

## Structural Investigation of Concrete Using NDT



### Engineering

**KEYWORDS :** Strengthening, Nondestructive testing, Rebound Hammer, Hardness of concrete, Retrofitting, Groutin

**Swati J. Sonule**

Rambhaue Ligade Polytechnic College Buldana, (MS)

**Archana A. Uparwat**

P.L.I.T.Buldana, (MS)

**Dinesh W. Gawatre**

Sinhgad Academy of Engineering, Kondhawa (BK), Pune (MS)

### ABSTRACT

At the time of strengthening the most important parameter of its strength and durability depending upon the structures. In this experimental investigation of nondestructive testing (NDT) is to obtain properties of in place specimens without the destruction of the specimen or the structure and also the study the strength, corrosion, crack monitoring of structural elements and effect of reinforcement on the obtained results. These Non Destructive Instruments were then used to test the columns, beams and slabs. To calculate the strength and durability without destructing it, using Rebound Hammer and Ultrasonic pulse Velocity Test.

### Introduction

To check 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 require

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. The purpose of establishing standard procedures for nondestructive 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.

### Importance and need of non-destructive testing

Ideally such testing should be done without damaging the concrete. The tests available for testing concrete range from the completely non-destructive, where there is no damage to the concrete, through those where the concrete surface is slightly damaged, to partially destructive tests, such as core tests and pullout and pull off tests, where the surface has to be repaired after the test. The range of properties that can be assessed using non-destructive tests and partially destructive tests is quite large and includes such fundamental parameters as density, elastic modulus and strength as well as surface hardness and surface absorption, and reinforcement location, size and distance from the surface. In some cases it is also possible to check the quality of workmanship and structural integrity by the ability to detect voids, cracking and delimitation.

Non-destructive testing can be applied to both old and new structures. For new structures, the principal applications are likely to be for quality control or the resolution of doubts about the quality of materials or construction. The testing of existing structures is usually related to an assessment of structural integrity or adequacy. In either case, if destructive testing alone is used, for instance, by removing cores for compression testing, the cost of coring and testing may only allow a relatively small number of tests to be carried out on a large structure which may be misleading.

### Typical situations where non-destructive testing may be useful are, as follows:

- Quality control of pre-cast units or construction *in situ*.
- Monitoring of strength development in relation to formwork removal, cessation of curing, pre-stressing, load application or similar purpose.
- Location and determination of the extent of cracks, voids, honeycombing and similar defects within a concrete structure.
- Determining the concrete uniformity, possibly preliminary to core cutting, load testing or other more expensive or disruptive tests.

- Determining the position, quantity or condition of reinforcement.
- Confirming or locating suspected deterioration of concrete resulting from such factors as overloading, fatigue, external or internal chemical attack or change, fire, explosion, environmental effects.

### Methods and applications of NDT

- Ultrasonic pulse velocity testing, mainly used to measure the sound velocity of the concrete and hence the compressive strength of the concrete.
- Schmidt/rebound hammer test, used to evaluate the surface hardness of concrete.
- Half-cell electrical potential method, used to detect the corrosion potential of reinforcing bars in concrete.
- Carbonation depth measurement test, used to determine whether moisture has reached the depth of the reinforcing bars and hence corrosion may be occurring.
- Permeability test, used to measure the flow of water through the concrete.
- Penetration resistance or Windsor probe test, used to measure the surface hardness and hence the strength of the surface and near surface layers of the concrete.
- Cover meter testing, used to measure the distance of steel reinforcing bars beneath the surface of the concrete and also possibly to measure the diameter of the reinforcing bars.
- Radiographic testing used to detect voids in the concrete and the position of stressing ducts.
- Sonic methods using an instrumented hammer providing both sonic echo and transmission methods.
- Topographic modeling, which uses the data from ultrasonic transmission tests in two or more directions to detect voids in concrete.
- Impact echo testing, used to detect voids, delimitation and other anomalies in concrete.
- Ground penetrating radar or impulse radar testing, used to detect the position of reinforcing bars or stressing ducts.
- Infrared thermograph, used to detect voids, delimitation and other anomalies in concrete and also detect water entry points in buildings.

### Situations where NDT is an option to consider for investigation of *in situ* concrete

- To investigate the homogeneity of concrete mixing
- Lack of grout in post tensioning ducts
- To determine the density and strength of concrete in a structure
- To determine the location of reinforcing bars and the cover over the bars
- To determine the number and size/diameter of reinforcing bars
- To determine the extent of defects such as corrosion
- To determine the location of in-built wiring, piping, ducting, etc.

- To determine whether internal defects such as voids, cracks, delimitations, honeycombing, lack of bonding with reinforcing bars, etc. exist in concrete
- To determine if there is a bond between epoxy bonded steel plates and concrete members.

### AIM OF INVESTIGATION OF THE PROJECT

To analyze the structure in respect of its strength and durability without destructing it, using Rebound Hammer and Ultrasonic pulse Velocity Test. These Non Destructive Instruments were then used to test the columns, beams and slabs of the JSW Ispat Industries Ltd., Nagpur Quarters No. 17, 18, 19 and 20.

### VISUAL INSPECTION

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, spelling, disintegration, color 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 programmed.

### JSW Ispat Industries Ltd. Quarters, Nagpur



### TOOLS AND EQUIPMENT FOR VISUAL INSPECTION

Measuring tapes or rulers, markers, thermometers, anemometers and others. Binoculars, telescopes, bore scopes and endoscopes or the more expensive fiber scopes may be useful where access is difficult. A crack width microscope or a crack width gauge is useful, while a magnifying glass or portable microscope is handy for close up examination. A good camera with the necessary zoom and micro lenses and other accessories, such as polarized filters, facilitates pictorial documentation of defects, and a portable color chart is helpful in identifying variation in the color of the concrete. A complete set of relevant structural drawings.

### APPLICAIONS OFVISUAL INSPECION

For existing structures, presence of some feature requiring further investigation is generally indicated by visual inspection, such as weathering, chemical attack, mechanical damage, physical deterioration, abuse, construction deficiencies or faults and many others.



Spalling



Exposure Of Reinforcement



Cracks

### OBSERVATIONS

As per the Non Destructive Tests carried out on JSW Ispat Quarters No. 17, 18, 19, 20 at Kalmeshwar, Nagpur Ultrasonic Pulse Velocity results with direct, semi direct and indirect methods indicates micro cracks and major cracks in concrete. The Rebound Hammer readings are within the acceptable limits. As per pH and carbonation of concrete test the pH of concrete is between 9.94 to 7.94 this indicates reduction of pH and corrosion of reinforcement has started. The phrasings indicate the passive layer over the reinforcement is destroyed and active corrosion started in the reinforcement. As per Half Cell potentiometer readings the same area between -284mV to- 369 mV this indicates active corrosion in the reinforcement. The range of Half Cell readings indicates corrosion is very fast and requires retrofitting to concrete structure. The detail repairs and retrofitting scheme is given in the report. As per the Non destructive tests carried out on building structure, it is to certify that the structure requires major repairs and retrofitting.

### OBJECTIVE OF STRUCTURAL AUDIT AND NDT

- 1) To check the strength of existing buildings, to assess the strength of concrete, corrosion of steel inside the concrete, integrity of concrete and durability of concrete.
- 2) To check Ph and Carbonation of concrete to assess the life of the structure and possibility of corrosion because of lowering ph value.
- 3) Damage assessment of buildings and structures because of wear and tear, unexpected loadings on the structure and ageing factor.
- 4) To check the durability aspect of structure.
- 5) To check probable locations of major retrofitting areas and minor repair areas.
- 6) To fix the major retrofitting areas and providing suitable scheme for repair.

### METHODOLOGY FOR STRUCTURAL AUDIT

- 1) Visual inspection of buildings.
- 2) Fix the locations of various testing and marking of the locations for actual testing.



- 3) To carry out relevant tests on the building and recordings of the reading in specific format.
- 4) Tabulation of N.D.T. readings in prescribed format (Table)
- 5) Interpretation of readings for fixing retrofitting methods and repair scheme as per the requirement of structure



- 6) Preparation of detail report including preparation of retro-

fitting scheme, repair methods, priority of repairs, specifications of material, method of grouting.

**NON-DESTRUCTIVE TEST CARRIED OUT ON BUILDING STRUCTURE**

Rebound Hammer Test to find out probable compressive strength of concrete.

**DETERMINATION OF DEFECTS IN CONCRETE**

The pulse velocity method of testing may be applied to the testing of plain, reinforced and pre-stressed concrete whether it is pre-cast or cast *in situ*. The measurement of pulse velocity may be used to determine.

- a) The homogeneity of the concrete.
- b) The presence of void, cracks or other imperfections.
- c) Changes in the concrete, which may occur with time or through the action of fire, frost or chemical attack.
- d) The quality of concrete in relation to specified standard requirement, which generally refer to its strength.
- e) The quality of one element of concrete in relation to another
- f) The values of elastic modulus of the concrete

**NON-DESTRUCTIVE TESTING BY REBOUND HAMMER**

**Table: 1 Rebound Hammer Test (As per IS 13311 (Part-2) 1992)**

Rebound Number	Probable Compressive Strength (N/mm <sup>2</sup> )
10 to 20	15 to 20
20 to 30	20 to 25
30 to 40	25 to 30
40 to 50	30 to 35
50 to 60	35 to 40
60 to 70	40 to 45

**Table: 2 Schmidt Rebound Hammer Test Results JSW I spat Industries Ltd.**

Sr. No	Particulars	Rebound No.	Avg.	Probable Compressive Strength from Rebound Hammer (N/mm <sup>2</sup> )
Name : Quarter No. 17,18,19,20				
1.	Column No. C-1 Left G.L.	32,32,22,24	27.5	20.00
2.	Column No. C-1 Left G.L.	26,26,24	25.32	18.00
3.	Staircase Landing G.L.	36,28,30,36	32.5	21.00
4.	Flight First	26,28,24,24	25.5	18.00
5.	Column No. C-1 First Floor Left	20,24,24,26	23.50	17.00
6.	Column No. C-1 First Floor Right	22,20,24,26	23.00	17.00
7.	Column No. C-1 Terrace Left	28,26,24	26.00	18.00

**FUNDAMENTAL PRINCIPLE**

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.

**Table: 3 Schmidt Rebound Hammer Test Results JSW I spat Industries Ltd.**

**Table:4 Schmidt Rebound Hammer Test Results JSW I spat Industries Ltd. (Kitchen Beam, Left Slab)**

	Particulars	Rebound No.	Avg.	Probable Compressive Strength from Rebound Hammer (N/mm <sup>2</sup> )
Name : Quarter No. 17,18,19,20				
8.	Column No. C-1 Terrace Right	24,26,24,26	25.00	18.00
9.	Flight First Terrace Floor	32,30,30,32,34	31.6	20.5
10.	Right Slab B-17 Ground Floor	34,38,40,36,42,38	38.00	23.00
11.	Kitchen Beam B-17	30,38,34,32	33.5	21.00
12.	Slab Corner B-18 First Floor	38,32,38,34,38,36	36.00	22.5
13.	Kitchen Beam B-18	36,34,30	33.33	21.00
14.	Left Slab B-19 Ground Floor	34,32,38,34,30,34	33.66	21.00
Sr. No.	Particulars	Rebound No.	Avg.	Probable Compressive Strength from Rebound Hammer (N/mm <sup>2</sup> )
Name : Quarter No. 17,18,19,20				
15.	Kitchen Beam B- 19	34,32,34,40,32	34.4	21.00
16.	Left Slab B-20 First Floor	38,36,40,38,38,40	38.33	23.00
17.	Kitchen Beam	32,34,34,36,36,32	34.00	21.00

**INTERPRETATION OF RESULTS REBOUND HAMMER**

After obtaining the correlation between compressive strength and rebound number, the strength of structure can be assessed.

As such the estimation of strength of concrete by rebound hammer method cannot be held to be very accurate and probable accuracy of prediction of concrete strength in a structure 15 ± 25 percent. If the relationship between rebound index and compressive strength can be found by tests on core samples obtained from the structure or standard specimens made with the same concrete materials and mix proportion, then the accuracy of results and confidence there on gets greatly increased.

The Rebound hammers showed erratic result when the compressive strength was below 15 N/mm<sup>2</sup>. Above 15 N/mm<sup>2</sup> the predicted compressive strength varied almost linearly with the actual compressive strength.

**CONCLUSIONS**

All structural members i.e. all columns, Beam, slabs, pardi need grouting as per Grid specified in details specification. As per NDT Report all column requires grouting as per detail specifications.

Grouting for cracks less than 15 mm wide in walls: All the cracks less than 15 mm wide should be grout with non shrink micro fine cement base polymer grouting.

**Sequence for polymer Grouting -**

- Clean the cracks with wire brush.
- Fix the nozzle in the crack; also fix the nozzle at take off point of grout.
- Grout the nozzle with 5 to 7 kg/cm<sup>2</sup> pressure.
- After grouting from main nozzle check that grouting material should flow from takeoff nozzle.

Finish the surface with same material and fill the surface cracks with poly-sulphide Sealant.



SITE PHOTOGRAPHS



Rebound Hammer Test

## REFERENCE

IS-1311 (Part-1): 1992 Non-Destructive Testing of Concrete -methods of test, Part-1, Ultrasonic Pulse Velocity. | 2. IS 13311 (Part-2): 1992, Non-Destructive Testing of Concrete -methods of test, Part 2, Rebound hammer. | 3. RDSO Report No.BS-53: Guidelines on use of ultrasonic instruments for monitoring of concrete structures. | 4. Handbook on Non Destructive Testing of Concrete" (second edition) by V.M. Malhotra and N.J. Carino | 5. "Non destructive testing" by Louis Cartz. | 6. "Concrete Technology" by M L Gambhir. | 7. "Concrete Technology" by M S Shetty | | | | | Related Books, Journals and Articles | | 1. V. Malhotra, Editor, Testing Hardened Concrete: Non-destructive Methods, ACI, Detroit, US (1976) monograph No. 9 | 2. Structural health monitoring using Non destructive testing of concrete by ayaz mahmood and Dr. S.k.sahu | | 3. ASTM C 805-85, Test for Rebound | Number of Hardened Concrete, | ASTM, USA (1993). | | 4. BS 1881: Part 202, 1986: Recommendations for Surface Hardness Tests by the Rebound Hammer, BSI, UK (1986). | 5. S. Amasaki, Estimation of strength of concrete structures by the rebound hammer. CAJ Proc Cem Conc 45 (1991), pp. 345-351. | | 6. ASTM C 597-83 (Reapproved 1991), Test for Pulse Velocity Through Concrete, ASTM, USA (1991). | 7. BS 1881: Part 203: 1986: Measurement of Velocity of Ultrasonic Pulses in Concrete, BSI, UK (1986). | 8. A. Nilsen and P. Aitcin, Static modulus of elasticity of high strength concrete from pulse velocity tests. Cem Concr Aggregates 14 1 (1992), pp. 64-66. |