received that much of the center was preleased more than 10 months prior to completion—despite many businesses hesitancy to expand from the eastern part of Australia to the western.

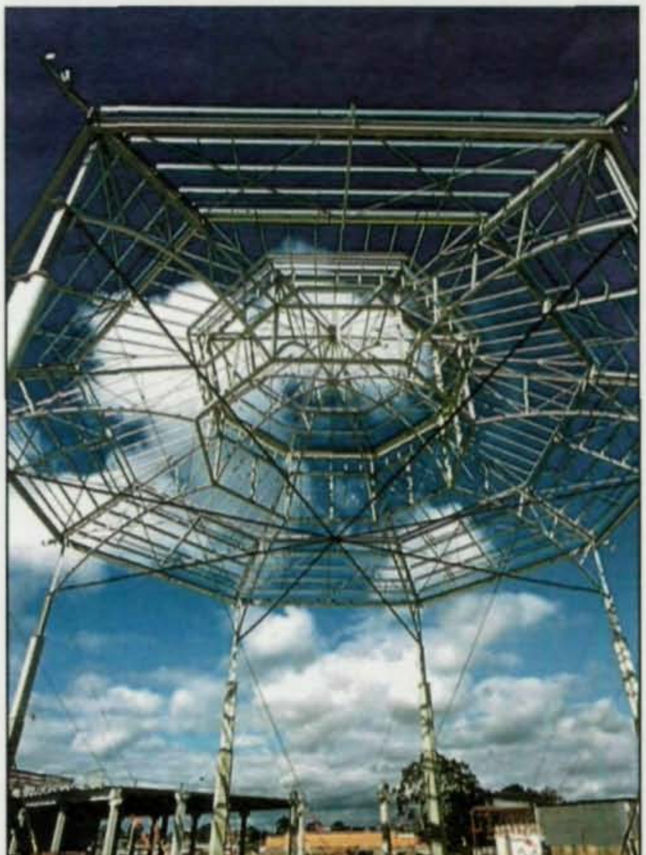
Perth is the second most isolated capital city (Vladivostock is first), and the nearest large city, Jakarta, is more than three hours away by air. Still, it has a population exceeding 1 million people and is one of Australia's most important cultural and economic centers. The area is known for its sparkling blue skies, crystal clear water and pristine beaches. Structures tend to be square-shaped with gable and hip roofs and wrapping verandahs. Nearby Fremantle (located to the Indian Ocean just west of Perth) has an older, more traditional architecture, with a tendency towards Victorian styles, though here too the pubs and hotels have an abundance of porches and verandahs, many on the second level and cantilevered out over the sidewalk.

Designed as a modern interpretation of the architectural styles prevalent in Fremantle and Perth, The Galleria Morley features colored corrugated metal rooflines combining hip and gable forms that reflect the architectural shapes so familiar to Western Australians. The project offers continuous vaulted skylights over the malls, as well as domed skylights over various courts, though in an angular or octagonal shape, rather than the more common barrel-shaped and rounded skylights. The center is distinguished by its main entry with 50-ft.-high composite columns and a 15-ft.-wide second-level verandah, reached via a pair of grand staircases. Located at the second level is a 700-seat food court that overlooks both the garden entrance and the activity within the center.

As its name indicates, the center is a two-level galleria structure. Open, light and airy in feeling, it is organized around a modified T-form plan, with anchors (a three-level flagship Myer Department Store, Kmart and Target) at each of the three extremities. Each spine is bounded by a soaring continuous skylight and a fanciful network of trusswork in the two-level interior. The main spine of the center, which stretches 445 ft. and also features two courts with domed skylights, is a two-story fashion galleria of shops and boutiques.

Splitting off from the central spine are two slightly curved 200-ft.-long two-level malls leading to two of the anchor tenants. Shops line the ground floor only, leaving the double height space above to give a sense of cool airiness as well as to maximize the view to the food court and a cinema located in the upper level of the central spine. There are no blind alleys—the sight lines are straight, the central court is always in view. A pair of escalators, travelators or curving stairs are incorporated into each interior court or node.

The focal point of The Galleria Morley is the central atrium—a 115-ft.-wide octagonal courtyard featuring a massive fountain pool flanked by towering royal palms. Soaring 82 ft. to its pinnacle and visible for miles around, day and night, the atrium design bestows the project with immediate landmark status.



Atop the central court is a huge skylight. The trusses are designed to appear to emanate from the columns and then leap out into the space, where they are linked together by an octagonal-shaped compression ring, from which the second tier of curved linear trusses spring to the top of the space.

Exposed Structure

As with many shopping centers, The Galleria Morley utilizes a structural system similar to that found in a warehouse—though the designers were careful to disguise that image.

While wood construction tends to prevail in Western Australia, it proved unsuitable for such a large structure. Instead, a composite structure was chosen. The challenge, though, was to convince the developers that the steel portion could serve not just structurally, but also architecturally. Far from the industrial image that steel usually represents in Australia, The Galleria Morley has light, airy, elegant interiors. No bolts were used;

The 700,000-sq.-ft. center was completed on budget and within the 18-month project schedule.

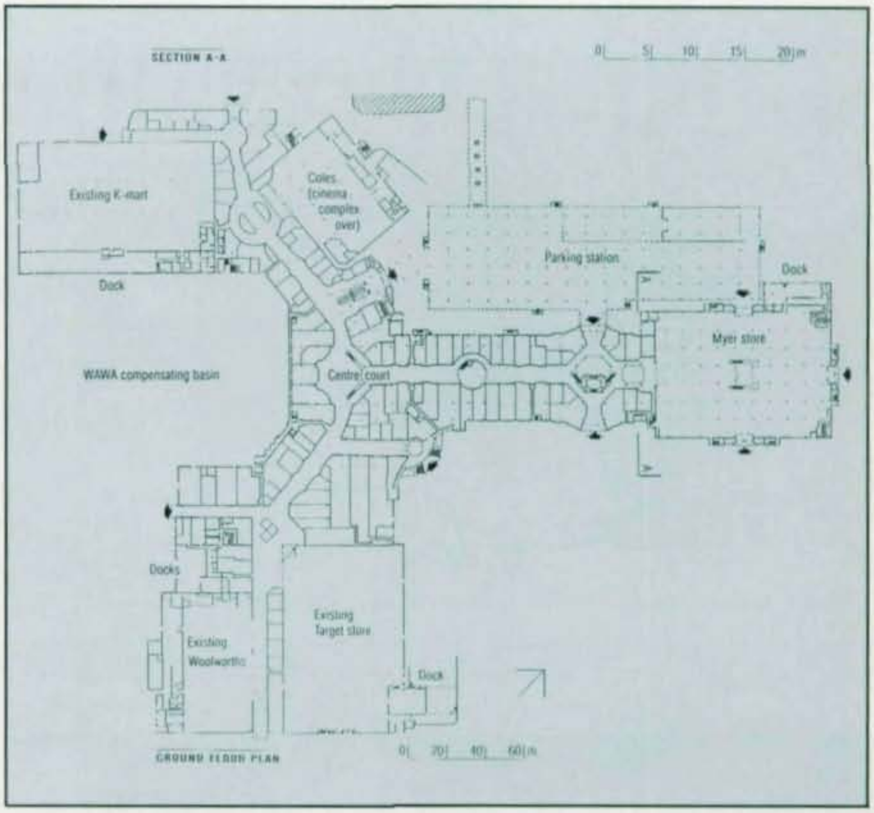
instead, all connections are welded and ground smooth. Sleek, streamlined, painted bright white and touched with brass accents, the steel inside the Galleria Morley resembles the finely detailed trellis-work found throughout this part of Western Australia.

The entire structure is basically a composite construction of precast concrete units for the lower level columns, the two-story external walls and the second floor framing, with the upper floor columns and roof framing of structural steel. Composite construction was adopted for this project for several reasons. First, it was less expensive than the more standard Australian technique of on-site erected steel units and insitu concrete. And second, it contributed versatility and efficiency to the erection of the project. Pre-contract and early contract works could be carried out on-site while fabrication occurred off-site. The overall process produced a project that was completed on budget and within the scheduled 18-month construction program. Structural engineer was Ove Arup &

Partners and general contractor was Multiplex Construction Company, both of Perth.

The upper floor steel construction allowed column spacing beyond the 30-ft.-by-30-ft. grid often found in American and Australian shopping centers—thus addressing the developers' concern that a smaller grid with more columns would create a wall blocking tenants' shopfronts from the view of consumers circulating though the center.

Whenever possible, the lightweight steel columns in the main fashion mall were reduced in size and twin 8-in.-diameter columns were used instead of a single 18-in.-diameter column. Spaced at more than 40 ft. along the entire length of the mall, these smaller twin columns were designed to appear to be resting on brass balls bracketed off of the second floor bulkheads, which gave the interior a terraced feel while also providing



maximum visibility for tenants.

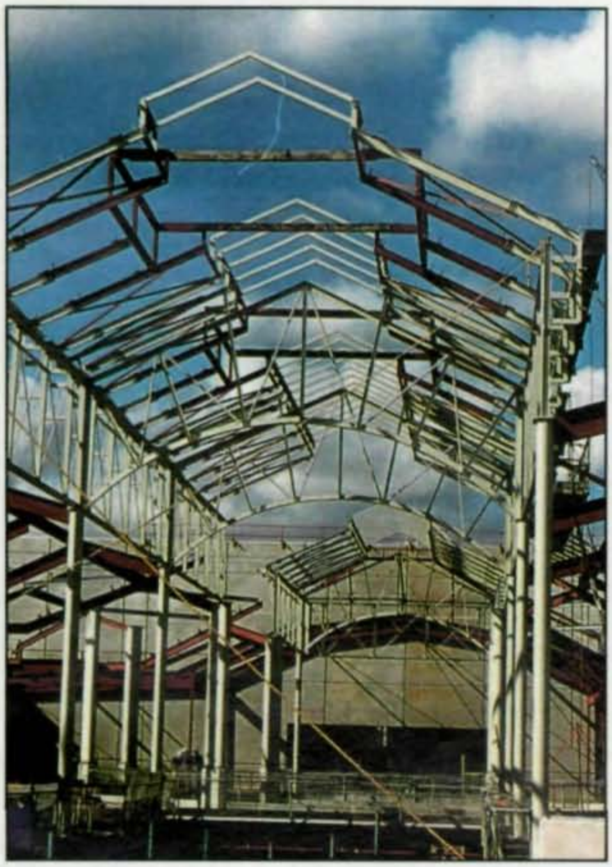
Composite construction also was used for the sloping floor to the cinemas. This consisted of sloping steel beams 18- to 24-in. deep with pre-cast hollow core concrete planks spanning between the beams topped with a concrete wearing slab. Although not specifically permitted under the building code, this design obtained a variance based on the fact that both the underside of the slope and the occupied space above were fully sprinklered and that alarms to warn of an inoperative system were installed. (This concession is now being applied to other new construction in Perth.)

LACY TRUSSES RESIST WIND LOADS

Although light and lacy throughout, the trusswork in the center was designed to resist what are termed the "Fremantle Doctor" sea breezes that blow from the west creating a cooling effect, as well as the erratic gusty winds that blow off the nearby ocean. The 7-ft.-6-in.-deep trusses that cross the mall to support the continuous skylights and roof along the three extremities are curved to evoke a sense of elegance.

While the trusses span across the mall, the upper chord of the truss is linear, reflecting the straight forward linear design of the gable and hip roof forms found in the region. The lower chord, however, is curved. The carefully assembled structural elements create a sense of depth articulating their shape through shade and shadow, reinforcing the notion of a light and delicate feel. The ladder trusses, running parallel along the length of the galleria, provide lateral stability to the overall structure, while their appearance is enhanced by the addition of criss-crossing tubular steel rods that provide stability while also creating a tracery of patterns for the sunlight to filter through.

Roof lights in the malls and center court are glazed with



trusses spring to the top of the space.

Two additional courts were created along the main galleria to serve as nodes to break the 445-ft. length of the space. The node at the opposite end of the center court has been dubbed the "fashion court." The structure of this court is similar to the center court, though significantly smaller at only 60-ft. across. In the stair court, midway between the fashion and center court, simplicity was achieved by bowing in plan the ladder trusses within a typical structural bay. This interrupted the linearity of the galleria and created a sense of place for the stair.

blue-green laminated glass which, together with an embossed white ceramic, help reduce ultra-violet penetrate and heat gain, yet allows the penetration of natural light during the daytime. At night, the embossed white ceramics provide a textured pattern to the roof lights.

As The Galleria Morley was envisioned as a "town center" for Perth, the monumentally scaled center court was designed as the heart of the project. To provide a sense of proportion and order, the double-tiered trusses break down the space. The lower portion provides a sense of scale while the top portion rises to a height that establishes the project as a landmark in the region. Crowned in glass, the pinnacle glows in the distant night sky when flooded with light. As the trusses emanating from the columns appear to leap out into the space, they are linked together by an octagonal-shaped compression ring, from which the second tier of curved linear trusses spring to the top of the space.

Steel roof construction of the center court and fashion court domes were assembled on-site from elements pre-fabricated off-site. Both structures were assembled on the ground under their final location and raised into position by two 100-ton mobile cranes. Long range weather forecasting was carefully analyzed with respect to the famous "Fremantle Doctor" winds, a necessary precaution while the 115-ft. center court structure was positioned atop eight slender composite columns 50 ft. in the air.

Norman M. Garden, AIA, is a vice president with RTKL Associates, Inc., in the firm's Los Angeles office. RTKL is a multi-discipline firm with a portfolio of work in 42 countries. Michael Connolly, ARAIA, is director of The Buchan Group, one of Australia's leading architectural firms.

Second of three parts

ESSENTIALS OF LRFD

An overview of LRFD as found in Part 2 of the *Manual of Steel Construction* (1994)

NEARLY A DECADE AGO, THE AMERICAN INSTITUTE OF STEEL CONSTRUCTION, INC. (AISC) BEGAN AN INDUSTRY-WIDE TRANSITION from Allowable Stress Design (ASD) to Load and Resistance Factor Design (LRFD). While acceptance has been slow, momentum is gathering: A recent Gallup poll showed that industry acceptance of LRFD is growing and a majority of structural engineers now believe that LRFD is the steel design method of the future. Some people, however, have interpreted the existence of two specifications as an indication of an unclear direction. Therefore, the AISC Board of Directors has adopted the following resolution:

"Based upon expert input from its Committee on Specifications, the Board of Directors of AISC affirms that the *1993 Load and Resistance Factor Design (LRFD) Specification for Structural Steel Buildings* is the preferred Specification for the fabricated structural steel industry. LRFD is a modern and technologically superior steel design specification. Its direct representation of ultimate structural behavior is especially relevant for seismic design, design of frames with partially restrained connections, and composite systems design. It offers engineers the opportunity to innovate in the analysis and design of highly reliable and competitive steel structures by encouraging the consideration of strength and serviceability criteria under appropriate combinations of gravity and lateral loads. In this way, LRFD is consistent with the prevailing trend toward limit-states design in all materials, both domestically and internationally."

This article is the second of a three-part summary of LRFD (part one appeared in June).

D. TENSION MEMBERS

DESIGN TENSILE STRENGTH

The design philosophy for tension members is the same in the LRFD and ASD Specifications:

a. The limit state of yielding in the gross section is intended to prevent excessive elongation of the member. Usually, the portion of the total member length occupied by fastener holes is small. The effect of early yielding at the reduced cross sections on the total member elongation is negligible. Use of the area of the gross section is appropriate.
b. The second limit state involves fracture at the section with the minimum effective net area.

The design strength of tension members, $\phi_t P_n$, as given in Section D1 of the LRFD Specification, is the lesser of the following:

a. For yielding in the gross section,

$$\phi_t = 0.90$$
$$P_n = F_y A_g \qquad \text{(D1-1)}$$

b. For fracture in the net section,

$$\phi_t = 0.75$$
$$P_n = F_u A_e \qquad \text{(D1-2)}$$

where

A_e = effective net area, sq. in. (see Section B)
A_g = gross area of member, sq. in.
F_y = specified minimum yield stress, ksi
F_u = specified minimum tensile strength, ksi
P_n = nominal axial strength, kips

For 50 ksi steels, F_y = 50 ksi and minimum F_u = 65 ksi. Accordingly,

a. For yielding in the gross section,

$$\phi_t P_n = 0.9 \times 50 \text{ ksi} \times A_g = 45.0 \text{ ksi} \times A_g \qquad \text{(2-3)}$$

b. For fracture in the net section,

$$\phi_t P_n = 0.75 \times 65 \text{ ksi} \times A_e = 48.8 \text{ ksi} \times A_e \qquad \text{(2-4)}$$

The limit state of block shear rupture may govern the design tensile strength. For information on block shear, see Section J4.3 of the LRFD Specification and Part 8 (in Volume II) of the LRFD Manual.

Example D-1

Given: Determine the design strength of a W8x24 as a tension member in 50 ksi steel. How much dead load can it support?

Solution: If there are no holes in the member, $A_e = A_g$ and Equation 2-3 governs,

$$\phi_t P_n = 45.0 \text{ ksi} \times A_g = 45.0 \text{ ksi} \times 7.08 \text{ in.}^2 = 319 \text{ kips}$$

Assuming that dead load is the only load, the governing load combination from Section A is 1.4D. Then the required tensile strength

$$P_u = 1.4P_D \le \phi_t P_n = 319 \text{ kips}$$

$P_D \le$ 319 kips / 1.4 = 228 kips maximum dead load that can be supported by the member.

Example D-2

Given: Repeat Example D-1for a W8x24 in 50 ksi steel with four 1-in.-diameter holes, two per flange, along the member (i.e., not at its ends) for miscellaneous attachments. See Figure D-1(a).

Solution: a. For yielding in the gross section $\phi_t P_n$ = 319 kips, as in Example D-1.

b. For fracture in the net section

$$\begin{aligned} A_e &= A_n = A_g - 4 \times (d_{hole} + {}^1\!/_{16} \text{ in.}) \times t_f \\ &= 7.08 \text{ in.}^2 - 4 \times (1 + {}^1\!/_{16} \text{ in.}) \times 0.400 \text{ in.} \\ &= 5.38 \text{ in.}^2 \end{aligned}$$

(continued on next page)

Example D-2, Continued

$\phi_t P_n$ $= 48.8$ ksi x A_e
$= 48.8$ ksi x 5.38 in.^{2} $= 263$ kips < 319 kips

Fracture in the net section governs.

$P_u = 1.4P_D < \phi_t P_n = 263$ kips
$P_D \leq 263$ kips / $1.4 = 188$ kips

Note: If the holes had been at the end connection of the tension member, the U reduction coefficient would apply in the calculation of an effective net area.

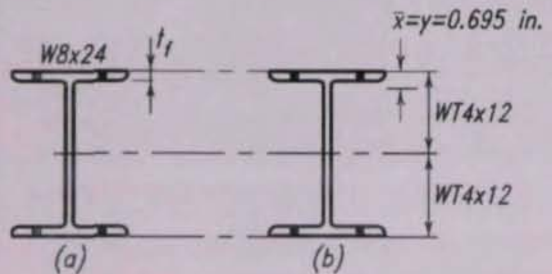


Figure D-1

Example D-3

Given: Repeat Example D-2 for holes at a bolted end-connection. There are a total of eight 1-in.-diameter holes, as shown in figure D-1(a), on two planes, 4-in. center-to-center.

Solution: a. For yielding in the gross section

$\phi_t P_n = 319$ kips, as in Example D-1.

b. For fracture in the net section, according to Equation B3-1 in Section B (see last month), the effective net area

$A_n = 5.38$ in.^{2} as in Example D-2

$U = 1 - \bar{x} / L$, $L = 4$ in.

Note: In lieu of calculating U, the Commentary on the LRFD Specification (Section B3) permits the use of more conservative values of U listed therein.

According to Commentary Figure C-53.1(a), $\bar{x}$ for a W8x24 in this case is taken as that for a WT4x12. From the properties of a WT4x12 given in Part 1 of the Manual, $\bar{x} = y = 0.695$ in. (See Figure D-1(b)).

U $= 1 - 0.695$ in. / 4 in. $= 0.826$

Thus

A_e $= 5.38$ in.^{2} x $0.826 = 4.45$ in.^{2}
$\phi_t P_n$ $= 48.8$ ksi x A_e
$= 48.8$ kips x 4.45 in.^{2} $= 217$ kips < 319 kips

Fracture in the net section governs. Again, assuming that dead load is the only load,

$P_u = 1.4P_D \leq \phi_t P_n = 217$ kips

$P_D \leq 217$ kips / $1.4 = 155$ kips maximum dead load that can be supported by the member.

E. Columns and Other Compression Members

Effective Length

For a discussion of the effective length Kl for columns, refer to Section C in last month's issue.

Design Compressive Strength

Although the column strength equations have been revised for compatibility with LRFD and recent research on column behavior, the philosophy and procedures of column design in LRFD are similar with those in ASD. The direct design of columns with W and other rolled shapes is facilitated by the column strength tables in Part 3 of the LRFD Manual, which show the design compressive strength $\phi_c P_n$ as a function of KL (the effective unbraced length in feet). Columns with cross sections not tabulated (e.g., built-up columns) can be designed iteratively, as in the past, with the aid of tables listing design strengths versus KL/r, the slenderness ratio. Such tables are given in the Appendix of the LRFD Specification for 36 and 50 ksi structural steels, and below (Table E-1) for 50 ksi steel.

There are two equations governing column strength, based on the limit state of flexural buckling, one for inelastic buckling (Equation E2-2) and the other (Equation E2-3) for elastic, or Euler, buckling. Equation E2-2 is an empirical relationship for the inelastic range, while Equation E2-3 is the familiar Euler formula multiplied by 0.877. Both equations include the effects of residual stresses and initial out-of-straightness. The boundary between inelastic and elastic instability is $\lambda_c = 1.5$, where the parameter

$$\lambda_c = \frac{Kl}{r\pi}\sqrt{\frac{F_y}{E}} \qquad \text{(E2-4)}$$

For axially loaded columns with all elements having width-thickness ratios $< \lambda_r$ (in Section B5.1 of the LRFD Specification), the design compressive strength $= \phi_c P_n$

where

$\phi_c = 0.85$

$$P_n = A_g F_{cr} \qquad \text{(E2-1)}$$

A_g = gross area of member, in.^{2}

a. For $\lambda_c < 1.5$

$$F_{cr} = (0.658^{\lambda_c^2})F_y \qquad \text{(E2-2)}$$

As is done in the Commentary in Section E2, this equation can be expressed in exponential form as:

$$F_{cr} = [\exp(-0.419^{\lambda_c^2})]F_y \qquad \text{(C-E2-1)}$$

where $\exp(x) = e^x$

b. For $\lambda_c > 1.5$

$$F_{cr} = [\frac{0.877}{\lambda_c^2}]F_y \qquad \text{(E2-3)}$$

where

- F_y = specified minimum yield stress, ksi
- E = modulus of elasticity, ksi
- K = effective length factor
- l = unbraced length of member, in.
- r = governing radius of gyration about plane of buckling, in.

For 50 ksi steel

$$\lambda_c = \frac{Kl}{r}\frac{1}{\pi}\sqrt{\frac{50\ ksi}{29000\ ksi}} = 0.0132\frac{Kl}{r}$$
$$or\ \frac{Kl}{r} = 75.7\lambda_c \qquad (2\text{-}5)$$

The boundary between inelastic and elastic buckling (λ_c = 1.5) for 50 ksi steel is

$$Kl/r = 75.7 \times 1.5 = 113.5$$

The column strength equations in terms of Kl/r for 50 ksi steel become

$$\phi_c P_n = (\phi_c F_{cr})A_g \qquad (2\text{-}6)$$

where $\phi_c = 0.85$

a. For $Kl / r < 113.5$

$$F_{cr} = \{\exp[-7.3 \times 10^{-5}(Kl/r)^2]\} \times 50\text{ ksi} \qquad (2\text{-}7)$$

b. For $Kl/r > 113.5$

$$F_{cr} = \frac{2.51 \times 10^5}{(Kl/r)^2}\ ksi \qquad (2\text{-}8)$$

Based on Equations 2-7 and 2-8, Table E-1 gives the design stresses for 50 ksi steel columns for the full range of slenderness ratios. Determining the design strength of a given 50 ksi steel column merely involves using Equation 2-6 in connection with Table E-1. The appropriate design stress ($\phi_c F_{cr}$) from Table E-1 is multiplied by the cross-sectional area to obtain the design strength $\phi_c P_n$.

Table E-1.
Design Stress for Compression Members of 50 ksi Specified Minimum Yield Stress Steel, $\phi_c = 0.85$*

$\frac{Kl}{r}$	F_{cr} (ksi)	$\frac{Kl}{r}$	F_{cr} (ksi)	$\frac{Kl}{r}$	F_{cr} (ksi)	$\frac{Kl}{r}$	F_{cr} (ksi)	$\frac{Kl}{r}$	F_{cr} (ksi)
1	42.50	41	37.59	81	26.31	121	14.57	161	8.23
2	42.49	42	37.36	82	26.00	122	14.33	162	8.13
3	42.47	43	37.13	83	25.68	123	14.10	163	8.03
4	42.45	44	36.89	84	25.37	124	13.88	164	7.93
5	42.42	45	36.65	85	25.06	125	13.66	165	7.84
6	42.39	46	36.41	86	24.75	126	13.44	166	7.74
7	42.35	47	36.16	87	24.44	127	13.23	167	7.65
8	42.30	48	35.91	88	24.13	128	13.02	168	7.56
9	42.25	49	35.66	89	23.82	129	12.82	169	7.47
10	42.19	50	35.40	90	23.51	130	12.62	170	7.38
11	42.13	51	35.14	91	23.20	131	12.43	171	7.30
12	42.05	52	34.88	92	22.89	132	12.25	172	7.21
13	41.98	53	34.61	93	22.58	133	12.06	173	7.13
14	41.90	54	34.34	94	22.28	134	11.88	174	7.05
15	41.81	55	34.07	95	21.97	135	11.71	175	6.97
16	41.71	56	33.79	96	21.67	136	11.54	176	6.89
17	41.61	57	33.51	97	21.36	137	11.37	177	6.81
18	41.51	58	33.23	98	21.06	138	11.20	178	6.73
19	41.39	59	32.95	99	20.76	139	11.04	179	6.66
20	41.28	60	32.67	100	20.46	140	10.89	180	6.59
21	41.15	61	32.38	101	20.16	141	10.73	181	6.51
22	41.02	62	32.09	102	19.86	142	10.58	182	6.44
23	40.89	63	31.80	103	19.57	143	10.43	183	6.37
24	40.75	64	31.50	104	19.28	144	10.29	184	6.30
25	40.60	65	31.21	105	18.98	145	10.15	185	6.23
26	40.45	66	30.91	106	18.69	146	10.01	186	6.17
27	40.29	67	30.61	107	18.40	147	9.87	187	6.10
28	40.13	68	30.31	108	18.12	148	9.74	188	6.04
29	39.97	69	30.01	109	17.83	149	9.61	189	5.97
30	39.79	70	29.70	110	17.55	150	9.48	190	5.91
31	39.62	71	29.40	111	17.27	151	9.36	191	5.85
32	39.43	72	20.09	112	16.99	152	9.23	192	5.79
33	39.25	73	28.79	113	16.71	153	9.11	193	5.73
34	39.06	74	28.48	114	16.42	154	9.00	194	5.67
35	38.86	75	28.17	115	16.13	155	8.88	195	5.61
36	38.66	76	27.86	116	15.86	156	8.77	196	5.55
37	38.45	77	27.55	117	15.59	157	8.66	197	5.50
38	38.24	78	27.24	118	15.32	158	8.55	198	5.44
39	38.03	79	26.93	119	15.07	159	8.44	199	5.39
40	37.81	80	26.62	120	14.82	160	8.33	200	5.33

* When element width-to-thickness ratio exceeds λ_r, see Appendix B5.3 of LRFD Specification

Example E-1

Determine the adequacy of a W14x120 building column

Given: 50 ksi steel; K = 1.0; story height = 12.0 ft.; required strength based on the maximum total factored load is 1300 kips.

Solution: $K_x L_x = K_y L_y = 1.0 \times 12.0\text{ ft.} = 12.0\text{ ft.}$

Because $r_y < r_x$,

$$\left(\frac{Kl}{r}\right)\ maximum = \frac{K_y L_y}{r_y} = \frac{12.0\ ft. \times 12\ in./ft.}{3.74\ in.} = 38.5$$

From Table E-1, $\phi_c F_{cr}$ = 38.14 ksi

Design compressive strength
$\phi_c P_n = (\phi_c F_{cr})A_g$ = 38.14 ksi x 35.3 in^3
= 1346 kips > 1300 kips required **o.k.**

Example E-2

Given: Design a 25-ft.-high, free-standing A618(F_y = 50 ksi) steel pipe column to support a water tank with a weight of 75 kips at full capacity. See Figure E-2.

Solution: *For a live load of 75 kips, the required column strength* (from Section A) is $P_u = 1.6P_L$ = 1.6 x 75 kips = 120 kips.

From Table C-2, case e, recommended K = 2.1.

KL =2.1 x 25.0 ft. = 52.5 ft.

Try a standard 12-in. diameter pipe (A = 14.6 in.^{2}, I = 279 in.^{4}):

$$r = \sqrt{I / A} = \sqrt{279\ in.^2 / 14.6\ in.^2} = 4.37\ in.$$

$$\frac{Kl}{r} = \frac{52.5\ ft. \times 12\ in./ft.}{4.37\ in.} = 144.2$$

From Table E-1, $\phi_c F_{cr}$ = 10.3 ksi
$\phi_c P_n = (\phi_c F_{cr})A_g$ = 10.3 ksi x 14.6 in.^{2}
= 150 kips > 120 kips required **o.k.**

To complete the design, bending due to lateral loads (i.e. wind and earthquakes) should also be considered. See Sections F and H.

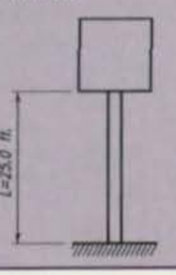


Fig. E-2

Example E-3

Select the most economical W14 column for the case shown in Figures E-3a and E-3b.

Fig. E-3a

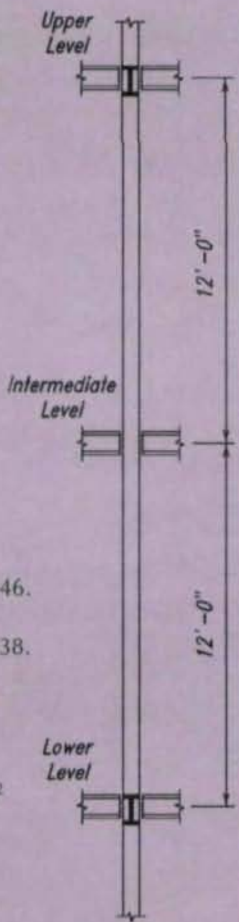


Fig. E-3b

Given: 50 ksi steel; K = 1.0; required strength based on the maximum total factored load is 1300 kips. The column is braced in both directions at the upper and lower levels, and in the weak direction at the intermediate level.

Solution: Try a W14x120 (as in example E-1):

$$\frac{K_x l_x}{r_x} = \frac{1.0 \times 24.0 \text{ ft.} \times 12 \text{ in./ft.}}{6.24 \text{ ft.}} = 46.$$

$$\frac{K_y l_y}{r_y} = \frac{1.0 \times 12.0 \text{ ft.} \times 12 \text{ in./ft.}}{3.74 \text{ in.}} = 38.$$

$$\frac{Kl}{r}\text{max} = \frac{K_x l_x}{r_x} = 46.2$$

From Table E-1, $\phi_c F_{cr} = 36.35$ *ksi*

$$\text{Required } A_g = \frac{1300 \text{ kips}}{36.35 \text{ ksi}} = 35.8 \text{ in.}^2$$

> 35.3 *in.*^{2}*provided*

W14x120 ***n.g.***

By inspection, W14x132 is ***o.k.***

Use W14x132

Flexural-Torsional Buckling

As stated in Section E3 of the LRFD Specification and Commentary, torsional and flexural-torsional buckling generally do not govern the design of doubly symmetric rolled shapes in compression. For other cross sections, see Section E3 and Appendix E3 of the LRFD Specification.

Built-Up and Pin-Connected Members

These members are covered, respectively, in Section E4 and E5 of the LRFD Specification.

F. Beams and Other Flexural Members

Chapter F of the LRFD Specification covers compact beams. Compactness criteria are given in Table B5.1 of the LRFD Specification and are summarized in Table B-1. To prevent torsion, wide-flange shapes must be loaded in either plane of symmetry, channels must be loaded through the shear center parallel to the web, or restraint against twisting must be provided at load points and points of support. Torsion combined with flexure and axial force combined with flexure are covered

Table B-1.
Limiting Width-Thickness Ratios for Compression Elements*

Beam Element	Width-Thickness Ratio	Limiting Width-Thickness Ratio, λ_p General	Limiting Width-Thickness Ratio, λ_p For $F_y = 50$ ksi
Flanges of I shapes and channels	b/t	$65/\sqrt{F_y}$	9.2
Flanges of square and rectangular box beams	b/t	$190/\sqrt{F_y}$	26.9
Webs in flexural compression	h/t_w	$640/\sqrt{F_y}$	90.5
Webs in combined flexural and axial compression	h/t_w	$253/\sqrt{F_y}$**	35.8
Column Element	**Width-Thickness Ratio**	**Limiting Width-Thickness Ratio, λ_r General**	**Limiting Width-Thickness Ratio, λ_r For $F_y = 50$ ksi**
Flanges of I shapes and channels and plates projecting from compression elements	b/t	$95/\sqrt{F_y}$	13.4
Webs in axial compression	h/t_w	$253/\sqrt{F_y}$	35.8

*For the complete table, see LRFD Specification, Section B5, Table B5.1.
**This is a simplified, conservative version of the corresponding entry in Table B5.1 of the LRFD Specification.

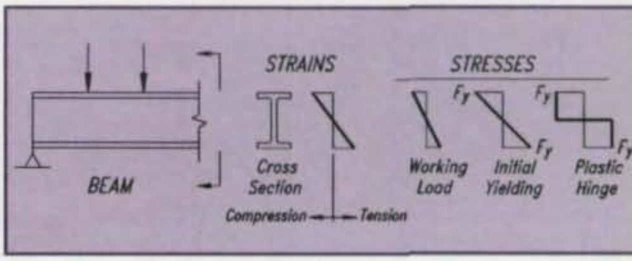


Figure F-1: Flexural strains and stresses

in Chapter H of the LRFD Specification.

This section explains the provisions of the LRFD Specification for compact rolled beams. For other compact and noncompact flexural members, refer to Appendix F of the Specification; plate girders are in Appendix G.

Flexure

To understand the provisions of the LRFD Specification regarding flexural design, it is helpful to review briefly some aspects of elementary beam theory.

Under working loads (and until initial yielding) the distributions of flexural strains and stresses over the cross-section of a beam are linear. As shown in Figure F-1, they vary from maximum compression at the extreme fibers on one side (the top) to zero at the neutral, or centroidal, axis to maximum tension at the extreme fibers on the other side (the bottom).

The relationship between moment and maximum bending stress (tension or compression) at a given cross section is

$$M = Sf_b \qquad (2\text{-}9)$$

where:

M = bending moment due to the applied loads, kip-in.
S = elastic section modulus, in the dir. of bending in.^{3} = I/c
f_b = maximum bending stress, ksi
I = moment of intertia of the cross section about its centroidal axis, in.^{4}
c = distance from the elastic neutral axis to the extreme fiber, in.

Similarly, at intitial yielding

$$M_y = SF_y \qquad (2\text{-}10)$$

where

M_r = bending moment coinciding with first yielding, kip-in.

If additional load is applied, the strains continue to increase; the stresses, however, are limited to F_y. Yielding proceeds from the outer fibers inward until a plastic hinge is developed, as shown in Figure F-1. At full plastification of the cross section

$$M_p = ZF_y \tag{2-11}$$

where

M_p = plastic moment, kip-in.

Z = *plastic section modulus, in the direction of* bending, in.^{3}

Due to the presence of residual stresses (prior to loading, as a consequence of the rolling operation), yielding begins at an applied stress of $(F_y - F_r)$. Equation 2-10 should be modified to

$$M_r = S(F_y - F_r)$$

where

F_r = the max. compressive residual stress in either flange, ksi
= 10 ksi for rolled shapes
= 16.5 ksi for welded shapes

The definition of plastic moment in Equation 2-11 is still valid, because it is not affected by residual stresses.

Design for Flexure

a. Assuming C_b = 1.0

Compact sections will not experience local buckling before the formation of a plastic hinge. The occurrence of lateral torsional buckling of the member depends on the unbraced length L_b. As implied by the term lateral-torsional buckling, overall instability of a beam requires that twisting of the member occur simultaneously with lateral buckling of the compression flange. L_b is the distance between points braced to prevent twist of the cross section. Many beams can be considered continuously braced; e.g., beams supporting a metal deck, if the deck is intermittently welded to the compression flange. Compact wide flange and channel members bending about their major (or x) axes can develop their full plastic moment M_p without buckling if $L_b \le L_p$. If $L_b = L_r$, the nominal flexural strength is M_r, the moment at first yielding adjusted for residual stresses. The nominal moment capacity (M_n) for $L_p < L_b < L_r$ is $M_r < M_n < M_p$. Compact shapes bent about their minor (or y) axes will not buckle before developing M_p, regardless of L_b.

Flexural design strength, governed by the limit state of lateral-torsional buckling, is $\phi_b M_n$, where ϕ_b = 0.90 and M_n the nominal flexural strength is as follows:

$M_n = M_p = Z_x F_y$ *for bending about the major axis if* $L_b \le L_p$ (2-13)

$M_n = M_p = Z_y F_y$ *for bending about the minor axis regardless of* L_b (2-14)

$$L_p = \frac{300 r_y}{\sqrt{F_y}} = 42.4 r_y \text{ for 50 ksi steel} \tag{2-15}$$

$M_n = M_r = S_x(F_y - F_r) = S_x(F_y - 10\text{ ksi})$ (2-16)

for rolled shapes bending about the major axis if $L_b = L_r$

M_n for bending about the major axis, if $L_p < L_b < L_r$, is determined by linear interpolation betweens equations 2–13 and 2–16; i.e., $M_n = M_p - (M_p - M_r)(\frac{L_b - L_p}{L_r - L_p})$ (2-17)

The definition for the limiting laterally unbraced length L_r is given in the LRFD Specification (in Equations F1-6, 8, and 9) and will not be repeated here. For bending about the major axis if $L_b > L_r$,

$$M_n = M_{cr} < M_r \tag{2-18}$$

The case of $L_b > L_r$ is beyond the scope of this section. The reader is referred to Section F1.2b of LRFD Specification (specifically Equation F1-13, where the critical moment M_{cr} is controlled by lateral-torsional buckling). This case is also covered in the beam graphs *in Part 4 of the LRFD Manual.*

b. All values of C_b

C_b is the bending coefficient. A new expression for C_b is given in the LRFD Specification. (It is more accurate than the one previously shown.)

$$C_b = \frac{12.5 M_{max}}{2.5 M_{max} + 3M_A + 4M_B + 3M_C} \tag{F1-3}$$

where M is the absolute value of a moment in the unbraced beam segment as follows:

M_{max}, the maximum
M_A, at the quarter point
M_B, at the centerline
M_C, at the three-quarter point

The purpose of C_b is to account for the influence of moment gradient on lateral-torsional buckling. The flexural strength equations with C_b = 1 are based on a uniform moment along a laterally unsupported beam segment causing single curvature buckling of the member. Other loadings are less severe, resulting in higher flexural strengths; $C_b \ge 1.0$. Typical values of C_b are given in Table F-1. For unbraced cantilevers, C_b = 1. C_b can conservatively be taken as 1.0 for all cases.

For all values of C_b, the flexural design strength $\phi_b M_n$, where ϕ_b = 0.90, is given in the LRFD Specification in terms of a nominal flexural strength M_n varying as follows:

$M_n = M_p = Z_x F_y$ *for bending about the major axis if* $L_b \le L_m$ (2-13)

$M_n = C_b M_r = C_b S_x(F_y - 10\text{ ksi}) \le M_p$ *for bending about the major axis if* $L_b = L_r$ (2-19)

for bending about the major axis if $L_m < L_b < L_r$, linear interpolation is used

$$M_n = C_b[M_p - (M_p - M_r)(\frac{L_b - L_p}{L_r - L_p})] \le M_p \tag{F1-2}$$

If $L_b > L_r$, $M_n = M_{cr} \le C_b M_r$ *and* M_p (2-20)

The determination of M_n for a given L_b can best be done graphically, as illustrated in Figure F-2. The required parameters for each W shape are given in the beam design table in Part 4 of the LRFD Manual, an excerpt of which is shown herein as Table F-2. If C_b = 1, the coordinates for constructing the graph are (L_p, M_p), and (L_r, M_r). For C_b > 1, the key coordinates are (L_p, $C_b M_r$) and (L_r, $C_b M_r$). Note that M_n cannot exceed the plastic moment M_p. L_m, then, can be derived graphically as the upper limit of L_b for which $M_n = M_p$. If $L_b > L_r$, the beam graphs in Part 4 of the LRFD Manual can be used to determine M_{cr}.

Table F-1.
Values of C_b for Simply Supported Beams Braced at Ends of Span

Load	Lateral Bracing Along Span	C_b
Concentrated at center	None	1.32
	At centerline only	1.67
Uniform	None	1.14
	At centerline only	1.30

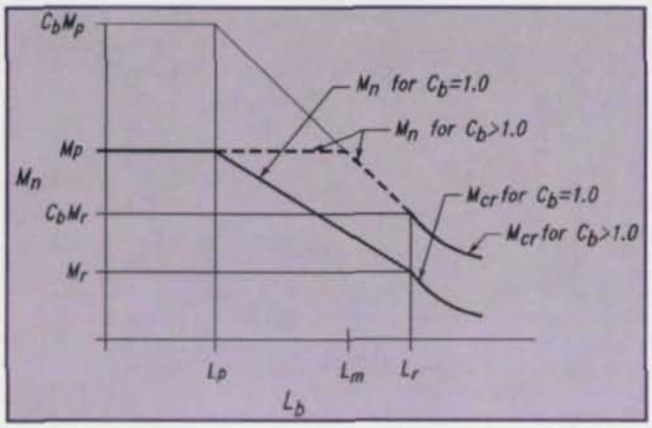


Figure F-2: Determination of nominal flexural strength M_n

Table F-2.
Excerpt from Load Factor Design Selection Table
(LRFD Manual, Part 4)

		For F_y = 50 ksi			
Zx (in.^{3})	Shape	ϕ_bM_p (kip-ft)	ϕ_bM_r (kip-ft)	L_p (ft)	L_r (ft)
224	**W24x84**	**840**	**588**	**6.9**	**18.6**
221	W21x93	829	576	6.5	19.4
212	W14x120	795	570	13.2	46.2
211	W18x97	791	564	9.4	27.4
200	**W24x76**	**750**	**528**	**6.8**	**18.0**
198	W16x100	743	525	8.9	29.3
196	W21x83	735	513	6.5	18.5
192	W14x109	720	519	13.2	43.2
186	W18x86	698	498	9.3	26.1
186	W12x120	698	489	11.1	50.0
177	**W24x68**	**664**	**462**	**6.6**	**17.4**
175	W16x89	656	465	8.8	27.3

Note: Flexural design strength $\phi_bM_n = \phi_bM_p$, as tabulated is valid for $L_b \le L_m$. If $C_b = 1.0$, $L_m = L_p$; otherwise, $L_m > L_p$. $\phi_b = 0.90$.

Example F-1

Given: Select the required W shape for a 30-ft. simple floor beam with full lateral support carrying a dead load (including its own weight) of 1.5 kips per linear ft. and a live load of 3.0 kips per linear ft. Assume 50 ksi steel and:

a. There is no member depth limitation
b. The deepest member is a W18

Solution: The governing load combination in Section A is A4-2:
$1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R) = 1.2 \times 1.5 \text{ klf} + 1.6 \times 3.0 \text{ klf} + 0 = 6.6 \text{ klf}$

$$\text{Required } M_u = \frac{wL^2}{8} = \frac{6.6 \text{ klf} \times (30.0 \text{ ft.})^2}{8} = 743 \text{ kip-ft.}$$

Flexural design strength $\phi_bM_n \ge 743$ kip-ft.

a. In Table F-2, the most economical beams are in **boldface** print. Of the boldfaced beams, the lightest one with $\phi_bM_n = \phi_bM_p \ge 743$ kip-ft. is a W24x76.

b. By inspection of Table F-2, the lightest W18 with $\phi_bM_n = \phi_bM_p \ge 743$ kip-ft. is a W18x97.

Example F-2

Given: Determine the flexural design strength of a 30-ft. long simply supported W24x76 girder (of 50 ksi steel) with a concentrated load and lateral support, both at midspan.

Solution: From Table F-1:
$C_b = 1.67$; $L_b = 30.0 \text{ ft.}/2 = 15.0$ ft.
From Equation F1-2:

$$\phi_bM_n = C_b[\phi_bM_p - (\phi_bM_p - \phi_bM_r)(\frac{L_b - L_p}{L_r - L_p})] \le \phi_bM_p$$

From Table F-2 for a W24x76:
ϕ_bM_p = 750 kip-ft.
ϕ_bM_r = 528 kip-ft.
L_p = 6.8 ft.
L_r = 18.0 ft.

$$\phi_bM_n = 1.67[750 \text{ kip-ft.} - (750 - 528)\text{kip-ft.}(\frac{15.0 \text{ ft.} - 6.8 \text{ ft.}}{18.0 \text{ ft.} - 6.8 \text{ ft.}})]$$
$$= 981 \text{ kip-ft.} > 750 \text{ kip-ft.}$$

Use $\phi_bM_n = \phi_bM_p = 750$ *kip-ft.*
In this case, even though the unbraced length $L_b > L_p$, the design flexural strength is ϕ_bM_p because $C_b > 1.0$.

Design for Shear

The design shear strength is defined by the equations in Section F2 of the LRFD Specification. Shear in wide-flange and channel sections is resisted by the area of the web (A_w), which is taken as the overall depth d times the web thickness t_w. For webs of 50 ksi steel without transverse stiffeners, the design shear strength ϕ_vV_n, where ϕ_v = 0.90, and the nominal shear strength V_n are as follows:

For $h/t_w \le 59$ (including all rolled W and channel shapes),

$$V_n = 30.0 \text{ ksi} \times dt_w$$
$$\phi_vV_n = 27.0 \text{ ksi} \times dt_w \quad (2\text{-}21)$$

For $59 < h/t_w \le 74$,

$$V_n = 30.0 \text{ ksi} \times dt_w \times 59/h/t_w$$
$$\phi_vV_n = 27.0 \text{ ksi} \times dt_w \times 59/h/t_w \quad (2\text{-}22)$$

For $h/t_w > 74$,

$$V_n = 132000/(h/t_w)^2 \times dt_w \text{ ksi}$$
$$\phi_vV_n = 118000/(h/t_w)^2 \times dt_w \text{ ksi} \quad (2\text{-}23)$$

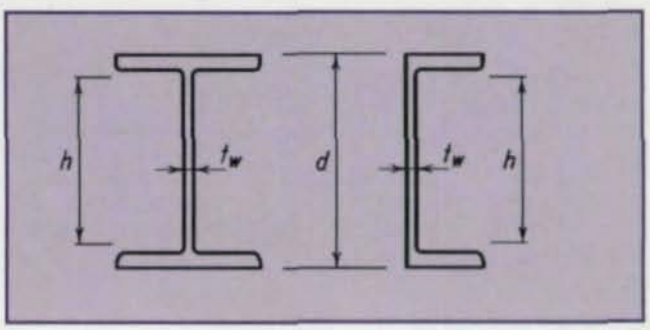


Figure F-3: Definitions of d, h, and t_w for W and channel shapes

Example F-3

Given: Check the adequacy of a W30x99 beam of 50 ksi steel to carry a load resulting in maximum shears of 100 kips due to dead load and 150 kips due to live load.

Solution:

Required shear strength $= V_u$
$= 1.2D + 1.6L$
$= 1.2 \times 100$ kips $+ 1.6 \times 150$ kips
$= 360$ kips

Design shear strength $= \phi_v V_n$
$= 27.0$ ksi $\times\ dt_w$
$= 27.0$ ksi $\times$ 29.65in. $\times$ 0.520 in.
$= 416$ kips > 360 kips req.
o.k.

Shear strength is governed by the following limit states: Equation 2-21 by yielding of the web; Equation 2-22, by inelastic buckling of the web; and Equation 2-23 by elastic buckling.

Web Openings

See Section F4 of the LRFD Specification and Commentary, and the references given in the Commentary.

Part Three of "Essentials of LRFD" will appear in the August issue of* Modern Steel Construction *and will discuss Members Under Combined Forces & Torsion and Composite Members.

For the past few years, *Modern Steel Construction* has conducted surveys on software for structural engineers. We've conducted open surveys of the entire MSC readership; we've surveyed a randomly chosen sample of MSC readers; and we've surveyed selected users chosen by the software vendors. This time, we've gone directly to the source and surveyed the software developers themselves.

While the survey results consume five pages, they are still not a substitution for actually seeing the program. If you're looking for a program with specific features, check the charts that follow and identify which programs offer these features. Then call the company and request a demo disk. Almost every software vendor offers one, and those that don't usually offer a 30-day money back guarantee.

The programs included in the survey, and the vendors that offer these programs, are:

ABD—Automated Bridge Design
Guy Cantrwell
10195 E. 86th St.
Indianapolis, IN 46256
800/62-BRIDGE
Fax: 800/622-7434

CIRCLE # 108

ADINA
SC Solutions, Inc.
1451 Grant Road
Mountain View, CA
94040
415/903-5050
Fax: 415/691-9452

CIRCLE # 109

AISC for AutoCAD
AISC Software
One East Wacker Dr.,
Suite 3100
Chicago, IL 60601-2001
312/670-5411
Fax: 312/670-5403

CIRCLE # 1

Analysis*Group*
Integrated Engineering Software
8840 Chapman Road
Bozeman, MT 59715
406/586-8988
Fax: 406/586-9151

CIRCLE # 87

AutoSTAAD
Research Engineers Inc.
22700 Savi Ranch Pkwy.
Yorba Linda, CA 92687
714/974-2500
Fax: 714/974-4771

CIRCLE # 34

CONXPRT
AISC Software
One East Wacker Dr.,
Suite 3100
Chicago, IL 60601-2001
312/670-5411
Fax: 312/670-5403

CIRCLE # 1

DAST
Das Consulting Inc.
865 Turnpike St.
North Andover, MA
01845
508/794-1487
Fax: 508/685-7230

CIRCLE # 82

DESCUS I-jr.; II-jr.
Opti-Mate, Inc.
P.O. Box 9097, Dept. A
Bethlehem, PA 18018
610/867-4077
Fax: 610/865-1030

CIRCLE # 53

SES Steel Design Package
Ecom Associates, Inc.
8324 N. Steven Road
Milwaukee, WI 53223
414/365-2100
Fax: 414/365-2110

CIRCLE # 90

ETABS
Computers & Structures, Inc.
1995 University Ave.
Berkeley, CA 94704
510/845-2177
Fax: 510/845-4096

CIRCLE # 31

FLOORVIB
Structural Engineers Inc.
537 Wisteria Dr.
Radford, VA 24141
703/231-6064
Fax: 703/639-0713

CIRCLE # 78

GTStrudl
Computer Aided Structural Engineering Center
Atlanta, GA 30332-0355
404/894-2260
Fax: 404/894-8014

CIRCLE # 71

IMAGES-3D
Celestial Software
2150 Shattuck Ave.
Ste. 1200
Berkeley, CA 94704
510/843-0977
Fax: 510/848-9849

CIRCLE # 91

LARSA
LARSA, Inc.
330 West 42nd St.
New York, NY 10036
800/LARSA-85

CIRCLE # 88

MDX
MDX Software
1412 Ridgemont Court
Columbia, MO 65203
314/446-3221
Fax: 314/446-3278

CIRCLE # 47

Merlin DASH
Opti-Mate, Inc.
P.O. Box 9097, Dept. A
Bethlehem, PA 18018
610/867-4077
Fax: 610/865-1030

CIRCLE # 53

Multiframe
Graphic Magic
180 Seventh Ave., Ste. 201
Santa Cruz, CA 95062
408/464-1949
Fax: 408/464-0731

CIRCLE # 92

Structural Engineering Software

PC SIMON
AISC Software
One East Wacker Dr.,
Suite 3100
Chicago, IL 60601-2001
312/670-5411
Fax: 312/670-5403

CIRCLE # 5

Quick-CONNECT
JJK & Associates
4009 Parsifal NE
Albuquerque, NM 87111
505/275-8299
Fax: 505/296-5257

CIRCLE # 95

RISA 2D
RISA Technologies
26212 Dimension Dr.
Suite 200
Lake Forest, CA 92630
800/332-7472
Fax: 714/951-5848

CIRCLE # 40

RISA 3D
RISA Technologies
26212 Dimension Dr.
Suite 200
Lake Forest, CA 92630
800/332-7472
Fax: 714/951-5848

CIRCLE # 40

Robot V6
Metro*soft* Structures, Inc.
332 Paterson Ave.
E. Rutherford, NJ 07073
201/438-4915
Fax: 201/438-7058

CIRCLE # 51

SABRE
Opti-Mate, Inc.
P.O. Box 9097, Dept. A
Bethlehem, PA 18018
610/867-4077
Fax: 610/865-1030

CIRCLE # 53

SAP 90
Computers & Structures, Inc.
1995 University Ave.
Berkeley, CA 94704
510/845-2177
Fax: 510/845-4096

CIRCLE # 31

SC-Bridge
SC Solutions, Inc.
1451 Grant Road
Mountain View, CA 94040
415/903-5050
Fax: 415/691-9452

CIRCLE # 109

SC-Push 3D
SC Solutions, Inc.
1451 Grant Road
Mountain View, CA 94040
415/903-5050
Fax: 415/691-9452

CIRCLE # 109

SDI Floor
Steel Deck Institute
P.O. Box 9506
Canton, OH 44711
216/493-7886
Fax: 216/493-7886

CIRCLE # 77

SODA
Acronym Software Inc.
465 Phillip St., Ste. 1
Waterloo, Ontario N2L 6C7
CANADA
519/885-2454
Fax: 519/746-7931

CIRCLE # 115

STAAD-III
Research Engineers Inc.
22700 Savi Ranch Pkwy.
Yorba Linda, CA 92687
714/974-2500
Fax: 714/974-4771

CIRCLE # 34

STAAD-Mate
Research Engineers Inc.
22700 Savi Ranch Pkwy.
Yorba Linda, CA 92687
714/974-2500
Fax: 714/974-4771

CIRCLE # 34

STAAD3-2D
Research Engineers Inc.
22700 Savi Ranch Pkwy.
Yorba Linda, CA 92687
714/974-2500
Fax: 714/974-4771

CIRCLE # 34

Steel Plus
Barry Bowen Associates
3394 Coleman Road
Memphis, TN 38128
901/373-6468
Fax: 901/373-6468

CIRCLE # 48

STRAP
ATIR Engineering Software
24 Fairfax Road
Needham, MA 02192
617/444-9944
Fax: 617/444-3464

CIRCLE # 28

STRUCAD*3D
Zentech Inc.
8582 Katy Freeway, Ste. 205
Houston, TX 77024
713/984-9171
Fax: 713/984-9175

CIRCLE # 96

Structural Engineering Library
ENERCALC Engineering Software
P.O. Box 188
Corona del Mar, CA 92625
800/424-2252
Fax: 714/644-4117

CIRCLE # 94

TRAP-jr.
Opti-Mate, Inc.
P.O. Box 9097, Dept. A
Bethlehem, PA 18018
610/867-4077
Fax: 610/865-1030

CIRCLE # 53

VisualAnalysis
Integrated Engineering Software
8840 Chapman Road
Bozeman, MT 59715
406/586-8988
Fax: 406/586-9151

CIRCLE # 87

WInSTRUDL
C.A.S.T.
P.O. Box 14676
Freemont, CA 94539-4676
510/226-8857
Fax: 510/226-7328

CIRCLE # 27

Structural Engineering Software

	Analysis Methods										Design Tools					Elements Library					
	lateral analysis	gravity analysis	non-linear analysis	second order analysis	direct P-Delta	B1, B2 approximation	linear analysis	dynamic analysis	2-dimensional analysis	3-dimensional analysis	member selection	member optimization	connection design	bolted	welded	plate & membrane	shell	beams	tapered beames	tension-only member	cable member
ABD	x	x					x		x	x	x	x	x	x	x			x			
ADINA	x	x	x	x	x		x	x	x	x						x	x	x		x	x
AISC for AutoCAD																		x			
AnalysisGroup	x	x	x				x		x	x						x		x			
AutoSTAAD	x	x	x	x	x		x	x	x	x	x	x	x		x	x	x	x	x	x	x
CONXPRT													x	x	x						
DAST	x	x		x	x		x	x	x	x	x	x				x	x	x	x	x	x
DESCUS		x					x			x	x	x						x			
ECOM	x	x	x	x	x		x	x	x	x	x	x						x	x	x	x
ETABS	x	x	x	x	x	x	x	x	x	x	x					x		x	x		
FloorVIB																					
GTStrudl	x	x	x	x	x		x	x	x	x	x	x	x		x	x	x	x	x	x	x
Images-3D	x	x	x	x	x		x	x	x	x						x	x	x		x	
LARSA	x	x	x	x			x	x	x	x	x	x				x	x	x		x	x
MDX Software		x					x		x		x	x	x	x	x			x	x		
Merlin DASH		x					x		x		x	x						x	x		
Multiframe								x	x	x	x	x						x	x		
PC SIMON									x		x										
Quick-CONNECT							x						x	x	x						
RISA-2D	x	x		x	x	x	x	x	x		x	x				x		x	x	x	
RISA-3D	x	x		x	x	x	x	x	x	x	x	x				x	x	x	x	x	
ROBOT V6	x	x	x	x	x		x	x	x	x	x	x				x	x	x	x	x	x
SABRE	x	x					x		x		x	x						x	x		
SAP90	x	x		x	x	x	x	x	x	x	x					x	x	x	x		
SC-Bridge	x	x	x	x	x		x	x		x	x	x	x	x	x	x	x	x	x	x	x
SC-Push 3D	x	x	x	x	x		x	x	x	x								x		x	
SDI Floor											x	x									
SODA	x	x		x	x		x		x	x	x	x						x			
STAAD-III	x	x	x	x	x		x	x	x	x	x	x	x		x	x	x	x	x	x	x
STAAD-MATE	x	x					x		x		x		x	x				x			
STAAD3-2D	x	x	x	x	x		x	x	x		x	x	x		x			x	x	x	x
Steel Plus																					
STRAP	x	x	x	x	x	x	x	x	x	x	x	x				x	x	x	x	x	x
STRUCAD*3D	x	x		x	x		x	x	x	x						x		x			
Struct. Eng. Library	x	x		x	x				x		x	x	x	x				x			
TRAP-jr.		x					x		x									x			
VisualAnalysis	x	x					x	x	x	x						x	x	x			
WinSTRUDL	x	x		x	x	x	x	x	x	x	x					x	x	x	x		

Structural Engineering Software

	Input			Load Generation													Materials Library					
	text-based input file	graphic input file	variable grid size	ASCE 7	UBC	BOCA	Southern Building Code	NEHRP	Canadian	AASHTO	moving loads	wind load	calculate tributary loads	user changed load comb.	prestress load	live load reductions	steel	concrete	masonry	timber	user-defined	foreign steel tables
ABD																						
ADINA	x	x	x											x	x		x	x	x	x	x	
AISC for AutoCAD		x															x					
Analysis Group	x		x											x			x	x	x	x	x	
AutoSTAAD	x	x	x	x	x	x	x		x	x	x	x	x	x	x		x	x	x	x	x	x
CONXPRT	x																x					
DAST	x	x	x	x	x					x	x	x	x	x	x		x	x		x	x	x
DESCUS	x		x							x	x		x				x				x	
ECOM	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x	
ETABS	x	x	x	x	x	x		x	x			x	x	x		x	x	x	x		x	x
FloorVIB	x																x	x				
GTStrudl	x	x	x							x	x	x	x	x	x	x	x	x			x	x
Images-3D	x	x	x											x			x				x	
LARSA	x	x	x							x	x			x	x	x	x	x	x	x	x	x
MDX Software	x									x	x			x			x	x			x	
Merlin DASH	x		x							x	x						x	x			x	
Multiframe	x	x										x		x		x	x			x	x	x
PC SIMON	x									x	x						x					
Quick-CONNECT	x				x												x			x		
RISA-2D	x	x	x	x	x	x	x			x	x	x	x	x		x	x	x	x	x	x	
RISA-3D	x	x	x	x	x	x	x			x	x	x	x	x		x	x	x	x	x	x	
ROBOT V6	x	x	x	x	x						x	x	x	x			x	x	x	x	x	x
SABRE	x		x							x		x					x				x	
SAP90	x	x	x							x	x			x	x	x	x	x			x	x
SC-Bridge	x	x	x	x					x		x	x	x	x	x	x	x	x			x	x
SC-Push 3D	x		x																		x	
SDI Floor	x			x	x	x	x						x	x		x	x	x				
SODA	x																x				x	
STAAD-III	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x		x	x	x
STAAD-MATE	x	x	x														x	x			x	x
STAAD3-2D	x	x	x		x					x	x	x	x	x	x							
Steel Plus	x	x															x					
STRAP	x	x	x								x		x	x	x		x	x			x	x
STRUCAD*3D	x	x	x	x	x		x					x	x	x			x	x			x	
Stuct. Eng. Library	x			x	x							x	x	x		x	x	x	x			
TRAP-jr.	x		x							x	x				x		x				x	
VisualAnalysis	x	x	x		x									x			x	x	x	x	x	
WinSTRUDL	x	x	x		x						x	x	x	x			x					

01146

MODERN STEEL CONSTRUCTION
Reader Service Card

Please type or print only

name

company name

address

city | state | zip code

( ) business telephone | ( ) fax number

For free information on advertisers and other companies mentioned in this issue, circle the appropriate number below:

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72
73	74	75	76	77	78	79	80	81	82	83	84
85	86	87	88	89	90	91	92	93	94	95	96
97	98	99	100	101	102	103	104	105	106	107	108
109	110	111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130	131	132

☐ Check this box to renew or start a **FREE*** subscription to *Modern Steel Construction* *This offer good only for practicing professionals within the U.S.

signature

1. Type of work
Please circle **all** that apply
a. Bridges
b. Office Buildings
c. Hospitals
d. Retail
e. Industrial
f. Schools
g. Multifamily
h. Institutional
i. Low-Rise
j. High-Rise

2. Your position
Please circle **ONLY** one
a. Owner/President
b. Chief Engineer/ Chief Architect/ Department Head
c. Staff Engineer/ Staff Architect/ Construction Manager
d. Other

3. Type of business
Please circle **ONLY** one
a. Structural engineer
b. Civil engineer
c. Structural steel fabricator
d. Other fabricator
e. Educator/libary
f. Architect
g. Building owner/developer
h. Steel mill
i. Erector
j. Steel product manufacturer
k. GC/CM
l. Student
m. Other

4. Reason for Inquiry
Please circle **ONLY** one
a. Information file
b. Immediate or Future Purchase

JULY

Use these cards to request information from manufacturers and other companies mentioned in this issue. Simply circle the numbers referenced in the advertisement or article, fill out the rest of the information requested on the card, and either mail it to: Modern Steel Construction, Creative Data Center, 650 South Clark St., Chicago, IL 60605-9960 or fax it to: **312/922-3165.**

Please type or print only

name

company name

address

city | state | zip code

( ) business telephone | ( ) fax number

For free information on advertisers and other companies mentioned in this issue, circle the appropriate number below:

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72
73	74	75	76	77	78	79	80	81	82	83	84
85	86	87	88	89	90	91	92	93	94	95	96
97	98	99	100	101	102	103	104	105	106	107	108
109	110	111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130	131	132

☐ Check this box to renew or start a **FREE*** subscription to *Modern Steel Construction* *This offer good only for practicing professionals within the U.S.

signature

1. Type of work
Please circle **all** that apply
a. Bridges
b. Office Buildings
c. Hospitals
d. Retail
e. Industrial
f. Schools
g. Multifamily
h. Institutional
i. Low-Rise
j. High-Rise

2. Your position
Please circle **ONLY** one
a. Owner/President
b. Chief Engineer/ Chief Architect/ Department Head
c. Staff Engineer/ Staff Architect/ Construction Manager
d. Other

3. Type of business
Please circle **ONLY** one
a. Structural engineer
b. Civil engineer
c. Structural steel fabricator
d. Other fabricator
e. Educator/libary
f. Architect
g. Building owner/developer
h. Steel mill
i. Erector
j. Steel product manufacturer
k. GC/CM
l. Student
m. Other

4. Reason for Inquiry
Please circle **ONLY** one
a. Information file
b. Immediate or Future Purchase

JULY

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS MAIL PERMIT NO. 12522 CHICAGO, IL

POSTAGE WILL BE PAID BY ADDRESSEE

MODERN STEEL CONSTRUCTION

c/o CREATIVE DATA SERVICES
650 S CLARK ST
CHICAGO, IL 60605-9960

Use these cards to request information from manufacturers and other companies mentioned in this issue. Simply circle the numbers referenced in the advertisement or article, fill out the rest of the information requested on the card, and either mail it to: Modern Steel Construction, Creative Data Center, 650 South Clark St., Chicago, IL 60605-9960 or fax it to: **312/922-3165.**

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS MAIL PERMIT NO. 12522 CHICAGO, IL

POSTAGE WILL BE PAID BY ADDRESSEE

MODERN STEEL CONSTRUCTION

c/o CREATIVE DATA SERVICES
650 S CLARK ST
CHICAGO, IL 60605-9960

MODERN STEEL CONSTRUCTION
Reader Service Card

Structural Engineering Software

	Units		Codes & Specifications												Output/Plots						
	metric	U.S. Customary	LRFD—2nd Edition	ASD—9th Edition	CISC	ACI	AITC	NCMA	NFPA	BOCA	Southern Bldg. Code	AASHTO	UBC	NEHRP	2D plots	3D plots	shear	moment	deflection	lateral deflection	stress contours
ABD	x	x										x					x	x	x		
ADINA	x	x													x	x			x	x	x
AISC for AutoCAD	x	x																			
Analysis Group	x	x																			
AutoSTAAD	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x	x	x
CONXPRT		x	x	x											x						
DAST	x	x	x	x	x	x						x	x		x	x	x	x	x	x	x
DESCUS	x	x										x			x						
ECOM	x	x	1st	x		x	x		x	x	x	x	x		x	x	x	x	x	x	
ETABS	x	x	x	x	x	x							x		x	x	x	x	x	x	
FloorVIB		x		x											x						
GTStrudl	x	x	x	x		x									x	x	x	x	x	x	x
Images-3D	x	x		x											x	x	x	x	x		x
LARSA	x	x	x	x	x	x						x			x	x	x	x	x	x	x
MDX Software	x	x										x			x				x		x
Merlin DASH	x	x										x			x		x	x	x		
Multiframe	x	x		x											x	x	x	x	x	x	
PC SIMON		x										x									
Quick-CONNECT		x		x			x								x						
RISA-2D	x	x	x	x	x		x								x		x	x	x	x	x
RISA-3D	x	x	x	x	x		x								x	x	x	x	x	x	x
ROBOT V6	x	x	1st	x		x							x		x	x	x	x	x	x	x
SABRE		x										x			x						
SAP90	x	x	x	x		x						x	x		x	x	x	x	x	x	x
SC-Bridge	x	x	x	x		x									x	x	x	x	x	x	x
SC-Push 3D	x	x													x	x			x	x	
SDI Floor		x	x																		
SODA	x	x	x	x	x										x	x	x	x	x	x	
STAAD-III	x	x	x	x	x	x	x			x	x	x	x		x	x	x	x	x	x	x
STAAD-MATE	6/95	x		x		x									x		x	x	x	x	
STAAD3-2D																					
Steel Plus	x	x		x	x										x	x					
STRAP	x	x	x	x		x									x	x	x	x	x	x	x
STRUCAD*3D	x	x	1st	x		x						x	x		x	x	x	x	x	x	
Stuct. Eng. Library	x	x		x	x	x		x					x		x		x	x	x	x	x
TRAP-jr.	x	x										x			x						
VisualAnalysis	x	x	x			x							x		x	x	x	x	x	x	x
WinSTRUDL	x	x	x	x		x							x		x	x	x	x	x	x	

Structural Engineering Software

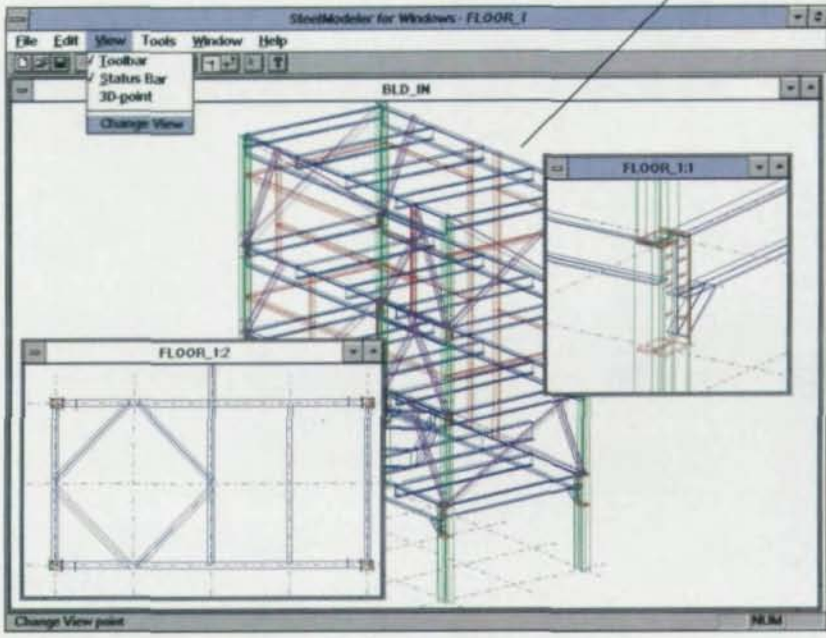
	Output/Printout																							
	span length	section	section properties	moment (Cb)	user changed factors	effec. length factors (K)	user changed factors	reactions	member end forces	element princ. stresses	element shear stresses	element int. stresses	interaction equations	flexure & tension	flexure & compression	tors., flex., shear, axial force	camber requirements	floor vibration checks	uniform distribution	optimum distribution	shear stud req. (for comp.)	column & beam takeoffs	individual levels	entire structure
ABD	x	x	x			x		x	x	x	x	x	x	x	x		x				x	x	x	x
ADINA			x					x	x	x	x	x	x	x	x	x								
AISC for AutoCAD			x																					
Analysis Group	x	x	x					x	x	x	x	x												
AutoSTAAD	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
CONXPRT																								
DAST	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
DESCUS	x	x	x					x	x		x		x			x	x				x	x		x
ECOM	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					x	x	x	
ETABS	x	x	x	x	x	x	x	x	x		x		x	x										
FloorVIB	x	x	x															x	x					
GTStrudl	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x	x	x
Images-3D	x	x	x					x	x	x	x	x	x	x										
LARSA	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					x	x	x
MDX Software	x	x	x					x	x	x	x		x			x	x				x			
Merlin DASH	x	x	x	x				x	x		x						x				x	x		x
Multiframe	x	x	x	x	x	x	x	x	x		x		x	x	x	x						x		x
PC SIMON	x	x	x					x		x			x		x		x				x			
Quick-CONNECT		x						x																
RISA-2D	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							x	x	x
RISA-3D	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						x	x	x
ROBOT V6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x					x	x	x
SABRE	x	x	x					x	x		x		x	x	x							x		x
SAP90	x	x	x	x	x	x	x	x	x	x	x		x	x	x									
SC-Bridge	x	x	x	x		x		x	x	x	x	x	x	x	x	x						x		
SC-Push 3D		x	x						x															
SDI Floor	x	x	x					x										x						
SODA	x	x	x	x	x	x	x	x	x				x	x	x	x						x		x
STAAD-III	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
STAAD-MATE	x	x	x	x	x	x	x	6/95	x				x	x	x	x								
STAAD3-2D	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
Steel Plus		x	x																					
STRAP	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						x		x
STRUCAD*3D	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x						x	x	x
Stuct. Eng. Library	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x			
TRAP-jr.	x	x	x			x	x			x							x					x		x
VisualAnalysis	x	x	x					x	x		x	x												
WinSTRUDL	x	x	x	x	x	x	x	x	x		x		x	x	x	x						x	x	x

Structural Engineering Software

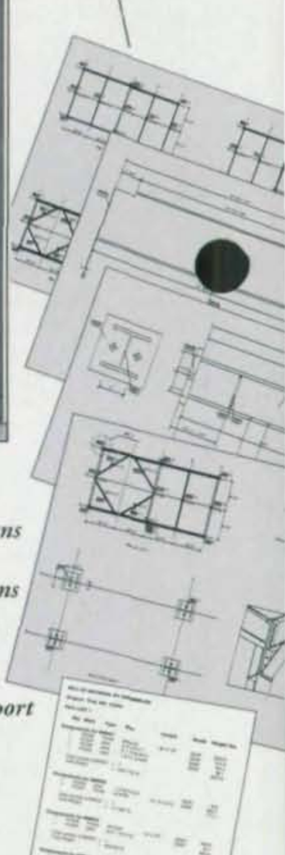
	System				Links		Miscellaneous						Program Data				
	Windows	DOS	Macintosh	workstation based	to CAD program(s)	to other program(s)	built-in editor	on-line manual	on-line tutorial	on-line report generation	on-line query	built-in stand. struc. lib.	date of prog. intro.	date of last upgrade	frequency of upgrades	program cost	demo. disk avail.
ABD		x											1989	n.a.	n.a.	lease	
ADINA		x		x	x	x	x	x		x	x	x	1980	3/95	6 mo.	$7000	x
AISC for AutoCAD		x			x								1990	12/92	--	$120	
Analysis Group	x	x					x	x	x	x	x		1994	4/95	yrly.	$295	x
AutoSTAAD	x	x		x	x	x	x	x	x	x	x	x	1991	6/95	6 mo.	$595	x
CONXPRT		x				x	x			x	x	x	1990	7/93	24 mo	$110-1230	x
DAST	x	x			x	x	x	x	x	x	x	x	1986	2/95	6 mo.	$300-3600	x
DESCUS		x					x	x	x	x	x	x	1978	95	6 mo.	n.a.	x
ECOM	x	x		x	x	x	x			x		x	n.a.	4/95	varies	$150-5999	x
ETABS	x	x			x		x	x		x			1975	94	12-18.	$3000	x
FloorVIB		x					x		x		x		1994	n.a.	--	$250	
GTStrudl		x		x	x	x	x			x	x	x	1978	3/95	6 mo.	$3900-5000	x
Images-3D		x			x	x	x	x			x	x	1984	1994	yrly.	$795-1395	x
LARSA	x	x	x		x	x	x	x		x	x	x	1987	5/95	6 mo.	$1500-8250	x
MDX Software		x											1985	4/95	4 mo.	$2000-7500	x
Merlin DASH	x	x					x	x	x	x	x	x	1978	95	6 mo.	n.a.	x
Multiframe			x		x	x	x			x	x	x	1987	2/95	6 mo.	$695-1995	x
PC SIMON		x											1978	94	--	$300/yr.	
Quick-CONNECT		x			x							x	1994	12/94	yrly.	$495	x
RISA-2D		x			x	x	x		x	x	x	x	1987	6/95	yrly.	$495	x
RISA-3D		x			x	x	x		x	x	x	x	1993	4/95	6 mo.	$1295	x
ROBOT V6		x			x	x	x	x		x		x	1985	2/95	8 mo.	$495-8070	$25
SABRE		x					x	x	x	x	x	x	1978	95	yrly.	n.a.	x
SAP90	x	x			x		x	x					1970	1994	12-18	$2000	x
SC-Bridge		x			x	x							1994	4/95	6 mo.	$2500	x
SC-Push 3D		x		x		x							1994	3/95	6 mo.	$2500	x
SDI Floor		x					x			x	x		1992	n.a.	n.a.	$295	x
SODA	x						x	x		x			n.a.	4/95	yrly.	$495	x
STAAD-III	x	x		x	x	x	x	x	x	x	x	x	1978	3/95	4 mo.	$900-3700	x
STAAD-MATE		x			x							x	1993	6/95	6 mo.	$495	x
STAAD3-2D	x	x		x	x	x	x	x	x	x	x	x	1991	6/95	6 mo.	$595	x
Steel Plus	x	x			x			x			x	x	1988	1/95	6 mo.	$129	
STRAP	x	x			x	x		x			x	x	1982	9/94	yrly.	$300-3500	x
STRUCAD*3D		x		x	x	x	x	x		x	x		1986	94	yrly.	$249-4500	x
Stuct. Eng. Library		x					x	x		x	x	x	1983	94	9-16	$1295	x
TRAP-jr.		x					x	x	x	x	x	x	1978	95	yrly.	n.a.	x
VisualAnalysis	x				x	x	x	x	x	x	x	x	1994	6/95	yrly.	$395	x
WinSTRUDL	x	x		x	x		x	x	x	x	x	x	1984	2/95	6 mo.	$400-3000	x

You do the thinking . . . SteelModeler does the rest.

You create a single model.



SteelModeler automatically generates the views, shop drawings and material lists you require.



At last! A truly interactive modeling system designed for structural steel detailers.

SteelModeler is efficient, accurate, and highly productive.

SteelModeler lets you concentrate on producing a single 3D model, while it takes care of everything else.

You define your structure by selecting steel shapes from a comprehensive built–in data base and make connections using your own custom library of macros. And as you work, **SteelModeler ensures that all components fit.**

There's no need to juggle drawings of plans, sections or components. SteelModeler automatically generates any view you want on the multi–window screen, and whenever you're ready, drawings, shop details and materials lists for the whole model or any section or part you require – all in a form customized by you to your specific standards.

Revisions or modifications? Simple. You change the model, and SteelModeler automatically revises all related drawings and lists to ensure total accuracy.

- *Shop drawings*
- *Anchor bolt setting plans*
- *Erection diagrams*
- *Floor/roof framing plans*
- *Connection details*
- *Perspectives*
- *Bills of materials*
- *Neutral file import/export*

SteelModeler

The tool you would have designed for yourself.

SteelModeler runs on standard PCs and Unix workstations. Versions available: MS-DOS; OS/2; Autocad; Windows 95 (summer)
For more information, contact: dcCAD; Tel: (416) 253-4848; Fax: (416) 253-4315; Toll-free: 1-800-776-4840

Please circle # 107

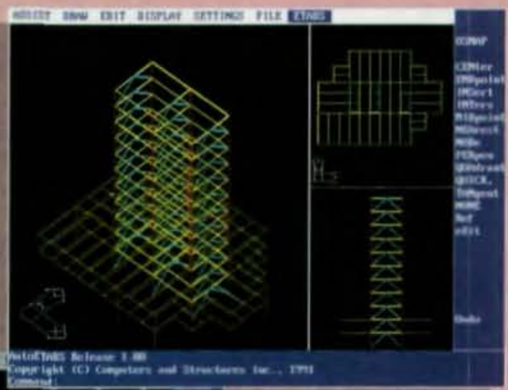
Advertisers' Index

STATE OF THE ART

INTEGRATED ANALYSIS ▪ DESIGN ▪ DRAFTING

Computer Software for Structural Engineering

This series of computer programs provides a quantum leap forward in the integration of structural analysis, design and drafting activities related to building design. Based upon a scheme that combines the engineering versatility of the ETABS building design system with the powerful drafting capabilities of AutoCAD, this software will significantly enhance the productivity of the structural design office. The programs run within AutoCAD and use customized commands that require no previous experience with AutoCad.



Structural Modeling

Floor Framing

Frame Elevations

COMPUTERS & STRUCTURES INC.

CELEBRATING 16 YEARS OF INNOVATION • ETABS 1975-1991

AutoETABS® - Structural Modeler for ETABS

This model generator is primarily for drawing and editing an ETABS model using AutoCAD. Additionally, this model information is directly available from the database for creating framing plans and elevations with AutoCAD. This scheme allows the draftsperson and the engineer to share common design information without duplication. Many data preparation steps associated with the ETABS model generation are also automated.

AutoFLOOR™ - Structural Steel Floor Modeler for ETABS

This program allows the automated analysis, design, optimization and drafting of structural steel floor framing systems of arbitrary configurations and loading. The program operates upon the entire floor framing system, distributing gravity loads to the various beams and girders as determined by the direction of the decking. The tributary areas and associated live load reductions are automatically computed. Composite and non-composite design options are available for ASD and LRFD specifications. Beam camber and vibrational characteristics are evaluated. Material quantity takeoff tables are also produced.

AutoFLOOR is closely interfaced with AutoETABS. The modules share information tha automates the tedious task of transferring tributary floor vertical loads to the columns an girders of the ETABS model.

For more information:

Computers & Structures, Inc.
1995 University Avenue
Berkeley, California 94704

TEL: (510) 845-2177
FAX: (510) 845-4096