What Can We Do about Our Ailing Bridges?

Automation of fabrication processes may be the key to faster, more cost-effective replacement of structurally deficient or obsolete steel bridges

BY TOM SIEWERT, KRISHNA VERMA, AND STUART CHEN

Both the bridge over the Muitzes Kill in New York (top photo), part of the NYS Thruway (I-90), and the Ford City Bridge in Pennsylvania (bottom photo) were manufactured from 70W steel manufactured by Mittal Steel USA.

The December 2004 National Bridge Inventory compiled by the Federal Highway Administration (FHWA) shows 26.7% of the nation's 593,885 bridges are structurally deficient or functionally obsolete (Ref. 1). The deficient bridges are handling today's traffic safely, and most do not need to be replaced or rehabilitated immediately, but they will need attention at some point.

The nation will never have the funds for all the needed work, but the Safe, Accountable, Flexible Efficient Transportation Equity Act: A Legacy for Users, approved on August 10, 2005, authorized $21.6 billion (FY 2005–2009) for the federal bridge program. With the available funds at the federal, state, and local levels, officials will be able to undertake thousands of bridge replacement and rehabilitation projects each year.

In developing these projects, officials will want to minimize the detours and delays that increase the cost to motorists in inconvenience, fuel, and time. Especially in the case of fire engines, ambulances, and other emergency vehicles, the problem goes beyond simple economic cost or inconvenience. However, we are increasingly finding that it is possible to reduce the time these projects take and the costs associated with the inevitable disruption during the construction period.

A committee of the National Research Council has looked at the competing needs in our infrastructure (such as dams and

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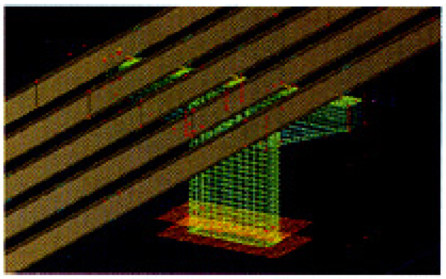

CAD drawing tools are being applied to bridge design and fabrication.

roads) and has concluded that we need to rethink our approach (Ref. 2). The committee's report states, "There is an urgent need to rebuild America, but the cost is prohibitive if this is not done intelligently...The nation must strive for intelligent renewal, a process that uses limited resources in a cost-effective manner. This calls for adapting existing knowledge to the tasks at hand and developing new scientific and engineering knowledge."

Such a process is under way for bridges, as illustrated by recent advances in automation for replacing steel bridges.

In 1999, the FWHA's Office of Bridge Technology reported that the United States has nearly 198,000 steel bridges, but that only about 1600 new steel bridges were built that year (Ref. 3). To identify efficiencies inherent in automation that might significantly reduce the costs of these bridges, or allow more bridges to be constructed for the same money, the Office of Bridge Technology led a team to review innovations for fabricating and erecting steel bridges in other countries. This team of experts identified a number of areas of automation that seemed appropriate for steel bridge applications in this country.

To develop a more detailed plan, the FHWA brought together organizations that wanted to support this effort by planning a workshop. That team held a three-day workshop in 2001 at the Edison Welding Institute (EWI) in Columbus, Ohio (Ref. 3). That workshop was sponsored by FHWA and the National Steel Bridge Alliance (a cooperative effort to improve steel bridge design and construction, and a part of the American Institute of Steel Construction). The American Association of State Highway and Transportation Officials (AASHTO), EWI, and the National Institute of Standards and Technology (NIST) were cosponsors.

Fifty-three experts from England, Germany, Japan, and the United States attended the workshop. They represented bridge fabricators, erectors, consulting engineers, welding engineers, government officials, and academicians. During the first day, participants learned about the 1999 fact-finding tour, and the technology that might be applied to bridge fabrications. The second and third days were spent in brainstorming sessions and developing consensus on action plans. Four breakout sessions were held, covering the following areas:

- Computer-generated drawings
- Standardized specifications
- Standardized design details that are amenable to automation
- The benefits of automation.

Results of the Brainstorming Sessions

Each session identified objectives, resources, obstacles, payoffs, and tasks (in the short, medium, and long term). The entire workshop reconvened to hear reports from the breakout sessions. Based on these reports, participants identified opportunities in

- Solid modeling (based on a simple 3-D model),
- Virtual assembly,
- Automated inspection and data recording,
- Higher productivity welding processes,
- Specifications (some seem overly restrictive, while others are not standardized between regions),
- A design-build approach (where the design teams join with fabricators during the bidding process, so each team can search for efficiencies), and
- A systems approach to fabrication (not just installing a robot in a fabrication plant).

Since the workshop, a steering committee under the leadership of the FHWA has been promoting these ideas. One initiative is to demonstrate the effectiveness of the workshop ideas during the fabrication of two similar bridges, one using current technology and one using advanced technology. The fabrication of both bridges will be carefully documented during this demonstration project.

On another front, the FHWA has been developing a strategic plan for fabricating bridges using computer-integrated manufacturing. This is a multi-faceted plan that will include concepts as they are developed in the demonstration program. The most recent version of this plan, developed on February 2, 2004, is organized into four outcomes, each with a series of objectives and strategies.

The first outcome is to achieve longer and more reliable performance from bridges, through optimal standards and materials. Following are some objectives that must be met in order to reach this outcome:

- Use of high-performance materials systems and construction practices, developed and implemented through research, specifications, education, and demonstration programs;
- Routine use of state-of-the-art design standards and guidelines, which incorporate better capabilities for inspection and maintenance,
- Routine use of state-of-the-art construction practices (based on the principle of "best practices"), and
- Confirmation that final statements are just as intended, with all quality assurance/quality control, inspection, and fabricator training and certification fully documented.

The second outcome is to produce bridges that reduce traffic congestion and improve safety. Following are some objectives to help reach this outcome:

- Better condition assessment information for use in making decisions about bridges,
- Routine use of cost-effective and innovative repair and rehabilitation techniques,
- Use of accelerated construction technologies, and
- Frequent use of modular or prefabricated components for faster completion.

The third outcome is to provide a high level of safety and service under all conditions. Some objectives and strategies include

- Increasing service life through appropriate system preservation strategies (e.g., better knowledge of deterioration mechanisms),
- Providing a higher level of service under normal conditions, and
- Providing better reliability when subjected to natural and human-made extreme events.

The final outcome is to improve the match (or fit) of the structures with their environments, through the application of context-sensitive solutions. Following are some of those objectives and strategies:

- Minimizing the environmental impact of highway structures, through such measures as development of appropriate standards, noise mitigation, greater consideration of wildlife and runoff, and use of recycled materials.
- Increasing participation by other stakeholders during conceptual design and location selection.
- Seeking context-sensitive conditions, while satisfying all functionality and safety requirements (e.g., esthetic treatments should not preclude the use of accelerated/modular construction technologies).

Further progress on the plan has occurred in the past few months. The scope has been confirmed to cover automation for construction of all bridges, independent of material. It also covers the initial fabrication and the repair of intentional and unintentional damage. Another step forward occurred recently when the AASHTO Subcommittee on Bridges and Structures passed a resolution acknowledging the importance of Comprehensive Integrated Bridge Project Delivery through Automation to achieve rapid construction.

Advantages of the Demonstration Project

The steering committee sees many potential benefits of this demonstration project. Perhaps the greatest benefit will be the quantification of the cost and time savings due to automation. Since most contracts are awarded on these criteria, the data will serve to drive both the customers (bridge owners) and vendors (manufacturers) toward the lowest cost solution.

Other potential benefits include

- Elevating visibility/image of current capabilities in the bridge industry,
- Improving health and safety of fabrication personnel by automating some dirty and dangerous tasks, and
- Showing how collaborations are possible over great distances without travel.

The FHWA will begin implementing these ideas soon. For the demonstration program, the planning team will be gathering information on the advanced technologies to be included. If you know of some technology that should be considered, contact Krishna Verma at *Krishna.Verma@fhwa.dot.gov*. The team will consider this new technology for addition to the inventory developed at the 2001 workshop when making decisions for the demonstration.◆

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References

1. *http://www.fwha.dot.gov/bridge/deficient.htm*.

2. *Civil Infrastructure Systems Research: Strategic Issues*. January 1993. National Research Council Press.

3. *Computer-Integrated Steel Bridge Design and Construction: Expanding Automation*. Report of a NIST-DOT-NSBA-EWI workshop held April 23–25, 2001, at EWI, Columbus, Ohio.