CENTER FOR INFRASTRUCTURE ENGINEERING STUDIES

GPR Investigation of Bridge Deck, Willow Springs, Missouri

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16. Abstract

The presence of surface “honeycombs” suggests that a segment of the concrete deck of Bridge A6329, Willow Springs, Missouri, was not properly vibrated. UMR will acquire seventy-five ground penetrating radar (GPR) profiles across the suspect area of the bridge (and other sites for comparison purposes) to determine if concrete in the “suspect” area contains unacceptable concentrations of air-filled voids (entrapped bubbles).

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Interpretation of Ground Penetrating Radar Data: In support of evaluation of the deck of a bridge at Willow Springs

Summary: Seventy-five ground penetrating radar (GPR) profiles were acquired at Willow Springs Bridge to locate parts of possible voids in the bridge deck. On the basis of the analysis and interpretation of these data, we estimate that the visible voids in the bridge deck extend vertically for not more than 5cm from the bottom surface of the bridge deck inside the concrete slab. Generally, no parts with possible voids were recorded in the concrete on the GPR profiles away from the parts that have visible voids.

Ground Penetrating Radar (GPR) Data: The GPR technique was used as a non-invasive tool to locate parts of possible voids in concrete slabs of the bridge at willow springs. The bridge deck has small visible voids at some parts (e.g. Fig. 1). Seventy-five GPR profiles were acquired at the bridge deck parallel to the bridge from five slabs marked as A, B, C, D, and E respectively. The average length of the GPR profiles was 1.5m and the spacing between the adjacent profiles was 10cm. The 1.5 GHz antenna was dragged on the bottom of the bridge deck along marked lines on the concrete.

The GPR profiles are presented as time-sections in Figure 2 to 5. The reflection from the surface of concrete is shown on the top of the sections. The reflection from the upper rebar mat is shown as strong diffraction hyperbolas. The reflections from the lower rebar mat are shown below the upper matt reflections with relatively weak diffraction hyperbolas relative to the upper rebar mat. The upper surface of the bridge deck is also shown on the GPR sections. Generally, the GPR has been documented as a successful technique to locate voids (with diameters on the order of 10cm) in the concrete. In the present study the diameter of either the visible voids or the non-visible ones is on the order of few centimeters. In this case we can rely on the very small upward shift in the travel time of the reflections from the upper rebar mat to indicate parts of possible voids (Fig. 2).

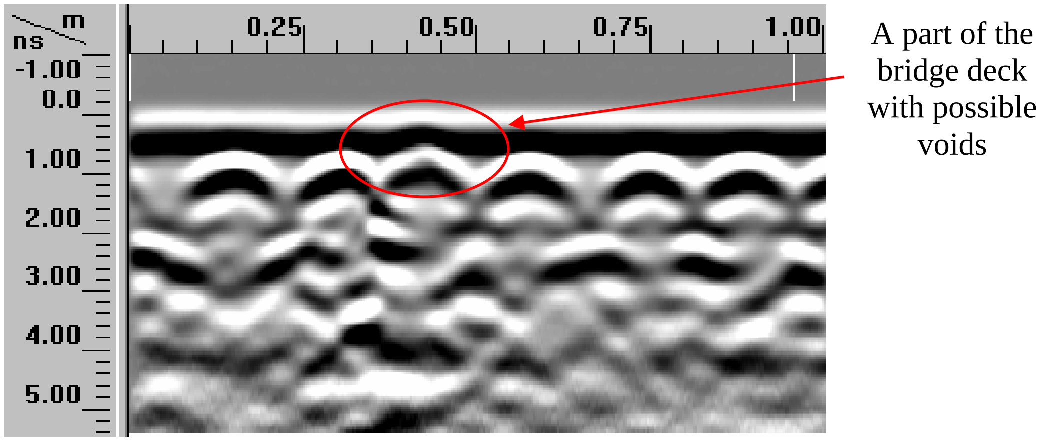

Figure 2. GPR time section showing the reflection from one of the rebars pulled up which can be indication of a part of the bridge with possible voids.

At the parts of concrete that have voids the radar waves travel to the rebars through the air while in the absence of voids the radar waves travel mostly through the concrete. Since the radar waves velocity through the air is two to three times faster than that through the concrete, we expect the travel times to the rebars in the areas that have voids to be shorter than that where there are no voids. Consequently the diffraction hyperbolas originated from the rebars will be pulled up on the radar time section.

Slap E: Seventeen GPR profiles were acquired from the slab E. The average length of these profiles was 1.2m. An example of these profiles is shown in Figure 3. The GPR profiles show clearly the bottom surface of the bridge deck, the lower rebars, the upper rebars, and the top surface of the concrete slab. Based on the analysis of the data of slab E, there were no parts of possible voids located on the GPR profiles.

Slab D: Thirteen GPR profiles were acquired from the slab D. The average length of these profiles was 1.7m. The radar data acquired from this slab shows parts of possible voids located at 30 to 60cm from the starting point of the radar profiles (e.g. Fig. 4). These voids may extend for not more than 5cm from the surface of concrete.

Slab C: Twelve GPR profiles were acquired from the slab C. The average length of these profiles was 1m. The GPR profile number 4 and 6 show indications of small voids that may be located at ~ 4cm (Fig. 5). The GPR profile number 7 shows possible voids that may extend to about 8cm from the surface. The estimated locations of these voids are circled with red line in Figure 5.

Slab B: Twelve GPR profiles were acquired from the slab B. The average length of these profiles was 1.25m. The GPR profiles (e.g. Fig. 6) don’t show any evidence for voids in the concrete within this slab. The visible voids seem to be very shallow (few centimeters) so that such voids were masked by the surface radar waves.

Slab A: Twelve GPR profiles were acquired from the slab B. The average length of these profiles was 1.4m. The GPR profiles acquired from this slab show parts of possible voids at 0.50cm to 100cm in the concrete (Fig. 7). These voids seem to be very close to the bottom surface of the concrete (~ 6 cm).