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leverage advances in materials science, design practices, and construction methods, along with an aggressive maintenance program, to extend the useful bridge service life, thus minimizing the need to replace many bridges within a short time. There is also a trend today toward developing major bridge projects for a longer service life by using advanced design and construction practices and high-performance materials.

Other issues that are becoming critical in bridge type selection are construction time and impact on the public during construction. Although these are short-term issues with respect to the bridge service life, they can have a significant impact on costs. The public is demanding reduced construction times and fewer impacts on businesses, adjacent landowners, and motorists. Meeting these demands requires evaluating bridge concepts that involve quick construction with minimum impact on the motoring public, such as off-site prefabrication and quick field erection. As a result, the desire to use other structural concepts based on long-term performance may be overridden.

Maintenance of bridges is a major concern for management because of the long-term impact on the budget and operation of the facilities. The overall objective of bridge maintenance is the safety and preservation of existing bridges. Maintenance and timely repair activities keep bridges in good condition, avoid more expensive repair or replacement costs in the future, and ensure that the bridges are safe for use by the public. However, the conduct of maintenance activity according to past practices will not keep pace with growing needs. The average age and number of bridges are increasing, resulting in more maintenance demand and cost. Accordingly, management must identify new means of making better use of the available resources.

In summary, the issues raised above reflect the complexity of the bridge program and its continuing challenges for management. The bridge program involves several disciplines within a transportation department that must work as a team so that decisions will be made with the objective of ensuring that all bridges will serve the needs of the public at the lowest possible cost.

Bridge Management Software Programs

EDGAR P. SMALL AND JAMES COOPER

BRIDGE MANAGEMENT DECISIONS are currently made using priority ranking procedures or rating formulas. For example, federal funding eligibility for bridges is determined on the basis of the sufficiency rating, which is calculated using information from the National Bridge Inventory (NBI). This rating combines information reflecting the structural adequacy of the bridge and the associated effect on public safety; the serviceability of the bridge, and whether the structure adequately services user demands or is functionally obsolete; and how essential or important the bridge is to the traveling public.

The ratings are determined by means of a point deduction system. A new bridge would receive a sufficiency rating of 100, given that the structure met or exceeded all level-of-service criteria. A failed structure would receive a rating of 0. Bridges with sufficiency ratings of 50 or lower are eligible for federal replacement funds, while bridges with ratings between 50 and 80 are eligible for rehabilitation funds. Sufficiency ratings often provide a basis for state bridge management activities.

This form of bridge management is responsive to specific conditions and is intended to address the worst structures first. Future conditions and future traffic demand are not considered in calculating the sufficiency rating. Given static and potentially shrinking funds, it has been widely recognized that a new form of bridge management is required. In

*Beautiful Railway Bridge
of the Silv'ry Tay!
Alas! I am sorry to say
That ninety lives have been
taken away
On the last Sabbath day of 1879,
Which will be remembered for a
very long time.*

Poem of William McGonagall,
1880, commemorating the collapse
of the Firth of Tay bridge,
quoted by Joseph Gies in *Bridges and Men*

response to the need for more effective and efficient bridge management, Congress, through the Intermodal Surface Transportation Efficiency Act, required the implementation of bridge management systems by state departments of transportation and metropolitan planning organizations.

Two national-level bridge management software programs have been developed: Pontis, developed through a collaborative effort between the Federal Highway Administration and state departments of transportation, and BRIDGIT, developed by the National Cooperative Highway Research Program. Both programs utilize element-level inspections, predict the future condition of the elements in the network using sophisticated deterioration modeling techniques, and optimize long-term expenditures for preservation and improvement of the highway bridge network. Decisions can then be made on the basis of economics and structural safety.

The National Highway System Designation Act of 1995 officially repealed the legislative mandate for bridge management system implementation by state highway agencies. Nevertheless, DOTs continue to pursue use of these systems. Today Pontis, which is now distributed by the American Association of State Highway and Transportation Officials, has been licensed by 40 state DOTs. Other states either have developed and are implementing their own bridge management software or are evaluating existing software for implementation. BRIDGIT has been well received within smaller bridge-owning agencies. Pontis is now an AASHTOWare-supported product. BRIDGIT is currently available through NCHRP and is expected to be supported by AASHTO in the near future.

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Managing Minnesota's Highway Bridges

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THE FEDERAL HIGHWAY ADMINISTRATION encourages states to use bridge management software programs to optimize transportation resources. Minnesota has decided to use Pontis as a bridge management tool

to provide information in support of (1) network-level bridge planning, (2) network-level bridge maintenance planning, and (3) project-level bridge planning.

Pontis' mathematical models can be used to optimize bridge funding for maintenance, repair, and rehabilitation, as well as for improvements. Both agency and user costs are taken into account. Agency costs are defined as the actual costs required to preserve or replace a bridge or a portion of a bridge. User costs are those costs incurred by the bridge user for detours, load postings, clearance limitations, and accidents due to poor geometrics or clearances on the bridge. The deterioration rates of various bridge elements and the costs of actions to fix or replace those elements are critical to calculating accurate benefit/cost ratios.

The focus of the Pontis preservation optimization model is on finding the long-term steady-state policy, for each bridge element in each environment, that will minimize maintenance funding requirements while ensuring that the element will not fail. The optimization model incorporates changes in condition, the effectiveness of agency or owner actions, and the cost of those actions into a benefit/cost ratio format for each element and determines the most cost-effective long-term actions. The Pontis improvement model is used to consider actions such as widening, raising, and strengthening bridges to minimize user costs due to detours and accidents. Pontis then combines the results of the preservation and improvement models to determine overall maintenance, rehabilitation, and replacement needs.

Pontis Element-Level Inspections

For the calculation of benefit/cost ratios, Pontis requires a different means of recording bridge inspection information from that previously used in Minnesota. In the past, bridges have been categorized into various components, and each component has been rated according to its condition. Under the Pontis element-level inspection system, bridge elements are defined and rated according to the type, severity, and extent of deterioration. A condition rating scale of 1 to 5 is used, with 1 being the best rating and 3, 4, or 5 the worst, depending on the element. Element-level reporting requires that data on each element be recorded to show the total quantity of each and the quantity in various conditions. Inspection of Minnesota's 19,570 state and local bridges is now documented using element-level techniques. Data are gathered on the extent of