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Comparison Between Two NDT Methods: Rebound Hammer Test and Ultrasonic Pulse Velocity Test for a Chemical Plant Structure situated in Coastal Area

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Abstract- *the two methods of Non Destructive Testing namely Rebound Hammer Test and Ultrasonic Pulse Velocity Test are applied on same concrete column of an old chemical industry plant. The results obtained from both the test are then compared to find out which method is more feasible in which condition.*

Keywords: *non destructive testing, NDT, Rebound Hammer Test, Ultrasonic Pulse Velocity Test, Cube Test, Rebound Number, Concrete structure in chemical plant, compressive strength, rebound test, plain and reinforced concrete*

I. INTRODUCTION

Basically, in construction Compressive strength of the concrete used in construction is always tested during the construction by Cube Test... Specifically casted cubes are crushed in the testing machine and compressive strength is obtained. But, all the structures are designed for a design life of certain years. So, after some years of the construction how can we decide the way in which concrete reacted to the exposure conditions prevailing. How can we decide the compressive strength of the concrete after those years? Cube tests as conducted during constructed cannot be conducted once concrete has been casted. That is where NDT Method comes in light. NDT stands for Non Destructive Testing and as the name suggests these methods are used for testing compressive strength as well as other quality parameters in existing concrete structures. In the following paper, two methods of Non destructive testing namely, Rebound Hammer Test and Ultrasonic Pulse Velocity Test are tested for same concrete structure in chemical industry.

II. REBOUND HAMMER TEST

The Rebound hammer is an easy to use instrument, which provides a quick and simple non-destructive test for obtaining an immediate indication of concrete strength in various parts of a structure.

Conversion of Rebound Number

The conversion of rebound number to compressive strength can be achieved by producing a calibration graph for the concrete concerned. This is undertaken by testing previously sampled concrete cubes strength or cores which extracted from the sample test location and crushed to determine the in-situ strength. The calibration chart may then be used to convert rebound number to estimated cube strength. If it is not possible to produce a calibration graph, most manufacture of rebound hammer are supplied with a conversion curve, which will enable the average rebound value to be converted to an estimated concrete strength in N/mm2. The angle (Horizontal, Vertical & Inclined) of application needs to be taken into account to give the correct reading.

For testing, smooth, clean and dry surface is to be selected. Any loosely adhering scale observed, is to be rubbed with a grinding wheel or stone, consisting of medium grain texture silicon carbide or equivalent material (the points of impact on the specimen was not nearer an edge than 20 mm and should be not less than 20 mm from each other). The same points should not be impacted more than once. The points of impart should be more than 20mm from edge and should not be less than 20mm from each other.

Factors Affecting the result of RH test:

a) Type of Cement
b) Type of Aggregate
c) Surface condition and moisture content of concrete curing

d) Age of concrete
e) Carbonation of concrete surface

III. REBOUND HAMMER TEST APPARATUS & METHOD

It consists a spring controlled mass that slides on a plunger in a tubular housing. The methodology adopted for Non Destructive Testing by Rebound Hammer method is in such a way that, 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. There bound is read off along a graduated scale and is designated as the rebound number or rebound index.

Test Photographs

Fig 1: Conducting Rebound Hammer Test

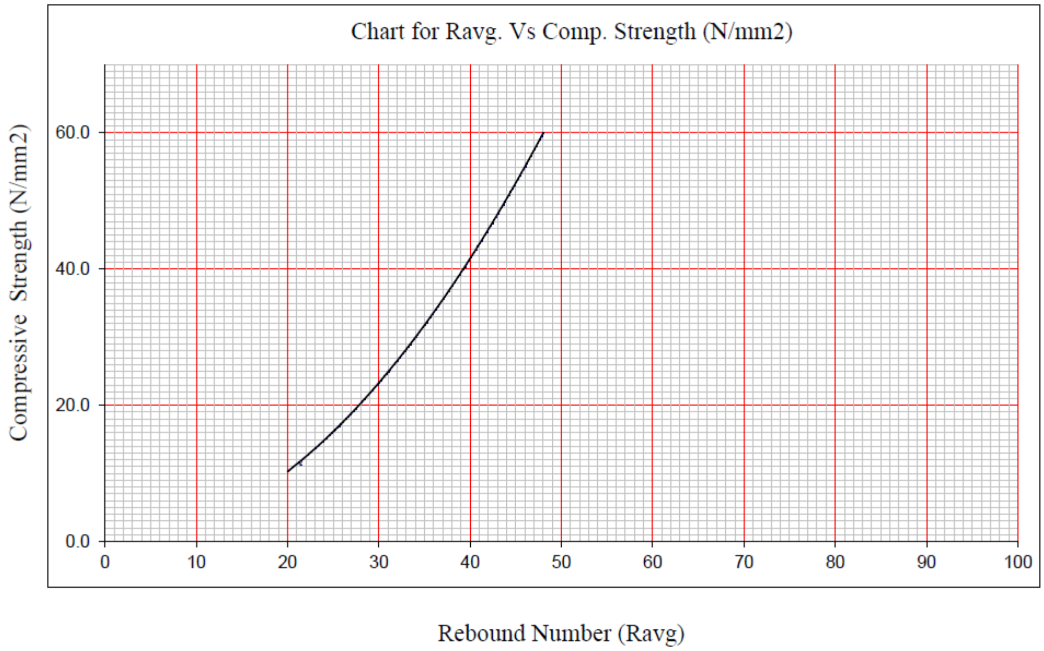
IV. REBOUND HAMMER TEST RESULT AND ANALYSIS

This data below were obtained by Self Observation during NDT testing of an old Concrete Structure in a Chemical Plant.

Sr No.	Location	Rebound Number						Mean Rebound Number	Corrected Compressive Strenght in N/mm2
1	C1(Bottom)	42.0	40.0	38.0	40.0	42.0	38.0	40.0	41.5
2	C1(Middle)	40.0	40.0	42.0	40.0	38.0	36.0	39.3	40.1
3	C1(Top)	42.0	40.0	38.0	39.0	40.0	41.0	40.0	41.5
4	C2(Bottom)	40.0	38.0	40.0	42.0	40.0	44.0	40.7	42.9
5	C2(Middle)	44.0	42.0	38.0	38.0	36.0	40.0	39.7	40.8
6	C2(Top)	45.0	42.0	40.0	39.0	38.0	38.0	40.3	42.2
7	C3(Bottom)	40.0	38.0	36.0	34.0	28.0	34.0	35.0	31.7
8	C3(Middle)	46.0	42.0	48.0	46.0	40.0	46.0	44.7	51.8
9	C3(Top)	36.0	32.0	35.0	46.0	45.0	40.0	39.0	39.5
10	C4(Bottom)	38.0	40.0	38.0	38.0	34.0	32.0	36.7	34.9
11	C4(Middle)	32.0	40.0	42.0	44.0	40.0	42.0	40.0	41.5
12	C4(Top)	45.0	42.0	44.0	43.0	41.0	40.0	42.5	46.9
13	C5(Bottom)	34.0	36.0	44.0	42.0	44.0	40.0	40.0	41.5
14	C5(Middle)	42.0	40.0	44.0	42.0	38.0	40.0	41.0	43.6
15	C5(Top)	40.0	42.0	40.0	4.0	39.0	38.0	40.3	42.2
16	C6(Bottom)	40.0	32.0	30.0	30.0	34.0	32.0	33.0	28.2
17	C6(Middle)	30.0	36.0	35.0	32.0	40.0	41.0	35.7	33.0
18	C6(Top)	42.0	40.0	38.0	36.0	39.0	40.0	39.2	39.8
19	C7(Bottom)	40.0	38.0	36.0	40.0	44.0	40.0	39.7	40.8
20	C7(Middle)	40.0	46.0	40.0	38.0	44.0	38.0	41.0	43.6
21	C7(Top)	45.0	46.0	42.0	45.0	49.0	44.0	45.2	53.0
22	C8(Bottom)	40.0	44.0	42.0	38.0	34.0	42.0	40.0	41.5
23	C8(Middle)	34.0	30.0	28.0	38.0	32.0	34.0	32.7	27.6
24	C8(Top)	40.0	38.0	36.0	32.0	45.0	45.0	39.3	40.1

Test Method: IS 13311 - Part - II: 1999

Remarks: Corrected compressive strength is obtained from the curve (Below Shown) provided by the manufacturer and results relate only to the location tested.



Considering the limitation of the method into account the Rebound hammer is still a valuable tool in the NDT to assess the condition of in-situ concrete, rapidly, impartially and in difficult locations.

V. ULTRASONIC PULSE VELOCITY TEST (UPV)

In Ultrasonic pulse velocity method, ultrasonic pulse is generated by an electro-acoustical transducer. When the pulse is induced into the concrete from a transducer, it undergoes multiple reflections at the boundaries of the different material phases within the concrete. A complex system of stress waves is developed, which includes longitudinal (compressive), transverse (shear) and surface (Raleigh) waves. The receiving transducer detects the onset of the longitudinal waves, which is the fastest. Because the velocity of the pulses is almost independent of the material through which they pass, and depends only upon its elastic properties, pulse velocity method is a convenient technique for Nondestructive tests for structural concrete. The underlying principle of accessing the quality of concrete is that comparatively higher velocity is obtained with a good quality of concrete, in terms of density, homogeneity and uniformity. In case of poor quality of concrete, lower velocities are obtained. In case of presence of crack, voi or flaw in the concrete, which comes in the way of transmission of the pulses, produces hindrance, thereby making the path length longer. Consequently, lower velocities are obtained. The actual pulse velocity obtained depends primarily upon density and modulus of elasticity of concrete.

VI. ULTRASONIC PULSE VELOCITY TEST APPARATUS AND METHOD

The apparatus for U.P.V measurement consists of the - Electrical pulse generator, Transducer (one pair), Amplifier and Electronic timing device.The apparatus capable of measuring transit times of an accuracy of ± 1 % over a range of 20 microseconds to 10 milliseconds. In this test, the ultrasonic pulse is produced by a (transmitting) transducer, which is held in contact with one surface of the concrete member. After traversing a known path length (L) in concrete, the pulse of vibrations is converted into an electrical signal by another (receiving) transducer held in contact with the other surface of the concrete member. An electronic timing circuit enables the transit time (T) of the pulse to be measured. The pulse velocity (V) is given by: **V = L / T** Once the electronic pulse impinges on the surface of the material, the maximum energy is propagated at right angles to the face of the transmitting transducer and best results are, therefore obtained when the receiving transducer is placed exactly opposite, on the opposite face of the concrete member (direct transmission or cross probing). However, in some situations, two opposite faces of the structural members may not be accessible or available for taking readings. In such cases, the receiving transducer is placed on the same face as of the transmitting transducer (indirect transmission or surface probing). Surface probing is not as efficient as cross probing, because the signal reached at the receiving transducer has amplitude of only 2% to 3% of that in case of cross probing. Also, the results are greatly influenced by the surface layers of concrete, which may have different properties from that of core concrete. The indirect velocity is invariably lower than direct velocity on the same concrete element. This difference may vary from 5% to 20% depending largely upon the quality of concrete.

To ensure that the ultrasonic pulses generated at the transmitting transducer enters the surface of concrete without resistance, and are then ejected out of the surface, into the receiving transducer, it is essential that there be adequate acoustical coupling between the surface of concrete and face of transducer. Typical couplants are petroleum jelly, grease, liquid soap and kaolin glycerol paste. In case of very rough concrete surface, it is required to smoothen and level the area where the transducer is to be placed.

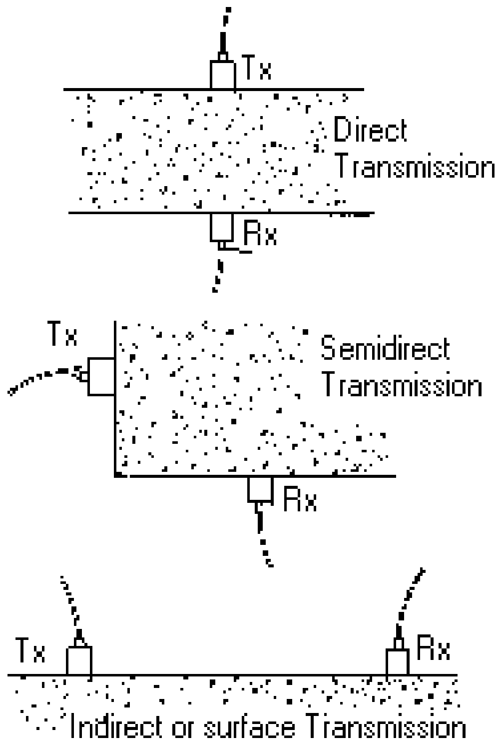


Fig 2 : Methods of Propagating ultrasonic pulses

Factors Affecting results of UPV method:

a) Surface condition and moisture content of concrete
b) Path length, shape and size (lateral dimension) of concrete member
c) Temperature of concrete
d) Stress and
e) Effect of reinforcing bars.

The quality of concrete in terms of uniformity, incidence or absence of internal flaws, cracks an segregation etc. can thus be accessed using th guidelines as per the table given below which have been evolved for categorizing of the quality of concret in structures in terms of the ultrasonic pulse velocity.

Velocity criteria for concrete quality grading

Sr No.	Pulse Velocity (Km/sec.)	Concrete Quality grading
1	Above 4.5	Excellent
2	3.5 to 4.5	Good
3	3.0 to 3.4	Medium
4	Below 3.0	Doubtful

Test Photographs

Fig 3 : Conducting Ultrasonic Pulse Velocity Test

VII. ULTRASONIC PULSE VELOCITY TEST RESULT AND ANALYSIS

This data below were obtained by Self Observation during NDT testing of an old Concrete Structure in a Chemical Plant.

Sr No.	Location	Type Of Transmission	Average Time (μ sec)		Distance between Transducer (m)		Velocity (km/sec)	Quality of Concrete (As per I.S 13311 P-1)
1	C1(Bottom)	Direct	402		0.76		1.89	Doubtful
2	C1(Middle)	Direct	1226		0.76		0.62	Doubtful
3	C1(Top)	Indirect	110.3	227	0.2	0.4	2.71	Doubtful
4	C2(Bottom)	Direct	301		0.76		2.52	Doubtful
5	C2(Middle)	Direct	894		0.76		0.85	Doubtful
6	C2(Top)	Indirect	85.7	170.5	0.2	0.4	3.36	Medium
7	C3(Bottom)	Direct	488		0.76		1.56	Doubtful
8	C3(Middle)	Direct	223		0.76		3.26	Medium
9	C3(Top)	Indirect	77.9	165.2	0.2	0.4	3.29	Medium
10	C4(Bottom)	Direct	321		0.76		2.37	Doubtful
11	C4(Middle)	Direct	547		0.76		139	Doubtful
12	C4(Top)	Indirect	80.3	182.1	0.2	0.4	2.96	Doubtful
13	C5(Bottom)	Direct	723		0.76		1.05	Doubtful
14	C5(Middle)	Direct	971		0.76		0.78	Doubtful
15	C5(Top)	Direct	551		0.76		1.38	Doubtful
16	C6(Bottom)	Direct	747		0.76		1.02	Doubtful
17	C6(Middle)	Direct	898		0.76		0.85	Doubtful
18	C6(Top)	Direct	541		0.76		1.19	Doubtful
19	C7(Bottom)	Direct	288		0.76		2.64	Doubtful
20	C7(Middle)	Direct	431		0.76		1.76	Doubtful
21	C7(Top)	Indirect	114.6	221	0.2	0.4	2.88	Doubtful
22	C8(Bottom)	Direct	271		0.76		2.8	Doubtful
23	C8(Middle)	Direct	297		0.76		2.56	Doubtful
24	C8(Top)	Direct	291		0.76		2.61	Doubtful

VIII. CONCLUSION:

By comparing results of both the metghods for same structural element, it is seen that the results obtained by Rebound Hammer Test are falling between the range of Average to Medium Compressive Strength. While the results obtained by Ultrasonic Pulse Velocity Test are falling between the range of Medium to Doubtful Compressive Strength.

As the structure inspected under the test is an old structure in a chemical plant situated in coastal area.The exposure conditions falls under Severe Category, and visual inspection at site as well as the results obtained by Ultrasonic Pulse velocity Test coincide with this.

Thus, from this experiment we can conclude that, Rebound Hammer Test Method is easy and handy in obtaining rough evaluation of Compressive Strength of the structure but due to Instrumental errors and Non availibility of ideal test surface on site these results are not fully accurate and cannot be trusted blindly.

On the othe hand, Ultrasonic Pulse Velocity Test Method is also easy and the results obtained by this method are more accurate compared to the results of Rebound Hammer Test Method.

Ultimately, it is advisable to conduct both the tests as well as visual inspection on site to get fairly accurate idea about compressive strength and quality of the concrete in any structure or an element of a structure.

IX. REFERENCES:

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