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A Comparative Analysis of Rebound Hammer And Ultrasonic Pulse Velocity Test In Testing Concrete

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Abstract- The strength of concrete determined in-situ never be same to cube strength determined in the laboratory. It is not possible to take core from the structure as it may damage the structure. Therefore, Non Destructive tests are mostly preferred than destructive testing for monitoring reinforced concrete structures. The manufacturers of test equipments provides a calibration chart to predict some desired property of concrete. These charts do not appear to be satisfactory because their development is based on their own test conditions. Therefore for prediction of strength, the statistical methods are generally adopted in the form of regression analysis. By the regression analysis, the correlation curve between the NDT results and compressive strength is plotted and used for predicting compressive strength. In the laboratory non-destructive rebound hammer test and ultrasonic pulse velocity test were carried out on concrete cube samples of unknown mix and of different age prior to destructive compression test. The investigation reported here is to present study of calibration graphs for non-destructive testing equipments. A correlation between rebound number and strength of concrete is established which can be used as well for strength estimation of concrete structures.
Index Terms- Non-destructive testing, Rebound hammer, Rebound number, Ultrasonic pulse velocity, Compressive strength, Impact energy.

1. INTRODUCTION

In India, from 1980 onwards the infrastructure industry witnessed stepping up of public investment and growth in infrastructure industry which results in construction of new multi-storey concrete apartments which are now in the age of thirty plus years. Estimating the quality and compressive strength of concrete is important for both new constructions and existing structures. For estimating the strength and quality of concrete, various tests are conducted on site and in laboratory. Cubes and cylinders of concrete are made in laboratory and tested but these strength is not represented in in-situ concrete. Getting core specimens from structural elements can affect the load carrying capacity of the element. Hence, non-destructive tests are used for predicting the in-situ strength of concrete. Among these tests, rebound hammer test and ultrasonic pulse velocity test are most commonly used worldwide. Rebound hammer test is preferred because of its low cost and simplicity.

2. LITERATURE REVIEW

Mahdi Shariati, Nor Hafizah Ramli-Sulong, Mohammad Mehdi Arabnejad K. H., Payam Shafigh and Hamid Sinaei

The experimental studies using Ultrasonic Pulse Velocity and Schmidt Rebound Hammer as Non-Destructive Tests (NDT) were presented in this paper to establish a correlation between the compressive strengths of compression tests and NDT values. These two tests have been used to determine the concrete quality by applying regression analysis models between compressive strength of in-situ concrete on existing building and tests values. The main members of an existing structure including column, beam and slab were included in the study. The relationship between compression strength of concrete collected from crashing test records and estimated results from NDT's records using regression analysis was compared together to evaluate their prediction for concrete strength. The test results show that the rebound number method was more efficient in predicting the strength of concrete under certain conditions. A combined method for the above two tests, reveals an improvement in the concrete strength estimation and the latter shows better improvement. Applying combined methods produces more reliable results that are closer to the true values. The resulting strength calibration curves estimation was compared with other results from previous published literatures.

J.C. Agunwamba, T.Adagba

This work presents a study on the comparison between some non-destructive testing techniques (Rebound Hammer and Ultrasonic Pulse Velocity). Tests were performed to compare the accuracy between the rebound hammer and the ultrasonic pulse velocity method in estimating the strength of concrete. Eighty samples (cubes of 150 _ 150 _ 150) were prepared using two mix designs of 1:2:4 and 1:3:6 with a constant w=c ratio of 0.45 and were tested at 7, 14, 21 and 28 days. The slump test was between 62-78mm. The results obtained from the non-destructive testing methods were correlated with the compressive strength results which showed that a higher correlation existed between the Rebound Hammer and the compressive strength than the Ultrasonic Pulse Velocity. The rebound hammer readings had a correlation coefficient of 0.794 while the ultrasonic pulse velocity had a correlation coefficient of 0.790 for the 1:2:4 mix and the rebound hammer readings for 1:3:6 was 0.783 and that for the ultrasonic pulse velocity was 0.777. Statistical analysis of the results obtained showed that there was no significant difference between the means of the two methods for both mix at a 0.05 level of significance.

Ferhat Aydin and Mehmet Saribiyik

In this study, a relationship is determined and correlated between non-destructive testing (NDT) named as Schmidt rebound hammer test and concrete destructive compression test. The Schmidt rebound hammer is principally a surface hardness tester with an apparent theoretical relationship between the strength of concrete and the rebound number of the hammer. In order to calibrate the Schmidt Hammer with the various-aged concretes, cube specimens of 28 - 90 days and a number of core samples from different reinforced concrete structures have been tested. This calibration has been done to get the related constant obtained from Schmidt and compression tests. The best fit correction factors for the concrete compressive strength-Schmidt rebound hammer relationship are obtained through processing correlation among the data sets. The correction factors can be easily applied to in situ concrete strength as well as existing concrete structures.

Tarun Gehlot, Dr. S.S. Sankhla, Akash Gupta

Structures are assemblies of load carrying members 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. The concept of non-destructive testing (NDT) is to obtain material properties of in place specimens without the destruction of neither the specimen nor the structure from which it is taken. However, one problem that has been prevalent within the concrete industry for years is that the true properties of an in-place specimen have never been tested without leaving a certain degree of damage on the structure. . The investigation reported here is to present study of Calibration Graphs for Non Destructive Testing Equipment, the Rebound Hammer and to study the quality of the concrete in existing structures. These Rebound Hammer Test were then used to test the quality of the concrete of the various structural elements (columns & beams) of single storied newly under constructed building of TPO office of MBM Engineering College Jodhpur. The use of this method produces results that lie close to the true values when compared with other methods A correlation between rebound number and strength of concrete structure is established, which can be used as well for strength estimation of concrete structures. The method can be extended to test existing structures by taking direct measurements on concrete elements.

3. EXPERIMENTAL ANALYSIS

3.1 Procedure For Obtaining Correlation Between Compressive Strength Of Concrete And Rebound Number

The correlation between compressive strength of concrete and rebound number is obtained by measuring both the properties simultaneously on concrete cubes. The concrete cubes are placed under compression testing machine, the rebound number is noted at various locations and then the compressive strength is obtained as per IS 516:1959. The fixed load is of order 7 N/mm^2 when impact energy of rebound hammer is 2.2 Nm. For calibrating rebound hammer with higher impact energy, the load should be increased and for calibrating rebound hammer with lower impact energy, the load should be decreased. For rebound hammer of impact energy 2.2 Nm the 100 mm concrete cube is preferred and for higher impact energy i.e. 30 Nm, the concrete cube size should not be less than 300 mm. After sufficient curing of concrete cubes, they should be removed from water and placed in the laboratory for 24 hours before the test. Minimum five readings should be taken by rebound hammer at two accessible faces under compression testing machine.

The aim of this investigation is to obtain calibration graph for rebound hammer and to use the graph for testing various structural elements like columns and beams. The experimental program involves following phases-

1) Concrete cubes are casted.
2) Rebound hammer test is performed on concrete cubes.
3) Ultrasonic pulse velocity test is performed on concrete cubes.
4) Cubes are tested under compression testing machine.
5) The results obtained from rebound hammer test and compression test are correlated and calibration graph is plotted.
6) The calibration graph is used for carrying out rebound hammer test on structural elements.
7)

4. RESULTS AND INTERPRETATION

4.1 Calibration Test

The procedure followed during the experiment is as follows-

1) Concrete cubes of various mixes are prepared of size 100 x 100 x 100 mm.
2) Some concrete cubes of unknown history was also brought for testing.
3) All the cubes are immersed in water for curing.
4) Before 24 hours, all the cubes were removed from water and kept in clean and dry place.
5) Two opposite faces of each cube was prepared for rebound hammer test and ultrasonic pulse velocity test.
6) The cubes were placed in compression testing machine and some load was applied and then rebound number at five different locations were recorded. The rebound hammer was in horizontal position during test.
7) Ultrasonic pulse velocity test was carried out on cubes.
8) Loads were applied on the concrete cubes upto failure.
9) Calibration graph was plotted using the obtained results.

Table 1: Rebound Number of Various Samples

Sample	**R1**	**R2**	**R3**	**R4**	**R5**
S1	20	21	21	22	21
S2	20	24	21	22	24
S3	20	18	21	20	23
S4	24	22	22	22	24
S5	24	22	28	20	28
S6	28	26	24	26	24

S7	11	10	11	10	10
S8	11	10	11	11	10
S9	12	10	12	13	11
S10	12	13	12	11	14
S11	12	14	13	14	13

Table 2: Dead load, Breaking load and compressive strength of Various Samples

Sample	Size	Breaking Load (kN)	Compressive Strength (N/mm^2)
S1	100x100	452.9	45.29
S2	100x100	543.7	54.37
S3	100x100	631.9	63.19
S4	100x100	670.8	67.08
S5	100x100	703.4	70.34
S6	100x100	748.0	74.8
S7	100x100	358.5	35.85
S8	100x100	379.5	37.95
S9	100x100	400.4	40.04
S10	100x100	421.4	42.14
S11	100x100	442.3	44.23

Following table shows results of ultrasonic pulse velocity test on concrete cubes.

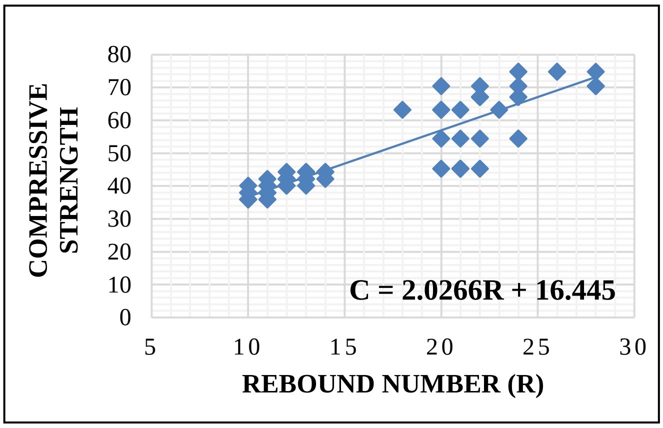
Table 3: Ultrasonic pulse velocity test results

Sample	T(μ sec)	V(km/sec)	Concrete Quality
S1	26.8	3.73	Good
S2	26.7	3.74	Good
S3	23.7	4.21	Good
S4	27.3	3.66	Good
S5	27.5	3.63	Good
S6	26.5	3.77	Good
S7	25.6	3.9	Good
S8	27.5	3.6	Good
S9	26.7	3.74	Good
S10	28.1	3.55	Good
S11	27.6	3.62	Good

The following graph is obtained between the Rebound number and Compressive strength. The regression equation for Rebound Hammer method is found to be:

$C = 2.0266R + 16.445$

Where, C is the compressive strength in N/mm^2.
R is the rebound number.

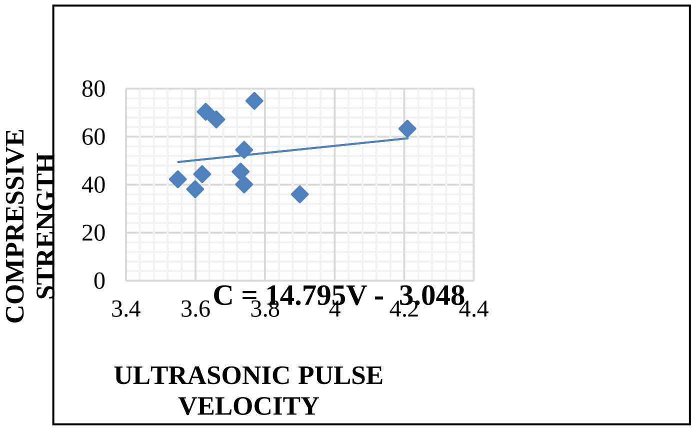


Graph 1: Calibration chart for Rebound Hammer Test

The following graph is obtained between the Ultrasonic Pulse Velocity and Compressive strength. The regression equation for Ultrasonic Pulse Velocity method is found to be:

$C = 14.795V - 3.048$

Where, C is the compressive strength in N/mm^2.
V is the Ultrasonic Pulse Velocity in km/sec.



Graph 2: Calibration chart for Ultrasonic Pulse Velocity Test

5. CONCLUSION

1. The results obtained from Rebound Hammer Test are not reliable and accurate, so it is necessary to correlate it with compression test on concrete cubes before performing it on structural members.
2. In structural auditing we cannot depend only on rebound hammer test, it is necessary to carry out rebound hammer test with Ultrasonic Pulse velocity test to compute the compressive strength and quality of concrete.
3. In this investigation, a calibration chart of rebound number and compressive strength is formed and its statistical equation is found to be $C = 2.0266R + 16.445$.
4. Also, a calibration chart of Ultrasonic Pulse Velocity and compressive strength is formed and

its statistical equation is found to be C = 14.795V - 3.048.

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