International Journal of Emerging Trends in Engineering and Basic Sciences (IJEEBS)
ISSN (Online) 2349-6967
Volume 7, Special Issue 4 (July-August 2020), PP. 038-045

Non-Destructive Testing of Concrete Structure

Shubham Desai, Niteenkumar Madapatte, Rahul Sahu, Rajan Papalkar, Srushti Hedau, Rutuja Gawande

Department of Civil Engineering, G. H. Raisoni Academy of Engineering and Technology, Nagpur, Maharashtra, India

Abstract: Concrete is considered as durable material but it is still, potentially vulnerable to deterioration unless certain precautions are taken. Strength and durability of concrete structures depend on a number of factors such as design, detailing, materials and workmanship, quality control, environment as well as periodic inspection and regular maintenance. This paper discusses the assessment of existing concrete structures by explaining the different non-destructive methods such as rebound hammer test and Ultrasonic pulse velocity tests etc. The main aim of the paper is to highlight the different NDT (Non-Destructive Testing) methods employed to assess the quality of concrete structures. The testing conducted on the two sites. The results of non-destructive tests conducted on different concrete structures are also included. Further, through the NDT tests and observations, recommendations to identify and improve the strength and performance of the structure are made. It is important to note that almost all the NDT methods indirectly estimate the concrete strength and strength obtained by these methods, in most of the cases, is comparable. Even then, no single method can be said to be fully reliable and therefore, more than one method should be performed and results should be correlated.

Keywords: Non-destructive testing, Rebound hammer test, Ultrasonic pulse velocity test and carbonation test.

1. INTRODUCTION

1.1 Non-Destructive Test (NDT)

NDT is a technique used in science and technology industry to evaluate the properties of material, component or system without causing damage. NDT is branch of engineering which helps in testing and inspection of materials and infrastructures to evaluate the condition of it, find the any flaws and defects and homogeneity of infrastructure and useful life of structure all nearby us.

Methods of NDT:-

1) Rebound hammer test.

2) Ultrasonic pulse velocity test.

3) Carbonation Test.

2. REBOUND HAMMER TEST

IS-13311 Part 2 (1998, reaffirmed 2008). The 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 surface against which the mass impinges. Rebound Hammer test gives us a tentative idea about the surface strength of concrete. Is suggest a variation of 25% (between the strength of specimen tested by RBH and by convention method) as the results of RBH are affected by factors like surface and internal moisture, carbonation of concrete, age of concrete, type of aggregates etc. More moisture gives less rebound number more carbonation implies more rebound number etc.

2.1 Rebound hammer Test procedure

The hammer is pushed hard against concrete surface, the body of the hammer is allowed to move away from concrete unit the latch connects the hammer mass to the plunger. The plunger is then held at right angles to the concrete surface and the body is pushed hard against the concrete. During the rebound, the slide indicator travels with the mass and stops at maximum distance the mass reaches after rebonding. With the help of button provided on the mass the reading is locked (also the plunger and mass get locked). This reading is the rebound number. Testing can be done by holding the hammer at vertically upward or downwards or at horizontal positions. The estimated compressive strength is obtained by reading the graph - rebound no. Versus Compressive strength. Graphs are given for different positions in which hammer is held i.e. upwards, downwards, and horizontal.

3. ULTRASONIC PULSE VELOCITY TEST

A pulse of longitudinal Vibration is produced by an electro-acoustic transducer, which is held in contact with one surface of concrete under test. When pulse generated is transmitted into concrete from transducer, it undergoes multiple reflection at boundaries of different material phases within concrete. A complex system of stress waves develop, which include both longitudinal and shear waves and propagate through concrete. The first wave to reach the receiving transducer is longitudinal wave, which is converted into electrical signal. The time required by the waves to pass through denser material is less and that through material which has less density would be relatively none. This time required to pass through dense or well compacted concrete would be less as compared to the concrete specimen having high degree of porosity. IS-13311 Part I, 1998 (re-affirmed 2008) mentions the following Concrete Quality Gradation and also mentions that in case of indirect probing the velocity is less as compared to the velocity that in case of direct probing and the difference is 1Km/sec.

3.1 **UPV Test Procedure**:

It is possible to arrange the transducers in 3 possible combinations.

a. Opposite faces (direct probing)

b. Adjacent faces (semi-direct probing).

c. Same faces (indirect probing).

Before starting the test one has to first determine. Before starting the test one has to first determine the

method of probing and then proceed for marking the position on the surface of structure to be tested. These points are to be smoothened using carborundum stone or grinding wheel etc. Grease or liquid soap is applied to the points to ensure perfect contact of the transducers to the concrete surface. Grease is applied to transducers and their faces are connected to each other and reading zero is set.

Transducers are held at the previously marked positions and reading of time required to travel the pre-determined length is noted.

Velocity (km/sec) = Distance in mm / Time in micro sec

This test was conducted as per IS-13311 part I. 1998 (re-affirmed 2008).

As per recommendation of the IS Code, the quality gradation of concrete follows.

For indirect method, the code mentions (Art. 5. 1) The Indirect velocity is invariably lower than direct Velocity on the same concrete element. The difference may vary depending on the quality of concrete under test. For good quality concrete, a difference of about 1.0km/sec. may generally be encountered

Table 1. Ranges of UPV

Velocity km/sec	Concrete quality gradation
Below 3.0	Doubtful (D)
3.0 – 3.50	Medium (M)
3.50 – 4.50	Good (G)
Above 4.50	Excellent (E)

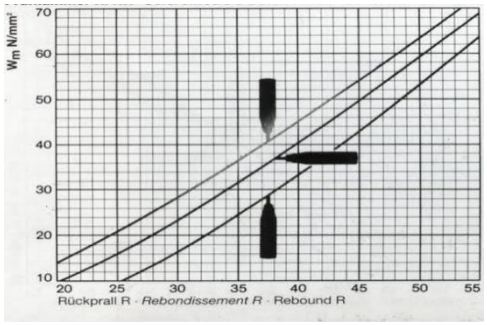

Fig. 1 Rebound hammer graph

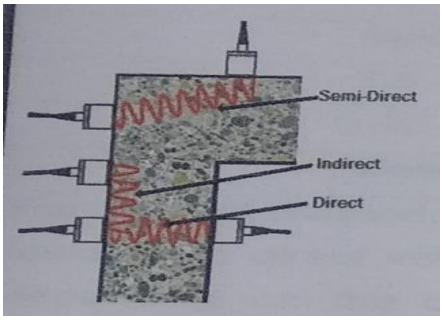

Fig. 2 Ultrasonic pulse Velocity

4. CARBONATION TEST

The method of testing consists of determining the depth of the carbonated layer on the surface of hardened concrete by means of an indicator. Carbonation of cement happens when the carbon dioxide, in the climate within the sight of dampness, responds with hydrated concrete minerals to create carbonates, for example calcium carbonate. Carbonation infiltrates underneath the uncovered surface of cement incredibly gradually. The centrality of carbonation is that the typical assurance of the fortifying steel commonly present in the solid because of the basic conditions brought about by the hydrated concrete glue is killed via carbonation. In this way, if the whole solid covering the strengthening steel is carbonated, consumption of the steel would happen if dampness and oxygen could arrive at the steel.

4.1 Carbonation test procedure:

First of all, remove material of concrete with the help of chisel and hammer apply the phenolphthalin solution on that surface wait for the indication of colour changes i.e. voilet or pink or colorless if the colour is violet or pink then carbonation of concrete is not happened if the colur is colourless is then carbonation is happen measure the depth of carbonation and repeat the above procedure up to the indication of solution is pink violet.

5. RESULTS

5.1 Rebound Hammer Test

Table 2. Readings of Rebound Hammer

Angle-Horizontal	Rebound Nos.						Average	Estimated Compressive Strength (N/mm^2)
Column 1	32	30	33	30	32	30	31.16	27
	38	40	33	40	38	44	38.83	41
Column 2	34	36	38	38	36	36	36.33	36
	38	38	40	36	38	40	38.33	40
Column 3	41	40	42	38	44	42	41.16	45
	42	41	39	40	42	42	41	45

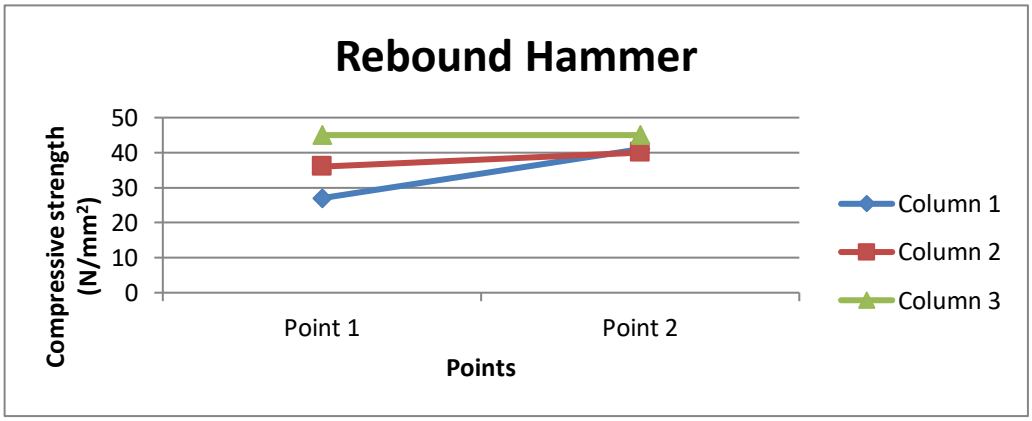

Fig. 3 Rebound Hammer Results

5.2 Ultrasonic Pulse Velocity Test

Table 3. Readings of UPV

Direct Method				
Points / Path	**Path Length (mm)**	**Time (ms)**	**Velocity (Km/s)**	**Concrete Quality Gradation**
Column 1				
1	630	257	2.45	D
2	630	239	2.64	D
3	630	220	2.86	D
4	630	218	2.89	D
5	630	224	2.81	D
Column 2				
1	400	180	2.22	D
2	400	142	2.82	D
3	400	186	2.15	D
4	400	112	3.57	G
5	400	144	2.78	D
6	400	132	3.03	M
Column 3				
1	230	88	2.61	D
2	230	84	2.74	D
3	230	76	3.03	M
4	230	78	2.95	D
5	230	90	2.56	D

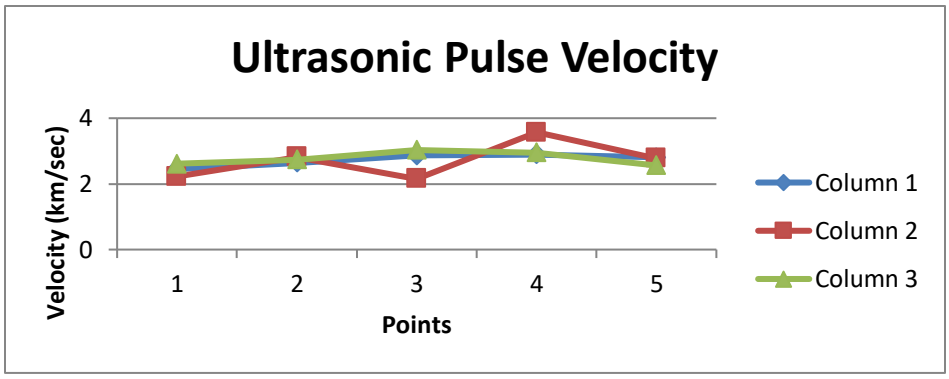

Fig. no.4 Ultrasonic pulse velocity Results

6. OBSERVATIONS AND SUGGESTIONS

Crack along a corner of a column was noticed so that carbon fibre warping to all the three columns from floor level to the top is suggested.

7. CONCLUSION

- From the results we get different conclusion for both of the sites. Firstly for site one through the rebound hammer test the quality of concrete was found to be doubtful. And by the UPV test the homogeneity was found to be doubtful so the remedial measure to be taken were that the carbon fiber wrapping was done on the column. And also the concrete was not affected by the atmosphere.

- At the second site from the results of rebound hammer test the concrete was found to be in normal condition. And from the UPV test the homogeneity was good so the structure can be used further was granted.

- if any changes in the structure are to be done then it should be done under engineer by studying all aspects.

8. ACKNOWLEDGEMENTS

We are sincerely thankful to Prof. Gitadevi Bhaskar to guide us and this research work was jointly supported by the Structural Diagnostics of the National Accredition Board for Testing and Calibration Laborataries (Grant no. TC-8355) under ISO/IEC 1705:2005. Also thankful to the

Dr.Tushar Shende HOD of Civil department and Dr. Vivek Kapoor principal of GHRAET.

REFERENCE

1. Tarun Gehlot, Dr. S. S. Sankhla and Akash Gupta, Study Of Concrete Quality Assessment Of Structural Elements Using Rebound Hammer Test, American Journal of Engineering Research (AJER) e-ISSN: 2320-0847 p-ISSN : 2320-0936 Volume-5, Issue-8, pp-192-198.

2. Huai-Shuai Shang, Ting Hua Yi and Lu-Sheng Yang, Experimental Study of Compressive Strength Of Big Mobility Concrete With NDT, Hindawi Publishing CorporationAdvances in Materials Science and Engineering, Volume 2012.

3. Emilia Vasanelli, Angela Calia, Vincenza Luprano, Francesco Micelli and Angelo Tati, Use Of Ultrasonic Pulse Velocity Test For The Diagnosis Of Historic Masonries,International Symposium Non-Destructive Testing in Civil Engineering (NDT-CE) September 15 - 17, 2015.

4. Lubos Pazdera, Libor Topolar, Jaroslav Smutny and Kristyna Timcakova, Non-Dstructive Testing Of Advance Concrete Structure During Life Time, Hindawi Publishing Corporation Advances in Materials Science and Engineering Volume 2015, Article ID 286469

5. Md. Roknuzzaman, Md. Bilal Hossain, Md. Lbrahim Mostazid and Md. Rashedul Haque, Application Of Rebound Hammer Methods For Estimating Compressive Strength Of Bricks, Journal of Civil Engineering Research 2017, 7(3): 99-104

6. IS code -13311 (part 1) -1992 NDT of concrete – methods of test with ultra sonic pules velocity.

7. Is code -13311 (part 2) -1992 NDT of concrete – methods of test with rebound hammer test