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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for Evaluating Asphalt-Covered Concrete Bridge Decks Using Ground Penetrating Radar[1]

This standard is issued under the fixed designation D 6087; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

ϵ^1 NOTE—Equations 6, 7, and 8 were corrected editorially in October 1998.

1. Scope

1.1 This test method covers several radar evaluation procedures that can be used to evaluate the condition of concrete bridge decks overlaid with asphaltic concrete wearing surfaces. Specifically, this test method predicts the presence or absence of delamination.

1.2 The most serious form of deterioration is that which is caused by corrosion of embedded reinforcement. Corrosion is initiated by deicing salts, used for snow and ice control in the winter months, penetrating the concrete. In arid climates, the corrosion can be initiated by chloride ions contained in the mix ingredients.

1.2.1 As the reinforcing steel corrodes, it expands and creates a crack or subsurface fracture plane in the concrete at or just above the level of the reinforcement. The fracture plane, or delamination, may be localized or may extend over a substantial area, especially if the concrete cover to the reinforcement is small. It is not uncommon for more than one delamination to occur on different planes between the concrete surface and the reinforcing steel. Delaminations are not visible on the concrete surface. However, if repairs are not made, the delaminations progress to open spalls and, with continued corrosion, eventually affect the structural integrity of the deck.

1.3 This test method may not be suitable for evaluating bridges with delaminations which are localized over the diameter of the reinforcement, or for those bridges which have cathodic protection (coke breeze as cathode) installed on the bridge or for which a conductive aggregate has been used in the asphalt (that is, blast furnace slag). This is because metals are perfect reflectors of EM waves, since the wave impedances for metals are zero.

1.4 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses are for information only. Specific precautionary statements are given in Section 5.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Summary of Test Method

2.1 A vehicle equipped with a short-pulse ground penetrating radar, data acquisition device, recording device, and data processing and interpretation equipment makes repeated passes, parallel to centerline across an asphalt covered bridge deck at specified locations. Bridge deck condition is quantified based on the data obtained.

3. Significance and Use

3.1 This test method provides information on the condition of concrete bridge decks overlaid with asphaltic concrete without necessitating removal of the overlay, or other destructive procedures.

3.2 A systematic approach to bridge deck rehabilitation requires considerable data on the condition of the decks. In the past, data has been collected using the traditional methods of visual inspection supplemented by physical testing and coring. Such methods have proven to be tedious, expensive and of limited accuracy. Consequently, radar provides a mechanism to rapidly survey bridges in a non-contact, non-destructive manner.

3.3 Information on the condition of asphalt-covered, concrete bridge decks is needed to estimate bridge deck condition for maintenance and rehabilitation, to provide cost-effective information necessary for rehabilitation contracts.

4. Apparatus

4.1 *Radar System*—Air-coupled, short-pulse monostatic radar(s) with a monocycle pulse, 150 mm (6 in.) free space resolution and a 50 scan/s data rate, minimum.

4.2 *Data Acquisition System*—A data acquisition system, consisting of equipment for gathering radar data at the maximum data rate of the radar system(s), 50 kHz for one radar, 100 kHz for two radars, and 150 kHz for three radars. The system shall be capable of accurately acquiring radar data with a 60 dB dynamic range.

4.3 *Distance Measurement System*—A distance measurement system consisting of a fifth-wheel or appropriate distance

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measurement instrument (DMI) with accuracy of ±100 mm/km (± 6.5 in./mile) and a resolution of 25 mm (1 in.).

4.4 *Test Vehicle*—A vehicle with all equipment necessary to perform the test and proper warning and safety devices installed.

NOTE 1—Fig. 1 shows a functional block diagram for multiple radars and support equipment. Real-time digital data acquisition and high-speed radar signal processing equipment and software have been designed around the Penetradar Model PS-24[2] radar system to meet the needs of this test method.

5. Hazards

5.1 During operation of the radar system, observe the manufacturer's safety directions at all times. When conducting inspections ensure that appropriate traffic protection is utilized in accordance with accepted standards.

6. Procedure

6.1 *Conditions for Testing*:

6.1.1 If soil, aggregate, or other particulate debris is present on the bridge deck surface, clean the bridge deck.

6.1.2 Test the bridge deck in a surface dry condition.

6.2 *System Performance Compliance*—Conduct a test on the radar equipment to ensure proper performance, at least once per year, or after periods of prolonged storage, or in accordance with manufacturers recommendations. This test shall consist of the following:

[2] Information regarding availability, use, or licensing of this product may be obtained from Penetradar Corporation, 2509 Niagara Falls Boulevard, PO Box 246, Niagara Falls, NY 14304.

6.2.1 *Signal to Noise Ratio*:

6.2.1.1 *Signal to Noise Ratio Test*—Position the antenna at its far field distance approximately equal to maximum dimension of antenna aperture above a square metal plate with a width of 4× antenna aperture, minimum. Turn on the radar unit and allow to operate for a 20 min warm up period or the time recommended by the manufacturer. After warming up the unit, record 100 waveforms. Then evaluate the recorded waveform for signal to noise ratio. The signal to noise ratio is described by the following equation:

$$\frac{\text{Signal Level } (A_{mp})}{\text{Noise Level } (A_n)} > 20 \ (26.0 \ dB) \quad (1)$$

6.2.1.2 This will be performed on each of the 100 waveforms and the average signal to noise value of the 100 waveforms will be taken as the "signal to noise of the system." Noise voltage (A_n) is defined as the maximum amplitude occurring between metal plate reflection and region up to 50 % of the time window after the metal plate reflection, normally used with the antenna (that is, 1.0 GHz/20 ns: 10 ns.). The signal level (A_{mp}) is defined as the amplitude of the echo from the metal plate.

6.2.1.3 The signal to noise ratio test results for the GPR unit should be greater than or equal to 20 (+26.0 dB).

6.2.2 *Signal Stability*:

6.2.2.1 *Signal Stability Test*—Use the same test configuration as described in the signal to noise ratio test. Record 100 traces at the maximum data acquisition rate. Evaluate the signal stability using the following equation:

$$\frac{A_{max} - A_{min}}{A_{avg}} < 0.01 \ (1 \ \%) \quad (2)$$

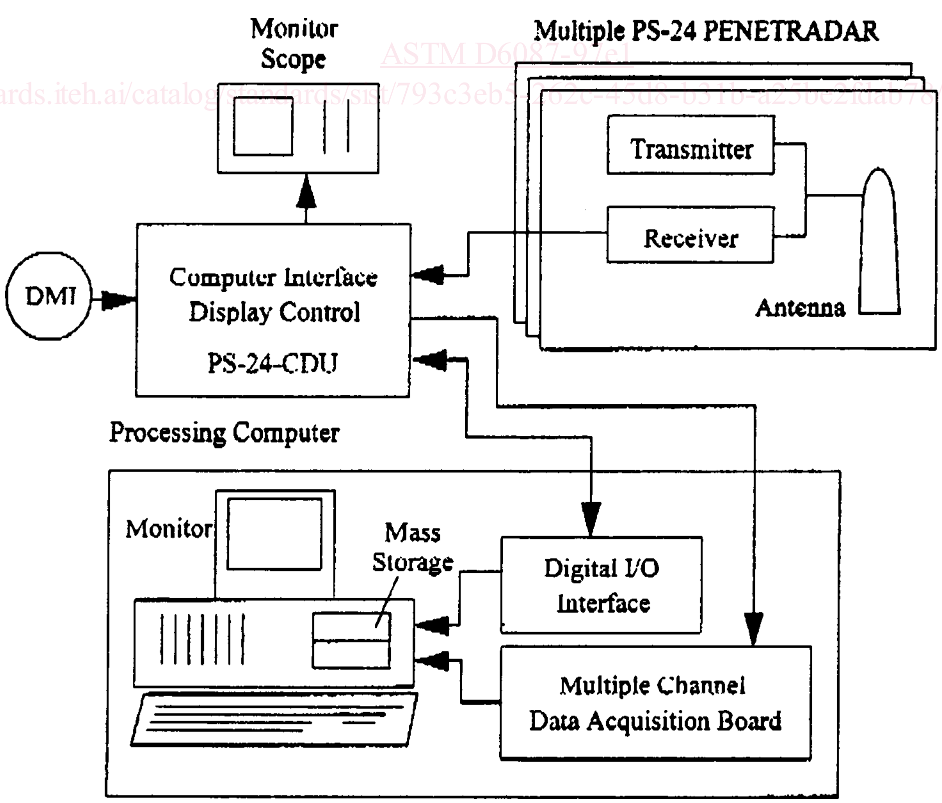

FIG. 1 Block Diagram of Radar and Support Equipment