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MODERN STEEL CONSTRUCTION

July 1991

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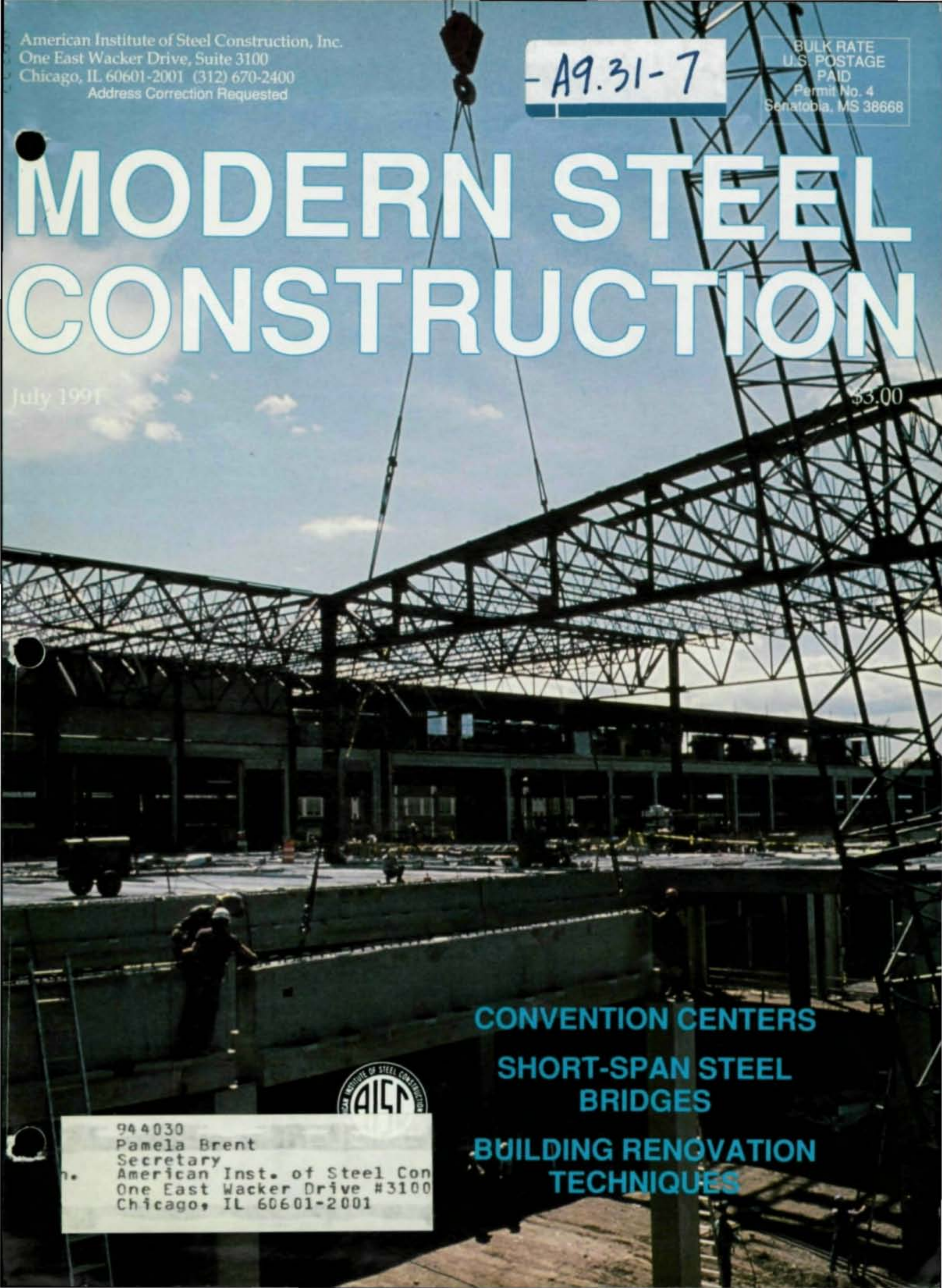

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DECK DESIGN DATA SHEET

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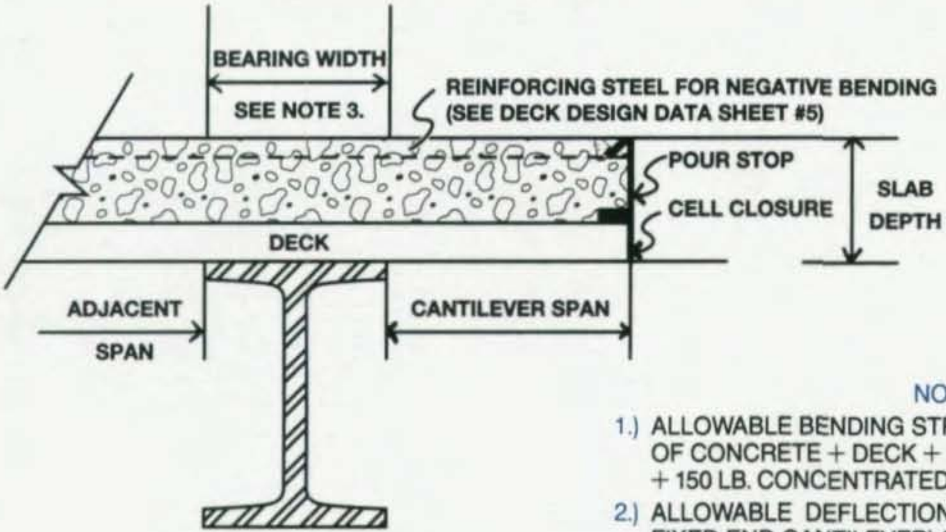
FOR UNITED STEEL DECK, INC.



NOTES:

1.) ALLOWABLE BENDING STRESS OF 20 KSI WITH LOADING OF CONCRETE + DECK + 20 PSF OR CONCRETE + DECK + 150 LB. CONCENTRATED LOAD, WHICHEVER IS WORSE.
2.) ALLOWABLE DEFLECTION OF FREE EDGE (BASED ON FIXED END CANTILEVER) OF 1/120 OF CANTILEVER SPAN UNDER LOADING OF CONCRETE + DECK.
3.) BEARING WIDTH OF 3½" ASSUMED FOR WEB CRIPPLING CHECK — CONCRETE + DECK + 20 PSF OVER CANTILEVER AND ADJACENT SPAN: IF WIDTH IS LESS THAN 3½"; CHECK WITH SUMMIT, NEW JERSEY OFFICE.
4.) CALL NICHOLAS J. BOURAS, INC. ANYTIME YOU NEED DECK INFORMATION.

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NORMAL WEIGHT CONCRETE (150 PCF)

	UNITED STEEL DECK, INC. DECK PROFILE															
	1.5 IN B-LOK				1.5 IN LOK-FLOOR				2.0 IN LOK-FLOOR				3.0 IN LOK-FLOOR			
Slab Depth	22	20	18	16	22	20	18	16	22	20	18	16	22	20	18	16
4.00"	1' 11"	2' 3"	2' 10"	3' 4"	1' 11"	2' 4"	3' 0"	3' 6"								
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"				
5.00"	1' 10"	2' 2"	2' 8"	3' 2"	1' 10"	2' 3"	2' 9"	3' 3"	2' 5"	2' 10"	3' 6"	4' 1"	3' 8"	4' 3"	5' 3"	6' 0"
5.50"	1' 9"	2' 1"	2' 7"	3' 0"	1' 9"	2' 2"	2' 9"	3' 2"	2' 4"	2' 9"	3' 5"	4' 0"	3' 7"	4' 1"	5' 0"	5' 9"
6.00"	1' 9"	2' 0"	2' 6"	2' 11"	1' 9"	2' 1"	2' 8"	3' 1"	2' 3"	2' 8"	3' 4"	3' 10"	3' 5"	3' 11"	4' 10"	5' 7"
6.50"	1' 8"	2' 0"	2' 6"	2' 11"	1' 9"	2' 1"	2' 7"	3' 0"	2' 3"	2' 8"	3' 3"	3' 9"	3' 4"	3' 10"	4' 8"	5' 5"
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MODERN STEEL CONSTRUCTION

Volume 31, Number 7 July 1991

The 970,000-sq.-ft. Denver Convention Center was designed and built in less than two years. The center features a second-floor, 300,000-sq.-ft. exhibit space on top of a large ballroom and supported by seven jumbo trusses. For more information on this project, *turn to page 28.*

FEATURES

NEWS AND DEPARTMENTS


HISTAR
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Cutting Edge Technology

Some thoughts garnered from the recent A/E/C Systems show in Washington, DC....

• It seemed like only yesterday that 486-based computers were written off as unnecessary and too expensive. Now engineering software manufacturers are providing programs that fully take advantage of the additional power supplied by the 486 PCs—and to such a degree that these faster computers are becoming firmly ensconced in the workplace and pushing the previous generation of 386 computers into the home market.

• Presentation software has advanced by leaps and bounds. A few years ago architects could wow their clients by showing them a three-dimensional view of a building—and maybe even rotating it. Now architects can actually "walk" their clients through a design—moving along corridors, showing spaces up close or from a distance. And thanks to today's powerful computers, Virtus's Walkthrough package even offers real-time movement. Intel took Virtus' basic tools and added a fancy piece of hardware—a "Buck Rogers" headset equipped with sensors so that head movement is translated into cursor movement: As you turn your head, the view changes. The headset has two drawbacks, however: Woefully inadequate, very slow screens and a $30,000 price tag. (Incidentally, Intel's demonstration was not meant as a practical system, but rather to show the possibilities provided by the most recent technology.) More affordable is a hardware/software package from StereoCAD, which even comes complete with special stereoscopic glasses. The package, which sells for less than $3,000, line drawings into true 3D presentations—and of a much higher quality than even the best 3D movies.

• Integration is no longer just a buzzword. Several manufacturers have either completed or are working on agreements that will bundle their software with products from other companies. In some cases this will create a full price-range of products within one family (such as an agreement between SoftDesk and Generic Cad. Other manufacturers are negotiating to integrate engineering software packages with detailing software.

The advancements have been mind-boggling. What was state-of-the-art only yesterday is outdated today. In this issue, MSC offers two software reviews and a myriad of software listings, all beginning on page 40. **SM**

CALL FOR PAPERS

1992
NATIONAL STEEL CONSTRUCTION CONFERENCE
Las Vegas Hilton Hotel
June 3-5

Primary Author:

Name ____
(First) *(Middle Initial)* *(Last)* *(Professional Suffix-Degrees)*

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City ____________________ State ____________ Zip ________
Home Phone ( ) ____________ *Preferred Mailing Address: ( ) Business ( )Home

Co-Author(s):
1. Name ____
(First) *(Middle Initial)* *(Last)* *(Professional Suffix-Degrees)*
2. Name ____
(First) *(Middle Initial)* *(Last)* *(Professional Suffix-Degrees)*
3. Name ____
(First) *(Middle Initial)* *(Last)* *(Professional Suffix-Degrees)*

Invitation/Call for Papers

The 1992 National Steel Construction Conference will be held at Las Vegas Hilton Hotel June 5-8 1992. 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;
Partially restrained connections and frames;
Economical fabrication and erection practice;
Quality assurance and control;
Case studies of unique projects;
Computer-aided design and detailing;
Case studies of unique projects;
Computer-aided design and detailing;
Material considerations;
Fire Protection;
Coatings and material preparation;
Structural systems.

Guidelines for Abstract Proposals

Abstracts for papers must be submitted before September 15, 1992.

Abstracts should be approximately 250 words in length, and submitted on a separate sheet of 8½" × 11" white paper attached to this form.

Authors will be informed of the Organizing Committee's decisions by November 15, 1991. Successful authors must submit their final manuscripts for publication in the official 1992 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 1992 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 acceptance 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, 1991 to:

American Institute of Steel Construction, Inc.
One East Wacker Drive, Suite 3100, Chicago, IL 60601-2001
Attention: Robert O. Disque
Phone: 312-670-5414/Fax: 312-670-5403

New System Offers Enhanced Corrosion Protection For Bridge Stay Cables

Immersing bridge stay cables in a lightweight, corrosive-resistant fluid can prevent deterioration, according to the developers of a new corrosion protection system.

In cable-stayed bridges, primary cables directly support the deck, rather than indirectly supporting the deck via suspenders from two main cables. The design has been used on approximately 200 bridges worldwide, and was introduced to the U.S. in the early 1970s.

In the new protection system, the corrosive-resistant liquid is retained in a cable sheath and isolates the bridge stay cables from the surrounding atmosphere, according to Thomas G. Lovett, P.E., associate vice president with Greiner, Inc., the Tampa-based engineering firm applying for a patent on the system.

A liquid flow control device drains condensation or purges the corrosive-resistant liquid from the cable sheaths, while a supply reservoir feeds the liquid to-and-from each sheath in response to temperature changes. An alternate point for introducing the liquid is provided at the lower anchor structure.

The system also incorporates either visual, float or electromechanical means of verifying the level of fluid in the supply vessel. "This is the only system that maintains the ability to verify the continued presence of a corrosion-resistance system," according to Lovett.

No Cost Premium

"The system has not been used yet, but we're currently doing a design/build study for a Korean bridge project," Lovett said. "We expect the system will be cost competitive with other existing systems; we don't anticipate any cost premium."

Another advantage of the system is the incorporation of an expansion device in each cable sheath to isolate stay cable strain from the sheath, which serves to minimize fatigue loading for the cable sheath assembly.

Also, the isolation mechanism provides the ability to rejack the cable strands after construction, such as when a future wearing surface is added. "With this system, if you're going to put a future wearing surface on the bridge, you can readjust the stays," Lovett explained.

> If you put a future wearing surface on the bridge, you can readjust the stays

Other stay cable protection systems typically work by coating the strands or wires with a synthetic resin or by injecting their surrounding sheaths with a rust-resistant solidifying filler.

"Unfortunately, the solidifying fillers found in such systems expand and contract due to changes in temperature and are exposed to cyclic stress variations due to live loads, eventually causing the solidifying fillers to crack or flow and thereby reducing the effectiveness of the corrosion protection system," Lovett wrote in his patent application.

However, a recent "Civil Engineering" article (May 1991) reported that cable-stayed bridges in the U.S. are not as prone to corrosion problems as was previously suggested in a 1988 study. The problems reported in the earlier study were apparently with bridges having locked-coil or structural-strand cables, which were an application of a technology designed for industrial and mining applications. Other problems were reported on foreign projects where quality control is not as tight as on U.S. projects.

Likewise, the article stated, problems with encased stays were primarily the result of poor maintenance and construction, rather than an inherent design flaw. For example, in several bridges the black polyethylene pipe that encased the solidifying filler and cable split, primarily due to an expansion/contraction sequence during the grouting operation.

New U.L. Ratings For Steel Joists

Underwriters Laboratories Inc. has substantially increased its fire ratings for steel joists, according to the Steel Joist Institute.

The allowable joist tensile strength for fire-rated construction of floor and roof joists has been increased to 30,000 psi and 26,000, respectively, as compared to the old allowable joist tensile strength of 22,000 psi for both uses.

For floor assemblies, K-Series Joists of equal or greater depth and weight per foot may be substituted for any S-, J-, and/or H-Series Joists in any floor-ceiling design that employs a structural concrete floor and a suspended membrane ceiling, with the following restrictions: minimum nominal depth = 8"; minimum nominal weight = 5 lbs./ft.; and maximum tensile stress = 30,000 psi.

For roof assemblies, the restrictions are similar: minimum nominal depth = 10"; minimum nominal weight = 5 lbs./ft.; and maximum tensile stress = 26,000 psi.

For more information, contact: Steel Joist Institute, 1205 48th Ave. North, Suite A, Myrtle Beach, SC 29577 (803) 449-0487.

Correspondence

Dear Editor:

We note with great interest the article in the May 1991 issue entitled "Steel Box Girders Create Clean Appearance" in which you report on a new steel box girder interchange in Shreveport, LA. Your article properly commends the fine design and notes the "unique tree structure" at the center of the interchange as well as the flared piers and the attention to aesthetics.

Interstate I-110 in Baton Rouge, LA

You should know that more than 15 years ago the New Orleans office of Modjeski and Masters designed a very similar interchange on Interstate I-110 in Baton Rouge, LA. That interchange also incorporated a "unique tree structure" at the center pier, using twin trapezoidal box girders and was supported by flared piers. That interchange was completed and opened to traffic in 1976 and was an entry in the AISC Prize Bridge contest of 1978 [winning an Award of Merit/Grade Separation].

William B. Conway, P.E.
Partner
Modjeski and Masters

Dear Editor:

We read an article in your January, 1991, edition about seismic isolation. The article lead to the one-sided impression that elastomeric mounts are the only or at least the main mounts for base isolation. But one should keep in mind—nowhere was it mentioned—that elastomeric mounts isolate earthquakes only in the *horizontal direction*. Our company, a worldwide leader in vibration control of heavy equipment, has developed a base isolation system with steel helical springs that do the job in *all three dimensions*.

Guenter K. Hueffman
President, GERB

[Editors note: For more information, contact: GERB, 900 Oakmont Lane, Suite 207, Westmont, IL 60559]

Announcements

Entries are being accepted for the Fazlur R. Khan Award for Innovation in the Design and Construction of High-Rise Buildings. The award, given by the Chicago Committee on High-Rise Buildings, will be presented to honor an innovative improvement for the technology of high-rise buildings. This can be a unique building, a revolutionary building system or component, an improved material or product, or a new process or construction procedure. The development or project must have been completed since Jan. 1, 1987 and can be located anywhere in the world. Deadline for entries is Sept. 9, 1991.

For more information, contact: Gerald L. Johnson, AIA, Chairman, CCHRB Awards Program, 111 E. Wacker Dr., Suite 3015, Chicago, IL 60601 (312) 565-2727.

1991 Symposium On Steel Bridge Construction scheduled for Sept. 16-17, 1991. Sessions are scheduled on a wide range of topics, including: seismic design; bridge paints and coatings; steel bridge aesthetics; short span bridges; economical detailing and connections; fatigue-resistant details; and long-range FHWA research. In addition, a panel discussion is scheduled on the subject of designing for constructability and a session is planned on the design of bridges in France. Prior to the symposium, a workshop will be held on bridge painting. The day after the symposium, there will be an in-depth, full-day workshop on the subject of fatigue resistant details.

To receive registration materials for the symposium, contact: Lew Brunner, AISC, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001 (312) 670-4520.

Papers are now being accepted for the Third Pacific Structural Steel Conference. Discussion topics for the conference, which will be held in Tokyo on Oct. 26-28, 1992, include: design concepts, codes and standards; materials and fabrication; structural behavior; fire, earthquake, wind and environmental effects; maintenance and durability; and innovative structures, high technologies, marketing and education. A summary of the proposed paper (100 to 200 words) must be submitted no later than Aug. 15, 1991.

To submit a paper or for more information on the conference, contact: Japanese Society of Steel Construction, Rm. 848, Shin-Tokyo Building, 3-3-1 Marunouchi, Chiyoda-ku, Tokyo, 100 Japan (phone: 81-3-3212-0875) (fax: 81-3-3212-0878).

Steel Proves Economical For Short Span Bridges

After examining both material and construction costs, the NY DOT opted to use steel construction on four recent short span bridge projects

The three-span State Route 7 Bridge over the Delaware and Hudson Railroad tracks encompasses end spans of 41' each and a center span of 73'. It's estimated that the concrete alternative would have cost an additional $100,000 to construct. Photo by Peter B. Treiber

Four new short span bridges in New York are helping to explode the mistaken belief concrete is less expensive for short span bridges. In each instance, the New York DOT prepared independent, alternate designs in both steel and concrete.

All of the bridges are plate girder structures and all use ASTM A588 weathering steel. While rolled beams are less expensive per pound of fabricated steel, a plate girder uses less steel and as a result can sometimes have a lower total cost, according to Charles Gorman, P.E., structural consultant with Bethlehem Steel Corp. "Which costs less will depend on the design of the bridge and market conditions, so both should be priced," he added.

- State Route 7 Bridge over the Delaware and Hudson Railway

tracks at Duanesburg. Completed in October, 1989, this three-span structure encompasses end spans of 41′ each and a center span of 73′. Transverse girder spacing is 9′4". Except for 12′ sections centered over each pier, the top flange of the girder is 12" x ¾" and the bottom flange is 15" x ¾", with a 34" x ⅜" web. Because the non-composite section over the pier acts as a negative moment area, the thickness of both the top and bottom flanges in that area were increased from ¾" to 1".

- Two County Route 15 bridges near Odessa, both completed in September, 1990. One is a 77′ span over Beardsley Hollow Creek, the other a 73′ span over McClure Creek, with the bridges separated 1,400 from each other. Both bridges have top flanges of 14" x ¾" and bottom flanges of 16" x 1¼", with 36" x 7⁄16" webs. Because NY DOT required four girders so it can redeck in the future while leaving half the bridge in operation, transverse girder spacing is only 8′.
- Broome County Bridge over Page Brook in Chenango Valley State Park, a 120′ span. The simple-span bridge has a 62" x ½" web with a top flange of 20" x ⅞". The center 70′ of the structure has a bottom flange of 18" x 1½", while the rest of the bridge has a bottom flange of 18" x ¾". All of the steel was erected in a nine-hour period on March 26, 1991.

Because NY DOT initially saw no clear-cut advantage to either steel or concrete, it issued bids for both full-steel and full-concrete al-

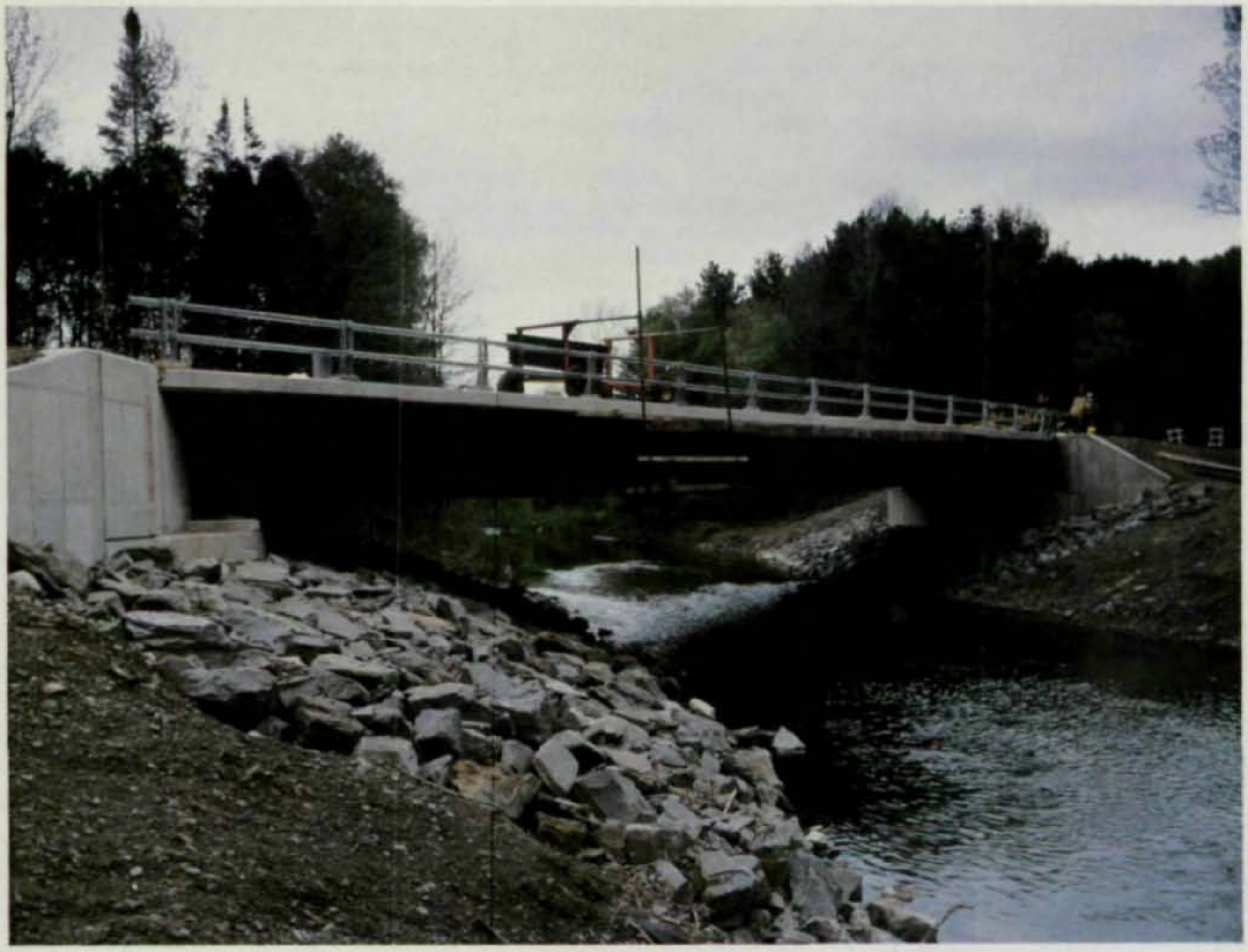
Steel was important for the curved Route 15 bridge over McClure Creek because of its inherent flexibility, which allowed easier adjustment. A prestressed concrete bridge would have had to have been made wider to accommodate the curve. Weathering steel was specified for all four New York State projects to minimize future maintenance costs. Photo by Peter B. Treiber

The winning steel bid for the two County Route 15 bridges was more than $130,000 less than the lowest concrete bid. Pictured here is the Route 15 Bridge over Beardsley Hollow Creek, which has a 77' span. Photo by Peter B. Treiber

ternatives, including foundations. The Broome County Bridge alternates were designed by a consultant, while the other bridges were designed in-house.

"We believe that the alternate design program has proved effective in helping us to hold down bridge costs without sacrificing safety, load capacity or durability," explained Thomas D. Quinn, of NY DOT's Preliminary Plan Bridge Unit, Structures Design & Construction Division. "On these four bridges, we let contractors tell us what was the most economical for the sites."

However, it wasn't simply the cost of the superstructure alone that made the difference. "Obviously, our initial cost concern is on construction of the bridge itself," Quinn said. "But with government today having to keep all costs down, we're also interested in life-cycle costs and we're pleased with



what we've seen accomplished by weathering steel. To date, New York State has built more than 100 weathering steel bridges, mostly in rural areas, and eliminating periodic painting is a definite money saver."

Flexibility also was a factor in choosing steel, according to Quinn. Where a bridge embodies a curved alignment, as with the twin County 15 bridges, steel has more flexibility for adjustment. Prestressed concrete units can only be made straight, whereas steel girders can allow the curve without having to widen the bridge. In designing a curved bridge, Quinn explained that haunch details—the gap between the bottom of the deck slab and the top flange of the girder—allow for adjustments that can better handle the banking of the roadway.

A steel bridge also is more adaptable when it has to carry util-

Even though the steel design for the Broome County Bridge was 17' longer than the prestressed concrete design, the steel bid was $30,000 lower, primarily due to faster and easier erection with steel. Photo by Peter B. Treiber ity lines—water, gas, and sewer pipes as well as phone lines. The pipes and lines fit conveniently into the individual bays between the steel girders and are usually carried on cross frames and braces in the bays.

Steel's lighter weight superstructure translates into many cost savings from foundations to erection.

Dollars And Sense

The various contractors on the four bridges had specific reasons for choosing steel.

"Not one contractor of the eight bidders [on the State Route 7 Bridge] even bothered to bid on the concrete design, which we estimate would have cost $100,000 more. In fact, one of the contractors owns a sister company that makes precast concrete beams and even he bid steel," said Mike DiNallo, project manager for Schultz Construction, Round Lake, NY.

"We bid steel for dollars-and-cents reasons," he added. "With the steel alternate, one advantage was that we were able to use a 45-ton crane vs. an 89-to-100 ton rig for concrete." In addition to low cost, DiNallo said that steel is more easily repairable and more visible to inspection if there is a problem, since if there is a problem it doesn't have to be taken apart as would concrete. If need be, stiffeners and cover plates can be attached to members to reinforce them and extend the bridge's service life.

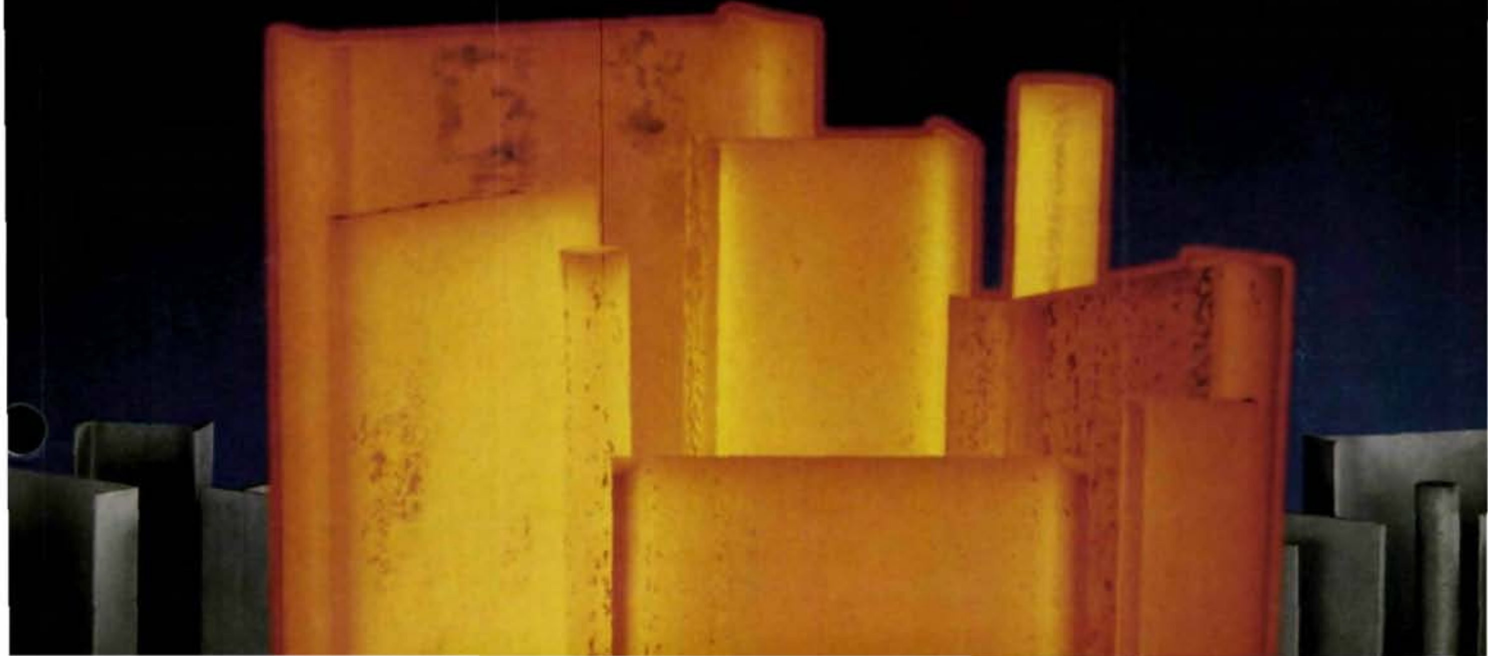
"Based on the qualities of material for the steel vs. concrete alternates for items such as foundation concrete, rebar, and piling, we definitely came out ahead by choosing the steel design," DiNallo said.

Cost also was important on the other bridges.

"Our steel bid for the total, two bridge [Route 15] project, $1,143,048, was $137,166 under the lowest concrete bid," explained Patrick Barry, vice president of A.L. Blades & Sons, Hornell, NY. "In fact, our winning bid was due strictly to the economies we could come up with by choosing the steel alternate. Each material had different requirements for just about all items. For example, in bearing piles alone, the steel version required only 1,066 linear feet compared to 1,681 for concrete."

On the Broome County Bride, the winning steel bid was $30,000 lower than the next bid, even though the 120′ steel span was 17′ longer than the prestressed concrete design, according to Wally DiStefano, owner of Harrison & Burrowes Bridge Construction, Glenmont, NY. "Not only is it easier and faster to erect steel, we were able to use two 90-ton cranes rather than the two 150-ton cranes we would have needed for concrete. This alone saved us $2,000 on the per-day crane rental charge. And on a materials cost comparison, we saved 15% by going with steel."

Fabricator for the Broome County and State Route 7 bridges was AISC-member High Steel Structures, Lancaster, PA, and fabricator for the twin County Route 15 bridges was AISC-member Reynolds Manufacturing Co., Avanmore, PA. □



Rooftop Expansion

An addition to San Francisco's renowned Moscone Center will add 126,000 sq. ft. of exhibit space

Moscone Center, San Francisco's underground exhibition center, was an immediate hit with convention-goers and architectural critics alike when it opened in 1981. But as many cities have since discovered, what was considered spacious a decade ago is often inadequate for today's larger conventions.

In response, San Francisco has embarked on an ambitious expansion plan that will add more than half-a-million square feet of exhibit space, as well as cultural, recreation, hotel, and office space in a three-city block development to be known as Yerba Buena Gardens. The first phase of the project opened in February 1991 and consisted of a 126,000-sq.-ft. rooftop expansion within a 90,000-sq.-ft. footprint.

The rooftop addition features a spacious lobby, administrative, mechanical, and ancillary space, and a main hall that can accommodate 7,000 people.

The supporting elements of the existing underground structure are reinforced, prestressed concrete paired arches, spaced 90' on centers and spanning 275'. The arch-pairs are spaced 25' apart, leaving 65' spans that are bridged by precast concrete single tees spaced 10' on center. The roof of the existing structure was designed for superimposed loads of 300 psf dead load and 100 psf live load.

Although the original underground structure was designed to accommodate vertical expansion, weight was still a consideration so a steel frame was the obvious choice. But in addition to its relative light weight, steel also answered other demands of the new construction.

Functional requirements included the elimination of columns within the meeting-room block—an area of nearly an acre. Structure constraints were introduced by, among others, the fact that column loads had to be positioned carefully along the arches so as not to produce detrimental loading. And aesthetic considerations demanded conformity with the entrance to the existing building, a distinctive tubular steel truss arrangement. Structural engineers on the project were Martin, Middlebrook & Associates, with subconsultants Faye Bernstein & Associates and AGS, all of San Francisco.

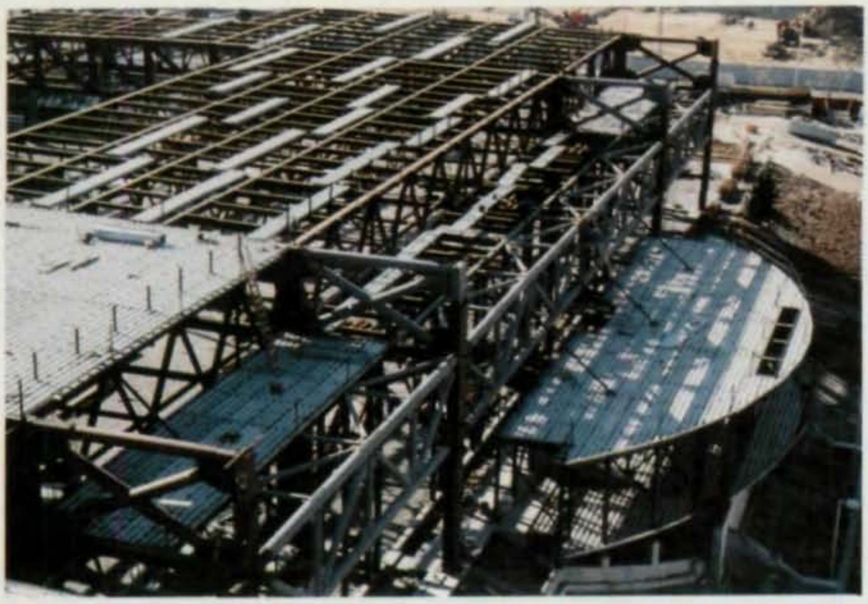
The resulting steel structure consists of a series of 12' to 14' deep trussed bents supported on eight paired columns, which land on the existing underground arches. The trusses span 155', with an outboard column 25' away at either end. The reason for the paired columns is because of the paired arches below. "Single columns would have had unbalanced loads on those paired arches," explained Robert McCartney, S.E., a project manager at Martin, Middlebrook & Associates.

The 16 moment resisting box columns have 1" to 3"-thick plates for flanges and 1½" to 2½" plates for webs, with 6'-high, ½"-thick stiffener plates at various locations.

Earthquake bracing is composed of longitudinal and transverse

A steel frame was the obvious choice for the rooftop expansion of San Francisco's Moscone Center both because of its light weight and the ease with which long spans can be created. The exhibit hall structure consists of 12'- to 14'-deep trussed bents supported on eight paired columns, with the trusses spanning 155'. On the perimeter, part of the structure was left exposed, and steel tubes were used in that area to complement the existing entry to the convention center.

Photos by Jorge Lee



The 126,000-sq.-ft. rooftop addition is part of a larger expansion project that will eventually add more than 500,000-sq.-ft. of exhibit space, as well as cultural, recreation, hotel, and office space in a three-city block development.
Photo by Jorge Lee.

trussed and braced frames that extend through the skin of the building to become architectural elements.

In order to equalize the new column loads to prevent differential deflections and undesirable secondary stresses, the interior column bases were left free until approximately 70% to 80% of the dead load was in place. The interior column base plates were then bolted and grouted, and, as the remaining dead load was applied, the paired columns were subject to a couple, shifting load from the exterior to the interior columns.

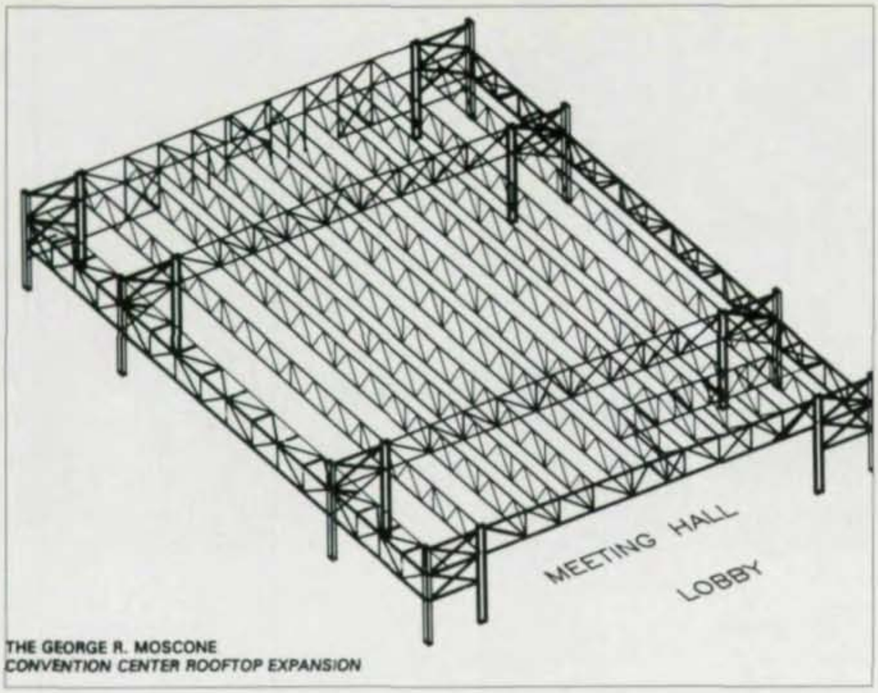
Interestingly, the interior columns were in this state of suspension when the Loma Prieta Earthquake hit on October 17, 1989. The quake caused the columns to move drastically up-and-down, as well as to swing laterally. Construction personnel at the site during the earthquake described seeing a wave of about 1' travel across the roof of the original Moscone Center.

As a result, several base plate anchor bolts were sheared off and the base plates contacted and bounced off concrete slab elements outside the depressions provided for the base plates. However, the columns settled back in place within a half inch of their original position. Damage was essentially nonexistent except for the re-welding of a few new anchor bolts, and no construction time was lost. Contractor on the project was Amoroso-Apersey and construction manager was Turner Construction Co. Project architects were Gensler & Associates and DMJM Architects.

Lobby Structure

The main lobby is a three-story structure with a series of setbacks. At each setback is a landscaped terrace. The top floor is mechanical space, the second level is administrative/office space, and the ground floor is a large lobby area with a 32'-high ceiling. The lobby is separated from the meeting hall with a seismic joint. The separation varies from 5" at the roof to merely

The addition used approximately 6,600 tons of structural steel, including pipes in diameters up to 24", 6'-deep built-up plate girders, built-up box columns 20" wide and 28" to 45" deep, wide flanged structural shapes and structural tubes.
Photo by Jorge Lee.



Steel tubes were used on the perimeter of the structure where the steel frame was left exposed. (green portion of upper diagram). One side of the lobby/meeting room structure (bottom) was stepped to allow the addition of decorative planters and to break up the visual mass of the building.

having offset columns at the main floor.

Most of the lobby structure is a braced frame with conventional wide flange beam and column construction. The exception is in the actual lobby area, which needed to be column-free.

"The architect required a big open space, but we also needed to support the terraced planters without having any columns coming down in that area," explained McCartney. The solution was to use two 6'-deep bent plate girders running transverse to the length of the building and spanning between them with trusses. "The bent plate girders come off the floor 10' and then bend 45198." The trusses span 65' and are primarily to support the terraced planters.

Architectural Expression

The entrance lobby to the original Moscone Center—which was the only portion of the structure visible from the exterior—was designed with distinctive tubular elements. To help the addition blend with the existing structure, tubes were used for all of the exposed trusses. Therefore, the joints and welding were carefully detailed for controlled architectural expression. Truss members are large diameter steel pipes connected with circular gusset plates. Because of their immense size, the trusses were shop fabricated, shipped in parts, and then field-welded and bolted in place. All of the exposed architectural trusswork is fireproofed using Albiclad 800, a weatherproof, intumescent coating that expands into a protective foam on exposure to fire.

The trusses that are not exposed are conventional wide flange construction.

Approximately 4,400 pieces of A36, A572 Grade 50, A53 and A500 Grade B steel totalling 6,600 tons were used. The pieces included wide-flange shapes, structural tubes, pipes in diameters to 24", 6'-deep built-up plate girders, and built-up box columns 20" wide and 28" to 45" deep. Structural steel fabricator was AISC-member Havens Steel Co., Kansas City. ☐

Expansion Creates New L.A. Hotspot

More than doubling the size of L.A.'s convention center is attracting the attention of meeting planners

A $390 million expansion of the Los Angeles Convention Center will not only more than double the size of the existing facility but will also provide a lively new entrance (model photograph by Nathaniel Lieberman). The addition is connected to the old center by a concourse level that crosses over a major street. And, befitting a facility in L.A., the entire convention center is surrounded by streets and freeways.

Los Angeles' convention center has always been an almost nondescript building in a questionable part of town. But just as new office construction creeping down Figueroa Street is rejuvenating the neighborhood, a giant expansion is enlivening the convention center.

The $390 million expansion will more than double the size of the existing center, from 1.5 million sq. ft. to 4 million sq. ft. Included is 346,000 sq. ft. of exhibit halls, 86,000 sq. ft. of meeting rooms, 2,800 parking spaces, and two new spectacular lobbies. When complete, it will be the one of the 10 largest convention centers in the United States. In addition to the center, there also is a proposal for a 1,200-room hotel across the street. Economists are predicting that the enlarged center will inject $504 million annually into the local economy through direct and indirect jobs/services, hotel rooms and sales taxes by 1995.

Exposed Structure

The most dramatic portion of the expanded convention center is the 155'-high South Lobby. The entrance pavilion features a three-dimensional array of exposed steel

The exterior of the center is curved to diminish its overwhelming bulk. The construction photograph was taken on May 1, 1991.

tubes clad with a glass curtainwall with pavilions distinctively illuminated at night to emphasize the drama of the exposed steel structure.

"We had to blend the old structure with the new, so we created new lobbies to connect the spaces," said Ki Suh Park, FAIA, managing partner with Gruen Associates, Los Angeles, and project director of the architectural team that consisted of Gruen and Pei Cobb Freed & Partners, New York City.

Night Beacon

"The lobby provides the entry with excitement. At night, it will be lit and will provide a beacon identifying the convention center from the nearby Santa Monica and Harbor Freeways." Also, Park explained, the lobby has multiple levels that provide direct access to the various levels of the convention center.

"All of the welded tubes are 12" in diameter to create a completely uniform design," explained Robert M. Barker, S.E., project manager, with John A. Martin & Associates, Los Angeles, the project's structural engineer. However, because of varying load conditions, some of the tubes were designed with thicker walls.

Also, in several locations where long spans were required the engineer designed double tubes connected with perpendicular tubular spacers. "It was similar in design to a truss," Barker said.

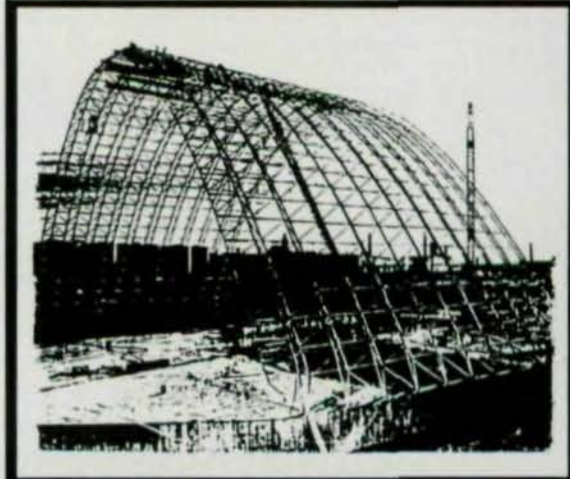
Unusual Configuration

The engineering was complicated by the lobby's unusual design. One side of the structure is circular, while on the other side it connects to a rectangular shape. In addition, the base of the structure flares out, resulting in sloping members. "It's a three-dimensional nightmare to visualize this space, especially for the fabricator," Barker said. "And it was very hard to keep track of how the stresses were distributed."

Erector on the job was AISC-member American Bridge Co. Contractor on the project is a joint venture of George Hyman Construction Co. and M.A. Mortinson Co.

One end of the lobby connects to a meeting room area that spans a major city street. The lower level of this area has concrete shear walls, while the upper story is steel framed. "Steel was essential for the upper floor where there are large meeting rooms," Barker said. However, because space was very tight, portions of the second-story of the meeting room bridge were designed using one-story-high trusses with the bottom chord supporting the floor and the top chord supporting the roof.

On the opposite side of the meeting room concourse is the new West Lobby, which was created to serve the existing exhibit halls. It is similar in design to the South Lobby with its exposed steel tubes, but is considerably smaller.



The roof of the giant exhibit hall is supported on a series of trusses, which in turn sit on steel "tree" columns. The columns are built up into a cruciform shape and consist of four 14" wide flange shapes welded together around a 16"-square central tube.

The new West Lobby is separated from the existing convention center with expansion joints. A metal plate was installed to span between the existing slab and the new slab. The plate is anchored on one side and is allowed to slide on the other.

Exhibit Hall

The roof of the giant exhibit hall is supported on a series of trusses, which in turn sit on steel "tree" columns.

Each column supports a pair of 20′-deep transverse primary trusses and a pair of 20′-deep longitudinal secondary trusses. The transverse trusses span 240′ and the longitudinal trusses span either 60′ or 120′. In addition, there are 10′-deep longitudinal secondary trusses at 30′ on center spanning either 60′ or 120′ between the transverse primary trusses. Between these shallower secondary trusses are 14"-deep rolled wide flange roof purlins at 10′ on center.

"The steel columns are built up into a cruciform shape," explained Barker. They consist of four 14" wide flange shapes welded together around a 16"-square central tube. To provide fireproofing the columns were encased in concrete. "Since we designed a steel roof, it was only logical to use steel columns," Barker said. "Also, forming concrete columns of the needed size in that location would have been difficult."

The exhibit hall's lateral system is a braced frame. The 60′-high frame consists of a series of 20′-high segments. In 22 locations along the perimeter, each of the segments is braced, for a total of 66 chevron frames. In addition, bracing was provided in some interior areas where it wouldn't interfere with egress—such as between the exhibit space and the end of the hall, which is devoted to concession stands, restrooms, storage and mechanical rooms.

The connections are a combination of welding and bolting. The design allowed for slip joints between the trusses and columns so there was an opportunity to erect some of the members without built-in stresses. "Until the roof was in place, the steel members were exposed to sunlight and temperature variances that could cause slight changes in dimensions. We provided slip joints to allow the structure to breath until the roof was on to shield the steel from the sun," Barker said.

Each column supports a pair of 20′-deep transverse primary trusses and a pair of 20′-deep longitudinal secondary trusses.

The exhibit hall floor is a concrete waffle slab designed for loads of 350 lbs./sq. ft. Below the exhibit hall are two basement levels with a column grid of 30′ on center. The basement levels are used for parking, though one of the levels has a 27′-high ceiling and is designed to be able to be renovated into additional exhibit space if needed.

The columns that are directly beneath the exhibit hall columns are steel, while the in-fill columns are concrete.

All of the steel framing and roof decking were erected first, and then the additional concrete columns were added later, when the floor slabs were poured. "That way we could build the concrete portion in the shade and control shrinkage," Barker explained. However, because the steel columns extended 87′ up in the air without a lateral load resisting system in place, an elaborate temporary bracing system was required. "Doing all of the steel work first was more of a time savings than a cost savings, though it also helped the quality of the concrete work."

Architectural Emphasis

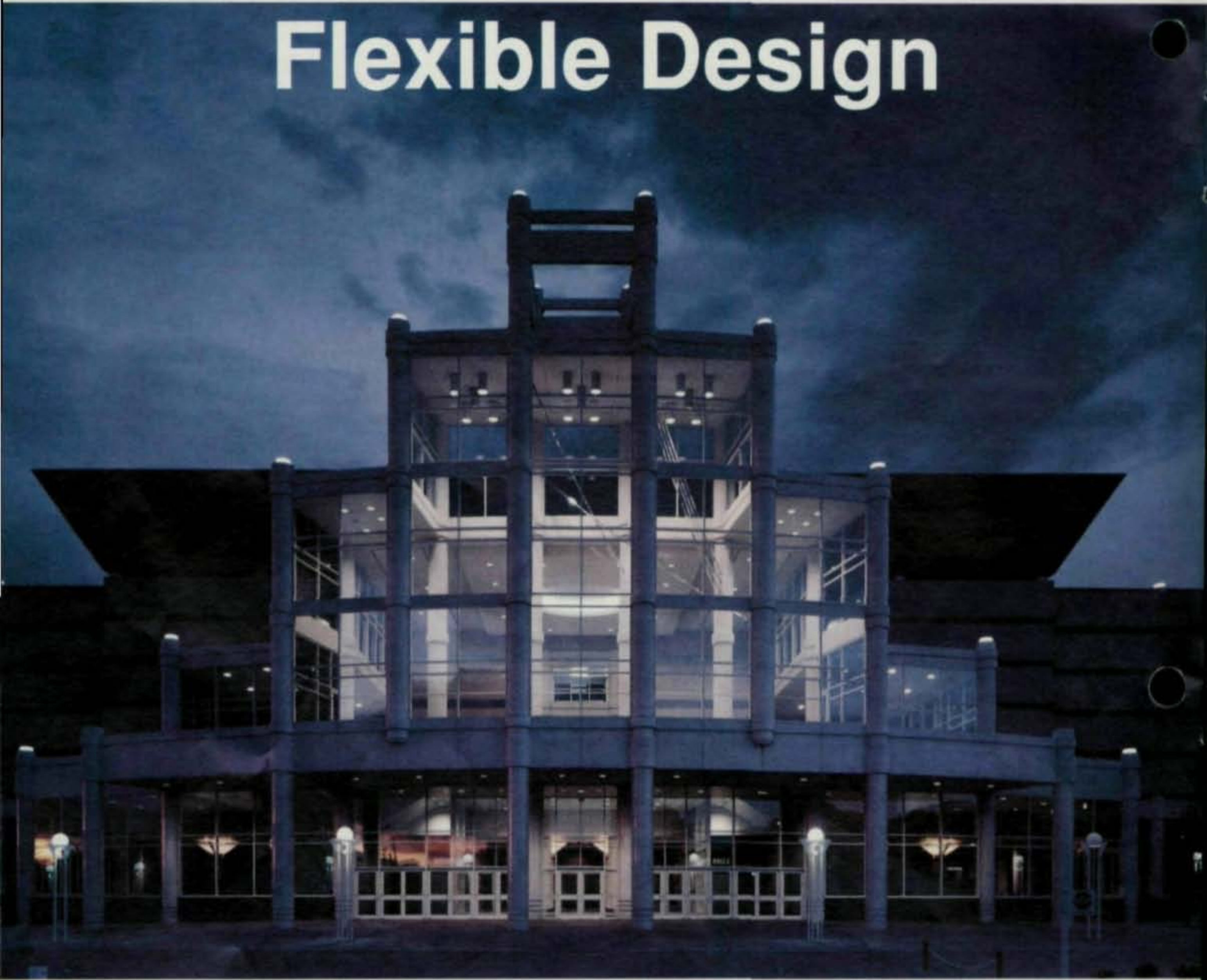
"The exterior of the center is curved to diminish the overwhelming bulk of the structure," explained Park. However, since the designers wanted a rectangular hall, the curved space was devoted to non-exhibit use.

To further visually break the bulk of the structure, each truck dock is covered with a canopy. "The canopies not only protect trucks from the weather, but also provide architectural interest," Park said. "They give a strong contrast in terms of shade and shadow." The canopies are supported off of the building's columns with diagonal steel tubes.

Additional architectural interest is provided in both lobbies through the use of custom artwork. In the South Lobby, the terrazzo floor includes an expansive map of the Pacific Rim, while the West Lobby floor includes a map of the galaxy. Granite panels along the major public concourse will depict the development of nature and human culture. And a large overhead sculptural piece using light refracting materials has also been commissioned for the concourse.

Oustide of the main entrance on Figueroa Street will be a five-acre open plaza highlighted by 40 palm trees. □

Flexible Design



Denver required a state-of-the-art convention center to be completed less than two years after design began

After a decade of public debate and political wrangling, the City of Denver in 1987 was finally on the verge of signing an agreement with a local developer for the construction of a new convention center. However, because the city was short of capital, it had to turn to the State for funding. And the state would only provide the needed additional $36 million on the condition that Denver would agree to an impartial site review.

Seizing a golden opportunity, Denver initiated a design/build competition. Each of the five entries was scrutinized carefully by a 12-member panel from the Urban Land Institute, the impartial voice that would make the final decision. The team consisting of David French, developer; C.W. Fentress and Associates, P.C., architect; and Hensel Phelps, contractor, was chosen for the approximately one million-sq.-ft., six city-block development.

The proposal was chosen both for its location near the heart of the urban core and most major downtown hotels as well as for its fulfill-

The $126 million Denver Convention Center includes 300,000-sq.-ft. of exhibit space on the second level. The exhibit space sits on top of a large ballroom and is supported by seven jumbo trusses, each 12'-6" deep and 150' long, with the heaviest weighing 135 tons. Opposite page photo by Nick Merrick of Heidrich Blessing.

ment of a laundry list of qualifications, from land acquisition to public access. Crucial to the decision was the opportunity to help revitalize Denver's downtown.

Time And Money

The city wanted to maximize its investment by building a convention center that was flexible, easy to manage, and could be completed in only 24 months. Since many convention centers take nearly two years to design alone, the city served notice that it wanted the project on a fast timetable.

And while scheduling was very important, it wasn't the only consideration. The cost of the project had to be held to $126 million. Deducting the price of the land, financing costs and fees, left only about $77 million for construction, or about $82/sq. ft. This makes the Denver Convention Center one of the lowest priced per sq. ft. new convention centers in the country. By comparison, San Diego's convention center cost about $130/sq. ft., while San Francisco's cost $202/sq. ft., according to the architect.

Before starting design, discussions were held with more than 40 user groups. These discussions revealed that the users' first priority was the ability to set up and break down exhibits quickly and easily. They also wanted a user-friendly center in which exhibit halls and meeting rooms were accessible and flexible.

Flexible Design

The 970,000-sq.-ft. center was designed with a lobby and meeting halls on the ground level and 300,000 sq. ft. of exhibit space on

Due to the size of the jumbo-sized ballroom trusses, they were brought to the site in three sections, each approximately 50′ long. The ballroom trusses were spliced together on the ground. Above the ballroom are typical 90′ x 90′ exhibit hall roof structure bays.

the second level. The upper level can be utilized as one contiguous space or can be divided into halves or thirds. Since 80% of U.S. conventions require less than 100,000 sq. ft. of exhibit space, the divisibility of the second floor is very valuable since up to three conventions—in various stages—can be handled simultaneously.

In addition, the center features completely separate and distinct main-level entrance and registration areas for each of the divided halls, which eliminates a lot of potential confusion and crowding when simultaneous conventions are held.

The project also includes a 35,000-sq.-ft. ballroom, 46 meeting rooms totaling 65,000 sq. ft., and food service that can accommodate a sit-down dinner for 3,000 guests in the ballroom. To ease access, the center has 27 covered loading docks and three ramps that allow trucks to drive directly onto each exhibit hall floor (350 psf live load).

Even the restrooms were designed for flexibility. The facilities feature 50% more fixtures than required by code, and can be modified through the use of movable partitions to accommodate either a primarily male or female convention audience.

Fast-Track Schedule

To complete construction in two years, the project was placed on a fast-track schedule. Construction documents were produced from March to September 1988, while bid packages were sent out from May 1988 through January 1989. The structural engineer, Martin/Martin Consulting Engineers, Denver, began construction documents in March 1988, construction began in June, and the project was completed in April 1990. In total, six bid packages were sent out, including packages for the foundation, superstructure, exterior cladding, and mechanical systems. Two

The tight construction schedule mandated the erection of one truss per week. Using two crews, each truss took two days to field splice together and another six hours for two cranes to hoist into place.

other engineering firms also were involved as subcontractors on the project: Richard Weingardt Consultants, Inc., and HS Engineering, both of Denver.

The lower level was designed partially as a concrete structure and partially as a steel structure, while the upper level's superstructure was entirely constructed of steel.

Steel Ballroom

The greatest challenge for the architect and engineer was the structure's first floor ballroom, a 150' x 240' steel-framed space.

Because the ballroom required a 30'-high ceiling, its floor was recessed 15' below grade so that the top of the steel trusses supporting the exhibit floor above would align with the rest of the first floor's framing. And because of the large clear spans required, steel was the obvious choice.

The ballroom ceiling is designed to serve a variety of functions while carrying a tremendous load:

- Above the ballroom ceiling is the floor of Exhibit Hall A, which was designed for loads of 350 psf—approximately five times greater than a standard office building. To accommodate this requirement, the floor system is constructed of composite steel beams, 2" metal deck, and 7½" of concrete—a total weight of 60 psf.
- In addition, the performance requirement for the floor of the exhibit hall over the ballroom demanded that it have no excessive deflections. The exhibit hall floor also carries the load of two roof columns, transferring the additional weight to the ballroom ceiling.
- An added weight consideration is from three lines of 30'-high acoustical folding partitions that hang from the ballroom ceiling.
- Because noise control is crucial, an acoustical barrier was installed between the exhibit floor and the ballroom.

Jumbo Chord Members

Steel framing provided the solution to all of the ceiling's problems. Seven jumbo, high-compression/tension chord members, size W14 x 665, were used.

Each truss was 12'-6" deep x 150' long, with the heaviest weighing 135 tons. Steel fabricator was AISC-member Zimmerman Metals, Inc., and erector was LPR Construction Co.

To facilitate transportation, the chord members were shop welded in three sections, each approximately 50' long, and field bolted with splice joints and 1½"-diameter bolts. Each splice joint consisted of 100 10"-long A325 high-strength field bolts. To ensure against counterfeits, random samples of bolts, nuts and washers were subjected to independent lab testing.

The design called for a 2" camber in the chord members. Unfortunately, due to the short allowable construction time, the field bolting had to be scheduled for January, when Colorado's temperature can easily range from arctic to balmy in one day. To control the steel's changes due to temperature, as well as to keep the accuracy of the camber, holes were reamed on site.

The tight schedule demanded the erection of one truss per week. Using two crews, each truss took two days to field splice together and another six hours for two cranes to hoist into place. The cross trusses, usually nominal bracing fill, were designed as structural trusses, allowing the structure to work in two directions. Total truss weight is 1,000 tons, with the total ballroom framing weighing 1,200 tons.

Second-Floor Exhibit Hall

Steel was the logical choice for the roof-framing above the second floor both because of its relative light weight and its size availabilities, according to Charles Keyes, P.E., S.E., a principal with Martin/Martin.

"The exhibit hall ceiling is 50' high, and it would be difficult to cast 50' columns above the exhibit floor," Keyes explained. "Also, concrete columns would have been very heavy. It wouldn't matter when the columns are directly over the first floor columns, but it would have posed a problem over the trusses."

Base plates and anchor bolts were used where the second-level steel columns connected to first-floor concrete columns. "Anchor bolts were cast into the concrete columns, the base plates were attached, and the concrete topping was poured over the base plate," Keyes said.

The steel columns were attached to the first-floor trusses using seated connections for erection and A325 high-strength bolts.

The project was completed on schedule, and the first convention was held in July 1990. Bookings have exceeded expectations and some reservations have already been booked into the next decade.

The 35,000-sq.-ft. ballroom is a 150' x 240' steel-framed space with an elaborate ceiling. Photo by Nick Merrick of Heidrich Blessing

Economical Upgrading Of Vintage Buildings

Two east coast projects illustrate different techniques in the structural rehabilitation of existing buildings

By Charles H. Thornton, Ph.D., P.E., Jagdish Prasad, P.E., Robert P. DeScenza, P.E., and Joseph V. Lieber, P.E.

(This is the second of two articles by the authors on the renovation of buildings. The first article appeared on pages 35-39 of the June issue of Modern Steel Construction.*)*

"They just don't build 'em like they used to" should be the motto of every structural engineer involved with renovating older "vintage" buildings.

Because restricted space, limited access, and, in occupied buildings, a need to perform work during off-hours can make reinforcing an existing building very expensive and time consuming engineers must try to minimize or avoid reinforcement. Fortunately, the structural quality of older buildings often means that major changes in building use, load path or gross square footage can be accommodated with only minor changes to the structural frame—if the structural engineer understands how to discover the "hidden" capacity of the structure.

Structural Clues

There are six clues to this treasure hunt: as-built drawings, changes in design method, changes in live load reduction, changes in use, load swaps, and choice of strengthening method.

As-built drawings can be extremely useful. However, even if these documents are available, some probes should be performed in the areas to be upgraded or modified to confirm that the drawings represent actual conditions. Also, the engineer must carefully inspect the condition of representative structural elements for corrosion, cracks or deterioration. Once structural condition is known, capacity of members and connections can be directly evaluated.

A new central refrigeration plant was installed in New York's GE Builidng.

Building codes are continually changing, and usually the changes are liberal. For example, when designing steel beams in the 1930s through 1950s, some codes limited allowable bending stress to 60% of material yield stress. Current allowable stress design (ASD) uses most compact steel members at 66% of yield stress. This 10% increase in member bending capacities can mean considerably more live load capacity.

Other changes in design methodologies also may provide reserve strength. Composite design can sometimes be used to advantage. Load and Resistance Factor Design (LRFD) has been adopted by many localities and may provide excess live load capacity in existing steel structures.

Building code changes also included live load reductions. Early building codes did not allow for live load reduction, so using this provision now can add capacity to girders and columns.

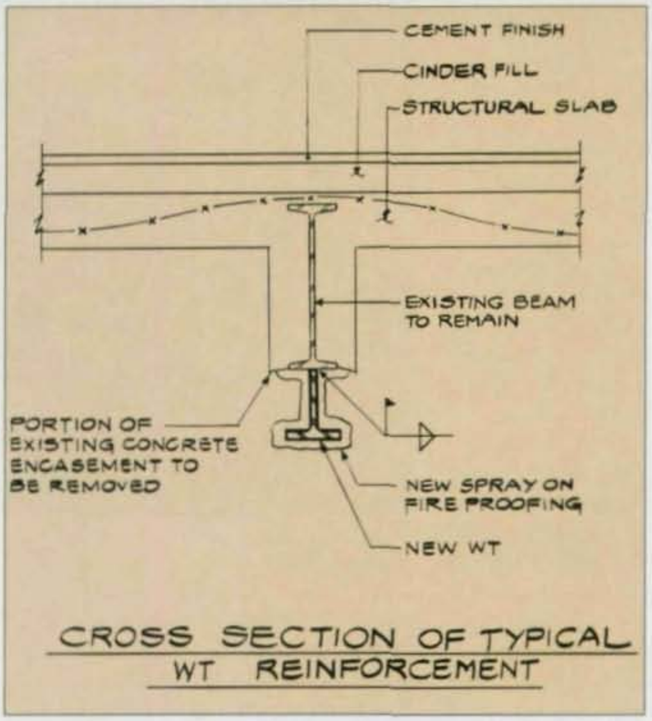
(For a more in-depth discussion of changes since the turn-of-the-century, see pages 35-39 in the June issue).

When existing drawings are available and an itemized list has been prepared, a careful review of existing loads may discover reserve capacity. This could be unused capacity, or it could involve a "load swap" of new loads for old.

During a recent renovation project, the original structural drawings indicated an allowance for heavy ornamental plaster below a structural slab. A check of framing members indicated that this allowance was indeed designed for, and the plaster was actually present. By removing this plaster and replacing it with a light-weight suspended ceiling, this recovered capacity could be utilized to avoid costly strengthening. Remember, though, that when removing any portion of an original design, the architect and engineer must consider the effect on the fire resistance rating of the structure.

Case Study One: Central Refrigeration Plant

A new state-of-the-art computer



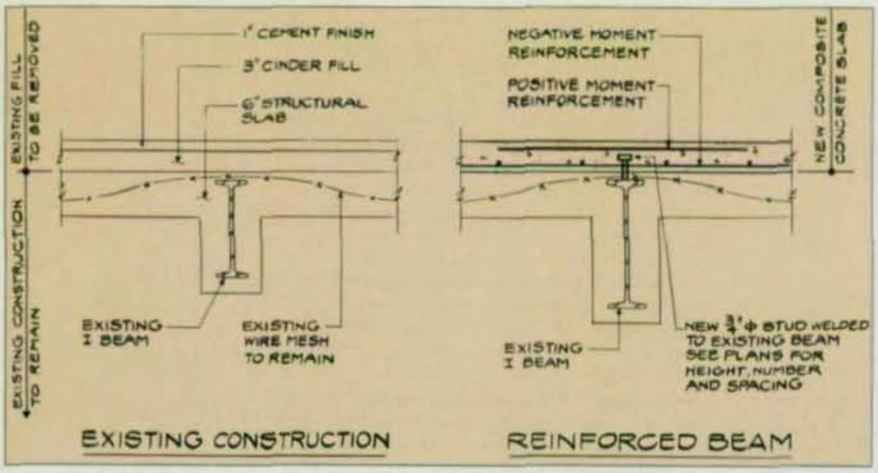
To support two refrigeration machines—each weighing 52,000 lbs.— on a framed floor, existing beams were strengthened with WT sections and new filler beams were added.

controlled central refrigeration plant has been installed in the GE Building (formerly the RCA Building). This 70-story building was constructed in the 1930s and is the centerpiece of New York City's Rockefeller Center.

Braced-steel frame

The structural system consists of a braced steel frame with formed concrete floors, and the floor beams are encased in concrete with the slabs. Typically, there is cinder fill and cement finish above the structural slabs. The building is clad in limestone for its full height.

The new plant cools large portions of the structure, including the world renowned Rainbow Room at the top of the GE Building. Provision for 18,000 cooling tons of new refrigeration equipment is located within the building 60' below street level. New pumps and eight new transformers and associated switch gear also were installed. A permanent access shaft, 50' deep and 14' x 16' in



In lieu of adding WT's to the bottom of existing beams in the sub-basement level, an innovative strengthening approach was developed.

plan, was created through an adjacent sidewalk for construction debris removal and equipment installation. A central computerized control station monitors electrical, mechanical and HVAC systems, including demand and production and allows for totally automated operation.

Locating Equipment

The first issue addressed was the location of all major pieces of new machinery. The four heaviest machines, each with an operating weight of 200,000 lbs., had to be on grade. Due to the height of the equipment, a two story high space was created by removing approximately 3,500 sq. ft. of slab and floor framing at the level above.

However, removal of the floor area left several columns unbraced at this level. These wide flange columns were reinforced with welding steel plates across the flange tips, creating box columns that work unbraced for the two-story height.

Two additional refrigeration machines, each weighing 52,000 lbs., did not fit on grade. To support these machines on a framed level, existing beams were strengthened with WT sections and new filler beams were added.

Thorough record keeping by Rockefeller Center Management Corp. (RCMC), the managing agents of the complex, meant substantial savings in reinforcement at the connections. Drawing encompassing 50 years of modifications to the building were preserved, including original tracings of shop and erection drawings.

By first probing the existing structure to determine that the drawings were indeed accurate, and then analyzing the drawings and finding the code required standard connections in effect when the building was built, the number of connections requiring reinforcement was significantly reduced, resulting in both cost and time savings.

Likewise, by increasing the allowable bending stress in some steel members from $0.6F_y$ to $0.66F_y$, we were able to reduce and/or eliminate some beam reinforcement.

The sub-basement level, about 30′ above the lowest basement level, now houses six new transformers and associated switch gear. The new loads exceeded the capacity of existing construction, so reinforcement was required. In lieu of adding WTs to the bottom of existing beams, a more innovative approach was developed.

The existing construction was a structural slab, 3" of cinder fill and 1" of cement finish. The fill and finish were removed. The girders were flush with the top of the existing slab and the filler beams were set down 1" into the structural slab, so local removal of concrete was sufficient to expose the top flanges. Removal was done carefully to avoid damaging the welded wire mesh in the existing slab.

Studs were welded to the tops of the filler beams and girders. After stud welding, the top surface of the structural slab was roughened, a bonding agent applied, and a new 4"-thick reinforced concrete slab was cast. The new slab has the strength required to support the new equipment loads, while acting compositely with the existing steel beams and girders to increase their capacity. This upgrading eliminated the need for additional filler beams and substantially reduced the number of WTs needed to strengthen the steel gridwork.

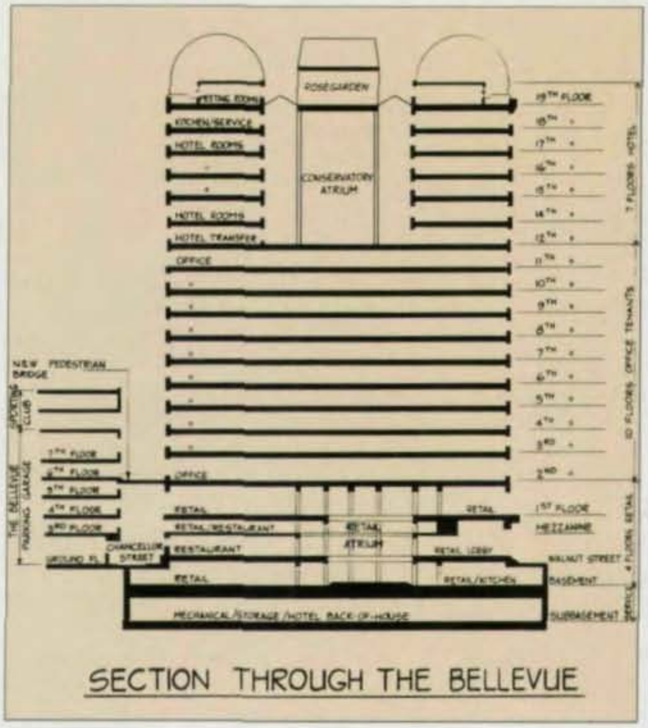
While a lot of work at first glance, the new slab reduced the amount of expensive rigging and welding of steel 30' in the air. Also, since the existing floor construction is encased in concrete, the removal and replacement of encasement was avoided. Since a majority of the upgrading work occurred above the existing structural slab, installation of refrigeration machines could proceed simultaneously. This design innovation resulted in significant cost and time savings for the owner.

Case Study Two: The Bellevue

Built in 1904 as a 19-story, 1,000 room hotel, The Bellevue in Philadelphia, is now a registered historic landmark. Beginning in 1986, The Bellevue was transformed into a mixed-use hotel, office and retail development.

In order to achieve these new use patterns, extensive renovations were required.

Two atria were carved out of the structure—one between the lower level (basement) and the second floor and the other between floors 12 and 19. The construction of each atrium left columns unbraced. Two existing light wells were framed over for most of each level from the fourth floor to the roof. New kitchens with heavy loads were installed on four floors and new public assembly areas were created at previous guest room locations. Two new fountains and pools were installed, as were new elevators and machine rooms. And several tenants had specific requirements for the support of high density files and storage loads, as well as floor openings, which left unbraced columns.



Work began in 1986 to convert the Bellevue into a mixed hotel, office and retail development (left). As part of the process, two atria were carved out of the structure, including one between floors 12 and 19 (right).

Original Design Loads

The first item addressed was determining the original design loads for the buildings. While the original design drawings were lost, and 82 years of alternations and additions were undocumented, a copy of the 1904 Philadelphia Building Code was located and additional research by the restoration architect succeeded in determining the original room locations and functions for the building. Used together, they established the original design load requirements for each area.

Exploratory demolition was performed in numerous parts of the building to determine the actual framing. The original building frame has finish and cinder fill on flat terra cotta arches spanning between embedded steel beams. The structure was mostly in excellent condition and followed the original building code very closely.

Because today's codes allow live load reductions for columns and girders that were not allowed in 1904, a substantial latent capacity was found to exist in the building.

New infill framing at existing light wells meant the imposition of new loads on existing framing. This was compared to two criteria: the capacity of the existing structure and the removal of existing loads.

At office floors, existing brick exterior lightwell walls were removed to create open floor plates. The weight of these walls was found to match the total load of the new floors, so no reinforcement was required.

On the hotel floors, however, the design intent was to remove existing brick walls only locally to create new corridors. The existing plate girders would have been unable to support both the existing heavy masonry and the new floor construction. It made sense in these areas to entirely remove the brick walls and rebuild the walls as typical drywall partitions to recover load capacity and avoid costly reinforcement of girders.

The exterior masonry walls serve as shear walls between the steel columns to resist lateral loads. The removal of extensive areas of

these walls at the lightwells required analysis of the frame for wind loads. The analysis found that the remaining wall area and bracing provide sufficient strength and no modifications were required. However, the sequencing of the construction had to be coordinated to maintain the stability of the building.

Assessing Distributed Loads

Heavy kitchen loads were planned for four different parts of the project. In all four areas, the structure was first assessed for uniformly distributed loads and subsequently analyzed for the effects of particularly heavy equipment.

On the first and 19th floors, the existing framing was analyzed for allowable bending strength at 66% of yield strength. This is 10% greater than the allowable bending stresses at the time the building was built. By including this strength increase, only three beams on the nineteenth floor needed reinforcement at particularly heavy equipment. This was easily accomplished by welding WT sections to the underside of the beams.

On the 12th and 18th floors, new kitchen live loads were about twice the original loads. These floors were upgraded by using composite action with new concrete slabs. Since existing beams protruded above the terra cotta arches, this was accomplished by removing the existing cinder topping, installing headed shear studs on the existing beams and placing a new concrete topping.

Doubled Live Load

The Conservatory is a new public assembly area on the 12th floor. Located within the upper atrium, it had a new live load requirement of twice the original load. The solution here was the same as in the kitchens: upgrade the existing beams through composite action.

After construction began, a fountain and pool were to impose additional loads in part of this area. The new loads were checked against floor capacity, and the one beam found to be of inadequate capacity was reinforced by installing a WT section on the bottom.

Portions of the new infill floors were required to sustain very high loads, up to 200 psf. These loads were far beyond any of the loads being relieved. But by locating some of these loads on the relatively low 12th floor, latent column capacity was developed through live load reductions from the upper floors. This arrangement helped to avoid costly column reinforcement.

The design of the hotel atrium presented several formidable problems. Five floors were to be removed below the Rosegarden, a small historic ballroom. This room is furnished with extensive delicate ornamental plaster, masonry walls, and terra cotta floors. It is surmounted by balconies, attic and roof levels. The new 72'-high atrium space required removal of two columns below the Rosegarden and left four existing columns without any lateral bracing for the full 72' height.

A new pair of transfer girders were inserted under the existing 19th floor to carry the load of the two removed columns. The remaining unbraced columns were reinforced by welding studs to the columns and encasing them in reinforced concrete. By installing these girders and encasement prior to demolishing the floors, temporary bracing was avoided.

The lower, retail atrium involved the creation of a 36'-high open space at the base of the 19-story building. This left two major columns unbraced with severe space limitations for reinforcement. These columns were reinforced by welding headed studs to the existing steel and encasing the columns with heavily reinforced concrete to make them work compositely.

Special Tenant Requirements

Some special tenant requirements required structural ingenuity.

One tenant needed a floor demolished to construct two new mezzanines in the clear space. This increased the unbraced lengths of the columns in the area. Because the space available for reinforcement was severely restricted, steel plates were added to the columns to increase their stiffness and permit the greater unbraced length.

Several tenants required live load capacities beyond the capacity of the structure. Reinforcement of each area was tailored to the specific conditions. Methods of beam reinforcement included adding WT shapes, bottom plates, or flat channels and using composite action with new concrete slabs. In other cases, adding intermediate beams reduced slab spans and/or reduced adjacent beam loads.

The existing connections of all beams and girders that carry new loads were carefully analyzed using working stress and ultimate strength techniques to determine connection capacity. As a result, only a dozen connections in the entire building needed to be reinforced, which resulted in significant cost savings.

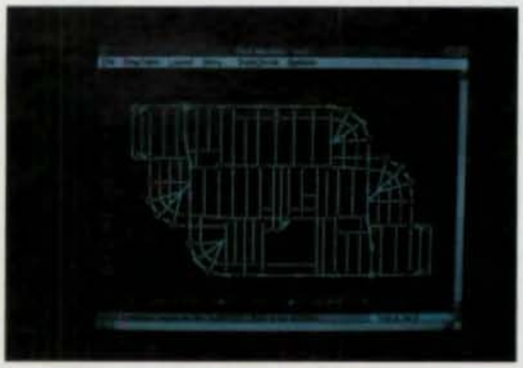
Charles H. Thornton and Jagdish Prasad are principals, Robert P. DeScenza is an associate, and Joseph V. Lieber is a project engineer with Thornton-Tomasetti Engineers, New York City.

Ram Analysis' RAMSTEEL Program

By Leo Argiris, P.E.

RAMSTEEL by Ram Analysis is a special purpose computer software program for the gravity design of structural steel buildings. The program runs under the Windows environment and offers the user a single program for the layout of floor framing and steel beam design. (The company announcements promise a column design module will be available in the third quarter of 1991.)

The program currently supports the BOCA (1990), UBC (1988), and SBC (1988) live load reduction provisions. For steel beam design, it supports the AISC Allowable Stress Design 8th and 9th Editions and the AISC Load and Resistance Factor Design Specification.



Using the Modeler, slab edges, floor openings, slab types, slab directions and floor loads can all be defined.

The RAMSTEEL program is divided into three modules: Modeler, Beam Design, and Post Processor.

The Modeler allows the user to graphically define floor plans. An entire building may be saved as a single model with each unique floor plan saved as a "floor type." The Modeler allows the user to define grid lines along an X-Y axis for each floor type with the story heights defined in the Z axis. Any number of grids may be defined as belonging to a lateral load resisting frame. The program highlights these members by displaying them in a different color, but does not perform any design. Through the Modeler Module, the user can define the slab edges, floor openings, slab types, and slab directions, as well floor loads.

The Beam Design module gives the user the option to design an entire floor type with a single command or to interactively design individual beams and view the results on the screen or print to a file. When designing members interactively, the user can view moment and shear diagrams of individual members on the screen as well as deflections along the span of an individual member.

The Postprocessor module allows the user to generate summaries of the input data, column loads and allows the creation of a DXF file that may be imported to AutoCAD to produce a CAD drawing of the floor plan. The Postprocessor also can assemble data for ETABS input by modifying an existing ETABS input file.

The program was reviewed in five areas: system requirements; ease of installation; completeness of documentation; functionality; and ease of use for practicing engineers. Each area was ranked from 1 to 5, using the following criteria:

5: This is a great program and I'd like to buy a copy.

4: This is a very effective, very useful program.

3: The program performs its stated goals adequately.

2: The program could be useful but needs to be improved.

1: The program is inadequate.

Please note that there is some variance in the rating criteria by each reviewer and programs reviewed by different reviewers cannot by judged directly against each other. Rather, the ratings should be used to provide a background impression of the program.

System Requirements

Rating: 4.0

The RAMSTEEL program requires an IBM-compatible computer running the Windows 3.0 environment. While Windows will run on an 80286-based machine, it is advisable that a fast 80386 machine be used with a minimum of 2 megabytes of RAM, a 40 megabyte hard disk, and a VGA monitor. Since the program runs under Windows, it will support all of the displays, cards and printers supported by Windows.

The list price of the program is $3,500 and the column design module when it becomes available will list at $1,400. A 30%

discount in offered for additional copies at the same site.

The program does not offer any network support and comes with a copy protection hardware device that plugs into the computer's parallel port. This device must be present in order for the program to run. While this device does not affect the performance of the parallel port, it is an inconvenience when a user must work on more than one machine. The lack of any network support also is an inconvenience. The program allows an entire building to be created as a single file but limits the operation to a single user on a single machine.

Installation

Rating: 4.5

Prior to installing the RAMSTEEL program, Windows 3.0 must be installed. The user is guided through the installation program within Windows. It is relatively painless even for a novice user to install the program on a hard disk. The user is allowed to define default values for such items as live load reduction codes, deflection criteria, and steel design specifications. The installation program also updates the computer's *autoexec.bat* file, saving the previous version as *autoexec.old.*

Documentation

Rating 3.5

The documentation for the program is divided into three sections: Tutorial; User's Manual; and Technical Manual.

The Tutorial guides the user through the creation and design of two floor plans and offers an excellent introduction on the use of the program for a new user.

The User's Manual does an adequate job of describing the operation of the three modules.

The Technical Manual gives the user information on the method of analysis and design employed by the program in such areas as the calculation of effective beam widths, deflection calculation, and shear stud connectors. However, many assumptions go into the creation of a program as extensive as RAMSTEEL and the Technical Manual is relatively condensed, leaving many program details unexplained.

Functionality

Rating: 4.5

The program is well suited to its stated task. It performs very well in the layout of repetitive or typical floor plans as well as giving the user the ability to handle unusual framing conditions.

However, one area in the layout option that could use improvement is the layout of beams that do not fall on regular grid lines. The "off-grid" beam layout options are somewhat cumbersome in comparison to the features available in some of the standard CAD packages. Overall, though, the floor layout options are very well designed.

In terms of designing steel members, both the composite and the non-composite sections of the program perform very well. In numerous examples checked the program design was accurate.

Ease Of Use

Rating: 4.5

The user's impression of the program will be heavily influenced by his impression of the Windows environment. While not absolutely required, the program relies heavily on the use of a mouse. The user looking for a good old-fashioned text-based program should look elsewhere.

The data entry forms and screens are well layed out and generally very clear to the user without extensive reference to the user manual. Again, the one area that could use some improvement is the layout of off-grid beams.

Conclusions

Overall the RAMSTEEL program is a very well layed-out program with powerful options for the design of steel buildings. The drawbacks which have been identified—lack of network support, minimal technical reference, and some cumbersome layout commands—do not detract from the program's power to perform its designated task. However, these shortcomings should be addressed in future revisions to the program.

The program's high price will preclude its use by the casual user and its lack of network support makes it more difficult for more than one user to work on the same structure. However, for a single user the program performs very well and is highly recommended.

Leo Argiris, P.E., is an associate with Weiskopf & Pickworth, a nationally recognized consulting engineering firm based in New York City.

For a single user, the program performs very well and is highly recommended

Paul J. Ford and Co.'s WEBOPEN Program

By James Manley, P.E. and Philip Terry, P.E.

When the first mechanical engineer argued with the first structural engineer, the subject without a doubt concerned interference between a mechanical duct and a steel beam.

Few projects escape this conflict. After a quick review of the costs of various alternatives, today's project manager is sure to direct the structural engineer to investigate penetrating the beam web. Unfortunately, beams with web openings don't fall under the purview of the steel designer's bible. Through the years, however, engineers have taken up this gauntlet by developing theories and design aids. Even so, most structural engineers still spend hours in front of their calculators.

As its name suggests, WEBOPEN is a computer program created to help engineers design web openings.

David Darwin, of the University of Kansas, and Paul J. Ford and Co. have tried to make this a less time-consuming process. Darwin wrote a design guide entitled *Steel and Composite Beams with Web Openings*, and Paul J. Ford and Co. wrote WEBOPEN, a microcomputer program based on the procedures presented in Darwin's guide.

The design guide covers design equations and assumptions, background and commentary, deflections, references and problem examples. A copy of this 60-plus-page guide is included with WEBOPEN and provides excellent background material. Although both the design guide and WEBOPEN are marketed by AISC, they do not represent an official position of AISC or preclude the use of other design methods.

Capabilities And Limitations

WEBOPEN is an interactive, easy-to-use program that analyzes noncomposite and composite steel beams for the localized effects of circular or rectangular web openings. Openings can be on, above, or below the centerline of the beam. The beam can be any W-, M- or S-shaped section from the AISC *Manual of Steel Construction*.

WEBOPEN does not consider openings for girders or noncompact shapes. WEBOPEN assumes that the beam's compression flange is fully braced laterally. If it is not, you must verify the lateral-torsional buckling strength of the beam with manual calculations. Interior or edge beams can be analyzed. Positive and negative shears and moments in the plane of the major axis are allowed, but WEBOPEN cannot check a composite beam with negative moment. Axial loads, minor axis bending, torsion, deflection and fatigue are not considered.

The program analyzes composite beams with or without metal decking. The deck can be cellular or noncellular, oriented parallel or perpendicular to the beam. If WEBOPEN determines that a beam is overstressed at an opening, it designs reinforcing bars above and below the opening. You also can specify a preferred reinforcing scheme, and the program will analyze the beam with this web reinforcing and report the stress levels in the beam.

WEBOPEN considers only the localized effects of individual openings, so you must allow for enough space between web openings to prevent interaction. There should be no concentrated loads in the vicinity of the opening, and the edge of the opening must be a minimum distance from a support. WEBOPEN computes and reports these required separation distances.

System Requirements

The program, which costs $495, is available on 5¼" and 3½" disks. It is not copy protected, but the licensing agreement states that the program can be used on only one computer at a time. AISC offers a defective-disk warranty.

WEBOPEN runs on IBM PC or compatible computers with 265K RAM minimum (though 640K is recommended). It requires DOS 2.0 or later, and while it will run from floppies, a hard drive is recommended. CGA graphics card is the minimum required, and EGA or VGA is recommended. Also recommended is a math coprocessor.

The software will work with most standard printers with ASCII extended character set.

Documentation

The 70-plus-page manual is well organized and most helpful. Its six chapters cover installation, use, input, design and output. The manual also has three appendices that contain example problems, verification problems and warning messages. The manual should be close at hand while running the program and is definitely a plus.

The program is written for one level of user; there are no novice or expert modes. It does not permit any customization, such as macros or assigning function keys, but these are probably not needed anyway. WEBOPEN does not interface with other types of programs, such as CAD, word processing or speadsheets.

User Interface

WEBOPEN guides you through a design with a series of screens that display menus and prompts. Using the ENTER key, you accept default values or enter new values and respond to questions. To replace values, the entire value must by retyped, as there is no typeover mode of editing. WEBOPEN does not permit metric units; only a fixed set of foot/pound-based units are allowed.

One irksome limitation is that the up and down cursor keys are not active. Only the ENTER key can be used to move down the fields on a screen. If you catch an input error after you press ENTER, you have to continue through all of the data fields. At the bottom of the window, you can accept the entire screen of data or return to the top and use the ENTER key to move to the field you want to change.

The program has some helpful input checks. For example, we could not enter negative values for the opening width, height and eccentricity. Rather than issue an error message, WEBOPEN used the absolute values. However, it did allow us to enter unreasonably large values.

Except for unrecognized beam sizes and placement of studs for cellular decks, WEBOPEN does not issue warnings or help messages on-screen during input. Instead, it changes an unacceptable value to an acceptable value or it doesn't accept the input and keeps the previous value.

WEBOPEN allows slab thicknesses from 2" to 49" and deck depths from 0" (meaning no deck) to 49". The headed stud length must be ½" or less than the slab thickness and 1½" greater than the deck depth. Thus, a 6" slab with a 4" deck can only have a 5½" stud. When you change slab thickness, the default stud length automatically changes, though this is not readily displayed.

The program does not have a tutorial, but the manual has two example problems—a noncomposite steel beam with a round opening and a composite beam with a rectangular opening. It also offers an example of the output section and four verification problems.

Program execution

WEBOPEN can be started or terminated from the main menu. Terminating the program returns the user to DOS. The program flows logically and you don't get lost in a labyrinth of menus. The screens are neat and self-explanatory.

In the project data window, you can enter optional information: project name, ID number and engineer's name. Each copy of the program is personalized so the purchaser's company name and project address appear on each page of the printed output.

WEBOPEN analyzes one load condition at a time, but you can perform multiple runs of the design before printing the final results. You have to keep track of which load cases have been considered and which require the most reinforcement. You also must ensure that the worst case has been considered.

The current load combination is dis-

The manual is well organized and most helpful. The program also comes with a copy of the guide on which it is based.

played near the bottom of the shear-and-moment input menu. WEBOPEN automatically computes and displays the total loads (service and factored) for this combination.

Design Sequence

Upon exiting the data-input menu, WEBOPEN automatically checks stability and proportioning when recommended in the AISC guide and the *Manual of Steel Construction*:

- Local buckling of the beam compression flange or reinforcement.
- Web buckling.
- Buckling of the tee-shaped compression zone.
- Lateral buckling.
- Maximum limits of the opening aspect ratio and depth of top and bottom tees.
- Maximum radius for corners of rectangular openings.
- For composite beams, minimum transverse and longitudinal concrete-slab reinforcement ratio and shear connector capacity.

If the opening fails any of these checks, the program displays warning messages on the screen that explain why the design failed and recommends options for revising the design. Many of these warnings can be overridden based on engineering judgement. When a warning is overridden it continues to appear on the screen and will be included in the output.

Reinforcing is assumed to be steel bars of the same material as the steel beam. The AISC design guide places the reinforcing bars flush with the edge of the opening, whereas WEBOPEN conservatively places the bars a distance from the opening to allow space for continuous fillet welds on both sides of the bars.

Printed Output

The reinforcing-design summary window summarizes the reinforcing-design details. It does not graphically show an elevation of the beam with the details of the unreinforced or reinforced opening.

The output contains a summary of input data and parameters, the overridden warnings, the steel beam or unshored construction load interaction checks (for unreinforced conditions) and unreinforced and reinforced composite-section interaction checks, followed by the reinforcing design summary. On the final page, WEBOPEN prints a summary of the criteria that must be satisfied in order for this particular design to meet the requirements of the AISC design guide. Each page tells which version of the program was used and the date and time of the output.

We did find one minor flaw. If there is no metal deck, the printout displays the perpendicular deck span and noncellular deck type. The screen display shows it properly by omitting the type of span and type of deck.

Recommendations

WEBOPEN is very straightforward and easy to use. It is very fast. With design loads and combinations in hand, engineers familiar with the program can complete the design of a reinforced web opening in short order. It was written by practicing engineers and incorporates design checks and warning messages that enhance the real-world application.

While many structural programs are deficient in documentation, this is not the case with WEBOPEN. The manual is well-written and helpful, and the package contains an excellent design guide.

As building costs continue to influence design and the floor-to-floor dimensions of buildings decrease, passing mechanical ducts, piping and other penetrations through beams becomes more common. With WEBOPEN, examining the localized effects of such openings in standard beams is almost too easy. Structural engineers who spend many hours calculating and recalculating beam reinforcing should take a look at WEBOPEN.

James Manley, M.ASCE, and Philip Terry, M.ASCE, are structural engineers with Burns and McDonnell, Kansas City, MO. Terry also is a member of CE Computing Review's editorial board.

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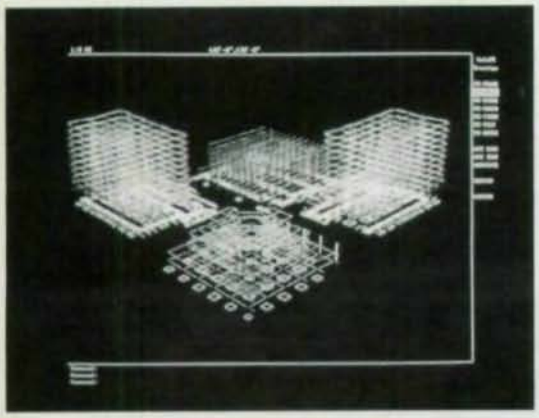
Engineering Computer Software



Softdesk

DCA Software, Inc., has changed its name to Softdesk. The Structural Designer Series consists of three software applications: Modeler, Plans & Elevations, and Details & Sections. The company's Modeler program allows structural analysis models to be created inside AutoCAD, letting the user trade files and exchange information easily across all disciplines. In addition, the program offers an interface to the STAAD III analysis package (interfaces with SAP90 and AutoSTEEL are in development). Plans & Elevations is a comprehensive structural production program that works within AutoCAD to draw all types of structures in plan, section, elevation or 3D. Details & Sections creates accurate construction details in any scale. Construction details can be drawn at any scale within the current drawing and stored for later use in other drawings.

For more information, contact: Softdesk, 7 Liberty Hill Road, Henniker, NH 03242 (603) 428-3199.

SODA

This PC-based program operates within the Windows environment and utilizes formal optimization to perform the least-weight design of steel structures, which translates into significant savings in material and construction costs. Both LRFD and the latest ASD Specifications have been incorporated into the program, as well as the Canadian S16.1 design code. The program also designs structures to satisfy any specified structural sway and beam deflection requirements. Design members are selected from a database of standard steel cross-sections. User-created databases containing customized sections can also be incorporated.

For more information and a demo disk, contact: Waterloo Engineering Software, 22 Dupont St. East, Waterloo, Ontario, Canada, N2J 2G9 (519) 885-2450.

Pro-Steel

This AutoCAD-based program produces both 2D and 3D structural steel drawings of both onshore and offshore structures. Any of more than 800 standard steel shapes (channels, angles, structural pipe and tubing, HP, M, MC, MT, S, ST, W, and WT shapes) can be easily selected, automatically drawn and viewed from any angle. The program also features an automatic Bill of Materials function. This is a sister program of Pro-Plant, Pro-Pipe and Pro-Iso.

For more information, contact: Applications Development, Inc., 3850 N. Causeway Blvd., Suite 900, Metairie, LA 70002 (504) 835-1627.

GenCADD

Generic Software, in conjunction with Softdesk, is offering a new line of AEC products that run within Generic CADD, a low-cost 2D drafting program running on personal computers. GenCADD packages are being sold for less than $1,000, with various modules retailing for less than $500.

For more information, contact: Generic Software, 11911 North Creek Parkway S., Bothell, WA 98011 (206) 487-2233.

AP Design Series

This 3D building design series for AutoCAD features several modules, including Utility, Architect, Quantity, Survey, Framing, and Manager. Formerly called AutoPLAN, the package was developed in Australia and is currently also being marketed in Europe. The program offers elevation views, perspective presentations, and section details. It also features a parametric and customizable database, imperial and metric units, symbol library, rendering library, complete bill of materials with assembly lists, plan to 3D model converter, enhanced dimensioning and automatic scaling of details and scheduling.

For more information, contact: CADSOFT International, 291 Woodlawn Road West, Suite 4A, Guelph, Ontario, Canada, N1H-7L6 (519) 836-3990.

RAMSTEEL

This specialized structural software package automates the gravity analysis and design of steel buildings. In addition, with a powerful, yet easy-to-use Windows interactive graphical modeler, this PC-based software allows the user to graphically model buildings, floor-by-floor, creating a database of floor loads, slab properties and member locations. The program provides accurate member loading, calculates live load reductions, optimizes beam design, optimizes column design, interfaces with ETABS data files, and incorporates applicable building code data.

For more information, contact: RAM Analysis, 55 Independence Circle, Suite 201, Chico, CA 95926 (916) 895-1402.

AutoSTEEL

This stand-alone computer-aided engineering program for 3D frame analysis and steel design is the stress and automated design solution for the AutoPLANT Structural series, and can integrate with other programs within the package. The AutoCAD-based program features advanced static analysis, model definition and editing, code checking, and optimal member resizing.

For more information, contact: Engineering Design Automation, 1930 Shattuck Ave., Berkeley, CA 94704 (415) 848-1245.

Novacad

Low cost scanning, editing and plotting is provided through this integrated system. NOVASCAN combines Novacad's raster editor (NovaEdit) with drivers for large format scanners and plotters from CONTEX, VIDAR or SCANGRAPHICS for scanners, and HP, VERSATEC, or CALCOMP for plotters. The company also offers NovaManage, a document management system that allows for complete application development for customized technical information systems.

For more information, contact: Novacad, 129 Middlesex Turnpike, Burlington, MA 01803 (617) 221-0300.

Structural Advantage

This program is part of a larger package for the design of industrial buildings. It is compatible with AutoCAD Rel. 10 or higher and is designed to simplify the drawing of structural plans, elevations and details. It will draw all of the supplied AISC shapes (W, M, S, and HP) in plan, elevation or end view, as well as produce a bill of materials and details. The entire package includes: Weld Advantage; P&ID Advantage; ISO Advantage; and Pipe Advantage.

For more information, contact: Advantage Engineering, Inc., 2141 W. Governors Circle, Suite B, Houston, TX 77092 (713) 683-7100.

Images-3D

This state-of-the-art finite element analysis program is designed for both accuracy and ease of use. The PC program is fully interactive, with on-line help and a short learning curve. It's design promotes immediate creativity through instantaneous feedback. Graphic options include: split screen format; display of deformed shapes; stress and displacement diagrams; displacement, force, and moment diagrams; and translators for popular CAD packages. The program is composed of three modules: Static, Modal, and Dynamic.

For more information, contact: Celestial Software, Inc., 2150 Shattuck, Suite 1200, Berkeley, CA 94704 (415) 843-0977.

ASG Structural

Designed to meet the needs of the structural engineer, this program provides built-in standard sizes and engineering standards to ensure the drawing of accurate structural connections. The programs symbol library includes: foundation plans; structural frames; rolled steel shapes; miscellaneous steel members; metal decking; and other structural materials. Special features include: automatic weld notes; layer management; and electronic manufacturers information.

For more information, contact: ASG, 4000 Bridgeway, Suite 309, Sausalito, CA 94965-1451 (415) 332-2123.

Calpro

This company offers a series of engineering software programs and includes a database based on the AISC *Manual of Steel Construction/Load & Resistance Factor Design*.

For more information, contact: CALPRO, 3119 Waterlick Road, Lynchburg, VA 24502 (800) 446-0959.

Computer Software

SPANS

Designed as a series of Lotus 1-2-3 templates, SPANS is an engineering design and analysis tool for beams with one, two or three continuous spans and cantilevers. When an engineer specifies the properties of members (modulus of elasticity E and moment of inertial I), the program computes and plots moment, shear, and deflection.

For more information or to receive a demo disk, contact: Craig Christy, Industry Consulting Engineers, 4314 S.W. Washouga Ave., Portland, OR 97201-1376 (503) 246-9222.

Multiframe

This 3D structural analysis and design software works on a Macintosh platform. Unique features include: the ability to render structure complete with web and flange detail on members; the animation of the deflection structures; and color overlays of force and stress levels along members. It also features advances in the 3D interface with spatial controls of visibility of a structure and selective display of areas of the structure according to geometry.

For more information, contact: Sharon Alger, Graphic Magic, 2-1645 East Cliff Dr., Suite 6, Santa Cruz, CA 95062 (408) 464-1949.

TPCFM1

This $225 program calculates 30 full and/or net torsional and flexural cross-sectional properties for any continuous open shape, or the flexural properties of structural shapes, distorted shapes, weld groups, and bolt/screw groups. The user may select standard open shapes from a menu, or enter the end point and thickness of each line element for a special shape. The program is written in C++ and uses Innovative Data Concepts' TCXL windowing system.

For more information, contact: Keck Tech Structural Engineering, 286½ E. State St., Salem, OH 44460 (216) 332-0556.

STAAD-III/ISDS

This industry-standard integrated structural analysis and design/drafting program offers: 2D/3D frame/plate/shell/spring elements; offset/release; UBC/moving load generation; master/slave capabilities; 2D/3D static/dynamic/P-Delta Analysis with forces/displacements at and between nodes; integrated steel/concrete/aluminum/wood design per American and Foreign Codes; and interactive graphics for model generation and post processing.

For more information, contact: Research Engineers, Inc., 540 Lippincott Dr., Marlton, NJ 08053(609) 983-5050.

FRAME Mac

Written especially for the Macintosh, this software program helps to analyze and design two-dimensional frames, trusses or beams. Any number of nodes, supports, elements, loads (including node, element, sloped moments, trapezoidal, etc.) can be used (limited only by RAM). Each node may be rigid or partially or fully hinged, and each element can be different. The program shows both original and deflected shapes.

For more information or to obtain a demo disk ($20), contact: Dorete Sivkin, Compuneering Inc., 113 McCabe Crescent, Thornhill, Ontario, Canada L4J 2S6 (416) 738-4601.

AISC for AutoCAD©®

(Version 1.0)

SAVE TIME doing those detail drawings and have AISC Shapes drawn at your command, with AISC for AutoCAD.

This software runs in AutoCAD (Release 10 and above) and draws structural steel shapes and lists their properties corresponding to data published in Part 1 of the 1st Edition, AISC *LRFD Manual of Steel Construction* as well as the 9th Edition, AISC *ASD Manual of Steel Construction*.

The program will draw to full scale the end, elevation, and plan views using the *design* dimensions of the following shapes:

- W, S, M and HP Shapes
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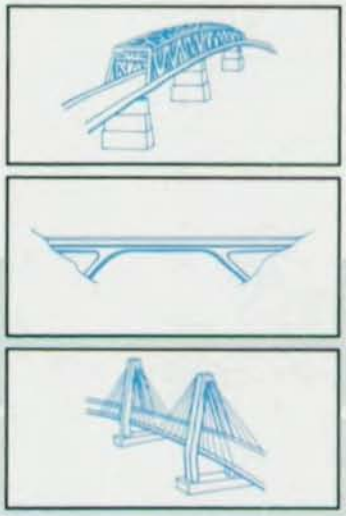

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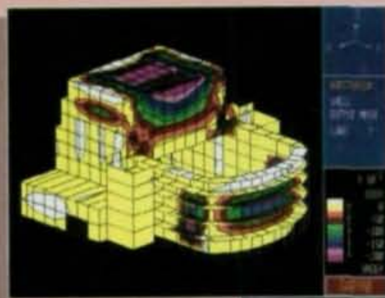

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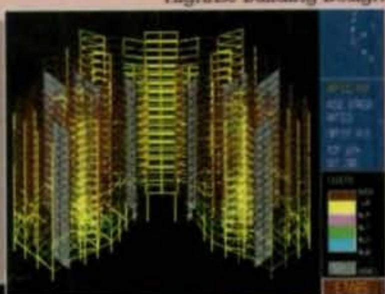

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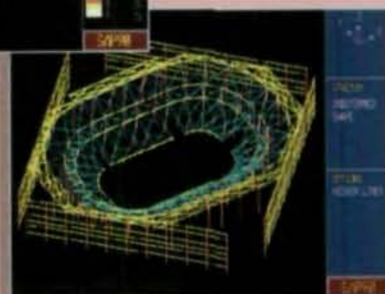

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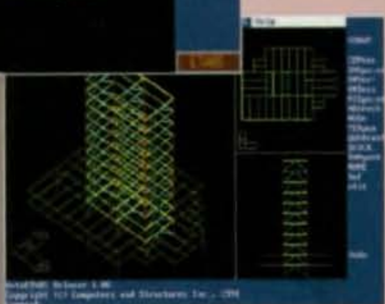

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