Innovations Needed If Steel Bridge Market To Flourish

Walter Podolny, Jr.

John M. Kulicki

Edward P. Wasserman

Steel has lost its dominance in the bridge market, and for it to regain prominence, the fabrication and design communities must begin adopting new technologies and design concepts, according to several speakers at this year's National Steel Bridge Symposium. Fortunately, concepts ranging from increased use of weathering steel to integral abutments are already available and new concepts—including corrugated webs and tubular flanges filled with concrete—are under consideration.

The biennial National Steel Bridge Symposium, presented by the National Steel Bridge Alliance and co-sponsored by FHWA, AASHTO, AISI and AISC, attracted more than 300 attendees, including representatives from more than 20 state highway departments and the FHWA. In addition to 1½ days of paper presentations, the symposium included the presentation of the 1996 Prize Bridge Awards and three technical workshops.

"As we, in 1996, contemplate the past we are aware that for approximately the first 60 years of the 20th Century, steel was king," stated Walter Podolny, Jr., a Senior Structural Engineer in the Bridge Division of the FHWA, in a session entitled *Winds of Change and Paradigms of Obsolescence.* But during the past four decades, the growth of concrete bridges has been rapid. "As we contemplate entrance into the 21st Century, have the winds of change already shifted? If so, what can the steel industry do to regain its title as the preferred material for bridges?" The answer, according to Podolny and other speakers at the Symposium is to look at the best in bridge design today and also improve on it by capitalizing on the new high performance steels that will soon be available.

Weathering Steel

Not surprisingly, weathering steel was strongly promoted at the Symposium. "Weathering steel has been used for highway bridges in the US since 1964," explained Robert L. Nickerson, president NBE, Ltd., and one of the speakers discussing the use of weathering steel for bridges. "Since then, approximately 2,500 bridges have been built in the US using uncoated weathering steel."

Essentially, weathering steel offers a reduced first cost and lower life cycle costs by eliminating the need to paint—and ultimately repaint—a bridge. "Although weathering steel (Grade 50W) costs a few cents—currently about $0.03—more per pound than the non-weathering Grade 50, the cost of the initial painting of the Grade 50 steel is often more than twice that difference. A cost estimate prepared for a 5,000 ton bridge project by a leading steel bridge fabricator indicated the cost to paint the steel was $0.085 per lb. Thus, the potential first cost savings is over $0.05 per lb. for this project, representing a potential savings of over $500,000." Nickerson also pointed out that a 1995 report on 67 bridges in 11 states and Puerto Rico revealed that except for certain bridges in Michigan, weathering steel bridges have performed exceptionally well in all types of environments, including areas using large quantities of de-icing salt, low-level water crossings and marine and industrial environments.

Integral Abutments

Another currently available technology that can improve the competitiveness of steel bridges is the use of integral abutments for jointless steel bridges, according to Edward P. Wasserman, director of the Division of Structures of the Tennessee Department of Highways. "Today's bridge designer is essentially striving to achieve the same goals as his counterparts were 70 years ago: long term serviceability; low maintenance characteristics; and economy of construction. While we have mastered new techniques such as welding, composite decks, load factor and Autostress designs, we still cling to many old ideas that lessen the potential for achieving our goals. One of the more important aspects of design, reduction or elimination of roadway expansion devices and associated bearings, is consistently overlooked or avoided by many bridge design practitioners," Wasserman stated.

"Over the past 30 years, engineers have become more aware of the pitfalls associated with the use of expansion joints and expansion bearings," he added. "Joints are expensive to buy and install, as well as to maintain and repair." In addition, recent studies have shown that providing for thermal movements by means of expansion joints and bearings does not avoid maintenance problems; "rather, their provision can facilitate problems."

High Performance Steels (HPS)

An important future development for the steel bridge industry is the ongoing development of high performance steels. "Recent advances in steelmaking and processing enable close control of melting, alloy addition, temperatures and cooling rates," explained John M. Barsom, Research Fellow with the U.S. Steel Group. "Technological advances have been so dramatic that a large percentage of available products could not have been produced 10 years ago." The next step is the development of Grade 70W and Grade 100W high performance steels (HPS), a development that is currently underway in a project sponsored by the FHWA. So far, several test heats of a Grade 70W steel have been produced and test results have been very positive. In addition, a case study is being initiated by the Nebraska Department of Roads in a cooperative effort with FHWA, AISI and NSBA. The three-phase project will include the construction of a 150' simply supported steel girder bridge fabricated with HPS 70W steel, the design and construction of a two-span continuous steel bridge using HPS, and ultimately the design, construction and monitoring of an actual highway bridge using HPS.

John M. Kulicki, Ph.D., a principal at Modjeski and Masters, Inc., explained that the new high strength steels will offer improved strength, weldability, ductility, fatigue and fracture resistance, and fabricability. Several innovative structural systems are now under consideration for future use with HPS, though Kulicki stressed that some of these systems still require a substantial amount of additional study—though he also noted that some could be used today with Grade 50W steel and at least one of the new systems has already been used in Europe. Among these systems are: built-up I-girders with corrugated webs; built-up girders with tubular, concrete-filled flanges; built-up I-girders with double, sheet metal webs; stacked rolled shapes; cold-formed self-stiffening box girders; and a tubular steel truss system.

"Some of these concepts could save as much as 25% of the steel quantity in some structures," according to Kulicki. "The corrugated web and tube flange girder, the sandwich web girder and the tubular space truss are particularly promising." Again, he emphasized that some of the concepts—including the corrugated web system—are worthy of marketplace testing now, while others require more research. As James Cooper, Chief of the Structures Division of the FHWA's Office of Engineering Research & Development added: "To quote Nike, 'Just do it.'"

Charles Nemmers, Director of the FHWA's Office of Engineering, Research & Development and the keynote speaker at the Symposium Banquet, summed up the matter by quoting that eminent philosopher Yogi Berra: "If you do what you've always done you'll get what you always got."

Other sessions at the Symposium covered design/build, seismic issues, composite design, short-span bridges and steel-bridge pre-assembly. The next National Steel Bridge Symposium is expected to be held in 1998, though no dates or location have yet been announced.

Copies of the Symposium Proceedings, including most of the papers presented, are available for purchase for $35 plus s/h. To order a copy of the 1996 National Steel Bridge Symposium Proceedings, call AISC Publications at 800/644-2400.

Optimized Steel Bridge Design Chosen For Mississippi River Crossing

The new U.S. Route 36 Bridge is in the foreground, the old is in the background.

In recent bidding for the new U.S. Route 36 Bridge over the Mississippi River at Hannibal, MO, welded steel girders were selected over prestressed concrete girders. While not an unusual outcome, what was special was the design process that led up to the choice.

Sverdrup Civil, Inc., of Maryland Heights, MO, was retained by the Missouri Highway and Transportation Commission to design the 4,490'-long bridge. As part of the design process, Sverdrup provided two completely independent packages of plans and specifications, each optimized for the specific structural material, for a major segment of the project. Both alternates were designed using the 1992 AASHTO Standard Specifications for Highway Bridges as modified by the Missouri Highway and Transportation Department (MHTD). Load Factor design was used for both alternates and each was designed for an HS 20 Modified live load (1.25 x HS20).

"Rather than merely adapt the same design to different materials, we tried to use the most beneficial aspects of each alternate to optimize the design," explained Robert D. Niemietz, P.E., S.E., project manager with Sverdrup.

For example, the span arrangement for the steel alternate was chosen in part to maximize span length while minimizing the number of shipping pieces of steel. "In addition, the arrangement was configured to allow the use of relatively inexpensive laminated elastomeric bearings," Niemietz explained.

The new bridge consists of four segments, the Missouri Approach, the Navigation Span, the Illinois Approach, and the Missouri-Illinois Approach, the latter of which was bid as concrete and steel alternates to meet then-current FHWA requirements. The 1,320'-long Missouri-Illinois Approach was bid as a concrete alternate with 10 spans of 132'-long prestressed girders and a steel alternate with six spans of 220'-long plate girders. The concrete alternate was arranged into two, three-span units and a four-span unit with each unit made continuous for live load, while the steel alternate was arranged into two, three-span continuous units.

"Sometimes, during the design phase we look for input from local fabricators," Niemietz said. In this case, advice was provided by personnel at AISC-member Stupp Bros. However, even though Stupp Bros. provided input in the design phase, they were not the successful bidder on the Missouri-Illinois bid package. Rather, AISC-member PDM Bridge won the contract for that portion of the bridge. General contractor on this portion of the project is Edward Kraemer and Sons, Inc., of Plain, WI.

The girders for the Missouri-Illinois Approach were designed using ASTM A709, Gr. 50W structural steel. The girders were designed as composite with the future concrete deck in the positive moment areas and non-composite in the negative moment areas. The girders were spaced at 13' centers with seven lines of girders required to support the 85'-8" wide deck slab.

The steel design made use of a braced, non-compact section using vertical transverse stiffeners only in regions of high shear stress. The web plate chosen for all segments of the 220'-long spans was $^{11}/_{16}$"x108". Longitudinal web stiffeners were not used.

"During the design process, an effort was made to minimize the number of field bolted splices required while keeping shipping piece lengths to a maximum of 120'," according to Niemietz. Also, changes in flange sizes that would require complete joint penetration butt welds were carefully critiqued by comparison of total weld cost to potential weight cost savings of structural steel resulting from reducing the flange size and then the more cost effective option was chosen.

Finally, weathering steel was chosen to minimize maintenance costs. "Painting of the structural steel was limited to the areas required by MHTD to be painted when using weathering steel," Niemietz explained. "These areas included a distance of approximately 10' from the ends of the girders where deck expansion devices will be installed and the top flange of the girders."

Bids for the first construction contract were received on August 23, 1996. Nine firms submitted bids for this contract, and all nine selected the steel alternate over the concrete alternate. Much of the cost advantage of the 4,084-ton steel alternate was due to the elimination of four river piers required in the concrete alternate. As a result, the steel alternate could use longer spans and achieve more favorable unit prices.

Mea Culpa

- The Prize Bridge Awards featured in the October 1996 issue were conducted in partnership with AISI and their generous contribution is greatly appreciated.
- The correct fabricator for the Route 19-Interstate 80 Prize Bridge Award winner in the Grade Separation category is AISC-member Carolina Steel Corp.
- The final configuration and details for the South Station Connector Ramp were prepared by the Massachusetts Highway Department (MHD). The structure will be jointly owned by MHD and the Massachusetts Bay Transporation Authority.
- Universal Structural, Inc. should have been listed as an AISC-member.

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For a directory of AISC Personnel, see page 13

News Briefs....

1997 National Steel Construction Conference

With today's economic climate and the fast and furious pace of advancing technologies and resources, questions mount seemingly faster than they can be answered. AISC's National Steel Construction Conference is a once-a-year opportunity to delve into the rapidly changing and advancing world of steel design and construction and surface with practical information to help your practice today. The conference and exhibition, scheduled for May 7-9 in Chicago, includes more than 25 problem-solving technical sessions as well as a comprehensive product exhibit.

This year, sessions are offered focusing on five areas: erection; fabrication; engineering management; engineering technical; and welding. In addition, following the conference will be a separate short course on HSS Connections.

Some of the papers to be presented at NSCC '97 include:

- Bracing and Stability. This session will focus on new methods of analysis and design for stability that have become possible and practical as computers have become more powerful and more affordable. Included will be a look at simple energy methods of stability and analysis and their applicability to practical stability problems.
- Cladding on Multistory Steel Frames. This session will discuss a variety of different cladding systems and their effects on frame design.
- Moment Connections. This session will address current alternative details for SMRF connections in regions of high seismicity; implications of Northridge SMRF connection failures for wind-controlled moment connection designs; and new developments in extended end-plate moment connection design-use in seismic applications and the use of snug-tight bolts.
- Erection of Large Scale Projects. This session will focus on two large projects (International Terminal Building at Vancouver International Airport and the Rose Garden Arena in Portland, OR) to illustrate innovations in the design and construction and their effects on erection.
- Detailing for the Shop. A detailed discussion of detailing issues, including software concerns.
- Structural Welding Code Requirements. An in-depth look at changes in the 1996 ANSI/AWS D1.1 Structural Welding Code.
- What an Engineer Should Know About Welding Procedures. This presentation will discuss the capabilities and limitations of the welding processes commonly used for structural work.
- Innovations in Cutting, Burning and Welding. Emerging developments will be discussed in terms of their applicability to the fabrication of structural shapes.

For more information on NSCC '97, either check at AISC's web page at http://www.aiscweb.com or use the NSCC faxback service at 800/787-0052 x110.

NSBA Presents Two Awards

The National Steel Bridge Alliance recently presented to Special Awards for outstanding service to the steel bridge industry.

Edward P. Wasserman, Director of the Division of Structures for the Tennessee Department of Highways, was recognized for his outstanding contribution to bridge design and construction, his leadership among AASHTO State Bridge Engineers, for initiating and implementing innovative research and for his work on numerous award-winning steel bridges.

Krishna K. Verma, P.E., Welding and Structural Engineer with the Bridge Division of FHWA, was recognized for his outstanding contribution to the field of fabrication and erection of steel bridges, particularly through his efforts in providing substantial technical support to state DOTs, various joint government/ industry organizations and committees, as well as his work in specification and code writing. He was also honored for his efforts in promoting new research ideas and developing training initiatives for new construction and inspection.

The two awards were presented by the National Steel Bridge Alliance, a division of AISC formed to to enhance the art and science of the design and construction of steel bridges.

PIE Initiates New Education Efforts

The Partners in Education (PIE) Committee of AISC is implementing a new campaign to encourage industry-university cooperation. The objective of the campaign is to forge productive interaction between fabricators and faculty of universities in their areas, to increase AISC's support and influence in higher education, and to inform university administrators of the educational needs and importance of the structural steel industry.

Among the chief goals of the campaign are to encourage civil engineering programs to offer sufficient structural engineering content and steel design courses to ensure that future engineers understand the requirements necessary to provide safe and economical structures. The program also aims to encourage interaction between practicing engineers and both professors and engineering students. In addition, a goal is to expose architectural students to various facets of steel design and construction.

PIE participants include: Frank Hatfield of Michigan State University; Paul Y. Thompson of the University of Florida; Mohammed Elgaaly of Drexel University; Donald R. Sherman of the University of Wisconsin—Milwaukee; Reidar Bjorhovde of the University of Pittsburgh; Stanley Rolfe of the University of Kansas; Lawrence D. Reaveley of the University of Utah; Charles Roeder of the University of Washington; Helmut Krawinkler of Stanford University; Harry Moser of E.I. DuPont in Wilmington; DE, H. Louis Gurthet of AISC; Michael F. Engestrom of Nucor-Yamato Steel; Gholam H. Masoumy of Engineering Design and Management in St. Louis; R. Philip Stupp of Stupp Bros., Inc.; Thomas S. Tarpy, Jr., of Stanley D. Lindsey & Assoc. in Nashville; Ora A. Winzenried of Kenton Structural & Ornamental Iron Works in Kenton, OH; and William D. Bast of Central Building & Preservation L.P. in Chicago.

For more information on the Partners-in-Education program, contact Fromy Rosenberg at 312/670-5408.