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MODERN STEEL CONSTRUCTION

NUMBER 4 • 1987

THIS ISSUE

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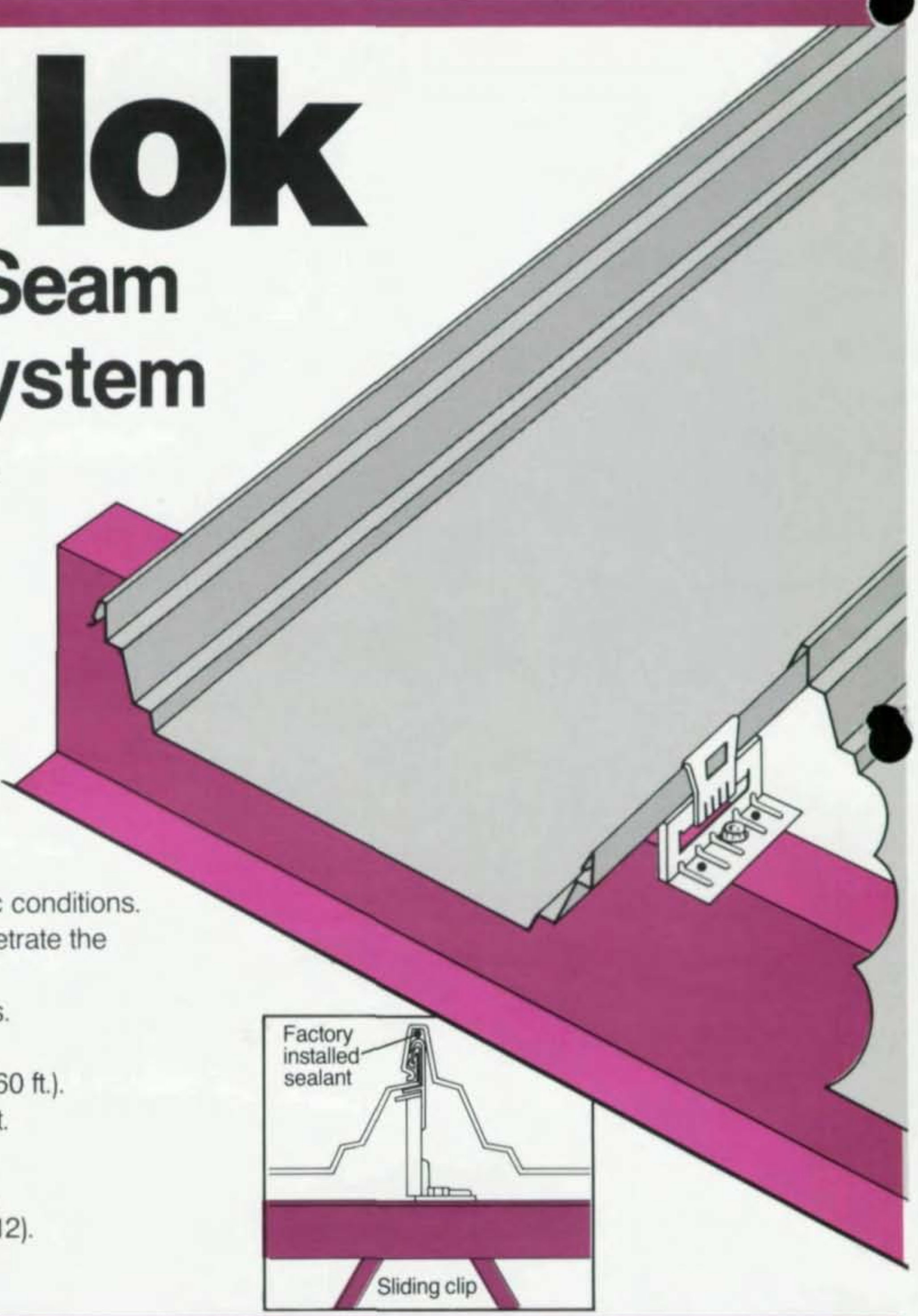

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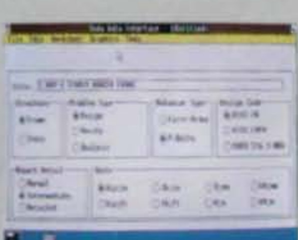

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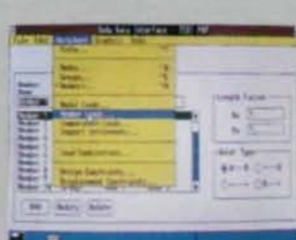

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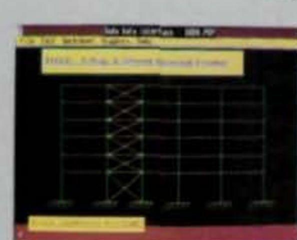

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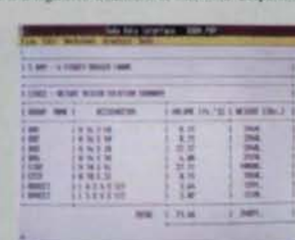

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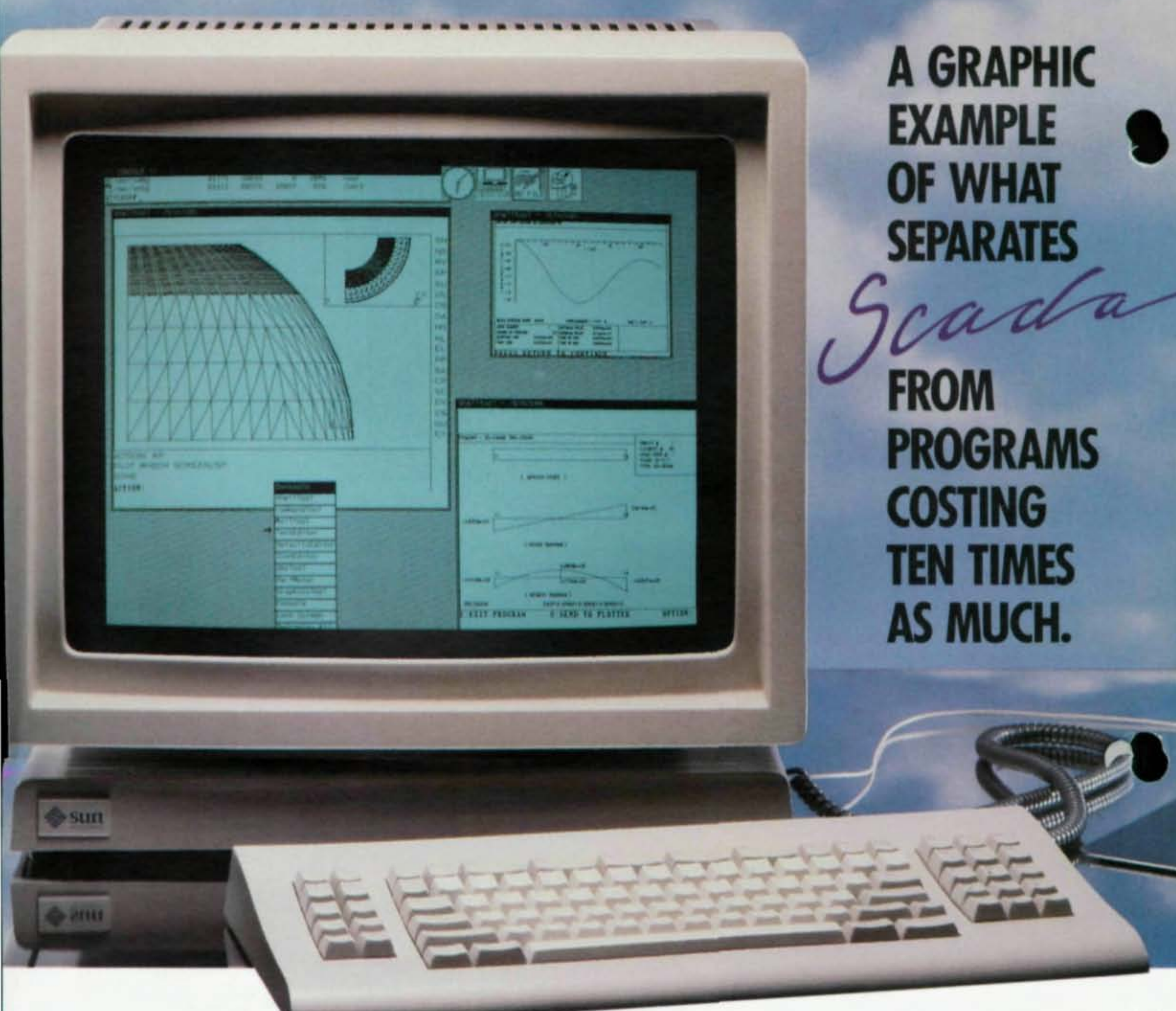

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MODERN STEEL CONSTRUCTION

VOLUME XXVII • NUMBER 4
JULY-AUGUST 1987

American Institute of Steel Construction, Inc.

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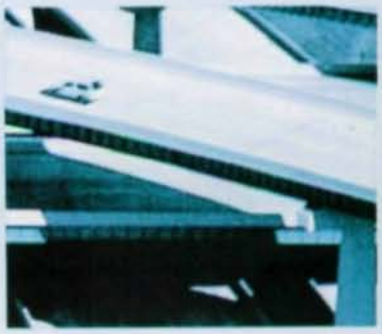
ON OUR COVER:
Georgia Botanical Garden Visitor's Center, Athens, Georgia



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STAPLETON INTERNATIONAL AIRPORT

Raising the Roof—with People Below!

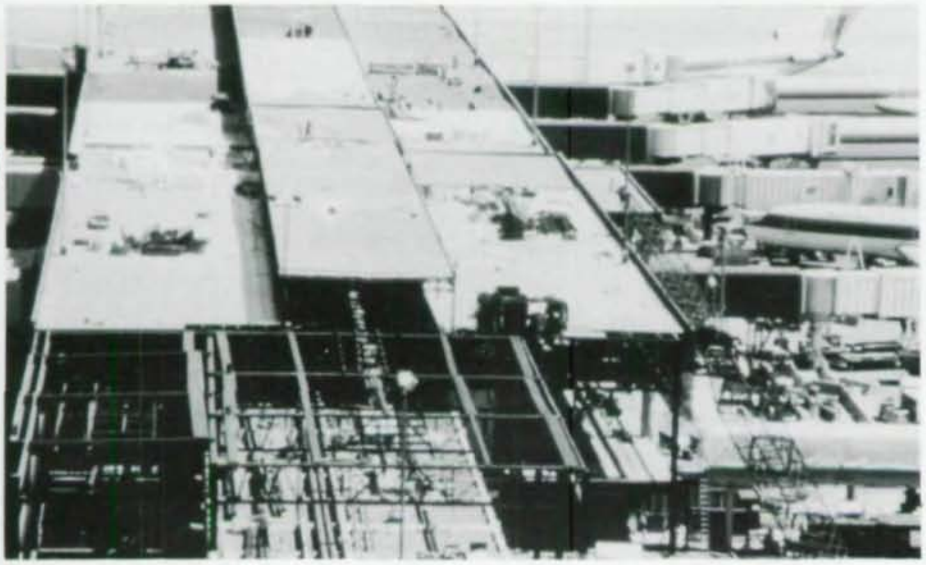
by Richard Weingardt

Finished photography by Ed Leland

To raise the roof, lengthen and widen the busiest concourse in the fifth busiest airport in the U.S., without disrupting aircraft activities or endangering 30,000 daily travelers, demanded precision design and construction coordination. Significant alterations to existing facilities were required to stay in budget and on an 18-month construction schedule and still maintain full operation of an airline.

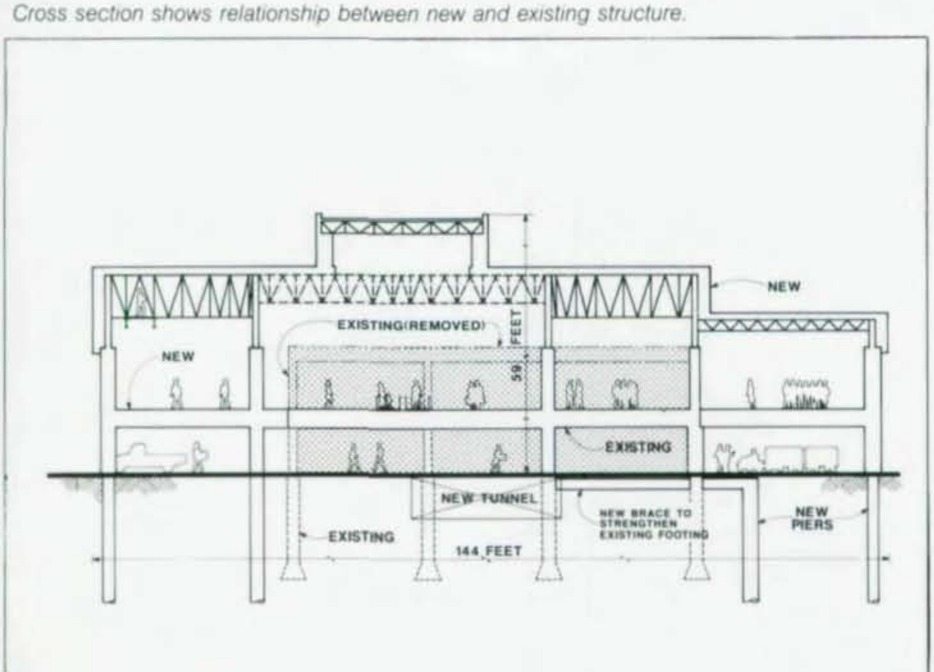
When United Airlines decided to remodel and expand Concourse B at Denver's Stapleton International Airport, they wanted a dramatic, image-conscious, yet cost-effective design. Despite plans to build a new $3-billion airport in Denver in the near future, United Airlines wanted a high quality solution—built to last, with low maintenance. Design of the new concourse was approached not as a temporary solution, but as a prototype for the quality to be expected in the proposed new airport.

Design and scheduling were the keys necessary to successfully meet the objectives for continuous operation, minimum passenger disruption and maximum passenger safety. The normal approach—first completing new construction and then demolishing the existing structure—would not work. The existing building was envel-



New steel-framed roof structure and roofing systems span entire concourse, creating attic space (below) to house mechanical/electrical systems.

Cross section shows relationship between new and existing structure.



oped with the new, utilizing the existing structure as the work platform and scaffolding for construction of the new concourse. The existing also served as the protected enclosure for passengers during construction.

Concourse B was widened to 112 ft and lengthened to 1,200 ft, with the roof raised to 49 ft above ramp level. A new VIP lounge area, the Red Carpet Room, was added to the terminal end of the 179,000 sq. ft facility.

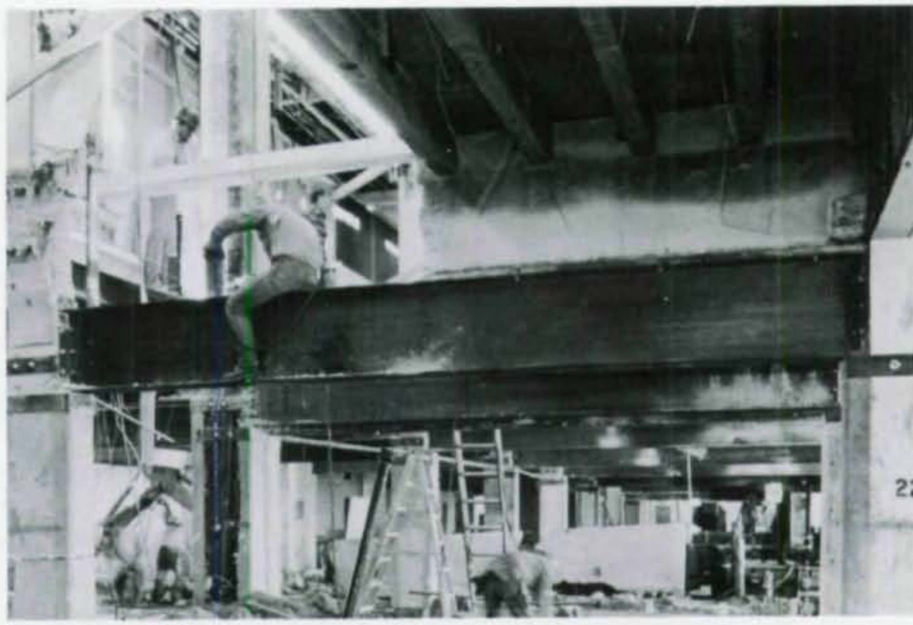
Structural Steel Envelope Economical

The new structural system was engineered so the existing building could remain intact while new construction stayed on schedule. Fast-track, phased construction techniques were necessary to tie new improvements into the spaghetti-like network of old construction in the existing buildings. In addition to the complexities of building an entirely new structure around the integral with an existing one, pedestrian circulation required a column-free 52-ft wide corridor. All existing interior columns supporting the roof had to be removed along the entire 1,200-ft length of the concourse while the facility stayed in full operation. And, the existing structure and foundation needed to be extensively modified because they could not support new loads and did not meet current codes.

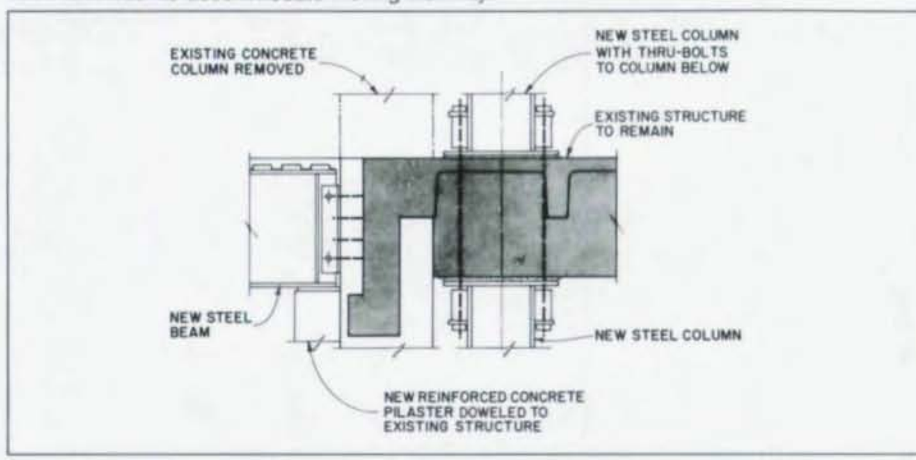
The existing, two-story framing is almost entirely concrete rigid frames supported by shallow foundations, originally built in the 1950's and added onto many times in ensuing years. Some steel columns were added in various phases between 1955 and 1966. After much investigation into viable alternative framing systems for the new building, structural steel was selected for the superstructure. Steel was chosen because it was faster to erect and because of its light weight. Also, it proved to be more economical and flexible.

The new roof was designed to completely span the existing concourse. Structural design used an independent series of steel rigid frames. Part of the new roof frame is supported on the existing concrete columns, while the steel frame that extends beyond the older structure is supported on deep-drilled piers anchored in bedrock. Every other existing column was strengthened and used to support the new roof frame on one side. The moment-resistive frame supports both gravity and lateral loads.

New drilled piers were placed along one side of the existing ones as the structure was widened. Below ground and beyond the perimeter of the concourse supplemental drilled piers were installed and poured integrally with concrete beams to form concealed sub-surface rigid frames to strengthen existing footings for the new, heavier loads. To brace existing below the floor columns and piers during excavation for foundations, a temporary steel-beam system proved economical. Beams were



New permanent steel beam supports existing concrete beam and floor to accommodate moving walkway.



New steel beam under existing floor permits removal of old structure to recess moving walkway.

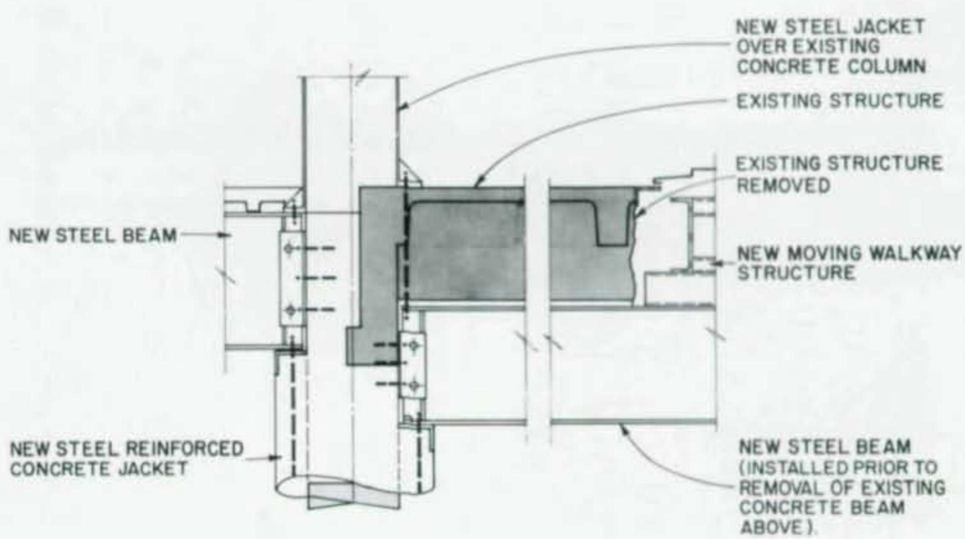
reused in the superstructure as framing for the new moving-walks.

The old columns were strengthened by either using steel plate jackets or round concrete shapes. Existing concrete columns were completely wrapped by steel jackets or were encased compositely in concrete for added strength. Existing steel columns were strengthened by welding steel plates to existing wide-flange shapes.

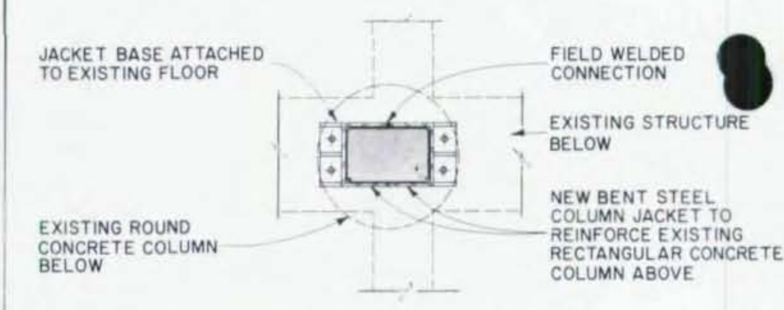
Installation of new moving-walks required existing concrete beams be notched their full depth. A new steel floor girder system, fitting underneath concrete beams within the existing headroom below was installed prior to notching to permit construction without disruption to traffic.

Steel Pre-ordered from Mills

Structural steel was pre-ordered from mills while structural drawings were in the early stages—1,600 tons of structural steel and 600 tons of joists. An extensive ceiling catwalk system, almost another full level of space, has 480 tons of structural steel. The largest column in the main structural roof frame, which spans the entire width of the concourse and is a moment-resistive rigid frame in both directions, is a W14 x 283.



Detail of new steel beam installation



Old concrete column (l.) was strengthened by pouring concrete and compositing with existing to form new column. Detail of column strengthened by new steel jacket (above).

Six-foot deep joist girders span 55 ft between the frames, while regular joists span the joist girders.

The steel bid package was included with the drilled-pier foundation package in August 1985, with bulk structural steel purchased from two mills. The first structural steel erection at Stapleton began Jan. 6, 1986. Design work continued through construction and final structural drawings for steel were completed in February 1986. Final erection of the major structural steel and structure was completed in June.

Temporary steel beam system to brace columns during excavation proved economical. Beams were re-used to frame new walkways.

New Structure Wraps Existing Building

Passengers were unaware of structural construction occurring under, above and around the existing concourse. Nearly 2,700 tons of custom-fabricated steel, requiring tight tolerances to fit the existing structure, were installed basically undetected by the public. Demolition of unnecessary existing members occurred only after the new structural envelope was completed and sealed.

Layout areas were designated along the existing concourse so that miscellaneous framework could be assembled during night shifts and erected during the day. The steel for the main frames, however, had to be lifted into place across the in-use concourse within narrow construction limits established by aircraft parking criteria at night time.

The contractor commenced construction at the runway (field) end of the concourse with 9,000 sq. ft of new construction and proceeded toward the terminal on a carefully coordinated schedule. All personnel and all materials had to be met at guarded gates, then escorted to the construction area to maximize security.

Ramp work and steel erection proceeded toward the terminal in a carefully-coordinated schedule. Ramp replacement involved changing fuel lines, underground tanks, and electrical and communication lines. The CPM program used for coordination of critical dates with the client, was integrated with the detailed design-build, phase construction schedule. The contractor employed a full-time coordinator to interface with the airline's operations. Continuous interaction between members of the design and construction team was necessary since construction was proceeding at the same time as final design and working drawings.

All construction work was scheduled by CPM, with a special chart updated monthly to show graphically where construction was, what was yet to be done and what had been turned over to the airline. As construction proceeded around the existing concourse, temporary covered walkways and stairs were installed to provide

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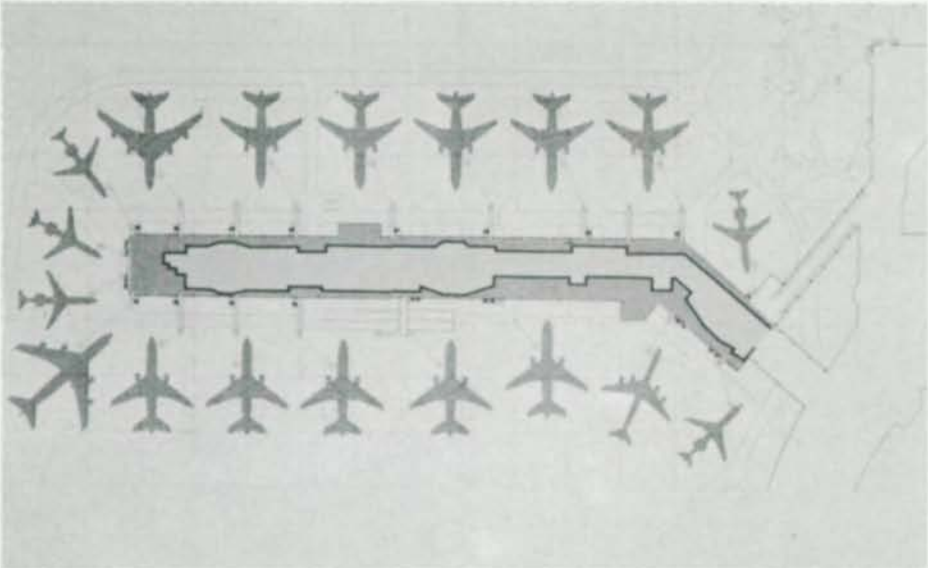
Existing structure was enveloped (above) by the new, using existing structure as work platform to construct new concourse and protect passengers. Enlarged concourse (l.) created by constructing steel superstructure around existing building.



Twenty-two gate concourse was made longer, wider and higher—without interrupting service.

passenger access to the aircraft once the jetways and appendages were removed. The maximum number of gates that had to be ground-loaded at any one time was held to nine. Most of the time, only four were ground-loading at a given time.

After construction was completed in the new holding areas, located in the 30-ft addition along the length of the concourse, they were put into service while demolition of the existing areas took place. Temporary covered walkways were installed to provide passenger access through the demolition area. Following completion of the new side of the concourse and the pedestrian corridor, construction was completed on the old part of the concourse. Because all finish work in the new concourse was completed out of sight of United's passengers and employees, demolition of the existing concourse, which occurred at night, allowed a dramatic revelation of the new completed sections at daybreak.

In addition to erecting the structural steel and other operations at night, the contractor employed people full-time as wingtip-watchers in areas of intense construction to prevent any damage to aircrafts.

The contractor stated construction of the concourse was like building a 1,200 ft high high rise laying on its side, finishing it from the top down.

Aesthetics and Architecture Achieved

The architects designed interiors to simulate the shape of the spaces in an aircraft. The entire row of columns down the center of the existing concourse was removed to create a spacious, 52-ft wide pedestrian corridor. To further open up the space, alternating existing columns on each side of the concourse were also removed.

A new roof system the entire width of the concourse created an attic space to house all mechanical/electrical systems. This eliminated visual rooftop obstructions caused by the protrusion of mechanical/electrical units, minimizing the potential for roof leaks and providing easy access for maintenance. An extensive catwalk system runs the full 1,200 ft of the concourse.

The final 16-ft ceiling height, from the pedestrian corridor floor to the ceiling, was enhanced by large clerestory windows to introduce natural light and minimize the glare of direct sunlight. Colorado has over 300 days of sunlight annually, so the clerestory windows result in increased energy efficiency by reducing the need for artificial illumination. The curved ceiling shape diffuses light, producing a soothing effect of

New United Airline's Concourse B is Grand Award winner in Consulting Engineers Council of Colorado 1987 Engineering Awards competition. Concourse now can handle 10 million passengers annually. Fast-tracking saved one year of design/construction time. Concourse was completed in 14 months, four ahead of schedule.

soft light in the pedestrian corridor. The indirect lighting used on the corridor duplicates the natural light.

Upper-level walls of the concourse consist of a lightweight architectural system which enabled use of existing structural systems with only nominal modifications and strengthening. The walls are steel studs welded to the structural steel and covered with 5/8-in. gypsum sheathing and Alucobond aluminum panels. Approximately 125,000 sq. ft of brown-colored panels were used. Solar grey insulated glass is also part of the exterior walls.

A new and luxurious 21,500 sq. ft Red Carpet Room, relocated at the terminal building end of the concourse in a secured area, serves United Airline passengers from both concourses A and B. Security reentry to use the VIP room is not required.

The concourse interior was designed for rugged use. Round versus square column corners were designed to reduce damage to both walls and luggage. Durable stainless steel column covers are an integral part of the structural system. Three moving walkways provide 485 linear feet of mechanized movement. Because the ground radar facility is directly across the field, that end of the concourse was beveled to deflect the radar waves upward, thus reducing interference.

Spectacular new Red Carpet Club is part of remodeled concourse. Marble floors, contemporary furnishings and panoramic view of Rockies are exciting features.

Ahead of Schedule, Within Budget

Construction was completed without the loss of a single day of business. The concourse design permitted continuous operations—with only two of the twenty-two gates out of service at any one time. The design, using a structural steel superstructure, provided a practical, economical solution. New construction could be interfaced with selective demolition and renovation, saving both time and money.

Completed at a cost of $48 million, Concourse B is one of the largest remodeling projects ever undertaken in Denver. Morgan Douglass of United Airlines stated, "We are highly pleased with the architect's and engineer's design concept which enabled this extremely difficult project to be constructed with a minimum of inconvenience to the public and disruption to our Denver operations. This passenger concourse contains the latest in state-of-the-art technology associated with the movement of passengers, display of flight information and service amenities necessary to operate a large hub airport in the 1990's. This new technology is contained with a highly aesthetic environment. . ."

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Seracuse Lawler and Partners/
Roybal and Associates (joint venture)
Denver, Colorado

Structural Engineer
Richard Weingardt Consultants, Inc.
Denver, Colorado

General Contractor
Hensel Phelps/Alvarado (joint venture)
Greeley, Colorado

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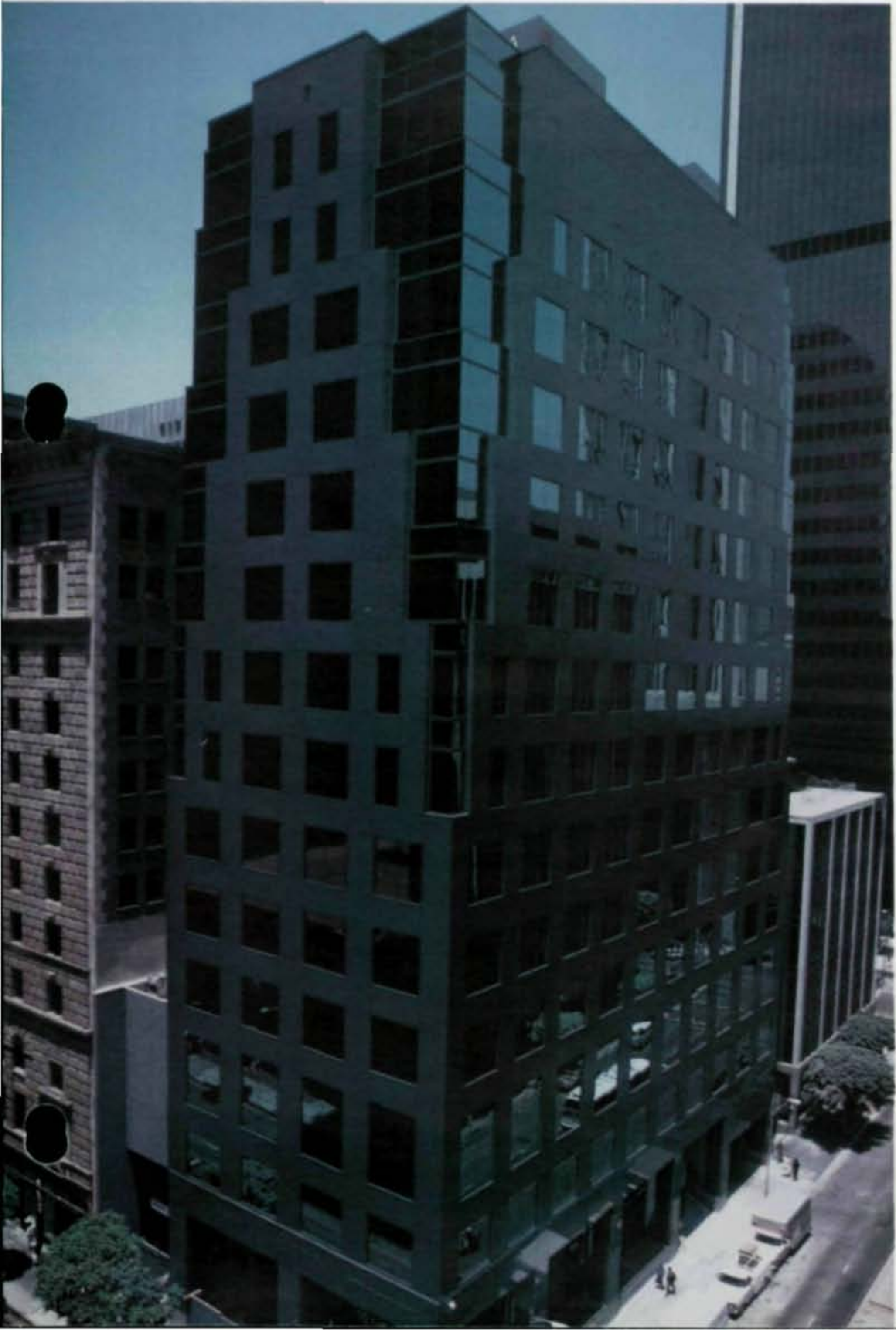
Richard Weingardt, *P.E., is president of Richard Weingardt Consultants, Inc., a structural engineering firm in Denver, Colorado.*

Remodeling with Steel

655 SOUTH HOPE

New Breath for an Old Site

by Pam Palmer and Gene Watanabe



The 655 South Hope Building, on a prime downtown Los Angeles site, posed an unprecedented renovation challenge. The building was originally designed in 1963 as an 18-story structure for Republic Federal Savings and Loan. But when an athletic club dropped its plans to house new facilities in the building, only eight floors were built.

In the next two decades, downtown Los Angeles grew up around this key site, now overshawdowed by towering high rises of the city's new financial district and at the center of a downtown construction boom. When a property corporation acquired the building in 1985, it commissioned the Gensler and Associates to redesign this nondescript building and add nine new floors atop the original structure—nearly doubling its size. The existing steel frame, three levels of above-ground parking and basic building systems were to be preserved.

Create a Breathing Space

The new design for the 655 South Hope Building transformed the structure's drab appearance with an elegant stepped facade. Corners were notched to give the building a receding crown which recalls the spirit of such traditional buildings as the Chrysler Building and the Los Angeles City Hall. The inward slant at the top creates "breathing" space between the building and its neighbors, anchoring it in its downtown canyon. The setbacks also reduced the floor space of higher floors to meet local building code regulations restricting the total square footage to 100,000 sq. ft. A major renovation requiring addition of new floors on top of an existing structure was a first for Los Angeles. Initial studies conducted by the structural engineer for the project showed that 17 stories would be the maximum possible under new seismic and building code regulations.

Since the foundation was originally built

VULCRAFT EXPERIENCE SIMP

5-foot spacing between Vulcraft joists permits easy installation and maintenance of heat pump units.

As the only national company in the United States that designs and manufactures joists, joist girders *and* steel deck, Vulcraft works with the relationships between joists and deck every day. So, they have a depth of experience that can often simplify many seemingly complex problems.

The Woodfield at the Crossing office complex in Indianapolis, Indiana is a good example. The open web configuration of the steel joists was ideal for the use of suspended, energy efficient heat pumps. But, the 3′ spacing between joists which is needed to support standard floor deck was not adequate for the installation and maintenance of the heat pumps. So, 5′ spacings were initially specified wherever the heat pump units would be installed. However, varying the joist spacings would make construction complicated, time consuming and expensive. This is where Vulcraft was able to help.

LIFIED A COMPLEX PROBLEM.

The Woodfield at The Crossing office complex in Indianapolis used 216 tons of Vulcraft joists and 169,000 sq. ft. of Vulcraft steel deck.

After reviewing the specifications and discussing the job with those involved, Vulcraft engineers came up with an idea that reduced the number of joists needed, sped up erection time, and stayed within budget. Drawing on their extensive application experience, Vulcraft recommended changing the joist size from the original "H" series to the "LH" series in order to provide a uniform 5′ spacing throughout the job. In addition, Vulcraft proposed using 2″ composite deck instead of standard 9/16″ form deck. Thus, a deeper slab was created without using any more concrete and transitory vibration was reduced.

By taking advantage of Vulcraft's experience as well as their products, construction of the Woodfield office complex was greatly simplified. In addition, Vulcraft's recommendations added greater value and flexibility to the overall design.

For more information about Vulcraft steel joists, joist girders and steel deck, or for copies of our joist and steel deck catalogs, contact the nearest Vulcraft plant listed below. Or see Sweet's 05100/VUL and 05300/VUL.

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First for Los Angeles, a major renovation added floors to existing structure. Complex framing, plus tight site conditions, proved construction challenge.

to accommodate 18 floors, little strengthening of lower floors was needed. The first-story columns were boxed in to make them stronger. Covered steel plates were used to create the boxed column to replace the original wide-flange columns. The existing structure, based on three rows of columns per floor, was extended into the new stories to distribute the load to the ground footings. Engineering studies showed that continuous columns would be much more cost effective than to create a transfer at the ninth floor.

Complex Framing and Site

Columns for the new floors were welded with full penetration welds onto the stubs of existing columns at the roof of the old building. Because the columns could not be staggered or stepped outward to accommodate the new setback design, the steel structure was tapered on the new floors, creating a very complex framing condition with unusual structural angles. The structural design, however, provides column-free glazed corner offices on upper floors, amenities normally offered only in much larger office buildings.

An additional 300 sq. ft. was added on upper stories with special framing along the back side of the building which is concealed within the parking structure. Extending the building towards the property line and enlarging the floor size permitted much more efficient interior space planning by tenants. Grade A36 steel was used for beams and girders and A572 Gr. 50 steel was used for columns. The floor system was comprised of steel beams, metal decking and lightweight concrete flooring, with composite flooring used on the floor beams and girders.

Access to this very tight site also proved to be a construction challenge. The additional floors were added in four vertical sections with the steel frame extended up 17 floors before the next section was begun. The more than 2,000 bolts used on the building were installed carefully to prevent ends falling on pedestrians.

The building offers a striking facade with a lightweight metal skin chosen to harmonize with the dark green granite base of the first three floors. The metal panels, green reflective glass and gloss window frames were chosen to create a quiet beauty appropriate to the quality of offices in the building. Subtle changes in finishes in the monochromatic scheme provide for color and textural differentiations. The green granite, for instance, contains two different finishes in the single colorstone. The steel-faced aluminum core panels that make up the curtain wall are finished in

Duranar. The curtain wall system, designed by H.H. Robertson, required a custom application because of the facade's complex stepped geometry.

The completed building includes three floors for retail and financial services, three for parking and 11 of high quality office space. The 17th floor houses the mechanical system and penthouse. To capture an additional 3,500 sq. ft., the remaining space was designed as a penthouse office space connected to the 16th floor, providing some of the most dramatic office views in the city. The 7,500-sq. ft floors are ideal for small or mid-size companies which normally might not be able to enjoy the advantages of full-floor occupancy. The plan configuration, wider and with three sides of glass, makes possible efficient and flexible planning.

Building systems have been upgraded to meet handicapped and life-safety standards. A new elevator provides handicapped access to the lobby from the sidewalk. A future MetroRail station, with entrance from the south side of the building at ground level, has been integrated into the design.

Reconstruction of this outdated building into a sophisticated structure in tune with its downtown Los Angeles neighbors testifies to the possibilities of building renovation. A safer and more harmonious project has been developed through the revitalization process, allowing it to compete successfully with the active downtown office market. □

Architect
Gensler and Associates/Architects
Los Angeles, California

Structural Engineer
Brandow and Johnson

General Contractor
Robert E. McKee

Steel Fabricator
Central Industrial Engineering Company
Santa Fe Springs, California

Owner
Hammerson Property Corporation
Los Angeles, California

Pam Palmer is a senior associate and *Gene Watanabe* an associate with the architectural firm of Gensler and Associates, Los Angeles, California

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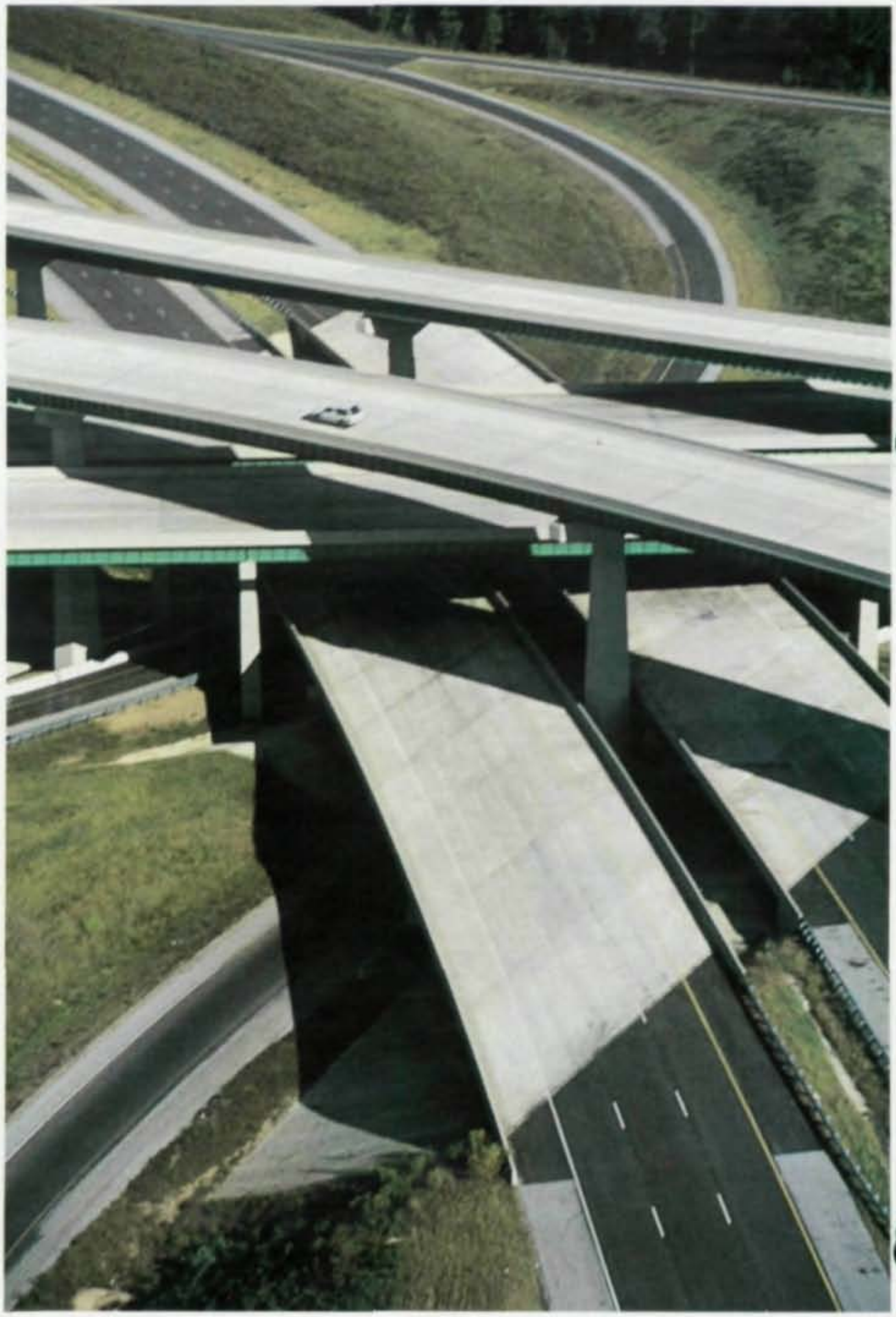
STEEL FIELDS THE CURVES ON COMPLEX INTERCHANGE

Tight geometric requirements made curved steel plate girders the most logical choice for this direct interchange between I-20 and I-459 in Jefferson County, just east of Birmingham, Ala. The combination of tight vertical clearances, minimum structural depth available for four-level stacking and curved spans of almost 200 ft practically eliminated consideration of alternative structures.

Basically, the interchange has six ramps at grade and six bridge structures:

- **Bridge No. 1 EBL:** I-20 EBL over Ramps 124 and 126; overall length 541 ft; spans 120.5 ft-150 ft-150 ft-120.5 ft continuous; 1°30-ft curve; approximately 45° skew, 56-ft roadway; web plate ⅜ in. x 54 in.
- **Bridge No. 1 WBL:** I-20 WBL over Ramps 124 and 126; overall length 541 ft; spans 120.5 ft-150 ft-150 ft-120.5 ft continuous; 1°30-ft curve; approximately 45° skew; 56-ft roadway; web plate ⅜ in. x 54 in.
- **Bridge No. 2 NBL:** I-459 NBL over I-20 EBL & EBL; overall length 815 ft; spans 141 ft-141 ft continuous, 120 ft-170 ft-120 ft continuous, 123-ft simple span; tangent alignment; 56-ft roadway; web plate ⅜ in. x 56 in.
- **Bridge No. 2 SBL:** I-459 SBL over I-20 EBL & WBL; overall length 807 ft; spans 127 ft simple span, 120 ft-170 ft-120 ft continuous, 135 ft-135 ft continuous; tangent alignment; 56-ft roadway; web plate ⅜ in. x 56 in.
- **Bridge No. 3:** Ramp 121 over I-459 NBL & SBL; overall length 1,065 ft; spans 131 ft-131 ft continuous, 166 ft-194 ft-166 ft continuous, 138.5 ft-138.5 ft continuous; 3°31-ft curve; 39 ft-3 in. roadway; web plate ⅜ in. x 60 in.
- **Bridge No. 4:** Ramp 123 over I-459 NBL & SBL; overall length 895 ft; spans 127 ft-127 ft continuous, 145 ft-182 ft-182 ft-132 ft continuous; 5°07-ft curve; 39 ft-3 in. roadway; web plate ⅜ in. x 60 in.



Lighter Sections Not Adequate

ASTM A36 steel was chosen for this interchange since lighter sections would not have been adequate for deflection requirements of L/1000 for curved girders of the required depth and span. Stress ranges were also reduced by using heavier sections. Total structural steel superstructure weight is about 5,113 tons. This interchange was designed in the late 1970s, but bids for the bridges were not taken until January, 1982. Bidding was very close, with the low bid about 14% below the engineer's estimate.

For horizontal clearance requirements and for aesthetics, all structures were designed with hammerhead piers on rock footings, with the exception of the dual I-20 bridges, where the extreme skew resulted in cap lengths ranging up to 85 ft. Massive rectangular, three-column framed bents were employed for these bridges to be more compatible with the heavy single shaft piers used for the higher levels. Because of excessive blasting during construction, some footings had to be redesigned as pile footings with short piles extending to sound rock. For the top level bridges, the hammerhead piers range up to about 96 ft from top of cap to bottom of footing. Pier shafts are 8 ft x 4 ft at bottom of cap and are battered ½ in. per ft (each face) normal to the roadway and ¼ in. per foot (each face) parallel to the roadway. Pier shafts for the 56-ft roadway I-459 bridges are 12 ft x 4 ft at bottom of cap, with battered faces as noted above for the higher bridges. Pier caps for the I-459 bridges have cantilever lengths of 22 ft-3 in. and are about 11 ft deep at the pier shaft with up to four rows of reinforcement in tops of caps.

An interesting and somewhat unusual design problem occurred at each of the top level bridges (Ramps 121 and 123) where practical span lengths required piers to be placed in the I-459 median width of 20 ft curb to curb. Vertical clearance provided is not enough to permit conventional pier caps extending over the I-459 roadways. At these locations, special steel girder pier caps are required. Pier caps were fabricated integrally with the longitudinal girders. Webs of the five longitudinal girders were cut for penetration by the pier cap girder, maintaining continuity of all flanges. Beveled fill plates were shop-fitted and welded between longitudinal girder flanges and pier cap girder flanges. Two field splices were provided in each pier cap girder. This permitted field sections of a pier cap girder section and two longitudinal girders (one girder for center section) extending to the longitudinal girder field splice locations in each adjacent span, with all diaphragms and lateral bracing connected. Temporary diaphragms were provided adjacent to field splices. Stress ranges were held to Category E allowables and special attention was given to grinding smooth radial transitions at the longitudinal girder flange to web-weld terminations at the penetrations for the pier cap girder. Heavy, fitted four-angle bolted connections were employed for web connections at these points. The pier cap girders are supported by two fixed rockers on 18-ft centers, which are supported by stub pier cap cantilevers which do not extend over the I-459 roadways.

Painted in Alabama Highway's green and supported on massive, graceful high piers, these curved steel girders blend harmoniously with the natural green and rock-colored setting to create an aesthetically pleasing interchange. □

Designer
David Volkert & Associates
Mobile, Alabama

General Contractor
R.R. Dawson Bridge Co.
Bessemer, Alabama

Steel Fabricator
Gamble's, Inc.
Montgomery, Alabama

Owner
Alabama Highway Department

STRUCTURAL DESIGN CONSIDERATIONS FOR STAMPING FACILITIES

by Henry L. Ritter

Stamping facilities historically have involved heavy steel construction with high, wide crane bays and floor areas designed to carry presses, die storage and material-handling vehicles. Today's modern stamping facilities often have larger, more sophisticated presses and a vast array of automatic material-handling systems to convey and store the product during its evolution from a coil of steel or flat sheet to a finished stamping.

Much of this feature focuses on the press line, particularly the automotive press line and the building systems at or below the floor line where structural steel, reinforced concrete and sometimes wood all play a role. The structural material used in the superstructure is almost exclusively steel. Steel columns support steel crane girders, equipment and control platforms and long-span roof systems with steel trusses, purlins and the like.

Another area where structural steel has no equal is for high-density storage rack structures. More and more use is being made of automatic storage and retrieval systems in stamping plants. In such systems, a computer-controlled stacker crane loads and unloads storage rack cubicles containing coils, small dies, blank sheets or stamped parts, from rack structures which may exceed 100 ft in height.

The heart of a stamping facility is the press line where the part starts as a flat sheet of steel and progresses through a series of stampings which form and trim it to a desired configuration. A press line may consist of a series of individual presses—perhaps five, six or seven, depending on the complexities of the part to be made, or as few as one or two presses if a transfer press is used. A transfer press, which automatically moves the stamping through a series of punching stations within one bed of the press, may have one or more beds.

Building bay with large transfer press (above). Below, two operating press lines were installed within one wide building bay.

Modern press lines employ a large degree of automation whether they are made up of individual presses or involve a transfer press. Conveyors and other transfer devices automatically move the stamping through the presses; die changes, which used to take hours, are now made in minutes with motor-driven bolster carriages that move in and out of the press beds on rails perpendicular to the flow of the stampings. The presses are programmed and controlled by vast arrays of panels and wiring.

Parallel Flow More Conventional

Press lines can be laid out so the product flow is either parallel or perpendicular to the length of the bay. It is more conventional to have the product flow parallel to the length of the bay. In this arrangement, one overhead crane can service the entire press line and also move dies to and from the press bolster carriages and store the dies on floor areas in the same bay. The bay must be wide enough to permit the crane to load and unload the dies from the bolster carriages free of the press and any control panels or other equipment located on the floor or, more typically, on elevated platforms near or on column lines. For larger transfer presses, this can mean bay widths up to 100 feet if a longitudinal aisle is included.

The length of a bay is a function of the space requirements of the press line(s) plus any die storage area requirements. In some cases, the length of a bay may be extended to include provisions for steel receiving, storage and possible blanker press operations. Blanker presses are used when the steel is received in coil form. A blanker line operation will uncoil the steel and cut the roll into flat rectangular or trapezoidal shapes. In larger facilities, steel receiving, steel storage and blanker operations are often contained in a separate crane bay.

Die changes in large presses are often made with the aid of top running overhead or gantry cranes. When full bay coverage overhead cranes are used, the bridge of the crane and hook must clear the presses. This results in heights from first floor to underside of roof structure of 45, 50 or even 55 ft. Large presses have large heavy dies. Overhead cranes sized to carry dies in older stamping facilities would typically have a capacity around 30 tons. Today, 50 to 80-ton capacity cranes are not unusual. While the overall size and height of the press bay are determined by layout and operational requirements, the structural engineer has some interesting design decisions to make especially with regard to the longitudinal elevations of the bay.

Interesting Design Decisions

Depending on the crane capacity and resulting deflections, the steel columns can be designed as a single deep building column with brackets for the crane girders, or steel columns can be placed under the crane girders instead of brackets. In cases of multiple columns, there are an endless variety of configurations and means to connect the individual columns. A single column has the advantage in that it takes up less floor space. Although the steel weight of a single column may be more than individual columns, the fabrication costs may be less because of the fewer pieces.

Many layouts, especially those where the material flow is parallel to the length of the bay, can tolerate close column spacings on the longitudinal column lines. For example, column spacings of 20 ft are still wide enough to permit an aisle between columns. From a cost standpoint, the most economical column spacing is usually 20 to 25 ft. A full-height vertical bracing system is ideal. Diagonal bracing need only be placed in a few select bays. Even if the layout will not tolerate diagonal bracing down to the floor line, usually a minimum headroom height can be established for a strut line with diagonal cross bracing above that height. If elevated control platforms are used, the platform girders can sometimes double as a strut in the bracing system.

The space below the first floor, in addition to supporting the press, is used to

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house tanks and equipment related to the presses, sometimes electrical substations and normally a conveyor system to carry the scrap pieces from the presses directly to railroad cars or truck or first to a baling machine. Access requirements from the first floor to the space below also must be considered. The choice between individual press pits and connecting scrap tunnels versus a full basement area is often an economic decision based on construction costs. Whether individual pits or full basement, the basement or pit to first floor height for large press installations is normally from 16 to 20 ft.

Transfer presses, automated conveyors and automated bolsters are all relatively new terms, or at least new in widespread use. To put things in perspective, consider the typical press plant of 30-40 years ago. A key word in such plants, especially a car-producing plant, was flexibility. Vehicle model changes were frequent and involved major retooling and significantly different stampings. This often required moving presses to form new lines. Because of this, many facilities were constructed of tiered or layered steel press framing so the upper tiers of framing could be disassembled and moved to the new location.

Rethinking the Process

The use of transfer presses, especially large transfer presses, has generated a rethinking of the concept of flexibility. Large transfer presses weigh millions of pounds and take months to assemble. To move a large transfer press after installation is not feasible, in most situations. Thus, the generally accepted view is that the initial location of a large transfer press is its permanent location.

Presses are supported by press legs or feet. Single-bed presses have four legs, double-bed presses generally six legs, while three-bed presses generally have eight. Single-bed presses can be supported by either steel girders or concrete piers. Multi-bed transfer presses are most often supported direct by concrete piers or in some cases by girders paralleling the long axis (direction of material flow) of the press. Regardless of the method of support, deflection under each press leg must be carefully controlled and differential deflection or foundation settlement must be accounted for or avoided. This is especially important on multi-bed presses where differential deflection or settlement under a press leg could fracture a press bed.

The press bed must be installed dead level at the proper elevation with respect to the adjacent floor. Levelness is imperative to the press operation. The proper elevation is necessary to permit the bolster carriage and die to travel on level rails from within the press bed to the adjacent flooring. The top of bolster rail is normally designed to be at or slightly above the finish floor elevation. If the rails are not level throughout, the bolster movement may be impeded. If the rails are set low with respect to the adjacent floor surface, the bottom of the bolster carriage may hit the floor. To obtain the proper elevations and levelness, bearing plate surfaces are often specified to be finished in a level plane and bolster rail support beam top flanges are specified to be straightened to a tight levelness tolerance such as within $\pm 1/32$ in. of design elevation over the entire top surface.

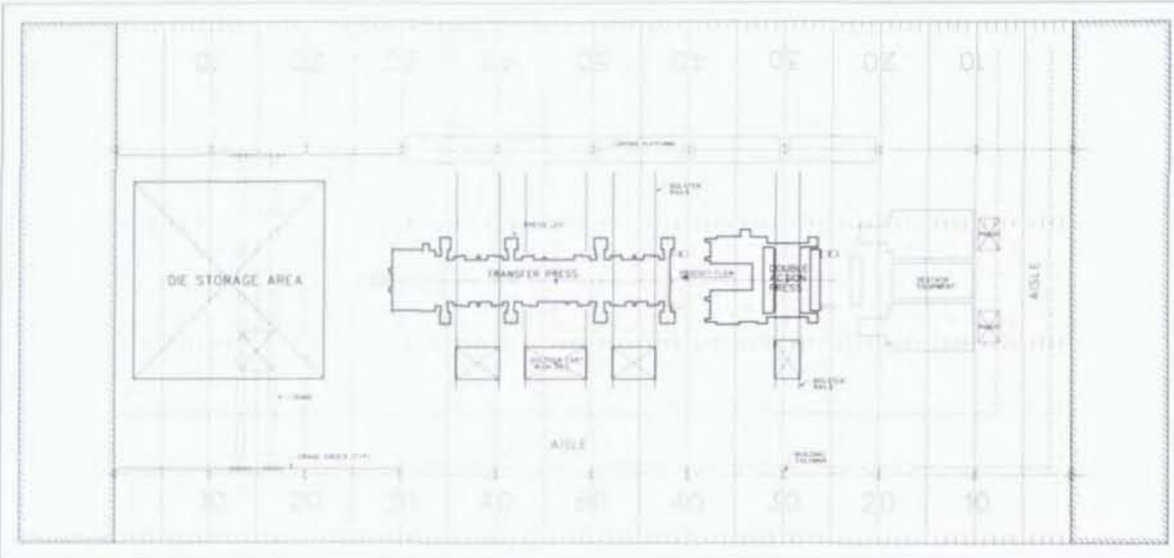
Press-bearing plates and bolster support beam elevations should be set with surveying with precision instruments handled by an experienced crew. Final setting of the press and bolster rail elevations are frequently made with the use of full bearing shim plates under the legs and bolster rails. It is also advisable to establish a permanent benchmark elevation for checking press leg elevations after installation.

Floor areas in press plants are designed for heavy loads. Die and steel coil storage can result in floor loading requirements in thousands of pounds per sq. ft. Forklift trucks, die carts and other vehicles are used widely in most plants. The effect of large concentrated wheel loads can often govern the design of floor beams, even when large uniform storage loads are included. The selection of vehicles with more and wider wheels can result in substantial savings in floor system costs.

Modular Repeat Configuration

When large presses are involved and "flexibility" for relocation is not a consideration, the floor framing in supported floor areas frequently can be laid out in modular repeat bay fashion. Spacing of the steel floor beams is normally governed by span capabilities of the floor surface—checkered plate, concrete or laminated hard wood panels, or combinations thereof. Because of the heavy loads, it is generally advisable to keep column spacings as close as the pit or basement layout will permit. Basement bay sizes of 200-400 sq. ft. of plan area are not uncommon.

The floor framing immediately adjacent to presses can be rather complicated, especially when transfer presses are involved. The irregular shape of the press, horizontal shafts, vertical shafts, inclined shafts, piping, conduits, access to the



Large transfer press line superimposed on football field.

press, scrap chutes, recessed floor areas for equipment, slots in the flooring for bolster carriage drive mechanisms, etc. are some of the items that impact the framing. Fortunately, structural steel affords the flexibility to allow members to be cut, stiffened or reinforced into an endless variety of configurations to suit conditions. Most of the framing immediately adjacent to the presses cannot be installed until the bed of the press is in place. Bolster support beams are normally supported by brackets on the press itself; press legs normally extend well beyond the bed width and require framing on or over such areas.

The logistics of shipping, rigging and assembling large transfer presses are elaborate, time-consuming and costly. Individual components such as press beds and crowns require special transportation because of large size and heavy weight. Specially fabricated trailers two traffic lanes wide with many axles for load distribution, or specially fabricated railroad cars, have been used to transport such components. Upon arrival at the site, the parts must be lifted, moved, subassembled into larger components, and then again lifted and moved into the press position and then further assembled. These operations are considerations in the building layout and design. For example, the subassembly of press parts prior to installing the bed takes floor space. If that floor space is the future die storage area in the same bay as the transfer press, the final movement is made much easier. In situations where floor space is not available within the stamping facility, lightweight, weathertight steel buildings have been erected for this purpose. Such buildings can be used for storage or other functions.

Hydraulic gantry cranes, normally four tower units, are frequently used to lift major components such as subassembled press beds. To distribute the floor load, large runner beams are used under the gantry crane rails. Some large, multi-bed transfer presses have required gantry crane capacities in the range of 1,200 tons. The assembled press weight can exceed 5 million lbs. on some of the larger transfer presses. Overhead building cranes may be useful in installing some of the lighter components.

In summary, today's stamping facilities have complex, sometimes huge presses with sophisticated material handling equipment resulting in an endless array of layout, logistical and framing considerations. The strength and versatility of structural steel make it the ideal material, adaptable to the myriad building requirements of modern stamping plants. □

Henry L. Ritter, *P.E., is a director and manager of structural and civil engineering with Albert Kahn Associates, Inc., Detroit.*

Steel Notes

THREE SCHOLARSHIP WINNERS NAMED

Kevin R. Smith, a student at the University of Washington, was awarded the $5,000 AISC/Klingelhofer Scholarship. Smith expects to receive his Bachelor of Science degree in civil engineering (structures option) in December 1988. The AISC/Klingelhofer Award was offered to undergraduates in civil or architectural engineering schools in the Pacific Northwest states of Washington, Oregon and Idaho this year. Next year, it will be available in the New England states, except Massachusetts.

Texas A & M University student Scott A. Moehlman receives the $5,000 Stupp Brothers Scholarship. Moehlman plans to obtain his Bachelor of Science degree in civil engineering (structures option) in May 1988. The Stupp Brothers Scholarship Award was available in Texas and New Mexico. In 1988, it will be offered to schools in Nevada, Arizona, Alaska and non-urban areas of California.

Anders E. Carlson of Cornell University was the winner of the $5,000 AISC/USS Scholarship. Carlson is studying structural engineering and expects to receive his Bachelor of Science degree in May 1988. The AISC/USS Scholarship was offered in Upstate New York schools. Schools in Tennessee, North and South Carolina could benefit from the scholarship next year.

All three annual scholarships were offered by the AISC Education Foundation.

AISC BANQUET TO HONOR AWARD-WINNING ARCHITECTS

Architects of 14 steel-framed buildings chosen as winners in AISC's 1987 Architectural Awards of Excellence Competition will be honored at the Seventh Annual Awards Banquet on Sept. 30 at the Westin Hotel, Chicago.

The Architectural Awards, presented biennially since their inauguration in 1960, have become the most prestigious in the construction industry. They recognize outstanding steel-framed structures of all types, many now considered benchmarks to the state-of-the-art, and landmarks in their own locales.

At the black-tie event, each winning architect receives a plaque adapted from a single-edition bronze sculpture by artist Joe Kinkel. It symbolizes the significance of steel in all Architectural Awards of Excellence and Prize Bridge Awards given by AISC.

Tickets are $95 per person; tables of eight $700 and tables of ten $850. For further information, call Lona Babbington, AISC headquarters, 312/670-5432.

STILL TIME TO SIGN UP FOR STEEL BRIDGE SYMPOSIUM

There is still time to make last-minute phone reservations for the National Symposium on Steel Bridge Construction, to be held Sept. 14 & 15, 1987 at The Shoreham Hotel, Washington, D.C. For room availability and rates, call Jim Herman, assistant director of meetings and conferences, 312/670-5431. The registration fee is $175.

The program opens with a panel discussion on "Quality Assurance/Quality Control," followed by "Use of Weathering Steel," "FHWA Region 3 Standardized Bridge Details," "NCHRP Steel Bridge Research," and "NSF Steel Bridge Research." After Monday evening's banquet, Robert E. Farris, deputy administrator of FHWA, will address attendees. "Autostress Application" will be covered on Tuesday, as well as "Bridge Fabrication—AASHTO/AWS Bridge Welding Code—Fracture Control Plans," "Material Considerations in Steel Bridge Construction," "Bridge and Structures Information Center," "Advantages of the AISC Certification Program," "Erection Considerations," "Construction of the Cable-stayed Mississippi River Bridge at Quincy, Illinois," and "How to Get the Project Built."

The symposium, co-sponsored by AISC, FHWA and AASHTO, will be beneficial to federal, state and municipal bridge, construction and materials engineers, bridge designers, consultants, fabricators, erectors, contractors, inspectors and educators. The symposium's theme is: "To create a dialogue between owners, designers and builders to enhance the economy, quality and reliability of steel bridges."

NEW YORK CITY ADOPTS AISC'S LRFD SPECIFICATIONS

The New York City Board of Standards and Appeals adopted AISC's new *Load and Resistance Factor Design Specification for Structural Steel Buildings*, on July 8, 1987, following a public hearing. The proposed building code revision, known as Reference Standard RS 10-5B, was submitted to the board by Commissioner Charles M. Smith, Jr. of New York's Dept. of Buildings.

Appearing at the hearing were I. Polsky, executive engineer, Dept. of Buildings, New York, and Daniel M. McGee, regional director of construction codes and standards, AISI. McGee prepared the text of the Reference Standards discussed at the hearing.

The revisions to the New York City building code, effective July 8, 1987, can be obtained by purchasing the Board of Standards and Appeals' Bulletin, which contains the minutes of the July 8 meeting (case calendar no. 617-87-BCR). Contact Daniel M. McGee, regional director of construction codes and standards, American Iron and Steel Institute, P.O. Box 311, Matawan, N.J. 07747; 201/583-5700.

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   c. M Shapes
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   f. Miscellaneous Channels (MC)
   g. Structural Tees cut from W, M and S shapes (WT, MT, ST)
   h. **Single & Double Angles**
   i. **Structural Tubing**
2. Explanation of the variables specified in each of the data fields.
3. Listing of a BASIC read/write program and **sample search routine.**
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ORLANDO TERMINAL

A Roof that "Floats"

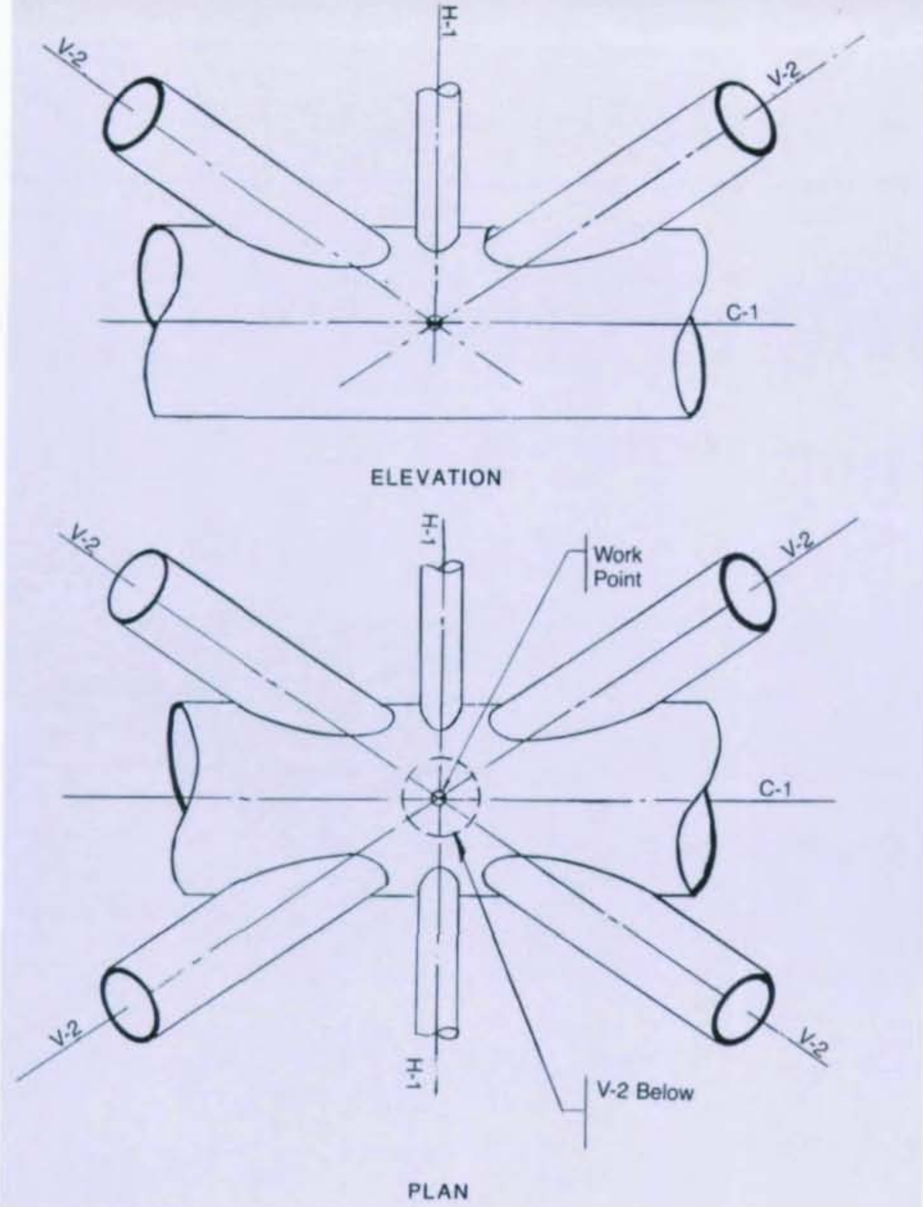
by Donald L. Moe

The new TriCounty Transit passenger terminal in Orlando, Fla. was designed to replace an aging terminal serving the Metro area. The site, in the center of downtown, was relatively small for a terminal that had to accommodate a peak capacity of 20 buses—as well as protect the public from sun and weather.

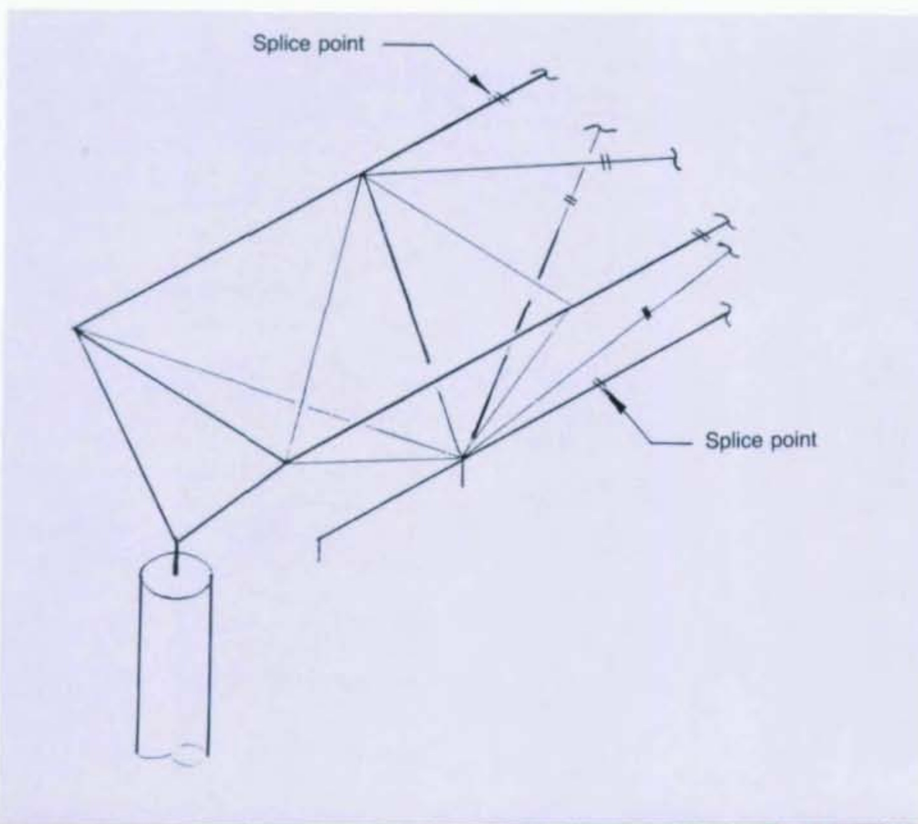
The solution proposed was a concept developed by Architects Design Group. Conceptually, the passenger terminal was to be protected by a large covered roof which, in essence, would be "column-free." The solution to this design criteria was a structural system *above* the roof area. It consists of two major steel pipe trusses spanning 208 ft and supported by columns at each end. Since the terminal is in the heart of downtown, the architect wanted to create both a functional project and a focal point for the city. The trusses align themselves parallel with one of the major interchanges through the city.

Four columns, 4 ft in dia., support the trusses. The columns frame to a 5-ft, deep-drilled caisson for foundation support. The caissons, 208 ft x 60 ft o.c., provide an open area for buses to navigate. And, they create a feeling of open space under the terminal building itself. Columns, clad in stainless steel, add to the feeling the roof is floating above the pavement.

During the initial design, a standard pad foundation was selected for the columns. After completing initial truss runs and gathering data for foundation load, the pad size was fixed at about 20 ft x 30 ft. This individual pad had to be set at a depth 10 ft below



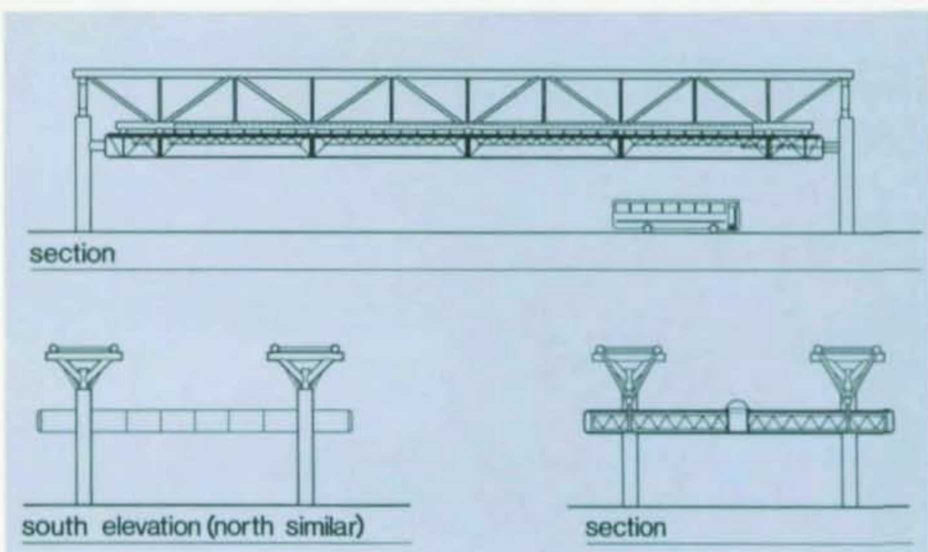
Typical bottom chord connection (l.). Isometric end section (below, l.)



finished grade to utilize dead weight of the soil and passive soil pressure to resist overturning forces. At this depth, the pad would be below the water table, resulting in dewatering and extensive excavation. At this point the footing considerations were re-evaluated and a drilled caisson pier selected, which resulted in considerable cost savings. Since the concrete column would spring from the top of the pier, no pile cap would be necessary. The pier foundation provided minimal settlement as well as minimal lateral displacements.

Because of the nature of tubular structures, several load combinations were considered. Extensive computer modeling was used during all phases of analysis and design. The expertise of the American Petroleum Institute (API), who compiled their years of dealing with offshore towers, was employed throughout the analysis design phase. Analysis of the bus terminal employed the PCSAP program. This Finite Element Code can easily model three dimensional truss or frame structures containing as many as 1,000 joints. Since the program runs on PC-based equipment, the design team could quickly examine alternate member geometry and/or configuration at economical cost. Program execution time was less than 20 minutes.

Dramatic TriCounty Transit terminal (above). Details of unique roof framing (r.) shows sections; terminal floor plan (bott.).

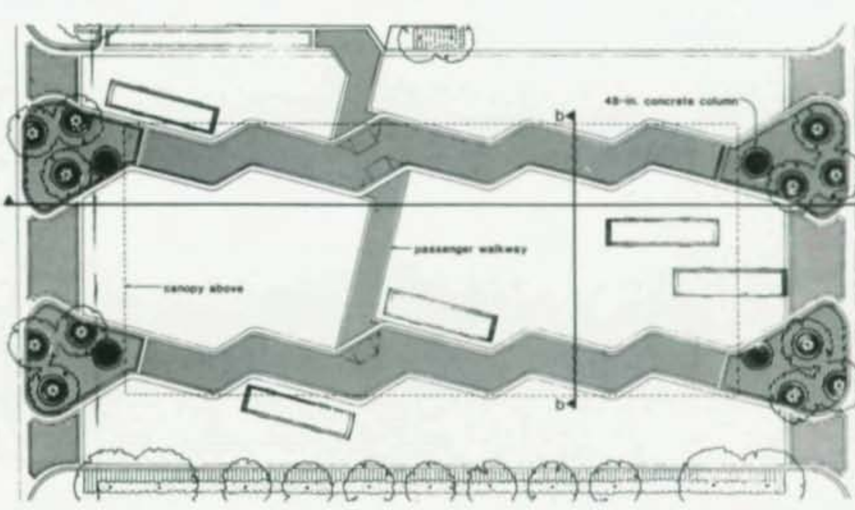


During the preliminary design phase, a simple, three-dimensional truss analysis was used to determine initial member cross section, investigate thermal stresses and investigate changes in geometry. Results of these analyses were used eventually to refine support framing conditions.

During the final design phase, a more refined three-dimensional truss/frame model was adapted. Moments, shears and axial forces resulting from this analysis phase were used to develop adequate connection details, as well as refine member sizes.

Once the initial truss configuration had been analyzed and refined and approved by the architect, individual member sizes and their associated connections were checked. Lateral buckling of the individual members and "punching" shear at the connections were of major concern. A quality control procedure was established with a testing lab to assure welding standards were met during fabrication and erection. All welded joints were checked closely for compliance with the latest American Welding Society guidelines. Finally, the completed design was again computer-modeled for overall integrity.

The end result is a three-dimensional "space-frame" truss spanning 208 ft, con-



Spectacular space-frame roof trusses (l.) were shop-fabricated (c.) in sections and field-spliced. Tricky delivery problems were solved by making truss its own truck bed (bott.).

sisting of 24-in. dia. top and bottom chords; 10-in. dia. and 5-in. dia. diagonals. One end of the truss is fixed, the other end bears on a Neoprene plate which simulates a roller type connection to relieve stresses related to temperature.

The roof structure is suspended at seven locations on the truss. The main support members for the lower roof consists of 4 ft-6 in. deep joist girders. These girders frame to a 10-in. dia. steel pipe, then cantilever approximately 12 ft past the support hanger. Joist girders were selected for economy, with the main roof structure constructed of 24-in. deep joists. Intermediate angle framing and light-gage framing supports the aluminum ceiling system for deadload and windload uplift. Roof dimensions are 85 ft x 195 ft.

Because of the size of the truss, 16-ft high x 16-ft wide and maximum span between splice points of 75 ft, trusses were delivered to the site in four sections, then spliced in the field. All welds were monitored and tested.

The task of delivering trusses to the site presented some tricky problems for the fabricator. The fabricator devised a trucking system which made the truss essentially its own truck bed. Connected to a truck cab, the trusses were literally driven to the project. □

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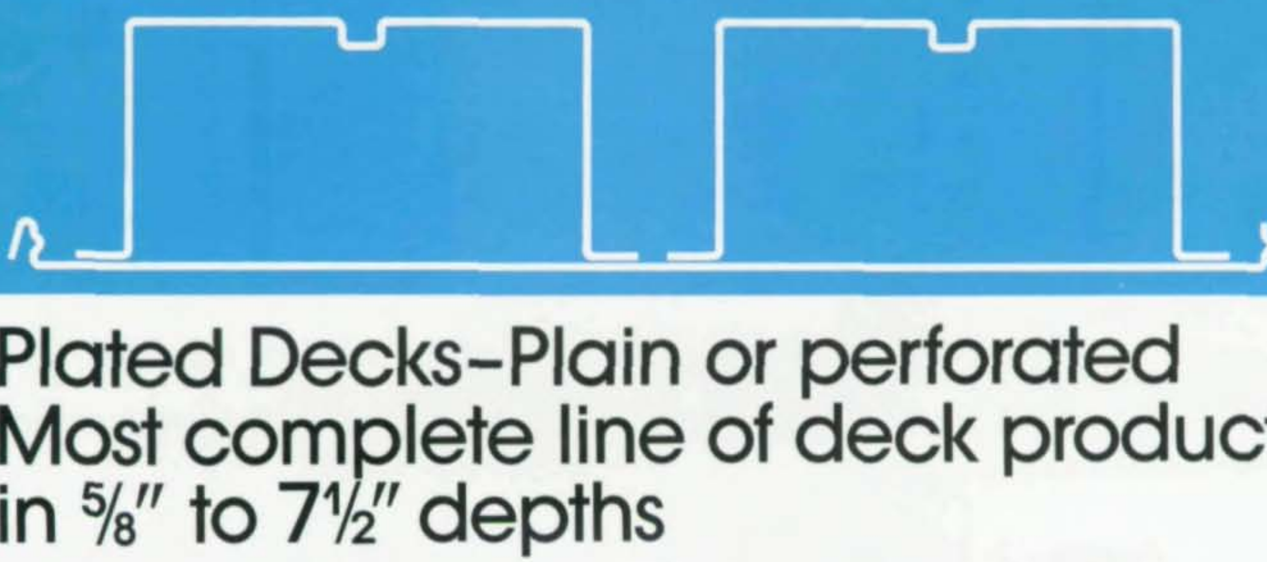

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