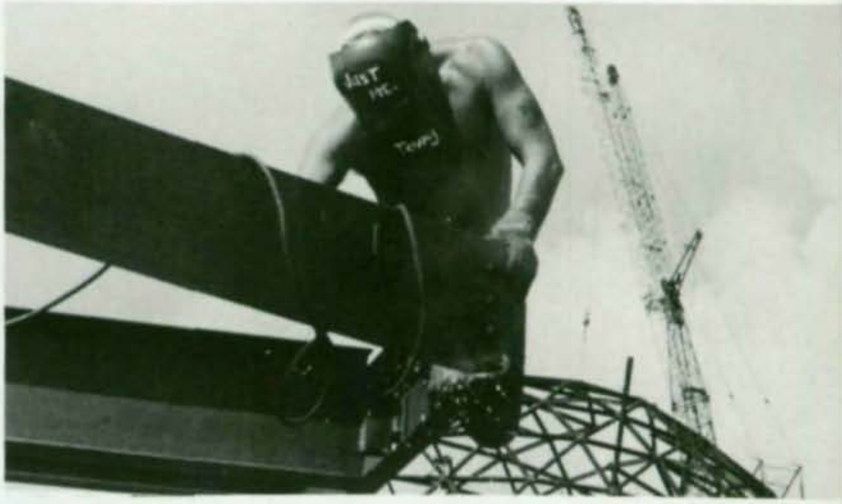
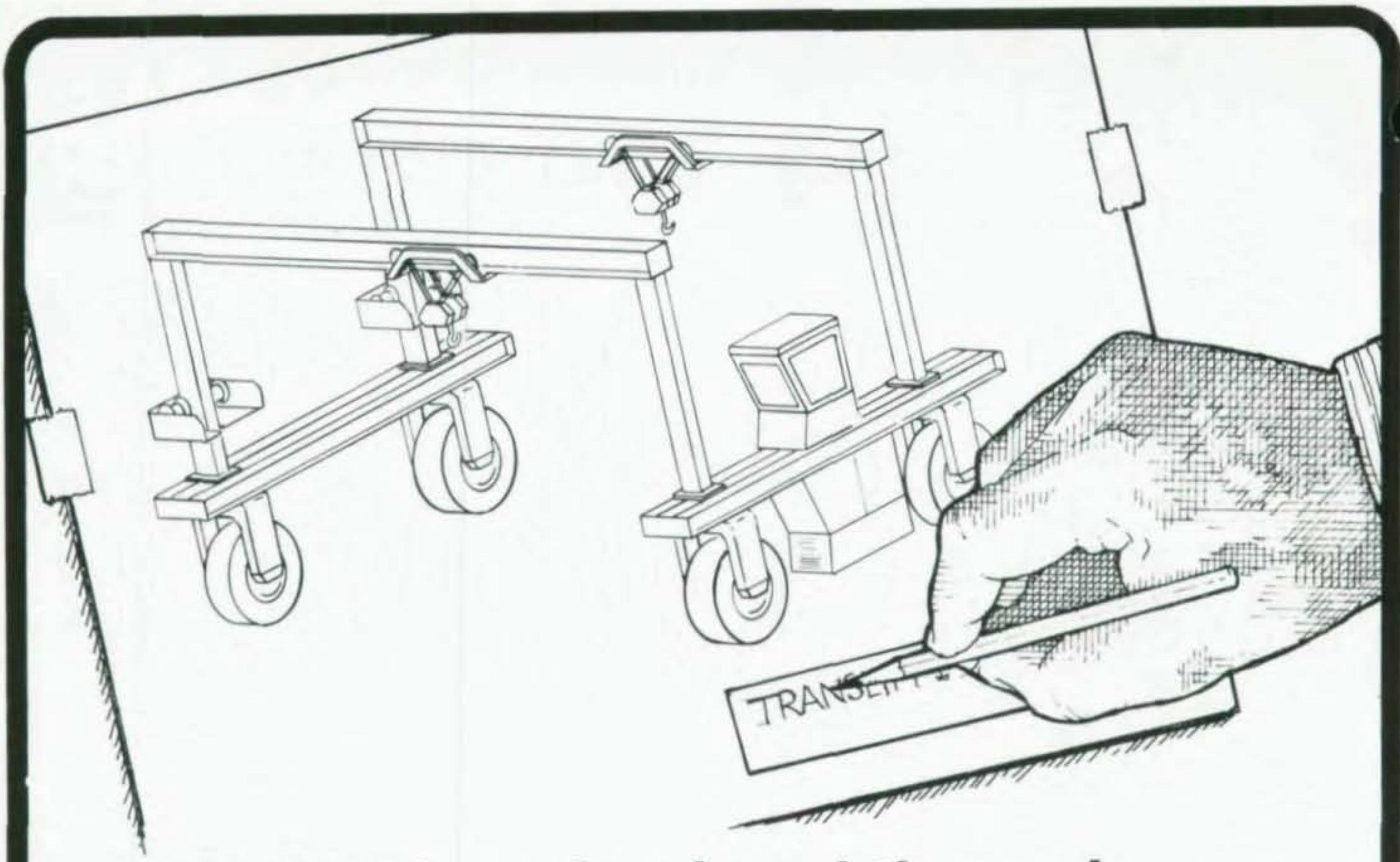
VOLUME XXII NUMBER 3/THIRD QUARTER 1982

MODERN STEEL CONSTRUCTION

A Building for the 21st Century
Weather, Strike Don't Slow a Fast-Track
Special Considerations in Cladding Attachments
Everyone Reads the Same Music!
1982 Prize Bridge Awards
EPCOT: Disney Does it Again!



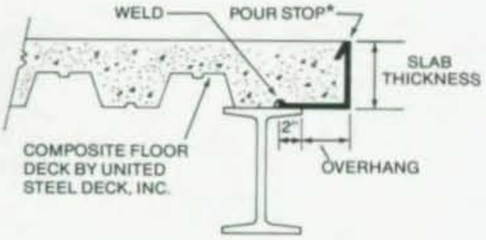

TRANS

DECK DESIGN DATA SHEET

NO. 1

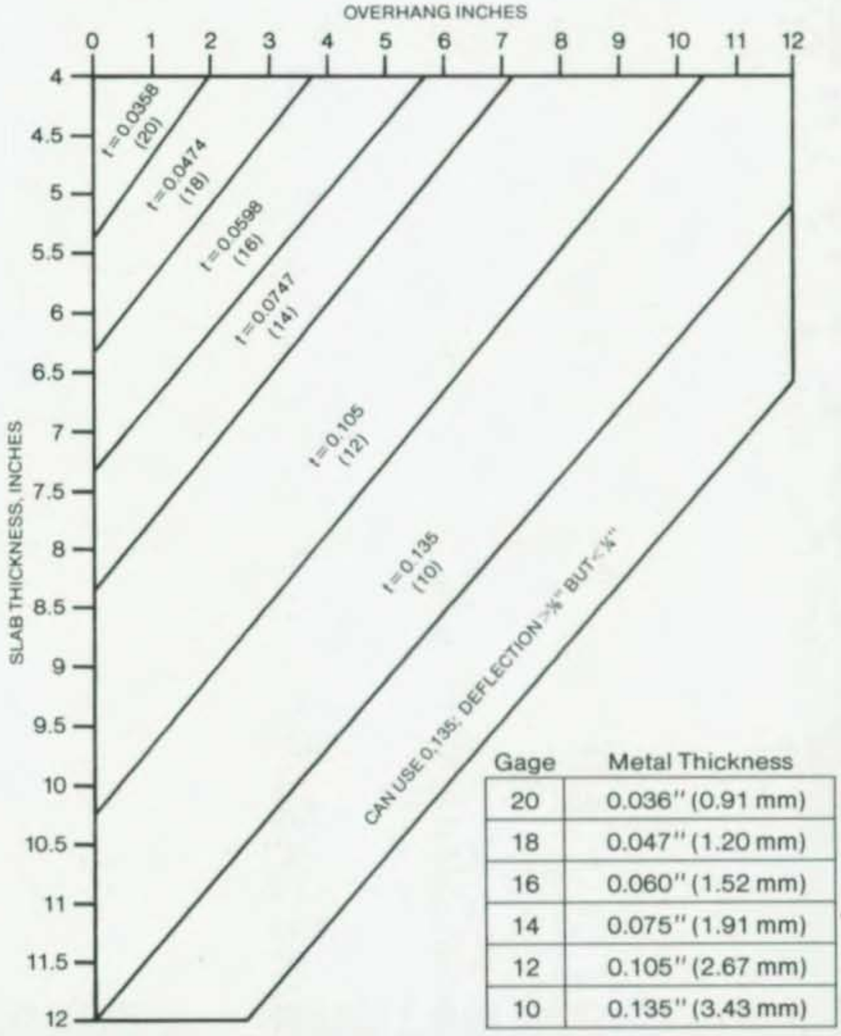
POUR STOP SELECTION CHART

The chart shows the thickness (gage) of the steel pour stop angle recommended by Nicholas J. Bouras, Inc. for the various slab thickness and overhang combinations. Two inches of bearing and one inch long welds at 12" O.C. are required. In determining these recommendations the steel stress was limited to 20000 psi and the deflection to ⅛".



Any time you need information on deck design, delivery, budget pricing, or bidding—call on us, your deckhands. Reprints of this chart are available on request.

*Return lip available on order.



Gage	Metal Thickness
20	0.036" (0.91 mm)
18	0.047" (1.20 mm)
16	0.060" (1.52 mm)
14	0.075" (1.91 mm)
12	0.105" (2.67 mm)
10	0.135" (3.43 mm)

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CONTENTS

AISC'S SECOND ANNUAL AWARDS BANQUET HONORS PRIZE BRIDGES

Slated for Oct. 26 at Chicago's Westin Hotel, the Second Annual Awards Banquet will feature the 1982 Prize Bridge Award winners—8 Prize Bridges and 11 Awards of Merit. The evening's highlight will be unveiling a bronze sculpture by artist Joe Kinkle. The 24-in. high sculpture represents an iron worker/erector on high steel. The single-edition bronze remains at AISC headquarters, along with nameplates designating annual Prize Bridge and Architectural Awards of Excellence winners. Individual winners receive a bas relief of the sculpture.

The Annual Awards Banquet was begun to provide a forum for the assembly of leading structural designers, contractors, subcontractors, fabricators and suppliers to the fabricated steel construction industry to recognize individuals who have received various awards from AISC throughout the year.

Guest speaker for the Awards Banquet will be author/historian David McCullough, whose subject will be the Brooklyn Bridge. He has written four highly regarded books including "The Great Bridge," the story of the Brooklyn Bridge, one of our country's favorite landmarks. McCullough will be remembered as a featured speaker during the Institute's 1980 Annual Convention.

Tickets are still available from AISC. Call Orley Vaughan, 312/670-2400.

FELLOWSHIP AND T. R. AWARDS ANNOUNCED

The AISC Fellowship Award program provides eight $4,750 awards to engineering students who propose a course of graduate study related to fabricated structural steel. 1983 Fellowship winners, in addition to the scholarships they receive, are guests of honor at the AISC National Engineering Conference.

The 1983 T. R. Higgins Lectureship winner receives a $2,000 award as the principal author of the most significant paper related to fabricated structural steel published during a five-year eligibility period (Jan. 1, 1977 to Jan. 1, 1982). The current T. R. Higgins Lecturer is Prof. Conrad P. Heins, author of "Box Girder Design—State of the Art."

Announcements and applications for both awards are already in the mail, according to Albert O. Wilson, Jr., chairman of the AISC Committee on Education. Further copies may be obtained from: Committee on Education, AISC, 400 N. Michigan, Chicago, Ill. 60611.

A Building for the 21st Century

by Reinhard Ludke and Jeppe Larsen

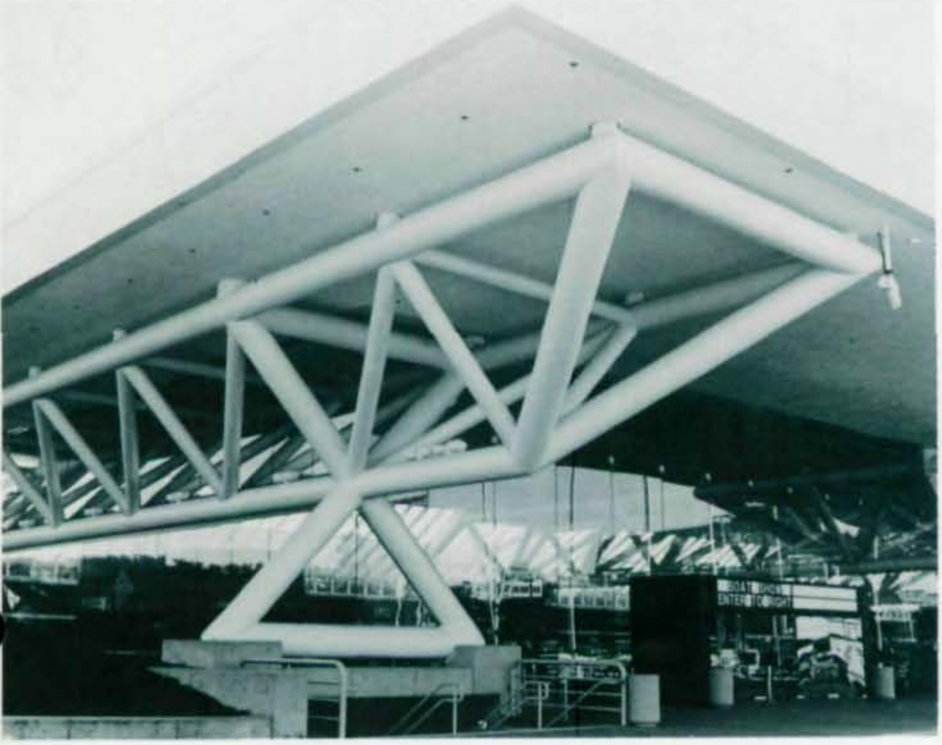
San Francisco's new Moscone Convention Center. Open street level lobby/atrium features four giant steel trusses that support roof (above & below).

San Francisco, one of the world's favorite cities, boasts a new convention center. When the Moscone Convention Center welcomed its first guests in December, 1981, visitors marveled at another of T. Y. Lin International's contributions to structures for the 21st century. The Moscone Center's eight pairs of tied concrete arches gracefully open 275,000 sq ft of column-free area to a variety of uses by the Center's guests. The architects designed a convention center where a bright and open crystal lobby welcomes San Francisco's guests to her newest attraction. The convention center facilities include a grand exhibit hall, a large ballroom, meeting rooms, kitchen, truck ramps and docks, storage and administrative offices. The street level lobby atrium has four sculptured steel trusses which support a roof covering over 30,000 sq ft of floor area. San Francisco, America's international city, has now opened this new convention center to bring major events and exhibits to the city.

Ten Years in Planning

The San Francisco Redevelopment Agency has labored over 10 years to plan a major rehabilitation of the South of Market area. Centerpiece of the area was the planned convention center.

A convention center or sports arena was to be the centerpiece of the Yerba Buena Redevelopment Area. The four-block area was to include hotel, retail and commercial mix of multiple uses, which would return vitality to a previously blighted area. In the mid-1970s, loss of the Bay Area's professional hockey team left the sports arena without major tenants. This contingency set the stage for development of the convention center. After a variety of architectural schemes were rejected, the present low-profile center was developed by the Hellmuth, Obata and Kassabaum and T. Y. Lin team in conformance with a proposition passed by San Francisco voters in 1977.



Architectural Solution

The solution for the exhibit hall was the aforementioned 300-ft span arches. This set of eight paired arches at 90-ft centers was designed to support loads from a future park with 3 ft of earth for planting, or three-story buildings built over the exhibit hall. A glass curtain wall rises over 30 ft to meet the lofty lobby roof, which rests on four sculptured tubular trusses.

The open glass enclosed lobby space invites visitors inside this building, where more soft curves and elegant balconies, stairways and escalators transport them to facilities below. The facilities include the 30,000-sq ft lobby atrium, 19 mezzanine-level meeting rooms, a 30,000-sq ft ballroom and a 275,000-sq ft exhibit hall. All large rooms contain movable partitions to allow infinite flexibility for adjusting room sizes.

Structure

The eight pairs of arches span 300 ft and rise 37 ft above the floor. Large concrete box beams, which also serve as exit tunnels, span over the large ballroom and support the front cross-supports of the steel lobby trusses.

Variable-depth plate girders span over the lobby trusses. Purlins and a lightweight concrete metal deck roof create a sloped roof for drainage. The 309-ft long plate

---

Reinhard Ludke is an associate, and Jeppe Larsen a vice president of T. Y. Lin International, a well-known structural engineering firm in San Francisco, California.

girders were provided with guided expansion bearings over the two exterior trusses to allow for the expansion and contraction of temperature variations. Seismic design criteria, increased 25% over San Francisco Building Code requirements, necessitated special treatment of details to insure transfer of mass inertial forces to the truss bearings.

The 65-ton lobby trusses are fabricated as triangular members with two 20-in. diameter top chords, 10 ft above a single 20-in. bottom chord; 8-in. and 10-in. tubular members are used to frame the web and bracing that connect these chords. The truss spans 90 ft from the rear bearings at the arch abutments to the front X-braced supports and cantilever 30 ft over these X-braced legs to form a final 120-ft long welded truss. These trusses are, in fact, structural space frames, and all elements are designed as beam-columns.

Lobby Seismic System

Longitudinal seismic forces from the roof are transferred to the four trusses by double-angle K-bracing joined into the girder support pots located at the top chord panel points. Truss members, acting in bending and shear, transfer these seismic forces to reactions at the trusses rear bearings. These bearings have guides which allow the truss to move freely during construction and temperature changes. This prevents overstressing the X-bracing in bending. After all dead loads are in place, the movement is restricted to ± 3/16-in. for temperature. But glides engage during earthquakes so that longitudinal forces will not overstress the cross-braced joint.

Transverse seismic forces are transferred to the exterior trusses after lateral movement exceeds the ± ¼-in. temperature movement allowed by the girder sliding bearings located at these trusses. All four trusses are then mobilized to transfer seismic forces to the bearings. The cross-bracing legs support over 350 tons of axial load during major seismic activity. A ½-in. shear plate is welded into the panel zone under the rear roof plate girder at the interior trusses. This plate is welded to the girder's bottom flange and to the top chord tie pipe for the two interior trusses. These panels transfer loads to the truss and then to the four pot bearings supporting each truss.

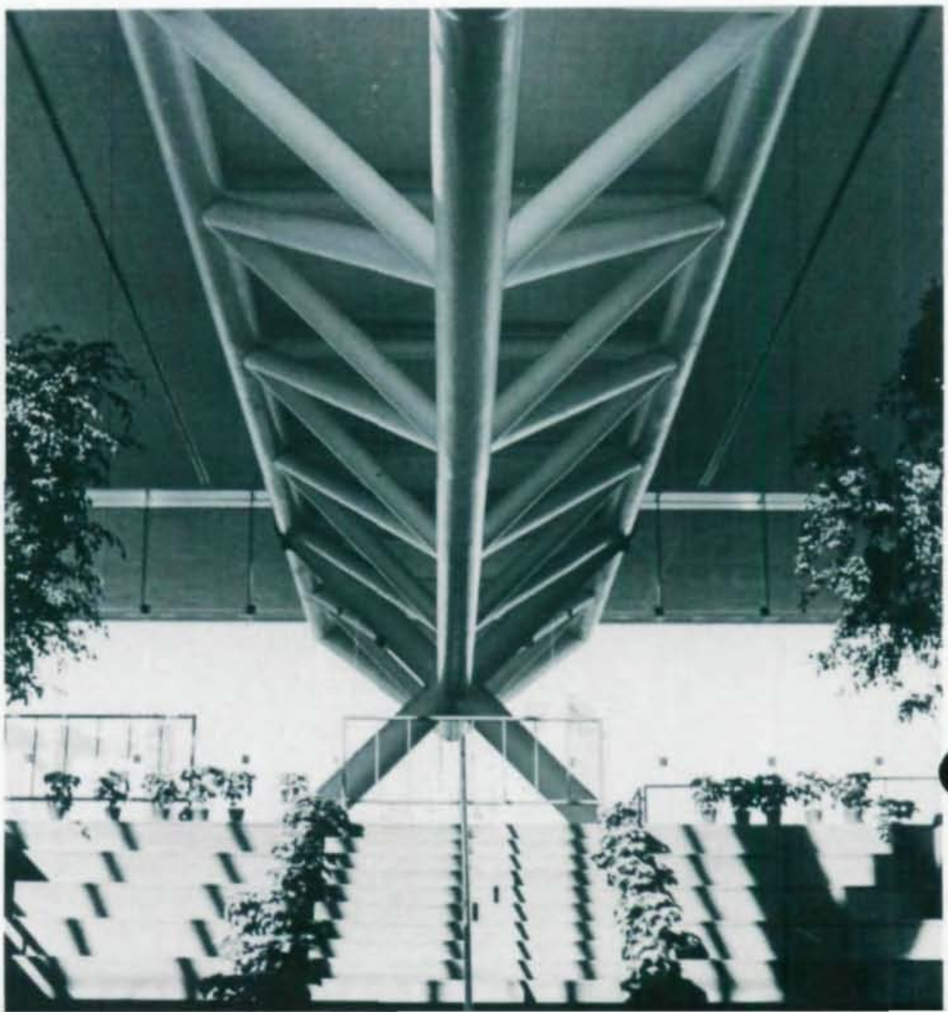
Lobby Design and Fabrication

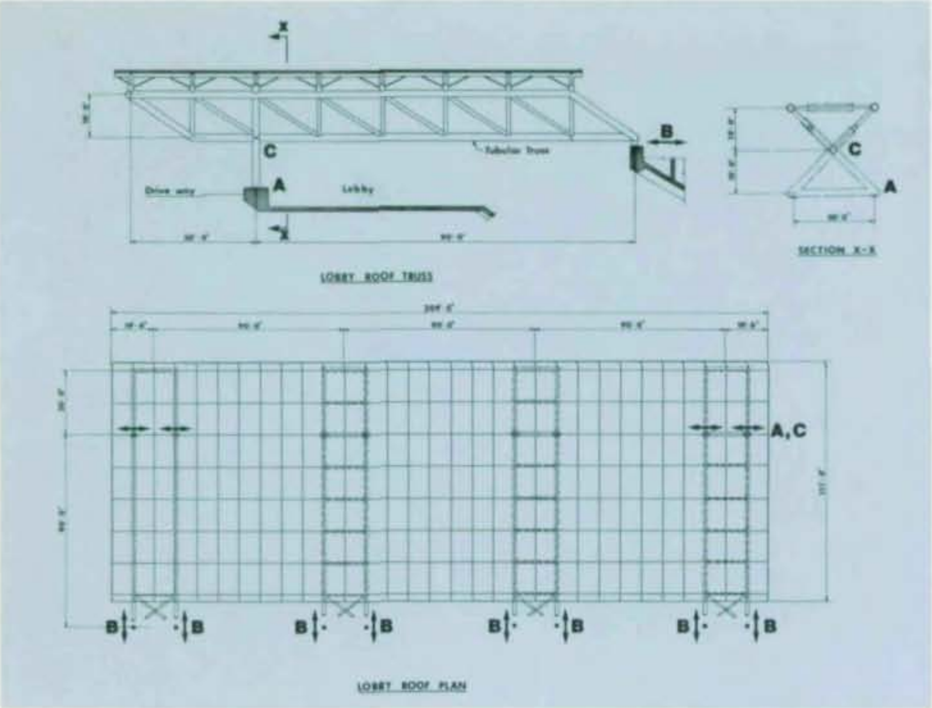
Reinhard Ludke, project engineer for the lobby structure, transferred his past experience in the design of tubular-framed offshore structures towards the design of these tubular steel-framed trusses. Members are sized using conventional AISC specifications for beam-columns under biaxial loading conditions. Tubular joints require special considerations of strength and stability for punching shear. Compression and tension members are properly overlapped in joints with up to eight members joined in some locations.

Local joint strengthening and stiffening is provided by four different methods: Internal plate stiffeners are welded in the chords; heavy walled chord joint cans are located at the joints; gusset plates are added; or increased material yield-strength is specified. Various welding procedures and automatic pipe preparation cutters were employed to fabricate the trusses. Continuous chord members were fabricated and then the top chord panels were welded together. The complete truss, without the bottom of the front cross-brace legs, was built upside down. It was uprighted and transported 20 miles to the San Francisco construction site. Two cranes lifted the 10-ft high x 120-ft long 65-ton truss onto the lower cross-leg section. Thus mated, it was field-welded at the final position. Over two in. of fireproofing covers this steel, and a white paint coating adds the final touch of beauty to these sculptured frames.

The design, fabrication and installation of these trusses helped create the bright environment which now await the Moscone Center's visitors. These lofty steel frames, surrounded by the airy glass curtain wall, draw a panoramic view of San Francisco into the visitors' hearts. □

Longitudinal seismic forces are transferred to huge trusses by double-angle K-bracing. Construction photo (above) gives idea of size.





Architect
Hellmuth, Obata & Kassabaum
San Francisco, California

Structural Engineer
T. Y. Lin International
San Francisco, California

Geotechnical Consultant
Dames & Moore
San Francisco, California

Steel Fabricator
USS Fabrication
San Francisco, California

Design of trusses creates bright lobby environment, lends panoramic view to city through glass curtain wall. Plan (above) details design and placement of trusses.

Bell Labs:
Weather, Strike Don't Slow a Fast-Track

By the time Bell Laboratories' four-story, 350,000-sq ft office-research center in Naperville, Ill. was completed June 1, the construction manager had demonstrated how effective fast-tracking can be—on one of the largest projects in the Chicago suburbs.

Despite 17 working days lost to bad weather, and an eight-week strike, Bell Labs' project was finished one month ahead of time, and well within budgetary parameters.

The design-build project, awarded in February, 1981, faced a July 1, 1982 completion date. The design concept was a structure with as many large components as possible, simple ones that could be erected rapidly. Since Bell Labs intends to occupy the building on a long-term lease, the developers wanted the structure adaptable both to Bell's immediate needs and also to the possible future office requirements. Consequently, the need for rapid construction and a dual-use criteria dictated design development.

Concept Implemented by CM

Working with the architect, the construction manager proposed a semi-rigid frame (AISC Type III) structure. By choosing simple, reinforced spread footings, a structural steel frame, precast panels on the exterior and ribbon windows, the design concept was geared to speed, cost-efficiency and minimal field labor.

To meet Bell Labs' requirements for alternating 30- and 35-ft bays to fit space planning modules—and to facilitate speed and cost-efficiency—the CM opted for a girder and beam floor system with a minimal number of supporting members and attachments. Precast brackets for beams were eliminated by supports attached at the columns only. The high efficiency of the design is reflected in its eight psf steel weight, despite heavier than normal design loads.

Concentrated design work began immediately after the Feb. 1 contract, and proceeded concurrently with construction. The team's basic plan was to complete the structural work, enclose the building and have it under roof as quickly as possible. "If we didn't get that done before November, we would never make the July deadline," says Randy Thomas, vice president of Jon Construction, the CM.

Quickly constructing a working surface involved a large number of workers on the job very early in construction. Project Manager John Coletta explained, "We wanted as much floor area as soon as possible. That way, we get people inside and working right away."

Construction Works Around a Strike

A team approach was used on the project—its nucleus was Bell Labs' personnel, the CM and the architect. Design or construction professionals were added as the fast-track project required. But the initial team shared a common purpose: to get the building erected as efficiently as possible to meet the July 1, 1982 move-in date.

Steel fabrication began on April 1, six days before the official groundbreaking. The design was still being refined as work proceeded on foundations and a mill order was placed for the building's 1,419 tons of A36 structural steel.

The steel fabricator was selected because of their ability to obtain, fabricate, deliver and

Bell Lab's latest office-research center, Naperville, Ill., is marvel in fast-paced construction.

start erection by late May, based on an April contract award. And, the fabricator offered an erection schedule that was one month shorter than schedules proposed by competitors; plus, they maintained their own erection crews. The result was tighter control and smooth scheduling of the job, both valuable capabilities necessary to the fast-track nature of the project. The fabricator also was responsible for the metal floor and roof deck, and the edge form for the present slabs (the form would be attached to the deck in the field). These additional factors promised further reduced construction time.

Foundation work began on April 27, 1981, followed on May 27 by structural steel work. Already one of the wettest springs in Chicago's history had taken its toll—by May 29, 17 working days had been lost. Then, on July 23, when all the structural steel framing was up and only 10 days from completion, an operating engineers' strike hit Chicagoland.

The strike slowed work at the Bell Labs' project, but did not stop it. While other Chicago-area construction projects were at a virtual standstill, the CM put its organizational capabilities into high gear. Work on the project continued at an estimated 60% capacity.

As the strike ran on through the summer, plumbing, HVAC systems, sheet metal and electrical work were installed. Progress was relatively smooth on the east side of the building, which was completely up and for which decks had been poured on the second, third and fourth floors prior to the strike. Only three-quarters of the west half was up, and none of the concrete completed. With no roof, and only half of the building clad, workers were subjected to the elements.

Move in on Schedule

The strike ended Sept. 16, 1981. By November, only eight months after contract award, the building was enclosed. Interior finishing proceeded all through the winter and spring, and Bell Labs' employees moved in on June 1, 1982—a full month ahead of schedule!

Credit for the project's exceptional progress goes as much to the people involved as to the nature of the design and choice of materials.

"There are three interrelated elements in getting a job done quickly and correctly," says CM Supt. Ed Long. "Excellent fabrication—where parts are consistently straight and holes accurately punched—which leads to speedy erection. And speedy erection is accomplished by people who know their job and do it right; they set the pace."

An important part of the "people" picture was experience, a mind for detail and a careful eye for scheduling and coordination to keep the fast-track moving.

Strong Aesthetics Receive Attention

The completed structure demonstrates an imaginative use of standard, readily available materials. While the Bell Labs project was fast-track in concept, long, studied thought was given to aesthetics. Ribbon windows that encircle the building have their reflective coating on the third surface, resulting in an unusual aquamarine color. Materials of the precast panels are aggregates whose colors complement the unusual glass.

The north entry, a unique, V-shaped structure topped by a sloping roof, projects outward between the building's two main sections. Its roof structure is a steel spaceframe supported by lightweight, vertical members. The shape creates a dramatic lobby interior, while placing the two entry doorways—one on either side of the "V"—closer to the outside of the building. The top of the sloped entry roof is enclosed in the same reflective glass as the ribbon windows.

Inside, the structure surrounds two 60- x 65-ft atriums, one a library, the other an employee dining area. The atrium walls feature an unusual acoustic treatment designed to break the building's strong horizontal lines by placing fabric-covered, high density fiberglass panels that suggest subtly the outline of a Greek temple. Horizontal panels form the base, topped by vertical columns, capitals and panel frieze. Aluminum pediments are actually air exhaust and supply grills. Aesthetics aside, the atriums serve a practical energy function by providing windowed areas for interior offices, yet minimizing both heat loss and solar gain.

Housing approximately 1,200 employees and 20,000 sq ft of computer facilities, the building has both a high power load and a high people load. It requires constant cooling, and eight fresh air intake louvers ensure a steady inflow of cool air during temperate weather.

Significant Energy Reduction

A significant reduction in energy usage was achieved by the shape of the building, which reduces the ratio of the perimeter to the square footage to under 23%, compared to 50% for most office structures. The building, designed to meet Bell Labs' sophisticated mechanical requirements, includes redundancy systems and a carefully controlled environment. It is serviced by 16 fan rooms that permit off-hour operations as low as eight percent of operating capacity.

From start to finish, the project represented fast-tracking at its best: superior coordination, carefully thought-out design and uncompromising attention to detail. The client got what he wanted, when he wanted it.

Make that one month *before* he wanted it!

Handsome atriums, one in each side of building, house library and dining areas.

Structural steel frame made possible work around inclement weather and other delays.

Architect/Structural Engineer
A. Epstein and Sons, Inc.
Chicago, Illinois

Contruction Manager
Jon Construction Inc.
Wilmette, Illinois

Steel Fabricator/Erector
Wendnagel and Company, Inc.
Rosemont, Illinois

Owner
The Alter Group
Naperville, Illinois

Special Considerations in Designing Cladding Attachments

by Roger W. Hotz

Cladding failures have received increasing attention over the past several years. Numerous articles have appeared in the trade press on specific cladding problems. Recently, *Engineering News-Record* published a feature article on "Facade Failures."[1]

Experts have identified various causes—including lack of design expertise, lack of coordination between architect and structural engineer, faulty construction, absence of inspection during construction and inadequate inspection and maintenance after completion. In many cases, more than one, if not all, factors were present. At a symposium of designers organized about a year ago by a major errors and omissions underwriter, just "plain ignorance" was cited as the common denominator[3]. Whatever the principal fault, simple lack of attention to important cladding connection details and indifference to field conditions at the time of facade installation always seem to be significant factors.

Publicized spectacular failures often involved large expanses of cladding crashing to streets and sidewalks below, so far with miraculously little loss of life and property. But the costs to repair and reconstruct an improperly designed or installed facade can be several times the original cost. And, for each of the attention-getting cases, we can only speculate on how many more instances gradual deterioration reached an unmaintainable condition and repairs were undertaken without publicity.

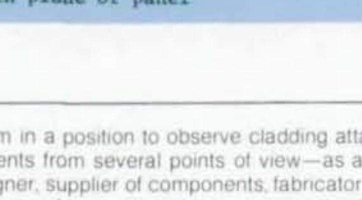
Numerous sources of authoritative information are now available on design considerations for attaching cladding elements to the structure for masonry [4, 7, 9], stone [10], metal and glass curtain walls and architectural precast units[13]. The common design principle for any materials is that provision must be made, by using horizontal and vertical expansion joints, for differential movement between the building frame and cladding. The facade must be divided into discreet panels or elements separated by a soft-caulked joint in such a way as to accommodate differential movements which result from horizontal and gravity loads in combination with thermal and moisture expansion and contraction of both frame and wall systems. If the designer does not provide the relief joints, the building will provide *them for itself.*

Let us assume the designer possesses the basic knowledge and expertise to know where expansion joints are needed, their required size and construction for various cladding materials. Now, look at attachment systems and commonly used details that can cause concern.

Cladding Problem Areas

Load-bearing connections support the weight of the panel and thus maintain a horizontal expansion joint. Horizontal ties, perpendicular to the plane of the wall transmit loads into the structure. At the same time, the connections must allow for anticipated movements between frame and cladding in a plane parallel to the wall. With large panels, provision should be made to firmly anchor the panel at one end near the bearing point to prevent it from creeping along the support as a result of thermal expansion and contraction. See Fig. 1.

Figure 1



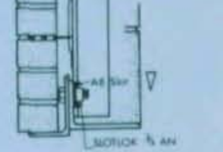
Arrows denote freedom of movement in plane of panel

While all parts of all anchoring systems are important, proper performance of the load-bearing component is vital. Any downward displacement of the support will impair the effectiveness of the expansion joint and may result in gravity loads being transmitted to the ties. The result will be distress to cladding components and, in extreme cases, complete separation from the building.

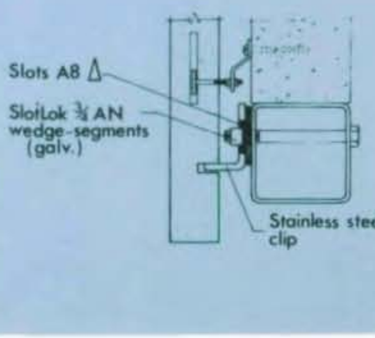
Examples of load-bearing connections are brick and stone support angles and precast bearing connections. Corresponding horizontal ties are provided by flexible masonry ties, disc or cramp anchors and tie-back angles. Sometimes, bearing and tie-back connections are combined, as in the case of a stone or precast support angle with integral dowel pin. See Fig. 2.

We will examine how these cladding connections are different from other connec-

Figure 2



With separate horizontal ties



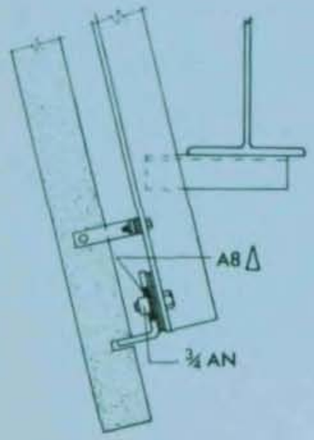
Roger W. Hotz, P.E. is president of the Hotz Corporation, North Branford, Connecticut. His structural steel contracting firm also operates a subsidiary that erects precast and metal curtain wall components. His extensive engineering experience, both shop and field, places him in a position to observe cladding attachments from several points of view—as a designer, supplier of components, fabricator and erector. He presented this paper at the 1982 National Engineering Conference in Chicago.

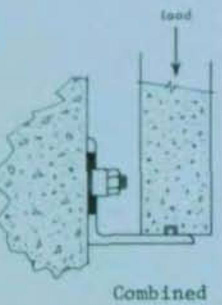
tions with which the structural engineer is familiar. We will point out how these unique characteristics in combination with the realities of construction practice interact in a way that can result in repetition of past failures on projects under construction. This paper is aimed at emphasizing the importance of singling out these otherwise mundane connection details for special attention.

The Contractor

Equally important to the structural requirements of cladding attachments are the field conditions under which installation takes place. The contractor is entrusted with execution of the design requirements once a workable connection system has been developed. Of course, "contractor" extends to various subcontractors. But think about the sometimes divergent and conflicting roles of these independent firms who act in their own self interest—and the possible adverse effect on facade installation.

Installation of some types of cladding traditionally has been performed by specialty contractors, and the trend toward subcontracting is increasing. Construction management, fast-tracking and awarding separate contracts will continue to place additional pressures on the designer to make sure that cladding attachments—sometimes supplied by one contractor for final installation by another—are chosen on the basis of their total utility and reliability, not just on material cost.





Combined

To illustrate, look at a steel-framed building with stone cladding. Conceivably, there could be a general contractor, a steel fabricator, an erector, a concrete slab subcontractor, a miscellaneous iron fabricator, another erector, the stone supplier and a mason contractor—as many as eight separate contractors, all with some part in facade attachment. More likely, there would be four or five on any given project.

This is significant to the designer because there is wide variation in the types of skills and levels of competence of the trades and contractors. Positioning of some types of facade support steel is intermittent, progressing as scaffolding is erected to keep pace with masonry work. Consequently, there is a tendency to shift the responsibility for final positioning of support steel to the trades normally on the staging, masons and laborers, regardless of where connections are specified. And remember, the low-bid system is at work. This means the work is likely to be assigned by the contractor who places the least value on the work, possibly a reflection of a lack of understanding as to what is required to do the job properly.

A good example of this process is in the final alignment of brick shelf angles or stone clips. Area practices, convenience and economics often dictate that the mason performs this operation, either as planned or as a last resort to keep the job progressing. Frequently, the adjustment detail, chosen strictly on the basis of material cost, is a slotted hole dependent on a high-strength bolt to prevent slipping after adjustment.

How many engineers would designate a mason or laborer to install high-strength bolts in a structural connection? And these are *definitely* structural connections. What about inspection? The intermittent nature of the work, the relatively short time the connections are accessible, and once again economics, make it unlikely there will be effective inspection of this critical operation.

Is it reasonable for the engineer to expect these connections will receive the same attention as those for the structure frame—to assume the work will be performed by workmen skilled in structural bolt installation, and as an extra safeguard to assume the work will be checked by a competent inspector? These connections may be shown on structural and erection drawings, but facade support steel is frequently set to final location long after steel erection is complete and steel inspectors have left. Often, neither assumption is correct, and almost never is the expectation of both trained mechanics and thorough inspection valid.

Closing the Gap Between Frame and Cladding Tolerances

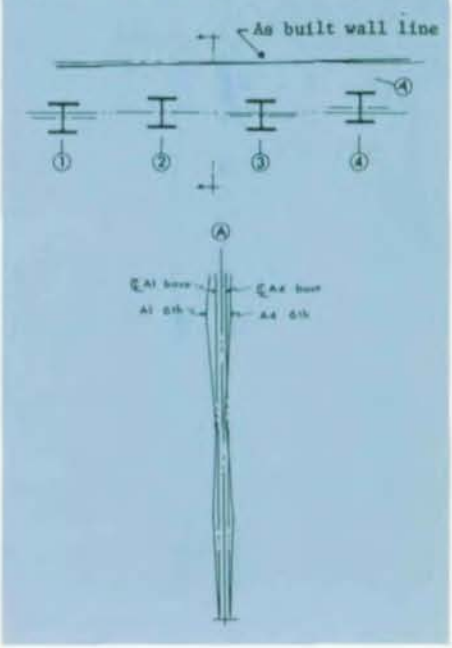
One of the functions of facade connections is to accommodate tolerances between the structural frame and cladding. This means they must be adjustable, and at the same time able to be securely locked into position in the direction for which they are responsible for carrying forces. Adjustments in the range of 3 in. or more may be needed to provide for tolerances between frame and facade for high-rise buildings with the facade erected in a true vertical plane.

But we seldom see connections with such capability, nor do we normally need them—if the structure is within established tolerances. Even if it were possible to erect the facade in a true vertical plane, this ideal condition might last for only a few hours or days until the sun shifted position or the temperature fluctuated by 20 or 30°.

Some of the problems in fitting the facade to the structure can be alleviated by preplanning and communications between the contractors and designers. Normally, there is more deviation of the frame from theoretical in the horizontal direction than in the vertical. The erected structure should be surveyed to determine discrepancies from the theoretical vertical plane at each attachment point before cladding work starts. The effect of variations can be minimized by allowing for slight divergence of the plane of the facade over large areas.

Figure 3 shows how constructing the wall slightly askew to column line A can reduce the amount of adjustment required.

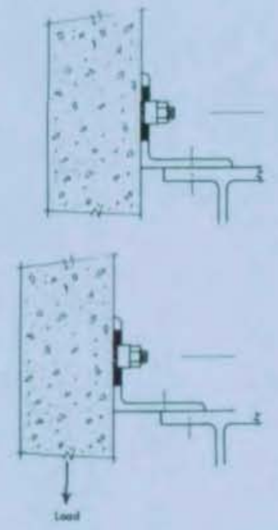
Figure 3



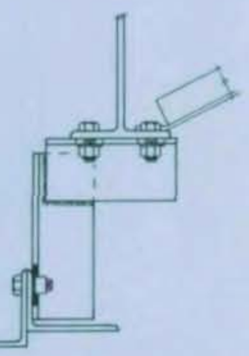
Nevertheless, it is desirable to plan cladding attachments with as much range of adjustment as practical. Frequently, the specific tolerances of the frame appear to be exceeded, but open to argument. And, as a practical matter, the cladding connection detail has to be capable of literally closing the gap.

We should design connections both geometrically and structurally with extremes of adjustment in mind. There is a natural tendency to think of adjustable connections at their theoretical midpoint, and we sometimes forget to provide adequate clearance between all components. It is useless to provide ±3/4-in. adjustment if clearance is provided for movement of only ¼-in. between some parts. Even more important, extremes in adjustment can introduce objectional forces on bolts, cladding, attachments and structure. See Fig. 4.

Figure 4



Increased bending and prying action caused by adjustment



No clearance between back-up shelf angle and hanger

Live and Dead-Load Deflections

Deflection is the governing design criteria for cladding attachments more often than for other parts of the structure. There are practical limits to the width and spacing of expansion joints provided to isolate the relatively stiff and brittle building skin. Therefore, we must restrict downward displacement of supports by torsional and flexural movement in order to maintain the space between vertically adjacent facade components.

The Brick Institute suggests the total deflection at the toe of a brick shelf angle be limited to 1/16-in.[4] To meet this criteria, a 4 x 4 x 3/8-in. shelf angle attached by ½-in. thick clips 12 in. long, spaced at roughly 3 ft, would be required for a common shelf angle to support a single story brick wythe. Comparable, and probably more economical, results are obtained by using a 4 x 4 x 5/16-in. continuous angle connected to the spandrel beam by 1/2-in. single bolt clips 8-in. long, spaced at approximately 2 ft.

Many commonly used off-the-shelf details do not meet these recommendations. The 1/16-in. criteria and the computational methods[1] used in this analysis could be criticized as overly conservative, but personal experience bears out the need for a more restrictive design basis than used in the past. Interestingly, we see design drawings more frequently reflecting a conservative trend.

With large panelized cladding systems, such as architectural precast, the importance of limiting deflections at support points on the structure is more obvious. Bearing locations for spandrel panels should be at points of minimal deflection, normally close to columns.

Where panels must be supported on flexural members, they should have only two bearing points, unless the support member is stiffer than the panel. Otherwise, the entire panel weight will be concentrated toward the end connections. From an erector's viewpoint, bearing on stiff brackets attached directly to columns is ideal. The support should have sufficient torsional rigidity to allow for unbalanced loading during construction, and imperfect shimming which can concentrate loads far away from the shear center of the bracket. Generally speaking, the larger and heavier the cladding component, the more desirable it is to separate the bearing connections from the horizontal ties.

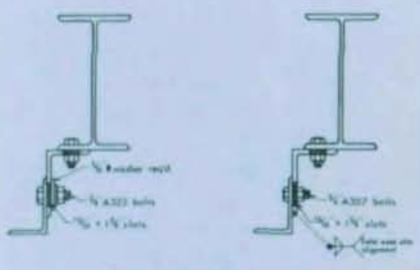
Deflections of structural supports during erection of the wall system causes problems for the erector. Walls supported by large cantilevers are of particular concern, especially where trusses or girders at one level support several floors. As erection proceeds, cumulative deflections can cause severe stress to both panels and attachments placed earlier in the sequence. Nonuniform cantilevers complicate this problem, as does the impracticability of setting panels around the entire perimeter, one floor at a time.

The designer cannot be expected to anticipate every problem which results from temporary loading conditions that may occur as construction progresses, but practical considerations cannot be ignored. Is it reasonable to design a support system that will work only when a delicate equilibrium is reached with the entire cladding, complete with braces in place?

Load Supporting Adjustable Connections

The importance of the load-bearing component of an attachment system in maintaining the integrity of horizontal ties and the effectiveness of a horizontal expansion joint is obvious. Yet, these connections often do not receive the attention they deserve. See Fig. 5.

Figure 5



Vertical Slotted Connections
Vulnerable to Unpredictable Field Conditions

Recently, we have seen increased acceptance of the use of vertical slots for these details, a readily apparent solution to the problem of adjustability. But the effectiveness of such connections against slipping relies totally on a critical secondary field operation—torquing of a high-strength bolt, or welding. Dependence on this added operation makes that type of detail very vulnerable to error or omission.

With increased confidence in the reliability of high-strength bolting and welding for structural connections, it would follow that these techniques could be relied upon to attach cladding. We must keep in mind, however, that field conditions at the same time these connections are completed are totally different from those at the time of frame erection.

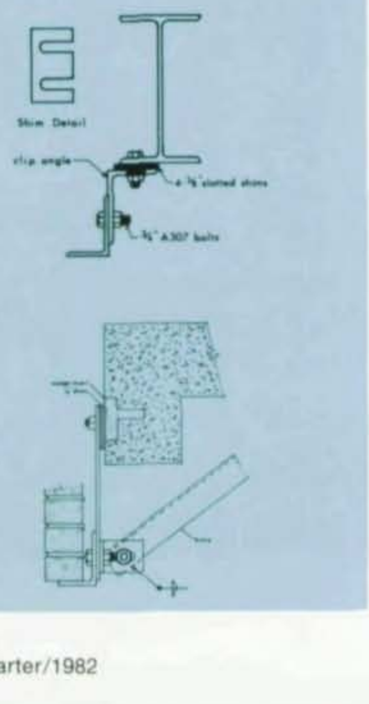
Several years ago, the use of vertical slots for these supports was discontinued among engineers in metropolitan areas where high-rise construction was commonplace. Instead, they require vertical adjustments be made with shims. There is a lack of knowledge among field personnel and draftsmen as to what is required to permanently secure slotted connections. How often have we seen notes suggesting that tack welding of nuts is sufficient? How persistent is the notion that high-strength bolts can be tightened satisfactorily with hand wrenches? The misconceptions, and other forces at work during facade construction, accentuate the shortcomings of vertical slotted connections. Technically, 100% inspection would be required to be in compliance with various codes.

Connections that do not depend on friction or welding to prevent slipping are the preferred choice for cladding attachment. Shims and adjustable wedging devices offer positive support without secondary operations that require special skills or equipment. Satisfactory performance is based on principles understood by every workman who plays a part in completion of the installation.

Where components are shop-assembled at the theoretical mean elevation, usually the case with brick shelf angles, connections using shims or a wedging device will carry their full assigned loads without further labor. It is a different story with vertical slots if, for instance, the masons work the brick to the initial position of the shelf angle without the need for adjustment. If alignment was to have been the responsibility of the erector, will the required welding or torquing take place?

What if there happens to be no qualified welder on the project and a crew of masons and laborers is on the scaffold waiting to start the next level? There is a great temptation to shortcut, or even skip this work, particularly when so many of those involved tend to minimize its importance.

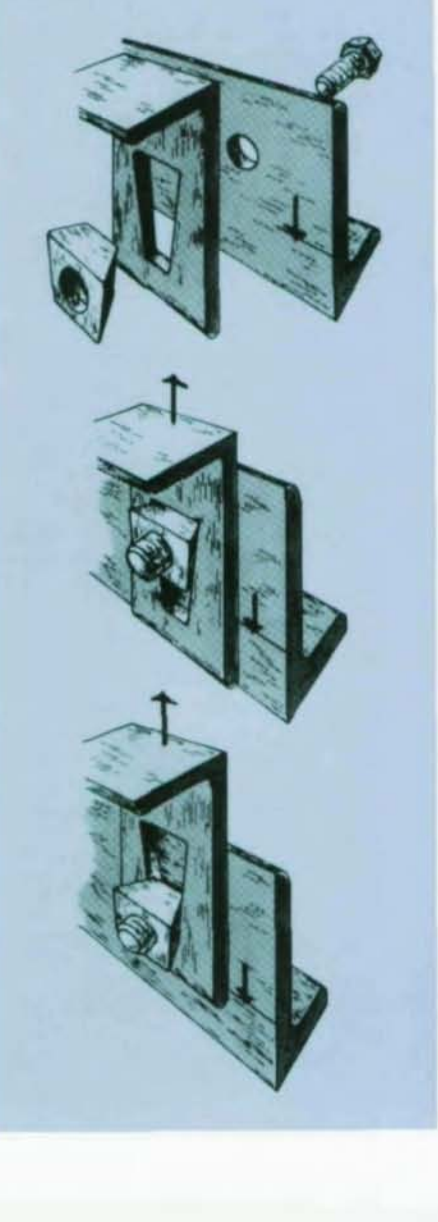
Figure 6



Most engineers are familiar with traditional shim details (Fig. 6) for conditions where vertical adjustment is needed. The wedge insert is a commonly used and proven method for load supporting adjustable attachment to concrete. Since it is designed to be embedded in the vertical face of concrete, there are limitations to its use. Another disadvantage is that the insert capacity is substantially less than that of the integral askew head machine bolts when designed in accordance with recommendations of PCI and most manufacturers. Also, they are not made in large bolt sizes.

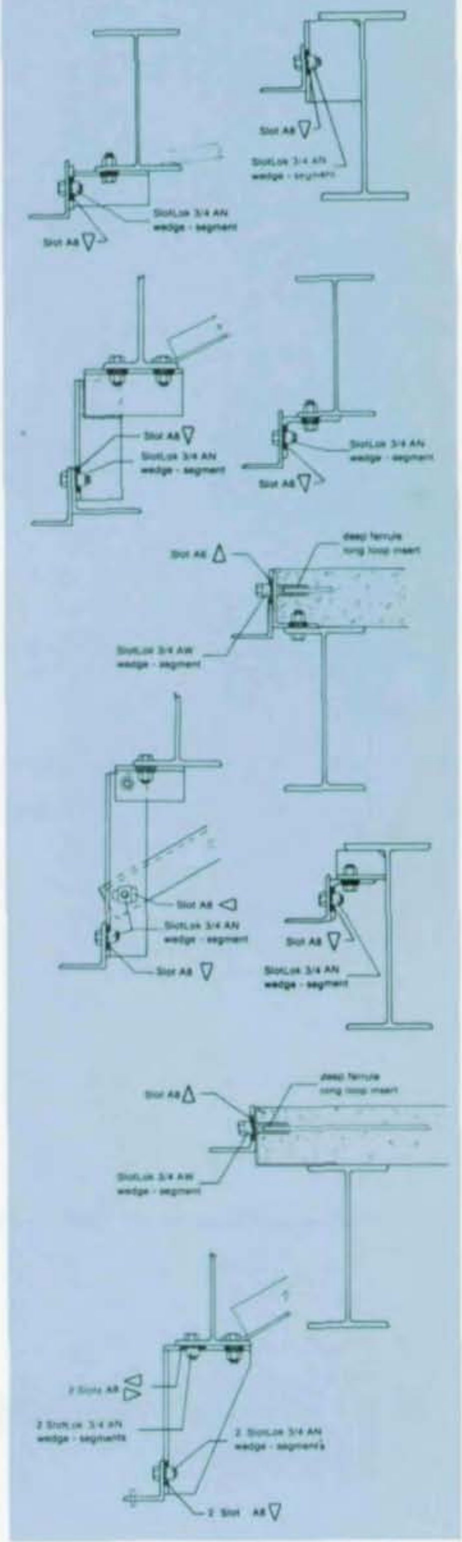
Wedge-type adjustable steel-to-steel connections are provided by the SlotLok Fastener System™. By changing the shape of the slot and the nut, the familiar slotted connection dependent upon friction has been transformed into a solid bearing connection. The converging edges of the punched slot interact with the compound taper of the wedge-segment to develop the inclined plane for wedging action (Fig. 7).

Figure 7



Hand-tightening the bolt draws the hardened wedge-segment into the slot, forming the bearing area needed to resist the applied load. Tightening with a small hand wrench (approx. 100 ft/lbs. recommended for 3/4-in. dia. A307 bolt) assures slipfree performance for the full capacity of the bolt. Adjustment ranges are offered from 3/4-in. (±3/8) to 2-in. (±1) with standard clip angles. See Fig. 8.

Figure 8



This system, in use for about four years, can be used for most conditions where ordinary slotted holes can be used. The tapered slot can be punched by any fabricator with capacity to punch standard slots of similar size. The wedge-segments are stocked for 3/8-, 1/2- and 3/4-in. bolts, in threaded or unthreaded styles. A large capacity series is available for use with large bolts for precast concrete applications. Punches and dies, components and literature are available from the manufacturer. With a material cost slightly less than for shims, this system claims to result in additional savings through simplification of alignment and final fastening.

Actually, all the details discussed are economical, with the installed cost representing a very small part of the cladding cost. Any kind of value engineering evaluation dictates that the governing criteria must be the expected performance and reliability.

Special Attention for Special Connections

Cladding attachments are special connections, literally at the interface of facade and structure. They are both an architectural and a structural detail, demanding close scrutiny by both design disciplines.

Why have there been so many problems? Does the structural engineer, routinely involved with details carrying much larger forces, take for granted connections subject to loads of, at most, a few kips? It is true that loads are usually relatively small, but cladding attachments are, in fact, more *likely to be subject to forces closer to their* capacity than other structural connections.

Too much reliance on contractors for selecting the proper attachment system has undoubtedly been a factor in cladding failure. While there are differences of opinion as to the degree of detail that should be provided by the designer, performance type specifications have generally provided good results for connections for the structural frame. It makes good sense to allow the fabricator to choose between field-welded or bolted moment connections, or between seated or framed-beam connections. Flexibility on the part of the engineer benefits the owner economically. The steel contractor will usually have the total performance responsibility and, in any case, the quality of the work will be assured by thorough inspection.

Facade connections are an entirely different matter. We have shown how components of the attachment system may be furnished by one contractor who has no stake in either its performance or the cost of subsequent steps to complete the installation. We know the competence of workmen involved with wall construction varies over a wide range. As a practical matter, it is unlikely there will be effective inspection.

Cladding attachments should be selected *with adequate consideration for unpredictable* field conditions. Connections should be as fool-proof as possible, and they should be chosen on the basis of expected performance and reliability—not on the basis of material cost.

Effective communication of design requirements and construction procedures is made through plans, specifications, shop drawing review, job meetings and conferences. To spell out practical and reliable details for facade connections is in the best interest of all concerned. The reputable contractor who always does good work may actually be placed in a better competitive position. The less dependable bidder is put on notice as to the designer's minimum standards. Adequate inspection assures conformity to job requirements.

Cladding attachment requires special attention by architect and engineer at all phases of construction. Problems that occur after completion are likely to vary inversely with the up-front effort during development of plans and specifications. ☐

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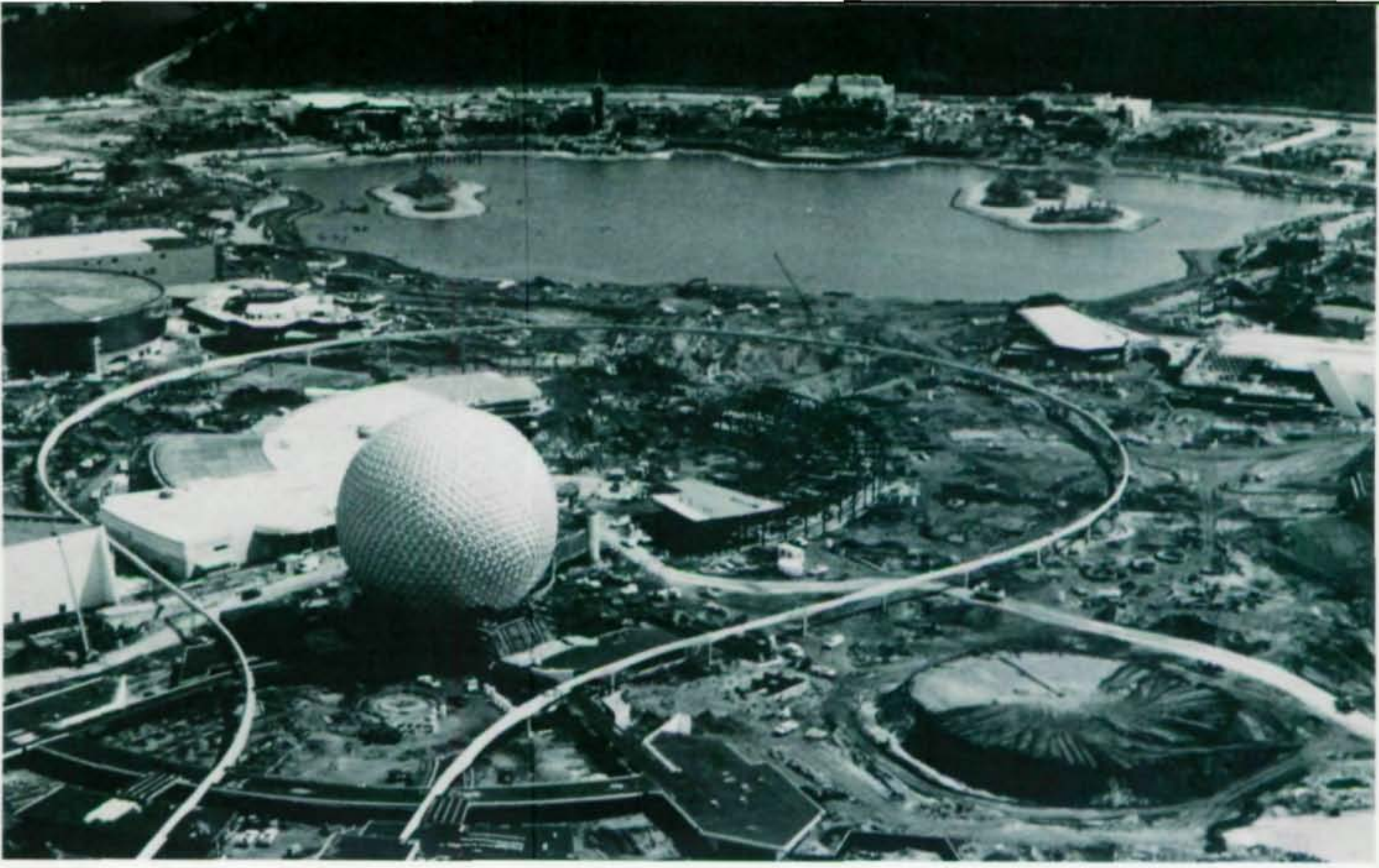


Photos courtesy Walt Disney Productions

EPCOT:
Disney Does It Again!

By the time you read this, another wonder of the world will be open to the public—Walt Disney's latest—The Experimental Prototype Community of Tomorrow. EPCOT Center, for short, opens Oct. 1, 1982.

As workmen on round-the-clock shifts make the last scramble to meet the deadlines, EPCOT promises to add a whole new dimension to the world of entertainment. For here, on 260 acres, is a whole new world of tomorrow, carved over the past three years out of the Florida lowlands just four miles from Disney World. A nearly $1-billion investment makes the project the largest ever financed by private capital in this country.

Words fail when you try to describe what the Disney "imagineers" have done this time. The imagineers are the WED Enterprises team in Glendale, Cal. responsible for implementing a dream. Disney's dream was a "never-completed place where industry, science and the arts could meet and exchange ideas . . . a community of tomorrow that will always be a showcase for the ingenuity and imagination of American free enterprise."

EPCOT Center, $1-billion Disney World addition (top), Orlando, Fla., fast approaches completion for Oct. 1 opening date. Eight million guests are expected annually. Steel-framed "spider"-leg platform (l.) is base for Space Earth, theme structure. Giant legs drop into place (c.). Photo (r.) shows structural details of unique sphere.

EPCOT Center is actually a two-part expansion of Disney World, each with its own theme. Future World zeroes in on the many aspects of technology, how they have developed over the centuries—and where they are going in the future. Spaceship Earth dominates the park as a theme structure, and in its 165-ft spherical environs, visitors will spiral upwards from a caveman environment to a simulated "landing" in a spaceship at 24,000 miles per hour.

The World of Motion traces the history and future of transportation. The Universe of Energy depicts the sources of energy, much of which comes from the sun through photovoltaic cells that power the pavilions. Journey into Imagination centers on human creativity, and The Land, on agriculture. Communicore is the unbelievably complex computer center that powers the entire complex of rides and displays. Future pavilions now under construction will include Horizons and an underwater panorama, The Living Seas.

The other part of EPCOT is World Showcase—more concerned with the past and present. In nine pavilions—Canada, Great Britain, France, Japan, Italy, Germany, China, Mexico, Israel, Spain, Africa and the U.S.—the cultures and culinary delights of these countries may be experienced and sampled.

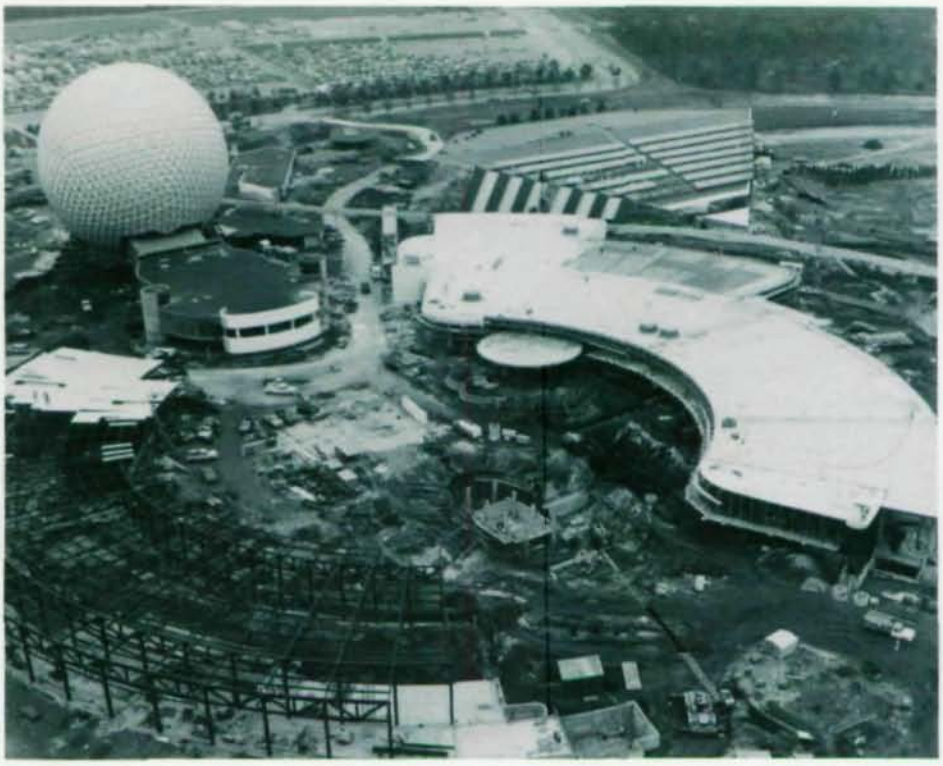
You really have to fly over EPCOT to grasp its impact. Over 50 million cu ft of earth were moved—and 20,000 tons of steel went into its construction. From the air, one gets the impression that the planners were believers in steel construction.

"Of all the materials considered, structural steel was selected as the basic material for roofs, walls and floors. Exceptionally long spans and unusual building configurations—the Transportation and U.S. pavilions are elevated, Communicore and Spaceship Earth have unusual shapes—demand that the structural system be as lightweight and strong as possible. Only structural steel can meet these needs." Right out of the imagineers' detailing manual!

We are only introducing you to EPCOT in these pages—for now. Future issues will contain detailed features on several of the exciting structures that grace this imaginative complex. They will be by-lined by the architects and/or structural engineers who implemented the artistry of Disney's hundreds of imagineers. □

Eight-story high web dwarfs worker on high steel.

Community of nations in nine pavilions circle 40-acre lake. UK pavilion (l.), Canada in foreground (above) with its tall-steepled buildings.



Communicore, center's core of activity, houses shops, attractions, restaurants in Future World.

Exxon's Universe of Energy tells story of energy needs and alternate solutions for future. Roof has 80,000 photovoltaic cells to provide power.

Computers in Design & Construction: Everyone Reads the Same Music!

by Joseph S. Brown

Major architectural/engineering firm pioneers use of computer graphics in design. In background (l.), main frame computers, disk storage units and plotter (r.). Digitizers (above) speed routine drafting work.

Steel—consistently one of the most advanced technologies in building construction—has also been a leader in computer-aided design. Computers now routinely speed structural design and detailing, control operations in the fabricating shop and facilitate ordering from the mill. The challenge to those who design buildings and plan their construction is to link this kind of computer expertise with that of other products and disciplines, to create a whole system. This task begins at home—with an integrated approach to computer-aided design in the architect-engineer's own office.

Computer use in design firms is broken typically into separate applications: computer-aided drafting (CAD), word processing, accounting and engineering. Seeking quick payback, many offices automate only the most repetitious tasks—for instance, specification writing (on a word processor) or mechanical/electrical drafting (on a simple CAD system). The equipment for these applications is relatively inexpensive and easy to use. The danger, within the office as within the construction industry, is that those who are "on the system" may come to speak a different language from those who do not yet use a computer. And also that each discipline may grow its own highly specialized form of automated design, frustrating one of computerization's biggest advantages: its interactive aspect, the unprecedented ability to let everyone on a job "read from the same sheet of music."

Down a Different Road

As one of the nation's 25 largest architectural-engineering firms, we had the opportunity to take a different approach.

Four years ago, our firm made the decision to get started in computer-aided building design. Basic to this move was a second decision: all in-house disciplines, including support staff, mechanical and electrical engineers, process designers, architects, space planners and civil and structural engineers, would participate—to some extent—from the beginning. Our system today, and the ways in which our architects and structural engineers use it, owes much to that fundamental decision.

Our office's current expansion into new markets, from its traditional specialty in schools, to military facilities, office buildings, light industrial facilities and hotels, depends to a large extent on this widely shared—and still open-ended and experimental—use of the computer. Integrated with word processing, computer-aided design serves both as a practical production tool and as a management catalyst for bringing everyone up to speed together. Today, at least half of our firm's 150 professionals use the computer graphics workstations, and nearly half of its projects are computer-designed from start to finish.

As a stable, three-generation family firm, we were able to resist the temptation to go after immediate savings. In fact, our firm's first "all-computer" generated building, a 1980 Indiana school believed to be the first such CAD project designed and built anywhere in the country, took almost 120% of the time that would have been required with conventional design methods. But by starting with such small projects, and involving interested people in every department from the beginning, we traded short-term savings for a long-term investment in expertise.

The payoff, while not swift, has been satisfying—and sometimes dramatic. Describing a just-completed design for solar-heated U.S. Navy housing, I was able to tell a recent World Computer Graphics Association roundtable that CAD has saved the project "over 20% in drafting time alone." For mechanical, electrical and structural drawings, however, repetitive documents for basically high-tech barracks, time saved was even greater.

Joseph S. Brown is managing partner of Everett I. Brown Company, Architects/Engineers, Indianapolis, Indiana

This Navy project, known as Unaccompanied Enlisted Personnel Housing, presented bidders with an unusually clear, well-coordinated set of plans and specifications. Changes in the structural system, and its close coordination with mechanical and electrical elements, came about as computer graphics revealed points of conflict as well as opportunities for simplification. Largely as a result of the coordinated approach, the housing scheme is expected to be built almost seven percent below initial estimates. A soon-to-be built version at the submarine base in New London, Conn., originally budgeted at $13 million, is expected to be built for close to $12 million.

A second version under construction at Great Lakes Naval Training Center, near Chicago, will house basic trainees and provide NCO quarters and classroom facilities. The New London prototype is purely housing, for a variety of submarine sailors. This change in housing program, plus adaptation to different sites, foundation conditions and site utilities, shows CAD at its best. Information "cells" from the computer memory, some as large as the floor plan of a multi-person sleeping room, can be added, subtracted and recombined. At any point, the designer can refer back to the structural design, for instance, and call up information such as beam and column sizes or fire protection material. The medium, except at certain review milestones, is the dual display screen of a computer terminal. Nothing has to be erased, pasted over or reprinted.

Accuracy Enhances Human Factor

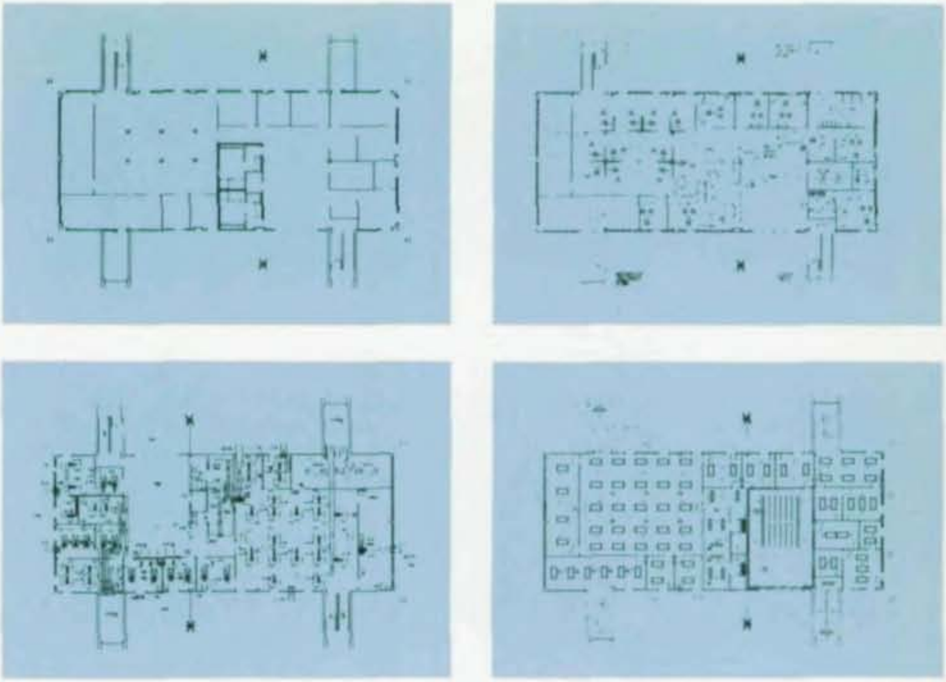
This flexibility is proving its power in many ways. It increases design quality, drawing speed and accuracy, enhances human factors and reduces the repetitious tedium that can make architectural and engineering talent hard to find, keep and motivate.

The initial installation, selected so that all design disciplines could enter the work into the system, consisted of one computer, four graphics work stations, a pen plotter and an 80 megabyte disc and tape-drive unit.

Our present system adds terminals, capacity and speed, with such recent acquisitions as a high-speed electronic plotter. Also being added are more color terminals, both to aid in complicated process, mechanical, and structural design, and for presentation graphics that can be photographed directly from the terminal.

Brown's system today consists of:

- Three graphics computers (2 DEC PDP 11/70s & 1 DEC PDP 11/23)
- Fifteen graphic work stations
- Two non-graphics computers
- One electrostatic plotter (Benson 9000)
- Two pen plotters (Calcomp 960)
- Five disc drives (2.7 billion bytes)
- One line printer
- Four word processing computers



Computer capability tests buildings before they are built. To guide design/construction, 72 of these acetate overlays are possible.

Beyond what might be called "perfecting the A/E office of the present," we look to computers as a path to the office—and the markets—of the future. Just as the Navy can adjust buildings to different sites, comprehensive facilities management programs will be able to relate all of a large client's sites to *all* of its construction past, present and future: new buildings, maintenance, renovation and even demolition. The computer helps make sense of the enormous body of information that accumulates around a large building complex or industrial facility, storing it and managing it as a useful data base.

With computer-aided facilities management, the design firm, having come to think of its own internal operation as a complete system, is now prepared to take on the entire complex construction process and see it as a whole. The computer memory will make it literally possible to build on past experience and information. For instance, the growing trend toward recladding and adding on to existing steel building frames—such as New York's Grand Hyatt Hotel (the reclad frame of the old Commodore Hotel) and Bank of America (built on the steelwork of the former Biltmore Hotel)—will be made easier and more economical in the future by computerized data bases that can retrieve the original structural drawings and calculations, the fabricator's drawings and all as-built information.

In today's world, and in the foreseeable future, the advantage will go to those products and technologies, like steel construction, that are committed to a systems approach. The challenge, again, is to make systems that are compatible—first between professionals, and then between professionals and the wide world of the construction industry. ☐

Design firm used computer graphics to design energy efficiency and flexibility into Wayne Township, Indianapolis, Ind. school administration building.

1982 Prize Bridge Awards Announced

Steel bridges were selected in a national competition sponsored by AISC as the most beautiful bridges opened to traffic during 1980/1981.

Unfortunately, "unsafe at any speed" could be posted on nearly a quarter million of the nation's bridges. "Bridge out" appears more and more on our highways as bridges wear out faster than funds are available to repair or replace them.

But there are some bright spots! This year's Prize Bridge Awards competition brought entries from 135 designers. The nineteen winners and merit awards appear on these pages.

Winners will be honored at AISC's Second Annual Awards Banquet, Oct. 26 at Chicago's elegant Westin Hotel. A reception at the gala black-tie event will be co-sponsored by *Building Design & Construction* magazine. Highlight of the evening will be the unveiling of a recently commissioned 24-in. bronze sculpture that represents the iron worker-erector on high steel. Winners will receive a replica bas relief plaque of a section of the sculpture. The original will remain on display at AISC headquarters, with the names of Architectural Award and Bridge Award winners added each year.

The Annual Awards Banquet provides a forum for the meeting of leading structural designers, contractors, subcontractors, fabricators and suppliers to recognize individuals who receive AISC awards throughout the year.

Tickets for this prestigious event may be obtained by writing: AISC Awards Banquet, P.O. Box 4588, Chicago 60680; or call Orley Vaughan, 312/670-2400.

And the winners are . . .

PRIZE BRIDGE 1982—
MEDIUM SPAN,
LOW CLEARANCE

NH Route 49 over Mad River

Thornton, New Hampshire

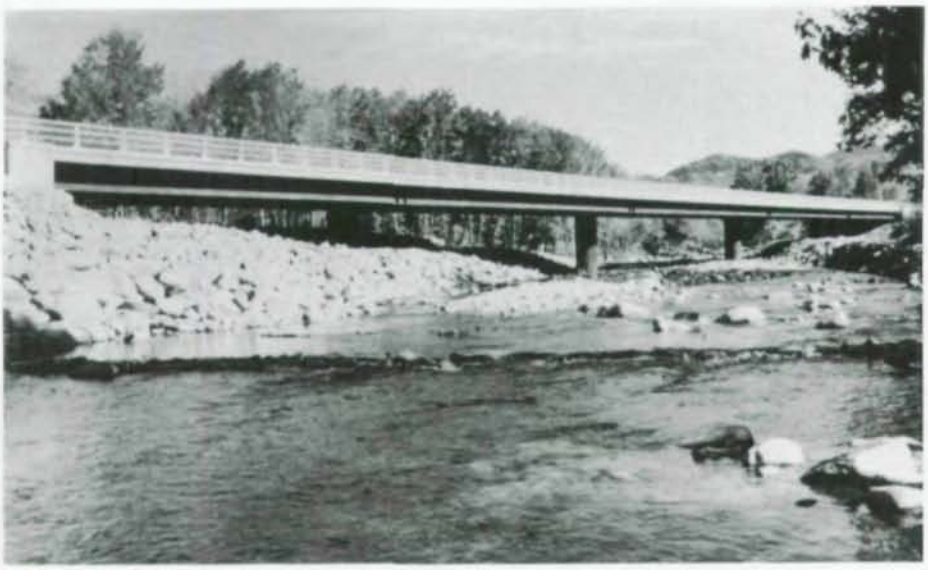
Designer
Pavlo Engineering Company, New York, NY

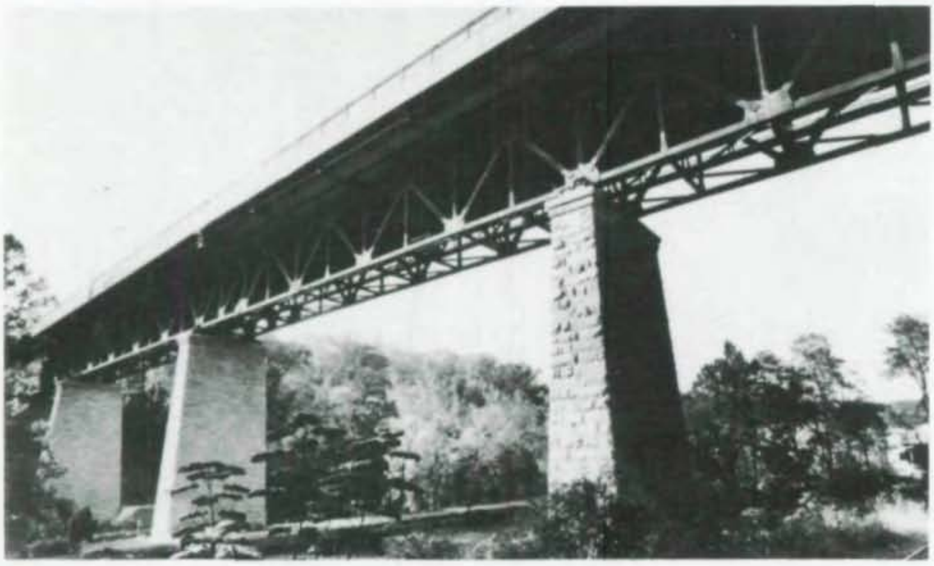
General Contractor/Erector
Shoals Corporation, Eliot, ME

Steel Fabricator
Bancroft & Martin, Inc., South Portland, ME

Owner
New Hampshire DPWH, Concord, NH

"Designer's treatment of the round piers, the slenderness of the structure and concealed caps really impressive—a straightforward solution."
—Jurors' comments





PRIZE BRIDGE 1982—
RECONSTRUCTED

Augustine Bridge over Brandywine Creek

Wilmington, Delaware

Designer
Pavlo Engineering Co., New York, NY

General Contractor
Whiting-Turner Contracting Co., Baltimore, MD

Steel Fabricator
Harris Structural Steel Co., S. Plainfield, NJ

Steel Erector
S.A. Lindstrom Co., Woodbury, NJ

Owner
Delaware DOT, Dover, DE

"Old substructure was used, new deck truss put on top. Given restraints of piers and roadways, it is interesting."
—Jurors' comments

AWARD CATEGORIES

LONG SPAN
Bridges with one or more spans over 400 ft

MEDIUM SPAN, HIGH CLEARANCE
Bridges with vertical clearances of 35 ft or more, with longest span not more than 400 ft nor less than 125 ft long

MEDIUM SPAN, LOW CLEARANCE
Bridges with vertical clearances of less than 35 ft, with longest span not more than 400 ft nor less than 125 ft long

SHORT SPAN
Bridges with no single span 125 ft or more long

GRADE SEPARATION
Bridges whose basic purpose is grade separation, as contrasted to categories above

ELEVATED HIGHWAYS/VIADUCTS
Bridges with more than five spans which cross one or more established traffic lanes, and may afford access for pedestrians or parking

MOVABLE SPAN
Bridges with a movable span

SPECIAL PURPOSE
Includes pedestrian, pipeline, airplane and other special purpose bridges not identified in above categories

RAILROAD
Bridges (non-movable) used primarily to carry a railroad, but may also be a combination railroad-highway bridge

RECONSTRUCTED
Bridges which have undergone major rebuilding/reconstruction using structural steel to upgrade them to current traffic requirements

PRIZE BRIDGE 1982— LONG SPAN

Sewickley Bridge

Sewickley, Pennsylvania

Designer
Richardson, Gordon & Associates, Pittsburgh, PA

General Contractor/Erector
American Bridge Division, Pittsburgh, PA

Steel Fabricator
USS Fabrication, Ambridge, PA

Owner
Pennsylvania DOT, Harrisburg, PA

"Extremely clean lines. Old piers being used added cost savings and gives the bridge character. A well-thought-out use of existing substructure."
—Jurors' comments

PRIZE BRIDGE 1982— SPECIAL PURPOSE

Galena River Pedestrian Bridge

Galena, Illinois

Designer
Homer L. Chastain & Associates, Decatur, IL

Consultant
Michael B. Jackson, New York, NY

General Contractor
Savanna Construction Co., Savanna, IL

Steel Fabricator
Theo. Kupfer Iron Works, Inc., Madison, WI

Owner
City of Galena, IL

"Chosen for the unique treatment of multiple arch ribs—well proportioned."
—Jurors' comments

PRIZE BRIDGE 1982—MEDIUM SPAN, HIGH CLEARANCE

Relocated Chapel Road over I-470

Bethlehem, West Virginia

Designer
Richardson, Gordon & Associates, Pittsburgh, PA

General Contractor
Marble Cliff Quarries, Columbus, OH

Steel Fabricator
Fort Pitt Div. of Spang Industries, Canonsburg, PA

Steel Erector
Vogt & Conant Company, Cleveland, OH

Owner
West Virginia DOH, Charleston, WV

"Chosen not only for its slenderness but also for the way it blended into terrain. Subtle detailing in the way slant legs go with superstructure."
—Jurors' comments

PRIZE BRIDGE 1982—SHORT SPAN

Dismal River Bridge

Thedford-South, Nebraska

Designer/Owner
Nebraska Dept. of Roads, Lincoln, NE

General Contractor/Erector
Dobson Brothers Construction Co., Lincoln, NE

Steel Fabricator
Lincoln Steel Division, Lincoln, NE

"Chosen for its simplicity of design. Functional—constructed economically."
—Jurors' comments

PRIZE BRIDGE 1982—MOVABLE SPAN

L&N Railroad Bridge #19 over Biloxi Bay

Biloxi, Mississippi

Designer/Consultant
Hazelet & Erdal, Louisville, KY

General Contractor
Scott Bridge Co., Opelika, AL

Steel Fabricator
Stupp Bros. Bridge & Iron Co., St. Louis, MO

Steel Erector
John F. Beasley Construction Co., Dallas, TX

Owner
Harrison County Development, Gulfport, MS

"A difficult category. This swing bridge is a functional, good looking structure."
—Jurors' comments

PRIZE BRIDGE 1982—RAILROAD

BN Bridge No. 106.6 over the Missouri River

Sioux City, Iowa

Designer
Howard Needles Tammen & Bergendoff, Kansas City, MO

General Contractor
Johnson Bros. Corp., Litchfield, MN

Steel Fabricators
Atlas Machine & Iron Works, Inc., Gainesville, VA
Bristol Steel & Iron Works, Inc., St. Louis, MO

Steel Erector
Nebraska Steel Erectors, Inc., S. Sioux City, NE

Owner
Burlington Northern RR Co., St. Paul, MN

"Good looking structure, powerful. It will stand for 100 years."
—Jurors' comments

AWARD OF MERIT 1982—MEDIUM SPAN, LOW CLEARANCE

Mountain Springs Road over I-86

Tolland, Connecticut

Designer
Frankland & Lienhard, New York, NY

General Contractor
Savin Brothers, Newington, CT

Steel Fabricator/Erector
The Standard Structural Steel Co., Newington, CT

Owner
Connecticut DOT, Wethersfield, CT

AWARD OF MERIT 1982—MEDIUM SPAN, HIGH CLEARANCE

Intake Channel-Havasu Pumping Plant

Yuma County, Arizona

Designer
U.S. Dept. of Interior, Denver, CO

General Contractor
S.J. Grove & Sons Co., Minneapolis, MN

Steel Fabricator/Erector
Marathon Steel Company, Phoenix, AZ

Owner
Arizona DOT, Phoenix, AZ

AWARD OF MERIT 1982— LONG SPAN

I-65 Bridge over the Mobile River Delta

Mobile, Alabama

Designer
Howard Needles Tammen & Bergendoff, Kansas City, MO

General Contractor
Expressway Constructors, Saraland, AL

Steel Fabricators
Gamble's, Inc., Montgomery, AL
Harris Structural Steel Co., S. Plainfield, NJ
High Steel Structures, Inc., Lancaster, PA

Steel Erectors
Vogt & Conant SW Corp., Little Rock, AR
Expressway Constructors, Saraland, AL

Owner
Alabama Highway Department, Montgomery, AL

AWARD OF MERIT 1982— SHORT SPAN

South Division Street Bridge

Salisbury, Maryland

Designer
Dewberry & Davis, Fairfax, VA

General Contractor
George & Lynch Inc., New Castle, DE

Steel Fabricator/Erector
High Steel Structures, Inc., Lancaster, PA

Owner
City of Salisbury, MD

AWARD OF MERIT 1982— SPECIAL PURPOSE

Grand Avenue Pedestrian Bridge

Eau Claire, Wisconsin

Designer
Owen Ayres & Associates, Eau Claire, WI

General Contractor/Erector
H.F. Radandt Inc., Eau Claire, WI

Steel Fabricator
Phoenix Steel Corp., Eau Claire, WI

Owner
City of Eau Claire, WI

AWARD OF MERIT 1982— ELEVATED HIGHWAYS OR VIADUCTS

27th Street Viaduct

Milwaukee, Wisconsin

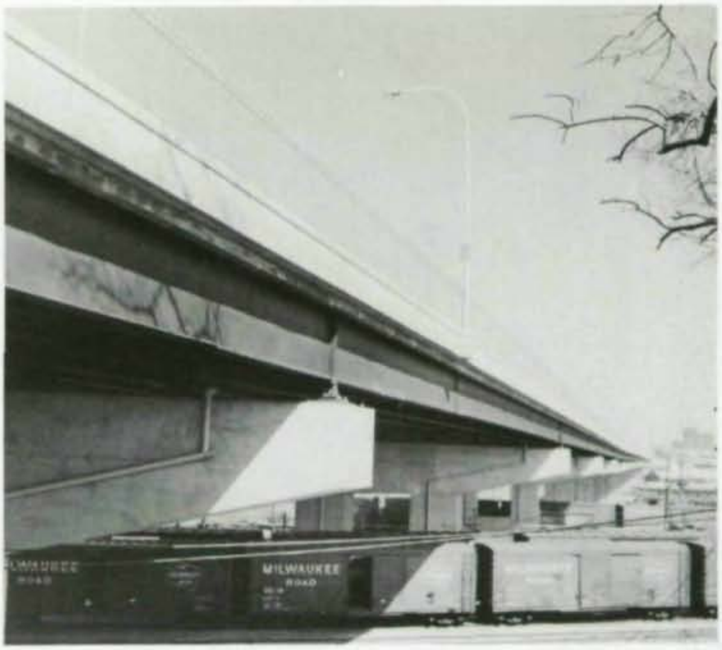
Designer
Howard Needles Tammen & Bergendoff, Milwaukee, WI

General Contractors
Allied Structural Steel Co., Chicago Hts., IL
Highway Pavers, Inc., Milwaukee, WI
Lunda Construction Co., Black River Falls, WI

Steel Fabricator
Allied Structural Steel Co., Chicago Hts., IL

Steel Erector
Edward Kraemer & Sons, Inc., Plain, WI

Owner
City of Milwaukee, WI



AWARD OF MERIT 1982— ELEVATED HIGHWAYS OR VIADUCTS

Wyoming Avenue over Tacony Creek

Philadelphia, Pennsylvania

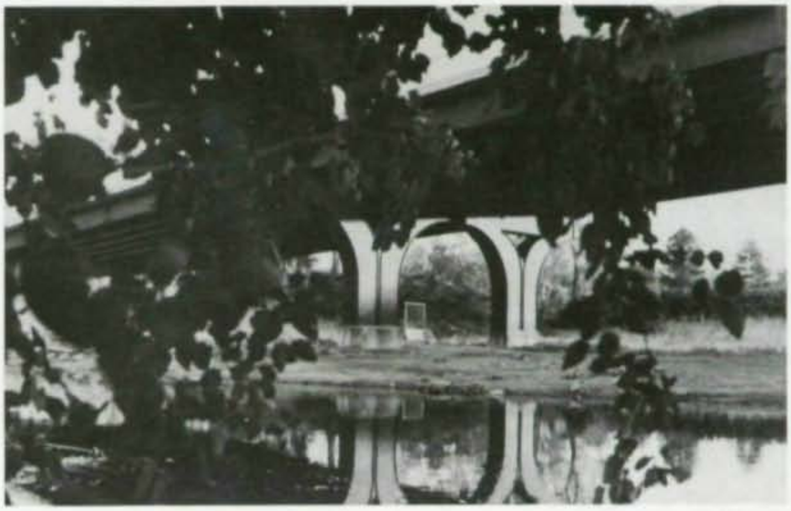
Designer/Owner
Department of Streets, Philadelphia, PA

Consultant
H2L2 Architects, Philadelphia, PA

General Contractor
Tel-Stock, Inc., Washington Crossing, PA

Steel Fabricator
Williamsport Fabricators, Inc., Williamsport, PA

Steel Erector
Cornell & Company, Woodbury, NJ



AWARD OF MERIT 1982— GRADE SEPARATION

S.R. 45 Connector Ramp over I-75

Sarasota, Florida

Designer
Beiswenger, Hoch & Associates, N. Miami Beach, FL

General Contractor
Wiley N. Jackson Co., Roanoke, VA

Steel Fabricator/Erector
Florida Steel Corporation, Tampa, FL

Owner
Florida DOT, Tallahassee, FL

AWARD OF MERIT 1982
LONG SPAN

S.R. 156 over the Tennessee River

Marion, Tennessee

Designer/Owner
Tennessee DOT, Nashville, TN

General Contractor
W.L. Hailey, Inc., Nashville, TN

Steel Fabricator
USS Fabrication, Ambridge, PA

Steel Erector
American Bridge Division, Pittsburgh, PA

AWARD OF MERIT 1982—
RAILROAD

BNI Railroad Bridge at Zillah

Yakima County, Washington

Designer/Owner
Washington DOT, Olympia, WA

General Contractor
Northwest Construction Inc., Kirkland, WA

Steel Fabricator
Isaacson Steel Company, Seattle, WA

Steel Erector
Max J. Kuney Co., Spokane, WA

AWARD OF MERIT 1982—
MEDIUM SPAN,
HIGH CLEARANCE

South Prairie Creek Bridge

Pierce County, Washington

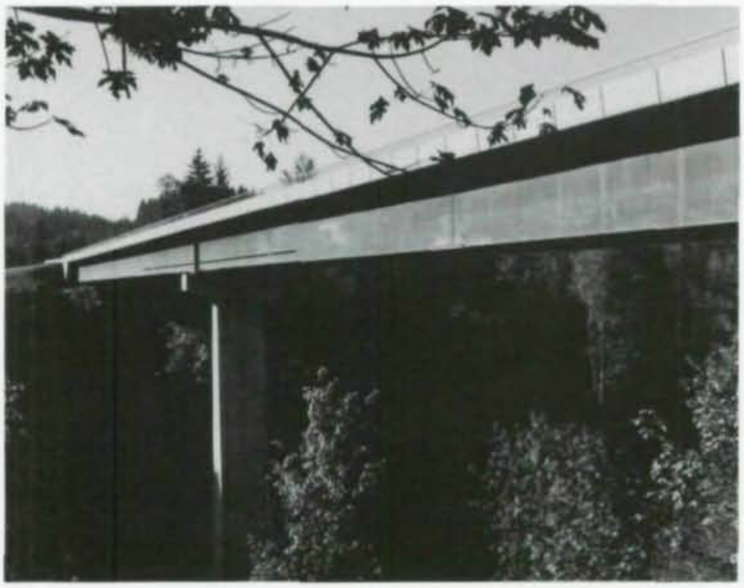
Designer
Arnold, Arnold & Associates, Seattle, WA

General Contractor
Donald B. Murphy Contractors, Federal Way, WA

Steel Fabricator
Fought & Company, Tigard, OR

Steel Erector
Cooney-McHugh Company, Tacoma, WA

Owner
Washington DOT, Olympia, WA



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