VOLUME XXVI NUMBER 1/FIRST QUARTER 1986

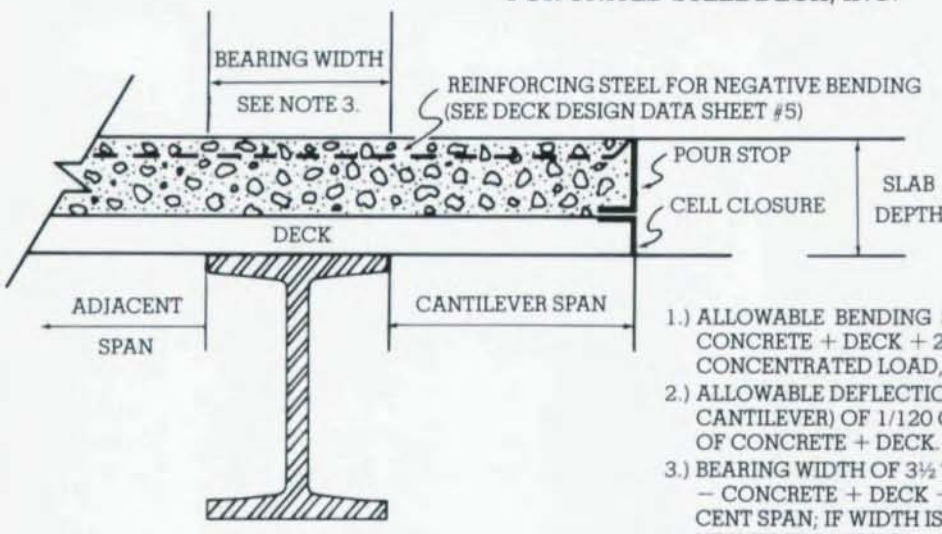
MODERN STEEL CONSTRUCTION

DECK DESIGN DATA SHEET.

NO. 7

MAXIMUM FLOOR DECK CANTILEVERS

FOR UNITED STEEL DECK, INC.



NOTES:

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

FLOOR DECK CANTILEVERS

NORMAL WEIGHT CONCRETE (150 PCF)

	UNITED STEEL DECK, INC. DECK PROFILE															
	1.5 IN B-LOK				1.5 IN LOK-FLOOR				2.0 IN LOK-FLOOR				3.0 IN LOK-FLOOR			
Slab Depth	22	20	18	16	22	20	18	16	22	20	18	16	22	20	18	16
4.00"	1'11"	2' 3"	2'10"	3' 4"	1'11"	2' 4"	3' 0"	3' 6"								
4.50"	1'10"	2' 2"	2' 9"	3' 3"	1'10"	2' 3"	2'10"	3' 4"	2' 6"	2'11"	3' 8"	4' 3"				
5.00"	1'10"	2' 2"	2' 8"	3' 2"	1'10"	2' 3"	2' 9"	3' 3"	2' 5"	2'10"	3' 6"	4' 1"	3' 8"	4' 3"	5' 3"	6' 0"
5.50"	1' 9"	2' 1"	2' 7"	3' 0"	1' 9"	2' 2"	2' 9"	3' 2"	2' 4"	2' 9"	3' 5"	4' 0"	3' 7"	4' 1"	5' 0"	5' 9"
6.00"	1' 9"	2' 0"	2' 6"	2'11"	1' 9"	2' 1"	2' 8"	3' 1"	2' 3"	2' 8"	3' 4"	3'10"	3' 5"	3'11"	4'10"	5' 7"
6.50"	1' 8"	2' 0"	2' 6"	2'11"	1' 9"	2' 1"	2' 7"	3' 0"	2' 3"	2' 8"	3' 3"	3' 9"	3' 4"	3'10"	4' 8"	5' 5"
7.00"	1' 8"	1'11"	2' 5"	2'10"	1' 8"	2' 0"	2' 6"	2'11"	2' 2"	2' 7"	3' 2"	3' 8"	3' 3"	3' 9"	4' 6"	5' 3"
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MODERN STEEL CONSTRUCTION

VOLUME XXVI NUMBER 1/FIRST QUARTER 1986

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1986 NATIONAL ENGINEERING CONFERENCE EMPHASIZES LATEST TECHNOLOGY

The 1986 National Engineering Conference will be held June 12-14 at the Opryland Hotel, Nashville, Tenn.

Its keynote session will focus on major advances in both building and bridge construction.

Building construction seminars, workshop and panel discussion topics will include: Load and Resistance Factor Design; bolted moment connections; ponding of concrete decks, systems approach for staggered trusses; advances in the design and construction of mixed steel-concrete buildings; designing for fire protection; examination of wind drift criteria; and the role and implementation of project specifications in the total construction process.

Bridge workshops will consider: 3D analysis of girder bridges; utilization of the new AASHTO Guide Specification for beam bridges; design for minimum total bridge costs; computer-aided design of horizontally curved girders; jointless steel bridges; and composite plate girder bridges. Both long and short span bridge design will receive attention.

A special Saturday morning session will examine the implications of the Mexico City Earthquake for future building design.

Concurrent sessions, with each session repeated twice, will permit attendees ample opportunity to hear subjects of particular interest to their own practice.

For details, call or write AISC, 400 N. Michigan Ave., Chicago, Ill. 60611, 312/670-2400. □

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In a continuous effort to provide design aids to structural steel designers, AISC has developed a Computer Data Base for properties and dimensions of structural steel shapes, corresponding to data published in Part 1, 8th Edition Manual of Steel Construction, *for these personal computers:*

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   - g. *Structural tees cut from W shapes (WT)*
2. *Data base formats*
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4. *Listing of a read/write program and complete data base images.*

Cost of this data base is $40 ($30 to AISC members). To order, enclose check—specifying one of the 5 PC models—to AISC, P.O. Box 4588, Chicago, IL 60680.

Lambert International:
Architectural Creativity in Steel

Airline deregulation proved very beneficial to business at Lambert-St. Louis International Airport. The physical growth of the airport broke ground for architectural innovations in steel construction. Deregulation led to the decision of two major airlines, TWA and Ozark, to build a hub in St. Louis, so much of the Lambert project responds to their hubbing and expansion needs. Since renovations began at the airport in 1979, Lambert has grown from 12th to sixth in the ranking of the nation's busiest airports. The project, a $250-million project, has already more than doubled the size of the airport and tripled the passenger handling capacity. Three major features of the expansion are a TWA concourse extension, Concourse C; an entire new concourse for Ozark Air Lines, Concourse D; and a cargo-handling facility.

Structurally, the expansion project has no new features to boast. Standard components and connections were used throughout. But what is unique is the architectural use of these standard steel components. According to Pat Askew, deputy project director for the A/E firm responsible for overseeing the entire landside project, the architectural and economic success of the expansion resulted from this innovative use of commonplace components. One such distinctive element is that Concourse D's curtain wall is in steel, which is "pretty unusual" for an airport concourse. "Steel siding used to be just used for utilitarian, industrial applications; now it is gaining acceptance for public buildings—as an architectural design element. We used what comes out of the catalog to really play with some concepts that saved time and money, and yet produced a unique, dramatic building."

TWA Concourse C, Lambert Field (above & below). Majestic blue-colored columns and 40-ft diameter skylight create gateway to main lounge.

Concourse C

TWA decided to build the Concourse C extension when it established St. Louis as its main hub. The airline needed to extend its existing concourse to double the number of gates, provide space for executive offices and an Ambassador's Club, and to set up a special baggage-handling facility. The $20-million, 120,000-sq ft extension accommodates these extra requirements

Spacious quality achieved by architectural interaction of exposed steel trusses and skylighting in 2-story rises of TWA concourse.

with a unique three-story design which blends with the existing two-story structure. Standard features of an airport concourse are on the middle level: passenger hold rooms at gates on both sides of the building, lounges, shops and offices. Three sections of moving walkways, each 140 ft long, make it easy for passengers to get to gates from the main terminal. The third, or upper, level houses the Ambassador's Club and TWA executive offices. The lower level houses a baggage-handling facility, independent from the system in the main terminal, to allow transfer of baggage quickly from one TWA flight to another in the hub system.

Because most airports do not have three-story concourses, the new arrangement permitted innovative design features. Over all lounge areas in the concourse the third story is left open to create a spacious effect and a stimulating atmosphere. Extensive use of skylighting accents the two-story spaces. "The added height visually enlivens the area," notes Askew, "while the skylights provide substantial supplementary lighting."

Steel played a significant role in the innovative architectural features of the concourse. Like existing concourses, the structural system of the extension includes 30-ft column spacing and 75-ft clear-span trusses. Because the columns and trusses are exposed to view, special care was taken in welding and finishing the connections. The fresh, spacious quality of the concourse results from the architectural interaction of the exposed steel trusses with the skylighting and carpeted interiors within the two-story rises.

Like other concourses at Lambert, the HVAC system is part of this architectural expression. Unique to Concourse C, however, are the sizable columns which conduct steam and chilled water from an underground utility tunnel to the HVAC system on the roof, and also house ducts to circulate warm or cool air. Carpeted in blue to complement the interiors, these 12-ft and 10-ft-diameter tubes rise majestically within the lounge areas to circular skylights on the ceiling. Moving walkways carry passengers into the heart of the extension, marked by a dramatic combination of a 40-ft dia. skylight and the large blue columns which serve as a gateway to the main two-story lounge.

The only structural difference between this concourse and existing concourses is that the extension has three stories. Yet, it is within this difference that major architectural changes in the standard design could be implemented. The result is an extension which blends with the connecting building, but has a distinctive, open quality of its own. At the same time, the extension meets the functional requirements of accommodating executive offices, club and baggage facilities.

Concourse D—a Fast Track

Concourse D is the showpiece of steel construction at Lambert, both in terms of construction methods and architectural design. The $46-million project used about $4 million in steel. Because Ozark wanted the 15 new gates opened quickly, the 210,000-sq ft concourse was built on a special fast-track schedule—shaving nine months off construction time. The fast-track was in two steps: first, the project was split into separate bid packages, starting with construction of the foundations, structural steel, exterior walls and roof. The exterior was completed enough by winter months for the second construction team to begin on the plumbing, HVAC, electrical systems and interior work, thus saving six months construction time.

In the second phase of the fast-track, three more months were saved by preparing structural steel shop drawings during the design stage. Approved shop drawings were ready before the contract was awarded. Askew notes, "Normally the design is completed before shop drawing detailing begins, but for Concourse D, once we had framing plans underway, we started talking to the detailer, who advised us of the most practical and cost-effective methods for connections and fabrication. Involving a detailer early was a great way to save time. Since we're talking about roughly 3,000 tons of steel, it was a practical solution to a difficult problem."

Fast-track schedule shaved nine months off construction time of 210,000-sq ft Ozark Concourse D.

Ozark's concourse was designed to accommodate people-mover above roof (top). Steel-framed project was split into separate bids to speed completion.

As in Concourse C, there was little unusual about the structural design of Concourse D. Once again, standard steel components were used to satisfy requirements, and at the same time create an architecturally distinctive building. Structural requirements for the concourse were dictated by several factors. First of all, unlike Concourse C, Concourse D is bounded on one side by a major highway. Boarding, therefore, can only take place on the other side of the building. This called for a narrower building, with no passenger hold rooms on the south side of the concourse. Secondly, in the expansion master plan, Concourse D will serve as a link between a new east terminal and the existing west terminal. To facilitate the eventual movement of passengers from one terminal to the other, a people-mover was designed into D. The structure is designed to accommodate a rubber-wheeled car system to run along a track above the roof of the concourse.

In considering these criteria, the concourse was designed with 60-ft span trusses, as opposed to C's 75-ft spans. Column spacing is 60-ft o.c. instead of 30-ft o.c. because the direction of the structure turns along the length of the concourse, instead of the width. Interior columns in the north bay were extended through the roof to support the future people-mover. And columns, beams, connections and footings were designed to carry the extra load.

Another design requirement was the incorporation of a moving walkway system to carry passengers the length of the 3,000-ft long concourse—about four times longer than TWA's extension. Six sections of moving walkways were designed into the concourse. In the first phase of construction a 300-ft × 12-ft hole was left in the floor, and steel supports put in for later installation of the walkways.

The structural outlines for the concourse—the highway boundary, one-sided nature of the building, and supporting columns for the people-mover—were the basis for the distinctive, aesthetic architectural design elements featured. The walkways are set off to one side of the concourse, basically in an environment of their own. Curving glass vaults rise above the walkways to stimulate the passenger as he walks from the terminal to his gate. Staggered with the glass-vaulted walkways are solid-vaulted sections made of curved steel panels, supported by bent-steel tubes. These panels were then carpeted to complement the concourse interior.

The two-level building houses aircraft operations on the lower level while the upper level includes passenger hold rooms, concessions, restaurants and other public conveniences. The concourse also houses a 90,000 sq ft, two-gate international facility.

The location of the utility distribution system for Concourse D was dictated by tight scheduling criteria, which precluded digging an underground utility tunnel. Because of fast-tracking, as well as the desire to make the exterior of the building attractive to highway travellers, it was also necessary to avoid roof penetrations. The roof could therefore be put in place more quickly, and the entire interior process continue without delay. Instead of placing the distribution system on the roof or underground, a 10-ft wide horizontal utility chase was built into the lower level, directly below the moving walkways, to house HVAC and mechanical systems. Since the existing utility plant is a full mile and a half from the middle of Concourse D, a new utility plant and electrical substation were built on the apron level. The plant, located adjacent to and below the public areas, is insulated and soundproofed, thus unnoticeable.

The exterior of the concourse is designed to complement the existing concourses and terminal, and also boast distinctive architectural features. One unique feature of Concourse D's exterior is that steel plays more than a structural role in

Curving glass vaults rise over walkways, set off in their own environment (l.). Exterior (r.) shows steel curtain wall which resulted in 60% savings.

the design. One advantage of the new technology in the use of steel, according to Askew, is that "now steel can be made into flat, lightweight panels, by using sandwich-type construction with a rigid, honeycomb center. The paper honeycomb between the two thin steel layers adds strength and lightness. Coatings that are available give steel panels the appearance and performance of much more expensive metals." The quality appearance of the concourse exterior was a critical concern, since the south side is the landside visitor's first view of the airport.

The 22-ga. steel curtain wall runs along the entire length of the concourse in 5-ft modules. The wall is supported by the building's steel frame, hung off the beams which support the roof. It is attached to the beams every two feet by 14-ga. steel studs. A 60% cost savings resulted by using this sandwich-type construction. A problem noticed by architects in the past with anodized aluminum exteriors is that the metal has a tendency to discolor in an inconsistent fashion. To protect the steel curtain wall, coatings of Kynar 500 Metallic, a state-of-the-art treatment, was applied. The coating, which has a 20-year guarantee, makes the concourse blend in with the other, aluminum-sided concourses. Says Askew, "The curtain wall is another standard component of the concourse—it is out-of-the-catalog, off the shelf—but we used it here in a distinctive way."

Cargo Complex

To make room for Concourse D, an existing cargo complex was torn down, requiring construction of a new facility. The new five-building, 150,000-sq ft cargo complex follows the general theme of steel construction at Lambert: standard components used to make architecturally attractive as well as practical, efficient, economical structures. Sverdrup worked closely with the nine airlines who were tenants of the $8.1-million complex so the buildings would be designed to fit their needs. The five warehouse-type buildings are all oriented towards a common public truck court, ensuring efficient traffic flow and permitting future horizontal expansion of all buildings along the length of the court.

The building complex is designed to minimize energy consumption by maximizing use of natural elements, all within the constraints of the varied requirements of the many airlines who occupy the facility. The roof system features a series of south-facing, recessed clerestories, designed to allow light and heat in during winter, yet block out the summer sun. Sloped roofs behind the clerestories reflect light indirectly into the buildings. Heat is exhausted by fans in the truss space of the sidewalls.

The versatility of the structures comes as a result of the 25-ft modular steel construction. For airlines with larger needs, the modules are 120 ft × 25 ft, while smaller buildings have 25-ft × 80-ft modules. To maintain the economical nature of the larger buildings, a center column uses 60-ft trusses. The modular construction facilitates future expansion of the buildings.

Building materials were chosen for their permanence and performance in an industrial environment. The structure is a series of columns and long-span trusses with joists and roof deck. Outside walls are demountable precast concrete panels with corrugated steel fascia. A standard spread-footing foundation was used. The high-bay buildings are 16 ft clear to the underside of the structure—large enough to allow palletized stacking of cargo, and to provide ample space for maintenance shops and offices. The flexibility of the space lets airlines build either a two-story office or a single-story area with an upper mezzanine.

The architecture of the cargo complex blends with the similar, standard construction of the airport terminal, while the repeated use of clerestories in the complex contributes a distinctive aesthetic pattern to the complex itself. □

Nine airlines share Lambert air cargo complex (l.). Structure's versatility comes with 25-ft modular steel-framed construction, adapted to each carrier's needs (below, l. & above).

Architect/Structural Engineer/ Project Manager
Sverdrup Corporation
St. Louis, Missouri

General Contractors
Hercules Construction Co. (Concourse C)
McCarthy Brothers Construction Co. (Concourse C)
Hankins Construction Co. (Cargo Complex)
St. Louis, Missouri

Steel Fabricators
Ozark Structural Steel Co. (C)

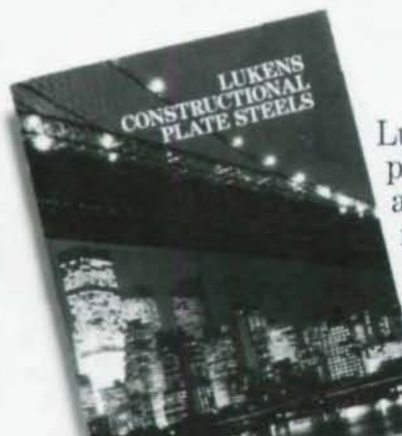
Acme Structural, Inc. (D)
Springfield, Missouri, and

Banner Iron Works (D)
St. Louis, Missouri, and

Kaysing Iron Works (Cargo)

Owner
City of St. Louis, Missouri

Don't miss the strip show on page two.



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Golden Gate Bridge:
They Worked by Night!

by Daniel E. Mohn

Daniel E. Mohn, P.E., M. ASCE, is chief engineer, Golden Gate Bridge, Highway and Transportation District, San Francisco, California.

A major inspection of the Golden Gate Bridge in 1968-69 revealed the reinforced concrete roadway to have widespread defects and local failures. Further investigations found the concrete of the roadway with a high level of chloride ion contamination and that it was beyond the threshold limit of one lb. of sodium chloride per cu. yd. of concrete. Therefore, the existing roadway could not be restored economically or practically. Independent studies confirmed complete replacement of the roadway and its supporting members was economically preferable over rehabilitation of the existing one.

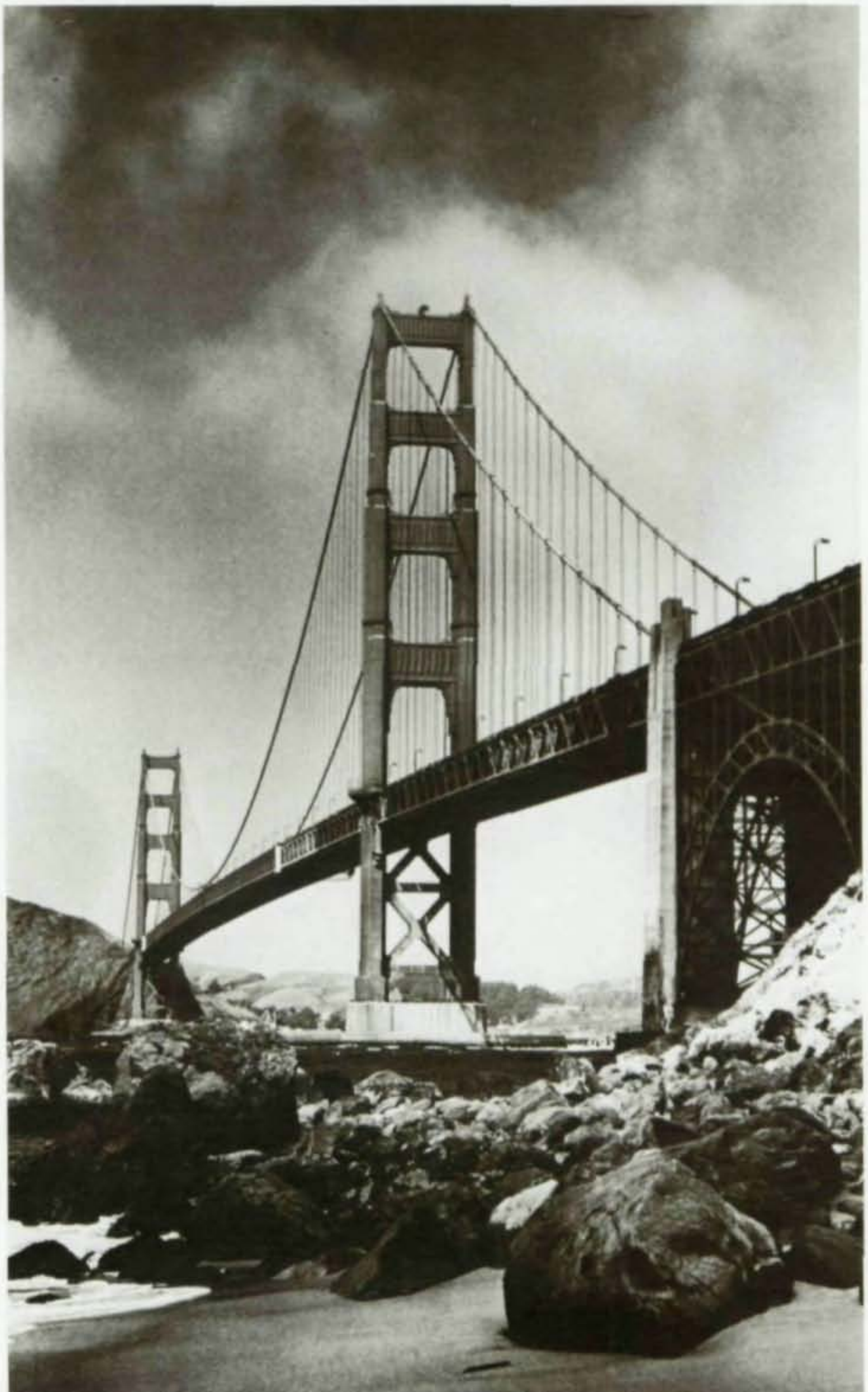
Following a feasibility study of three potential structural elements for the roadway replacement, a scheme using orthotropic design technology was adopted as the replacement element.

Work by Night

All work on the bridge that required traffic diversion was performed at night, during a time volume in which one lane in each direction could provide the necessary lane capacity. All lanes were open and available for use during peak commute periods starting at 5:30 a.m. each weekday and 7 a.m. Saturday morning.

On Aug. 15, 1985, at 2:30 a.m., exactly 401 nights and days of work after the first section of the 47-yr. old reinforced concrete deck was saw-cut from the Golden Gate Bridge and replaced with a modern orthotropic steel deck section, the 747th deck section was lowered into place to complete the structural work on the $60.3-million project.

This project replaced the entire roadway slab and its supporting steel stringers with an orthotropic steel deck system consisting, in general, of a ⅝-in. steel plate, stiffened longitudinally with ⅜-in. steel trapezoidal ribs 11-in. deep, and ½-in. x 12-in. deep subfloor beams spaced 25 ft transversely.



World-renowned Golden Gate Bridge undergoes major re-decking. Careful planning kept traffic delays to minimum—motorists were only inconvenienced 13 times.

History of the Golden Gate

The Golden Gate Bridge was originally opened to traffic May 27, 1937. The bridge extends 9,150 ft (2,790m) from the Presidio on the south to the Marin shores of San Francisco Bay on the north. It is the only direct vehicular transportation link between San Francisco and the counties to the north via U.S. Hwy. 101. Actually, the bridge is three separate structures: the suspension bridge proper, consisting of a 4,200-ft (1,280m) mainspan and sidespans of 1,125 ft (343m) each; the San Francisco approach viaduct, 1,268 ft (387m) long; and the Marin approach viaduct, 1,432 ft (437m) long.

Highway 101, north of the Golden Gate Bridge, is an eight-lane divided freeway serving the counties to the north of San Francisco, including the Redwood Empire. Between July 1, 1983 and June 30, 1984, the bridge carried 38,520,000 vehicles. On a typical weekday, it will carry between 110,000 and 115,000 vehicles. About half of these cross between 6 and 8 a.m., and 4 and 6 p.m. Peak traffic is southbound into San Francisco in the a.m. and northbound during the p.m.

To accommodate these directional peak demands, the centerline of the bridge is changed, using PVC pylons placed manually on the structure, to provide four southbound lanes and two northbound lanes in the a.m., four northbound lanes and two southbound lanes in the p.m. and three lanes in each direction during midweekdays and weekends. During those times when traffic volume demand is less than the full capacity of the bridge, either one or two lanes are taken out of service to provide a space-buffer, for safety, between opposing directions of traffic.

Since completion of the bridge in 1937, the salt atmosphere took its toll. Recognizing the bridge had suffered a considerable amount of corrosion exposure, the board of directors in 1968 commissioned Ammann & Whitney, consulting engineers, of New York City, to inspect major structural components. The report of this inspection on November 1969 stated, among other things, that the original reinforced concrete roadway was showing signs of distress. The consultants recommended further study to determine the extent of, and solution to, the problem. In 1976, it was determined the salt content of the original reinforced roadway slab exceeded the threshold limits for rehabilitation, and the roadway would have to be entirely replaced. Further studies concluded an orthotropic steel deck replacement scheme for the roadway was more cost-effective than any other replacement scheme. Final design engineering and the preparation of contract plans, specifications and bidding documents started early in 1979.

Huge new deck section drops into place (top) during all-night operations. Disintegrating sections (bott.) come out in complex operation.

Design Determined by Traffic

There are no practical alternative routes between Sonoma and Marin Counties and the City and County of San Francisco. So, a major consideration during the design of the replacement element was the ability to perform the work and still maintain a sufficient number of lanes to accommodate traffic at all times, day or night. The decision to use modular construction techniques was based on this design parameter. An analysis of traffic volume patterns indicated all deck replacement work would have to be performed at night. Starting at 8 p.m. week nights, it was possible to take three of the six lanes out of service and still accommodate the volume with only minor congestion.

At midnight, an additional lane was taken from service to provide four traffic lanes or a total of 40 ft in which replacement work was done. Traffic volume allowed the four lanes to remain out of service until 5:30 a.m., at which time the bridge had to be configured to accom-

Deck plates were fabricated from 5/8-in. steel plate. Sections were S.A.W-welded on site.

modate morning commuters. Therefore it was a contractual requirement to have all six lanes in service no later than 5:30 a.m. each weekday morning.

Generally, the original bridge was constructed with a 50-ft longitudinal module. The replacement deck was designed to this same dimension. The typical replacement section is about 15 ft, or one and one-half traffic lanes wide, and 50 ft long. During the design phase a prototype construction contract was performed to check design parameters and traffic-handling plans. Under this contract, three 15 ft x 50 ft roadway sections were replaced. Based on information obtained, it was determined that two deck sections could be replaced each night. Construction contract time was set at 600 total working days for the performance of all the work in the project, including mobilization, off-site fabrication, deck and sidewalk replacement.

The original reinforced concrete sidewalks and their structural steel supporting systems needed rehabilitation as well. This work was incorporated in the deck replacement contract. Incidental to replacing the roadway deck and sidewalks, the total width of the roadway was increased from 60 ft to 62 ft. This permits curb lanes to be 11 ft wide for safer operation of trucks, buses and recreational vehicles. This is the maximum roadway width that can be accommodated between the tower legs of the bridge.

Since the orthotropic steel replacement roadway element is approximately 40% lighter than the original reinforced concrete roadway element and its supporting stringers, consideration to require balanced reduction in weight was examined. Computations proved, however, that no part of the structure would be stressed beyond allowable unit stresses under combined loading conditions if a balanced roadway replacement sequence were not required. Since it would be less costly if the deck replacement began at one end of the structure and progressed uniformly across the bridge to the other end, balanced unloading was not a contract requirement.

One of the price considerations during this project was to accommodate peak commute-hour traffic volume. As an added incentive for the contractor to plan his operations so that all lanes were available by 5:30 a.m., a penalty program was part of the contract. Under it the contractor was assessed a penalty of $1,000 for each 10-minute segment of time past 5:30 a.m. the structure was not cleared. In retrospect, this was a wise decision by the Golden Gate Bridge District. During 401 nights of roadway replacement work, morning commuters were inconvenienced a total of only 13 times.

Funding Unique

The total cost of this project exceeded the funding ability of the Bridge District. Prior to 1978, all capital improvements and maintenance of the structure was funded entirely from tolls. Since the Golden Gate Bridge, Highway and Transportation District is chartered as a California public corporation and is not a part of any city or county, nor part of the State of California, neither state nor federal funding was available. The District successfully sought an amendment to the 1978 Surface Transportation Act which established eligibility of the Golden Gate Bridge to compete for FHWA Bridge Rehabilitation and Replacement discretionary funds. Following enactment of this legislation, FHWA agreed to fund 80% of the participating project costs, which amounts to approximately 78% of the $65 million total project cost. The remaining costs are funded from bridge tolls and no increase in tolls was required.

The total $65-million project cost includes design, preparation of plans, specifications and bidding documents; the construction contract; contract administration and on- and off-site inspection for the complete replacement of the bridge deck and supporting members; removing and replacing sidewalks using rehabilitated sidewalk structural steel frames and new precast concrete panels; complete replacement of all bridge utility services, including air and water lines, high- and low-voltage electrical conduits, conductors and electrical substations, signal, control and closed-circuit television cables, District-owned and public telecommunication lines and other electrical and mechanical services used on the bridge and its approaches.

Construction Very Complex

The deck replacement project was advertised for bids during the Fall of 1982. Nine bids, ranging from $52.495 million to $79.993 million, were submitted. The low bid was accepted and a contract was awarded Nov. 16, 1982. The Bridge District retained the project designers to provide construction engineering advice and perform shop plan checking services during the construction phase. The Transportation Laboratory of the California DOT (Caltrans) was retained to provide offsite and fabrication inspection along with material testing services. Caltrans also provided, on a loan basis, engineering personnel to augment the District's engineering department for job-site inspection, construction engineering and contract administration services.

The contractor set up a project management office and yard at the north end of the Golden Gate, and also a final assembly and staging yard in Napa, Cal. about 40 miles east. The contractor subcontracted structural steel fabrication.

Twenty-eight million pounds of ASTM A709 Grades 36T and 50T, Zone 2 impact, structural steel plate was rolled into plate and stockpiled for fabrication into deck units that varied in size and shape from 9 ft-6 in x 25 ft to 17 ft x 75 ft. Most of the deck units were 14 ft-3 in x 50 ft. The odd-sized deck units were used at abutments, pylons, towers and curved parts of the San Francisco and Marin approach viaducts.

The deck plates were fabricated from ⅝-in thick ASTM A709 Gr. 36T mill-run steel plate welded to size using full-penetration butt welds. The longitudinal stiffeners were formed into trapezoidal shape from ⅜-in ASTM A709 Gr. 36T plate welded to the deck plates using 80% penetration welds. Each deck unit was fitted with a ½-in x 12-in deep end subfloor beam and a ½-in x 12-in deep intermediate floor beam 25 ft o.c., fabricated from ASTM A709 Gr. 36T steel plate.

Pedestals fabricated from ASTM A709 Gr. 50T ½-in, ⅝-in, 1-in and 1½-in plate attached the orthotropic deck units to the main floor beams using ASTM A325 high-

New sidewalk section is set in place. Photos by D. Siemans.

strength bolts, and compensated for the difference in depth between the 7-in original concrete deck supported on 24-in deep steel stringers and the orthotropic deck units. Deck units were sandblasted and painted with organic zinc primer and vinyl top coats prior to shipping to the contractor's Napa yard.

A seal coat of ¼-in crushed rock embedded in an epoxy asphalt mastic was applied to the riding surface of the units at Napa to form a temporary riding surface. The final 2-in of epoxy asphalt concrete will be applied over the temporary riding surface during the Spring of 1986.

The structural steel sidewalk framing, including traffic curb, pedestrian railing and electrolier standards, was taken to the Napa yard for sandblasting, rehabilitation and painting. Each sidewalk frame was fitted with a new precast, lightweight concrete sidewalk slab prior to being reinstalled. Nineteen 4-in dia. Fiberglas utility ducts, one 3-in dia. water line and one 6-in dia. air line were installed under the sidewalk slabs, within the structural steel framing, by mechanical and electrical subcontractors each day prior to the sidewalk unit's installation. Each conduit run was joined together the day following the unit installation. Pullboxes for the utilities were installed in blockouts in the sidewalk slabs.

The main bridge expansion joints at the pylons and the towers were spanned with bronze flexible conduits. Fiberglas slip joints were used at all other expansion joint crossings. In addition to conduits for bridge operations—which include air, water, high- and low-voltage electrical power, roadway lighting, closed-circuit video and security systems and District-owned telecommunications—the bridge provides four conduits for use by the U.S. Army and two conduits for public communications links using fiber optics media.

The epoxy reinforced Fiberglas was specified in lieu of rigid galvanized steel conduit because experience has shown that galvanized steel conduit would rust through at the threaded joints in 5-7 years of weathering unless an extensive maintenance program was performed. It is anticipated the Fiberglas conduit will last for many years, with little or no maintenance. Further, it is lighter weight and less costly to furnish and install. □

Design/Consulting Engineer
Ammann & Whitney
New York, New York

Consulting Engineers/Administration
California Dept. of Transportation

General Contractor
Dillingham/Tokola (joint venture)
San Francisco, California

Steel Fabricators
Flint Steel Corporation
Tulsa, Oklahoma; and
Chicago Bridge & Iron Co.
Salt Lake City, Utah

Owner
Golden Gate Bridge, Highway & Transportation District
San Francisco, California

525 Vine Building:
Fast Track on a Tight Site

by Shayne O Manning

Shayne O Manning is a partner in the structural engineering firm of THP Limited, Cincinnati, Ohio

The 525 Vine office tower, a 23-story, 494,000-sq ft building, is situated on one of the most attractive sites in downtown Cincinnati. Its front yard is Fountain Square, a very successful urban plaza in the heart of downtown. Another desirable feature of this site is a skywalk which has one of its busiest arteries integrated with the building at the second floor. The skywalk is an elevated walkway connecting five hotels, five major department stores, the Convention Center, and downtown's major parking garages. More than 8,000 people pass through the building's lobby in using the skywalk at noontime.

The external appearance and the internal layout (core, atrium, and lobby) of this building have an integral relationship with Fountain Square and the skywalk. The front of the building is kitty-corner to, and faces the Square. Large windows are arranged in a wing-spread pattern to emphasize the front of the building, which interestingly enough, is actually a corner. The lobby, with its seven-story atrium topped by a three-ton stainless steel rosette/ceiling sculpture, was placed at the second floor to take advantage of the skywalk concept. The core is along the north wall, which faces a blank wall of an adjacent building. This provided an excellent opportunity to conceal the longitudinal and transverse bracing, as well as to maximize a clear view of the Ohio River and the Square to the south and west of the building. This arrangement created a more desirable open layout of office space giving tenants maximum flexibility, and permits emphasis of the openness of the seven-story atrium.

The building skin is a combination of precast concrete and glass. The concrete aggregate is green granite and the cement is standard grey. To blend with these colors, a blue-green glass with charcoal-green mullions were used. This, combined with relief from the half-round topped precast panels, produced a very attractive building envelope. The city granted air rights over the skywalk, which not only increased the tenant space in the first seven levels, but also increased the building footprint enough to permit an additional 11 tower floors based on code-permissible heights.

525 Vine Building, Cincinnati, O. Skywalk is busy traffic artery.

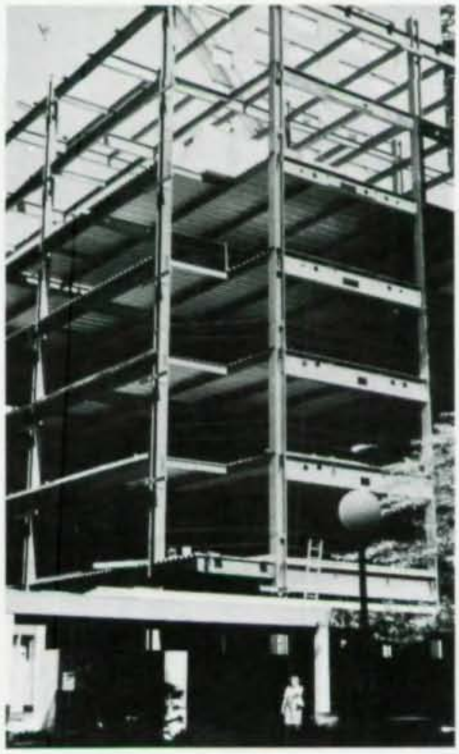
Difficult Site Problems

The 83-ft x 224-ft site is constrained by an existing hotel on two sides, a skywalk and alley on the third side and a street on the fourth. There was no on-site storage of construction materials, but permission was granted to block temporarily only one traffic lane of Vine Street, a downtown street with a very heavy traffic flow. This lane also provided the only major access to the site. The alley with the skywalk overhead had to remain open for service access to adjacent businesses, and the City required the existing skywalk to be open around the clock seven days a week to minimize any economic impact on businesses. When the tower was under construction, the skywalk was first rerouted through the tower via a temporary enclosed bridge. Another enclosed bridge had to be built over the existing skywalk to provide access to a department store cutoff by the initial rerouting.

Structural Steel Framing

There are 23 levels of structural steel floor framing in the tower—3,150 tons of almost 100% A572, Gr. 50 structural steel—steel weight averages 12 psf. In addition, bearing bars and other miscellaneous metal required for the attachment of the precast panels, added another one psf.

To achieve the required slab two-hour fire rating, a 3-in. composite metal deck with 3½-in. lightweight (115 pcf) concrete fill was used. A three-hour fire rating was

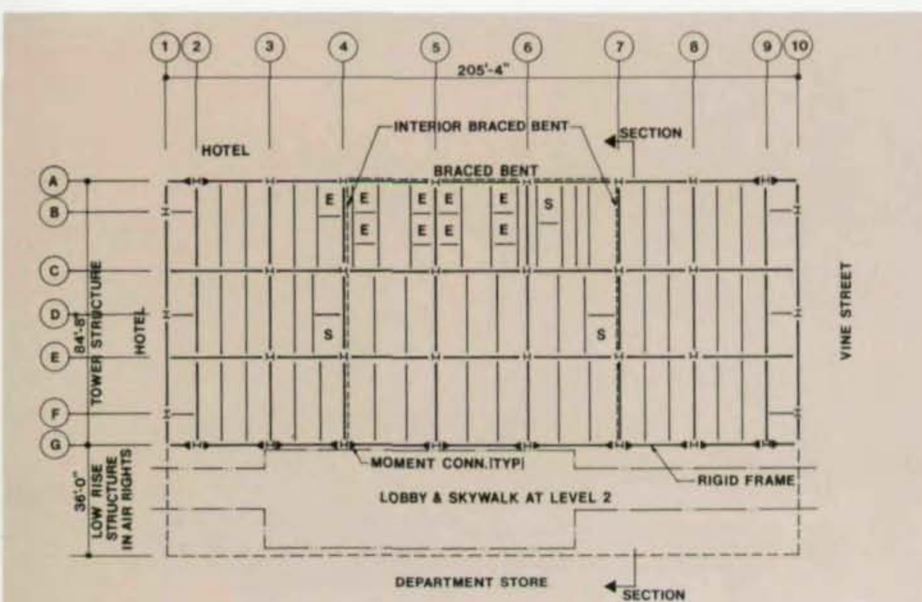


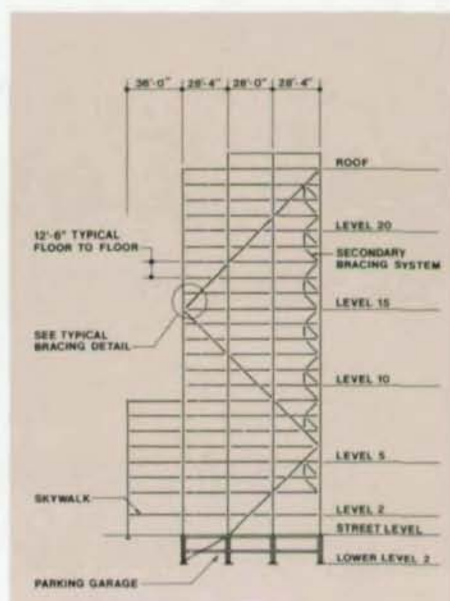
Fast tracking with steel frame made early occupancy possible. Typical framing plan (Fig. 1, below) and section (Fig. 2, below r.) detail building structural design.

required on the ninth level to separate office and retail space; and on the second level to protect retail space from the loading dock area. These two floor decks were sprayed with a cementitious fireproofing to meet the three-hour fire rating.

Typical floor beams are cambered W14 sections at 8 or 10 ft o.c. supported by W21 girders on 30-ft modules. All beams and girders, except those on the rigid frame, were designed composite with simple, Type 2 connections. The floor framing, checked for vibration potential, has performed satisfactorily.

The building columns, which vary in size from W14x605 to W14x45, were all detailed long to account for gravity induced shortening. The typical columns and the exterior chord members of the braced bents had an ⅛ in. and 1/16 in. added per floor, respectively. The design of the braced-bents exterior columns were controlled by stress due to combined wind and gravity loads. They shorten only about one-half the amount of the typical columns during construction. Without the differential column length detailing, the four major wind bent columns would have been ap-





proximately 1½ in. higher than the typical columns at the roof.

Three Framing Systems Considered

Selection of the framing system for the tower had to not only consider the basic economies of the structural frame, but also site constraints, phased construction and the architectural considerations of column location and open space. Three basic framing systems were considered:

1. A concrete flat plate with shear walls
2. A rigid-steel frame
3. A braced-steel frame

The concrete scheme proved uneconomical for several reasons:

1. The frame would have required a mat foundation because of frame dead weight and constraints on exterior column footing size.
2. Efficient flying formwork could not be used with existing construction so tight on all sides.

Handsome seven-story lobby/atrium is topped by three-ton sculpture.

3. Large shear walls required for transverse stability would have interfered with the open office layout.
4. The lobby/atrium framing with hangers and setbacks would be very expensive in concrete.
5. Future tenant changes would be difficult to handle.

The rigid-steel frame scheme was inefficient because of the excessive floor depth required and an extra 3-4 psf steel weight premium above a comparable braced-steel frame. This translated into over a $1,000,000 premium, including steel weight, skin costs and electrical/mechanical systems.

The conventional braced-steel scheme had the advantages of low steel weight, minimum cost premium for lateral load resistance, simple framing connections and maximum flexibility for economical and easy tenant changes. The use of the structural steel framing system also facilitates fast-track construction. The primary disadvantage was the interference of at least one bay of diagonal bracing framing per story.

The conclusion of this study was to design a braced-steel frame building, thereby maximizing its economical advantages and minimizing the lost tenant space. However, the other two schemes were incorporated into the final structure where they were most advantageous. The concrete scheme was used in the lower level garage area, and the rigid-frame scheme where diagonal braces were not permitted.

Bracing Design

In the longitudinal direction of the building, a conventional braced bent-frame was used to take advantage of the blank exterior wall along one side of the core (see Fig. 1). This resulted in an unacceptable torsional rotation on the building axis, therefore a rigid frame was added on the opposite exterior wall to control this movement. This rigid frame, necessary only because of the torsional movement, added $100,000 to the cost of the building because of the heavier beams required for both stiffness and strength.

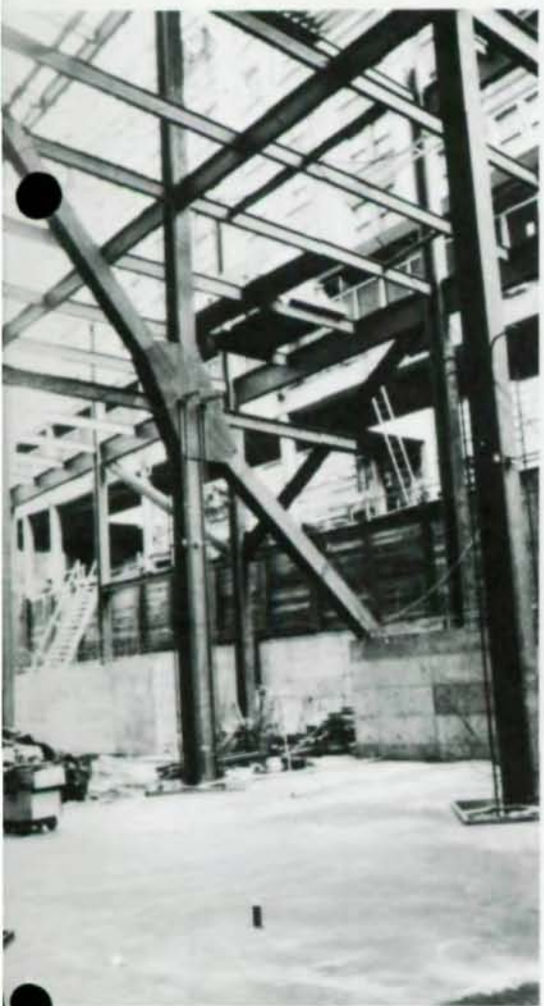
The transverse building direction was more difficult to brace. No bracing was permitted on the exterior column lines and only minimal disruptions to interior tenant space were allowed. With a relatively high building aspect ratio of 6 to 1, it is advantageous to use the full building width to resist lateral load overturning moment in terms of both stress and building drift. With that criteria, a non-conventional bracing scheme was chosen.

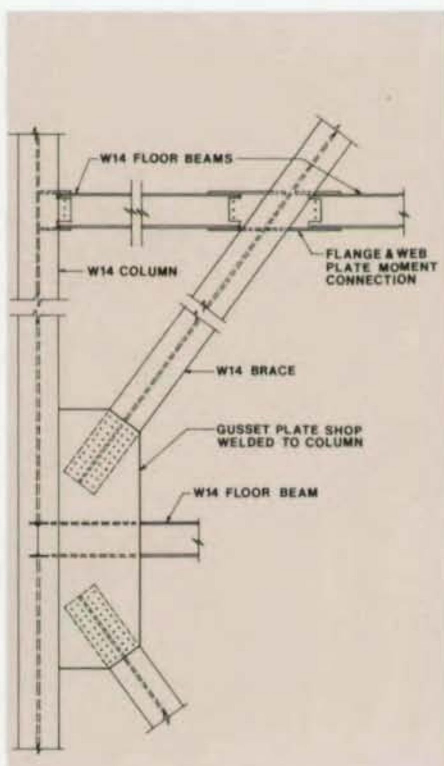
Two interior bays of bracing resist the transverse lateral load. They also assist in stiffening the building from torsion caused by the eccentric longitudinal bracing. The diagonals extend up nine floors from one side of the building to the other (see Fig. 2). The diagonal typically intersects interior column lines every third floor, and is braced by and supports each floor level in between. Only about one third of one bay width is obstructed by the braced bent at each floor level and the diagonal's effective length is also smaller than a diagonal found in a conventional braced bent. In addition to the major bent, a secondary bent on the same column line transmits lateral shears from the floors above and below to the major floor/diagonal nodes. This secondary bent causes minimal space disruption since it is concealed within the core walls.

In the transverse direction, not only do the exterior chord columns resist overturning stresses, but also the longitudinal braced and rigid frames act as flanges to limit chord shortening and the resultant lateral drift.

All bracing connections were designed as field-bolted connections, with gusset plates shop-welded to columns (Fig. 3).

To establish the correct length of a brace nine stories long, building shortening during construction had to be taken into account while allowing for standard construction procedures. Some of the gusset plates had to be field-reamed to fit the 1⅛-in. A325 bolts and/or field-welded, because of inadequate tolerance.





All bracing connections are field-bolted, with gusset plates shop-welded to columns (l.). Typical bracing detail (Fig. 3, above). Photos by David McCullough and THP Limited.

Garage Constructed Later

The garage structure and first floor with loading dock were constructed with cast-in-place concrete framing to maximize the advantages of durability and fire protection in these areas. All concrete exposed to salt contamination was constructed using epoxy-coated reinforcement, and all concrete surfaces were treated to minimize water absorption.

Construction of the concrete levels with ramps and depressions would have delayed structural steel erection. Instead of constructing the garage levels first and then erecting the steel frame, the steel columns continued down to and were supported on the foundation. Structural steel was erected to the fifth level prior to placement of the first concrete structural level of the garage. In this manner, completion of the tower and garage proceeded simultaneously. The concrete levels are supported off concrete encasements poured around the steel columns.

Tower Crane Interesting

The tower crane was another interesting feature of this project. Because of the narrowness of the site, a standard saddle jib tower crane which rotates 360° when it is weather vaning in a wind storm could not be used. Instead, a Pecco SN 355 luffing jib tower crane with a movable counterweights below the turntable was chosen. There was only one other SN 355 in the U.S. at the time of construction. The crane was mounted to an enlarged foundation which also supported the building columns. Every five floors, the crane was tied to the structural frame using a wide-flange beam strut. Because of the high floor diaphragm brace forces, temporary diagonal cable braces were required to tie back the strut to the braced frames.

The execution of the design, development and construction of a fast-track project such as this required extraordinary effort by all concerned to maintain the continued emphasis upon the importance of coordination with various disciplines and trades. There were unusual time and space constraints which called for resourceful solutions. The successful completion of this building was the result of the combined effort of the many participants involved in all phases of construction. □

Architect
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Structural Engineer
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Construction Manager
P. R. Duke Construction Company, Inc.
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Steel Fabricator/Erector
Southern Ohio Fabricators, Inc.
Cincinnati, Ohio

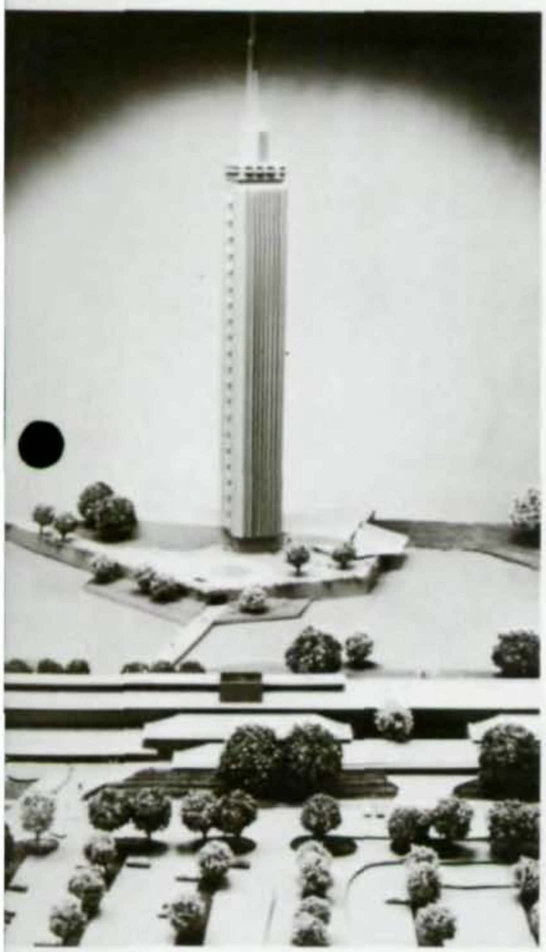
Owner/Developer
Phillip R. Duke Associates
Indianapolis, Indiana

Domino's Farms:
A Tribute to Frank Lloyd Wright

by Vural Uygur and Donald Cuatt

Vural Uygur, P.E., is executive vice president, business development for Giffels Associates, Inc., architects and engineers, Southfield, Michigan.

Donald R. Cuatt, AIA, is Giffels Associates' project director for the Domino's Farms project.



Domino's Farms is the new $120-million headquarters complex for Domino's Pizza Company, Ann Arbor, Mich. Phase 1 was ready for a pre-Christmas opening. Designed as a tribute to the philosophy and style of one of America's best-known architects, Frank Lloyd Wright, the 300-acre complex, located in the rolling countryside northeast of Ann Arbor, will be recognized by its low-lying buildings cut into the landscape, much like Taliesin East, Wright's summer home/studio in Madison, Wisc.

An avid admirer of Wright, Thomas S. Monaghan, founder and president of Domino's Pizza, Inc., commissioned a Southfield-based architectural and engineering firm, and its architectural design consultant to create a design in keeping with Wright's architectural philosophy. As a result, Domino's Farms, with more than 1,000,000 sq ft of office space, features several Wright-inspired structures including a 750,000-sq ft, low-rise headquarters building; and a Usonian home, purchased disassembled by Monaghan in 1984.

Focal point of the Farms is Wright's Golden Beacon, a tower he originally designed as a 56-story apartment building for Chicago's waterfront. Taliesin Associates will modify the design for use as a 250,000-sq ft, 30-story office tower. Many of his design features will be visible. From the standing seam, copper-hipped roofs, and long ribbon windows and extended cantilevers, all blended into a natural surrounding, the complex will showcase Wright's unique prairie style of architecture.

Model of Domino's Farms' new headquarters (above), which features 30-story Golden Beacon tower and 750,000-sq ft low-rise buildings. Near-completed structure (top, r.) Construction photo (r.) shows steel framing details of roof and cantilevers.

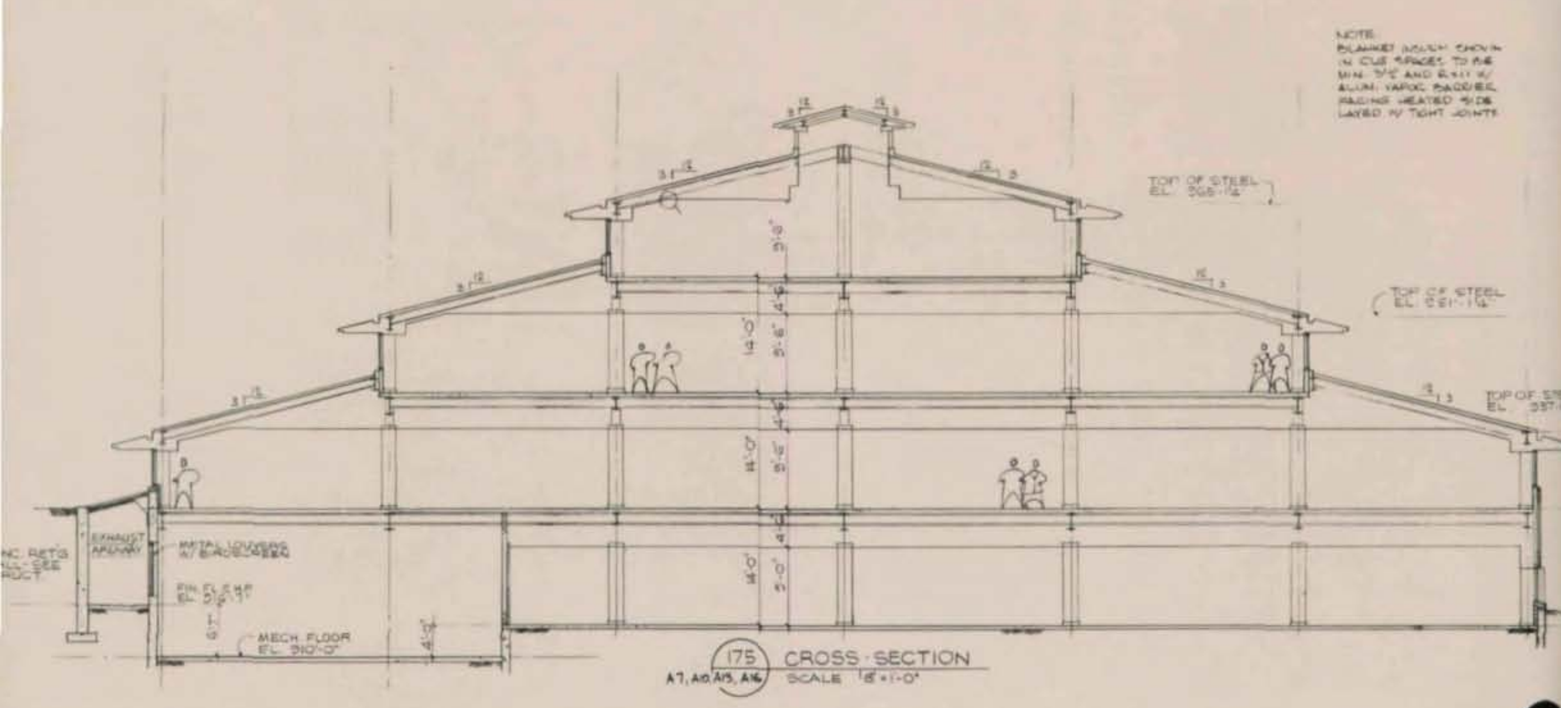
Steel-frame supported trellis carries through on Wright design.

Master Plan Phased

The master plan calls for phased construction of Domino's Farms. The first phase, with December 1985 occupancy date, includes 220,000 sq ft of the low-rise headquarters building, parking for 400 cars and a relocated mile of country road. The headquarters structure will contain executive offices, lease space, a cafeteria, physical fitness facilities, a video production area, food preparation and food service equipment, testing laboratory facilities, and word processing and computer facilities. The rest of the 750,000-sq ft low rise will be completed later.

A demonstration farm, lodge and conference center, daycare center and facilities for Domino's Pizza Distribution Corporation and regional distribution warehousing will complete the complex. The site will be modified to include an artificial lake, fed by a natural watercourse, to separate the tower and the low-rise building.

Domino's Farms uses several unique concepts to develop its Frank Lloyd Wright characteristics. It is intended to have a practical functional use. And, as with any contemporary office building, budget and schedule are critical factors in its design and construction. To meet a December 1985 occupancy date, the entire design



Architectural cross section shows monitor area at top for courtyards.

team developed an 18-month schedule, incorporating materials and design concepts which permitted maximum flexibility and fast-track construction.

Fast and Flexible

Structural steel was a logical choice for the superstructure because it provided the flexibility required to design and build a project of this magnitude with utmost integrity, and still meet the budget and schedule requirements. The design team began immediately on working drawings for the site, architectural, foundations and structural steel contracts. To meet the 18-month construction schedule, it was imperative to complete the superstructure as soon as possible. Nearly all structural drawings were completed using in-house CADD workstations. The steel design proceeded without the benefit of finished architectural drawings. Flexibility to accommodate the yet-to-be developed architectural design and details was maintained by using steel.

During the conceptual design of the low-rise headquarters structure, full-story height Vierendeel trusses were anticipated to cantilever 34 ft at each end of the building. Eventually, more conventional cantilevered systems of reduced length were used, and several courtyards as large as 70 ft × 28 ft and 56 ft × 36 ft were introduced into the structure. The typical building bay is 28 ft × 28 ft and uses only ASTM A36 grade structural steel. The architectural wall system is a 6-in. steel stud and brick veneer, with strip glazing reflecting Wright's long, continuous window style. The floor system consists of fully composite beams and girders with a 5-½ in. concrete slab including a 3-in. metal deck. Floor beams are typically spaced at 9 ft-4 in. o.c. The composite floor system is consistent with AISC Specifications and vibration criteria. The structural steel fireproofing, a spray-on type, provides a 2-hr. fire rating for the floors and a 3-hr. fire rating for columns.

Type 2 semi-rigid framing was assumed in the design of the structural steel frame. Typically, end-plate type moment connections were used for beams spanning in the narrow (east-west) direction and web-angle type connections with top and bottom clip angles were used for girders spanning in the long (north-south) direction. Typical two-bay and four-bay bents were modeled and analyzed by a STRUDL program to determine applicable wind moments.

The most striking element of the building, however, is the roof. Its 3/12 pitch is formed by sloped steel rafters which support a unique copper roof. The roof terminates along the long building edges with cantilevers, at some points as much as 14-ft from the building frame. The unique roof and use of copper throughout reflect Wright's philosophy of incorporating natural materials into structure. Built-in gutters handle all expansion and roof drainage (see Fig. 1). At all roof levels, 6-ft cantilevers extend from the edge of the building. Their top surfaces are pitched 3/12 to form a continuation of the roof. They are cut out near the high end to provide inboard gutters for roof drainage. The outriggers are 3/16-in. plate bent along the bottom to form an L-shape and then cut along the top to accommodate the 3/12 pitch and built-in gutters. The top edge is then reinforced with 3/16-in. plate to form a C-shaped cross section.

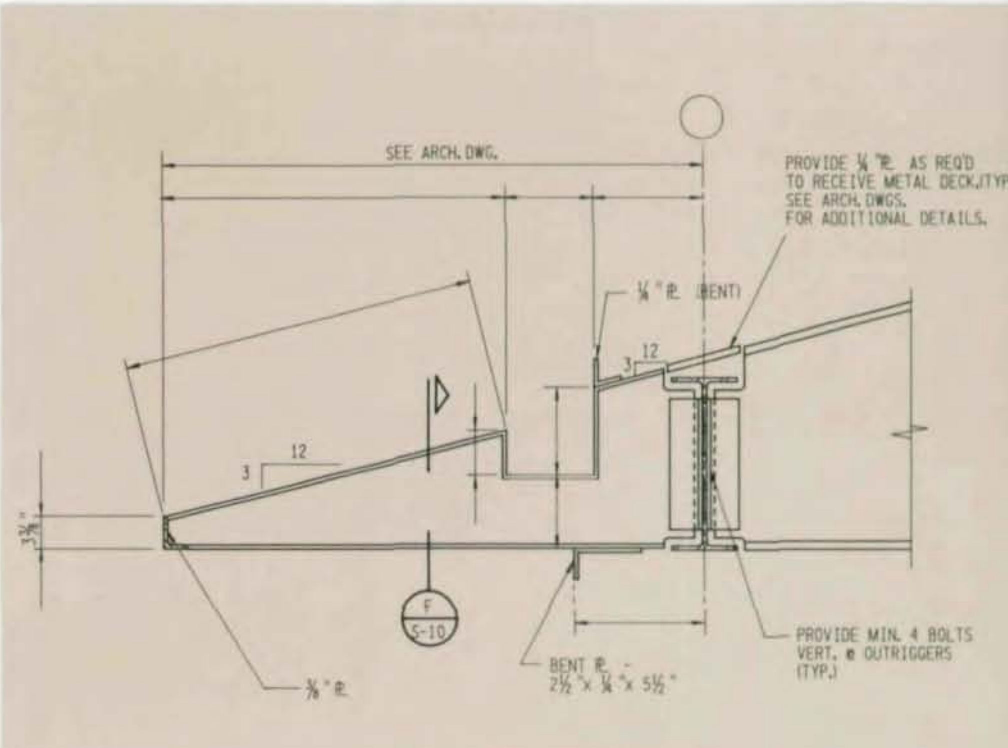
Several areas of the top floor, framed as hip roofs, require skewed, sloping connections. Single- and double-plate connections were used. The monitor along the peak of the roof at the north end of the building provides areas of the fourth floor with natural sunlight. Special features, such as narrow copper fascias of 2 ft-2 in. high and bent heavy copper sheet returns into soffit will develop a narrow, thin-appearing roof overhang approximately 5 ft wide. The copper standing-seam roofing system has an applied patina finish, and monitor roofing and overhangs below gutters feature a lead-coated copper finish. Additional copper features include window sills, copings, balcony and planter fascias, beam covers and flashings.

Phase 1 also features a 2,350-sq ft outdoor patio area with a trellis-like roof of exposed structural steel tubing latticework supporting a multiple arch-shaped skylight. The perimeter of the patio roof is brimmed with a triple-stepped wood outrigger and a continuous planter, also supported by the steel framework.

Challenges Three-fold

Site work, which was considerable, began in the Fall of 1984, with most site work completed for all phases. The challenges with a project of this magnitude were tri-fold: The architect was responsible for developing a plan which complements the rural site; the design had to be in keeping with Frank Lloyd Wright's unique prairie architectural style; and most importantly, very real budget and schedule requirements had to be addressed.

One particular problem posed by both the schedule and Michigan's harsh winter was the east elevation between the first and second floors. On the west, the first floor is at grade and overlooks a man-made lake, and eventually will overlook the



Details of gutter and cantilever from roof were drawn with CADD.

Golden Beacon tower. On the east building elevation, however, the grade is at second-floor level, about 14 ft higher. Conventional design would have been a cantilever wall or one spanning from foundation to the second floor with the steel frame extending up from that level. This, however, would have required wall concrete placement during January and February, the two worst construction months in Michigan. In addition, structural steel erection had to start in February 1985, if the December 1985, occupancy date was to be met.

To avoid a steel erection delay, it was decided to extend all columns and framing on the east side down to the foundation level. The concrete wall would be placed *after* the steel was erected and lateral backfill forces would be resisted by the steel frame. Construction of only those foundations necessary to receive structural steel was completed by December 1984. Steel erection began in February 1985 and completed in April. Spring brought more suitable weather, and the concrete wall and site structure work were completed.

Architectural development of details was completed simultaneously and modifications coordinated with the erected structure. Most modifications required only minor adjustments, with little impact on budget and schedule.

Conclusion

The use of steel for the superstructure of Domino's Farms' Phase 1 played a vital role as a simple, workable solution to help the architect/engineer team meet design, schedule and budget considerations. The team is pleased to be closely involved in a project which helps the owner accomplish a boyhood dream—to open the company's new headquarters on its 25th anniversary—and at the same time salute the creativity and unique designs of Frank Lloyd Wright. □

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Southfield, Michigan

Architectural Design Consultant
Gunnar Birkerts & Associates
Birmingham, Michigan

General Contractor
Barton Malow Company
Oak Park, Michigan

Steel Fabricator/Erector
J.L. Peters Company
Ferndale, Michigan

Owner
Thomas S. Monaghan, Inc.
Ann Arbor, Michigan

Southern Bell had their corporate data center six months early, thanks to steel-framed construction. Column stubs (top, r.) provide for vertical expansion. Completed structure in heavily wooded site (r.).

Southern Bell: A Corporate Data Center—Six Months Early

Recognizing the need to replace leased computer space, T. S. Cates, operations manager–Building Design and Construction for Southern Bell in North Carolina, appointed Dan Wilson in early 1982 to direct and coordinate the planning, design and construction for a new facility that consolidated their North and South Carolina computer operations.

In the Fall of 1982, Southern Bell selected a Charlotte, N.C. architectural-engineering-planning firm with a long association of working with the Bell organization, to design the Carolina Corporate Data Center. "With leases expiring in May 1985, Bell's first priority was to have the building designed, constructed and operational in 2½ years," states John Komisin, the project architect.

The site selected for the Carolina Corporate Data Center was 27 acres in University Research Park, a 3,500-acre complex of high technology and research facilities near the University of North Carolina Charlotte.

In January 1983, architects and engineers and members of the Bell organization teamed up with a noted construction firm. A CPM schedule was developed by the project team, with a fast-track approach for design and construction. "By fast tracking we were able to cut more than 26 weeks from the normal project schedule," Komisin commented.

Site clearing began in May 1983. The project, bid in five separate packages, allowed Bell to benefit from the cost savings of competitive bidding. By using separate bid packages, on-site delivery of materials also was easily monitored.

Completed in December 1984, the Data Center is clad in clear and black anodized aluminum panels, with areas of solar grey glass and a four-story expanse of glass block at one end of the computer wing. A common building core area links the five-level, 270,000-sq ft data processing wing to a three-story administrative wing of approximately 50,000 sq ft. Future vertical expansion has been planned for two computer floors and one administrative floor, as well as lateral expansion for the administrative wing.

Special care was given to the preservation of the heavily wooded site, and parking was broken into small areas with treed buffers. Mechanical and electrical systems are designed for maximum efficiency with stand-by power provided for all systems.

Heat generated by the computers warms the administrative areas of the building through a reclaim chiller. The hydronic cooling and heating systems are designed as primary-secondary pumping systems and use variable flow in the secondary system for economical operation. All variable-speed drives are also installed on all variable volume air systems in the administrative areas of the building. The computer wing employs on-floor chilled water air handlers. Other loads and humidity requirements are handled by an overhead spray coil system.

Almost without exception, all mechanical, electrical, life safety and security equipment within the building is controlled and monitored by a direct digital control system.

Medium voltage switch and fuse distribution switchgears, coupled with four 1,400 KW emergency engine generators, supply power to nine substations through an automatic primary selective radial distribution system.

The distribution system incorporates a by-pass switching arrangement whereby substation testing is accomplished while providing continuous service to the UPS/computer systems. Over three megawatts of UPS equipment serve the computer wing. The UPS features a central battery system with DC switchgear and on-floor mobile power distribution units.

A structural steel frame with a composite slab on metal deck, beams and girders was selected for its compatibility with the overall design concept of fast construction, versatility and economy.

The steel system provided the versatility to meet several project requirements. The data processing wing required a raised floor to permit adequate space below for cable distribution. However, the administrative wing required distribution of power, data processing and telephone cables within the floor slab. A three-cell metal deck with preset inserts was provided in this area. The steel columns were stubbed up above the roof to allow future vertical expansion with a minimum interruption of the roof membrane. The four-story expanse of glass block in the computer wing required an intermediate steel support system, which was easily attached to the basic steel frame.

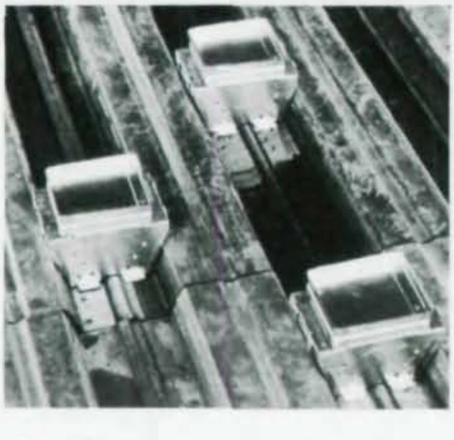
In accordance with the Uniform Building Code, the facility was designed not only for the prescribed lateral wind loads, but also for seismic Zone II loads. The impact of the seismic loads was reduced by the lighter weight steel structure. The facility has no central core areas and interior vertical bracing was prohibited. Therefore, lateral seismic and wind loads were resisted by moment-resisting frames in the short direction and vertical K-bracing located in the exterior walls in the long direction. Lateral loads were distributed to the frames and bracing by the floor diaphragm.

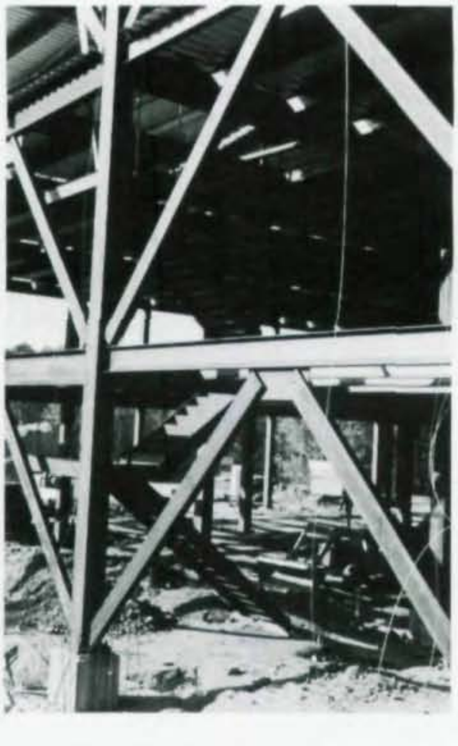
The CPM schedule included an early mill order and only a few days for the processing of shop drawings. On-site delivery of steel had to coincide with foundation construction.

"We were fortunate to be working with an excellent fabricator and contractor, as speed of construction was especially important to the owner. The use of structural steel certainly enhanced the overall success and economy of this facility," states Wyatt Bell, the project's structural planner and a senior vice president of the architect/engineer firm.

Superior teamwork and cooperation among the architects, engineers, owner, contractors and material suppliers resulted in a completion date several months earlier and a construction cost under the owner's budget. □

Handsome entry (l.) is steel-framed. Lateral seismic and wind loads resisted by K-bracing in exterior walls (below). Three-cell metal deck (bott., l.) with preset inserts provides adequate power outlets.





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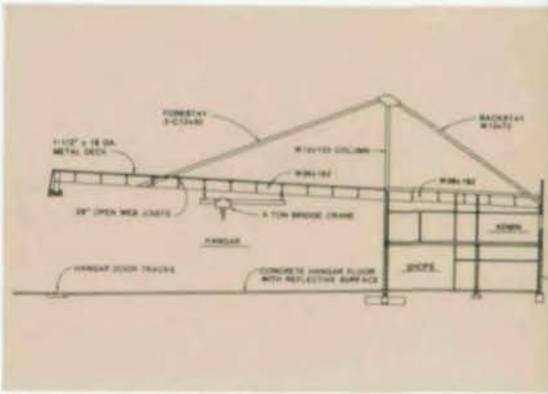
North Island Air Station: Cantilever Trusses— Key to Column-Free Hangar

by James A. Willis

James A. Willis is president of Blaylock-Willis and Associates, Structural Engineers, San Diego, California.

North Island Air Station—street side



Building section of San Diego facility

Hangar bay showing steel trusses

Operational side of North Island hangar

Helicopter Maintenance Hangar Building 1474, now in place at the North Island Naval Air Station, San Diego, provides covered, weather-protected space for maintenance of Sikorsky SH-60B helicopters. A 104,000-sq ft aircraft hangar space, shop space, crew and equipment space, maintenance/administrative offices, operations offices and squadron offices were constructed to house three new helicopter squadrons. Cost of the building was $6.8 million.

A large column-free area in the hangar bay without columns in the doorline was required to allow flexibility and future use by different types of aircraft. To provide the clear area, a steel cantilever-type of structure was used: 100 ft-long high-strength steel (50 ksi) 33-in. WF rolled beams, spaced 36 ft o.c., are supported by steel forestays, backstays and center columns to frame the column-free 100-ft by 470-ft area. The cantilever beams support open web steel joists, metal decking and a 5-ton bridge crane. The cantilever structure is supported by, and anchored to, a 2-story box type office and shop building. The operating side of the hangar consists of a 470-ft long by 28-ft high column-free opening enclosed by six sets of self-propelled steel doors that slide on rails. The top of the doors "float" in a header attached to the cantilever beams allowing the roof to move freely with temperature changes.

The building, the first in a series of hangars on this site, sets the level of exterior design quality. It is also sited near the new Naval Flight Instruction Building. Consequently, design features were made to complement the instruction building. Office and shop areas are enclosed with the same 4-in. high sandblasted gray concrete masonry units. Similar massing of the exterior stairs was designed to break up the long facade exposed on the street side of the building. Roof metal decking over the office and shop module was filled with concrete to provide mass for an acoustical envelope.

The wall between the hangar and office is reinforced masonry with a 2-hr. fire resistant rating. The entire building is provided with an automatic fire sprinkler systems of wet-type automatic sprinklers and a foam deluge system which is activated by a system of automatically supervised pneumatic detectors. □

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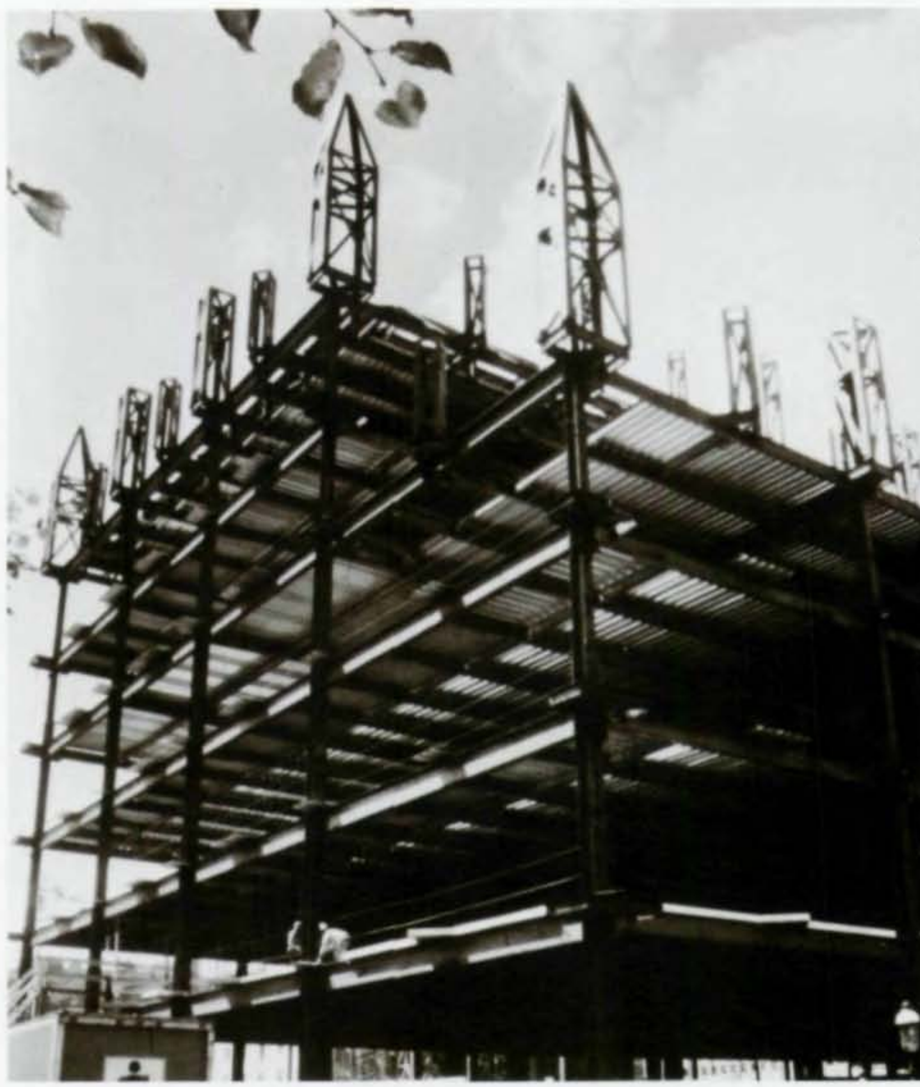
The Intelligent Building: Steel Framing and Flooring are "Musts"



In the next decade, billions of dollars may be spent to erect what are known as "smart" or "intelligent" buildings. Scores of them are already going up or planned, and there is little question they will comprise the next generation of large commercial office buildings, whether developer-built or company-owned.

The steel industry contends these buildings will achieve their full potential . . . and, more important, be adaptable to upcoming and even unforeseen technologies . . . only if they encompass the flexibility of two structural elements: electrified flooring supported by structural steel framing. First, let's update the still-new concept of the intelligent building.

Based on computer control of building functions, a centrally directed system regulates electronically the total building environment and all equipment. Plus, building owners gain extra revenue by offering tenants such shared services as information processing and telecommunications.

In operating the building itself, this state-of-the-art approach controls elevators, lighting, cooling, heating, ventilation, security and fire protection. As its name implies, the building has the "intelligence" to diagnose, adjust and regulate its environment. For example, lighting—the single largest energy cost item—can be turned on or off automatically by microprocessors which detect people movement. Elevators are programmed to handle all the daily traffic patterns and could even incorporate voice synthesizers to announce floors and provide emergency information. Sensors are alert to temperature changes and automatically adjust HVAC controls.

The bottom line here is today's ultimate in efficiency, comfort and safety, all at lower energy, labor, maintenance and other operating costs. Keep in mind that in a building with a 40-year life span, only 14% of the total life cycle cost is for design and construction—but 86% is for operation and maintenance.

Electronic services, the latest in office technologies, are shared and paid for by tenants, and could include: access to databases; computers/data processing; electronic mail; facsimile; telecommunications systems, including a PBX capable of transmitting voice and data; telex; video teleconferencing; and word processing.

These days, complex office technologies change every 18 to 24 months. On the average, 25% of all electronic equipment is relocated annually within an office. For an intelligent building to remain competitive, it has to keep ahead of these changes. The key essential is flexibility, important both in attracting sophisticated tenants in an era of surplus office space, and in preventing building obsolescence at resale time.

How to Keep a Building Up-to-date

How does a developer or a corporate owner keep an intelligent building permanently up-to-date? The solution lies in *remembering this structure operates via* an organized highway of wires and/or fiber optics which control building functions and equipment. The economical, flexible and proven method is in-floor electrical distribution—combined with a steel-framed building.

What we are describing is cellular steel flooring. Installed on each building level, it consists of tunnel-like raceways through which pass all current and future electrical wiring or glass fiber-optic strands that integrate building systems and services into a single network.

According to steel industry, two essentials that keep an intelligent building up-to-date and adaptable are structural steel framing and electrified flooring (l. and above). The tunnel-like raceways hold wiring and fiber optics that control systems and services. Central switching system (r.) is fully digital, capable of voice and data transmission simultaneously.

Paul Blanchard, manager of structural/electrical systems at H. H. Robertson, Pittsburgh, says, "The cellular floor is the single most important element to keep an intelligent building constantly contemporary. This electrical distribution and delivery system permits any-time rearrangement of equipment locations and has ample capacity for expansion. Changes are made at preset outlet boxes at regularly spaced intervals."

Robert McFarlane, vice president and director of technology for the Wilke Organization, New York City, one of the oldest communications consulting engineering firms, believes any tenant who rents a significant amount of office space should be wary of a building's provisions and flexibility for communications needs. He feels that good wiring provisions are essential to be compatible with IBM cable plans. And he says the numbers and locations of risers are important to service each floor's lateral wiring needs, which, in a steel building, are best done through properly sized cellular floors.

At each level, the cellular floor is welded to the steel beams at that level, thus combining floor and framing into a complementary system known as "composite construction." It unites the concrete-surfaced floor with the structural steel beam to save 1 to 1½ psf of steel when compared to non-composite construction.

Like electrified floors, structural steel framing also fulfills the intelligent building's need for flexibility.

- Framing can be changed to suit a new tenant's requirements for a stairwell or other feature.
- Framing can be reinforced to accommodate heavier floor loads.
- Routing of wiring, piping and ducts is simpler, faster and more flexible in steel-framed structures.
- It economically affords greater spans between columns to permit imaginative design or redesign of tenant space.
- And its faster erection and enclosure time reduces interim financing costs, permits winter construction and starts rental and equipment services income that much earlier.

The 10 newest intelligent buildings, all developer-owned and all steel-framed and cellular-floored, include: Multi Foods Tower, Minneapolis; 33 West Monroe, Chicago; 10 South LaSalle, Chicago; World Financial Center, New York; Connecticut Plaza, Hartford; One Oxford Center, Pittsburgh; Prudential Insurance, Jacksonville; Barclay Bank, New York; 1600 Market Street, Philadelphia; and 301 Howard, San Francisco.

Ideas for "Smart" Buildings

1. Low-rise. The minimum building area necessary to support the intelligent building concept has been estimated in a wide range from 200,000 to 500,000 sq ft. Although new, high-rise office structures are the immediate targets, the low-rise, suburban office building—adaptable to both corporate and multi-tenant occupancy—is also a candidate. And also, the concept is applicable to a central system servicing satellite buildings in an office park.

2. Framing Grade. A572-Gr. 50, a high-strength steel, can provide further economy as an intelligent building's framing material. Compared to conventional A36 steel, it provides a materials cost saving of 15 to 20%. A572-Gr. '50 also permits shallower-depth beams to reduce floor-to-floor height while providing longer, column-free spans.

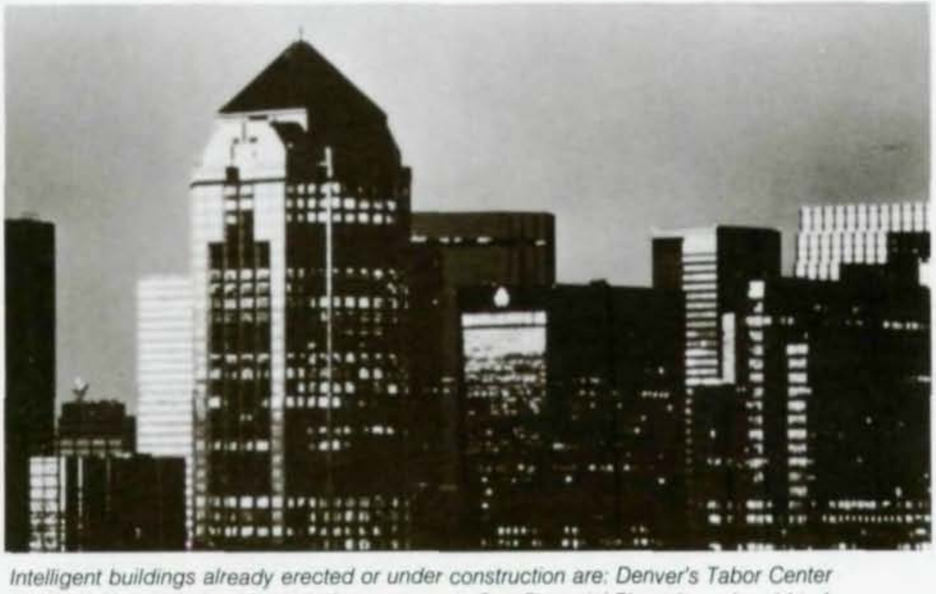
3. Fast Track. Another cost saver, the fast-tracking technique, where construction starts even before a final design is completed, is practical with structural steel framing. It permits substantial off-site fabrication, with such elements as site clearing, foundations and grade beams constructed on-site before final design work. It is not unusual for fast tracking to permit far earlier occupancy at significantly lower first costs.

4. Sensitivity. In controlling building functions, the intelligent building can fine-tune individual aspects to a high degree of sensitivity. Take a fire emergency as an example. By interconnecting major equipment, all systems communicate with each other, all activation is automatic. Sensors detect and locate the fire. The computer system is notified as well as security and the local fire department. Alarms ring inside and outside the building. Elevators return to and remain in the lobby. Smoke is purged from the fire floor. And, to prevent its spread, adjacent stairwells are pressurized along with floors above and below the fire.

5. Preset Outlets. With electrified flooring, preset outlet boxes are positioned on a predetermined grid to deliver power, light, telephone and data service to any workstation location or relocation. One preset opening for each 25 sq ft should be about the minimum; one per 12.5 sq ft is more adequate; and one every 6.25 sq ft provides maximum flexibility.

6. Tenant Selection. In an intelligent building, the developer gains added occupancy and revenue by selling electronic office services to tenants who cannot afford or do not wish to own the equipment. What this may come to mean is preferential selection of small-to-medium-size tenants, who could be major renters of equipment time. Even non-tenants, those in nearby buildings or areas, can be an extra source of revenue for these services, assuming time-sharing capacity is available.

7. On Premise. After planning and installation is complete, one approach to successful operation of a building's functions/tenant services system is maintenance of a service facility in the building itself, with a permanent, on-site staff. Response to technical problems can be swift, aided by an on-premise inventory of replacement parts. It should also be this staff's responsibility to prepare for future needs in the high-tech, fast-changing office systems field, so the building can be adapted to new office arrangements and equipment as they are available. □



Intelligent buildings already erected or under construction are: Denver's Tabor Center (top l.), which includes 32- and 40-story towers; One Financial Place (top r.), said to be most technically advanced structure in Chicago; City Place (c.), a 38-story tower in Hartford, Conn., which claims to be world's first intelligent building; and LTV Center (bott.), a 50-story tower in Dallas.

We are indebted for information and photos in this feature to the Committee of Structural Steel Producers, American Iron and Steel Institute.

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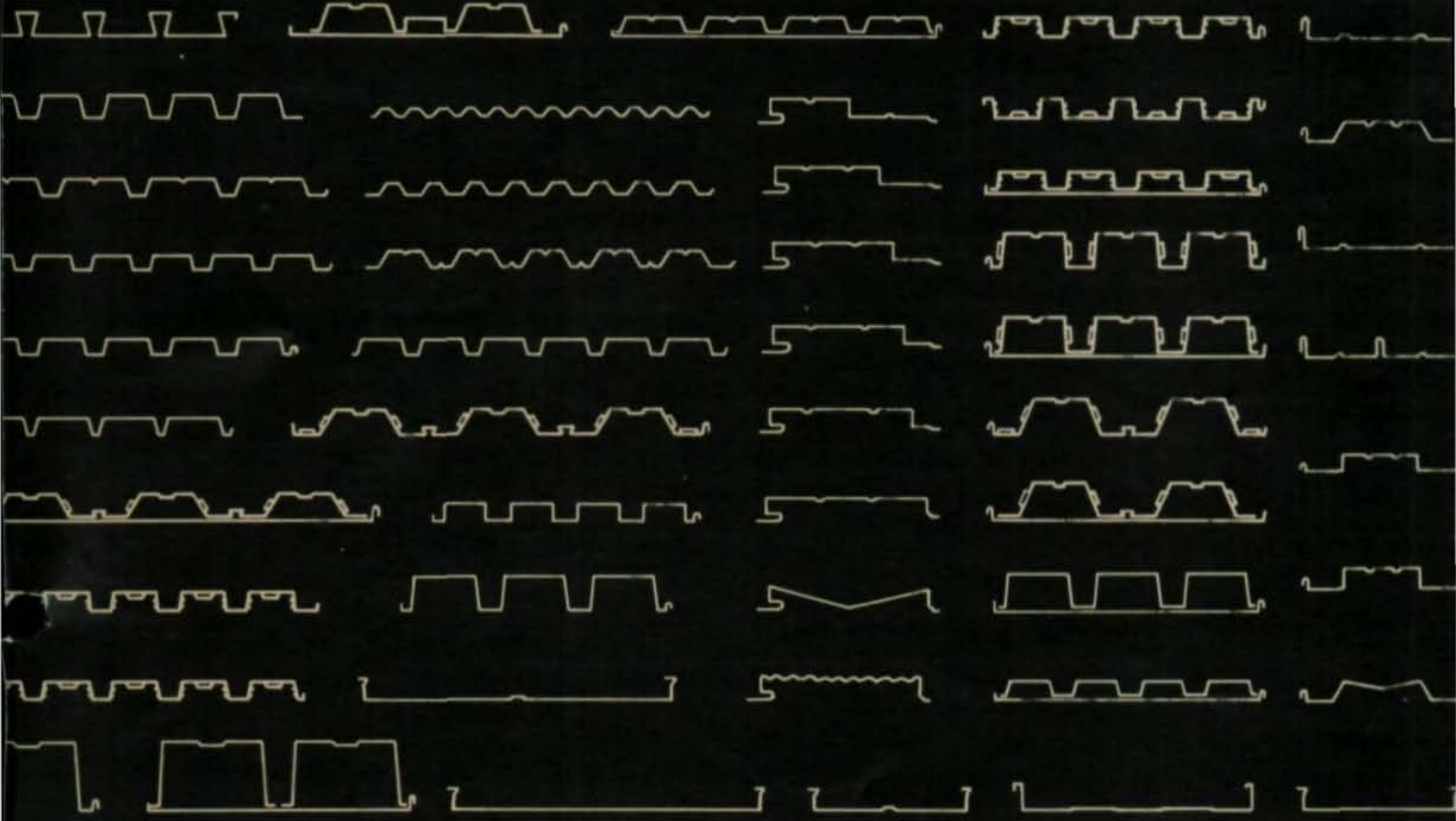

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