NDT METHODS OF CONDITION SURVEY FOR BRIDGE DECKS

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Exposed Concrete Decks suffer from various deterioration mechanisms; i.e. corrosion of steel reinforcement, freezing and thawing. The most significant consequence is the delamination of concrete, which could eventually trigger other damage mechanism, such as corrosion.

The Second Strategic Highway Research Program (SHRP 2) has identified four major deterioration mechanisms that are of highest concern to bridge structures. These deterioration mechanisms are:

- Delamination in Concrete Deck
- Concrete Degradation
- Corrosion of Steel Reinforcement
- Vertical Cracking

Existing (traditional) methods of condition survey for bridge decks involve chain dragging to identify and quantify delaminated areas; This practice has certain limitations: i.e. traffic noise can make it difficult to detect deleminated concrete, relatively slow, and requires lane closure and traffic control. In this article, we will describe how non-destructive testing (NDT) and evaluation methods provide additional information about the condition of the deck slab.

Impact-Echo

In Impact-Echo test, a stress pulse is generated at the surface of the element. The pulse spreads into the test object and is reflected by cracks, flaws or interfaces, and boundaries. The surface response caused by the arrival of reflected waves, is monitored using a high precision receiving transducer (Malhotra and Carino, 2004). The data received by the transducer is normally analyzed in the frequency domain to measure the wave speed and the thickness. This procedure has been standardized as the ASTM C1383, "Standard Test Method for Measuring the P-Wave Speed and the Thickness of Concrete Plates Using the Impact-Echo Method".

Applications

Imapct-Echo method can be used for the Condition assessment of reinforced concrete elements with respect to delamination. The test method can be used to study the surface-opening cracks (i.e. vertical cracks in bridge decks); and to study the characterization of concrete material.

Limitations

The use of Impact-Echo method for detection of delamination in concrete decks with asphalt overlays is somewhat limited to low temperatures. The detection of the boundaries of delaminated area requires using a very dense test grid.

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Pulse-Echo

The ultrasonic pulse echo (UPE) method is used for thickness measurements, flaw detection, detecting delamination, and evaluation the integrity of concrete. The concept behind this method relies on the propagation of stress waves through materials. The emitted impulse and the reflected acoustic waves are monitored at the receiving transducer. Test results can be used to evaluate the thickness of medium, and identify potential subsurface defects.

Applications

Imapct-Echo method can be used for thickness measurement of concrete elements with one-side access. The method is ideal for thickness evaluation of abutment walls, and linings. The test method can be used to study the surface-opening cracks (i.e. vertical cracks in bridge decks); and to study the characterization of concrete material.

Limitations

The application of UPE method for bridge deck scanning can be time consuming, since a proper scan requires very close spacing between the test locations. The application of the method is somewhat difficult over rough surfaces.

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Ultrasonic Pulse Velocity

The UPV methods have traditionally been used for the quality control of materials, mostly homogeneous materials such as metals and welded connections. With the recent advancement in transducer technology, the test has been widely accepted in testing concrete materials, used to evaluate the quality of concrete quality (learn more), evaluate Homogeneity and Uniformity of Concrete, and measurement of Surface Crack Depth (read more). Ultrasonic testing of concrete is an effective way for quality and uniformity evaluation, as well as crack depth estimation. The test procedure has been standardized as “Standard Test Method for Pulse Velocity through Concrete” (ASTM C 597, 2016).

Applications

UPV can be used to evaluate the quality of concrete materials. It can also provide information about the crack depth that are visible on the surface. When combined with other NDT methods, UPV can be used for on-site evaluation of concrete strength

Limitations

UPV measurements are sensitive to the presence of steel rebar. Delamination in concrete can affect the test results.

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Ground Penetrating Radar

GPR uses pulsed electromagnetic radiation to scan concrete. It can be used to locate rebar, voids, and delamination in the depth of concrete deck. GPR has a great advantage in testing the bridge decks, as it is currently the only non-destructive method that can be used to evaluate a concrete bridge deck with an asphalt overlay. The practice has been standardized by ASTM D6087, 2008. GPR emits electromagnetic pulses (radar pulses) with specific central frequency to scan the subsurface medium. The reflected waves from subsurface layers, and objects are captured by the receiver antenna. The main advantage of GPR method is the speed of test, since the scanning apparatus can be mounted on a truck oto perform the scanning at the speed of traffic.

Applications

Application of GPR in concrete bridge deck evaluation can be as simple as locating the reinforcement, or thickness of concrete cover. It can also be used to identify potentially delaminated areas. Large areas can be scanned in a limited period.

Limitations

GPR cannot directly identify delamination in bridge decks, unless they are filled with water. GPR does not provide any information on mechanical properties of concrete.

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Half-Cell Corrosion Mapping

Half Cell corrosion mapping offers a rapid, cost-effective and non-destructive way for corrosion assessment. The test provides valuable information on the likelihood of corrosion, and helps in the quality assurance of concrete repair and rehabilitation. Several standard associations have standardized the test procedure including the ASTM C 876, UNI 10174 and RILEM TC 154. Depending on the measured half cell corrosion potential value, the probability of active corrosion is determined.

Applications

Half-Cell corrosion potential survey (mapping) provides information about the probability of active corrosion of embedded steel rebar. It provides a cost-effective way to identify the locations with higher risk of corrosion.

Limitations/Challenges

Half-Cell potential measurement does not provide information about the kinetics of corrosion activity, that is the rate of corrosion. Moisture content, density of concrete cover, and availability of oxygen can affect the measurements.

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