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January 1994

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Engineering Software Survey

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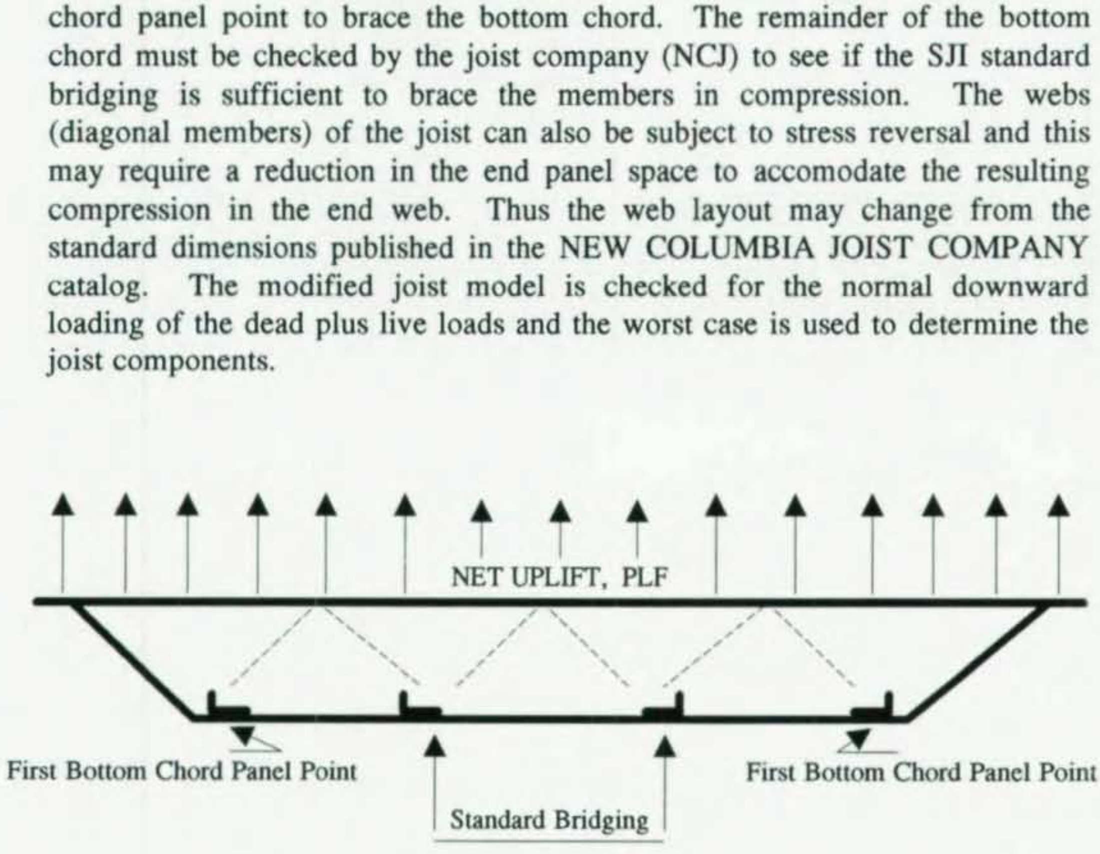
No. 2

HOW TO DESIGN FOR WIND UPLIFT

Wind uplift forces must be determined by the design professional and shown on the contract drawings as NET UPLIFT. (The net uplift force on the roof joist is the gross uplift minus the dead load including the joist weight.) This temporary reversal of loading creates compression forces in the bottom chord which, as a result, may require lateral bracing. The Steel Joist Institute (SJI) recognizes this by specifying a single line of bridging near the first bottom chord panel point to brace the bottom chord. The remainder of the bottom chord must be checked by the joist company (NCJ) to see if the SJI standard bridging is sufficient to brace the members in compression. The webs (diagonal members) of the joist can also be subject to stress reversal and this may require a reduction in the end panel space to accomodate the resulting compression in the end web. Thus the web layout may change from the standard dimensions published in the NEW COLUMBIA JOIST COMPANY catalog. The modified joist model is checked for the normal downward loading of the dead plus live loads and the worst case is used to determine the joist components.



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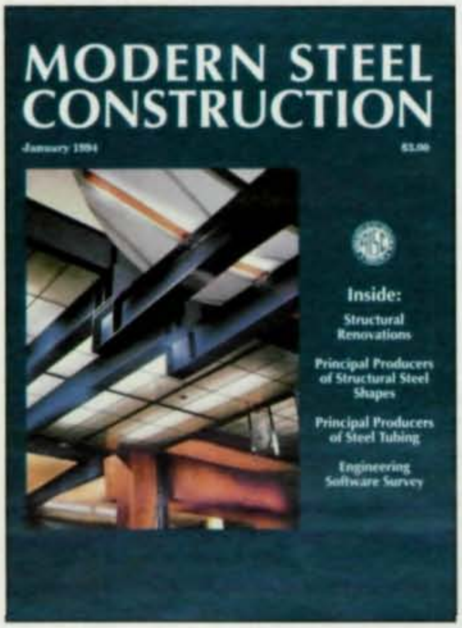
MODERN STEEL CONSTRUCTION

Volume 34, Number 1 January 1994



The designers of the headquarters for the Portland Chapter of the AIA chose a steel vocabularly both for its structural attributes and its appearance. The story behind this project begins on page 34.

FEATURES

DEPARTMENTS

Modern Steel Construction (Volume 34, Number 1). 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: Pattis/3M, O'Hare Lake Office Plaza, 2400 E. Devon Ave., Des Plaines, IL 60618 (708) 699-6030.

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.

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

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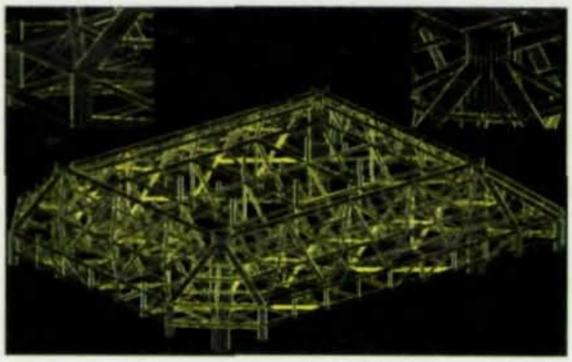
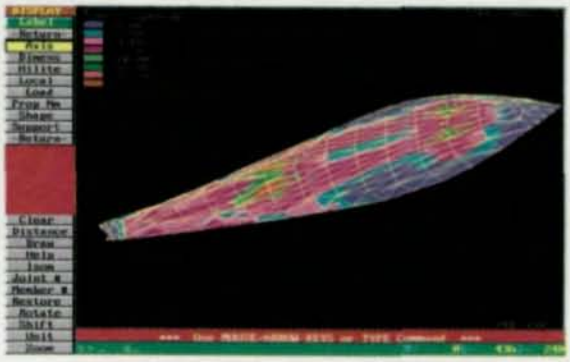
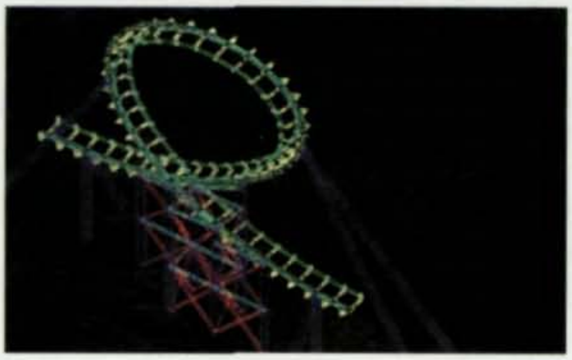


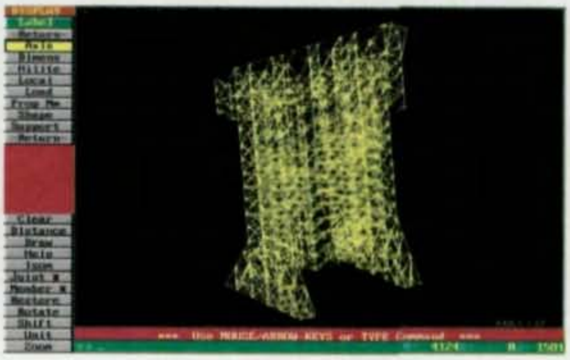
Offshore structure. Courtesy AKER Engineering, Norway



Concrete Canoe, Courtesy Drexel University, Pennsylvania



Roller Coaster. Courtesy Arrow Dynamics, Utah



NASA Launch Pad. Courtesy Brown & Root, Texas

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Balancing Cost And Need

Whenever I'm anywhere near a computer store, I tend to stop in and take a look at what's new. Recently, I've been window-shopping for a CD-ROM player, and yesterday I came very close to buying one. It was an NEC external player for only $199—including the SCSI connections and cables needed to run it on my computer.

There was, of course, a catch. It had an extremely slow access time of 800 ms. While that might be sufficient (barely) for my computer at home—which much of the time is really just an expensive toy—it would be inadequate and frustrating for my office demands. In addition, while its low price was attractive, it was missing some crucial features, such as Kodak photo compatibility.

Given both the expense of computer products and their rapid obsolescence due to technological advances, it's important to know your requirements before leaping into the electronic marketplace. This issue was raised repeatedly by respondents to MSC's second Structural Engineering Software Survey (starting on page 40).

A lot of the smaller firms, companies working primarily on such projects as small retail centers or light industrial buildings, pointed out that programs such as STAAD-III or GT Strudl may be overkill. They don't need all of the available features. Manufacturers are addressing this problem in three ways. First, many of the programs are modulized, so you can buy the base program and then upgrade to whatever modules meet your specific needs. Second, some manufacturers are introducing smaller versions of their program—most of the features are intact, but the maximum number of nodes are limited. In most cases, you can later purchase an upgrade to the full version of the program. And finally, there are less expensive programs on the market aimed entirely at the smaller user.

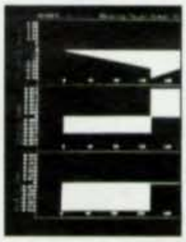
In addition to analyzing your current needs, it's important look ahead. Your office may currently be using the ASD Specification, but when purchasing software it might be desirable to anticipate a future move to LRFD and to purchase software that can handle both. Also, government projects are rapidly moving towards complete metric design, and the public sector probably isn't far behind. Other important features unique to structural engineering software are CAD compatibility and compatibility with fabrication and detailing software.

As with any computer software purchase, you should consider the clarity of documentation and the quality of user support offered by the manufacturer. Another useful inquiry concerns the cost of purchasing future upgrades. As every computer user knows, once you start using a program you're bound to want to purchase upgrades—sometimes as often as every 18 months. And upgrades don't come cheap.

Finally, look long and hard at system compatibility. Don't just be satisfied that the program is designed to run on any IBM-compatible computer. Last year I purchased a Windows-based tax program, only to discover that Windows 3.0 wasn't sufficient and that I needed to upgrade to Windows 3.1. While that was a fairly minor problem, horror stories abound, especially about graphics incompatibility.

Fortunately, many manufacturers offer trial versions of their programs at a nominal cost. Often, these are full-featured, but limited (either in the number of nodes or total number of designs allowed). If you're one of the 70% of MSC readers who are considering buying new software this year, I recommend you get hold of several of these trial versions and do a direct comparison. Purchasing the wrong software can be an expensive mistake—both in direct dollars and in lost productivity. **SM**

How to get from here



Engineering, Analysis and Design Module

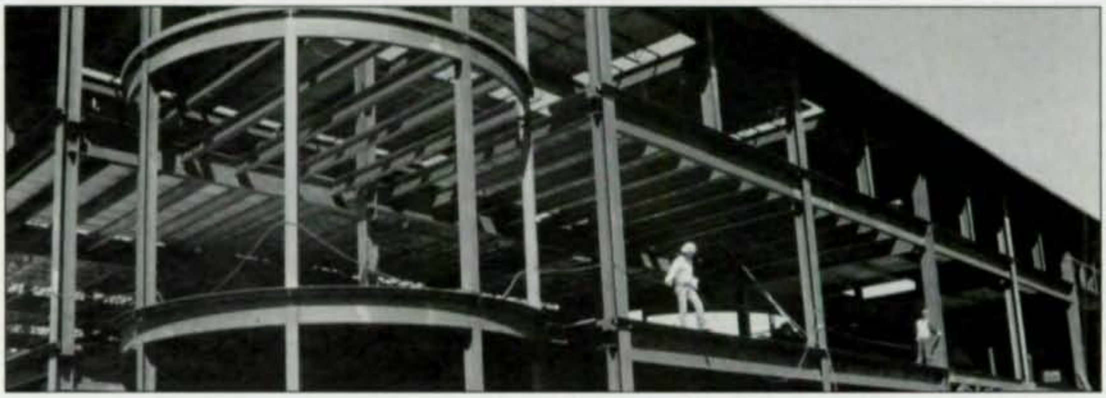
Estimating Module

Detailing Module

Production Control Module

CNC Interface Module

to here.



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Steel Interchange

Steel Interchange is an open forum for *Modern Steel Construction* readers to exchange useful and practical professional ideas and information on all phases of steel building and bridge construction. Opinions and suggestions are welcome on any subject covered in this magazine. If you have a question or problem that your fellow readers might help 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 expertiseof 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 312/670-2400 ext. 433.

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

How can one take into account blast effects in the design of steel structures?

I read with great interest the response by Richard P. Linck, P.E. in the October 1993 Steel Interchange. It was an excellently written response and it brought to the attention of many of those who have not concerned themselves with this serious problem.

As the article pointed out, there are many many factors and parameters that influence the response of structures to blast loadings. I have over 30 years of experience in the design of structures to resist blast loadings, and I have written the article, Dynamic Structural Analysis with Short Time History, in June 1965, for the Journal of the Structural Division of ASCE. This was one of the main articles that revealed how structures responded to blast loadings.

I would like to point out a few things that Mr. Linck did not go into detail in his response:

1. A structural member does not have to absorb energy in order to resist a blast loading. It may absorb energy if one wishes, which will depend upon the conditions of how one wishes to design the structure. If one wishes the structure to absorb energy, then there must be some kind of failure that occurs, which may also be minor. If one does not wish any failure to occur, then the response of the structure is very similar to the response of a static load. The structure will deflect under loading and then return to its original position after loading. There is no absorption of energy under such conditions.

2. There is a great deal of discussion about the Pressure Wave that strikes a structure as a result of an explosion. There is another wave that is generated by the same explosion at the same time, which is called the Dynamic Wave, and which can be of almost equal significance in the response of structures. These two waves have different time histories and are superimposed on one another when striking the structure. In order to obtain a correct response of the structure, both of these waves should be taken into consideration.

3. The shape of the time- history curves for all explosions is strikingly very similar. About the only differences is in the initial peak overpressure and the duration of time for the blast wave to run its course. This is a very fortunate phenomenon for the understanding of blast waves and for the design of structures to resist such waves.

The design of structures to resist the effects of explosions is a condition that should be seriously considered for many structures. To date, the concept has not had a very high priority. It is also extremely important to obtain help from those who have enough experience in this field, so as to feel confident that when one has designed a structure to resist blast loadings, it will do just that.

George L. Henderson
San Mateo, CA

The letter on blast effects from Richard P. Linck, P.E., in the October 1993 Steel Interchange is well written and provides a tremendous amount of information on the subject. However, I would go one step further and caution structural engineers who are otherwise unfamiliar with blast effects against attempting to evaluate these effects simply by reading literature on the subject.

There are several firms who specialize in characterizing and quantifying the effects of accidental explosions. These firms are typically familiar with the many volumes on the subject and have extensive background in observing actual explosion damage. Our firm has worked with some firms and find that our knowledge of local structural engineering practices and project requirements and their knowledge of "blast engineering" produced very satisfactory results.

James R. Miller
J.R. Miller & Associates, Inc.
Brea, CA

(The next question and answer is in response to the reply by Mr. Khasat that was published in the Steel Interchange column in the October 1993 issue.)

Under what circumstances does the designer have to consider torsion in the design of a beam?

Steel Structures by Salmon and Johnson is a good reference that addresses this subject. They consider the use of the flexural analogy without modifications as presented by Mr. Khasat to be "...a very conservative approach." They follow up with examples on a "modified flexural analogy" that is also very simple to follow and produces solutions that closely approximate differential equation solutions. However, this procedure is applicable to wide flange shapes only.

For crane girders with cap channels, as depicted in Mr. Khasat's example, the AISC Design Guide No. 7, Industrial Buildings, by Fisher and Buettner (AISC publication D801) is an excellent reference.
Gerrett Swearingen
BE & K Engineering
Mobile, AL

When welding to AWS D1.1 requirements what is a "seal" weld and what are the applicable inspection criteria for same?

Seal welds are non- structural welds intended to fill or seal the crevice formed where two surfaces are joined. Structures subjected to heavy corrosion incorporate these welds as a detail when using hot-dipped galvanizing or protective coatings. Without seal welds to bridge the crevice, surface preparation and coating application are difficult.

Crevices which are not sealed adversely affect galvanizing in several ways. Molten zinc will not bond properly to steel when these crevices are contaminated and not cleaned. Even where cleaned, the crevice tends to hold pickling solvents or alkalis from the galvanizing preparation process. A safety problem occurs when the hot zinc contacts with the solvent or other liquid. Lastly, the crevices can trap excessive amounts of zinc raising the material costs for galvanizer and creating a disfigured product.

Similarly, without a seal weld, a crevice can hold contaminates which react with a protective coating or create a stress riser in a protective coating. A crevice can also wick causing an uneven coating application.

The size of this weld is controlled by the welding equipment used and the skill of the welder. Per se, AWS D1.1, the Structural Welding Code, does not apply to non-structural welds. Nevertheless, there are some important things to keep in mind:

Concern—Fatigue critical members. (An otherwise good weld can be fractured by the poor design of a seal weld). Possible Solutions: Consider smaller throat continuous welds in lieu of seal welding between intermittent fillet welds. For protective coating applications, consider caulking instead of seal welds.

Concern—Sloppy workmanship with sharp peaks, slag intrusions, undercutting, etc. Possible Solutions: Repair the welds. For protective coating applications, consider caulking instead of seal welds.
Hugh Lee, P.E., S.E. C.C.S.
City of Los Angeles
Los Angeles, CA

New Questions

Listed below are questions that we would like the readers to answer or discuss.

If you have an answer or suggestion please send it to the Steel Interchange Editor, Modern Steel Construction, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001.

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

I have been unable to locate the historical origination of the Vierendeel truss. I am curious about who was Vierendeel, when the truss structure was first utilized, why was it names, and for what contributions to structural engineering was he/she recognized.
Rick Love
Garver & Garver
Little Rock, AR

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? Are there any special considerations?

The AISC Manual includes dimensioning information for countersunk bolts, are there any special design requirements for these bolts?

Are there any good connection details for a truss made up of all WT sections?

Is is possible to use clamps in structural steel connections? Are there any design requirements?

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Book Review: *Flexural-Torsional Buckling Of Structures*

Reviewed By Nestor R. Iwankiw, P.E.

Structural stability is a theoretically demanding subject with many intriguing aspects and important design ramifications. The type of buckling instability (local, member flexural and/or torsional, and system), elastic or inelastic, and the effects of end restraints, bracing, section geometry, and imperfections all provide a wide range of problems and solutions. Many of these considerations are beyond the scope of elementary texts and most design codes. The classical texts of Timoshenko and Bleich first captured the essentials of the more rigorous development and application of elastic stability principles for structural elements during the first half of this century. Now, a new book by Professor Nicholas Trahair from the University of Sydney gives this general subject an updated and expanded modern treatment that includes numerical methods and the more recent research information.

Flexural-Torsional Buckling of Structures covers the broad spectrum of stability issues related to flexural and/or torsional displacements of beams and columns. As such, Professor Trahair's book is an excellent addition to the technical literature alongside other recent advanced texts written by the new generation of stability experts.

The first four chapters introduce elastic stability theory and approximate manual and computer (finite elements) buckling solutions. Simple and restrained columns, simple and restrained beams, cantilevers, braced and continuous beams, and beam-columns are thoroughly covered in Chapters 5-11. Plane frames, arches, and rings are addressed in Chapters 12 and 13. Chapter 14 on inelastic buckling serves as the final lead-in to the "capstone" Chapter 15 on strength and design of members. Miscellaneous related topics, such as stepped and tapered members, optimization, post-buckling response, and vibrations are summarized in the concluding Chapter 16.

With the text's emphasis on members, local (plate) and overall frame buckling are only marginally covered. Given the nature of this material, there are relatively few complete examples, but several assignment problems are presented at the end of every chapter.

Flexural Torsional Buckling of Structures indeed offers both a top-notch reference for the non-routine member design applications and a teaching aid for upper level university courses. Therefore, it can be a valuable resource to practitioners, academics, and graduate students.

The author, Professor Trahair, is a recognized world-wide authority on stability and structural steel design. Monosymmetric and unsymmetric cross-sections subjected to bending and/or compression has been one of the author's main research interests and is well covered in his book. His experience includes not only a long history of research achievements, but nearly 30 years of work with the Standards Association of Australia that develops the national building code. International sabbaticals in the USA, United Kingdom, and

Canada included extended collaborations with the renowned Professors T.V. Galambos (USA) and David Nethercot (UK) who are credited with inspiring the author's fascination with this subject. Professor Trahair's expertise is particularly reflected in Chapter 15 that compares and contrasts European, Canadian, American, and Australian design criteria.

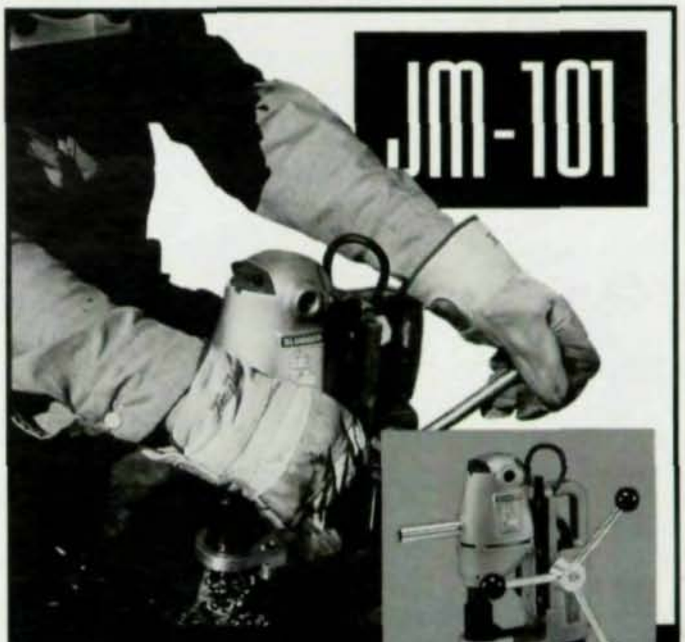
Whether one's objective is to increase their understanding of structural stability or to have access to answers for a wide range of potential special problems, Professor Trahair's new text provides an excellent current source.

Nestor R. Iwankiw, P.E., is AISC Director of Research & Codes.

AISC Info Line

Engineers, fabricators and other construction professionals can quickly and easily obtain information about AISC publications and software through a new Information Fax Line. The automated service provides information on: manuals and supplements (e.g., the Manual of Steel Construction); specifications and codes (e.g., the Code of Standard Practice for Steel Buildings and Bridges); AISC Design Guides; technical and fabricator publications (e.g., Steel Fabrication Safety Manual); conference proceedings (from recent National Steel Construction Conferences) and AISC software (e.g., CONXPRT).

To reach the information line, dial: (800) 644-2400 from any pushbutton phone. A recorded voice will list the types of publications available, and with the press of a few button, the materials will be faxed to you within minutes.



Steel Calendar

An introduction to the new 1993 LRFD Specification will highlight a new four-part seminar series from AISC Marketing, Inc. ***Innovative Practices In Structural Steel*** also will provide information on state-of-the-art structural steel design software, the latest NEHRP Seismic Regulations, and a review of Semi-Rigid Composite Connections.

The new 1993 LRFD Specification is the first major revision to the original 1986 LRFD Specification. The lecture will include a discussion and explanation of the major changes, including such items as the stability of unbraced frames, web crippling equations, slip-critical joints at factored loads, *alternative fillet weld design* strength and Chapter K clarifications.

The session on Software for Structural Steel will demonstrate methods for using the latest steel design software to create the more efficient designs. Also, a practical transition to LRFD will be explored. Integration in designing various elements and connections in steel also will be featured.

National building codes have undergone a major overhaul on their rules for seismic design of buildings as recommended by the Building Seismic Safety Council and federal agencies. This lecture will cover the "why" and the "how to" of these changes, and their impact on steel design.

And finally, the lecture on semi-rigid composite connections will explain the use of this very economical system.

The seven-hour, four-part seminar costs $90 ($75 for AISC members), including dinner. The lecture has a CEU value of 0.4.For more information, call 312/670-2400.

1994 Seminar Dates & Locations

WEST

San Diego 3/17
Irvine 4/21
Sacramento 6/15
San Francisco 6/16
Los Angeles 6/23
Seattle 9/27
Salt Lake City 9/29
Phoenix 10/20
Portland, OR 11/15
Las Vegas 11/17

MIDWEST

Chicago 3/8
St. Louis 3/24
Des Moines 5/5
Milwaukee 5/31
Minneapolis 6/2
Detroit 10/11
Indianapolis 10/13

NORTHEAST

Meriden 2/1
Boston 2/2
Portland, ME 2/3
New York 4/14
Albany 9/13
Rochester 9/14

SOUTHWEST

New Orleans 2/8
Alburquerque 2/10
Denver 2/17
Kansas City 3/10
San Antonio 3/15
Dallas 4/19
Oklahoma City 6/9
Houston 6/21

SOUTH

Greenville 3/1
Charlotte 3/2
Raleigh 3/3
Birmingham 5/3
Atlanta 9/20
Richmond 9/22
Memphis 10/18
Miami 11/1
Orlando 11/3

continued on following page

Steel Calendar

Seminar Locations, Cont.

Mid-Atlantic

Baltimore	4/5
Washington, DC	4/7
Pittsburgh	4/12
Edison, NJ	10/4
Philadelphia	10/6
Cleveland	10/25
Columbus	10/26
Cincinnati	10/27

One of the hottest topics among steel designers—the effect of blasts on steel structures—will be the subject of a plenary session at the 1994 National Steel Construction Conference. Other sessions will cover long span roof structures and bridge construction life cycle costs. The conference will be held on May 18-20 in Pittsburgh.

An expected highlight will be a presentation on the second day of the conference by Lester Robertson, president of Leslie E. Robertson Associates and structural engineer on the project and Jack Daly of Karl Koch Erecting Co., Inc. on the World Trade Center Explosion. The session will take a close look at the design of the structure and the effect of the explosion on the steel superstructure, as well as the required retrofit work.

The superb line-up of technical sessions also should attract a lot of attention from the expected attendance of more than 1,000 engineers, architects, fabricators and educators.

Sixteen technical sessions will be offered, including:

•***Building Innovations***, featuring Tom Sputo, a Florida-based consulting engineer, speaking on innovations in low-rise design;

•***Lean Engineering***, featuring Mark Holland of Paxton & Vierling, plus a design engineer, discussing connection economics;

•***Quality Certification: Directions for the '90s***, featuring Tom Schlafly, AISC Director of Fabricating Operations & Standards, discussing new revisions to the AISC Quality Certification program;

•***Effective Use of High-Strength Steel in Building Construction***, featuring Abraham J. Rokach, AISC Director of Building Design, who will be discussing a new ASTM structural material Specificiation.

•***Experience from Wind Damage & Design Load Requirements***, featuring R.J. Willis of AISI and Lawrence Griffis of Walter P. Moore and Associates;

Continuing Education Units (CEUs) will be offered for attendees of the technical sessions.

Also, a live version of the Steel Interchange section of this magazine will be presented. The session will be limited to questions on connections. Another important session, "Bridge Construction-Myths & Realities of Life Cycle Costs," will be offered by Robert Nickerson, former Chief of the Structures Division of FHWA.

The conference will kick off on May 18 with a presention by Dan Cuoco, Thornton-Tomasetti, on Long Span Roof Structures. During that same session, the 1994 T.R. Higgins award will be presented and the first of a series of six lectures will be given.

In addition to the conference, an Exposition will run concurrently. More than 100 booths are expected and more than a dozen exhibitors are expected to offer technical product sessions.

For more information on the conference, call AISC at (312) 670-5421 or fax a request to AISC at (312) 670-5403.

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Section Weight Per Ft.	Producer Code	Section Weight Per Ft.	Producer Code
W44 x 230-335*	T	W21 x 83, 93	B, I, N, W
W40 x 321*, 372*, 431*, 503*, 593	T	W21 x 62-73	B, C, I, N, W
W40 x 297	N	W21 x 44-57	B, C, I, N, W
W40 x 278*	T	W18 x 258-311	B
W40 x 277	N, T	W18 x 175-234	B, W
W40 x 264*	B, I, T	W18 x 130-158	B, W
W40 x 249	N, T	W18 x 76-119	B, N, W
W40 x 235*	B, I, T	W18 x 65, 71	B, I, N, W
W40 x 215	N, T	W18 x 50-60	B, C, I, N, W
W40 x 211*	B, I, T	W18 x 35-46	B, C, I, N, W
W40 x 199	N, T	W16 x 67-100	B, N, W
W40 x 183	B, I, N, T	W16 x 57	B, I, N, W
W40 x 174*	T	W16 x 36-50	B, C, I, N, W
W40 x 149, 167	B, I, N, T	W16 x 26, 31	B, C, I, N, W
W36 x 439-848	T	W14 x 808*	B
W36 x 393	B, T	W14 x 455-730	B, I, T
W36 x 230-359	B, I, N, T	W14 x 342-426	B, I, T
W36 x 256	B, I	W14 x 311	B, I, T, W
W36 x 232	B, I	W14 x 145-283	B, I, N, T, W
W36 x 135-210	B, I, N, T	W14 x 90-132	B, I, N, T, W
W33 x 263-354	B, T	W14 x 82	B, N, W
W33 x 201-241	B, N, T	W14 x 74	B, C, N, W
W33 x 169	B, I, T	W14 x 61, 68	B, C, N, W
W33 x 118-152	B, I, N, T	W14 x 43-53	B, C, N, W
W30 x 391-477	T	W14 x 38	B, I, N, W
W30 x 261-326	B, I, T	W14 x 30, 34	B, C, I, N, W
W30 x 284*	I	W14 x 22, 26	B, C, I, N, W
W30 x 173-235	B, I, N, T	W12 x 252-336	B, I
W30 x 148	B, I, T	W12 x 210, 230	B, I, T
W30 x 99-132	B, I, N, T	W12 x 170, 190	B, I, T, W
W30 x 90	B,	W12 x 65-152	B, I, N, T, W
W27 x 307-539	I, T	W12 x 53, 58	B, C, N, I, W
W27 x 258	I, N, T	W12 x 50	B, C, N, I, W
W27 x 235	I, N	W12 x 40, 45	B, C, N, W
W27 x 146-217	B, I, N, T	W12 x 26-35	B, C, N, W
W27 x 132*	I	W12 x 16-22	B, C, N, W
W27 x 129	B, I, T, W	W12 x 14	B, C, W
W27 x 84-114	B, I, N, T, W	W10 x 88-112	B, I, N, W
W24 x 250-492	T	W10 x 49-77	B, C, I, N, W
W24 x 279	I, T	W10 x 33-45	B, C, N, W
W24 x 250	B, I, N, W	W10 x 22-30	B, C, I, N, W
W24 x 229	B, I, N, T, W	W10 x 15-19	B, C, I, W
W24 x 207	B, N, W	W10 x 12	B, C, W
W24 x 104-192	B, I, N, T, W	W8 x 31-67	B, C, I, N, W
W24 x 103	B, N, W	W8 x 24, 28	B, C, N, W
W24 x 84-94	B, I, N, W	W8 x 18, 21	B, C, N, W
W24 x 68, 76	B, C, I, N, W	W8 x 15	B, C, W, Y
W24 x 55, 62	B, C, I, N, W	W8 x 10-13	B, C, M, W, Y
W21 x 182, 201	I, W	W6 x 15-25	B, C, I, N, W
W21 x 101-166	B, I, N, W	W6 x 12, 16	B, C, 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*

Principal Producers Of Structural Shapes

B. Bethlehem Steel Corp.
C. Chaparral Steel
F. Florida Steel Corp.
I. 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.	Producer Code
W6 x 9	B, C, J, W, Y
W6 x 8.5*	C, J, M, Y
W5 x 16, 19	B
W4 x 13	B, C, M, Y
M12 x 10.8, 11.8	C, J
M12 x 10.0	J
M10 x 8-9	C, J
M10 x 7.5	J
M8 x 8.2*	J
M8 x 6.5	C, J
M5 x 18.9	B
M4 x 6*	C
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	B, C, S
S6 x 12.5, 17.25	C, S, Y
S5 x 10	C, Y
S4 x 9.5	C
S4 x 7.7	C, Y
S3 x 7.5	C, J, Y
S3 x 5.7	C, J, M, Y
HP14 x 73-117	B, I, N, W
HP12 x 53-84	B, I, N, W
HP10 x 42, 57	B, C, I, N, W
HP8 x 36	B, C, I, N, W
C15 x 33.9-50	B, N, W
C12 x 30	B, 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, 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, U, W, Y,
C5 x 9	M, U, W, Y
C5 x 6.7	F, M, U, W, Y
C4 x 5.4, 7.25	F, M, U, W, Y
C3 x 6	M, U, W, Y

Section Weight Per Ft.	Producer Code
C3 x 4.1, 5	F, M, R, U, W, Y
MC18 x 42.7-58	B, N
MC13 x 31.8-50	B, N
MC12 x 31-50	B, N
MC12 x 10.6	J, S
MC10 x 28.5-41.1	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
MC7 x 19.1, 22.7	B
MC6 x 18	B
MC6 x 15.1, 16.3	B, S
MC6 x 12	B, S
MC4 x 13.8*	S
MC 3 x 7.1*	S

Section by Leg Lengths & Thickess		Producer Code
L8 x 8 x	$1\frac{1}{8}$	B, T
	1	B, S, T
	$\frac{7}{8}$	B, S, T
	$\frac{3}{4}$	B, S, T
	$\frac{5}{8}$	B, S, T
	$\frac{9}{16}$	B, S
	$\frac{1}{2}$	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
	$\frac{9}{16}$	B, 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, U, Y
	$\frac{3}{8}$	F, M, R, U, W, Y

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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
	5/16	F, M, R, U, W, Y
	1/4	F, M, R, U, W, Y
L3 1/2 x 3 1/2 x	1/2	F, M, R, U, W, Y
	7/16	U, Y
	3/8	F, M, R, U, W, Y
	5/16	F, M, R, U, W, Y
	1/4	F, M, R, U, W, Y
L3 x 3 x	1/2	F, M, U, W, Y
	7/16	U, Y
	3/8	F, M, R, S, U, W, Y
	5/16	F, M, R, S, U, W, Y
	1/4	F, M, R, S, U, W, Y
	3/16	F, M, R, U, W, Y
L2 1/2 x 2 1/2 x	1/2	F, U
	3/8	F, S, U
	5/16	F, S, U
	1/4	F, S, U
	3/16	F, U
L2 x 2 x	3/8	F, S, U
	5/16	F, S, U
	1/4	F, S, U
	3/16	F, S, U
	1/8	F, S, U
L8 x 6 x	1	B, S
	7/8	B
	3/4	B, S
	5/8	B
	9/16	B, S
	1/2	B, S
	7/16	B, S
L8 x 4 x	1	B, S
	7/8*	B, S
	3/4	B, S
	5/8*	B, S
	9/16	B, S
	1/2	B, S
	7/16*	B, S
L7 x 4 x	3/4	B, Y
	5/8	B, Y
	1/2	B, S, Y
	7/16*	B, Y
	3/8	B, S, Y
L6 x 4 x	7/8	B
	3/4	B, M, S, U, W, Y
	5/8	B, M, S, U, W, Y
	9/16	B, M, S, U, W, Y
	1/2	B, M, S, U, W, Y
	7/16	B, U, Y
	3/8	B, M, S, U, W, Y
	5/16	B, M, S, U, W, Y

Section by Leg Lengths & Thickness		Producer Code
L6 x 3 1/2 x	1/2	M, U, W, Y
	3/8	M, U, W, Y
	5/16	M, U, W, Y
L5 x 3 1/2 x	3/4	M, U, Y
	5/8	M, U, W, Y
	1/2	M, U, W, Y
	3/8	M, U, W, Y
	5/16	M, U, W, Y
	1/4	M, U, W, Y
L5 x 3 x	1/2	F, M, U, W, Y
	7/16	F, Y
	3/8	F, M, U, W, Y
	5/16	F, M, U, W, Y
	1/4	F, M, U, W, Y
L4 x 3 1/2 x	1/2	F, M, U, W
	3/8	F, M, R, U, W
	5/16	F, M, R, U, W
	1/4	F, M, R, U, W
L4 x 3 x	5/8*	M, U, Y
	1/2	F, M, U, W, Y
	7/16	U, Y
	3/8	F, M, R, U, W, Y
	5/16	F, M, R, U, W, Y
	1/4	F, M, R, U, W, Y
L3 1/2 x 3 x	1/2	U, W
	3/8	M, U, W
	5/16	M, U, W
	1/4	M, U, W
L3 1/2 x 2 1/2 x	1/2	U
	3/8	U, W
	5/16	U, W
	1/4	U, W
L3 x 2 1/2 x	1/2	U
	3/8	U, W
	5/16	U, W, Y
	1/4	R, U, W
	3/16	U
L3 x 2 x	1/2	F
	3/8	F, S, U
	5/16	F, S, U
	1/4	F, R, S, U
	3/16	F, R, U
L2 1/2 x 2 x	3/8	R, S, U
	5/16	S, U
	1/4	R, S, U
	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.
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Principal Producers Of Structural Tubing

A. Acme Roll Forming Co.
B. Bull Moose Tube Co.
C. Copperweld Corp.
D. Dallas Tube & Rollform
E. Eugene Welding Co.
H. Hanna Steel Corp.
I. Independence Tube Corp.
J. Vest Inc.
L. LaClede Steel Co.
M. Maruichi American Corp.
N. Hannibal Industries, Inc.
P. IPSCO Steel
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
Z. Welded Tube of Canada Ltd.

Nominal Size and Thickness	Producer Code
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	V*
14x14x5/8	V*,W
14x14x1/2, 3/8	V*,W
14x14x5/16	W
12x12x5/8	B,S,W
12x12x1/2, 3/8	B,S,T,V*,W
12x12x5/16, 1/4	B,S,T,W
10x10x5/8	B,C,S,W
10x10x1/2, 3/8, 5/16, 1/4	B,C,S,T,U,W
10x10x3/16	B,C,S,T,U,W
8x8x5/8	B,C,S,W
8x8x1/2	B,C,S,T,U,W,Z
8x8x3/8, 5/16, 1/4, 3/16	B,C,S,T,U,W,Z
7x7x5/8	B,C,S
7x7x1/2	B,C,S,T,U,W,Z
7x7x3/8, 5/16, 1/4, 3/16	B,C,S,T,U,W,Z
6x6x5/8	B,S
6x6x1/2	B,C,S,T,U,W,Z
6x6x3/8, 5/16	B,C,R,S,I,J,T,U,W,Z
6x6x1/4, 3/16	B,C,R,S,I,J,T,U,W,Z
6x6x1/8	B,C,S,I,J,Z
5 1/2x5 1/2x3/8, 5/16, 1/4, 3/16, 1/8	B,S,I,Z
5x5x1/2	B,C,R,S,T,U,W,Z
5x5x3/8, 5/16	B,C,D,I,J,P,R,S,T,U,W,Z
5x5x1/4	B,C,D,I,J,P,R,S,T,X,U,W,Z
5x5x3/16	B,C,D,I,J,P,S,T,X,U,W,Z
5x5x1/8	B,C,I,J,P,S,T,Z
4 1/2x4 1/2x3/8, 5/16	T,I,P,W,Z
4 1/2x4 1/2x1/4, 3/16	B,C,D,I,P,T,X,W,Z
4 1/2x4 1/2x1/8	B,C,I,P,T,Z
4x4x1/2	B,C,P,R,S,T,U,W,Z
4x4x3/8, 5/16	B,C,I,J,R,S,T,D,P,U,W,Z
4x4x1/4, 3/16, 1/8	B,C,D,E,I,J,L**,M,N,P,S,T, X,U,W,Z
3 1/2x3 1/2x5/16	I,J,P,S,T,U,Z
3 1/2x3 1/2x1/4, 3/16, 1/8	B,C,D,E,I,J,L,N,P,R,S,T, U,W,X,Z

Nominal Size and Thickness	Producer Code
3x3x5/16	I,J,P,S,T,W,Z
3x3x1/4, 3/16	A,B,C,D,E,I,J,M,N,P,S,T ,U,W,X,Z
3x3x1/8	A,B,C,D,E,I,L**,N,P,R,S,T, U,W,Z
2 1/2x2 1/2x5/16	I,S,T
2 1/2x2 1/2x1/4, 3/16	A,B,C,D,E,I,J,L,N,P,R,S,T, U,W,X,Z
2 1/2x2 1/2x1/8	A,B,C,D,E,I,J,L**,N,P,R,S, T,U,W
2x2x5/16	I,S
2x2x1/4	B,C,D,I,J,L,M,N,S,T,U,W,X,Z
2x2x3/16	B,C,D,E,I,J,L**,M,N,P,R,S, T,U,W,X,Z
2x2x1/8	B,C,D,E,I,J,L**,N,P,R,S,T, U,W,X,Z
1 1/2x1 1/2x3/16	B,E,L,N,P,R,S,U,W,Z
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	V*,W
20x8x5/8, 1/2, 3/8	V*,W
18x12x1/2 3/8	V*
18x6x1/2 3/8 5/16	B,W
18x6x1/4	B
16x12x1/2, 3/8, 5/16	V*,W
16x8x1/2, 3/8, 5/16	B,W
16x4x1/2, 3/8, 5/16	B,W
14x12x1/2, 3/8	V*
14x10x1/2, 3/8	B,S,V*,W
14x6x5/8	B
14x6x1/2, 3/8, 5/16, 1/4	B
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,V*
12x8x5/8	C,S,W
12x8x1/2, 3/8, 5/16, 1/4	B,C,S,T,W
12x8x3/16	B,C,S,U
12x6x5/8	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.
**LaClede does not produce the 1/8; instead, it produces a .120 size.

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B. Bull Moose Tube Co.
C. Copperweld Corp.
D. Dallas Tube & Rollform
E. Eugene Welding Co.
H. Hanna Steel Corp.
I. Independence Tube Corp.
J. Vest Inc.
L. LaClede Steel Co.
M. Maruichi American Corp.
N. Hannibal Industries, Inc.
P. IPSCO Steel
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
Z. Welded Tube of Canada Ltd.

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

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

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.
**LaClede does not produce the 1/8; instead, it produces a .120 size.

Principal Producers Of Structural Tubing (Round)

A. Acme Roll Forming Co.
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I. Independence Tube Corp.
J. Vest Inc.
L. LaClede Steel Co.
M. Maruichi American Corp.
N. Hannibal Industries, Inc.
P. IPSCO Steel
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
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
16x.125	
14x.500, .438, .375, .250	P, W
14x.188	P
14x.125	
12.75x.500, .406, .375	P, W
12.75x.188	P, W
12.75x.125	P
12.5x.625, .500, .375, .312, .250, .188	C
10.75x.500, .365, .250	P, W, Z
10x.625, .500, .375, .312	C
10x.250, .188	C
10x.125	V
9.625x.500	C, U, Z
9.625x.375, .312, .250, .188	C, P, U, Z
8.75x.500, .375, .312, .250, .188	C
8.625x.500	P, S, U, Z
8.625x.375	P, S, U, Z
8.625x.322	P, S, U, W, Z
8.625x.250, .188	P, S, U, Z
8.625x.125	P, S
7.5x.500, .375, .312, .250, .188	C
7x.500	C, P, U, Z
7x.375, .312, .250	C, P, R, S, U, Z
7x.188	C, P, R, S, U, Z
7x.125	C, P, Z
6.875x.500, .375, .312, .250, .188	C
6.625x.500, .432	P, U, Z
6.625..375, .312	P, R, U, Z
6.625x.280	P, R, U, W, Z
6.625x.250, .188	P, R, U, W, Z
6.625x.125	P, Z
6.125x.500, .375, .312, .250, .188	C
6x.500	S, Z
6x.375, .312	R, S, Z
6x.280	S, X, Z
6x.250, .188	R, S, Z
6x .125	Z
5.563x.375	P
5.563x.258	P, R, W, Z
5.563x.134	P, R, Z
5.5x.375, .258	U
5x.500, .375, .312	C, P, T, Z
5x.258	P, R, T, U, X, Z
5x.250, .188	C, L, P, R, S, T, U, Z
5x.125	C, L*, P, R, S, T, U, Z
4.5x.237, .188	L*, P, R, S, U, W, Z
4.5x.125	L*, P, R, S, U, Z
4x337	R, S, U
4x.250, .188	C, R, S, U, W, Z
4x.237	R, S, W, Z
4x.125	C, R, S, U, Z
3.5x.300	P, S, Z
3.5x.250, .203, .188, .125	P, S,
3.5x.216	P, S, X
3x.250, .203, .188, .152	L, R, S, U, Z
3x.300	S, X
3x.216	R, S, X, U
2.875x.276	
2.875x.250	L*, P, U, Z
2.875x.203, .188	L*, P, U, W, Z
2.875x.125	L*, P, U, Z
2.375x.250, .218, .188	L, P, S, Z
2.375x.154	L, P, S, U, W, Z
2.375x.125	P, R, S, U, W, 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.
**LaClede does not produce the 1/8; instead, it produces a .120 size.

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P.O. Box 5000
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Bethlehem Steel Corp.
501 East Third St.
Bethlehem, PA 18016-7699
(800) 633-0482

British Steel Inc.
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Schaumburg, IL 60173
(800) 542-6244

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

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

J&L Structural Inc.
111 Station St.
Aliquippa, PA 15001
(412) 378-6490

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

North Star Steel Co.
1380 Corporate Cntr. Curve
P.O. Box 21620
Eagan, MN 55121-0620

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
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New York, NY 10022
(212) 486-9890

Structural Tube Producers

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Sebewaing, MI 48759-1120
(800) 937-8823

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

Bull Moose Tube Company*
1819 Clarkson Road, Suite 100
Chesterfield, MO 63017-5040
(800) 325-4467

Copperweld Corporation*
4 Gateway Center, Ste. 2200
Pittsburgh, PA 15522
(412) 263-3200

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

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 58814
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
(416) 271-2312

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

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

Standard Tube Company*
P.O. Box 430
Woodstock, Ontario N4S 7Y6
(519) 537-6671

UNR-Leavitt,
Div. of UNR Industries, Inc.*
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Chicago, IL 60643-4399
(800) 532-8488

Valmont Industries, Inc.*
(Structural Tube Division)
801 North Xanthus
P.O. Box 2620
Tulsa, OK 74101
(918) 583-5881

Vest Incorporated*
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Los Angeles, CA 90058
(213) 581-8823

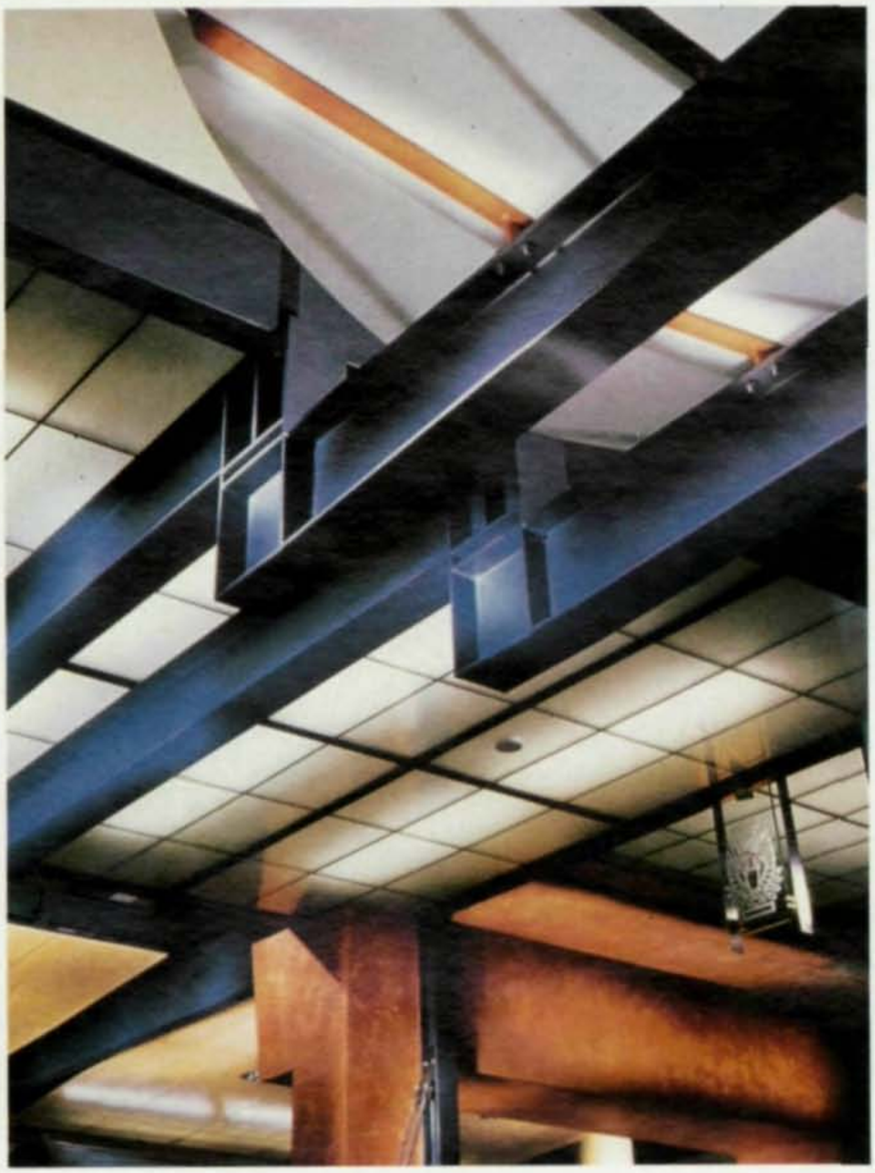
Welded Tube Co. of America*
1855 E. 122nd St.
Chicago, IL 60633
(800) 733-5683

Welded Tube of Canada, Ltd.*
111 Rayette Road
Concord, Ontario L4K 2E9
CANADA
(800) 837-3616

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

Building Within A Building

Creating a new steel-framed space within an old building allowed a local AIA chapter to create an architecturally unique space



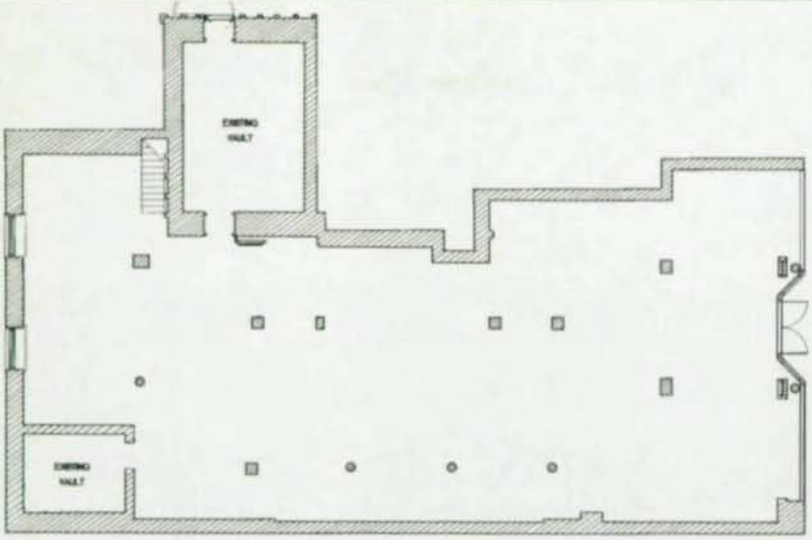
Given the growth of the renovation market, it was both logical and appropriate for the Portland Chapter of the AIA to turn to the renovation market when they needed more room.

The chapter's search for new space in downtown Portland eventually led to the Henry Building, a vintage building *circa* 1909. The upper floors of the building had recently been renovated into a mixed-use project that included an SRO hotel and the project's developer, the Portland Development Commission, was looking for a ground-floor tenant. "We were happy to support this kind of development downtown," explained Alan J. Beard, a principal with GBD Architects in Portland and, at that time, the president of the local AIA chapter.

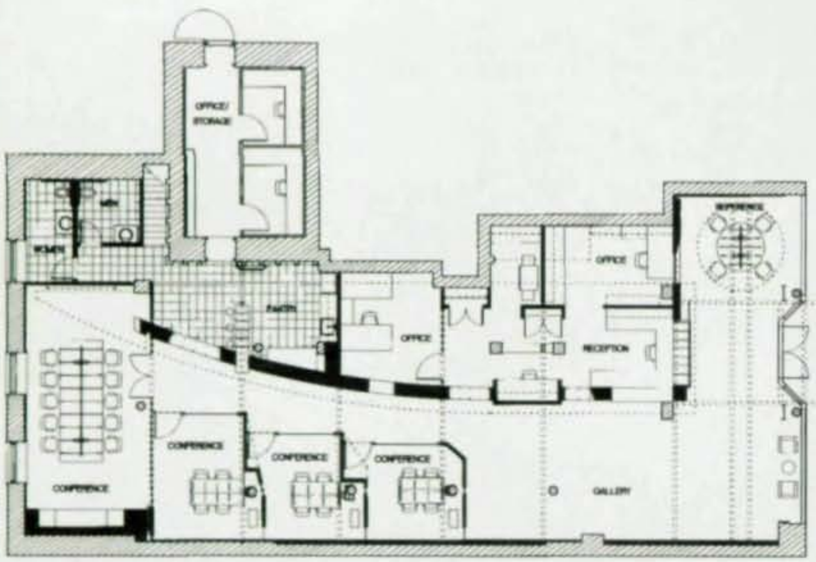
Joint Design Effort

Selection of the project team was as unconventional as the space itself. Instead of sponsoring a competition or choosing a design firm, the chapter organized its members into a working team, which took the name "Fine Young Constructivists." Heading the team was Jeffrey Lamb, AIA, at the time an architect with BOOR/A in Portland and now a senior project designer with GBD Architects.

"The existing space was an empty, 3,400-sq.-ft. shoebox, with 12-ft.-high ceilings, two concrete vaults and lots of columns,"



EXISTING FLOOR PLAN



NEW FLOOR PLAN

Lamb said. "The program called for a lot of office and conference space. Our design introduces order into the space."

Within the open shell—it was originally a bank and was most recently a Japanese restaurant—the designers imposed order by inserting an exposed structural steel frame—both columns and beams. While in many areas the steel is functional and supports both solid and glass walls, in other areas the steel beams snake along the ceil-

Continued on page 28

The exposed beams pictured on the opposite page serve both a structural and aesthetic purpose. Shown top right is the installation of these beams, while above right is a view of some of the rich and varied finishes used in the office space. The floor plans (above left) show before and after views.

Since 1962, we've helped And a lot

Over 200 bridges in Ohio are constructed of weathering steel. Most of it produced by Bethlehem.

They use it for the same compelling reasons the New Jersey Turnpike Authority, Maine, Maryland, and numerous other states do.

That's because weathering steel cuts costs both initially and over the life of the structure. Plus, it's attractive and offers engineers broad design flexibility.

Ohio is particularly enthusiastic about the use of weathering steel for appropriate locations in conjunction with their jointless bridges.

They began the jointless concept in the 1930's. Since then, they've refined their jointless designs to the point where joints have been eliminated not just over the piers, but at the abutments, as well.

As a result, drainage problems associated with jointed bridges, such as failure of joint seals, or clogged drains overflowing onto structural members, have been eliminated.

Bridge lengths have also increased. Initially, the limit was 200 ft. Today, it's been increased to 300 ft., and even greater lengths are being constructed.

Engineers in the Buckeye state began using weather

ing as an aesthetic device.

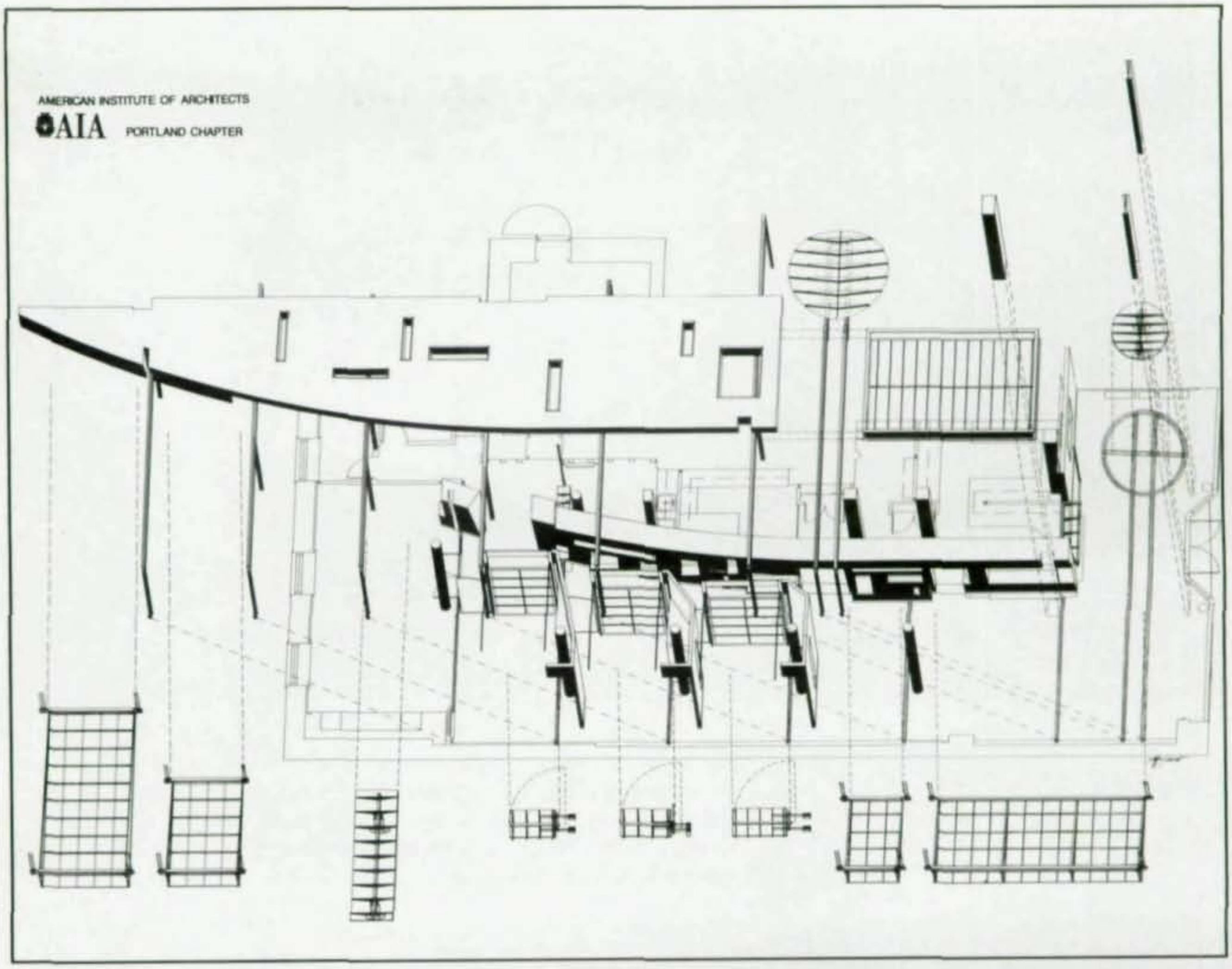
"We picked a steel vocabulary both for its flexibility and lightness," Lamb explained. "It was a very dull space and the beams gave us flexibility and beauty. They established a whole new structural order."

The space is long and rectangular, and the public and private areas are separated by a 70-ft.-long arcing wall, which terminates in a large conference room. The main entrance opens into a gallery space, featuring exhibitions by both architects and artists. "The floating curved wall separates the offices from the gallery and conference rooms, and the steel beams both support and penetrate the wall," Lamb said. The wall contains seemingly random rectangular cutouts, which house a variety of models and drawings.

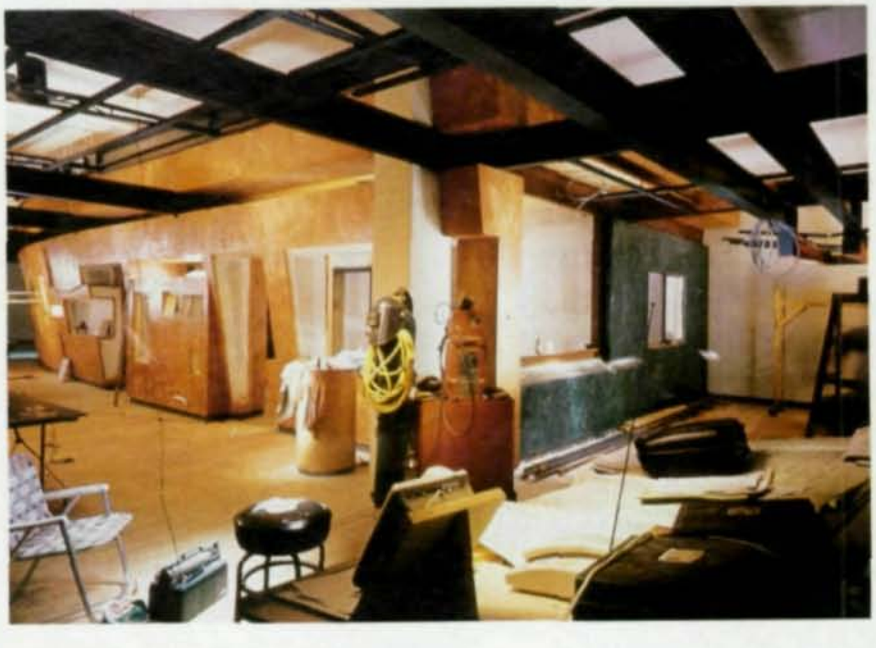
"We picked a steel vocabulary both for its flexibility and lightness"

The beams, which are primarily W12x22 with some W10x22, are supported on new new W4x13 steel columns, according to Grant Davis, a structural engineer with KPFF in Portland and a member of the Fine Young Constructivists design team. Since the steel beams were left exposed, the detailing on the project was crucial. "We took standard shapes and modified them to meet the architect's requirements." Primarily, this involved stacking beams with offset splicing to create an interesting angular effect.

The steel frame was designed primarily to support the ceiling and various items that the archi-



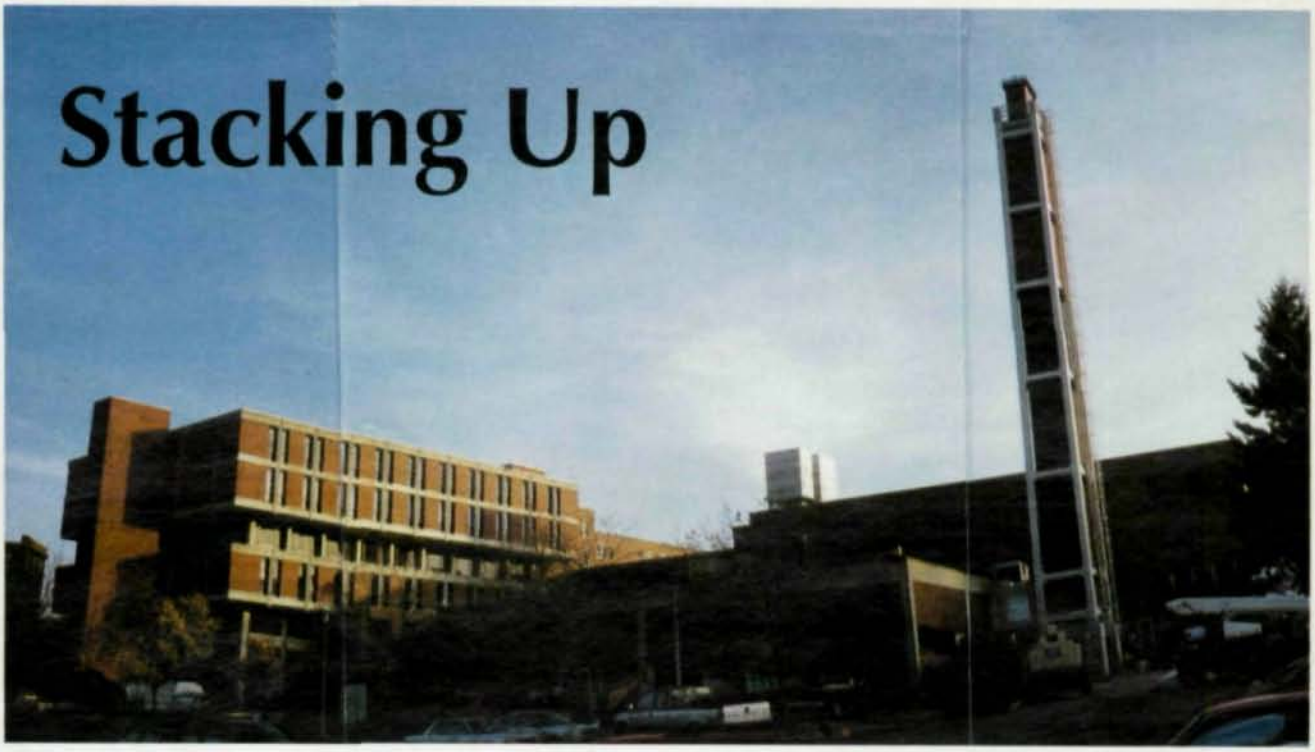
Shown above is an exploded axiometric view of the new space. Pictured at right is the main public space during construction.



tect chose to suspend from the beams. For example, in each of the three smaller conference rooms a large glass-and-steel conference table is suspended from the ceiling. Likewise, door frames, partition walls and light fixtures are suspended. Total anticipated loads are approximately 10 to 15 psf.

One of the old vaults was removed, while the other was converted into three offices. While they have no window openings, the texture of the massive walls creates a delightful space. "After we stripped the old paint off, we discovered it was cast iron and we incorporated it into our design," Lamb said.

Stacking Up



Aesthetics and economics both played key rolls in deciding on how to raise a 75- ft.- high boiler stack an additional 45- ft.

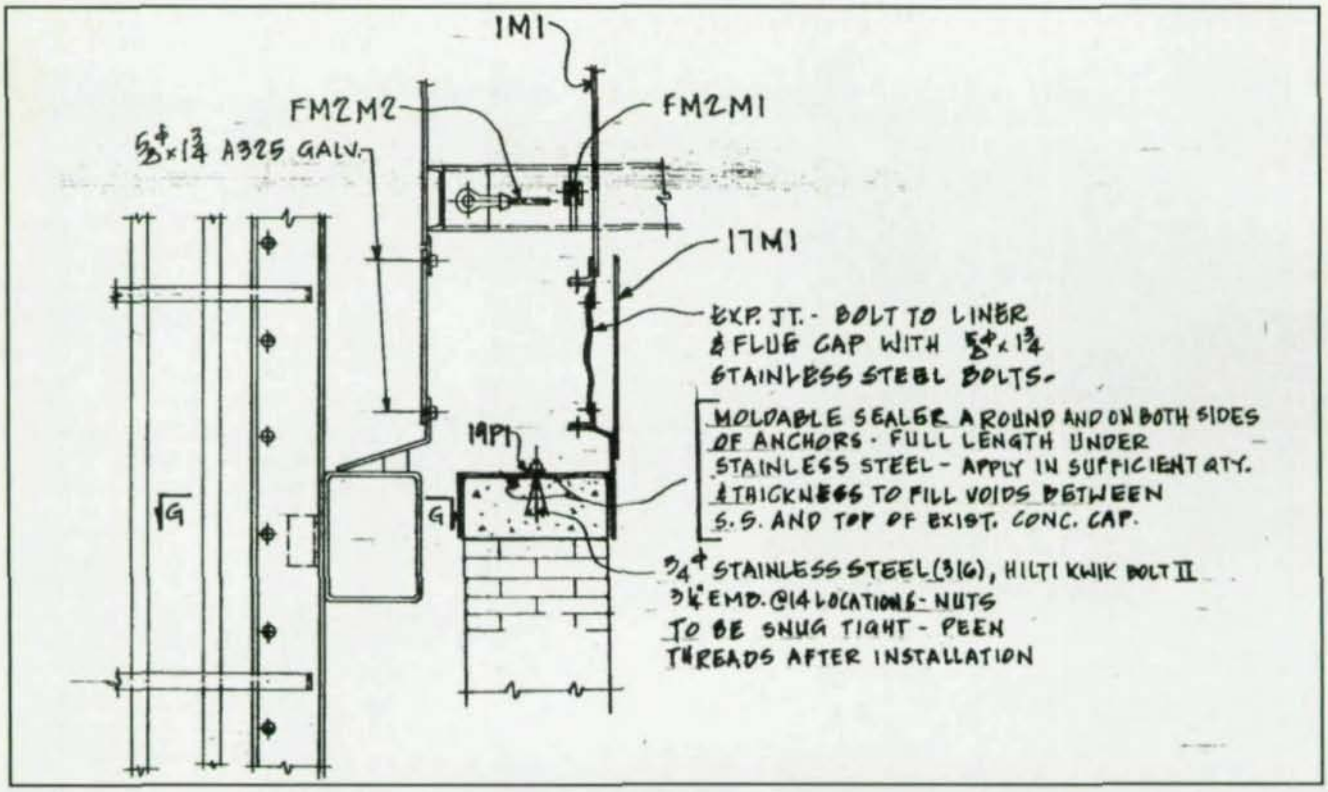
By Howard I. Epstein, P.E., and George Torello Jr., P.E.

Adding a new floor to a wing of a hospital in Norwich, CT, had an unintended side effect: on some windy days, effluent from the facility's 75-ft.-high boiler stack could reach the air-intake vents of the new structure. After receiving the results from a dispersion study, environmental consultants recommended that a 45-ft.-high addition to the boiler stack would remedy the situation.

The existing buildings at Backus Hospital, along with the new addition, have extensive areas of brick facade delineated with ribbons of concrete. An integral part of the complex is the very visible brick boiler stack, which can be seen from a large portion of the hospital grounds. Unlike many other stacks that are strictly utilitarian, this one blends nicely with the surrounding architecture and does not overpower the surrounding buildings. The stack is rectangular in plan and has a slight uniform taper over the entire height. As a result, the structural engineers, Torello Engineers, Old Lyme, CT, needed to be cognizant of aesthetic concerns in any addition to the stack.

Regardless of the type of extension chosen, analysis showed that the foundation would need to be enlarged. Probably the simplest solution would have been a lattice steel structure. This would have minimized the weight and the required foundation work. The final look, however, would have been out of place to the existing architecture and so this alternative was quickly eliminated from consideration. A free-standing insert also was eliminated, mainly due to the down-time involved, which would have resulted in temporary boiler fees as well as other extensive shutdown costs.

The next alternative considered met both the aesthetic and down-time requirements. The existing 75-ft.-high stack would be encased within four large concrete columns that were joined, horizontally, by beams at intervals consistent with the architecture of the surrounding structures. The existing foundation



would be enlarged and a concrete cap would be installed at the top of the existing structure to accept an additional 45-ft.-high steel liner. The only down-time was the approximately two hours needed to place and secure the new 45-ft.-high steel stack liner on the new cap. After the steel liner was installed and the boiler was back in operation, it could be encased with either a continuation of the brick and concrete treatment of the lower shell or painted steel tubes.

Too Costly

Discussions with contractors to obtain preliminary pricing information quickly eliminated a continuation of the brick and concrete for the new top section. The cost of the necessary scaffolding and high brick work were prohibitive, as was the cost of forming and pumping concrete at heights of 75-ft. to 120-ft. In addition, even though the stack could still be in operation during the concrete construction work, the area surrounding the stack, which is used for fuel and oxygen deliveries, would be disrupted for too long a period. Still anoth-

The composite view (opposite page) shows the completed boiler stack and its relationship to the existing hospital buildings and other new construction. Pictured at left is the stack addition under construction.

Shown above is the connection assembly that fit on top of the existing stack prior to its installation.

er problem with the concrete structure was how to tie it into the brick.

After further investigation it was decided that the new concrete columns and many band beams required to encase the existing brick stack would also be too expensive and too disruptive to hospital operations. And finally, there were structural questions about whether the concrete columns would provide adequate seismic strengthening to the existing stack to accommodate the additional shear forces delivered from the new top section.

It soon became apparent that it would be beneficial to construct as much of the structure off-site as possible. Thus, while precast elements were a possibility, a steel frame would be even better. Concrete would be used up to 10-ft. above grade, so that no staging was required, and steel would be used above that level.

Steel Solution

The final design incorporated another change. Rather than requiring many retrofit strengthening operations of the existing stack to accommodate the weight of the new stack, it was decided to make the new steel addition completely structurally independent of the existing structure.

The new concrete columns and band beams encompass the base of the structure, with steel column base plates standing off each corner. The design minimizes the clearance between the steel columns and the brick while having the new structure stiff enough so that there would be no interference when the existing and new structures deflect during wind or earthquake events (see figure).

The new liner section is hung from the outer jacket. The only connection to the existing stack, aside from the concrete base, is at the connection of the new liner. This is essentially a flexible membrane that transmits negligible forces to or from the existing stack.

Aesthetic Concerns

The dimensions of the new exposed steel tubular columns and beams were selected not only for structural strength, but also to meet the desire of Torello's architect, Steve Joncus, to match the concrete of the surrounding structures. The vertical tubes are 16x16x$^1/_2$, while the beams are 12x16x$^1/_2$. Fabricator and erector on the project was AISC-member The Berlin Steel Construction Co.

The elevations of the horizontal tube band beams also were carefully orchestrated with the architect. The new tube color was selected to approximate concrete and the new top steel jacket, which serves as a big wind

Pictured above is the last plate being fitted into the stack addition.

screen, was painted with a color approximating that of the existing brick.

Many of the details of the structure were accomplished with aesthetics in mind. For example, rather than provide an observation platform that protrudes from the structure, the outer jacket was tapered inward to allow for a platform that is encompassed within the new columns. In effect, the top of these columns are rather large railing posts.

During the design phase, the forces between the tubular beams and columns precluded a simple tube-to-tube welded connection at most locations. After much consultation with the architect, a tapered transition plate connection using gusset plates was chosen.

This connection consisted of a 14-in. x 30-in. plate welded to the end of the horizontal tube and also welded to the vertical tube. Four 6-in. x 6-in. vertical triangular gusset plates connect the horizontal tube to the plate at each corner of the horizontal tube.

Erection Sequence

This is an unusual structure in that it was built, almost entirely in the shop. Sections were fitted together and then disassembled for transport and re-assembly in the field. The order of field assembly and the sizes of pieces to be galvanized, transported and eventually lifted dictated many of the details. The interaction between design, fabrication and erection was greatly facilitated by Berlin Steel being both the fabricator and erector.

The stack extension consists of a flexible transition section between the brick and the new steel liner. The top third of the 45-ft. high flanged, rectangular liner is stainless steel. The liner is insulated and a hat section on the top prevents water from getting into the space between the liner and the outer structure from which the liner is hung.

The outer structure was made in three sections. The bottom section, a tapered frame, is slightly less than 50-ft. high. The middle section, also approximately the same height, extends about 35 ft. above the existing brick, and this portion contains the plates that shield the liner. The upper section consists of the extension of the tapered columns (which become the railing supports), the outer jacket and the observation platform.

A crane and two 120-ft. man lifts were used for the erection. First, the flexible transition section atop the existing brick was erected. Deflector plates that are part of this assembly not only protect the flexible membrane, but also as a bonus enabled full operation of the stack while the erection took place. Design was based on a minimal shutdown time. (A maximum two-hour window was allowed on a Sunday, but, as it turned out, no shutdown at all was required.)

The bottom 50-ft. section of the outer structure was then lifted over the brick and placed atop the 32 anchor bolts. Placement of the eight bolts power leg required careful coordination with the concrete contractor. Shims were used to adjust the level so that clearance from the existing structure was maximized. The second section was lifted with hanger rods and only four of the eight plates attached.

Early in the morning, the liner was lifted and dropped into place, and the rods from which it hangs were attached, as were the bolts in the flanged connection to the transition section. The four areas where the outer plates were not yet attached were needed for access to assemble the liner connections. Therefore, once this assembly was initiated, the surrounding structure needed to be quickly completed before any possibility of the liner getting wet. On the same day, the outer plates were attached as was the top section of the outer structure and the hat atop the liner. Remaining detail work, including touch-up painting, was subsequently completed.

Howard I. Epstein, P.E., is a professor of civil engineering at the University of Connecticut (Storrs) and an ongoing consultant to Torello Engineers, Old Lyme, CT. George Torello Jr., P.E., is president of Torello Engineers, Old Lyme, CT. Part of this article is taken from a paper to be delivered at the ASCE Structures Congress in Atlanta in April 1994 (permission was granted by ASCE).

Shown above is the completed stack. Note how its appearance blends with the existing building in the background.

ROBOT V6

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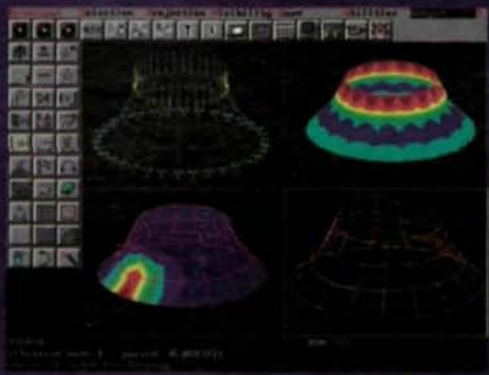

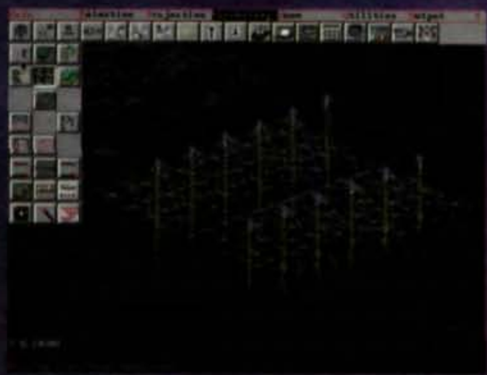

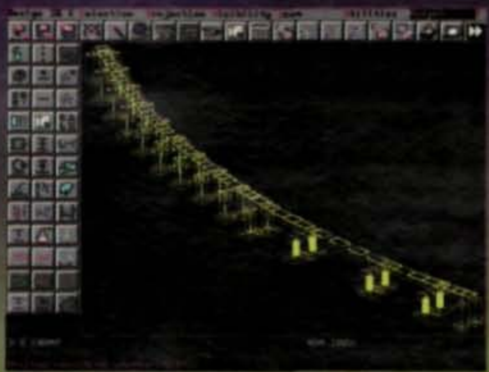

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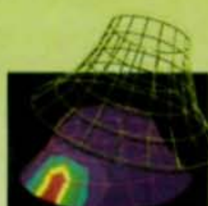

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Designing Better Steel Structures

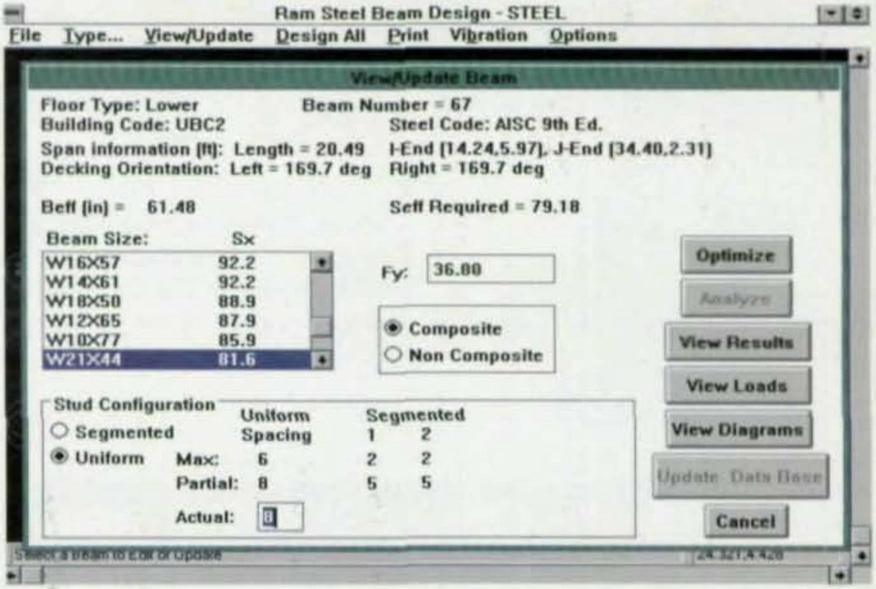
Contemporary design software allows engineers to explore more options and to use the latest Specifications

By Gus Bergsma, P.E.

Analyzing, comparing and re-analyzing different design alternatives is a process all design engineers go through to develop the most efficient design. Unfortunately, time constraints usually prohibit us from looking at as many alternate schemes as we would like.

By its very nature, engineering involves a vast number of calculations—from the sizing of simple fillet welds to analyzing an entire structure under dynamic seismic forces. While some calculations are almost trivial, others are extremely elaborate. Performing these calculations can consume a significant portion of an engineers time and attention, often to the point that the engineer does not have the opportunity to spend as much time as he would like creatively thinking of and investigating more optimum alternate solutions.

Fortunately, faster computers and a new generation of design software is becoming increasingly available. What sets the new generation apart from its forebears is that not only does it automate specific tasks, but it also integrates these various tasks and eliminates duplication of effort. Whereas we once used output from one program and manually transferred data to another program, new advanced programs are providing "seamless" integration of these two programs and changes are immediately updated throughout. Not only does this integration save time, it also helps to prevent inadvertent errors in



Today's state-of-the-art software allows structural engineers to quickly examine a wide variety of designs.

hand calculations and data manipulations.

In addition to allowing us to operate more profitably, the new generation of software can reduce a young engineer's learning curve. In the Winter/Spring 1992 issue of A/E/C Systems Computer Solutions magazine, Alton B. Cleveland, Jr., discussed the advantages of computer automation in the design office: "Technologies such as 3D modeling, animation and expert systems can enhance and accelerate the acquisition of expertise by removing the drudgery and tedium, and thus much of the time, required to propagate our conceptual decisions into concrete implementation details. This allows a person to 'go through it' many more times than previously possible. While this could never serve as a complete replacement for real-world, hands-on experience, it can provide a tool to move quickly between he abstract and the concrete, accelerating learning and the development of true expertise."

A simple example of this principle is the Shear, Moment and Deflection diagrams of a frame member. It is much more valuable to see the actual diagrams than to read a listing of the output values. The behavior of the member due to the loads and other conditions is more apparent.

By taking advantage of the speed of computer analysis, the engineer can easily explore a number of design options in a short period of time, allowing him to make immediate comparisons and see the impact of changing a given design parameter. In this way, he can begin to develop significant engineering judgement over the course of a single project, rather than having to await the accumulative experience of several projects.

Software also can help us in applying new techniques. The advantages of Load & Resistance Factor Design (LRFD) are well established, yet designers are still reluctant to begin using this method for steel design. The "new generation" of software available for steel design makes it feasible—and fairly simply—to extensively implement LRFD in the design office.

Preliminary Design & Design Documents

Using a graphically oriented design package during the preliminary design or design development phase of a project allows easy investigation of alternative design schemes. For example, a designer could easily consider: a standard framing system with no special considerations; a design with limited floor-to-floor heights; different design live loads; different elevated slab properties; different steel strength grades; a variety of framing configurations; a comparison between ASD and LRFD; and different column splice points for increased design efficiency.

Without the aid of advanced computer software, a designer rarely has the time to investigate such a large variety of schemes. In addition to revealing the impact of these many design alternatives, the best of the current crop of engineering software will also allow the engineer to control the design parameters such that when the program selects a member design size it selects the same size that the engineer would have had he designed the building without the aid of a computer.

Case Study

The power of the new generation of structural software rests in its ability to quickly analyze different building schemes. For example, a computer program was integral in a recent effort to redesign a proposed 21-story office building to maximize flexibility while minimizing cost.

The structure is located in an area that traditionally uses reinforced concrete for buildings of this type, so it was no surprise when the proposed design used that material. However, upon reviewing the architectural plans, a steel fabricator felt a strong case could be made for designing and constructing this building in steel. A structural engineering consultant was retained, and, using one of the new generation structural design packages, analyzed five different schemes, all using LRFD and composite steel framing:

Scheme 1: $4\frac{1}{2}$-in.-thick hardrock concrete fill on 3-in. steel deck; design live load = 80 psf; interior partition load = 20 psf;

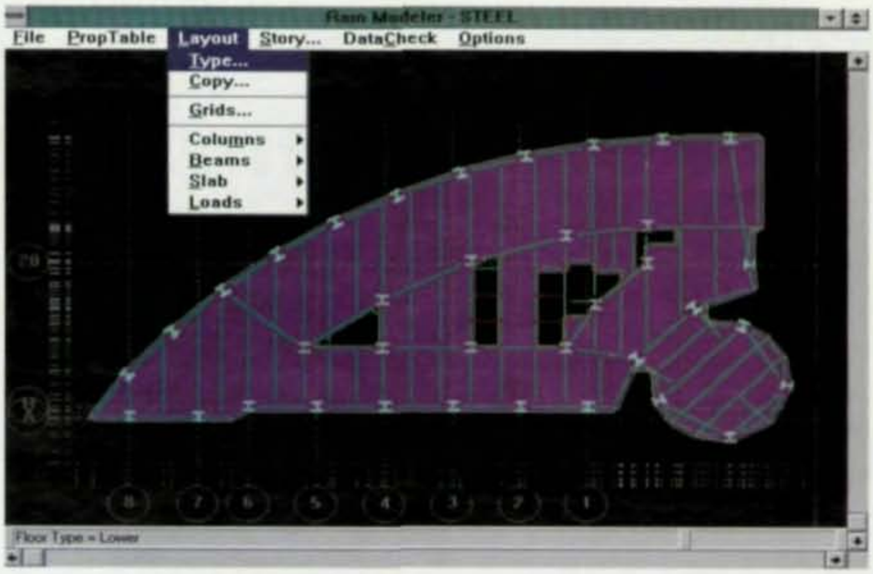
Scheme 2: $2\frac{1}{2}$-in.-thick hardrock concrete fill on 3-in. steel deck; design live load = 80 psf; interior partition load = 20 psf;

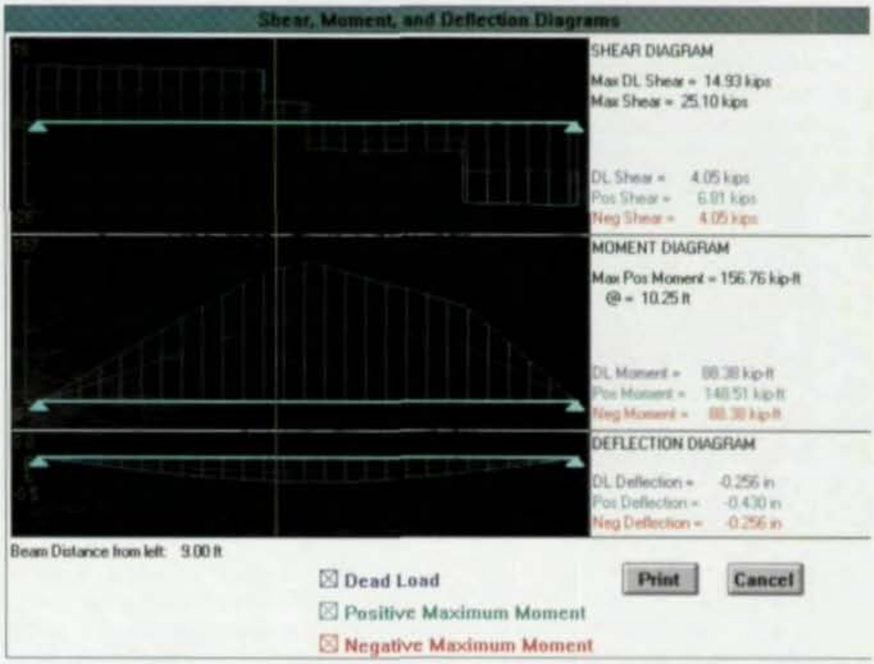
Scheme 3: $4\frac{1}{2}$-in.-thick hardrock concrete fill on 3-in. steel deck; design live load = 50 psf; interior partition load = 20 psf;

Scheme 4: $3\frac{1}{4}$-in.-thick lightweight concrete fill on 3-in. steel deck; design live load = 80 psf; interior partition load = 20 psf;

Scheme 5: $4\frac{1}{2}$-in.-thick hardrock concrete fill on 3-in. steel deck; design live load = 80 psf; interior partition load = 20 psf; modified framing from that of scheme 1 was used at radius.

For each scheme, every beam, girder and column was designed. Structural steel material take-offs were obtained, and framing plans were generated for the CAD system. This work was completed by a single design engineer in less than three days. Working with the steel fabricator, the design engineer determined which structural steel system would be best for this project.





As a result, the owner is now considering a steel design. However, without state-of-the-art design software, the owner would never have been presented with an option that may prove more economical than the original design.

Due to the new graphical interfaces available with this new generation of software, the engineer can concentrate on design, rather than how to get the software to perform the necessary calculations for which he purchased it in the first place. While no software product is capable of determining what the "best" design for a specific project should be, computer programs can aid engineers in investigating a far greater number of options than would have been economically feasible in the past.

This article is based on a paper given by Gus Bergsma, P.E., of Ram Analysis and L. Allen Adams, S.E., of Culp & Tanner Structural Engineers, Chico, CA, at the Third International Symposium & Sixth National Symposium on Steel Structures in Oaxaca, Mexico.

1994 Structural Engineering
Software Survey

Less expensive, faster computer systems, combined with more powerful software packages, are fueling an explosion in purchasing activity by structural engineers. In a survey of 168 structural engineers currently using computers for design work, nearly three-quarters reported they planned to buy new hardware during the next 12 months, almost seven out of 10 planned to buy new software and more than two-thirds planned to buy new peripherals, such as plotters, digitizers and printers.

The survey, conducted by mailing a form to 1,000 randomly selected Modern Steel Construction readers, is a follow-up of an earlier survey conducted in late 1991. In addition to the 168 tabulated responses, another 26 responses were excluded from the survey results for a variety of reasons, primarily incompleteness of responses.

The large majority of respondent—95%—used PC-compatible computers, while 40% used a dedicated workstation and less than 10% used Macintosh computers (less than 2% used only Macintosh).

Most of the respondents worked at medium size firms (approximately 40 employees).

Building and Bridge Analysis Programs

# of responses:		*rating:*
64.	STAAD-III	3.78
47.	GT STRUDL	4.19
37.	RISA-2D	4.14
27.	ETABS	3.8
24.	SAP90	3.94
23.	Enercalc	2.97
14.	SAI	3.11
14.	M-Strudl	3.07
8.	Images 3D	3.73
7.	MERLIN DASH	3.71
6.	ROBOT V6	4.5
4.	MDX	3.5
3.	CBRIDGE	3.66

Member Design Programs

# of responses:		*rating*
37.	RISA 2D	4.05
23.	RAMSTEEL	4.2
18.	SAI	3.22

As in 1991, the most widely used building analysis program was STAAD-III/ISDS from Research Engineers. It was used by 64 respondents, who rated it 3.78 on a scale of one to five, with one being a very poor program and five being an excellent program that the respondent would highly recommend. The package has the reputation of being a very complete package for the design and analysis of any structural member, ranging from a single beam to a three-dimensional multistory structure in a seismic area. While most users rated it to be a very good program, one complaint that cropped up in 1991 and continued to appear in this survey, especially among smaller companies, concerns confusion in using the documentation. However, Research Engineers has recently upgraded its manual to include more examples and a simplified format.

Also, many engineers who use STAAD-III for building analysis also use it for member design. In addition, a number of users reported favorably on using STAAD-III for bridges. Research Engineers also offers AutoSTAAD, a complementary AutoCAD based software that allows model generation and drafting through AutoCAD. Five respondents reported using this feature, and all of them gave it the top rating.

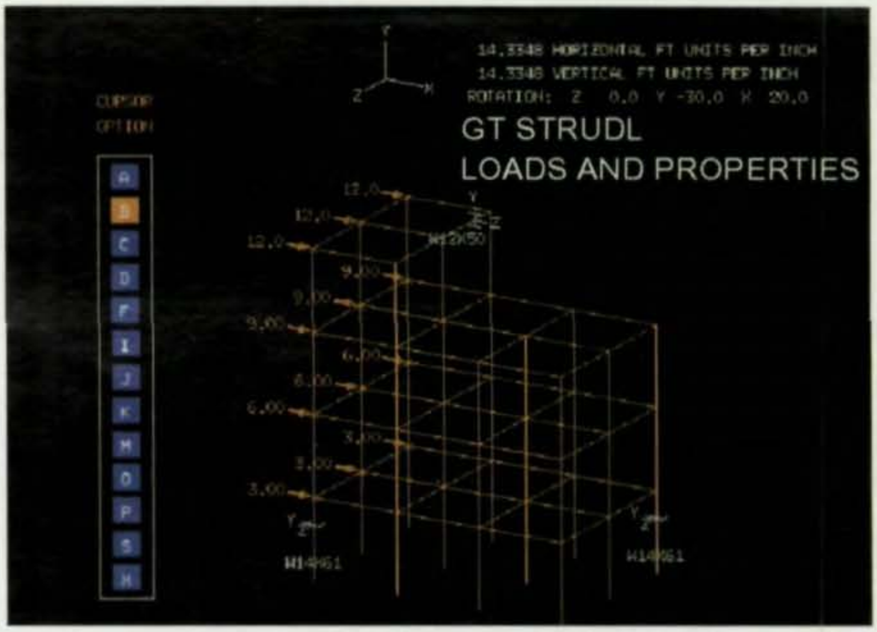
According to its developer, STAAD-III is a comprehensive and flexible general purpose structural software package for integrated analysis, design and drafting for both buildings and bridges. The analysis capabilities include 2D/3D static, dynamic/seismic, P-Delta and non-linear analysis. Design includes steel, concrete and timber using AISC, ACI and AITC specifications as well as a variety of international codes. The program is equipped with a state-of-the-art graphics-based model generator and a graphics post-processor allows verification of geometry and analysis/design results.

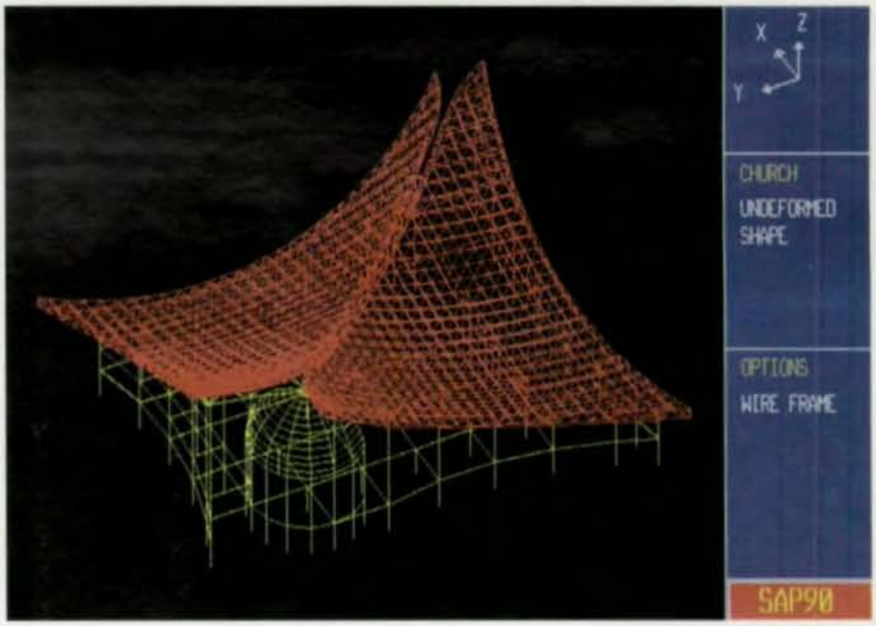
For more information on STAAD-III, contact: Research Engineers, Inc., 1570 N. Batavia, Orange, CA 92667 (800) 367-7373; fax 714/974-4771.

The second most commonly used analysis program was GT Strudl from Georgia Tech Research Corporation. It was used by 47 respondents and garnered a 4.19 rating. (Note, however, that the response for GT Strudl was slightly skewed by an inadvertent mailing to some engineers on a GT Strudl customer list.) GT Strudl has a reputation for being a very complete program with excellent customer support. It's a fully integrated system for graphical frame and finite element modeling as well as static, nonlinear and dynamic analyses. One common complaint about the program, though, is its high cost. A complete package on a PC platform can cost $11,000, though the basic program sells for approximately $5,000. In response, Georgia Tech has authorized its West Coast agent, SC Solutions, to sell GT Strudl-Lite, a scaled down version of the program that limits the number of members and sells for around $2,500.

According to the program's developers, GT Strudl integrates state-of-the-art finite element analysis with superior 3D color graphics, a database management and structural steel and reinforced concrete design to give the engineer a compete structural engineering system. Analysis includes both linear and non-linear static, and linear dynamic structural analysis. More than 100 finite element types, including conventional, isoparametric, transition, axisymmetric and hybrid formulation elements are available. Dynamic analysis can solve the eigen problem, as well as perform transient, response spectrum, steady state, and harmonic analysis. Nonlinear analysis includes the ability to solve cable-stayed and tension or compression only members, non-linear spring supports, non-linear geometry and boundary contact problems. All pre- and post-processing is fully integrated. GT Modeler is a powerful interactive graphics-oriented, menu-driven, full 3D modeling system. Graphical display includes undeformed static deformed and dynamic mode-shape plots, FE stress, strain and displacement contours, and member force diagram and envelope plots.

For more information on GT Strudl, contact: Georgia Tech Research Corp., GTICES Systems Lab/ Georgia Tech, Atlanta, GA 30332-0355 (404) 894-2260; fax 404/894-2278.





Pictured at top is a screen capture from GT STRUDL, while above is a screen capture from SAP90.

A program with a growing usage is RISA 2D from Risa Technologies. It was used by 37 respondents for both analysis and member design and received a high rating in both areas: 4.14 and 4.05, respectively. While not as sophisticated as either STAAD-III or GT Strudl, many respondents reported they prefer it, especially for smaller projects, due to its ease of use and relatively low cost. As one respondent reported, "For 90% of our applications, RISA-2D is all that is needed or appropriate."

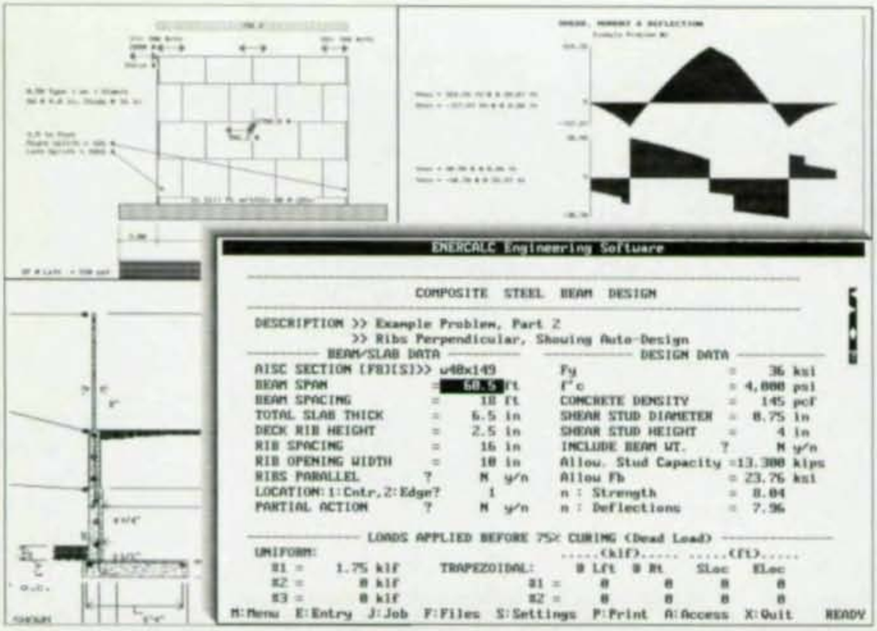
According to its developer, RISA-2D provides a high-speed, fully interactive environment for solving a wide range of structural design problems. RISA-2D handles frames, trusses, shear walls, continuous beams and much more. Virtually any problem that can be modeled in two dimensions can be solved with the program. Static, dynamic and P-Delta capabilities are included, with full steel design (including member selection) based on the 8th or 9th edition ASD criteria. The $495 program is easy to learn and use, offering powerful data generation function, intuitive spreadsheet editing and extensive graphics.

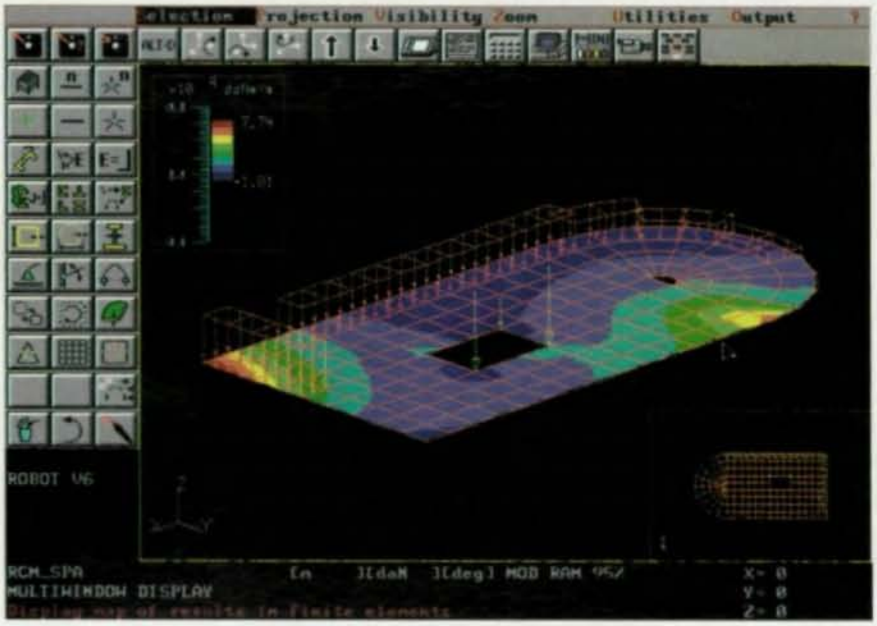
For three dimensional structural design solutions, RISA-3D offers a fast, truly interactive environment, according to the program's developers. Static, dynamic and P-delta capabilitiels are incorporated into this powerful new program, with full 1989 ASD steel design (including member selection). RISA-3D handles up to 2,500 joints (15,000 degrees of freedom) and its optimized, multilevel active column solver provides very quick solutions to models of all sizes. Extensive interactive graphics provide a display of loadings, deflected shape diagrams, force diagrams, to scale renderings of structural shapes and much more. General purpose data generation functions, powerful spreadsheet editing and full mouse support make RISA-3D easy to learn and a snap to use. The program is offered at an introductory price of $1,295, and registered owners of RISA-2D can purchase it for $895.

For more information on RISA-2D or RISA-3D, contact: RISA Technologies, 26212 Dimension Dr., Suite 200, Lake Forest, CA 92630 (800) 332-7472.

The next two most frequently used analysis programs are both from Computers & Structures. SAP90 received 24 responses and was rated 3.94, while ETABS received 27 responses and a 3.8 rating. ETABS also was mentioned for member design, but these results were not tabulated.

According to its developer, SAP90 is an efficient large capacity structural analysis PC computer program intended for use on projects involving civil structures such as bridges, *dams, stadiums and industrial* plant facilities. Finite element based,this program offers both static and dynamic analyses (either response spectrum or time-history) and a wide range of element types. Additional modules are available that automate the generation of moving loads and influence lines for bridge





Pictured at top is a some data from Enercalc, while pictured above is a screen capture from Metrosoft's ROBOT V6.

analyses and perform AISC steel stress checks using either ASD or LRFD. Included with the package are graphical pre- and post-processing programs, including an interactive input module for Microsoft Windows.

ETABS, according to its developer, provides sophisticated 3D analysis of multi-story building structures, such as office buildings, apartments, hotels and hospitals. This program has been specifically developed to take into consideration the special characteristics that are unique to building-type structures, making it easier and faster for the user to prepare the models and to review the results. AISC stress checks (either ASD or LRFD) of an ETABS model may be done directly by utilizing the STEELER module. Also included in the suite of programs are AutoFLOOR (composite floor design) and AutoETABS, integrated analysis, design and drafting programs operating inside of AutoCAD.

For more information on either SAP90 or ETABS, contact: Computers & Structures, Inc., 1995 University Ave., Berkeley, CA 94704 (510) 845-2177; fax 510/845-4096.

Another program that received a large number of responses for both building analysis and member design is ENERCALC and its structural library, which received 23 responses and a 2.97 rating for analysis and 26 responses and a 3.05 rating for member analysis. Enercalc offers two engineering software systems. According to its developer, the Structural Engineering Library is a "calc-pad" style set of 44 programs for low- to mid-rise building design. Each program is a "fill-in-the-blank" calcsheet for entry and refinement of design data. The system is designed for quickly developing sets of calculations and includes material databases, drawing and stress graphics, automatic design, file management, and flexible printout styles. FastFrame provides 2-D frame analysis, graphics and AISC design/code checks. ENERCALC provides a three-month satisfaction gurantee and free technical support.

For more information, contact: ENERCALC Engineering Software,

Ramsteel from Ram Analysis is a pure member design program and was used by 23 respondents. It was rated 4.2. Most users were highly favorable of this program. Users were especially happy with the support and the user manual. The only drawback mentioned is that it the program is limited to wide flange sections and joists and does not accommodate structural tubes.

According to the program's developers, RAMSTEEL is a special purpose structural engineering program for the analysis, design and drafting of steel buildings. The program does not compete with the various finite element analysis programs available today; rather it is a complementary tool. RAMSTEEL eliminates the process of designing steel purlins, girders, joists, joist girders, columns and base plates. Within the program, the design engineer builds a model of the entire building structure graphically. At that point, the program computes the tributary loads to all members (columns, beams, etc.), reduces the live load in accordance with the applicable code and designs all columns, beams/joists and base plates from roof to base for your structure using either ASD or LRFD methods.

Ram Analysis also offers RAMSBEAM, a full-featured single beam design program. According to the program's developers, it is ideal for designing one beam at a time. RAMSBEAM uses a MS Windows based interactive graphical user interface for entering data. The program designs and analyzes any loading for either steel or steel composite beams and girders. ASD or LRFD designs can be compared at the click of a button. Features include: virtually any loading configuration; cantilever beams; partial or full composite; shored or unshored construction; shear, moment, deflection diagrams with numeric output at any point; composite stud spacing accounts for concentrated loads; deflection criteria specified by user; and depth restrictions specified by user.

For more information on RAMSTEEL or RAMSBEAM, contact: Ram Analysis, 5315 Avenida Encinas, Suite M, Carlsbad, CA 92008 (800) 726-7789; fax 619/431-5214.

ECOM Analysis' programs also received ratings for both analysis and design. ECOM was used by 15 respondents, and received a 3.73 rating for analysis and a 3.43 rating for member design.

ECOM provides a complete integrated library of analysis and design programs including a steel package that allows the user to choose from either the ASD 9th Edition or LRFD 1st Edition. According to the developer, the package includes three modules: SD1C Steel Beam Design, which will design or check simple beams with cantilevers using any standard steel shape; SD2C Steel Column Design, which will design or check columns with axial loads, biaxial moments, and interior moments using any standard AISC shape, as well as design or check base plates; and SD3C Composite Beam Design, which will design or check composite beams, with short- or long-term deflections calculated, as well as the number of shear connectors for partial or full composite action.

For more information, contact: ECOM Associates, Inc., 8324 N. Steven Road, Milwaukee, WI 53223 (414) 365-2100; fax 414/365-2110.

Structural Analysis Inc.'s large library of structural design and analysis programs was mentioned by 14 respondents for building analysis, where it received a 3.11 rating and 18 respondents for member design, where it received a 3.22 rating.

According to the company, SAI offers a large number of personal computer programs for designing plane frames, trusses, beams, composite beams, columns and space frames in accordance with AISC Specifications. Each program is supplied with a menu-driven spreadsheet module with built-in text editor to facilitate input and editing. SAI also sells programs for designing foundations. The company is currently offering a "Buy-One, Get-One Free" sale for its steel design programs.

For a free copy of SAI's 1994 Structural Engineering Software Catalog, contact: Structural Analysis, Inc., 555 South Federal Highway, Suite 210, Boca Raton, FL, 33432 (407) 394-4257.

M-Strudl from CAST also was used by 14 respondents for building analysis and received a 3.07 rating. The general purpose finite element program is capable of solving 5,400 3D joints, 16,000 members, 8,000 plates, thousands of load cases, and hundreds of dynamic mode shapes on the PC. According to its developer, it includes static, P-Delta, and dynamic analysis. It also includes ACI and AISC code checks. Input can be intereactive, from an input file, or generated from AutoCAD. Graphic output of the model, deformed shape, shear and moment diagram is available and the graphic output can be accepted by AutoCAD. Loads include: joint; member; linearly varied; and temperature.

For more information on M-Strudl, contact: CAST, P.O. Box 14676, Fremont, CA 94539-4676 (415) 226-8857; fax 415/226-7328.

IMAGES-3D from Celestial Software was used rated 3.73 by the eight respondents who reported using it.

Images-3D is a general purpose finite element analysis program for the PC. According to its developer, the fully interactive and menu-driven program is ideal for analyzing structures of any complexity by providing linear static, modal, dynamic/seismic and thermal analysis capabilities. The program displays every node and element as the user inputs geometry. With prompts and on-line instructions to help you every step of the way. It contains powerful modeling features like automatic pattern and mesh generations, hidden-line removal, multiple axis images rotation and zoom, and automatic node renumbering for bandwidth optimization.

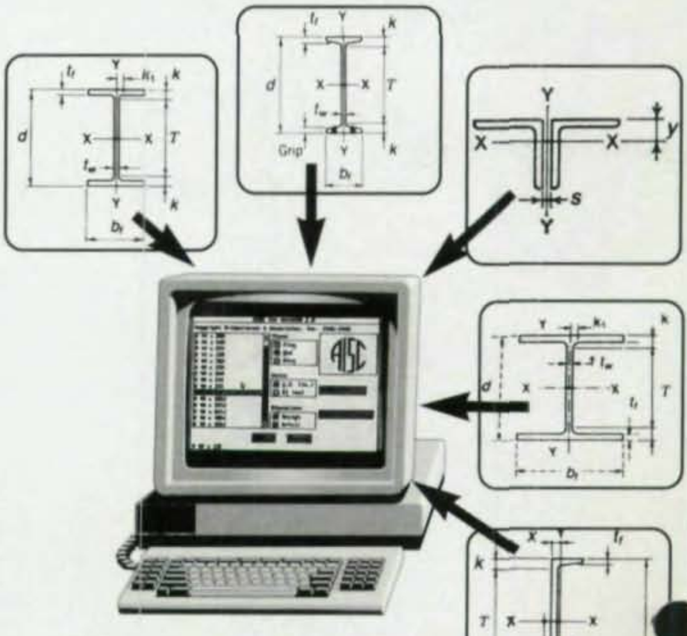
Celestial Software also offers IMAGES-AISC, which performs code checking and translating for CAD programs.

For more information on IMAGES-3D or IMAGES-AISC, contact: Celestial Software, 2150 Shattuck Ave., Suite 1200, Berkeley, CA 94704 (510) 843-0977; fax 510/848-9849.

One new addition to the survey is ROBOT V6 from Metrosoft. This relatively new software package was used by five respondents, who gave it a 4.5 rating. According to the program's developers, ROBOT V6, a fully integrated analysis and design software, is available in 150, 1,500 and 32,500 node capacity packages. Each package possesses the same core program and can easily be upgraded. The program is written in C and C++ and utilizes state-of-the-art programming techniques. It is extremely fast and powerful, yet easy to learn and use. Simple as well as complex problems can be handled with ease. Rapid input creation is possible using CAD-like generating and editing commands (automatic bar, plate, and shell element mesh generation and refinement, multiview displays). Analysis capabilities for 3D bar and finite element models include: linear; non-linear; buckling; and dynamic. Output configuration can be performed with user specified units, selecting, sorting, and printing parameters. Print and save screen capabilities for model input and results. DXF file import and export. Design capabilities include the latest U.S. codes. Also, several foreign code and language supplements are available.

For more information on Robot V6, contact: Metrosoft, 332 Paterson Ave., E. Rutherford, NJ 07073 (201) 438-4915; fax 201/438-7058.

StruCAD*3D, a 3D graphics-oriented suite of programs for structural FEM design and analysis from Zentech was only mentioned by two respondents, and so is not included in the ratings. However, according to the developer, the program performs stress calculations and code checks in accordance with the latest AISC ASD and LRFD Specifications. Included are full AISC section libraries. Analysis includes static, eigen, seismic, P-Delta, wind and gravity load generation; fatigue and steady state analysis; an 3D non-linear soil pile interaction. Moving loads, UBC seismic loads, ANSI wind loads and AASHTO codes are in the latest release. An edu-



AISC for AutoCAD

cational version, with a capacity of 150 nodes and 150 members, is introductory priced at $249 and comes with a 30-day money-back guarantee. A 100% credit is given for an upgrade to the Professional Version, which has a capacity of 6,000 nodes, 12,000 members, 200 load cases and 200 load combinations.

For more information on StruCAD*3D, contact: Zentech, Inc., 8582 Katy Freeway, Suite 205, Houston, TX 77024 (713) 984-9171; fax 713/984-9175.

While the survey was primarily directed towards building engineers, a small number of bridge engineers also responded. The most commonly used bridge program (aside from SAP90, which was not separately considered for bridge vs. building use) was MERLIN DASH, which was mentioned by seven respondents and received a 3.71 rating. The program is available from OPTI-MATE.

MERLIN DASH (Design Analysis of Straight Highway Bridge Systems) is fast running and features an extremely user-friendly menu-driven system, according to the program's distributors. The program performs analysis, optimum design, rating and AASHTO code check for WSD and LSD. Any multiple of HS live load or user-defined vehicles are allowed. An option allows for LRFD loads and load factors. Newer features include: design capability for up to 40-in. rolled sections; pouring sequence analysis including aging of deck; degree of fixity and settlement of supports; and frame simulation.

Also available from OPTI-MATE is SABRE (Sign Bridge Analysis), a program that drastically reduces time to analyze/design highway sign structures and creates more efficient structures, and DESCUS (Curved Girder Bridge Software), a very fast running analysis/design program. According to the program's distributor, DESCUS designs curved and straight rolled beam, welded plate and box girder bridges with variable curvature. Input is data prepared using a menu-driven preprocessor with CAD-like features to view the bridge geometry before analysis. Live loading is automatic and user may input any vehicle configuration; structures may be skewed, bifurcated, composite, and continuous up to eight spans.

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

Other bridge programs that received multiple mentions were CBRIDGE from Telos Technologies (three mentions/3.66 rating), AASHTO's Bridge Design System (5 mentions/4.2 rating), and MDX (four mentions/3.5 rating).

CBRIDGE, the Syracuse University Bridge Design program, is a full featured, 3D bridge analysis and design system for straight or curved girder bridges. According to the program's developers, the rigorous 3D analysis handles both simple and complex highway and rail bridges. Offering standard and custom loadings, vehicles up to 30 axles are automatically positioned on an influence surface. Multiple vehicle types may exist simultaneously. Automatic or user defined dead loads may be used. Mouse-driven graphical interface allows rapid building and editing of design model. AASHTO code check performed during design sequence. A free demo disk is available.

For more information on CBRIDGE, contact: Telos Technologies, 1201 E. Fayette St., Syracuse, NY 13210 (315) 471-0113.

Curved and straight girders also can be designed using MDX's integrated grid analysis and girder design software. According to the program's developers, this PC-based software uses either grid force distribution with influence surfaces or wheel load distribution to develop optimal girder designs that conform to AASHTO specification and the designer's preferences. Generated girders can be easily modified and re-analyzed. Comprehensive tabular output is available, as well as stress and deflection plots, whether developing girder designs or analyzing existing girders. The scope of application includes: plate girders, box girders, rolled shapes, variable horizontal curvature, skewed bents, 1992 AASHTO specification including 1993 interims, and the 1993 Curved Girder Guide Specification. A free trial is available.

For more information on MDX Software, call (314) 446-3221 or fax 314/446-3278.

Only two programs received multiple mentions in the Specialty Category.

CONXPRT, which is marketed by AISC Software, received nine responses and a 3.67 rating. CONXPRT is a knowledge-based PC software system for the design of connections in steel-framed buildings. All strength limit states are checked and expert advice from long-time fabricator engineers is used to augment the design rules. The program incorporates provisions to set dimensional and material defaults for a particular project or general shop needs. Additionally, CONXPRT is menu-driven and incorporates help screens designed for easy use. The program generates cope sizes, allows bolt stagger, and permits different bolt diameters for shop and field use. Tightening clearances are automatically checked. Module 1: Shear Connections is available in both ASD and LRFD versions and costs $300 for each module or $550 for both. Module 2: Moment Connections is available for ASD only and costs $400.

For more information on CONXPRT, contact: AISC Software, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001 (312) 670-2400; fax 312/670-5403.

WEBOPEN, which also is marketed by AISC Software, received seven responses and a 3.64 rating. The program is based on the *AISC Design Guide Steel and Composite Beams with Web Openings* (which is included with the purchase of the software). It is designed to enable engineers to quickly and economically design beam web openings. An expedient tool, WEBOPEN uses state-of-the-art criteria and features a clear and logical data entry system with easy to use color-coded input windows.

Furthermore, it accesses a shape database allowing the selection of any W, S, or M shape for use in the design procedure. The program was written by practicing engineers and incorporates expert design checks and warning messages that enhance the application of the AISC Design Guide to specific problems. Cost for the program is $495.

For more information on WEBOPEN, contact: AISC Software, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001 (312) 670-2400; fax 312/670-5403.

A unique program that was only mentioned by one respondent but which is expected to generate future interest as more structural engineers consider partially restrained connections is PRCONN from the RMR Design Group. According to its developer, the program supports the analysis and design of noncomposite and composite (shored and unshored) beams having typical bolted and/or welded connections, e.g., flush and extended end plates, top and seat, single or double web angles, header plates, and single plates. Composite and noncomposite connection options also include top and seat or seat only combined with the web connections, providing a library of 36 connection types. These connection models are based on a data base developed from laboratory tests and published research. Program screen and output include: beam stresses, connection forces (including bolt, weld, seat and concrete slab/steel forces), and moment rotation curves with superimposed constant and variable load beam lines for the uniform and concentrated load options. The $395 program also supports metric units.

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

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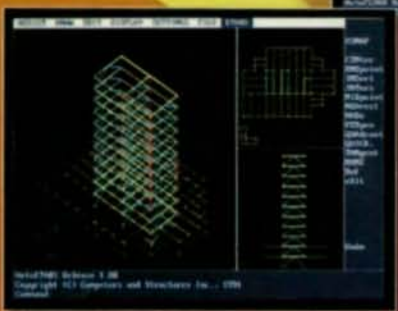
Composite Floor Design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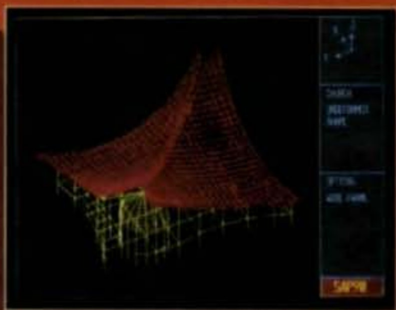
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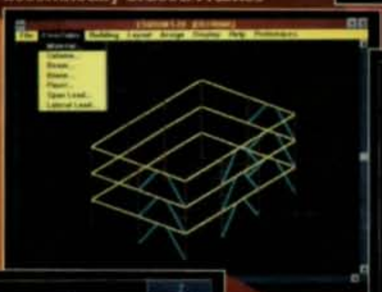
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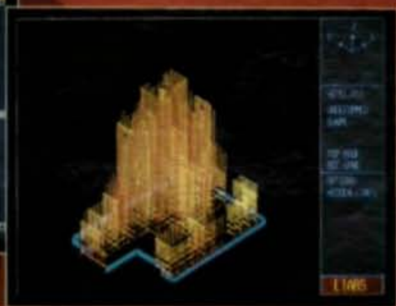
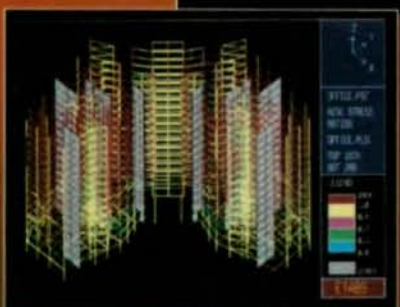

Highrise Moment Frames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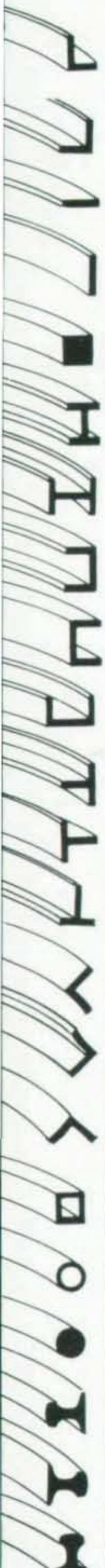

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