MODERN STEEL CONSTRUCTION

November 1993

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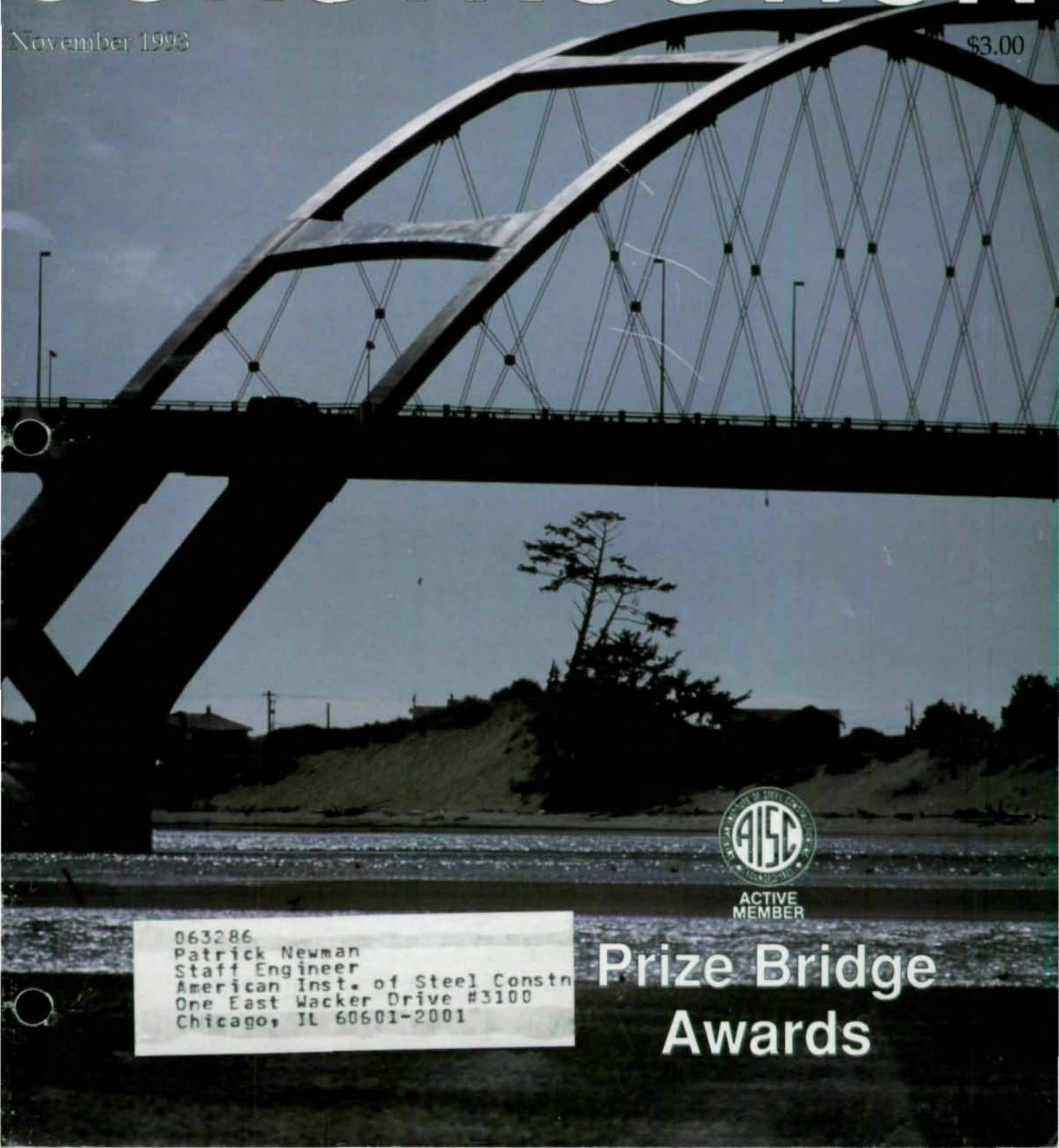
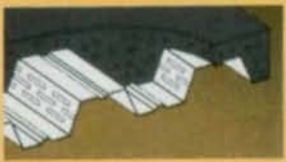
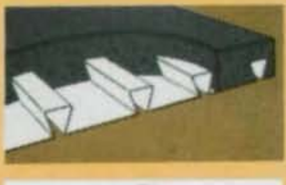


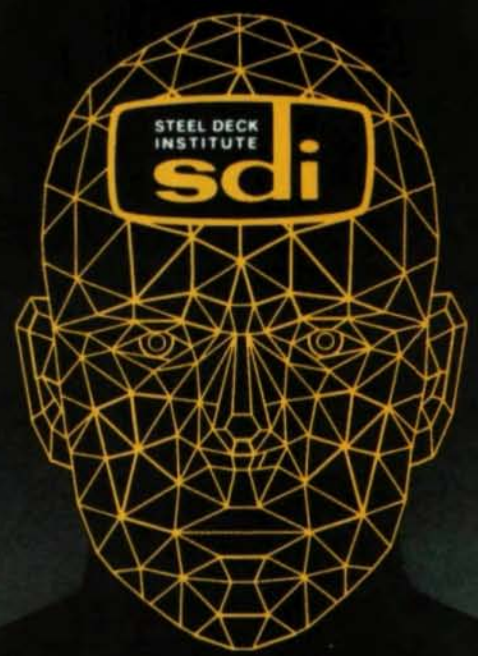
Prize Bridge Awards

WHO WE ARE

The Steel Deck Institute is comprised of manufacturers of steel floor and roof decks concerned with cold-formed steel products.







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- Maintain a full time Executive Director who supervises the programs developed through the combined efforts of the total membership.

for more information contact the

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WHAT WE DO

Since 1939 the Steel Deck Institute has provided uniform industry standards for the engineering, design, manufacture, and field usage of steel decks.

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Diaphragm Design Manual

Manual of Construction With Steel Deck

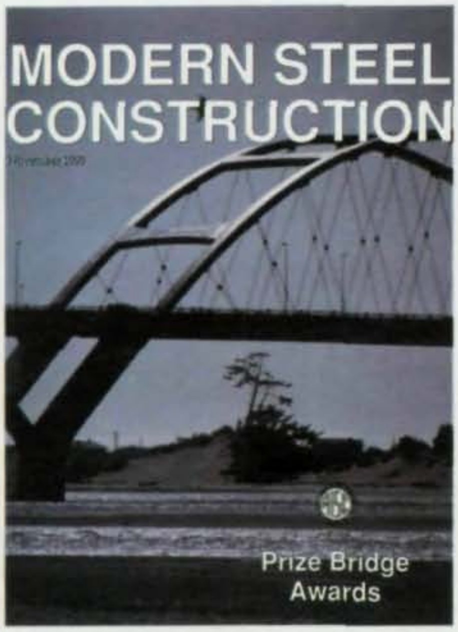
Composite Deck Design Handbook

Standard Practice Details

Members Literature Binder

MODERN STEEL CONSTRUCTION

Volume 33, Number 11 November 1993



Aesthetics played a large part in the design of a replacement bridge across Alsea Bay in Oregon. The bridge, designed by HNTB and fabricated by Fought & Company, won a 1993 AISC Prize Bridge Award in the Medium Span, High Clearance category. The story behind this exciting project begins on page 24.

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FEATURES

NEWS AND DEPARTMENTS

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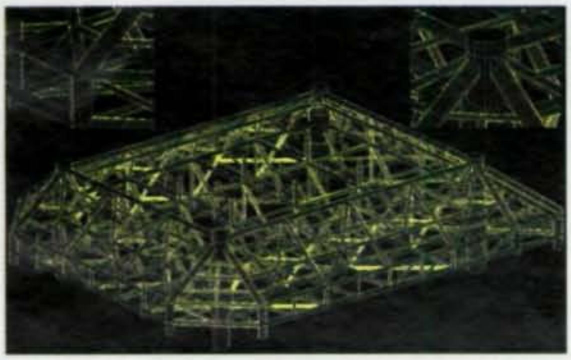
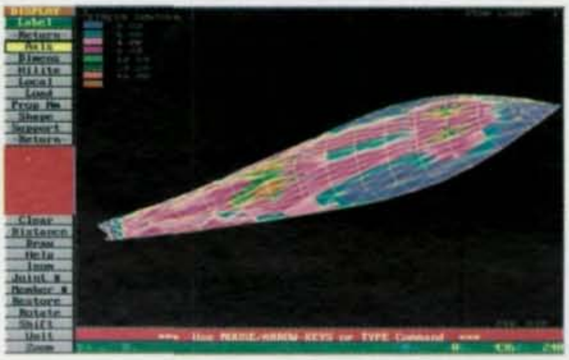
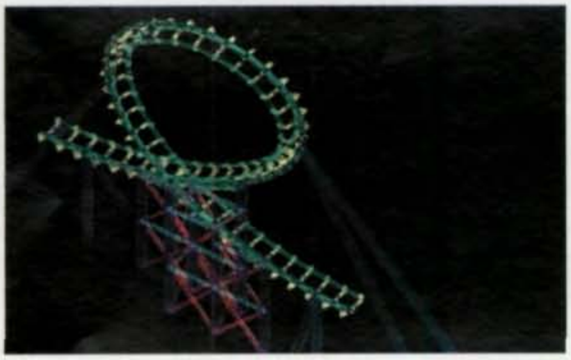
Structural Software For The Nineties



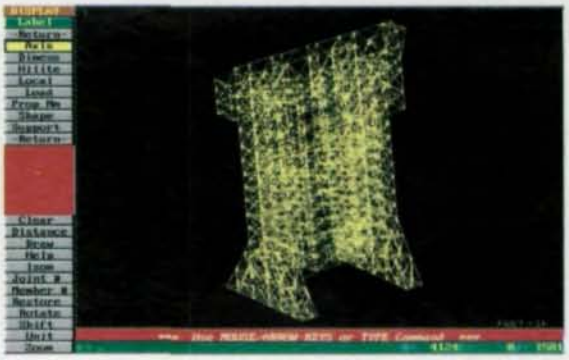
Offshore structure. Courtesy AKER Engineering, Norway



Concrete Canoe, Courtesy Drexel University, Pennsylvania



Roller Coaster. Courtesy Arrow Dynamics, Utah



NASA Launch Pad. Courtesy Brown & Root, Texas

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Favorite Bridges

I don't envy James E. McCarty, current president of ASCE. Or James J. Powers, president of Envirodyne Engineers in Chicago. Or Joseph Siccardi, staff bridge engineer with the Colorado DOT. Or Frederick Gottemoeller, a private consultant based in Maryland. Hour after hour, these four men sat in a large conference room in Chicago during this past summer and read entry after entry in the 1993 AISC Prize Bridge Award competition—rating bridges against each other and the standard upheld by previous winners.

To me, the toughest part of the judging comes near the end, when the judges must get together and pick the winners. While the decision is sometimes obvious (how hard could it have been the year the Golden Gate Bridge won?), more often than not there is substantial disagreement and discussion—and not just among the judges.

I won't argue, however, with the judges' choices. All of the winners are magnificent structures.

For pure dramatic impact, my favorite is the Alsea Bay Bridge in Oregon (page 24 and the cover photo). This two-hinged through arch with Vierendeel bracing was designed with the intent of becoming a local landmark. Or maybe my favorite is the Veterans Administration Skybridge (page 60), also in Oregon. This cable assisted, three-dimensional truss stretches more than 600' across a 150'-deep ravine.

The most interesting of the winners, though, was definitely the Green Bay and Western Railroad Bridge #95.6 in Wisconsin (page 52). For a variety of reasons, this 12-span, 626'-long replacement bridge needed to be placed in the same location as the existing bridge. However, the bridge could only be out of service for 75 hours at a stretch, so careful coordination was needed to install each span during that tight window. Or maybe the most interesting was the I-70 Eastbound Mainline Approach Structure in Colorado's Glenwood Canyon (page 42). I've been up there, and am amazed that anything could be built in that area.

Or maybe...well, take a look for yourself. The 17 Award winners and Merit winners are presented beginning on page 19. Congratulations to all of the winners. **SM**

Steel Interchange

Steel Interchange is an open forum for *Modern Steel Construction* readers to exchange useful and practical professional ideas and information on all phases of steel building and bridge construction. Opinions and suggestions are welcome on any subject covered in this magazine. If you have a question or problem that your fellow readers might help to solve, please forward it to *Modern Steel Construction*. At the same time feel free to respond to any of the questions that you have read here. Please send them to:

Steel Interchange
Modern Steel Construction
1 East Wacker Dr.
Suite 3100
Chicago, IL 60601

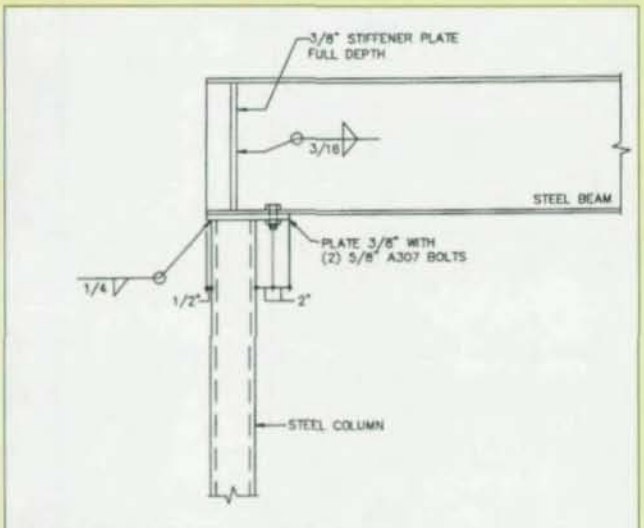
Answers and/or questions should be typewritten and double spaced. Submittals that have been prepared by word-processing are appreciated on computer diskette (either as a Wordperfect file or in ASCII format).

The opinions expressed in *Steel Interchange* do not necessarily represent an official position of the American Institute of Steel Construction, Inc. and have not been reviewed. It is recognized that the design of structures is within the scope and expertise of a competent licensed structural engineer, architect or other licensed professional for the application of principles to a particular structure.

Information on ordering AISC publications mentioned in this article can be obtained by calling AISC at 312/670-2400 ext. 433.

The following responses to questions from previous *Steel Interchange* columns have been received:

When designing a horizontal beam resting on columns with an unbraced compression top flange, may full-height web stiffeners at the bearing ends provide bracing to the compression flange without any intersecting beams? (See Detail)



COLUMN TO BEAM CONNECTION

This is in response to the answer by Mark W. Cunningham that appeared in the July 1993 *Steel Interchange* column. That answer apparently approves of a seated beam connection with no lateral support for the web or top flange. It has been my belief that some type of support for the upper part of the beam should always be provided at seated connections. This belief is buttressed by comments in almost any text on steel design as well as by statements in AISC publications, e.g., the first line on page 4-35 of the 9th Edition, *Manual of Steel Construction - Allowable Stress Design and Plastic Design*. The purpose is to provide some lateral stability so that the beam can not "roll" on its support with prevention of web buckling as a secondary consideration. I, too, have sometimes wondered if full height web stiffeners at the beam seat could be considered to serve the same purpose.
Frank C. Hartzell, Jr.
Wynnewood, PA

This response is intended to offer an opinion on the above question as well as the response by Mark W. Cunningham in the July 1993 *Steel Interchange* column. The July answer downplays the significance of a top flange restraint at the end of the span.

I believe Mr. Cunningham misunderstood the question. The inquiry specified that the top flange of the beam was unbraced. Common sense suggests that if the top flange is unbraced and the ends are unrestrained the possibility of the beam "rolling over" is significantly greater than if the beam were restrained at the end. To extend the column buckling analogy given in the July answer, consider the classical pinned-end column. The pinned end of a column is a restraint from lateral displacement while allowing rotation. If the end of a column to be tested were placed on a roller it would simply fall out of the testing device. In a similar sense, the end of the compression flange needs to be restrained. The matter is one of boundary conditions, not the magnitude of compressive stress.

Regarding the original question, I believe the stiffeners are required for end restraint of the beam. In typical clip angle framing to the side of a column, top flange lateral restraint is provided by connection of the clip angle to the upper one-third portion of the beam web. For the beam seat detail, even with stiffeners, a large beam placed on a relatively light column would not be adequately restrained since the stiffeners derive their restraining capacity from the bending stiffness of the column below.

I am not aware of applicable code requirements or experimental or theoretical studies on this subject. It would be worth a literature search. If the information is not already available, a study of relative beam, column, and stiffener properties required to provide the required restraint would be worthwhile. As stated by Mr. Cunningham, the derivations I have seen require axial stiffness of a lateral brace to be only a small percentage of the top flange stiffness. A relationship relating the equivalent rotational resistance of

Steel Interchange

the column and the stiffeners to the axial stiffness of an adequate lateral brace would be easily applied in practice.
Gordon C. Glass, P.E., S.E.
S.E.A. Engineers, Inc.
Lexington, KY

The 9th Edition ASD Manual states on page 4-84 that, when using single angle connections, "Where possible, the distance between the centers of the top and bottom connecting bolts should equal or exceed one-half the T-distance of the supported member to guard against overturning of the beam." Alternatively, Volume II - Connections of the Manual says, on page 3-96, "To guard against overturning of the beam, it is recommended that the distance between the centers of the top and bottom connecting bolts be equal to or exceed one-half the T-distance of the supported member when possible. This is not a Specification requirements and the fabricator may elect to satisfy T/2 by using the more traditional length of the connecting angle."

This is somewhat confusing. Why is there a difference in the two publications?
John Simon, P.E.
Chantilly, VA

When single angle connections were introduced into the 9th Edition of the *Manual of Steel Construction - Allowable Stress Design and Plastic Design*, the requirement that T/2 be met, if possible, by using the distance from the centers of the top and bottom bolts was arbitrarily included in the design aid. When the AISC Committee on Manuals, Textbooks, and Codes was developing Volume II, it was called to our attention that this is more restrictive than any other one sided connection where T/2 is satisfied by the more traditional method of using the length of the connection. It is believed that the clamping action of the bolts in the connection, even when snug tight, approximates the length of the connection material, making the more traditional method of satisfying T/2 acceptable.

To be consistent, the Committee has now revised this statement and T/2 for single angle connections may be met using the dimension of the connection angle. References to the centers of the bolts will be deleted in future printings of both publications. T/2 is not a Specification requirement and is violated by connection designers as joint geometry dictates such as in a deeply coped beam. When this is done, it is important to be sure that the beam is laterally restrained by struts, bracing, metal deck or other means to guard against overturning.
Barry L. Barger
Vice Chairman
AISC Committee of Manuals, Textbooks, and Codes

AWS D1.1-92 Section 8.8.5 states, "Fillet welds deposited on the opposite sides of a common plane of contact between two parts shall be interrupted at a corner common to both welds." Is this necessary?

This is a comment on Richard W. Mudd's response (*Steel Interchange* August 1993) to a weld detail which showed an all-around weld symbol (*Steel Interchange* April 1993). He states that this violates Section 8.8.5.

AWS D1.1-92, paragraph 8.8.5 is ignored in the offshore industry in the North Sea and also Southeast Asia. Of my 20 years in steel construction supervision of probably 50,000 short tons of above water level steel Offshore structures all fillet welded members are always continuously welded around the perimeter. The reason is to seal the overlapping surfaces. With respect to paragraph 8.8.5, it shall continue to be ignored in the offshore industry unless qualified to allow seal welding.
Roger Steele
Unocal Thailand, Ltd.
Bangkok, Thailand

New Questions

Listed below are questions that we would like the readers to answer or discuss.

If you have an answer or suggestion please send it to the *Steel Interchange* Editor, Modern Steel Construction, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001.

Questions and responses will be printed in future editions of *Steel Interchange*. Also, if you have a question or problem that readers might help solve, send these to the *Steel Interchange* Editor.

In designing the connection of a tubular beam to a tubular column for a required moment, the provision of AWS Chapter 10 were not met because the beam width was only a fraction of the column width. Can this connection be made by simply adding a plate to the end of the beam (larger in dimensions than the beam), and if so, what is an appropriate design approach to size the plate and the welds between beam to plate and column to plate.
Howard Epstein
The University of Connecticut
Storrs, CT

When welding to AWS D1.1 requirements what is a "seal" weld and what are the applicable inspection criteria for same?
Roy Hogan
ABB Environmental Systems
Knoxville, TN

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NSCC 1994: From Explosions To Long Span Roofs

One of the hottest topics among steel designers—the effect of blasts on steel structures—will be the subject of a plenary session at the 1994 National Steel Construction Conference. Other sessions will cover long span roof structures and bridge construction life cycle costs. The conference will be held on May 18-20 in Pittsburgh.

An expected highlight will be a presentation on the second day of the conference by Lester Robertson, president of Leslie E. Robertson Associates and structural engineer on the project and Jack Daly of Karl Koch Erecting Co., Inc. on the World Trade Center Explosion. The session will take a close look at the design of the structure and the effect of the explosion on the steel superstructure, as well as the required retrofit work.

The superb line-up of technical sessions also should attract a lot of attention from the expected attendance of more than 1,000 engineers, architects, fabricators and educators.

Sixteen technical sessions will be offered, including:

- *Building Innovations*, featuring Tom Sputo, a Florida-based consulting engineer, speaking on innovations in low-rise design;
- *Lean Engineering*, featuring Mark Holland of Paxton & Vierling, plus a design engineer, discussing connection economics;
- *Quality Certification: Directions for the '90s*, featuring Tom Schlafly, AISC Director of Fabricating Operations & Standards, discussing new revisions to the AISC Quality Certification program;
- *Effective Use of High-Strength Steel in Building Construction*, featuring Abraham J. Rokach, AISC Director of Building Design, who will be discussing a new ASTM structural material Specificiation.
- *Experience from Wind Damage & Design Load Requirements*, featuring R.J. Willis of AISI and Lawrence Griffis of Walter P. Moore and Associates;
- *Electronic Data Transfer*, featuring Harry Moser, Dupont, and Sayle Lewis, Fluor Daniel, will discuss the hot issue of tranferring data from mills to fabricators and from engineers to fabricators, and vice versa.

Continuing Education Units (CEUs) will be offered for attendees of the technical sessions.

Also, a live version of the Steel Interchange section of this magazine will be presented. The session will be moderated by Robert O. Disque, Besier, Gibble & Norden, and will be limited to questions on connections. Geoffrey L. Kulak, University of Edmonton, will handle questions on fasteners, while Omer Blodgett, The Lincoln Electric Company, will field questions on welding.

Another important session, "Bridge Construction—Myths & Realities of Life Cycle Costs," will be offered by Robert Nickerson, former Chief of the Structures Division of FHWA.

The conference will kick off on May 18 with a presention by Dan Cuoco, Thornton-Tomasetti, on Long Span Roof Structures. During that same session, the 1994 T.R. Higgins award will be presented and the first of a series of six lectures will be given.

In addition to the conference, an Exposition will run concurrently. More than 100 booths are expected and more than a dozen exhibitors are expected to offer technical product sessions.

For more information on the conference, call AISC at (312) 670-5421 or fax a request to AISC at (312) 670-5403.

New Metric Design Aids

Designers, fabricators and contractors working on government and other projects where metric designations are required will appreciate a new publication from AISC. "Metric Properties of Structural Shapes with Dimensions According to ASTM A6M" includes all of the shapes currently rolled in the United States. To ease the transition to metric, both SI and U.S. Customary units are shown for all members.

The format follows the AISC "Manual of Steel Construction" Part I approach with all the necessary dimensions shown on tables in a two page layout. The dimensions and properties follow the guidelines of ASTM A6M.

The 97 page booklet includes all W-shapes as well as M, S, HP, channels, angles, pipe, and tube. Properties and dimensions for structural tees and double angles also are also included. U.S. Customary units are also shown for all members to ease the conversion to the metric system.

The properties and dimensions booklet can be used along with the AISC draft document, "Metric Conversion: Load and Resistance Factor Design Specification for Structural Steel Buildings," which is a 159-page metric version of the 1986 LRFD Specification.

Congress has mandated that soon all federal construction projects will have to be designed using the metric system, and many projects are currently under way requiring the use of metric. As the transition progresses, it is expected that many private projects will follow suit. Also, the new AISC publications are useful for designers working on foreign projects.

"Metric Properties of Structural Shapes with Dimensions According to ASTM A6M" is available from the AISC Publications department at (312) 670-2400, ext.433 for $16, while the draft document, "Metric Conversion: Load and Resistance Factor Design Specification for Structural Steel Buildings," is available for $10 from AISC at (312) 670-5411.

What Went Wrong For Amoco?

For almost 18 months beginning in April 1990, black scaffolding made a dramatic juxtaposition against the white cladding of the 82-story Amoco Building in Chicago. During that time, 44,000 Carrera marble panels were removed and replaced with Mount Airy granite panels.

A four-hour seminar on November 11 at the Fairmont Hotel in Chicago will, for the first time, discuss the reasons why the replacement was done, the design of the new cladding, the methods and logistics of the recladding, the impact on the building's owner, and the lessons learned. Presenting the seminar will be representatives from the building's owner, architect/engineer, contractor and construction manager.

The seminar will cover:

- Initial studies and project information, including the marble design, inspection and testing, organization of the project team and public relations;
- Design of the new system, including temporary measures, alternatives considered, material selection, structural design and documentation;
- Site logistics and construction parameters, including hoisting/material handling, scaffolding, scheduling, safety and contingency plans;
- Post construction considerations, including uses of marble, feedback on construction, lessons learned, and the contributions to the building industry.

For more information, or to register, contact: Ian Chin at (312) 372-0555.

CALENDAR

The final three "New Ideas In Structural Steel" seminars will be held in November.

The program, which has a CEU value of 0.4, includes four lectures: Low-Rise Buildings; Connection Manual—Volume II; Eccentric Braced Frames; and Partially Restrained Connections.

The seminars are scheduled for:

Des Moines 11/3
El Paso 11/16
Oklahoma City 11/18

For more information, call AISC at **(312) 670-2400**; fax 312/670-5403.

It's also not too late to attend the "Steel Design Seminar Series: Design of Steel Connections", conducted by the **Steel Structures Technology Center**. The one-day, professional level program discusses joint analysis methods, design criteria and methods, constructability and economical design. Seminars are scheduled for:

Kansas City 11/4
Costa Mesa, CA 11/29
Los Angeles 11/30
San Francisco 12/2
Sacramento 12/3

For more information, contact: Steel Structures Technology Center, 40612 Village Oaks Dr., Novi, MI 48375 **(313) 344-2910**; fax 313/344-2911.

AISI and AISC Marketing are sponsoring a bridge training course featuring Robert L. Nickerson, former Chief of the Structures Division of FHWA. The full-day course, "Cost Effective Design of Steel Bridges," includes four modules: Design & Detailing; Material Selection; Fatigue and Fracture—Design & Retrofit; Joints, Scuppers & Innovative Design. Course material is based on actual case histories. The courses currently are scheduled for:

Austin, TX 11/4
Jefferson City, MO 11/19
Sacramento, CA 11/30
Olympia, WA .... 12/2 & 12/3
Boston, MA 12/9

For more information, contact Jeri Irwin at **(312) 670-5433**; fax 312/670-5403.

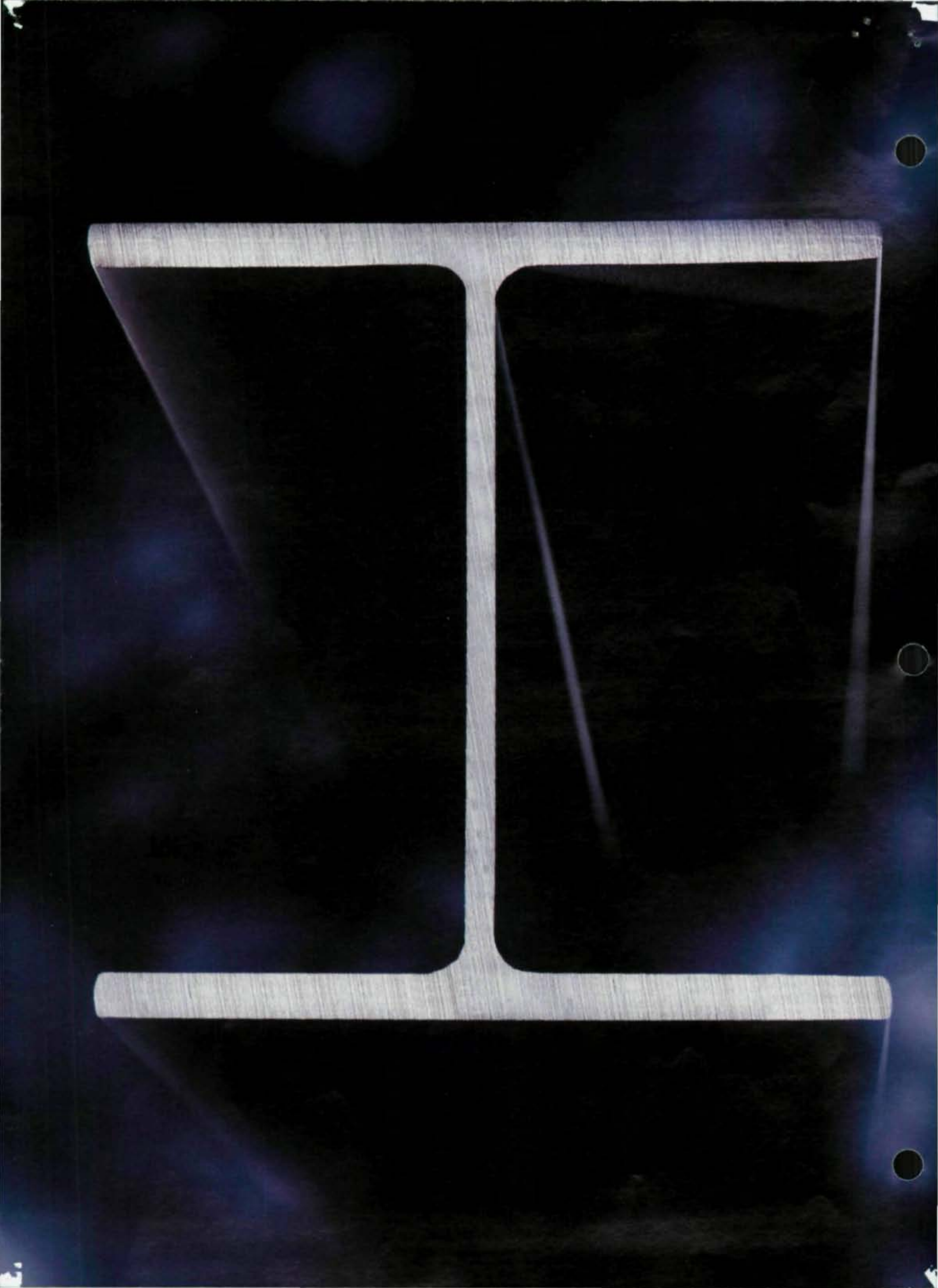
For high-rise building aficionados and fans of building fiascoes, the **Chicago Committee on**

CALENDAR

High-Rise Buildings is sponsoring an all-day seminar on "Amoco Building Recladding—Lessons Learned." For more information on this November 11 meeting, call Ian Chin at **(312) 372-0555**; fax 312/372-0873.

One of this year's highlights for anyone interested in bridge design or fabrication is **The National Symposium on Steel Bridge Construction** in Atlanta Nov. 11-12. Registration costs $275 plus $50 for the optional pre-symposium workshops. For more information, contact: AISC, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001 **(312) 670-2400**; fax 312/670-5403.

Bridge Coatings, Fracture Critical Design, LRFD, and Life Cycle Costs vs. Performance will be discussed at the next **Steel Bridge Forum** on Nov. 15 in Trenton N.J. Contact: Camille Rubiez at **(202) 452-7190**.



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AISC Prize Bridge Competition

From the more than 100 entries in the 1993 AISC Prize Bridge Competition, a jury of four bridge experts awarded nine Prize Bridge Awards and eight Awards of Merit.

The winners ranged from a 660'-long pedestrian bridge connecting two medical centers across a deep ravine to twin 2,703'-long (909'-long main span) tied-arch bridges across the Mississippi River to a railroad bridge reconstruction project where each span could only be taken out of service for a maximum of 75 hours. Descriptions and photographs of all 17 winners are included in the pages that follow.

The members of this year's jury were:

- Frederick Gottemoeller, P.E., president of Frederick Gottemoeller & Associates, Columbia, MD, and the author of several articles on bridge aesthetics;
- James E. McCarty, P.E., a consulting civil engineer, and current president of ASCE;
- James J. Powers, P.E., president of Envirodyne Engineers, Inc., Chicago;
- Joseph Siccardi, P.E., Staff Bridge Engineer with the Colorado Department of Highways.

The winning Prize Bridge designers will be honored at a banquet during the 1993 National Symposium on Steel Bridge Construction in Atlanta on November 11-12 For more information on the symposium, call AISC at (312) 670-2400 or fax a note to (312) 670-5403.

The following AISC members fabricated a winning bridge:

- Harris Structural Steel Co.
- Fought & Company
- Keiser Steel Fabricators, Inc.
- Carolina Steel Corp.
- Grand Junction Steel
- Utah Pacific Bridge & Steel Corp.
- Canron Construction—Western
- National Eastern Corporation
- Utah Pacific Bridge & Steel Corp.

Congratulations to all of the winning designers, fabricators, erectors, contractors and owners.

Pictured, from left to right, are this year's jurors for the AISC Prize Bridge Competition: Joseph Siccardi, James E. McCarty, James J. Powers and (seated) Frederick Gottemeoller.

AISC Prize Bridge Award

Long Span

I-255 Over The Mississippi River

Design firm:	Alfred Benesch & Company
General contractor:	Bristol Steel & Iron Works, Springfield, IL
Steel erector:	Triune Steel Erectors, North Onalaska, WI
Owner:	Illinois DOT/Missouri Highway & Transportation Dept.
Total cost:	$61 million
Span lengths:	909' max.
Roadway widths:	52'
Steel wt./sq. ft. of deck:	95 lbs/sq. ft.
Vertical clearance:	61'-2"
Steel tonnage:	20,363 tons
Structural system:	Steel tied arch main span with plate girder approach spans
Innovative concepts:	Design of tied arch based on rigorous "large deflection" analysis; arch & tie ribs were "pre-stressed" so neither member would experience flexural stresses

After more than two decades of planning, the southern segment of the interstate bypass around St. Louis is complete. The I-255 Jefferson Barracks Bridge over the Mississippi River links I-270 in Missouri with I-255 in Illinois. The project consists of twin 4,019'-long bridges with 909'-long steel tied arch main spans. Each structure carries three traffic lanes, plus shoulders, replacing an obsolete two-lane, cantilever girder truss bridge.

Each bridge is a 15-span structure resting on 14 piers and two abutments. The superstructure consists of an 8" deck supported by 3,109' of welded plate girder approach spans and a 909'-long tied arch main span over the navigation channel. The Illinois approach spans are carried on 12 piers for a total distance of 2,703'. This long approach from the American Bottoms flood plain has a 2.5% grade from its start to pier seven.

The 52'-wide concrete deck is supported on the approaches by six-girder spans with a web depth of 6'-6" at the abutments and increasing to 10' before meeting the channel span. On the channel span, the roadway is constructed atop a steel frame suspended from the steel arches. The massive I-shaped ties have a total out-to-out depth of 12'-5". These girders have a shipping length in the range of 40' to 50' and are spliced using conventional bolted splices.

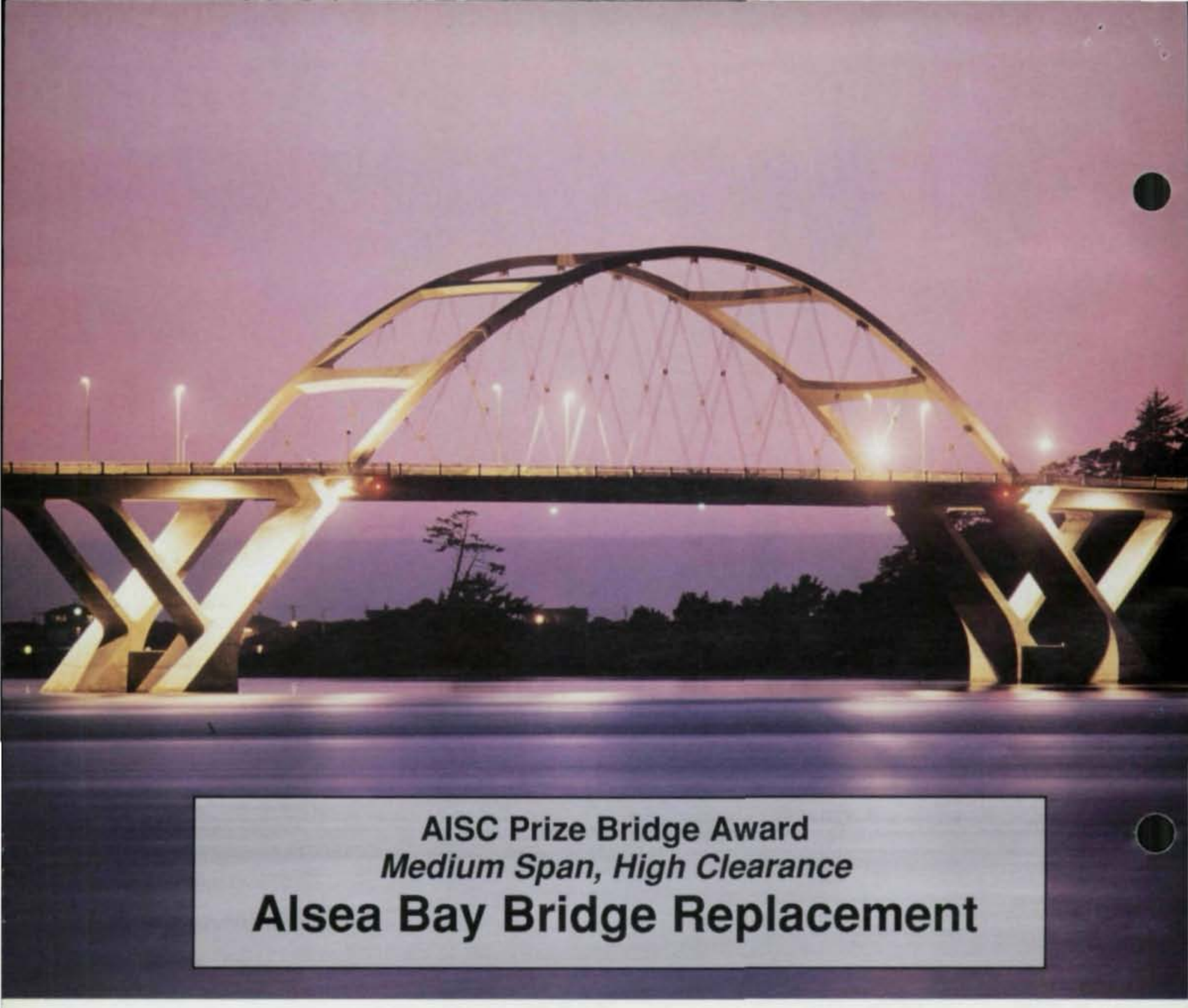
The cables suspending the tie beams and roadway are tied to the deck in 17 locations on each side, for a total of 34 per bridge. Each cable is capable of supporting 250 tons. Galvanized structural strands are attached to the deck steel at each location in an 18"x15" rectangle. To improve aesthetics, the upper anchorages are concealed within the arch.

The arch and main span rises 180′ above the deck and 280′ above the mean river level. The arch-ribs and lateral struts are box beams 5′-6" deep and composed of 2" thick weathering steel. Inspectors and maintenance personnel are able to climb throughout the interior of the structure via inclined ladders.

There were two major innovations in the design of the project. First, computer programs were written to consider the large deflections inherent in a tied arch structure and to establish the riser and hanger spacing that would optimize the arch's efficiency. Second, the bridge members were "prestressed" during fabrication; that is, the effect of dead load was calculated so that no shortening of the arch-rib or elongation of the tie would occur. This process saved approximately 150 tons of steel.

The approach spans arrangement, length and superstructure also were optimized by a computer program specifically designed for this task. The program helped to determine that the final design of three- and four-span continuous steel stringer units, with span lengths of 250′ to 300′, would result in the most economical construction.

Unlike other tied arch bridges, the girder was I-shaped instead of a traditional box girder. Box girders usually are used due to their inherent torsional stiffness. However, the designers of this bridge determined that an I-shaped girder, working in conjunction with the other components on this project, could provide the same stability and dynamic response. The advantages of the I-girder, though, were greatly simplified connection details and fabrication, as well as a reduced potential for harmful secondary stresses.



AISC Prize Bridge Award

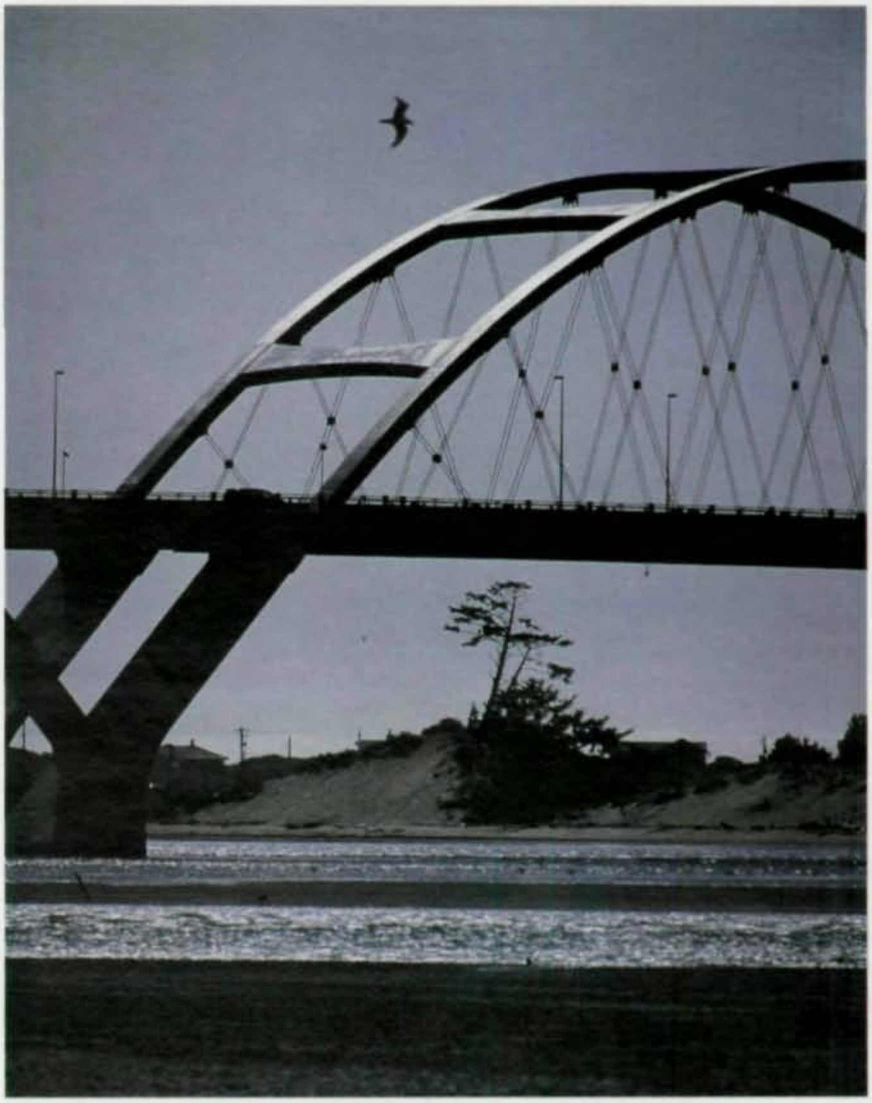
Medium Span, High Clearance

Alsea Bay Bridge Replacement

Design firm:	HNTB Corporation, Bellevue, WA
General contractor:	General Construction Co., Seattle
Steel fabricator:	Fought & Company, Tigard, OR
Steel erector:	Cooney/McHugh, Federal Way, WA
Owner:	Oregon Department of Transportation
Approximate cost:	$43 million
Steel wt./sq. ft. of deck:	86 lbs.
Span lengths:	350'
Roadway widths:	64'
Vertical clearance:	66'
Steel tonnage:	1,330'
Structural system:	Two-hinged through arch with Vierendeel bracing
Innovative concepts:	Steel arch was designed to accommodate constantly moving Y-shaped piers

Visual appearance was a crucial component of the design for a replacement bridge across Alsea Bay near Waldport, OR. Tourism is an important part of the local economy and it was important the new bridge have the impact of a new landmark.

Renderings and approximate costs of 17 alternate designs—ranging from a modern cable-stayed to a classic deck arch to a traditional box girder—were prepared and presented to the public, a citizen's advisory committee and the state DOT staff. After careful consideration, a replacement bridge featuring a two-hinged steel through-arch main span 350'-long, with Vierendeel bracing, was chosen. The approaches are post-tensioned concrete box girders, giving the bridge a total length of 2,910' and a four-lane width, with a sidewalk on each side.



Economical Steel

Although both concrete and steel alternatives were designed for the center main span, no bids were made on the concrete alternative due to its high cost. The steel alternative was much more economical both because it required less falsework for construction over the bay and because it substantially reduced construction time. Reduced falsework had another benefit as well: The Alsea Bay marine environment was spared some of the intrusiveness that is usually unavoidable in major construction.

According to the designer: "Steel allowed the aesthetics of the bridge to become affordable in an environmentally friendly manner."

The main span of the new bridge recalls the historic tied arches of the original bridge and the concrete Y-shaped piers form a contemporary version of the deck arches of the original structure. Although these two components met the project's aesthetic requirements, their combination posed a unique problem during design. The Y-shaped piers that support the arch are constantly moving due to temperature variation and creep of the concrete.

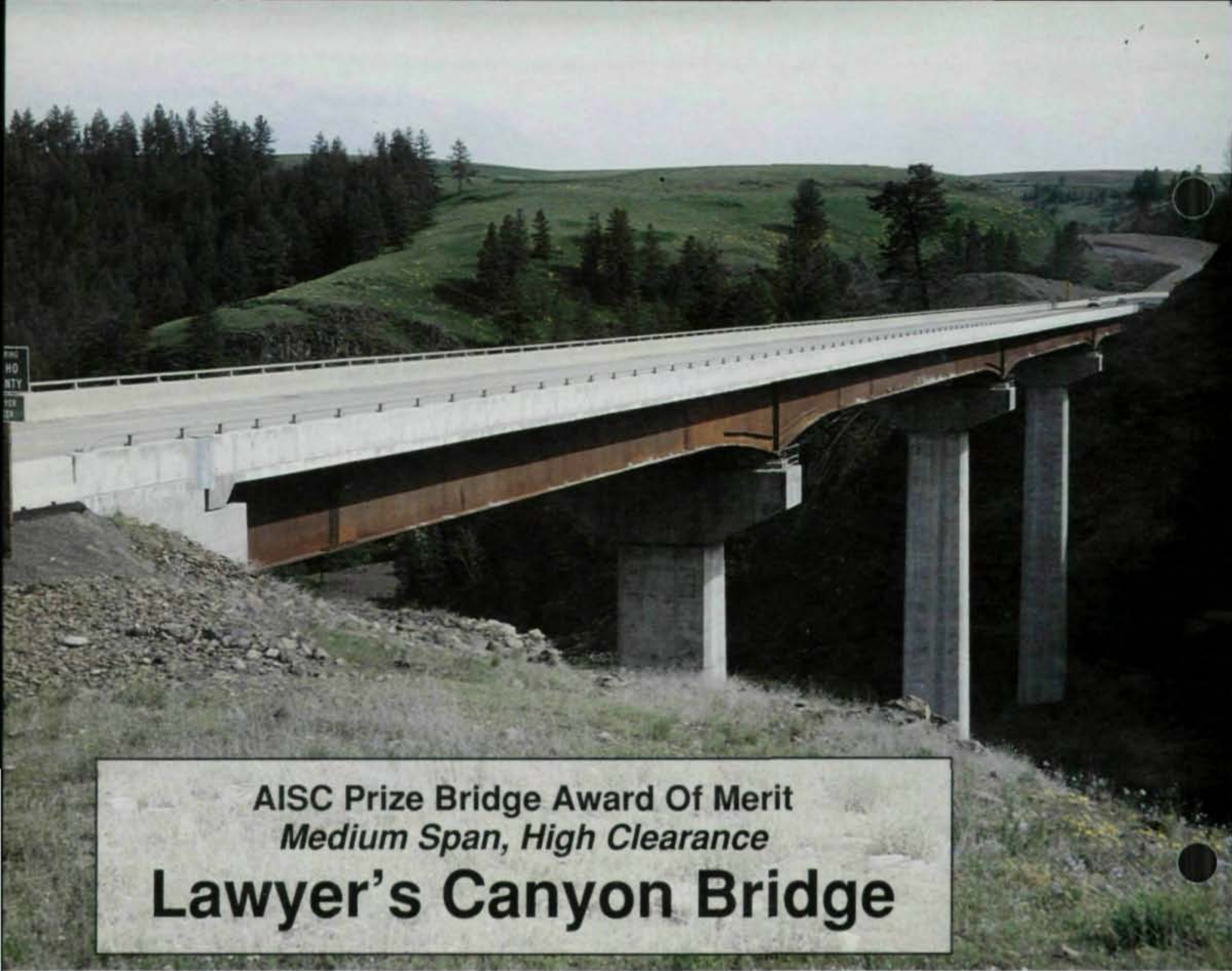
Two-Hinged Arch

A two-hinged type arch was selected to allow the pier to move and rotate while minimizing any effect on the arch. The steel stiffening girder, which carries the steel floor beams and concrete roadway deck, is supported by diagonal ca-

bles from the arch rib and by sliding bearings at each end. "We put in a very short, 16' transitional span, hinged on both ends, that allows for the differential movement," explained Lee Holloway, P.E., Bridge Department Manager at HNTB.

The coating system for the main span is a shop-applied inorganic zinc prime coat, epoxy intermediate coat and a finish coat on all exposed exterior surfaces. An inorganic zinc prime coat was applied on interior surfaces as well. Arch bearing pins and hanger pins are stainless steel. Hanger cables are zinc-coated steel structural strands.

After the replacement structure was complete, the old bridge was demolished. Two of the original pylons (in their original location) and some railing from the old bridge have been incorporated into a wayside interpretive center on the south end of the bridge.



AISC Prize Bridge Award Of Merit

Medium Span, High Clearance

Lawyer's Canyon Bridge

Design firm:	Idaho Transportation Dept., Boise
General contractor:	Flatiron Structures Co., Longmont, CO
Steel fabricator:	Fought and Co., Tigard, OR
Steel erector:	Grett Steel and Iron, Denver
Owner:	Idaho Transportation Dept., Boise
Total cost:	$4.5 million
Span lengths:	190'-265'-265'-190'
Roadway widths:	42'-8"
Steel wt./sq. ft. of deck:	46.5 lbs/sq. ft.
vertical clearance:	190'
steel tonnage:	977 tons
Structural system:	Four continuous I-shape plate girders with composite deck
Innovative concepts:	Girders were launched for erection; hollow concrete piers were utilized

Winter weather made driving through Lawyer's Canyon in Idaho on US 95 a risky trip. To cut down on the number of accidents, US 95 was recently realigned and the roadway was moved from the canyon to the surrounding plateau. As a result, a bridge was needed to span the canyon.

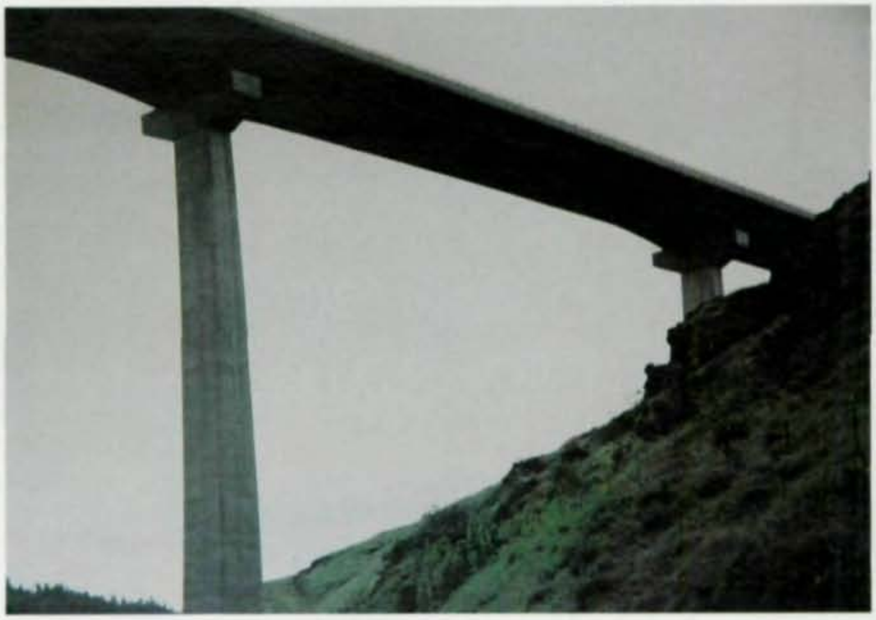
During the concept phase, nine different alternatives were considered, including: concrete segmental cantilever construction; long-span precast prestressed concrete I-girders; and concrete and steel arches.

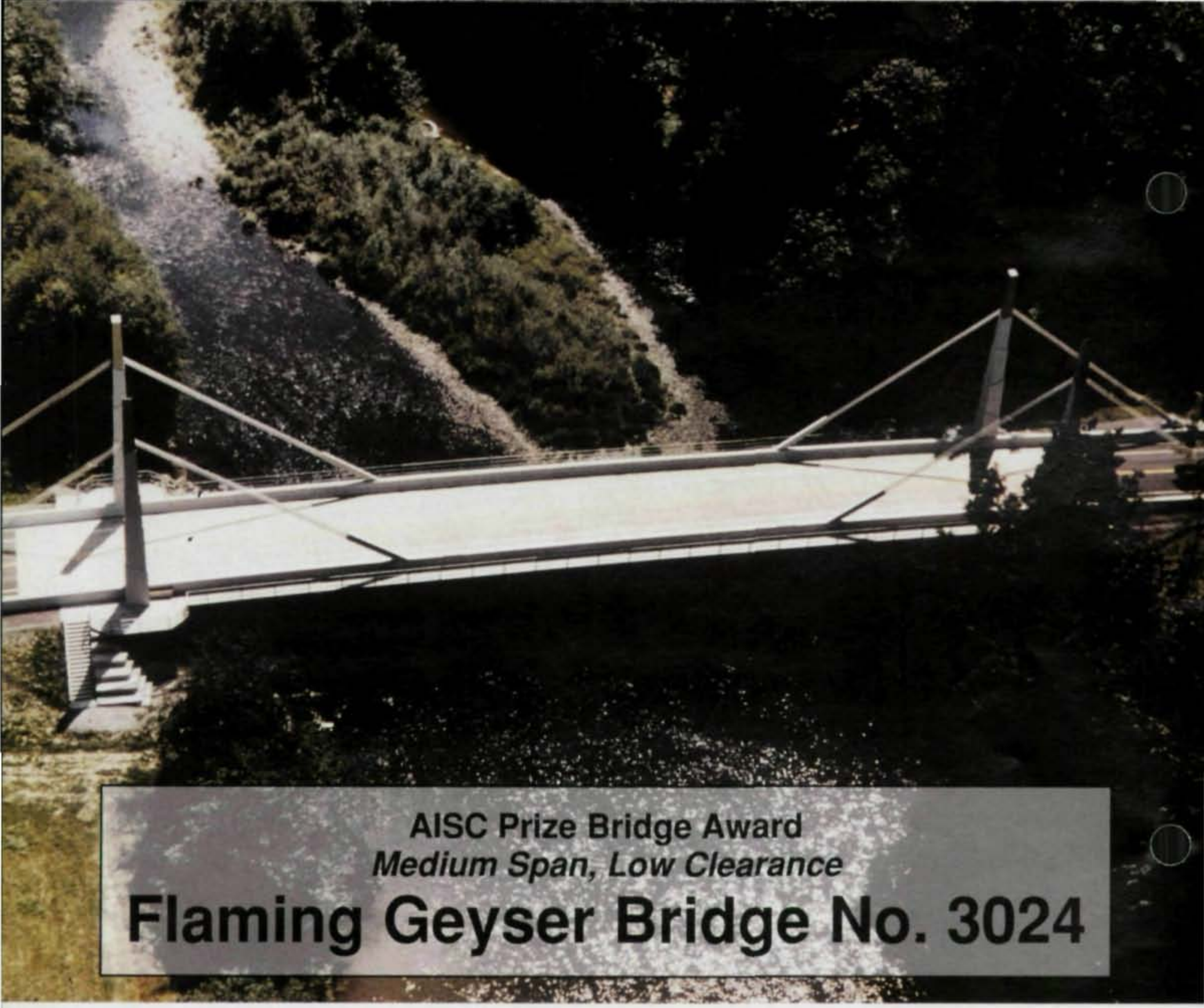
A 919′-long, four-span (190′-265′-265′-190′) continuous steel plate girder bridge with a concrete deck was chosen for its superior aesthetics, constructability and economy. The superstructure consists of four I-shaped steel plate girders with web depths varying from 8′ near mid-span and haunched to 12′ at the piers. The bridge was designed using the Load Factor Design method and unpainted A588-Grade 50 weathering steel was used for the steel girders.

Another advantage of a steel superstructure on this project was that it enabled the use of smaller substructure units, which in turn meant substantially less excavation in the rugged canyon walls. As a result, in addition to saving money, the project minimized damage to the canyon environment. The substructure consists of hollow rectangular tapered concrete pier shafts supported by 2′-diameter concrete drilled shafts founded on basalt bedrock. The abutments also are founded on concrete drilled shafts.

To eliminate the need for cranes to lift the girders near the rugged canyon walls, the contractor elected to launch the girders from both abutments towards the center pier. The four girders were launched as a unit, with each unit approximately 380′ long. All of the cross frames were installed between the girders and additional temporary bracing was added prior to launching. The contractor utilized hydraulic jacks to advance and restrain the girders, particularly near the haunches. Vertical hydraulic jacks also were used to position the girders from the pier tops for final field bolting. The section at the center pier was lifted into place with a crane from the canyon floor.

The structure was completed on time and on budget in a remote area in Idaho.





AISC Prize Bridge Award

Medium Span, Low Clearance

Flaming Geyser Bridge No. 3024

Design firm:	ENTRANCO, Bellevue, WA
Consulting firms:	The Hastings Group, Seattle; George Tsutakawa, Seattle; and Richard Haag Associates, Seattle
GC & erector:	Structures, Inc., Kenmore, WA
Steel fabricator:	Keiser Steel Fabricators, Kent, WA
Owner:	King County Department of Public Works
Total cost:	$1.42 million
Span lengths:	66'-230'-66'
Roadway widths:	34'-6"
Steel wt./sq. ft. of deck:	30 lbs/sq. ft.
Vertical clearance:	6' (to 100 year floodplain)
Steel tonnage:	170 tons
Structural system:	Steel box girders and floor beams with a reinforced concrete deck, pretensioned high-strength cable-stayed bars, and concrete foundations
Innovative concepts:	The project demonstrated that long-span cable-stayed bridge engineering technology could be economically applied to medium-span bridges

The designers of a new gateway across Washington's Green River into the beautiful Flaming Geyser Recreational Area had two key concerns. First, it was important to keep all piers out of the river. And second, the bridge needed to both blend into the surrounding area and also provide an appropriate entry to a heavily used state park.

The design team presented King County with an innovative cable-stayed bridge design concept featuring a 230' main span of painted high strength weathering steel and end spans of 66' to balance the stay forces. The bridge utilizes structural steel box girders and floor beams with a reinforced concrete deck, pretensioned high strength bars, 40'-high, symmetrical, cast-in-place concrete towers capped with stainless steel, a 34'-wide two-lane roadway surface that also accommodates bicyclists, and 5'-wide pedestrian walkways.

Innovative Design

One crucial step was to convince King County officials to accept the cable-stayed bridge concept in spite of the reluctance of state and federal agencies to fund an innovative design. Officials were won over, however, when it was demonstrated that the cable-stayed steel bridge would be less expensive than a shorter span conventional concrete bridge with piers in the river that was being constructed down the river at the same time.

A challenging design element was analyzing the complex interaction of the bridge acting as a complete structural unit. The analysis considered more than 120 different load cases, temperature ranges between winter and summer, long term creep and shrinkage of the approach grade beams and towers during a 20-year period, and the change in stay pretension forces as the concrete roadway deck changed in length.

Another challenging aspect was the variable nature of the structure-soil aspect. The design for the connections between the stays and the girders was critical and involved highly indeterminate stress conditions that had to account for the residual stresses in the structural steel and the stresses present during welding. A complex finite element three dimensional program was used to analyze these stresses. The top tower connections include eight fore stay bars and eight back stay bars, each loaded to about 50 tons and joined in a compact heavy

steel assembly. Each stay allows for future destressing replacement (utilizing two at a time) without closing the bridge to traffic.

The stainless steel caps on the concrete towers provide access for inspecting the towers and protection from weather. The hollow steel box girders contain and protect the connections at the girder ends of the stays. Access holes provide for inspection at the deck level. The end connections are all contained within the 16"x72" steel box girder. The bridge's high strength steel bars include special corrosion protection details at the end anchors.

Overall, the 230′ main span plus the two 66′ end spans provide a total bridge length of 362′—all constructed without costly expansion joints. This design feature was made possible by analyzing the bridge as a complete unit including the interaction on the steel support pilings, which were driven about 30′ to rock, with the surrounding soils.

The low profile bridge blends into its surroundings without visually dividing the park. Structurally, the cable-stayed bridge required only 33" of depth from the river clearance line to the roadway surface.

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AISC Prize Bridge Award

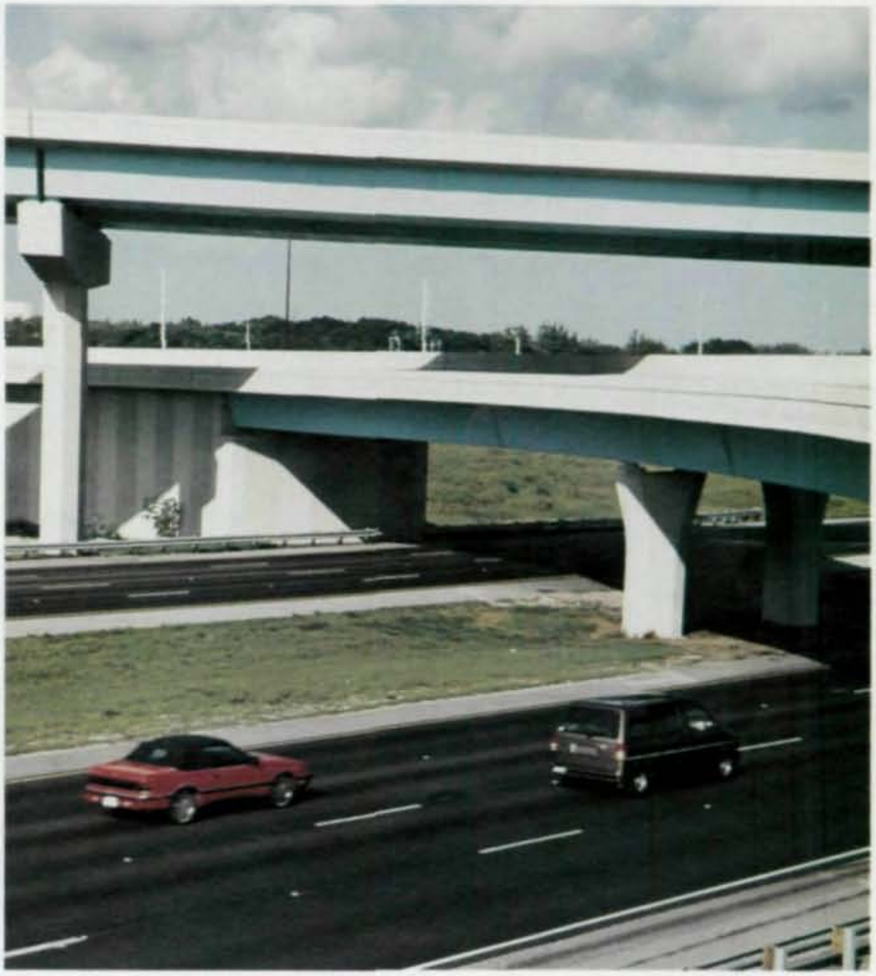
Grade Separation

Florida's Turnpike/I-595 Interchange

Design firm:	Greiner, Inc., Tampa, FL
GC & erector:	Gilbert Corp., Cape Coral, FL
Steel fabricator:	Carolina Steel Corp., Greensboro, NC
Owner:	Florida DOT
Total cost:	$5.7 million
Span lengths:	180' max.
Roadway widths:	44'
Steel wt.sq. ft. of deck:	34.7 lb/sq. ft.
Vertical clearance:	16'-6" min.
Steel tonnage:	1,216 tons
Structural system:	Continuous curved trapezoidal box girder
Innovative concepts:	Treatment of torsion at abutment & cellular-spine approaches

During the planning phase of this project, the owner established that special attention be given to aesthetics. As a result, a steel box girder superstructure and clean-looking single column piers were selected. In addition to aesthetic considerations, the design also proved economical. To further enhance the project's aesthetics, all concrete surfaces were treated with an applied finish coating to further enhance their appearance.

The project consists of a fully directional three-level interchange between the existing Florida's Turnpike and the new Interstate 595 in Broward County, FL. The second- and third-level bridges are curved steel trapezoidal box girder bridges with composite concrete decks. The second level bridge is a three-span structure on a 14° horizontal curve with span lengths of 118'/156'/122'. The third level bridge is a seven span structure on a 9° horizontal curve, with a three-span continuous unit of spans 144'/172'/144' and a four-span continuous unit of spans 136'/181'/164'/136'.



The second-level bridge is supported on individual flared columns that are staggered in order to provide the necessary horizontal clearances in the I-595 median. This staggered pier layout results in a difference in span lengths of approximately 16' for the inside and outside box girders. In order to minimize differential deflections between the box girders, full-depth plate girder diaphragms are provided at midspan locations. Full-depth plate girder diaphragms also were utilized at the abutments in conjunction with single pot bearings supporting each box girder in order to eliminate the uplift condition that would have existed—due to torsion—with a pair of bearings supporting each box girder.

The third-level bridge is supported on hammer-head piers placed radially. It utilizes a similar column shape as the flared second-level columns.

A particularly difficult founda-

tion condition existed at the south abutment of the second-level bridge. Soil borings and an exploratory test pit revealed the presence of an old landfill, including large quantities of construction debris, timber, waste concrete, old tires, and even motorcycle and auto parts. The predicted settlements for an embankment fill at this location were unacceptable.

Unfortunately, costs associated with removal and disposal of the landfill material also were too high—plus there could be unforeseen delays and costs associated with potentially hazardous materials. However, the extension of the steel box girder structure across the landfill was restricted by vertical geometry, and the use of a shallower superstructure type was undesirable from an aesthetics viewpoint. The solution was the use of a "cellular-spine" structure that has the outward appearance of a retaining wall. It consists of a central longitudinal pile bent (the spine) in conjunction with two vertical walls supported on soldier piles that combine with the spine to support a concrete deck slab and to create an open cell. The resulting structure provided an acceptable structural solution and a pleasing appearance, while maintaining the overall project economy.

"Down the road, weathering steel

The Pennsylvania Turnpike is considered one of the safest and best maintained roads in the nation.

But improvements were badly needed near Pittsburgh to provide better access to the City's airport and I-80.

The Mahoning River Bridge, the largest of the 21 bridges being built on the new Beaver Valley Expressway, is a dual-lane, continuous-span, welded plate structure. The five interior spans are 258 ft. with end spans of 182 ft. and 228 ft. for an overall length of 1,700 ft.

WHY WEATHERING STEEL?

The bridge is built with 4,600 tons of Bethlehem's ASTM A588 weathering steel. According to Kempf, the PTC finds weathering steel a very cost-effective bridge material for a number of reasons.

For example, its high-strength permits longer spans, thus reducing the number of piers required. And that leads to foundation cost savings.

OTHER STRONG REASONS.

For another, it can be easily inspected, measured and evaluated. If necessary, it can be readily repaired. It's also highly adaptable to redecking, widening, or performing other structural modifications.

Weathering steel also eliminates the need for both initial and maintenance painting. What's more, it's as attractive as it's environmentally sound.

Kempf comments, "The PTC's principal criteria for selecting materials for bridges and other Turnpike applications aren't based on price alone, but also includes long-term serviceability and durability. And with environmental restrictions being what they are today, it's only prudent to use weathering steel wherever possible."

Quite simply, weathering steel is a natural for a

will save us more than money."

Frank J. Kempf, Jr., P.E. Bridge Engineer, Pennsylvania Turnpike Commission.

broad variety of bridge applications.

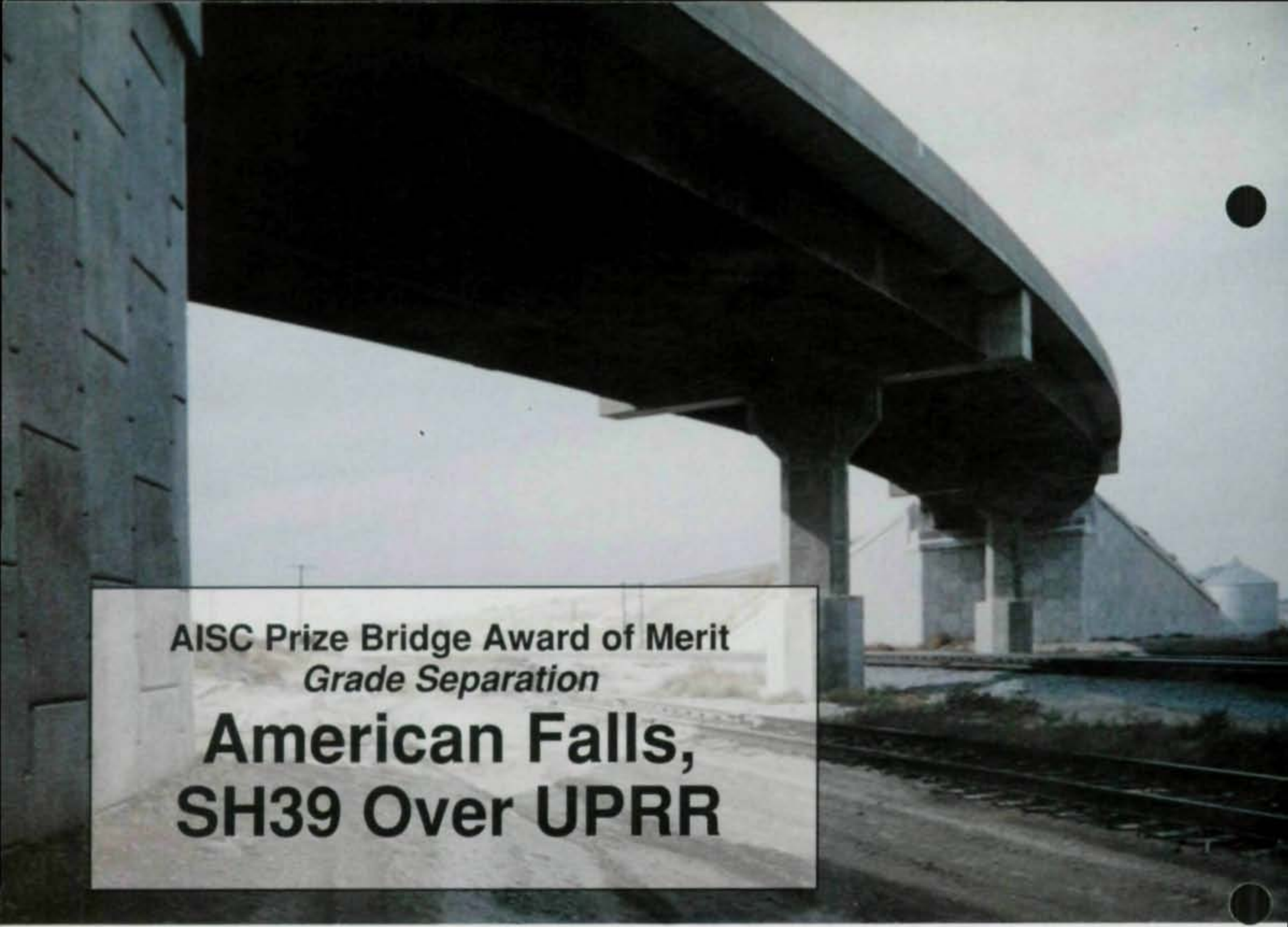
Including yours. Especially if you want to save more than money.

TECHNICAL LITERATURE AVAILABLE.

We would like to tell you more about weathering steel for bridge applications. For a copy of our Product Booklet No. 3790, and our latest Technical Bulletin, TB-307 on "Uncoated Weathering Steel Structures," get in touch with your nearest Bethlehem sales office. Or call: Brian Walker at **(215) 694-5906.** Bethlehem Steel Corporation, Construction Marketing Division, Bethlehem, PA 18016-7699.

Bethlehem

Owner: Pennsylvania Turnpike Commission, Harrisburg, PA
Design Consultant: URS Consultants, Akron, OH
General Contractor: National Engineering and Contracting Company, Strongsville, OH
Steel Fabricator: High Steel Structures, Inc., Lancaster, PA
Steel Erector: Middle States Steel Construction Company, Eighty Four, PA
Weathering Steel Supplier: Bethlehem Steel Corporation, Bethlehem, PA



AISC Prize Bridge Award of Merit

Grade Separation

American Falls, SH39 Over UPRR

Design firm:	Idaho Transportation Department
General contractor:	Bannock Paving Company Inc., Pocatello, ID
Steel fabricator:	Utah Pacific Bridge & Steel, Pleasant Grove, UT
Steel erector:	Idaho Construction Co., Kimberly, ID
Owner:	Idaho Transportation Department
Total cost:	$1.19 million
Span lengths:	140' - 153' - 116'
Roadway widths:	36'-8"
Steel wt./sq. ft. of deck:	34.5 lb.
Vertical clearance:	26.1'
Steel tonnage:	283.5 tons
Structural system:	Four continuous curved steel plate girders with composite deck
Innovative concepts:	Post tensioned diaphragm at piers to act as pier cap; hidden abutment columns; and the first use of curved steel plate girder in Idaho

In an unusual twist, the designers of the re-routed State Highway 39 project in American Falls, ID, discovered that building a longer bridge would cut costs.

The highway was re-routed to prevent heavy truck traffic from entering the city. The new alignment parallels the Union Pacific Railroad tracks along the south shore of the American Falls reservoir and turns 90° at the north end of town to connect to I-86. At the curve, the highway crosses two mainline and two siding railroad tracks at an angle of 26°. This alignment was chosen because it yielded the shortest highway, required the least right-of-way, and because a single structure could span all the existing railroad tracks. The horizontal alignment places the bridge on a $4\frac{1}{2}°$ curve and at the severe skew angle of 64°.

While the Union Pacific Railroad required a vertical clearance of at least 24′, the design demanded a structure with the lowest possible elevation because of height limitations in the retaining walls at the approaches and a lack of suitable embankment material close to the project. In addition, the project needed to be completed on a fast-track schedule in order to meet the city's requirement that it be completed within the 1992 fiscal year.

Several alternatives were considered and quickly eliminated: a prestressed concrete girder bridge would have had difficulty with the long spans; cast-in-place concrete box girders were ruled out because the low clearance and severe skew made falsework and forming impractical; and steel box girders and concrete box girders were excluded after an economic study.

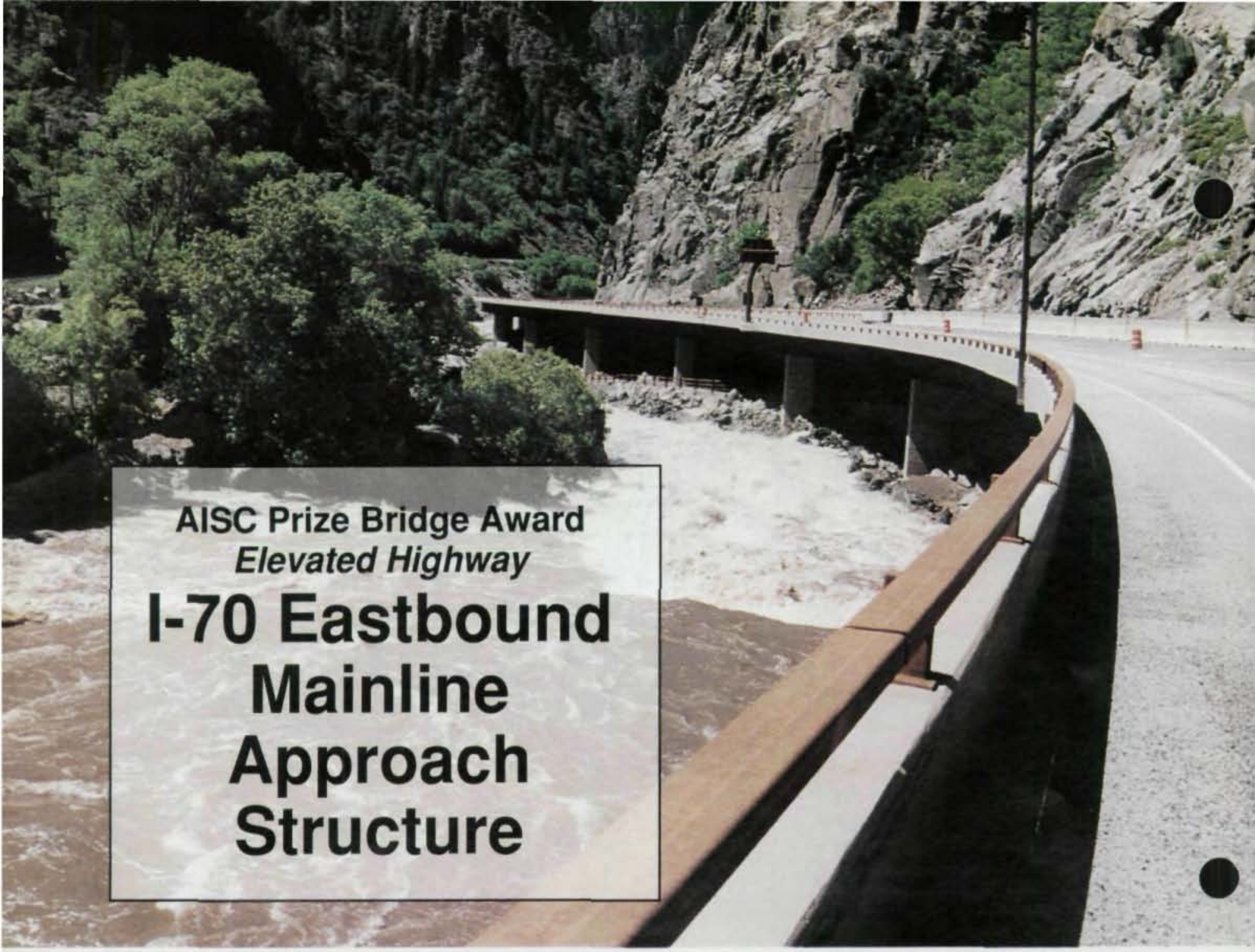
The chosen design is a curved steel plate girder bridge with three continuous spans of 140′, 153′ and 116′. It consists of 5′-deep, curved I girders fabricated from A588 weathering steel, carrying two lanes of traffic on a 6% deck superelevation.

The problems associated with the severe skew were eliminated by "squaring" the piers and abutments with respect to the road. Although squaring the bridge resulted in a longer structure, it saved money by reducing the required embankment material, substructure and retaining wall quantities, and by requiring smaller expansion joints. It also simplified design and construction.

Another design innovation was the replacement of conventional pier caps with internal post-tensioned pier diaphragms to support the girders. The use of these diaphragms allowed the designers to square the piers and provided the required vertical clearance without raising the structure.

Also, the abutments were placed on columns that carried the loads directly to bedrock, rather than being placed on the retaining wall backfill. This was done to eliminate problems resulting from unpredictable settlements of the backfill and to reduce the size of the required columns. Since the columns were unsightly, they were buried behind the retaining walls.

This was the first use of a curved steel plate girder bridge in Idaho and it came in slightly under budget. "We felt the project was very successful and we're now in the design phase of another curved steel plate girder bridge," said Marvin Fallon, P.E., a design group leader with the Idaho DOT.



AISC Prize Bridge Award
Elevated Highway
I-70 Eastbound Mainline Approach Structure

Design firm:	Meheen Engineering Corporation, Denver
General contractor:	Centric/Jones Co., Lakewood, CO
Steel Fabricator:	Grand Junction Steel
Steel erector:	Grett Steel & Iron, Denver
Owner:	Colorado Department of Transportation
Total cost:	$4.6 million
Span lengths:	two @ 105'; 10 @ 130'
Roadway widths:	33.5'-67'
Steel wt./sq. ft. of deck:	38 lbs/sq. ft.
Vertical clearance:	15'-30'
Steel tonnage:	1,200 tons
Structural systems:	12 span viaduct using ASTM A588 plate girders and single column concrete piers and steel pier caps
Innovative concepts:	The spans were optimized for the least expensive combination of superstructure and substructure costs; the use of high strength steel and prestressing steel pier caps cuts costs

The drive through Colorado's Glenwood Canyon has always been breathtaking. Now, it's also a lot simpler. A new 1,530'-long viaduct carries I-70 traffic east bound within the canyon, hugging the north bank of the Colorado River with graceful horizontal curves. The viaduct is part of a larger project, consisting of four structures, that forms the Shoshone Dam Interchange.

While alternative designs and bids were not necessary on this structure since it did not exceed a cost of $5 million, the designers did opt to prepare a comprehensive alternative analysis and constructability study. In the analysis, four alternatives were considered: steel box girders; cast-in-place prestressed concrete; segmental prestressed concrete; and steel plate girders. For the sake of consistency and aesthetic consideration, it was decided to build all four structures of the same type. The analysis ultimately showed steel plate girders to be the most advantageous.

For the I-70 Eastbound Mainline Approach, steel plate girders offered several clear advantages.

- Since this structure flared from 33.5′ to 57′ to accommodate an

off-ramp, the number of girders were increased easily from three to seven.

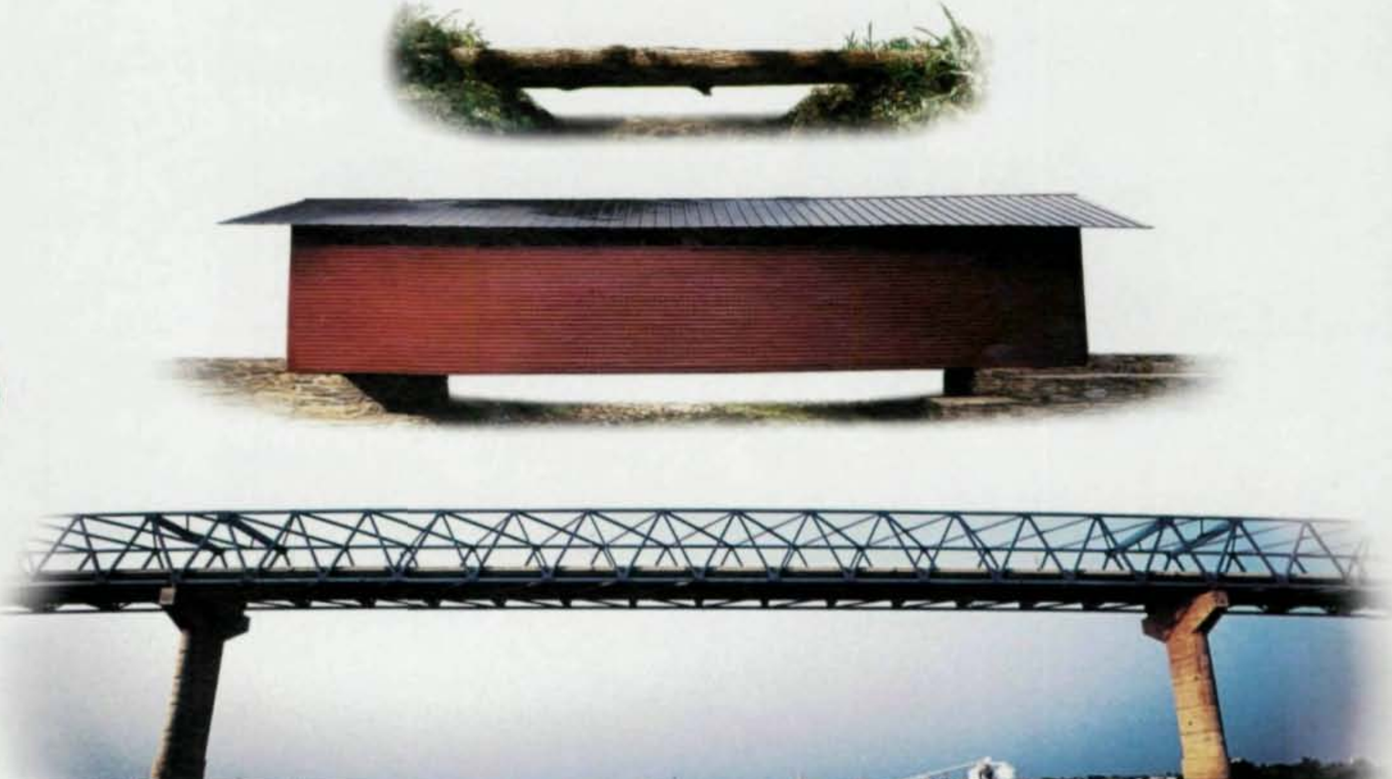
- Plate girders provided the lightest superstructure, consequently allowing longer spans and a more economical substructure.
- The plate girders relative light weight increased constructability by allowing larger pieces to be erected with smaller cranes.

The planners and architectural consultants agreed that plate girders met the necessary aesthetic considerations. And just as importantly, the steel plate girder alternative was estimated to be 12%-18% less costly than the other alternatives. Weathering steel was chosen both to reduce maintenance costs and for its high strength.

The value engineering study revealed that 130′ spans were the most economical. Composite prestressed pier caps, resting on the 12′-wide diamond shaped pier shafts, were integral with the girders.

The prestressed pier cap girders were fabricated with short lengths of longitudinal girders on both sides. This scheme facilitated the erection of the bridge by needing only two splices for each girder per span. Standard construction methods using pile drivers, drilling rigs and cranes were utilized.

Thank God Some People Are Never Satisfied.



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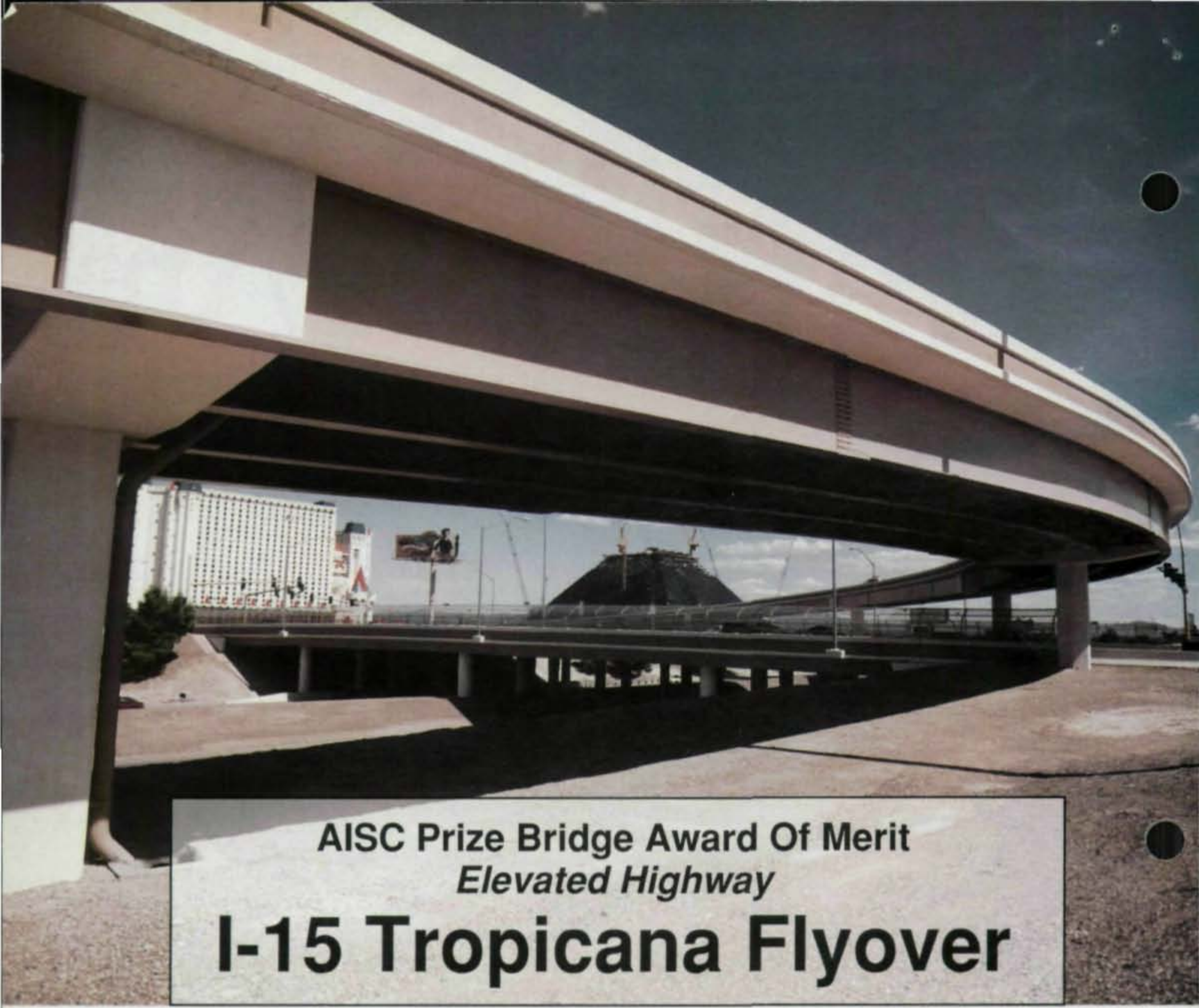


AISC Prize Bridge Award Of Merit
Elevated Highway

I-15 Tropicana Flyover

Design firm:	Sverdrup Corporation, Kirkland, WA
General contractor:	Max Riggs Construction, Las Vegas
Steel fabricator:	Utah Pacific Bridge and Steel Ltd., Pleasant Grove, UT
Steel erector:	Olsen-Beal Associates, Orem, UT
Owner:	Nevada Department of Transportation
Total cost:	$4.02 million
Span lengths:	75' to 173'
Roadway widths:	32'
Steel wt./sq. ft. of deck:	37.7 lb/sq. ft.
Steel tonnage:	792 tons
Structural system:	Continuous composite welded plate girder
Innovative concepts:	Integral prestressed concrete pier caps and expansion joints at abutments only; temperature movements taken up by flexibility of single column bents

Contructability played a major role in the design of a "horseshoe" shaped elevated highway in Las Vegas. "The Tropicana Flyover Ramp Bridge is constructed over a freeway and a major street and it was important that the construction did not require falsework," explained Paul Treman, P.E., manager of Sverdrup Corp.'s bridge engineering section. "Also, we wanted a design with fast erection to minimize the impact on traffic during construction."

Another important consideration was the need to meet a tight radius curve. The nine-span, 1,209'-long structure is located on a 400' radius curve with a delta angle of 128° between abutments. Span length also played a role in the choice of superstructure because of limited possibilities for pier location due to the existing roadways. Spans ranged from 75' at the eastern end to 173' where the bridge crosses the elevated Tropicana Avenue.

Each of the crossroads is of varying heights, which made a shallow depth an important consideration. The superstructure cross-section consists of four lines of welded steel plate girders at 9' centers with an 8.5"-deep composite cast-in-place concrete deck slab and varying depth webs from 4'-3" to 6'-3". The maximum clearance from the ground to the superstructure is approximately 40', while the minimum depth from the cross roads is only 16'-9".

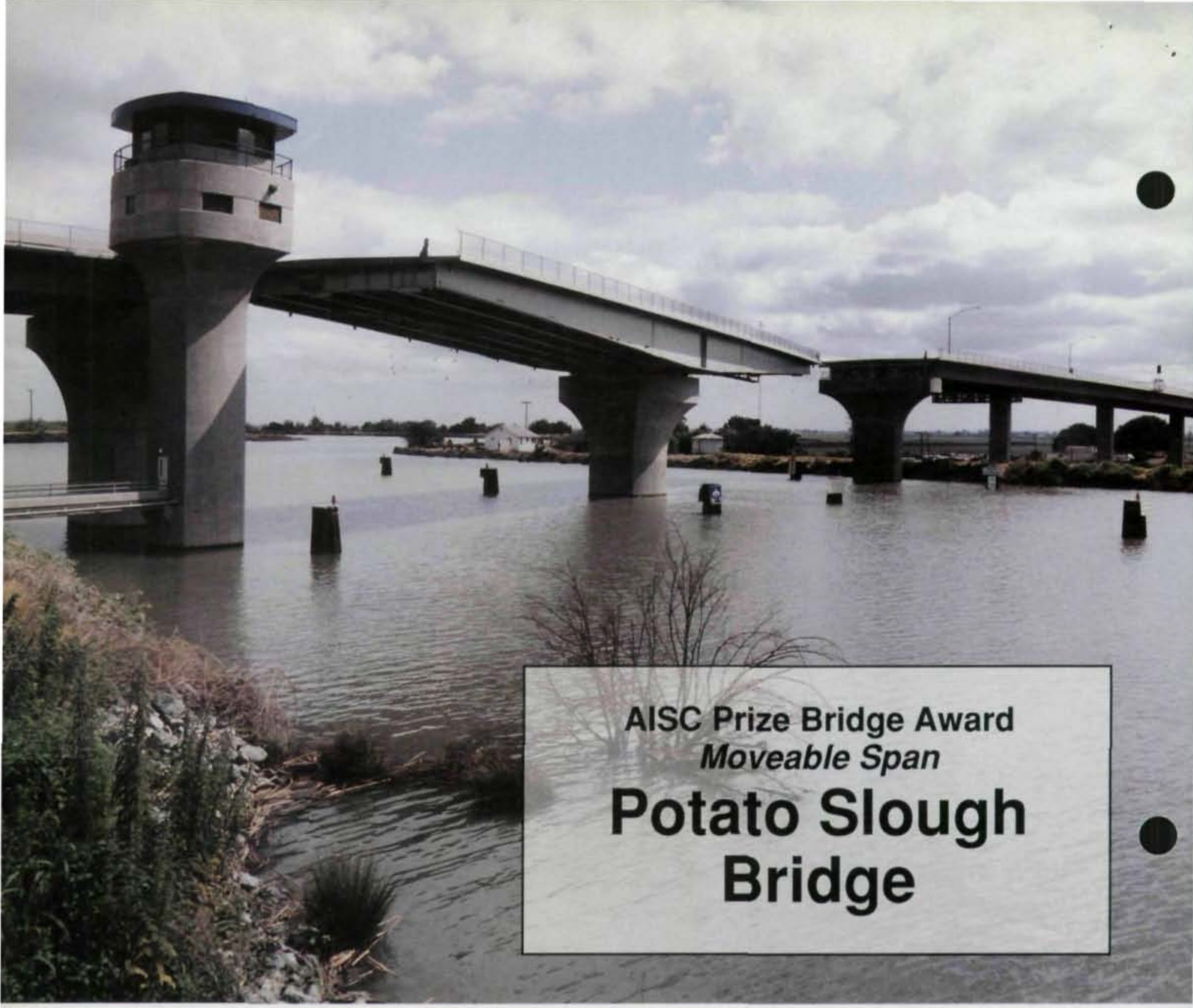
Support cross girders at each pier location are cast-in-place concrete and are raised within the level of the longitudinal steel girders. This arrangement proved both visually attractive and was important for providing good continuity for transmitting the seismic and thermal forces to the columns.

The integral crossbeams have mild steel reinforcement as well as thread bar prestressing reinforcement. Holes were fabricated into the longitudinal structural steel girder webs to allow placing of the mild steel reinforcing and prestressing bars in the field. Concrete caps cover the anchor assemblies on the outside face of both exterior girders. Additional transverse prestressing is provided by thread bars located in the deck slab directly above the integral crossbeams.

To minimize maintenance costs, the design utilizes expansion joints only at the abutments. Structural analysis indicated that the horseshoe shape of the bridge, in combination with the integral crossbeams and taller, more flexible, intermediate piers, resulted in the thermal and seismic forces being transferred to the columns in a radial direction with very little movement at the abutments. Lateral bearing keepers at the abutments allow only nominal transverse movement while providing for the required longitudinal movement due to thermal and seismic forces.

Supporting columns are of a six-sided oblong (angular) shape to provide the necessary structural capacity and aesthetic compatibility with the superstructure and integral crossbeams.

Due to the tight radius, the girders were designed in accordance with the AASHTO "Guide Specifications for Horizontally Curved Highway Bridges" using a curved girder analysis and design computer program. Also, the Load Factor Design method was utilized.



AISC Prize Bridge Award

Moveable Span

Potato Slough Bridge

Design firm:	California Department of Transportation
General contractor:	MCM Construction, Northhighlands, CA
Steel fabricator:	Utah Pacific Bridge & Steel Corp., Pleasant Grove, UT
Steel erector:	Olson-Beal Associates, South Linden, UT
Owner:	California Department of Transportation
Total cost:	$14.3 million
Roadway widths:	51'
Steel wt./sq. ft. of deck:	66 lbs.
Vertical clearance:	35'
Steel tonnage:	525
Structural system:	Structural steel welded plate girder swing span
Innovative concepts:	Dynamically balanced swing span

As traffic in the San Francisco East Bay commerce area steadily increased, it became painfully obvious that the $8\frac{1}{2}'$ vertical channel clearance of an existing half-century old swing bridge on Route 12 in San Joaquin County was inadequate. The repeated opening and closing of the old bridge—2,300 times in 1982 alone—was severely clogging traffic. In addition, the machinery was rapidly wearing out.

A comprehensive value engineering study considered several alternatives, including a tunnel and various heights of moveable and fixed bridges. The criteria for the evaluation were weighted factors for annualized life cycle costs: safety; impact on the environment; and aesthetics for both mariners and motorists. Because the new structure would have to accommodate large dredges, tugs and cranes in levee emergencies, and because the structure would need a minimal approach height due to the soft organic soil (peat moss), the design team chose a structural steel welded plate girder swing span with a 35′ vertical clearance.

The 310′ swing span of the Potato Slough Bridge in California pivots on a massive single concrete column. The bridge is designed to accommodate a wide range of traffic, including large dredges, tugs and cranes.

The final configuration of the swing span is 310′ long and 51′ wide. The middle of the span rests on a massive single hollow reinforced concrete pier. The span provides two 12′ traffic lanes and 9′ shoulders on either side plus a 5′-wide pedestrian walkway on the south side of the bridge.

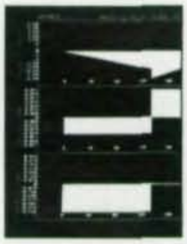
Six main longitudinal girders support the structure. The deepest section is 10′ at the center of the span, tapering to 4′ at the west and east ends. In the middle of each girder bay, a supplemental W18x50 longitudinal stringer adds support, thus reducing the unsupported transverse span length of the bridge deck. In the center girder bay, a permanent catwalk is attached to the superstructure for access to the center pier and routine structural maintenance inspection. Vertical and horizontal braces were installed inside the interior girder bays. Specially designed latex base coatings protect the structural steel

from corrosion and a light gray finish coat matches the appearance of the reinforced concrete approach spans. The total effect is a sleek, streamlined exterior profile that blends in with the flare-shaped center pier, end piers and the adjoining approach spans.

One of the biggest challenges on the project was to balance the 1,250 ton swing span. The span is balanced longitudinally over the center pivot bearing. Along the south edge of the deck is a 5'-wide pedestrian walkway. Balancing counter weight concrete was cast in a calculated location and the centerline of the roadway was shifted 2½' from the centerline of the bridge span to compensate for this inbalance.

Mechanically, the swing span is driven by two 20hp, eddy-current drive electric motors. These motors independently drive two pinion gears connect to a 25'-diameter ring gear. This swing span is unique in that to reduce the span dead load, the ring gear is attached to the superstructure and the drive machinery is mounted on the center pier concrete floor, rather than the reverse. The swing span was dynamically balanced to a tolerance of plus or minus 1⁄16" on the 32'-diameter balance wheel track, well within the required tolerance for gear alignment.

How to get from here



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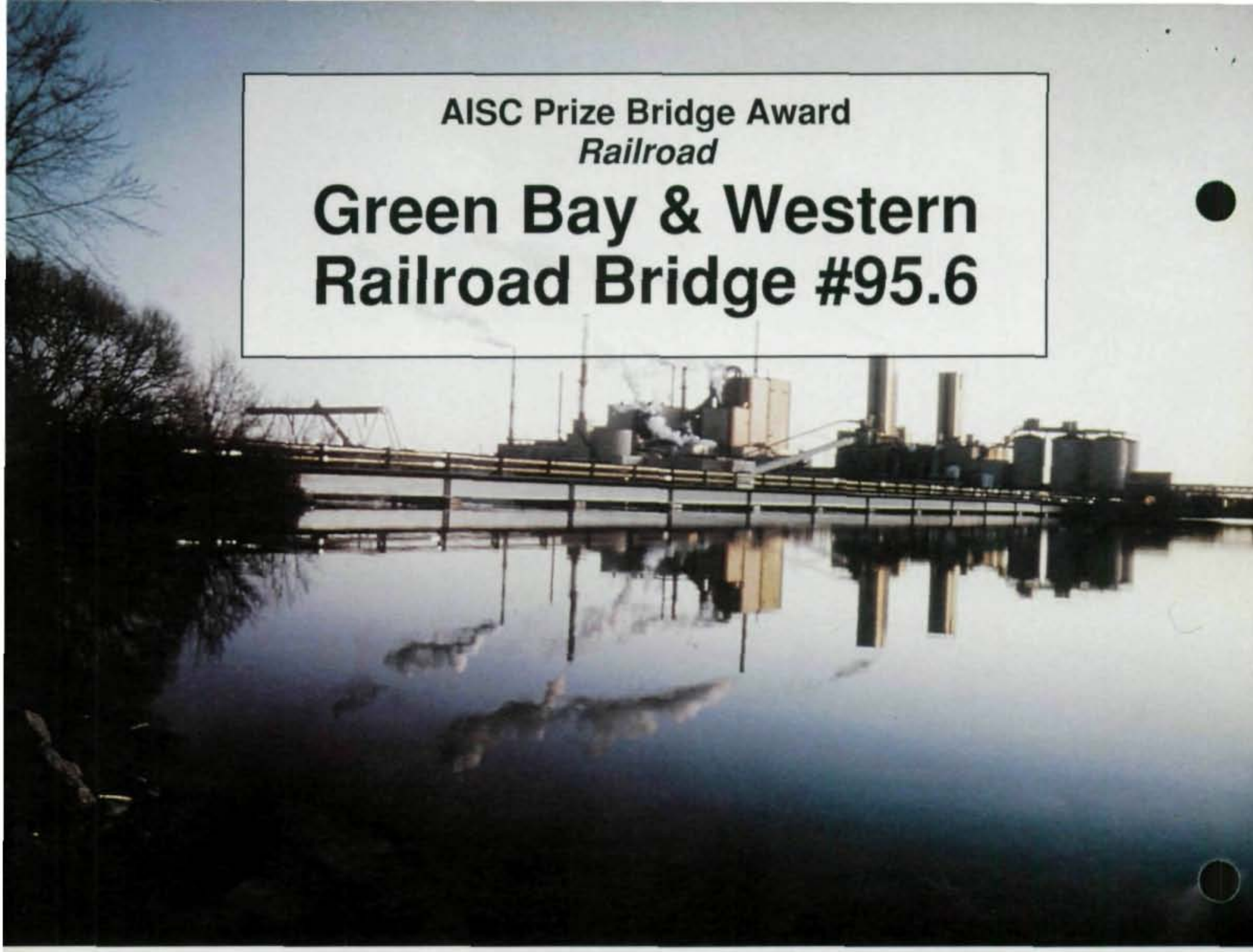


AISC Prize Bridge Award

Railroad

Green Bay & Western Railroad Bridge #95.6

Design firm	Ayres Associates, Eau Claire, WI
General contractor:	Lunda Construction, Little Chute, WI
Steel erector:	Hi-Boom Erecting, Inc., Black River Falls, WI
Owner:	Green Bay & Western Railroad Company
Total cost:	$1.8 million
Span lengths:	12 spans @ 52'-2" each
Roadway width:	single track
Steel wt./sq. ft. of deck:	1,266 lb/linear ft.
Vertical clearance:	1.7'
Steel tonnage:	437 tons
Structural system:	Simple span deck girders, non-ballasted deck
Innovative concepts:	Fast-track construction sequence; steel pier shell

Taking a railroad bridge out of service for a maximum of only 75 hours at a stretch was just one of the complications in the replacement of a 620'-long railroad bridge over the Wisconsin River in Wisconsin Rapids, WI.

The existing four-span, steel-through truss bridge dates back to 1897 and needed to be replaced due to its overall deteriorated condition. Normally, given the importance of maintaining service, the track and bridge would be relocated or a temporary bypass bridge would be constructed. However, this was not practical for this job because the bridge connected a long causeway on one end with an extensive switchyard on the other. Further complicating the project was the need for a minimum depth structure and the location of bedrock at riverbed level that precluded the use of conventional foundation piling.

The replacement bridge is a steel deck girder structure supported on a combination of new and existing piers. Because the existing masonry piers were in good condition, they were capped with reinforced concrete and used to support part of the new spans. The new span supports are composite steel and concrete piers tied directly on bedrock.

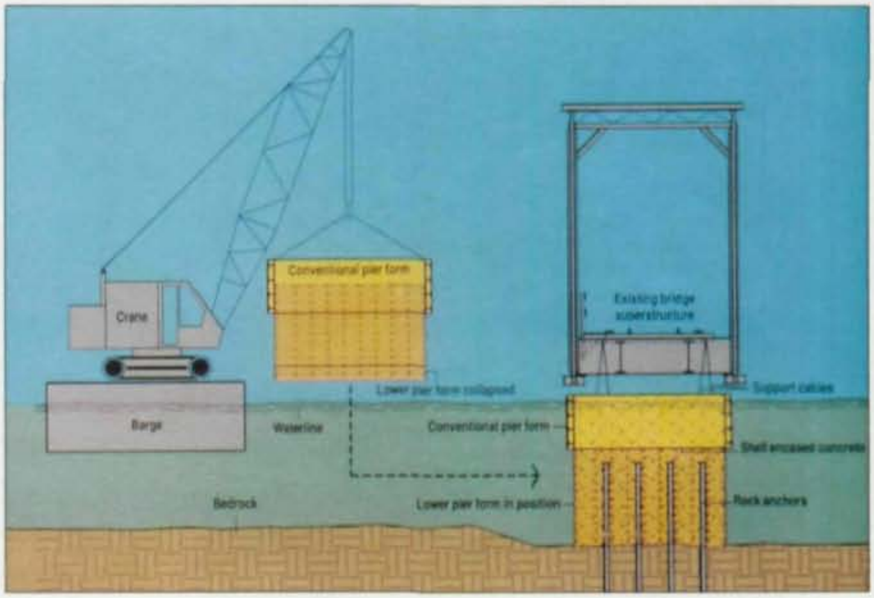
The superstructure consists of 12 identical spans, each approximately 52′ long. The spans were designed in accordance with American Railway Engineering Association specifications for an E80 loading. The girders were fabricated from A36 steel and painted with a three-coat epoxy paint system. To minimize fabrication costs, unstiffened webs were utilized.

Span length determination was governed by two considerations. First, since the depth of the girder was limited to 48", a shorter span was required to maximize girder economy. And second, the 52′ length simplified shipping and handling of the girders. The four 52′-long girders that form one span were fully assembled and painted at the fabrication plant and shipped as one unit by truck to the site. This eliminated all field assembly and painting. Each span, including ties, weighed approximately 40 tons and was easily maneuvered by mid-sized cranes.

Design also was complicated by the need to meet tight clearances. The distance from normal water level to track was 7.5′; from normal water level to the lowest steel was only 21"; and from the track to the lowest steel was 5.8′.

The piers were constructed in two sections. The lower half was made up of concrete placed in a compositely designed steel shell. The concrete was placed underwater in the shell and acted as a seal, while the shell served three different purposes: a cofferdam; a forming for the concrete; and structural reinforcement for the concrete shaft. A conventional cofferdam was not used because it would have been too difficult to construct under the existing bridge.

The upper half of the pier was formed by a conventional concrete



New spans for the Green Bay & Western Railroad Bridge were fully assembled on shore and loaded onto barges for final transport to the bridge site.

form that telescoped over the outside of the steel shell. The pier was first constructed onshore with the two halves overlapped and then floated under the bridge. This overlapping allowed the form to pass below the low steel of the existing bridge with its 21" of clearance and avoid rock outcrops of the river bed.

The form was telescoped out to extend to the riverbed. The pier was stabilized by attaching it to the bedrock with eight rock anchors. These anchors were drilled through the lower half of the pier and into the bedrock. After the rock bolts were anchored in the bedrock, they were pretensioned to 100 kips to assure proper anchorage and pier stability.

Each of the four existing truss spans were replaced individually during separate weekends to meet the 75-hour closing limit. Work crews constructed the timber ties and deck on the assembled girders before final erection. The spans were then placed on barges and floated over the piers. Once positioned, the barges were flooded with water to lower the span into final position. The 75-hour construction window was easily met, with nine to 12 hours allowed for the removal of the existing truss, eight to 12 hours to erect the three replacement spans, and six hours to place and adjust the track rails.

The actual construction cost of $1,800,276 amounts to $2,922 per linear foot and represents a $70,000 savings over the original 1988 estimated cost of replacement and a nearly $200,000 savings over the estimate of $2 million to repair and strengthen the existing structure. Part of the savings came from the use of the steel shell instead of a temporary cofferdam. Also, an estimated $50,000 was saved by designing the girders with unstiffened webs, which also enhanced the bridge's appearance and are easy to clean and maintain.

Each fully assembled span was floated into position and lowered onto the bearings by pumping water into the barges.

AISC Prize Bridge Award Of Merit
Short Span

Pine Street Bridge Over Palmetto Canal

Design Firm:	Modjeski and Masters, Inc., New Orleans
GC & Erector:	Boh Brothers Construction Co., New Orleans
Owner:	City of New Orleans Dept. of Streets
Sponsor:	Sewerage & Water Board of New Orleans
Total cost:	$580,000
Span length:	84'-8"
Roadway width:	28'
Steel wt./sq. ft. of deck:	70 lbs/sq. ft.
Vertical clearance:	15'
Steel tonnage:	82 tons
Structural system:	Varying depth through plate girders with transverse floorbeams
Innovative concepts:	Structure depth minimized to maintain clearance over canal flow with minimal approach modifications

Stormwater drainage is an important consideration in almost every city—but it's especially important in a river city such as New Orleans. Unfortunately, the old Pine Street bridge over the Palmetto Canal obstructed the flow of storm drainage.

Both steel and concrete were considered for the replacement bridge, but steel won out because it minimized needed alterations to the approaches.

The bridge roadway geometry is constrained by existing roadways parallel to the canal, making it difficult to raise the bridge approaches without extensive roadway construction.

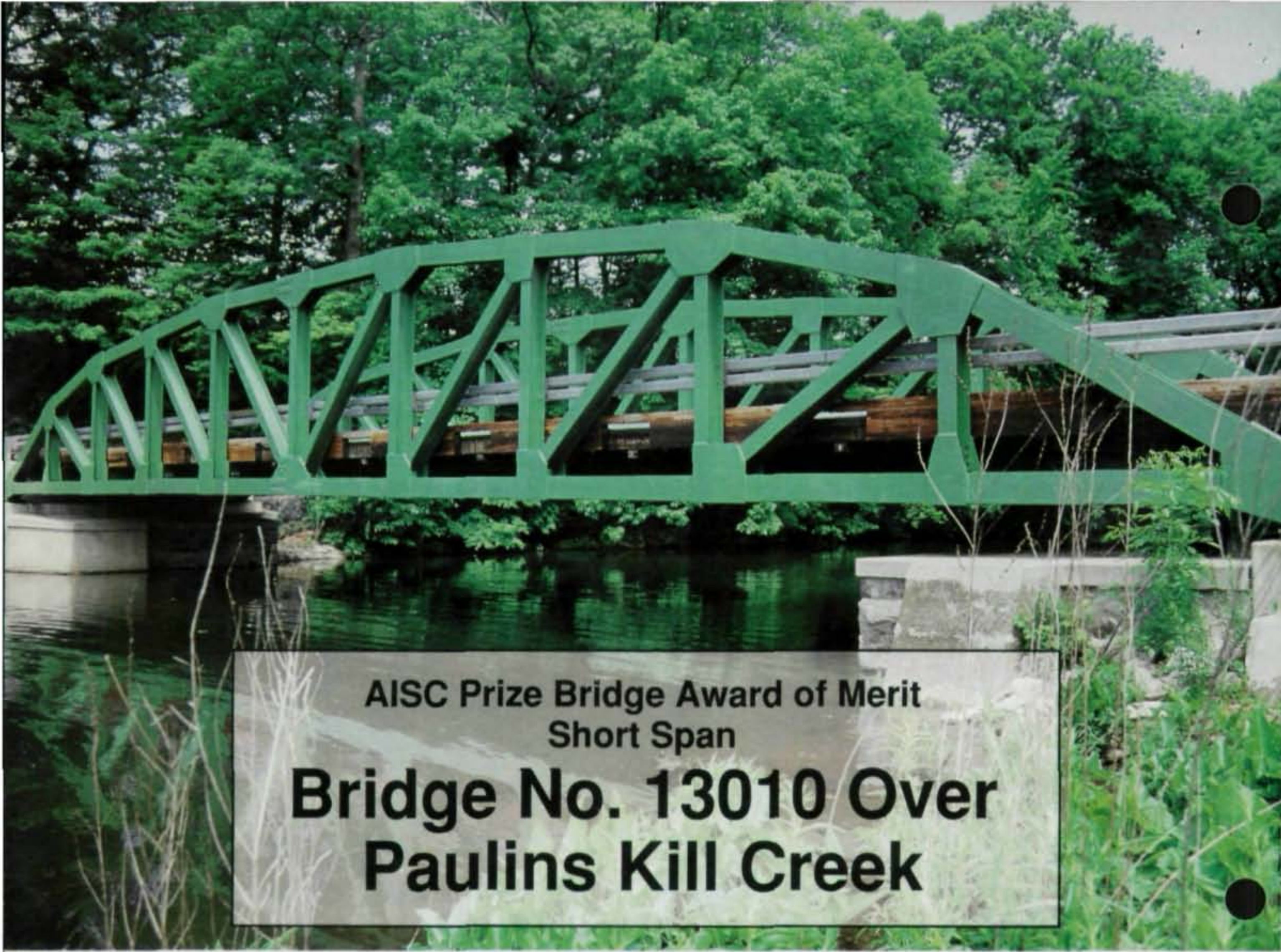
These geometric limitations made steel the preferred choice for the replacement span. While a concrete structure could have provided the clear span across the canal, the resulting thicker structure depth would have led to extensive approach work, requiring the raising of adjacent streets and construction of a costly sheet pile wall along the canal edge. Instead, a simple-span, steel through-girder bridge with minimal structure depth was chosen.

Composite Deck

The 28'-wide roadway is carried by a 6½"-thick (minimum) concrete deck supported by transverse steel floorbeams. The deck acts compositely with the floorbeams to reduce the required structure depth.

The floorbeams are supported by 83'-4" steel plate girders. Steel brackets connect the floorbeams and girder stiffeners to provide lateral support for the girder compression flange. The brackets conform to the shape of a standard highway barrier face and fit flush with the front of the concrete barrier. The girder depth is reduced at the ends to improve sight distance for drivers crossing the bridge, and the girders are cambered to meet the pertinent roadway geometry and sight distance requirements.

Walkways bracketed to the exterior of each plate girder are used by pedestrians for access to an adjacent university. Utilities are carried below the walkway to eliminate the need for an additional utility crossing of the canal.



AISC Prize Bridge Award of Merit
Short Span
Bridge No. 13010 Over Paulins Kill Creek

Design firm:	Pickering, Corts & Summerson, Inc., Newtown, PA
GC & erector:	Simpson & Brown, Inc., Cranford, NJ
Owner:	Warren (NJ) County
Total cost:	$292,000
Span lengths:	110'
Roadway widths:	20'
Steel wt./sq. ft. of deck:	35 lbs/sq. ft.
Steel tonnage:	40
Structural system:	Parker Truss

While still structurally sound, a Northwest New Jersey steel truss bridge (circa 1885) with a posted limit of three tons was clearly functionally obsolete. The county required the replacement bridge to have two 10' lanes and an AASHTO HS 20+10% load rating. In addition, the new bridge had to meet the existing roadway without infringing on the Paulins Kill Creek, which it crosses, or adjacent wetlands. In addition, the local community requested that the new bridge retain the character of the original.

To avoid encroaching on the creek, the superstructure was designed above the deck. Because of the span length, a truss configuration was deemed more economical to build compared with a through girder design. The design team evaluated both steel and wood, and steel was selected for its strength, cost, and ease of fabrication, assembly and installation.

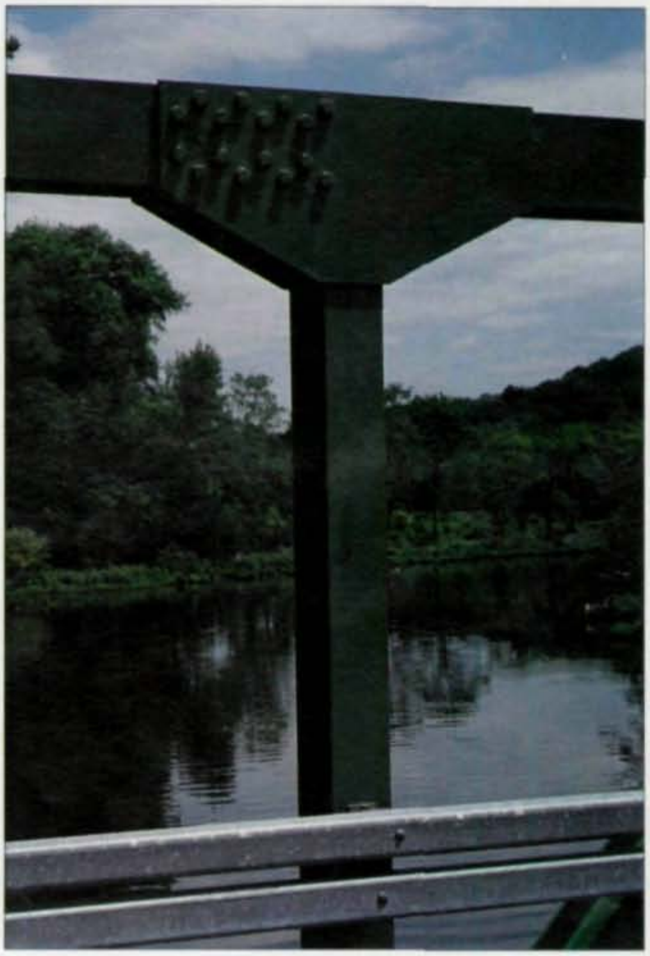
Although the original bridge was a Pratt truss, the designers chose a Parker truss for the replacement structure. While visually similar, the Parker uses a camelback top chord configuration and was therefore more economical.

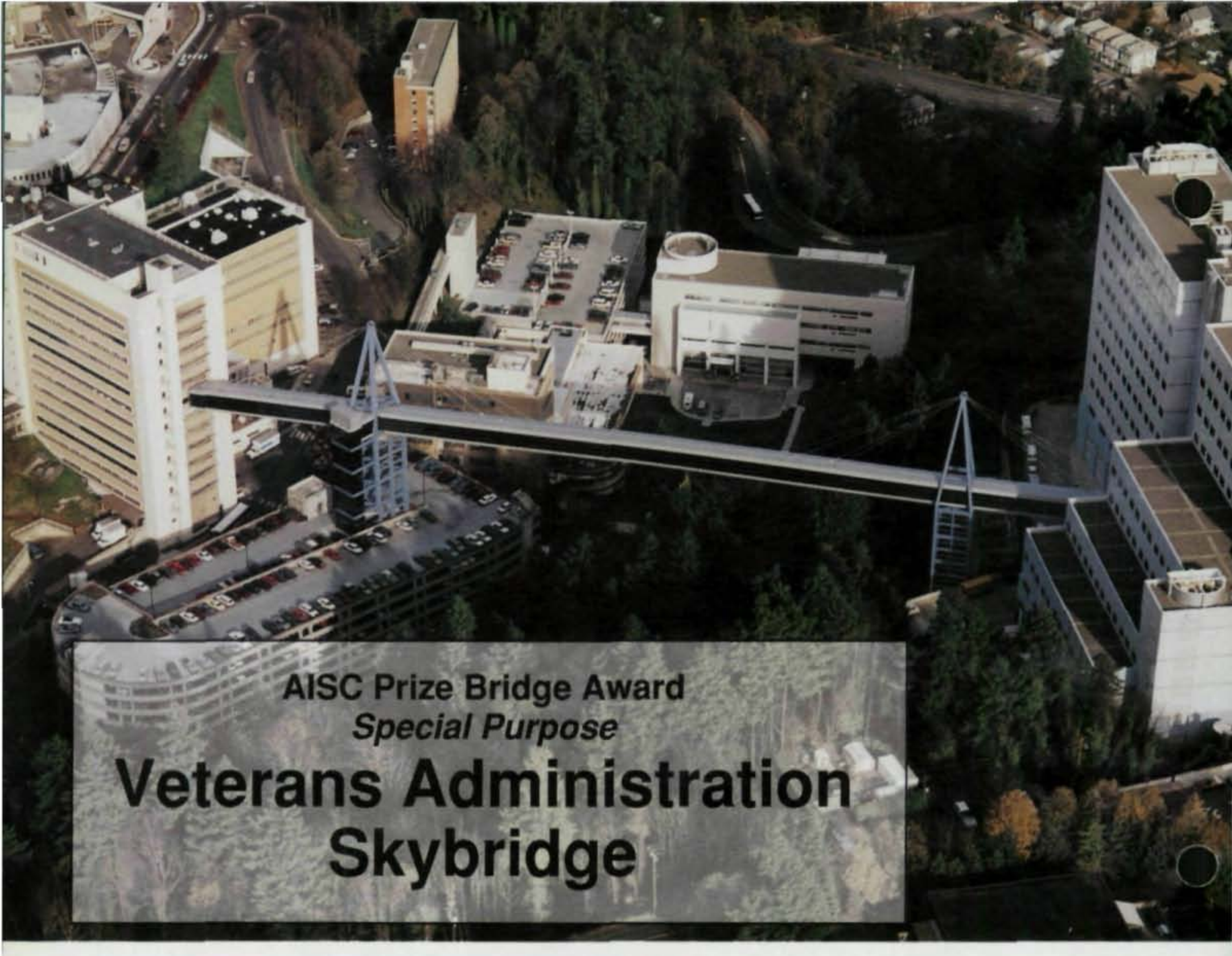
New Abutments

The trusses bear on new abutments placed behind the original ones. The new abutments consist of reinforced concrete pile supported grade beams. The truss bearing areas are cantilevered to achieve maximum roadway width while still keeping the pile group within the confines of the existing stone approach parapets.

The bridge spans 110′, measured center-to-center of bearing. Each truss consists of A36 steel for verticals, diagonals, and floor beams, and A572 steel for upper chords, lower chords and gusset plates. The paint system consists of a two-part epoxy mastic aluminum primer and a two-part aliphatic polyurethane enamel topcoat. To help the bridge fit in with the natural setting, a foliage green paint color was selected.

Each truss was fabricated in two pieces and shipped by truck to the job site, a distance of approximately 175 miles. The pieces were bolted together before erection. Each truss weighted 30,000 lbs., and the floor beams weighed 2,000 lbs. each.





AISC Prize Bridge Award
Special Purpose
Veterans Administration Skybridge

Design firm:	Zimmer Gunsul Frasca Partnership/Skidmore Owings & Merrill, A Joint Venture and KPFF Consulting Engineers, Portland
Consulting firm:	Rowan Williams Davis & Irwin, Guelph, Ontario, Canada
General contractor:	Donald M. Drake Co., Portland
Steel fabricator:	Canron Construction-Western, Portland
Steel erector:	Steel Engineering & Erection, Anchorage, AK
Owner:	Veterans Administration
Total cost:	$6.7 million
Span lengths:	360' center
Roadway widths:	10'
Steel wt./sq. ft. of deck:	300 lbs.
Vertical clearance:	170' max.
Steel tonnage:	1,210 tons
Structural system:	Cable-assisted, three-dimensional flexural truss
Innovative concepts:	Innovative design methods were required to deal with logistical problems of spanning 660'-wide ravine with limited access

For more than 30 years, Dr. John Kendall, dean of the Oregon Health Sciences University (OHSU) School of Medicine, dreamed of a skybridge over the 150'-deep ravine separating his institution from the Veterans Administration Medical Center (VAMC). Although the two facilities shared many operations, logistics were a constant difficulty. For instance, a liver transplant patient had to endure a time-consuming ambulance trip to travel around the ravine to get from the VAMC to OHSU. Construction of a skybridge would not only cut travel time, it would also reduce manpower costs.

Last year, Kendall's dream became a reality with the opening of a 660'-long skybridge.

The skybridge spans from the second floor of the VAMC to the ninth floor of OHSU's medical center. Two towers support the steel bridge structure, with the south tower located at the south edge of the ravine, adjacent to the VAMC, and the north tower extending through an existing OHSU parking garage. Located near quarter span, the south tower rises 150' from its base through the basement and eight floors of the parking structure to its peak.Two elevators at the north tower provide access from the top two floors of the garage to the skybridge. The 377'-long center span between the two towers is a dramatic 150' above a roadway through the ravine.

The design of the structure evolved into a cable-assisted, three-dimensional flexural truss comprised of 14" wide flange chord members and 8" structural tube diagonals. To meet the Veterans Administration's safety standards, the truss itself, without cable supports, was designed to support the full dead load weight of the structure in addition to 25% of the design live load based on strength, ignoring serviceability requirements. Four sets of cables splay out from each tower ring assembly, 75' above the bridge deck, to complete the full loading and serviceability requirements.

Shown opposite is an aerial view of the completed Veterans Administration Skybridge in Portland, while the top photo shows a similar view during construction. The photo above shows the interior of the completed bridge.

"Pedestrian bridges are very sensitive to vibration. If it bounces, people won't use it," explained Michael R. Walkiewicz, P.E., associate structural engineer with KPFF Consulting Engineers. "It's a 650'-long box, but when you go out on the bridge, you feel just like you're walking in the hospital corridor."

The location of each cable was optimized to limit live load deflections and vibrations. The cable design utilized high-strength threaded steel rods rather than traditional high-strength stranded cables, which allowed simple anchorage assembly details, simplified construction, and will reduce maintenance. Also, during construction the rods were used to support the cantilevered bridge sections, then adjusted to the proper lengths and load levels as the skybridge was completed.

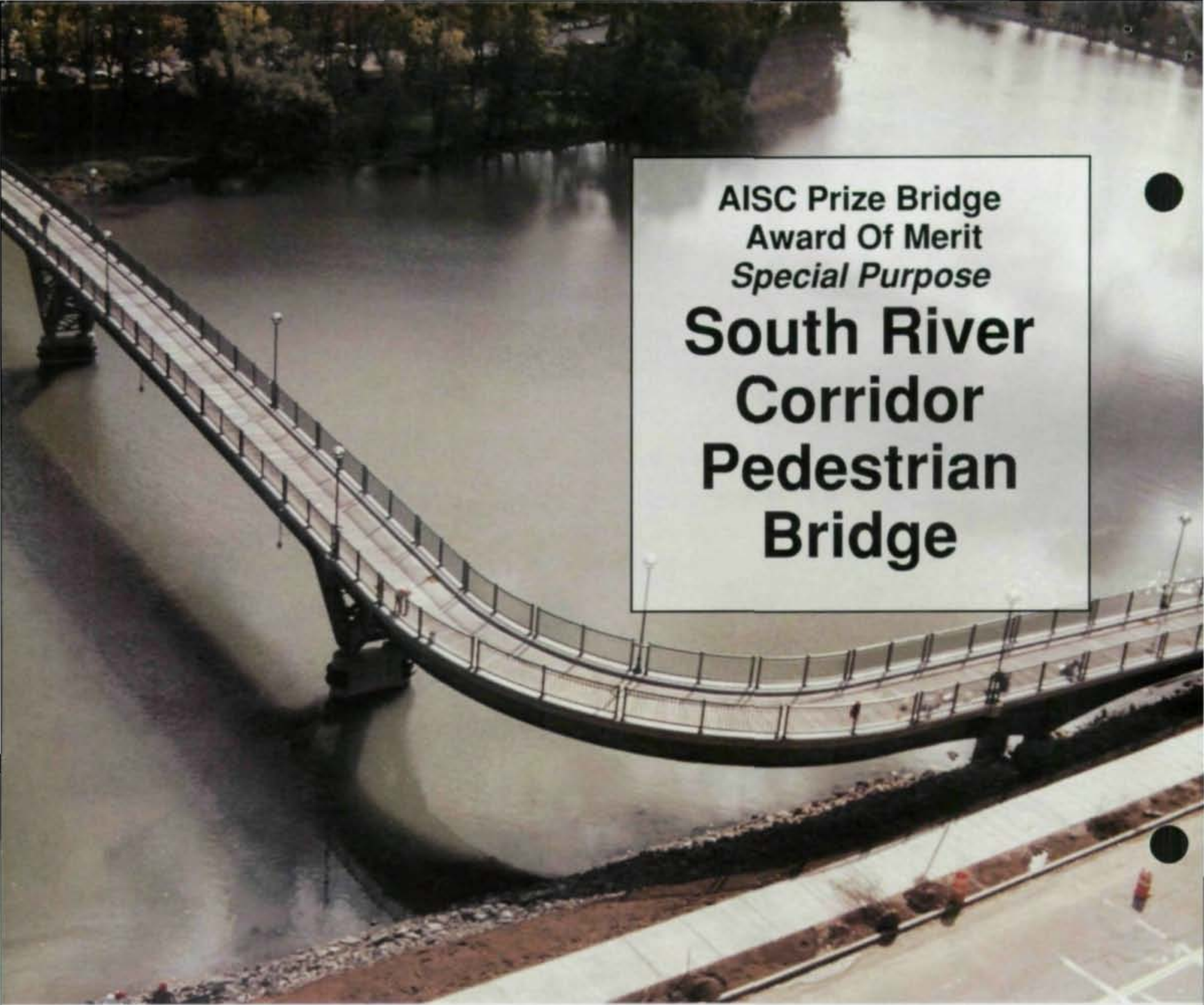
An elaborate computer study was undertaken using SAP 90 to evaluate the bridges response to foot traffic induced vibrations. A three-dimensional finite element computer model of the structure was subjected to half-harmonic loading in resonance with the respective bridge modes most closely representing pedestrian traffic patterns, such as walking, jogging and running. The same computer

model was utilized to determine the dynamic response of the bridge to wind and seismic forces.

The use of threaded steel tension rods was not limited to the cables supporting the skybridge structure. Similar rods were incorporated into hold-down assemblies at both ends of the skybridge. Due to limited access and architectural design considerations at both buildings, large towers could not be built to support the cantilevered ends of the skybridge. Instead, threaded steel tension rods were used as hold-downs to prevent vertical movements.

The design of the project required state-of-the-art modeling and computer analysis. Consultant Rowan, Williams, Davis & Irwin performed an aeroelastic wind tunnel test of the bridge. A geometric and dynamic replica of the full bridge was used to measure selected forces, bending moments and deflections at various locations on the skybridge under wind loading. The test also evaluated the bridge's aerodynamic behavior and its potential for vortex shedding and torsional or vertical instabilities.

The final construction cost of $6,760,000 was within the project's $7 million budget. The Veterans Administration estimates the bridge will save at least $900,000 annually in the operation of both hospitals.



AISC Prize Bridge
Award Of Merit
Special Purpose

South River Corridor Pedestrian Bridge

Design firm:	Bergmann Associates, Rochester, NY
Consulting firm:	Sasaki Associates, Watertown, MA
General contractor:	C.P. Ward, Inc., Rochester, NY
Erector:	Syracuse Rigging Co., Syracuse, NY
Owner:	City of Rochester
Total cost:	\$2.6 million
Span lengths:	90'-162.5'-162.5'-112.5'-90'-76.5'
Roadway widths:	10'
Steel wt./sq. ft. of deck:	70 lbs/sq. ft.
Vertical clearance:	15'-6"
Steel tonnage:	340 tons
Structural system:	Rigid frame/continuous multi-span plate girder
Innovative concepts:	Incorporation of vertical & horizontal shadow plates for aesthetics

The South River Corridor Pedestrian Bridge is part of a long-range master plan for the redevelopment of a three-mile stretch of the Genesee River in Rochester. A critical element of the planned development was the construction of a pedestrian bridge linking the residential and commercial districts on the west side of the river with the University of Rochester campus on the east side. A secondary function of the bridge was to link the east and west side pedestrian trails along the river.

While the east bank elevation allowed for a bridge touchdown point directly onto an adjacent boulevard, the west bank landing was more complicated. The close proximity of the navigation channel to the west shoreline, due to a bend in the river, plus the slight elevation differences between the bank and the river, precluded a straight alignment across the river which would satisfy both the required navigation channel vertical clearance and handicap access requirements. A ramping configuration study concluded that a ramp running parallel to an adjacent street on the west bank best satisfied the criteria and minimized obstruction to site lines and views of the river. The end result is an "L-shaped" structure.

Overall aesthetic appearance played a major role in bridge type selection. Bridge types studied included: suspension; cable stayed; steel truss; conventional multi-span steel plate girder; and post-tensioned concrete box bridges. Budget, aesthetics and constructability concerns led to the selection of a combination rigid frame/ multi-span plate girder structure incorporating triangular "delta" legs at the main river piers.

The six span continuous bridge superstructure is comprised of two fabricated steel plate girders made composite with 7½" monolithic concrete deck slab. Triangular steel rigid frames were integrated with the girders at the three main river piers. All structural steel is ASTM A36.

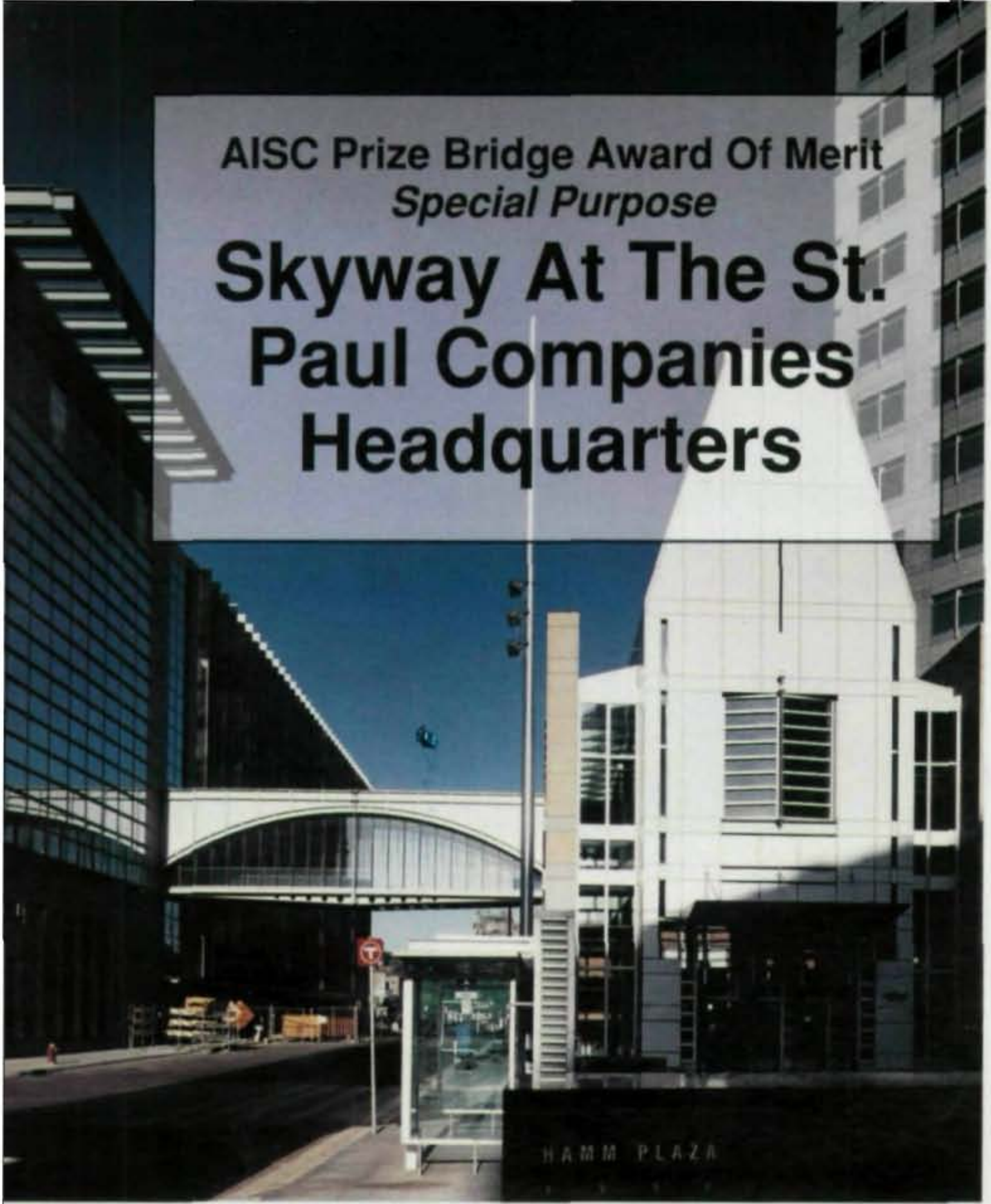
The selection of span length was based on the navigation channel size and location, creature comfort deflection criteria, economics and aesthetics. Delta legs, incorporated in the design for aesthetics, posed special design considerations due to their rigidity. The rigid legs, coupled with the sharp curvature (42' radius) of the bridge, required a detailed 3-D model structural analysis in order to predict the structures behavior under imposed external and thermal loads. Special bracing and bridge movement demands resulted. The relatively small elevation difference between

the west bank and the water dictated a tapered girder configuration along the west shoreline in an attempt to keep the bridge superstructure out of the water under design flood conditions. The resulting variable depth girder cross section increased the complexity of the analysis and design.

One of the more unusual features of the bridge is the addition of "shadow plates." Horizontal and vertical plates were welded to the outside face of the girder webs to add visual interest by their physical presence and to cast shadow patterns. The horizontal plates accentuate the horizontal scale of the structure, while the vertical plates are located in pairs to coincide with railing and light posts.

AISC Prize Bridge Award Of Merit
Special Purpose

Skyway At The St. Paul Companies Headquarters



Design firm	Kohn Pedersen Fox Associates, New York
Consulting firm:	Weiskopf & Pickworth, New York
General contractor:	McGough Construction Co., Inc., St. Paul
Steel erector:	Danny's Construction Co., Shakapee, MN
Owner:	The St. Paul Companies, St. Paul
Total cost:	$435,000
Span lengths:	60'
Roadway width:	12'
Steel wt./sq. ft. of deck:	54 lbs/sq. ft.
Vertical clearance:	22'-3"
Steel tonnage:	19.5 tons
Structural system:	Load carrying members at top of bridge suspend a light floor system from a series of hangars
Innovative concepts:	Slenderness and transparency were emphasized

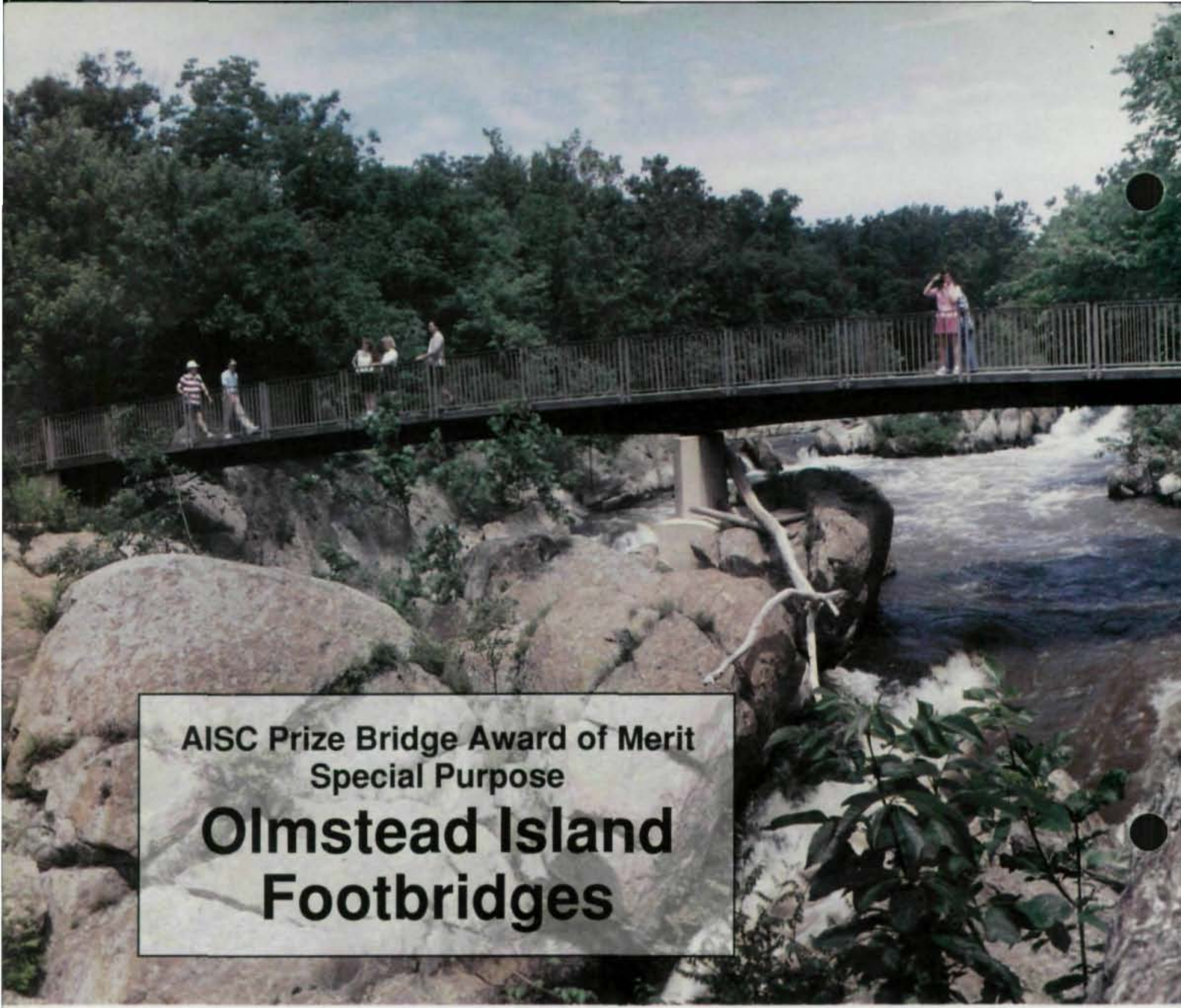
Slenderness and transparency were the design goals for the new Skyway at the St. Paul Companies Headquarters in St. Paul. The Skyway spans over a city street to link a new headquarters complex with an existing complex at the second floor.

The bridge's architectural design called for an extremely slender floor and transparent window walls. The architects selected a "see-through" bridge so the through-block view of historic St. Paul's Cathedral would not be obstructed.

Responding to the architectural parameters, the project structural engineers decided to place the main floor carrying members at the top of the bridge and suspend a thin floor system from a series of narrow hangars.

The skyway roof contains two W30x211 girders to which the hangar rods for the bridge floor are attached. Two horizontal trusses are incorporated in the roof framing system to provde the lateral wind-resisting system while permitting the mechanical equipment for the bridge to be located along the center of the bridge.

Continuous exposed structrual steel channels on each side of the bridge deck provide the means to attach the suspension rods to the bridge floor. These channels also are used as flange elements and a 3" cellular deck is used as the web element of a horizontal girder that is used to resist the wind loads at the bridge floor.



AISC Prize Bridge Award of Merit
Special Purpose

Olmstead Island Footbridges

Design firm:	Robinson Engineering, Raleigh, NC
Project management:	Montgomery County Dept. of Facilities & Services
GC & erector:	Allied Contractors, Inc., Baltimore
Owner:	National Park Service
Total cost:	$220,000
Span lengths:	100'
Roadway widths:	6'
Steel wt./sq. ft. of deck:	45 lbs/sq. ft.
Vertical clearance:	30'
Steel tonnage:	13.5 tons
Structural system:	Steel box girder with composite concrete deck
Innovative concepts:	"Flood proofing" of a pedestrian bridge, including incorporation of removable handrails

More than two decades ago, Hurricane Agnes' floodwaters ravaged Olmstead Island at the Great Falls in the C&O Canal National Historic Park, MD. In addition to severely damaging four bridges on the island, the storm destroyed the superstructure of the only bridge providing land access to the island—effectively closing the island to the public. Finally, in 1991, a consortium led by Montgomery County Councilman William Hannan obtained a mixture of public and private funds to repair the existing bridges and build a new connection to Olmstead Island.

A key consideration in the design of the new access bridge was the possibility of future flooding. As a result, the center pier was socketed and rock bolted into the existing exposed bed rock formation, and bridge bearing connections were designed to withstand both the horizontal and vertical uplift forces of flood waters. Also, the steel handrails were designed to be quickly removable when flooding is predicted so that the amount of debris the bridge will trap during a flood would be minimized.

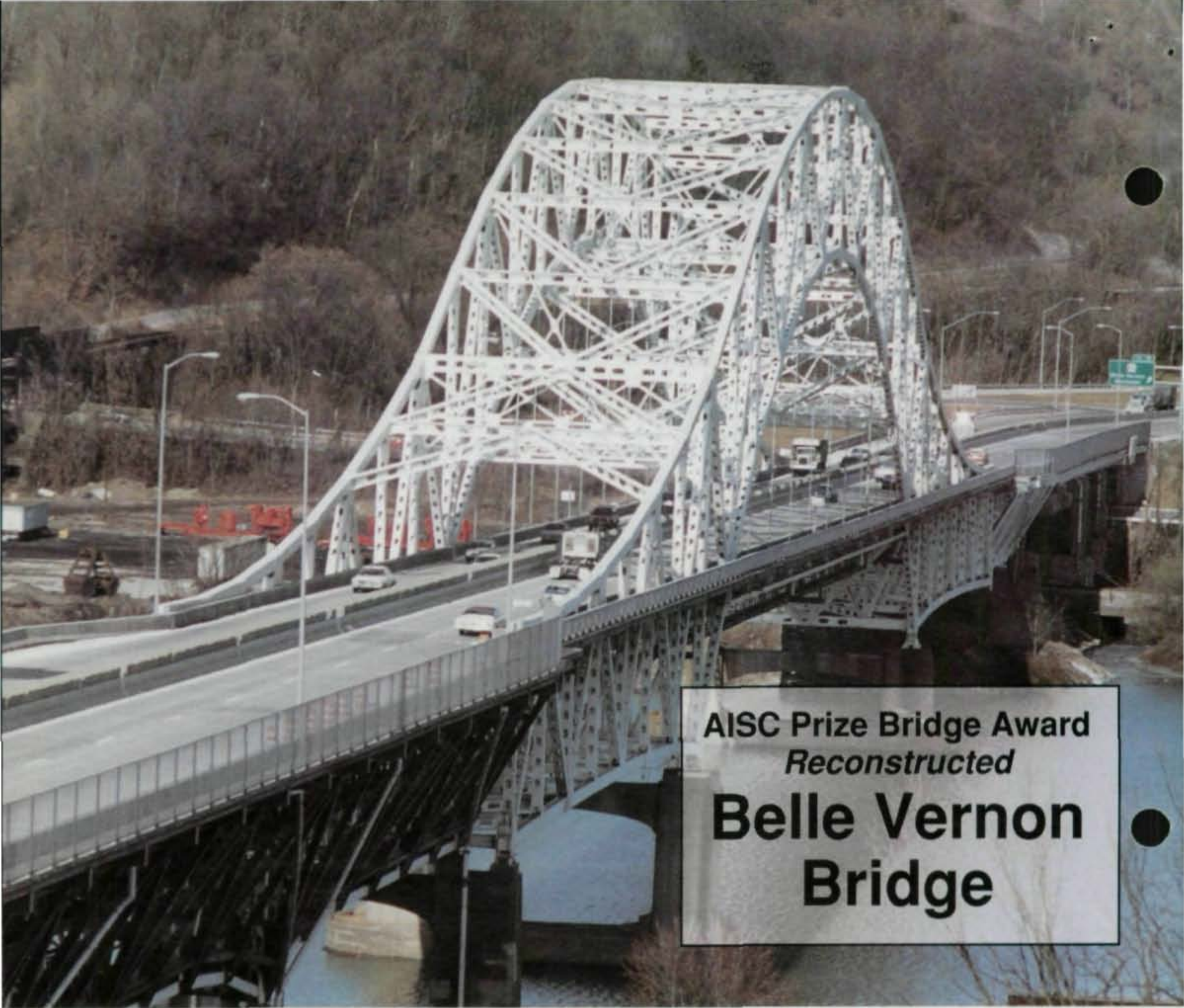
Another consideration in the bridge's design was its setting. The Park Service did not want a structure that was obtrusive or overpowering; rather, they wanted a structure that would blend with the natural setting. A box girder design superbly fit those requirements. In addition to its shallow depth minimizing the bridge's visual impact, a box girder creates a more rigid and torsionally stronger structure than other design alternatives, thus providing a greater ability to resist future flood waters. Finally, it was decided to use 50 ksi weathering steel to reduce maintenance costs and further blend the bridge with the rustic setting.

The location of the bridge added an additional constraint to design and construction. The only access was across existing Lock 19 of the C&O Canal and along the canal's treelined tow path. The load limit of the access bridge across Lock 19 was restricted to 10 tons gross weight and an immediate sharp 90° turn was required to negotiate onto the narrow, 12'-wide tow path. This access restriction prohibited the use of conventional equipment to construct the bridge. Also, strong cross winds caused by the deep gorges of the river ruled out the use of a skycrane. As a result, the box girder was designed with two full penetration welded field splices to permit the girder sections to negotiate the narrow tow path as it was moved along on a dolly by a small rubber-tired front end loader.

Primarily due to the efforts of the Montgomery County Government and with private contributions, a new bridge to wonderfully scenic Olmstead Island was constructed. As a result, for the first time in almost 20 years, the park was readily accessible to the public.

Once at the site, the contractor used a cableway to erect the 100' box girder. All components of the cableway had to be light enough to be transported and erected by hand at the bridge site. Therefore, the contractor designed the cableway around the use of heavy duty modular shoring frames for towers with light steel beams that could be ginpoled into place on top of the shoring frames to create the sliding headworks of the cableway. The tiebacks to the cableway were anchored into existing bedrock outcroppings surrounding the work site. The cableway also was used to transport other materials, such as formwork and concrete, as well as small equipment such as generators, across the roaring waters of the gorge at the access bridge site.

The project was funded, in part, by private contributions through an effort lead by the Montgomery County Government.



AISC Prize Bridge Award

Reconstructed

Belle Vernon Bridge

Design firm:	Tensor, Inc., Upper St. Clair, PA
Project management:	Montgomery County DF4S
GC & erector:	Dick Corporation, Pittsburgh
Steel fabricator:	National Eastern Corporation, Plainville, CT
Owner:	Pennsylvania DOT
Total cost:	$34 million
Span lengths:	52' to 452'
Roadway widths:	30.5' to 55'
Steel tonnage:	2,150 tons
Structural system:	Steel through truss, deck truss & multigirder
Innovative concepts:	Widening of deck for acceleration and deceleration lanes by addition of slope trusses

Despite the need for major renovation work, the large daily traffic flow—in excess of 38,000 vehicles—on the 2,064'-long Belle Vernon Bridge required that at least one lane of traffic in each direction be kept open at all times.

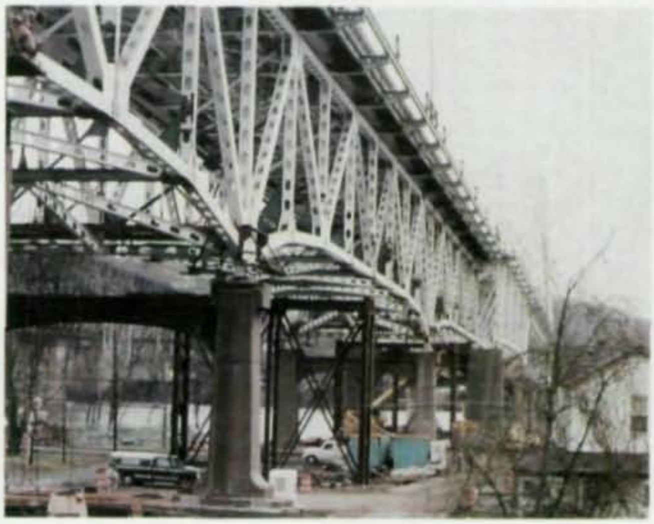
The bridge carries Interstate 70 over the Monongahela River at Belle Vernon, PA, and consists of four steel deck truss spans and five girder spans, with the main river spans comprised of a three-span continuous, humped-back trussed arch. In addition to the main waterway, the structure spans two railway systems, two state highways, and local streets.

While the renovation work included repairs and strengthening of the existing superstructure and substructure components, as well as ramp and mainline reconstruction and culvert extensions, the key to the project was the addition of acceleration and deceleration lanes, both on and off the structure, to provide safe access and egress for the interchanges immediately adjacent to both sides of the bridge.

Widening was achieved by a unique conversion of the existing deck trusses to trapezoidal space frames. This design maximized the effective use of the existing trusses while minimizing substructure widening and additional steel. It also eliminated hydraulic involvement with an adjacent stream and the related right-of-way costs.

Other innovative design approaches included:

- Floor beam extensions—New sections of floor beams were spliced on to the existing floor beams to facilitate widening. The extensions are supported on new slope trusses, which were added to the existing trusses to form the space frame system.
- Stringer continuity—Continuity was created by splicing existing and new stringers. This eliminated an existing connection problem of popped rivet heads as a result of excessive stringer flexibility.
- Composite action—The addition of shear studs to the floor system members and main girders increased strength.
- Lightweight concrete—A concrete-filled steel grid deck was replaced with a standard 8" reinforced concrete deck comprised of lightweight concrete to minimize additional dead load.
- Maintaining traffic—An unusual inside lane-outside lane variation of the half-width construction method was used for the maintenance and protection of traffic.
- Superstructure jacking—Superstructure jacking allowed for the replacement of 52 bearings, improved vertical underclearance, and for the erection of the new slope trusses. Additional jacking provided for complete pier re-



Pictured above is the reconstructed Belle Vernon Bridge after construction. A similar view is shown at left prior to reconstruction.

Pictured above are the new floor beam extensions supported on the sloped truss.

placement accomplished while maintaining traffic.

- Suspender testing and replacement—Selected suspenders were removed for testing. Subsequently, all suspenders were removed and replaced. The jacking and suspender operations were monitored by measurement of the suspender tension at various stages by means of a vibration sensing device.
- Abutment Stabilization—The existing west abutment was stabilized by the addition of permanent tie-backs.
- Side-swipe impact attenuator—A side-swipe type impact attenuator was added at the merge point of each acceleration lane on the structure.

All of the work was completed during two construction seasons and the renovated structure was opened to traffic in December 1992.

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