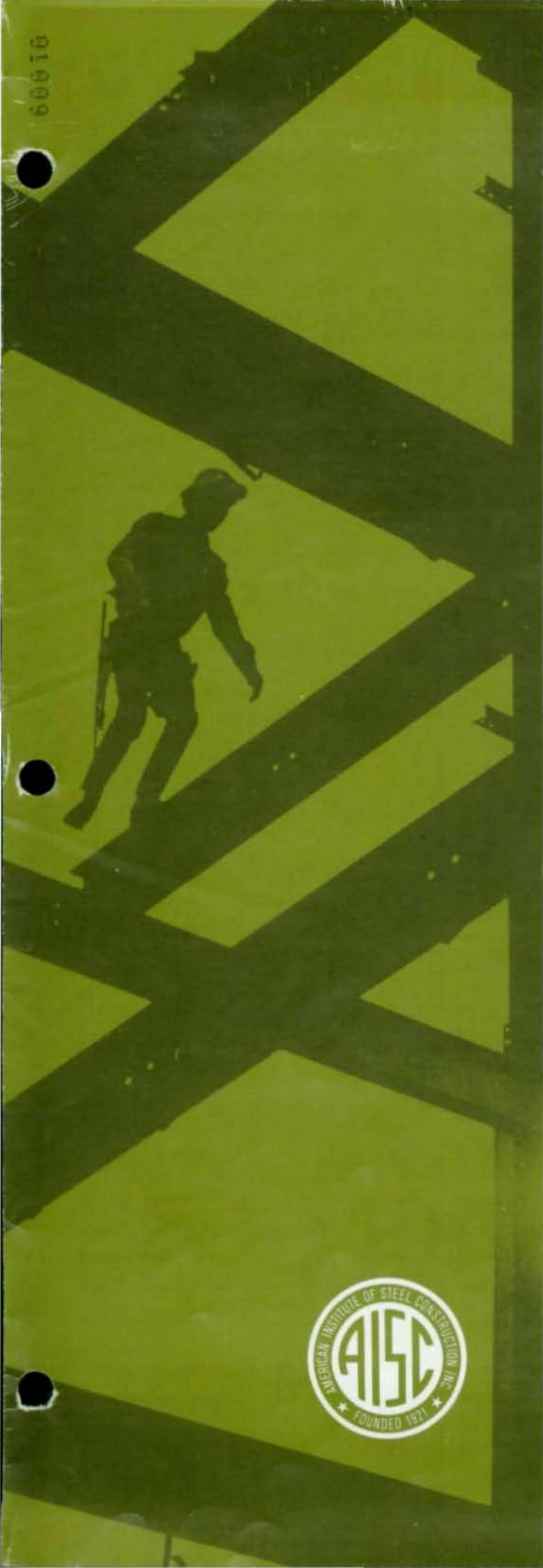

VOLUME XXVI NUMBER 2/SECOND QUARTER 1986

MODERN STEEL CONSTRUCTION

Special Section:
Fast Tracking

New Bolt Specification Approved
Space Form in Steel
A Study in Simplicity
State-of-the-Art—in Steel
Fast Track: Where are We Now?
Steel Framing + Teamwork = Fast Track
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DECK DESIGN DATA SHEET

NO. 8

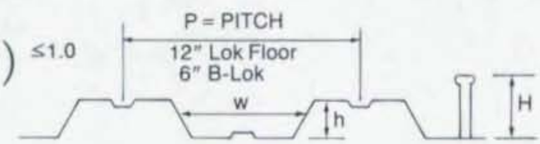
COMPOSITE BEAM DESIGN INFORMATION

1. Stud shear connectors should extend at least 1½" above the top of the deck.
2. The slab thickness above the steel deck should be at least 2".
3. Studs installed in metal deck can be placed as close to the web of the deck as needed for installation and to maintain the necessary spacing.
4. Deck anchorage may be provided by the stud welds.
5. For composite construction, studs should not be spaced greater than 32" on center.
6. "The minimum distance from the edge of a stud base to the edge of a flange shall be the diameter of the stud plus ⅛" but preferably not less than 1½"."—A.W.S.D1.1—79 Section 4.24.8
7. For many bay sizes it is advantageous to lay out the deck so that a deck valley lies over the center of the girder. For most composite girders there is no reduction in capacity if the deck is not split and spread apart at the girder.
8. N-Lok composite floor deck has a w/h ratio of 0.75 which makes it inefficient for composite beam design. N-Lok Cellular deck can be blended with 3" Lok-Floor and acceptable composite beam design can be obtained.
9. Designers are urged to check for the possible use of partial composite.

DESIGN VALUES FOR STUD SHEAR CONNECTORS (KIPS)

UNITED STEEL DECK, INC. SLAB TYPE			¾"Ø STUD SIZE	w/h OF DECK	NUMBER OF STUDS PER RIB	RIB COEFFICIENT	ASTM C33 NORMAL (150 PCF) WEIGHT CONCRETE			ASTM C330 LIGHTWEIGHT (115 PCF) CONCRETE		
							3000 PSI	3500 PSI	4000 PSI	3000 PSI	3500 PSI	4000 PSI
SOLID CONC.			3"	—	—	1.0	11.5	12.5	13.3	9.9	10.8	11.4
MIN. SLAB DEPTH	3½"	B-LOK	3"	1.5	1	1.0	11.5	12.5	13.3	9.9	10.8	11.4
	3½"	B-LOK	3"	1.5	2	0.9	10.4	11.3	12.0	8.9	9.7	10.3
	4"	B-LOK	3½"	1.5	2	1.0	11.5	12.5	13.3	9.9	10.8	11.4
	3½"	INVERTED B-LOK	3"	2.5	2	1.0	11.5	12.5	13.3	9.9	10.8	11.4
	3½"	1½" LOK-FLR	3"	3.85	2	1.0	11.5	12.5	13.3	9.9	10.8	11.4
	4"	2" LOK-FLR	3½"	3.0	2	1.0	11.5	12.5	13.3	9.9	10.8	11.4
	5½"	3" LOK-FLR	5"	2.0	2	0.8	9.2	10.0	10.6	7.9	8.6	9.1
	5½"	3" LOK-FLR	5"	2.0	1	1.0	11.5	12.5	13.3	9.9	10.8	11.4
	6"	3" LOK-FLR	5½"	2.0	2	1.0	11.5	12.5	13.3	9.9	10.8	11.4

Rib Coefficient $= \frac{0.85}{\sqrt{N}}\left(\frac{w}{h}\right)\left(\frac{H}{h} - 1.0\right) \leq 1.0$



N = Number of Studs Per Rib
H = Length of Stud
h = Height of Rib; 1½", 2", 3" Lok Floor; 1½" B-Lok
w = Average width of Rib

NICHOLAS J. BOURAS INC.
P.O. BOX 662, 475 SPRINGFIELD AVE.,
SUMMIT, NEW JERSEY 07901 (201) 277-1617

UNITED STEEL DECK, INC.

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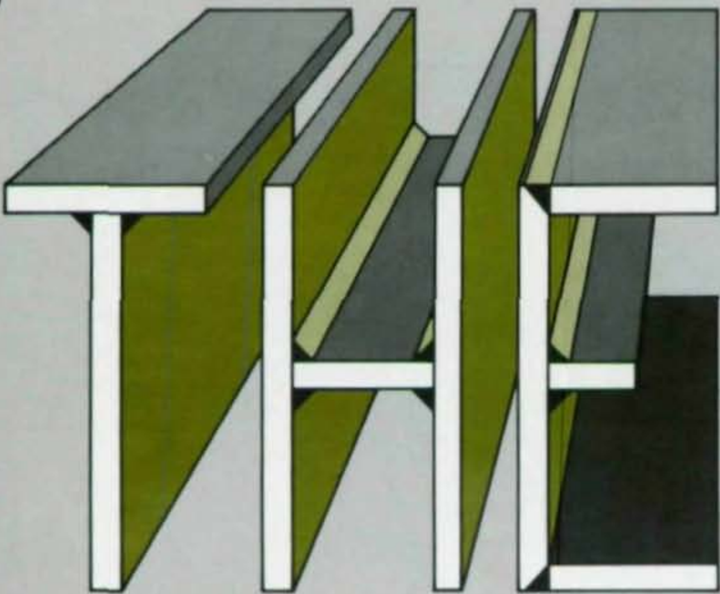

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VOLUME XXVI NUMBER 2/SECOND QUARTER 1986

MODERN STEEL CONSTRUCTION

American Institute of Steel Construction, Inc.

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CONTENTS

1986 FELLOWSHIP AWARD WINNERS NAMED

Eight winners of AISC's 1986 Fellowship Awards competition have recently been named. Each winner receives a $4,250 study fellowship, with another $750 going to the academic department heads for administering the awards. Students are judged by an outstanding award jury on the basis of grade point averages, faculty recommendations and contributions their expected programs will make to the engineering profession and the structural steel industry as a whole. The 1986 winners are:

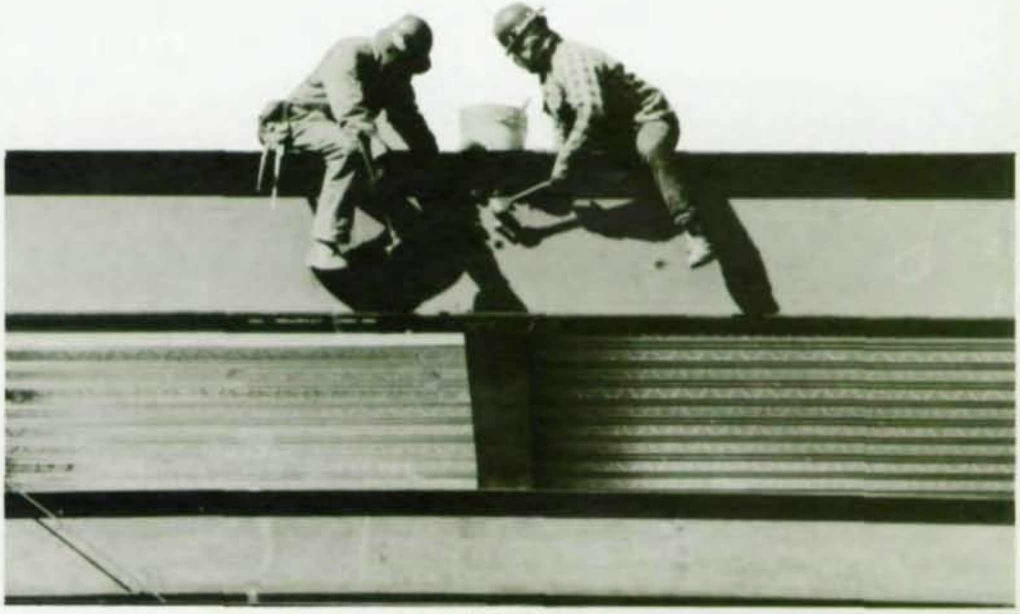
Miguel Betancourt, Purdue University
Michael D. Engelhardt, University of California-Berkeley
Stephen M. Herlache, University of Wisconsin-Milwaukee
Christopher D. Hill, University of Kentucky
James M. LaFave, University of Illinois
Marc C. LeBouton, University of Arizona
W.M. Kim Roddis, Massachusetts Institute of Technology
Dan F. Schertler, University of Kentucky

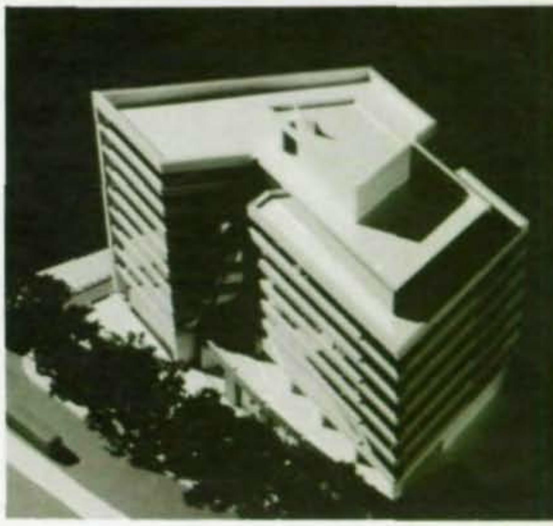
PROF. RALPH RICHARD RECEIVES 1986 T.R. HIGGINS AWARD

Prof. Ralph Richard of the University of Arizona in Tucson will receive AISC's prestigious 1986 T.R. Higgins Lectureship Award at the AISC National Engineering Conference in Nashville, Tenn. on June 12, 1986. His award-winning lecture is "Single Plate Framing Connections—An Overview."

His award, an engraved citation and a check for $4,000 will be presented by Robert P. Stupp, executive vice president of Stupp Bros. Bridge & Iron Company, St. Louis, Mo. Richard will present the paper at five other cities and events during the year.

New Bolt Specification Approved





Ironworkers perform final installation of A325 bolts to double-angle beam-to-girder connection according to new snug-tight procedure. The 1055 Washington Blvd. Building (r.), Stamford Conn., is first structure on which new procedure was authorized.

A new *Specification for Structural Joints Using ASTM A325 on A490 Bolts* has been endorsed by the American Institute of Steel Construction and is scheduled for publication in June.

One of the procedures approved in the new RCSC Specification has already been applied in at least one structure—a 17,000 sq-ft corporate office building under construction at 1055 Washington Boulevard, Stamford, Conn. Structural engineers for the project, LeMessurier Consultants, Inc., approved a request from the steel fabricator and erector to ease the high-strength bolt-tightening procedures and permit installation of snug-tight bolts. On this project, field ironworkers were authorized to tighten certain bolts to a snug-tight condition, which requires only the full effort of a worker with a spud wrench. Previously, all bolts had to be fully tightened to a prescribed and verifiable level of tension.

In the Stamford project, installation of snug-tight bolts was required for all connections, except those in the braced frames. This represents a dramatic, and significant, change in procedure, which should be considered by structural engineers for each job by specifying clearly those connections which only need to be snug tightened.

In essence, the new Specification clarifies criteria for design of high-strength connections to provide for separate consideration of strength and serviceability. That is, connections are designed for strength, considering bearing, shear and tension. Subsequently, for slip-critical connections, the connections are checked for resistance to slip at working load, which requires prescribed levels of tension in the bolts.

Recognition of the calibrated wrench method of installation has been reinstated, but with the requirement for closer control. Rules for use of each of five methods of installation—snug-tight, turn-of-nut, calibrated wrench, use of alternate design fasteners and use of tension-indicating devices are presented separately to avoid confusion.

The format of the Specification in its new edition has been reorganized. The new publication will include an expanded Commentary, based on experience with earlier versions of the Specification, and will emphasize often overlooked material and shipping requirements, the effect of galvanizing on fasteners and connected material, the effect of burrs and paint overspray on faying surfaces, the importance of proper use of installation methods and implementation of effective inspection. The Commentary will also provide background and references to enhance understanding and a basis for exercise of engineering judgment in application.

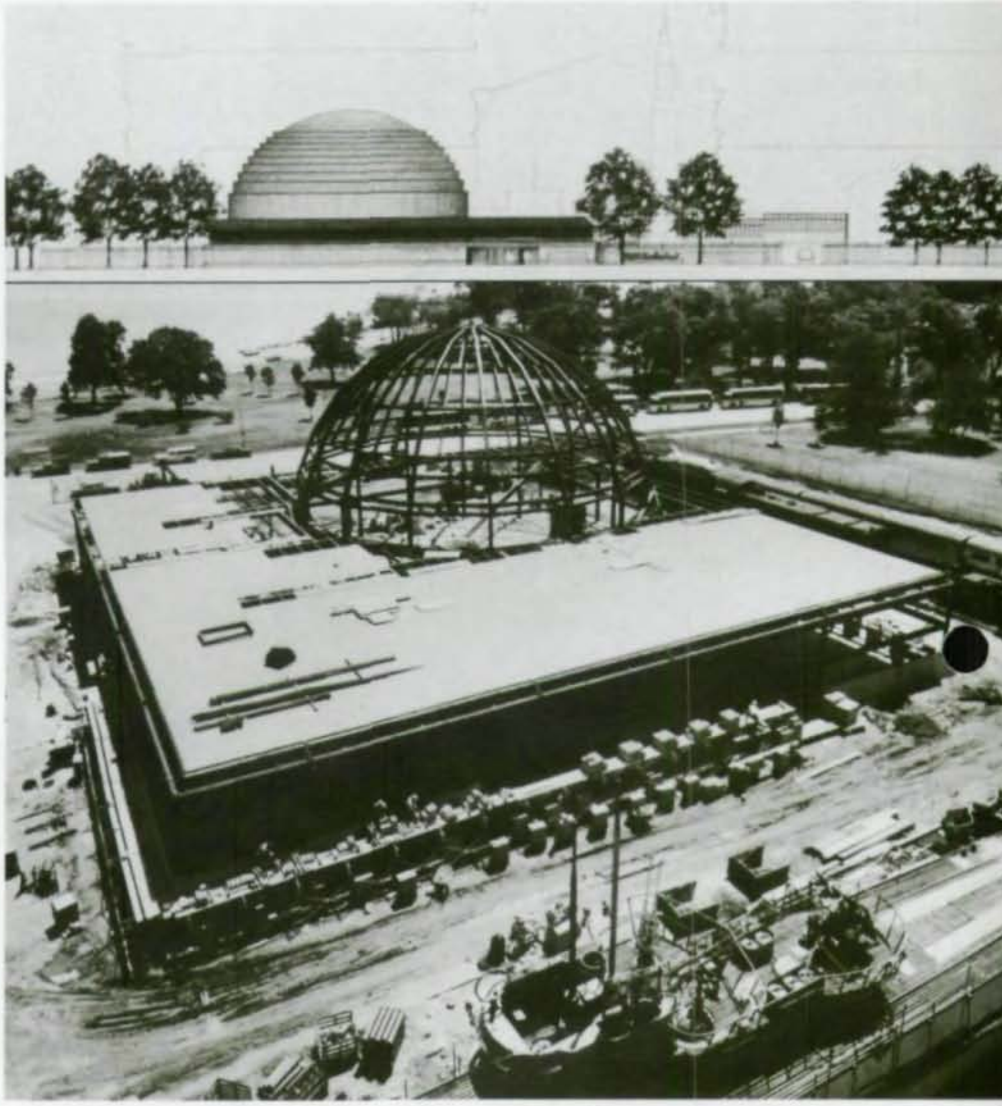
The new RCSC Specification will be the subject of a session at the National Engineering Conference sponsored by AISC and scheduled for the Opryland Hotel, Nashville, Tenn., June 12-14. William A. Milek, who was involved (as the previous director of AISC's Engineering and Research Department) with the development of the new Specification from inception to completion, will discuss the process and application of the new procedures. Fred P. Haas, vice president and general manager of the Vogt & Conant Company, will present "Economics of Field Bolting," with field examples showing how fastener selection and joint design affect speed of erection, job safety and other aspects of construction.

Copies of the new Specification will be available from AISC, P.O. Box 4588, Chicago, IL 60680. Price: $3 each. Publication slated for June 1986. □

Henry Crown Center: A Space Form in Steel

by Yanak Shagalov

Yanak Shagalov, P.E., is a senior project structural engineer with Hammel Green and Abrahamson, Inc., Architects/Engineers, Minneapolis, Minnesota.



Henry Crown Center, Chicago, nears completion on lakefront site. German sub exhibit in foreground. Rendering (top) shows completed structure, slated for mid-summer debut.

When the architect was commissioned to design the Henry Crown Space Center addition to Chicago's Museum of Science and Industry, one of the significant challenges was to house a new Omnimax Theatre in a dome structure.

The museum itself, which occupies a classic Greek revival building on Lake Shore Drive, is the only remaining structure from the 1893 World's Columbian Exposition. Scheduled to open in July, the Space Center is the first major addition since the original Museum complex opened in 1933. The museum management decided to create a permanent exhibit to reflect the growing importance of space exploration in today's world. The exhibit will have three areas: an outdoor space hardware plaza, a 10,000-sq ft exhibit hall and a 25,000-sq ft Omnimax Theatre.

With a seating capacity of 330, the theatre contains 13 rows of seats sloped on a 30° plane. This permits visitors to sit in a reclining position to view the dramatic film image surrounding them. The projection screen, a 76-ft dia. hemisphere, tilted at 30° to be parallel with the seats. The 70-mm fish-eye lens projection system, the 12-channel, six-track surround-sound audio system, and other special effects projectors are synchronized by a computerized controller.

Architectural Relationship Important

Design requirements of the museum stipulated the new structure must relate architecturally to an existing building, with the mass of the structure kept as low as possible. The site is on the east side of an existing structure along the Lake Michigan shore. Connection to the existing Museum was difficult because of the proximity of a submarine display and three exhibit trains. The trains were relocated.

Two major elements of the architectural design are the repetition of the 8-ft high stone base and the dome used on the existing museum building. The 20-ft high exhibit hall area is enclosed by a dark, setback wall which reinforces the strong horizontal lines of the stone base. Although the dome shape ties the two structures together visually, it created acoustical problems within the dome-shaped theatre which required special acoustical treatment.

The Steel-framed Dome

Domes, one of the oldest structural forms, found architectural use dating back more than two thousand years. They provide a very efficient structural solution when a large area must be enclosed without columns in auditoriums, arenas, stadiums, exposition halls, theatres and government buildings. One of the earliest domes built with steel was a design in 1863 by J.W.A. Schwedler, in Berlin. In 1865, the National Capitol in Washington D.C. was construct-

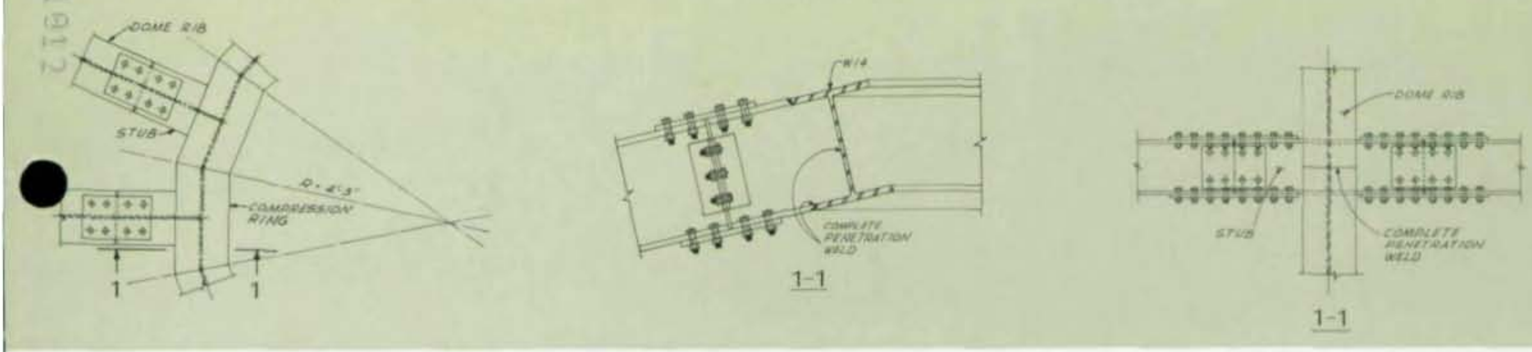


Figure 1

Intricate steel-framed dome is one of more popular and economical types.

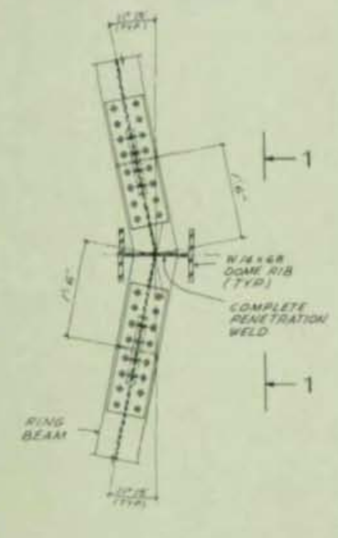


Figure 2

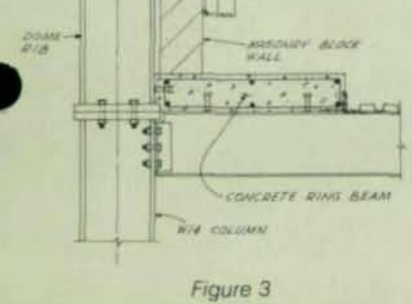


Figure 3

ed using one of the first steel domes in the U.S.

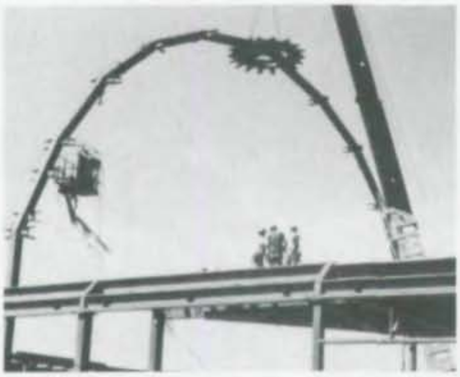
Based on cost input from the project's construction manager, steel was chosen as the least expensive and the most appropriate structural material for the museum's dome roof structure. The particular framing system selected was the Schwedler-type—with its radial ribs and concentric rings—one of the more popular and economical types of steel-framed domes.

The 100-ft dia. steel dome is supported on 11 columns and five transfer beams. Sixteen W14 steel ribs radiate from an 8.5-ft dia. compression ring (Fig. 1). A tension ring was designed around the periphery near the base of the dome to resist the horizontal thrust from the ribs, leaving only vertical load to be transferred to supporting beams and columns. Four intermediate circumferential rings were added to reduce unbraced length of the ribs and provide a means to distribute live and dead loads.

The lateral load-resisting system is a reinforced concrete ring beam at the dome support level (Fig. 2), which redistributes and delivers all wind forces to four rigid steel frames in the lower level. Also, the reinforced concrete ring beam supports the exterior wall around the dome base. The dimensional restriction of the dome diameter imposed by architectural profile considerations resulted in tight interior space allowance. Consequently, projection room framing was suspended from several dome ribs, which resulted in a non-symmetrically loaded and highly indeterminate structure. (Very little recent design information based on practical experience of others was available.) AISC furnished the results of a study it had conducted in the 1960's on symmetrically loaded domes.

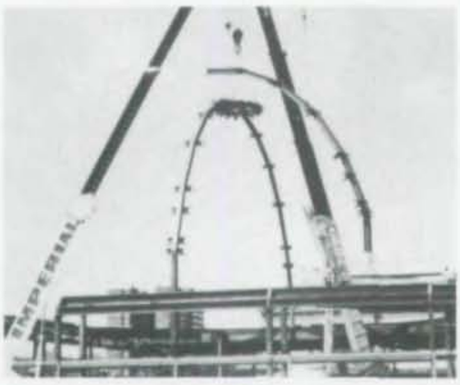
The extensiveness of analysis for non-symmetrical loading is directly related to the large number of members involved. Preliminary design was done by hand calculation, using various engineering publications. The final design included a 192 member space-frame design using a three-dimensional frame-analysis computer program. Dome ribs and ring beams were designed for continuity, reducing considerably the magnitude of the bending moments and making the structure more economical. Also, each rib was detailed as a single element with shop-welded stubs for ring beam connections. Since shop fabrication is typically more economical than field assembly, it proved cost-effective to transport even very large fabricated structural elements to the job site. All remaining connections for the dome framing were designed as field-bolted moment connections (Fig. 3).

The dome surface is a 4.5-in. thick lightweight concrete slab. Heavy metal lath, used as a form, remained after concrete was placed by shotcreting. A system of purlins supported the metal lath between the main framing. Extensive and costly shoring and formwork were eliminated by this system. The concrete dome surface provides both stiffening for the entire



Interesting erection photos (above) show compression ring swinging into place.

Photos below detail ribs dropping into place. World-famous Museum of Science and Industry in background (bott.)



dome structure and meets acoustical isolation requirements for the theatre.

Fabrication/Erection

The 16 dome ribs, each 61.5 ft long, were fabricated full length to eliminate field splices. Special permits and an oversize trailer, with special frames, moved four ribs at a time from shop to job site. The 8.5-ft dia. dome compression ring, 16 separate mitered W14 pieces to form a segmented circle, was fabricated on a table jig, with full-penetration welds.

Fabrication dates were met and erection of the dome began as scheduled. The thorough efforts in designing, detailing and fabricating the steel resulted in a rapid, efficient erection sequence. Dome erection began by raising and suspending overhead the compression rings with a 25-ton crane. A second 50-ton crane hoisted and set the ribs. Bolting was completed from below with two manlifts with 60-ft booms located in the dome center.

Elimination of all field welds by designing bolted connections was a major factor affecting the speed of erection. Field-bolted connections eliminated the need for a scaffold tower to support the compression ring during erection, which resulted in further time and cost savings. In three days, ironworkers had erected all 16 ribs and the crane supporting the compression ring was no longer necessary. A five-man crew remained on the job setting purlins and impacting bolts. Fourteen days and over 10,000 bolts later, the structural steel erection was completed.

In July 1986, the Henry Crown Space Center opens with space artifacts, hands-on-exhibits, a Space Shuttle Program entitled "The Dream is Alive." Yearly attendance at the new center is expected to average 750,000 people.

Architect/Engineer
Hammel Green and Abrahamson, Inc.
Minneapolis, Minnesota

Construction Manager
Schal Associates
Chicago, Illinois

Steel Erector
Midwest Steel Erection Company
Chicago, Illinois

Owner
Museum of Science and Industry
Chicago, Illinois

First Interstate Bank: A Study in Simplicity

by Robert E. Langdon, Jr.

Robert E. Langdon, Jr., AIA, is a partner-in-charge, Langdon-Wilson-Mumper Architects, Newport Beach, California.

With the completion of its new operations center, First Interstate Bank of California continues to provide state-of-the-art data processing capabilities for customers.

The 12-story facility, distinctive for its grey and macaroon-accented facade, is located on a five-acre site next to the new financial area of Los Angeles. The Center, embracing the latest in facilities for financial operations, includes 10 acres of data processing equipment. Within the 764,000-sq ft building are nine floors above grade for administration and, to facilitate high-level security, for three floors below grade to house the computer/data processing operations. These three floors total 125,000 sq ft each, equivalent to eight and one-half acres. With over 120,000 sq ft devoted to computers.

Seismic Considerations

The building structure has four interconnected modules of 120 ft × 120 ft, three of which are in line and have a one-bay offset, with the fourth module carried around one end. The bays, 30 ft × 30 ft, are composite A36 steel beams spaced at 10 ft o.c. The floor slab, of 2½-in. rock aggregate concrete over a 3-in. metal decking, contains electrified cells in the floors above ground. The floors were designed for superimposed live loads of 100 psf typically, and 125 psf in the lower computer floors.

Additional requirements were to: design a steel structure (for below grade levels) capable of supporting a future 21-story building; and span a 60-ft bridge from the fourth floor to the parking structure.

Of major importance is the seismic design of the building, which limits movement between floors to a one-inch maximum during a major earthquake. Lateral resistance for major earthquake load conditions was resisted by ductile moment-resisting frames above the ground floor and a combination of frames and concrete walls be-

First Interstate Bank, Los Angeles. Below, 60-ft long bridge takes pedestrians from 4th floor directly to parking deck.

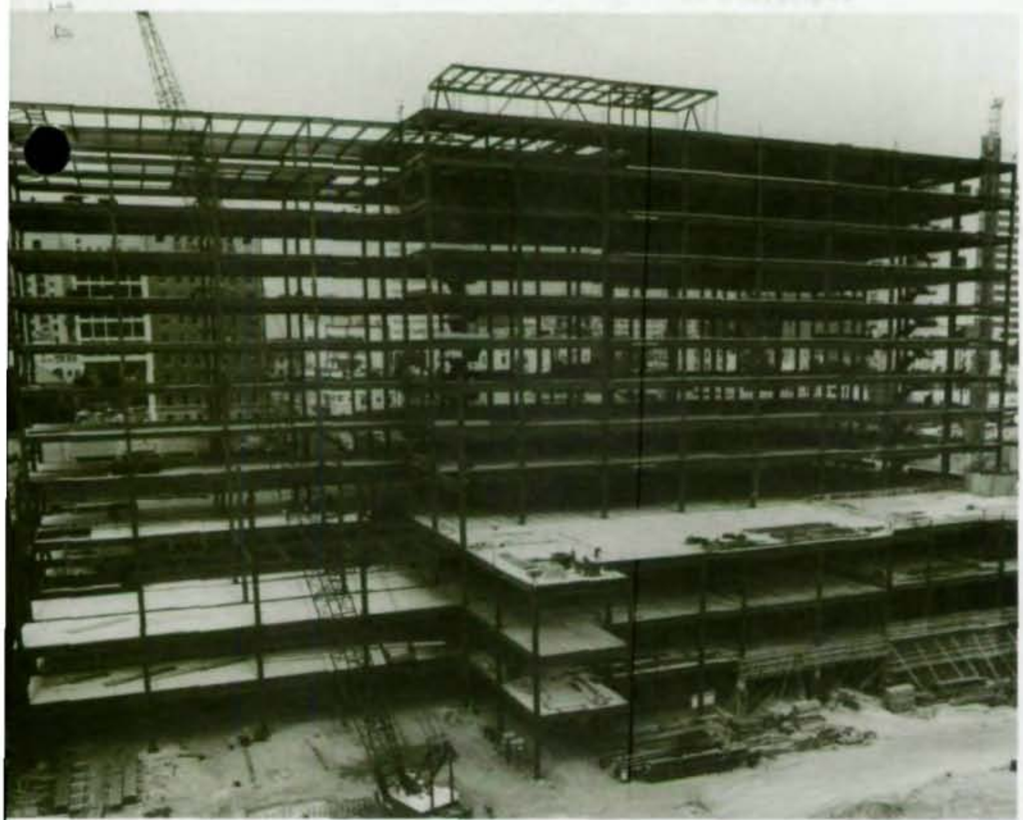
low. There are four transverse frames, two at each end of the building and two at each of the building offsets at 120-ft modules. The two longitudinal frames, at the perimeter, have one offset condition on each side.

Frame columns are of 50-psi steel and all other steel conforms to A36 for a total of 6,000 tons. The building was fast tracked in phased construction to permit placing of the tie-back shoring system and basement walls during the steel fabrication. The net result was a continuous construction process, with overall savings over other structural support systems.

Sloping Site Accommodated

The architect took advantage of the 40-ft sloping site by placing the Operations Center's entrance on 7th Street, the high point of the site—and the parking deck entrance at the low point. The two structures are joined by a pedestrian bridge which extends from the fourth floor of the operations building over the landscaped plaza to the top level of the parking structure. The

Steel-framed building was fast tracked to permit tie-back shoring and placement of basement walls during steel fabrication.



Structure is four interconnected modules designed to support a future 21-story building.

1,660-car deck has four levels above grade and five below grade, a design plan which visually reduces the massive expanse of the complex.

First Interstate worked closely with employees to incorporate their ideas in the Center's design—to create an environment to best serve both employees and management. The Plaza on the entrance level contains a 500-seat cafeteria with around-the-clock service. This level also boasts a fitness center, for all employees, featuring professional instructors, aerobic classes and Nautilus equipment.

The building's power system is housed below ground level. Five 1,100 kw diesel engine generators supply standby power for life/safety, security and essential bank operations. These generators, which come on line within 10 seconds, can support the facility at least a week without outside utilities. A 1,500 kva, uninterruptable power supply with 15-min. battery backup provides continuous and stable power to all computer operations, security systems and the telephone switch.

The building's air conditioning systems include a 4,000-ton refrigeration system, 500 tons of which operate on emergency power. The concrete cooling towers adjacent to the parking structure are uniquely designed for high security and minimum disturbance to an adjoining hotel. On-site water storage permits the towers to operate in an emergency without outside water.

The Operations Center also features an uninterruptable telecommunication system. By using microwave and satellite technology, the private network handles all data between the Southern Center and the Northern Operations Center in Fremont, Cal., which opened in 1983 and serves as the back-up for the Los Angeles Center.

The First Interstate Operations and Administration Center was designed simply and systematically to meet the client's requirements, budget restraints and fast-track construction schedule. First Interstate Bank justifibly claims to be one of the best equipped and finest operations centers in the world. □

Architect
Langdon-Wilson-Mumper Architects
Los Angeles, California

Structural Engineer
Brandow & Johnston Associates
Los Angeles, California

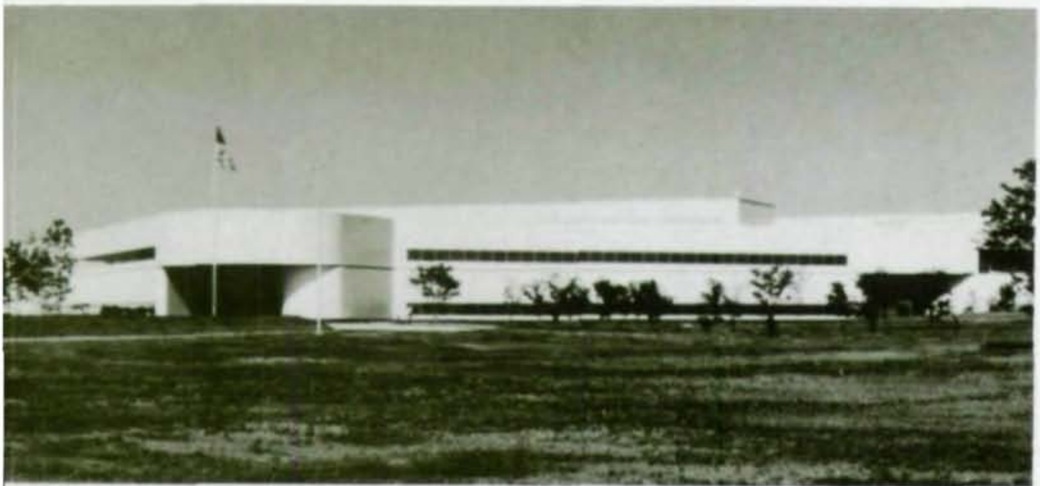
General Contractor
Turner Construction Company
Los Angeles, California

Owner
First Interstate Bank of California
Los Angeles, California

Nissan Motor: State-of-the-art—in Steel!

by Henry L. Ritter

Henry L. Ritter, P.E., is senior associate and assistant chief, structural/civil engineering with Albert Kahn Associates, Detroit, Michigan.



Nissan Motors building transformed 782 acres of pasture into state-of-art assembly plant. More than 14,000 tons of steel framing went into 2.8-million sq ft facility.

Nissan Motor Co. captured international headlines when it announced plans to form Nissan Motor Manufacturing Corp. U.S.A. (NMMC), a wholly owned subsidiary to manufacture its first North American-made vehicles.

Today, NMMC captures headlines of its own. In 1984, *Fortune* magazine named the plant one of the 10 best-managed factories in the U.S. *Building Design & Construction* magazine gave NMMC its 1985 Owner of the Year award for the positive impact the plant has made in the community. And that same year, the Michigan Society of Architects presented its prestigious Honor Award for architectural excellence.

Beyond the headlines, however, is yet another story—transformation of 782 acres of limestone-laden pasture land in Smyrna, Tenn., into a state-of-the-art automotive assembly plant; the relationship between the owner, the architect-engineer, and the construction manager/contractors, which enabled the 3,400,000-sq ft plant to begin production two months ahead of schedule; and the major role steel played in the design and construction of the plant.

The plant design reflects its dual purpose as NMMC's corporate headquarters and the firm's first North American manufacturing facility. A two-story, triangular-shaped building containing corporate and administrative offices and employee facilities is attached to one side of a 3,700-ft spine, the facility's main product movement and pedestrian link. On the other side of the spine are three major buildings—body, frame and stamping (1.1 million sq ft); paint (524,000 sq ft); and trim and chassis (1.2 million sq ft)—which comprise the manufacturing component of the plant. Large outdoor courts separate the buildings, providing perimeter access, storage areas, employee recreational areas and expansion zones for the buildings. On-site ancillary facilities include a vehicle storage yard, service parts warehouse, emissions testing facility, vehicle test track, employee training center, boiler house with trestle for utility distribution to the main buildings, baler building and waste treatment plant.

More than 3,000 are employed at NMMC. Operating two shifts, the plant is scheduled to reach its annual production capacity of 100,000 cars and 140,000 light trucks late this year. Currently, the plant, representing a $745-million investment for Nissan, is the company's largest overseas investment and the largest to date by a Japanese company in the U.S. It also is one of the most technologically advanced in the automotive industry. Computers monitor and control the manufacturing processes, energy management, security and maintenance functions. Assisting in the assembly process are 237 robots which perform various welding and painting tasks.

Accelerated Design Schedule

An accelerated design schedule began immediately after NMMC announced selection of its site Oct. 30, 1980. On Feb. 6, 1981, the three main manufacturing buildings and spine, representing over 2.8-million sq ft of facilities and 14,000 tons of steel, were out for structural steel bids. In those three months, a remarkable chemistry had developed between the owner and the architect-engineer to allow this challenging project to evolve from concept to finalized design in such a short period of time.

Handsome employee entrance to administration building. Photos courtesy Albert Kahn Associates.

From the beginning, Nissan presented a well-developed plan of material flow and production requirements. The owner's original concept called for 15-m × 15-m bays with 7 m clear height in the body and frame areas and the trim and chassis building. These dimensions were ultimately rounded off to 50-ft × 50-ft bays, with a 23-ft clear height.

Resolution of the paint building bay sizes required considerable discussion between the owner, the paint equipment consultant and the architect-engineer so column lines could be located to meet the process equipment layout requirements. Ultimately, a series of 50-ft × 50-ft and 100-ft × 50-ft bays were selected. By recessing some equipment in shallow pits, the same 23-ft clear height could be used, as in adjacent buildings. Maintaining the same bottom chord elevation throughout the building areas served by conveyors was an advantage because the overhead conveyor system could avoid extra level changes.

The 336-ft × 600-ft stamping area consists of a 100-ft × 336-ft steel receiving bay and three 112-ft × 500-ft long stamping bays. All bays have a 46-ft bottom chord height above the first floor and full coverage crane runways for 30-ton top running cranes. A 19 ft-8 in. deep basement spans the full 336-ft stamping area width. Four tier steel framing supports the presses and the first floor framing. The presses include several huge and heavy "tri-axis" transfer presses. Foundation bearing capacity was no problem as the basement rests on solid limestone.

Typical Bay Space Optimized

The administration building is a two-story steel structure. Architecturally, its bay modules are 25 ft o.c. at right angles to outside diagonal walls. The structural module is the diagonal of the 25-ft square architectural module or 35 ft-4¼ in. square. The typical second floor construction is steel floor beams located at the quarter points of the bay and framing into shallow floor trusses. The floor beams use steel studs in composite with the concrete floor slab. Roof construction is beams and purlins. With several million sq ft of the project comprised of 50-ft × 50-ft bays, the architect-engineer obviously gave considerable thought to optimizing design of the typical bay.

The buildings have extensive overhead conveyor coverage. As a result, roof trusses were placed 16 ft-8 in. o.c., as opposed to 25 ft o.c., to lessen the weight of steel framing required to support conveyors. Since most of the conveyors run east/west, roof trusses span north/south 16 ft-8 in. o.c. east/west.

Minimum truss depths were dictated by the space requirements for the mechanical and electrical building and process utilities. The major utility lines enter the main buildings on trestles from the boiler house and then loop around inside each building. A minimum truss depth of 7 ft-6 in. was selected. To give more open truss space, a Warren-type truss was used. This gave the design option of eliminating every other vertical unless required for support of conveyors. Actually, very few of the omitted verticals were installed.

The project, governed by the provisions of the Southern Building Code, permits a roof live load reduction from 20 to 12 psf for tributory load areas over 600 sq ft, for which most trusses qualified. Of greater concern than the absolute code live load minimum was the prevention of major water buildup on the roof.

Aerial photo of finished car assembly plant displays mass of project.

Computer-designed Trusses

The paint building has a constant one-way 1% sloping roof across the full 350 ft width of building. Truss depth at the high point is 11 ft; the truss depth at the low point is 7 ft-6 in. Roof scuppers placed in the low point parapet supplement the roof drains and prevent major water ponding. The increased truss depth was used effectively to support fan rooms on the roof across the full width of the 100-ft bay at the high end.

Since the other two major buildings—body, frame and stamping and trim and chassis—were segmented with interior parapeted expansion joints, a roof scupper approach was not feasible. The roof system selected for these buildings has a 1% roof slope with ridge lines and valleys alternating 50 ft o.c. A secondary ½% slope built into the valleys assures positive drainage to the roof sumps. These two buildings then were designed for the possibility of water completely filling up a 100-ft wide trough. As an extra safety precaution, overflow drains projecting several inches above the primary roof drains were installed in each valley.

When the computer-designed trusses were run for the typical roof truss (50 ft long, 16 ft-8 in. o.c.) using the dead-, live- and wind-load combinations, it was found that both the top and bottom chords selected had significant reserve capacity for approximately 25% additional downward applied loading. Further analysis determined the increased loading could be accommodated by bringing the chords to full capacity by increasing only two diagonal members.

The principal reason for the reserve referred to was that the code stipulated wind with dead-load case which created a net uplift condition. This caused most members to have stress reversals due to load conditions in compression from either a net upward wind with dead load or downward from the dead with live load condition. With a relatively small tributary load area and relatively deep truss height, the member forces were relatively small. Most members were controlled by the minimum slenderness ratio l/r of 200 for compression members as opposed to the magnitude of the force.

This additional load capability was incorporated and used effectively by increasing the load allowance for mechanical and electrical services from 6 psf to 12 psf on the typical 50-ft long trusses 16 ft-8 in. on center. This allowed the building services to be located with a greater degree of flexibility without requiring special truss reinforcing.

Perhaps the most useful design aid developed during the design phase of the project was a series of drawings, one for each of the three manufacturing buildings, which indicated the design loadings by bay for: bottom chord hanging load provisions for conveyors and other equipment below the bottom chord; and mechanical and electrical services in the truss space.

The conveyor loads in particular involved extensive research because of the variety of load combinations. The architect-engineer was furnished data for all conveyor components, the product weights and spacing and a series of layouts showing conveyor routing for both present and future considerations. To their further delight, this data was furnished in the early stages of the project and all loading provisions were incorporated into the initial fabrication without requiring any subsequent reinforcement.

Steve Steele, the Nissan staff engineer assigned as structural/civil liaison during the project reported, "The loading charts allowed us to find out easily the design loads for a specific area. Representatives from the architect-engineer's office and our company really did their homework during the original design phase of the project in order to include provisions for future plans. As a result, we recently converted our operations from truck production to truck and car production within the existing structure without the need to reinforce a single truss." □

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Fast Tracking:
Where are We Now?

Emile W.J. Troup
AISC's Boston regional engineer

The fast-track method for building design and construction has been in use for quite a number of years now, accounting for a vast majority of the work done in many offices. Late in 1985, the AISC New England Advisory Committee decided the time had come to take a critical look at the first 10 years (or thereabouts) of fast-track accomplishments and disappointments and, in the process, perhaps develop some useful points from "lessons learned."

A panel of distinguished professionals representing the "supply side of the building equation" (see Michael Nelson's remarks) was convened at a workshop during BUILD BOSTON/'85, the annual two-day everything sponsored by the Boston Society of Architects. During their presentations and the lively discussion that followed, the architect, structural engineer, steel fabricator and erector frankly addressed what they perceived as the issues raised by fast-tracking.

As you will see, fast tracking has different implications for each of the four disciplines reporting here. However, there is a general sense that, given the right type of project, a dedicated supply side team and an experienced owner and construction manager, the fast-tracked project can yield rewards for all.

Another common thought: fast tracking is probably here to stay. And you will sense the speakers believe it is important to understand the weaknesses and disadvantages of the process as well as its positive aspects. In this regard, we think you will find the following discussion revealing and useful, despite the fact the options are individual ones by professionals operating in the New England market.

The reader should appreciate the willingness—even eagerness—to discuss the undiscussable: the need for earning a financial reward for a job well done in servicing a demanding client.

Fast Tracking:
THE ARCHITECT . . .

E. Crawley Cooper
Principal, Jung/Brannen Associates
Boston, Massachusetts

It is not immediately clear why the steel industry would ask someone from our firm to speak about fast tracking. Actually, fewer than three percent of the projects in our office are done on a fast track basis—the rest are done on "zoom-track"!

The fast track process, of course, has been around for some time, and for many good reasons. A very prominent component of the decision to go to fast track, and probably the reason most frequently mentioned, is the influence of high interest rates on debt service during design and construction. Even with interest rates coming down, however, we are going to be dealing with this process for some time. We think this is good.

There are many positive things about fast track, especially for certain types of buildings. For a client in a volatile market who needs to produce a product quickly, the window of opportunity is open only a short time. If a client needs a warehouse or factory, the fast-track process is the obvious choice. Or, if a contractor needs to get into the ground before the building is designed, because of New England weather, it is again a reasonable solution.

It is a fact that fast tracking can shorten the objection time posed by reviewers. We find the approval process today actually takes longer than the design and construction processes combined. There is always an army of "ag'inners" out there. But if the project is already underway, the opposition is somewhat inhibited.

Better Communications

From the architect's viewpoint, fast track provides an opportunity to better communicate before and during the design process with suppliers, fabricators and erectors. Aspects such as moment connection details, erection problems and sequencing can be resolved in cost-effective ways with the open communications available in having the steel fabricator participate with the architect and engineer in reviewing design options. Early feedback on costs can help keep a project within budget.

Not the least of the reasons for fast tracking, however, is that the contracting industry strongly favors it. Those contractors with strong marketing departments face less competition, and there are fewer risks involved from their point of view. Not all sub-contractors are in a position to bid on this kind of job, and the competition

Early feedback on costs can help keep a project within budget.

among sub-contractors is reduced generally to only three or four bids. Because construction starts before the design is complete, changes become a cost burden to the owner, and the contractor almost has a blank check. This provides a good incentive for the owner to keep changes to a minimum. Coupling all of these reasons together, fast tracking sounds like a good

Strangely enough, it is much easier to design a building which is very adaptable and flexible than to design one specific to a particular program.

idea from both the owner's and the contractor's points of view.

Some building types, such as commercial office buildings, warehouses or single-story factories, make a great deal of sense if done fast track. However, on other kinds of buildings, such as institutions, hospitals, more complicated concert halls and laboratories, where fast track is probably *not* a good idea because the process tends to inhibit innovation. The architect tends to go back to the tried-and-true design formulas, refining them, but not really creating or developing new ideas. This may be a good thing occasionally, but it certainly should not be the process on every type of build-

We recently designed a concert hall using the fast-track process. The building, on a very tight site, had an egg-shaped plan and a radial column grid with intersecting ellipses. As you know, a concert hall has balconies and unusual shaped spaces. We actually had to program a computer to determine the exact location of all of the column intersecting grids. We provided a computer with the identical program to both the contractor and the structural engineer. You can imagine trying to create shop drawings where beams are on a sloped diagonal, on a chord of an ellipse that may have a radius of 500 ft. It was a very difficult kind of project to do using the fast track process. The result is a nice building, but it should not have been done under the intense pressure of fast tracking.

Strangely enough, it is much easier to design a building which is very adaptable and flexible than to design one specific to a particular program. One of the problems of fast track is the necessity to integrate the various systems in a building early in the process, including the heating system, ductwork, risers, elevators, shaft openings, etc. It is quite easy to provide a very flexible design, if the client is willing to spend a lot of money, but few owners or developers are willing to do this. If you are unconcerned about cost on an exterior wall area

Boston's new World Trade Center (top) is remodeled Commonwealth Pier (bott.). Fast tracking was major consideration in exciting renovation project.

(a very costly item), a floor-to-floor height in an office building can be 14 ft. Even with a 40-ft span, it is quite easy to design the structure fast track, knowing it will work out later when you start developing the branch duct design. It is much more difficult to design in advance when trying to keep the overall building costs down. The costly perimeter wall must be squeezed. A lot of beam penetrations must be eliminated because they can be costly, especially if made after steel is erected.

Modified Procedures for Documents

Thus, it is ironic that many aspects of fast-track design are relatively easy. Yet, without concentrated effort at the appropriate time, the building can be very expensive. At our firm, fast track is the normal process of producing building designs, as we do very little public institutional work. As a result, we have modified our procedures for producing documents. We have 10 distinct bid packages to develop and release during the process:

1. Site utilities and earthwork
2. Foundations
3. Steel frame or bearing walls
4. Mechanical and electrical
5. Vertical circulation
6. Building skin and roof
7. Doors, frames and hardware
8. Interior finishes
9. Specialties and equipment
10. Landscaping and site improvements

These 10 packages are presented here in the general sequence in which they are needed to keep construction moving. Most senior people in the office spend more time on "zoom-track" projects than those bid in the normal way architects were trained to practice when I was in school. The complications of the design process demand more senior staff attention.

We developed checklists in our office for these 10 packages. An interesting aspect of these checklists, and one which demonstrates the major complications of fast tracking, is that they are inter-related. It is difficult to have the steel complete unless you know pretty much where you stand with the elevators. The shaft size is a function of the size of the cab and the number of cars. Thus, each package has to be brought up to a minimum level of completion before it can go out. This is particularly true of the steel package on which so many *building parameters depend*.

It is certainly clear to all who work with fast track that the process is around to stay. It meets a great many needs posed by today's economy, business climate and operational procedures. However, there is a real need to refine the process considerably, so that each job runs more smoothly and the individuals involved are more comfortable as they work within the process. This refinement requires the evolution of ground rules that become accepted throughout the industry, so rules are not developed on an *ad hoc* basis.

It is certainly clear to all who work with fast track that the process is around to stay. It meets a great many needs posed by today's economy, business climate and operational procedures.

Above all else, the process demands open lines of communication that often do not exist in the traditional building process. The designer, owner, fabricator, erector and structural engineer must all communicate yet maintain their separate areas of responsibility. Each must initiate contact with the others, providing expertise and cost information as required.

Fast tracking is not favored by everyone in the industry. The architect is pressured to develop final answers earlier than most like to do. Owners assume a greater risk, permitting decisions to be made before design is complete, and spending money before they are sure of a final product. The pressure and intensity are great, but some economic and market conditions dictate fast track as a process with merit for a great many buildings.

Fast Tracking:

THE STRUCTURAL ENGINEER

Michael J.A.H. Jolliffe

Vice president, Zaldastani Associates
Boston, Massachusetts

To be sure that my remarks may be properly interpreted I think it is important for me to first define some terms relating to method of contract. I would like to discuss 3 methods: *Traditional—Advanced Construction Award—Construction Management.*

Traditional assumes a completed set of coordinated design documents, bid on and awarded to a general contractor.

In the *Advanced Construction Award* method, fast tracking, which can be defined as providing a series of sequenced sub-contract documents to advance construction operations, is usually used for only a few trades such as excavation, substructure concrete and superstructure steel. These subcontracts are assigned to a general contractor, who is awarded the work after bidding conventionally the remainder of the project. The contractor then works against a lump sum and has the responsibility to coordinate all the trades and complete the building on a schedule. He has the incentive to function efficiently and make a profit. The owner has the advantage of bidding the majority of the work and has a clearer idea of his final costs, the architect and his consultants have the opportunity to provide a set of documents that are internally coordinated except for the initial trades and they are able to function in the traditional way during the construction phase.

With *Construction Management*, in most cases the CM acts as a broker to purchase different elements of the building from a number of different subcontractors. Although, in many cases, the CM assumes a role similar to that of a general contractor during the construction process, all too frequently in my experience, it is not clear who is the "licensed builder;" who is responsible for coordination between the work of the subcontractors and who is responsible for quality control; who stops the earthwork subcontractor from backfilling against the retaining wall before it has attained sufficient strength, who polices the concrete subcontractor for the integrity of his work. Too often, it appears the CM considers his role to be principally that of maintaining schedule. Often there appears to be absent the recognition that, because of the sequential issue of drawings, there is a demand for considerably more construction engineering, planning and coordination than in a traditional project where, to a greater extent, the building systems have been coordinated within construction documents. Emile Troup (AISC's Boston regional engineer) has talked about the fact we have had construction managers in our midst long enough for us to have learned some lessons and reached some conclusions. Perhaps!

We have reached a time when we should be defining the issues. What we have attempted to do over the last few years is to try and use the traditional method of preparing design documents and the traditional relationship between the parties during the construction phase to respond to a totally different set of circumstances created by the CM approach. This has jeopardized the cost and the integrity of the project and potentially, and in reality the safety of the public. I am convinced it is a condition we cannot responsibly allow to continue.

Design Phase

As a structural engineer, one who is responsible for the structural design of the building frame and usually responsible for the first set of construction documents issued to the CM, I am acutely aware of some potential pitfalls. Except for the simplest buildings, we frequently prepare final working drawings without adequate information about dimensions, the location of floor openings, and occupancies (and therefore loadings) in different parts of the building changing. All without decisions having been made about the materials to be used to enclose the exterior, with little information about the size of mechanical ducts which must be accommodated, and so on. Often, while the building is still in a state of flux, when neither gravity nor lateral loads can be established, there is a request for a foundation design.

This is not to say that given a set of circumstances which warrants fast-track construction, we should not respond. But we should consider whether this method of construction is appropriate for a particular set of circumstances and develop better techniques, during both the design and construction phases to accommodate it.

When is fast tracking appropriate? There are differing opinions. Clearly, the purpose must be to reduce the time between initiation of the design and delivery of the building—not to reduce the overall cost of the building, because there are certainly many cost penalties associated with this approach. It would therefore appear appropriate when it is necessary to construct a building to meet market timing demands—for product manufacture, identified early real estate demand, changes in tax structures and anticipated interest rates and so on. Fast-tracking should not be a substitute for advanced planning. We have seen buildings, which were originally conceived as CM projects, being bid subsequently at considerable savings.

One idea that is helpful in designing a structure for fast-track construction is to consider the building is going to be remodelled.

If it is possible to follow the traditional route, I would recommend it. If an earlier start is required, the advanced construction award approach should certainly be considered as a substitute to using construction management.

We should be sure CM is adopted for the right reasons. Frequently it appears to be adopted by the owner to control costs in the design stage. There are methods to enjoy the joys and rewards of cost control without marriage.

One idea that is helpful in designing a structure for fast-track construction is to consider the building is going to be remodelled. In all likelihood, it will occur before the construction is completed. This remodelling will occur either because of modifications to the architectural design intent, because of changed loading conditions, or the needs of a tenant, or to accommodate unknown mechanical ducts, and for countless other reasons. A structure, which in its basic concept is responsive to changes and is not designed for the absolute minimum loading allowed by Code, will be much more accommodating and flexible to conditions created by fast-track construction. This is why we see a predominence of structural steel buildings—their ability to accommodate change.

Construction Phase

Although we may have such a responsive building structure designed and presented on our construction documents, it is vital that we keep track of it. We all know there are likely in all but the simplest buildings to be changes of considerable significance. There has been the tendency in the past by many owners, architects and engineers to somehow consider that because changes, which always precipitate increased charges by the contractor, occurred to the structure, there must have been something defficient in preparing the documents. One thing we can now say with confidence is that it is the contract method which incurs the increased cost—and this cost should certainly not be borne by or assigned to the design team.

But more than the design of these changes is important. It is vital they be followed through shop drawings and carefully tracked in the field.

It is in the field the greatest jeopardy to the integrity of structures occurs under the CM approach. There has been a tendency for CMs to sell their services as providing quality control and assurance. There is no substitute for the design engineer providing quality assurance. Traditionally, field inspection represents the last opportunity to verify the structure has been designed and built according to the designer's intent.

When fast-track construction is used, it is even more vital the design engineer have the opportunity to follow construction in the field. This assures him no changes other than those to which he has responded have been made, and that those required have been incorporated. Periodic inspection provided in the standard Form of Agreement of the American Institute of Architects is inadequate.

But clearly, other parties must be involved in the process. Because the structural engineer has not had the opportunity to coordinate his work with that prepared by the architect and his other consultants in their construction documents, and because details of other trades' requirements were not available to the concrete or steel fabricator at the time of shop drawing preparation or fabrication, it is vital the CM be prepared with qualified staff to identify those parts of the structure which must be amended to accommodate the trades included in later construction drawing packages. This effort should receive much more attention than at present, and should be formalized.

Building Design Philosophy

In reflecting on the issues of present day construction, I was reminded of some analysis done almost 20 years ago when we were looking at systems housing construction and which was expanded on when we were involved with masterplanning a new city in the Mid-East. What is interesting is that many criteria which appeared important to the economical development of buildings have been adopted in structures now being built. For instance, in this analysis, building elements were divided into three categories—enclosure subsystems, service subsystems and finish subsystems. Structure, along with plumbing, HVAC and electrical distribution subsystems, is seen as a service subsystem. It fixes the enclosures in space—this is much more how structure is now being used. One of the goals for enclosures was that all exposed surfaces should have an unexposed surface so service functions could be distributed to them—the ubiquitous drywall partitions and suspended ceilings and raised floors respond to this. These concepts, and the others derived from the analysis, permit greater independence of the building subsystems. With the CM method, it may well be we should be looking more carefully at the selection of building components and the dimensions of unexposed volumes to reduce the amount of interface between trades. Where interfaces are necessary, we should attempt to standardize them.

Conclusions

In summary, in using fast-track construction, firstly, it is imperative the method of construction be a vital parameter considered in making decisions regarding the design of all building elements and their assembly, so documents may be prepared which are, to the greatest extent possible, not dependent on subsequent coordination with other trades. However, these documents must consider the ease with which other trades may be incorporated into the total building in a sequence which is coordinated by an organized and disciplined CM. These staged documents must exist in their own right and should be amended and revised, when required by the further development of the building design, in a formal manner with change orders to each of the multiple subcontracts, and with appropriate compensation to the design team for the preparation of these changes to the completed stage documents.

Secondly, after developing a schematic design in response to the building program developed by or with the owner, the input of the CM, with regard to economies which can be achieved, must be integrated into the design process. The impact of this input on the immediate and long-term objectives and value to the owner and to the public weal, to which the design professional must always recognize his responsibility, must be assessed by the owner and the design team. Then the manner in which the adoption of any of these proposals is incorporated into the design must remain under the control of the design professional to ensure clear lines of responsibility are drawn and the secondary impact of any changes are recognized and accounted for.

Thirdly, during the construction phase, it is vital that there be centralization of control of document coordination and the delivery of coordinated documents to all affected parties. Equally important, because of the added complexities associated with this coordination, is the more frequent presence of the design professional to ensure correct interpretation of current documents in the field, and that proper control procedures are adopted.

Failure to recognize the need to adopt these procedures is likely to cause confusion, delay, error and added cost to a project and produce results which run counter to the original intent in adopting the CM method.

Fast Tracking:

THE STEEL FABRICATOR . . .

Michael L. Nelson

Vice president, Leake & Nelson
Bridgeport, Connecticut

If I could sell one thing to all with regard to fast tracking, it would be the *spirit* of fast tracking—to get it accomplished as a team—the initial rush of excitement when it has been determined the job will go fast track.

Everyone sits down in a room together. The architect has a concept, the engineer has a typical bay framed and the fabricator has an idea of how to best implement them most efficiently and at the lowest cost. There is where the dollars and cents are saved, and when the time is saved. Everything after that is mechanical, although it takes a certain amount of time to accomplish it. But the dollars and cents savings, and the ability to make a fast-track job a *good* job, are accomplished even before a whole lot is on paper.

It is the spirit of fast tracking that makes me look forward to coming to the office. A lot of fabricators can do what I do every single day as well as I do it, but I think we have an opportunity when it comes to fast tracking to show something special, to do something special. It is a different kind of opportunity.

The people on this panel—an architect, engineer, erector and myself, a steel fabricator—really represent the supply side of the fast-track equation. The other half, the demand side of the equation, is represented by the owner-developer. Equilibrium in this fast-track market place can only be reached through a clear definition or understanding of what needs to be accomplished and how to accomplish it for the mutual benefit of both parties.

Great Opportunity to Pool Know-how

The best thing about fast-track construction is that it presents the greatest opportunity for all parties concerned to use their accumulated knowledge and skills to accomplish construction of a building in an extraordinary time frame. The incentive for a fabricator to get involved with this type of construction is the elimination of some of the competitive forces of an openly bid project. The incentive for the developer is that he can complete the structural frame weeks, or even months, ahead of what he might expect ordinarily.

Suppose, for example, we have a job with equilibrium between the supply side and the demand side of the fast-track equation. By the way, I rule out as legitimate fast tracking the following situations:

1. A buyer who wants to meet an accelerated completion schedule, but insists on five prices and three weeks to evaluate the bids.
2. A buyer who has an accelerated completion schedule, but who does not have the talent, or has not hired a contractor with it, to process and understand your drawing needs.

Bayside III was prominent fast-tracked project for this Boston Society of Architects conference.

3. A buyer who has an accelerated completion schedule, but who has not shared the schedule with all the components of the supply side, i.e. architect, engineer or erector.
4. A buyer who insists upon unilateral liquidated damage clauses. He is not part of a team, but rather someone looking to place blame and point fingers.
5. A buyer whose accelerated schedule is beyond the reasonable.
6. A buyer who does not pay his bills in a timely fashion, no matter how reasonable all other aspects of the project are.
7. A buyer who has not gone fast track before. Let someone else be his guinea pig. Of course, depending on the strength of your relationship with the buyer, there are exceptions.
8. A buyer who has no good reason to go so fast; i.e. other parts of the construction or site work, or demolition, cancel the need to have steel ready early.

This may all seem like stating the obvious, but many a fast-track job was ill-conceived. We all have horror stories about lawsuits, revisions, misunderstandings and ruined relationships because of them. I like to think of this saying relative to fast tracking, "It is better to be part of a solution than part of a problem."

A Candidate for Fast-track

Anyway, suppose we legitimately identify a candidate job for fast tracking. The job is a 100,000-sq ft office building with on-grade parking. The framing scheme, and hopefully the fabricator had some input, has been chosen to be structural steel. The building footprint is a given, there are typical wall details, elevations and architectural renderings. The engineer has been chosen, but he has only come up with the typical bay framing. The owner says he wants the structural frame to be delivered to the job site within 14 weeks. Can you do it with the limited amount of information already supplied? My answer would be "yes," and even faster if:

1. The engineer gives me typical floors, roof and spandrel sections within two weeks.
2. The engineer agrees to a drawing turnaround time of three days.
3. Shop drawings are hand-carried, or at worst, mailed overnight in both directions.
4. The buyer agrees to agree on a price, that price to be in his hands within one week of receiving the fast-track bid documents. During that week the fabricator's detailer is authorized to make an anchor bolt plan and preliminary mill orders. If the bid price were unacceptable, all drawings and detailing time would be paid for and turned over to the buyer.

Unit prices would form the basis of adds and deducts. (A caution here: detailing would be charged by the hour and would not be part of a per-ton allowance.) As we all know, and certainly in the initial stages of fast tracking, the detailer can make several changes without really affecting the weight of the building. And if he is part of a unit price, $1,200/ton, let's say, the detailer in fact may be donating his time. Also, a sufficient number of unit prices would be provided to cover a variety of circumstances.

How might you agree to agree on unit prices? The buyer must have at least a reliable budget in order to enter into an agreement that also protects the fabricator. The fabricator should have an historical perspective of what a typical job might cost. For instance, this 100,000-sq ft office building is 250 ft × 100 ft, has unlimited site access, 25-ft × 25-ft bay framing, and a glass curtainwall. It has 90° corners, three stories and a roof. The typical floor framing is composite beam and girder, and a bar-joist roof.

In my market place, that floor should be about $6.50 per sq ft and the roof about $5.25 per sq ft, excluding a penthouse. Each floor is 25,000 sq ft, or 75,000 sq ft in all, at $6.50, or $487,500. The roof is also 25,000 sq ft at $5.25, or $131,250, for a total building cost of $618,750. If I were to check that figure, and at the same time indicate to the buyer we knew what we were doing, we might do the following:

Say the floor area, historically should weigh about 8.5 psf and roof about 7.5 psf. This type of square framed building in A36 steel should cost about $1,200/ton. Therefore,

8.5 psf × 75,000-sq ft floor area	= 637,500 lbs.
7.5 psf × 25,000-sq ft roof area	= 187,500 lbs.
Total 825,000 lbs. @ $1,200/ton	= $495,000
Add 75,000-sq ft floor deck @ $1.25	= 93,750
Add 25,000-sq ft roof deck @ $1.00	= 25,000
Add 15 studs (an historical number) per 100 sq ft of floor area @ $1.60 ea.	18,000
Total	$631,750

This compares to the square-foot budget of $618,750. Then, take the average of the two prices at $625,250 and a plus or minus range of 5%, the job could be expected to cost between $594,000 and $656,000. This is very, very rough, but it should give the developer an indication of the neighborhood in which that building should cost. If the developer or architect wants to add a corner office with a little skew, that is not too bad—but not a *curved* corner office. These kinds of things add to delivery time and cost. Now that the developer is convinced of the fabricator's competence with relation to budget and unit costs, we should talk about the things designers need to do to make sure the job does not get hung up.

This budget could form the basis of an agreement, but it must be an agreement of respect, common goals, and, above all, mutual benefit. Items beneficial to the early completion of detailing and fabrication include, overtime premiums for detailers and approvers. Remember that in a job taking 14 weeks to deliver, actual fabrication time may consume only three or four weeks. The rest of the time is consumed by the submittal and approval of shop drawings. Of course, material is gathered during that same time period. The hours consumed by the drawing submittals is totally disproportionate to the dollars spent during that time. The job previously discussed might cost typically $40/ton to detail, or $16,000 to $20,000. As a percentage of the total job cost, this amounts to about 3%. That means 3% of the job cost consumes 60 to 70% of the lead time. There certainly should be no hesitation on the part of the buyer to cooperate in the expeditious processing of shop drawings.

Tips for Tighter Cooperation

The fast-track buyer must be very careful to dovetail his other trades. A granite skin with an 18-week lead time, or a mechanical system requiring a depth of construction greater than the theoretical floor heights—and therefore, beam penetration details and locations—might cancel the gains in fast tracking the frame. Ideally, a building should be sectionalized immediately after the contract has been awarded. This permits the detailer, approver and fabricator to concentrate on producing the items required first (i.e. 1st floor before the roof).

The engineer should size the sections conservatively. This may allow for duplication and also speed the engineering time required. For instance, if a W21 × 62 will work without further engineering investigation, while a W18 × 60 might work if the design were more thoroughly investigated or live load reduction accounted for, the extra time spent might not be justified. Particularly, where this type of change results in material-only saving of $500/ton—not fabrication eliminated, resulting in savings of $1,200/ton.

This is absolutely crucial: the fabricator should submit and the engineer *verbally* approve job standards as quickly after contract is issued as practicable. Nothing slows a job faster than a detailer who proceeds with all possible haste in a manner the engineer is eventually going to disapprove. If there is a problem with the job standards, they should be resolved by phone and confirmed in writing ASAP. The engineer must try to be as sympathetic toward the fabricator's standard details as possible. If the fabricator is reputable, he will submit only job standards of good fabrication practice.

Obviously, there are conditions where the engineer is going to say, "I need this type of loading and this type of connection in this particular instance." The fabricator who is going to go fast, however, is the one who uses his own standards.

Try whenever possible to avoid painting the steel. Not only is it about $40/ton cheaper, but also it is about one hour/ton quicker to fabricate. This could represent a reduction of as much as 10% in fabrication time. Hard-to-get-items, such as a long lead time metal deck or exotic materials should not be specified.

Consider the feasibility of high-strength steel, remembering that the more competitive, and therefore available, materials are A36. We do not recommend high-strength steel at this time in a fast-track project, unless the weight savings are at least 25%. Market conditions may change rapidly, so this relationship bears close monitoring.

Fabricators should be allowed to use sepias of the engineers' plans for their own erection plans. Of course, the fabricator becomes responsible for their ultimate correctness, but this may save as much as two weeks or more of detailing time.

Beyond all of these items, the single most important part of fast tracking is the relationship between those who supply the materials and expertise and those who create the demand. The developer or buyer should not employ the supplier, and then use money for leverage. Nor should the buyer consider his time or opinion more valuable than that of those he hires. In return, the supplier must recognize he is involved in the project to provide extraordinary service for which he has been paid a premium. He is, therefore, obligated to fulfill his promises if the terms and conditions (which he has insisted upon as conditions of his employment) are adhered to.

Ideally, the measure of success should be the willingness of all parties concerned to co-venture another fast track project on time and within budget.

Fast Tracking:
THE ERECTOR . . .

James F. Stearns, IV

President, L. Antonelli Steel Erecting Co.
Quincy, Massachusetts

I suggest the following considerations in fast tracking:

- Maintain close contact with architects and engineers when designing in steel, and try to incorporate as many duplicate beams as possible, and use slap-type connections where possible.
- Have pre-job meetings with unions or erection crews to stress the importance of a fast-track, problem-free job.
- Predetermine with the engineer, contractor and testing company the type and amount of testing required to insure a timely test of steel where it is to be erected on an accelerated schedule.
- Arrange for prompt availability of power because all critical phases of backup work depend on it—welding, bolt tightening and lighting.
- Request use of torque-control bolts where easy tightening and visual inspection qualities will save time and money.
- Zone steel storage carefully with respect to contractor needs. Promotes better crane timing, less job site room and rehandling of steel.
- Determine what types of accelerated methods of steel erecting are required, such as pre-unloading of steel, need for more cranes, overtime when erecting or on backup work.
- Plan carefully for added shifts with proper lighting, supervision, night deliveries, etc.
- Reach agreement with engineer and contractor regarding field changes—beam penetrations, added steel or modifications. □

Sugar Loaf Mountain:
Steel Framing + Teamwork = Fast Track

A remarkable example of fast-track construction unfolds at Sugar Loaf Mountain in Central Maine. It is not a new expert slope, but rather the Thomas Center Hotel and Conference Center under construction near the base lodge. And two key factors emerge as essential ingredients of a successful fast-track project: a commitment by the entire team to the owner's schedule, and the use of fabricated structural steel framing.

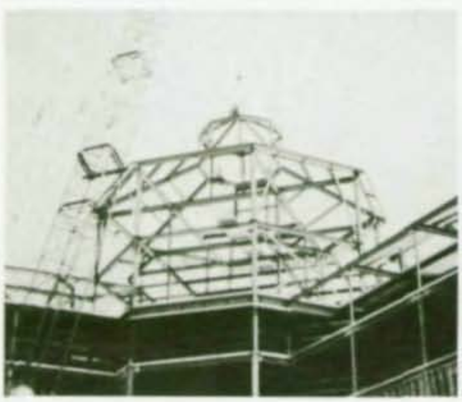
Fast-tracking does not omit any of the necessary steps in the design/construct process. But it does require that foundation and structural steel drawings be issued and materials ordered prior to completion of architectural plans. The owner must weigh the increased probability of shop or field changes in the steel framing against an occupancy date several months earlier than with the conventional process. Earlier occupancy means reduced finance costs and earlier income, and often results in savings of hundreds of thousands of dollars, even on modest projects.

"It is a more risky proposition for the entire team," says Jonathan Buhl, formerly a principal with the structural engineer. "You cannot always do things by the book. You have to be prepared to bend, adjust and change as the need arises. The project is more difficult to control, and because of the inevitable field changes during construction, the designer winds up spending as much time on the project during this phase as during the design, and he must allow for that."

One of the crowning achievements of the team involved in the Thomas Center was a "three-day turnaround time" for review and approval of shop drawings during design revisions. This was no easy task, considering: the design team is in Watertown, Mass.; the steel fabricator is in Berlin, N.H.; the steel detailer in Canada; the construction manager in Providence, R.I.; and the owner at Sugar Loaf Mountain (Central Maine). "None of the overnight services could accommodate delivery of shop drawings," according to Buhl. Drawings were often hand-carried to airports at either end and placed on commercial flights.

The Thomas Center is a condominium hotel. One of the issues not resolved until very late in construction was just which spaces in the six-story building would be residences and which would be commercial. Changes in occupancy occurred in areas sometimes after steel had already been erected. To Buhl, it seemed that parts of the Thomas Center were changed three or four times.

Model of Thomas Center Hotel and Conference Center on famed Sugar Loaf Mountain. Closeups show details of steel framing on $8-million hotel. Center opened just one year from time structural engineer received commission to design frame.



The fabricator recommended single-plate connections at many locations. These were especially economical and fast for framing beams into 4 × 4 and 6 × 6 structural tube columns. "The fabricator did an incredible job in getting material to the site so fast," says Buhl. They had purchased all the steel from service centers to save time. This allowed field changes to be completed within two weeks after changes were ordered by the owner.

The construction manager, when informed of the owner's schedule, instructed the structural engineer to submit structural plans in three weeks in order to have the project completed in one year. Fourteen drawings for this $8-million building were completed by the end of February 1985, and the final architectural plans were not finished until May. "That's the fast-track process in its truest form," in Buhl's opinion.

The structural engineers considered other framing materials, including masonry bearing wall, composite steel joists and light gage metal. But the construction manager ultimately went with composite steel beams and steel columns. One reason for this was the tremendous transfers of load required between the second and third floors, where the occupancy changes from open commercial space to residential above (with bay sizes of 15 × 21 ft). The decision turned out to be the right one. "There is no way we could have kept on schedule with all these changes had any other framing system been used," Buhl reports.

In spite of the challenges imposed on the entire team by the fast-track method, there is a major advantage for the owner, ironically, in quality assurance. Since the designers were totally involved in the project throughout construction, these professionals were on top of the job and in constant contact with other team members during the most crucial phase. A better building has to be the result!

The Thomas Center opened in February 1986 at the height of the ski season. This was just one year from the date the structural engineer received the assignment to design the frame in three weeks—quite an achievement for an $8-million building. But that was only the start of this fast-track project, and its ultimate success depended on the commitment of all team members.

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Sugar Loaf Mountain Corporation

Nevada Administrative Facility: A Perfect Fit Insured by Steel

by Thomas J. Schoeman

Thomas J. Schoeman, AIA, vice president of JMA Architects, Las Vegas, Nevada was design architect for this facility.

Committed to a service concept which stressed an integrated administrative, preventive and treatment program, in 1974 the State of Nevada initiated a comprehensive master plan study for the State Industrial Insurance System. To satisfy the operational delivery needs of Southern Nevada, the study called for a single-site phased facility development program.

Phase one is a rehabilitation center and industrial therapy facility. Phase two—featured in this article—called for a centralized administration facility. Phase three, to be completed in the future, calls for a patient housing facility to serve the needs of clients living in areas remote from available treatment programs.

Located on a 16-acre site in central Las Vegas, the administration facility expansion project creates a central home for previously scattered State Insurance Services. The two-story, 75,000-sq ft facility maintains a low profile image complementary to the existing complex by matching its existing parapet heights. Public hearing and employee services are situated on the first floor to provide ready access to the disabled, with policy holders' and administrative services on the second. By cradling the new facility in the arm of the existing southern facing complex, a sheltered outdoor atrium zone is created. This area serves as a protected recreational, dining and conversation area for staff and clientele.

The building exterior is finished in 30-in. × 22-ft weathering steel panels. The prefabricated panels afforded rapid construction and created a maintenance-free exterior. The exterior envelope is well insulated, with all glazed areas either recessed from the building edge or screened with louvers to provide shading from the sun.

A vaulted skylight extends the full length of the building to define circulation and provide a visual focus to adjacent administrative areas. The skylight provides natural light to the office areas and dilineates volumetrically different open office areas.

Nevada Administrative Facility, Las Vegas, created central home for scattered insurance operations. Model (l.) details steel-framed skylights so important to project.

A structural steel grid, 22-ft × 22-ft at Level one and 22-ft × 44-ft at Level two, was developed as the optimum module for compatibility with proposed open office layouts and systems. A steel rigid frame was chosen as the structural system for its design possibilities, efficiency and its capacity for fast construction.

Poor soil conditions required the use of either drilled-in concrete piers connected together at the top by grade beams, or a mat foundation. Concrete piers and grade beams were determined to be the more economical solution. The piers range from 2 ft-6 in. to 6 ft-6 in. in diameter.

The building was designed as a ductile moment-resisting frame in both directions, with five ductile frames in the short direction and two in the long direction. As a

Structure was designed with moment-resisting frames. Horizontal X-braces provide continuous roof opening to frame skylights.

Steel-framed atrium zone joins addition to existing facility.

Interior photos highlight several uses of structural steel to accommodate skylights and overhang framing.

result, about one-fourth of the frames in each direction are moment resisting. This arrangement resulted in maximum freedom of design because there was no bracing. And, at the same time, it contributed to the economy of construction because only about one of four had to be moment resisting.

To accommodate a 12-ft overhang above continuous glazing on all four building edges, special attention was paid to construction details and stiffness of framing members. Two large horizontal X-braces were used to provide the continuous roof opening required to frame the vaulted skylight. The X-braces were wrapped in drywall to create an integral architectural feature.

Greater flexibility of telephone, data and electrical systems was achieved in the open office areas by using flat-wire distribution. The mechanical system for the new facility is an all-air variable volume system with air-handling units on each floor to serve both interior and perimeter zones. The central plant consists of two hermetic, electric-driven centrifugal water chillers, two induced-draft cooling towers, one natural gas-fired hot water boiler for morning warmup and the associated pumping and ancillary systems. The facility also incorporates a flat plate solar collection system for generating domestic hot water. Anticipated energy performance is well below federal guidelines, analyzed at only 40% of total demand levels recommended by those guidelines.

In summary, the selection of a structural steel frame and weathering steel panels permitted not only rapid construction but also created a humane, flexible environment compatible with the operational requirements of the State Industrial Insurance System. □

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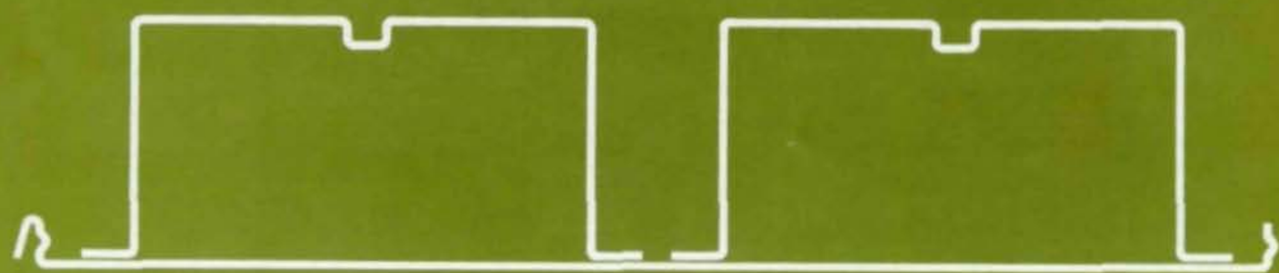

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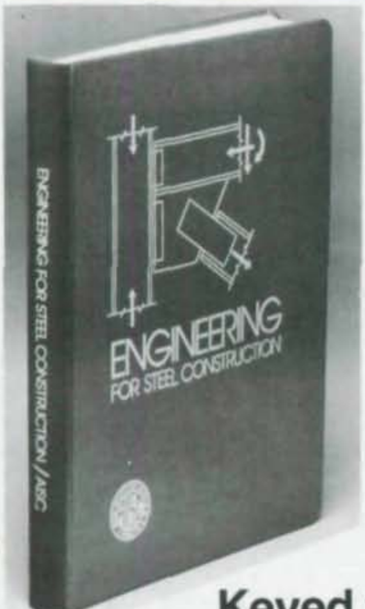

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