restricted to 2-ton vehicles. Since the strengthening, 16-ton vehicles have been permitted to use the bridges.

Numerous laboratory investigations and field installations of CFRP, such as those described here, suggest that it is the strengthening material of the future.

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Federal Highway Administration's Nondestructive Evaluation Validation Center

STEVEN B. CHASE

IMPROVING AND MAINTAINING the nation's aging surface transportation system is an enormous challenge. To succeed, decision makers will require one thing above all else—good information. Complete, accurate, and reliable information is essential to determine where best to allocate limited resources and to establish various policies.

One area in which current practice could be improved to provide more accurate and useful information is the condition assessment of highway structures. Standard practice is to perform a subjective visual inspection in order to identify and record obvious problems and deterioration. In most instances, this approach is effective and cost-efficient. However, there are some important and potentially critical deterioration processes that are not adequately detected by visual inspection. For example, it is not possible to detect and quantify the condition of an overlaid reinforced concrete bridge deck adequately through visual inspection alone; fatigue cracks in steel bridge members cannot be detected visually under paint; and it is difficult to detect loss of prestressing in prestressed concrete by visual inspection unless there are large deflections or distortions. To overcome these limitations of visual inspection, the Federal Highway Administration is developing nondestructive evaluation (NDE) technologies and methods.

Similar in concept to the routine or specialized procedures used by the medical profession to assess health or diagnose disease, NDE can provide previously unavailable information about the condition of the nation's highway infrastructure. NDE technologies are used routinely today in quality control and acceptance testing during fabrication or construction; examples are magnetic particle inspection and radiography, commonly used in welding. However, FHWA is working to expand the application of NDE to the condition assessment of the existing highway infrastructure. Existing NDE technologies commonly used in other industries, such as eddy current systems used to detect cracks in aircraft skins, are being evaluated for application to highway structures.

FHWA is also sponsoring the development of new and innovative technologies for the condition assessment and evaluation of highway structures. Some of these technologies will help ensure the safety of highway structures by detecting potentially serious deterioration before visible damage occurs. Other technologies will provide for the rapid, efficient, accurate, and quantitative assessment of invisible deterioration. Many of these technologies have been developed to the prototype stage and are ready for field testing and evaluation, which will be used to refine the design of the technology to the point where it is ready for validation.

Validation is a necessary step in the development process and is essential for widespread adoption of new technologies and methods. To achieve the objective of providing reliable information for decision makers, it is essential to know how good the information is. A formalized validation program can be used to answer this question. Such a program is similar in concept to the clinical trials medical diagnostic technologies undergo before they are accepted for widespread use by the medical profession. To support this work, FHWA is creating a new facility—the FHWA NDE Validation Center.

FEDERAL HIGHWAY ADMINISTRATION

This test bridge selected for the NDE Validation Center will serve as a full-scale laboratory for evaluation and validation of a wide range of nondestructive evaluation technologies and methods in a real-world environment.

Proof Load Testing in Michigan

ANDRZEJ S. NOWAK

Proof load testing can be used as an efficient method for verifying the minimum strength of existing bridges, particularly structures with questionable load-carrying capacity due to extensive corrosion or other forms of deterioration. For the proof load test to be meaningful, a heavy load must be used. The target proof load can be calculated using the draft report on National Cooperative Highway Research Program Project 12-28(13). To reduce the risk of collapse during the test, the load is increased in several steps until a prespecified load limit is reached. If the target proof load is reached successfully with no distress, the structure is deemed adequate to support legal loads.

Because of the heavy truck loads allowed in Michigan, a proof load of about twice the legal limit is used. It is, however, difficult to find a vehicle that can be loaded to the level of twice the legal load. An innovative idea at the University of Michigan was to use M-60 military tanks, provided by the Michigan National Guard. Each tank weighs over 490 kilonewtons (kN). This load is distributed over a small track of 4.5 meters. For spans of up to 20 meters, two such tanks are required.

DR. PAWEL STANKIEWICZ

M-60 military tanks were used by the University of Michigan for proof load testing.

The test results are closely monitored for any sign of distress. Strains and deflections are measured. In all tested bridges, the maximum strains/stresses were much smaller than had been predicted by analysis because of unintended composite action; partial fixity of supports; and additional stiffness due to the presence of parapets, sidewalks, railings, and the like.

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The objective of the NDE Validation Center is to provide FHWA, researchers, industry, and state highway agencies with quantitative, independent, and reliable validation of NDE methods. Scheduled to open in April 1998, the center will develop specimens and methodologies to validate NDE performance both in the laboratory and in the field, and will serve as a resource for the highway and bridge inspection community. The laboratory and field testing elements to be used include validation protocols, component specimens, and test bridges.

Validation Protocols. The primary role of the NDE Validation Center will be to develop and execute effective test protocols for validating the performance of NDE technologies and methods. Component specimens and test bridges will serve as a critical resource in the process by simulating the many factors that affect NDE reliability. Testing at the center will help define the proper application and limitations of NDE technologies and methods, and determine their ability to provide quantitative measurements of flaw size, material properties, or structural condition. The validation process will provide performance parameters for NDE methods, procedures, and systems to enhance safety and maintenance inspections of the highway system.

Component Specimens. The NDE Validation Center will develop, test, and catalog a library of bridge component specimens containing flaws. The specimen library will contain a significant distribution of flaws of different types and sizes, suitable for determining the probability of detection for NDE. These component specimens will play a critical role in the validation process, allowing for quantitative evaluation of NDE technologies and methods at the center. Component specimens will be available on loan to researchers and state highway agencies wishing to evaluate new or currently used technologies.

Test Bridges. Instrumented test bridges will be used as field test sites. Decommissioned highway bridges containing flaws at critical locations will be used to evaluate NDE technologies and methods under realistic environmental conditions. A fully characterized and instrumented bridge that is open to traffic will be used to test NDE methods affected by live loading. Instrumentation on the bridges will be linked to the center via modem so that the environmental and structural conditions during a test will be well defined. These bridges will be critical to evaluating the effects of restricted access, structure geometry, surface conditions, platform stability, and human factors on the application of NDE during normal bridge inspections.

The NDE Validation Center is intended to provide a national resource for the development and application of NDE for the inspection of transportation facilities. The center will provide consistent and reliable evaluation of NDE technologies and methods, and accelerate the implementation of NDE in the condition assessment and inspection process. Questions or comments about the center can be sent to glenn.washer@fhwa.dot.gov.

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New Design Specifications To Promote Uniform Safety

JOHN M. KULICKI

IN 1993, AFTER A 5-YEAR CONCENTRATED EFFORT, the American Association of State Highway and Transportation Officials adopted the AASHTO LRFD Bridge Design Specifications for load and resistance factor design. In 1997 the AASHTO Subcommittee on Bridges and Structures decided that the LRFD Specifications will become the primary specifications for bridge design in 1999 (see "Research Pays Off," page 35).

Development of New Specifications

The *AASHTO LRFD Bridge Design Specifications* is the first complete rewrite of U.S. bridge design specifications. It is based on a radical departure—LRFD—in establishing bridge safety and structural integrity, but maintains many of the current mechanics of the design process. This shift in philosophy represents a major improvement over the traditional Standard Specifications. The new philosophy facilitates future maintenance and development of the specifications in a rational, consistent way.

There were several operational objectives in the development of the new specifications:

- Develop technically state-of-the-art specifications that will position U.S. practice at or near the leading edge of bridge design.
- Make the specifications as comprehensive as possible.
- Make the specifications more readable and easier to use.
- Encourage a multidisciplinary approach to bridge design.
- Place increased emphasis on concepts of redundancy and ductility of structures.

To achieve these objectives, many changes had to be made in both the content and format of the Standard Specifications. In addition to the introduction of a new philosophy of safety, LRFD, these changes include the identification of design limit states; the development of new load and resistance factors; improved load models, including a new live load model; revised techniques for analysis and calculation of component loads; and incorporation of applicable guide specifications.

To make the design process more rational, a combined presentation on plain, reinforced, and prestressed concrete was developed, as were limit-state-based provisions for foundation design and soil mechanics. Expanded coverage of hydraulics and scour was added, consistent with today's heightened awareness of their destructive nature. The earthquake provisions were changed to eliminate the Seismic Performance Category concept by making the method of analysis a function of the importance of the structure. Large portions of the Guide Specifications for Segmental Concrete Bridge Design were adopted, as were many provisions of the AASHTO Guide Specifications for ship collision design. The coverage of bridge railings was expanded to include methods of analysis for designing the specimen for crash testing. Finally, a parallel commentary was introduced to provide rationale, references, nonprescriptive guidance, and insight into how various provisions were developed.

The new philosophy facilitates future maintenance and development of the specifications in a rational, consistent way.