COMPARATIVE STUDY OF EFFECT OF CURING ON COMPRESSIVE STRENGTH OF CONCRETE BY USING NDT & DT

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Abstract- *This paper represents the work of comparison & graphical correlation between compressive strength of concrete by Non Destructive & Destructive testing.(This paper & its work limited to Rebound Hammer NDT test only). Concrete cubes of 150mm x 150mm x 150mm were prepared using concrete mix of grade 25N/mm^2 and cured for 7, 14 and 28days. A total of 27 cubes were made and used for the study. The graphical study done & develop the relation between compressive strength and rebound number. The Compressive strength and rebound number were taken as the dependent and independent variables. The results showed that the average error in measuring compressive strength for 7 days, 14 days, 28 days cubes by Rebound Hammer & by CTM is near about 2.01%, 1.37% & 0.99% respectively. As curing period is increases the percentage strength decrease in compressive strength is less by DT & NDT methods. For 28 days curing percentage decrease in strength is less as compare to 7 days percentage decrease in strength*

Keywords- *Non destructive Evaluation (NDE), Rebound Hammer*

I. INTRODUCTION

It is often necessary to test concrete structures after the concrete has hardened to determine whether the structure is suitable for its designed use. 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 delamination.

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. Non-destructive testing can be used in those situations as a preliminary to subsequent coring.

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

- To investigate the homogeneity of concrete mixing
- 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.

Structural audit

Structural Audit is done by appointing an experienced and expert Consulting Structural Engineer registered with the Municipal Corporations or Chartered

Engineers. The owner shall give his brief of use or operation in the building and old data, drawings, details of modifications/additions etc. to the structural consultant. The consultant carries out detailed internal and external inspection. This is done by visual inspection using a hammer sounding (a small hammer to find out hollow plaster and hollow concrete and not Schmidt Hammer used for NDT.) In fact this is nothing but Inspection Report on the condition of building.

Non-Destructive Testing/Destructive testing check-up in addition to the visual inspection is required in exceptional cases where deterioration is severe.

II. MATERIAL AND METHODS

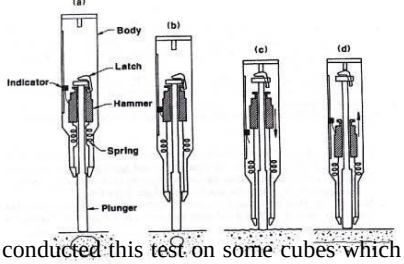
NDT is divided into various methods of non-destructive testing, each based on a particular scientific principle. Major testing is done by this type of test methods.

1) Rebound hammer test
2) Pulse velocity test
3) Core cutter test

1) Schmidt rebound hammer test:

The method of using the hammer is explained. With the hammer pushed hard against the concrete, the body is allowed to move away from the concrete until the latch connects the hammer mass to the plunger.

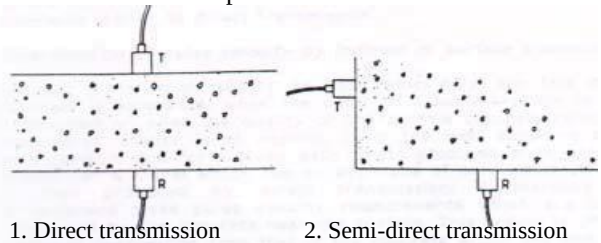
The plunger is then held perpendicular to the concrete surface and the body pushed towards the concrete. This movement extends the spring holding the mass to the body. When the maximum extension of the spring is reached, the latch releases and the mass is pulled towards the surface by the spring.The mass hits the shoulder of the plunger rod and rebounds because the rod is pushed hard against the concrete. During rebound the slide indicator travels with the hammer mass and stops at the maximum distance the mass reaches after rebounding. A button on the side of the body is pushed to lock the plunger into the retracted position and the rebound number is read from a scale on the body.



We have conducted this test on some cubes which later we compared this strength to the strength given in the IS 13311 (Part 2):1992

2) 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.



1. Direct transmission 2. Semi-direct transmission

Sr. No.	Pulse velocity by cross probing(km/sec)	Concrete quality grading
1.	Above 4.5	Excellent
2.	3.5 To 4.5	Good
3.	3.0 To 3.5	Medium
4.	Below 3.0	Doubtful

3) Core cutter test:

The examination and compression testing of cores, extracted from hardened concrete is a well-established method, which enables visual inspection of the interior region of a structural member. This can be coupled with strength estimation and physical properties such as density, water absorption etc. The cores can be used as samples for chemical analysis subsequent to strength testing. (IS: 1199-Methods of sampling and analysis of concrete) gives information regarding securing and preparing test specimens from hardened concrete. To prepare guidelines for using the instrument for taking out core of different sizes from the hardened concrete structures for conducting different physical, chemical analysis and to estimate the compressive strength of concrete. A core is usually cut by means of a rotary cutting tool with diamond bit. Water supply is also necessary to lubricate the cutter.

Research Significance:

The results showed that the average error in measuring compressive strength for 7 days, 14 days, 28 days cubes by Rebound Hammer & by CTM is near about 2.01%, 1.37% & 0.99% respectively

III. Experimental Investigation:

The study was limited up to Rebound Hammer testing for NDT, 27cube of M25 grade were produced as following quantity

Cement =360 kg/m^3

Water = 176 kg/m^3

Fine aggregate= = 761 kg/m^3

Coarse aggregate 10mm = 390 kg/m^3

Coarse aggregate 20mm =781 kg/m^3,

Chemical admixture = 3.6 kg/m^3

Water-cement ratio= 0.49.

The 27 cubes were cast and allow to cure for 7, 14, 28 days. The Rebound hammer test & Compressive strength test on CTM having capacity 40 ton were perform on 9 cubes of 7 day curing and it was repeated for 14 day & 28 days curing also.

IV. Result & Discussion:

Table 1: Compressive Strength by NDT & DT for 7 days of Curing

Cube Number	NDT by Rebound Hammer		Destructive Testing
	Average Reading	Indicative strength (MPa)	Compressive Strength (Mpa)
Cube-1	21.56	12.5	11
Cube-2	21.28	17.5	15.4
Cube-3	20.72	16.8	14.5
Cube-4	19.25	15.4	13.4
Cube-5	22.68	18.2	16
Cube-6	21.28	17.5	15.5
Cube-7	20.93	16.8	14.9
Cube-8	19.53	15.4	13.5
Cube-9	22.47	18.2	16

Table 2: Compressive Strength by NDT & DT for 14 days of Curing

Cube Number	NDT by Rebound Hammer		Destructive Testing
	Average Reading	Indicative strength (MPa)	Compressive Strength (Mpa)
Cube-1	26.18	18.75	17
Cube-2	25.84	21.25	20.5
Cube-3	25.16	20.4	19.2
Cube-4	23.375	18.7	17.2
Cube-5	27.54	22.1	21.5
Cube-6	25.84	21.25	19.3
Cube-7	25.415	20.4	19.1
Cube-8	23.715	18.7	17.2
Cube-9	26.83	22.1	20.3

Table 3: Compressive Strength by NDT & DT for 28 days of Curing

Cube Number	NDT by Rebound Hammer		Destructive Testing
	Average Reading	Indicative strength (MPa)	Compressive Strength (Mpa)
Cube-1	30.8	25	24
Cube-2	30.4	25	23.4
Cube-3	29.6	24	22.8
Cube-4	27.5	22	21.5
Cube-5	32.4	26	23.9
Cube-6	30.4	25	24.5
Cube-7	29.9	24	23
Cube-8	27.9	22	21.3
Cube-9	32.1	26	25.7

Table 4: Percentage Decrease in Compressive Strength of cube

Cube Number	**Percentage Decrease in Compressive Strength**		
	7 days	**14 days**	**28 days**
Cube-1	12.00	9.33	4.00
Cube-2	12.00	3.53	6.40
Cube-3	13.69	5.88	5.00
Cube-4	12.99	8.02	2.27
Cube-5	12.09	2.71	8.08
Cube-6	11.43	9.18	2.00
Cube-7	11.31	6.37	4.17
Cube-8	12.34	8.02	3.18
Cube-9	12.09	8.14	1.15

The above table 1, 2 & 3 shows the Compressive strength of concrete cubes by using Non Destructive

Testing (By Rebound Hammer) & Destructive Testing (By CTM).
Table 4 shows percentage strength decrease in compressive strength of cube tested by DT & NDT.

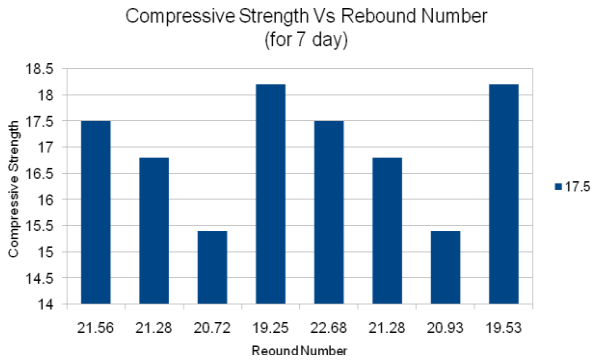


Figure 1: Compressive Strength Vs Rebound Number (7 days)

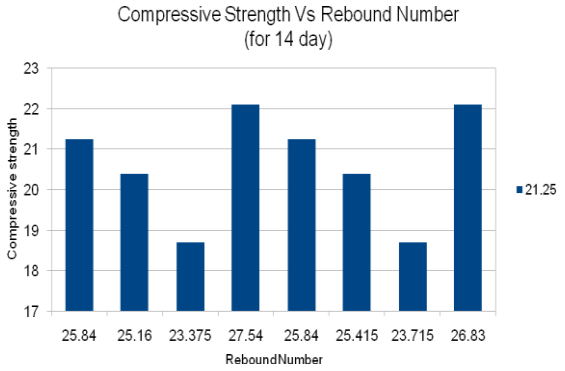


Figure 2: Compressive Strength Vs Rebound Number (14 days)

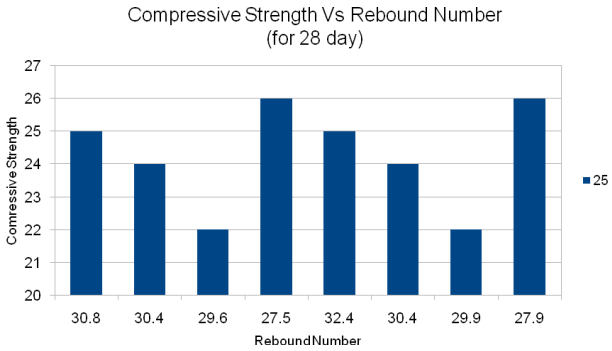


Figure 3: Compressive Strength Vs Rebound Number (28 days)

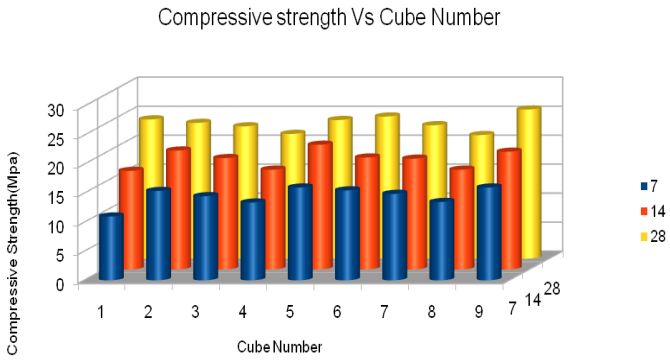


Figure 4: Compressive Strength Vs Cube Number

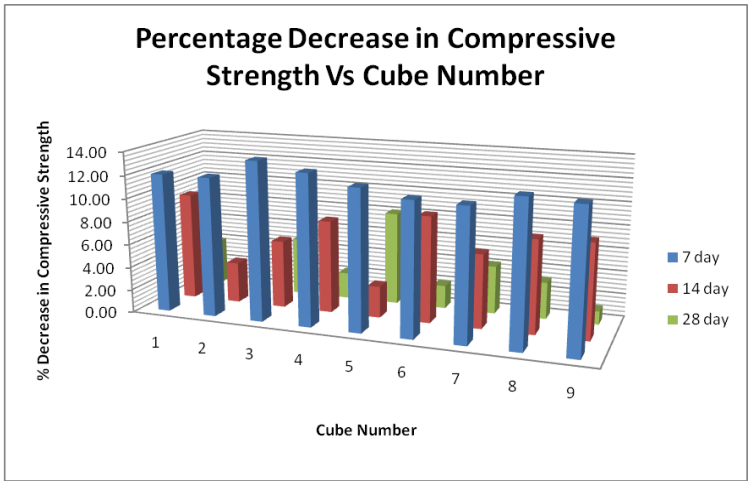


Figure 5: % decrease in compressive strength by NDT & DT Method

Figure 1, 2 & 3 shows Compressive strength Vs Rebound number for 7, 14 & 28 days curing respectively. Figure 5 shows percentage strength decrease in compressive strength of cube by DT & NDT methods, from that graph it is concluded that as curing period is increases the percentage strength decrease in compressive strength is less by DT & NDT methods. For 28 days curing percentage decrease in strength is less as compare to 7 days percentage decrease in strength.

V. CONCLUSION

From experimental & graphical study following conclusions were made

[1] As rebound number increases the compressive strength of concrete also increase & vice versa.

[2]As curing period is increases the percentage strength decrease in compressive strength is less by DT & NDT methods. For 28 days curing percentage decrease in strength is less as compare to 7 days percentage decrease in strength

[3] The average error in measuring compressive strength for 7 days, 14 days, 28 days cubes by Rebound Hammer & by CTM is near about 2.01%, 1.37% & 0.99% respectively.

[4]From above results compressive strength or rebound number can be produced when only one value of above is known.

VI. ACKNOWLEDGMENT

The Authors would like to thanks Prof K L Bidkar HOD of Civil department SIEM, Nasik, Prof K T Phalak Associate professor in Civil Department for their guidance & support for the work.

REFERENCES

[1] IS: 13311 (Part 2) : 1992 Non-destructive Testing of Concrete –Methods of Test, Part 2 Rebound Hammer, BIS, New Delhi.

[2] IS: 13311 (Part 1): 1992 Non-destructive Testing of Concrete – Methods of Test, Part 1 Ultrasonic Pulse Velocity, BIS, New Delhi.

[3] National Seminars on “Potential of NDT for Quality Assurance and Diagnosis” 24th February 2004 at Hotel Le Meridien, Andheri (E), Mumbai and ‘Diagnosis & Evaluation of Concrete Structures using Non-Destructive Techniques’ 25th & 26th February, 2004, P.I.E.T. Campus, Pune organized by India Chapter of ACI.

[4] V.M. Malhotra, Testing Hardened Concrete: Non-destructive Methods, Published jointly by The Lowa State University Press, Lowa and ACI, Michigan, 1976.

[5] "Workshop on Non-Destructive Testing of Concrete Structures" : 22nd Sep. 2000 : Organized by The Institution of Engineers (India), Pune Local Centre

[6] Dr. A.K. Gupta and Dr. Ravi Kumar Sharma, “Short term course on Non-destructive Assessment of Structure (MOMDAS)”. Department of Structural Engineering, M.B.M. Engineering College, Jodhpur

[7] E.A. Whitehurst, Evaluation of Concrete Properties from Sonic Tests, Published jointly by The Lowa State University Press, Lowa and ACI, Michigan, 1967.

[8] Ferhat Aydin* and Mehmet Saribiyik “Correlation between Schmidt Hammer and destructive compressions testing for concretes in existing buildings” Scientific Research and Essays Vol. 5(13), pp. 1644-1648, 4 July, 2010