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Nondestructive Evaluation of Concrete Structures
Acoustic Methods

Introduction:

To ensure the safety and reliability of a component in any structural element, the mechanical properties of the material which can be anisotropic and the number, size and distribution of cracks must be tested. Non-destructive evaluation (NDE) techniques are used to assess the conditions of concrete structures, predict future performance, and provide quality control during construction.

Existing NDE methods for assessing reinforced and post-tensioned concrete structures include surface hardness methods, acoustic methods, radiography, electromagnetic methods, resistivity measurements.

This paper gives an introduction to different types of NDE methods with an emphasis and detailed study of acoustics methods.

Visual Inspection:

Visual inspection is very important in assessing the reason for deterioration of concrete structures. The first stage in an evaluation of a concrete structure is to study the condition of the concrete, to note any defects in the concrete, to note the presence of cracking and the cracking type, the presence of rust marks on the surface, the presence of voids… Visual assessment determines whether or not to proceed with detailed investigation i.e. non-destructive testing.

Rebound Hammer Technique:

The Schmidt rebound hammer is basically a surface hardness test with little apparent theoretical relationship between the strength of concrete and the rebound number of the hammer. However, within certain constraints, empirical correlation has been established between strength properties and the rebound number.

Thermography:

Thermography is a technique of obtaining an image distribution over the surface of an object. The usual method is to use a special television camera with an infrared sensitive detector and a lens which transmit infra-red radiation. Such camera can operate at normal video rate. The main application related to building inspection is to survey damage and energy- related condition of the building envelope.

Ray Kordahi 4/4/2004

Pachometer:

Reinforcement bar in concrete can be located using electromagnetic method (pachometer). Pachometer can be used to locate the bar position and the cover thickness. The cover thickness is an important item to be checked whether it is within the value specified by the specification or not. Too thin cover thickness may result in bar corrosion.

Radiography:

Radiography can be used to check the condition of the bar and also to detect void in concrete. High energy gamma-ray source is normally used. Typical sources are Iridium-192 and Cobalt-60. Although Cobalt-60 has better radiation penetration in concrete, the equipment is bulky and difficult to handle in order to meet on-site safety requirement. A very high energy gamma radiation emitted by Cobalt-60 requires a very large safe operational area which is not practical in most of the construction site. The use of collimator may reduce this problem significantly.

Acoustic Emission:

An acoustic emission (AE) is the stress wave in a structure which results from cracks or other dynamic sources within a material. These stress waves can be detected at the surface of the structure, and can be analyzed to evaluate properties of the cracks which generated the AE event. Acoustic emission can be considered a passive NDE technique since the measured ultrasonic waves are generated by the structure itself, as opposed to being interrogated by some external source (active NDE).

The mechanism by which acoustic events are generated from corrosion activity is the build up of corrosion product around the bar. As corrosion product forms, the overall volume of the bar increases, placing additional stresses at the steel-concrete interface. This additional stress ultimately leads to cracking in the concrete which causes the acoustic emissions. It is likely that cracking at both the rebar interface as well as in the concrete matrix is the source of the AE activity.

An ultrasonic (acoustic) wave is generated by exciting a piezoelectric material with a high-amplitude, transient electrical pulse from a high-voltage, high-current pulse. The short burst of ultrasonic energy from the crystal is transmitted into the concrete and imposes upon the various interfaces within. The change in acoustic impedance at the various interfaces, air voids, water-filled voids, reinforcing bars, cracks and other interfaces or inclusions within the concrete causes a portion of the input energy to reflect (echo) back to the surface. There the energy is detected by a second piezoelectric element. A larger portion of the energy continues to travel forward, strike other interfaces

and return an amount of energy based on (1) the area of the reflecting surface, (2) the angle of the reflecting surface, and (3) the acoustic impedance of the reflecting material.

Ultrasonic method is applied for measurements of composition (e.g. monitor the mixing materials during construction, to estimate the depth of damage caused by fire), strength estimation, homogeneity, elastic modulus and age, check presence of defects, crack depth and thickness measurement.

Conclusion:

The cheapest NDE method is by visual inspection. However the valuable information can only be gathered by the well-trained eye. Ultrasonic method is the most flexible method which can be applied to check various concrete characteristics that are related to the quality. Thermography is very good for general or overall inspection and can be performed at a distance from the object. NDE can be correlated to the quality of concrete and it has replaced many destructive tests in the mechanical construction.

Most of the structural integrity can be evaluated by NDE method. It is a matter of putting it as a tool for quality in the maintenance or construction program. This program has been applied successfully in mechanical construction. Furthermore necessary steps have been taken to further improve the technique so that it may yield more accurate and reliable data useful for assessing the quality of concrete structures.

References:

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