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To Determine the Correlation between Laboratory and In-situ Strength of Concrete

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Abstract **– Concrete structures are assemblies of load carrying members which transfer the load of the superstructure to the foundation. However the main quality which is sought after in the structure is its characteristic strength. Since determining compressive strength through compressive strength testing machine involves a complex procedure and a tedious task, non-destructive testing methods have gained prominence over a period of time. However it has been found that the results of non-destructive testing methods are subjected to various environmental conditions and different physical and chemical properties of concrete. In the present report, Rebound Hammer Test has been used as the non-destructive test and the purpose behind using Rebound Hammer Test is to calculate compressive strength of the cubes without damaging and altering the existing properties of concrete structure. Thereafter, the cubes are tested against compressive strength testing machine and a correlation has been established between the two testing methods.**

Keywords **– Compressive Strength, Compressive Strength Testing Machine, Non Destructive Test, Rebound Hammer Test.**

I. INTRODUCTION

In the present scenario, concrete happens to be one of the most prominent building materials in the construction industry. However since the infrastructure in our country is growing at an exponential rate it is important to keep the structure safe, durable and long lasting. In the context, the assurance of quality of structure during and after the construction subjected to various environmental conditions, degree of saturation, carbonation and such other physical and chemical factors is of urgent importance. In the recent years, several Non destructive techniques have been developed to evaluate the characteristic strength and evaluate the material properties of concrete. Yet not much investigation has been done to test the reliability of Non destructive technique in various environmental conditions. In the present report, an attempt has been done to establish a correlation between laboratory tests and in-situ strength of concrete of the various samples obtained from Bhopal.

II. THEORY

Rebound Hammer Test is done to find out the compressive strength of concrete using Rebound Hammer as per IS: 13311(part 2) - 1992. The hammer can be used in the horizontal direction, vertically upward or vertically downward as well as at any intermediate angle, provided the hammer is perpendicular to the surface under test.

The Rebound Hammer Test could be used for -

1. Assessing the compressive strength of concrete with the help of suitable correlations between rebound index and compressive strength.
2. Assessing the uniformity of concrete.
3. Assessing the quality of concrete in relation to the standard requirements.
4. Assessing the quality of one element of concrete in relation to another.

Test Principle:

The Rebound Hammer Test is based on the principle that the rebound of an elastic mass depends on the hardness of the surface upon which it impinges. When the plunger of the 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 in relation to the compressive strength of concrete. The rebound is read off along a graduated scale and is designated as the rebound number or rebound index.

Table 1. Impact Energy of Rebound Hammer (As per IS 13311 part 2).

S. No.	Applications	Approximate Impact Energy (N-m)
1.	For testing normal weight concrete	2.25
2.	For light weight concrete or small and impact sensitive part of concrete	0.75
3.	For testing mass concrete, i.e., in roads airfield pavements and hydraulic structures.	30.00

Table2. Rebound Hammer types, Impact energy and Grades of concrete.

Hammer Type	Grade of Concrete	Impact Energy (N-m)
N	M-15 To M-45	2.2
L	Light weight Concrete	0.75
M	Mass concrete	30
P	Below M-15	<2.2

Procedure for Obtaining Correlation between Compressive strength of Concrete and Rebound Number:

The most satisfactory way of establishing a correlation between compressive strength of concrete and its rebound number is to measure both the properties simultaneously on concrete cubes. The concrete cubes specimens are held in a compression testing machine under a fixed load, measurements of rebound number taken and then the compressive strength determined as per IS 516:1959. The fixed load required is of the order of 7N/mm2 when the impact energy of the hammer is about 2.2 N-m. The load should be increased for calibrating rebound hammers of lesser energy. The test specimens should be as large a mass as possible in order to minimize the size effect on the test result of a full scale structure. 150mm cube specimens are preferred for calibrating rebound hammers of lower impact energy (2.2 N-m), whereas for rebound hammers of higher impact energy, for example 30 N-m, the test cubes should not be smaller than 300 N-m. If the specimens are wet cured, they should be removed from wet storage and kept in the laboratory atmosphere for about 24 hours before testing. To obtain a correlation between rebound numbers and strength of wet cured and wet tested cubes, it is necessary to establish a correlation between the strength of wet tested cubes and the strength of dry tested cubes on which rebound readings are taken. A direct correlation between rebound numbers on wet cubes and the strength of wet cubes is not recommended. Only the vertical faces of the cubes as cast should be tested. At least, nine readings should be taken on each of the two vertical faces accessible in the compression testing machine when using the rebound hammers. The points of impact on the specimen must not be nearer an edge than 20mm and should be not less than 20mm from each other. The same points must not be impacted more than once.

III. METHODOLOGY

For fulfilling the objective of the present work, following methodology is adopted. Methodology comprises of preparation of cubes, testing of cubes and development of correlation curves.

1. Several cubes of 150mm size have been prepared, covering almost all the strength range to be encountered on the job site. Cubes had been cured under standard moist curing room conditions.
2. Then the cubes are placed in a compression testing machine under an initial load of approximately 15% of the ultimate load to restrain the specimen.
3. Ensuring that cubes are in saturated surface dry conditions. Then Rebound hammer test has been performed as per Indian codes.
4. Cubes are then tested to failure in compression testing machine and plot the rebound numbers against the compressive strength on a graph.
5. Perform regression analysis to obtain equations for determining compressive strength of a concrete through rebound numbers.
6. Values of rebound number have obtained through rebound hammer testing in horizontal and vertical positions.

IV. OBSERVATIONS

Cubes	Nh	Sh	Nd	Sd	F
1.	22	12.06	20	12.41	13
2.	24	13.10	21	11.03	12.5
3.	23	12.41	21	11.03	13.6
4.	21	11.03	20	12.41	11.8
5.	27	16.55	25	17.24	15.7
6.	28	17.24	25	17.24	15.7
7.	33	24.13	31	25.85	26.2
8.	24	13.10	22	13.79	14.6
9.	25	13.79	24	16.55	14.7
10.	20	10.34	20	12.41	11.5
11.	21	11.03	20	12.41	12.6
12.	25	13.79	23	15.51	13.0
13.	28	17.24	25	17.24	16.5
14.	30	20.68	28	21.37	19.4
15.	32	22.75	27	20.68	21.8
16.	29	18.96	25	17.24	17.2
17.	33	24.13	31	25.85	26.2
18.	36	28.27	32	27.58	26.7
19.	26	15.51	22	13.79	13.6
20.	28	17.24	27	20.68	15.7

Cubes	Nh	Sh	Nd	Sd	F
21.	27	16.55	24	16.55	14.5
22.	30	20.68	29	22.75	18.7
23.	32	22.75	31	25.85	23.7
24.	24	24.13	22	13.79	23.4
25.	27	25.85	23	15.51	23.8
26.	33	24.13	30	24.13	25.3
27.	35	27.58	31	25.85	26.5
28.	36	28.27	33	28.27	27.3
29.	29	18.96	25	17.24	18.5
30.	24	13.10	21	13.10	11.2

Nh - Rebound number in horizontal position.

Sh - Compressive Strength in Mpa obtained by curve provided on Rebound hammer.

Nd - Rebound number in downward position.

Sd - Compressive strength in MPa obtained by curve provided on Rebound hammer.

F - Crushing strength of cube (MPa).

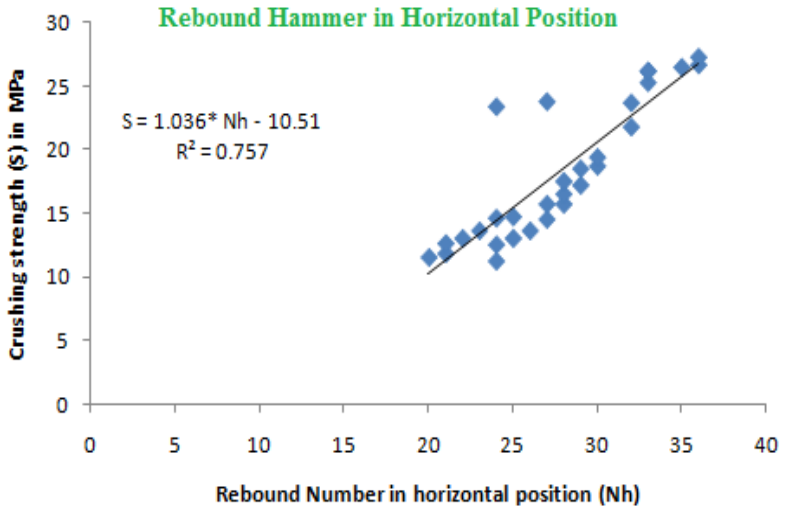
Regression analysis of the above mentioned table had been done in Ms Excel and thereafter correlation curves and subsequent equations showing relation between Rebound number and Crushing strength of concrete blocks.

V. EXPERIMENTAL RESULTS

Rebound Hammer in Horizontal position:

A graph has been plotted with rebound number (Nh) and compressive strength (S) in MPa of respective concrete cubes for performing regression analysis. By curve fitting tool, best fitted relationship with highest regression coefficient is-

$$S = 1.036* Nh-10.51$$

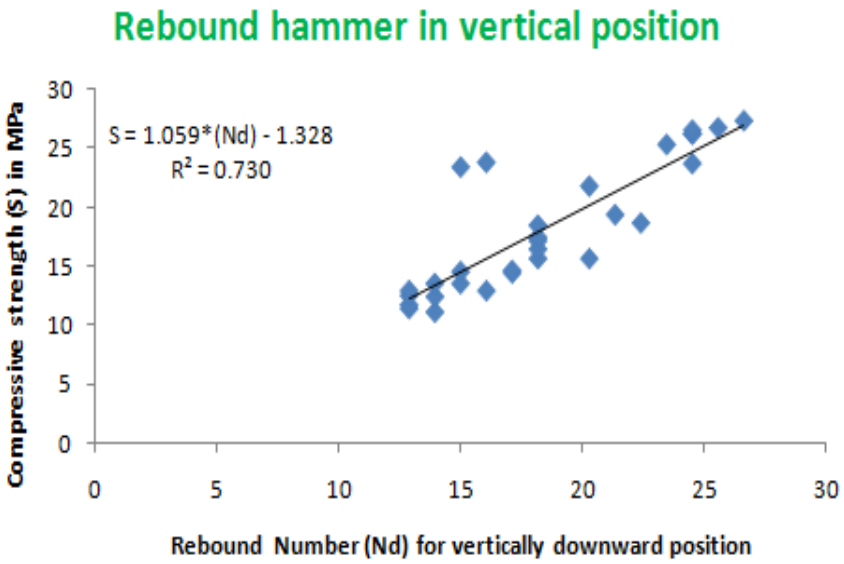


Relation between Rebound Number and Compressive Strength for horizontal position.

Rebound Hammer in Vertical Position:

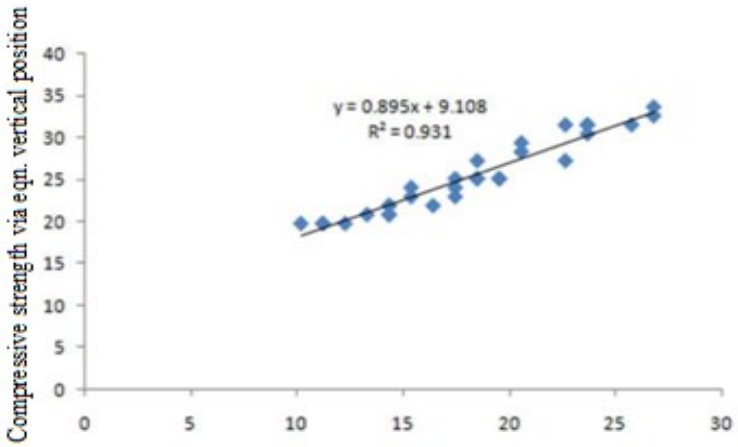
A graph has been plotted for vertical position of rebound hammer between rebound number (Nd) and compressive strength (S) in MPa best fitted relationship with highest regression coefficient-

$$S = 1.059*(Nd)-1.328$$



Relation between Rebound Number and Compressive Strength for vertical position.

Having obtained the two equations, these equations were validated by keeping the values of Rebound Numbers in the equations, the following graph was obtained:



Compressive strength in horizontal position.

VI. Discussions and Conclusions

1. Rebound Hammer Test is widely used to assess the compressive strength of concrete.
2. As Rebound Number increases, the Compressive strength also increases.
3. Rebound Hammer is provided with a correlation curve for determining the compressive strength by measuring rebound number. However, values obtained may get affected by material properties and environmental conditions.
4. Following equations have been developed for horizontal and vertical positions of Rebound hammer:

S = 1.036*(Nh)-10.51

S = 1.059*(Nd)-1.328

5. The above equations give a Regression coefficient of 0.93, i.e. 93% is obtained while correlating the values of Compressive Strength Testing machine test and Rebound Hammer Test.

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