MODERN STEEL CONSTRUCTION

December 1991

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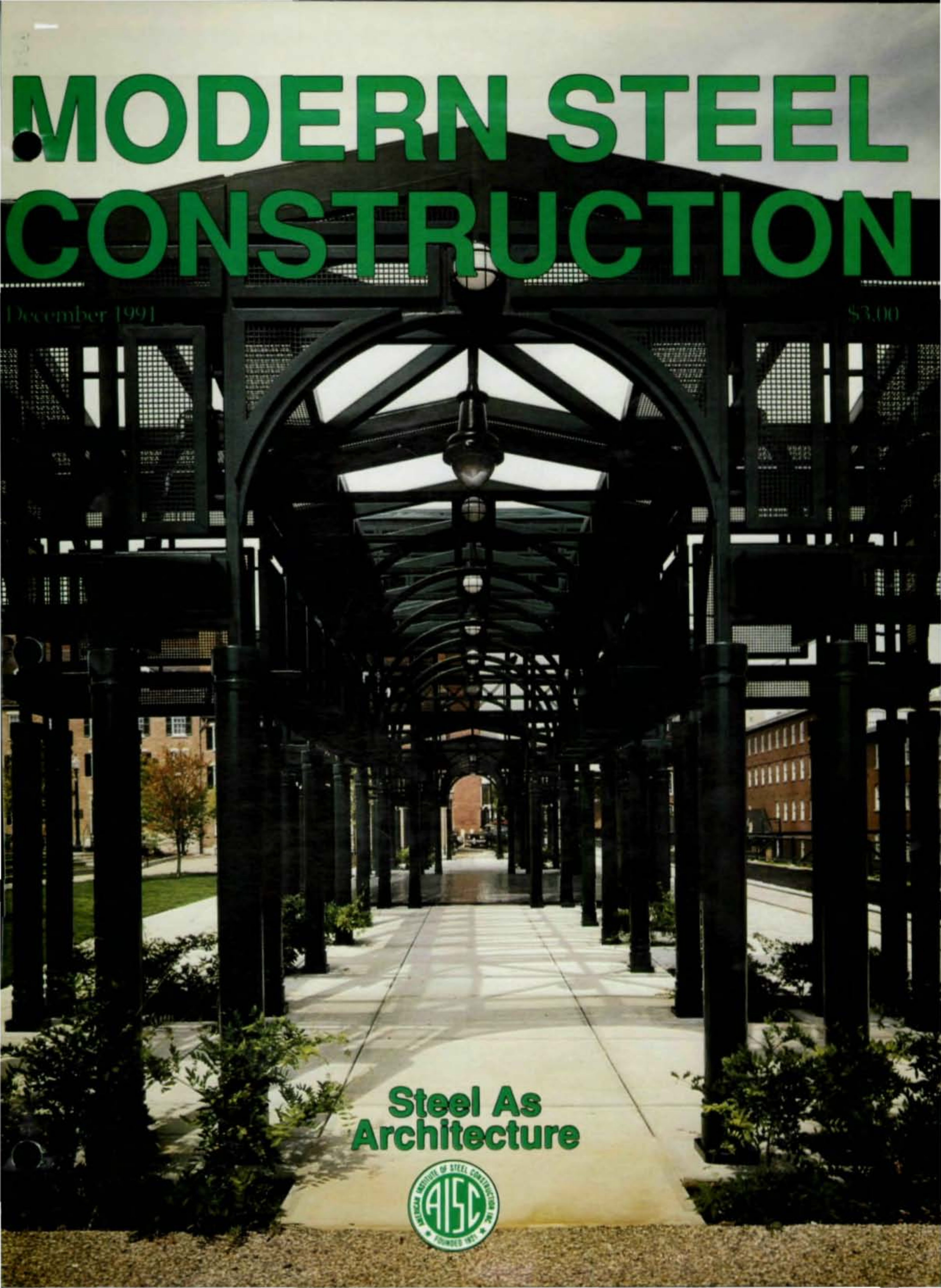

Steel As Architecture

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THE TABLE REPRESENTS NORMAL INVENTORIES; HOWEVER ANY FINISH ON ANY PRODUCT MAY BE AVAILABLE ON SPECIAL ORDER.

NOTES — ROMAN NUMERALS IN THE TABLE CORRESPOND TO NUMERALS IN NOTES.

I. A. CHECK U.L. FIRE RESISTANCE DIRECTORY FOR FINISH REQUIREMENTS. GALVANIZED DECK SHOULD BE USED ON *ROOF* CONSTRUCTION WITH SPRAYED FIRE RESISTIVE MATERIALS. (SFRM).
B. GALVANIZED DECK IS RECOMMENDED FOR HIGH HUMIDITY AREAS.
C. GALVANIZED ROOF DECK IS RECOMMENDED FOR ROOF CONSTRUCTIONS WITH INSULATION BOARDS THAT ARE FASTENED TO THE DECK WITH PIERCING FASTENERS.
D. USD RECOMMENDS THE USE OF GALVANIZED MATERIALS FOR MOST EXPOSURES.
E. GALVANIZED STEEL IS COVERED BY ASTM A446; GALVANIZING IS COVERED BY ASTM A525; G60 AND G90 ARE COATING WEIGHTS.

II. A. "PHOS/PTD." MEANS THE FLOOR DECK IS ONLY PAINTED ON THE EXPOSED SIDE—THE CONCRETE SIDE SHOULD DEVELOP TIGHT RUST BEFORE THE CONCRETE IS POURED.
B. USE ONLY FOR INTERIOR APPLICATIONS—I.E. OFFICES OR HOTELS.
C. CHECK U.L. FIRE RESISTANCE DIRECTORY—SEE NOTE I.A.
D. "PHOS./PTD." IS APPLIED TO ASTM A611 STEEL.

III. A. "PRIME PAINTED" MEANS A PRIMER COAT OF PAINT IS APPLIED OVER CLEAN BARE STEEL. THE PRIMER PAINT IS FORMULATED TO HAVE "TOOTH" TO HOLD SUBSEQUENT APPLICATIONS OF FINISH PAINT BUT IT IS NOT INTENDED TO PROVIDE EXTENSIVE WEATHER PROTECTION; IT IS FREQUENTLY LEFT EXPOSED IN WAREHOUSES AND MANUFACTURING PLANTS, AND WHEN USED WITH SUSPENDED CEILINGS.
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C. SALT SPRAY (AND OTHER) TEST RESULTS ARE AVAILABLE ON REQUEST.
D. "PRIME PAINTED" DECK IS MADE FROM ASTM A611 STEEL.

IV A. "GALV. + PAINT" MEANS PRIMER IS FACTORY APPLIED OVER GALVANIZED STEEL. THE PRIMER PAINT IS AS DESCRIBED IN III.
B. THIS FINISH IS MOST ECONOMICAL WHEN A FINAL COAT OF PAINT IS TO BE FIELD APPLIED.
C. USE IN HIGH HUMIDITY AREAS—THE PAINT PLUS GALVANIZING PROVIDES EXTREMELY GOOD MOISTURE PROTECTION.
D. "GALV. + PAINT" USES ASTM A446 STEEL.

V. A. FINISH COATS OF PAINT CAN BE FACTORY APPLIED. THIS IS DONE ON THE COILS OF STEEL BEFORE FORMING INTO DECK. ALMOST ANY COLOR OR PAINT TYPE CAN BE USED—HOWEVER TO BE ECONOMICAL, THE ORDER SHOULD BE FOR AT LEAST 20,000 SQUARE FEET.
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C. FINISH PAINT IS NORMALLY APPLIED OVER GALVANIZED STEEL CONFORMING TO ASTM A446.

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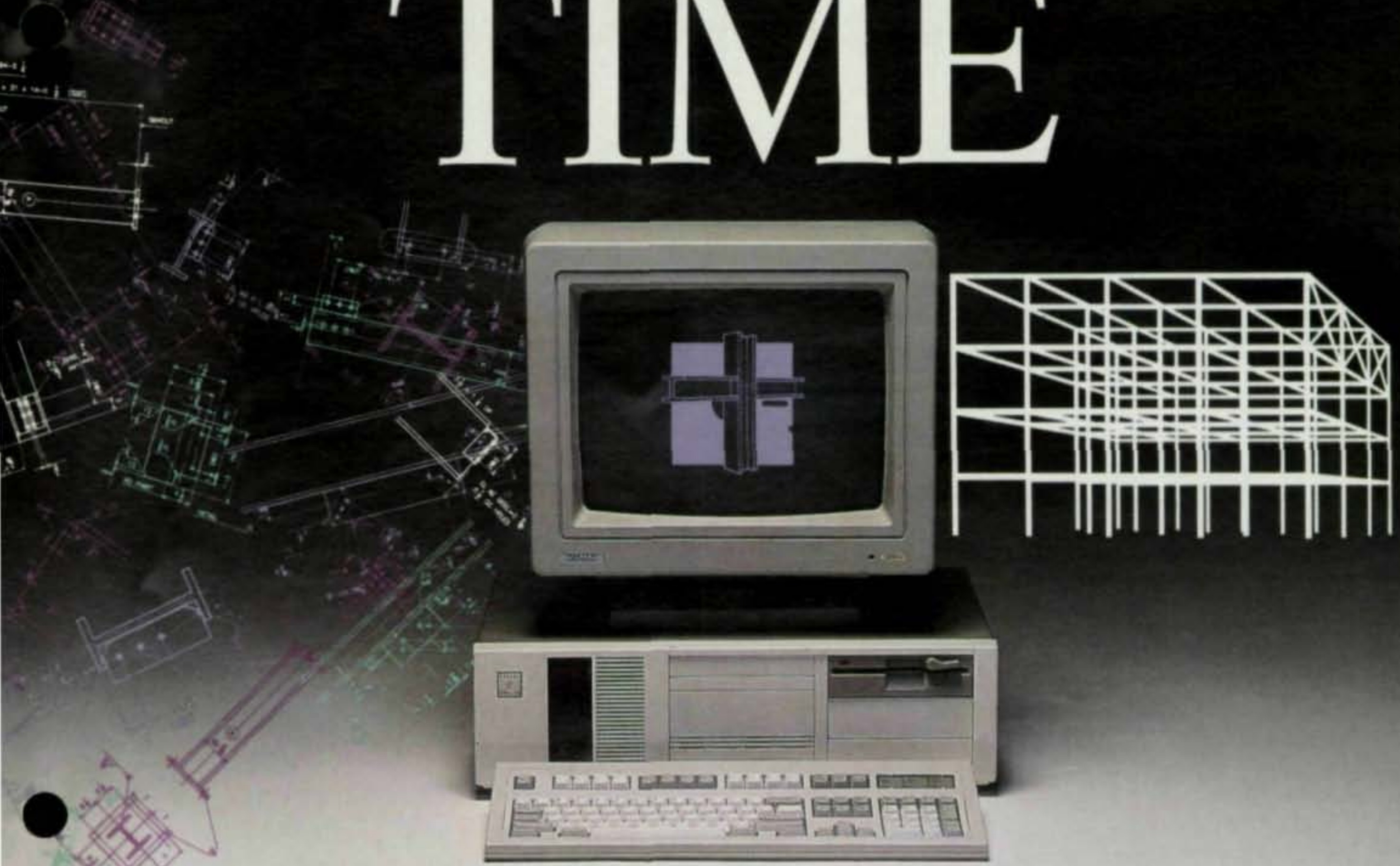

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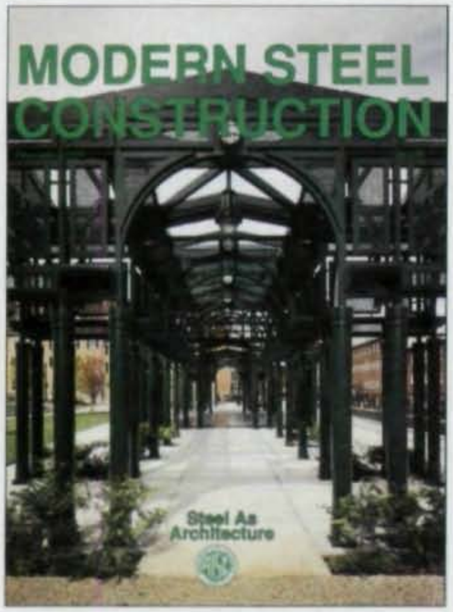
MODERN STEEL CONSTRUCTION

Volume 31, Number 12 December 1991



While modern in design, the exposed steel performance pavilion is still evocative of the late 19th century industrial period. For more information on this project turn to page 14.

FEATURES

Modern Steel Construction. Published monthly by the American Institute of Steel Construction, Inc. (AISC).

Executive, editorial, circulation office: One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001. Advertising office: Pattis/3M, 7161 North Cicero, Lincolnwood, IL 60646.

Subscription price:
Within the U.S.—single issues $3; 1 year $30; 3 years $85.
Outside the U.S.—single issues $5; 1 year $36; 3 years $100.

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

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Trendy Tubes

While working on a project a few months back, I had occasion to interview an architect with McClier, a small Chicago-based design/build firm with a growing reputation. As often happens during the course of one of my interviews, we eventually meandered off topic. Over a cup of coffee, this architect confided that his dream was to someday design a building with exposed weathering steel (yes, he was a graduate of that old Miesian stronghold, the Illinois Institute of Technology).

While using weathering steel on buildings is a rarity today (bridges, of course, are a different story), exposed structural systems are becoming increasingly popular.

Once, the only exposed steel in buildings was in industrial settings. Then, a few avant garde architects began exposing the structural system as part of a building's architecture. Today, exposed structural steel has clearly entered the mainstream (using Chicago as an example, three recent notable buildings with the steel members serving the dual purpose of structure and architecture come immediately to mind: United's O'Hare Airport terminal; the addition to the Shedd Aquarium; and Helmut Jahn's State of Illinois Building).

The latest trend is the increased use of hollow structural sections—in square, rectangular and round configurations. Featured in this issue are four wonderful examples of structural tubes: a performance pavilion in Lowell, MA (page 14), a museum in Schaumburg, IL. (page 18), a chapel in Orange City, IA (page 24), and the ceiling of a law library in Chicago (page 28).

Some engineers are hesitant to use tubes because of a perceived difficulty with connections. However, engineers experienced in designing with tubes report just the opposite experience. And in addition to their beauty, the projects in this issue demonstrate innovatively designed connections. For example, in the museum project, two different size pipes come together at the same point as several built-up sections.

Incidentally, if it seems odd that there are no retail projects in an issue devoted to exposed steel, there's a simple explanation. We're saving them for our April issue, which will be entirely devoted to retail.

And if you're a fan of weathering steel, don't worry. While we haven't unearthed any new orange-colored buildings, our September issue on bridges will be sure to have more than just a passing mention of weathering steel. **SM**

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IBM-Marathon—Nov. 30, 1989

Le 1000 de la Gauchetiere—Nov. 30, 1989

IBM-Marathon—June 21, 1990

Le 1000 de la Gauchetiere—June 21, 1990

IBM-Marathon—March 6, 1991

Le 1000 de la Gauchetiere—March 6, 1991

As with almost every other structure in Montreal, the 51 story Le 1000 de la Gauchetiere building was designed with a reinforced concrete structural frame.

But an analysis of the proposed 50' clearspans between the perimeter and the core revealed that substantial costs savings were possible by switching to steel. However, while the cost savings were attractive to BCE Development Corp., the project's developer, the real benefit of steel was in a faster construction time.

The developer had gotten a late start on the project and knew it would have a tough time meeting tenant occupancy commitments. Also, the project's leasing agents were in a tough battle for tenants with the nearby 51-story, concrete-framed IBM-Marathon Building, which had begun construction while Le 1000 de la Gauchetiere building was still in design. Catching up with IBM-Marathon was crucial since downtown vacancy rates for Class A and B space were rising towards the 12% mark.

One-Year Head Start

By the time ground was broken on Le 1000 de la Gauchetiere building, its crosstown concrete rival had a nearly one year head start. Yet the two buildings ended up topping out within days of each other—despite an only-average steel erection speed of one story every 4.1 days.

The rule of thumb in Canada is a story every three days, but this project was hampered by several factors, including the loss of 20 working days due to temperatures below -4 degrees F (-20 degrees C) when tower cranes couldn't operate and the loss of two weeks when shoring in one sector was washed away in flooding after an unusually heavy rainfall. In addition, construction crews in Montreal weren't familiar with jump-form construction and needed time to get up to speed.

Reduced Financing Costs

In addition to helping with leasing efforts, the faster speed of erection also drastically cut financing costs for the project. Carrying costs on a $250 million (Canadian) project are approximately $2.5 million per month, according to Michel Saint-Cyr, senior vice president of Brookfield Development Corp., the successor to original developer BCE. "It gives you a ballpark idea of the kind of savings we're talking about", he added.

Another advantage to the developers was the smaller column size with steel construction. The maximum size of the steel columns in this building were 24" x 24", while the equivalent original concrete column was 55" x 31½". And that's quite a space savings on a 51-story building.

The building has perimeter steel columns and a composite floor system consisting of a 6" concrete slab on 3" metal decking. Floor trusses with a 36½" depth are spaced 10' on center and span 50' from the perimeter to the concrete core. In response to a fairly high wind load in one direction, a moment frame was designed for floors 17 through 39 on two end walls.

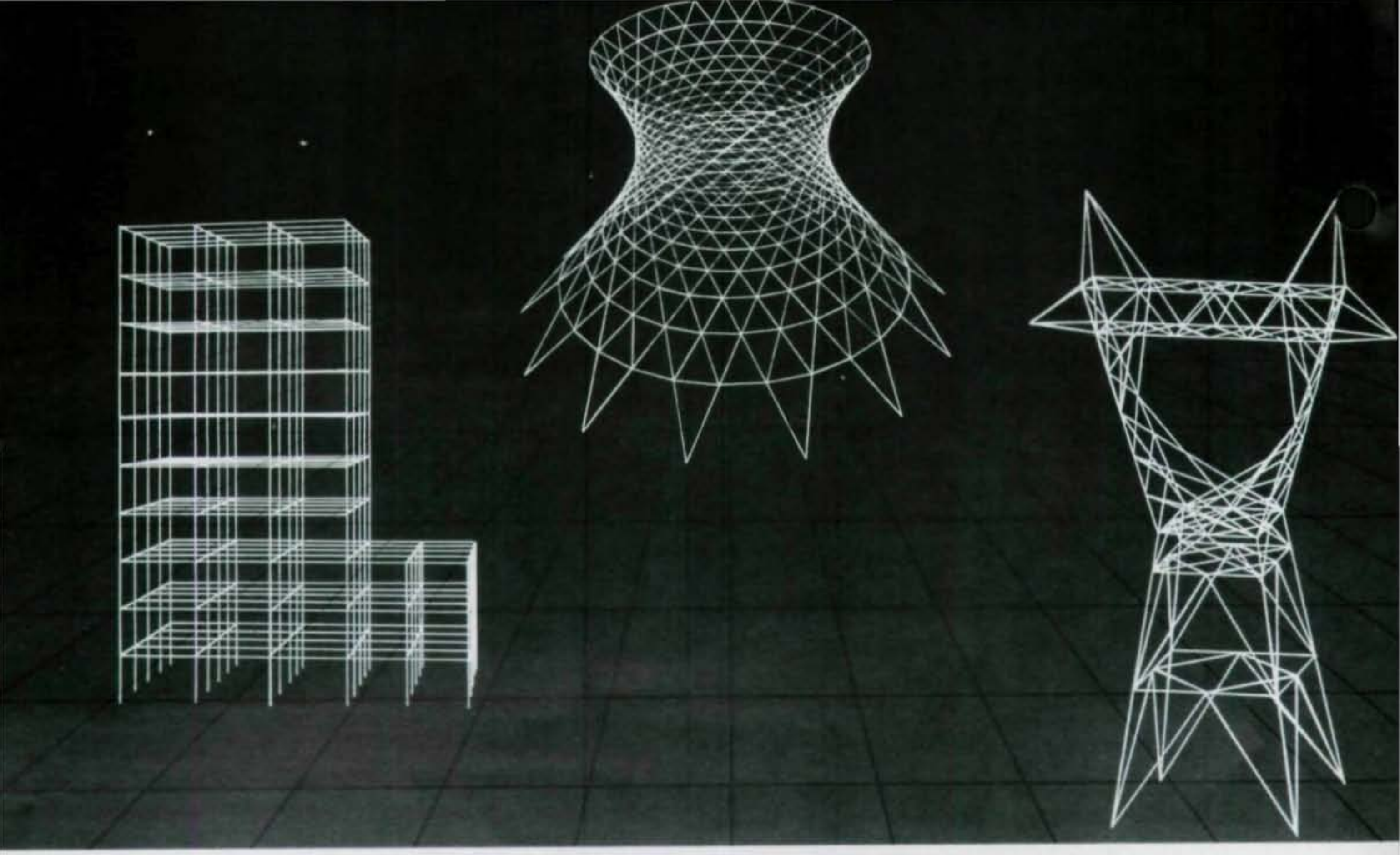
Seismic Considerations

Montreal is in a relatively high seismic zone, but because of steel's lesser mass, the design for the structure was wind governed. Due to its higher mass, the original concrete design was earthquake governed, which would have added to the structural costs.

Another complicating factor in the design was the presence of a bus terminal in the basement on one end of the building and an ice skating rink on the other end, both of which required wider column spacing than the office space above. Additionally, a five-story lobby is located atop the bus terminal. To accommodate the wider column spacing, a large transfer girder system was located on the sixth floor above the five-story lobby, and another was located on the second floor above the skating rink. Again, the steel's lighter weight provided a sizable cost advantage.

Pictured above is Le 1000 de la Gauchetiere on Aug. 30, 1991, when the project topped off within days of its cross-town rival. Shop fabrication, such as on this truss for Le 1000 de la Gauchetiere, helps make steel construction more efficient than concrete.

Architect on the project was a joint venture of Dimakopoulos & Associates and Lemay & Associates, both of Montreal. Engineer was the Montreal office of Lavalin Co. ■



TRB Workshop Explains New Spec For Bridge Bolts

A full-day workshop and demonstration of the use of high-strength bolts for steel bridges will be presented at the Transportation Research Board Annual Meeting on Jan. 12, 1992, at the Sheraton-Washington (DC) Hotel.

The workshop is a condensed version of two-day sessions held around the country that explains the "Supplemental Contract Specifications for Projects with AASHTO M164 (ASTM A325) High-Strength Bolts," issued by the Federal Highway Administration in November 1989. The workshop demonstrates the application of the Supplemental Specification and proper field installation practices. Two-day sessions were scheduled during 1991 in Illinois, Tennessee, Alabama, Minnesota, Washington, Idaho, Louisiana, Georgia, North Carolina, Colorado, Oregon, and South Dakota.

Comments from engineers attending the sessions have been very positive. One DOT engineer reported: "It was a good experience to see the actual testing in progress. And it was interesting to see the different types of bolts that are available for construction projects." He added that some of the presented examples will aid him on a bridge inspection project on which he is currently working.

Another engineer noted that as a result of the session, he will recommend that several amendments be made to his state's Specification.

Specification Requirements

A federally-funded research project at the University of Texas investigating many aspects of the manufacture and installation of high-strength bolts provided the recommendations leading to the development of the 1989 Supplemental Specification, which applies only to bridge bolts and not to bolts used in building construction.

The Supplemental Specification requirements modify existing manufacturing, testing, documentation, shipping, and installation requirements. On the manufacturing end, the FHWA recommendations include new hardness requirements for certain nuts and bolts as well as new tolerances for oversized tapping of galvanized nuts. Testing now includes proof load and wedge testing for bolts and nuts, zinc coating thickness measurements, and detailed rotational-capacity test requirements. Documentation requirements include Mill Test Reports, Manufacturers' Certified Test Reports, Distributors' Certified Test Reports, and Lot number control.

Except under certain conditions, bolts, nuts, and washers need to be shipped in the same containers. During installation, rotational-capacity testing is required in the field and a Skidmore-Wilhelm or equivalent tension measuring device is required at the job site.

The free January workshop will emphasize hands-on demonstrations. Topics include: bolt problems encountered; bolt theory and behavior; receipt inspection, storage and paperwork; bolt installation; and demonstrations on rotational-capacity tests, turn-of-nut procedures, calibrated wrench procedures, tension control bolts, direct tension indicators, and lock pin and collar fasteners.

In addition, attendees will receive a detailed workbook that explains, with both text and graphics, such topics as stripped bolts, rotational-capacity tests on fastener assemblies, hardness tests, alternate fasteners, load indicating washers in assemblies, and high-strength bolt installation.

For more information on the condensed workshop, contact: Frederick D. Hejl, Engineer of Materials and Construction, Transportation Research Board, National Research Council, 2101 Constitution Ave., N.W., Washington, DC, 20418 (202) 334-2952. For information on both the condensed workshop and the two-day sessions, contact: Krishna Verma, FHWA, 400 Seventh St., S.W., HNG-32, Washington, DC 20590. ■

AISC SOFTWARE

CONXPRT - Steel Connection Design

CONXPRT is a knowledge-based PC software system for the design of steel building connections. Three basic types of connections are included in Module I: double framing angles; shear end-plates; and single-plate shear connections. More than 80 configurations are possible.

ASD modules use rules and procedures from the AISC 9th Edition ASD Manual—LRFD modules follow the AISC 1st Ed. LRFD Manual. The latest available references are used to supplement the program's procedures. CONXPRT includes complete data bases for standard shapes, the structural steel, weld and bolt materials. All strength and serviceability limit states and dimensional requirements for each design are checked. Also, help menus are included.

Module I is $300.00. NOTE: if you purchase both the ASD & LRFD versions of Module I you pay only $550.00, a savings of $50.00!

Module II (Moment Connections) will be ready soon—call for details.

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AISC Data Base

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The AISC Computer Data Base contains properties and dimensions of structural steel shapes corresponding to data published in Part I of the AISC 1st Edition LRFD Manual as well as the AISC 9th Edition ASD Manual.

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New Publication Contrasts World-Wide Standards

An evaluation of more than 100 international specifications and codes for steel buildings and bridges is now available from the Structural Stability Research Council. "Stability of Metal Structures—A World View" (Second Edition) is the only available resource that evaluates specifications and codes, compares and contrasts them, and explores some of the major reasons for their differences, according to Lynn S. Beedle, PhD., the book's editor-in-chief and the director of the SSRC.

"World View" is intended to enable designers and building contractors to be more confident in designing and bidding on construction in various parts of the world, Beedle added. The book is the result of a world-wide effort by more than 90 editors from universities, research institutes, and engineering firms.

Divided into 14 topics, the 940-page hardcover book presents a condensed view of major specification provisions and then provides regional and international comparisons and an expert commentary. The topics are: compression members; built-up members; beams; plate and box girders; beam-columns; frames; arches; triangulated structures; tubular structures; shells; cold-formed members; composite members; earthquakes; and general provisions & design requirements.

Copies of the volume can be obtained for $85 (including shipping and handling/$68 for SSRC members) from: SSRC, Fritz Engineering Laboratory 13, Lehigh University, Bethlehem, PA 18015 (215) 758-3522; fax: (215) 758-4522. ■

Urban Artifact

A steel trellis design provides a contextual presence for a new performance pavilion

A new performance pavilion's location in Boardinghouse Park, a national historic park located in Lowell, MA, meant that it needed to be more than just a fancy stage. "Our goal was to create an urban artifact that would help define the park," explained Alan Joslin, AIA, an associate with William Rawn Associates, Boston.

Prior to the construction of the pavilion, the site housed a parking structure within the increasingly popular park. On one edge of the site is a canal, and across the canal are a large number of renovated mill buildings, some of which are open to the public. On the opposite edge is the Mogan Cultural Center. The design of the park and pavilion is intended to create both a location for local festivals and theater and a connecting point between the Cultural Center and the neighboring mill buildings.

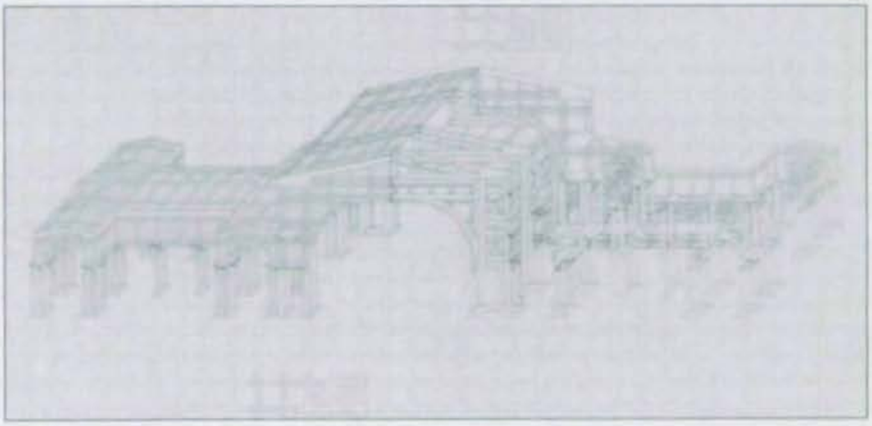
To satisfy both of these functions, the architects designed a 142'-long structure featuring repetitive trellis elements. The center of the structure is a full-sized proscenium stage with accompanying side stage wings. Flanking the structure are arcade-like arms and end pavilions that embrace the park and create a covered path.

"We wanted to create an urban garden," Joslin explained. And given the structure's location amidst old, masonry industrial buildings, the designers felt that wood would be inappropriate and instead turned to steel. "The shape and the material of the Pavilion is evocative of 19th century metal architecture such as the Crystal Palace and reflects a kinship with the industrial and Victorian history of Lowell. The detailing, on the other hand, offers a direct abstraction of ornament which brings a contemporary freshness to the structure."

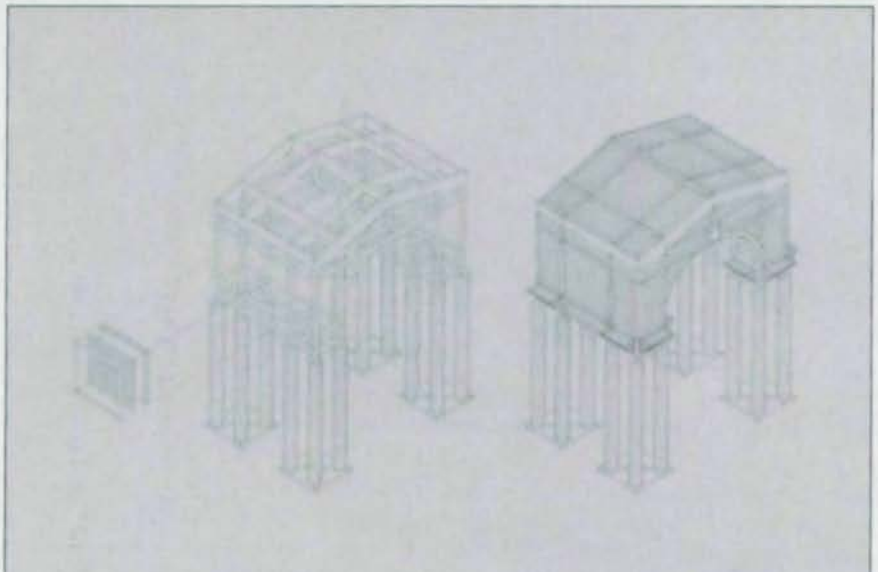
Scaled For People

The structure itself is divided into an upper and lower part. The lower 8½' consists of 8" steel pipes, while the rest of the structure is constructed of 3" x 3", 6" x 3", and 12" x 3" rectangular tubes. Draped over the whole is a grille skin of painted perforated sheet metal set within steel angle frames that cover all elements of the pavilion above the 8' level. The grille consists of ¾" open squares and ¼" connecting supports.

"We were interested in creating a dramatic juxtaposition between the area through which people move and the ornamental area of the structure," Joslin explained. "The light and airy part of the structure is out of reach, while people walk through an area of soft curves." The trellis design supports plantings of climbing wisteria shrubs, which serve as a



While modern in design, this exposed steel performance pavilion is still evocative of the late 19th century industrial period.
Photography ©1990 Steve Rosenthal (Auburndale, MA)



Much of the pavilion is covered with a perforated sheet metal grille painted "Park Service Green".

Photography ©1990 Steve Rosenthal (Auburndale, MA)

sharp juxtaposition to the crisp steel structure. The design has become so popular that the pavilion is now a stop for the local tourist trolley.

The architect designed a series of repetitive elements to relate back to the repetition found in typical mill structures. "Mill buildings are austere buildings with repetitive window openings. We repeated a series of bents to establish a repetitive element for the pavilion. That repetitive quality also harkens back to the repetitive quality of the old Crystal Palace structure," Joslin said.

Structural Design

The base of the structure is a colonnade of steel pipes cantilevered out of the ground and designed to be strong enough to resist wind loads, according to Peter Cheever, P.E., a vice president with structural engineer LeMessurier Consultants, Cambridge, MA. The pipes are attached to 4'-deep foundation piers with 2'-6"-long anchor bolts. To accommodate thermal movements during erection, the anchor bolts were left loose until the upper portion of the structure was erected.

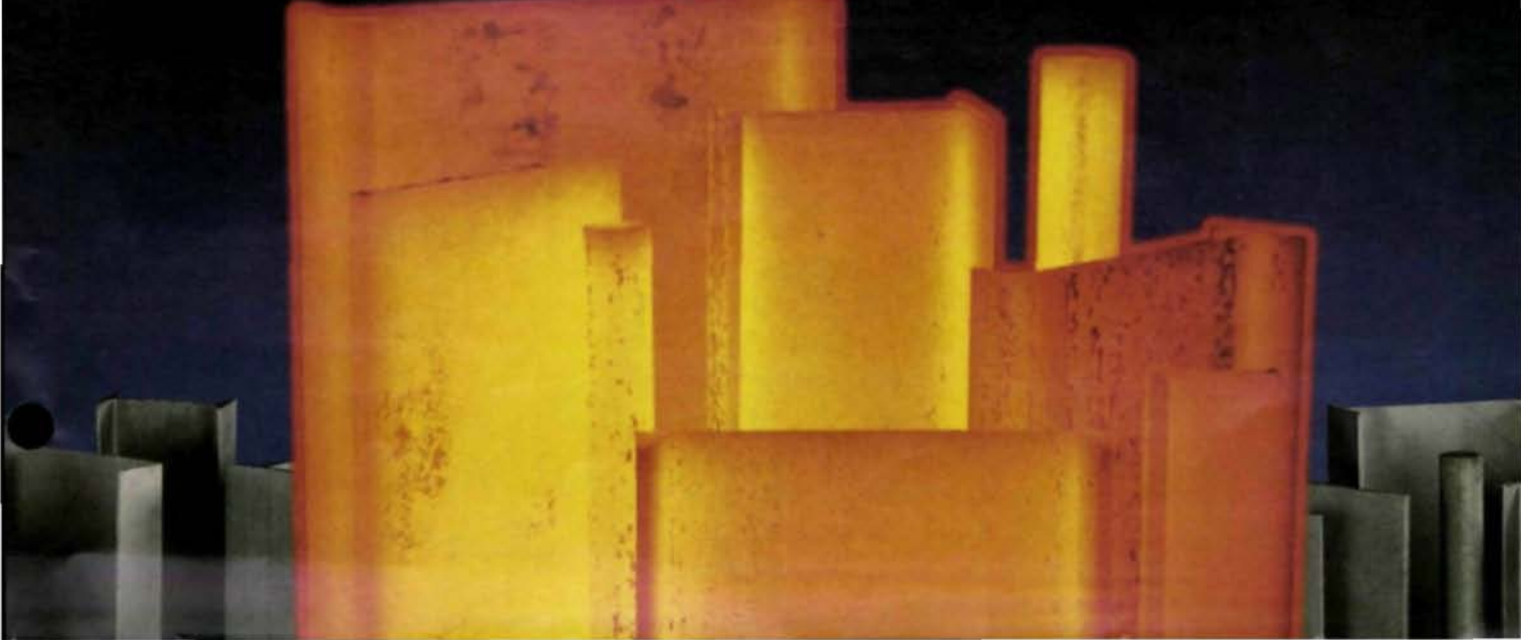
On top of each pipe is a shop-welded cap plate with A325 bolts, while the base of the steel tubes feature a shop-welded base plate. In the field, the tubes were through-bolted to the pipes. A decorative cover was then fastened in place to conceal the connection.

Much of the upper portion of the structure was shop assembled and transported to the site in large sections. "The only field welding was for the horizontal struts tieing the frames together," Cheever explained.

"We worked very closely with the architect to design the connections. The challenge was to make it look right since the structure is completely exposed."

Since the structure is completely exposed to sunlight, the structure is governed more by thermal movement than by gravity load. "In the short direction of the structure, rather than taking all of the force in the columns, we used a series of X-braces." Each brace consists of four pairs of 1" x 1" bars connecting in the center to a decorative gusset plate.

Because there are no architectural finishes, some horizontal movement was acceptable. "We had to make the frame just rigid enough to be stable," Cheever explained. ■



Dramatic Exhibition

A steel cap conceals the complex connection where two different sized tube columns connect with a series of arched built-up members

Few travelers driving northwest from Chicago will pay much attention to the new brown brick and limestone clad buildings that recently sprang up in the Motorola headquarters complex in Schaumburg, IL. But the understated exterior of the new Motorola Museum of Electronics belies the vibrancy of its interior.

The 75,000-sq.-ft. museum complex consists of four interconnected steel framed building structures supported on reinforced concrete substructure. While three of the buildings feature conventional braced steel beam and column construction, the fourth building contains a dramatic exposed structural system that includes steel tubes and arched built-up sections.

"The design of the main exhibit hall started as a spacial concept," explained William Ketcham, AIA, project architect with Booth/Hansen & Associates, Chicago. "We wanted something special both architecturally and structurally—not just a black box." The architect's solution was an arched ceiling to break up the scale of the space.

Steel Arches

"The main architectural as well as structural feature of the museum complex is its main exhibit hall consisting of a 48' center bay flanked by two 34' lower side bays for a length of 290'," explained Wing L. Lam, P.E., S.E., a principal with Martin/Martin, Inc., Chicago, the project's structural engineer. The center bay ceiling is a "quarter-barrel" vaulted exposed steel structure with an individual bay expressed as a dome. "The two side bays adjacent to the center bay were conceived as six 48' modular cylindrical quarter-barrel shells, positioned in a row," Lam said.

"The curves in the building are

The heart of the museum features a vaulted, exposed steel structural system.
Top photo by Timothy Hursley, The Arkansas Office; right photo by Mc Shane Fleming Studios, Chicago.

not just decorative, but are also functional," added Shankar Nair, P.E., PhD., a former principal with Martin/Martin's predecessor firm, KKBNA.

At each corner of the 48' x 48' center bay are 18"-diameter, Schedule 120 steel pipe columns. Framing diagonally between these columns are built-up steel arches. "To maintain the architectural concept, another set of steel arches was introduced on grid lines in the east-west direction," Lam said. "In the north-south direction, W30 x 99 steel beams were used to define a barrel structure boundary and to serve as gravity and lateral load resisting structural components."

Complex Connections

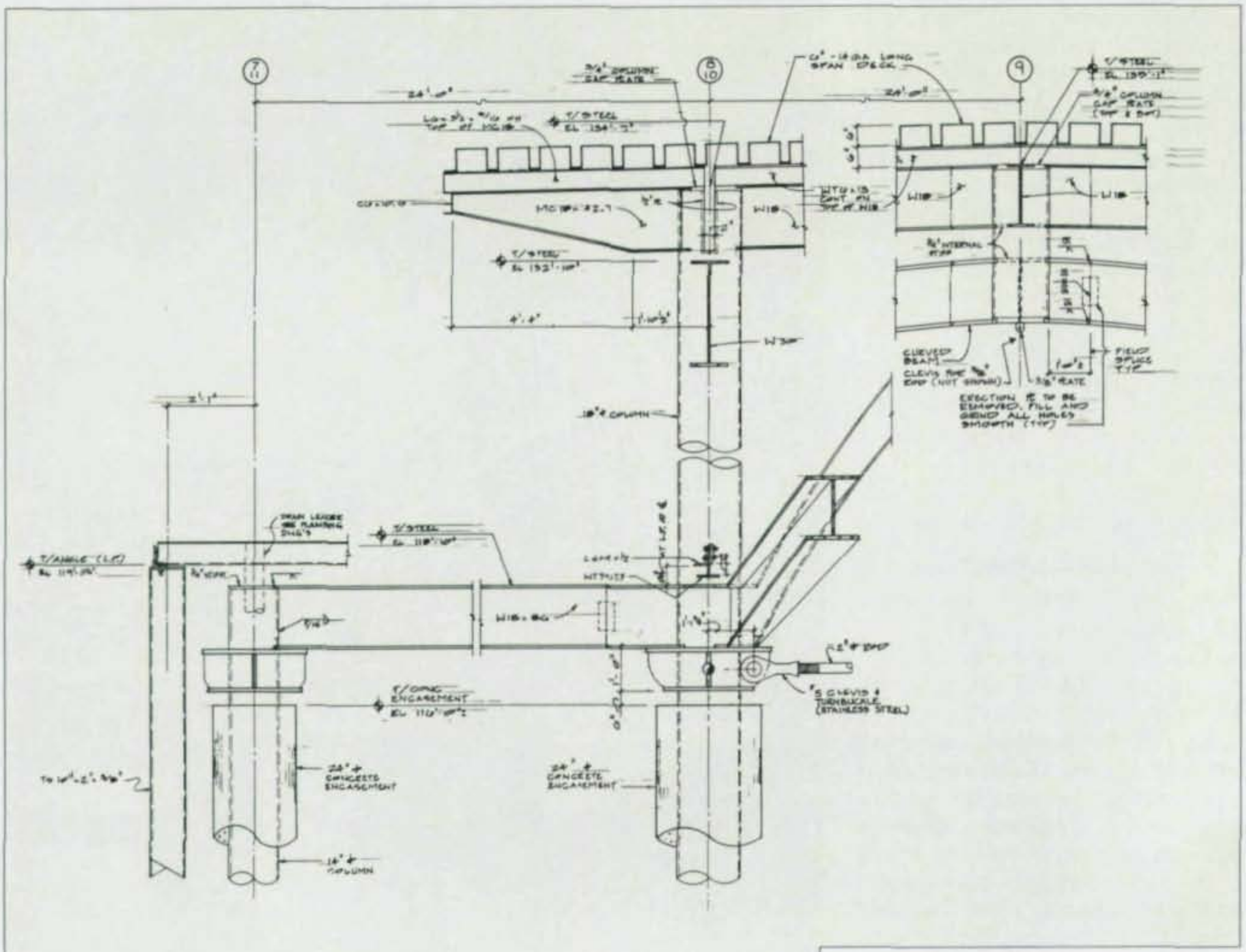
"The most difficult part of the project was working out the connections where curves in different planes come into a single member," Nair said.

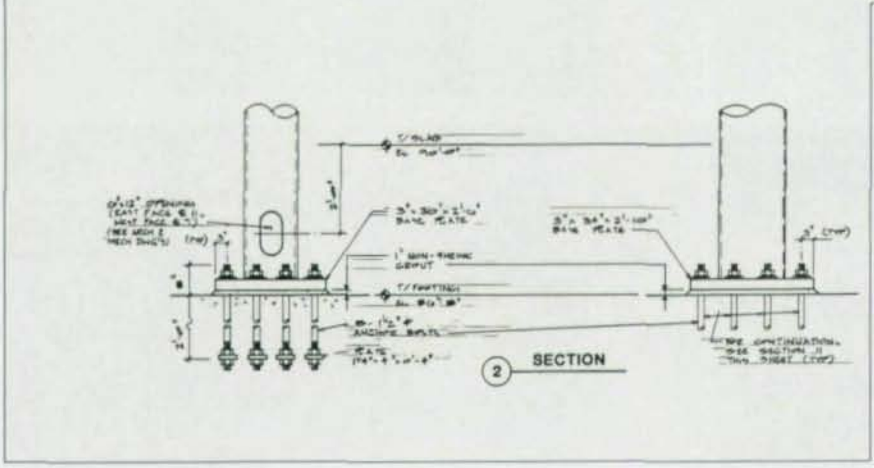
Because the slopes of the arches framing into the columns varied, it was necessary to maintain a constant vertical dimension. Because stresses were greater at the center of the arch, the depth of cross-section was variable, thus requiring the use of built-up sections instead of standard wide flanges. The arch is I-shaped in cross-section and consists of a ¾" web and 1" x 11" flanges shop-welded together. Arch-to-column connections were field welded.

Fabricator of the 530 tons of structural steel used in the project was AISC member Zalk Josephs Fabricators Inc.

At the apex of the arch and the mid-point of the beams, a 16"-diameter steel pipe stub was positioned to receive loads from the orthogonally erected framework of the main roof. W18 x 50 roof beams are located 2'-2" above the arch crown point and slope down from the main bay centerline at ¼" per ft. A 6"-deep, 14 gage steel roof deck spans 24' in the north-south direction and carries the roofing and snow load to the W18 roof beams. Total height of the steel framing from the support on the concrete substructure to the steel high point was approximately 45'.

An arch over the main entrance to the museum, as well as a series of arches atop the exhibit hall, hint at the exposed structural system inside the main hall.
Photos by Timothy Hursley, The Arkansas Office.



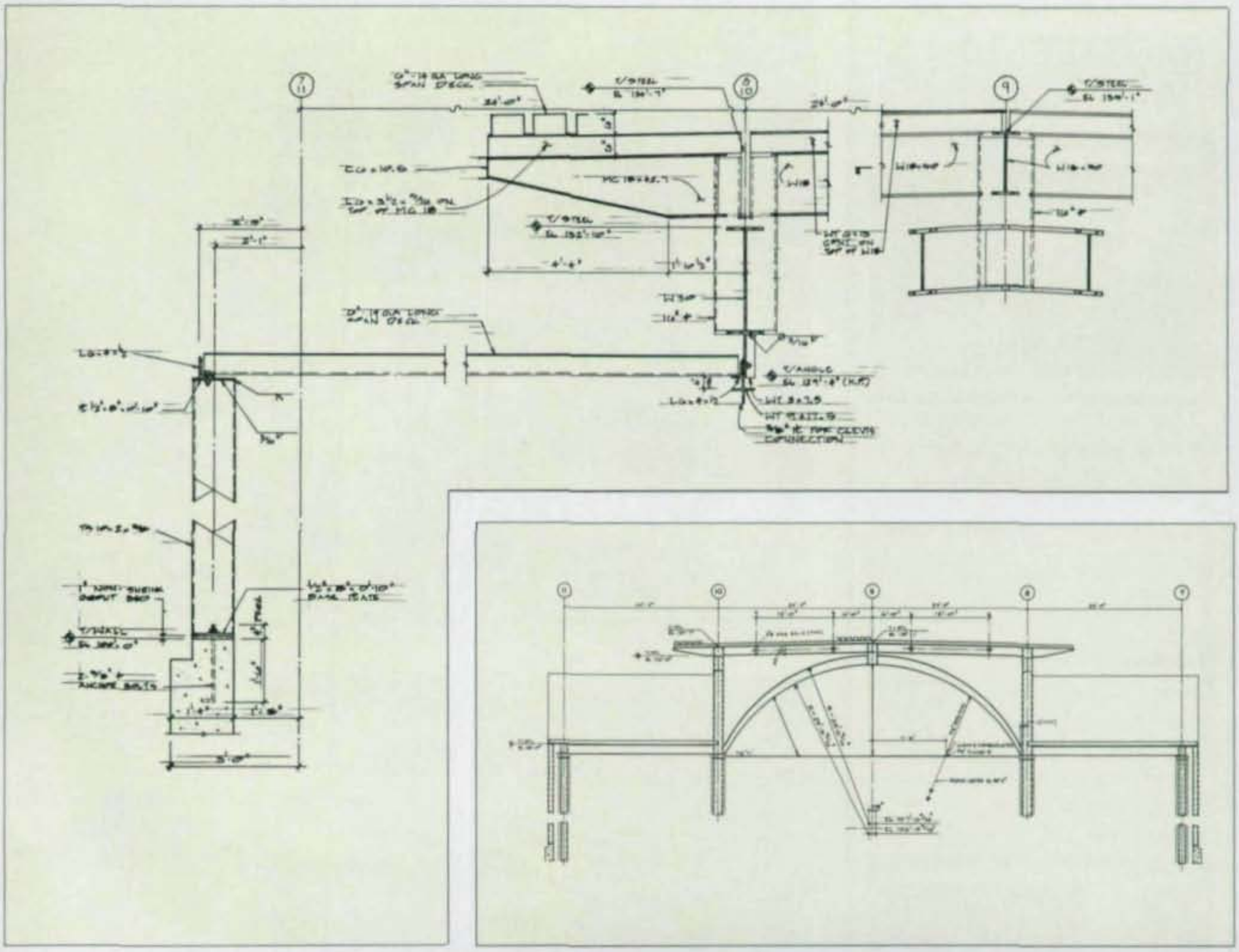


(2) SECTION

The roof beams also are supported by 16"-diameter steel pipes extending from the top of the 18"-diameter pipe columns.

"The horizontal thrust of the arches is resisted by a system of 2"-diameter solid steel tie rods with clevises placed orthogonally on grid lines," Lam said. Sagging of the rods is prevented by the use of aesthetically patterned ⅜"-diameter sag rods off of the arches.

"Side bays of the main exhibit hall were framed using 6"-deep 14 gage steel roof deck spanning east-west and supported by vertically curved 6 x 4 x 1/2" angles at each end," Lam said. "Tubular steel columns 10" x 2" spaced at 6' on center provide vertical support for the angles along the exterior walls. Variable length angle hangers off W30 beams supporting curved 6 x 4 angles on the interior provide space for modular clerestory glazing panels."



Rigid frames positioned on grid lines within the side bay area and spaced at 48′ on center provide lateral stability for individual bays. The longitudinal W30 beams previously mentioned rigidly connect to the 18″ diameter columns to provide structural stability in the north-south direction.

Truss Conceals Mechanical Ducts

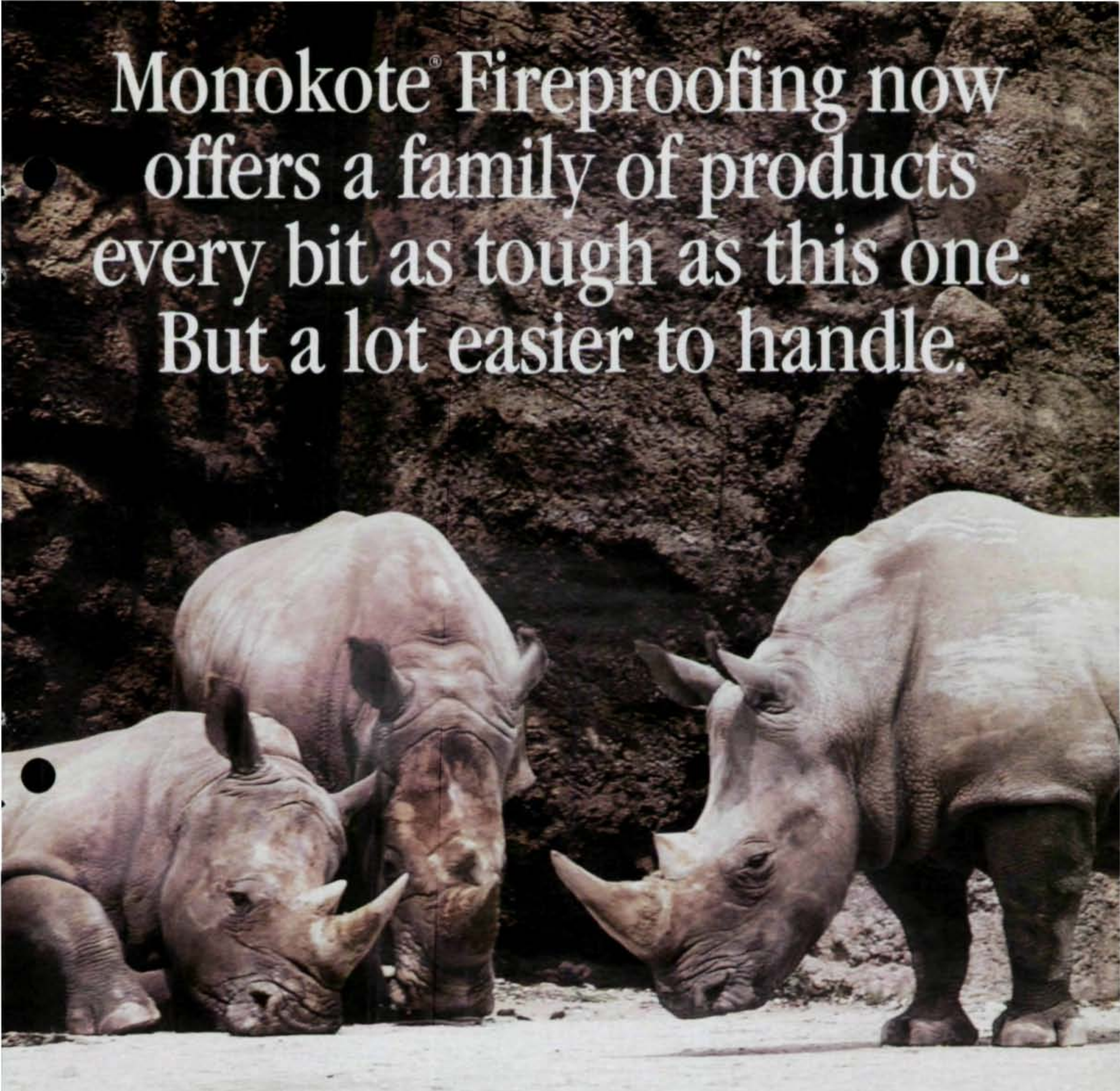
The architectural design of the project included a 48′-wide glass entrance set back 22′ from the curtainwall exterior. In addition to supporting the fascia and interior stone cladding, the structure above the entrance needed to accommodate an irregularly shaped major mechanical duct. The solution was to introduce a 48′-long steel truss. "Designed as a combination vertical and horizontal truss and a horizontal beam, this structure carried all of the direct loads along with

A 48'-long truss supports the glass entryway while also concealing an irregularly shaped mechanical duct.
Photos by Mc Shane Fleming Studios, Chicago.

torsion induced by them," Lam explained. As a result, a very stiff structural element was created with a 13' vertical depth and 2'-3" horizontal depth. The top chord consists of W24 x 68 members and the bottom chord consists of W10 x 49 members.

The remaining portions of the museum complex are steel framed structures with wide flange columns and beams, and LH-series and K-series joist framing. Roofing is supported on 1½" or 3" steel roof deck, with the deeper metal decking used to create a curved panel. Each individual building has a system of X- or partial X-bracing with, respectively, steel rods or double-angle members providing lateral stability.

Because the structure is located in a 100-year flood plain, a special foundation was designed to accommodate the high water table. "We needed to have enough dead load to counter uplift force," Lam explained. The solution was to design a foundation mat filled with 4½' of stone aggregate to counter the water pressure. On top of the aggregate is a 5" concrete slab. ■



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GRACE
Construction Products

Variation On Tradition

The design of this building is sensitive to its function as both a center for worship and for the performing arts

While the designers of a new 33,395 sq. ft. chapel and performing arts center for Northwestern College in Orange City, IA, chose traditional steel and concrete construction for much of the building, they opted for an exposed steel roof truss in the chapel itself with dramatic results.

"Our choice was primarily based on the economy of steel, but we also were greatly concerned with aesthetics," explained Dave Duimstra, AIA, project manager with RDG/Bussard Dikis, Inc., Des Moines.

The chapel is the setting for both daily religious services as well as performing arts events and seats 1,000 and is connected to classroom and rehearsal buildings. The exterior of the building is clad in red brick and the roofline slopes down and outward in a contemporary adaptation of the traditional "Dutch kick", an appropriate touch given the Dutch heritage of the area. Likewise, the chapel's entrance recalls the flying facade so often used in traditional Dutch architecture.

The chapel's interior has a very traditional church layout—a cruciform form with a long nave and a peaked roof. A marked point of departure occurs at ceiling level, however, where brightly painted steel trusses are left exposed. The trusses are constructed of steel pipes spaced 20' apart and spanning 50', according to Terry Shuck, P.E., of Shuck-Britson, Inc., Des Moines, the project's structural engineer. The top chord of the truss are 8" pipes, while the bottom chord and webs are 6" pipes.

Round Shapes Create Finished Look

Pipes were chosen instead of tubes as being more compatible with the entire feel of space, which also features a large pipe organ and a substantial amount of pipe railing, as well as round columns. "Also, the pipes create a more finished effect than would a series of angles and tees," Shuck said.

An alternate considered was a wood joist system, but because the trusses would have had to have been closer together than with the steel system, it would not have provided as dramatic an appearance. Another alternative considered was a conventional steel truss system, but that would have required a wood finish to meet the project's aesthetic requirements, and that would have been more expensive.

Easy Connections

"Connections were not a problem with the pipe. We split the pipe and used welded plates between them," he explained.

The pipes were connected to the ⅜" circular plates with fillet welds. Running perpendicular and attached to the top of the trusses are 12" x 8" steel tubes, and attached to the top of the tubes with threaded steel studs are wood blocks. The wood roof deck was then nailed into the wood blocks. Maximum load on the steel pipes is 100 kips.

The designers had considered using wood, but given the re-

The chapel's exterior reflects the community's Dutch heritage, while the interior has a traditional church layout—but with the added twist of substituting exposed steel trusses for more traditional wood or stone architecture.

The round shape of the steel pipes presents a finished architectural look that also emphasizes the design of the chapel's large pipe organ.

quired spans, steel was substantially less expensive and also stopped the structure—which is used for secular entertainment—from looking "too much like a church."

Dynamic Repetition

"The repetitive steel arches refer to a church form while also creating a very dynamic expression of space. Also, people have commented on steel's substantial feeling of strength," Duimstra said.

That desire for a strong image also is apparent in the choice of columns. "We normally would have used steel columns, but the architect wanted something that would look more massive, so we went with 20" diameter concrete columns," Shuck explained.

On the east side beyond the column line is a wall with a substantial number of windows. To support this window wall, the engineer designed a secondary steel system. Spanning between the exterior wall and the columns are W16 x 26 steel beams, which support W16 x 31 beams running within the wall. Between the window openings are W8 x 10 steel members, with the top lintels formed with 3" tubes.

Acoustic requirements of the $3.3 million center were met by the high wood ceiling and the gently


Connections were created by connecting the pipe to ⅜" circular plates with fillet welds. Attached to the top of the trusses are 12" x 8" steel tubes, which support the wood roof deck.

curved balconies running around the entire perimeter of the chapel. Each balcony segment protrudes slightly further than its predecessor, improving acoustics while also reducing the visual size of the space to a more human scale.

Award-Winning Design

"Finished and in active use, the structure succeeds in unifying this wide range of user needs," wrote Iowa Architect in its description the structure after it won an Iowa Chapter AIA Design Award. "The completed chapel ably fulfills its dual purpose, offering an appropriate setting for daily religious services as well as a center for performing arts. Its cruciform plan and traditional seating arrangements inspire the reverence of religious devotion, while the magnificent space both enhances this spiritual quality and makes for superb acoustics." ■

Dramatic Juxtaposition

An exposed framework of steel tubes and nodes will be painted black, while the metal deck above the tubes will be painted white. The lamella space frame is reminiscent of old European libraries, but the traditional wood structure has been translated into more modern materials.

Photo by Mc Shane Fleming Studios, Chicago.

The reading room atop a new law school building features an exposed steel tube space frame painted black to contrast with a white metal deck

Because the new building for Chicago Kent College of Law, Illinois Institute of Technology, needed to be able to adapt to changing program requirements, the designers chose a steel frame. And since image is almost as important as function for a law school's recruitment efforts, the designers opted to make a statement by exposing part of the frame.

The 10-story, nearly cubical structure contains classroom space on the three lower floors, leasable space on floors four and five, and a library on the upper five floors. At its top is an imaginatively designed lamella space frame above a reading room.

Gothic Expression

"The reading room is not just for the law school, but also will host events for the IIT campus," explained Margaret Lehto, AIA, project architect with Holabird & Root, the Chicago-based architect and engineer on the project. The 32'-high room features millwork for the first 15', then a band of drywall and translucent windows, and finally an exposed steel structural element.

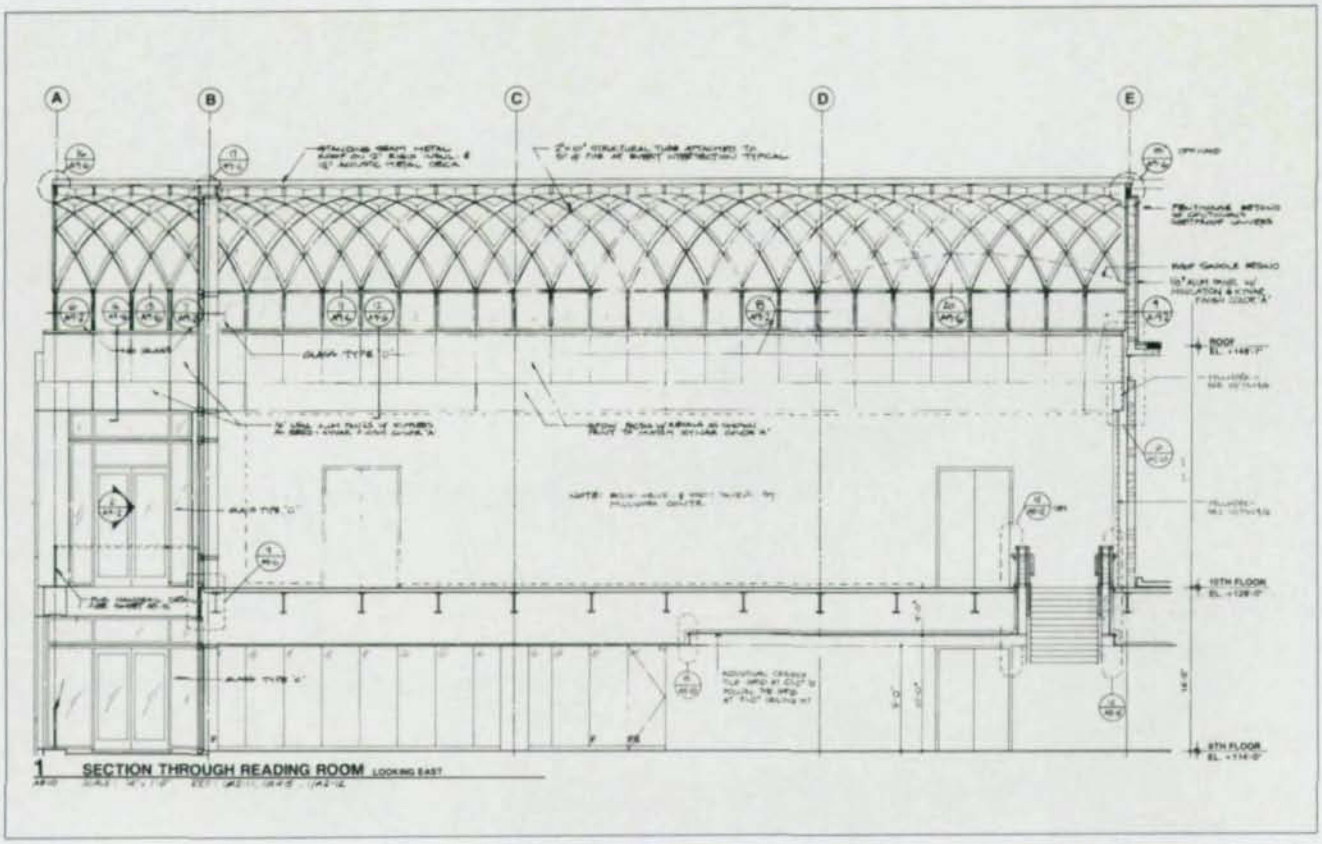
"We didn't want a skylight, both because the sunlight might damage

The 10-story building will contain classroom space on the lower three floors, leasable office space on the next two floors, and a library on the upper five floors.
Photo by Peter Fish Studio, Inc.

reading material and because of concerns about glare," Lehto said. Instead, a space frame of steel tubes and nodes was designed in an updated Gothic configuration. "The diamond pattern is reminiscent of what you might find in old, European libraries, but we translated it from wood to more modern materials," she explained. The diamond pattern also is expressed in various other parts of the building, such as on the terrazzo floor tiling and the atrium railing.

The space frame is topped with a metal deck, which also will be left exposed. The metal tubes are being painted black, while the deck will be painted white, creating a dramatic juxtaposition.

The space frame consists of 10" x 2" x ¼" tubes with nodes made of 3"-diameter extra-strong pipes, according to Nicholas Bilandic, P.E., director of civil and structural engineering at Holabird & Root. The columns, which are formed with two parallel tubes, are bent near the top to provide a clerestory, while the rest of the members are straight, with changes in the elevation occurring at the nodes. "The double tubes are strictly an architectural feature," Bilandic said, and the weight could have been accommodated by simply using heavier tubes. The frame has a radius of 36'. Lateral thrust on the roof structure is taken by adjacent



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1 SECTION THROUGH READING ROOM

The space frame consists of 10" x 2" x ¼" tubes with nodes made of 3"-diameter extra-strong pipe. The frame has a radius of 36" and lateral thrust on the roof structure is taken by adjacent framing members. Photo by Mc Shane Fleming Studios.

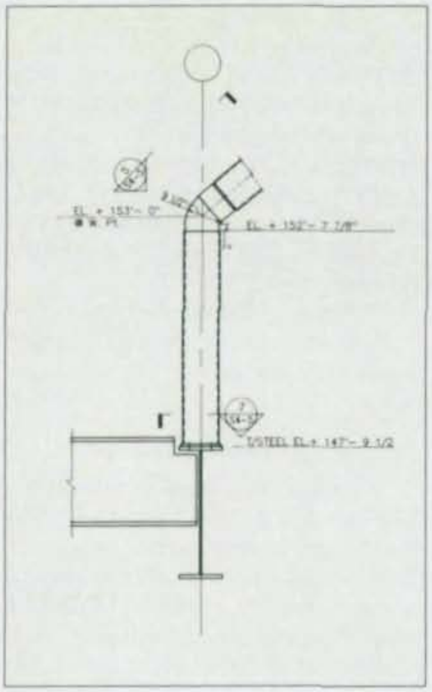
framing members.

The rest of the building is a conventional steel braced and moment resisting frame, though occupancy requirements—including a central atrium—forced the engineers to design an eccentric core. Braces are concealed in the elevator core, stairwells and utility rooms.

Exterior columns rest on foundation walls at grade and interior columns bear on foundation caissons.

High Strength Steel

All steel members in the building are A572 Grade 50 steel. "We used high-strength steel to reduce the weight of the building and to make erection easier," Bilandic said. He estimated that using A572 instead of A36 steel reduced the steel weight from 20 lbs./sq. ft. to 18 lbs./sq. ft. The structure used 2,200 tons of structural steel. Steel fabricator was AISC-member Zalk



The columns supporting the space frame are formed with two parallel tubes bent near the top to form a clerestory.

Josephs Fabricators, Inc.

Bilandic reports that vibration and deflection were controlled by utilizing a composite deck slab with sheer connectors.

Columns range in size from W14 x 90 to W14 x 455, with the exception of one area framed with W21 x 402 columns. "We omitted one row of columns to accommodate the main entrance, and in that area we have a Special Moment Resisting Frame," Bilandic explained.

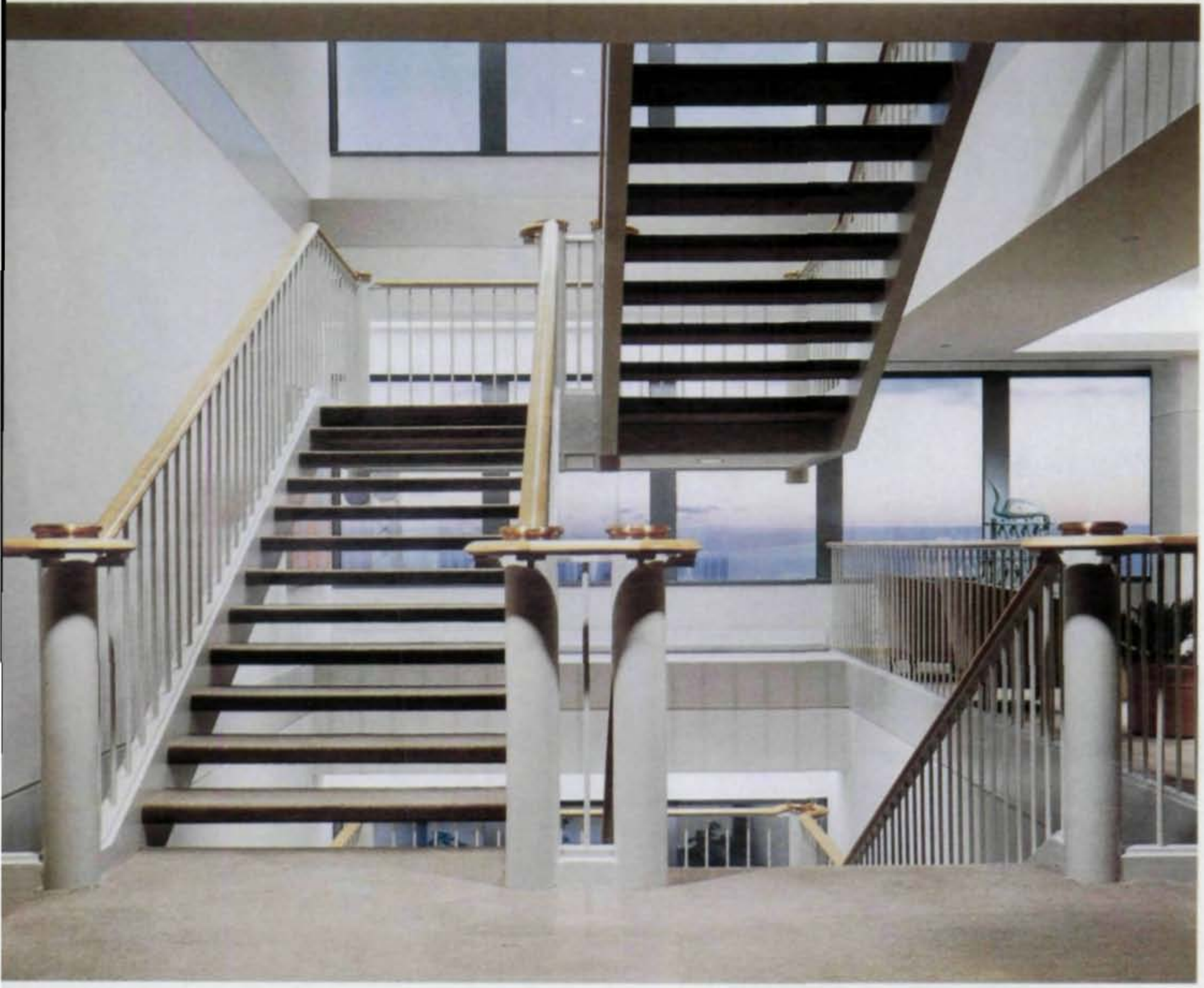
The floor beams are W24 x 76 wide flange sections. The first four floors of the structure are designed for 100 psf live loads, while the upper six floors are designed for 150 psf.

Accommodating The Future

Currently, floors four and five are intended as commercially leasable space, but ultimately the design calls for classrooms to expand up to the fourth floor and the library to expand down to the fifth floor.

Beam spacing on the upper floors is 6'-8" in response to the compact spacing of library stacks. Beam spacing on the lower floors is a more conventional 13'-4". Floor-to-floor height is 14', in part to accommodate extensive electrical conduit. "Today's education buildings require a tremendous amount of wiring," Lehto said. "This building is very advanced electronically. On the first floor alone, there are almost four miles of conduit, all in the floor slab."

"A steel frame was chosen because it provided flexibility to change the use of interior space in the future," Bilandic said. In addition, the lighter weight of a steel structure compared to a concrete structure reduced foundation costs. "Steel also allowed us to have longer spans, which meant fewer intrusive columns. There was a better payback with steel." ■



Monumental Stair Design

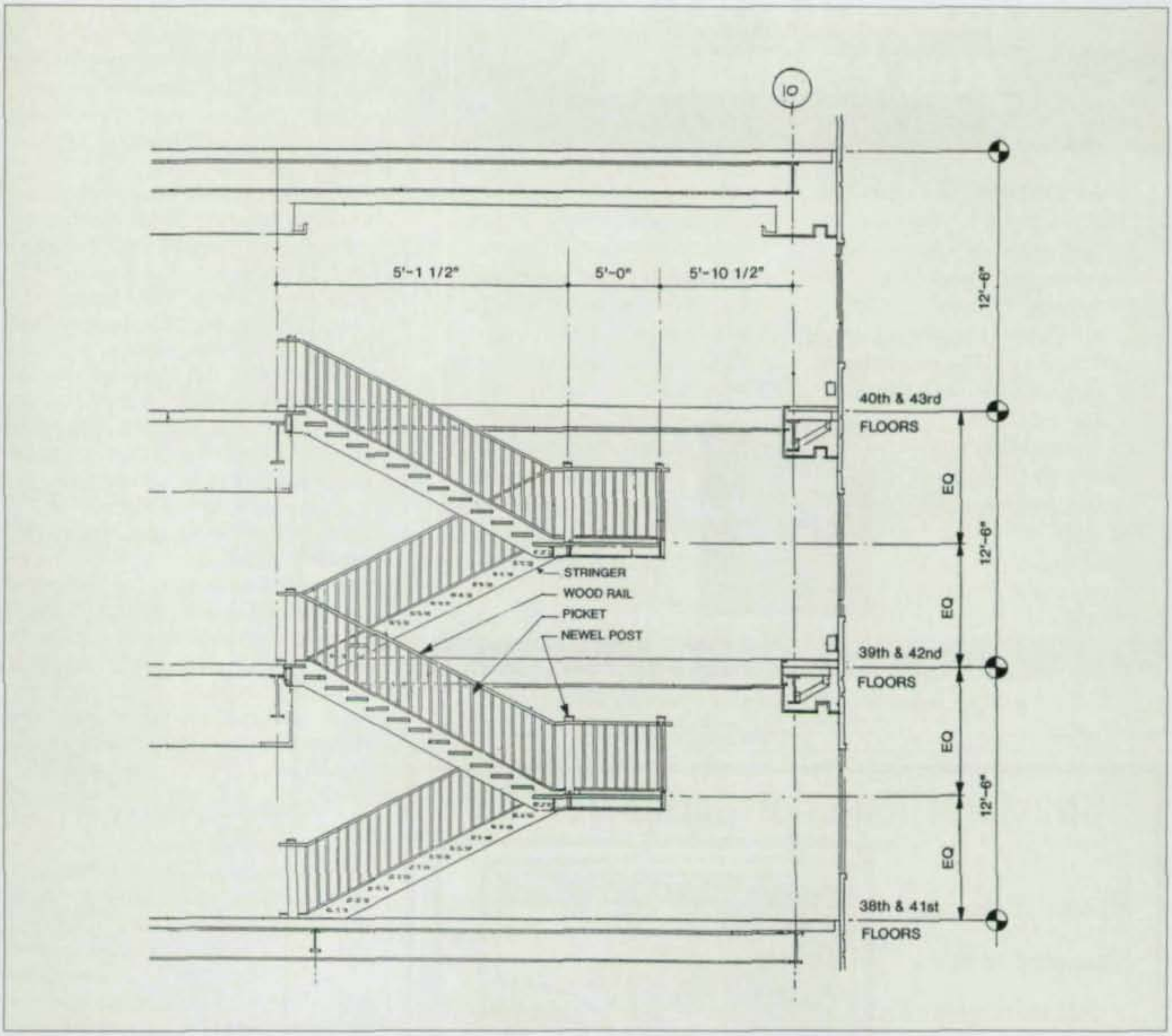
Tenant modifications were simplified by the structure's existing steel frame

By Nancy B. Goldberg, P.E.

When the law firm of Duane Morris & Heckscher planned their move into One Liberty Place, one of Philadelphia's most prominent office buildings, they had a specific program in mind—one that included projecting an image of energy and activity to visiting clients.

The firm's separate practice groups were scheduled to occupy more than 200,000 gross sq. ft. late in 1990 on seven floors of the 60-story structure, which had been completed three years earlier (see *MSC* Issue Number 2, 1987 and *MSC* November-December 1990).

After evaluating a number of alternative solutions, the project's architect/engineer/interior designer,



The Kling-Lindquist Partnership, Inc. (TKLP), established that a series of monumental communicating stairs within the public lobby spaces would best convey this feeling of directed energy.

While clearly meeting the program, the stairway proved to be a monumental structural design challenge. The exposed steel, open riser, cantilever design, combined with unique vibrational criteria and retrofit constructability requirements, created a situation where serviceability was of crucial significance. Although many engineers shy away from the design challenges associated with the "unpredictable" nature of stairs such as these, TKLP recognized an opportunity for their structural engineers to apply sophisticated static and dynamic analyses to develop a definitive solution for the stair.

Each of the two pairs of monumental stairways connect three floors of the law firm. Floor openings of 16' x 25' penetrate the existing framing of four floors (39, 40, 42 and 43) adjacent to the east exterior wall as shown on the floor plan. The addition of the new stairs required reinforcing the existing structure and accessing existing connections, both of which were facilitated by the original building frame being steel.

The stairs, each with two 5'-wide runs and a 5' x 11' landing, cantilever out 20', floating in the floor

While the law firm was the first tenant to occupy these seven floors, their modifications were made three years after the building was completed. However, since the building was steel-framed, modifications to accommodate the stair openings were easily and inexpensively made.

Photo opposite by Robert Miller.

opening. The rails of the stair are solid wood supported from the stringers by ¾"-diameter steel bar pickets. At the entrance to each stair, 6"-diameter steel newel posts sport a brass cap bearing the law firm's logo.

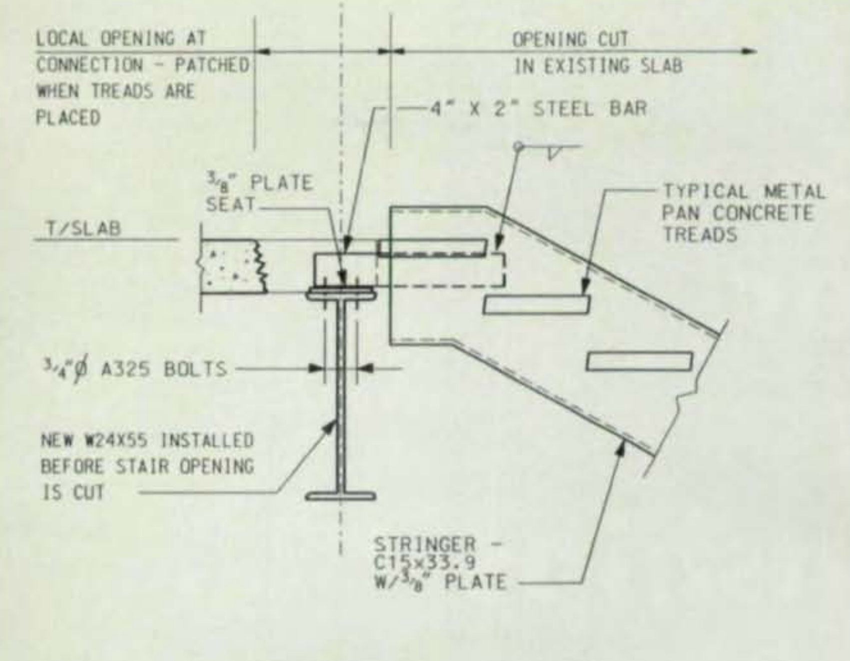
The stairs were located adjacent to the exterior curtain wall offering exceptional views of the city's skyline. However, psychologically, this view, when combined with the light, open stair design, had the potential for creating a situation where the perception of movement or vibration would be very intimidating. It was therefore critical that vibration perception be maintained at acceptable levels.

Due to the fact that these stairs were tenant modifications to an existing building, it was desirable to simplify as much as possible the stair connection to the floor structure. Rather than using a complicated, "rigid" stringer connection to stiffen the stair frame and reduce perceptible vibrations, the stiffness of the stair itself was designed to control the vibration.

Computer Analysis

A computer analysis was performed with Celestial Software's Images 3D program using a model that accounted for each principal element of the stair. The properties of each tread, the framing members of the middle landing, and the stringers were incorporated into the computer model. All interior stair connections were considered fully fixed. The weights of all the miscellaneous materials, including the handrails, their supports, and the pickets, were included in the calculations.

Several different load combinations of varying magnitudes, directions, and points of application were applied to the stair model to analyze the stair's static displacements, and thus the system stiffness. With regard to dynamic analysis and vibrational concerns, a modal analysis was performed to determine the mode shapes, frequencies (eigenvalues), and time period of the stair model. Stringer support conditions of varying degrees of fixity were investigated to



STRINGER CONNECTION DETAIL

establish their effect on vibration and stiffness. When the results of the pinned-end support analysis proved that this stair model satisfied the design criteria as well as the other support conditions, the stair and its connections were detailed.

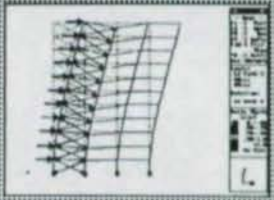
An integral part of the design process involved an independent dynamic evaluation for vibration perception by the Boston firm of Acentech, Inc., acoustical and vibrational consultants. This evaluation indicated that the stairs "may be expected to vibrate predominantly at a frequency of about 4 Hz and that a person walking on these stairs may be expected to generate vibrational velocities that do not exceed 0.21" per second in the vertical direction and 0.44" per second in the lateral horizontal direction." It was determined that these values were within acceptable limits for vibration perception.

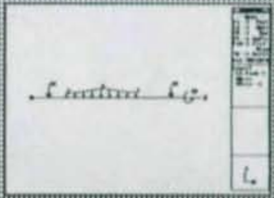
Connection Details

The stringers are 15"-deep channels with 3⁄8"-thick coverplates. The concrete diaphragms of the treads and landing promote the lateral stiffness of the stringer pairs. Shear studs installed at each side of the treads and landing transfer horizontal shear forces from the stringers to the diaphragms. Within the stair framework, full and partial penetration welds assure continuity at the member-to-member connections even though the connection forces are generally small in magnitude.

The connection from the stringers to the steel floor framing is detailed as a pinned end simple seat connection. The detail consists of a 2" x 4"-steel bar extending from the end of the stringer with a plate bearing on the floor beam. The steel bar and its welded connection to the stringer are designed to resist axial, shear, and flexural forces imposed by the stair and the internal connection eccentricities. The loads transferred to the beam are concentric vertical loads and horizontal forces resulting from the couple generated by the cantilever geometry. The horizontal forces are, in turn, transferred to the slab diaphragm.

Nancy B. Goldberg, P.E., is a project structural engineer with The Kling-Lindquist Partnership, Inc., a leading architecture, engineering, interior design, and consulting firm headquartered in Philadelphia. ■





NEW COATING PRODUCTS

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For more information on either product, contact: Tnemec Co., Inc., Box 411749, Kansas City, MO 64141-1749 (816) 483-3400.

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For more information, contact: Nick Hecei, Dir. of Mktg., Republic Powdered Metals, Inc., 2628 Pearl Road, Medina, OH 44256 (216) 225-3192.

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For more information, contact Carboline Co., 350 Hanley Industrial Court, St. Louis, MO 63144 (314) 644-1000, attn: Mitch Braun, ext. 2326.

Air Powered Sprayer Designed For Protective Coatings

Speeflo Manufacturing Corp.'s new heavy duty, high pressure airless sprayer delivers up to 2.6 gpm at pressure to 4,500 psi. This higher pressure capability makes this model ideal for hard-to-atomize coatings such as sprayable mastics, urethanes, and below-grade waterproofing.

For more information, contact; Speeflo, P.O. Box 111249, Houston, TX, 77293-0249 (800) 231-9929 ext. 406.

Coating Stops Corrosion

Permite's new Permox coating is a two-component, two-coat epoxy reinforced with a layered structure of treated glass flakes. This flexible coating has an exceptional combination of corrosion, abrasion, chemical and impact resistance. As Permox cures, chemical reactions between the hardener, epoxy resin and treated glass flakes cause the glass flakes to form into a plate-like layered structure, which retards the passage of corrosive elements through the film.

For more information, contact: The Permite Corp., 5239 Brer Rabbit Road, Atlanta, GA 30083 (404) 292-4842.

Increased Wear Resistance

Duralcan is now manufacturing a thermal-spray wire for wear-, abrasion-, and corrosion-resistant coatings. Duralcan 90/10 is an aluminum-matrix composite thermal-spray wire composed of 90 vol% Al + 10 vol% Al_2O_3 (8 to 10 microns in diameter). The composite makeup of the wire improves wear performance as compared to thermal-sprayed aluminum and organic coating systems while providing equal or superior corrosion resistance. Compared to aluminum thermal-spray coatings, this new product provides up to ten times the wear resistance and 1/3 more abrasion resistance.

For more information contact: Duralcan USA, 10505 Roselle St., San Diego, CA 92121 (619) 587-1415.

Arc Spray System For Metallizing

Miller Thermal's new BP400 metallizing gun is easy to use and fast to operate. Because of the units efficiency, better metal coatings can be achieved at a lower cost, according to the manufacturer. Thermal arc spraying is an efficient method of applying metal coatings to base materials.

For more information, contact: Miller Thermal, Inc., 555 Communication Dr., P.O. Box 1081, Appleton, WI 54912 (800) 637-8307.

New Equipment Provides Dust-Free Blastcleaning

LTC International, has introduced a new portable vacuum blasting machine. The LTC 1060B automatically and continuously recycles the abrasive, providing continuous blast cycles of one to two hours and waste reduction of more than 90% compared with open blasting. The machine features an easy access control panel, lifting rings, waste disposal into dust bags, and adjustable blast and vacuum pressures.

For more information, contact: LTC International, Inc., 101-G Executive Dr., Sterling, VA 22170 (703) 742-7860.

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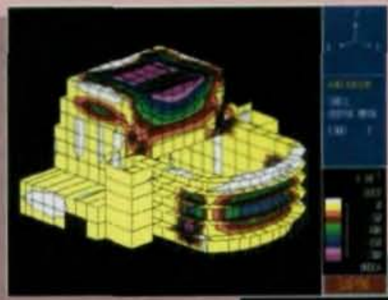

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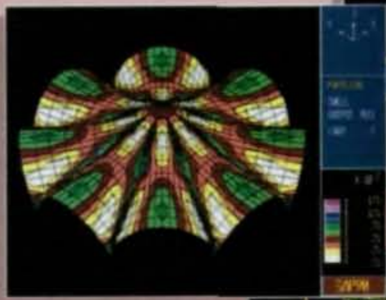
Highway Engineering



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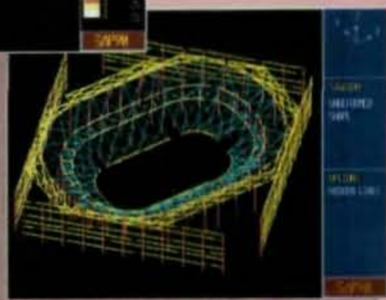

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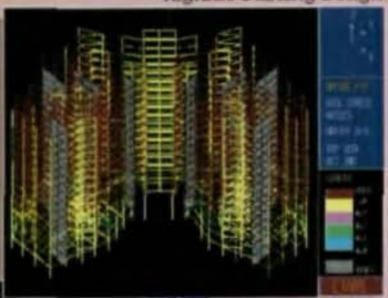

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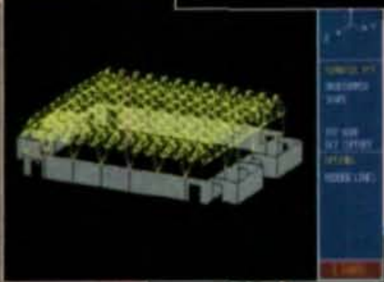

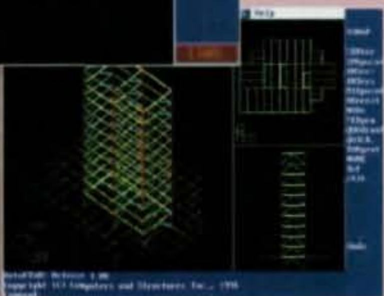

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