The HollowDeck

for acoustic inspection of structures

Diagnostic Instrumentation and Analysis Laboratory at Mississippi State University

Background

The determination of concrete integrity, especially in concrete bridge decks, is of extreme importance. The effective life span of a bridge deck is only 15 to 20 years, but the associated substructure and superstructure of a bridge can last considerably longer. If knowledge about the internal structure of a bridge can be gathered quickly and efficiently, that information can then be used to detect problems before structural failure occurs, prevent unnecessary repairs, and reduce costly maintenance schedules. Current systems for testing concrete structures are expensive, slow, or tedious. Current state of the art systems for the determination of concrete integrity, especially delaminations include:

- Ground penetrating radar (GPR)
- Ultrasonic pulse-echo
- Impact-echo
- Direct observation

Although ground penetrating radar can potentially provide a CAT scan like view of a bridge, the enormity of data collected prevents real-time analysis. Further, GPR has inherent problems with ghosting and signal signature overlap. Ultrasonic pulse-echo techniques typically must have a direct contact to the bridge often through the use of a difficult to maintain water bath. Impact-echo techniques are easy to implement and interpret, but time consuming to use on large structures because the measurement is made at discrete points. Direct observation by coring, chipping, and under bridge inspection, although reliable, is extremely time consuming particularly for evaluation of large bridges.

The older method of locating delaminations in bridge decks involves either tapping on the surface with a hammer or metal rod, or dragging a chain-bar across the bridge deck. Both methods require a “calibrated” ear to determine the difference between good sections and bad sections of concrete. As a consequence, the method is highly subjective, different from person to person and even day to day for a given person. In addition, archival of such data is impractical, or at least improbable, in most situations.

System Description

The Diagnostic Instrumentation and Analysis Laboratory has constructed the HollowDeck, an instrument that automates the chain-drag method of concrete inspection. The HollowDeck is capable of real-time analysis of recorded signals, archiving of processed data, and high-speed data acquisition so that post-processing of the data is possible for either research purposes or for listening to the recorded signals. The detection system includes a microphone with an amplifier, a data acquisition system, a computer for data processing, a pair of headphones for signal monitoring, and a chain for excitation. This equipment is mounted on a hand-pushed cart (see Fig. 1). The chain, which is hidden from view, is attached to the bottom of the cart and drags along the surface of the bridge deck.

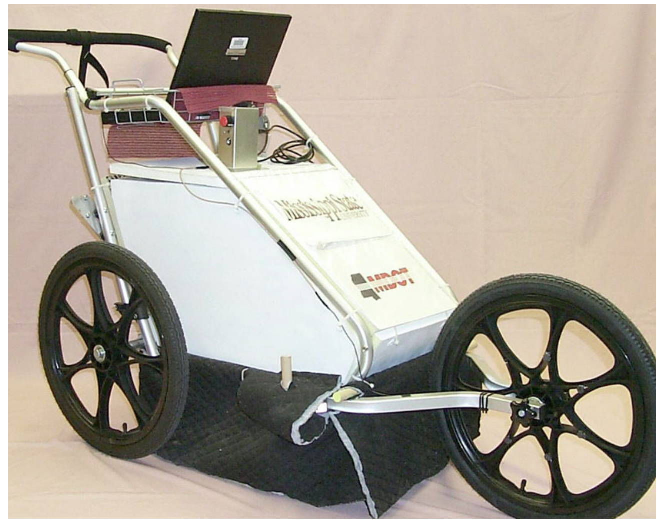

Figure 1. The HollowDeck in its present configuration.

Figure 2. The HollowDeck, in action, performs the same regardless of traffic conditions. In this particular configuration, a second operator lays down chalk lines to ensure consistent, accurate coverage of the deck.

A common problem with the “old school” chain drag is that the sounds generated are not very loud and are easily swamped by passing traffic noise. To address these problems the HollowDeck has been designed to mechanically filter extraneous noise and to selectively amplify the sounds of interest. Furthermore, filtering methods completely remove traffic noise before the signals are processed. Consequently, the system works as well in heavy traffic conditions as it does in the absence of traffic noise, as illustrated in Figure 2.

Since the HollowDeck is capable of real-time analysis of the signal, the HollowDeck is capable of marking the road where delaminations are detected. Currently paint is used as the marking system, but other marking products, such as colored chalk, can be used. The paint clearly denotes the location of delaminations so that road crews can be sure they are working in the correct location. In addition to marking the bridge deck in real-time, the system also archives the data to a computer map file. This “map” file contains defect locations in an “overhead” view for use in archival and bridge maintenance systems.

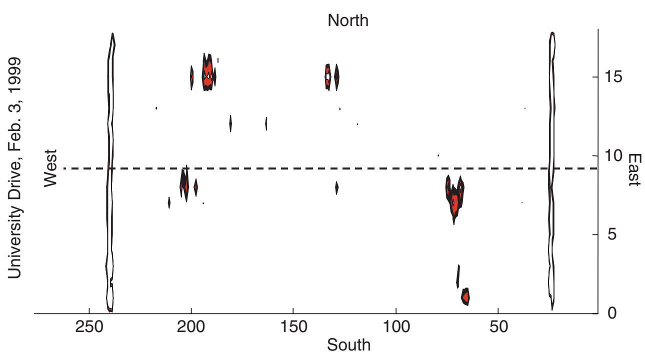

Figure 3. Data collected from the University Drive Bridge over Highway 12, Starkville, MS. The dark bands on either end represent the expansion joints of the bridge. The colored areas represent areas detected by the HollowDeck, the block overlays are the results from “expert” soundings.

An example of the “map” file generated by the system is shown in Figure 3. The uneven bounded markings are areas detected by the HollowDeck. The block areas shown in Figure 3 are those areas confirmed to be defective. Distances on the horizontal axis are in feet and the vertical axis is in pass number. Each pass represents 20 inches width and thus can be used to calculate the horizontal scale. The heavy markings at either end of the bridge are expansion joints. The signals from the expansion joints are used to patch the various passes together. If a bridge lacks metal expansion joints a portable artificial joint can be used.

In addition to providing archivable data, marking the bridge in real-time, and locating delaminations, the HollowDeck is fast. The bridge in Figure 3 was scanned in less than 30 minutes. A bridge 940 feet long and 40 feet wide was analyzed in less than one hour. One individual, with little specialized training, is required for operation of the Hollow-Deck. The HollowDeck permits the operator to walk at a comfortable pace and stand erect to observe traffic. Plans are being made to incorporate the HollowDeck technology into an electric vehicle that will increase the scanning speed and convenience.

For more information on the HollowDeck and related technologies contact the Diagnostic Instrumentation and Analysis Laboratory at the number given below.

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