VOLUME XI / NUMBER 1 / FIRST QUARTER 1971



# MODERN STEEL CONSTRUCTION

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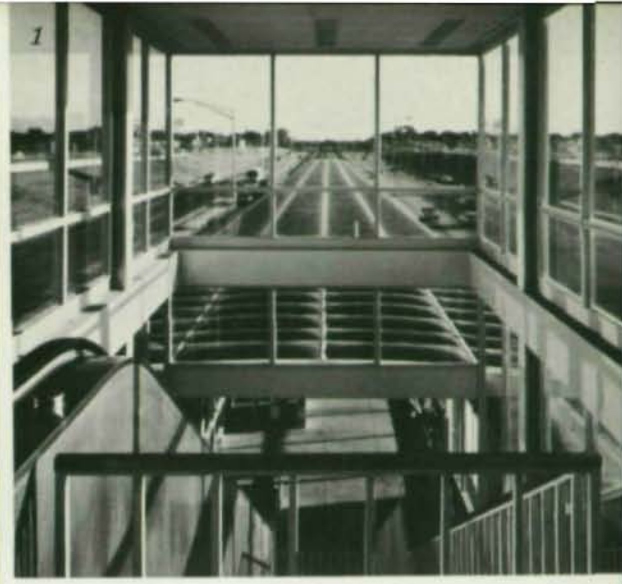



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MODERN STEEL CONSTRUCTION

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VOLUME XI / NUMBER 1 / FIRST QUARTER 1971

## CONTENTS



## 1971 PRIZE BRIDGE COMPETITION

*Entries are invited for the 43rd Annual Prize Bridge Competition to select the most beautiful steel bridges opened to traffic in the U. S. during the calendar year 1970.*

*The Competition will be judged by a distinguished Jury of Awards.*

*A new category has been added this year, that of Elevated Highways or Viaducts, to the existing seven categories: Long Span; Medium Span, High Clearance; Medium Span, Low Clearance; Short Span; Highway Grade Separation; Movable Span; and Special Type.*

*Entries must be postmarked prior to June 5, 1971 and addressed to the Awards Committee, American Institute of Steel Construction, 101 Park Avenue, New York, New York 10017.*

## NATIONAL ENGINEERING CONFERENCE IN CLEVELAND, OHIO

*The 23rd Annual AISC National Engineering Conference will be held on May 6 and 7, 1971 at The Sheraton Cleveland Hotel, Cleveland, Ohio.*

*Leading authorities in steel design, research, and construction will meet to exchange ideas and information about the latest developments in these fields. This conference is a "must" for anyone who designs structures.* *See page 10 for details of program.*

# Rapid Transit Stations Enhance Chicago Expressways

Fifteen new stations have been added to Chicago's existing rapid transit system. One line, containing nine stations, is located in the median of the Dan Ryan Expressway. The second line, containing six stations, is in the median of the John F. Kennedy Expressway. Both lines utilize existing median strips, which were planned for future transit development.

The program for the project included the following criteria: the stations should create a pleasant environment for the passengers; they must be conveniently arranged to permit the flow of many people at rush hours to and from the trains and buses; they must provide security when few people use the sta-


tions at late hours; they must be designed to preserve a good appearance, with little maintenance, and must conform to the geometry of the existing right-of-way.

**Meeting The Objectives**

To meet this program, the architects developed stations consisting of three main elements: the fare collection area, a waiting area for connecting buses, and the boarding platform for trains.

The structures required large cantilevers to clear the existing right-of-way and to provide unobstructed passenger access to trains and buses. Clear spans and widely spaced columns of minimum size were needed to permit easy flow of passengers through the stations. Long span bus bridges of shallow depth were needed to meet existing highway clearances. Steel was the obvious solution to the many construction problems

posed by structures of these types. Welded steel connections were used to give a finished appearance, and to obtain smooth surfaces. Finally, the architects were able to make the steel construction the basis of the architectural expression of the stations, since the building code permitted non-fireproofed steel in most cases.

The waiting and fare collection areas are single-story buildings raised on recessed columns to adjoin existing bridges over the expressway. The roofs are lightly supported on few columns with clear spans to give maximum clearance for passenger traffic. The walls are entirely of glass to enhance the feeling of openness, and permit easy surveillance at all times. The glass walls also contribute to the clear expression of the steel frame. Some waiting areas are gently curved, to follow the right-of-way of the highway.


## Tubular Sections for Canopies

The canopies that cover the boarding platforms have curved glazed roofs, supported on a single row of steel columns spaced at 22-ft intervals. The maximum cantilever span is 18 ft in each direction with 10-in. square columns. The roofs are often curved in plan to follow the highway, as well as being tapered in width to follow the tapering of platforms. The canopy extends 1 ft-0 in. beyond the center line of the tracks on either side, eliminating the need for interior roof drains. The columns support a central spine girder from which the beams are cantilevered.

All the steel framing members of the canopy are tubular sections. These tubes resist the severe torsion and vibration stresses a structure of this kind encounters due to unequal wind and snow loads. The hollow members also provide raceways for electrical wiring, and eliminate ledges where dirt could collect — an important consideration in an open structure. The steel frame roof is glazed with tinted acrylic plastic domes, giving an open, airy character to the platform. The steel frame also gives a neat appearance when the canopy is viewed from above.

## Steel Allows Maximum Clearance

The bus bridges at the terminal stations are supported by welded steel plate girders, and span up to 130 ft. They were designed with shallow profiles to allow maximum clearance over the highways, and yet have long spans with a minimum of supports to interfere with rail or auto traffic and passenger traffic on platforms. For visual effect, all stiffeners were concealed to enhance the horizontal sweep of the bridges over the expressway.

The appearance of the exposed steel structure in the fare collection and waiting areas, canopies, and bridges was carefully coordinated. All steel is painted off-white to give a sense of lightness to the structures, and crisply define them amid the flow of traffic. These stations have a cumulative visual effect when viewed sequentially from the expressway.

**Architect-Engineer:**
Skidmore, Owings & Merrill
Chicago, Illinois

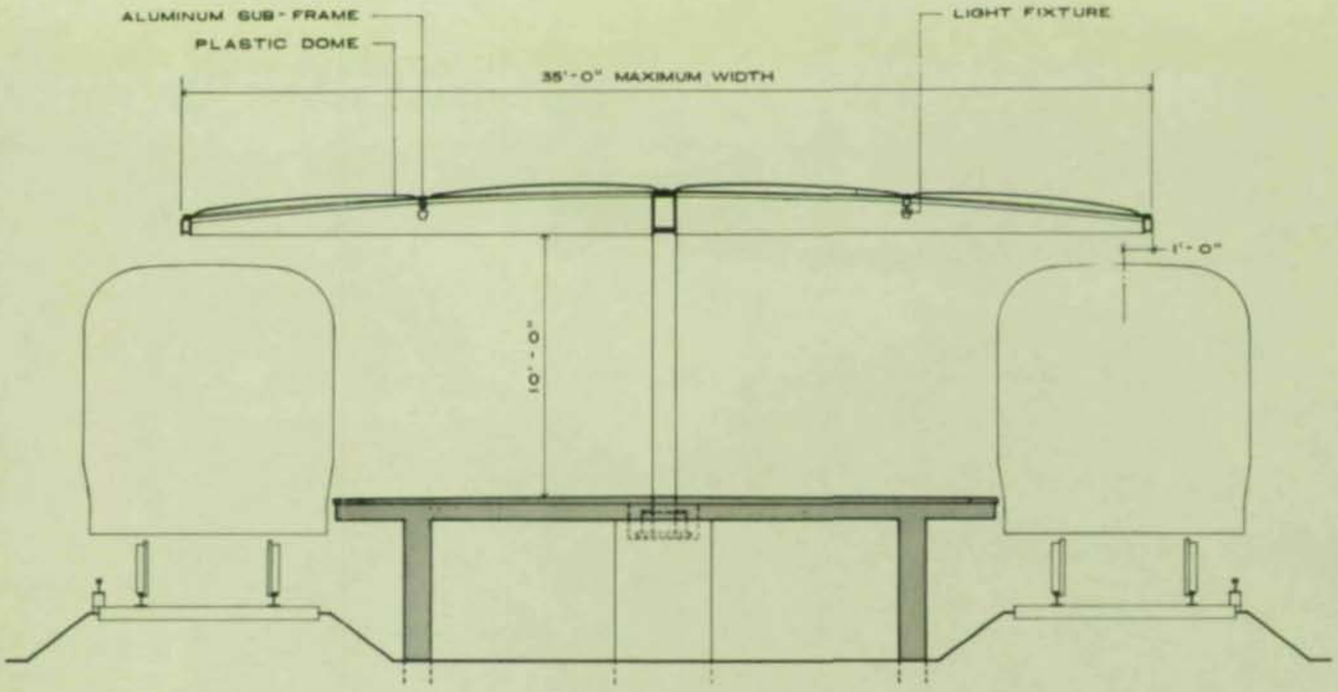
**General Contractors:**
J. M. Corbett Co.
Chicago, Illinois

Paschen Contractors, Inc.
Chicago, Illinois

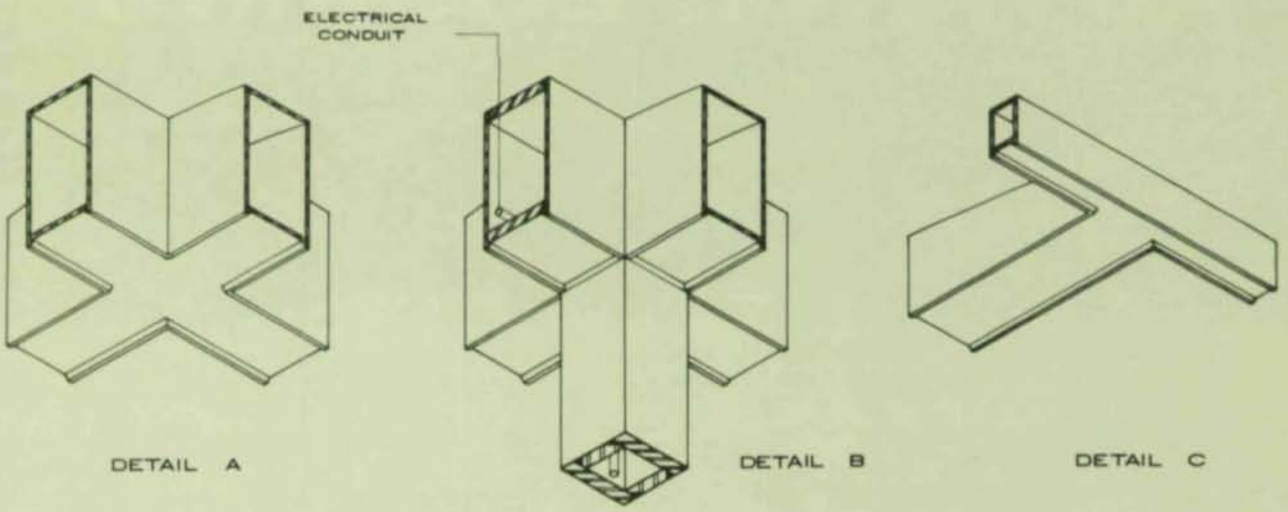
W. E. O'Neil Construction Co.
Chicago, Illinois

**Fabricators:**
Joseph T. Ryerson & Son, Inc.
Chicago, Illinois

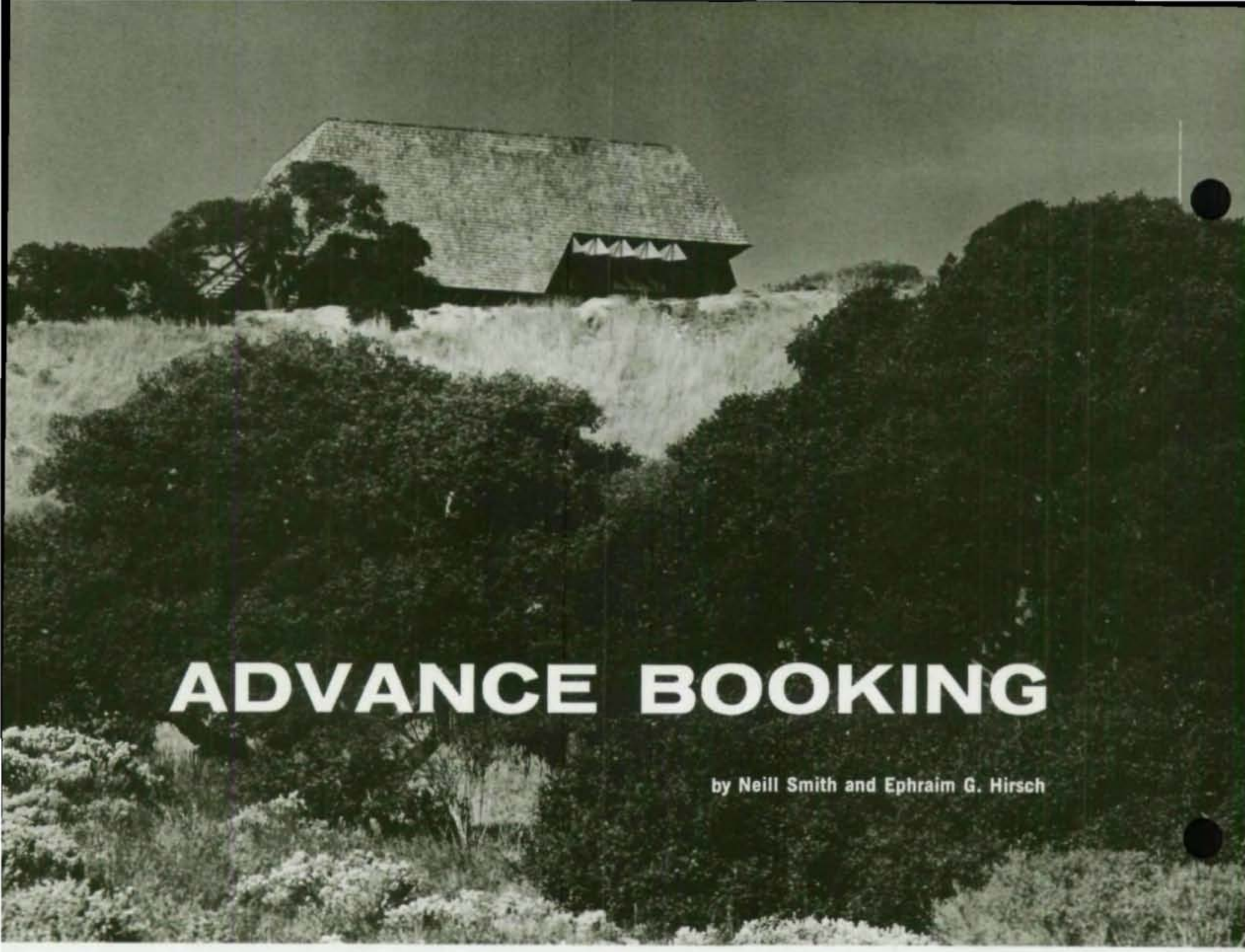
Pittsburgh-Des Moines Steel Company
Pittsburgh, Pennsylvania




*Cross section*




*Platform canopy details*



# ADVANCE BOOKING

by Neill Smith and Ephraim G. Hirsch

*The Frank C. Bishop Library at the York School, Monterey, California, was one of the winners in the 1970 Architectural Awards of Excellence Competition, sponsored by AISC.*

**PROGRAM** — A private Episcopalian preparatory school, located in the country outside a coastal California community, required a new library. The school, founded after the war, is growing within a master plan that envisions independent buildings, linked around a central court, constructed as growth of the school dictates.

The library program showed the need for a 15,000 volume library with a work and study capacity for approximately 50 students. The program planners and the school headmaster agreed that the library should clearly represent in form the primary importance of its function in the school's educational program.

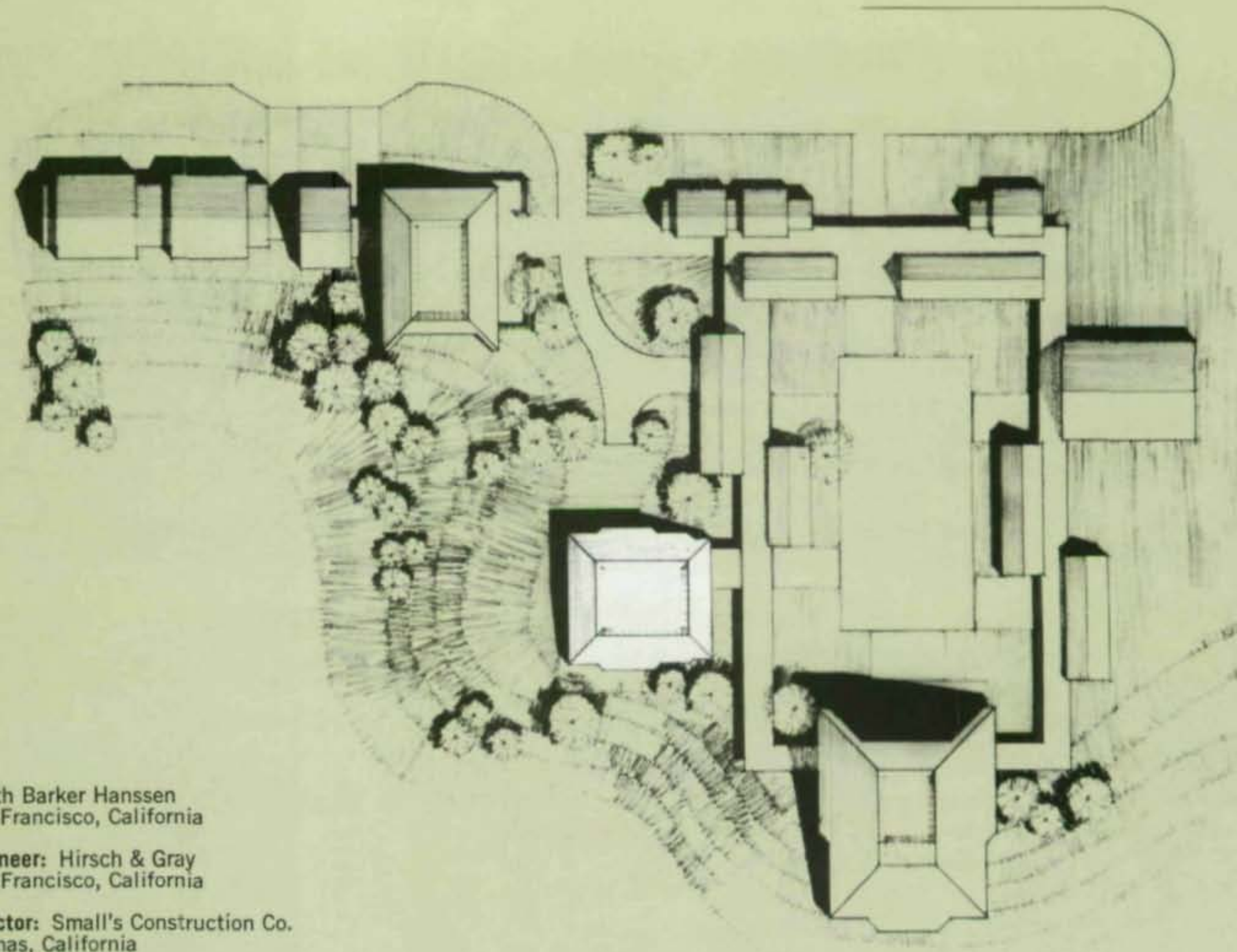
Mr. Smith of Smith Barker Hanssen and Mr. Hirsch of Hirsch & Gray were the library's principal architect and structural engineer, respectively.

**SOLUTION** — The simple rectangular plan for this small library grew out of the program's stated requirement of a simple open plan that allowed maximum future flexibility, and the need to compress the building to allow for expansion around the quad. The entrance level contains the circulation desk and reference area with reading and stacks on the lower level and mezzanine.

**TYPE OF CONSTRUCTION** — The entire building structure, walls and roof, is a space truss that provides for both a column-free interior space and flexibility in the location of openings. The 27-ft front cantilever and broad overhangs at the other sides made it possible to open up the library to the surrounding hills and view down to the ocean, despite the harsh sun conditions. The exterior of the truss is sheathed in wood shakes to make it compatible with the other buildings on the campus.

All wall and roof truss units, rhomboidal in cross section, are formed of 2½-in. steel angles and tees. They range in length from 22 to 81 ft and were shop-welded to full erection size. Shop fabrication of the truss units substantially reduced the on-site construction problems. Workers field-bolted 40 tons of steel trusses in only seven days.

The space truss, analyzed with the help of an EASE computer program, provides a 68 x 86-ft clear span building at a total cost of $154,000. The library structure encloses a split level ground floor and a 32-ft square, free-standing mezzanine.



**Architect:** Smith Barker Hanssen
San Francisco, California

**Structural Engineer:** Hirsch & Gray
San Francisco, California

**General Contractor:** Small's Construction Co.
Salinas, California

**Steel Fabricator:** Schrader Iron Works, Inc.
San Francisco, California

# 23rd ANNUAL AISC NATIONAL ENGINEERING CONFERENCE 1971

**SHERATON-CLEVELAND HOTEL • CLEVELAND, OHIO**

## Thursday, May 6, 1971 — Morning Session

**Fire Protection of Steel in Building Construction**

**Standard Fire Resistance Tests — Their Conduct and Interpretation**
J. A. Bono, Assistant Chief Engineer, Underwriters' Laboratories, Inc.

**Fire Insurance Company Evaluation of Building Design**
C. R. Anderson, Supervising Engineer, Continental Insurance Company

**A Designer's Approach to the Building Fire Problem and Building Design**
Ira Hooper, Seelye Stevenson Value & Knecht

**Fire Safety with Steel-Frame Structures**
Roger H. Wildt, Structural Consultant, Bethlehem Steel Corporation

**Panel Discussion**
Bono, Anderson, Hooper, Wildt

## Thursday, May 6, 1971 — Afternoon Session

**1971 T. R. Higgins Lectureship Award Paper**

**Cyclic Yield Reversal in Steel Building Connections**
Egor P. Popov, Professor of Civil Engineering, University of California at Berkeley

**Design — For Economy and Function**

**Recommended Design Procedure for Beams with Web Openings**
John Bower, United States Steel Corporation

**Steel Framed Parking Decks**
Roger W. LeRoy, Bethlehem Steel Corporation

**Practical Aspects of Plastic Design**
Horatio Allison, Consulting Engineer

**The Staggered Truss System — Structural Considerations**
John B. Scalzi, United States Steel Corporation

## Friday, May 7, 1971 — Morning Session

**Research — For Today and Tomorrow**

**Welding by Explosion**
Major Charles Lindbergh, Instructor of Civil Engineering, U. S. Air Force Academy

**Bracing of Steel Structures**
Joseph A. Yura, Associate Professor of Engineering, University of Texas

**Vibration and Deflection of Steel Bridges**
R. N. Wright, Associate Professor of Civil Engineering, University of Illinois

**The New High Strength Bolting Specification**
John L. Rumpf, Dean of Engineering Technology, Temple University

**Effect of Connection Costs on Steel Framing Systems**
William D. McCabe, Jr., Recipient, 1969 AISC Fellowship

## Friday, May 7, 1971 — Afternoon Session

**Notable Steel Structures**

**Space Age Structures in Steel**
Charles M. Thornton, Lev Zetlin Associates

**Railway Box Girder Bridge Erected by Launching**
Jackson L. Durkee, Chief Engineer-Bridges, Bethlehem Steel Corporation

**Standard Oil Building of Indiana**
E. Alfred Picardi, Partner, The Perkins and Will Partnership

**Steel Structures for the Seventies**
Robert O. Disque, Chief Engineer, AISC

# A Structural Engineer Looks at Fire Protection

by Ira Hooper, Consultant
Seelye Stevenson Value & Knecht

In the current swing to steel constuction caused by sharp increases in field labor costs of concrete, designers are confronted with the need to evaluate the performance and cost of fire protection. The performance of fire protection is now under close scrutiny and more stringent requirements may be expected. This article will examine some of the probems of present methods in order to suggest improvements.

**Average Costs**

Approximate costs for the usual fire protective methods in an average multilevel steel building are:

Spray:

| | |
|---|---|
| Heavy beams | — 5% of beam steel cost |
| Light beams | — 10% of beam steel cost |
| Avg. for beams | — 8% of beam steel cost |

Block:

| | |
|---|---|
| Heavy cols. | — 10% of col. steel cost |
| Light cols. | — 40% of col. steel cost |
| Avg. for cols. | — 30% of col. steel cost |

Combined Average:

10% of beam plus col. steel cost
6% of steel plus floor deck cost
1% of total building cost

The combined averages show that the effect of possible increases in the cost of fire protection will not be great. A cost increase of 50 percent in the cost of protection will raise the cost of the superstructure (steel plus floors) only 3 percent.

**Sprayed Protection**

When the first Underwriters Laboratories (UL) ratings were awarded to sprayed protection, designers rapidly adopted the new technique as an inexpensive solution to a formerly costly problem. And in the rush, competition for business among applicators lowered the quality standards along with the prices. Performance in the field has not been what it should be. On steel frames under construction, it is not uncommon to see bare patches where sprayed protection ought to be. The spray is knocked off by workmen making attachments to the steel members, such as pipe hangers or duct supports. Exterior beams and columns might be drenched by rain which loosens and washes away the spray.

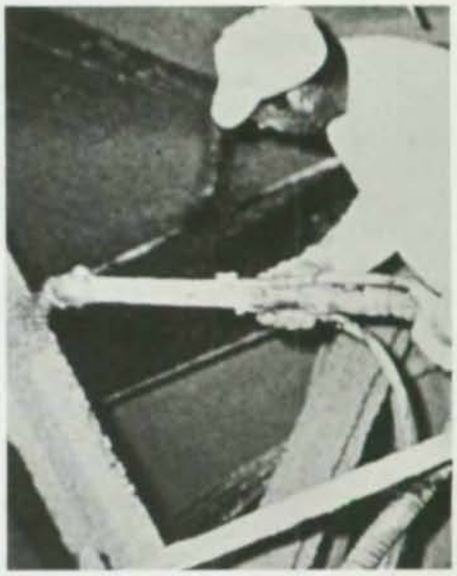
Where the spray coat has been dislodged, patching is not easy and it costs the applicator a part of the profit he anticipated. The engineer must be observant and insistent to get the patches made. Also, he must move quickly or the bald spots will be obscured by other construction before they are discovered.

Not enough attention is paid to the density and the thickness of the sprayed coat. Few persons are aware that the UL Building Materials List, January 1970 edition, has the following statement on page 186 regarding floor and beam protection. A similar statement on page 143 covers column protection:

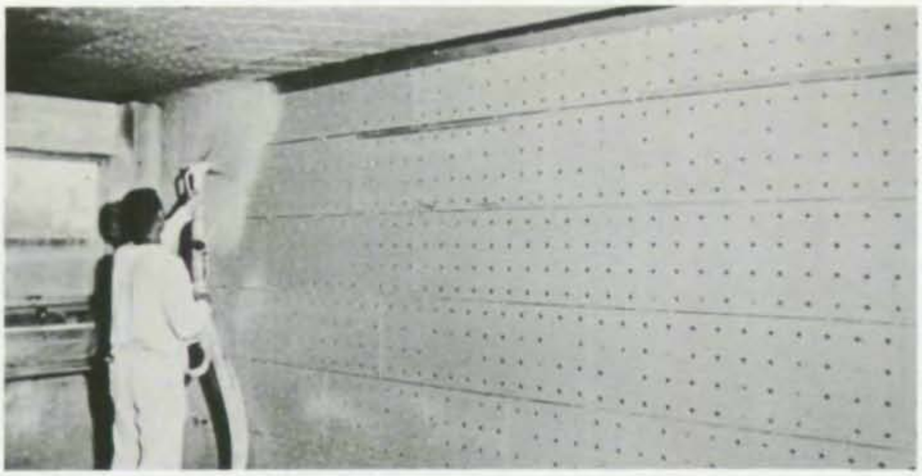
> Variation from the dimensions given in the designs may affect the classification. The dimensions given for the protective materials in the following assemblies are to be construed as the minimum for each classification. . . . The densities shown in the following illustrations for direct, field-applied materials should be obtained by removing at least 6-in. square sections randomly selected from the building, subjecting them to 120 F in an oven to constant weight usually 24 to 48 hours followed by accurate weighing, measuring and calculation of the density in lbs per cu ft.

These requirements of the UL should be strictly observed. Standard procedures must be developed to state the frequency and locations of the tests, who is to make the tests, and how they shall be paid for.

Many designers think they can save money by not painting steel that will be located in the building interior. Corrosion due to condensation is unlikely in the controlled atmosphere of a building. But delays in construction may occur and steel delivered to a delayed job may rust before it is erected. If the rust is not removed before spraying, it can expand and flake off the sprayed coat. Some engineers include a clause in the specifications stating that the rust must be removed before spraying. Since it is not clear who is to remove the rust, arguments arise among the steel erector, the spray applicator, and the general contractor.



*Application of sprayed protection*



*Plasterer spraying basecoat over perforated lath on wall*

To avoid these difficulties and shortcomings, all steel that will be sprayed should receive at least one coat of paint in the shop. The cost of $8 to $10 per ton is a small price to pay for insurance that life-saving fire protection will perform as anticipated.

The health hazards of sprayed materials have been widely publicized. The major offender is asbestos and its use is now restricted in New York City by stringent protective measures. It is expected that asbestos spray will be completely banned in New York City within one year. Several producers are in the closing phases of fire testing new formulations without asbestos. They expect to achieve the same ratings with the same thicknesses at little increase in cost. Some difficulty has been encountered with getting sufficient adhesion, but this is also now being solved. There is also a wet-mixed material that spreads no dust when sprayed.

**Present Alternates for Spray**

Some cities are considering the prohibition of all sprayed applications. Columns will not be much affected, since recent practice has been to encase them in masonry, gypsum block or gypsum board. The alternates to sprayed beam protection are concrete encasement, lath and plaster encasement, intumescent paint, or rated suspended ceilings.

Concrete encasement of beams is prohibitively expensive for many reasons:

1. The forms for the beam sides and bottom cost five times as much as sprayed protection.
2. The concrete costs three times as much as the spray.
3. Mesh-wrapping the beam costs about the same as the spray.
4. The extra dead weight of the concrete uses up 10 percent of the beam load capacity.

Taking all these effects into account, concrete encasement of a beam will cost 10 times as much as sprayed protection. In New York City, concrete encasement of a W16x36 beam will cost about $8 per lineal ft, while spraying can be done for about 75 cents per ft.

Plaster troweled on metal lath involves a great deal of field labor and usually costs about seven times as much as spraying. It gives a very good appearance and should be kept in mind for possible use in localities where labor rates are low.

Intumescent mastic has everything a designer wants. It is attractive, lightweight, dust-free, vandal-proof, and has excellent wearing ability; only a low price is lacking. When flame impinges on the 7/16-in. thick coating, it puffs up to form a thermal insulation. For a 2-hour rating, intumescent mastic costs about eight times as much as spray. In spite of its high price, intumescent mastic has its uses in special structures, such as hangars, and in the petrochemical field.

**Suspended Ceilings**

In many buildings, the choice between steel or concrete framing systems depends on whether a suspended ceiling will be provided in both cases. Exposed concrete can be an attractive material, but sprayed steel must be hidden from view except in mechanical spaces and utility rooms.

Suspended non-rated tile ceilings cost about $1 per sq ft; fire-rating adds approximately 20 cents per sq ft. If a suspended ceiling is not an architectural requirement, but is provided only for fire-protection of the steel system, its cost can reduce steel's economic advantage. But if a suspended tile ceiling is required for both steel and concrete systems, the additional cost for steel fire protection is only 20 cents per sq ft.

Gypsum wallboard ceilings are effective and inexpensive. The 3rd Quarter, 1970 issue of **Modern Steel Construction** contains an article that shows how multi-story steel apartment building structures can be built in New York City for $4.60 per sq ft. The cost includes a suspended, 3-hour rated wallboard ceiling at 50 cents per sq ft.

Penetrations through fire-rated ceilings for air diffusers and recessed lighting fixtures require special treatment. Air diffusers must have self-closing dampers, which requires adding a spring and a fusible link to each standard unit at a cost of a few pennies per sq ft of ceiling. The openings for

*Workmen spraying mastic on beam*

recessed lights are protected by installing tents of fire resistive material over the fixture at a cost of about 20 cents per sq ft of ceiling.

Suspended ceilings are not needed in warehouses, manufacturing plants, shopping centers, and similar buildings. In New York City, the Board of Education will discourage the use of suspended acoustic ceilings in classrooms because they present a tempting area for vandals.

With all the current emphasis on the systems approach, it is curious that a practical factory assembled enclosure has not yet been developed for the fire protection of steel beams. In addition to obtaining the usual advantages of factory production, the problem of air pollution would be avoided. The prefabricated units could consist of two sides and a bottom that enclose the beam and are attached to the floor slab by stud welds or powder-actuated fasteners. Or the units could be hung from studs welded to the bottom flange while the sides are braced by studs welded to the web.

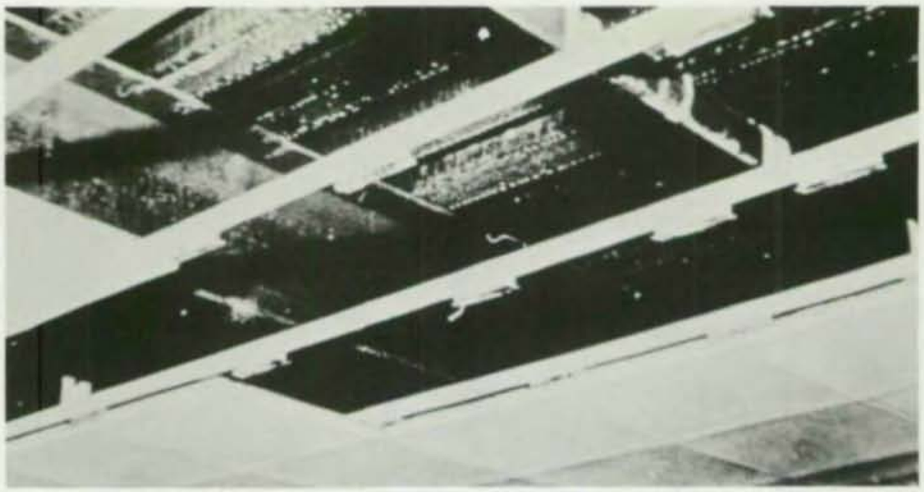
If the problems of providing all the size variations become too difficult, the bottoms and the sides could be prefabricated separately in standard width variations of two inches. The bottom unit would be installed first by stud welding to the bottom flange, and the sides would then clip into inserts in the bottom unit and would be braced by stud welds to the beam web.

### Insurance

One area in which designers particularly lack useful information is fire insurance. In any comparison of alternate systems, insurance cost for the life of the building is a large item. But, other than the residue of limited past experience, designers have few sources of information.

Rating bureaus cannot or will not readily quote rates on preliminary schemes. If quoting waits for final drawings, it will be too late to make major changes to reduce the insurance rate.

Designers need a concise, clear booklet that will list approximate insurance rates for the most usual occupancies and for the most usual types of construction. The booklet should be revised and reissued periodically about every two years. It would give designers a general understanding of comparative rates. If it is felt necessary, a statement can be included that final insurance rates must be obtained from a rating bureau to back up the general information in the booklet.



*Fire-rated acoustic tile ceiling showing exposed steel decking and beam*

Rating bureaus should revise their methods of operation to accommodate requests for opinions on approximate rates from designers based on preliminary sketches. At present, such contacts are not encouraged and the insurance industry is losing a valuable opportunity to inform and educate an important segment of its market.

### Poke-Through

Poke-through is a brutally simple solution to a difficult problem — if you want a fixture at a particular floor location, just break a hole through the floor at the very spot and bring the connection up from below. The distribution is made below the floor in the space above the ceiling of the floor below. It is simple, cheap, effective, and widely used in low-budget construction.

But designers are now learning that oversized holes ruin the effectiveness of the fire-resistant assembly by permitting excessive temperature rises above the floor. If poke-through is to be used, the specifications should include requirements for cutting the holes carefully and neatly with diamond core masonry drills; and the holes should be filled with concrete after the conduit or duct has been put in place.

### Who Chooses the System?

The whole subject of fire protection falls into an area between the responsibilities of the architect and the responsibilities of the structural engineer, with the result that it often does not receive the attention from either party that it deserves.

After the architect has formed a clear picture of what the owner wants, he chooses the approximate size of the building, the number of stories, the location on the property and the arrangement of the spaces. With this information, he consults the local code and chooses fire ratings that are given in tabular form. Most architects then proceed to choose structural and fire-protective systems in order to develop preliminary sketches.

This is the most engrossing stage of the building design and the architect is most anxious to arrive at a firm conception of his solution. He does not want to be interrupted by conferring with the engineer over information that he feels is still too vague. By the time the engineer does receive sketches, the architect has already invested a lot of time and resists suggestions of other systems.

There may be an argument for letting the architect choose the systems because he is involved in the occupancy classification. But the integrity of the structure must remain the responsibility of the engineer. And anything that can affect that integrity is the engineer's concern. Instead of waiting for preliminaries, the architect, engineer, and owner should jointly compose a written program of intended purposes and functions for the building so that appropriate systems can be selected. If the engineer is to be fully effective as a member of this team, he will have to become better informed on fire protection and fire prevention.

# A Bridge Designer's View of Structural Steel

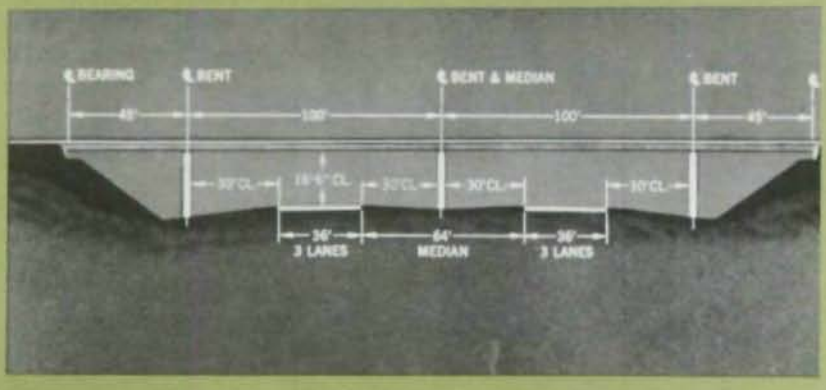
Based on a slide presentation by F. L. Breen, Jr., Project Control Engineer, State Highway Department of Georgia, delivered at the AISC National Engineering Conference in Pittsburgh, Pa., on April 30, 1970.

This is how they built a bridge in Georgia in the 50's.

This is how they build a bridge in Georgia today.
Both steel. Both to specifications.
And then the differences begin.

| 1953 | | | 1969 | | |
|---|---|---|---|---|---|
| | ASTM | AASHO | | ASTM | AASHO |
| ① | A7 | M94 | ① | A 36 | M 183 |
| | | | ② | A 242 | M 161 |
| | | | ③ | A 440 | M 187 |
| | | | ④ | A 441 | M 188 |
| | | | ⑤ | A 572 | M 223 |
| | | | ⑥ | A 588 | M 222 |
| | | | ⑦ | A 514/517 | – |

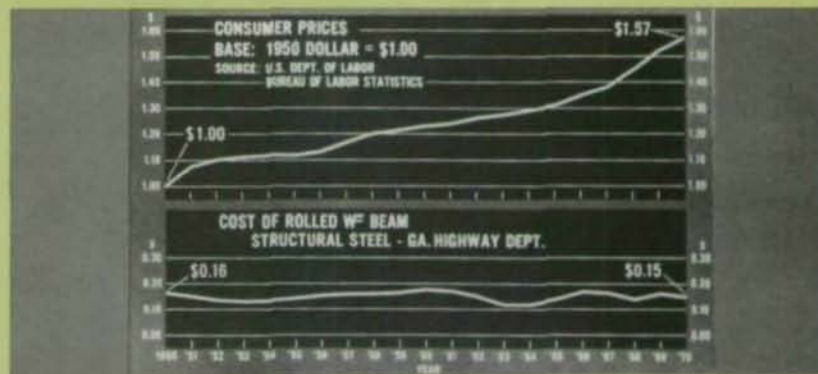
Why? It's the numbers game—with steel specifications. Eight numbers to replace A7, which wasn't good enough. ASTM A7 steel had a design strength of 33 ksi. The new steels start at 36 ksi and go up to 100 ksi.
Today's bridge sometimes takes on the quality of a recipe, where the designer mixes his steel for economy reasons, using steels of different strengths, as required, within the same structure.



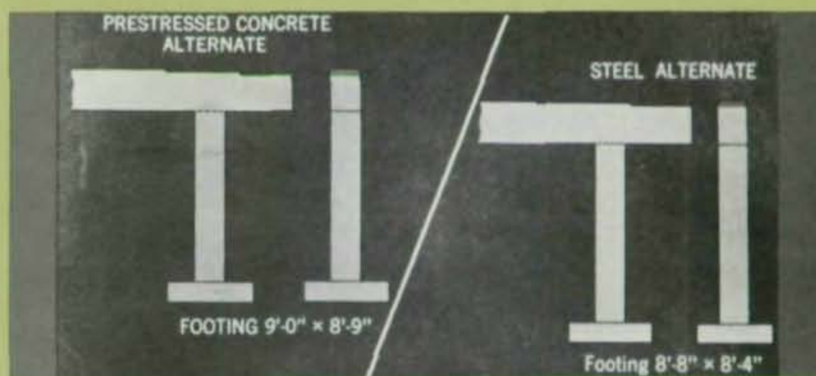

This additional strength is needed. Today's interstate highways are built for high speed travel. The unit width of road encompasses three-lane traffic and 30-ft recovery lanes or unreinforced slopes for cars going out of control.

Two-span, continuous units over difficult terrains are no problem. Prior to the recognized need for recovery lanes this bridge would have been a four-span continuous unit with bents at the shoulders, using rolled beams, at a sacrifice in safety requirements.

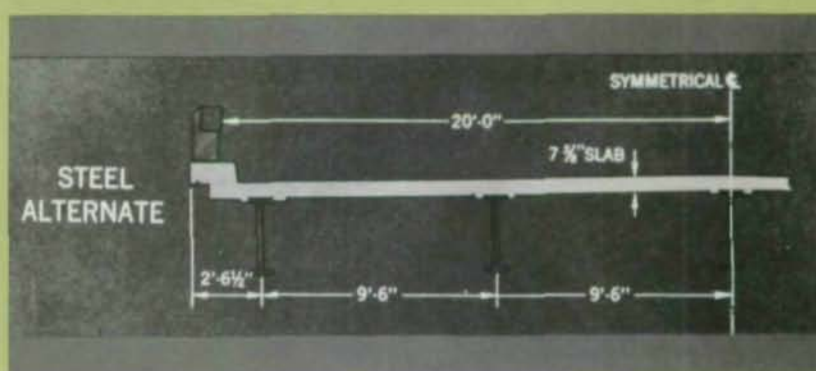
Although today's spans could have been bridged by A7 steel, the costs of cover plates, stiffeners, and connections to develop the necessary strength would have been very high. Today's steel, with its greatly increased strength to weight ratio, is actually cheaper by about 15%, because of improved design and fabrication techniques. Structurally, it's a best buy.



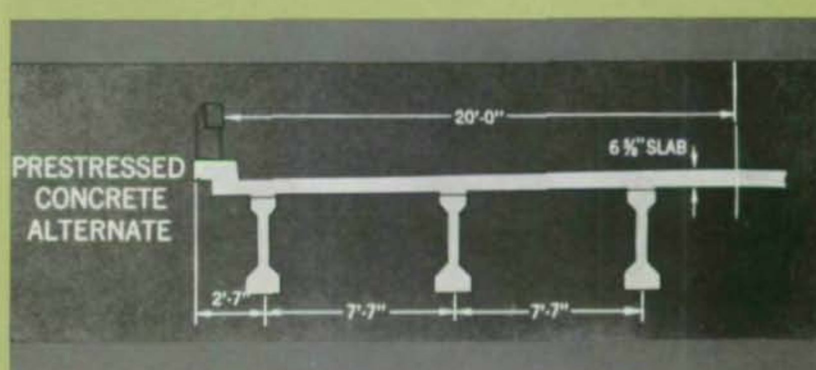

Concrete, too, has been improving in efficiency and, in 1969, the State Highway Department of Georgia, interested in making a comparison, let out for bid alternate superstructures of prestressed concrete and structural steel for the same project. The alternate designs included separate substructure designs, where the most significant difference between the two was in the footings, where those for the concrete superstructure were 9 ft-0 in. x 8 ft-9 in. and those for the steel were reduced to 8 ft-8 in. x 8 ft-4 in., since a steel structure is lighter.




The bridge consisted of twelve 70-ft spans, and the superstructures were the same except for beam and slab thickness. The steel alternate required five beams at 9 ft-6 in. centers with 7⅝ in. slab thickness.




The prestressed concrete required six beams at 7 ft-7 in. with a slab thickness of 6⅝ in. The outcome of the bidding? The first three low bids were based on the use of structural steel.



**AMERICAN INSTITUTE OF STEEL CONSTRUCTION**
**101 Park Avenue • New York, New York 10017**

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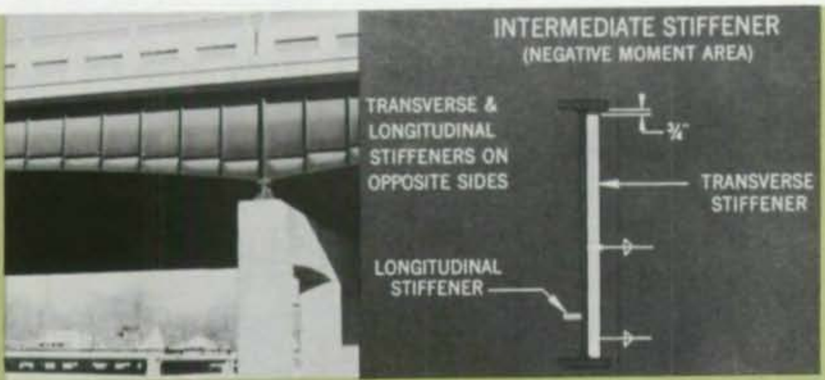
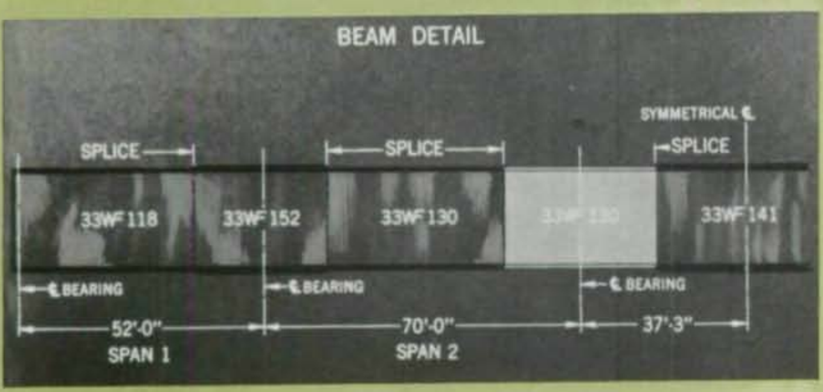
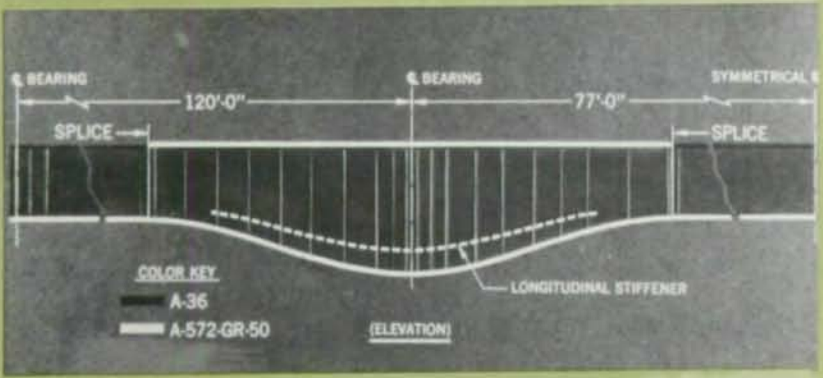



This bridge of the 50's was reinforced with longitudinal and transverse stiffeners on the same plane. This required cutting and fitting of the transverse stiffeners at points of intersection. Modern design techniques fully consider labor costs as well as those of material, and are more selective in placing steel effectively. By locating the transverse stiffener on one side of the web and the longitudinal on the other, considerable labor cost is saved.




An understanding of the savings inherent in the use of the new steels is a comparison of a 1956 beam with a beam of the 60's. Both are designed for the same spans. The equivalent 1956 beam is a W33X152 with a 9" x ½" x 14'-0" cover plate top and bottom. The use of high strength steel now permits lighter sections and eliminates the need for cover plates at a substantial saving in labor cost.




This hybrid girder demonstrates long span efficiency using new steels. Here, with a combination of A36 material in the web and A572 Grade 50 for the flange plates, a girder is developed for a stream crossing spanning close to 200 ft. The omission of stiffeners in the positive moment section at the expense of adding slightly more weight to the web and the use of constant thickness flange plates results in an appreciable savings in cost.

The 70's will see the increasing use of computer technology in bridge design. At present bridges are the tail end activities in the planning of a highway. A systems approach will allow the engineer to see the effect of alignment changes on bridge structures during planning and phases, and enable him to influence the design of the highway in its early phases.