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MODERN STEEL CONSTRUCTION

March 1991

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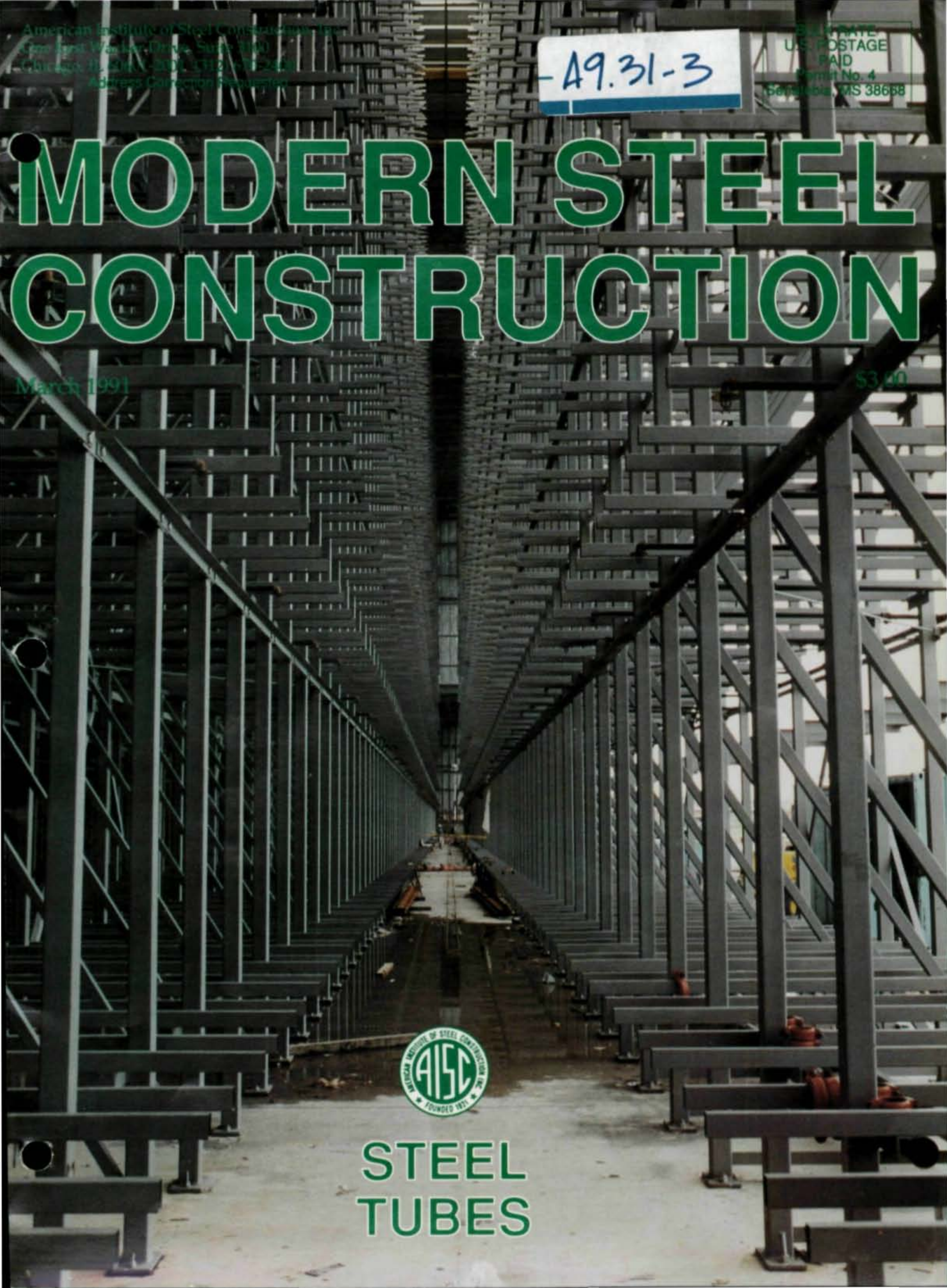


STEEL TUBES

UNITED STEEL DECK, INC.

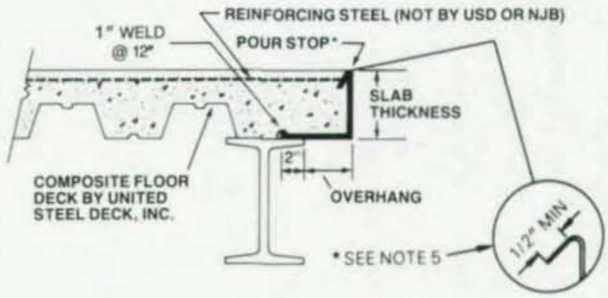
DECK DESIGN DATA SHEET
No. 1

POUR STOP SELECTION CHART

SLAB DEPTH (Inches)	OVERHANG (INCHES)												
	0	1	2	3	4	5	6 POUR STOP TYPES	7	8	9	10	11	12
4.00	20	20	20	20	18	18	16	14	12	12	12	10	10
4.25	20	20	20	18	18	16	16	14	12	12	12	10	10
4.50	20	20	20	18	18	16	16	14	12	12	12	10	10
4.75	20	20	18	18	16	16	14	14	12	12	10	10	10
5.00	20	20	18	18	16	16	14	14	12	12	10	10	
5.25	20	18	18	16	16	14	14	12	12	12	10	10	
5.50	20	18	18	16	16	14	14	12	12	12	10	10	
5.75	20	18	16	16	14	14	12	12	12	12	10	10	
6.00	18	18	16	16	14	14	12	12	12	10	10	10	
6.25	18	18	16	14	14	12	12	12	12	10	10		
6.50	18	16	16	14	14	12	12	12	12	10	10		
6.75	18	16	14	14	14	12	12	12	10	10	10		
7.00	16	16	14	14	12	12	12	12	10	10	10		
7.25	16	16	14	14	12	12	12	10	10	10			
7.50	16	14	14	12	12	12	12	10	10	10			
7.75	16	14	14	12	12	12	10	10	10	10			
8.00	14	14	12	12	12	12	10	10	10				
8.25	14	14	12	12	12	10	10	10	10				
8.50	14	12	12	12	12	10	10	10					
8.75	14	12	12	12	12	10	10	10					
9.00	14	12	12	12	10	10	10						
9.25	12	12	12	12	10	10	10						
9.50	12	12	12	10	10	10							
9.75	12	12	12	10	10	10							
10.00	12	12	10	10	10	10							
10.25	12	12	10	10	10								
10.50	12	12	10	10	10								
10.75	12	10	10	10									
11.00	12	10	10	10									
11.25	12	10	10										
11.50	10	10	10										
11.75	10	10											
12.00	10	10											

TYPES	DESIGN THICKNESS
20	0.0358
18	0.0474
16	0.0598
14	0.0747
12	0.1046
10	0.1345

This chart is a repeat of our first DECK DESIGN DATA SHEET; the format has been revised to make the type (gage) selection easier.



NOTES: THE ABOVE SELECTION TABLE IS BASED ON THE FOLLOWING CRITERIA:

1. NORMAL WEIGHT CONCRETE (150PCF).
2. HORIZONTAL AND VERTICAL DEFLECTION IS LIMITED TO 1/4" MAXIMUM FOR CONCRETE DEAD LOAD.
3. DESIGN STRESS IS LIMITED TO 20 KSI FOR CONCRETE DEAD LOAD TEMPORARILY INCREASED BY ONE-THIRD FOR THE CONSTRUCTION LIVE LOAD OF 20 PSF.
4. POUR STOP SELECTION TABLE DOES NOT CONSIDER THE EFFECT OF THE PERFORMANCE, DEFLECTION, OR ROTATION OF THE POUR STOP SUPPORT WHICH MAY INCLUDE BOTH THE SUPPORTING COMPOSITE DECK AND/ OR THE FRAME.
5. VERTICAL LEG RETURN LIP IS RECOMMENDED FOR TYPE 16 AND LIGHTER.
6. THIS SELECTION IS NOT MEANT TO REPLACE THE JUDGEMENT OF EXPERIENCED STRUCTURAL ENGINEERS AND SHALL BE CONSIDERED AS A REFERENCE ONLY.

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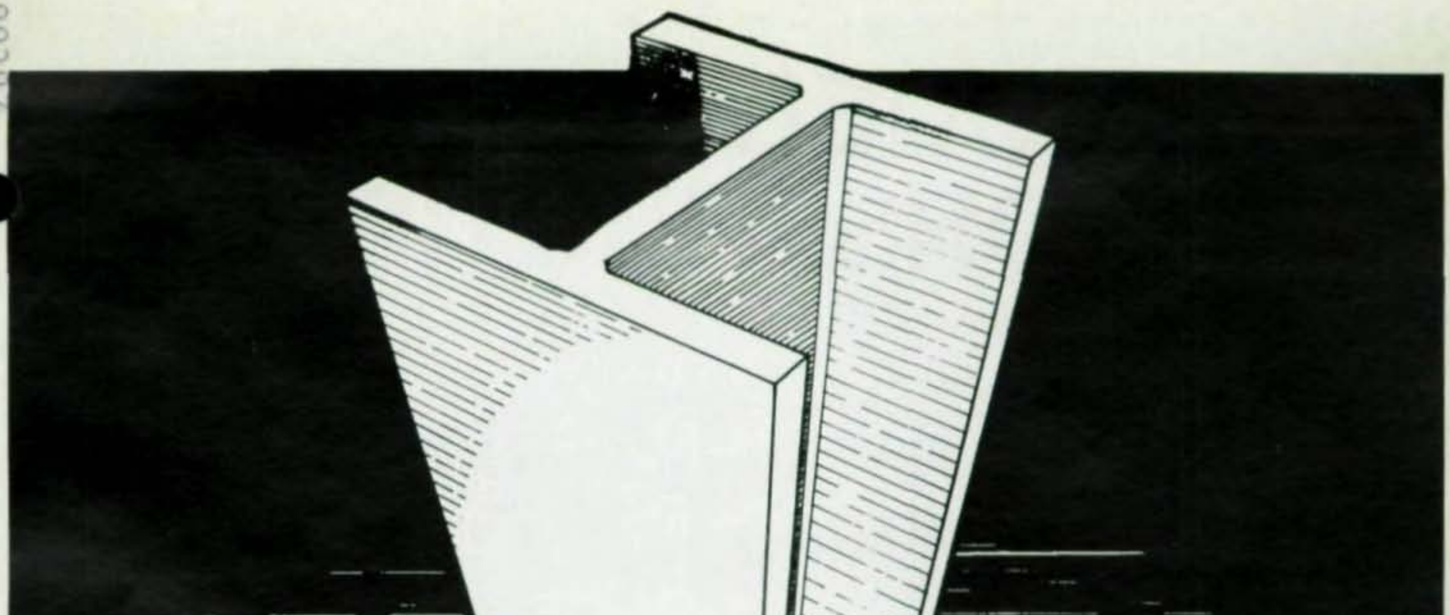

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MODERN STEEL CONSTRUCTION

Volume 31, Number 3 March 1991

More than 4,500 vertical steel elements were used on the Canadian Tire Automated Storage and Retrieval System building. The row-upon-row of structural steel tubing creates a geometric imagery worthy of an Escher painting. A description of this project begins on page 28. And, for a glimpse of how structural steel tubing is manufactured, turn to page 42.

FEATURES

17 BIDDING ALTERNATE DESIGNS FOR BRIDGE CONSTRUCTION
Innovatively utilizing the FHWA-required alternate designs can be the difference between an average bid and the lowest bid

23 UPSIDE-DOWN CASTING COMBINES ADVANTAGES OF STEEL AND CONCRETE
A proprietary composite bridge system reduces costs, speeds construction and improves deck performance

28 TOTALLY TUBULAR
Rectangular tube steel provides the most efficient structural system for automated storage warehouses

34 INNOVATIVE DESIGN SPEEDS CONSTRUCTION, CUTS COSTS
Using free-standing steel tube columns was crucial to the creation of a new budget hotel by the founder of the Holiday Inn chain

39 DEMONSTRATING TUBES CAPABILITIES
A manufacturer of steel tubes used its own expansion as a field laboratory

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A photographic display demonstrates step-by-step the process of converting steel coils into finished tubing

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It's Not Just Retail Anymore

One of the advantages of working on a monthly magazine devoted to the fabricated steel industry is the opportunity to see how different building types relate to each other. This morning I was examining an early copy of the February issue on Retail Construction, putting the finishing touches on the March issue on Structural Steel Tubing, and starting to work on next month's issue on Airport Construction.

I happened to glance at a picture of the Oglethorpe Mall in Savannah, GA, and immediately noticed that the atrium framing consisted of steel tubing. Well, that made sense. Whenever tubing is mentioned, I immediately think of the exposed hollow structural sections seen in so many malls today.

But then it dawned on me that in our Steel Tube issue, we didn't write about any retail applications. Instead, we wrote about a warehouse, a motel, and a manufacturing facility. And in thinking about airports for the April issue, I realized that an increasing number of terminals are utilizing steel tubing—including the award-winning United Airlines terminal at O'Hare International Airport, which was featured in the November/December 1990 issue.

I quickly gave a call to Fred Palmer, director of the American Institute for Hollow Structural Sections, and asked if tube use was rising. While he couldn't offer historic data, he did unequivocally state that inquiries about tubing from fabricators, architects and engineers was on the rise. Estimates of total use range from 3% to 8% of the fabricated steel industry in the U.S., which is low compared with the 20% usage in Canada and 15% to 20% usage in Europe.

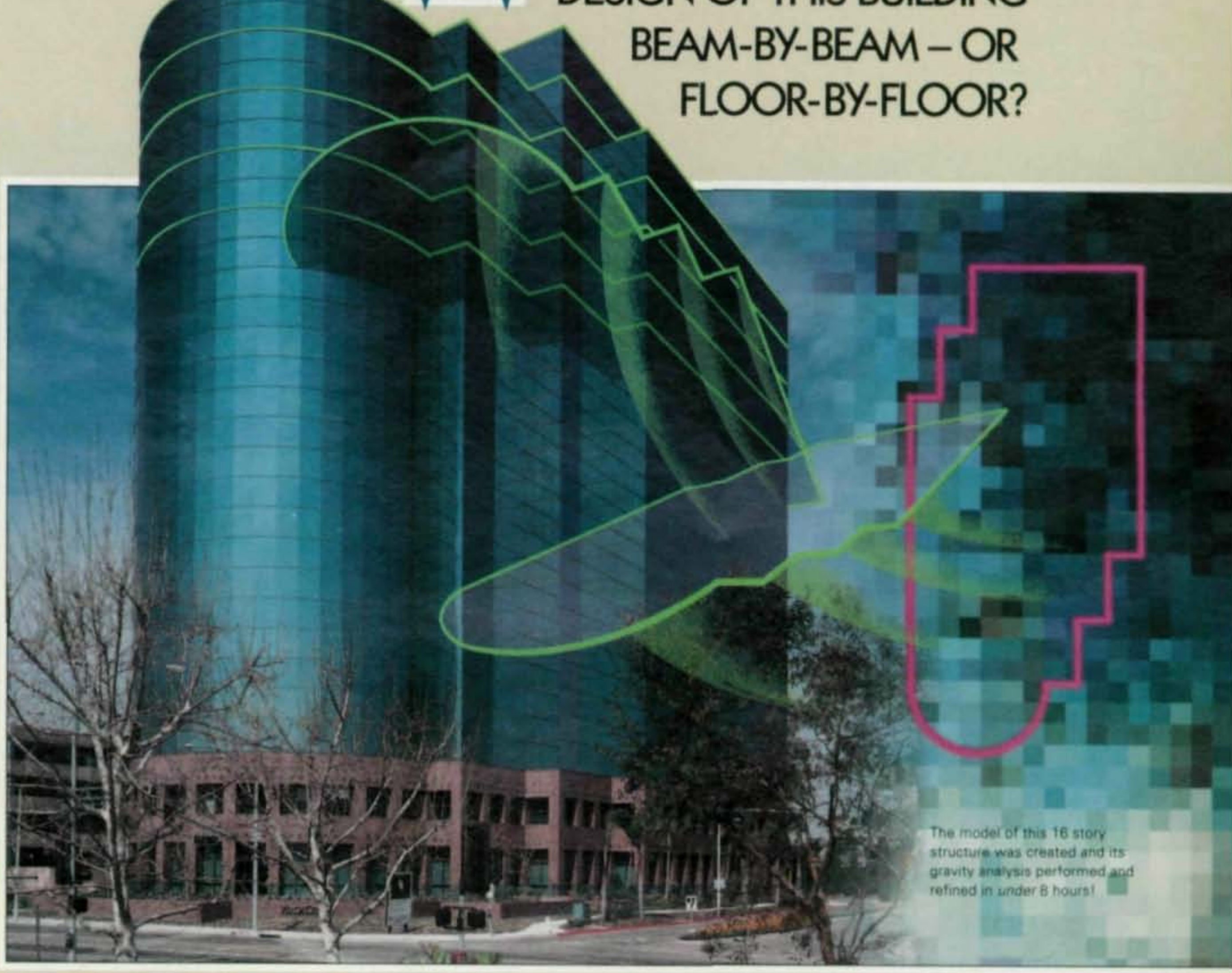
And he confirmed that steel tubes weren't just for retail applications. "Tubing is at its best in long columns—compression members," Palmer told me. "Warehouses are a natural, as are any large open spaces."

Some people hesitate to use structural tubing because of their concerns about connections. But Palmer says that the connection between a tube and a wide flange is identical to that of a wide flange to a wide flange. The difference is that people are simply less familiar with a material that was only introduced to this country in the mid-1960s, versus the wide-flange shape that dates back almost to the turn-of-the-century.

Help is out there. For example, Palmer's group has produced some technical literature, with more on the way. And at this year's National Steel Construction Conference in Washington, DC, a seminar will be offered on "Simple Connections in Tubular Construction" (for more information, see page 10).

For immediate information on tube steel, contact: American Institute for Hollow Structural Sections, 929 McLaughlin Run Road, Suite 8, Pittsburgh, PA 15017. **SM**

WOULD YOU RATHER DO THE STRUCTURAL DESIGN OF THIS BUILDING BEAM-BY-BEAM – OR FLOOR-BY-FLOOR?



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Non-member	$95
Including Manual	$145
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Including Manual	$110

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name	☐	☐	#________	$
name	☐	☐	#________	$
name	☐	☐	#________	$
			Total	$____

Mail this form with your check (Payable to AISC) or credit card number to: AISC-LRFD Lectures, P.O. Box 806286, Chicago, IL 60680-4124 or FAX 312-670-5403

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Card # ____________

Signature ____________

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*Manuals will be mailed to company contact.

The first sessions of AISC's new lecture series, *Practical Steel Design Using LRFD*, were tremendously successful, according to Robert Lorenz, AISC director of education and training. Attendance has averaged nearly 75 engineers at each session.

The lecture program is designed to help structural designers become more familiar with Load and Resistance Factor Design. The lecture includes the design of a steel frame for a four-story office building. A set of design notes, including pertinent calculations, outline the LRFD process. The lecture begins with a description of the project as well as a short review of principles, and also covers the topics of roof and floor design, and framing systems and connections.

The design notes handout provides realistic design solutions not found in manuals and textbooks. The analysis includes evaluation of various load combinations as required for the 100' x 150' building and the utilization of design limit loads for components and frames.

In evaluations, attendees reported that the handouts and slides will prove invaluable to their future practice. "These kind of meetings are very helpful to practicing engineers like me, who like to be in touch with the latest design methods," wrote one attendee in Pittsburgh.

Fees are $65 ($110 with Manual) for AISC members and $95 ($145 with Manual) for non-members. To register, send the adjacent form to: AISC-LRFD Lectures, P.O. Box 806286, Chicago, IL 60680-4124. For more information, call (312) 670-5422.

Seminar Schedule

West

Salt Lake City (3/7); Irvine, (3/28); Seattle (4/24).

Midwest

Milwaukee (3/21); St. Louis (4/2); Minneapolis (4/4); Grand Rapids (4/9); Detroit (4/10); Kansas City (5/2); Indianapolis (5/7); Cincinnati (5/8); Columbus (5/9);

South

Orlando (3/6); Greenville (3/12); Charlotte (3/14); Knoxville (3/20); Birmingham (3/26); Raleigh (4/9); Richmond (4/11); Oklahoma City (4/16); San Antonio (4/23); Albuquerque (4/25); San Juan (5/21); Columbia (T.B.A.); Norfolk (T.B.A.); Wilmington (T.B.A.);

East

Baltimore (3/6); Washington, DC (3/7); Harrisburg (3/12); Philadelphia (3/13-14); New York (3/19-20); Newark (4/24); Buffalo (5/14); Rochester (5/15); Syracuse (5/16).

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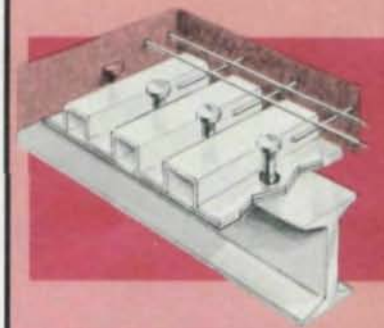
Applications



Composite Bridges – Shear connectors provide equal shear in all directions, eliminate distortion that might result from hand welding and permit more satisfactory compaction of concrete around the connectors.

Composite Buildings – Shear connector studs welded to the beam or through a permanent form steel deck result in increased live load capacity. As much as 20% less steel may be used and shallower floor sections reduce building height.

Retrofitting – Bridge retrofitting usually involves removing the old concrete and replacing it with new concrete tied to the beam with stud welded shear connectors.
Applying new facia and interior retrofitting of old buildings requiring installation of new electrical fixtures, sprinklers and piping can be accomplished by welding threaded studs to structural members.

Concrete Anchoring – Stud welded headed concrete anchors deliver specified axial tension and shear strength values and can be applied up to three times faster than hand welded anchoring devices. Other advantages include much higher yield points, elimination of costly set-up time for shearing and bending, stronger welds, reduced material handling and no distortion.

Insulation/Lagging – Stud welded fasteners secure all types of insulation material in all density ranges faster, easier, more economically and better than any other methods.

Precast/Prestressed – Because of their known values, anchor studs can be used in standardized designs for such connections as bearing plates for beams and tees, shear keys for tees, column baseplates, and various other embedded steel elements. In these applications, stud welding reduces cost per plate, ensures consistently high weld quality, frees certified welders for other jobs, eliminates long lead time and storage problems.

Electrical/Mechanical – Threaded studs and a variety of stud configurations are used to fasten conduit clamps, lighting fixtures, outlet boxes, sprinkler systems, cable runs and piping. Fast positive attachment is achieved without holes or costly clamping devices.

Other cost saving construction applications are securing concrete forming and timber shoring, wood nailers, crane and guide rails, grating, refactory and wear resistant materials.

Video Review:
"Today's Structural Steel"

By Robert Lorenz, P.E.

For those who require an audio-visual update to their structural steel educational file, the Architectural/Engineering Department of Penn State has produced a wonderful 33-minute videotape that should do the job. Titled "Today's Structural Steel", it presents a quick—though surprisingly comprehensive—overview of the role of structural steel in the construction industry.

The narrator is Patty Satalia, and she provides a professional and informative commentary from various job site locations. The introduction is a collage of industry scenes with the World Trade Center as a symbolic focus of activity. Also included are historic snippets from films of the erection of the Empire State Building—scenes from the 1930s with its emphasis on the old, hot rivet days.

The film then shifts venue to provide a glimpse of a mill operation, and this segment opens with an exciting shot of glowing, molten steel. For anyone who thinks of the steel industry as boring or humdrum, these powerful images should quickly dispel that false notion.

The centerpiece of the story is the fabrication shop. The camera zooms in to look over the shoulder of the computer operator as machine instructions are punched in. Steel shapes are then automatically drilled and cut. And the latest in bolting and welding techniques are demonstrated.

Steel erection gets equal time in footage using the helicopter-assisted setting of the CN Tower mast and pre-assembly of the Seattle Space Needle restaurant as dramatic counter-points. In addition, field cutting of intolerant fit-ups gives insight into real world problems.

Wrapping-up the film are some comments from industry experts warning of false economies from the overuse of computers and the need for professionals to know the limits of the industry's tools and machines.

This short film is extremely well done. It avoids the broad cliches found in self-serving industry promotion pieces. Likewise, neither does it descend into mindless technical jargon.

Steel fabricators and others may wish to use this film at business lunches and community meetings. Steel educators can use it as a supplement to other teaching aids. All-in-all, it presents a message from the steel industry that today's technology is the result of the right mixture of innovation and common sense.

Copies of this tape can be obtained by sending $25.00 ($60.00 outside the U.S.) to: Abbas Aminmansour, Architectural/Engineering Dept., The Pennsylvania State University, 104 Engineering Unit A, University Park, PA 16802 (814) 865-9281. ☐

Robert Lorenz is director of education and training at AISC.

Steel Bridge Symposium

This year's Prize Bridge Awards will be presented at the 1991 National Symposium On Steel Bridge Construction in St. Louis. The presentation, one of the highlights of the two-day symposium, will be made during a banquet on September 16.

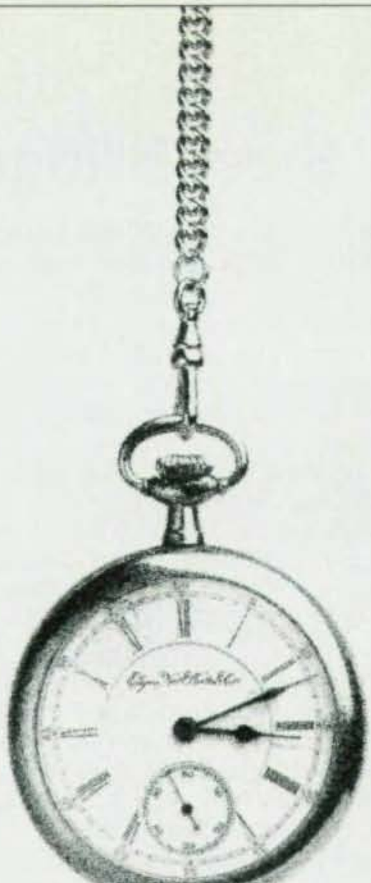
Previous winners have ranged from such historic structures as the Golden Gate Bridge at San Francisco to smaller projects such as the Trinity Church Pedestrian Bridge near Wall Street in New York City. (See pages 13-14 of this issue for an entry form.)

While speakers have not yet been announced, sessions are scheduled on a wide range of topics, including: seismic design; bridge paints and coatings; steel bridge aesthetics; short span bridges; economical detailing and connections; fatigue-resistant details; and long-range FHWA research.

In addition, a panel discussion is scheduled on the subject of designing for constructability and a session is planned on the design of bridges in France.

Prior to the symposium, a workshop will be held on bridge painting. On the Wednesday after the symposium ends, there will be an in-depth, full-day workshop on the subject of fatigue resistant details by Professor Peter Keating of Texas State A&M University, College Station, TX, a recognized authority on the subject.

To receive registration materials for the symposium, contact Lew Brunner, American Institute of Steel Construction, Inc., One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001 (312) 670-5420. ☐



Steel Events

The *Steel Structures Painting Council (SSPC)* will hold its Fourth Annual Conference on Lead Paint Removal from Industrial Structures at the Omni Charlotte Hotel in **Charlotte, NC** on **March 18-20**. The conference will include panel discussions and case histories.

On **April 29-May 3**, *SSPC* will hold a Conference on Coatings Evaluation and Durability at the Westin William Penn Hotel in **Pittsburgh**. The purpose of the conference is to assess the state of the technology and reach a consensus on testing and reporting methodology.

As part of the International Bridge Conference, *SSPC* will hold a seminar and forum on "Maximizing the Service Life of Bridge Coatings" at the **Pittsburgh** Hilton Hotel on **June 12-14**.

For information on these SSPC activities, contact: Rose Mary Surgent, SSPC, 4400 Fifth Ave., Pittsburgh, PA 15213-2683 (412) 268-2980.

The *AWS International Welding Exposition and Convention* is scheduled for **April 16-18** in **Detroit**. More than 100 in-depth seminars and conferences are planned, and the exposition will include more than 400 exhibitors.

For more information, contact: AWS, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, FL 33135 (800) 443-9353.

The *1991 National Steel Construction Conference*, the industry's only "All-Steel" conference, is scheduled for **June 5-7** in **Washington, DC.** More than 20 informative seminars are scheduled, and more than 70 exhibitors will be present.

For more information, contact: David Wiley, AISC, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001 (312) 670-5422. □

AISC 1991 Prize Bridge Competition

Eligibility

To be eligible, a bridge must be built of fabricated structural steel, must be located within the United States (defined as the 50 states, the District of Columbia, and all U.S. territories), and must have been completed and opened to traffic from July 1, 1986 through May 1, 1991.

Judging Criteria

Will be based primarily upon aesthetics, economics, design and engineering solutions. Quality of presentations, though not a criterion, is important.

Award Categories

Entries will be judged in one or more categories, but may receive only one award.

Long Span One or more spans over 400 ft. in length.

Medium Span, High Clearance Vertical clearance of 35 ft. or more with longest span between 125 and 400 ft.

Medium Span, Low Clearance Vertical clearance less than 35 ft. with longest span between 125 and 400 ft.

Short Span No single span greater than 125 ft. in length.

Grade Separation Basic purpose is grade separation.

Elevated Highway or Viaduct Five or more spans, crossing one or more traffic lanes.

Movable Span Having a movable span.

Railroad Principal purpose of carrying a railroad, may be combination, but non-movable.

Special Purpose Bridge not identifiable in one of the above categories, including pedestrian, pipeline and airplane.

Reconstructed Having undergone major rebuilding.

Entry Requirements

All entries must contain an entry form, photographs and a written description of the project.

1. *Entry form:* All information requested on the form must be completed in full.

2. *Photographs:* Professional quality 8x10 color prints of various views showing the entire bridge, including abutments, 35 mm slides should also be submitted if available. All photographs must be cleared for use by AISC.

3. *Description:* Explanation of design concept, problems and solutions, aesthetic studies, project economics and any unique or innovative aspect of the project. Include no larger than 11x17 drawings showing elevation, framing system and typical details.

Method of Presentation

Each entry should be submitted in an 8½" x 11" binder, containing transparent window sleeves for displaying inserts back to back. The entry form included in the brochure must be easily removable, so that the identification of the entry can be concealed during judging. All information requested on the entry form must be included.

Awards

The winners will be notified shortly after the June judging. Public announcements of the winners will be made in the September issue of *Modern Steel Construction* magazine. Award presentations will be made to the winning designers during the National Steel Bridge Symposium, September 16, 1991, in St. Louis, MO.

Deadline for Submission

Entries must be postmarked on or before ***May 24, 1991****, and addressed to: American Institute of Steel Construction, Inc., Attn: Awards Committee, One East Wacker Drive, Suite 3100, Chicago, IL 60601-2001. For further information, call 312/670-2400.*

AISC 1991 Prize Bridge Competition

Entry Date__________

Name of Bridge__________ Completion Date__________

Location__________ Date opened to traffic__________

Category in which entered__________ Approx. total cost__________

Span lengths__________ Roadway widths__________ Steel wt./sq. ft. of deck__________

Vertical clearance__________ Steel tonnage__________ Painted: Yes__________ No__________

Structural system(s) (describe briefly here)__________

Innovative Concepts__________

Descriptive data: Attach separate sheets (see entry requirements)

No. of photographs enclosed: Color prints__________ 35 mm slides__________

Design Firm:__________ Phone

Address:__________ Street: City and State Zip

Person to contact:__________ Title

Consulting Firm (if any):__________ Phone

Address:__________ Street City and State Zip

Person to contact:__________ Title

General Contracting Firm:__________ Phone

Address:__________ Street City and State Zip

Person to contact:__________ Title

Steel Fabricating Firm:__________ Phone

Address:__________ Street City and State Zip

Person to contact:__________ Title

Steel Erecting Firm:__________ Phone

Address:__________ Street City and State Zip

Person to contact:__________ Title

Owner:__________ Phone

Address:__________ Street City and State Zip

Person to contact:__________ Title

This entry submitted by:

Name:__________ Title

Firm:__________ Phone

Address:__________ Street City and State Zip

(ADDITIONAL ENTRIES MAY BE SUBMITTED ON COPIES OF THIS FORM)

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- **Surveyors Expo** for surveyors
- **CAS (Computer-Assisted Specifying)**
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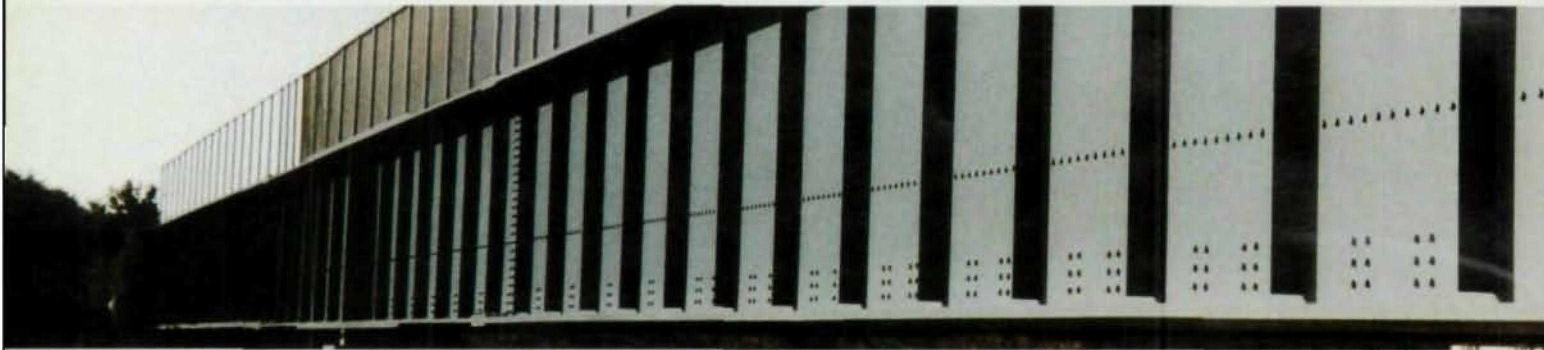

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Bidding Alternate Designs For Bridge Construction

By Robert J. Desjardins

To foster more efficient and less costly design, the FHWA requires that bridge projects with an estimated cost of more than $10 million be put out to bid with at least two alternate designs, usually with one steel and one concrete design. In addition, contractors often are allowed to prepare and bid on their own alternate designs. This option sometimes is crucial because one of the state's alternate designs often is less efficient than the other.

Cianbro Corporation, a large bridge contractor headquartered in Pittsfield, ME, has been bidding alternate designs for more than 11 years. Our first alternate bid was for a 3,000'-long bridge in Chesapeake, VA, in 1979. We were the low bidder at $9,836,000 using precast concrete AASHTO beams for the approach spans, and steel beams for the three center spans. Since that time, we have bid on many bridges for which the owner has prepared alternate designs.

> We were shocked when the bids were opened and the lowest bid was on a contractor designed alternative.

Bid Failure

We became interested in submitting our own alternate designs after *not* receiving a contract in Tennessee in 1981. We hadn't given the option of preparing an alternate design much consideration and were shocked when the bids were opened and the lowest bid was on a contractor-designed alternative. The low bidder won by bidding the state's steel design with modifications consisting of increasing the span lengths to eliminate several piers.

Shortly after that, we were the low bidder on two projects using an alternate design prepared by a consultant hired by us.

The first was the 1,550'-long Bangor-Brewer bridge advertised by the Maine DOT in early December, 1983. The state prepared a design using conventional steel girders, and T.Y. Lin prepared a design using a cast-in-place segmental concrete superstructure. The state also allowed bidders to submit their own alternatives.

We retained the services of Figg & Muller Engineers of Tallahassee, FL, and Paris, France, to prepare an alternate design using a precast segmental concrete superstructure. This design eliminated one land pier on the Bangor side, and moved one water pier to land by increasing the main span to 430', from 300' in the state's steel design.

Lowest Two Bids

Because alternative designs are subject to the state's approval, we bid both our alternative and the state's steel design. When bids

Robert J. Desjardins is executive vice president with the Cianbro Construction Corporation, Pittsfield, ME. This article is adapted from a talk he presented to the New England Steel Bridge Conference on September 27, 1990.

A segmental concrete bridge over the Albemarle Sound in Edenton, NC, was completed two years behind schedule and with claims totaling 61% of the original contract price.

signed alternatives.

After reviewing the bid documents and preparing preliminary estimates for the various options, we decided not to prepare our own alternative since the state's design's were very cost effective. Because of the large number of state-provided alternates, we opted to bid on only the most cost-effective, which turned out to be the segmental concrete option in the amount of $22,389,000. The seven lowest bids were only separated by an aggregate amount of approximately 11%, and no bids were received for contractor-designed alternatives.

Over Budget And Behind Schedule

We were awarded the project and the Notice to Proceed was issued in March 1985. The bridge was opened to traffic in June 1989, *two years after the scheduled opening date.*

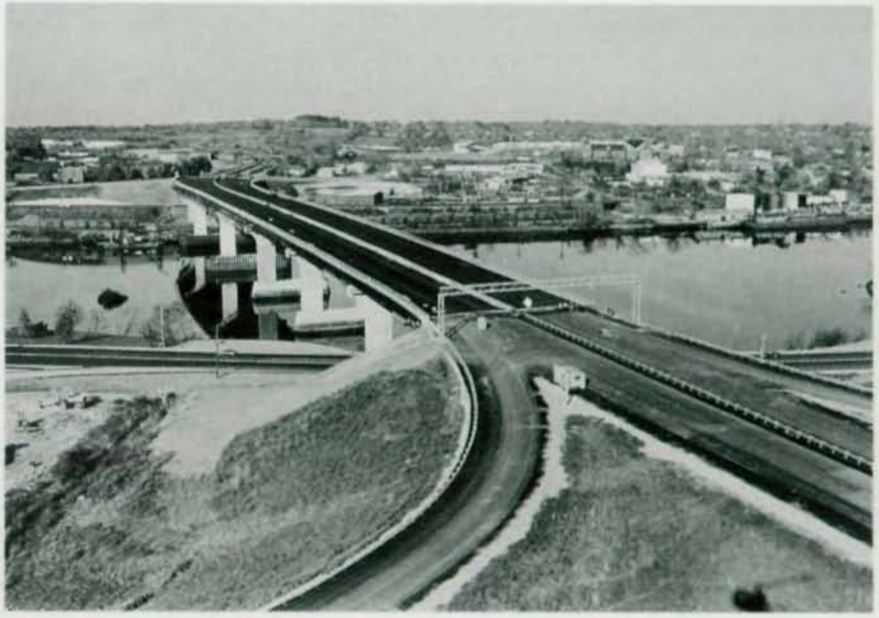
During construction we suffered delays caused by numerous problems resulting from inadequate design and incomplete plans and specifications.

Because of the design problems, we were directed to perform a substantial amount of extra work. We have submitted claims for these delays and extra work totalling $13.8 million.

Our experience on this bridge is similar to that of other contractors working on segmental concrete bridges. The final cost of these bridges is usually substantially more than the original bid price. The November 2, 1989 issue of *ENR* contained a cover story entitled "Segmental Bridges—A Question of Constructability". The article stated:

"State departments of transportation say that contractor's claims on segmental elevated highways and bridges run far higher than other types of construction. For example, 10 segmental bridges with bid prices totaling $242 million generated a total of $101 million in claims. On one bridge, the contractor is asking for nearly 50% more than the contract sum. Contractors contend that the claims result from designs that are incomplete or not constructable."

Claims on our North Carolina project total 61% of the original contract price. When bidding for a bridge, it is essential that the final cost of the project be considered.



Maine's 1,550'-long Bangor-Brewer Bridge was Cianbro's first successful project using an alternate design. The steel bridge was completed on time and on budget. Photo courtesy of the Bangor Daily News.

were opened in February, 1984, our alternative was the low bid at $13,882,000, while our steel bid was the second lowest at $13,939,000. The specifications allowed a 45-day review period following bid opening for the state to decide if the alternative design was acceptable, and after the review and several meetings with us and our designers, the state elected to award us the project based on our bid for the state's steel design at an additional price of $57,000. Construction proceeded with no significant problems or claims, and the bridge opened to traffic on schedule in November, 1986.

In hindsight, after looking at the problems on other segmental concrete bridge projects, this turned out to be a very wise decision.

Imperfect Process: Contractor Beware

Not everything works out perfectly with contractor-designed alternatives, however. The second job we bid using a contractor-designed alternative was the Dame Point Bridge in Jacksonville, FL. Again, we engaged the services of Figg & Muller Engineers. Their design for the approach span contract provided for the use of modified AASHTO beams with an integral deck. They also made substantial changes to the superstructure design.

When the bids were opened in November, 1984, our bid of $24,049,000 was the lowest submitted for the approach span contract. We were shocked when the Jacksonville Transit Authority later announced, after review, that the contract would be awarded to the seventh lowest bidder. No explanation was forthcoming, though we suspected they were influenced by their personal preferences for that contractor. While we didn't get the job, we did succeed in recovering our expenses in the amount of $750,000.

In 1985, we discovered firsthand the problem with segmental concrete bridges. Cianbro and our joint venture partner from Texas submitted a bid for the construction of a bridge over Albemarle Sound in Edenton, NC. This was a new 18,500'-long bridge consisting of low-level approach trestles and a high-level center section over the navigation channel. The state provided some 16 bid alternatives, as well as allowing contractor-de-

Two factors need to be considered when evaluating structural steel and segmental concrete designs:

- The increased inspection costs incurred by DOT on segmental concrete designs;
- The major delays and claims resulting from segmental concrete construction, which has not occurred with more conventional designs.

I am aware of claim settlements on three major segmental bridge projects. If these settlements of $16 million, $8.2 million, and $6.4 million were added to the original low bid, the segmental bridge option would not have been low at all.

The problem may take care of itself as more contractors that have built a segmental concrete bridge decide not to bid on another one because of the problems encountered, difficulties in resolving claims, and the long delay in collecting final payment. However, it is important that DOTs spend more money during the design stage to make sure that the design is complete and is constructable. Also, the total cost of a project should be evaluated before deciding between alternate bids. The total cost should include design review and inspection costs as well as the construction cost.

State DOTs also need to design more competitive steel alternatives. We bid on the Baldwin Bridge for the Connecticut DOT in December 1989. The state provided alternate designs for structural steel and segmental concrete construction. Cianbro and our joint venture partner from Kansas City were the low bidder for the structural steel option at $99,985,000, but lost out to the only bidder on segmental concrete at $95,807,000.

While it may not have effected whether or not we were the low bidder, we did note several requirements of the steel design that made it less competitive than concrete. These included:

- Shop painting of ASTM A588 weathering steel. Our bid included approximately $2.5 million for shop painting. We feel that the painting could have been eliminated. If painting was necessary for some reason, then A572 steel should have been specified, which would have saved more than $500,000.
- The steel design required installation of an inspection walkway under the bridge. The design of this walkway required a substantial amount of field welding, and was very difficult to install. The design also required the use of fiber glass grating. Total cost of this walkway was $870,000. A more efficient and simple design would have cut this cost in half, to approximately $435,000. In addition, a movable platform system was specified that cost approximately $2 million. We question the need for such an elaborate inspection system, as we haven't seen it used on other bridges we've bid.

•The crossframes were specified to be installed using field welded connections. Field bolted connections would have saved approximately $380,000.

In addition to the specifics I cited for the Baldwin Bridge, we've noticed that one of the biggest problems in bidding alternate designs is that the various designs are not always comparable. Differences include:

• Different estimated pile lengths. One designer assumes the piles will reach refusal at a higher elevation than the other designer.
• Different pier designs. One designer will have a less cost-effective design (size, shape, etc.).
• Different span lengths. One designer will have a more efficient design, which results in fewer piers.

I believe it is extremely important for the state DOT to closely review alternate designs being prepared for the same project to ensure that each design is as efficient as possible. This is very important, especially because of the growing number of contractors only bidding the steel design because of the difficulties normally encountered in constructing a segmental concrete bridge.

Preparing more efficient designs would eliminate the need for costly contractor-prepared alternatives. Our own company is no longer interested in preparing contractor alternative designs because of the high cost of preparing these designs, the added design liability risk we would incur, and the bad experience we've had on previous jobs.

Other Suggestions

Three more suggestions for improving the design and construction of bridges:

• The use of design competitions. This practice is fairly common for major building projects, but is rarely used for bridges. This procedure would allow the submission of preliminary designs by several designers, after which the DOT would select the best design, and only that designer would prepare detailed plans.
• Constructability reviews during the design stage. Cianbro has done a number of these at the request of a designer or owner. We are generally asked to review the plans at various stages and make suggestions that might make construction easier and less costly.
• Value engineering clauses. We have used value engineering very successfully on a recent bridge rehabilitation project in New York. The plans called for a precast concrete deck because of the limited time available to remove the existing deck and construct the new one. We felt that we could give the owner a better schedule using cast-in-place concrete. We submitted a value engineering proposal that saved nearly $140,000, and this proposal was accepted. ☐

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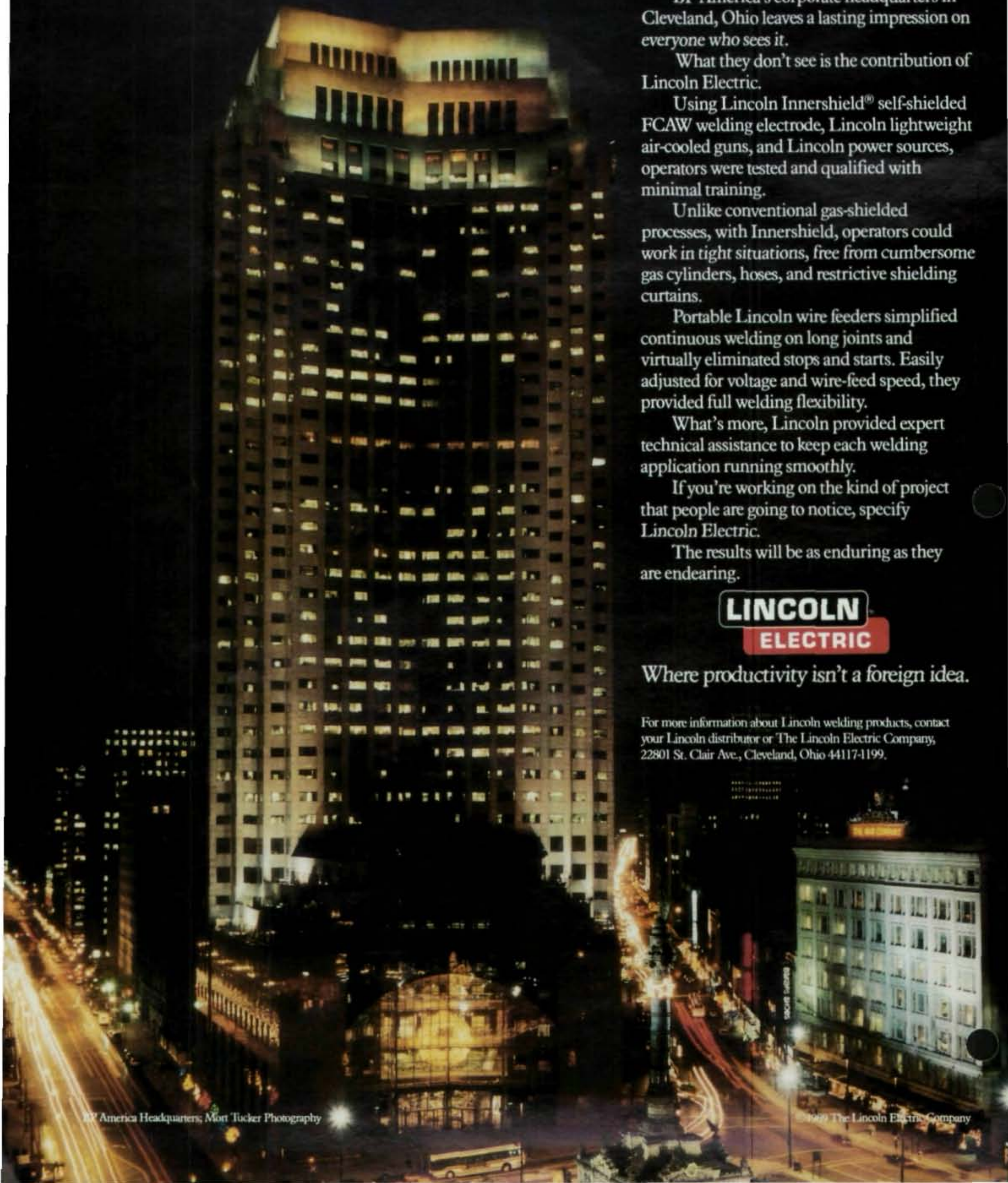

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Upside-Down Casting Combines Advantages Of Steel And Concrete

A proprietary composite bridge system reduces costs, speeds construction and improves deck performance

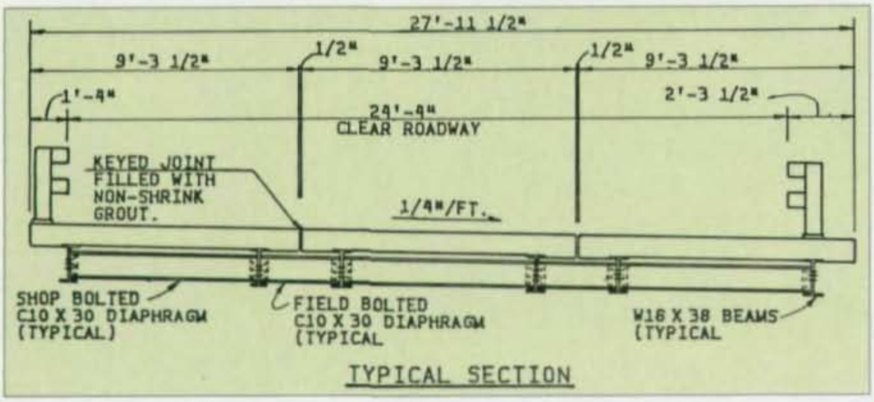
By Stanley J. Grossman, P.E.

When a major route to the ski resorts in Upstate New York was hampered by a deteriorated bridge, the New York DOT turned to an "upside down" bridge to quickly and inexpensively remedy the problem.

The steel-beam Horseshoe Bridge across Spruce Creek on busy Route 23A in Greene County, NY, was originally built in the 1930s. But by 1987, it had deteriorated to such an extent that it was posted for seven tons, which was a significant impediment to traffic.

After carefully considering replacement options, the New York DOT chose INVERSET, a proprietary pre-stressed, composite steel bridge system. The contract was awarded to Eastern States Construction Co. of Upper Nyack, NY, with the stipulation that the road could not be closed for more than three weeks. Three 9' 3 1/2"-wide by 31'-long units were ordered from The Fort Miller Co., Schylerville, NY, which holds a license to make and distribute this type of

Faced with a deteriorated, load-reduced bridge (left), the New York DOT opted chose a cost-saving INVERSET system for the replacement bridge (above).



The new bridge has three 9'-3½"-wide by 31'-long units, each consisting of two W16x36 steel beams supporting an 8½"-thick slab. The cost of the superstructure, excluding the rehabbing of the abutments, was $60,000, or $70/sq. ft.

structural unit in nine northeastern states. Steel fabricator was AISC-member Schenectady Steel Co., Schenectady, NY.

Each unit consisted of two W16 x 36 steel beams supporting an 8 1/2"-thick concrete slab. While the previous 37 bridges of this type used a 7" slab, the minimum thickness allowed by New York DOT is 8 1/2".

Following a procedure developed by Grossman & Keith Engineering Co., Norman, OK, Fort Miller cast the units upside-down in their plant. The forms were suspended from the beams, which were supported at extended ends beyond the ends of the form. In this position, the weight of the form, beams, and wet concrete stressed the steel beams producing compressive stress in what would be the bottom flange when the unit is turned over.

Increased Strength

When the concrete hardened, the unit assumed the greatly increased sectional properties of a composite member instead of those of the beams alone. As a result, after the unit was turned over, the bottom flange had approximately a zero stress leaving almost the entire allowable stress range to resist the live load plus impact stresses. As well as having the composite section support all of the dead loads, this "prestressing" of the steel results in approximately a 30% reduction in the weight of the steel beams.

The concrete also benefits from being cast upside down. The process of turning the unit over induces longitudinal compressive stress in virtually the entire slab, producing a crack-resistant deck with sufficient residual stress to even allow the unit to be supported at its middle and still have the deck remain in compression throughout.

Another advantage of upside-down casting is reduced water permeability. During casting, small air bubbles trapped in the concrete rise to the top, thereby increasing water permeability. By casting the concrete upside down, the air bubbles form on what will eventually be the bottom of the slab instead of the top. A test conducted on a sample 4"-diameter, 8"-high cylinder showed substantial differences between the top and bottom. A testing lab determined that a 2" slice off the bottom was 50% less permeable than a 2" slice off the top.

Upside-down casting also increases the density of the concrete wearing surface, providing increased resistance to deck deterioration. Further, as was done with the Horseshoe Bridge, a form liner can be used to mold a rough texture into the wearing surface so that the deck is ready immediately for traffic.

Steel Structure Cuts Costs

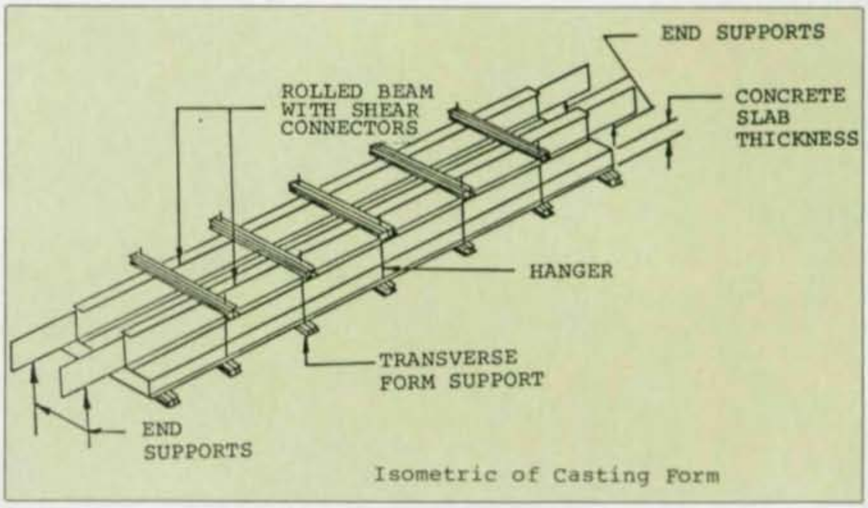
Upside-down casting is only practical with a steel structure, however. With a concrete structure, the dead load costs escalate rapidly and the weight of the system makes it too hard to handle. Also, there are substantially increased prestressing costs with a concrete structure.

After casting, the Horseshoe Bridge was transported to the site in three pieces. On Nov. 22, 1988, Route 23A was closed. The deteriorated deck was removed, and the abutments seats were modified and repaired. On Dec. 6, the units were lifted from trucks and lowered onto pre-set bearings. The erection of the units took about half a day. A steel diaphragm was bolted between the units and the joints were filled with non-shrink grout. Also, the precast backwalls were connected and steel guard rails were attached using sleeves cast in the decks. On Dec. 13, just 21 days after it was closed, the Horseshoe Bridge was reopened.

The cost of the superstructure, excluding the rehabilitation of the existing abutments, was $60,000, or $70/sq. ft.

Because of the extremely short time-frame for the project and the possible difficulty in locating A588 beams, the deck units were designed using A36 steel. However, after the bid award, Fort Miller was granted permission to substitute A588 steel, which removed the painting requirement in the original contract. However, due to time constraints, no redesign was done to take advantage of the higher allowable stress permitted with A588 steel. The latter grade steel has been used on most bridges built with this system not only to reduce maintenance costs but also to exploit the higher strength.

Stanley J. Grossman, P.E., is president of Grossman & Keith Engineering Co., Norman, OK, and the developer of the INVERSET system. □



Pictured at top is a bridge near Oklahoma City, OK, which was cast in a similar fashion to the Horseshoe Bridge in Green County, NY. Forming the beams by stacking a W14x22 on top of a W14x34, reduced the weight by 30%.

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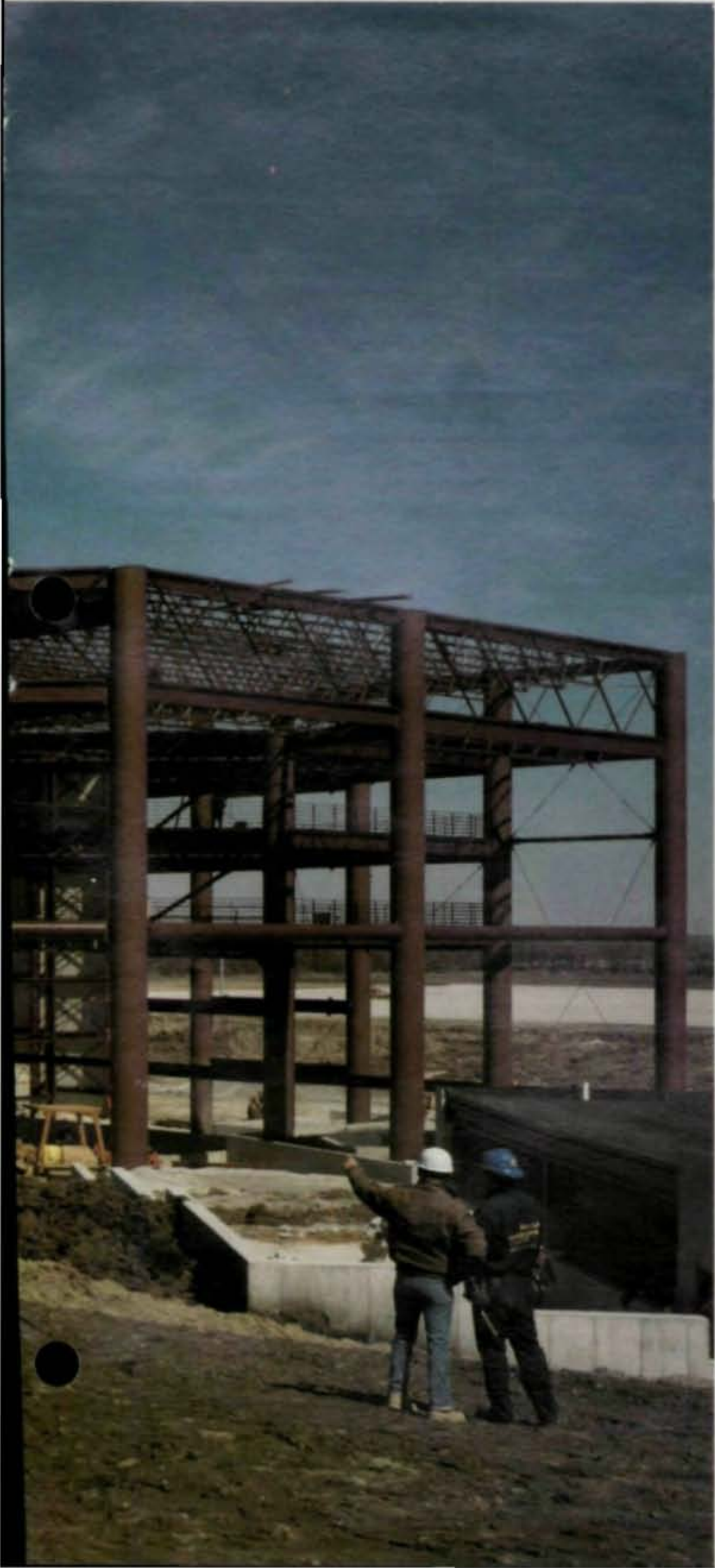


T U B U L A R   S T E E L

Totally Tubular

Rectangular tube steel provides the most efficient structural system for automated storage warehouses

The entire structure of an Automated Storage and Retrieval System is designed to facilitate a computer controlled system that receives, stores, inventories, and retrieves pallet loads of material—with a minimal manpower requirement. Pictured above is a newly completed facility for Canadian Tire Corp., Ltd., in Brampton, Ontario. The storage facility is one of the largest of its kind and can store 78,000 pallet loads, each weighing as much as 2,500 lbs. Photography by J. Wayman Williams

Imagine a 234' x 637' x 107'-high box with more than 4,500 vertical steel members spaced evenly throughout. Imagine the structure filled with 78,400 pallet loads of merchandise, each weighing as much as 2,500 lbs. And finally, imagine that this storage facility is almost completely manned by robots.

While it may sound like something from a science fiction novel, the building—and a large number of brethren—actually exists.

The building is known as a "rack structure", and includes what the material handling industry refers to as an Automated Storage and Retrieval System (AS/RS). Simply put, an AS/RS is a computer controlled system that automatically receives, stores, inventories, and retrieves a palletized load. The major components of the system are the input/output conveyors, the aisle cranes or retriever machines (robots), the steel storage racks, and the computerized control system.

The building described above is one of the largest of its kind and was erected in Brampton, Ontario, Canada, by the Rack Structures Group of AISC-member Broad, Vogt & Conant, Inc., River Rouge, MI, for Canadian Tire Corp., Ltd.

If ever a building completely followed the axiom that form follows function, it is a rack structure. "The parameters of the building are rooted in the handling equipment," explained Thomas C. Esper, P.E., general manager of the Rack Structures Group.

Design begins with an accurate description of the pallet itself, progresses to the number and maximum weight of loads, and only then considers such factors as seis-

mic conditions. "Given the project specifics and a description of the material handling system from Eaton-Kenway, Inc. [a Salt Lake City-based supplier of material handling systems], the building is designed to be entirely supported by the rack system," said Esper. Owner representative/project manager on the Canadian Tire project was Giffels Associates Ltd., Toronto.

Other important considerations in rack design include: the required flue space, which is the space between two pallets for mechanical piping, fire protection, heating, and ventilation; the space requirements for the exterior girt wall; and the space requirements for the lighting and mechanical items above the storage racks and below the roof structure.

The rack system itself provides structural support for the building. "The rack frame acts as a vertical truss," Esper explained, "with multiple arms that come off the side to support the load shelves."

The racks are constructed from rectangular steel tubes. "Tubular steel is very efficient for this type of building," Esper said. "The weight of a 4" x 4" tube is much less than the equivalent wide flange. Also, square tube is good in compression and doesn't have a weak axis. The reason you use wide flanges in most buildings is that it's easier to fabricate the connections. In this building, most of the components are welded together, so tubes are much more efficient." As with other rack structures, ASTM A500 Grade B 46 ksi steel was specified for this project.

Rectangles are used instead of round tubes to simplify the welding of connection plates. "When creating the rack frames, it's much easier to work with flat surfaces rather than round."

Lateral support of the rack frame is provided in the down-aisle direction with down-aisle tie angles spaced every 10' to 12', while the structure's storage shelves provide lateral support in the cross-aisle direction. All of the lateral loads on the structure are brought to the floor through vertical bracing in the flue spaces.

Foreign Construction

"One of the challenges of the project was the cultural differences between the U.S. and Canada," according to Esper. Canadian holidays are different, there are labor restrictions and different labor practices, and shipment of materials and equipment across the border is difficult. In addition, the design had to comply to Canadian building codes and standards.

To simplify the code issue, the building was first designed to U.S. standards and then checked against the Canadian codes with modifications made where needed. "We roughly doubled the engineering cost [to approximately $100,000], but we made sure the building would work." A Canadian engineer was required to certify the design.

On Broad, Vogt & Conant projects, the vertical truss rack frames are shipped to the jobsite in one piece. Because of their size it is essential that the fabricator that does the final assembly of the frames be located near the jobsite. For the Canadian Tire project, each rack frame was more than 100'-long, and the logistics of transporting the frames were further complicated by the need to pass through Toronto. As a result, the racks could only be transported at night prior to 6 a.m.

Broad, Vogt & Conant often uses multiple fabricators for its rack projects. "One fabricator located near the site does the final assembly. We select other sources for the components," Esper said. On this project there were nine major material suppliers and five fabricators.

Other manufacturer's of rack structures have their own fabrication plants and ship the rack frames in 40' sections to be assembled at the site. "This method realizes some economies in fabrication, but loses its advantage in long-distance trucking costs and job site labor costs," Esper said.

Since most fabricators are unfamiliar with rack structures, Broad, Vogt & Conant has developed fabrication techniques for these projects and trains the selected fabricators. The firm brings with it specialized equipment and provides in-plant supervision. Broad, Vogt & Conant provides the fixtures used to assemble the rack frames.

"During the past two years, we have developed robotic welding techniques," Esper said. "The majority of the fabrication labor is in welding. On the Canadian Tire project, we installed our robot at the fabrication plant and we manned the whole robotic operation." The material handling requirements with robotic welding are about the same, but labor costs are cut by as much as 75%, according to Esper.

To simplify erection, the rack building is preassembled on the ground into large modules, each of which includes nine, three-post rack frames. After assembly on the ground, the 28-ton modules are tilted up and lifted into position (top photo). Lateral support is provided in the down-aisle direction with down-aisle tie angles spaced every 10' to 12', while the structure's storage shelves provide lateral support in the cross aisle direction (left photo).

Innovative Construction

Another innovative technique on this project was the use of three-post, double-sided rack frames instead of two-post frames. The typical design of a rack structure features two rack frames placed back-to-back with a flue space in between. Each rack has two posts, for a total of four posts. To reduce costs, one of the center posts was eliminated. "We strengthened the middle post of the three-post frame by using a heavier gauge tube," Esper said. "It's much more efficient than having four posts."

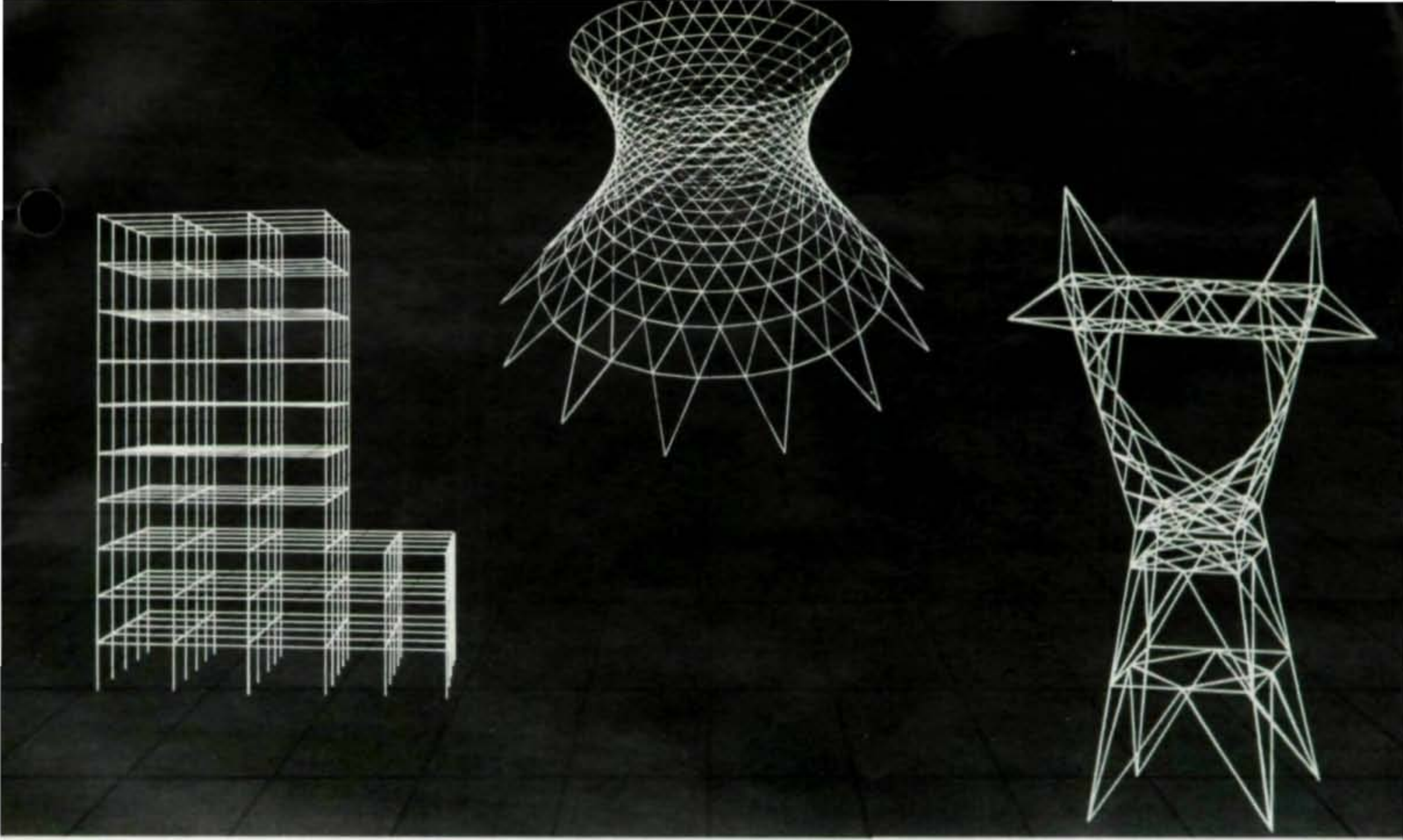
According to Esper: "The construction process used by Broad, Vogt & Conant is unique in that we preassemble the rack building in large modules on the ground." Each assembly is then tilted up and lifted into place. Each 28-ton module consists of nine, three-post rack frames, down-aisle ties, bracing and, in this case, the fire protection system. "We try to reduce the number of man-hours of people working high in the air," he said. In addition to reducing the erection time by as much as 20%, the preassembly process enhances the safety of

The vertical truss rack frames are shop fabricated into one piece (bottom photo). While this complicates shipping, it reduces field labor and improves quality control. Pictured at top is the erection of a rack frame.

the workers, Esper stressed. More than 80% of the work is performed on the ground. "Everyone working in the air is tied off 100% of the time."

AS/RS are used in warehouse and distribution operations, and as an integral part of many manufacturing operations. Many industries are utilizing these hi-tech warehouses, including the steel industry, where steel coils are "gently" handled in and out of storage racks both at the mill and at the steel processor.

The storage rack structure is an innovative application of a steel structure to efficiently and economically service the need of various industries to store thousands of products. Once operational, these facilities are computer operated, with very low demand for manpower or maintenance. □



Innovative Design Speeds Construction, Cuts Costs

Using free-standing steel tube columns was crucial to the creation of a new budget hotel by the founder of the Holiday Inn chain

The attractive but commonplace exterior belies the innovative structural system used in the new Wilson Inns.

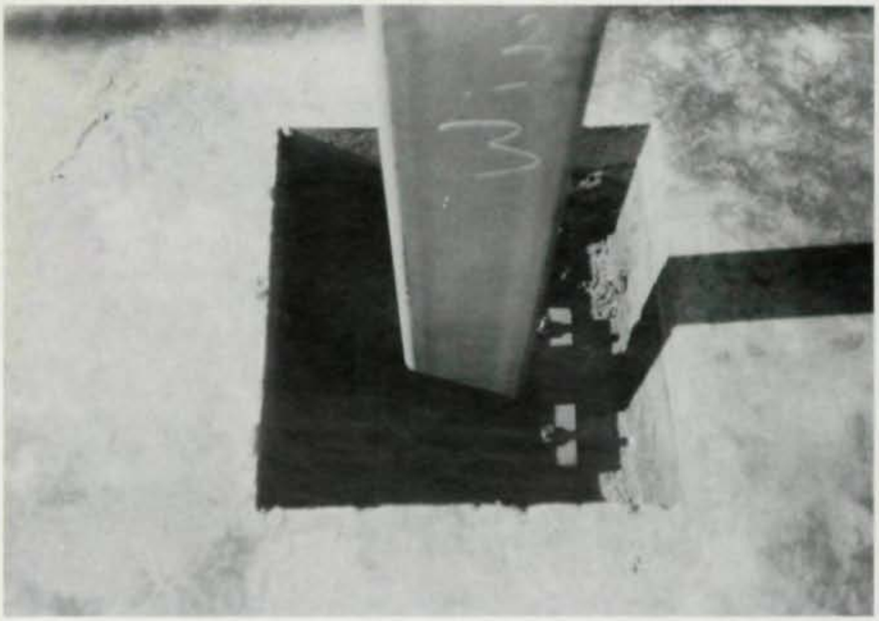
When Kemmons Wilson founded Holiday Inns in the 1950s, his intent was to create a worldwide chain of clean, comfortable—and most importantly—inexpensive hotel rooms. But while Holiday Inns have gone upscale, Wilson remained true to his original concept and has introduced a new chain bearing his name.

The Wilson Inns and Wilson World Hotels are primarily located in the Southeast and the 15′ x 27′ rooms are priced from as little as $29.95 per night.

Low Construction Cost

Crucial to this value-oriented pricing is a low construction cost. Including furnishings, but excluding land, the 110-room Inns cost only $2 million, or $18,181 per room, according to Robert McCaskill, P.E., who formerly was vice president of construction for Wilson Inns but who now has his own consulting firm in Memphis. By comparison, the average construction cost of a "budget" motel room in the United States is between $20,000 and $25,000, according to Stephen W. Brenner Associates, a New York City-based consulting firm specializing on the hotel industry.

"The low construction cost is



With an innovative construction technique, five-story steel tube columns with steel plates spaced every 8½' are bolted to a concrete strip foundation (above and top left). Form work is then put in place and the first floor is poured (left).

achieved through a very efficient construction method," explained McCaskill. As with many buildings, the design involves steel tubular columns and poured-in-place concrete floors. The difference, however, is in the use of free-standing five-story-high columns.

Evolutionary Technique

"We found that people used a similar type of construction in the 1930s, but with one-story columns sitting on top of each other," McCaskill said. McCaskill had used that same method on the all-suite Lagniappe Inns which he had earlier designed in the Louisiana area.

What's different on the Wilson Inns project is that the steel columns are erected at full height, instead of one story at a time.

"We tried to get a contractor to go full height on the Lagniappe Inns, but we couldn't find one that would. Fortunately, Mr. Wilson had enough influence to get a contractor to give it a try." Also, unlike lift-slab construction, the forms are moved into place instead of the slabs being hydraulically lifted into place.

"Once a contractor tried it, he usually liked it", McCaskill added. "The construction process is safe, quick and efficient."

The Inns have 64 columns with each column spaced 15' on center. The columns are 8" x 4" x $\frac{5}{16}$" rectangular A500 Grade B (F_y = 46ksi) steel tube. "We chose tubes because with them we can maintain a relatively small dimension, which meant we could keep the column within a wall stud," McCaskill said. "Also, steel tubing is very strong." Each Inn uses approximately 40 tons of steel.

Prior to erection, a 1"-thick steel plate with a hole in the center is slipped over the column and welded to it every 8½'. After the columns are erected and bolted to the foundation, forms are placed below the plates, reinforcing rods and electrical conduit are laid, and then 6" of concrete is poured for each floor. After each floor is poured, the columns are plumbed to ensure that they remain straight.

Diagonal Bracing

For stability, diagonal tube bracing is added to the frame. Typically, braces are added to three bays in the long direction and four bays in the short direction, though on coastal projects with high winds six braces are used in the short direction. "We put the bracing in after pouring the third floor," McCaskill said. "The structure is fairly stable until it gets taller than that." The bracing is added to all five floors and is located so that it falls in a partition and is not visible once the hotel is complete.

The construction process is safe, quick and efficient.

In addition to a low construction cost and fast construction time, the innovative design and small column size allow great flexibility in the location of interior partitions, according to McCaskill.

Another advantage of this type of construction system is simplified foundation construction. "The columns are in a row, so we put in a 3½'-wide strip footing the full length of the building. The footing went in very quickly. We used a back hoe to dig a trench and then poured concrete." The trench is 2' deep.

Total construction time on the Inns is about 8½ months, and more than 20 have been constructed. In addition to the Inn design, Wilson also has developed three Wilson World Hotels, each with 200 rooms and a 100' x 232' center atrium, and a 136-room Wilson World Hotel with a 100' x 180' center atrium.

The 200-room Wilson World Hotels have 130 columns and rigid framing for the atrium. Construction time for the $7 million hotels is about 14 months. □

TWO NEW DESIGN AIDS

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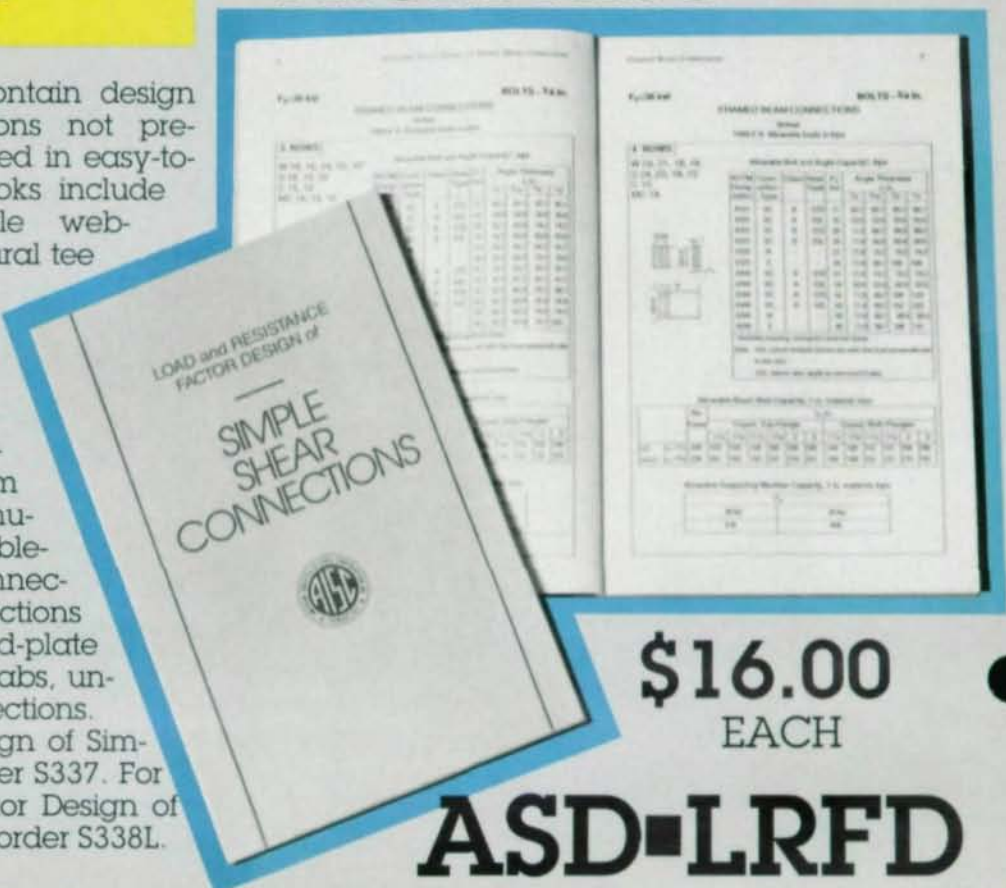
These 120-page books contain design aids for shear connections not previously published. Presented in easy-to-use tabular form, the books include designs for double-angle web-bolted connections, structural tee single shear connections and single-angle connections welded to the support. Included in these easy-to-use references are design aids for other connections reprinted from AISC, ASD and LRFD Manuals. They include double-angle web-welded connections, single-angle connections bolted to the support, end-plate shear connections, shear tabs, unstiffened and seated connections.

For Allowable Stress Design of Simple Shear Connections order S337. For Load and Resistance Factor Design of Simple Shear Connections order S338L.



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Demonstrating Tubes Capabilities

A manufacturer of steel tubes used its own expansion as a field laboratory

By Mike West, P.E., AIA

When Welded Tube Co. of America needed to expand its Chicago manufacturing facility, it was only logical to build with steel tubes. The company has a vested interest in increasing the use of structural tubes, and this project gave them first hand experience with the issues involved in designing, fabricating, and erecting a steel tube structure.

The addition was needed to enclose a fourth production line and store its production. The production equipment was designed and fabricated by Kusakabe Electric and Machine Co., Ltd., of Kobe, Japan, and will produce tubes that range in size from 1" square to 2" square and from ¾" round to 2½" round in thicknesses from 0.060" to 0.188". The production speed of the mill is 650′ per minute with an annual production based on expected sales mix of 125,000 tons per year. Tubes will be produced to ASTM Specifications A53, A135, A513, and A500 Grades A, B, and C.

The new mill is laid out parallel to the three existing mills but is in an independent gable-framed building that connects the existing coil storage building to the existing warehouse. Additional warehouse space also was constructed.

The linear nature of the production process (uncoiling, accumulating, forming, welding, squaring, cutting, painting and bundling—see sidebar) dictated a long, narrow building. The requirement for a maintenance crane and the

Welded Tube Co. of America's expansion included a new mill laid out parallel to three existing mills (top) and a warehouse connected to the existing warehouse space (above). Photos by Dan Pollack Photography, Inc.

Connections are often a concern with steel tube structures. Shown above is a gusset plate welded to a column and bolted to a brace. Shown at left is the bracing for both the warehouse columns and crane girders.

building's relatively narrow 58' width meant that there would only be a single clear span.

And the building's shape suggested the use of rigid frame bents to resist transverse loads.

On the exterior, a standing-seam roof and metal-panels were used to match the exiting facility.

Structural Framing

The mill building uses rigid framing spanning 58'. The columns are square tubes. The beam element is a king post truss constructed with tubes. These bents are spaced at 24' to match the column grid of the existing mills. The roof purlins are rectangular tubes, which are two-span continuous. The crane girders are supported by cantilevered tube brackets from the rigid frame columns.

The bracing for the lateral loads in the longitudinal direction is consists of three sets of paired bents connected by diagonal round tube struts in the planes of the roof and side walls. Steel fabricator was AISC-member Jones and Brown Co., Inc., Addison, IL.

The warehouse extension is a lean-to structure on the side of the existing warehouse and has a clearspan of 88'. In order to maximize crane hook height while connecting the new roof below the eave of the existing roof, a low-slope standing seam roof was used. The roof framing uses rectangular tube purlins, which span to a simply supported single-span inverted king post truss. The top chord of the truss is a TS 12x20x½, which is the largest tube size that is domestically produced. In addition, its length of 88'-6" may be a record.

The warehouse is served by two 10-ton overhead cranes, one of which is radio operated. Both of the cranes are equipped with magnetic hooks. The crane girders are paired rectangular tubes with a top full width plate under the crane rail. The crane girders and the roof truss are supported at the outside wall by cantilevered Vierendeel trusses of two columns and horizontal webs. The outboard column supports the roof truss, while the inboard column supports crane girders. This cantilevered framing supports all transverse lateral loads.

The Vierendeel trusses are laid out so that the lowest web is high enough so that there is a useable walkway between the columns. The support of the structure on the interior side of the building is from the existing column, while the roof truss is framed to the face of the existing column flange. Also attached to the existing column flange is a diagonally stiffened wide flange bracket, which supports the runway beam. As in the mill building, the resistance to longitudinal lateral loads is by means of struts in the plane of the roof and sidewalls. There also is a line of bracing to stabilize the bottom of the inverted king post truss.

Simplified Connections

In addition to the previously stated parameters, another design concern was the need for simplicity and clarity in detailing and fabrication. Despite the many benefits of structural tubing, some designers are hesitant to use it because of perceived difficulties with connections. To simplify connections on this project, butt joints, end capped or side plated joints were used wherever possible. Also, in general thicker tube walls were used in lieu of complex stiffening and reinforcing schemes.

The connection of the crane girders to their supports was by means of oversized end plates with projections on each side so that the plate could be bolted to the projecting cap plate on the column or on the top side of a bracket. The end connection to the bracing struts was by means of a short tee. The tee flange was welded to the end of the tube and the projecting web was connected to a gusset plate using bolts in single shear.

During the planning stage consideration was given to fabrication at the site to eliminate the cost of shipping the material to a fabrication shop and then back to the site where it had originally been produced. However, this was not done because an analysis revealed that the cost of field fabrication exceeded the shipping costs.

Design Details

The design philosophy employed on the project is best illustrated by the following examples:

- The primary roof framing elements are king post trusses that consist of only six major pieces, while the horizontal chord is a single piece.
- In the case of the gabled truss, the diagonal chords meet at the ridge by butting to a vertical plate. The web members, of which there are three, are connected between the top and bottom chords, and the diagonal chords are fitted to the horizontal chords and reinforced with side plates.
- In all instances, the trusses are attached to the sides of the columns. An end plate with projecting sides is bolted to a matching plate on the face of the column, and in the case of the mill building, this joint is designed to include the forces induced by the rigid frame bending moments.

As cited above, the cantilevered Vierendeel truss in the warehouse allows separate crane and building columns and a walkway at the building perimeter. The square panels of the truss simplified the square cut butted joints of the web members.

All of the joints were designed to be field bolted. The girt and purlin angle clips were welded to the framing and requiring a field weld between clips and purlin or girt. The fabricator added an erection bolt through the outstanding clip leg so that the girts and purlins could be held in place prior to field welding.

Straightforward Erection

Erection of the structure was straightforward, though careful consideration was needed for the connections between the existing and new structure.

Because the tube purlins were too narrow to be "walked", they were set from below using bucket lifts. Also, the tubes mostly did not provide hand and foot holds familiar to the iron workers, which required new strategies on their part. There also was a concern that the rounded tube corners did not grip into the hoisting slings as would the square edge of a wide flange shape. Fortunately, these concerns were met during construction to everyone's satisfaction.

Those concerns, however, were a prime impetus to Welded Tube using structural steel tubes on this project. One of the company's goals is to increase the use of structural tubes, and the construction of their own facility gave them first hand experience designing, fabricating, and erecting a building using structural tubing.

It also pointed out the advantages of the tubular shape, including: minimized surface area for painting and cleaning; uncluttered appearance; high ratio of strength to weight in columns; and high lateral stability which eliminated the need for flange bracing. □

Mike West is vice president of Computerized Structural Design, Inc., a Milwaukee structural engineering firm. He is both a regisistered architect and a registered engineer.

The top photo shows the top of a mill building column, including a crane girder supported off of a cantilevered tube bracket as well as an inverted single-span king post truss. The second photo shows roof framing with king post truss and rectangular tube purlins.

Making Tubes

One—Large steel coils are warehoused. Some of the coils weigh as much as 40 tons.

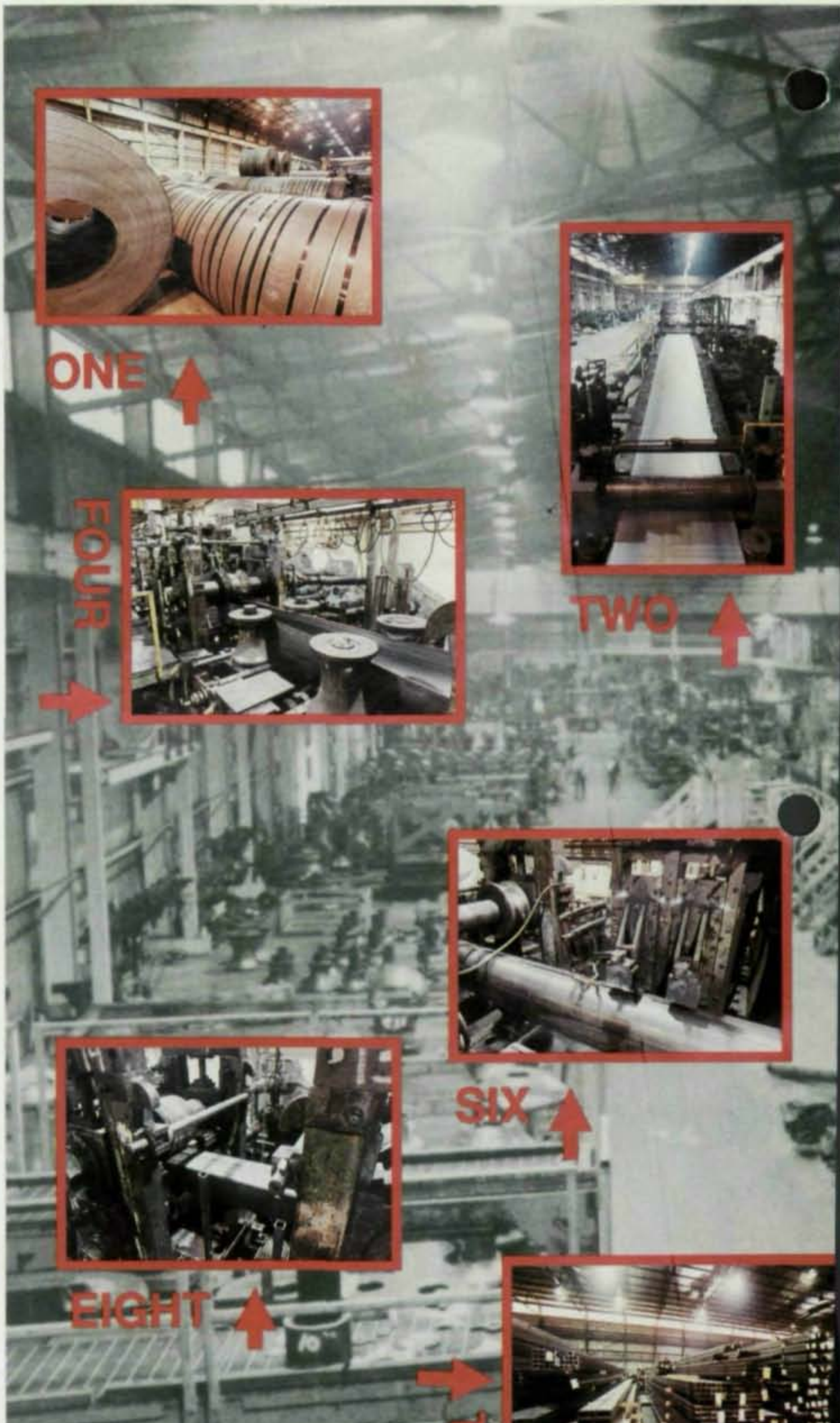
Two—The coils are uncoiled at the beginning of a long process line. This line is almost 800′ long.

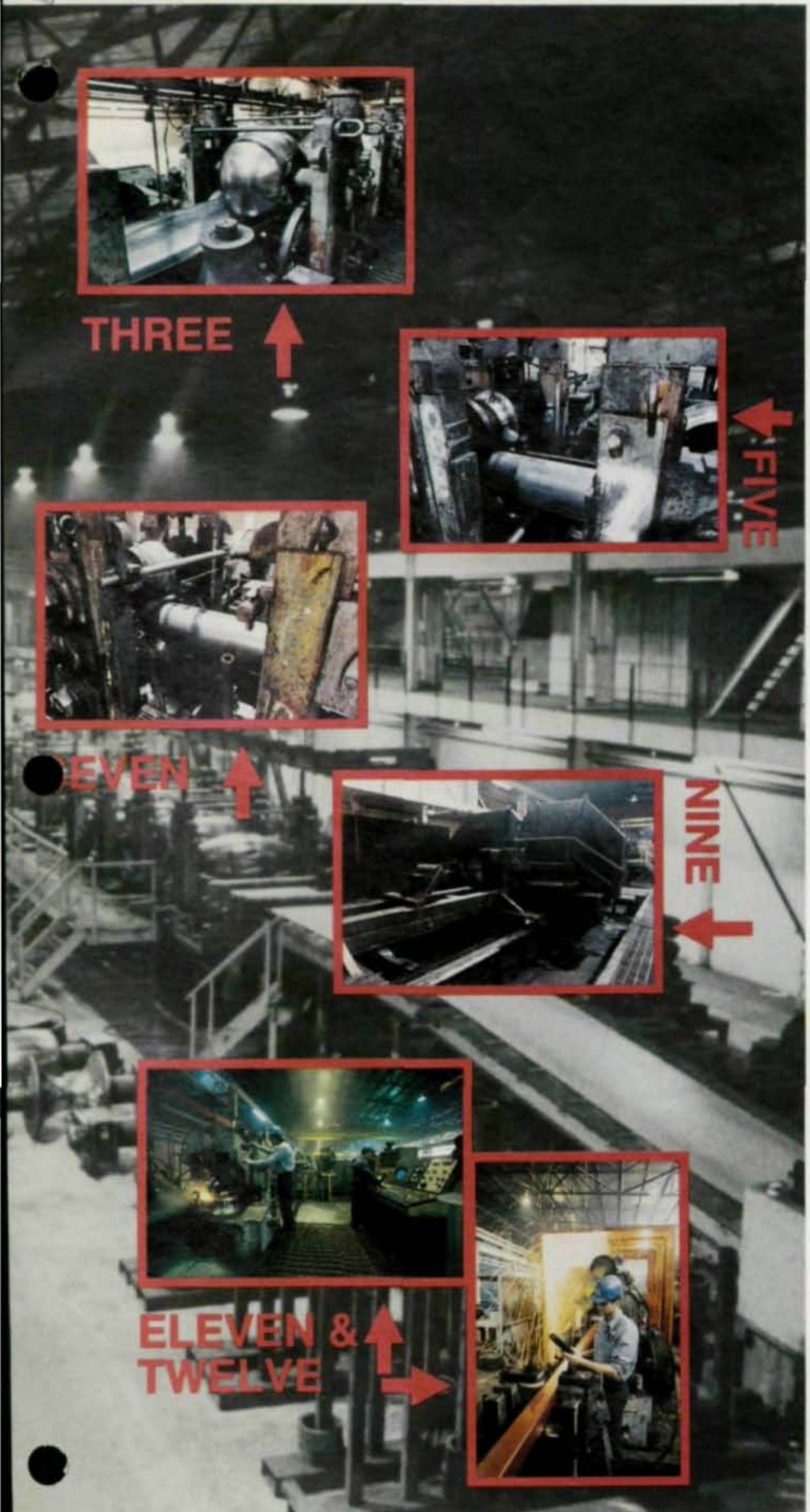
Three—The coil is pulled through a series of forming stands, which shape the flat steel into a tube. The first five stands are breakdown sections.

Four—Next, the strip is pulled through three fin stands, which presents the strip into the weld pass.

Five—The strip is pulled through a seam guide, which centers the seam for correct weld location.

Six—The strip is welded into tube with a high frequency contact welder and adjoining squeeze roll stand.





Seven—The tube goes thorugh an air cool section, then a water cool section, and then into a two-stand sizing section, which finalizes the round shape before shaping it into either a rectangular or square shape.

Eight—The tube is pulled through a four-stand sizing section, which progressively shapes the round tube into the desired shape.

Nine—The tube is cut into the desired length by a friction cut-off saw.

Ten—The tube is discharged onto a bundling table and stacked into the desired configuration and then banded. It's then warehoused and shipped.

Eleven & Twelve—Another line in operation.

Information and photography courtesy of Welded Tube Company of America.
Photography: Dan Pollack Photography, Inc.

Welding Innovations Are Expected To Slash Costs

Alan W. Pense

By Alan W. Pense

High-strength yet highly weldable materials, heavier shapes, innovative welding processes and new quality control methods will enhance the role of welding in structural applications.

Higher-strength, more-durable steels will soon replace more traditional types used today, possibly within five years. Already, microalloyed compositions are available with yield strengths in the 50 to 100 ksi range. But perhaps more important than their strength and toughness, these new steels have substantially improved weldability. They achieve their improved strength with decreased carbon contents, allowing much more flexibility in welding and reducing both the preheat required and the hardness of heat-affected zones after welding.

And materials of even higher strength with good weldability likely will be prevalent soon. In fact, within 20 years, the industry could see more weldable materials with yield strengths that are two or three times current ones. These economical, high-strength weldable materials should be even more competitive on a cost basis with concrete materials.

Easier Fabrication

Currently in development are new high-quality heavy construction shapes that will allow easier fabrication of large-size structures. Rolled sections of jumbo sizes with flanges and webs in the 3" to 6" range now are being produced with excellent toughness, strength and weldability.

For heavy section materials, toughness and weldability are as important as strength. Heavier sections of these constructional materials will be developed within five to 10 years, which will improve the productivity of welded connections. If the expected strength and combinations can be achieved, welded steel shapes—jumbo sections, especially for large structural systems—will generate increased interest.

New Welding Processes

Laser welding and other high-energy density processes will emerge probably within 20 years, replacing older arc processes. Medium power lasers are beginning to mature into systems that will be small enough to be used both in the shop and in the field. In addition, prices are dropping to levels that will make laser equipment a reasonable investment for fabricators and erectors.

High-density welding processes will radically change the joint designs currently used in welding. Present designs rely on weld preparations in which a substantial amount of metal is removed to provide an open joint that accommodates limited penetration.

Using deeply penetrating processes, joint designs would be radically altered. For example, very narrow gap joints could be welded with relatively small amounts of filler metal, which will greatly improve welding productivity and reduce weld defects.

In the future, welding through highly penetrating processes will utilize essentially square butt preparations—through laser cutting followed by laser welding of two abutting surfaces with little or no filler metal required. Among other things, inspection of these joints will prove simpler. Overall, radical changes in weld design and production will result in rapid and substantial improvement in productivity—which also will lower costs of welded products. Both labor and consumable costs should be reduced by 20%.

Detecting Defects

Within 10 years, new control systems are expected to be available that will detect and prevent welding defects before they form. Several organizations, including the United States Army Construction Materials Laboratory and the ATLSS Center at Lehigh University, are working on systems that detect defects during their formation and feed back this information immediately.

Real-time measurements by acoustic emission will identify when and how welding configurations are changing from preset quality standards. Automatic feedback controls will then adjust welding parameters to prevent defect formations. These quality control systems already are very close to reality. □

Alan W. Pense is an American Welding Society Expert to the Commission IX on the Behavior of Metals Subjected to Welding of the International Institute of Welding. He also is provost and vice president at Lehigh University, Bethlehem, PA. Prior to this, he was dean of the College of Engineering and Applied Sciences and R.D. Stout professor in the Department of Materials Science and Technology.

Session Touts Certified Welder Program

By Richard A. Huber

The benefits of the American Welding Society Certified Welder Program are described in a special series of presentations scheduled to be held at most of 21 accredited test sites throughout the country in 1991.

The certification program is designed so that welders can transfer their certification from employer-to-employer and location-to-location. Essentially, it allows certified testing laboratories to test to D1.1. Ideally, a standardized testing procedure will provide validity, credibility and reliabilty.

The AWS kicked off the Certified Welder tour presentations last December in Allentown, PA, the location of the Welder Training & Testing Institute, the first accredited welder certification laboratory. Two open-to-the-public sessions attracted 70 people, with an even mix of welders and users/specifiers.

Growing Program

More than 35 welders have been certified through the program, which was inaugurated in February, 1990. Program administrators—confident that the on-site tours will increase interest in the program—expect 1991 to be a watershed year. By the end of 1991, AWS hopes that at least 200 welders will be certified and the number of test facilities will increase to more than 40.

When it matures, the certification program is expected to generate significant cost savings for the industry. Because AWS Certified Welders can be listed in an easily accessible nationwide registry (subject to the approval of the employers from whom they work when they are first certified), employers will save on retraining and recertification costs.

Nationally Recognized

Certified Welders will have earned a natinally recognized, independent, third-party, portable certification that travels them and enhances their professional standing.

Test facilities are accredited to AWS QC4 (Standard for Accreditation of Test Facilities) by the American Bureau of Shipping (ABS), an independent technical organization with more than 125 years of experience in administering standards. Only facilities accredited by ABS may administer the AWS Certified Welder examinations.

Registrants at the 1991 AWS Welding Exposition in Detroit (April 14-19) can learn more about the AWS Certified Welder Program at two events during the show. Session E1: "Symposium on AWS Welder Certification" is a two-hour program to be held on Wednesday, April 17, at 10 a.m. "AWS Test Facility Accreditation Seminar" is a two-day program to be held on Thursday, April 18, and Friday, April 19, at 8 a.m.

Richard Huber is president of the American Welding Society and a developmental group leader at Martin Marietta Energy Systems, Inc., Oak Ridge, TN. □

Code Changes Effect Steel Construction

By John Bartley

The welding industry owes much of its success to a code that is revised frequently to incorporate the latest in technology and practical experience. The *Structural Welding Code* (ANSI/AWS D1.1-90) for welding structures fabricated with carbon and low-alloy steels is updated every two years to keep pace with rapid industry development and improved practices.

The *Structural Welding Code—Steel* remains the definitive working document for designers, engineers, fabricators and contractors concerned with creating tubular and statically or dynamically loaded steel structures. It covers detailed welding requirements, allowable unit stresses, structural details, workmanship, inspection procedures and acceptance criteria.

Changes in the 1990 edition include:

- Prequalified partial penetration groove welds: Detailed root face tolerances have been revised.
- Skewed T-joints: A subsection on skewed T-joints has been added, along with a figure and table.
- Workmanship: Extensive revisions include provisions that have been revised for the preparation of access holes, new allowable camber measurements and maximum fillet weld convexity.
- Box tube welder qualification: The requirements for the qualification of welders performing box tube welding have been revised to include corner macroetch tests.
- Revised wire image quality indicator (IQI) requirements: Wire sizes are now given for a revised set of thickness ranges.
- Radiation imaging systems: Real-time imaging requirements are now included.
- Girder web flatness provisions: The requirements for the flatness of girder webs have been modified.
- Radiographs of tubular groove welds: Requirements are given for the quantity and location of film exposures for tubular circumferential groove welds.
- Revision to Appendix IV: The prequalified welding procedure specification checklist is deleted; the Code now addresses only requirements that may be changed by procedure qualification tests.
- Revision of Appendix E (Welding Procedure Specifications): Revised forms replace the 1988 prequalified and qualified WPS forms.
- Addition of Appendix H: This new non-mandatory appendix includes a list of the Code provisions that are required to give prequalified status to a joint welding procedure specification.
- Addition of Appendix J: This new non-mandatory appendix outlines the general requirements for safety in an environment where welding and cutting operations are being performed.
- Mechanical testing: ANSI/AWS B4.0, *Standard Methods for Mechanical Testing of Welds*, provides additional details of test specimen preparation and details of test fixture construction. □

John Bartley is president-elect of the American Welding Society and the head of the Welding Engineering Division at Mare Island Naval Shipyard, Vallejo, CA.

Richard A. Huber

John Bartley

WELDING PRODUCTS

Burco, Inc.

The company has recently acquired L-TEC's stud welding business. Burco will exhibit at the 1991 AWS International Welding Exposition, Booth #1378, a complete state of the art stud welding product line from 600 AMP to 3,000 AMP power supplies, including short-cycle and towable engine-powered systems. Also on display will be a line of stud welding guns and accessories.

For more information, contact: BURCO, Inc., Box 2115, 530 Chapel Hill Road, Burlington, NC 27215 (919) 228-0760.

Lincoln Electric Co.

Member

The new Weldanpower 250 D10 Pro is a combined engine-driven multi-process arc welding machine and portable 10,000-watt auxiliary generator. Powered by a fuel efficient water-cooled Perkins diesel engine, this unit has been insonorized (sound insulated) for ultra-quiet operation. The unit is designed to provide 100% duty cycle and a full 250 amps of welding output for either AC or DC operation and has a built-in contractor for use with a wide range of processes and semiautomatic wire feeders.

For more information, contact: Lincoln Electric Co., 22801 St. Clair Ave., Cleveland, OH 44117-1199.

TRW Nelson Stud Welding Division

Stud welding is three-to-four times faster than hand welding. Two brochures describe the stud welding process used in the construction industry.

"Nelson Stud Welding For Non-Residential Construction" includes information on composite construction, concrete anchoring, electrical/mechanical, retrofitting, and facia.

"Nelson Stud Welding Process" is a more technical description, and discusses stud welding methods, designing for stud welding, stud selection, weld fillets, welding power, and surface conditions.

For more information, contact: TRW, 7900 West Ridge Road, P.O. Box 4019, Elyria, OH 44036-2019 (216) 329-0400.

Henrob

The Dillon MKIII is designed to make the welding of difficult materials easier. A very concentrated, low velocity flame produces a soft mushroom-like shield that protects the weld puddle, allowing difficult metals—such as very-thin sheet aluminum, stainless steel, and other specialties including cast iron and aluminum alloys—to be welded easily.

Other features include: a precise flame; optimum combustion, minimum oxidation; and reduced preparation time.

For more information, contact: Henrob Corp., 3551 Voyager St., Suite 106, Torrance, CA 90503 (213) 214-4946.

Hornell Speedglas, Inc.

A new welding hat with a lens that automatically darkens in 1/500 of a second after an arc is struck is now available. The lens turns dark when an arc is present and transparent when there is no arc. The lens works in either indoor or outdoor light and with any arc welding process, including low-current TIG welding and inverter welding.

The company also offers a new powered air-purifying respirator/helmet system for welders. The Speedglas Fresh-Air Welder Protection system blows a cooling supply of filterd air through a lightweight helmet that sheilds the welder's eyes and head. The belt-worn respirator filters gases, vapors, and particulates and can be customized to match specific occupational environments. The extremely light, 1½ lb. helmet also features the automatic lens described above.

For more information, contact: Hornell Speedglas Inc., 2374 Edison Blvd., Twinsburg, OH 44087-2340.

PowCon

New welding products include an add-on device that brings plasma cutting and gouging capability to a standard welding power source and an improved power source. StarCut is an inverter plasma cutter weighing just 68 lbs. It takes direct welding current input and increases its voltage to provide a plasma cutting output rated for 110 VDC at 80 amps. PlasmaPlUS is a series of power sources. The units weigh 85 lbs. and can air plasma cut steel up to ½" thickness and weld with 225 amps at 50% duty cycle.

For more information, contact: Wade Chase, PowCon Inc., 8123 Miralani Dr., San Diego, CA 92126 (800) 833-9925.

Woodland Cyrogenics Inc.

This company offers a wide range of products, including: pumps; vaporizers; manifolds; pigtails; fittings; carts; computer controlled systems; specialty gas equipment; tools; and a variety of parts.

For information, contact: Woodland Cyrogenics, P.O. Box 311, Darby, PA 19023 (215) 727-0950.

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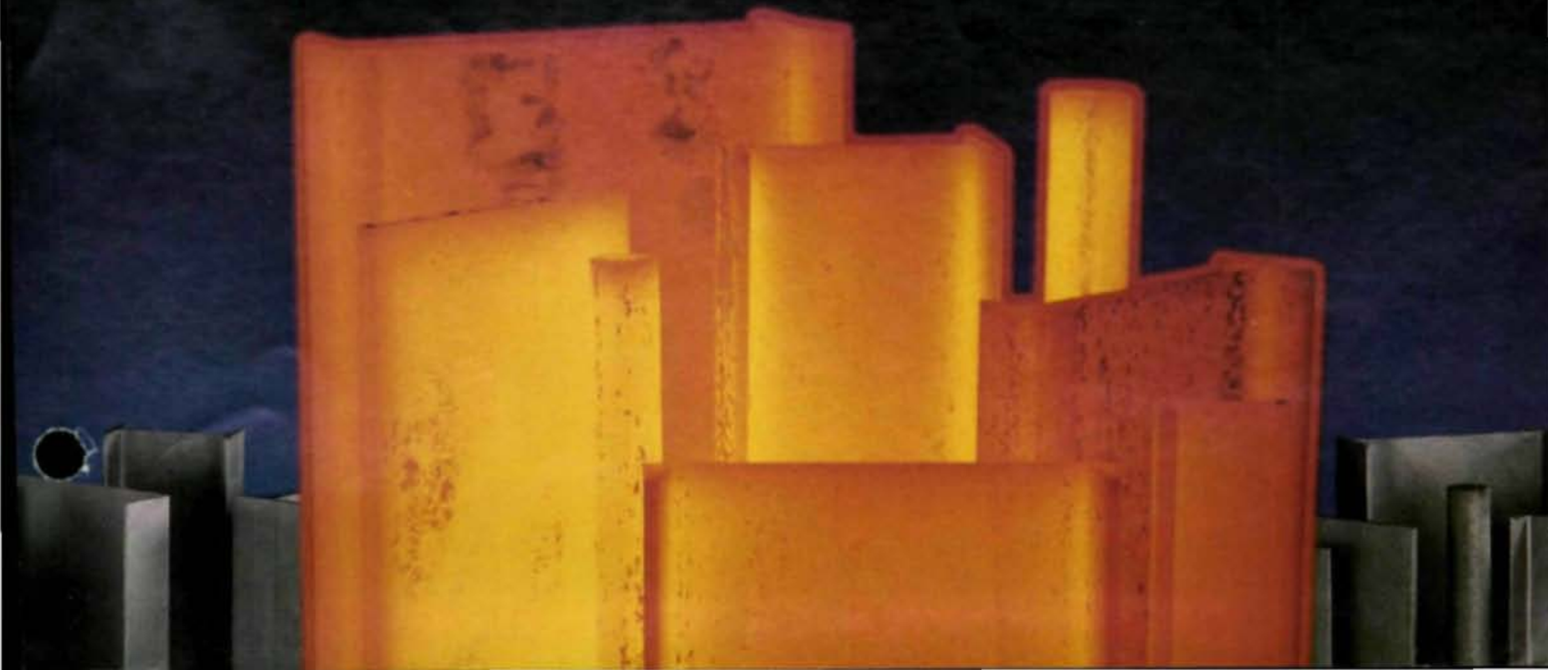

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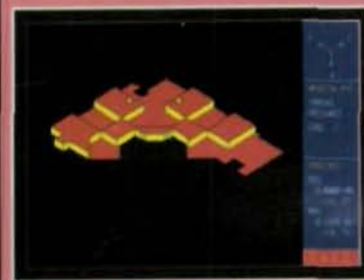
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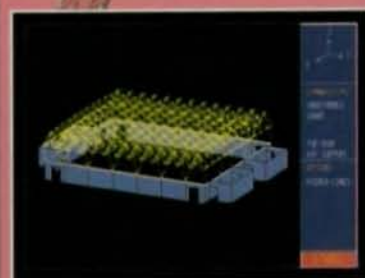
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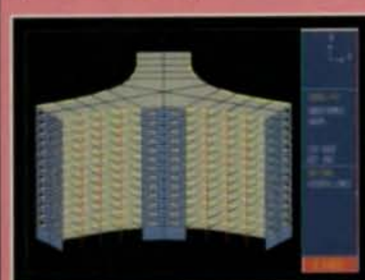
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