STUDY ON SOUNDNESS OF REINFORCED CONCRETE STRUCTURES BY NDT APPROACH

Lokesh V[1], B. Shivakumara Swamy[2], S.Vijaya[3]

[1]*PG Student, civil engineering dept., Dr.AIT Bangalore, Karnataka, India*
[2]*Head of the department, Civil engineering department, Dr.AIT, Bangalore, Karnataka, India*
[3]*Prof., Civil engineering department, Dr.AIT, Bangalore, Karnataka, India*

Abstract

Non-Destructive Evaluation (NDE) techniques, are being used for Structural Health Evaluation. Structures are assemblies of load carrying member capable of safely transferring the superimposed loads to the foundations. Their main and most looked after property is the strength of the material that they are made of. Concrete, as we all know, is an integral material used for construction purposes. Thus, strength of concrete used, is required to be 'known' before starting with any kind of analysis. The various methods and techniques, called as NDT. 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.

Key Words: *Non Destructive Evaluation(NDE), Structural Health Evaluation, profometer half cell potentiometer, carbonation test, quality/strength, Structural health and reinforcement etc…*

--***--

1. INTRODUCTION

Structural health monitoring is at the forefront of structural and materials research. Structural health monitoring systems enable inspectors and engineers to gather material data of structures and structural elements used for analysis. Ultrasonic can be applied to structural monitoring programs to obtain such data, which would be especially valuable since the wave properties could be used to obtain material properties.

Any structure that is in use for which it is intended to, shows some structural disorder, requires to be assessed for its quality, structural integrity and in place concrete compressive strength. Standing structure can not be assessed by conventional methods adopted to evaluate structural integrity and in place concrete compressive strength same as by testing standard specimens up to failure. Hence for structures, standing decades together, an efficient system of assessment of structure for in place strength is urgently required. It is also true to the new structures, as more and more clients and their consultants are well aware of the quality assurance in booming infrastructure sector in India. Non Destructive Testing (NDT) has the potential of becoming an effective tool for quality assurance and damage assessment.

2. NON-DESTRUCTIVE METHODS

The objective of a non destructive test is to obtain an estimate of properties of material by measuring certain quantities which are empirically related to it. To make a strength estimation, it is necessary to know the relationship between the result of the non destructive test and strength of material. The accuracy of interpretation of results depends directly on the correlation between strength of material and measured quantity. Thus, the user of NDT should have an understanding of what quantity is measured by the test and how this quantity is related to the strength of material. Test methods range widely in reliability and complexity. Hence, appropriate experience is necessary in selection of the proper tests and corrects interpretation. The following NDT techniques are generally employed -

1. Schmidt‟s Rebound Hammer test for assessing the concrete compressive strength.
2. Ultrasound pulse Velocity tests for establishing quality of concrete.
3. Coring for taking out concrete cores for laboratory testing for determining compressive strength.
4. Rebar locator tests for locating reinforcement bars and for determining their diameters and spacing.
5. Carbonation test for determining the depth of carbonation of concrete.
6. Half- cell potential test for determining the likelihood of corrosion.
7. Determination of chloride contents of concrete

In the present paper, health assessment methods such as A) Rebar locator test B) Carbonation test and C) Half- cell potential test are closely scrutinized to explore some fundamental aspects of R. C. structure health monitoring.

2.1 Profometer/Rebar Locator

It is used for detecting location and size of the reinforcement, and the concrete cover.This instrument is also known as rebar locator. The method is based on measurement of the change in electromagnetic field caused by the steel embedded in the concrete. It is covered by BS 4408:1969-Part1. The device is a portable and handy instrument, normally used to locate the reinforcement, with an electronic display. To ensure satisfactory working of profometer and to get accurate results, it should be calibrated before starting the operations and at the end of the test. To check the calibration accuracy, the size and cover of the reinforcement of the test block is measured at different locations on test block and the recorded data should match with the standard values prescribed on the test block. Path measuring device and spot probes are together used for path measurements and scanning of reinforcement bars. These are connected with profometer and are moved on the concrete surface for scanning the reinforcement bars and measuring the spacing. Diameter and depth probes are used in conjunction with the profometer to measure the diameter of rebar and its concrete cover respectively For carrying out this test, proper access to the test section is essential. Before actual scanning, marking is done with chalk on the concrete surface by dividing it into panels of equal areas. The method is very fast and gives quite accurate results if the reinforcement is not heavily congested. The equipment is light and a single person can perform the test.

Fig 1 profometer

2.2 Half Cell Potentiometer Test/Corrosion Analyzer

Electrochemical Half-cell Potentiometer test provides a quantitative assessment of reinforcement corrosion over a wide area without the need of major removal of the concrete cover. The method detects the likelihood of corrosion of steel but cannot indicate the rate of corrosion. Distinction can be made between corroded and non-corroded locations by making measurements over the whole surface.

Principle and code: Corrosion analyzer is based on electro-chemical process to detect corrosion in the reinforcement bars of structure. During active corrosion, the steel-concrete system in the reinforced concrete element represents short-circuited galvanic cell, with the corroding area of the reinforcement bar acting as the anode, the passive surface as the cathode and concrete as electrolyte. The excess electrons generated during corrosion flow through the concrete between anodic and cathodic sites, generating current which is accompanied by an electric potential field surrounding the corroding bar. The equipotential lines intersect the surface of the concrete and the potential at any point can be measured using the half potential method.

Device and Methodology: Before starting the test, the test surface is made wet (this should be done at least 45 minutes prior to conducting the test). To measure half-cell potentials, an electrical connection is made, through a small drilled hole) to the steel reinforcement in the concrete member to be tested. This is connected to a high impedance digital millivolt meter, often backed up with a data logging device. The other connection to the millivolt meter is taken to a copper/copper sulfate or silver/silver chloride half-cell, which has a porous connection at one end which can be touched to the concrete surface. This will then register the corrosion potential of the steel reinforcement nearest to the point of contact.

2.3 Carbonation Test

Carbonation test was carried out on RC members at random using phenolphthalein indicator in 0.1 N methyl alcohol solution to assess the extent of carbonation in cover concrete.

Carbonation of concrete occurs when the carbon dioxide, in the atmosphere in the presence of moisture, reacts with hydrated cement minerals to produce carbonates, e.g. calcium carbonate. The carbonation process is also called depassivation. Carbonationpenetrates below the exposed surface of concrete extremely slowly. The time required forcarbonation can be estimated knowing the concrete grade and using the following equation:

$$t = \left(\frac{d}{k}\right)^2$$

Where
t is the time for carbonation,
d is the concrete cover,
k is the permeability.
Typical permeability values are shown in Table 5.1.

2.3.1. Equipment for Carbonation Depth Measurement Test

If there is a need to physically measure the extent of carbonation it can be determined easily by spraying a freshly exposed surface of the concrete with a 1% phenolphthalein solution. The calcium hydroxide is coloured pink while the carbonated portion is uncoloured.

2.3.2. General Procedure for Carbonation Depth Measurement Test

The 1% phenolpthalein solution is made by dissolving 1gm of phenolpthalein in 90 cc of ethanol. The solution is then made up to 100 cc by adding distilled water. On freshly extracted cores the core is sprayed with phenolphthalein solution, the depth of the uncoloured layer (the carbonated layer) from the external surface is measured to the nearest mm at 4 or 8 positions, and the average taken. If the test is to be done in a drilled hole, the dust is first removed from the hole using an air brush and again the depth of the uncoloured layer measured at 4 or 8 positions and the average taken. If the concrete still retains its alkaline characteristic the colour of the concrete will change to purple If carbonation has taken place the pH will have changed to 7 (i.e. neutral condition) and there will be no colour change.

2.3.3. Range and Limitations of Carbonation Depth Measurement Test

The phenolphthalein test is a simple and cheap method of determining the depth of carbonation in concrete and provides information on the risk of reinforcement corrosion taking place. The only limitation is the minor amount of damage done to the concrete surface by drilling or coring.

3. APPLICATIONS

Nondestructive testing has wide application in the field of civil engineering. Nondestructive testing can be carried out to know about feasibility and soundness of the structure In order to ascertain the structural soundness of the building for the proposed additional floor construction, following studies were carried out:
1. Dimensional measurement of structural members.
2. Examination of foundation and tests on soil at foundation level.
3. Semi-destructive test to assess the quality/strength of in-situ concrete in RC footings
4. Non-destructive tests to assess the quality/strength of in-situ concrete in RC member
    - Ultrasonic pulse velocity test on RC columns and beams
    - Rebound hammer test on RC slabs.
5. Cover meter studies to map the disposition and probable dia of peripheral rebars in RC members
6. Theoretical analysis and design verification for the proposed additional floor

Depending on the results the strength of existing structure is evaluated.

4 CONCLUSIONS

In this study, various non-destructive condition evaluation methods have been studied and they have been used in the field testing of reinforced cement concrete structural members

REFERRENCES

[1]. Guidebook on non destructive testing of concrete structures International atomic energy agency, Vienna, 2002
[2]. Handbook on Non Destructive Testing of Concrete" (second edition) by V.M. Malhotra and N.J. Carino