BRIDGE REHAB by Allen G. Davis

Working for keeps

Non-destructive testing helps owners restore historic bridges

To save or not to save is often the question facing owners of historic reinforced concrete bridges built in the first half of the 20th century. For decades, most have been subjected to much heavier traffic than their original designers ever imagined, not to mention the wear and tear of weather and deicing salts.

Although the jury is still out on whether or not it is more cost-effective to restore or rebuild, other factors also play a major role in the decision. These include limited or non-existent funds for rebuilding America's aging infrastructure, safety issues such as approach alignment and lane width and a heightened interest in preserving historic structures on the part of local communities, all of which have helped fuel a rapidly growing demand for evaluation of older bridges.

Call off the invasion

Non-destructive testing (NDT) techniques provide a fast, economical and reliable way to evaluate the viability of any restoration solution—and to avoid discovering expensive-to-repair surprises in the middle of rehabilitation.

Advanced NDT methods, which have not been commonly used within the industry, offer several advantages over traditional evaluation methods. Traditional approaches generally depend on notes and plans based on visual observation and the testing of core samples taken sporadically from the structure. By using NDT techniques during the field investigation phase of the evaluation project, combined with petrographic and chemical analysis of samples in the laboratory, engineers can obtain much more thorough and reliable information regarding structural integrity, spalling, freeze-thaw damage and possible chemical attack. At the same time, the NDT approach minimizes invasive investigation, disruption to bridge operations and cost. And the larger the bridge, the bigger the benefit, since NDT techniques can test a substantial area very quickly.

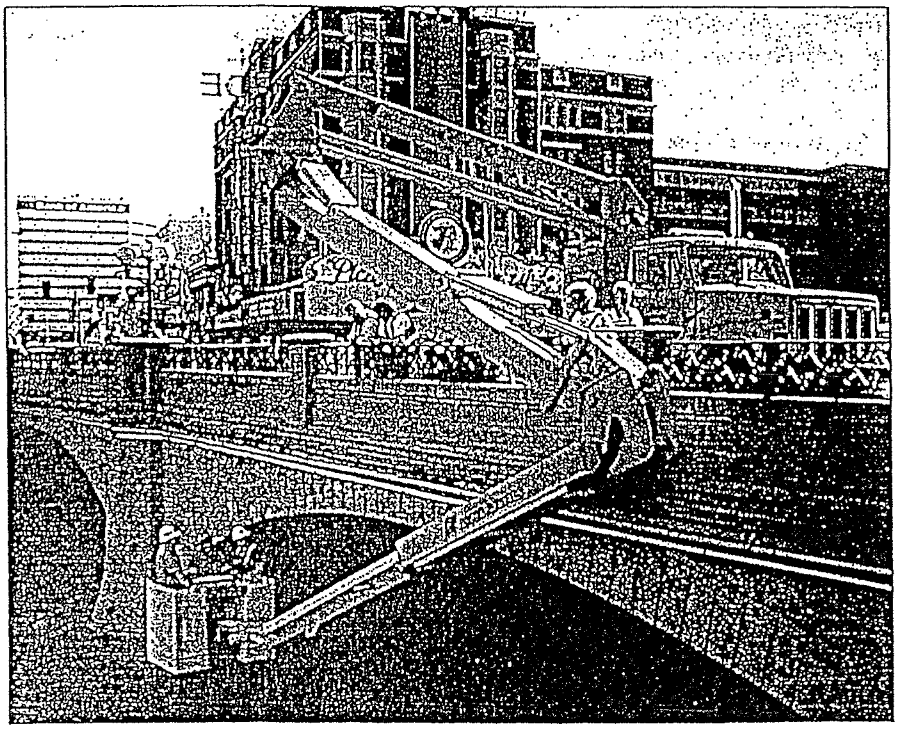
Initially, NDT is used to identify areas with potential problems within a bridge's three principal units: the main supporting structure, the deck and ancillary features such as parapets and services. Core samples are then taken from these problem zones, rather than randomly. NDT techniques also are used to characterize the bridge's material properties—helpful for developing repair materials to match existing concrete and finishes—and to create a database for future maintenance.

Detection systems

Six principal NDT tools are available for evaluation purposes as needed: impulse response, impact-echo, ultrasonic pulse velocity, impulse radar, covermeter and corrosion testing.

Impulse response (IR) is a stress wave test used extensively in evaluating machined metallic components in the aircraft industry. Basically, it's a scientific hammer test that provides a way to rapidly zero in on zones of poorer concrete quality. The engineer plots out a grid on the bridge's surface and hits the grid cross points with a special sledgehammer, sending the results directly to a computer which creates a contour map indicating areas of sharp change—and potential problems.

Like the IR test, the impact-echo (I-E) method relies on stress waves to detect flaws within the bridge. However, it uses a higher frequency range, since much shorter wavelengths are required to locate smaller anomalies. The ultrasonic pulse velocity method also uses stress waves and can be used to measure changes in the strength of the concrete.



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Impulse radar testing, developed from ground penetration radar used by geologists, is used to identify where steel is, as well as to locate changes in concrete density. The covermeter measures the depth through the concrete to the rebar, while corrosion testing measures the amount and rate of corrosion that has occurred.

NDT in action

Engineers from Construction Technology Laboratories Inc., Skokie, Ill., used IR testing to locate and map changes in concrete quality during evaluation of a double spandrel arch bridge built in 1907 in Reno, Nev. They established 5-ft x 5-ft test grids on the underside of each arch, accessing the test surface by snooper truck. After plotting the IR parameters, they performed I-E tests at selected locations to measure the thickness of the concrete or the depth to cracks or delamination. The combination of results from both methods determined the selection of core locations. This testing phase of the two-span 160-ft bridge was completed in only three days and gave easily read contour plots of concrete quality variations throughout the arches.

The coring confirmed zones of poorly consolidated concrete, and the cores also were examined by petrographic methods. They revealed no evidence of freeze-thaw or ASR, and carbonation appeared limited to the outer 2 in. of concrete in the arches. At the same time, the aggregate types and sizes as well as the nature of the cement were identified. This information was used to design concrete and mortar for required repairs that closely matched the original.

In another case, an open spandrel single arch bridge in Putnam County, Ind., built in 1925, appeared to be in very poor condition. However, IR testing along both spandrel arch beams showed that the interiors of the beams were in relatively sound condition, with good concrete consolidation and little cracking.

Most of the damage had occurred because water draining through the deck beam expansion joints flowed down the arches, resulting in freeze-thaw damage of the cover concrete.

The IR testing did pinpoint zones that appeared to be sound concrete on the surface but revealed poorly consolidated concrete, confirmed by selective coring.

Not a hunch

Nearly all concrete bridges constructed before 1940 have unknown as-built conditions, including both the concrete and steel reinforcement properties. Air-entrained concrete was seldom used, leaving them particularly susceptible to freeze-thaw in the northern states and Canada. In addition, maintenance records tend to be sparse or unavailable. As a result, NDT provides a valuable and economical tool for evaluating the viability of these structures.

NDT methods can be used to quickly and accurately identify problems, even in areas with difficult access, as well as to determine the nature of anomalies not visible on the surface, such as cracking, delamination, poor consolidation and honeycombing. Once problems are identified, recommendations based on real information rather than guesswork can be made. Results may indicate, for example, that it makes economic sense to preserve the supporting structure while reconstructing the deck and parapets. For owners of historic concrete bridges, NDT testing provides a fast, economical answer not only to the question of whether or not to save their bridge, but exactly what needs to be done to restore it, should they choose that route. ■

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