Bridges: Innovation

ANSWERED BY M. MYINT LWIN, MALCOM THOMAS KERLEY, P.E., AND RAY MCCABE

Some important questions have complex answers and benefit from reflection and discussion. In this series designed to reflect that understanding, NSBA asks leading minds in the bridge community to weigh in on some of life's imponderables.

QUESTION: What innovations are needed to make steel bridges more competitive?

Answer: Malcom Thomas Kerley, P.E.
Chief Engineer, Virginia Department of Transportation

From a state perspective, state DOTs want strong, both technically and financially, industry partners. Strong steel industry partners create competition both within their industry and with other industries that states can benefit from. In a Design-Bid-Build environment, low bid is, of course, important. As states move to other delivery systems such as Design-Build and Public Private Partnerships, schedule may become more important in delivering a project.

In terms of past innovation related to steel bridges, weathering steels, high- performance steels, and new welding procedures ensure that the steel industry remains competitive with other industries. Continued improvements in materials and procedures are needed. The AASHTO Subcommittee on Bridges and Structures has an excellent relationship with the steel industry. The Subcommittee's "Grand Challenges: A Strategic Plan for Bridge Engineering" suggests innovative ways that the steel industry can optimize steel structural systems and how the industry can accelerate bridge construction.

Innovation is defined as "something newly introduced: new method, custom, device, etc., a change in the way we are doing things." The AASHTO/ National Steel Bridge Alliance (NBSA) Steel Bridge Collaboration has helped to define the needs of both partners and help achieve quality and value in steel bridges. Virginia, for example, participated for many years in the Federal Highway Administration's Mid-Atlantic Structural Committee for Economic Fabrication. Standardization of design, fabrication, and erection and the sharing of resources may not be considered innovative, but it provides for good engineering.

Answer: M. Myint Lwin

Director of the Office of Bridge Technology, Federal Highway Administration

Since the all-steel Eads Bridge in St. Louis, Mo. was completed in 1874, significant and progressive advancements in steels have been made through innovations in steelmaking and processing.

Today, there is a wide variety of structural steels with outstanding properties for modern bridge construction. These properties include a combination of strength, ductility, uniformity, fracture toughness, fabricability, repairability and recyclability. The bridge designers have a broad range of structural steels, such as, high-strength steels, weathering steels, high-performance steels, at their disposal in meeting the demands of their projects.

As we're learning from the aging interstate system, life cycle considerations are becoming more important as we replace bridges originally designed for a 50-year service life with more sustainable structures. It is of utmost importance that steel bridges (like all bridges) are protected from the corrosive effects of their service environment. Many materials and methods have been developed in the last 50 years for corrosion protection, such as, use of weathering steels, improved paint coatings, powder coatings, galvanizing, thermal spraying, etc.

Bridge designers will have to be innovative in meeting the challenge of providing cost-effective corrosion protection systems for further extending the service life of steel bridges. For complex bridges in a corrosive environment, designers may need to engage the service of corrosion specialists to work together in protecting bridges from the corrosive elements of the site.

FHWA, AASHTO and industry support research in the development of high-performing steels, cost-competitive high corrosion resistant steels, two-coat and one-coat paint systems, and other means to optimize the performance of steel bridges. In general, innovations need to focus on (1) selection of the right steels for the purpose, (2) design details and joints should be self-cleaning, self-draining, watertight and accessible for maintenance, (3) quality in fabrication and construction, (4) good workmanship in surface preparation and application of coatings, and (5) investment in preventive maintenance, such as, seasonal cleaning, debris removal, coating repair, leak control, to keep steel bridges in a state of good repair.

In summary, innovations must be directed to keep water and/or oxygen from steel components of bridges. The Eads Bridge is still in service. Many steel bridges in the National Bridge Inventory are 100 years or older. With proper care, steel bridges can have long service life!

Answer: Ray McCabe

National Director of Bridges and Tunnels, HNTB Corporation

Steel continues to bring the advantages of light weight, slenderness, flexibility, toughness and repairability to the bridge industry. For spans over 500 ft, steel continues to dominate and thus I will not focus my comments here except to say there are many areas of improvement or innovation here. But what about short and medium spans, accelerated bridge design and the upcoming need for efficient high-speed rail bridges? Here the choice is not so clear and needs to be the focus of the steel industry. More competitive steel bridges of the future will require improvements and innovations in the following areas: material, fabrication, design codes and design concepts.

Material. While the development of high-performance steels has certainly boosted the competitiveness of steel, the industry needs to continue its research on toughness, weldability and corrosion resistance. Economical steel bridges of the future will undoubtedly incorporate fewer main load carrying elements to where redundancy becomes a concern. Owners await the day when they will no longer have to worry about crack growth and corrosion.

Fabrication. The steel industry needs to get on board with production of longitudinally profiled plates. This process is common in Europe and should be here in the U.S. These plates allow thickness to follow actual stress thereby reducing material and improving fatigue performance. I also believe we need to develop reliable, economical and rapid automated field welding techniques that would lead to the possibility of segmental steel construction.

Design Codes. Continued work with the LRFD steel specifications is necessary as new steel concepts come on board with details that have little or no design criteria. We need to continue toward more simplistic design specifications. In general, complicated specifications lead to conservatism and thus increased cost.

Design Concepts. Perhaps the biggest area for innovation comes in the area of design concepts, but only through innovations in the prior areas can better design concepts become reality. A book can be written on innovative design concepts but due to the need to keep this discussion short, I will only mention a few.

- Two-Girder Systems: Use of two-girder cross-sections with transversely prestressed concrete deck will provide more economical girder bridges. This system has been used extensively in Europe. It can be demonstrated that in most cases of continuous spans, these systems are redundant. For wide bridges, floor beams can be used.
- Double-Composite Systems: Providing composite action at the bottom flange of box girders (or I girders) by using cast-in-place concrete or precast slabs with closure pours will reduce steel and stiffen the bottom flange for buckling. For continuous bridges, the girders can be erected as simple spans and continuity achieved with the bottom flange concrete.
- Use of Cold-Formed Sections: Short-span bridges and other steel components will need to incorporate greater use of cold-formed sections. Improved steel toughness will be key to this advancement as the bending process will reduce toughness.
- Composite Space Trusses: These systems provide high stiffness/weight ratios, high strength/weight ratios and significant reliability due to their numerous alternate load paths. Only through fully modularized fabrication techniques will these systems become popular. MSC