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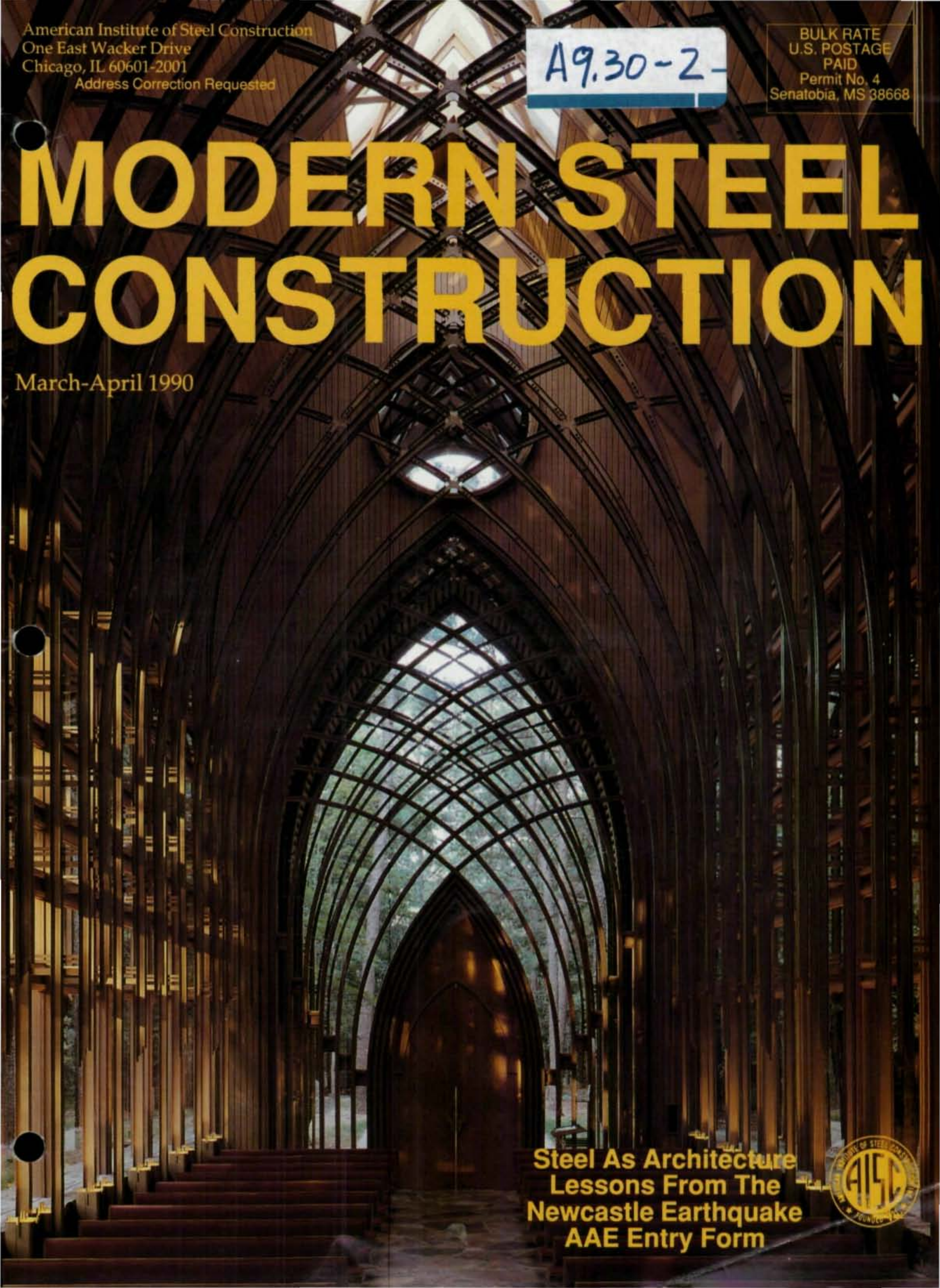
MODERN STEEL CONSTRUCTION

March-April 1990



Steel As Architecture
Lessons From The Newcastle Earthquake
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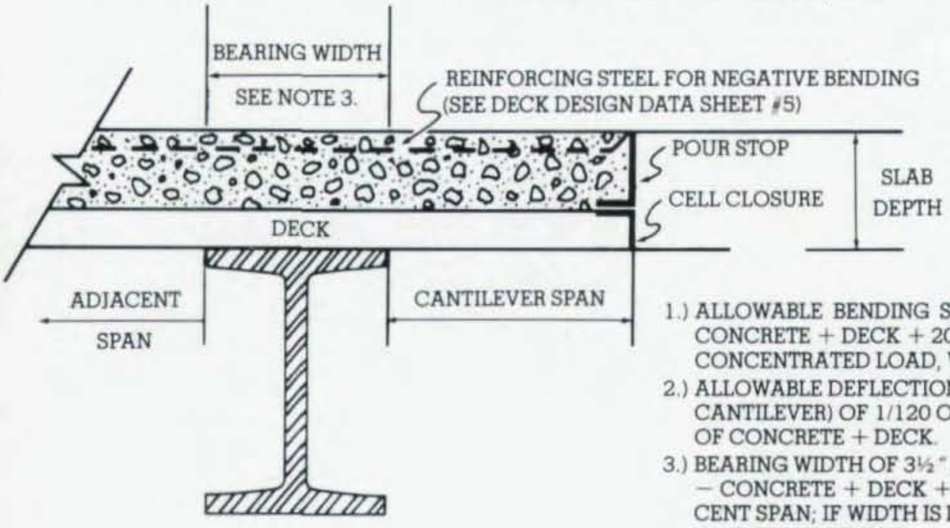

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4.50"	1'10"	2' 2"	2' 9"	3' 3"	1'10"	2' 3"	2'10"	3' 4"	2' 6"	2'11"	3' 8"	4' 3"				
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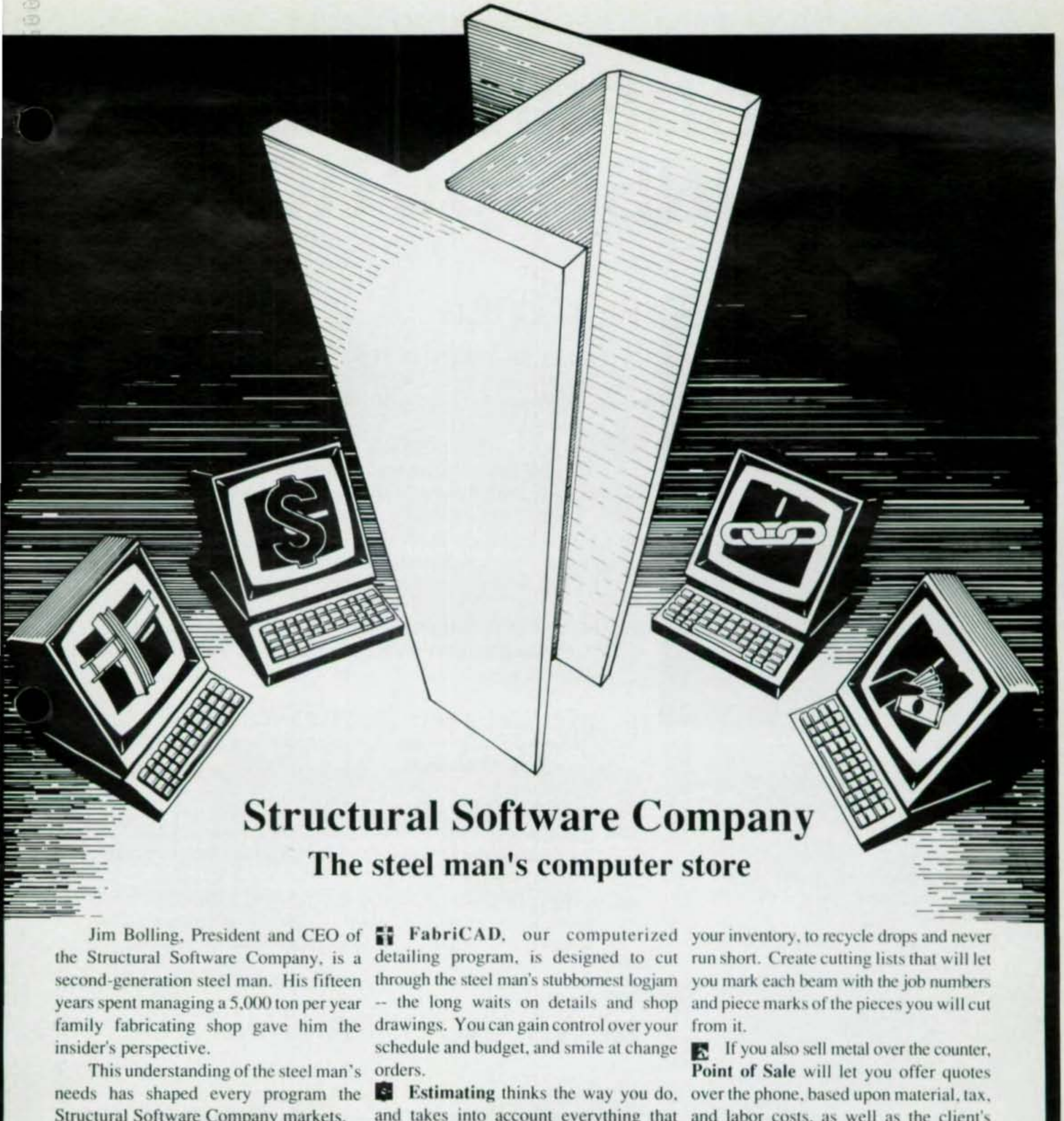
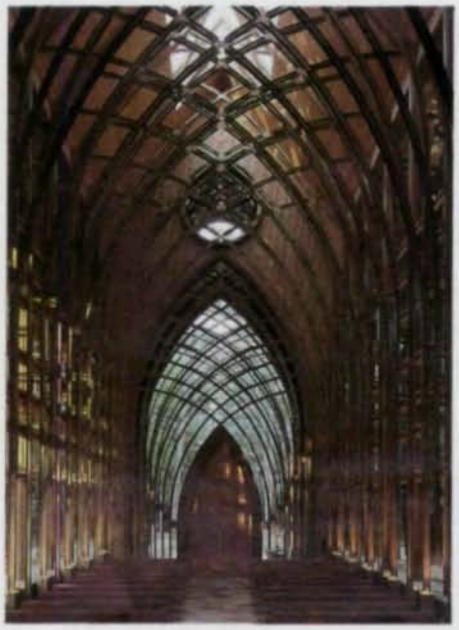


MODERN STEEL CONSTRUCTION

Volume 30, Number 2 March-April 1990



Fay Jones, the 1990 AIA Gold Medal Winner, often takes historical styles and expresses them in different materials. For Cooper Chapel in Arkansas, Jones applied the principal of "Operative Opposites" to the Gothic Style through the use of curved steel members. Photography by Timothy Hursley, the Arkansas Office.

FEATURES

NEWS AND DEPARTMENTS

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Unsafe At Any Height

Even after more than 20 years, I'm still outraged when I think of Ralph Nader's revelations that some car companies were willing to design unsafe cars because they calculated that their profits would exceed their payments from lawsuits.

But is the automakers' decision any less offensive than that of municipal officials who refuse to adopt seismic provisions?

Too often Americans unrealistically believe that the earthquake problem in the U.S. is confined to the west coast. Unfortunately, the reality is that the seismic hazard zone in this country is far greater, and includes such areas as Seattle, Salt Lake City, Charleston, the Mississippi River Valley from St. Louis to Memphis, New England, and New York.

Some of the hesitancy might be due to the supposed cost of seismicly sensible construction. But the facts belie that fear. Martin Walsh, a St. Louis building commissioner, was recently quoted in *Civil Engineering* magazine as saying: "On a square foot basis, seismic provisions cost less than the difference between low and high grade carpeting. Seismic provisions add 1% to the cost of the structural framing, and structural framing is about 20% of the cost of the building."

In 1989, St. Louis joined the small number of municipalities with seismic provisions in their building code. Likewise, New York City is currently working on seismic provisions. They join such cities as San Francisco, Los Angeles, San Diego, Salt Lake City, Honolulu, Anchorage, Boston, and Charleston.

Charleston adopted seismic provisions in 1981, reportedly due in large part to the support of the South Carolina Seismic Safety Consortium, which includes homebuilders, building officials, and local ASCE chapters. And that effort provides a starting point for everyone interested in promoting safer construction practices.

City officials are not going to simply wake up one morning and decide that local building codes need seismic provisions. But design professionals—engineers, architects, and contractors—do recognize that need. And it's up to the design community to lobby for these changes. Let's not wait for a consumer activist to write a book titled: *Unsafe At Any Height*. **SM**

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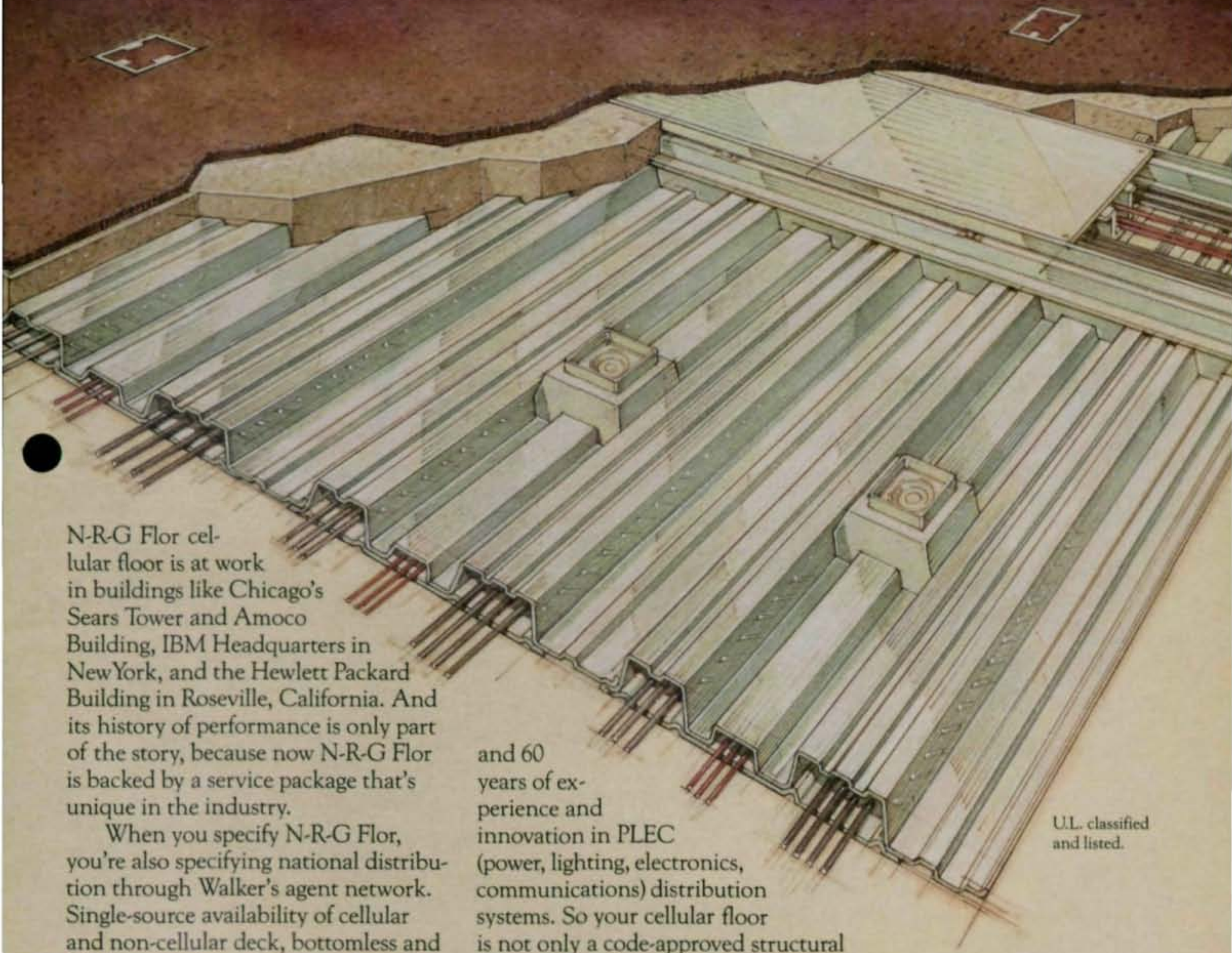

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New Stadium Returns To Baseball's Roots

When the Maryland Stadium Authority began discussing plans for a new home for the Baltimore Orioles they made one thing abundantly clear: They didn't want a modern concrete hulk.

"The stadium authority and the Orioles [who are owned by Eli S. Jacobs, who has had a long interest in architecture] wanted a stadium built the way a stadium should be built. They wanted the character of the old-time ballparks, such as Wrigley Field in Chicago," explained Joseph Spear, AIA, a senior vice president with Hellmuth Obata & Kassabaum (HOK), the St. Louis-based design firm with an international reputation for sports facility design.

Traditional Design

"We always felt a steel frame would be more in keeping with the aesthetic scheme the stadium authority wanted than would a concrete scheme," Spear continued. "Our only hesitancy was that initially it appeared that concrete would be less expensive." Fortunately, that wasn't the case, explained Bob Alewood, vice president of business affairs with the Baltimore Orioles. "Is there a cost premium? A lot of research indicated that in a worst case scenario there would be a small premium, but there might also be a small savings," he said. "But when you consider the aesthetic factors, there was no comparison."

Even the architectural critics approve of the design. As Paul Goldberger of the *New York Times* stated: "The Baltimore stadium, to

Continued on page 10

The new home of the Baltimore Oriole's (top) will be a steel stadium in the tradition of Fenway Park, Ebbets Field, Tiger Stadium, and Wrigley Field. Pilot Field (above), in Buffalo, N.Y., is a recently constructed steel stadium designed by HOK, the same firm responsible for the design of the new Baltimore stadium.


DH

Orioles, Cont.

be built on the site of the old Camden rail yards at the edge of downtown, will have a structure of steel, not the concrete used in most stadiums of our age, and its facade will be a series of brick arches. It will thus look like a *building* from the outside, not like some vast feat of engineering. This radical idea—that a stadium should look like a building and not like a chunk of Boulder Dam—comes, of course, from the great ball parks that inspired this design, places like Fenway Park in Boston, the late Ebbets Field in Brooklyn, Tiger Stadium in Detroit, and most beloved of all, Wrigley Field in Chicago."

A stadium should look like a building and not like a chunk of Boulder Dam

While most recent stadiums have been built of concrete, anyone who questions the practicality of a new steel stadium has to look no further than Buffalo for reassurance. Pilot Field, a 19,500 seat *steel* stadium opened in 1988 and in its first year broke minor league attendance records by drawing nearly 1.2 million fans, despite the Bisons finishing the season 17 games out of first place. In 1989, the team again drew more than 1 million fans. HOK also was the designer of that stadium.

As with Pilot Field, the Baltimore stadium is an exposed steel facility. "The design relies heavily on a lot of trusses and exposed connections to create a lacy, interesting exterior instead of the monolithic design of so many new stadiums," explained John Nyitray, P.E., president of Bliss & Nyitray Inc., the Miami-based structural engineer on the Baltimore project.

Lateral bracing also is achieved with exposed trusses, which means there are trusses running in two directions. The main bents that support the seating are 42' on center, and they also support cantilevered trusses, Nyitray said.

"We were afraid that the trusses would raise the price, but it turned out not to be a substantial increase," Spear said. To simplify maintenance, the structural engineers designed the trusses without double members. "It makes it easier to paint the frame and trusses," Nyitray said.

Ahead Of Schedule

The first game is scheduled to be played in the new stadium in April 1992, and design and construction is currently two months ahead of schedule, according to Alewood. While the designers kept the visual "feel" of an old-time stadium, they did take steps to improve the patrons' comfort. Leg room will vary from 32" to 33", compared with 24" to 26" at the Oriole's old park. And seats will be 19" to 21" wide, compared with 16" to 19". And because the stadium will be used only for baseball and not for football also, most of the 46,800 seats will be located between the foul lines, which will bring the fans close to the action.

The original cost estimate of \$78.4 million has risen to \$105 million, primarily due to the addition of customized features such as luxury club lounges and a television studio. The stadium is connected to an existing eight-story warehouse, which is set back slightly from the right field wall. The interior of the warehouse is being converted into ancilliary space for the ballclub, including the team's new executive offices.

"Steel is more exacting then concrete," Nyitray explained. "But that's not a penalty. It's an aesthetic advantage." If Larry Lucchino, the president of the Orioles, is right, his team's new home won't just be some cookie-cutter stadium. It will be a *ballpark*.

Australian Earthquake Provides Lessons For U.S. Construction Market

By Stephen K. Harris and Michael J. Griffin

At 10:27 a.m. on December 28, 1989, the first fatal earthquake in Australia's history struck the city of Newcastle and the surrounding Hunter Valley region of New South Wales. The epicenter of the 5.5 Richter magnitude trembler was estimated to be only five kilometers west of the city center.

Combined with the lack of seismic design in the local building stock, the proximity of this earthquake resulted in far greater damage than usual for such a moderate magnitude event. The Newcastle Earthquake lasted only five seconds, but killed 12 people, damaged more than 3,000 buildings, and caused losses estimated at more than (US) $900 million.

The reinforced concrete block retaining wall at the west end of the Newcastle Workers' Club was heavily reinforced, which may have cuased a brittle failure mode. Photos courtesy of EQE Engineering.

While tragic, the lack of seismic design in the region is understandable because earthquakes are so rare in the area. The only notable earthquakes in Newcastle's history were one in 1841, an estimated 5.3 magnitude event in 1868, and a third measuring 5.0 in 1925. None caused any significant damage. Thus, the damage caused by the recent Newcastle Earthquake was a shock to residents and most seismologists.

Seismic Code Requirements

In 1979, Australia adopted a seismic code with four seismic zones, modeled after the Structural Engineers Association of California's 1974 recommendations. Unfortunately, Newcastle was in zone Zero; so there are no earthquake requirements. Even if the city were not in zone Zero, it is likely that there would have been little difference in building performance since almost all of the buildings suffering severe damage were built before the code came into effect.

In order to prevent severe damage and loss of life in future earthquakes, Australia would need to require a seismic retrofit program similar to those now underway in California, as well as revise the seismic zone map for Australia and make more stringent requirements for unreinforced masonry construction.

Damage to commercial structures was spread throughout the lower Hunter Valley region. Although most damage was limited to older, unreinforced masonry

Continued on page 14

Quake, Cont.

structures, some damage was also observed to newer unreinforced masonry structures and relatively modern concrete-frame structures. Among the latter was the Newcastle Worker's Club, in which 10 people were killed. The other two fatalities were caused by collapsing awnings in a neighboring district.

Damage at Newcastle TAFE College included many fallen parapets and some delaminated walls and shear cracks.

Newcastle Worker's Club

The central business district of Newcastle sustained the heaviest damage. The most catastrophic failure was the Newcastle Worker's Club, where a section built in 1972 collapsed.

The Worker's Club was really two buildings: an older, unreinforced masonry section and a newer (1972) non-ductile concrete-frame section. The newer building was four stories tall, with parking below grade. It was constructed as a concrete "waffle" slab supported by square concrete columns at approximately 20 feet on center. The roof was corrugated metal over wood purlins and steel trusses. The concrete waffle slabs and the concrete block retaining wall that failed were heavily reinforced, which may have caused a brittle failure mode. Also, the large reinforcing bars that were used left little room for grout in the concrete block cells.

The collapse appears to have started in the basement with the failure of the load-bearing retaining wall. This failure caused the supporting columns to fail, pulling down the western edge of the building. The roof, spanning clear from the west to the east side of the building, collapsed entirely, leav-

Continued on page 16

Quake, Cont.

ing only the eastern wall standing.

Newcastle TAFE College

Newcastle Technical and Further Education (TAFE) College is a complex of 13 buildings built between the 1930s and 1970s. All are reinforced concrete-frame structures with unreinforced brick infill and cladding, ranging from three to four stories high with about 12' ceilings. The infill walls and parapets are two brick wythes (layers) thick, with about 1" of air space between the wythes. Parapets often were sitting unattached on top of the roof membrane.

Damage to the TAFE College structures ranged from light to moderate, including many fallen parapets and some delaminated walls and shear cracks. Some exterior walls moved away from the buildings by a few inches, causing partial collapse of the ceiling framing in at least one room.

About three-quarters of the columns at the Junction Motor Inn failed due to shear cracking, spalling, an buckling of longitudinal reinforcement.

Junction Motor Inn

Apart from the Worker's Club, the Junction Motor Inn was the only modern building to be severely damaged. Built circa 1980, it was a concrete-frame structure with concrete joist slab floors and brick infill above the first level.

The building was essentially open at the ground level for parking; so there was little to resist lateral motions. The only lateral force-resisting systems apparent in this lower level were two small walls, one brick and one concrete, toward the west end.

The lower level columns were about 12 inches square, reinforced longitudinally with large (approx. #9) deformed bars and reinforced transversely with small (approx. #2) undeformed ties about 16" apart. This reinforcing pattern, typical in concrete columns in areas considered to be non-seismic, often leads to sudden failures in earthquakes. In fact, about three-quarters of the lower-level columns failed due to shear cracking, spalling, or buckling of longitudinal reinforcement, causing the east side of the building to settle 6" to 12".

Block partitions at the Rankin Park Hospital were severely cracked in a chevron pattern, due to connection of the infill walls to the columns rather than to the beams.

Rankin Park Hospital

Rankin Park Hospital, about 10 kilometers from central Newcastle, was scheduled to open about six weeks into 1990. Damage to the hospital appeared to be entirely nonstructural, but will delay the opening by several months. Total damage was estimated at about 5% of the replacement cost of the building, although this estimate may be somewhat high.

The hospital is a reinforced concrete-frame structure with concrete flat slab floors and an aluminum curtain wall system. The main wing is a long, narrow, four-story structure, approximately 260′ x 825′. It is separated into five sections, each 165′ long, with expansion joints between the sections. For fire resistance, there are interior partitions of unreinforced concrete blocks.

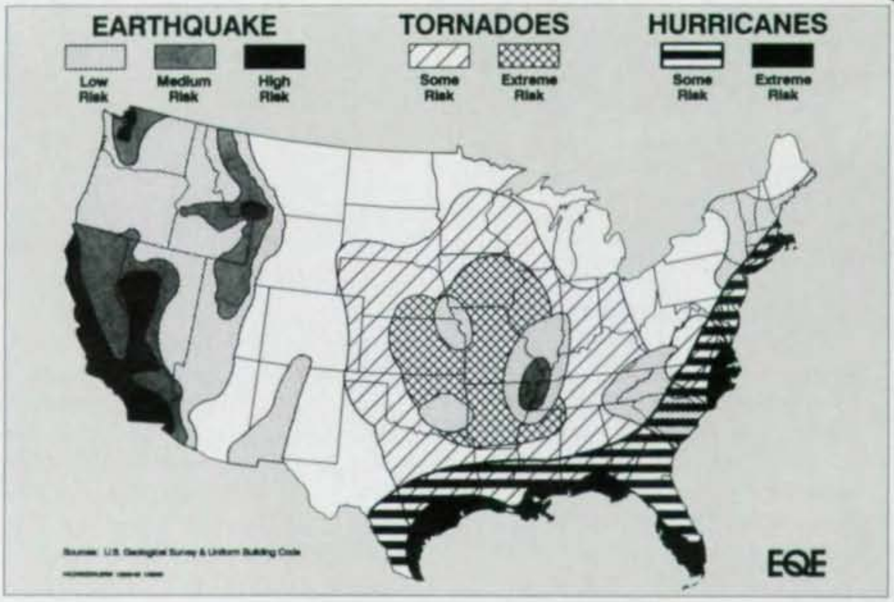
Many of the unreinforced concrete-block partitions were severely cracked in a chevron (inverted "V") pattern, rather than the typical "X" patterns, due to the connection of the infill walls to the columns and not to the beams. The damage was more severe on the upper levels, where an expansion joint was damaged.

On the hospital's top floor, which is used for electrical and mechanical equipment, several of the air-conditioning units moved as much as 11", damaging the ducting and sheet-metal housing.

Industrial Facilities

Newcastle is a highly industrial-

Quake, Cont.



ized area, with major port installations, and steel, aluminum, fertilizer, and coal processing facilities. In general, these facilities performed extremely well. That was to be expected from the low magnitude quake, and the fact that the predominate form of construction is steel frame. Among the facilities investigated were an oil terminal and storage facility, and a steel manufacturing plant.

The oil terminal and storage facility, which contains 10 large fuel oil storage tanks and loading facilities, is located close to the epicenter.

The terminal manager stated that the site was given a visual inspection after the quake. There was no damage to either the pipeline, the tanks or any of the equipment.

There was minor structural damage to a maintenance building, which had an unreinforced masonry wall pull away from the steel frame. There was also evidence of motion at various locations along the above-ground piping. However, there was no evidence of base movement.

The steel manufacturing plant produces rod and bar products and is capable of producing 1.8 million tons of steel per year. Located approximately 5 kilometers from the epicenter, it has been in operation since 1915.

The plant sustained only minor structural damage, largely to the roof structure of one building and to several ancillary buildings. No misalignment of the machinery was found. The only major problem was the loss of power, which was restored within four hours.

Implications For U.S. Construction

Like Newcastle, many parts of the United States have significant seismic risk without adequate seismic design of buildings and structures. In addition to California, Hawaii and Alaska, areas of moderate to high risk include the Seattle, Salt Lake City, and Charleston Regions, as well as the Mississippi River Valley between St. Louis and Memphis, a region that

Continued on page 23

GUIDE TO DESIGN CRITERIA FOR BOLTED AND RIVETED JOINTS
2nd edition
by
Geoffrey L. Kulak, John W. Fisher
and John H.A. Struik

The American Institute of Steel Construction, Inc., in cooperation with the Research Council on Structural Connections, is pleased to make the GUIDE TO DESIGN CRITERIA FOR BOLTED AND RIVETED JOINTS, 2nd Edition, available to all designers of bolted joints.

This comprehensive and authoritative reference and design guide will be of interest to steel designers, fabricators, inspectors, erectors, educators, students and others involved with bolted steel connections.

The current requirements contained in the AISC Specification for the design, installation and inspection of high-strength bolted joints are based, in large measure, upon the recommendations of the Research Council on Structural Connections, under whose guidance this book was written.

The 2nd edition of the GUIDE incorporates the wealth of research results published since the 1st edition more than a decade ago. Additional information on topics such as slip-resistant connections, fatigue, and beam-column connections (see Table of Contents following) will be of particular interest to many steel designers.

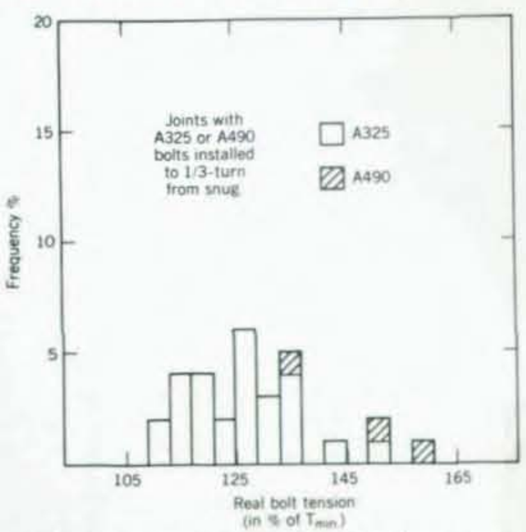


Fig. 5.8. Joints with A325 or A490 bolts installed to $\frac{1}{3}$ turn from snug.

About the Authors

Dr. Geoffrey L. Kulak, P.Eng., Professor of Civil Engineering at the University of Alberta, Edmonton, a Vice-Chairman of CSA Technical Committee, Steel Structures for Buildings, S16, member of the Specifications Committee of the Research Council on Structural Connections, Ontario Highway Bridge Design Code and the ASCE Committee on Load and Resistance Factor Design. He has published many articles based on his research on the behaviour of bolted or welded connections, member stability, steel plate shear walls, and fatigue. He is co-author of the textbook LIMIT STATES DESIGN IN STRUCTURAL STEEL.

Dr. John W. Fisher, P.E., Professor of Civil Engineering at Lehigh University, member of Specification Committees of the Ontario Highway Bridge Design Code, Research Council on Structural Connections, American Institute of Steel Construction, American Railway Engineering Association, and Transportation Research Board. He has authored over 120 publications and four books, including FATIGUE AND FRACTURE OF STEEL BRIDGES, (John Wiley & Sons). His vast research interests and activities include bolted or welded connections, fatigue, bridge behaviour, and steel-concrete composite members.

Dr. John H.A. Struik is with A/S Norske Shell, Forus, Norway. He obtained his Ph.D. at Lehigh University working closely with Dr. Fisher on research related to structural connections and worked extensively in preparing the first edition of the Guide.

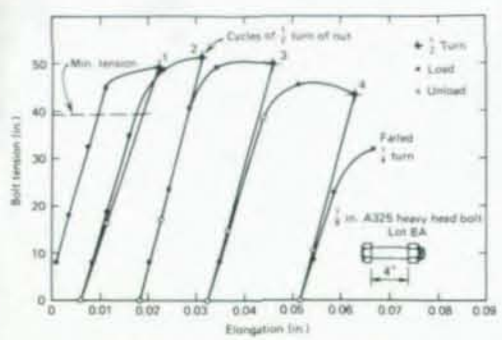


Fig. 4.23. Repeated installation of A325 bolts.

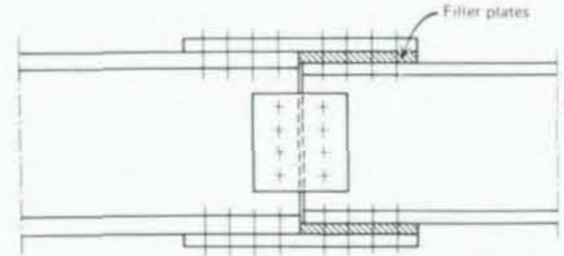


Fig. 10.1. Beam or girder splice with filler plates.

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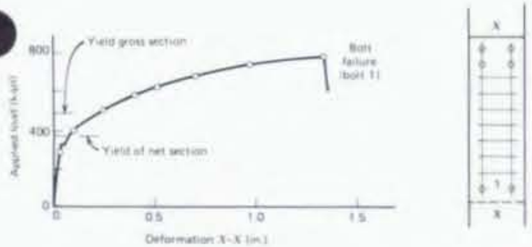

Fig. 8.2. Typical load versus deformation curve for lap joints in which restraints against bending are provided.

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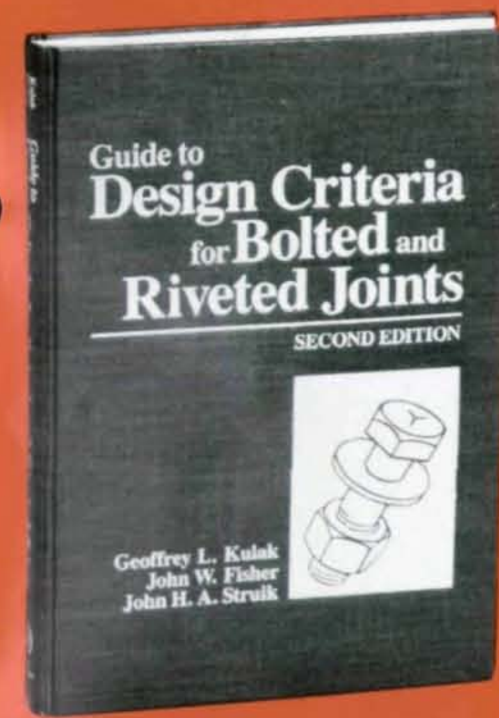

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January 1990

RCSC Promotes Research On Structural Connections

By John H. Bickford

Last year marked the 40th anniversary of a common element in most steel structures: the ASTM A325 High Strength Bolt. During the past four decades, high strength bolts, both ASTM A325 and A490, have been used on practically all steel structures with an outstanding record of safety and economy.

The Research Council on Structural Connections (RCSC), which was formed in 1947, wrote the first specification for the use of high strength A325 bolts in 1951. The council has continuously played the major role in the development, design, and implementation of all aspects of high strength bolting in bridge and building construction.

Funded by the American Institute of Steel Construction (AISC), American Iron and Steel Institute (AISI), and the Canadian Institute of Steel Construction (CISC), the council supports and promotes research on structural connections, and prepares and publishes related standards and other documents. Membership includes steel fabricators and erectors, fastener manufacturers, government organizations, trade associations, and researchers.

One of the council's most important publications is the "Guide to Design Criteria For Bolted and Riveted Joints", now in its second edition. The reference text, which was authored by G.L. Kulak, J.W. Fisher, and J.H.A. Struik, provides information on high strength bolting as well as the research background to the council's specification. A brochure included in this issue contains more information on the text and an order form.

Although the entire council only meets once a year, its research activities are continuous. Recent studies have been sponsored, for example, on such subjects as the actual tension achieved in bolts installed by various tightening methods, bolts subject to tension and prying action, methods for testing the friction coefficients of paints and other coatings, stress corrosion cracking of structural bolts, and shear tab connection behavior.

Today, two versions of the current bolt specification are available: one based on load and resistance design (LRFD) and the other on allowable stress design (ASD).

The specification, which includes a comprehensive commentary, which is available from AISC. It covers in detail the design assembly and inspection of structural joints using either A325 or A490 bolts. It specifies such things as: bolt hole dimensions; bolt strengths (shear, tension, etc.); the minimum tension, if required; and the four alternative methods for controlling bolt tension during assembly. It also permits the use of bolts installed to a snug-tight condition.

In addition to the guide and specification, the RCSC also has published a series of bulletins on current information about structural bolting. For example, one bulletin on the inspection and handling of high strength bolts was issued because of recent concerns about sub-standard or "counterfeit" bolts. Another deals with a variety of bolting factors meriting special attention from the engineer of record. An RSCC bulletin has been prepared for purchasing agents and is expected to be published soon. The bulletins, guide, and specification are available from the AISC. For more information, contact: AISC Publications, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001.

John H. Bickford is a vice president with the Raymond Engineering Co. in Middletown, Conn.

CALL FOR PAPERS

1991
NATIONAL STEEL CONSTRUCTION CONFERENCE
Sheraton Washington Hotel - Washington, D.C.
June 5-8, 1991

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Invitation/Call for Papers

The 1991 National Steel Construction Conference will be held at the Sheraton-Washington Hotel, Washington, D.C., June 5-8, 1991. Participants will include structural engineers, fabricators, erectors, educators and researchers. Potential authors may submit abstracts of papers on design, fabrication and erection of steel structures for buildings and bridges.

Topics of particular interest include:
Practical application of research;
Advances in steel bridge design and construction;
Composite members and frames;
Buildings designed by LRFD;
Heavy framing connections;
Steel-framed high-rise residential buildings;
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Guidelines for Abstract Proposals

Abstracts for papers must be submitted before September 15, 1990.

Abstracts should be approximately 250 words in length, and submitted on a separate sheet of 8 1/2" x 11" white paper attached to this form.

Authors will be informed of the Organizing Committee's decisions by November 15, 1990. Successful authors must submit their final manuscripts for publication in the official 1991 Conference Proceedings by March 15.

Registration fees for the Conference will be waived ONLY for the Primary Author presenting a paper.

Preparation of Final Paper

Final manuscripts for publication in the official 1991 Conference Proceedings are expected to be approximately 20 pages in length. Copy (including photographs) must be camera-ready. Complete instructions will be forwarded to authors upon acceptnace of Abstract Proposals.

Poster Session

Papers not accepted for presentation at the Conference may, at the Author's expense, be presented at the Conference Poster Session. Guidelines for the Poster Session will be provided upon request.

Return your Abstract with this Submission Form before September 15, 1990 to:

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Education Series Focuses On ASD Manual

A refresher course on steel building design for practicing structural and civil engineers will be offered in more than 30 cities during the first half of 1990.

The seminar program, which visited 30 cities last year, is geared for use with the new Ninth Edition Manual of Steel Construction from the AISC.

The lectures cover the use of the newly created composite beam tables, beam load tables, small base plate analysis, shear tab connections, and, for the first time, semi-rigid connection design.

Also included are updated procedures on traditional steel design methods, such as beam load tables, small base plate analysis, moment connections, fatigue, and eccentric joints. The seminar also will cover the 1989 AISC Specification, the rules of which have been reframed into a chapter format following the LRFD logic to provide correlation between both Specifications.

Seminars are scheduled in the following cities:

Albany (March 2); Greenville (March 20-21); Boise (March 21); Salt Lake City (March 22); Las Vegas (March 24); San Francisco (March 26-27); Indianapolis (March 26-27); Miami (March 28-29);

Harrisburg (April 3); Pittsburgh (April 4-5); Springfield, Ill. (April 10); Memphis (April 10-11); Des Moines (April 11); Nashville (April 16-17); Knoxville (April 18-19); Syracuse (April 23-24); Rochester (April 25); Raleigh (April 25-26); Buffalo (April 26); Charlotte (April 30-May 1);

Norfolk (May 7-8); Richmond (May 9-10); San Juan (May 13); Oklahoma City (May 21-22); and Albuquerque (May 23-24).

To register, return the form at right, along with payment, to: AISC-ASD Lectures, P.O. Box 806286, Chicago, IL 60680-4124. Or, for more information, call (312) 670-5422. □

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T.R. Higgins Lecture Focuses On Earthquakes

The greatest threat from earthquakes is for existing structures, according to the winner of this year's T.R. Higgins Lectureship Award. The award is presented annually by the AISC to an individual based on his published work during the past five years.

"The devastating M_S=7.1 Loma Prieta earthquake of October 17, 1989, has again reminded all of us that the U.S. has a serious earthquake problem, one that the growth of the population and increased urbanization has markedly exacerbated," said Vitelmo V. Bertero, a professor of civil engineering at the University of California at Berkeley and director of the Earthquake Engineering Research Center. He is a nationally recognized expert on seismic construction and the recipient of the 1990 *Engineering News Record's* Man of the Year Award.

He presented a talk titled: "Earthquake Hazard Reduction: Implications Of Lessons Learned From Recent Earthquakes And Research" at this year's National Steel Construction Conference in March. During the next 12 months, Bertero will present the lecture five times in various locations still to be announced.

In his paper, Bertero discusses the nature of the earthquake problem and discusses methods of improving earthquake-resistant construction.

According to Bertero, one of the most promising ways of developing efficient methods for improving earthquake-resistant construction is to predict the response of structures to earthquake ground motions through an energy approach. "In this approach, it is recognized that the total energy input can be resisted by the sum of the kinetic energy, the elastic strain energy, and the energy dissipated through plastic deformations, and the equivalent viscous damping," he said.

"Although the advantages of controlling the seismic response of civil engineering structures by increasing their capacity for dissipating energy through increased damping and plastic deformations have long been recognized, the rational application of this in practice has been more an exception than the rule," Bertero explained. "The UBC has only specified the seismic forces on the basis of the concept of ductility, through the use of a structural system factor R_W. However, the rationale for and reliability of the values recommended for the R_W factor can be questioned in view of recent research results. The UBC recommended values appear to be too high, particularly for short-period buildings which are designed to just satisfy the minimum strength required by the UBC provisions."

Instead, Bertero proposes in his paper a more reliable method for estimating the values. The method considers R_W as the product of four different main contributions: the difference between yielding strength design methods and working stress design methods; the actual available strength of the structure that is designed in compliance with code requirements; the reduction due to increase in equivalent viscous damping in the inelastic range with respect to the elastic response; and the reduction of the required elastic force due to the dissipation of energy as a consequence of the ductility supplied to the structure.

The entire text of Bertero's paper will be reprinted in an edition of AISC's *Engineering Journal* at a later date. □

Quake, Cont.

produced the largest seismic events ever to occur in the U.S. (1811 and 1812). The New England and New York areas pose moderate seismic risks.

Good seismic performance of a structure requires that seismic considerations be incorporated from the beginning of the design process. These considerations include selection of materials, structural and framing layout, and detailing of the basic elements. Ductility in the lateral-force resisting system is essential, unless the building is designed to withstand (real) seismic forces several times higher than code design forces.

Design and detailing required to achieve adequate seismic performance is generally lacking in the buildings in Newcastle, as it is in much of the U.S. Design for wind often produces comparable lateral forces, but without meeting ductility requirements. This lack of ductility in eastern and central U.S. construction is the primary cause of the great seismic vulnerability of these areas.

The Newcastle Earthquake demonstrated the consequences of ignoring even a limited seismic history. Although all of the earthquakes in that area have been moderate, the unreinforced masonry that predominates was inadequate to resist even a short, moderate earthquake, albeit with a close epicenter. Even some modern structures proved unable to resist this moderate earthquake, because seismic concerns had not been incorporated into their design.

This article is based on an on-site investigation by a team of engineers from EQE Engineering, one of the world's leading earthquake engineering firms. Stephen K. Harris, S.E., is a senior project engineer with EQE's San Francisco office and Michael J. Griffen, P.E., is a principal engineer with the firm's Costa Mesa, Calif., office. □

Specification For:

Architecturally Exposed Structural Steel

Adopted by the American Institute of Steel Construction, Inc., August 25, 1960

INTRODUCTION

Exposed structural steel as a medium of architectural expression may require closer dimensional tolerances and smoother finished surfaces than required for ordinary structural steel framing. This specification establishes standards for these requirements that reconcile finished appearance with construction costs.

SECTION 1 SCOPE

(a) This specification shall only apply to members specifically designated on the design drawings as "architecturally exposed structural steel" which shall be fabricated, handled and erected as directed in this specification, and except as noted below, in conformity with the American Institute of Steel Construction Specification for the Design, Fabrication and Erection of Structural Steel for Buildings. Because these members so designated are subject to close inspection by the public, the fabrication tolerances in this specification shall govern when such tolerances are in conflict with those of the AISC Specification.

SECTION 2 MATERIAL

(a) Material shall be the same as specified for Structural Steel by the AISC specification.

(b) Permissible tolerances for out-of-square or out-of-parallel, depth, width and symmetry of rolled shapes shall conform to ASTM Specification A6. Overall profile dimensions of built-up members shall be adequate to provide for the accumulated permissible overrun of the component parts.

(c) The as-fabricated straightness tolerances of members shall not exceed one half of the standard camber and sweep tolerances in ASTM A6.

SECTION 3 FABRICATION

(a) Fabrication shall be performed with special care and necessary straightening to maintain the condition of the material as described above.

(b) Shop details shall show clearly the required fabrication tolerances. Erection plans and/or anchor bolt plans shall show the required tolerances for setting embedded items.

(c) All copes, mitres and butt cuts in surfaces exposed to view shall be made with uniform gaps of 1.8" if shown by the architect to be open joints, or in uniform contact if shown without gap.

(d) Where the fit-up of adjacent members is such that permissible tolerances specified in Sections 2b and 2c may result in an unsightly joint, the architect shall specify on the design plans the tolerances required. These tolerances shall be maintained by special attention in detailing the joint, or if necessary by refined fabrication techniques.

SECTION 4 WELDING

(a) **Fillet Welds**

Faces of welds exposed to view shall have as-welded surfaces that are reasonably smooth and uniform. No finishing or grinding shall be required except where clearances or fit of other items may so necessitate, or as specifically required by design drawings.

(b) **Butt and Plug Welds**

Faces of butt and plug welds exposed to view shall have as-welded surfaces that reasonably smooth and uniform and shall not project more than 1/16" above the surfaces joined. No finishing or grinding shall be required except where clearances or fit of other items may so necessitate, or as specifically required by design drawings.

SECTION 5 PAINTING

(a)After inspection and approval and before leaving the shop, all steelwork shall be cleaned by hand wire brushing, or by other means, elected by the fabricator, of loose mill scale, loose rust, accessible weld slag or flux deposit, dirt and other foreign matter. Oil and grease deposits shall be removed by solvent.

(b) After cleaning all steelwork shall be given one coat of shop paint applied thoroughly and evenly to dry surfaces, by brush, spray, roller coating, flow coating, or dipping, at the election of the fabricator.

(c) Surfaces within two inches of any field weld location shall be free of materials that would prevent proper welding or produce objectionable fumes while welding is being done. If shop painted, surfaces to be welded shall be wire brushed in the field before welding to reduce the paint film to a minimum.

SECTION 6 ERECTION

(a) The erector shall use special care in unloading, handling, and erecting the steel to avoid bending, twisting, or otherwise distorting the steel members. The erector shall handle the material in such a way as to minimize the damage to shop coat of paint.

(b) The erector shall plan and execute the erection in such a way that the close fit and neat appearance of the joints and the structure as a whole will not be impaired.

(c) If temporary braces or erection clips are employed, care shall be taken to avoid any unsightliness upon removal. Tack welds shall be ground smooth and holes shall be filled with weld metal or body solder and smoothed by grinding or filing.

SECTION 7 INSPECTION

(a) The architect shall inspect the steel at the point of fabrication prior to shipment.

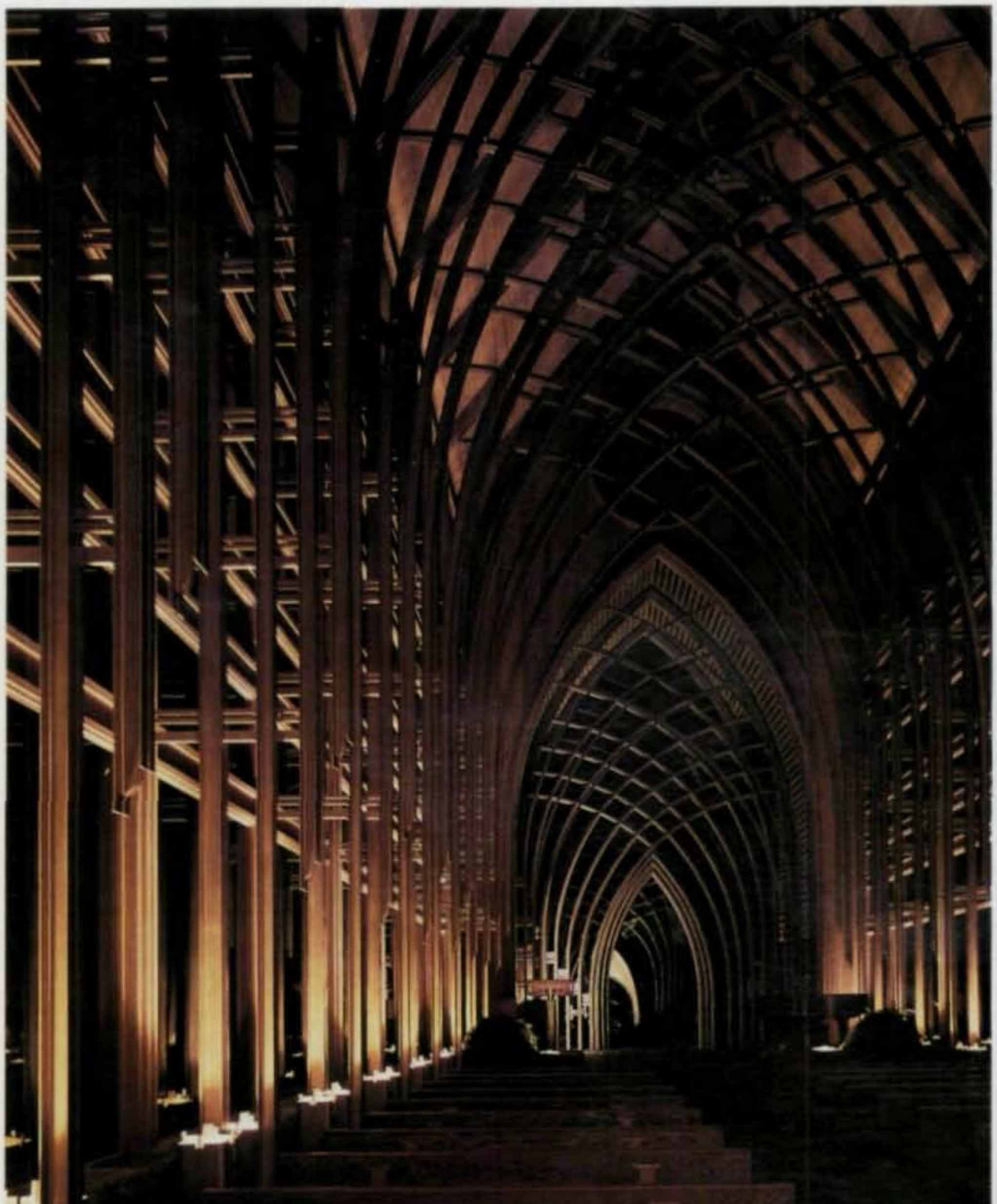
STEEL AS ARCHITECTURE

Design has come full circle during the past century. In 1889 Gustave Eiffel thrilled the world with his fabulous iron tower. And nearly 100 years later Fay Jones (see story on following page) created a modern masterpiece with exposed steel.

Designers have rediscovered that steel's strength and flexibility readily lends itself to the creation of delicate and airy spaces.

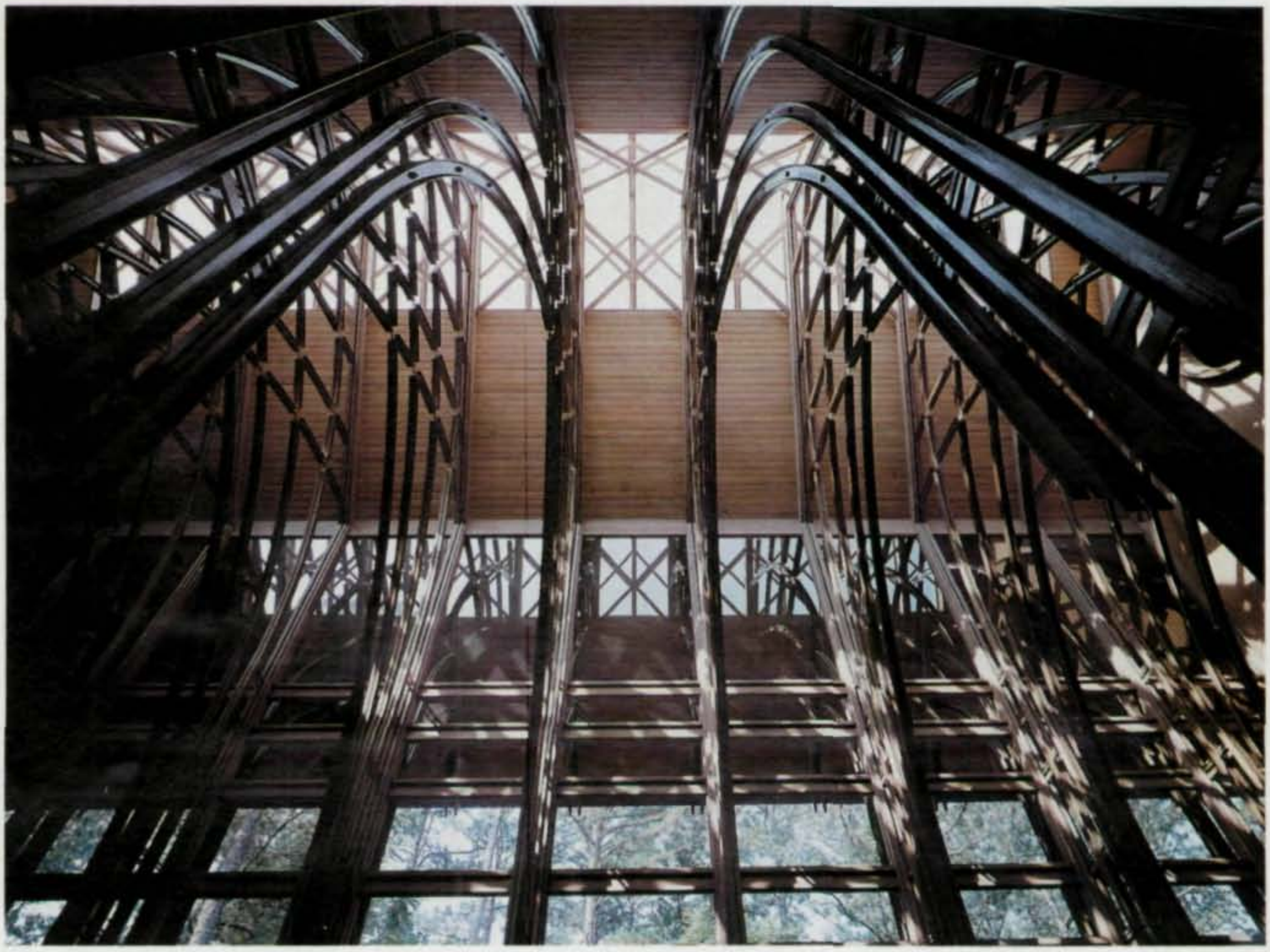
Operative Opposites

Using steel within the traditional geometry of Gothic design created a dramatically airy structure



At night, Fay Jones' majestic Cooper Chapel in Bella Vista, Ark., is lit with a series of uplights. The lights (see detail on opposite page) are covered with a steel grill that creates an interesting pattern on the steel members overhead. The same pattern is repeated in the walkway lights outside the chapel.

During the day, gazing up at the chapel's ceiling creates the illusion of a huge stained-glass window, as the arched curved columns intersect and re-intersect across the windows and skylight revealing flashes of blue sky(opposite). Photography by Timothy Hursley, The Arkansas Office.



By applying the principle of "operative opposites" to Gothic design, E. Fay Jones, FAIA, of Fay Jones & Maurice Jennings Architects, Fayetteville, Ark., succeeded in creating a stunning landmark in a most unlikely location.

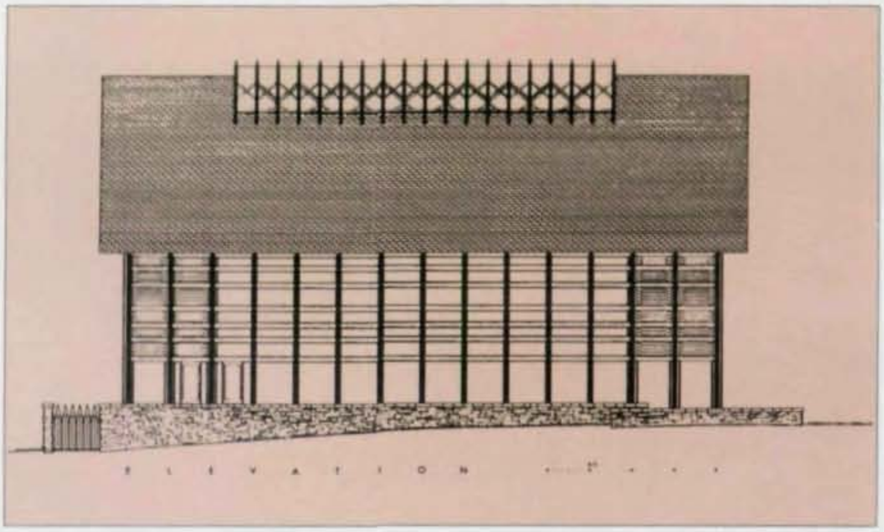
Jones, the winner of the prestigious 1990 American Institute of Architects Gold Medal Award, inverted the heavy stone design of traditional Gothic architecture and created a spiderweb-like steel structure for Cooper Chapel in Bella Vista, Ark.

"I wanted something light and delicate for the bracing of the building," Jones said. "There's a reference to Gothic architecture in the characteristic geometry of the building, but we wanted a web shape. Steel, being very strong, could produce a thinner structure than could wood."

Jones has often referred to classical architecture in his projects. "There's a design approach on a number of my projects where I've taken various historical styles and expressed them in different materials," he explained. "Gothic architecture is usually stone—an oppressive, compressive material. Here we switched to something light and delicate—steel.

A New Interpretation

"There's a nothingness where the stone was, and instead an expression in the joint areas," Jones continued. "The joints in the stone are the non-material, but here, the steel is where the joints were. Thus, an operative opposite. We made reference to classical architecture, but because of the nature of a different material, it's a different expression."



The chapel is situated only a few hundred feet from a nearby highway and shopping center. But because of its strategic placement behind a wooded hill overlooking a small lake, the sounds and sights of modern civilization are almost non-existent by the time a visitor reaches the chapel.

The 24'-wide by 84'-long chapel is clad in glass and wood, and the structure is almost completely exposed. There are three wooden frames on each end, and nine structural steel webs in between. The steel members have two small channels, and where the members are connected, a flat X appears.

"The channels are cut to specific lengths, and in each steel web there is a slightly different angle of connection," Jones explained. The top part of the steel bents are locked into wood rafters, and the ceiling is screwed to the rafters. "It looks like the steel runs right into a slot between the wooden members," Jones pointed out.

Engineering Background

Jones, who studied civil engineering for three years before switching into architecture, acted as the structural engineer for the project. Contractor was LaBounty Construction Co.

The chapel rests on two low stone walls, which in turn are supported by concrete footings. The heating and air conditioning is pumped through concealed hollow boxes in the stone floor, and the return air ducts are concealed under the sound cabinets on the podium.

On the roof—it's 54' to the chapel's peak—is a large skylight extending almost the entire length of the chapel, which brings in even more light and creates a stained-glass window effect when the blue sky is viewed through the latticework of steel members.

"The side walls are glass and there's a ridged skylight above," Jones said. "In creating a path to the sky, there's an everchanging amount of light, and it has a decorative quality as it plays over the structural members. It's a constantly changing shadow pattern."

Further shadows are cast by the nuts and bolts evenly placed on the steel members. Even at night, lighting plays a key role. "We situated sidelights on each side of the steel webs on both sides of the chapel and along the path outside the chapel," Jones said. Covering the uplights are decorative steel grills that reflect the lights and create intriguing patterns on the steel members overhead. □

Using steel allowed Jones to open up the chapel to allow a large amount of natural light to enter. In addition, the glass walls help to "bring" nature into the chapel.

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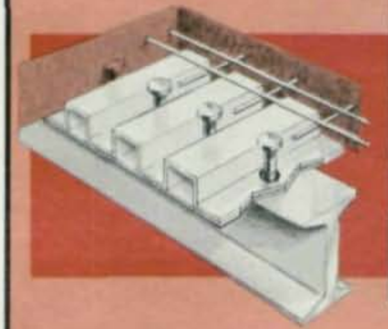

Composite Bridges – Shear connectors provide equal shear in all directions, eliminate distortion that might result from hand welding and permit more satisfactory compaction of concrete around the connectors.

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.

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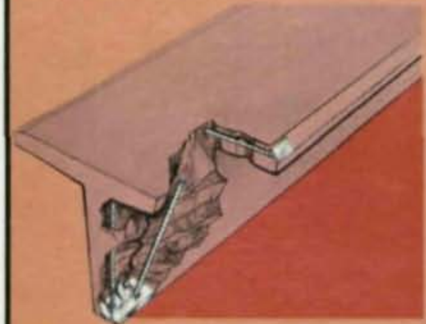

Precast/Prestressed – Because of their known values, anchor studs can be used in standardized designs for such connections as bearing plates for beams and tees, shear keys for tees, column baseplates, and various other embedded steel elements. In these applications, stud welding reduces cost per plate, 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.

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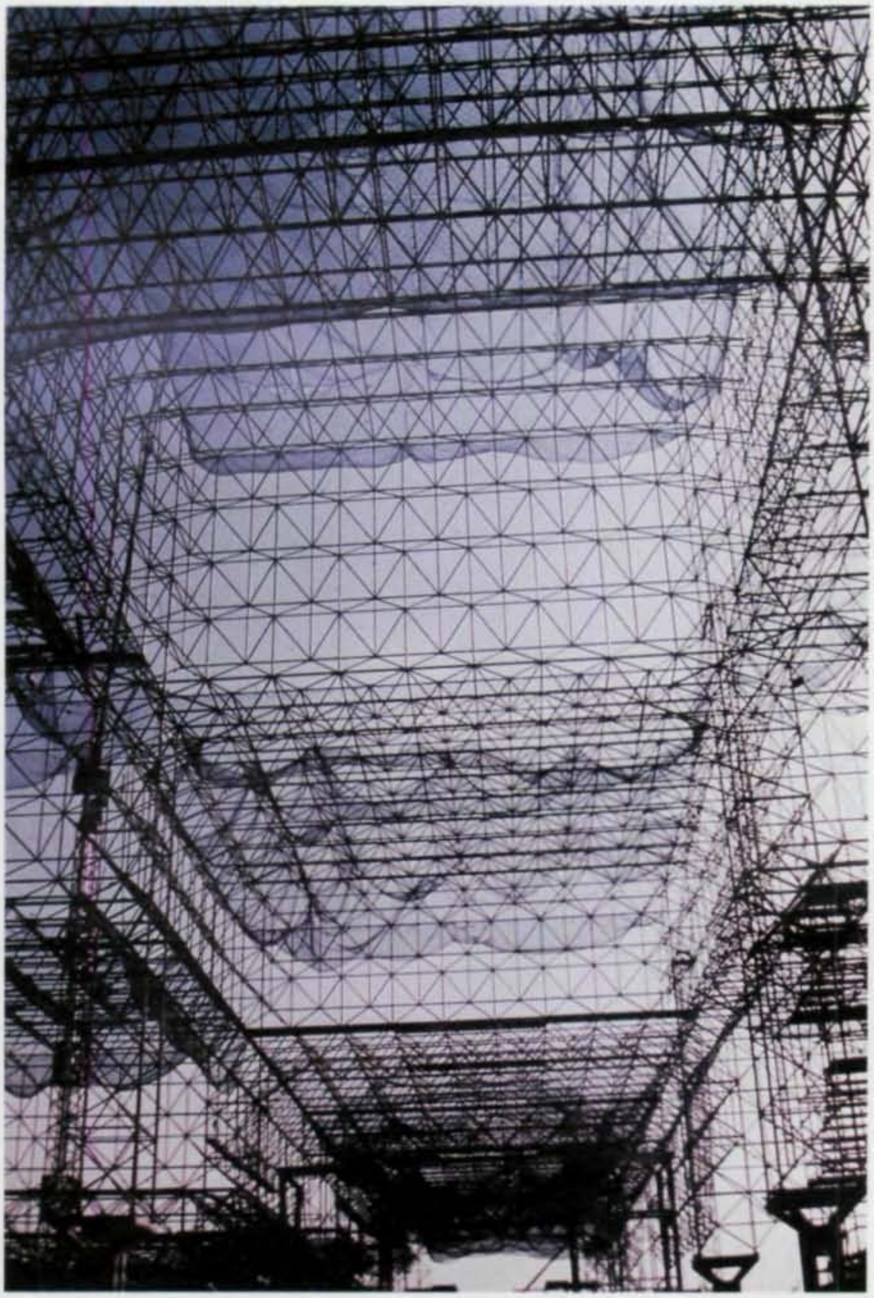


Pictured above is the magnificent Jacob K. Javits Convention center in New York, which uses HSS to create a memorable main hall to a mostly undergound convention facililty. On the opposite page is the United Airlines Terminal at O'Hare Airport in Chicago, which recalls the glorious train stations of an earlier age.

Architects love Hollow Structural Sections for their visual impact, and owners are developing an affection for their low cost

From Helmut Jahn's United Airlines Terminal to I.M. Pei's Jacob Javits Convention Center, many top designers have turned to Hollow Structural Sections (HSS) to achieve their aesthetic goals. But in addition to providing visual drama, the use of HSS can also provide substantial cost savings for columns.

Compared with open-profile structural steel (W-, M- and S-shapes, channels and angles), HSS can be less than half the weight for equivalent load-carrying capabilities on columns. "The weight of an HSS column, a compression member, could be 40% to 45% of the weight of an open section," explained Frederick J. Palmer, P.E., director of the American Institute for Hollow Structural Sections, a trade group representing eight steel mills.

Ideal For Columns

"HSS works best for columns," said Lawrence Kloiber, president of Le Jeune Company, a Minneapolis fabricator that manufactures both HSS members and open-profile structural steel. "The unit price for raw material is substantially more expensive (for HSS), the material cost can be 25% higher, but the weight savings are


B16
B17

about 45% to 50%." Savings of up to 20% can be realized, he said.

There also are savings due to reduced shipping costs, Palmer said. "And because there are six surfaces on a wide flange member compared with four surfaces on a Hollow Structural Section, there is approximately 30% less surface area, which results in savings in painting and fire protection," he added.

Currently, HSS accounts for only 3% of all steel fabricated for buildings and bridges in the U.S. Overseas is a different story, though. In Europe, HSS accounts for 15%, and in Japan, HSS represents 25% of the market, and is still growing, according to Palmer. "The trend is continuing upwards," he explained. For HSS columns alone in Japan, the estimates for last year range from 500,000 to 800,000 tons of steel.

Use On The Upswing

Palmer said he expects HSS use to increase in the U.S. for several reasons. "There's an increased awareness of the cost of construction. While most of the attention for HSS is focused on some large and glamourous projects, the real bread and butter structures are the ones that use HSS purely for economics—such as gasoline stations that are essentially a number of vertical columns with a canopy on top," he said.

While Palmer insists that cost savings are the number one reason for specifying HSS, aesthetics also are playing a large role. "There's more use of exposed steel in structures, and that's a perfect use for HSS," Palmer said.

And finally, for the first time there's a concerted effort by steel producers to promote HSS. In the past individual manufacturers have attempted to broaden HSS' share of the market. The formation of a new institute will allow the funding of broad technical and promotional programs.

While HSS is very efficient for long, slender columns, they aren't usually cost effective for beams. "I wouldn't use them for beams, except where they're exposed or in a food processing plant [where health codes require the elimination of ledges that could cause food contamination]", Kloiber said. "They're not as efficient in bending as an open shape, and the connection cost is higher. They do work well for torsional problems, and they work well where an attractive appearance is necessary."

Hollow Structural Sections are used in a wide variety of structures, such as the Rolfs Aquatic Center at Notre Dame in South Bend, Ind., designed by Ellerbe Becket.

Wide Range Of Sizes

Most of the HSS used in construction are produced in accordance with ASTM A500, a carbon steel specification. They're made in round, square and rectangular profiles with perimeters up to 64" and wall thicknesses from 1/8" up to 5/8". Common sizes include squares from 2" through 16"; rectangulars from 2" x 21/2" to 12" x 20"; and rounds from 2" to 20" outer diameter.

Specification A-500, grades A, B, and C, offer yield strengths up to 50 ksi. Weathering steel grades comparable to A242 and A588, with enhanced atmospheric corrosion resistance, also provide yield strengths of 50 ksi. HSS corresponding to ASTM A441 and A572, high strength low allow grades, offer yield strengths as high as 65 ksi. And filling the interior with concrete, for composite action, can significantly increase column strength (see LRFD First Edition manual, pages 2-37 through 2-45 and 4-103 thorugh 4-118).

Fabrication and erection of HSS is accomplished with standard welding procedures.

Production of the structural steel tubing involves two basic sequences. First, coils of flat-rolled steel are uncoiled and the edges are trimmed, followed by precise slitting and recoiling. In the second stage, a continuous process, the strip is passed through a series of consecutive rolls that gradually cold form it into a round shape. Electric resistance welding of the edges closes it into a round tube.

If a square or rectangular configuration is the goal, it proceeds through a series of reshaping rolls, and is finally cut to desired lengths.

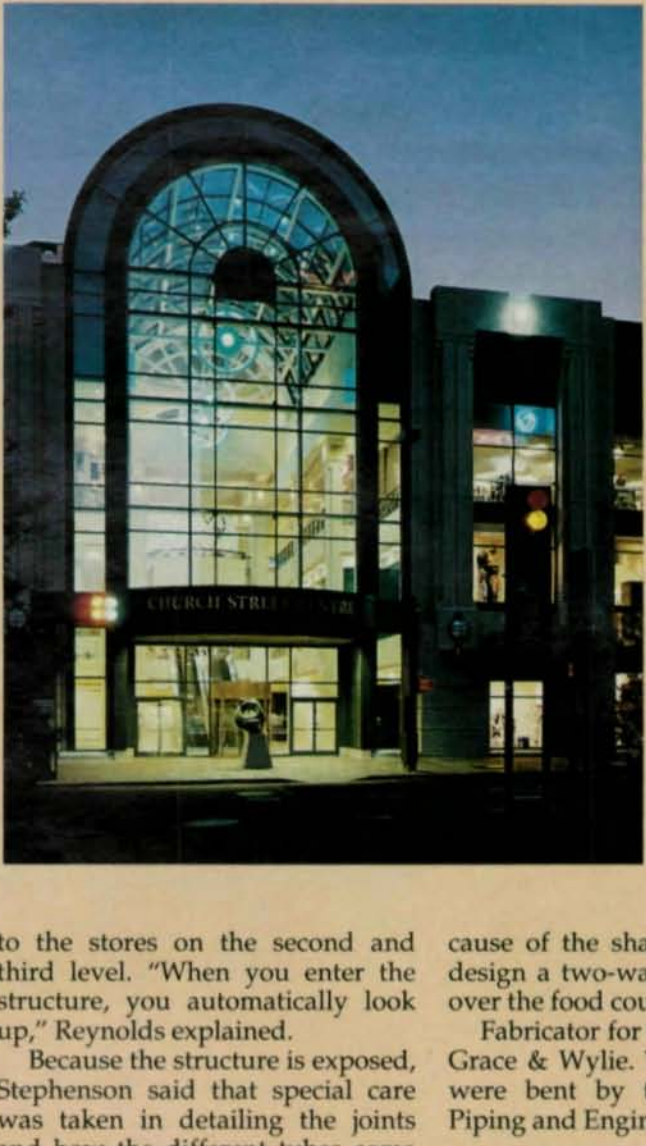
For more information on HSS, contact: Frederick J. Palmer, Director, American Institute for Hollow Structural Sections, Suite 8, 929 McLaughlin Run Road, Pittsburgh, PA 15017. □

New Excitement For Downtown Nashville

As with many of America's downtowns, Nashville's urban core has been steadily losing its retailers. So when a new 180,000-sq.-ft. center was planned for downtown Nashville, the architects knew they needed a vibrant design.

"We knew we needed something visually exciting to attract attention," said William D. Reynolds, AIA, a principal with Atlanta-based Smallwood, Reynolds, Stewart, Stewart & Associates, Inc., the project's architect. "We wanted something that would attract people into the center, and once there, make it an exciting experience."

The architect's solution was to create a huge barrel vault extending the full length of the center and to use exposed steel tubes in open area. "The members are not only decorative, but also structuralø, he added. The Hollow Structural Sections support both the barrel vault and a large arched window over the entrance.



The dramatic entrance to Church St. Centre is helping to bring new retail life to downtown Nashville.

Visual Excitement

"Aesthetics were the prime consideration," explained James Stephenson, PE, of the Nashville office of Stanley D. Lindsey & Associates, the project's structural engineer. "Architecturally, the designers wanted to create an open-air effect. We could have done something similar with a lot of angles and a conventional truss system, but this has a more exciting look and a similar cost," he said.

The visual excitement overhead also helps bring customers to the stores on the second and third level. "When you enter the structure, you automatically look up," Reynolds explained.

Because the structure is exposed, Stephenson said that special care was taken in detailing the joints and how the different tubes come together. "And we needed to specify the proper welds for the tubes," he added. For this project, partial penetration welds were specified.

A similar, though slightly more complex, system was designed for the 60'-square food court area. "Because of the shape, we had to design a two-way truss system over the food court."

Fabricator for the project was Grace & Wylie. The steel tubes were bent by the Associated Piping and Engineering Co.

Unusual Site

Complicating the project was its unusual site. The center is built on top of three separate existing city parking garages, none of which were designed for future expansion. "We had to analyze each column, and fortunately the foundation rested on rock," Stephenson said. Each existing 24" round column was encased in a new concrete column and converted into a 36" square column. "It sounds like a big change, but people don't really notice the change in size," according to Stephenson.

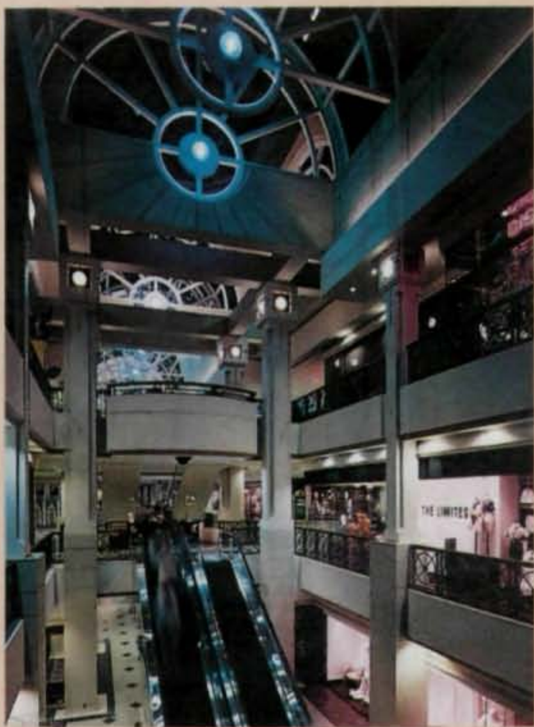
Clear Line Of Sight

Extra reinforcing also was needed because the designers didn't want any columns in the central core area. "The entrance lines up with the State Capitol and the architects wanted a clear vision line in the entry court," Stephenson said. The cost for reinforcing the garages was $3 million.

The holes for the anchor bolts were drilled before the base plates for attaching the steel structure of the new center to the concrete columns of the existing garages were fabricated. "Because of the large amount of steel reinforcing bars, each hole is in a slightly different location. Essentially, each base plate is custom made," Stephenson said. "The whole crux of this job was putting a lot of forethought into each aspect."

Because of the reinforcing costs, it was essential to keep the structure as light as possible. "The need for a light structure was the overriding concern, and that automatically ruled out concrete."

Instead, the perimeter of the new retail center is metal stud covered with an exterior insulating system. The floors are composite, and the roof is a continuous beam and simple purlin system. And of course, the main core of the building is Hollow Structural Sections. "We evaluated a bar joist scheme, but we had very long, 58' spans and composite gave us good resistance to the human perception of vibration and motion." □



When faced with the challenge of drawing customers back to downtown Nashville, the designers of the 180,000-sq.-ft. Church St. Centre responded with a dramatic barrel-vaulted roof. In addition to acting as a beacon to bring people into the center, the dramatic exposed steel shapes attracts the eye upwards and draws attention to the stores on the upper levels.

Design Aesthetics Require Steel Framing

Masonry construction proved impractical to meet the owner's desire for an unobtrusive structure

The outdoor dining terrace at Canterbury place is shielded from the wind by a plexiglass panel attached to a steel framework. The steel trellis is tied into the building frame on the fifth and sixth floors to resist the wind forces. Photography by Lockwood Hoehl

Architectural critics who complain about extraneous and unrelated ornamentation should be pleased by Canterbury Place in Pittsburgh. While the steel trellises and entry canopy at the new elderly housing facility clearly have a cosmetic purpose, they also relate back to the structure's steel frame.

Canterbury Place is part of a large elderly-care complex that provides both independent housing units and nursing home facilities, with the newest building housing 138 personal care residents and 59 nursing beds. The complex is located in Lawrenceville, a mature working class neighborhood of Pittsburgh with predominantly masonry homes. Episcopal Elder Care Services Inc., the project's owner, insisted that the new structure fit in with the existing neighborhood as unobtrusively as possible.

Minimize Visual Impact

As a result, even though zoning permitted a massive construction envelope with a 1' horizontal to 4' vertical setback above 45' in height, the designers opted for much larger setbacks of 2' horizontal to every 1' vertical. "By zoning ordinance, we could have built almost straight up," explained William Heaton, AIA, project architect with The Design Alliance, Pittsburgh. "But we wanted to be good neighbors."

While this created an attractive

design, it also created headaches for the structural engineers. "The setbacks don't occur at the normal bay spacing, so there was no way to introduce a bearing partition at that point," said Gilbert Kaufman, an engineer with Structural Engineering Corporation, Pittsburgh. In addition, each level features more than one setback.

Underground Parking

Another problem was caused by the need to construct beneath the new building a one-story parking garage with a larger footprint than the new structure. "The flow pattern of the parking area determined that load bearing masonry construction was not feasible," he said. Instead, a steel frame was used and a brick curtainwall was added to help weave the building into the fabric of the community.

While the brick curtainwall fit in with the character of the community, the architects found it to be too "visually" heavy when used in a building of this size, despite

The large setbacks, combined with the decorative exposed steel, breaks up Canterbury Place's huge mass and allows it to better meld with the surrounding commmunity. Exposed steel is used in a variety of ways on the project, including the prote cochere/entrance, trellised walkway, upper level wind and sunscreens, and for the steel-framed windows.

the numerous setbacks. To lighten the building's appearance and create an airy, open look, the designers added a series of decorative steel trellises and a steel prote cochere/entrance. In addition, they specified steel-framed windows.

"We wanted a light and airy look, but also a sense of security," said Heaton. While not structural, the trellises do provide a sunscreen for the complex's elderly residents.

Plexiglass Wind Screen

And in addition to visually reducing the scale of the building, the decorative steel at the base of the building is reflective of the more functional steel on the upper floors. The roof of the fifth floor is used as an outdoor extension of the top floor dining room. The steel trellis in this area is attached to the building frame and is covered with a plexiglass screen to block the wind. "There's a lot of wind force and the bases of the larger columns are connected to the exposed trellises," said Kaufman. "The connections are not visible, however, because they occur below the deck."

The new building rests on caissons, and the structural system utilizes steel joists. The girders are mostly W24 x 55, while the columns were typically W12, with a variety of weights. The fabricator of the steel frame, not including the decorative elements, was Littell Steel Company.

Complicated Stairway

Connecting the new building to the adjacent existing masonry building was, for the most part, straightforward and accomplished mainly with expansion joints. The only complication, however, was the stair tower between the buildings. "Where the new construction interfaces with the existing building, there's a stairway," Kaufman explained. "The original building at that end was three stories high, while the new structure was six stories plus a penthouse." Unfortunately, poor soil conditions prevented the designers from simply adding four landings to the existing stair. "Doubling the load would have caused settlement and severe cracking."

The steel-framed windows complement the wood stairway on the interior. The view into the courtyard shows the steel terrace.

Instead, the stairways additional height was suspended from above. "There are four columns in the elevator area. We connected them with two big transfer trusses in the penthouse and suspended the stairway from the trusses," Kaufman said.

Consultants on the project included: Mirick, Pearson, Batcheler (associate architects for construction documentation); Structural Engineering Corporation (structural engineers); Jackson Seay Associates (landscape architects); Thomas Moody Associates (mechanical engineers); and John Schade Associates (electrical engineers). □

Waterfront Revitalization

A new steel addition to an old warehouse in Pittsburgh's historic riverfront district allowed the developers to create needed office space

By William Hartlep, AIA

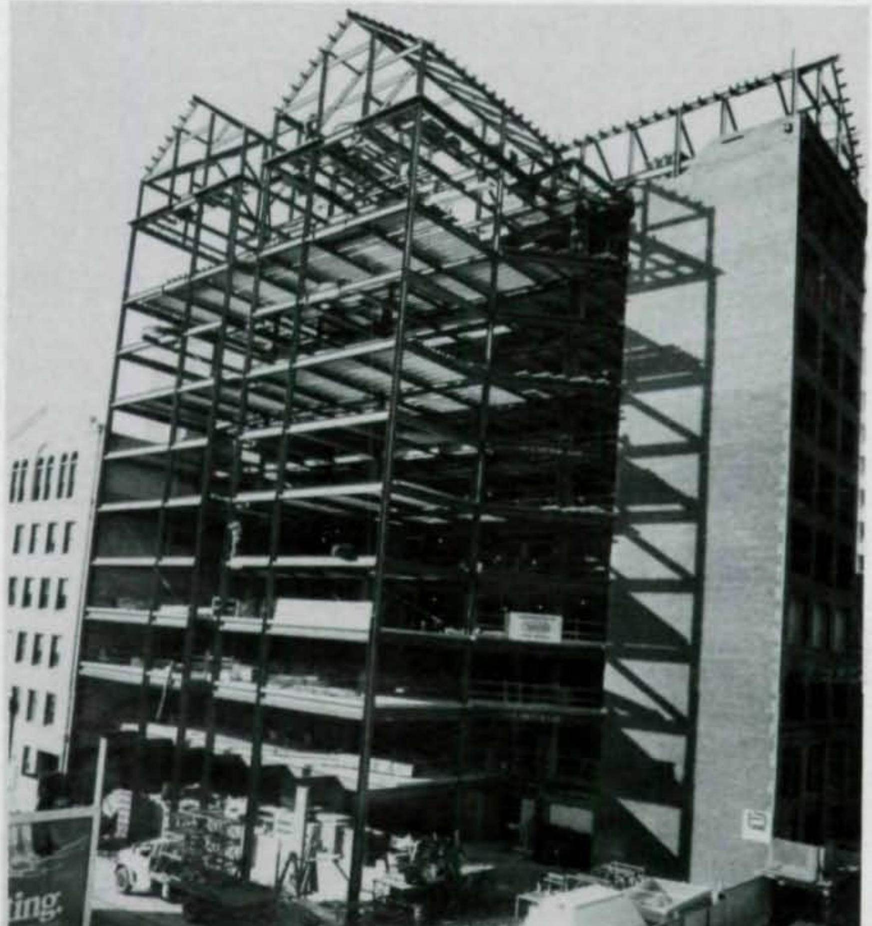
Preservation and expansion can go hand-in-hand, as evidenced by the recent transformation of the former Shields Rubber Co. Warehouse in Pittsburgh into a much larger office building.

The warehouse was built in 1904 along the Monongahela River in the now historic Firstside District. For most of the 18th century, the district was the center of Pittsburgh's riverboat trade. But when railroads began to dominate the transportation industry, Firstside fell into a long period of decline.

Recently, though, the burgeoning rehabilitation movement, combined with many cities renewed interest in waterfront areas, has led the Pittsburgh City Planning Commission to begin efforts to revitalize the area. The project's developer, The Casto/Skilken Group, turned to L.D. Astorino & Associates, Ltd., a Pittsburgh-based architectural and engineering firm, to create a plan to expand the building and convert it into office space while maintaining its turn-of-the-century appearance.

Eleven Story Addition

The architect's plan for the renamed First & Market Building involved completely renovating the existing 56,000-sq.-ft., 10-story building, constructing an 11-story, 28,845-sq.-ft. addition, and adding



an 11th story penthouse to the original building.

Complicating the expansion, however, was the need to design a new light steel framing system that could match the floor heights and ceiling clearances of the old building—including an unusually wide 35' on center bay spacing. In addition, the new wing was designed to match the proportions and masonry detailing of the existing warehouse.

The old warehouse was a steel frame structure resting on wooden piles driven into bedrock. Extensive testing revealed that the steel was ASTM A9 (circa 1903) with an allowable bending stress Fb of 16,000 psi. Although most of the original connections were riveted, some bolted joints also were discovered. The old steel was tested for weldability with positive results.

L.D. Astorino's in-house structural engineer, Sherwin Mandelblatt, designed the framing system for the addition to match the floor heights and ceiling clearances of the existing space.

The atypically wide bay spacing was accomplished through the use of one-way composite slabs equipped with shear studs for stiffness. The new steel frame incorporated ASTM A36 beams and purlins, and A572 columns.

Welded Connections

Connections to the existing steel structure were made by welding clips onto the existing beams and columns and bolting on the new A36 beams through elongated holes using 3/4" high-strength bolts. All welds were visually and ultrasonically inspected following AWS D1.1 procedures.

Column-splices at the roof to connect with the new eleventh floor and roof structure also had to be carefully designed. The existing columns were found to be com-

A 28,845-sq.-ft. addition was constructed as part of the renovation of the former Shields Rubber Co. Warehouse into a modern office building. The use of a lightweight steel frame was essential to match the floor heights of the existing building and to provide the desired 35' on center bay spacing. Construction photography by Fred P. Kenderson; finished photography by Maureen Wikiera.

posite sections, made up of multiple arrangements of A9 zees and plates. Large new steel plates were bolted on, covering the tops of the existing columns.

The new columns were clipped and welded, sometimes eccentrically, to the steel plates. The hipped and gabled shape of the roof was accomplished by using small steel members in a similar manner as wood stick-framing.

Two Hundred Tons Of Steel

In all, more than 200 tons of steel were used in the addition. General contractor was Tedco Construction Co., Pittsburgh, and steel fabricator was Lincoln Fabricating.

For the roof deck and roofing, an Epic Metals Corp. steel system was chosen, incorporating the company's SL3x22 gauge structural decking with their preformed standing seam roofing panels sandwiching 2" of rigid polystyrene insulation. The roofing panels were finished in a custom green copper-patina color. The five-gabled roof and ceiling recall the essence of the Beaux-Arts buildings surrounding the First & Market Building Site.

Nine balconies complete the south and east elevations. The balconies are constructed of 14" exposed rolled channels tied into the new and existing structures with moment connections and full penetration welds. The channels serve not only as the structural support but also as the architectural fascia and the balcony railing base.

Ten-Story Glass Entrance

Exposed structural steel also serves as part of the architectural aesthetic in the arcade clerestory beams and in the intermediate supports for the 10-story glass entry portico.

The First & Market Building's new structure rests on 14" diameter auger cast piles, clustered in groups of two to five and topped with concrete pile caps. Cantilevered grillage beams were

An 11th-story penthouse (above) was added on top of the former Shields Rubber Co. Warehouse during its recent conversion into office space.

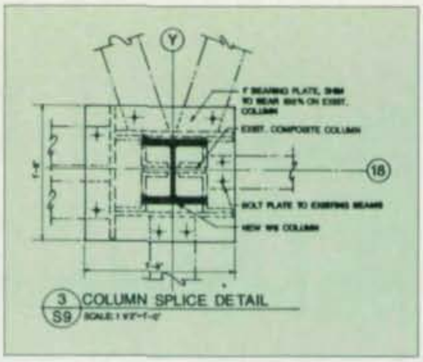
Visitors to the building are greeted by a 10' sq. wrought iron cartouche, set inside the 10-story triangular glass entrance portico.

employed along the south property line abutting an adjacent building to allow the new columns to be placed within 10" of the line.

The grillage beams are made up of two A572 W33x188 wide flanges each. The beams, which are encased in concrete, span over two pile caps to cantilever to the line.

The structure is crucial to the area's revitalization effort due to its prime location at the Firstside Intersection, where two of the city's major axes meet.

By moving its main entrance from its former location overlooking the river to the corner of First Avenue and Market Street, the orientation of the building was turned to face the important intersection. A new 800-sq.-ft. brick and stone plaza in front of the entrance serves not only as a local foreground for the building, but also satisfies the city's open space requirements.



Visitors to the building are greeted by an extraordinary 10' sq. wrought iron cartouche, set inside the 10-story triangular glass entrance portico.

Reminiscent of the works of Louis Sullivan, the cartouche sets the tone for a series of turn-of-the-century statements throughout the building. In addition, the new wing features a 75' long two-story high exterior arcade detailed in herringbone and basket weave brick panels, and lighted with six period pendant light fixtures. Exposed structural steel beams 14' above the sidewalk provide a gas-light-period flavor to the arcade.

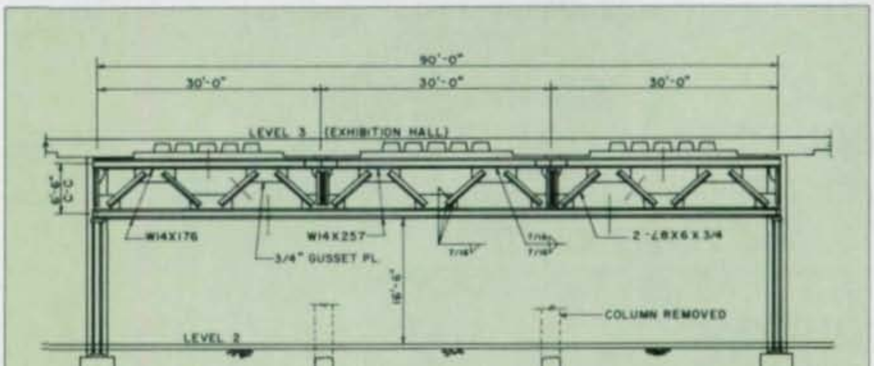
The building's main lobby adds to the 1900s Theme with its coffered and period pressed metal ceilings, ebonized oak crown molding, base, and chair-rails, and brass-trimmed wall sconces.

The building's unused 10-story lightwell was transformed into an 11-story skylighted atrium housing an art gallery on the first floor adjacent to the main lobby.

William Hartlep, AIA, is vice president with L.D. Astorino & Associates, Ltd.

Steel Trusses Create Expansion Opportunity

Replacing 22 concrete columns with a series of steel trusses allowed Kansas City's convention center to capture 88,000 sq. ft. of additional space



Twin 90' Warren Trusses were erected on each side of a column line during the removal of 22 large concrete columns. The trusses, which worked in pairs, supported the ceilings 300 lb. live loads on crossbracing installed between the two trusses. Photography by PHOTOtechnique

Big is definitely better, at least when it comes to convention center design. But unfortunately for the owners of the H. Roe Bartle Convention Center in Kansas City, that discovery came 13 years too late.

The center is built on a 1,700'-long site with a 43' slope. The upper floor houses the main convention hall, while the smaller lower level contains kitchen/dining and storage space. The medium-sized intermediate level was left vacant for future expansion.

Changing Needs

During the early 1970s, when the center was designed, the plan was to add small meeting rooms to the intermediate level when demand warranted the addition. "Back then, small meeting rooms were in vogue," said Dwight Horner, a partner with Horner/Blessing Associates, the project's Kansas City-based architects (in association with Seligson & Associates). "Today, however, the demand is for larger rooms."

The problem, though, was the 22 30′-on-center concrete columns that supported the upper level convention hall. The evenly-spaced columns severely limited the available room size.

The solution was to develop a system of steel trusses that could support the ceilings 300 lb. live loads and that would enable the removal of the concrete columns without disrupting the convention activity in the upper hall.

"The first thing we did was to put in new drilled shaft foundations to support new steel columns," explained Benjamin J. Biller, P.E., the project engineer with Howard Needles Tammen & Bergendoff, Kansas City. The new columns reached to within 7′ of the bottom of the waffle slab.

The next step was to erect twin 60′ and 90′ Warren Trusses on each side of the column lines. The trusses converted three 30′ spans into one 90′ span, or two 30′ spans into one 60′ span. "The trusses worked in pairs, with a column sandwiched between," Biller said. Crossbracing was installed on each end of the span to tie the two trusses together. A flat hydraulic jack was placed on the chord of each truss, and the jacks were used to remove the load from the concrete columns.

Load Completely Removed

The contractor, Massman Construction Co., then cut through the concrete columns slightly below grade level. It was crucial that there be zero load on the columns at that point, Biller explained, because otherwise the columns might have sprung out.

"After the concrete was severed at the bottom, we took a steel A-Frame, moved it around the column, and fastened it to the midpoint of the column," Biller said. The A-Frame had a pivot point at the top of the "A" and a collar that fastened around the column. After the column was secured, the contractor cut through the top of it. "We then took the column and rotated it in a vertical plane, pivoting at the top of the A-Frame, to a horizontal position," Biller explained. The column was hung from the steel trusses on either side and the A-Frame was removed. Finally, the column was lowered onto a flat truck and hauled off the site.

After the concrete columns were removed, a steel diaphram (W33 x 118) was installed between the two trusses. A steel pedestal—extending to within a few inches of the concrete waffle slab—was placed on the diaphram in the same position as the old concrete column.

Slight Upwards Deflection

The jacks were raised to create a slight—less than 1″—upwards deflection in the waffle slab, and

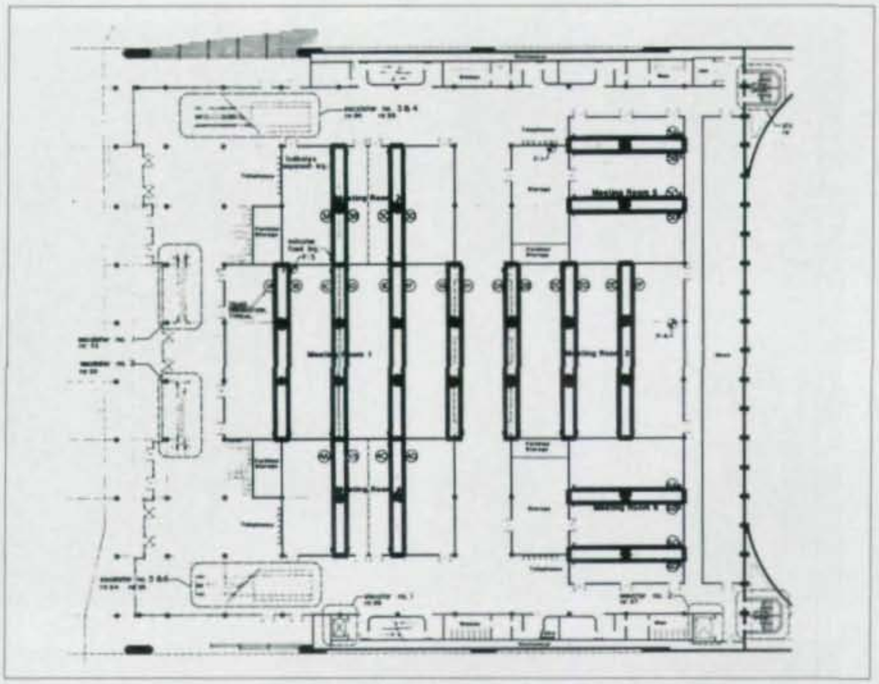
Crossbracing (above) was installed on each end of the span to tie each pair of trusses together.

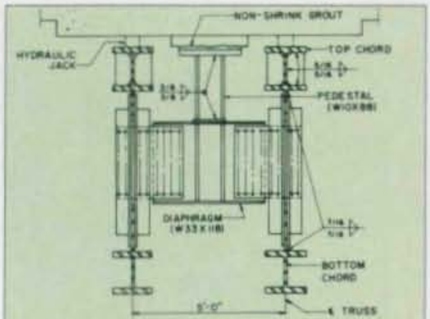
After the concrete column is severed at the bottom, a steel A-Frame was fastened to the middle of it, and the column is rotated to a horizontal position (left).

the space between the steel pedestal and the slab was filled with non-shrink grout. Finally, the jacks were removed and the load was taken by the pedestals. "The reason for the upward deflection is that the steel trusses behave somewhat like springs," Biller explained. "We had to induce a slight upward deflection under the dead load so when the live load was applied, the waffle slab would deflect along with the steel trusses and the slab wouldn't be under stress."

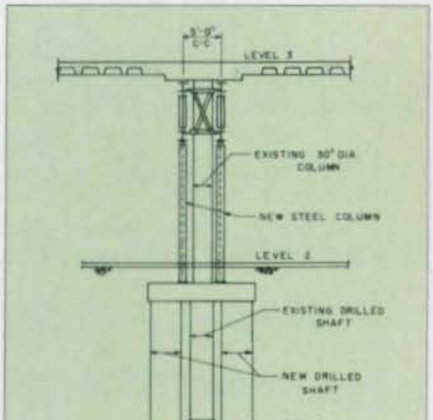
Before the trusses were designed, the engineers performed a space frame analysis to take into account the two-way behavior of the slab in combination with the trusses. "When we put the load on the jacks, we had to know how much the slab would deflect."

The relatively low, 6'-6" height of the steel trusses was also a factor in the design of the structural system due to the space's functional needs. "Audio-visual requirements today are such that high ceilings are needed to show slides and movies," Horner said. "After construction, the 88,000 sq. ft. of convention space added by the conversion had 16' headroom."





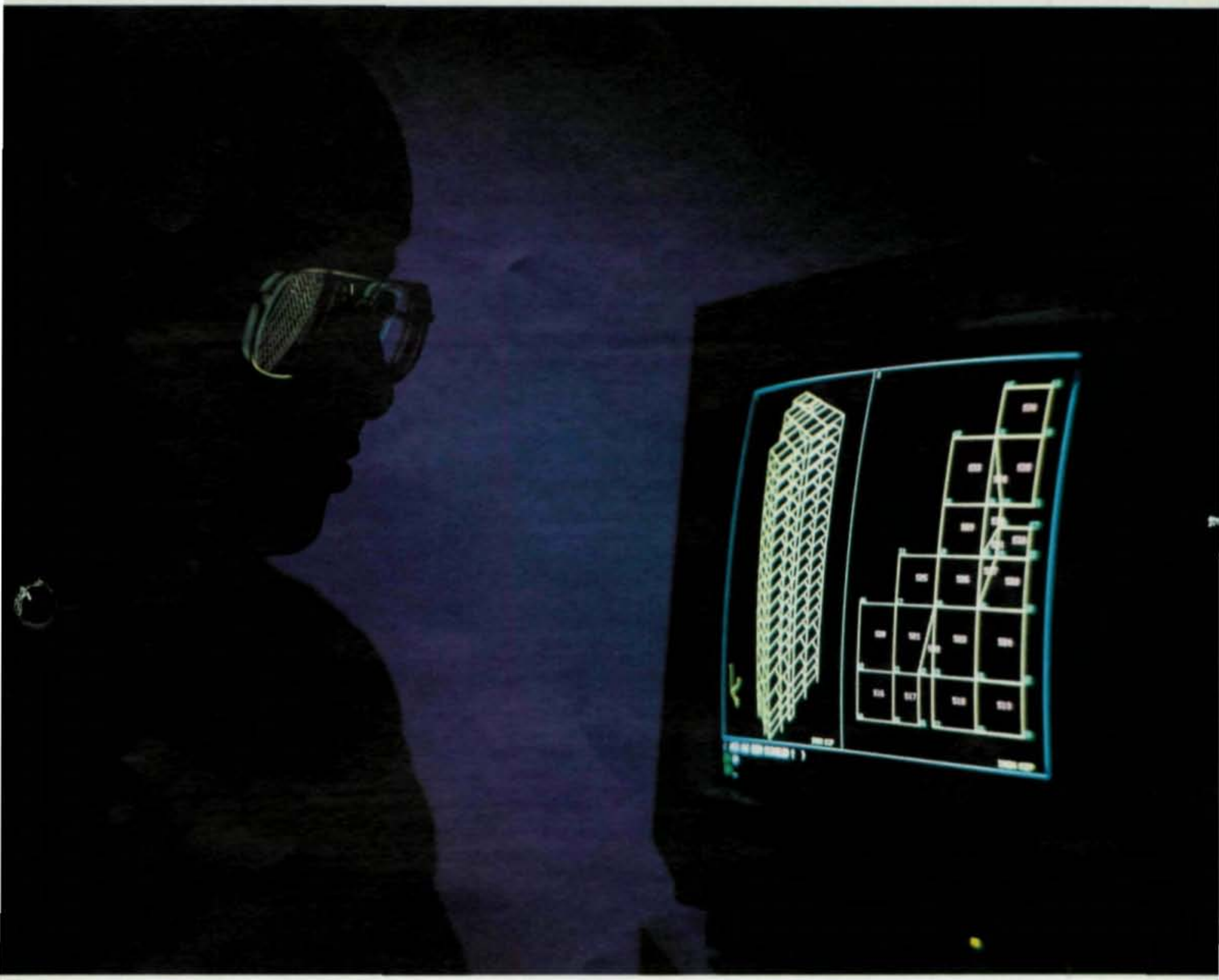
Cross Section At Diaphragm



Cross Section At Foundation

The floor plan of the second floor (above left) shows the location of the columns that were removed.

At left is the steel diaphragm/pedestal after installation between the trusses (also see diagram at top).



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For more information, contact TRW Nelson Stud Welding Division, 7900 Ridge Road, Elyria, OH 44036 (216) 329-0400.

Nucor Fastener

The company's products include grade 2, 5 and 8 hex head cap screws and A325 and A490 structural bolts and nuts. Nucor makes cold-formed products in diameters from 1/4" through 1 1/4", and lengths from 1/2" through 10". In addition, Nucor produces hot-forged bolts in diameters from 3/4" through 2 1/2" in lengths up to 22". Due to automated opeartions, extensive use of robotics and employee incentives, the company claims to have met its goal of being the lowest cost manufacturer of standard commercial fasteners in the industry. For more information, contract Nucor Fastener, P.O. Box 6100, St. Joe, IN 46785 (219) 337-5611.

Pneutek Air/Safe Fastening System

Heavy duty fastening into steel and concrete without powder loads or booster of any kind is possible with Pneutek's Air/Safe Fastening System. The low velocity fastening tool features a tamper-proof actuated drive system that virtually eliminates the possibility of accidental misfiring. There is no loud noises, no sharp recoil, and no time lost for cleaning or oiling. In addition, the system has 20-fastener repeating action that makes heavy duty fastening eight to 10 times faster than other fastening methods.

The system meets or exceeds all OSHA safety requirements, is fast to use, has a very low in-place fastening cost compared to other fastening systems, and has low-maintenance requirements. For more information, contact Pneutek, Inc., 29 Flagstone Dr., Hudson, NH 03051 (603) 883-1660.

Struct-Fast, Inc.

Several fastening systems from Struct-Fast are designed to fasten to structural steel without welding or drilling.

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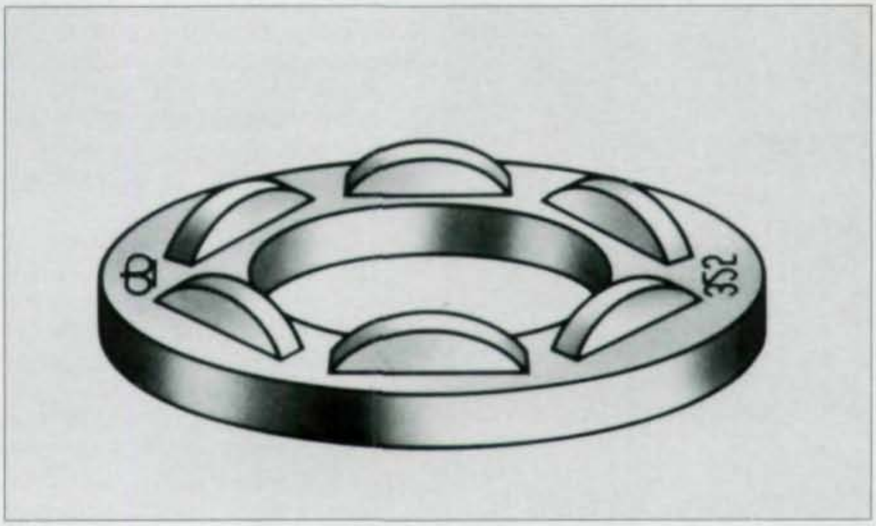
Plasti-Grate-Fast is a look-alike version for fiberglass, stainless, or aluminum bar grating. It is narrower to fit into the smaller bar space opening common to bar grating of those materials.

Floor-Fast is for fastening metal floor plate to structural steel. It functions like the quarter turn fastener seen on electronic cabinetry. The holes in the plates are prepared in the shop and the fasteners are then installed on the plate either in the shop or on the site.

Beam-Fast is a series of bolt adapters for turning a standard A-325 structural bolt into a hook bolt for fastening secondary beams to the primary members without welding or drilling.

For more information, contact Struct-Fast, Inc., 20 Walnut St., Suite 101, Wellesley Hills, MA 02181 (617) 235-6734.



J & M Turner, Inc.

Direct Tension Indicators from J & M Turner assure correct tensioning of high-strength bolts. A high-strength bolted structural joint obtains its superior strength characteristics through friction on the contact surfaces. If the bolts have not reached required tension, there is insufficient clamping force and the joint is not up to specification.

Unfortunately, calibrated torque wrenches do not assure the correct tension because the amount of work, or torque, required to properly tension bolts is significantly affected by the condition of the threads. Likewise, installing a bolt by the "turn-of-the-nut" method depends on guesswork because it depends on where the rotation is started and how it measured.

The Direct Tension Indicator is a specially hardened washer with protrusions on one face. The DTI is usually placed under the bolt head, and the protrusions create a gap. As the bolt is tensioned, the clamping force flattens the protrusions, reducing the cap. Correct bolt tension is evaluated by observing the remaining gap. The advantage is both accuracy and consistency.

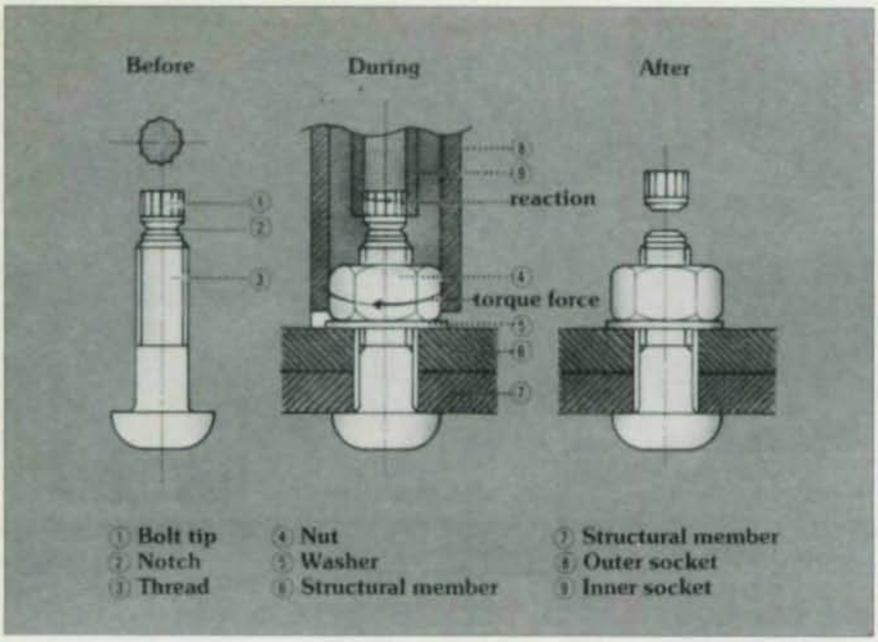
For more information, contact J & M Turner, 1300 Industrial Blvd., Suite 110, Southampton, PA 18966 (215) 953-1118.

ITW Buildex

The TRAXX line of self-drilling fasteners includes a variety of 5/15" and 3/8" hex washer head fasteners perfect for light to heavy gauge applications. The unique TRAXX point has sharp milled cutting edges for dependable, consistent drilling and requires less end pressure during installation than other systems. A line of wood-to-metal fasteners are available.

Available on many of the fasteners and tappers is a SCOTS 300 series stainless steel head. The SCOTS head will never rust, which provides maximum corrosion protection for long-life panels.

For more information contact ITW Buildex at (800) 323-0720.



Le Jeune Bolt Co.

The Le Jeune Tension Control Bolting Systems combine a unique high-strength bolt design with a precision delayed-fracture material and are manufactured under strict quality standards. Because tension control is built into the bolts, installation and inspection costs are minimized.

Advantages of the system include: meeting or exceeding ASTM requirements for a variety of bolts; providing positive tension control; allowing for visual inspection to insure proper installation and eliminate continuous torque testing; utilizing a non-impacting electric wrench that eliminates the need for air compressors, minimizes installation fatigue, and reduces tool maintenance; shipping pre-assembled to eliminate onsite assembly.

For more information, contact Le Jeune Bolt Co., 8330 West 220th St., Lakeville, MN 55044 (612) 469-5521.

Haydon Bolts

The 125-year-old company manufactures anchor bolts, sag rods, swage bolts, U-bolts, and crane rail anchors. Sizes range from 1/2" to 4" diameters.

In addition, Haydon Bolts has a complete line of A325, A490, and positive tension shear bolts. Larger and longer lengths for custom applications can be forged up to 21/2" diameter. Various grades of steel also are available, including A36, A588, A449, A193, A687, and A615 stainless.

For more information, contact Haydon Bolts, Adams Ave. and Unity St., Philadelphia, PA 19124 (215) 537-8700.

Flexalloy, Inc.

Flexalloy recently announced that they are now fully accredited by the American Association of Laboratory Accreditation in the mechanical field of testing. Current capabilities include the full range of mechanical, performance, and dimensional testing and measurements required for fastener products. The company has installed a computerized electronic gaging system that provides automated variable gaging of critical characteristics with a statistical analysis of the results.

For more information, contact Flexalloy Inc., 26000 Richmond Road, Cleveland, OH 44146.

Erico Fastening Systems

Stud welding is an arc welding process in which a fastener can be end-joined to a metal workpiece instantaneously. It is a complete fastening system, using a wide variety of fasteners with literally hundreds of uses—each permanently installed by one man, working on one side of the workpiece, in less than one second. Erico offers two systems: a Capacitor Discharge Stud Welding system and an Arc Stud Welding system.

Capacitor Discharge Stud Welding is generally used to weld smaller diameter fasteners to thin base metals. Since the entire weld cycle is completed in milliseconds, welds can be made without pronounced distortion, burn-through or reverse side discoloration.

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Stud welding provides uniformity and repeatability, high production, accuracy, an attractive appearance, the elimination of secondary operations, and impressive weld strength.

To receive a copy of *Stud Welding—A First Look*, contact Erico Fastening Systems, 301 New Albany Road, Moorestown, NJ 08057 (609) 235-6900.

LOHR Structural Fasteners

The firm has recently opened a new world class domestic manufacturing plant to produce high-strength fasteners (A325 and A490). LOHR's product line includes tension control, hex head and 2H nuts. For more information, contact LOHR Structural Fasteners, P.O. Box 1387, Humble, TX 77347 (713) 821-3509.

AISC 1990 ARCHITECTURAL AWARDS OF EXCELLENCE COMPETITION

COMPETITION RULES

Eligibility

All registered architects practicing professionally in the United States are invited to enter steel-framed buildings of their design constructed anywhere in the United States (the 50 states, District of Columbia and all U.S. territories), and completed during calendar years 1987, 1988 and 1989. Each building must have been designed, fabricated and erected in the U.S.

The structural frame of the building must be steel, although it is not a requirement that the steel be exposed or a part of the architectural expression. Buildings of all classifications are eligible, with equal emphasis given to all sizes and types in the judging. Older buildings which have undergone major reconstruction/rehabilitation using steel as the major structural material also are eligible for entry if they meet all other requirements of this competition. There is no limit to the number of entries by any individual or firm. Buildings named as previous AAE winners will not be eligible, except in the rehabilitation category.

Method of Presentation

Each entry should be submitted in an 8 ½ 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

Winners will be notified before August 30, 1990. Public announcement of the winners will be made in the *November/December issue of Modern Steel Construction* magazine. Award presentations will be made to the successful architects' representative on the evening of December 5, 1990, at the AISC Ninth Annual Awards Banquet in Chicago. Local awards not presented at the banquet will be presented later to recognize owner, general contractor, structural steel fabricator, structural engineer and erector as appropriate for each winning structure.

All entries will be retained by AISC for publicity purposes. The use of any entry's submitted data, detail and/or photographs by AISC shall be unrestricted.

Entry Requirements

An entry must consist of an entry form, photographs and descriptive data, all as described below:

Entry Form

Entry Form must include the following:

1. Name, location and completion date of the building.

2. Name, mailing address, telephone number and contact of the following:

Architect	*Structural engineer*
General contractor	Steel fabricator
Steel erector	Owner

Photographs

1. 8" x 10" color prints should include a minimum of two exterior photographs, showing all principal exposed sides of the building or building group, several interior photographs, any innovative or outstanding applications of steel that might not be evident in exterior photographs. Similar 35 MM color slides are helpful.

2. Photographs (B & W or color) or 35 MM color slides of the building under construction and showing portions of the structural steel framing are encouraged.

3. All photographs should be of professional quality and must be previously cleared for use by AISC in publicity and publications.

Descriptive Data

The following descriptive data is required:

1. An architectural description of the owner's requirements, the design solution, the building's outstanding features and reasons for using a structural steel frame.

2. A site plan, a floor plan and any details that amplify and/or clarify architectural description.

All descriptive data must be on 8½" x 11" sheets.

Deadline for Submission

Entries must be postmarked prior to **August 4, 1990** and addressed to the Awards Committee, American Institute of Steel Construction, Inc., One East Wacker Drive, Suite 3100, Chicago, IL 60601-2001.

AISC 1990 ARCHITECTURAL AWARDS OF EXCELLENCE COMPETITION

ENTRY FORM

Entry date: ____________________

Name of building: ____________________ Completion date: ____________________

Location: ____________________ City, state, zip: ____________________

Descriptive data: Attach separate sheets (see completion rules)

No. of photographs enclosed: B & W ________ Color prints ________ 35 MM slides ________

Architectural Firm: ____________________
Phone

Address: ____________________
Street City and State Zip

Person to Contact: ____________________
Title

Structural Engineering Firm: ____________________
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.)

Superbolt, Inc.

One of the industry's most common problems has been solved by the introduction of Superbolt torquenuts, which can be tightened to any desired pre-load by using ordinary hand tools. Tensioning is accomplished by torqueing multiple bolts around the main thread, eliminating the need for hydraulic tighteners, sledge-hammers, etc.

For example, a hex nut would require 18,000 lbft of torque to pre-stress a 3" bolt to 70,000 psi. However, a Superbolt torquenut requires only 190 lbft of torque on each of its jackbolts to create the same stress.

To receive a catalog describing the company's complete line of multi-bolt tensioning devices, contact Superbolt, Inc., P.O. Box 683, Carnegie, PA 15106 (412) 279-1149.

Weld Engineering Co.

Submerged arc welding has been improved with the introduction of the HAMX-25 Auto Mixing Hopper by Weld Engineering.

The product is a flux recovery separator/hopper used in conjunction with either the Mighty-Mac 1500, 300 or 5000 flux vacuum system. It automatically recovers unfused flux at the weld zone; mixes the desired ratio of recovered flux to new flux; deposits mixed flux to the welding nozzle; and keeps flux heated to 250° F.

The HAMX-25 enables manufacturers with strict code requirements of using recovered flux mixed with a certain portion of new flux to mix, recover, heat and return flux to weld zone all in one step, therefore greatly reducing handling costs and increasing profitability.

For more information, contact Weld Engineering Co., 6 Depot St., South Grafton, MA 01560 (508) 839-9875.

L-TEC Welding & Cutting Systems

A new generation of stud welding equipment is now being offered by L-TEC.

Featured is a full range of SCR-controlled power supplies, from 800 amps to 2,600 amps, along with the newest development, a portable, diesel-driven stud welding system. The power units are based on the closed loop principle in which consistent welding parameters are met, independently of commonly used cable lengths.

L-TEC also offers a complete line of weld studs.

For more information, contact L-TEC Welding & Cutting Systems, P.O. Box F-6000, Florence, SC 29501 (803) 669-4411.

Welding Research Council

Bulletin No. 345, *Assessing Fracture Toughness and Cracking Susceptability of Steel Weldments*, reviews the domestic and foreign literature to determine, document, and evaluate: the parameters of welding that control weld-metal and HAZ cracking; tests for assessing the susceptibility of structural steel to weld metal and HAZ cracking; the parameters of welding that control HAZ toughness; and test for measuring the toughness of weld metal and HAZ. Purchase price is $35, including postage.

Bulletin No. 350, *Design Criteria For Dissimilar Metal Welds*, includes data on the metallography of dissimilar metal welds, including a data base relating to the failures to service loads and an evaluation of improved filler metals and weld configurations. Cost is $35.

Bulletin No. 351 contains three reports on research work performed at the University of Kansas onCTOD and J-integral test studies of A36 steel. Cost is $40.

For more information, contact Welding Research Council, United Engineering Center, 345 East 47th St., New York, NY 10017 (212) 705-7956.

Advertisers' Index

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Eric K. Nieman
Pattis-3M
4761 West Touhy Ave.
Lincolnwood, IL 60646
(708) 679-1100
FAX (708) 679-5926