VOLUME XX NUMBER 3 / THIRD QUARTER 1980

MODERN STEEL CONSTRUCTION

Beauty on a Budget
Bingham Hospital: Metamorphosis in Steel
Woonsocket Savings: Banking on Urban Renewal
Eccentric Braced Frames for a Major Hospital
A "Prize" of a Bridge

MODERN STEEL CONSTRUCTION

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The T.R. Higgins Lectureship Award will recognize an outstanding lecturer and author whose technical paper(s) may be identified as an outstanding contribution to engineering literature on fabricated structural steel publishing within the five-year eligibility period from January 1, 1975, to January 1, 1980. The award winner will receive a $2,000 prize during a ceremony at the 1981 National Engineering Conference in Dallas, Texas, where he presents his paper.

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Nominations must be received by December 1, 1980.

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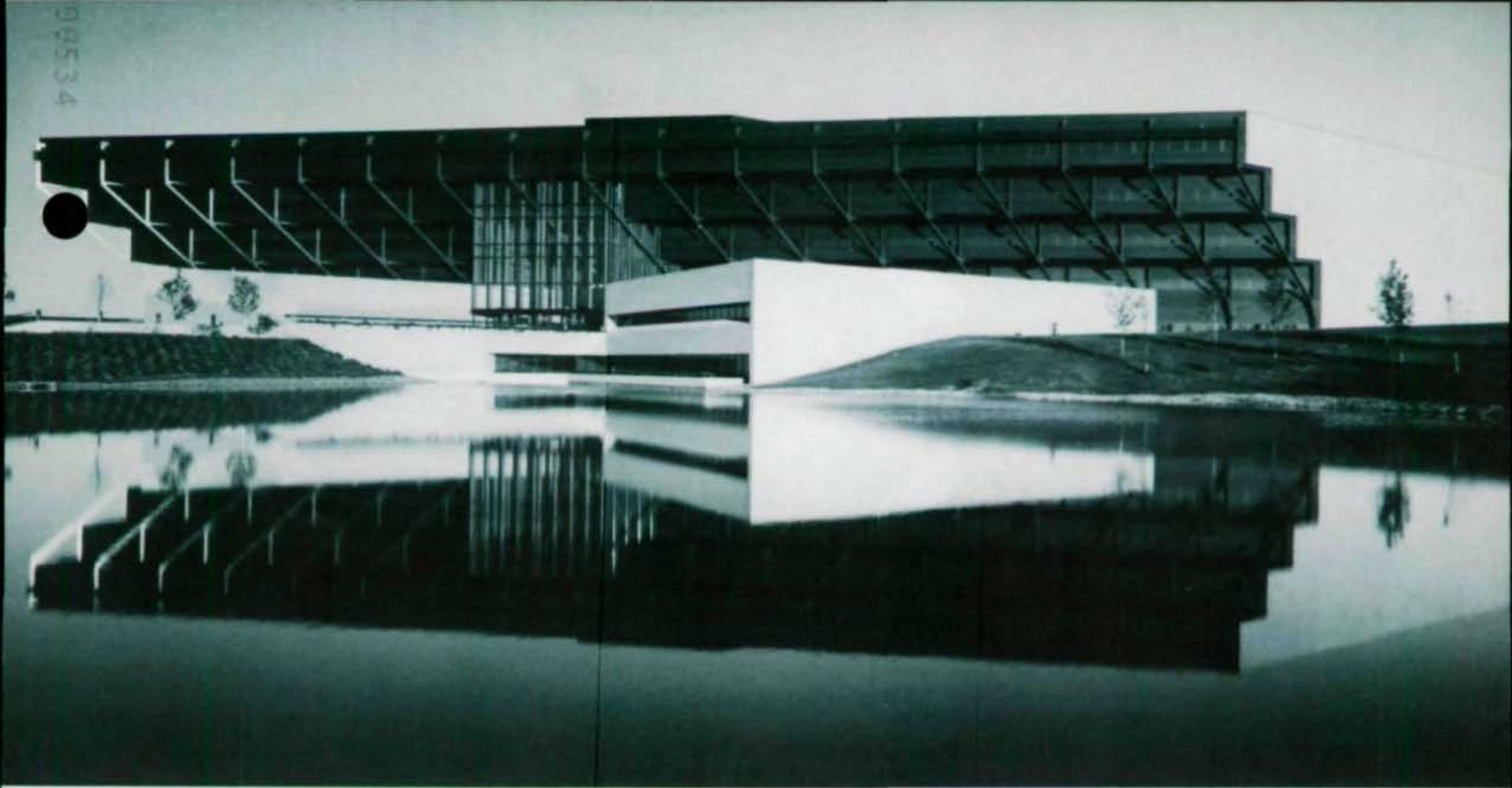
For further information on this special program, or on the standard AISC Quality Certification Program, write: AISC Quality Certification Administrator, 400 North Michigan Ave., Chicago, IL 60611



Western Life's sparkling new headquarters in downtown St. Paul, Minn. Lower masses met requirement for more ground floor area for training center and cafeteria, and to meet night-time security controls.

Western Life: Beauty on a Budget

by Wayne R. Bishop and Richard Waite

In 1975 Western Life Insurance Company decided to design a new corporate headquarters in downtown St. Paul, Minn., on land adjacent to its parent corporation, the St. Paul Companies. This site was discarded subsequently and a 22-hectare (55 acres) hillside location outside the city was selected. The new site, bounded on the north and west by two major highways, had only a small pond to enliven the landscape. Western Life then selected Ellerbe Associates — also a Twin Cities-based firm as its architect, engineer and interior design firm.

Design Considerations

Design considerations for the corporate headquarters were numerous. The budget was approximately $14 million, and the company was anxious for the new building to be completed quickly—which meant designing on a fast-track system within strict budgetary guidelines. The facility was designed for a projected 1,200 employees, mostly clerical, as an open office plan to utilize space efficiently, but not monotonously.

Wayne R. Bishop and Richard Waite are architect and structural engineer, respectively, of the firm of Ellerbe Associates, Bloomington, Minnesota.

In addition, the facility contains a data processing center for all the St. Paul Companies' business. As the project developed, it was apparent the data processing center within the structure could be an advantage in meeting the client's demand for efficient energy utilization. The potential for effective use of recycled computer heat had been demonstrated in other Ellerbe projects. But at Western Life, its use became the focus of the entire heating/cooling system. In fact, recyçling of computer heat has been so successful that Western Life did not need to rely on boilers at all during the 1979-80 winter. No small accomplishment in Minnesota.

One final consideration for Ellerbe Associates was that Western Life wanted a unique, definitive design to identify them clearly in the public mind, and separate them from a submerged identity within the St. Paul Companies. Thus, they were predisposed to entertain design solutions not entirely conventional. ☞

Striking "steps" contribute to both building's architecture and energy efficiency, major consideration in structure designed to recapture computer heat.

Soaring five-story entrance atrium cascades down as each floor overlooks others, provides spacial amenity for employees. Photos and drawings (see facing page) define "K" braces (top drawing) and trusses (bottom).

Structural System

Western Life's new building is a parallelogram placed at a 45° angle to surrounding freeways, thus permitting maximum utilization of passive solar energy. The 350,000 sq ft facility is five stories high. On the southwest exposure, each successive floor "steps" out from the lower one. Solar energy warms the interior during winter months when the Minnesota sun is low on the horizon, and shades it when the summer sun moves to a higher angle.

A 60-ft grid was selected to provide the flexibility and openness the owner desired in the interior. Structural steel was chosen as the most appropriate framing material for the purpose, a decision based on several key issues:

1. Structural steel was the most economical material to span the 60-ft grid, and to frame the overhang portion of the building.
2. Steel resulted in a lighter building, which, in turn, reduced the cost of the foundation system.
3. Erection of structural steel was faster, thus enabling the contractor to conform to a fast-track construction schedule.
4. Mill order and fabrication of the typical floor trusses could commence prior to completion of building plans.

Framing System

Typical bays are 20 ft x 60 ft. The structural framing system consists of 6-ft deep steel trusses spanning 60 ft between W12 columns; W16 floor beams 10 ft o.c., designed to act compositely with a 3¼-in. lightweight concrete slab; and a 3-in. deep electrified composite metal deck. The columns are supported on spread footings that bear on natural sand strata.

The overhang section of the building uses a special extra lightweight concrete fill with a 1½-in. lightweight concrete topping to reduce dead load. The diagonal compression strut, along with the vertical and horizontal struts, are exposed on the exterior of the building for aesthetic reasons. The horizontal struts act as tension members along with the top chord of the floor trusses to tie the overhang portion back into the structural floor slab on the third, fourth and fifth floors. Struts deliver gravity loads to the diagonal compression strut, which then delivers horizontal thrust back into the structural floor slab at the second floor level.

The 120-ft wide structural floor slab is reinforced to act as a horizontal diaphragm to deliver tension forces at the third, fourth and fifth floors—and the compression thrust at the second floor to four vertical structural steel "K" braces within the frame. Two of the "K" braces are located on the exterior wall, and the other two are on either side of the elevator-atrium lobby. All four "K" braces deliver all lateral loads from the overhang and lateral wind forces to the foundation system.

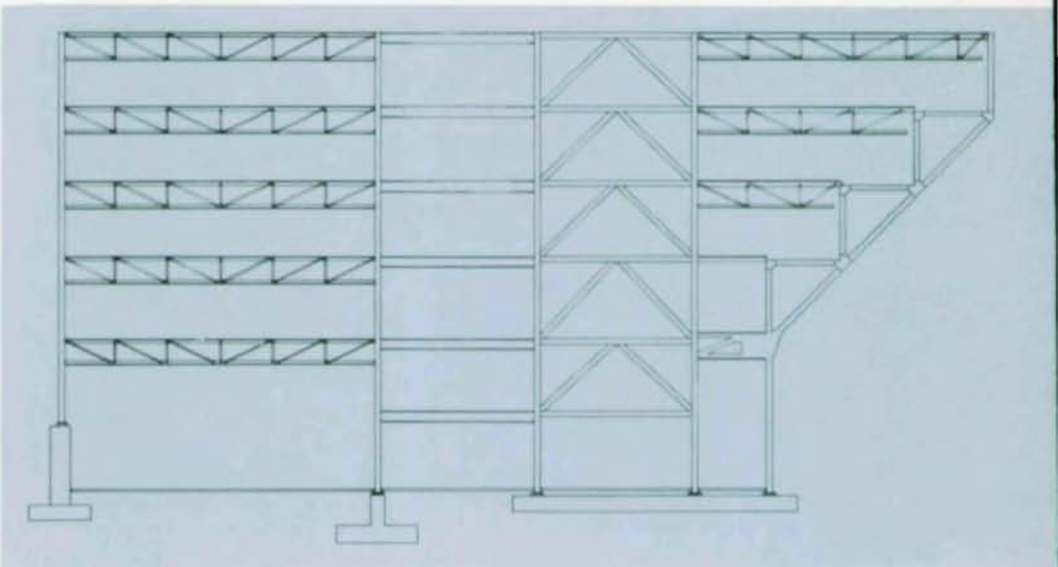
Fire Protection

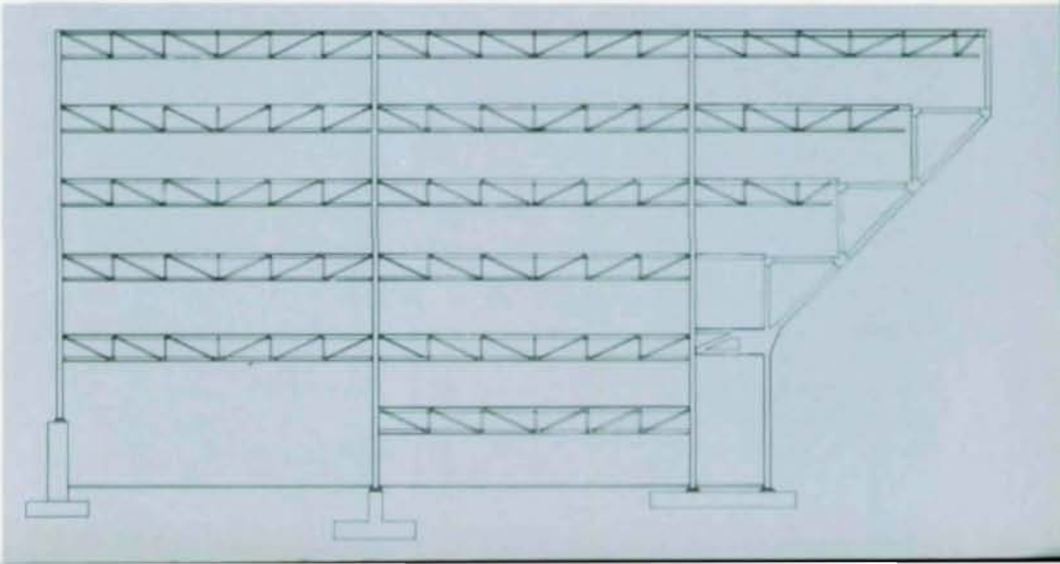
The exposed structural steel framework on the exterior raised some special concerns about fire protection, since the steel was to remain untreated with fireproofing for aesthetic reasons. To maintain the aesthetic value of the exposed steel, the following measures were taken:

1. A three-hour rated fire barrier was provided in the exterior wall just behind the exposed vertical strut to divert any flames away from the strut.
2. A "deluge" fire sprinkling system was installed along the building's exterior wall.
3. The gravity load stresses in the exposed structural frame supporting the overhang was limited to 50% of the allowable stresses permitted by the building code. No stress exceeded 12.0 ksi in any member.

Summary

When Western Life opened its doors, both design and energy expectations had been met. The energy efficiency of the facility has proven to be even greater than anticipated. And the company now has a unique and distinctive building with which to identify itself. □





Architect/Engineer
Ellerbe Associates
Bloomington, Minnesota

General Contractor
Kraus Anderson of St. Paul
St. Paul, Minnesota

Steel Fabricator
Paper, Calmenson & Co.
St. Paul, Minnesota

Steel Erector
Sandberg Erection
St. Paul, Minnesota

Owner
Western Life Insurance Co.
St. Paul, Minnesota

Keeping pace with area's needs, Bingham Memorial Hospital underwent extensive remodeling

Bingham Hospital: Metamorphosis in Steel

Bingham Memorial Hospital, in Blackfoot, Idaho, had a serious problem. It had served the community for over 25 years, but now its building could no longer keep pace with demands placed upon it. Health care techniques had changed and the community had grown. But the facilities had not. And the quality of care that could be offered by the professional staff was limited severely. In addition, the two-story, plus basement, steel-frame complex included a one-story nursing home, also in need of expansion.

The Bingham County commissioners and the hospital board, recognizing the need to provide long-term, modern health services, convened a conference that included architects, engineers, hospital staff and community representatives. Out of the conference came a decision that the hospital's best option was to expand and remodel on the existing site.

New Image Needed

The new Bingham Hospital and nursing home represents a structural and architectural metamorphosis. The owners wanted a whole new image. The finished project, compared with the original building, is like an emerging butterfly—and almost as remarkable. Although the original building was outdated, non-conforming and lacked a progressive public image its owners desired, it did have some positive features that allowed the design team to recommend a metamorphosis.

The interior structure was steel frame, and the column spacing provided modulation to conform to future planning. Floor-to-floor dimensions were adequate to house mechanical and electrical installations, and the non-conforming exterior masonry skin could be removed to allow contiguous growth. It also became apparent the hospital's three levels could be zoned for separation of basic functions.

The most outstanding feature of the new hospital is the cocoon of structural steel woven around the old building. That cocoon actually tied to the existing steel framing and braced the old structure so it could meet current seismic code requirements. A steel skin was chosen to clad the structural steel frame which extended the second floor on four sides. The steel skin, was the most appropriate material because of its light weight and strong visual image.

Bingham's administrator Carl Staley (l.) reviews plans with Michael Henderson, president of Design West. Drawing (r.) details structural metamorphosis.

Planning

Expansion of the hospital facilities was planned around the existing structure in the horizontal level at each of three levels, and thus required extension of floor slabs and roof at the periphery of the building. Expansion at the basement level was limited primarily to tunnel construction for corridor access to stairs, elevators, loading dock and the adjacent nursing home.

Plans that affected the existing hospital required removal of most interior partitions and all exterior masonry bearing walls above the first floor, but allowed interior columns and floor construction to remain. Exterior basement walls also remained, although it was necessary to provide some new openings and close up the existing ones.

Other structural elements retained in the existing building, in addition to the first and second floors, were roof joists, beams and girders and the basement foundations.

The design solution for the hospital permitted centralizing of functions, with patient rooms on the upper floor, diagnostic/treatment services on the ground floor, and all support services, surgery and delivery in the basement. Expansion of the nursing home includes a solarium and physical therapy center.

Structural Steel Framing Features

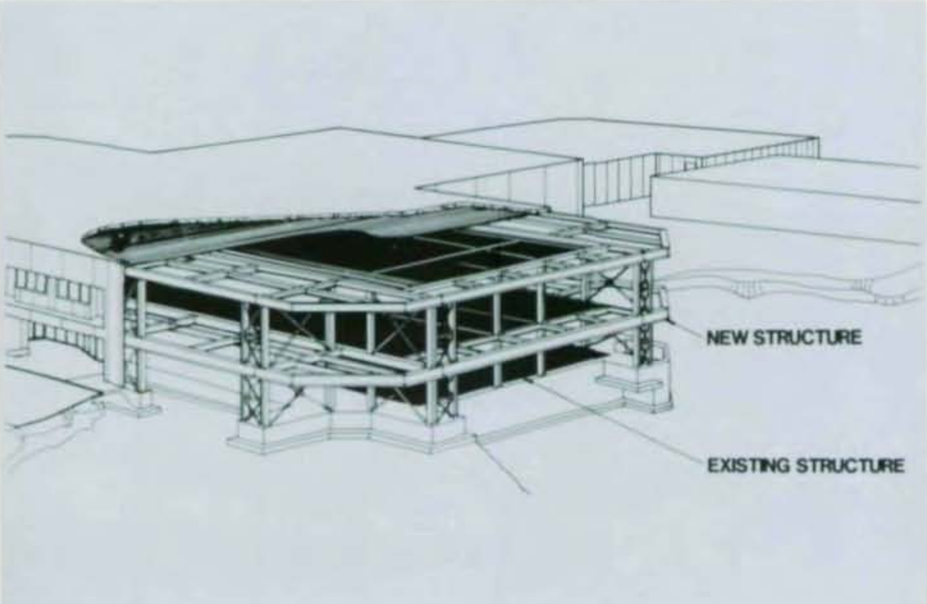
Structural steel used for the expansion preserved the existing steel framing. The entire structure was upgraded to conform to provisions of the 1973 Uniform Building Code for Seismic Zone 3. Since the hospital was considered an essential facility, an importance factor of 1.5 was used in the seismic design.

Seismic resistance was provided for the facility by a series of vertical cross-braced frames in both directions. In addition, removal of the existing masonry walls permitted a significant 65 percent reduction in seismic load for the entire building, including the nursing home expansion.

The structural scheme consisted of a series of two-story, two-legged frames where girders cantilevered to the inside face of existing exterior walls at both the second-floor and roof levels. Holes were punched in the exterior walls to permit girders to extend beyond existing joist bearings. This made it possible to support beams that would later be placed under the joist bearings after existing masonry walls were removed.

This framing scheme had several advantages: girder cantilevers resulted in reduced steel sizes due to girder continuity; the use of eccentrically loaded footings adjacent to the existing building exterior foundations was avoided; and the additional second-floor slab and roof-deck simplified and expedited removal of existing masonry walls.

Rolled structural steel sections were compact, efficient, easy-to-erect and connect to the existing structure—and adapted easily to many different kinds of field conditions.

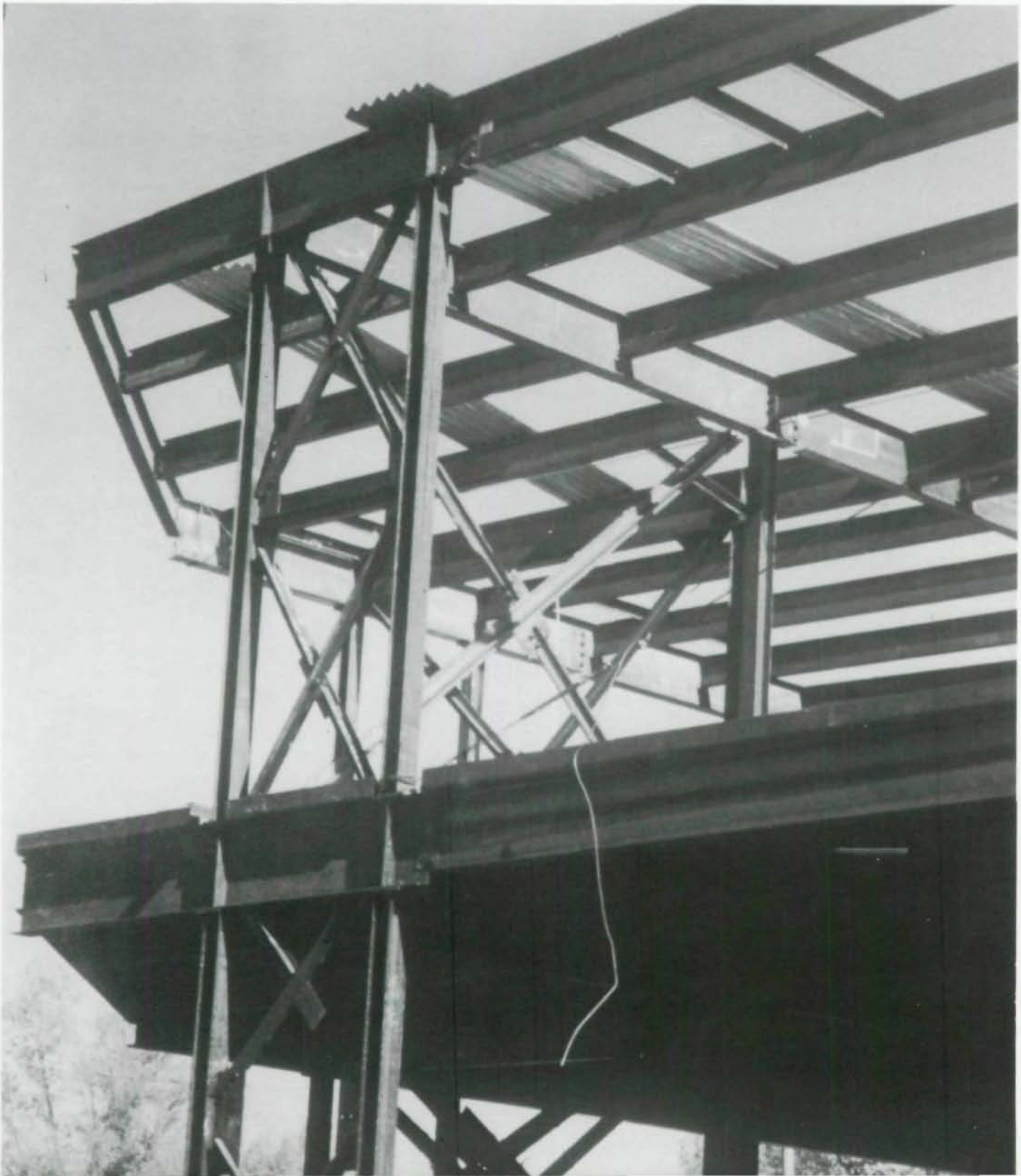


Completing the Project

After as much as possible of the new structure was erected around the old building, existing floor and roof joists were shored continuously through each floor down to the basement. Masonry walls were removed, proceeding from parapet down to the first floor. Then new beams were installed under existing joist bearings. Shores were removed, again proceeding from roof to basement. The strip of floor slab left void by removal of masonry walls was then installed, thus bonding new and existing construction together and achieving a continuous concrete floor.

The second floor is 3½-in. lightweight concrete on a fluted metal deck. It was not possible to keep the existing roof-deck because it could not transmit lateral forces to the vertical cross-braced frames. The gypsum concrete roof was removed and vermiculite concrete on metal deck installed over the entire roof. Both floor slab and roof deck have a two-hour fire rating. Addi-

Cocoon of structural steel weaves around old structure, ties to existing framing and braces it to meet seismic requirements.



Spacious entry opens into handsome foyer to enhance hospital image.

tional fireproofing was applied only to the rolled-steel sections.

This construction team created a butterfly, using steel. The final product presents a totally new image to the community. Bingham Memorial Hospital is now an exciting public building with a powerful image. But more importantly to the people of Bingham County, the hospital can now provide efficient patient care equal to any in the nation.

And, the project's cost was far below that of a new facility on a new site. In fact, net savings in construction costs are estimated to exceed $200,000. □

Glassed-in stairwell adds openness. Lightweight steel skin lends strong visual image to hospital.

Architect
Architectural Design West
Logan, Utah

Structural Engineer
Kurily & Szymanski
Santa Monica, California

General Contractor
Christiansen Brothers
Salt Lake City, Utah

New Woonsocket Institution for Savings' corporate headquarters designed to attract commercial neighbors.

Woonsocket Savings: Banking on Urban Renewal

The urban renewal program in Woonsocket, R.I., got an economic and aesthetic boost with the completion of the corporate headquarters for the Woonsocket Institution for Savings. The banking firm traces its roots to 1845, when the Woonsocket bank was founded.

The new four-story building occupies a 3.3-acre site, which anchors the easterly end of the redevelopment area. In addition to broadening the city's tax base, the $4.9-million steel-framed building is expected to attract new commercial and residential neighbors.

David I. Grist, AIA, senior associate with Keyes Associates, who designed and engineered the new facility, noted one of the reasons for selecting a structural steel frame was because it was more economical than other materials, such as reinforced concrete, and it also permitted greater design flexibility.

Innovative Concepts

The 120-ft square building is 58 ft from the ground to the top of the fourth floor level, and 72 ft to the top of the mechanical penthouse.

A cost-efficient atrium was designed by reducing the size of the atrium on each succeeding floor. Moving up to the fourth floor, each floor has an increasing amount of usable floor space without giving up the scenic open atrium effect. A skylight at the roof over the atrium floods the lower floors and the interior with natural light. A stainless steel and glass covered elevator rises through the atrium.

The building, faced in silver reflecting glass, adds a distinctive sparkle to its surroundings. The overall effect of the structure reflects the dignified philosophy of the bank and its long, stable position in the community.

Steel Details

The building's composite floor system, designed for 80 psf live load, consists of a 2½-in. concrete toping on a three-in. galvanized steel floor deck. The first floor, designed for 100 psf live load, is constructed of a 10-in. and 12-in. reinforced concrete slab supported on pile caps and grade beams. Lateral wind loads are transmitted through the upper floors and roof diaphragm to the two stair shafts, elevator shaft and a two-story vault.

Exterior columns for the top three floors are supported on cantilevered beams at the second floor level. The beams are set back four feet from the ground floor columns. The spandrel beams have moment connections at the columns to stiffen the exterior against movement in the plane of the glass curtain wall.

Economy Achieved

The fast-track approach to this project reduced construction time considerably. For example, the structural steel mill order was placed before drawings were completed. Foundations, grade beams, stair and elevator shafts were ready for the fabricated structural steel when it was delivered to the work site.

Approximately 300 tons of structural steel went into the new building, consisting of ASTM A36 and high-strength A572 Gr. 50. Connections were made with ASTM A325 high-strength bolts. □

☞

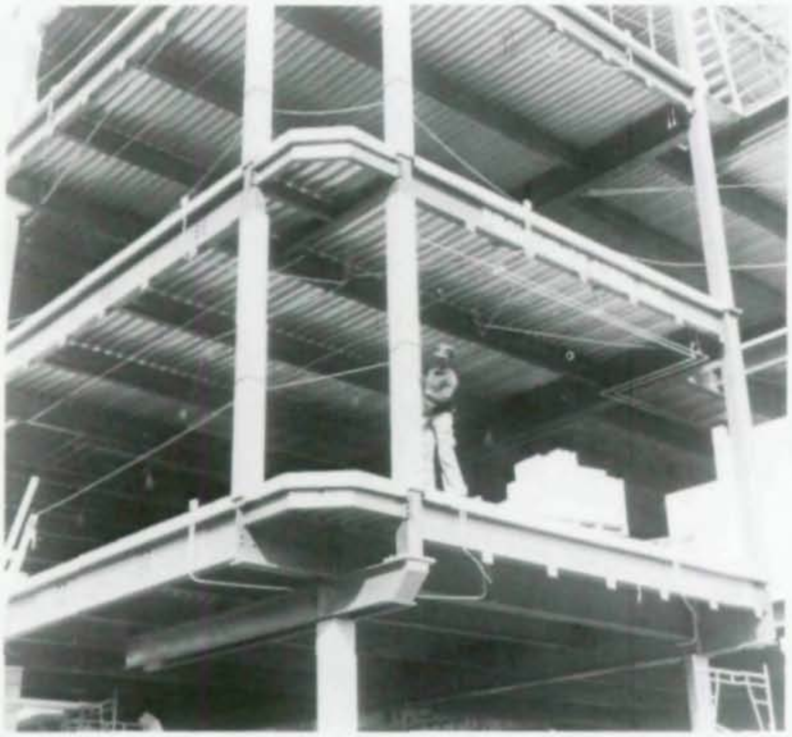
Cost-efficient steel structure surrounds innovative atrium concepts. Building faced with silver reflecting glass (below) adds sparkle to urban renewal area.

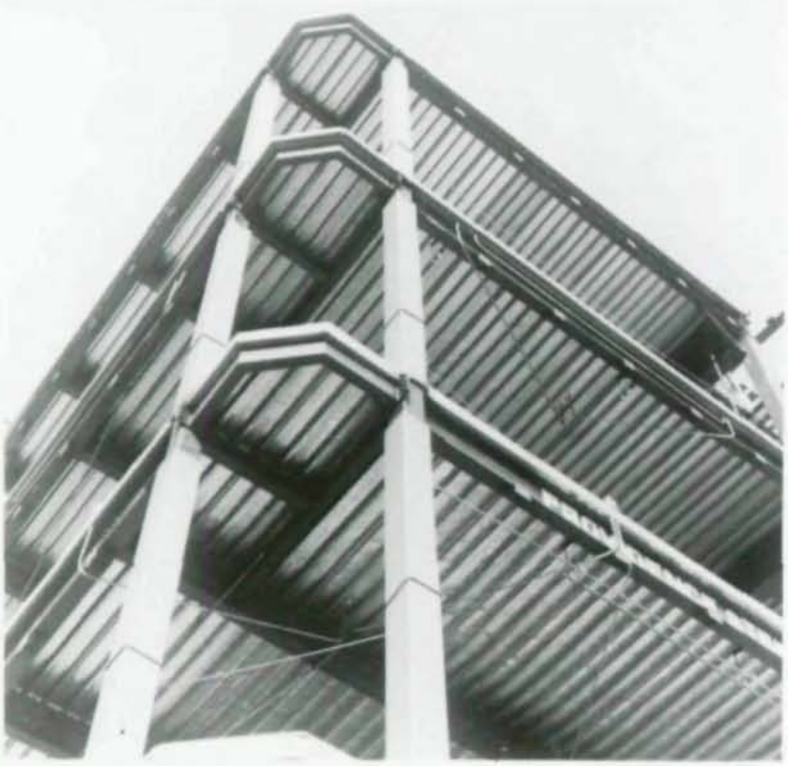
Architect/Engineer
Keyes Associates
Providence, Rhode Island

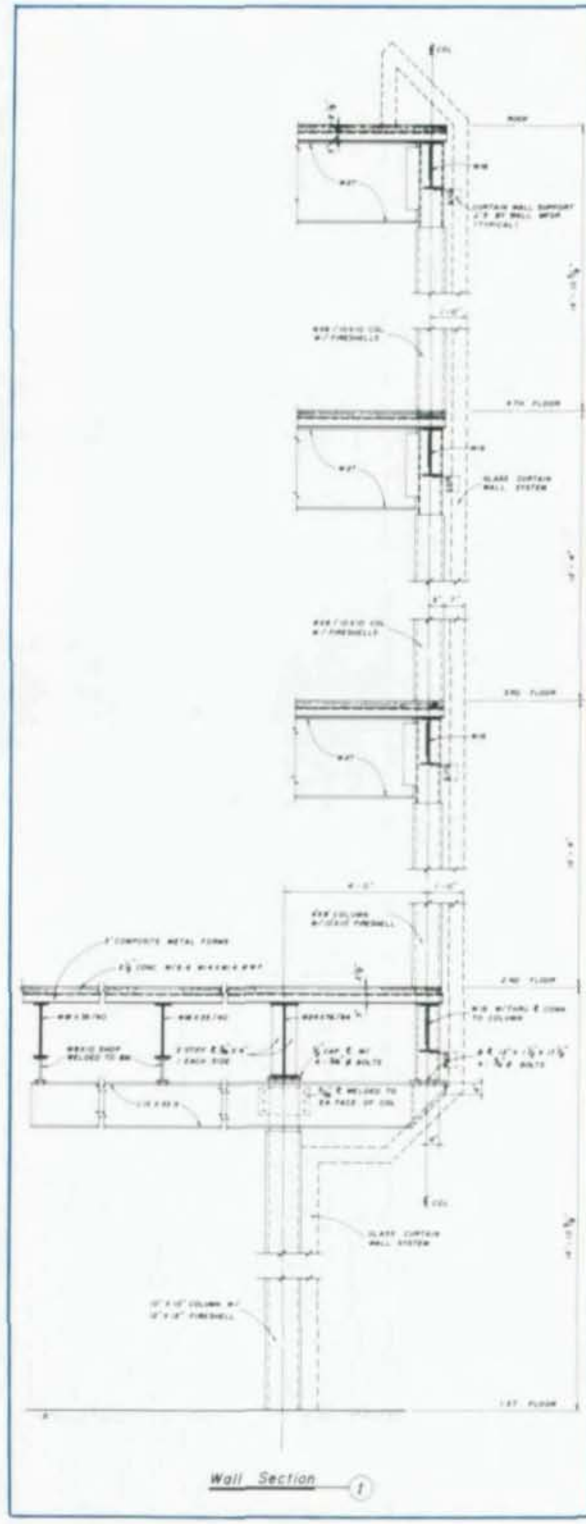
Construction Manager & General Contractor
Dimeo Construction Company
Providence, Rhode Island

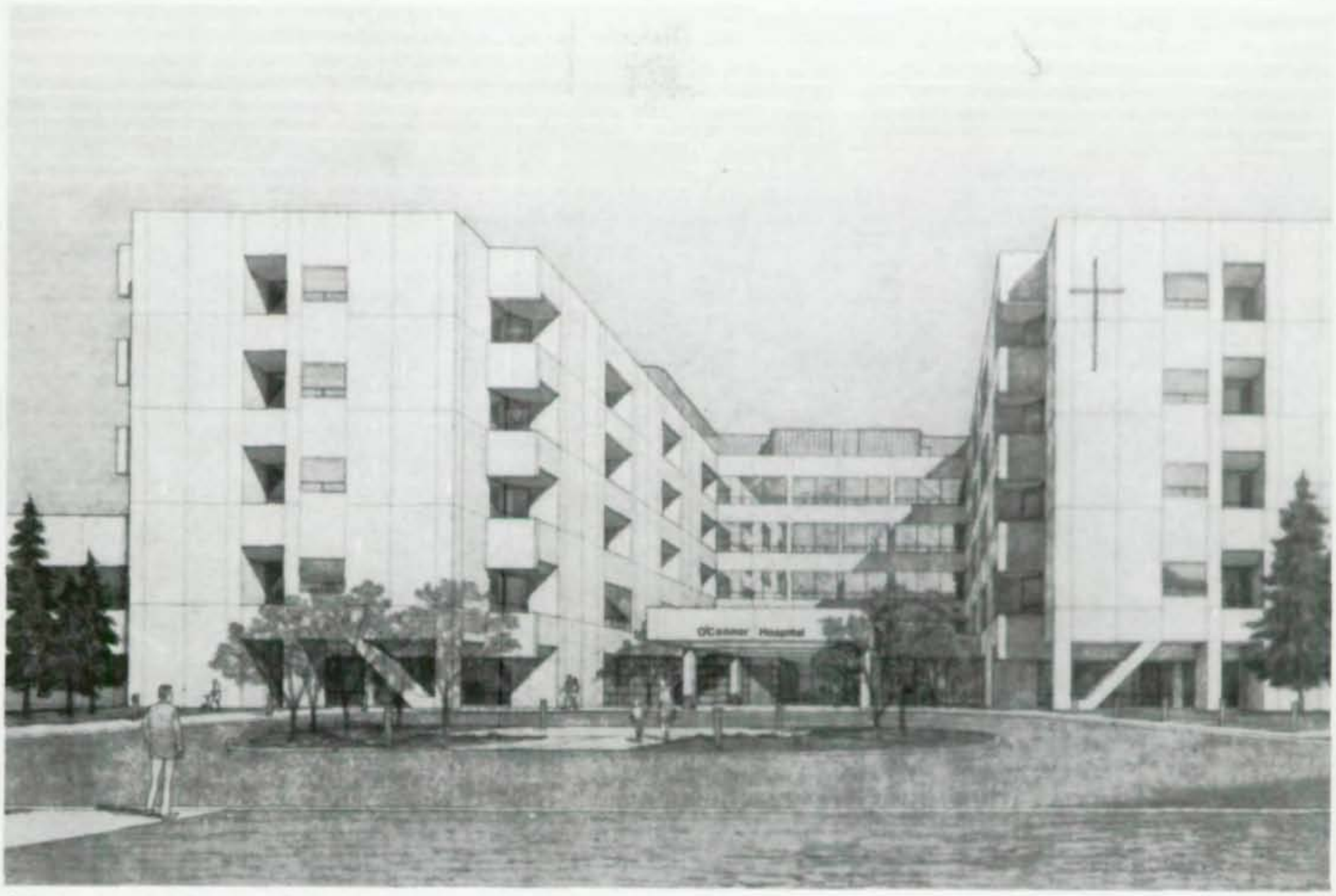
Steel Fabricator
Providence Steel, Inc.
Providence, Rhode Island

Corner details show first floor columns set back four ft from three-story columns above. Upper columns are supported on double cantilever beams at second floor at corners of structure.









O'Connor Hospital, San Jose, California. Open steel (below) exhibits eccentric braced framing.

Eccentric Braced Frames for a Major Hospital Structure

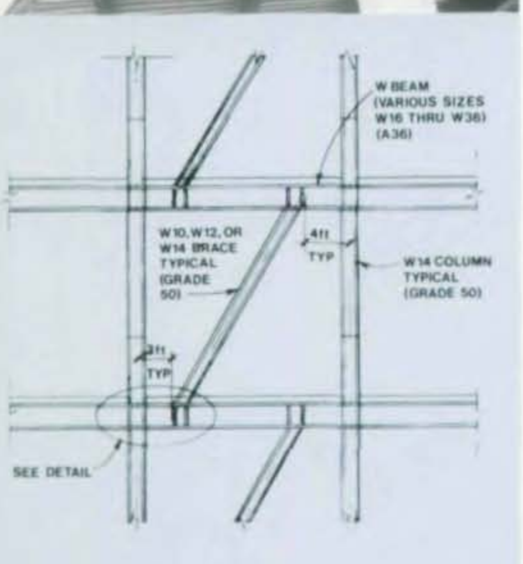
by C. Mark Saunders

According to the provisions of the California "Hospital Code" (Title 22 of the California Administrative Code), most hospital buildings in California must be designed for lateral forces obtained from a dynamic analysis utilizing the ground accelerations derived from an earthquake with a 100-year recurrence interval. Such analysis normally results in much higher lateral forces than those prescribed by the Uniform Building Code or other building codes. Also prescribed are very tight limits on interstory drift under such forces. The intent of the regulations, written after

C. Mark Saunders is a director of Rutherford and Chekene, Consulting Engineers, and was project engineer on the O'Connor Hospital project.

the Feb. 9, 1971 San Fernando earthquake, is to have hospitals in California remain functional after major earthquakes.

The replacement facility at O'Connor Hospital in San Jose, California, has been conceived by Architects Stone, Marraccini, and Patterson, San Francisco, as a five-story interstitial building with relatively large column-free interior spaces. As a result of this architectural scheme, and the requirements of the above noted code, Rutherford and Chekene, Structural Engineers, was faced with the task of providing a strong, stiff building, with high energy-absorbing characteristics, while maintaining large open spaces and high floor-to-floor dimensions. The steel eccentric braced frame system was selected as an ideal solution to those requirements.



TYPICAL ECCENTRIC BRACED FRAME

Design Requirements

As mentioned above, the lateral force resisting system for this structure required inherent lateral stiffness, to limit architectural damage under high lateral forces, and high energy-absorbing ability (ductility), to reduce the effect of the high lateral forces on the structure and prevent sudden (brittle) failure, while causing minimum structural interference with architectural and mechanical freedom. A further design consideration was speed of construction. To this end the construction manager recommended that an all-steel system be used.

Design Solution

In response to the above-noted requirements, three possible solutions were explored:

1. Steel ductile moment resisting space frame
2. Conventional braced frame
3. Eccentric braced frame

Based on preliminary studies, steel ductile moment resisting space frames, while an excellent solution to most of the design criteria, required very heavy members to meet the lateral stiffness requirements (drift limitations), with the high floor-to-floor dimensions and long spans. Studies showed about 25% more steel tonnage compared to that required for the selected system.

Conventional braced frames were rejected because of their relative lack of energy-absorbing capability (ductility).

The steel eccentric braced frame was selected as the only system to meet economically all of the project requirements.

The Eccentric Braced Frame (EBF)

The eccentric braced frame has evolved out of concepts that engineers have considered for years, but which have only recently been properly tested and documented — in the work of Roeder and Popov at the University of California at Berkeley (see references). The EBF is a braced frame where the diagonal braces are connected to the floor beam members eccentric from the beam column connection. Thereby it creates a "link beam," which is designed to yield in shear and acts as a shock absorbing fuse, both dissipating energy and protecting the brace member from overload. By designing the brace conservatively (usually with an additional factor of safety of 1.5), it assures that a buckling failure of the brace is prevented. For design information on the system, the reader is referred to the papers by Roeder and Popov and the publication by Teal, as listed in references at the end of this article.

To supplement the previous research with data pertinent to the specific conditions of this project, Rutherford and Chekene performed an inelastic time-history analysis of a typical eccentric braced frame as proposed for use on the project. The results of this analysis verified that significant reductions of accelerations do occur within the structure due to the inelastic action of the eccentric braced frames. The reductions, thus corroborated, were used to reduce the seismic design spectrum, resulting in much lower design lateral forces than would have been appropriate for a regular braced frame system.

The eccentric braced frames for this structure were designed using steel wide-flange sections for all members. Columns and braces were of ASTM A572 Grade 50 structural steel, while beams were of A36. Several configurations of bracing were used, as seen in the photographs. Columns were W14 sections, varying in weight from W14x109 through W14x342, while braces consisted of W10, W12 and W14 column-type sections. Beams were W16 through W36 sections. Connections were assembled with erection bolts, then full penetration-welded at flanges and webs. A photograph of a typical connection, along with a detail drawing of same, is shown.

The shear and overturning forces at the base of the EBF's were transferred by embedding the bottom of the steel columns and the bottom level beam in large (typically 4' x 8') reinforced concrete grade beams supported on drilled cast-in-place concrete caissons. The shear transfer from steel to concrete was effected by welded studs on the embedded steel members (see photo).

In cooperation with the architects, the initial configurations of the EBF's were selected to minimize interference with architectural features such as doors, windows and corridors. In these initial designs, the recommendation of Roeder and Popov that the eccentricity be approximately equal to twice the beam depth was followed. As the architectural design evolved, minor changes were required. Due to the fact that the EBF is not constrained by a requirement of concentric connections, such modifications could be relatively easily made. Eccentricities were increased or decreased in several locations, *with the only needed modification* of the braced frame design being a beam size change.

Construction

The O'Connor Hospital Project is currently being constructed under a fast-track contract, with William Simpson Construction Company as construction manager. Stockton Steel is the fabricator/erector. Erection of the structural steel was effected in approximately 75 working days. No major field problems were encountered with the use of the EBF system. Steel weight, not including the interstitial floors, amounts to approximately 21 lbs. per square foot. Framing for the interstitial floors, which are hung from the main structure, amounts to about 2 lbs. per square foot. Total tonnage of structural steel is about 3,200 tons.

Conclusion

Steel eccentric braced framing is an excellent lateral force resisting system, especially where the design criteria include:

1. Long spans and high floor-to-floor heights
2. High seismic ground accelerations
3. Tight drift limitations
4. Need for architectural and mechanical flexibility □

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Owner
Daughters of Charity of
St. Vincent de Paul
San Jose, California

Architect
Stone, Marraccini and Patterson
San Francisco, California

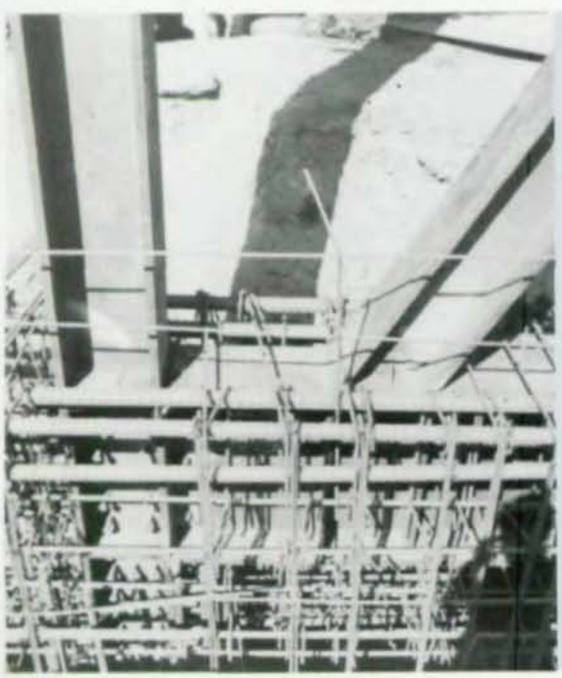
Structural and Soils Engineers
Rutherford and Chekene
San Francisco, California

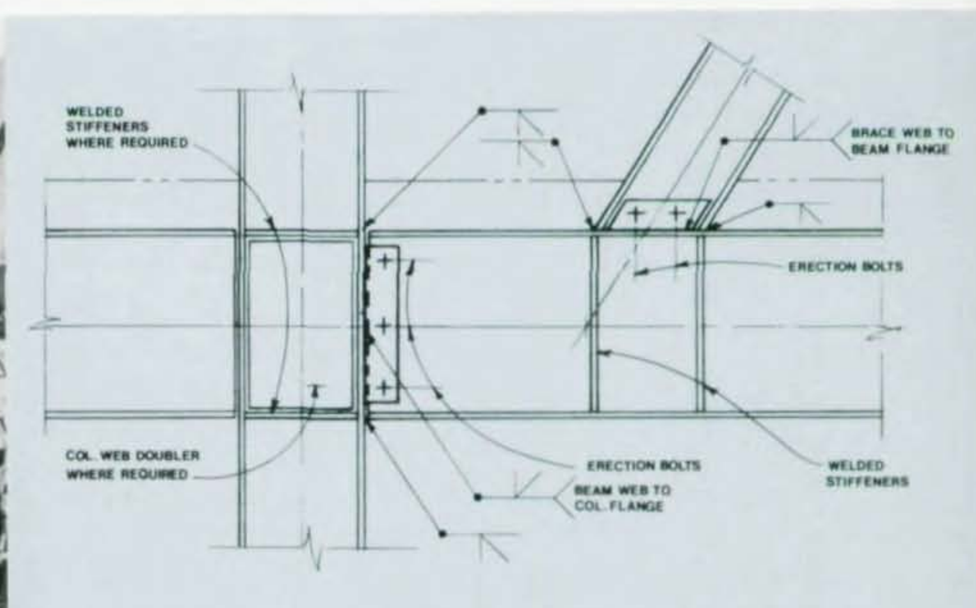
Mechanical/Electrical Engineers
Syska and Hennessy
San Francisco, California

Construction Manager
William Simpson Construction
A Dillingham Company
Los Angeles, California

Building Description

Beds:	357
Gross square footage:	280,000 square feet
Basic bay size:	18 feet by 36 feet
Floor-to-floor height:	Levels 1 and 2—17'-6" Levels 3, 4 and 5—16'-6"
Configuration:	"H" shaped tower on rectangular base. Overall plan dimensions are about 287 feet by 306 feet.





TYPICAL ECCENTRIC CONNECTION

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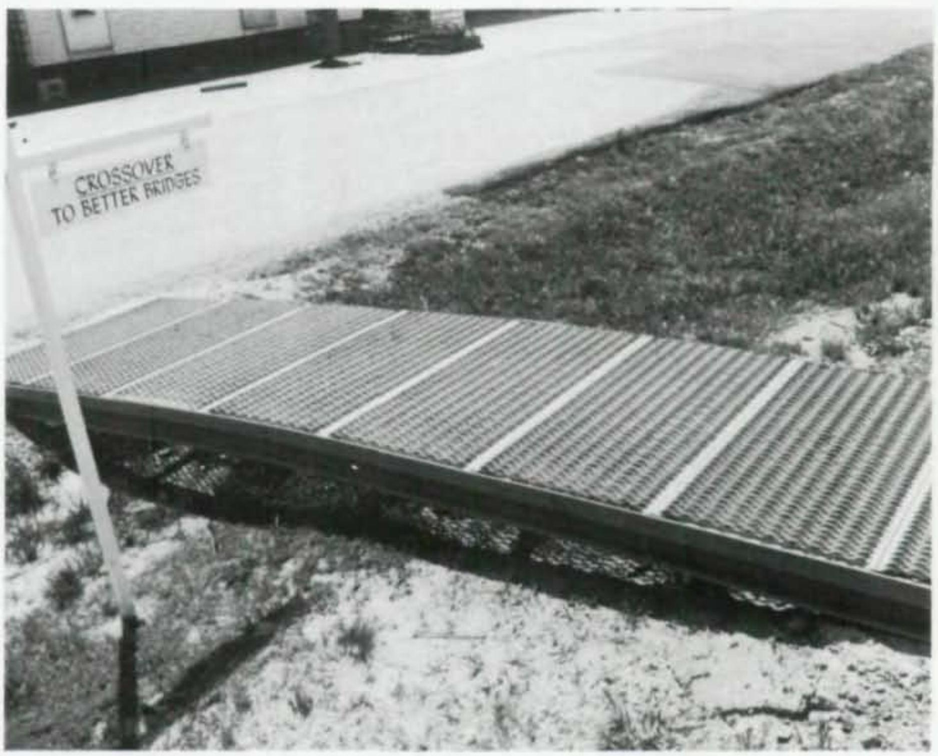
A "Prize" of a Bridge

Several weeks after judging of the 1980 Prize Bridge Competition had been completed, a very special entry arrived at AISC headquarters. Although some staffers considered this bridge was entered in jest, MSC editors felt compelled to share its gem-like beauty with our many readers. The following "comments" are those the staff feel might have been earned if the real jury had received the entry: "The ultimate in simplicity and harmony with its clean lines and gentle arch. It is particularly handsome from underneath, blending well with a rather mundane landscape . . . a splendid example of ingenuity and responsiveness to man's need."



Design Considerations

Two factors were utmost in the design and construction of this bridge: time and economy. The previous bridge was washed downstream and broken up by flash flooding. Therefore, the first criteria was to replace the bridge quickly. Secondly, it was hoped the bridge could be built from readily available materials, hopefully scrap items, or material left over from other bridges.

Because of the clearance required due to flooding, the relative shallowness of the banks for building the abutments and the shortness of the span, a single simple span arch-type design was chosen. This required a low depth main load beam to minimize excavation and still allow a smooth transition from approaches onto the bridge. Span length is 16'-0"; the vertical clearance is 0'-8½".

Calculations indicated W4x13 sections, readily available, would be satisfactory for the main beams if the dead load was held to a minimum. The conventional concrete deck had already been ruled out due to labor considerations and drainage factors. Since dead load needed to be small, grip-strut type grating was chosen. This provided a slip-proof surface, excellent drainage and was quickly available through our steel service center. The main beams were heat cambered 3¼ in. to provide more vertical clearance.

The last consideration was paint and subsequent maintenance. The structure would be subjected to splash and possible partial submersion in water during heavy rains, and welding through the coating would be required. An inorganic zinc coating was chosen because of its excellent resistance to water exposure and weathering. The grip-strut deck would be galvanized to make the structure maintenance-free for at least 10 years. □

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