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CASE STUDY ON A EXISTING STRUCTURE BY USING NDT TECHNIQUES

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Abstract - *Damage assessment of structures is one of the most important and emerging fields in Civil Engineering. Damage to structures may occur as a result of normal operations, accidents, deterioration or severe natural events such as earthquakes and storms. Most often the extent and location of damage may be determined through visual inspection. However, in some cases this may not be feasible. Non destructive testing is conducted on the main structural and relatively more affected column and beam members in various buildings. In the present work, a case study of the Reinforced Concrete (RC) buildings is carried out with special reference for the further usage of the structures. NDT are conducted to assess the real strength gained by the RC elements like columns, beams and slabs. Initially visual inspection is conducted on the building which is selected for case study. All the damages present in the building are identified in visual inspection. Non destructive tests are conducted at all the damaged areas. Rebound hammer test is conducted at many points on & near by the damages and the readings are noted. UPV test is also conducted at different places near damages in three different methods such as direct-direct, semi direct and indirect and the quality of the concrete in the building is determined. From the result analysis it is concluded that the structure requires immediate attention for strengthening the existing structures by adopting suitable rehabilitation techniques.*

Key Words: NDT; REBOUND HAMMER, ULTRA SONIC PULSE VELOCITY, CARBONATION DEPTH

1. INTRODUCTION

Concrete is a composite material produced from the combination of cement, fine aggregate, coarse aggregate and water in their relative proportion. It is a ubiquitous building material because its constituents are relatively cheap, and readily available. In addition to that, concrete in its fresh state has the ability to be moulded into any desired shape and size. The strength of concrete is its most important property (especially when needed for structural purposes) alongside its durability. Deterioration or damage of reinforced concrete may be caused due to several reasons and is nowadays commonly observed because of improper construction techniques. Deterioration of concrete has significant effect on the performance and serviceability of structures. Many factors can contribute to the deterioration of concrete structures such as; poor construction, overloading, aging, corrosion of steel, chemical reactions, natural disasters, etc. Unfortunately, damage propagation is a time dependent process with serious effect on structural capacity and durability. Deterioration signs can be visible such as concrete cracking or excessive deflections which can be detected with visual inspection. In these cases, the concrete member has probably reached significant level of damage. Early detection of damage minimizes the repair costs and preserves the service-life of the structure.

Non destructive testing (NDT) methods are used to inspect or measure the materials or structures without destroying their surface texture, product integrity and future usefulness. The field of NDT is a very broad, interdisciplinary field that plays a critical role in inspecting that structural component and systems perform their function in a reliable fashion. Certain standards has been also implemented to assure the reliability of the NDT tests and prevent certain errors due to either the fault in the equipment used, the miss-application of the methods or the skill and the knowledge of the inspectors. Successful NDT tests allow locating and characterizing material conditions and flaws that might otherwise cause planes to crash, reactors to fail, trains to derail, pipelines to burst, and variety of less visible, but equally troubling events. However, these techniques generally require considerable operator skill and interpreting test results accurately may be difficult because the results can be subjective. These methods can be performed on metals, plastics, ceramics, composites, cermets, and coatings in order to detect cracks, internal voids.

Compressive strength of the hardened concrete can be determined using the non-destructive testing (NDT) methods. The rebound (Schmitz) hammer and ultra sonic pulse velocity test are some of the most popular non destructive testing (NDT) methods used to test the strength and homogeneity of concrete. Concrete is susceptible to a variety of environmental degrading factors which tend to limit its service life. This therefore has brought about the need for (NDT) test methods to measure the in-place properties of concrete for quality assurance and for evaluation of existing conditions. Since such test are expected not to impair the function of the structure and allow for re-testing at the same location to evaluate the changes in property at some other point in time, these methods should be non destructive. Non destructive tests as applied to concrete are those tests that

do not alter the concrete quality. Non - Destructive Testing (NDT) as the name implies refers to a test that does not impair the intended performance of the element, member or structure under investigation.

NDT of concrete is of great scientific and practical importance especially the need for quality characterization of damaged constructions made of concrete. Its importance can also be seen in the desire for a proposed change of usage or extension of a structure, acceptability of a structure for purchase or insurance, assessment of the quality or integrity of the repairs, monitoring of strength development in relation to formwork stripping, curing, pre-stressing or load application. This research is to assess the condition of existing reinforced concrete structure by non destructive testing and recommend rehabilitation procedures.

2. EXPERIMENTAL STUDY

In the present study, existing structure is considered.

1. Methodology includes identifying the structural damage by Visual inspection.
2. Identifying various Non-Destructive Test Methods to be carried out on the structure/building.
3. Identification of the possible causes leading to the damage of the structure.

Assessing the amount of damage caused and to determine its suitability for future use

2.1 REBOUND HAMMER

OBJECT AND PRINCIPLE OF TEST

The rebound hammer method could be used for:

i) Assessing the likely compressive strength of concrete with the help of suitable correlations between rebound index and compressive strength

ii) Assessing the uniformity of concrete,

iii) Assessing the quality of the concrete in relation to standard requirements, and

iv) Assessing the quality of one element of concrete in relation to another.

NOTE- The rebound hammer method can be used with greater confidence for differentiating between the questionable and acceptable parts of a structure or for relative comparison between two different structures.

Principle

When the plunger of rebound hammer is pressed against the surface of the concrete, the spring controlled mass rebounds and the extent of such rebound depends upon the surface hardness of concrete. The surface hardness and therefore the rebound is taken to be related to the compressive strength of the concrete. The rebound is read off along a graduated scale and is designated as the rebound number or rebound index.

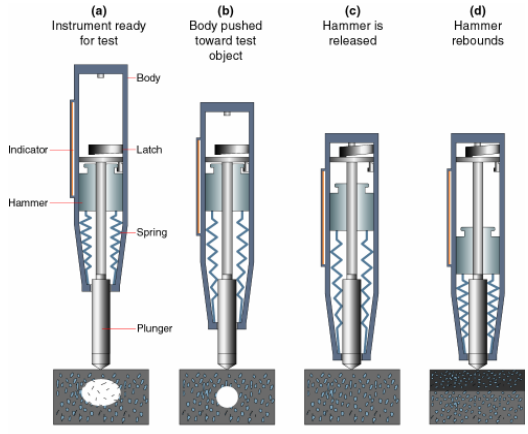

Fig 2.1 Rebound hammer

Table 2.1: Rebound Number v/s Quality of concrete surface

Average Rebound Number	Quality Of Concrete Surface
> 40	Very good hard layer
30 to 40	Good layer
20 to 30	Fair
< 20	Poor concrete
0	Delaminated

2.2 ULTRA SONIC PULSE VELOCITY:

UPV testing is a wave propagation test. It transmits electro acoustic pulses through the concrete medium from one side, receiving the signal from other side and measuring the transit time. The path length between the transmitting and receiving point is measured and the pulses velocity is calculated by dividing the path length by the transit time.

Pulse velocity is influenced by the properties of concrete which determines its elastic stiffness and mechanical strength. There is a reduction in the pulse velocity if the concrete under the test has low compaction, voids or damaged material. The pulse velocity increases or decreases as the concrete matures or deteriorates or changes with time. This method is considered to be a

valuable and reliable method of examining the interior of concrete in a non-destructive way. The pulse velocity measurements may be used to establish

- The homogeneity of the concrete
- The presence of cracks, voids and other imperfections
- Changes in the structure of the concrete which occur with time
- Quality of one element of concrete in relation to another
- The values of elastic modulii of concrete
-

Fig2.2 U.P.V apparatus

Table 2.2: UPV velocity v/s concrete quality

Velocity(km/sec)	Concrete Quality
>4.0	Very good to excellent
3.5-4.0	Good to very good, slight porosity may exist
3.0-3.5	Satisfactory but loss of integrity is suspected
<3.0	Poor and loss of integrity exists

2.3 CARBONATION TEST:

FUNDAMENTAL PRINCIPLE

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- as depassivation. Co_2penetrates below the exposed surface of concrete medium, if the entire concrete cover over the reinforcing steel is carbonated, corrosion of the steel would occur.

GENERAL PROCEDURE

1% phenolphthalein solution is made by dissolving 1gm of phenolphthalein in 90 cc of ethanol. The solution is then made up to 100 cc by adding distilled water. On freshly extracted cores, the surface is sprayed with phenolphthalein solution, the depth of the uncoloured layer (the carbonated layer) from the external surface is measured at 4 - 8 points, and the average is 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 is measured at 4 - 8points and the average is taken. If the concrete still retains its alkaline characteristic, colour of the concrete will change to purple..

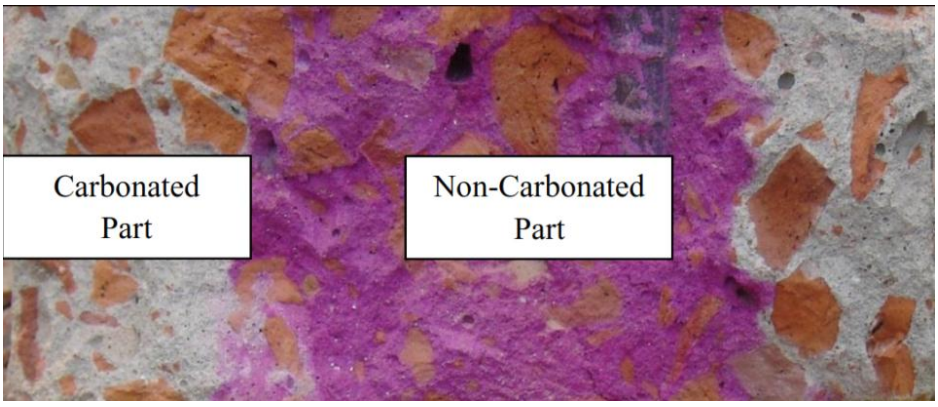

Fig 2.3: Carbonation Effect on Concrete

3. Results and Discussion

Table 3.1 proposed test methods

Proposed testing methods to determine damage identification							
			Information gained				
Test location	Test type	Test method	colour change	lateral extent of damage	Depth of damage	Compressive strength	Corrosion percentage of reinforcement
On site	Non-Destructive	visual Inspection	√	√	√		
		Rebound Hammer				√	
		Ultra sonic pulse velocity				√	
		Half cell potential method			√		√
		carbonation depth measurment			√		

Fig .3.1 damages on a existing structure

3.1 Visual inspection*:*
From the external appearance of structure pealing, cracking status, corrosion and the like can be surveyed. The corresponds to the daily and periodic inspections performed for ordinary structure. It also conducted as needed before performing a detailed inspection. Preliminary qualitative data is obtained through this type of survey.It would be most effective if this data could be reflected in performance evaluations of the structure as shown below table

Table 3.2 Visual inspection / each floor

Class of damage	Element	surface appearance of concrete			Structural condition			
		Condition of finishing	Colour	Crazing	spallation	Exposure and condition of main reinforcement	Cracks	Deflection/Distortion
0	Column	slightly some places	No	Normal	None	No exposure	Normal	No

	Slab	Good	No	Minor	None	correction happened	None	No
	Beam	slightly some places	No	Major cacks appers at joints	Located in bathrooms	Upto 15% of reinforcement exposed and correted in toilets	Severe	No
1	Column	Good	No	Minor	None	No exposure	Slightly	No
	Slab	Good	No	None	None	Upto 10% of reinforcement exposed and correted in toilets	None	No
	Beam	Good	No	Minor	None	correction happened	Minor	No
2	Column	Good	No	Majority of crack appers at C-Block ECE Dept.	None	No exposure	Slightly	No
	Slab	Good	No	Minor	None	Upto 15% of reinforcement exposed and correted in bathrooms	None	No
	Beam	Good	No	Silghtly	None	correction happened	Minor	No
3	Column	Substantial loss to circular columns in varandas	No	Major	None	correction happened to circular columns	Normal	
	Slab	Good	No	Minor	None	Upto 10% of reinforcement exposed and correted in toilets and steps	Minor	No
	Beam	slightly some places	Some places	Minor	None	At joints	Minor	No
4	Column	Substantial loss to circular columns in varandas	Some places	Major cracks appears in MBA Dept.	none	No exposure	Normal	no
	Slab	some plces in C-Block	Some places	Major	C-Blocks	Upto 14% of reinforcement exposed and correted in toilets and steps	Major	no

	Beam	Substantial loss to circular columns in varandas	Some places	Major	None	No exposure	Major	no

3.2 REBOUND HAMMER

Rebound Hammer test is conducted on the column faces using an N type Schmidt hammer test for concrete. The test covered critical column, Slab and beam locations in the building. The test is conducted as per the procedure mentioned in IS 13311: Part II. For each column, six readings are taken ensuring a minimum distance of 20mm between two successive points. Finally, average of these readings is taken as the representative rebound number for the concrete. The following tabular column is respective rebound numbers at the damage spots with respective to notations choosen

Notations

A BLOCK C 1,2..n -COLUMN

B BLOCK B 1,2..n-BEAM

C BLOCK

Table 3.3 Rebound test results

	Rebound number		
s.no	Structure	Near the damage	Quality
1	A C1	15	Poor concrete
2	AC2	12	Poor concrete
3	B C1	5	Poor concrete
4	B C2	28	Fair concrete
5	B C3	31	Good layer
6	C SLAB	16	Poor concrete
7	B B1	15	Poor concrete
8	B C4	21	Fair concrete
9	C B1	14	Poor concrete
10	CB2	19	Poor concrete
11	C B3	18	Poor concrete
12	C B4	22	Fair concrete
13	TEERACE 1	16	Poor concrete
14	TEERACE C1	27	Fair concrete
15	TERRACE C2	20	Fair concrete

Fig 3.2 Conducting rebound hammer test

From Table it shows less than that of rebound number 20 quality of concrete for column beams and slab gives very poor and loss of integrity exists

3.3 ULTRASONIC PULSE VELOCITY*:*

Ultrasonic Pulse Velocity test is conducted on critical column and beam locations in the building. The test is conducted as per the procedure mentioned in IS 133111: Part I. Before measuring the pulse velocity using the transducers, a thin layer of grease is applied to testing members so as to act as acoustic coupling between the transducers and the concrete surface.

Table 3.4 UPV test results

s.no	Structure	Near the damage m/s	Quality
1	A C1	3506	Good
2	AC2	3412	Medium
3	B C1	3096	Medium
4	B C2	3727	Medium
5	B C3	3309	Medium
6	C SLAB	-	Doubtfull
7	B B1	-	Doubtfull
8	B C4	3672	Good
9	C B1	3121	Medium
10	CB2	3362	Medium
11	C B3	3347	Medium
12	C B4	3527	Good
13	TEERACE 1	3477	Medium
14	TEERACE C1	-	Good
15	TERRACE C2	-	Medium

Fig 3.3 Conducting UPV test

3.4 CARBONATION DEPTH

The phenapthalene indicator test and pH test is also conducted at the places where reinforcement is exposed. The CO_2 penetration level can be identified by doing phenapthelene test as shown table below. Actually pH of concrete is equal to 13 but carbonated concrete pH value after testing is equal to between 7 to 8.

Table 3.5 CO2 Penetration

S.NO	structure	Size	Near the damage
1	C B1	230mm	55mm
2	C B2	200mm	28mm
3	C B3	230mm	21mm
4	C B4	230mm	10mm
5	Terrace C2	300mm	47mm

Fig 3.4 Applied phenapthelene indicator on a exposed reinforcement

The results suggest that some structures has been subjected to carbonation

Based on the results and discussion we can identify and rectify the damages by using this following table

Table 3.6 Rehabilitation techniques

Class of Damage	Repair Classification	Repair Requirements
0	Decoration	Redecoration if required
1	Superficial	Superficial repair of slight damage not needing fabric reinforcement
2	General repair	Non-structural or minor structural repair restoring cover to reinforcement where this has been partly lost.
3	Principal repair	Strengthening repair reinforced in accordance with the load-carrying requirement of the member. Concrete and reinforcement strength may be significantly reduced requiring check by design procedure.
4	Major repair	Major strengthening repair with original concrete and reinforcement written down to zero strength, or demolition and recasting.

4.CONCLUSIONS:

In the present case study from results we can conclude that

1. The damages are identified through visual inspection. NDT tests were conducted to assess the cause of crack.
2. During this investigation, quality of concrete has been determined using rebound hammer and UPV tests.
3. Carbonation depth has been identified using phenapthalene indicator .It is observed that the areas which are not affected by carbonation are in pink colour and the affected areas are colourless
4. Class of damage has been determined and recommendations for the repair work have been identified.

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BIOGRAPHIES

Ms. K.Rohini is pursuing postgraduate studies at AITS, Tirupati. He is keen in conducting research in the area of concrete technology and use of green materials in the construction."

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