AMERICAN INSTITUTE OF STEEL CONSTRUCTION, INC.
101 Park Avenue / New York, New York 10017 / MUrray Hill 5-7374

December 1964

Dear Reader:

I want to call your attention to three articles in the issue of Modern Steel Construction which you are holding:

1. America's Most Beautiful Steel Bridges

Italy's Ponte-Vecchio, England's Tower Bridge, Spain's Puente del Diablo--classic bridges, all of them, works of beauty inherited from other times. America's bridges, stronger and even more durable than those famous landmarks, are also often more beautiful in the way they blend with their surroundings. Which will last? Which will represent to future generations the best bridges of these times? This article offers a hint; it presents the twenty winners of the AISC 1963-64 Prize Bridge Competition--all chosen by an eminent jury of designers and editors for their success in combining aesthetics and utility.

2. Tulsa's New Assembly Center

Problem: Given an outstanding design (by Edward Durell Stone) for a new assembly center, find a way to build it when estimates far exceed allocated funds. Solution: Redesign it. Tulsa did--and saved $1,000,000. With steel, of course.

3. The New San Francisco Subway System

San Francisco is one city that's doing something about the ever-tightening stranglehold of automobile traffic. The city has begun work on a 75-mile rapid transit system to cost about a billion dollars. Sleek, modern, quiet trains will speed commuters at up to 70 mph in an effort to entice motorists away from the city's congested roads. This story tells how the system was designed and how it's being built.

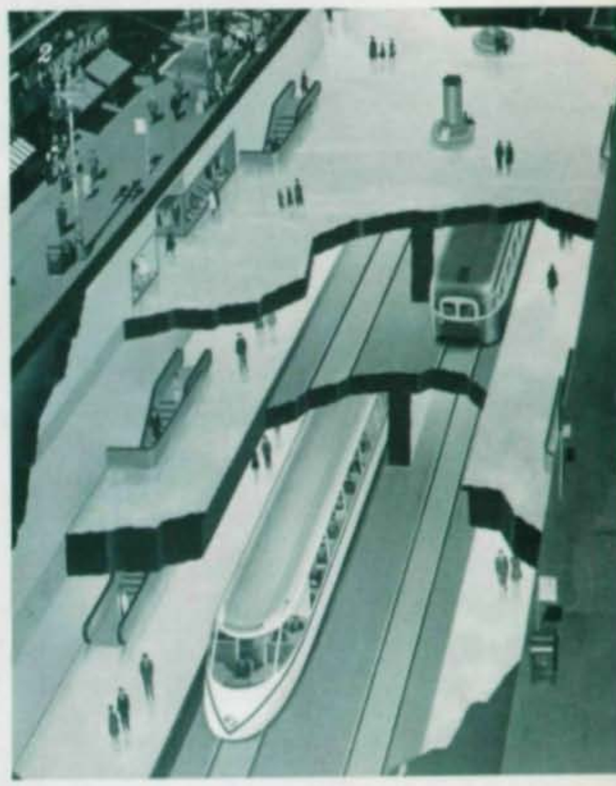
Cordially yours,

A. M. Hattal, Editor
Modern Steel Construction

P. S. Modern Steel Construction is available on request, without charge, to professional architects and engineers. Please write, on your letterhead, to the American Institute of Steel Construction, Inc., 101 Park Avenue, New York, N. Y., 10017, Room 1501.

VOLUME IV / NUMBER 4 / FOURTH QUARTER 1964

MODERN STEEL CONSTRUCTION



MODERN STEEL CONSTRUCTION

Published by

American Institute of Steel Construction

101 Park Avenue, New York, N. Y. 10017

REGIONAL OFFICES

Atlanta, Georgia
Birmingham, Alabama
Boston, Massachusetts
Chicago, Illinois
Cleveland, Ohio
Columbus, Ohio
Dallas, Texas
Denver, Colorado
Detroit, Michigan
Charlotte, North Carolina
Hartford, Connecticut
Houston, Texas
Los Angeles, California
Memphis, Tennessee
Milwaukee, Wisconsin
Minneapolis, Minnesota
New York, New York
Oklahoma City, Oklahoma
Omaha, Nebraska
Philadelphia, Pennsylvania
Pittsburgh, Pennsylvania
St. Louis, Missouri
San Francisco, California
Seattle, Washington
Syracuse, New York
Washington, District of Columbia

VOLUME IV / NUMBER 4 / FOURTH QUARTER 1964

CONTENTS

1964 AISC Research Fellows Are Named

Two young men – one from Erie, Pa., the other from Little Rock, Ark —have won the first in the series of research Fellowships established this year by AISC. The awards, valued at $2,000 each, are made on the basis of choice of research project, undergraduate performance, and recommendation of college authorities.

John Hendrich of Erie, a graduate of Stanford University, will concentrate on "Earthquake and Blast Effects on Steel Frame Structures" at M.I.T.

George R. Motley of Little Rock, will devote his studies to an evaluation of the design procedures affecting steel column base plate design. A graduate of the University of Arkansas, Mr. Motley will continue his gradaute work there.

The Institute will make an additional $2,000 Fellowship Award each year for the next three years until a total of $10,000 a year is awarded to five Fellowship winners.

Articles for Modern Steel Construction Invited

Modern Steel Construction aims to focus attention on unusual architectural and engineering accomplishments made possible through the use of structural steel. The editors invite your participation. Although publication of all articles cannot be guaranteed, the editors welcome and encourage the submission of any which fit the purpose of the magazine.

LONG SPAN PRIZE BRIDGE,
for bridges with one or more spans of over 400 feet.

Cold Spring Canyon Bridge, Santa Barbara, Calif.

OWNER: State of California
DESIGNER: State of California
FABRICATOR: American Bridge Division, U. S. Steel Corporation

Open to Traffic: December 1963

MEDIUM SPAN PRIZE BRIDGE,
for bridges with fixed spans under 400 feet and costing more than $500,000.

White River Bridge, Rogers, Ark.

OWNER: Arkansas State Highway Department
DESIGNER: Howard, Needles, Tammen and Bergendoff
FABRICATOR: St. Joseph Structural Steel Company

Open to Traffic: August 1963

1963-64 PRIZE BRIDGES

Twenty steel bridges have been named by the American Institute of Steel Construction as the most beautiful opened to traffic between Jan. 1, 1963, and Oct. 10, 1964. The jury selected "Prize Bridges" in each of four categories and 16 "Awards of Merit" from 135 entries received by the Institute in this year's competition.

The jury was composed of: Waldo Bowman, publisher of *Engineering News-Record* and past president of the American Society of Civil Engineers, New York, N. Y.; Eric L. Erickson, chief, Bridge Division, Office of Engineering, Bureau of Public Roads, Washington, D. C.; Alfred C. Ingersoll, dean, School of Engineering, University of Southern California, Los Angeles, Calif.; Eugene Kingman, director, Joslyn Memorial Art Museum, Omaha, Neb.; Charles M. Nes, Jr., FAIA, Fisher, Nes, Campbell & Associates, Baltimore, Md.

In appraising the winners, the jurors agreed that bridge designers are taking advantage of the new steels as they are brought out by industry.

"The current quality of bridge design," the jury said, "is very good. Bridges are getting better looking, as well as more economical. There is an obvious attempt on the part of the designers in this competition to do something about appearance. The winners all show that a great many types of bridges can be designed beautifully and harmoniously in steel."

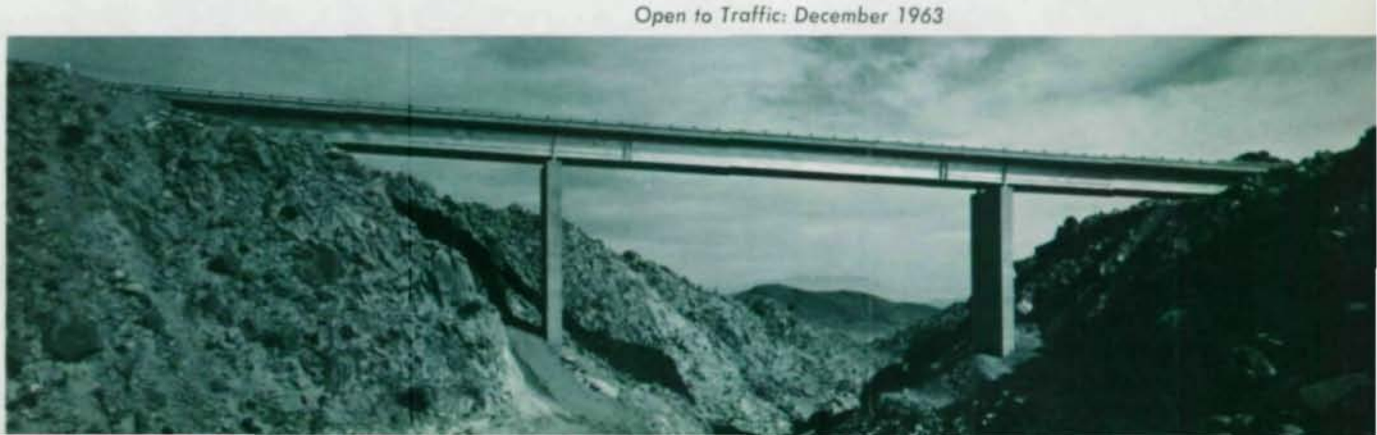
One trend noted by this year's jury was toward the use of welded plate girders. More bridges of this type were

SHORT SPAN PRIZE BRIDGE,
for bridges with fixed spans and costing less than $500,000.

Devil's Canyon Bridge No. 2,
5 miles east of San Diego County line, Calif.

OWNER: State of California
DESIGNER: State of California

Open to Traffic: December 1963

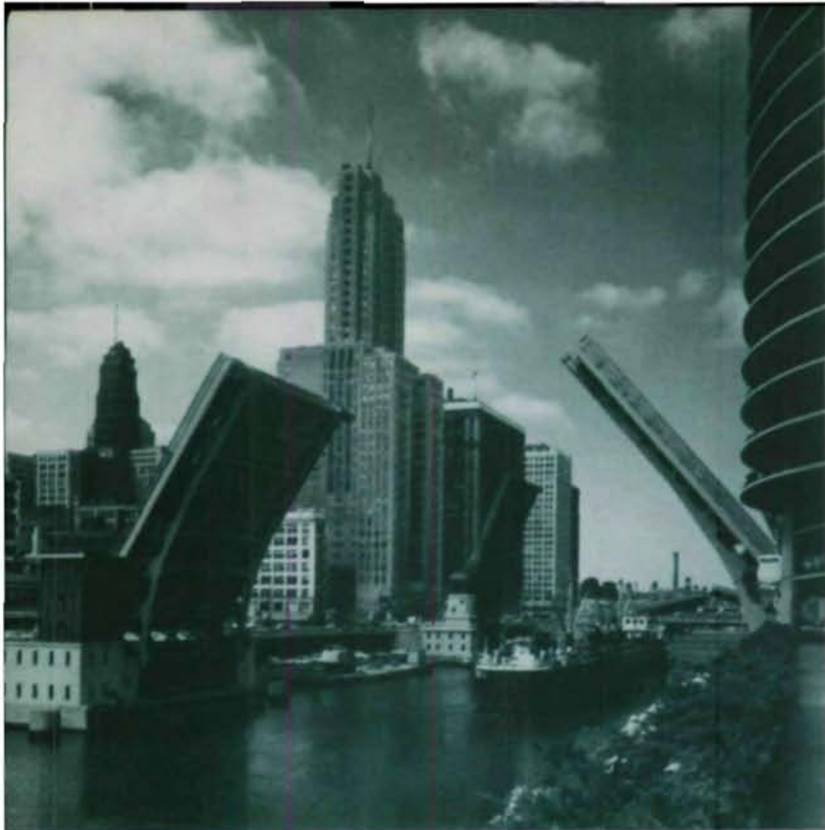


entered than in recent years. "They are streamlining bridges more than they have before," the jury said.

In their criticism, the jurors stated that in many instances "the main part of the bridge often ends abruptly before the road has reached land again. The extremities are thinly or lightly done and don't seem to integrate as a total design." In addition, they stated, "there was often a lack of proportion in the relationship of the main span to the approaches to it, or in the relationship of the vertical support to the over-all span."

The four Prize Bridges will have stainless steel plaques affixed to them as a permanent tribute to their designers for combining aesthetics and utility in graceful river crossings. The designers, owners, fabricators, and contractors of all twenty winning bridges will receive award certificates.

The winning bridges are shown on these pages.



MOVABLE SPAN PRIZE BRIDGE,
bridges having a movable span.

North Dearborn Street Bridge, Chicago, Ill.

OWNER: City of Chicago
DESIGNER: Division of Bridges & Viaducts, Department of Public Works, Chicago; A. J. Boynton & Company, Consultants
FABRICATOR: American Bridge Division, U. S. Steel Corporation
Opened to Traffic: October 1963

AWARD OF MERIT

Long Span Bridges with one or more spans of over 400 feet.

Vincent Thomas Bridge, San Pedro, Calif.

OWNER: State of California
DESIGNER: State of California
FABRICATOR: Kaiser Steel Corporation, Yuba Erectors, J. A. Roebling's Sons Corporation
Opened to Traffic: November 1963

AWARD OF MERIT

Long Span Bridges
with one or more spans of over 400 feet.

Lake Charles By-Pass Bridge, Lake Charles, La.

OWNER: Louisiana Department of Highways
DESIGNER: Howard, Needles, Tammen & Bergendoff
FABRICATOR: American Bridge Division, U. S. Steel Corporation
Opened to Traffic: June 1964

AWARD OF MERIT

Long Span Bridges with one or more spans of over 400 feet.

John Fitzgerald Kennedy Memorial Bridge, Louisville, Ky.

OWNER: Commonwealth of Kentucky and State of Indiana
DESIGNER: Hazelet & Erdal
FABRICATOR: Allied Structural Steel Company, Chicago, Ill.
Opened to Traffic: December 1963

AWARD OF MERIT

Long Span Bridges with one or more spans of over 400 feet.

Newburgh-Beacon Bridge, Newburgh, N. Y.

OWNER: New York State Bridge Authority
DESIGNER: Modjeski and Masters
FABRICATOR: Bethlehem Steel Company

Opened to Traffic: November 1963

AWARD OF MERIT

Medium Span Bridges with fixed spans under 400 feet and costing more than $500,000.

Bridge Across Pickwick Landing Dam, Tennessee River, Hardin County, Tenn.

OWNER: Tennessee Valley Authority
DESIGNER: Tennessee Valley Authority
FABRICATOR: American Bridge Division, U. S. Steel Corporation

Opened to Traffic: June 1963

AWARD OF MERIT

Medium Span Bridges with fixed spans under 400 feet and costing more than $500,000.

The Theodore Roosevelt Bridge, Washington, D.C.

OWNER: District of Columbia Government
DESIGNER: Modjeski and Masters
FABRICATOR: Nashville Bridge Company

Opened to Traffic: June 1964

AWARD OF MERIT

Medium Span Bridges with fixed spans under 400 feet and costing more than $500,000.

Webber Creek Bridge, 16 miles east of Sacramento County Line, Calif.

OWNER: State of California
DESIGNER: State of California
FABRICATOR: San Jose Steel Company, Inc.

Opened to Traffic: July 1963

AWARD OF MERIT

Medium Span Bridges with fixed spans under 400 feet and costing more than $500,000.

Haleford Bridge, Franklin County-Bedford County, Va. (17 miles southeast of Roanoke, Va.)

OWNER: Virginia Department of Highwa

DESIGNER: Hayes, Seay, Mattern & Mat

FABRICATOR: American Bridge Division, U. S. Steel Corporation

Opened to Traffic: April 1963

AWARD OF MERIT

Medium Span Bridges with fixed spans under 400 feet and costing more than $500,000.

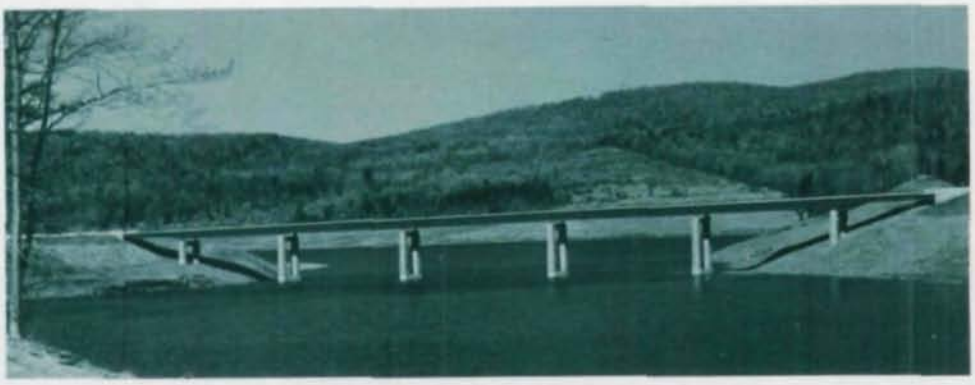
Cannonsville Bridge, 9 miles east of Deposit, N. Y.

OWNER: City of New York, Board of Water Supply

DESIGNER: City of New York, Board of Water Supply

FABRICATOR: Ingalls Iron Works Company

Opened to Traffic: June 1963



AWARD OF MERIT

Short Span Bridges with fixed spans and costing less than $500,000.

Keno Road Bridge, Burnside, Ky.

OWNER: Southern Railway System

DESIGNER: Sverdrup & Parcel and Associates, Inc.

FABRICATOR: Allied Structural Steel Company

Opened to Traffic: April 1963

AWARD OF MERIT

Short Span Bridges with fixed spans and costing less than $500,000.

Tower Junction Bridge, Yellowstone National Park

OWNER: National Park Service

DESIGNER: Western Office, Division of Design and Construction, National Park Service

FABRICATOR: Western Steel Company

Opened to Traffic: June 1963

AWARD OF MERIT

Short Span Bridges with fixed spans and costing less than $500,000.

Agua Fria River Bridge, 40 miles north of Phoenix, Ariz.

OWNER: Arizona Highway Department

DESIGNER: Bridge Division, Arizona Highway Department

Opened to Traffic: September 1964

AWARD OF MERIT

Short Span Bridges with fixed spans and costing less than $500,000.

Apex Bridge, 15 miles east of Deposit, N. Y.

OWNER: City of New York, Board of Water Supply

DESIGNER: City of New York, Board of Water Supply

FABRICATOR: Lehigh Structural Steel Company

Opened to Traffic: November 1963

AWARD OF MERIT

Short Span Bridges with fixed spans and costing less than $500,000.

Ash Street Bridge, Londonderry, N. H.

OWNER: State of New Hampshire

DESIGNER: Robert J. Prowse, assistant bridge engineer, State of New Hampshire

FABRICATOR: American Bridge Division, U. S. Steel Corporation

Opened to Traffic: June 1963

AWARD OF MERIT

Short Span Bridges with fixed spans and costing less than $500,000.

South Street Bridge, Middlebury, Conn.

OWNER: Connecticut State Highway Department

DESIGNER: Connecticut State Highway Department

FABRICATOR: Ingalls Iron Works Company

Opened to Traffic: July 1964

AWARD OF MERIT

Movable Span Bridges having a movable span.

Red River Bridge, Alexandria, La.

OWNER: Louisiana Department of Highways

DESIGNER: Bridge Design Section, Louisiana Department of Highways

FABRICATOR: Ingalls Iron Works Company

Opened to Traffic: April 1963

Cross-section of Market Street subway planned for downtown San Francisco as part of the modern rapid transit network being developed by Bay Area Transit District.

THE NEW

By Samuel H. Clark

It's no secret that auto traffic tie-ups are putting a stranglehold on some of our major cities. And the problem is getting worse. Believing that it may well take a kind of Gargantuan solution, San Francisco has dreamed one up — a truly new subway system. Now under construction, the system will be 75 miles long and cost about one billion dollars. It will also be the largest ever built at one time by any world metropolitan center.

Samuel H. Clark is project coordinator for Parsons Brinckerhoff-Tudor-Bechtel, San Francisco, Calif., general engineering consultants to the San Francisco Bay Area Rapid Transit District.

This is an exciting project, not only for its size, but because it attacks traffic snarls with solutions born of imaginative thinking. At the core of all the ideas developed is a premise as fresh as a breeze from the Pacific. In this automobile-and-freeway-oriented area, the planners aim to entice people away from their cars.

They hope to do it with sleek, modern trains powered to glide along at speeds up to 70 mph and acoustically engineered for a quiet run. What's more, commuters are being promised a trip that will be comfortable, well lit, and air conditioned. Much of the responsibility for creating an attractive passenger environment has been given to the industrial firm of Sundberg-Ferar, Inc., of Detroit. It's their belief that the latest advances in air conditioning and sound abatement, coupled with careful selection of colors and materials, can go far towards insuring that commuters will be willing to leave their cars at the station and ride the transit system.

In addition to the care being taken in design of the transit vehicle, the appearance of the aerial structures has been given primary consideration. One of the early actions by BARTD was to engage Donn Emmons, an outstanding San Francisco architect, to prepare designs for these structures which will be aesthetically pleasing as well as functional.

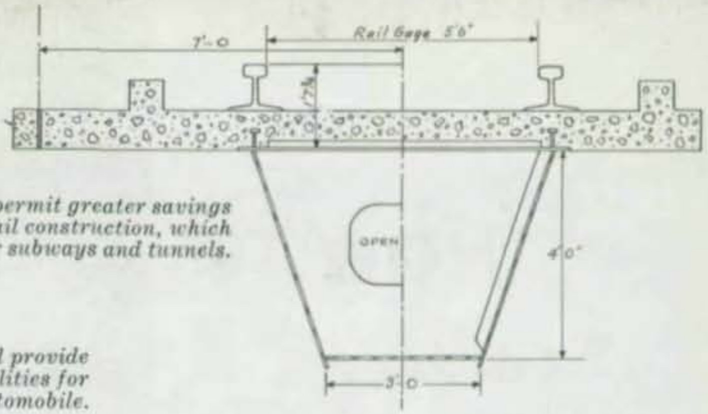
When completed in 1971, the route will extend through San Francisco, under the bay in a tube to Oakland, and beyond Oakland to Richmond in the north, Concord in the east, and Fremont in the south.

The 75 miles of double-track lines will be divided into 20 miles of underground construction, 25 miles of surface construction, and 30 miles of aerial structure. All tracks will be grade-separated. Much of the surface and aerial construction will extend along existing railroads or in the median strip of new or proposed freeways. The system will include 37 stations, with parking for approximately 26,000 autos in outlying residential areas.

Begin Oakland Section in 1965

Design of the first section of subway in downtown Oakland is progressing and construction of this section will begin in early 1965. The 3.3-mile-long Berkeley Hills Tunnel design is well along now and exploratory core drilling has been completed. Exploratory tunnel drifts, which will form part of the final bore, have been completed to assist bidders on the prime tunnel contract.

Suburban stations will provide convenient transfer facilities for feeder bus service and automobile.



Duorail system will permit greater savings than monorail construction, which requires higher subways and tunnels.

AN FRANCISCO SUBWAY SYSTEM

Six-mile tube between San Francisco and Oakland is core of system.

A good gauge of the job size is the fact that up to 100,000 tons of structural steel may be required – enough for more than 50 modern, 20-story office buildings. As an example, the total requirements for structural steel in the design of the aerial structures may amount to 15 miles of box girders. These will have a trapezoidal shape consisting of steel plates with shear connectors at the top flanges on each side, and a concrete deck.

To match the magnitude of the project, and to solve design problems which are unique in this system, due to the use of the new, light-weight, high-speed trains, a computer program has been developed for dynamic analysis of the aerial structures. It accommodates simple, suspended, or continuous spans; it can include the effects of non-rigid support points and of varying girder stiffness and span length; and it will predict structural behavior for any vehicle suspension system once the dynamic characteristics of that system are known. The computer program is useful in the study of other related problems. For example, the dynamic effects of differential settlement between adjacent support piers can be analyzed to assist in the establishment of criteria for the foundation design.

Why Duorail?

Some people have wondered why a two-rail system was finally selected when so much interest has been generated in monorails during recent years. This question was thoroughly studied, considering both the bottom-supported and suspended monorail systems and the duo-rail system. In the end, the duo-rail system won out on the basis of cost. In subways, the monorail systems would require a higher, larger bore, and in aerial or at-grade sections, more structure is required. Also, the duo-rail lines are more easily adapted to switching mechanisms.

Since noise is a major objection to present rapid transit systems, this is being studied intensely. Here are the 10 acoustical contributions presently under study: (1) an insulated body shell, (2) fixed windows, (3) design of an acoustic wheel, (4) a brake system with very low noise levels, (5) resilient chassis and mountings, (6) deep side skirts to blanket sound, (7) acoustic treatment of the road-bed, (8) resilient track mountings, (9) continuously welded rails, (10) trackside sound barriers.

A major segment of the system is the 3.5-mile-long underwater tube that will extend beneath San Francisco Bay. Early studies indicate that the tube will be built by constructing long, prefabricated steel sections in a dry dock and sinking them in a trench in the bottom of the bay. The deepest sections will be about 120 feet below the water surface.

Because the San Francisco area is subject to seismic action, extensive tests have been conducted to determine the effects of earthquakes on such a structure. The test staff placed geophones (electric seismic recorders) in wells constructed under the bay. Over a period of three years these geophones – one placed in the bay mud, one in alluvial material below the mud, and one in firm shale – have been recording the measure of relative movement brought on by a number of earthquakes of varying intensity. Results of these tests have indicated that there is no hazard in such a tube, provided it is properly constructed.

When completed, the San Francisco subway system will provide a model for other areas with similar geographical and transportation problems.

HOW TO SALVAGE A "USELESS" LOT

Entire house is framed in steel, much of it exposed and painted black. A footbridge, handrailings, spiral stairway, and fireplace — all of steel — complement the structural skeleton.

Solving an "impossible" design problem for a client is nearly always a rewarding experience for an architect or design engineer. So it was recently for Berkeley, Calif., architect David Thorne, who designed the one-of-a-kind house you see here for owner-builder Charles B. Hahn of El Cerrito, Calif.

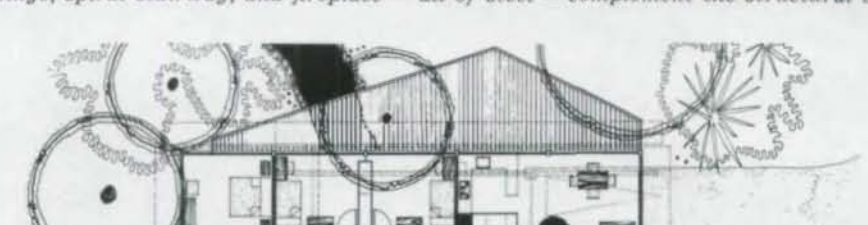
The problem was this. Hahn owned a steep parcel of land, studded with fine, old shade trees and cut through by a meandering, musical creek. In California that's referred to as "view property" — a fine place to stand and gaze at the valley below, or a spot for a summer picnic. But build on it? Never. Regrading would have cost a fortune and ruined the landscape. And building on the undisturbed land wasn't feasible either, thought Hahn.

Thorne thought otherwise. "We'll use steel to bridge the stream, and steel to wrap your house **around** the biggest shade tree on the lot," he explained.

The Hahns liked Thorne's other ideas, too.

The result is a home the Hahns consider more satisfying than any they've ever owned. The family has nothing but admiration and respect for architect Thorne.

For example, the Hahns find their new home a more exciting place to live. Lifted over the stream and cantilevered out into space, the house is a theater for a continuing, spectacular view over the valley below. There's the practical side, too. For a family of four (the Hahns have a teen-age son and daughter), the home is spacious without being ostentatious. There are 2,100 sq. ft. of living area and 1,200 sq. ft. of decking. The plan is trim and highly functional. Note especially where Thorne sandwiched the laundry — keeping it away from areas where guests would gather; making it convenient to the source of soiled linen and clothes, and providing a boot and rainwear dumping spot during stormy weather.



Floor plan shows tree, left relatively undisturbed, protruding through house.

The real base for the home consists of two 40-ft., wide-flange steel beams. Each beam rests on two points: the concrete shear wall on the south side of the creek (sleeping wing of the house), and an 18", square, reinforced concrete column on the north side. An 18" x 30" foundation tie beam supports the columns—and with them forms an inverted rigid frame. The wide-flange beams cantilever 18 feet beyond the columns to support most of the living room, and serve as a roof for the post-free carport below.

Architect Thorne chose steel — more than 10 tons of it—for more uses throughout the home. In all selections, technical accuracy was checked out by Oliver Baer, a consulting structural engineer familiar with experimental high tensile steel rigid frames. Here are some of those uses:

- The triangular-shaped decks on both sides of the house also rest on cantilevered WF beams, atop the main supports and perpendicular to them. Aesthetically, the decks make the transition between the geometric shape of the house and the natural curve of the stream, according to Thorne.
- Floors within the house are applied over 1⅛" 2-4-1 plywood subflooring

Two wide-flange steel beams span 40 feet between supports and cantilever 18 feet beyond, providing carport area. Attractive steel footbridge, replacing plank shown at this stage of construction, serves as main entryway to house.

These 1⅛-in.-thick plywood panels are easily dropped into place on steel floor beams. New adhesive simplifies wood-to-steel connections.

which is **glued** directly to cold-formed steel Z-shapes, 30" o.c. laid over the uppermost WF beams.

• Heat is delivered to the house through a plenum created between the bottom of the subfloor and the enclosed bottom of the upper WF beams (which left only the main WF beams showing). Besides eliminating unsightly ductwork beneath the house, this system has the advantage of permitting floor registers at any location the Hahns desire.

• Glass walls along the entire west side and half the east side were made possible by steel framing within the house. The six rigid bents doing the job were fabricated from 14 ga. high tensile steel sheets. Here's how each bent was made. Block-letter "C" shapes with a returned toe were formed on a press break. Two of them welded intermittently together, toe to toe, made 5" x 12" tubular sections from which the bents were then fabricated. Tapered eave sections folded on a press break jut out from each top end of the rigid frames to form support for the louvered overhangs above both decks.

• Wherever steel is exposed, within or without the house, spaces between intermittent toe welds were carefully filled with a metal putty and painted with a specially developed black coating. The Hahns feel these tubular sections look best as exposed columns and beams.

• The unique fireplace is hung from the steel bent in the living room. It was designed and fabricated by Carl H. Francee, an associate in Mr. Hahn's firm. He made it from a 48"-diameter steel stack with a 17" deep steel "dished head". (Dished heads are normally used as ends for welded steel tanks, but extra deep ones are being used increasingly as fireplaces.)

• Francee also designed the spiral steel staircase leading from the carport to the living area. He coated the underside of the steps to muffle the "ring" of steel.

• The base of the stairs, and the tree trunk alongside it are enclosed in glass on three sides and a framed wall on the carport side. Mrs. Hahn uses the room to raise plants. Incidentally, those branches of the tree which go directly through the house pass through holes cut in the skylight above the stairwell. The space between tree bark and skylight was sealed with a pliable mastic.

• And, finally, guests on foot reach the Hahn home from the street by means of a decorative steel footbridge.

STEEL REPLACED CONCRETE IN ORIGINAL DESIGN. EDWARD DURELL STONE WAS ARCHITECT, WITH MURRAY-JONES-MURRAY AS ASSOCIATES.

REDESIGN SAVES 1,000,000 ON TULSA ASSEMBLY CENTER

How to build a new assembly center that would have an outstanding architectural design, yet be possible on a limited budget? This was the question faced by the City Commission of Tulsa, Oklahoma.

The city commissioned an architect who developed an appropriate design, but initial bids for construction of the new center far exceeded allocated funds. To bring costs in line with the budget, the architects trimmed some desirable features and effected a few other economies, but costs were still above the limit.

In exploring other ways of trimming costs, engineers and architects considered alternate structural systems that would preserve the striking contemporary design – and the budget. The original design called for prestressed concrete. Redesign in structural steel was found to save more than $1,000,000.

This put the project within the budget limits. Construction could proceed. And many of the "extras" that had been trimmed in an attempt to bring the original design in line with estimates could be restored. The Assembly Center was dedicated on March 8 of this year.

The Assembly Center was designed by Edward Durell Stone who also had over-all responsibility for the project. Murray-Jones-Murray of Tulsa were associate architects responsible for preparation of all working drawings and specifications and for supervision of construction. Structural engineers were Severud-Elstad-Krueger.

A few changes were made in redesigning. The size of the building was reduced slightly – from 280 x 570 feet to 260 x 520 feet – and some meeting rooms were consolidated, but the original design concept and appearance were preserved. Cost for the building amounted to less than 60 cents per cubic foot for 10.5 million cubic feet, or only $13.98 per square foot for the Center's 432,000 square feet of floor space. Total Cost was $6,046,347.

Coliseum Seats 10,000

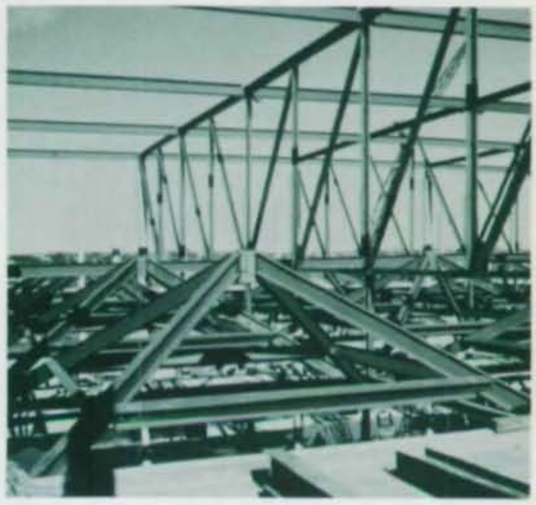
Located in different parts of the Assembly Center are a coliseum, or arena, seating 10,000, an assembly hall with a 40 x 80-foot stage and a seating capacity of 1,300, fifteen meeting rooms and underground and surface parking for more than 1,000 cars. The entire building is air conditioned, and the arena has a built-in steel pipe refrigeration system that turns the floor into a rink for ice hockey. Movable seats adapt the hall for various types of sports, theatrical, musical and civic events.

In its new design, the Assembly Center contains 1,300 tons of structural steel in roof trusses, beam framing and bracing, fascia framing and ceiling pyramids designed for a pleasing geometric appearance as well as for illumination, ventilation and acoustics. In addition, the building's roof required 60 tons of open web joists and 1,510 squares of corrugated steel sheets that serve as in-place forms for the lightweight concrete roof.

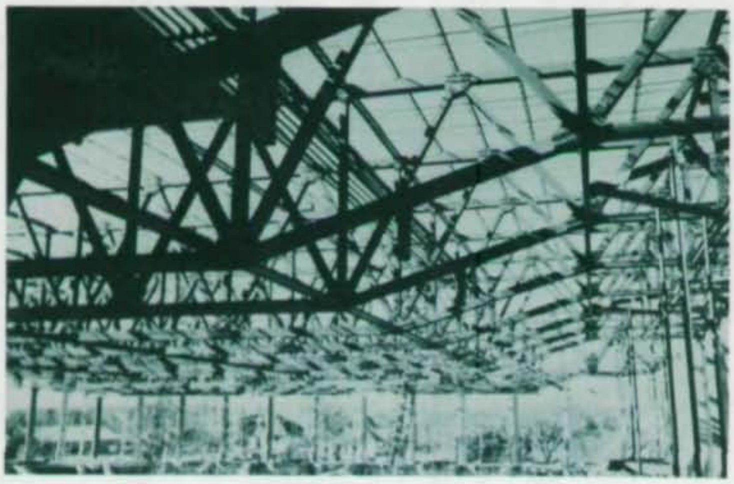
Most of the structural steel is in the roof framing, which provides a 240-foot clear-span ceiling for the arena and an 80-foot clear span for the assembly hall. The differences in size and location of the two roof structures enabled the steel fabricator to take advantage of steel's light weight and ease of assembly by tailoring fabrication and erection procedures to suit different parts of the Center. As a result, erection of all steel for the Center's roof was completed in just 45 working days.

For the assembly hall, Patterson Steel Co. of Tulsa, the steel fabricator, delivered the 80-foot trusses preassembled in three sections. There are ten trusses weighing four tons each. Because the assembly hall roof is well within the perim-

Scaffolding provides work platform 58 feet off ground for erection of 97-ton truss over arena.



Cranes hold roof truss sections in place while connections are made, bracing members installed.



Roof trusses were fabricated in shop. After checking and match marking, they were disassembled and delivered for reassembly and erection at the job site.

eter walls of the Assembly Center, the trusses were assembled outside the wall and then lifted into position by cranes. Manhattan Construction Co. of Tulsa, the general contractor, also handled steel erection.

Roof Trusses Assembled at Site

For the arena roof, by contrast, trusses were delivered to the job site completely disassembled. Prior to delivery, Patterson completely fabricated all components, sub-drilled them and shop assembled the trusses so the required 4-inch camber could be checked. Then all connection holes were reamed, and the truss was disassembled and painted prior to delivery. Two trusses could be assembled and disassembled simultaneously on Patterson's main assembly floor.

Most trusses for the arena roof weigh 40 tons apiece. They were assembled into half sections on the arena floor, where tension in the high-strength steel bolts was checked prior to erection. During erection, each truss half-section was lifted into position with a 50-ton crane. Then a 30-ton crane came in and held the end of the half-section while the larger crane lifted the other half into place. Both cranes held the two truss sections until all connections were made and bracing members were swung into place and attached to the framework.

Arena roof trusses are 240 feet long and 18 feet 8 inches deep. In addition to the thirteen 40-ton trusses, the roof includes one truss weighing 97 tons and another weighing 64 tons. The heaviest truss members weighed four tons.

Special erection procedures were devised for the big 97-ton truss. It was assembled in place on a work platform supported 58 feet above ground on scaffolding. Truss members were lifted either piece by piece or in small subassemblies. Gusset plates were delivered bolted to chord members with regular machine bolts, which were replaced with high-strength steel bolts as the truss members were erected.

Forming the ceiling structure in both the assembly hall and arena are 146 square, steel-framed pyramids erected in rows between the roof trusses. The pyramids support lighting installations, provide some degree of ventilation around each light fixture, support sprayed asbestos ceiling surfaces that provide acoustical control and contribute a decorative effect.

Each pyramid measures 20 x 20 feet and is 7 feet high. To verify drawings and details, Patterson first fabricated and shop assembled one pyramid and then fabricated the remaining 145. They were shipped to the job disassembled but were assembled at the site and erected as complete units.

Models Constructed in Drafting Room

Along the outside of the Assembly Center, the fascia consists of steel-framed, pyramid-type frames supported between the perimeter columns and the spandrel beams. Tops of the fascia frames are bolted to beams cantilevered from the roof truss system. Because the fascia framing involved complex details, Patterson first constructed models for use in the drafting room to assist in visualizing and verifying details.

The pyramid-type fascia gives a classic-lined yet striking and contemporary flair to the Assembly Center, which serves as a focal point for downtown Tulsa. Its efficient facilities attract local residents to cultural, industrial, and athletic events, and it serves as a drawing card for business conventions and shows.

ROOF DECK COSTS — By Type, for Industrial Buildings with 24 x 24-ft bays

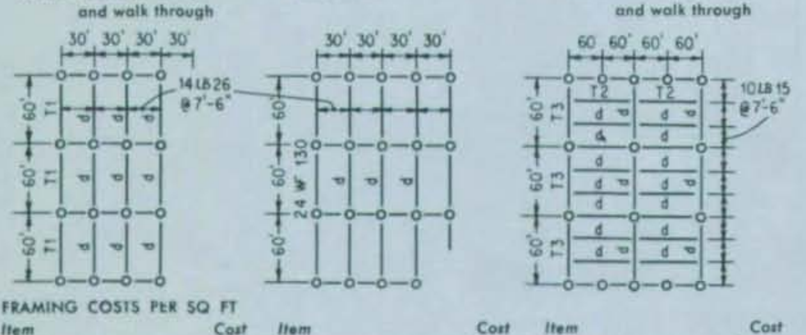
Type of Deck & Insulation	Weight (psf) Deck	Weight (psf) Struc St	Maintenance	Miscellaneous Advantages	Miscellaneous Disadvantages	U Factor	Insurance Preference	COST— $/Sq Ft
20 Ga steel deck, 1-in board insulation	*2.45*	*3.1*	*Requires* Periodic Painting	*Low cost,* fast erection		*.24*	*Usually* accepted with no rate difference	*Deck* *$0.31* Insul 0.15 Str stl 0.49 Paint 0.10 Total $1.05
Aluminum deck 1-in board insulation	1.8	3.0	None	Building cooler in summer		.24	Same as steel deck	Deck $0.60 Insul 0.15 Str stl 0.48 Total $1.23
Poured gypsum on 1-in glass fiber	10.5	4.0	None	Low cost	Erection apt to be slow in bad weather	.19	Excellent	Deck $0.55 Str stl 0.64 Paint 0.05 Total $1.24
Precast channel roof, 1-in board insulation	15	4.0	None	Resistance to high humidity	High initial cost	.20	Excellent	Deck $0.55 Insul 0.15 Str stl 0.70 Total $1.40
Precast cellular roof, 1-in board insulation	46	3.8	None	Resistance to high humidity	High initial cost		Excellent	Deck $1.20 Insul 0.15 Str stl 0.60 Total $1.95
2-in Compressed wood fiber deck	5	3.5	Paint to cover stains	Low cost		.20	Accepted	Deck $0.50 Str stl 0.56 Total $1.06

STEEL FRAMING COSTS: How they change with size of bay, type of frame

Bay Size: 30 x 60 ft
Frame: Trusses, 7 ft high and walk through

Bay Size: 30 x 60 ft
Frame: 24WF

Bay Size: 30 x 60 ft
Frame: Trusses, 7 ft high and walk through



FRAMING COSTS PER SQ FT

Item	Cost	Item	Cost	Item	Cost
Truss (T1)	$0.42	24 WF	$0.57	Truss (T2)	$0.45
				Truss (T3)	0.37
Purlins	0.46	Purlins	0.48	Purlins	0.28
	0.88		*1.05*		*1.10*
Columns	0.07	Columns	0.07	Columns	0.07
Total	$0.95	Total	$1.12	Total	$1.17
Cost difference	Par		+$0.17/sf		+0.22/sf

January 1964; Philadelphia, Pa., area.

COSTS OF Structural Systems for INDUSTRIAL BUILDINGS

These comparative costs, based on the experience of The Ballinger Company, Philadelphia architects and engineers, can help in estimating alternative costs of major components for industrial buildings. The cost estimates shown are pegged to Philadelphia area costs between 1961 and 1963.

They also serve to point out that superficial analysis may not produce a reliable decision on the most economical design.

A comparison of five floor constructions (opposite page, top) resulted from cost analysis for two small buildings, one of which is to be an office building. This table, which includes structural cost and the cost of providing flexible electrical distribution, shows how the lowest price structurally may not result in the lowest cost building. The reason is that lowest structure cost may not provide for electrical distribution or may not accommodate the necessary mechanical system.

Framing costs vary with bay size, type of frame and live load. The table at the left shows how increasing the bay size increases the cost of framing. It also compares costs of different framing systems for bay size 30 x 60 ft.

The cost of using 24-in.-wide flange beams for framing this size of bay adds $0.17 psf, 12% above the cost of using 7-ft trusses. But it's estimated to cost only an additional 5% to increase the

FLOOR CONSTRUCTION COSTS — By Type, for Industrial Buildings

Type	Deck	Section	Cost — $ per sq ft		Cost Difference	Advantages	Electrical availability	Cost Difference including built-in electrical services $/sq ft
1—PRE-CAST DECK AND FRAME	2" Topping on 8" deck	Composite prestressed girder; 36"	Floor & columns*.. Foundation extra ... Total	$3.00 0.12 $3.12	+$0.61		Must be pre-determined	
2—PRE-CAST DECK AND STEEL FRAME	Same deck as above	27" girder; 37"	Floor & columns*.. Foundation extra ... Total	$2.71 0.12 $2.83	+$0.32	More flexibility of framing openings, etc. than Scheme #1.	Must be pre-determined	
3—METAL SUB-FLOOR AND STEEL FRAME	2½" conc. fill on metal deck	30" girder; 34"	Floor & columns*.. Foundation extra ... Total	$2.51 0.00 $2.51	Par	Openings and hanging loads (present & future) more easily accommodated	Unlimited (present & future)	For electrical headers, $2.51 add: 0.18 Total $2.69
4—CAST IN PLACE CONCRETE PAN CONSTRUCTION	3" deck pans 20"x10"	48"; 21"	Floor & columns*.. Foundation extra ... Total	$2.48 0.12 $2.60	+$0.09	Flexibility of framing openings, etc. Allows maximum headroom	Same as Scheme #1	
5—CAST IN PLACE CONCRETE ONE WAY SLAB	7" Slab	48"; 22"	Floor & columns*.. Foundation extra ... Total	$2.71 0.12 $2.83	+$0.32	Same as Scheme #4, plus smooth ceiling between beams	Would accommodate underfoot duct	For underfloor duct, $2.83 add: 0.60 Total $3.43

*Not including ceiling or fireproofing .... Excluding built-in electrical services

bay size to 60 x 60 ft, using trusses.

Below another table demonstrates the effect on framing costs of increasing bay size or increasing the design load.

The table shows that increasing the bay size from 30 ft to 36 ft on a side, enlarging the area of the bay by 44%, is estimated to raise the framing cost by $0.70 psf. And to increase the design load from 200 psf to 250 psf, adds half as much more, or $0.34 psf to the cost of the framing.

At the right is a handy chart for making quick rough estimates of the steel framing costs. The lb per sq ft — beams and joists but no columns — for the desired bay size simply needs to be multiplied by the going price per pound of structural steel in place to get the superstructure steel cost.

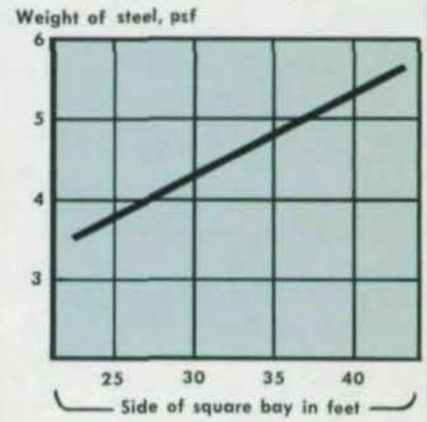
The design that was used for this table at the right is based on dead-level roof, continuous steel girders and open-web joists. The steel weights are based on light roof deck (4 psf) and 30-psf live load.

Comparative costs of roof deck for light, level roofs appear in the table at the upper left (opposite page.) These costs are for buildings with square bays 24 ft on a side.

The cost includes structural steel framing, roof deck and insulation only, because in the comparison made the cost of roofing, foundations, exterior walls, etc., would not be variables.

STEEL FRAMING COSTS:

Weight of steel increases with the size of bay.



*For industrial buildings with light roof deck (4 psf) and live load (30 psf). Columns not included.

STEEL FRAMING COSTS: How they change with bay size and design load

(Includes the concrete slab.)

Bay size	30 x 30 ft	30 x 30 ft	36 x 36 ft	36 x 36 ft
Live load, lb per sq ft	200	250	200	250
Girder	36 WF	36 WF	36 WF	36 WF
Beam and spacing	24 WF @ 10 ft	24 WF @ 10 ft	27 WF @ 9 ft	27 WF @ 9 ft
Cost difference, $ per sq ft	Par	+$0.26	+$0.70	+$1.04

May 1963; Philadelphia area

Modern Steel Construction INDEX

SEPTEMBER 1961 – FOURTH QUARTER 1964

(Issues from Sept. 1961 through Oct. 1962 are designated by month; subsequent issues are identified by quarter.)