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Non-Destructive Testing On RCC Structure

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ABSTRACT
Non destructive testing plays an important role in identifying and detection of internal defects and cracks in many industrial applications such as concrete structures, pavements, and metal testing. Non destructive testing of concrete allows the inspection of larger areas of concrete members at lesser cost than coring and provides more information than visual inspection. The deterioration of reinforced concrete structure such as elevated service reservoir is major problem in many countries of the world. Many of the existing water tanks in service today are inadequate to need the present water demand. To ensure safe durable service and selecting the most appropriate repair strategy it is essential to perform in situ inspection for a distressed concrete structure. The main objective of present work is to propose the developed systematic investigation for metrology and a condition ranking procedure based on Analytical hierarchy process (AHP). DER rating technique is used to find out the condition ranking of elevated service reservoir in Karad region in Maharashtra. The ranking assessment for elevated service reservoir structure has been carried our using different Non-destructive test methods like surface hardness, ultrasonic pulse velocity test, half-cell potential methods and cover depth measure.

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I. INTRODUCTION

A. **General**

To keep a high level of structural safety, durability and performance of the infrastructure in each country, an efficient system for early and regular structural assessment is urgently required. The quality assurance during and after the construction of new structures and after reconstruction processes and the characterization of material properties and damage as a function of time and environmental influences is more and more becoming a serious concern.

Non-destructive testing (NDT) methods have a large potential to be part of such a system. NDT methods in general are widely used in several industry branches. Aircrafts, nuclear facilities, chemical plants, electronic devices and other safety critical installations are tested regularly with fast and reliable testing technologies. A variety of advanced NDT methods are available for metallic or composite materials.

In recent years, innovative NDT methods, which can be used for the assessment of existing structures, have become available for concrete structures, but are still not established for regular inspections. Therefore, the objective of this project is to study the applicability, performance, availability, complexity and restrictions of NDT. The purpose of establishing standard procedures for non-destructive testing (NDT) of concrete structures is to qualify and quantify the material properties of in-situ concrete without intrusively examining the material properties. There are many techniques that are currently being research for the NDT of materials today. This chapter focuses on the NDT methods relevant for the inspection and monitoring of concrete materials.

II. OBJECTIVE

The objective of the project is to study the various instruments used in NDT and to determine the strength, durability, quality and life of structure. Also, to identify the cracks in the RCC structure and other properties.
1) Estimating the in-situ compressive strength.
2) Estimating the uniformity and homogeneity.
3) Estimating the quality in relation to standard requirement.
4) Detection of presence of cracks, voids and other defects.
5) Identification of reinforcement profile and measurement of cover, bar diameter, etc.
6) Condition of reinforcement steel with respect to
corrosion.

III. LITERATURE REVIEW

Non destructive techniques are useful for evaluating the condition of structure, by performing indirect assessment of concrete properties. These techniques have been improved in last few years and the best part is that NDT avoids concrete damage for evaluation. Several researchers perform NDT test to evaluate the condition of concrete structure. Methods range from very simple to technical depending on the purpose.

Several mechanical and physical properties of concrete structure can be used to assist the condition and capacity of the structure.
Almir and Protasio (2000)
Rens and Kim (2007)
Amleh and Mirza (2004)
Dias and Jayanandana (2003)
Shiotani et al. (2009)

IV. NDT METHODS COMMONLY USED ON FIELD

a) Visual Inspection Test

Visual testing is probably the most important of all non-destructive tests. It can often provide valuable information to the well trained eye. Visual features may be related to workmanship, structural serviceability, and material deterioration and it is particularly important that the engineer is able to differentiate between the various signs of distress which may be encountered. These include for instance, cracks, pop-outs, spalling, disintegration, colour change, weathering, staining, surface blemishes and lack of uniformity. Extensive information can be gathered from visual inspection to give a preliminary indication of the condition of the structure and allow formulation of a subsequent testing programme.

b) Acoustic Emission TEST

Acoustic Emission (AE) is a non-invasive, non-destructive method that analyses the noises created when materials deform or fracture. Each acoustic emission event is a signature of an actual mechanism, a discrete event that reflects a given material response there is a critical difference between acoustic emission and ultrasonic methods. In the former, a known signal is imparted into a material and the material's response to on the signal is studied while in the latter the signal is generated by the material itself. These waves are originated by micro crack formation or propagation in concrete.

Fig: Acoustic Emission Instrument

c) Ultrasonic Pulse Velocity Test

A pulse of longitudinal vibrations is produced by an electro-acoustical transducer, which is held in contact with one surface of the concrete under test. When the pulse generated is transmitted into the concrete from the transducer using a liquid coupling material such as grease or cellulose paste, it undergoes multiple reflections at the boundaries of the different material phases within the concrete. A complex system of stress waves develops, which include both longitudinal and shear waves, and propagates through the concrete. The first waves to reach the receiving transducer are the longitudinal waves, which are converted into an electrical signal by a second transducer. Electronic timing circuits enable the transit time T of the pulse to be measured.
Longitudinal pulse velocity (in km/s or m/s) is given by:

$$v = \frac{L}{T}$$

Fig: Ultrasonic Testing Equipment

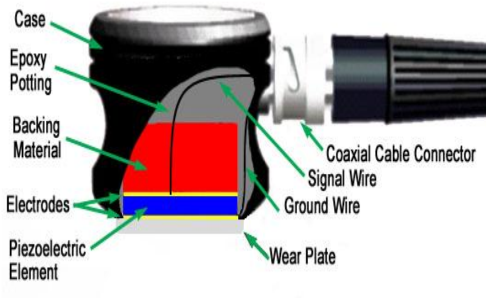

Fig: Component Parts of Transducer

d) Impact Echo Test

This is an effective method of locating large voids or delamination's in plate like structures, e.g., pavements or bridge decks, where the defect is parallel to the test surface. A mechanical impact produces stress waves of 1 to 60 kHz. The wavelengths of from 50 mm to 2000 mm propagate as if in a homogeneous elastic medium. The mechanical impact on the surface generates compression, shear and surface waves. Internal interfaces or external boundaries reflect the compression and shear waves. When the waves return to the surface where the impact was generated, they can be used to generate displacements in a transducer and subsequently a display on a digital oscilloscope. The resulting voltage-time signal is digitized and transformed, in a computer, to amplitude vs. frequency plot. The dominant frequencies appear as peaks on the frequency spectrum. The dominant frequency is not necessarily the thickness signal. Using each of the frequencies identified as peaks on the frequency spectrum, the distances to the reflecting surfaces can be calculated from

$$d = \frac{v}{2f}$$

Fig: Equipment for Impact Echo Test

Fig: Testing of Concrete Member

e) Rebound Hammer Test

The Schmidt rebound hammer is principally a surface hardness tester. It works on the principle that the rebound of an elastic mass depends on the hardness of the surface against which the mass impinges. There is little apparent theoretical relationship between the strength of concrete and the rebound number of the hammer. However, within limits, empirical correlations have been established between strength properties and the rebound number. Further, Kolek has attempted to establish a correlation between the hammer rebound number rand the hardness as measured by the Brinell method.

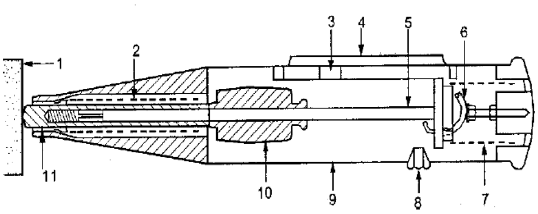

Fig: Components Parts of Rebound Hammer

f) Half-Cell Potential Test

The method of half-cell potential measurements normally involves measuring the potential of an embedded reinforcing bar relative to a reference half-cell placed on the concrete surface. The half-cell is usually a copper/copper sulphate or silver/silver chloride cell but other combinations are used. The concrete functions as an electrolyte and the risk of corrosion of the reinforcement in the immediate region of the test location may be related empirically to the measured potential difference. In some circumstances, useful measurements can be obtained between two half-cells on the concrete surface. ASTM C876 - 91 gives a Standard Test Method for Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete.

Fig: Equipment For Half Cell Potential Method

V. RESULT

The result of performing NDT at the selected site was, the structure was in very bad shape, structural condition of the building was posing question mark on its condition. At effort to find out structural condition of the building is made. The details and observation are shown in table.

ULTRASONIC PULSE VELOCITY TEST RESULTS

SR. NO.	REMARKS	PARTICULARS	TRANSIT TIME (T)	PATH LENGTH (L) (mm)	VELOCITY V=(L/T) (in KM/SEC)	EQUIVALENT VELOCITY WITH CO-RELATION/FACTOR (KM/SEC)
1.	Column 1	Indirect	131.5	200	1.52	3.00
		Indirect	103.8	200	1.92	
		Indirect	101.3	200	1.97	
2.	Column 2	Indirect	64.3	200	3.11	2.82
		Indirect	76.5	200	2.61	
		Indirect	72.9	200	2.74	
3.	Column 3	Indirect	67.5	200	2.96	3.92
		Indirect	70.7	200	2.82	
		Indirect	154.4	200	1.29	
4.	Column 4	Indirect	71.2	200	2.80	3.49
		Indirect	120.3	200	1.66	
		Indirect	110.3	200	1.81	
5.	Column 5	Indirect	97.6	200	2.04	3.07
		Indirect	96.8	200	2.06	
		Indirect	139.5	200	1.43	
6.	Slab	Indirect	67.2	200	2.97	3.49
		Indirect	72.3	200	2.76	
		Indirect	99.6	200	2.00	
		Indirect	68.1	200	2.93	
		Indirect	61.0	200	3.27	
		Indirect	123.7	200	1.61	

Recommendations Suggested On The NDT Conducted are:-

Based on the visual inspection and NDT results correlation between different results/ observations should be carried out. The summary of all results including acceptance guides, if available should be provided. It should include variability of results and statistical data. Where appropriate, a separate compilation of results for different structural elements, categories of structures, should be provided along with statistical analysis. The serviceability assessment or remnant life assessment, durability etc. should also be calculated. The overall condition assessment of the structures/ buildings should be categorized as follows:

• **Column 1:** The building is structurally unsafe and has been found to be in extremely dangerous condition. This building needs to be vacated immediately and demolished.

• **Column 2**: Only a portion of this building is in extremely dangerous condition (not repairable and worthy of demolition), while other portion can be repaired or strengthened. This building need not be vacated completely. The extremely dangerous portion should be cordoned off.

• **Column 3:** The building has been found to be dangerous (need major repairs/ strengthening urgently, but need not be vacated).

• **Column 4:** The building condition is satisfactory (need minor repairs).

Recommendations should be given for further testing if test results are inconclusive. Finally suitable repair, protection, restoration, strengthening techniques along with their materials and method statements should be recommended. Also, future maintenance and inspection schedules should be recommended.

VI. CONCLUSION

Structural Health Monitoring is relatively new concept worldwide and very recent for India. It has proved to be effective and fruitful in many countries, now being practices often, and has a great potential and usefulness for India for gaining confidence over the structures we are making so that development happens faster and with accurate results.

Non-destructive testing has not yet been adopted as routine testing. Whenever there are some problems with cement/ concrete strength and finish, then NDT is used only as a rescue tool. Now the time has come to use these NDT techniques as routine testing to have more effective quality control. The main advantage of this testing is to assess the in-situ quality of concrete. These techniques help to decide the acceptability of the concrete structure. NDT has become mandatory testing, in addition to cube testing, in some parts of the world. In India some Govt. agencies have included NDT as mandatory testing, in addition to cube testing. All other agencies, RCC consultants, Municipal Corporations, etc. should specify these tests in their tenders as an additional quality control tool.

- We have studied various instrument used in NDT.
- We have performed Rebound Hammer Test on concrete block.
- By studying different instrument, we are able to know how the different instruments work and how it gives different readings or details.

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