MODERN STEEL CONSTRUCTION

October 1991

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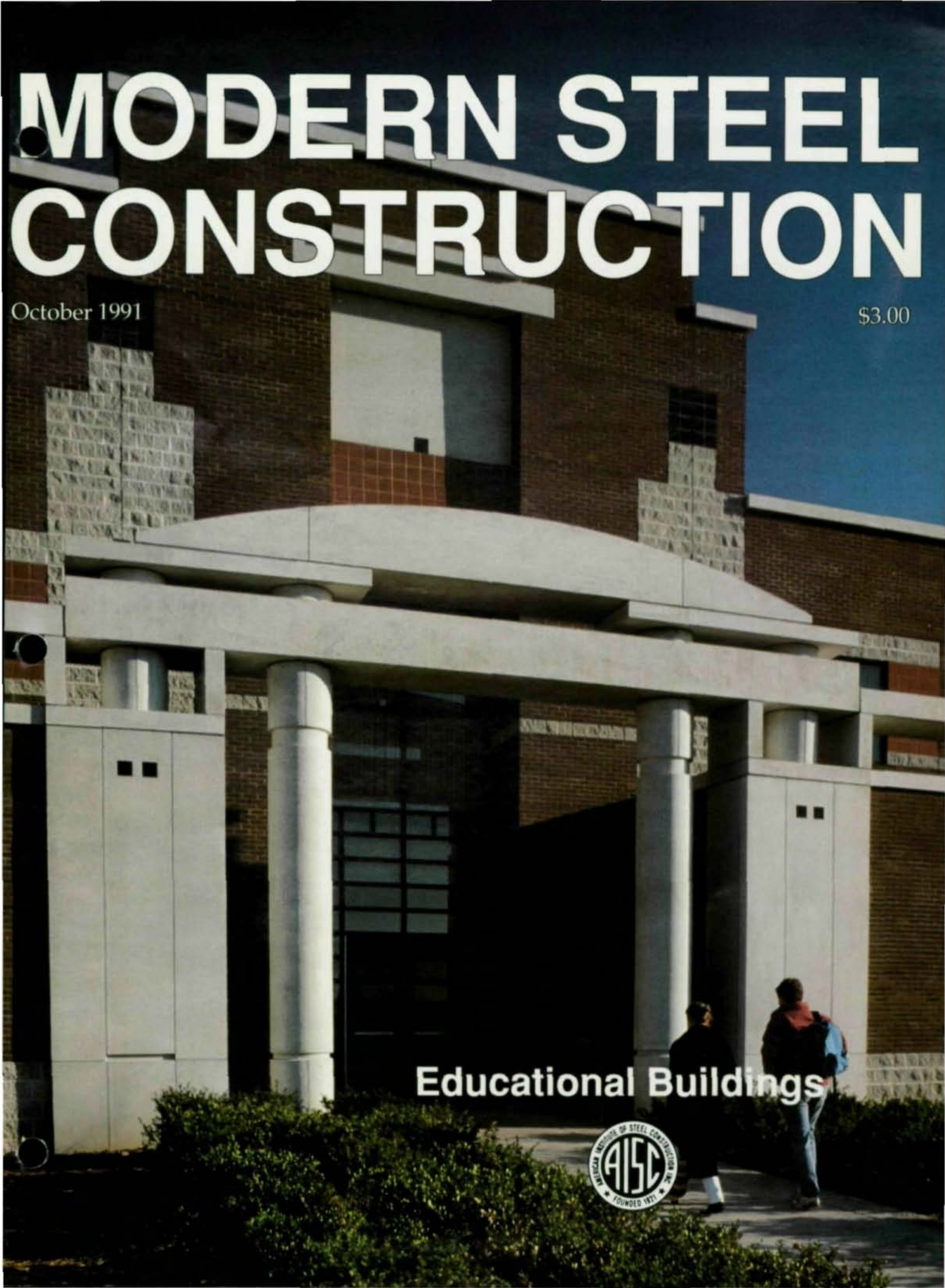

Educational Buildings

UNITED STEEL DECK, INC.

DECK DESIGN DATA SHEET
No. 13

DECK FINISHES

STANDARD FINISHES COMMONLY AVAILABLE ON USD PRODUCTS

PRODUCTS	GALV. G90 or G60 I.	PHOS/PTD II.	PRIME PTD III.	GALV. + PAINT IV.	FINISH PAINT V.	UNCOATED VI.
1½" & 3" Roof Decks	X		X	X	X	
4½", 6", 7½" Roof Deck	X					
1½", 2", 3" Composite Deck	X	X				
UFX36, UF2X, UFS (Form Deck)	X			X	X	X

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

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

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

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

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

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

V. A. FINISH COATS OF PAINT CAN BE FACTORY APPLIED. THIS IS DONE ON THE COILS OF STEEL BEFORE FORMING INTO DECK. ALMOST ANY COLOR OR PAINT TYPE CAN BE USED—HOWEVER TO BE ECONOMICAL, THE ORDER SHOULD BE FOR AT LEAST 20,000 SQUARE FEET.
B. WHEN INSTALLING DECK WITH A SPECIAL FINISH, SCREWED SIDE LAPS ARE RECOMMENDED: AND, IN MOST CASES, SCREWS, PNEUMATIC OR POWDER DRIVEN FASTENERS SHOULD BE USED AT SUPPORTS.
C. FINISH PAINT IS NORMALLY APPLIED OVER GALVANIZED STEEL CONFORMING TO ASTM A446.

VI. A. UNCOATED STEEL MEANS THERE IS NO COATING AT ALL. IT IS FREQUENTLY REFERRED TO AS "BLACK" STEEL.
B. UNCOATED STEEL CONFORMS TO ASTM A611.

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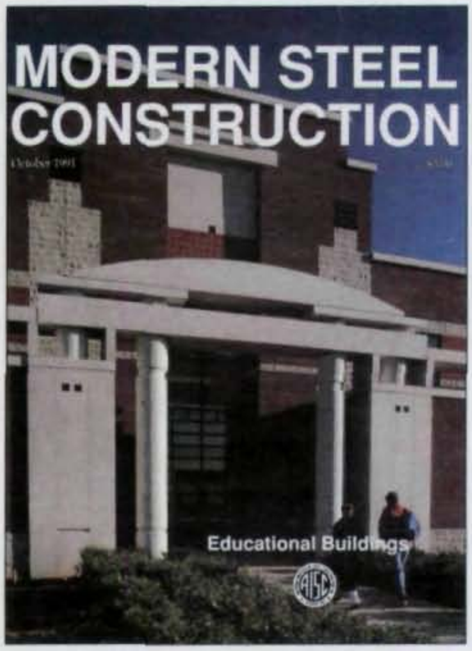
MODERN STEEL CONSTRUCTION

Volume 31, Number 10 October 1991



Business schools, such as the Janice H. Levin School of Business and Management at Rutgers University are designed to foster a sense of community within a single building. Story begins on page 12.

FEATURES

NEWS AND DEPARTMENTS

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Choosing Software

With so many engineering software packages on the market today, no firm can afford the cost—either in dollars or time—of trying them all. *Modern Steel Construction* began addressing this problem earlier this year by running a series of software reviews.

This month we're going one step further and surveying our readership about the type of software programs they use and what they think of them. While we won't report data from individual firms, we will print the aggregate results in the February 1992 issue. We expect the survey results will prove extremely useful to any engineering firm considering the purchase of software in the coming year.

However, to be a success, we need your help. Please take the time to fill out the survey form on page 9. It shouldn't take more than a few minutes. The survey form was made as simple as possible to minimize the time required for completion. In addition to basic firm data (type of firm, number of engineers, etc.), which will be used in the statistical analysis of the data, the survey only has five questions. Essentially, the survey asks you to list the type of hardware and software your firm owns and to rank the software from 1 to 5, with 1 being a poor program and 5 being an excellent program.

To maximize the usefulness of the data, the software information has been broken down into Bridge/Building Analysis, Member Design, Specialty Areas/Connections, and CAD Programs.

As with any survey, it will only be useful if a large number of people take the time to fill it out and return it. Please mail it by October 31 to: Scott Melnick, *Modern Steel Construction*, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001. **SM**

New Pubications

A new study declares that steel-framed buildings resist earthquakes better than those built of other materials. The study, conducted by EQE Engineering of San Francisco, reports that "in recent large, destructive earthquakes, few structural steel buildings were severely damaged, while literally hundreds of comparable buildings of other construction types collapsed or were seriously damaged."

The EQE Engineering study evaluated the performance of buildings in 11 major earthquakes that occurred during the past three decades. The earthquakes investigated were selected to ensure a wide variety of construction materials in structures designed and built to standards comparable to those used in the U.S. and Canada.

The key results of the study are contained in a brochure, *Steel—An Investment in Seismic Safety*, published by the American Iron and Steel Institute. The free brochure discusses the strong probability of large earthquakes striking Central North America, where three of North America's largest earthquakes occurred in the past. Also discussed are the benefits of steel in retrofitting existing structures to increase their seismic performance.

For a free copy of the brochure, or for more information on the study, write: American Iron and Steel Institute, 1133 15th St., N.W., Washington, DC 20005-2701.

In response to the increasing activity in the renovation market, the American Society of Civil Engineers has published a *Guideline for Structural Condition Assessment of Existing Buildings*. The new publication provides comprehensive procedures, advice and expert opinions to help engineers accurately gauge the structural integrity of existing buildings.

The Guideline documents the step-by-step processes necessary for evaluation, including investigation, testing methods and the format of the condition assessment report. Tables, charts and checklists abound, including detailed tables for materials employed in older structures.

Copies are available for $21 to ASCE members ($28 to non-members) from the ASCE Publications Department (212) 705-7288.

Correspondence

Dear Editor:

The article "Rocketing To New Heights" (August pp. 19-24) was very interesting as was the rest of the information about tall buildings. When trying to run some simple calculations of pressure due to wind loading using the formula:

$$P = 0.00256V^2C_d$$

some questions arose. The results of the calculation apparently yield a pressure per sq. ft., but in what units must the wind velocity be expressed?

Also, once a pressure is calculated, to what area should the pressure be applied when the structure presents a curved surface? For example, given a cylindrical shape 10'-tall x 10'-in-diameter is the calculated pressure applied to the presented surface of 100 sq. ft. or to the total curved surface of 157.08 sq. ft.?

Michael A. Potash
Manager-Fabricated Metals
Sioux City Foundry Co.

According to Joseph T. Colaco, P.E., president of CBM Engineers, Inc., the variable "P" is a unit pressure in lbs. per sq. ft. and the variable "V" is measured in miles per hour. He also noted that the equation is used for a steady wind stream and with turbulence a gust factor (C_g) should be included (though some engineers will include the gust factor in the velocity variable).

The wind pressure variable "P" should be applied to the presented surface, which in the above example would be 100 sq. ft.

MODERN STEEL CONSTRUCTION

STRUCTURAL DESIGN COMPUTER SURVEY

Please complete and return this form to: Scott Melnick, *Modern Steel Construction*, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001. Deadline for submission is October 31. All individual company information will be kept confidential. Survey results will be published in the February 1992 issue of *Modern Steel Construction*.

Type of Business (Check ONLY one)

☐ Architect/Engineer
☐ Engineer
☐ Architect
☐ Other: ______________________________

Total Number of Employees: ____________ Number of Draftspeople: ______________

Number of Engineers: __________________ Number of Architects: _________________

Computer Hardware Systems Used (include type, e.g. 386-based IBM clone or Macintosh workstation, and number of each type of system):

Please list the types of software owned/used and rank them from 1 to 5, with 1 being a poor program and 5 being an excellent program.

Bridge/Building Analysis (such as STAAD-III, SAP90, etc.) Ranking

Member Design (such as SAI CONTBEAM, RISA 2D, etc.) Ranking

Specialty Areas/Connections (such as CONXPRT, WEBOPEN, etc.) Ranking

CAD Programs (such as AutoCAD, Intergraph, etc.) Ranking

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DEADLINE: OCTOBER 31

Going from CAD to CADD

When computer-aided design and drafting (CADD) first became a design industry buzzword, the idea was that design/analysis and drafting would be linked electronically and productivity would skyrocket. It rarely happened, however, primarily because software programs did not link design and drafting (though some mid-size and larger firms produced in-house software to achieve this, and enlarged their practices as a result).

Previous software packages aimed at design/drafting integration often were, at best, unreliable, according to interviews conducted by Institute of Management & Administration and published in *Engineering Office Management Administration Report (EMAR)*. For example, one CEO reported that his firm paid a vendor $40,000 for such a package four years ago, has not yet received satisfactory software, and is even considering suing.

New Generation Of CADD

In the past six months, electronic design-to-drafting integration has finally started to become available even for small firms running PCs. In a June report, *Civil Engineering* mentioned four vendors whose structural software reportedly offers varying degrees of design-drafting integration: Computers & Structures, Inc., Berkeley, CA (415) 845-2177; Das Consulting, Inc., North Andover, MA (508) 794-1487; Intergraph Corp., Huntsville, AL (205) 772-2000; and Research Engineers, Inc., Orange, CA (800-367-7373). And *EMAR* adds a fifth vendor, Ram Analysis, Chico, CA (916) 895-1402.

However, not all programs offer the same functions.

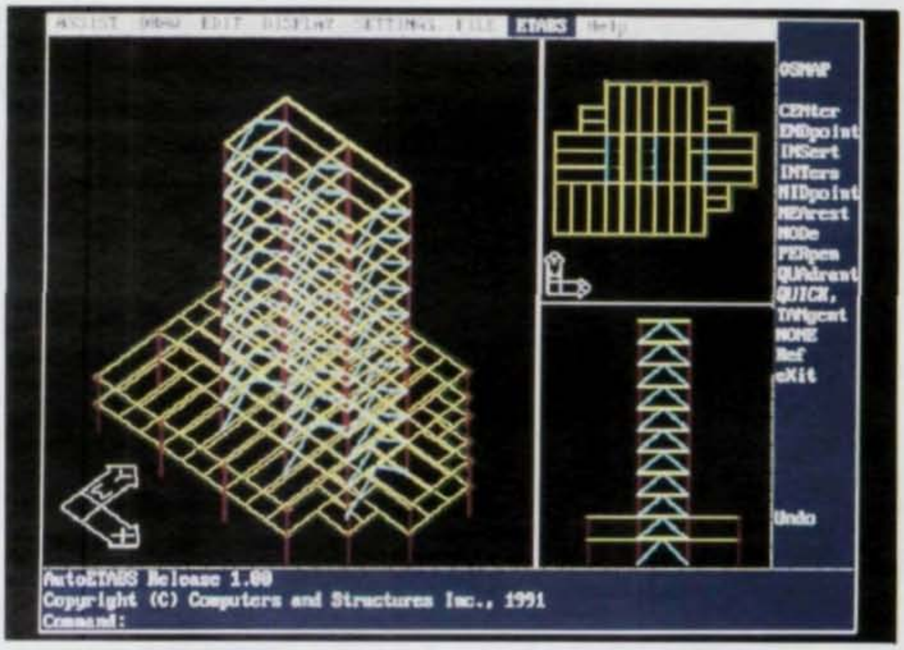
Buyers should carefully check out vendors' promises. For example, one vendor's software offers integration, but not if you want a composite structure and floor, which is cost-optimal for many buildings. *EMAR* suggests a two-step screening process before purchasing (software prices range from about $1,200 to $12,000):

1. Talk with at least one firm that has successfully used the soft-

ware for several months. It takes at least that long to smoke out all the limitations and pitfalls.

2. If you're strongly interested, visit a firm using the software package. Watch how its engineers or CAD drafters use the technology, and ask to do hands-on work. Packages differ in how you input. For example, in one case the drawing must be created in AutoCAD (and some engineers don't know how to do that), while in another, reportedly almost no training is required since inputting is done via a mouse that moves a cursor on the screen.

Before buying a package, attempt to understand the productivity boosting strengths and limitations of each package.



The lastest generation of software, such as CSI's "AutoFLOOR" and "ETABS" programs, allow engineers to rapidly assess design changes.

Faster Designs

The number one source of savings is in expediting the structural redesign needed to accommodate design changes.

To illustrate the benefit, Wilson Hanna, S.E., principal with Nabih Youssef & Associates, Los Angeles, described a recent project meeting. "When we met yesterday, the architect asked us to move the building's core and rotate the stairs. I began running the changes this morning, and all analysis, beam sizing, and drafting were done by noon." In the past, calculations would have taken two days and drafting an additional day, Hanna said. The savings were realized using the RAMSTEEL package from Ram Analysis.

Robert J. McNamara, P.E., president of Boston's McNamara/Salvia, Inc., agrees that the speed of making design changes is the key benefit. "We can redo an entire floor without incurring significant costs. We do many high-rise hospitals, and changes during design—in location of stairs, moving of lobbies, and others—are extremely common." McNamara's firm uses an integrated system from Computers & Structures (CSI).

Cost-Effective Software

The best software enables the engineer to go through the iterative trial-design process so quickly that it is cost-effective, within the structural engineer's fee, to do many more such iterations than could be done manually. The owner thereby gets a less costly structure.

For example, CSI's "AutoFLOOR" package is so fast that it enables an engineer to do as many as *10 iterations of the structural* steel framing for a mid-rise office or apartment tower, according to McNamara. Previously, McNamara reported he could only justify the cost of two iterations. Today, he says that in running five times as many iterations, the owner often gets a 10% less costly structure and foundation.

The Autofloor package is an add-on to CSI's decade-old ETABS structural software, which does most of the analysis work. AutoFloor's main function is to transfer the structure's digital database to AutoCAD and back. According to McNamara, the program makes it a snap to calculate the extra cost of adding extra capacity to a floor above that required by code.

Upgrade Availability

Before buying, ask each vendor and structural firm using the package what software upgrades can be expected in the near future and how much they will cost.

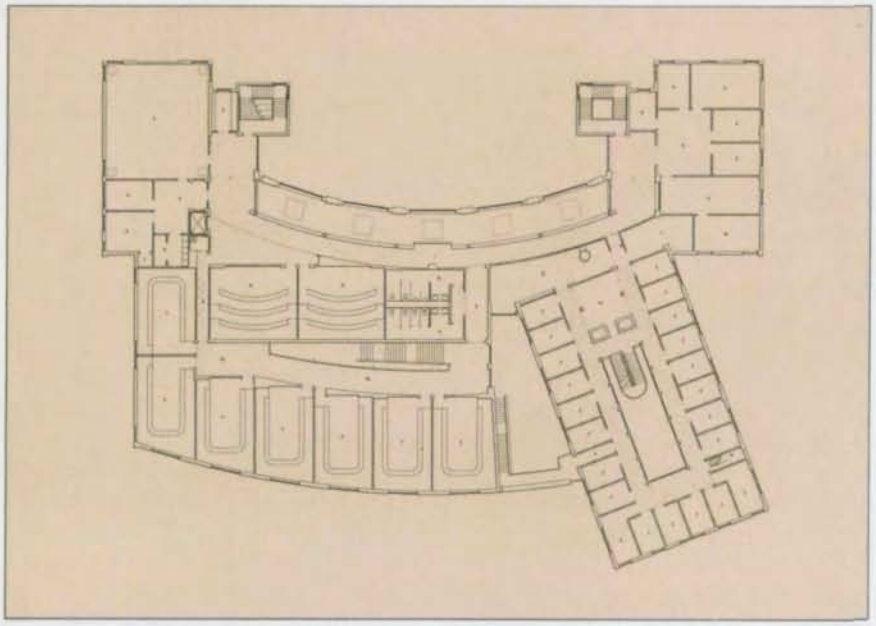
McNamara, for example, predicts the next change in AutoFloor will be automatic checking of the steel fabricator's connection designs against the design loads on those connections.

While integration will initially lead to increased profits, once the majority of firms switch to this new generation of software, competition will increase and fees will begin to drop. The key is not to be the last player in and instead stay ahead of the pack.

(This article is adapted from a report first appearing in the August 1991 issue of Engineering Office Management Report, *29 West 35th St., New York, NY 10001 212/244-0360).*

EDUCATION REPORT

Designing For Tomorrow's Business



While the plan of the building is very complex, the exterior of Monmouth College's new School of Business Administration features a very traditional appearance with columns, arches and a brick facade.

Three new business schools designed by The Hillier Group provide an exciting learning environment for future leaders of industry

Business schools tend to function as self-contained entities within the larger university setting and therefore need a strong sense of internal identity. "It's important that the building's design helps to develop a sense of community within the building," explained Joel C. Spaeth, AIA, a principal with Hillier, a Princeton, NJ, based architecture firm. "There needs to be a sense of a relationship between the different parts of the building—classroom, faculty office, computer areas, and research centers."

Three recent projects—Janice H. Levin School of Business and Management at Rutgers University, New Brunswick, NJ; College of Business and Economics at Lehigh University, Bethlehem, PA; and Monmouth College Business School, West Long Branch, PA—appear radically different from the outside, but all share a common concept focused around an atrium space that provides a point of orientation to students and teachers who spend much of their day moving from room-to-room in one large building.

Monmouth College

Despite its small size, the design of the new School of Business Administration proved to be very challenging. The two-story, 43,000-sq.-ft. structure is highly site specific and features two rectangular wings connected by a arced central portion. In addition, a large rectangular faculty office area is set into the main portion of the building at a skewed angle.

"The curved walls result from the relationship of the building to the site and a desire to create a relationship between this new building and nearby existing structures," explained Tony Fellnor, AIA, project architect with Hillier. "In addition, the site geometry required the faculty block to be set skewed to the rest of the project." The separate nature of the faculty block also granted the ability to seal off the faculty office area from the rest of the building for security and privacy.

To help tie the project together, while at the same time providing a "visual broadening", the building features three atria. While the variety of architectural features creates a wonderfully concise teaching and study environment, the disparate nature of the design creates a structural headache.

"The geometry of the building is very complex, with a rectangular section rammed in at an obtuse angle, several curved walls, and several large open spaces," explained Terry Blackburn, P.E., principal with Blackburn Engineering Associates, P.A., in Princeton. "Lateral loads are resisted by moment frames, and since the geometry is so complicated, quite a few moment frames were required."

Most of the structure consists of A36 steel W8 wide flange columns with steel beams and girders and a composite floor slab. In areas with very short spans but high loads, A572 Grade 50 girders were used.

Because the architectural details would not allow the use of expansion joints, the engineer had to find

Construction photography by Bernstein Associates.

The school's curving hallways complicated the design of the building but were desired by the architect to help relate the building to nearby existing structures.
Photo by Esto Photographics.

another way to tie the sections of the building together to prevent differential movement. "The architect had designed several walkways across the open areas and we used horizontal trusses in those areas to tie the structure together," Blackburn said. The trusses consist of regular floor members connected with 8"-deep wide flange sections and are designed for axial loads of 30 kips.

The curved section of the building was accommodated by cantilevering the deck beyond the straight steel members to form the radius of an arc. In exterior areas, the steel members were designed to handle torsional loads created by the weight of the cladding.

"Steel was the only viable system for this building," Blackburn said. "The lack of repetition made concrete prohibitively expensive. In addition, the small column size with steel construction allowed the steel members to disappear into the architectural finishes. That wouldn't have been possible with concrete."

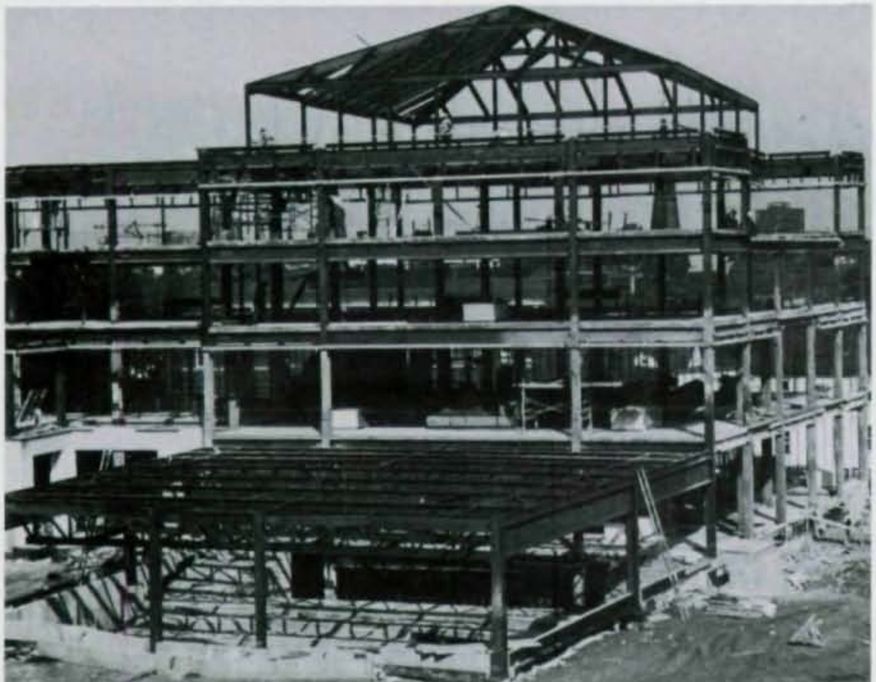
Lehigh University

The four-story, 115,000-sq.-ft. facility includes 44,000 sq. ft. of instructional space with computer classrooms, 23,000 sq. ft. of faculty offices, and 6,500 sq. ft. of administrative and support space. In addition, the business school houses six research centers and a 200 seat auditorium.

The building is located on the site of the old football stadium, "the last remaining flat surface on campus," explained Craig Ronning, AIA, project designer with Hillier. Future plans for the site include a new Performing Arts Center and a parking structure. The building's footprint anticipates the future construction through its L-shape which begins to form a courtyard.

"With any academic building, it's important to group the classrooms together," Ronning said.

Because the facility is also used for seminars for business executives, high quality finishes were essential to the design of Lehigh University's new Business School.



The design of a two-story gallery in the middle of the Lehigh University's new Business School required that girders be discontinuous in that area. In that area, the roof is the only structural link.

The classrooms are all grouped on the first, second, and a below-grade level and connected with stairways. The faculty offices are on the fourth floor and the research center is on the third floor. A two-story gallery space runs through the main portion of the classroom area.

A composite structural steel frame was chosen for the building primarily for economic reasons, but also because it allowed a column spacing that provided maximum flexibility, according to Emad Youssef, P.E., senior associate with Paulus, Sokolowski & Sartor, Inc., a structural engineering firm headquartered in Warren, NJ. "Steel construction was lighter, which helped reduce our foundation costs, and it provided faster erection, which was important in getting an academic building open as soon as possible. Also, steel was more economical given the required bay spacing."

Columns are W10 wide flange shapes and the engineer designed moment resisting connections. "The building isn't high enough to warrant the expense of X-bracing," Youssef said. In addition, architectural requirements would have made bracing location difficult. The only exception of simple beam and column construction occurs in the auditorium area, which features 60'-long trusses.

The major area of complexity for the project is the gallery. Because the gallery runs through the middle of the building, girders are discontinuous in that area. "We used a computer model for a wind frame to accommodate the two areas of the building," Youssef explained. "In that area, the roof is the only structural link between the two areas."

The beams, columns and truss members were protected with spray-applied fireproofing, while lightweight concrete provided fire protection for the metal decking.

Rutgers University

The three-story, 58,000-sq.-ft. structure houses offices and classrooms for approximately 150 faculty, staff and continuing-education students.

"The building is organized around an atrium running the length of the building," explained Andrew Buchsbaum, AIA, project designer with Hillier. Four groups—the business school, graduate school of management, Institute for Management and Labor Relations, and Management Development Center—regularly use the building and the atrium provides a point of orientation as well as separation.

The building is rectangular in plan and a master plan for the university calls for the building to form the first edge in a proposed new quad of buildings.

A steel moment frame was chosen for the project because of a need for flexible column layout. "The architectural design called for differing space layouts on each level, so some columns couldn't continue straight down," according to Alger R. Ross, P.E., a now-retired project manager with H2M Associates, Inc., in Totowa, NJ. Deep steel girders were used to pick up the W10 wide-flange columns in locations where the architect required column-free spaces.

As with the Lehigh project, the central atrium posed the problem of discontinuous girders. "We had to design the columns on each side of the atrium to individually carry the wind load," Ross explained. □

Business schools, such as this one at Rutgers University, feature a unified environment combining classrooms, faculty offices, research space and facilities to house various management programs.

EDUCATION REPORT

Exposed Structure

Iowa State University's new recreation/athletic facility is not just noteworthy for its size, but also for its lively, exposed design.

Terry A. Shuck, P.E.

While the structural and mechanical systems in many gymnasium buildings are left exposed, the inner workings of the 216,000-sq.-ft. ISU Rec Center go one better: An elevated jogging track permits a birds-eye inspection of the roof's huge trusses.

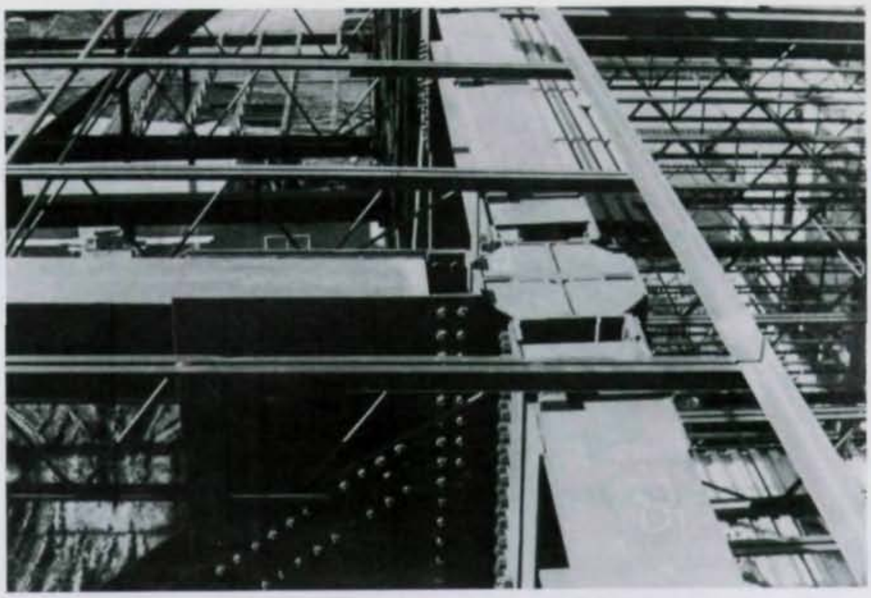
The facility was designed for combined use by students and varsity athletes and serves as a retreat from the collegiate educational atmosphere. Specific program requirements included a 60-yard indoor practice football area with synthetic turf flooring; an indoor eight-lane 300-meter track; a large multi-purpose floor area to alternately offer 20 basketball courts, eight volleyball courts or three tennis courts; an elevated jogging track; weight rooms; nine racquetball/handball courts; a varsity wrestling room; a sports medicine clinic; and locker and equipment rooms.

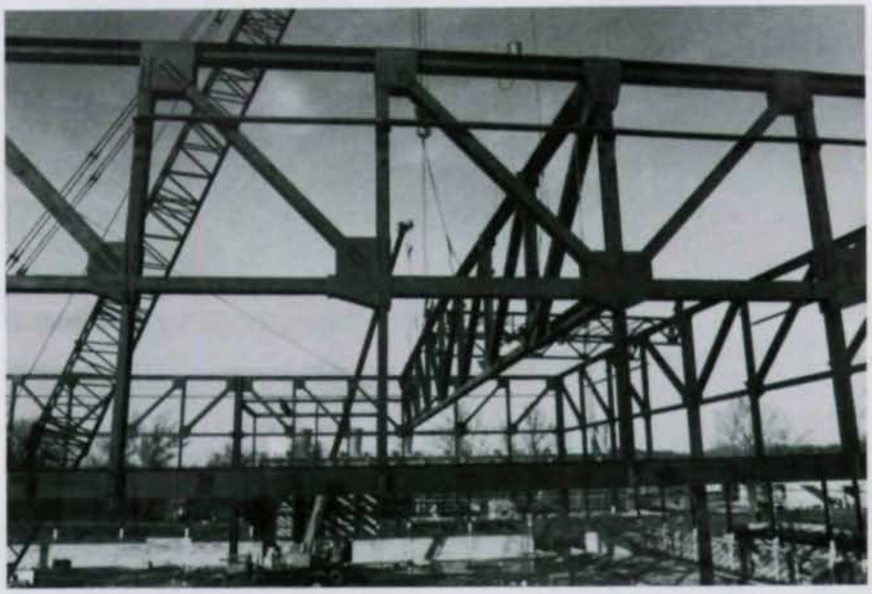
Dividing curtains segment the multi-purpose space to allow concurrent use of the space. Fast conversion of space for various sports was a major design consideration.

Large-Scale Design

Ground level footprint of the Rec Center is 460′ x 256′. Columns

The steel structure of Iowa State University's new recreation center was left exposed both to reduce costs and to add visual texture to the space. (Construction photo by Person Studio)





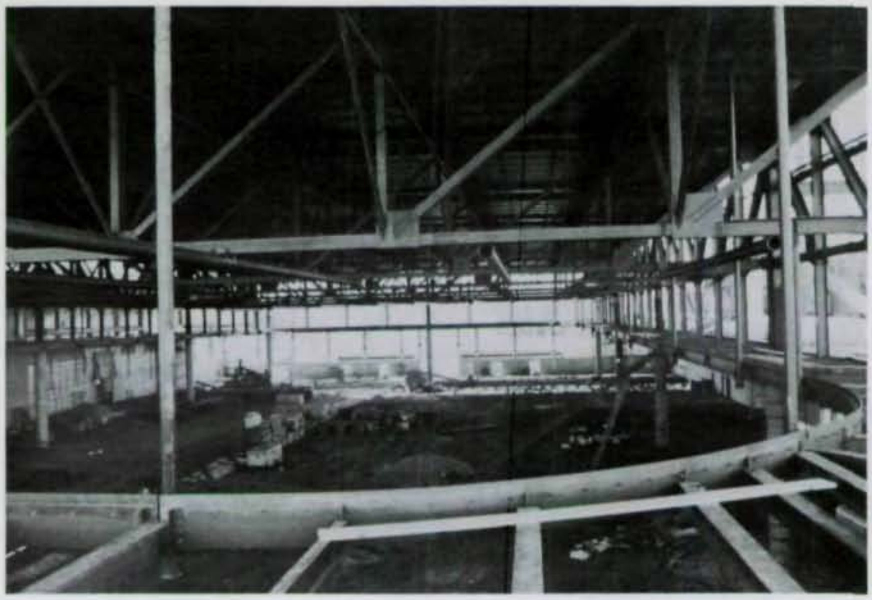
The cruciform shape of the column (top) helped provide stability during truss erection. Joist girders and steel joists were erected as preassembled units to reduce erection time and cost. The end wall support trusses (bottom) eliminate the need for intermediate columns and provide more open space in the facility.

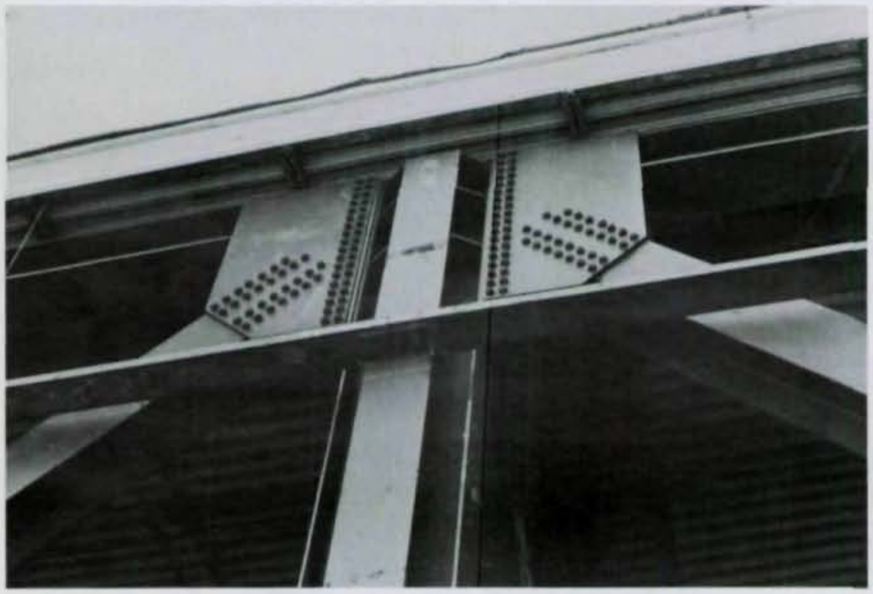
are spaced at 94'-6" centers east/west and 170' centers north/south to create a column-free interior space 378' x 170' x 39' high.

Due to the requirement of a large column-free space, steel trusses were an obvious solution. As a result, steel also was used for the columns because of the ease of making steel-to-steel connections. In addition, steel gave us a very rapid erection process.

The columns were fabricated into a cross configuration using a W21 x 101 and two W12 x 65 wide flange sections welded together. The column provided stiffness and stability during erection and allowed all truss/column connections to be similar.

Truss-to-column connections were made with 6" x 4" x 34" angles shop welded to the column flange and field bolted to the truss gusset plate. The steel erector requested the trusses be bolted into the side of the column instead of the top to



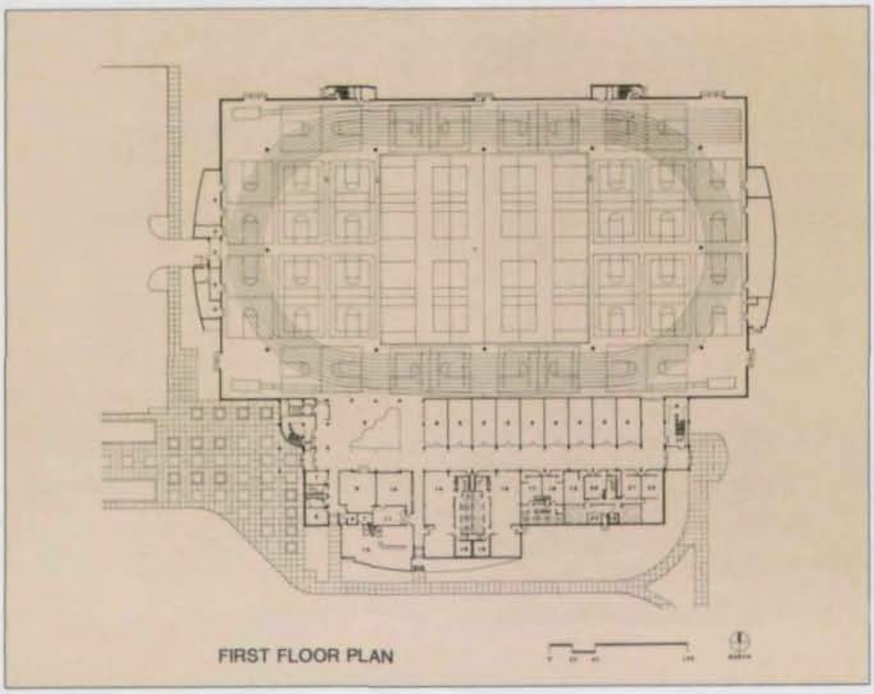


Slender vertical pipe hangers and diagonal rods were used to support the elevated track, which eliminated the need for support columns that would have interferred with the column-free nature of the lower level (top). The use of bolted connections helped to enhance the visual character of the structure.

provide stability/rigidity during erection.

The lower portion of the columns were encased in concrete to form a 3'-diameter shape, while the upper portion was left exposed. The concrete encasement provided fireproofing, which was required by code in the lower portion of the structure, and stiffened the column. In addition, the rounded edges of the concrete encasement provided an added margin of safety for the facility's users compared to the square edges of a steel column. Column reactions are 1400 kips.

The main roof trusses are spaced at 47'-3" centers and clear span 170' over the multi-purpose arena. Truss depth varies from 18' at mid span to 16' deep at ends. Trusses were fabricated using W14 wide flange sections produced from high strength ASTM A572 Grade 50 steel and bolted connections. Trusses were fabricated and shipped in three pieces for simplified field erection.



The facility features a large column-free area for sports as well as support space, including locker rooms, a sauna, equipment storage, and meeting rooms.

Suspended Running Route

One of the most unusual aspects of this job was the elevated jogging track. The 1⁄5-mile track is located 29′ above the main floor at the perimeter of the multi-purpose area.

Track construction is a 5" concrete slab on 2" composite steel deck. The jogging track is suspended from the main roof trusses with vertical 5" diameter pipes and diagonal 2" diameter solid rods. Clevises and turnbuckles were used to add character to the unique support system. X-bracing at the perimeter sidewalls also were fabricated with solid rods, clevises and turnbuckles.

Construction cost of the facility was $13 million and construction took 1½ years. General contractor on the project was McHan Construction, Inc., Sioux City, IA.

Terry A. Shuck, P.E., is president of Shuck-Britson Inc., a consulting engineering firm headquartered in Des Moines, IA. □

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EDUCATION REPORT

Schoolroom Expansion

A steel-framed high school built in the 1960s was easily expanded to accommodate large science classrooms

West Valley High School in Spokane, WA, was typical of secondary schools built in the 1960s: A low-rise structure with many small rooms. But with society's renewed interest in the sciences, laboratory space was too limited for today's needs.

Before investigation, the brick columns appeared to be load bearing...

...but the real columns were structural steel I-beams that doubled as window mullions and were spaced less than 6' apart...

"At the time the school was built, science laboratories were comparatively small," explained Bill James, project designer and a partner with Integrus Architecture (formerly WFML Architects & Engineers) in Spokane. "In this case, the school district asked for enlargement of existing laboratories and at the same time the enlargement and conversion of some adjacent classrooms into laboratories." The plan was to add six 20' x 32' bays to the first floor, while leaving the second floor alone.

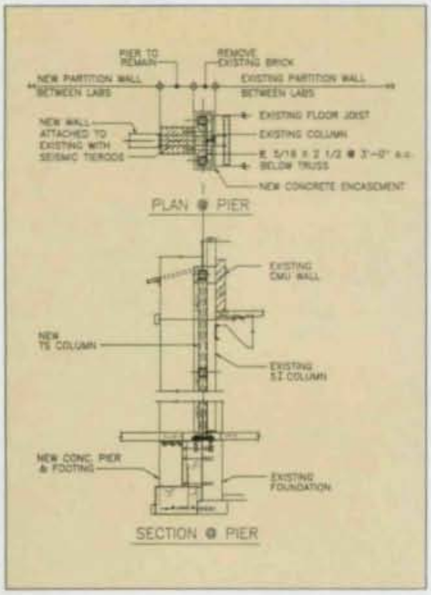
At first glance, the project seemed as simple as removing the lower exterior wall be-

...a new steel truss was added to carry the load supported by the I-beams...

tween columns and roofing over a new space. However, the large brick piers that were spaced at 20′ centers and looked as if they carried all of the loads were found to be mostly decorative. Instead, the "real" columns were structural steel I-beams that doubled as window mullions and were spaced less than 6′ apart.

"The 5" I-beams were encased in steel jackets and looked like window mullions, rather than load-bearing elements," explained John Plimley, P.E., partner in charge of the Integrus' structural department.

Upon further examination, Plimley noticed that the columns projected beyond the face of the building. "It just seemed to suggest welding a

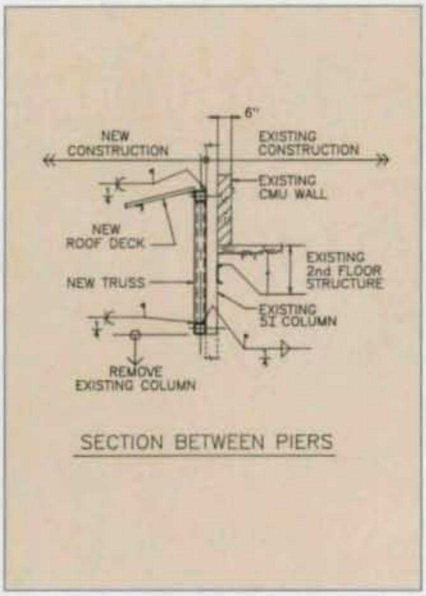


steel beam or truss up against the columns at the second floor so that the lower columns could be removed."

The first step was to put a

...a steel tube was installed on each side of the brick pier to support the new truss...

...the truss consists of rectangular steel tubes...



steel column on each side of the existing brick piers. "We used rectangular steel tubes both for torsional resistance and because the flat surface simplified the attachment to the existing structure," Plimley said. "We could put the flat surface right up against the steel columns."

Prior to removing the old structural system, the new truss was installed. To simplify connections to the new columns, steel tubing also was used for the trusses. The columns and chords are 5" x 5" tube while the web members are 5" x 3" and 5" x 2" tube.

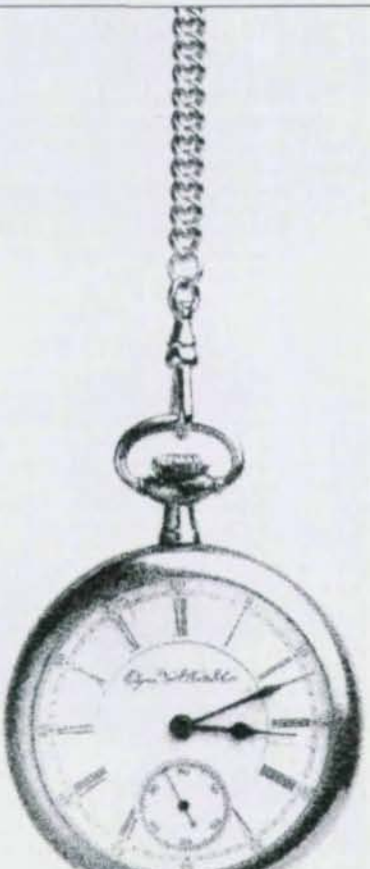
The new structure consists of open web steel joist purlins supported primarily on steel stud bearing walls and, in one case, wide flange columns where two bays are joined together.

The trusses were estimated to deflect a maximum of ¼" under dead load. This was considered small enough to forgo the necessity of pre-loading with full dead load. However, a small pre-load was applied in

...while the new construction consists of open web steel joist purlins supported primarily on steel stud bearing walls...

...after the truss was fastened to the new columns, the old steel I-beams were cut away and removed...

order to make sure that the load would be transferred elastically from the columns to the truss. This decision was vindicated by the fact that the trusses only deflected 3⁄16", well



within the limits required to prevent masonry cracking, Plimley explained.

After adjacent trusses were successfully installed, they were linked together by field welding horizontal tubes between their top and bottom chords. These connections provided two benefits. First, it provided a continuous frame to resist lateral forces. And second, it provided continuity to reduce as much as possible further deflection of the masonry when live loads were applied.

Because the existing structure remained in place during the installation of the new trusses, the upper floors of the school could remain occupied during construction. General contractor on the project was C&D General Contractors, Helena, MT. □

...and the completed building provides the needed classroom space.

The Swedish Solution For Residential Buildings

Engineers in Sweden have modified traditional construction design to enhance the use of steel on residential and other low-rise projects

By P.O. Thomasson

Steel was chosen for this office building in Stockholm primarily for economic reasons. With a steel frame and lightweight concrete deck, the structural system cost $5.8 million, while with a cast-in-place concrete frame, the project was estimated to cost $6.75 million. Much of the cost differential came from a reduced construction time with steel, which resulted in lower interest charges. Another cost advantage was the added leasable space provided with steel construction.

While the use of steel for office construction in Sweden has risen dramatically during the past decade, a corresponding increase in the multifamily residential market is only slowly occurring.

During the 1980s, the use of steel for office buildings rose from less than 5% to more than 50% of the Swedish market, in large part for the same reasons that are applicable to U.S. construction, including: faster speed of erection; smaller structural elements that can be accommodated within floors and walls to increase usable area; longer spans, which eliminates the need for loadbearing walls and increases layout flexibility; lower weight, which reduces foundation costs, especially on weak soils; and flexible design that readily accommodates renovations and additions.

Height limitations, however, have traditionally been the bane of steel construction. In response to the height requirements commonly imposed by municipalities in Sweden, many designers have begun using a system whereby precast concrete floors are supported on the bottom flange of a welded "hat" profile built into the floor construction, or on the bottom flange on a W-shape. Because the steel is predominantly encased in the concrete slab, little or no fire protection is required.

This steel construction system results in the same floor-to-floor height as occurs with concrete construction, but with all of the other requisite advantages of steel construction.

Design Principles

The most common column/beam system in Sweden comprises multi-story columns and simply supported floor beams spanning between the columns. Columns are most commonly wide flange shapes, though hollow structural sections also are occasionally used.

The building can be stabilized either by concrete staircases/rigid concrete gables or by steel trusses in staircases, internal walls and gables. Experience has shown, however, that stabilization by steel trusses provides advantages over shear walls. The spaces in the truss allow for holes and openings and the alignment of the truss can be such as to have a minimal effect on the architecture of the building. Also, by altering the alignment of the trusses, the incremental forces due to stabilization can be spread over several columns.

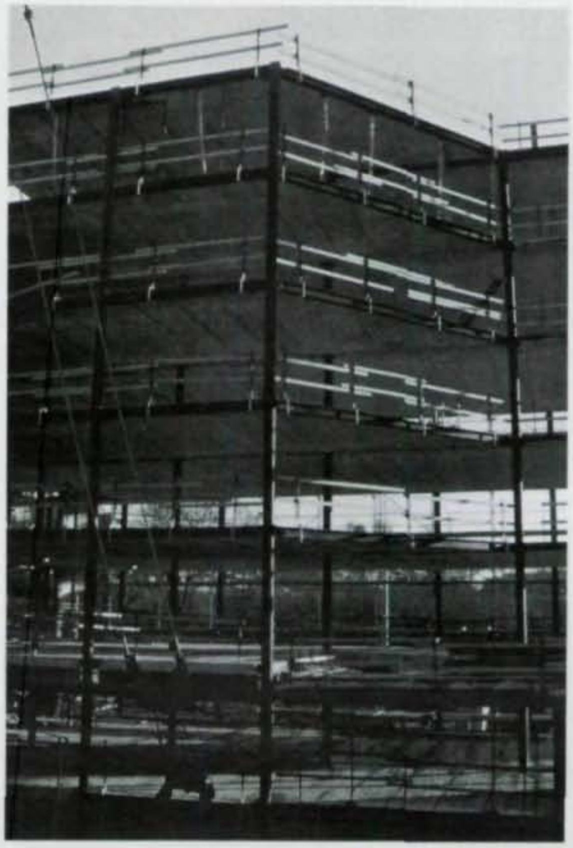
Floor Design

Because of the need for a separate ceiling when metal decking is specified, prefabricated hollow concrete units dominate the Swedish market. With the aim of creating a composite floor with a smooth soffit, a new steel floor deck profile was developed at the Swedish Institute of Steel Construction in collaboration with Dobel AB. The profile is available in two versions, one providing a ceiling prepared to accept standard finishes and the other with a built-in fixing rail for the suspension of building services installations.

In the U.S., engineers can specify cellular floor deck to achieve a flat bottom that will readily accept ceiling finishes without the need for a suspended ceiling.

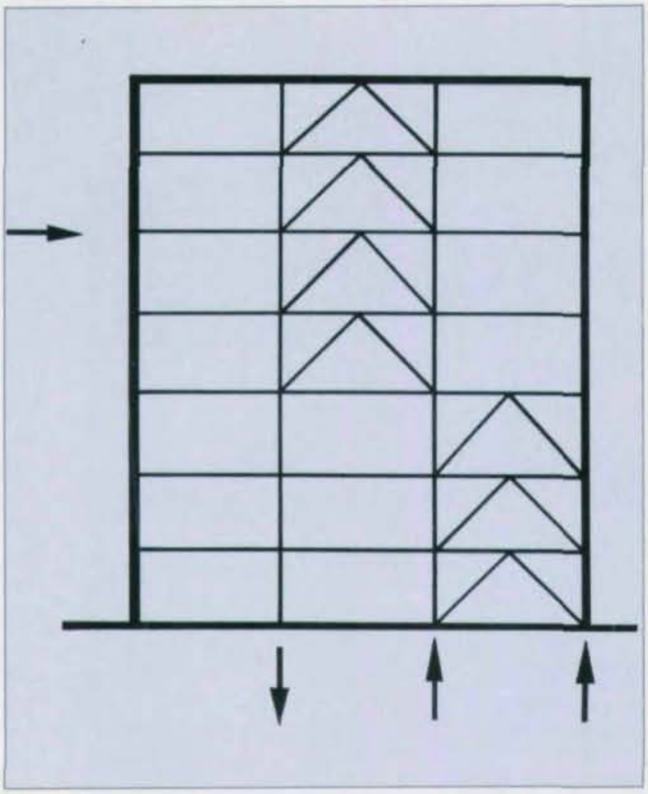
The design has been subjected to fire tests and meets Swedish Building Code standards by providing a minimum of 90 minutes—despite the sheeting surface being exposed to fire.

This design offers several advan-



Shown at left is a typical low-rise office building in Stockholm with a steel frame and precast concrete hollow decks. Below left is a close-up of a workman welding a column-beam joint on the same building. Below right is a detail photograph showing a precast concrete slab supported on the bottom flange of a welded "top-hat" profile. The system is highly efficient in that the floor beams are accommodated inside the floor slab, which reduces the overall thickness of the floor while also reducing, where codes allow, the required amount of fire protection.

Stabilization by steel trusses provides an advantage in that the spaces in the trusses provide ready-made penetrations with a minimal impact on the building's architecture. Also, by altering the alignment of the trusses, the incremental forces due to stabilization can be spread over several columns.



tages, especially for confined work spaces. Since the deck is a self-supporting work platform, deck erection, work on building services and fixing of reinforcement can be carried out several levels above a floor on which concrete is being cast. Also, the deck can be used to stabilize the steel frame during construction.

Connections

The connections developed for use in this construction method are designed to be easily fabricated and constructed. The connections between different frame components must be selected with regard to space requirements and the effect the connections will have on other parts of the structure. Because stiffeners are sometimes difficult to fit and may interfere with architectural finishes, it is generally better to use thicker material for the connections and details.

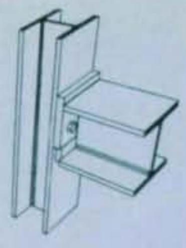
Critical factors governing the choice of connections include: ease of mounting; accommodation of dimensional deviations; and ability to be fireproofed.

Swedish designers are commonly using eight types of connections in this design method.

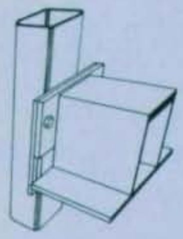
- BP1 is a simple shear connection between a wide-flange or box beam and a wide-flange column section. The connection is easy to mount and the beam is supported on a cleat on the column. The cleat can be partly or wholly concealed. When shear forces are small, the bolts can carry the load and the cleat is used only to facilitate erection.
- BP2 is a simple shear connection between a wide-flange or box beam and a rectangular column. A cover plate is welded to the column so the beam can be easily bolted on. Otherwise, this connection is similar to BP1.
- BP3 is a simple shear connection between a wide-flange beam and a wide-flange column. The beam is laid on an angle welded be-

The system of through columns and simply supported beams, such as on this low-rise office building in Stockholm, can easily accommodate dimensional deviations and has become the dominant system in Sweden.

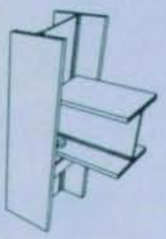
BP1



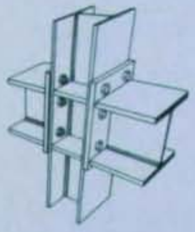
BP2



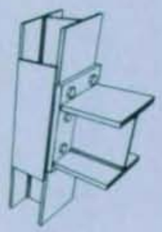
BP3



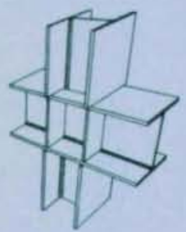
BP4



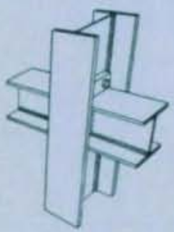
BP5



BP6



BP7



BP8

tween the column flanges. Two bolts between the bottom flange of the beam and the seat hold the beam in position. If the beam is wider than the depth of the column web, the edges of the beam flanges of the beam must be coped near the connection so the beam can be fitted in between the column flanges.

- BP4 is a rigid moment connection with bolted end plates. The beam is a wide flange section. For this type of connection, the column must in most cases be reinforced by stiffeners between the flanges. The beam can be mounted relatively quickly if an erection cleat is welded on the column.
- BP5 also is a bolted rigid moment connection between a beam and a wide flange column section. The column is reinforced by external vertical plates between the flanges. BP5 permits the installation of services between the reinforced flanges.
- BP6 is a beam-column connection for continuous beams. The beam and column may have an open or closed section. During erection, the beam is placed directly on the column and is joined to this by fillet welds around the column periphery. Welding is carried out in the overhead position which is the most difficult position for welding. The next story-high column is laid on the beam and welded around its base. Each column must be braced story-by-story. The continuous beam need not be assumed to transmit moment to the column.
- BP7 is a beam-column connection where the beam also is regarded as continuous. The beam may be a wide-flange section or box section. The column is a wide flange shape and the beam is connected to the column in the direction of its minor axis. This type of connection is used for heavy columns and the beam is connected by bolts to the end plates. Any gaps between beam and column is taken up by spacers.
- BP8 is a connection of a continuous beam to a slender column, for instance in a facade. The beam may be a wide flange section or a channel. In a facade, continuity is an advantage since it prevents progress collapse due, for example, to collision between a vehicle and the facade column.

In selecting the type of connection, attention also must be paid to non-structural components and fireproofing.

This article was adapted from a paper delivered by Professor P.O. Thomasson of the Swedish Institute of Steel Construction in Stockholm, Sweden, at the National Steel Construction Conference in Washington, DC. A full copy of the paper, along with other engineering papers presented at the conference, is included in the Conference Proceedings and can be purchased for $35 + $4 shipping and handling ($5 outside U.S.) from: American Institute of Steel Construction, Inc., P.O. Box 806276, Chicago, IL 60680-4124 (312) 670-2400 ext. 433.

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MetalMizer's new upright metal cutting bandsaw incorporates standard, readily available components to produce a less expensive cutting tool. The simple air-hydraulic feed system is designed for years of rugged operation and is easy to adjust and maintain. Expensive gear boxes have been eliminated by transferring power to the blade simply and efficiently. Because of this, the saw takes up to 30% less floor space than competitive saws. The saw is equipped with a 2 HP motor, 1" x 14′6" variable tooth blade, 6 point guide assembly, a wire chip removal wheel, and 18" x 20" cutting capacity. The cutting head is counterbalanced and easily adjusted by one operator up to 45 degrees in either direction.

For more information, contact: MetalMizer, 8180 West 10th St., Indianapolis, IN 46214-2430 (800) 553-0182.

Punches And Dies

The Cleveland Steel Tool Company has published its new four-color catalog. It details products available both in stock and by special order. Included are punches; dies; tooling for Hydraulic Angleline, Hydraulic Beamline, and Hydraulic Portable Punching Machines; and tooling for W.A. Whitney, Fabriline, Buffalo Ironworkers, Schotchman/Dvorak, Uni-Hydro, Lehman/Bateman, Nitto Kohki, Enerpac, Cold/Hot Punching Spring Steel, Metal Culvert Punching, and Adapt Machines.

For more information, contact: The Cleveland Steel Tool Co., 474 East 105th St., Cleveland, OH 44108 (800) 446-4402.

Plate Duplicator

COMEQ now offers a CNC Plate Duplicator/Automatic Positioning Table from GEKA as optional original equipment on GEKA Hydraulic Ironworkers and punches or for retrofit on GEKA and other-make hydraulic ironworkers and single-end punches and radial drills. The table is available in two sizes, 20" x 40" and 30" x 60", and offers an affordable solution for those customers with material layout and handling problems.

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Bench-Top Coper

A hairline fit is critical to the quality and appearance of joints, but is not always easy to achieve. The Linders Bench-Top Coper rounds off any shape of pipe, tubing, channel or bar, creating a precise-fitting joint in seconds. For example, a 90 degree cope on a 1½ SCH 40 steel pipe can be completed in only 10 seconds without precoping. A self-centering vise allows the stock of any shape ranging from ¾" to 3" to be coped to a surface from ¾" to 4½" round.

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Electronic Level

The SmartLevel Series 200 from Wedge Innovations is the second in a family of digital electronic levels. Unlike traditional "bubble" levels, these durable electronic levels give precise readings. The level can measure all angles, and depending on which model is used, can display degrees, percent slope, and rise/run (pitch).

For more information, contact: Wedge Innovations, 2040 Fortune Dr., Suite 102, San Jose, CA 95131 (408) 434-7000.

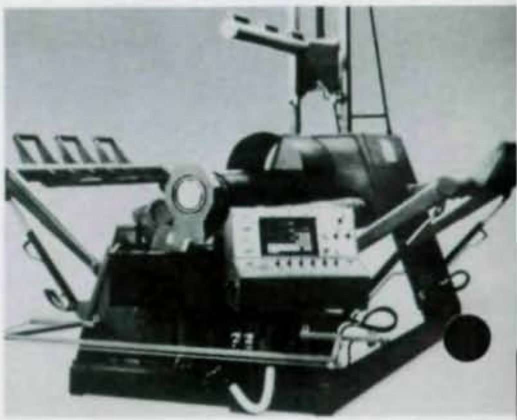

Plate Bending Machine

The Heller/Davi 4-Roll Plate Bending Machine features the ability to roll 1.1 times the upper roll diameter, which is up to 30% tighter than competitive machines. In addition, the plate bender offers: more productivity; the ability to introduce plate in the machine in an absolute horizontal position; two central rolls, which eliminates slippage; planetary gear drives for increased controllability; automatic lubrication; choice of manual or CNC controls; automatic squaring of plate; and a capacity of 6' x ¼" thru 12' x 2".

For more information, contact: E.G. Heller's Son, Inc., 18330 Oxnard St., Tarzana, CA 91356-1502 (800) 233-0929.

Angle Fabrication

Angle fabrication is simplified with W.A. Whitney's 846D CNC Anglematic. The compact machine features two 75-ton presses and a 70-ton shear all mounted on one rigid frame and a continuous feed which eliminates drop-off sections. The machine fabricates up to 6" x 6" x ½" A572 angle, punches holes up to 1½" diameter, and process flat stock up to 6" x ½".

For more information, contact: W.A. Whitney Corp., 650 Race St., P.O. Box 1206, Rockford, IL 61105-1206 (815) 964-6771.

Mobile Crane

Rugged mobile cranes from Giant Lift Equipment Manufacturing Co. operate in areas where fork trucks are not useable. The cranes feature an adjustable boom that moves up-or-down, in-or-out, and side-to-side for positioning accuracy of 0.01".

For more information, contact: Giant Lift Equipment Manufacturing Co., P.O. Box 626, 136 Lafayette Road, North Hampton, NH 03862 (800) 52-GIANT.

Punches And Dies

The American Punch Co. offers a wide range of low-cost punches, dies, and shear blades for angleline, beamline and portable punches. In addition, the company offers a variety of shear blades, coupling nuts and punch stems.

For more information, contact: The American Punch Co., 685 S. Green Road, Cleveland, OH 44121 (800) 243-1492.

Saw Blades

A wide variety of segmental saw blades, bandsaw blades and an ICAS Software Program for high-speed cutting is available from Insco Saw Division. ICAS selects the proper blade, correct feeds and speeds to maximize beam cutting efficiency.

For more information, contact: Insco Saw Division, 320 International Circle, Summerville, SC 29483 (803) 873-7850.

Kaltenbach/Behringer

Kaltenbach, the world's largest manufacturer of circular cold saws, announces the addition of two models. The all new HDM-1000 and HDM-1400 structural saws are designed for use in a "tandem system" with our structural CNC drill. Unique design includes a traveling saw arm and fixed datum fence to include miter cutting, optifeed, and vertical clamp. Popular options include CNC control for 89 cutting angles and FABCUT software package for fabricators. For more information, contact: Joseph A. Dick, executive vice president, Kaltenbach, Inc., 6775 Inwood Dr., Columbus, IN 47201 (812) 342-4471.

Aerial Lift

The new SL-26 Aerial Work Platform from Up-Right offers all-terrain capability, powerful 4-wheel drive, multiple power options, and a large, high-capacity deck. Standard features include: 32' working height; 1,500 lb. workload, and 70" x 144" platform. The lift meets or exceeds all applicable OSHA and ANSI standards.

For more information, contact: Up-Right, Inc., 1775 Park St., Selma, CA 93662 (800) 437-0770.

Pangborn Corporation

Pangborn offers a wide range of blast cleaning systems for descaling plate, rolled shapes, weldments and fabrications, for both pre- and post-blast descaling. Scale models and visual aids will be used to depict a wide variety of blast cleaning systems used in surface preparation of materials for burning, welding and applications of coatings.

For more information, contact: Pangborn Corp., P.O. Box 380, Hagerstown, MD 21741-0380 (301) 739-3500.

Peddinghaus Corporation

Peddinghaus has introduced the Fabriline 2000 Model BPL 1000/5 is an innovative machine for automatically punching steel sections. It features a patented flange press configuration that punches opposing flange holes simultaneously and automatic mechanisms to adjust the die height of the web press.

Also newly introduced is a machine with the capability of punching up to three different hole diameters through 1¼"-thick material using a 154 ton hydraulic punch. Also, the machine has plasma cutting for cut-to-length shapes. This unique combination affords the user the capability of quick machine setup as well as enhanced production capabilities with little changeover time.

For more information, contact: John J. Holland, vice president, system sales, Peddinghaus Corp., 300 North Washington Ave., Bradley, IL 60915 (815) 937-3800.

Pipe Notching Machines

Almi Jancy pipe notching machines allow inexpensive productive notching of all types of pipes and tubing. The machine ensures that pipe is notched quickly and accurately the first time, so filing and grinding becomes a thing of the past. It is available in manually operated and electrically driven models. All of the notchers are portable and a single unit can notch several diameters of pipe without changes or attachments.

For more information, contact: Jancy Engineering Co., P.O. Box 3098, 4616 Kimmel Dr., Davenport, IA 52808 (319) 326-6251.

The Steel Market Today And Tomorrow

By T.W. Eagar

While the domestic steel industry's troubles were widely reported in the 1970s, its recovery has been widely ignored. As a result, many people continue to carry misconceptions about the future of the steel industry.

Currently, there is intense worldwide interest in advanced materials and processing. And while many pundits have called attention to the rapidly expanding markets for materials such as fine ceramics, composites and semiconductors, few are paying attention to the growth of steel. Part of the reason is that steel's growth rate is low—around 2% annually. But even with that low rate, the increase in the steel market in terms of both dollars and tons far outstrips the growth of other materials.

The steel construction market also is crucial as a major component of the U.S. GNP. For example, while many people decry the loss of the consumer electronics industry to offshore suppliers, they don't realize that the value of that market pales in comparison with the metals market. Purchase one new VCR and one new television for each of the 100-million households in the U.S. during the next decade and it will cost $60 billion. Purchase a new car for each household and it will cost $2 trillion. But rebuild the nation's infrastructure, and the cost will range from $5 trillion to $10 trillion.

The primary advantage of metals as a structural material is its exceptional combination of strength and toughness. Ceramics have exceptional strength, but their extreme brittleness precludes their use in true structural applications. Polymers have the required elasticity, but their low strength creates many structural problems. And while polymers have proven to have the requisite chemical and environmental stability needed for structural design, concerns over waste disposal may make this as much a liability as a benefit.

Mature Industry

Many observers suggest that the metals industry is based on old, outdated technology, and that the advanced ceramics, semiconductors, polymers and composites represent the high-technology wave of the future. For those whose professional interests have straddled the traditional metals industries, as well as the newer "high technology" industries, the claim of technological sophistication of advanced materials is striking.

From the point of view of materials science and fabrication technology, our knowledge of traditional materials far exceeds our knowledge of advanced materials. As one of my colleagues says, with traditional materials "all the easy problems have been solved." For example, the scrap rate for the steel industry is extremely low, especially when compared with to the advanced materials industries where rejection rates of 75% to 90% or more are not uncommon. Given the sophisticated applications of advanced materials, the processing employed in their production is remarkably crude.

In addition, extensive development has raised the physical properties of metals to exceptional levels. For example, a 10 ksi improvement in the fracture toughness of steel would represent an approximate 10% relative improvement, while an equal increase for a ceramic would represent a relative increase of 400% or more. Thus, major relative gains in the structural properties of metals are much more difficult to achieve than for other classes of materials.

The U.S. has moved from importing 40% of its structural steel to being a net exporter—including shipments to both Europe and Japan

Steel Today

During the 1970s, foreign producers made substantial inroads into the U.S. steel market—reaching, at one point, more than 40% of the total U.S. structural steel market. The domestic steel industry responded by upgrading its production facilities to produce a lower-cost, high-quality product.

Chaparral Steel, which began operating in the mid-1970s, is a good example of the domestic response to foreign incursion. The company uses steel scrap as a raw material, electric furnaces for melting, and continuous casting and rolling to produce bar stock and structural beams. The corporate strategy is to be the world's low-cost producer of quality steel products.

Given that world labor rates are much lower than U.S. wages, the company's philosophy was to reduce the labor content of a ton of steel to less than the shipping cost of a ton of imported steel. Thus, as Chaparral President Gordon Forward said: "Even if other countries pay their workers nothing, they would not be able sell steel in the United States at a lower cost than Chaparral." The strategy has worked. With less than 1,000 employees, Chaparral produces 1.5 million tons of product per year, which is equivalent to 1.2 man-hours per ton of steel. By comparison, the best integrated steel producers, both in the U.S. and abroad, require six man hours per ton.

Through the use of unconventional management, near-net-shape continuous casting and progressive rolling schedules, the company has reduced the cost of structural steel beams by approximately 30%. It completes the rolling process in seven to 11 passes, as compared with 25 to 30 passes for conventional processing. Today, virtually no structural beams of the size produced by Chaparral are imported, and the company is exporting to both Europe and Japan. And Chaparral is not alone, as can be witnessed by the success of Nucor and several smaller brethren.

At the same time that mills are refining their production processes, they also are introducing new products. For example, a quenched and tempered low-alloy structural steel plate with 70 ksi minimum yield strength (ASTM 852) was recently introduced. This steel was developed to close the gap between the 100 ksi and 50 ksi yield strength steels used in bridge construction. It is weldable, utilizing shop and field methods similar to those required by 50 ksi ASTM A588 steel. Also, it is a weathering steel with greater atmospheric corrosion resistance than carbon steel. By following the Federal Highway guidelines for the use of uncoated weathering steel, it virtually eliminates the need for painting, which can result in significant life-cycle cost savings.

Various techniques for timed quenching also have resulted in new product offerings. These structural shapes and plates have improved properties and weldability. TradeARBED HISTAR rolled beams and column shapes are produced by quenching and self-tempering steel with low carbon equivalent and result in a high yield strength, improved toughness, and excellent weldability. For plate steel, USS O-TEN is a low carbon steel made to an inclusion-shape-controlled practice and is quenched and tempered to provide 50 ksi minimum yield strength with improved through-thickness properties, notch toughness and weldability through 4" thick.

The Future Of Steel

While steel has retained its prominent place in the market, the lesson that has been learned is that competition is unending. Thus, efforts are continuing to reduce the cost of structural steel while continuing to improve its properties.

Among the most likely new technologies to produce cheaper products are new smelting processes which eliminate blast furnaces and coke ovens, and alternate solidification processes that produce a cast product much closer to finished size, e.g. "dog-bone" beam blanks or thin slab casting.

Steels of less than 50 ksi yield already are very weldable and have little need for improved microstructure. Instead, there will be a push towards higher toughness that will require increased used of clean steel melting and processing, specifically lower sulfur, lower nitrogen (if practical) and more uniform heating, rolling and cooling.

Steels with 50 to 100 ksi yield strengths are expected to show rapid improvement in weldability during the next decade. In addition, improved weld metals are expected to be developed that will permit higher inputs and increase productivity in fabrication.

This article was based on a talk given by T.W. Eagar at the 1991 National Steel Construction Conference and a paper previously published in Welding Journal. Eagar is the Richard P. Simmons Professor of Metallurgy, Department of Materials Science and Engineering, Massachusetts Institute of Technology, Cambridge. Part of this article also was based on a presentation by John Barson, a senior consultant at US Steel during the "Fundamental Aspects of Structural Alloy Design" conference at the Jaffee Symposium in Monterey, CA.

Estimated World Markets For Advanced Materials In The Year 2000

	Market Volume	Annual Growth
Fine Ceramics	$5 billion	20%
Composites	$15 billion	10%
Semiconductors	$100 billion	5%
Steel	$500 billion	2%

Comparison Of Expected U.S. Expenditures Between 1991 and 2000

A new TV and VCR for every U.S. household	$60 billion
Savings & Loan Bailout	$500 billion
A new car for every U.S. household	$2,000 billion
Defense Budget	$3,000-5,000 billion
Health & Human Services Budget	$5,000-$10,000 billion
Rebuild the nation's infrastructure	$5,000-$10,000 billion

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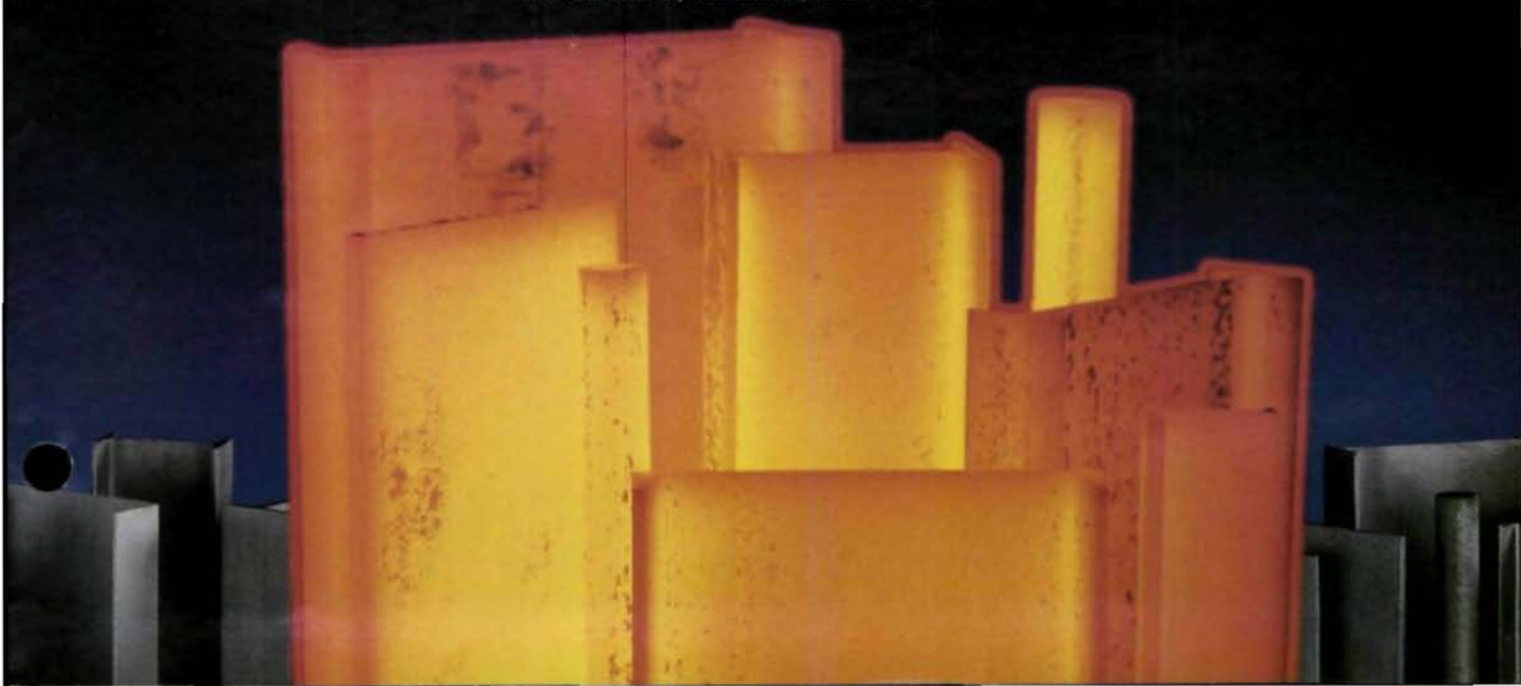

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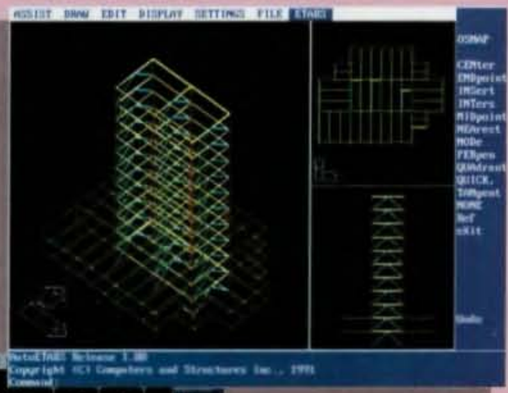

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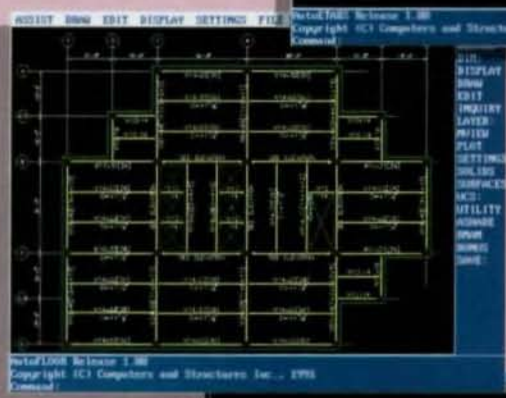

Floor Framing

Frame Elevations

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AutoETABS® - Structural Modeler for ETABS

This model generator is primarily for drawing and editing an ETABS model using AutoCAD. Additionally, this model information is directly available from the database for creating framing plans and elevations with AutoCAD. This scheme allows the draftsperson and the engineer to share common design information without duplication. Many data preparation steps associated with the ETABS model generation are also automated.

AutoFLOOR™ - Structural Steel Floor Modeler for ETABS

This program allows the automated analysis, design, optimization and drafting of structural steel floor framing systems of arbitrary configurations and loading. The program operates upon the entire floor framing system, distributing gravity loads to the various beams and girders as determined by the direction of the decking. The tributary areas and associated live load reductions are automatically computed. Composite and non-composite design options are available for ASD and LRFD specifications. Beam camber and vibrational characteristics are evaluated. Material quantity takeoff tables are also produced.

AutoFLOOR is closely interfaced with AutoETABS. The modules share information that automates the tedious task of transferring tributary floor vertical loads to the columns and girders of the ETABS model.

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