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MODERN STEEL CONSTRUCTION

1

1 Giant Trusses Span Jai-Alai Fronton 6
2 Five Tower Hotel Soars in L. A. 3
3 Center of the City 15

2

3

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CONTENTS

Five Tower Hotel Soars in L. A.	3
Giant Trusses Span Jai-Alai Fronton	6
Two Simplified Steel Bracing Systems	12
Center of the City	15

1977 T. R. HIGGINS LECTURESHIP AWARD

Professor John W. Fisher has been named recipient of AISC's Seventh Annual T. R. Higgins Lectureship Award. Professor Fisher was chosen to receive the $2,000 award for his contribution to the fund of engineering knowledge based upon his paper entitled "Fatigue Strength of Steel Beams with Welded Stiffeners and Attachments," which was judged as the most significant engineering paper on fabricated structural steel published within the last five years. The paper was coauthored by P. A. Albrecht, B. T. Yen, D. J. Klingerman, and B. M. McNamee, and published by the Transportation Research Board in 1974.

1977 FELLOWSHIP AWARDS

Four engineering students have been awarded $3,500 fellowships in AISC's 15th Annual Fellowship Awards Program. The program is designed to encourage expertise in the creative use of fabricated structural steel.

Lawrence W. Curry	*Case Western Reserve University*
Keith A. Duerling	*University of Maryland*
Nelson E. Kittredge	*West Virginia University*
Edward C. Smetak	*Carnegie-Mellon University*

REVISED JOIST SPECIFICATIONS

A new edition of "Standard Specifications and Load Tables for Open Web Steel Joists, Longspan Steel Joists, Deep Longspan Steel Joists" (Publ. No. 316) is now available from AISC.

This booklet contains revised Standard Specifications for Longspan Steel Joists (LJ-Series and LH-Series) and Deep Longspan Steel Joists (DLJ-Series and DLH-Series) adopted February 16, 1977. No changes have been made to the Standard Load Tables for these joists, nor to the Standard Specifications and Load Tables for Open Web Steel Joists (J-Series and H-Series).

The new joist specification booklet can be purchased from AISC, 1221 Avenue of the Americas, New York, New York 10020. Price is $1.50 per copy.

Five Tower Hotel Soars in L. A.

by Richard Campbell, AIA

A soaring cluster of five cylindrical towers comprises the recently completed 1,474-room Los Angeles Bonaventure Hotel, designed by John Portman. Now the largest hotel in Southern California, the Bonaventure epitomizes Portman's design philosophy of starting with the human being and his natural reaction to space, then building on that to create stimulating, exhilarating structures that function through the use of modulated space.

The complex consists of a 375-ft, 35-story central tower interconnected via elevator lobbies with four 300-ft, 30-story peripheral towers. The central tower has 23 floors of guest rooms, with 16 rooms on each floor and a revolving restaurant on the top floor. The smaller towers have 21 floors of guest rooms, with 14 rooms per floor. The guest rooms begin on the ninth floor, directly above the mechanical level.

Mr. Campbell, resident architect on the project, is with John Portman & Associates.

Directly below the mechanical level is an 80-ft atrium lobby that descends to the street level. Truly a Portman landmark, the lobby is complete with hanging gardens and trees, pools, cantilevered cocktail areas, and Tivoli elevators. Also opening onto the atrium are five levels of stores, containing 145,000 sq ft. Pedestrian sky bridges and an open air escalator afford easy access to the hotel from four major surrounding office complexes.

Five Tower Scheme

A 295-ft square, 7-story podium supports the central tower and four peripheral towers. Above the podium, the four peripheral towers are connected to the central tower by bridges at every level.

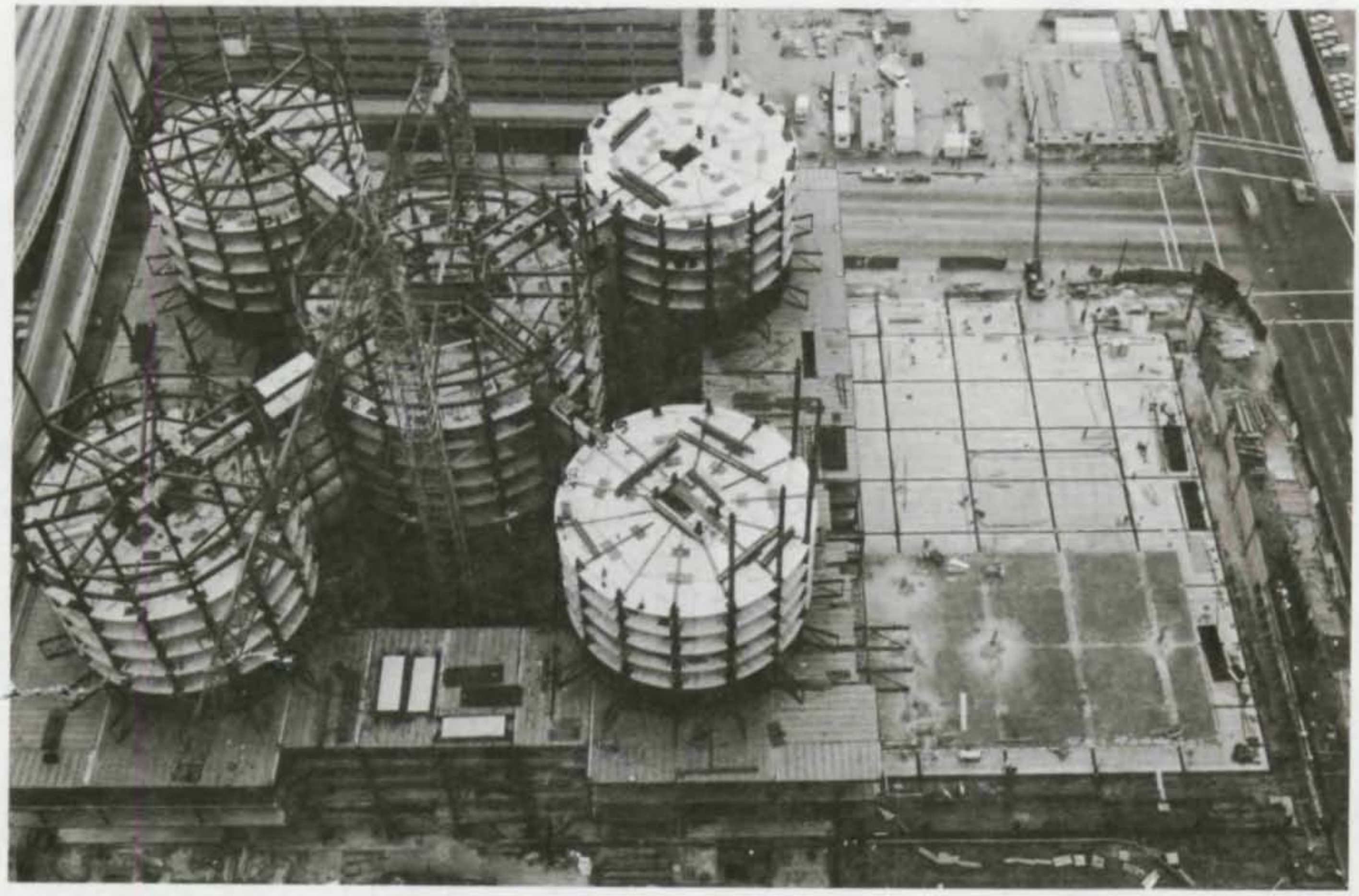
Separated by an expansion joint from the podium is an adjacent 191-ft x 295-ft, 6-level building. This separate structure houses a swimming pool, ballroom, parking, and service and exhibition areas. A maximum of four levels of this structure are below grade.

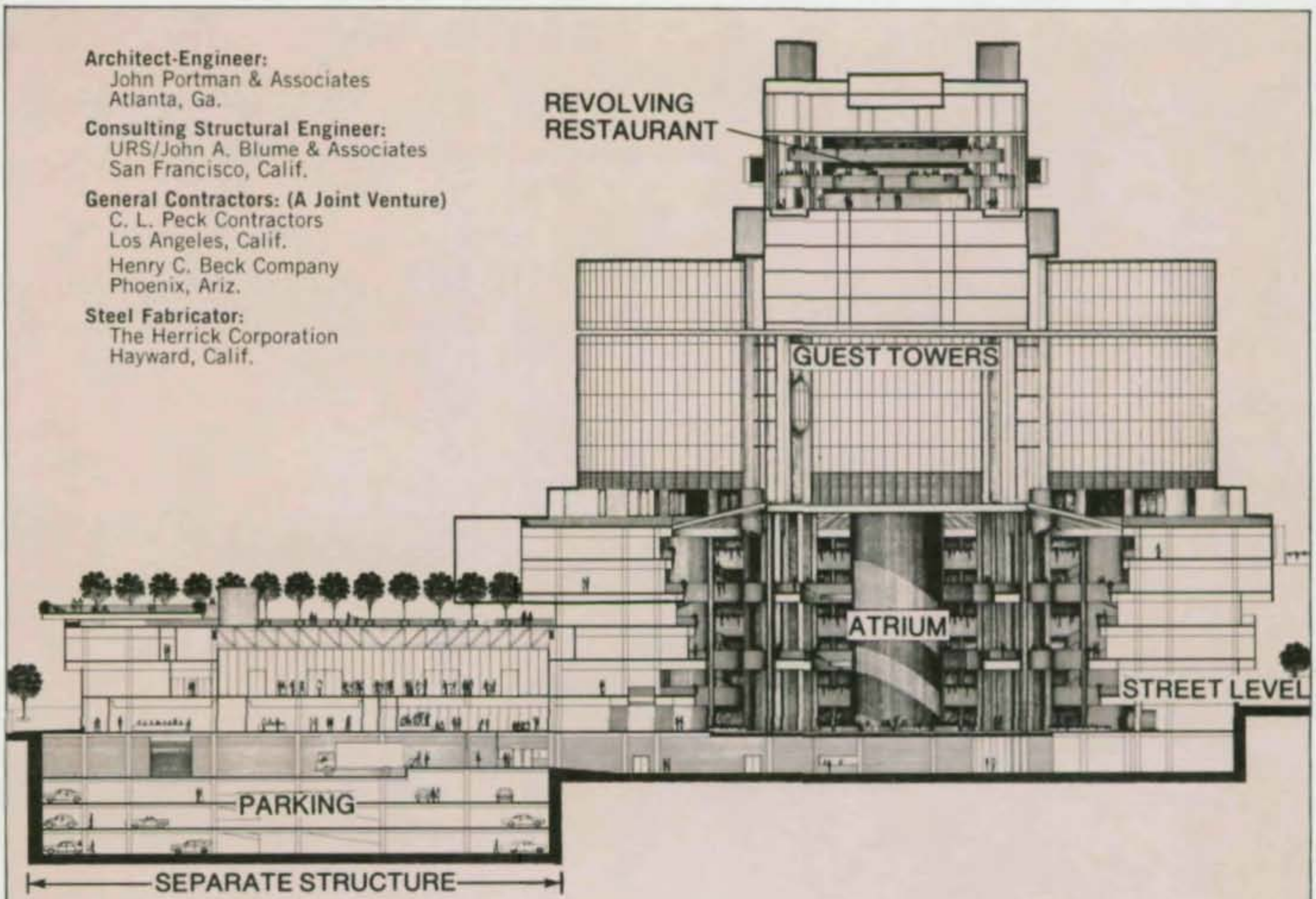
Steel Framing

The entire structure is supported primarily by steel framing resisting both vertical and lateral loads. The towers each consist of two concentric frames composed of vertical columns and horizontal beams. Except for a few girders with moment connections along the diagonal direction, the two concentric frames within each tower are connected primarily by rigid diaphragms. Lateral loads are therefore resisted mainly by the tube actions of these two concentric frames. Gravity loads are transferred to the main framing either directly or by a system of simply supported beams and girders.

Below the seventh story there are a series of frames with moment-resisting connections in the two directions parallel to the sides of the podium. The bridges connecting the central tower

A 295-ft square podium supports five towers.





Cross-section of Los Angeles Bonaventure Hotel

with the peripheral towers are assumed to behave as elastic diaphragms in the horizontal plane. The columns were assumed to be fixed at the base in the static analyses. However, to model the structure more accurately in the dynamic analysis, the base was assumed to be hinged, and the concrete walls along the perimeter below the second story were also included.

Meeting Seismic Requirements

The Los Angeles City Building Code requirements for seismic loads were similar to those of the Uniform Building Code. However, the Los Angeles Code was in the process of being modified, requiring a dynamic analysis. The modification also specified a maximum probable ground motion of 0.5g.

In designing the towers, the initial concept was to design five separate structural steel towers each with its own lateral support system and separated by expansion joints. The seismic code requires that such expansion joints increase proportionately with the height of the building. This would have created waterproofing problems and resulted in excessively wide joints. After extensive discussion both in-house and with structural engineers URS/John A. Blume & Associates, San Francisco, who worked with Portman's engineering team in conducting structural analysis on the towers, it was concluded that the best solution was to tie all the towers together. Once tied together, it was essential that they act as a unit; therefore, the elevator lobbies that connect the towers were designed to transmit the seismic forces between the five structures. They actually became horizontal trusses transmitting shear and axial loads.

Although the structural framing is designed to remain elastic under code gravity and lateral loads, it is recognized that plastic hinges may form in the rigid frames under response to severe seismic motion in excess of code requirements. With only a few limited exceptions, the frames for this structure were designed under the weak beams/strong columns criterion, which implies that plastic hinges would form at the ends and thereby limit the forces to be resisted by the beam-column panel zone, column splices, and column-base connection. The connection design criteria developed for the structure required that all elements of the above connections would be designed to resist, at or below yield stress, the forces associated with formation of plastic hinges in the beams or in the columns for those few exceptions where column yielding would occur before yielding of the beams.

Giant Trusses Span JAI-ALAI Fronton

by Philip Wesler

Architect:
Irwin Joseph Hirsch Associates
West Hartford, Conn.

Structural Engineer:
Fraioli-Blum-Yesselman of New England, PC
Hartford, Conn.

General Contractor:
Horn Construction, Inc.
Hartford, Conn.

Steel Fabricator:
Topper & Griggs, Inc.
Plainville, Conn.

"Jai-alai" (pronounced hi-li) is a Basque term meaning "merry festival." An ancient betting sport, currently enjoying a sweeping popularity in the northeast United States, the game attracts both young and old, avid bettors and non-betting spectators alike.

World Jai-Alai, Inc., owners of four facilities in Florida—the center of activity in the U. S. for 50 years—chose Hartford, Conn., for the site of their fifth fronton. (Two others have since opened in Connecticut, and one in Rhode Island, under other ownership.

Jai-alai (also called "pelota", the Spanish name for the small, rock-hard, goatskin-covered ball used in the game) is probably the fastest and most dangerous sport in the world.

Mr. Wesler is president of Fraioli-Blum-Yesselman of New England, PC.

Description of Game

Two opposing teams, each having one or two players, are in action at any given time during play. Each player wears a "cesta," a ribbed wicker, crescent-shaped device, strapped to his right arm, with which he catches the pelota and then hurls it, at speeds of up to 150 mph, at a granite wall. Should the opposing team fail to return the ball cleanly, the first team wins a point, and continues to play a third team. By this process of rotation, three winners are determined among the eight participating teams in each game. (Usually, 12 games are played in one session.) The betting is similar to horse-racing or dog-racing, complete with "exotic" quinielas, perfectas, and trifectas.

The size and shape of the playing court ("la cancha") effectively govern the overall design of the building housing it.

A monolithically-placed concrete playing court, 36 ft x 176 ft, alongside a 19-ft wide wood-floor forecourt of the same length, runs parallel to the spectators' seating. A vertical, taut wiremesh screen protects the spectators from errant bounces and hurtling players, without obstructing their view. The screen extends more than 40 ft above the court, serving to safeguard the bright overhead lighting fixtures.

Capacity of Building

Located on 34 acres on the outskirts of Hartford in the North Meadows area, with parking spaces for 2,275 cars and 38 buses, the Hartford Jai-Alai Fronton contains 4,575 plush, theater-type seats, as well as standee areas close to the playing court, which can accommodate an additional 1,050 spectators. The seating area, gradually stepped in a single plane, affords clear viewing of the entire playing court from all locations back to the farthest seat, 192 ft from the screen.

A large restaurant and cocktail lounge, accommodating several hundred more persons, uses closed-circuit TV to provide live coverage of the action. The betting lobbies are also equipped with color TV monitors.

Since some patrons tend to arrive and leave early, while others follow the reverse pattern, as many as 11,000 persons can be accommodated during the five-hour single afternoon or evening performance.

Roof Trusses Span 184 Ft

A roof system of long steel trusses provides an unobstructed view of the playing court from all seats and standee areas. This roof system contains four typical main trusses over the seating and one special truss forming the step in the roof levels, directly over the playing court.

Spaced at 44 ft o.c., the trusses span 184 ft between the vertical supporting columns which are part of the two-column pylon assembly. The relatively wide spacing minimizes the number of main trusses and supporting pylons and resulted in reduced fabrication and erection costs, and improved circulation at the side walls.

Heavy W14 shapes were used for the top and bottom chords and main web members, and light W10 shapes for the auxiliary web members. The typical trusses taper from a maximum depth of about 10 ft at the supports to about 14 ft at midspan, thus affording roof drainage toward the outside.

A572-Gr50 steel was used for most of the heavier shapes, both to save on erection weight and to effect greater overall economy. The balance of the structural steel was A36.

The top and bottom chords were shop-spliced with full penetration butt welds, at about the quarter points of the span. The web member connections to the chords were also fully shop welded, using both fillet welds and full penetration welds, of only such length as to develop axial stresses, and in such manner as to minimize the possibility of lamellar tearing.

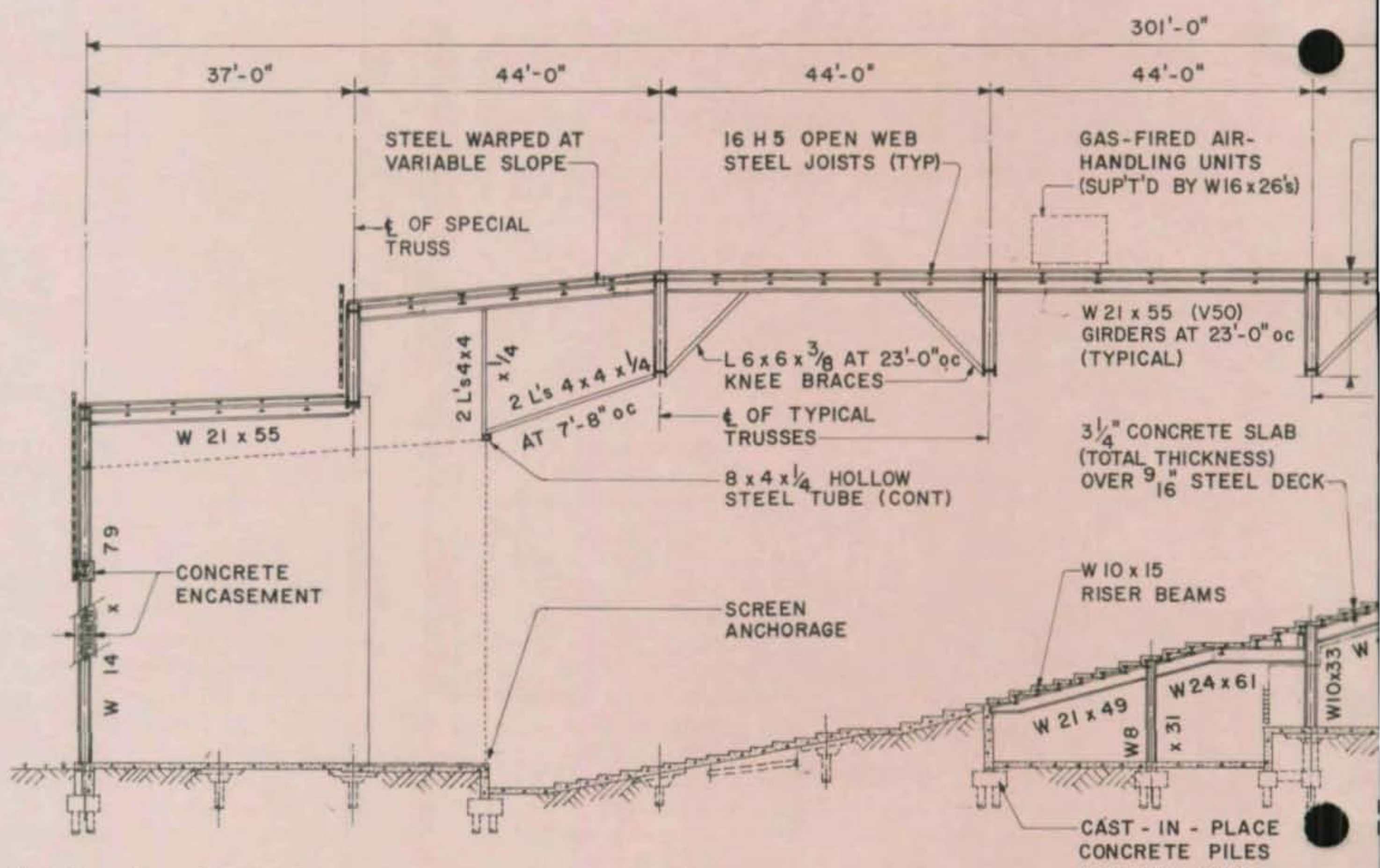
The balance of roof framing over the seating area is essentially conventional framing, consisting of W21 girders spanning between the trusses, at 23-ft centers, supporting open web joists.

Painted 22-gage steel roof-deck, 1½-in. deep, spans between the joists. A built-up roof over rigid insulation completes the assembly.

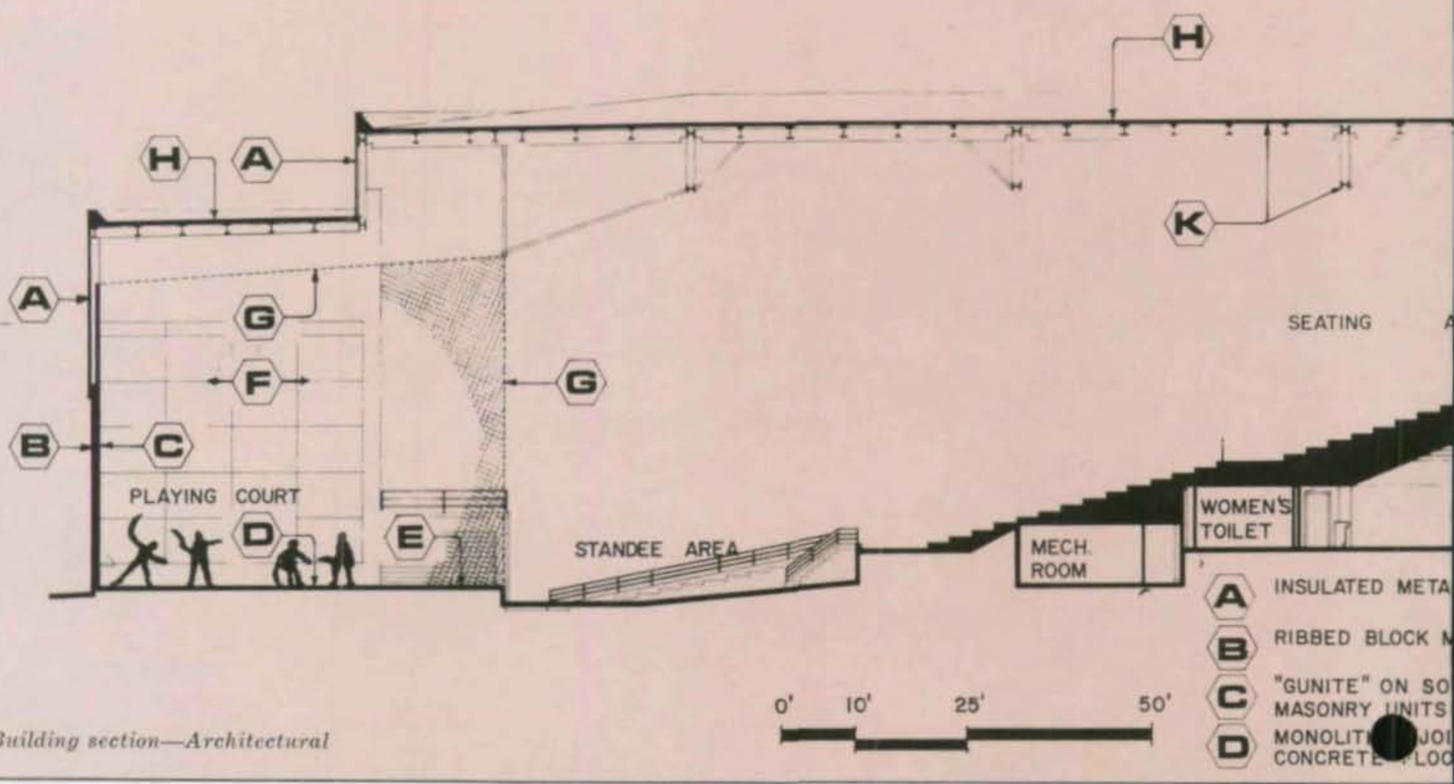
Main Truss Erection

Each main truss was shipped by flatbed trailer from Pennsylvania, in two sections, each 93 ft long and 14 ft at its widest. Field splicing was accomplished at ground level in the approximate final position of each truss. The splices consisted of ⅝-in and ⅞-in. thick gusset plates, and a 1-in. A490-N bolts. A maximum camber of 3¼ in. at midspan was built into each truss. Neither shoring nor falsework was required in any of the erection operations.

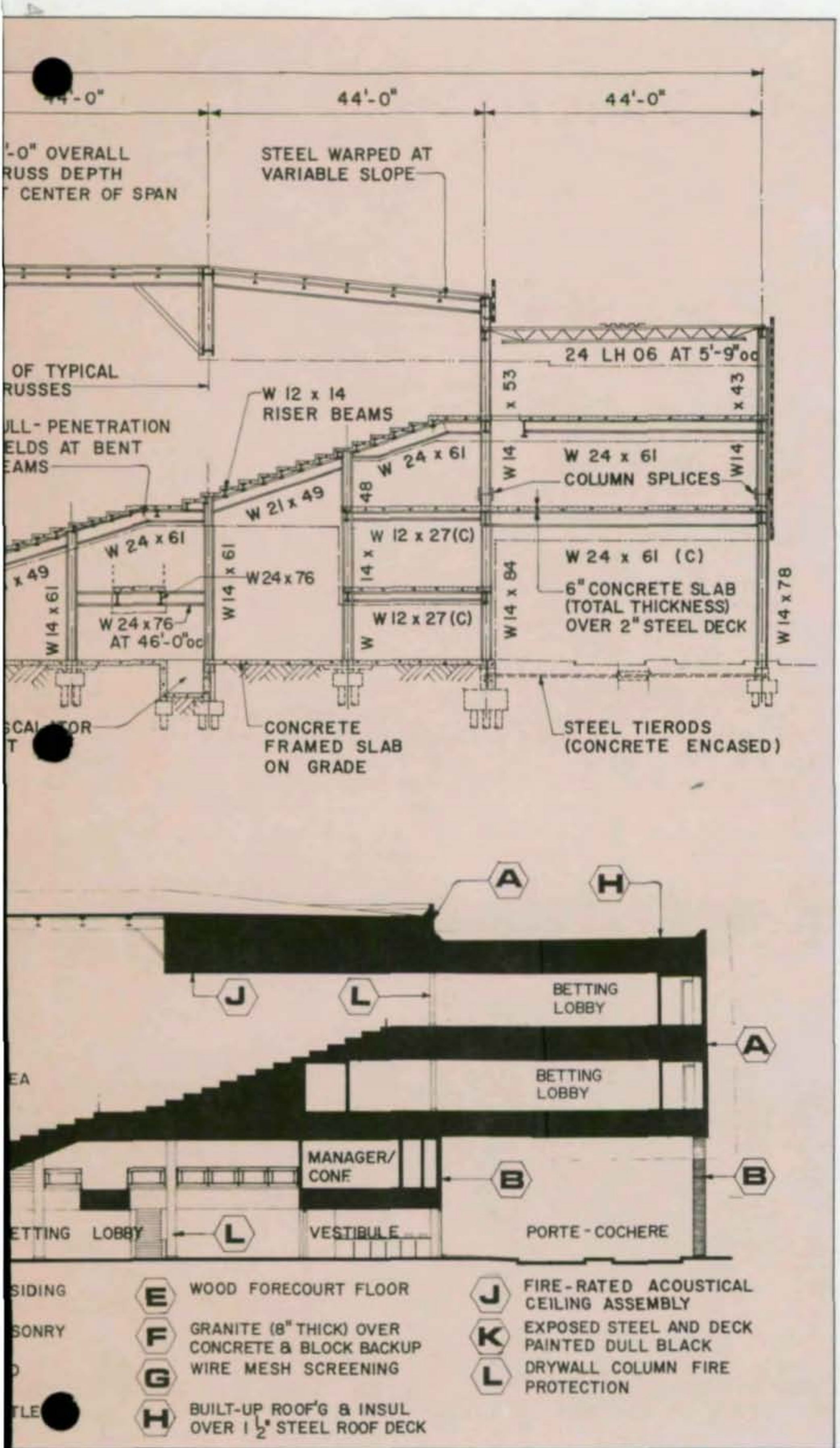
Two truck-mounted cranes, (one of 120 tons capacity, the other 90 tons),



Building section—Structural



Building section—Architectural



lifted each 27-ton main truss into place atop the previously erected pylons. The heavier crane was equipped with a 140-ft boom and 30-ft jib. A third crane, a 65-ton capacity model, with a 120-ft boom and 30-ft jib, was used to erect the bracing trusses and roof framing to stabilize each newly-erected main truss.

Pylons Support Main Trusses

The fully shop-welded twin-column pylons supporting the main trusses, each weighing about six tons, are combination truss and Vierendeel-type frames, so designed to resist wind stresses.

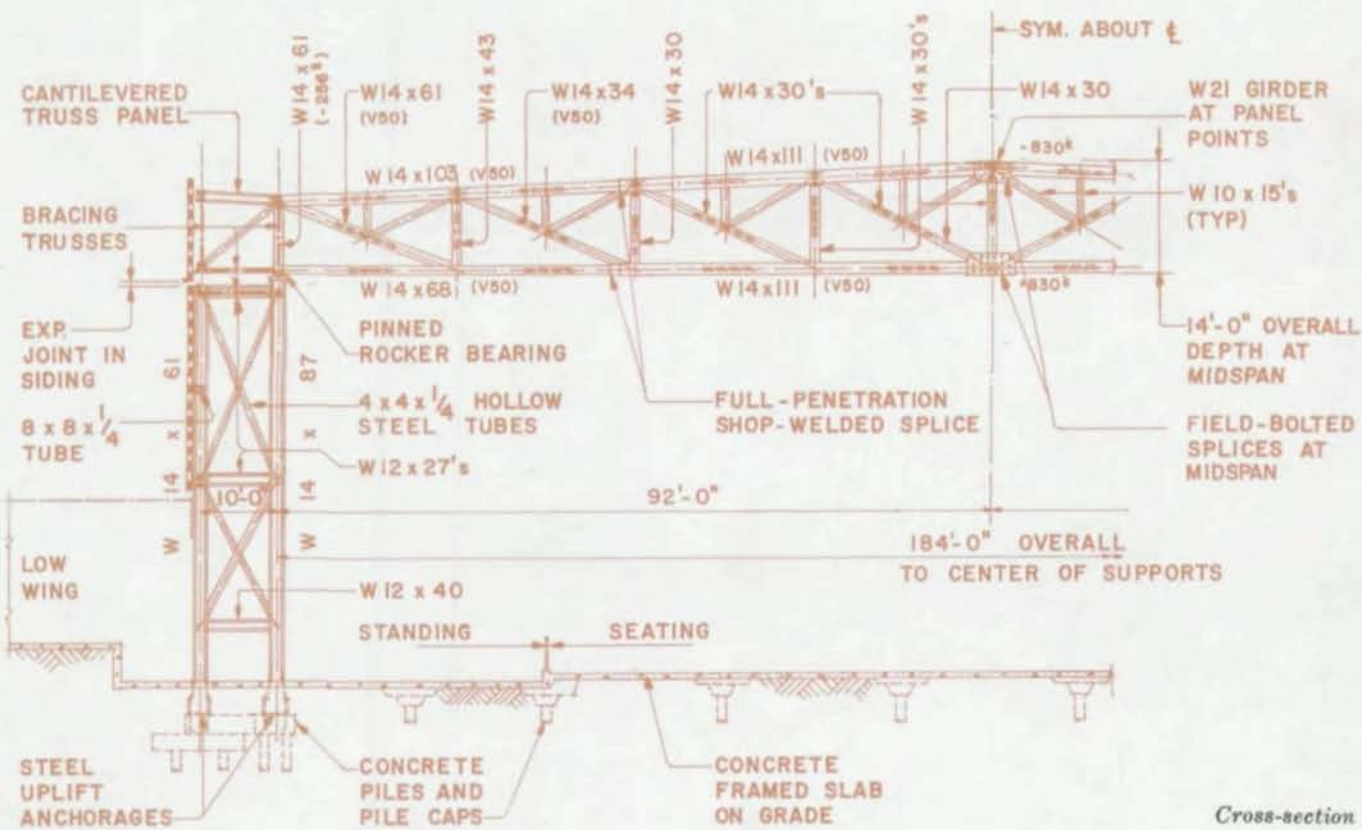
To allow for free rotation of each truss at each end under full snow loading (30 psf), a steel rocker bearing was provided. A single truss panel, cantilevered from the ends of each main truss, supports the several bracing trusses, and the narrow end bay of the main roof.

Cladding of Building

At the main stair towers, a ribbed block masonry cavity wall extends to the roof line. Elsewhere, ribbed block extends only to the soffit level at the large porte-cochere. An insulated painted steel siding, with steel liner, occurs above, and continues around the entire building, acting as a parapet at the roof levels. Where the cantilevered panels occur at the ends of the main trusses, a vertical expansion joint was provided in the siding to accommodate the truss rotation. To avoid deep ponding in the end bays caused by possible clogging of the drains, emergency scuppers were provided in the parapet formed by the siding.

Bracing System

Light, all-welded steel bracing trusses between the pylons along each main wall, spanning 44 ft, serve a triple purpose: as vertical supports for roof loading; as vertical and lateral supports for the metal siding; and as overall braces of the roof system and wall girts. In addition, because the main roof structure is essentially pin-jointed, vertical diagonal cross-braces, generally consisting of flat steel bars, were provided in certain peripheral walls to transfer all lateral stresses down to the



Cross-section

foundations. In the main roof itself, where the structure is exposed to view, the horizontal diagonal bracing was installed just below the joists, and heavy knee braces were provided from the roof girders down to the bottom chords to stabilize the trusses.

Seating Floor Construction

In order to afford the most economical design, the stepped seating areas, representing the largest proportion of suspended floors, have light rolled sections parallel to each step, supporting a thin concrete slab placed over galvanized light steel deck. These light purlins, generally W10's and W12's, span 23 ft typically, and are supported by steel girders which either slope to follow the seating, or are level, or, by cutting and rewelding, are a combination of the two. The W21 and W24 girders span 24 ft between rolled shape steel columns of varying sizes.

The light dead load afforded by this framing system was helpful in reducing foundation costs. In addition, the only wood forming required was for the risers of the stepped floor.

Conventional Floor Construction

At level, suspended floor areas, for betting lobbies and at other occupied areas where crowds would congregate, a rigid system was desired which would prevent annoying vibrations, especially in the 44-ft spans. Therefore, composite rolled steel beams were used, spaced at 7 ft-8 in. A 6-in. concrete


View of assembled steel framing

slab on composite, galvanized steel deck spans between the beams. The supporting composite girders generally span 23 ft, using ¾-in. round headed studs. This system has resulted in a very rigid floor in all areas used.

Fire Protection Assemblies

In most areas of the building, the ceiling construction provides the required fire-rating, generally 2 hours. For certain girts and pylon bracing exposed to view, an intumescent fireproofing material was applied.

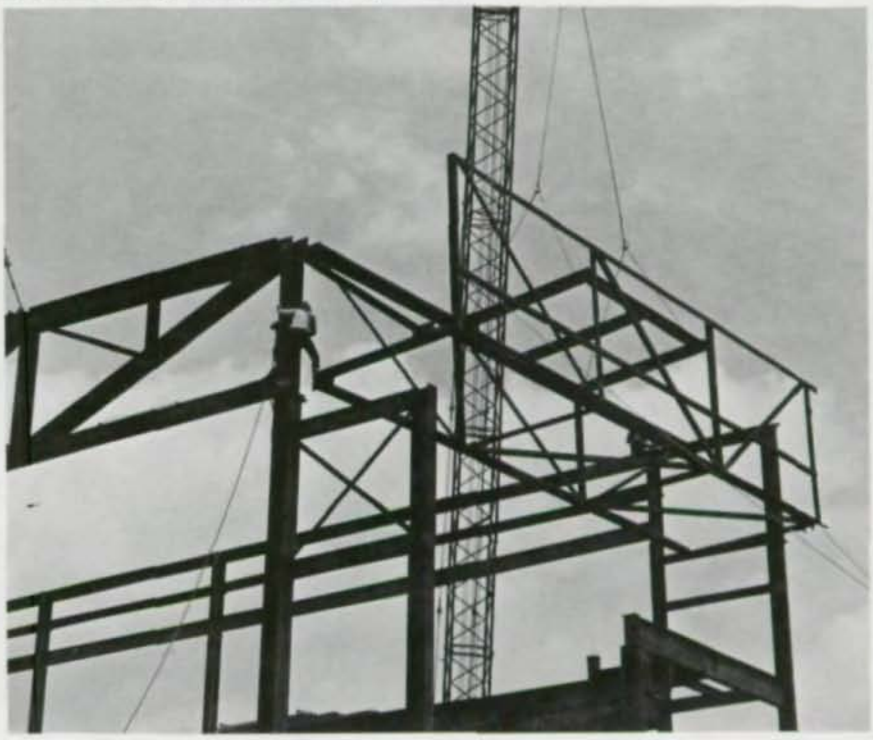
Most of the steel columns are enclosed by multiple-thickness drywall assembly, except those at the playing court, which are concrete encased for rigidity and compatibility with the adjacent masonry and gunite wall construction.

Because of the height above the seating area, the majority of the roof steel, including the metal deck, requires no fire-rating and is left exposed to view. In these areas, the deck, joists, and structural steel are all painted a dull black. With the fluorescent strip lights set at the level of the bottom of trusses, this causes the entire framing to practically "disappear" into the darkness. No acoustic treatment was provided, since the thrilling sound of a rock-hard pelota striking a granite wall is one which will remain in the memory of anyone who has ever attended a jai-alai game, and the exposed metal deck is a perfect material to reflect this sound.

If a building's success is measured by attendance, then the 1,415,000 persons who attended during the first seven-month season of operation attest to the success of the Hartford Fronton. In addition, the invaluable cooperation of the owner, the architect, the general contractor, and the steel fabricator, not to mention all of the other consultants and the suppliers, has caused this exciting project to be a most successful and satisfying one for my firm, which performed the structural engineering. It is quite clear to all concerned that the choice of structural steel framing, which totaled 1,000 tons on the entire project, was an excellent choice and contributed immeasurably to the overall success of the construction.

Seating end of first truss on rocker bearing

Erection of shop-assembled bracing trusses



Two Simplified Steel Bracing Systems

by Gerhard H. Graf and
Putinas V. Masalaitis

EVERGREEN HOUSE

CENTENNIAL TOWERS

Use of a simplified steel bracing system on two similar housing projects, designed and constructed by the same team, resulted in early completion and substantial savings in construction mortgage costs.

A steel frame with joist floors was selected for both a 4-story nursing home and a 9-story home for the elderly. Both projects are subject to Zone 1 seismic design requirements and are enclosed with steel stud exterior walls. This is an economical, well-insulated system easily adaptable to a variety of veneers and finishes. Prefabricating the exterior walls permitted quick enclosure of the buildings without use of staging.

The limited extent of masonry or other rigid elements required special design considerations to resist lateral loads. With the selected wall and partition systems, the structural steel skeleton became the only reliable component available to resist and transmit lateral forces to the foundation. In addition to providing adequate strength in all directions, the framing systems were designed with enough stiffness to limit distortions to proportions that could be safely tolerated by wall and partition materials. Working with the erector and fabricators during the preparation of contract documents gave the designers additional data regarding such specific requirements as shipping limits of shop fabricated members, preference for types of connections, and a simplified erection procedure. For both buildings, beam-to-column connections projected beyond the columns, permitting easy, direct bolting without spreading the columns.

Mr. Graf, in-house structural engineer and vice-president of The Robinson Green and Beretta Corporation, Architects, and Mr. Masalaitis of A. W. Lookup, Structural Consulting Engineers, collaborated on the planning of both Evergreen House and the Centennial Towers.

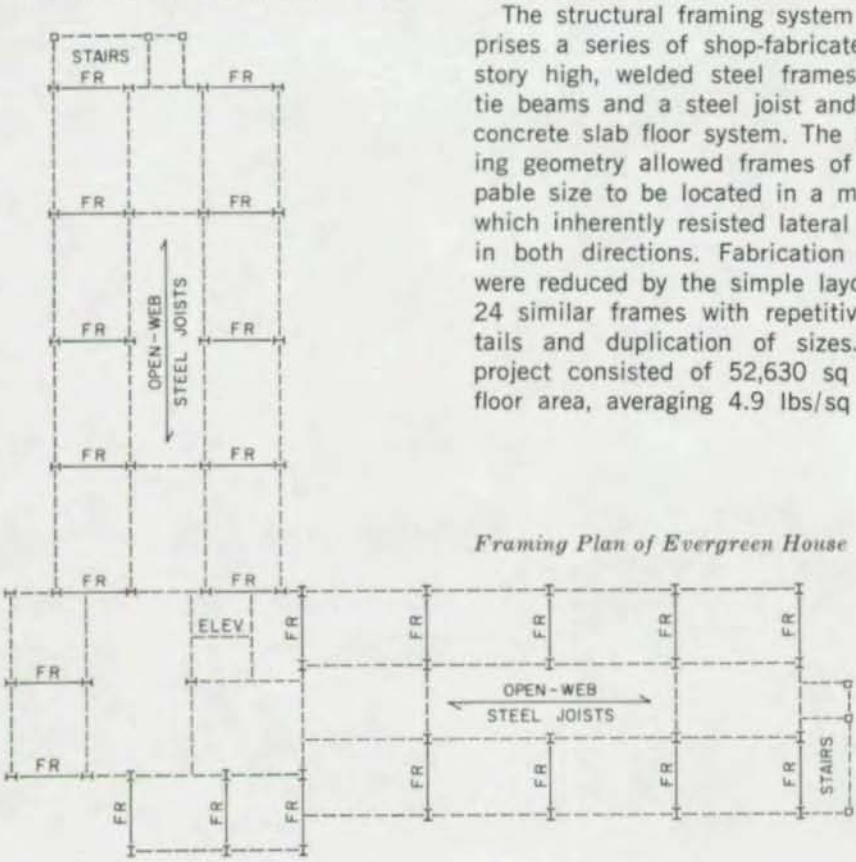
Evergreen House

Located in East Providence, R.I., Evergreen House, the 4-story nursing home, is L-shaped, with each segment measuring 165 ft x 47 ft. The ground floor contains the administrative and supporting facilities. The remaining three stories house 186 patients.

The structural framing system comprises a series of shop-fabricated, 4-story high, welded steel frames with tie beams and a steel joist and 3-in. concrete slab floor system. The building geometry allowed frames of shippable size to be located in a manner which inherently resisted lateral loads in both directions. Fabrication costs were reduced by the simple layout of 24 similar frames with repetitive details and duplication of sizes. The project consisted of 52,630 sq ft of floor area, averaging 4.9 lbs/sq ft of A36 structural steel and 1.9 lbs/sq ft of H-Series joists.

The "frame" system permitted easy compliance with the OSHA safety requirements in that the fourth floor and roof steel could be erected following the installation of the third floor deck. The full-height frames having inherent stiffness allowed the upper two levels to remain unbraced until the infill members were placed. In the strong direction, the frames were adequately stiff, thereby limiting plumbing requirements to the weak direction only.

Careful field preparation of the steel, foundations, and anchor bolts resulted in erection of all frames, columns, and two levels of steel in just 12 working hours. No frames required resetting after being set on the leveling plates and anchor bolts.



Framing Plan of Evergreen House

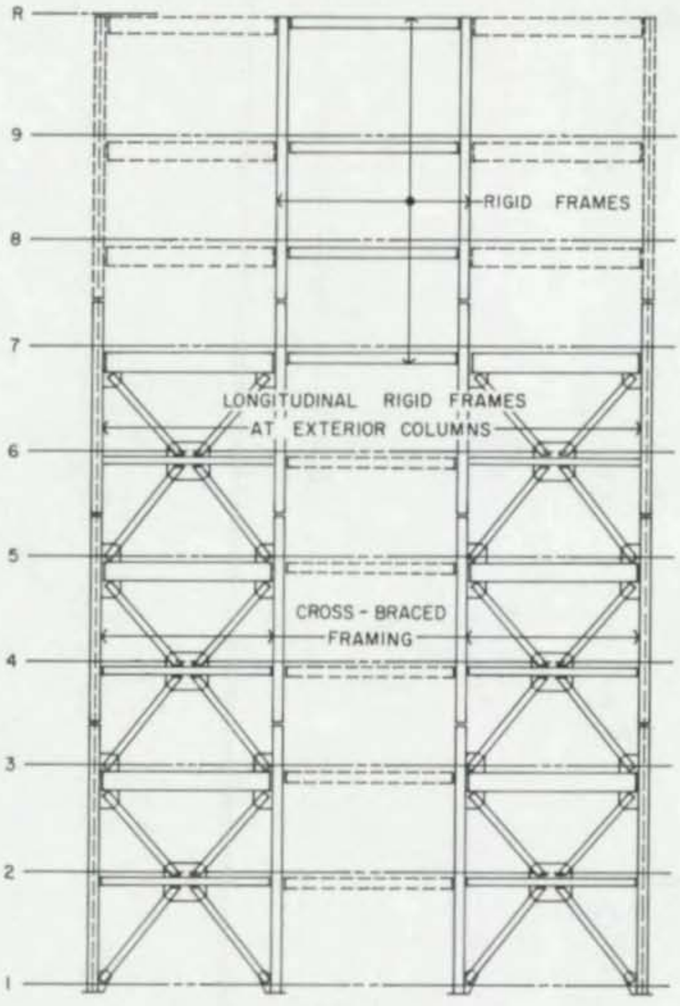
Centennial Towers

The second project, Centennial Towers, is a 9-story home for the elderly containing 101 units, located in Pawtucket, Rhode Island. The exterior, veneered with brick, stucco, and metal panels, produces a harmonious composition. Brick masonry was limited to vertical bands with a minimum of significant openings, thus eliminating the need to be supported by the steel frame.

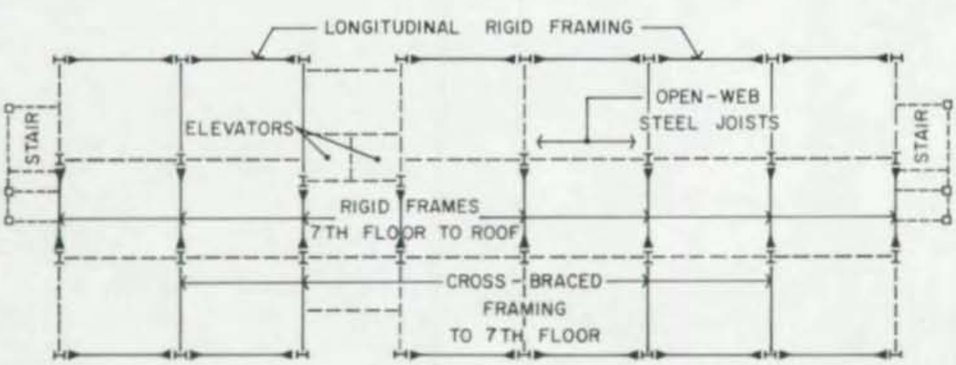
The structure consists of simple steel framing with joists and concrete slabs. Since the designers felt the frame action would be less efficient, they chose to provide lateral stability in the transverse direction by "X" bracing the outside bays up to the seventh floor. The three upper levels, however, are braced with rigid frame bents in the center bay. Consequently, the uplift forces from the bents are counteracted by the axial forces of the bracing below. In effect, the lateral loads at the base are resisted by the full width of the building. Longitudinal stability is provided by frame action between the exterior columns and the spandrel beams for the full height of the building.

The simple, repetitive architectural layout resulted in many identical bays and permitted the most effective orientation of all columns, that is, strong

CENTENNIAL TOWERS



Typical section



Typical framing plan

axis in the direction of frame action. In addition, erection was simplified, since most floor beams had at least one end connected to a column flange. The total weight of the A36 steel and H-Series joists was 8.3 lbs/sq ft.

Erection proceeded effortlessly in 2-story lifts without safety netting. Steel erection, bar joists, and metal deck were completed in approximately two months. At the end of this period, about 75 percent of the prefabricated walls were in place.

Steel Proves Economical

The use of steel on both projects enabled the designers to resolve the architectural and structural needs in an efficient, simple, and economical manner. Also, it suited the contractor's concept of construction in having the building watertight in the shortest time once steel erection began. By erecting prefabricated exterior (steel stud with sheathing) walls, in conjunction with the steel frame, crane costs were reduced and all interior trades could commence work. By completing these projects at least two months ahead of schedule, the contractor realized substantial savings on construction interest money.

Evergreen House

Architect:
The Robinson Green Beretta Corporation
Providence, R. I.

Structural Engineer:
A. W. Lookup Company
Philadelphia, Pa.

General Contractor:
Forcier Industries, Inc.
Coventry, R. I.

Steel Fabricator:
Providence Steel and Iron Company, Inc.
Providence, R. I.

Centennial Towers

Architect:
The Robinson Green Beretta Corporation
Providence, R. I.

Structural Engineer:
A. W. Lookup Company
Philadelphia, Pa.

General Contractor:
Forcier Industries, Inc.
Coventry, R. I.

Steel Fabricator:
American Welding, Inc.
West Greenwich, R. I.

CENTER of the CITY

The downtown area of Columbus, Ind., has a small-scale urban fabric and a 19th Century architectural heritage. Its core consists primarily of four commercial blocks on Washington Street. At the southern end of Washington is the County Courthouse, one of the most beautiful buildings in the city. It is an 1870's structure in red brick with limestone trim and a tall clock tower. The Commons and Courthouse Center, which combine a modern retail complex and a large public hall, stands across the street from the Courthouse itself.

Washington Street also is lined with the beautiful facades of old two-story Victorian buildings, the second story in brick with cast-iron cornices and lintels, with storefronts below. Many of the facades have been restored and repainted with a new overall color scheme.

It is difficult to fit such a large new element as this project into a small-scale fabric without doing great harm to the fabric itself. It required a careful weaving of particular responses to two kinds of situations: (1) function of the shopping center and public hall as they relate to the functions of the city, and (2) scale and aesthetics as they relate to the diverse conditions of the surroundings.

On all sides the building is scaled to match the predominant height and proportion of the surrounding structures. The main exterior material is glass, tinted brown when transparent; when opaque (as spandrel glass), it is brown-red, exactly matching the color of the adjacent post office building. The wall is a membrane, independent from the structure, enclosing or wrapping a volume of space.

The 40,000 sq ft enclosed public hall, which acts as a hinge between the one-story, air-conditioned shopping center and the sidewalks of the city's downtown, was designed to be a place where everybody in the city gravitates. It was specifically designed as a center of community activity and functions as a modern American equivalent of the Italian piazza.

Steel Construction

Structural steel was chosen because it offered strength and economies. It was also important aesthetically and intellectually — aesthetically, because the complexity and linear quality of the trusses exposed on the ceiling of the public hall were important to the design of the space; intellectually, because steel, like the glass skin of the building, is an industrial product assembled on the job.

Roof construction of the shopping center consists of vermiculite insulating concrete fill over high-strength galvanized metal decking, supported by light rolled-beam purlins. These in turn are carried by continuous light steel

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CENTER of the CITY continued

girders and columns. Lateral force rigidity is provided by continuity connections of the continuous girders and columns and by double-angle knee braces in the opposite direction.

The main framing of the longitudinal skylight is of rolled steel sections and tubes. The secondary framing consists of aluminum extrusions that support the glass.

Roof framing of the public hall is similar to the shopping center, with the exception that the main steel framing consists of primary and secondary steel trusses which form a rigid space frame in both the north and south directions.

A 45½-ft-high curtain wall, located at the front of Washington Street, is framed with steel tubing. The vertical mullions are 2½ in. x 5 in. rectangular tubes. In order to keep the size of the mullions to a minimum, the framing is hung from the roof and braced back to the main roof framing members. Considerable care was given to detailing fabrication and field connection work, in order to maintain close tolerances of flatness, plumbness, levelness, and in-plane trueness. This maintains the uniform appearance of the large surface of solar bronze glass which forms the facade.

The public hall allows multiple activities, specific and undifferentiated events, such as, dances and benefits, a stage for lectures, shows, concerts, exhibition platforms, conference rooms, central information, cafeteria, and twin movie houses. As part of the public hall, there is a large air-conditioned playground with play opportunities for children of all ages.

The focal point of the public hall is Chaos No. 1, a sculpture by the internationally renowned artist Jean Tinguely. Chaos No. 1 is a huge machine with wheels and gears, a large augur-bit, and racing metal spheres, all of which move at varying speeds. The entire sculpture slowly rotates on its massive base of steel.

A Sears Department Store anchors the retail mall, which contains over 113,000 sq ft of space and 25 specialty shops.

The shopping mall is covered by a 15-ft-wide skylight with sloping glass on the north side and a solid wall on the south, faced with mirrors in the interior. The mirrored wall above eye level doubles the skylight into an apparent 30-ft opening and opens the entire shopping street to the sky.

Architect-Engineer:
Gruen Associates
Los Angeles, Calif.

General Contractor:
F. A. Wilhelm Construction
Indianapolis, Ind.