

Utilization of Combined NDT in the Concrete Strength Evaluation of Core Specimen from Existing Building

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ABSTRACT: In this paper, a series of compressive strength of core specimen's to correlate the rebound hammer indices and UPSV results obtained from member of existing buildings. The combined method (SONREB) was used to quality control and strength estimation of the concrete. This combined method requires short time to obtain the results, it's a non-invasive method and it does not affect the resistance of structural elements. The best fit equation of SONREB method for the determination of concrete compressive strength is obtained through processing correlation among the data sets. Finally the investigation and comparison of experimental results of non-destructive tests and core strength with the help of statistical data obtained by testing of specimen as per recommended procedures by IS 13311:1992 and IS 516:1959 respectively. The use of the combined methods (SONREB) increases the accuracy of the estimation of the in situ concrete compressive strength.

KEYWORDS: Concrete core specimen, Compressive strength, Rebound indices, Ultra sonic pulse velocity, SONREB Method

I. INTRODUCTION

Any structure that is in use for which it is intended to, shows some structural disorder, requires to be assessed for its quality, structural integrity and in place concrete compressive strength. Standing structure cannot be assessed by conventional methods adopted to evaluate structural integrity and in place concrete compressive strength same as by testing standard specimens up to failure. Service life of concrete is found to be limiting in various environmental degrading factors as it is exposed to it. This therefore has brought about the need for test method to measure the in-place properties of concrete for quality assurance and for evaluation of existing conditions. Since such test are expected as non-impairing the function of the structure and allow for re-testing at the same location to evaluate the changes in property at some other point in time, these methods should be non-destructive.

The combination of several techniques of non destructive testing is often used empirically, combining two techniques mostly used to enhance the reliability of the estimate compressive strength of concrete; the principle is based on correlations between observed measurements and the desired property. The standardized combine method and the most widely used internationally is Son Reb method. The best approach is generally to develop a relationship of correlation between the Ultra Sonic Pulse Velocity, the index of rebound hammer and the compressive strength of standardized laboratory specimen.

The Non Destructive Testing is being fast, easy to use at site and relatively less expensive can be used for

- a. Test actual structure instead of representative cube sample.
- b. Test any number of points and any locations

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- c. Assess the structure for various distressed conditions
- d. Damage assessment due to fire, chemical attack, impact, age etc.
- e. Detect cracks, voids, fractures, honeycombs and weak locations
- f. Monitor progressive changes in the properties of concrete, reinforcement etc.
- g. Assess overall stability of the structure
- h. Scanning for reinforcement location, stress locations.

II. LITERATURE REVIEW

The objective of the combined tests is to evaluate the compressive strength of concrete in situ; the best approach is generally to develop a relationship of correlation between the upv/the index of rebound hammer and the compressive strength of standardized laboratory specimen, in some cases specimen are not available, then a number of cores must be taken to establish this relationship [1].

The compressive strength of concrete is usually the most sought after property. This leads to the development of a method that combines index rebound hammer and the ultrasonic pulse velocity UPV [2].

All available methods for evaluating in-situ concrete are limited, their reliability is often questioned, and the combination of two or more techniques is emerging as an answer to all these problems [3].

The combination of several techniques of nondestructive testing is often implemented empirically, combining two techniques most often used to enhance the reliability of the estimate compressive strength of concrete; the principle is based on correlations between observed measurements and the desired property [4].

The standardized combined method the most widely used is SonReb method developed by RILEM [5], first born and established in Romania then developed in Australia and in Europe. The improvement in the reliability of the measures is explained by taking into account the contradictory effect of variability factors of some properties for each of the two techniques (ultrasonic pulse velocity/rebound hammer).

III. METHODOLOGY

NDT methods:- Core Test

A. PRINCIPLE: - In this method concrete cores of sizes ranging from 20 mm to 150 mm in diameter and 50 mm to 500 mm long are drilled out by diamond cutters. The recommended diameters are 100 to 150 mm, but if the drill depth is insufficient as in of case slabs, then smaller diameters may be used but not less than three times nominal aggregate size. The core diameter to length ratio shall be normally between 1.0 to 2.0 Reinforcement shall be avoided in the core. At least three cores shall be tested for acceptable accuracy. These cylindrical concrete cores are then made smooth at both ends by capping of the faces shall be done. The specimen shall be cured in water for 48 hours before testing. IS - 516 suggest a multiplying factor of 1.25 for converting cylindrical strength to equivalent cube strength.

Methodology: - The chart 1 shows the operation carried out in core test in sequentially at site.

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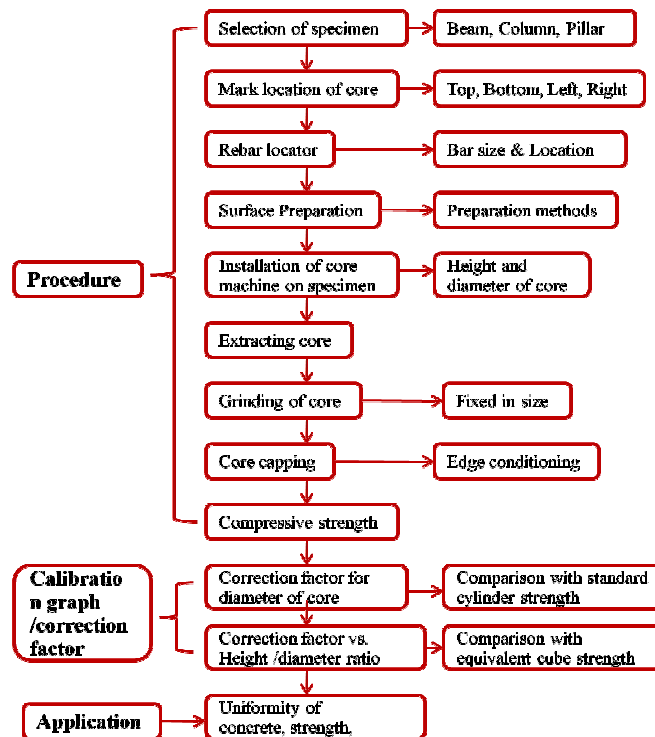


Chart -1: Process of core cutting test

B. ULTRASONIC PULSE VELOCITY

Principle: - The transducers converts' electrical signals into mechanical vibrations (transmit mode) and mechanical vibrations into electrical signals (receive mode). Transducers with natural frequencies between 20 kHz and 200 kHz are available, but 50 kHz to 150 kHz transducers are common. This instrument basically is dependent on the Dynamic Young's Modulus, density, Poisson's ratio of the material. The transducers are placed on the smooth concrete surface to measure the time required for travel. A coupling media such as petroleum jelly, grease are applied to the surface to have good acoustical coupling.

The velocity is calculated as $V = L / T$ (L is the distance between two probes and T is the time required to travel the distance between two transducers). Concrete quality grading using velocity criterion is shown in table 1.

Table 1: Concrete quality grading with velocity criterion (IS13311 (part 1):1992)

Pulse velocity by cross probing (Km / Sec)	Concrete quality grading
Above 4.5	Excellent
3.5 to 4.5	Good layer
3.0 to 3.5	Medium
Below 3.0	Doubtful

Methodology:- The chart 2 shows the operation carried out in ultrasonic pulse velocity test in sequentially on specimen member.

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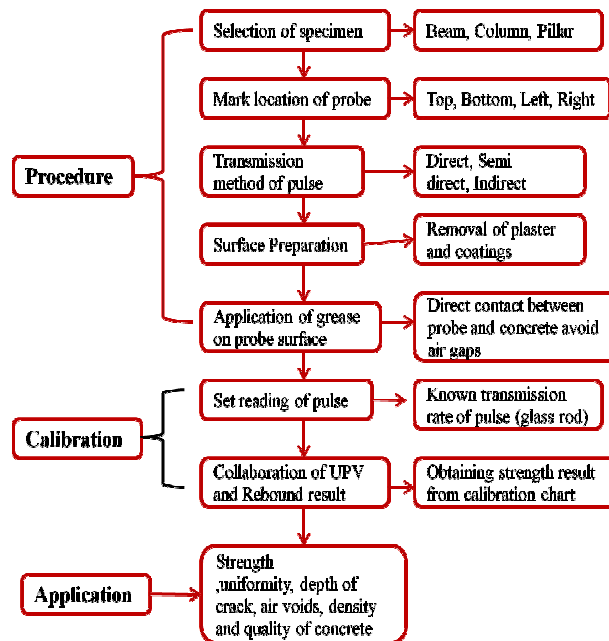


Chart -2: Process of Ultrasonic pulse velocity test

C. REBOUND HAMMER TEST

Principle: Rebound of an elastic mass depends on the hardness of the surface against which mass strikes. The plunger of hammer is pressed strongly and steadily against the concrete surface at right angles to its surface, until the spring loaded mass is triggered from the locked position. The distance travelled by the mass as a percentage is defined as rebound number.

A hardness criterion for Concrete quality grading is shown in table 2.

Table 2: Concrete quality grading with Rebound number (IS13311 (part 2):1992)

Rebound number	Quality of concrete
More than 40	Very good and hard layer
30 to 40	Good layer
Less than 20	Fair
0	Delaminated

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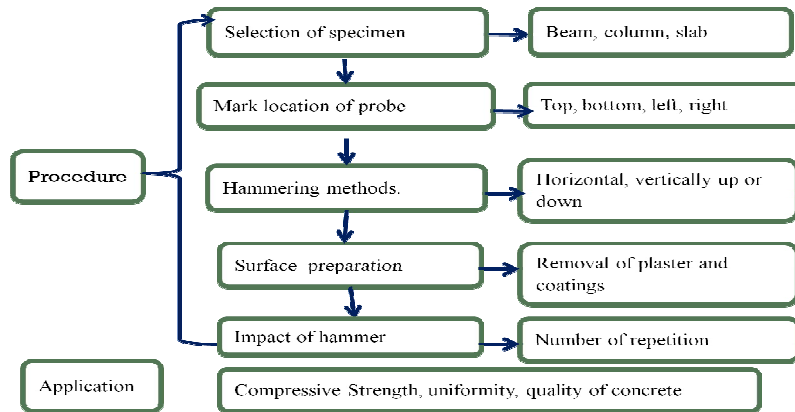


Chart -3: Process of Rebound hammer test

IV. EXPERIMENTAL RESULTS

Table 3: Experimental results of core specimen, rebound index and UPSV

Member	Column	Column	Column	Column	Beam
Location	Bottom	Top	Bottom	Top	North
Age of Concrete	20 yr	20 yr	20 yr	20 yr	20 yr
Core Recovery fraction / total	170-185	170-190	175-193	80-88	155-168
Weight of capped core	1.479	1.518	1.486	0.91	1.512
Mean Diameter of Core	73.52	73.6	73.61	73.41	73.52
Mean Height of capped Core	141.8	145.96	142.75	90.47	144.32
H/D Ratio	1.93	1.98	1.94	1.23	1.96
Correction factor (K) for H / D	0.992	0.998	0.993	0.917	0.996
Correction factor for Diameter (Cd)	1.08	1.08	1.08	1.08	1.08
True Crushing Load	74.1	130.3	79.7	42.6	93.3
Comp. Strength of core cylinder - fo	17.44	30.61	18.71	10.07	21.98
Equivalent Cube strength =1.25 x Cdx K x fo	23.36	41.25	25.1	12.47	29.55
Temp. Corrected Dry Velocity at site location	3.598	3.074	2.834	2.06	3.401
Rebound index	40.02	39.01	38.08	39.93	39.77

Calculation

Pucinotti 2005 express the law of correlation among compressive strength, Rebound Hammer index and ultrasonic velocity by using SONREB method is given in equation number 1.[6]

$$fck = a \cdot V^b \cdot R^c \dots 1$$

Where, fck = compressive strength of the core specimen

a, b, c are constants

V - Ultrasonic Pulse Velocity

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R - Rebound Number

So determine the constants *a*, *b* and *c* from the data by using SONREB method

$$a = 27746.41672$$

$$b = 1.626039293$$

$$c = -5.447926595$$

$$R\text{-Square Value} = 0.670979593$$

Law of correlation among *fck*, *R* and *V* for this set of data would be given in equation no 2:

$$fck = 27746.41672 * V^{1.626039293} * R^{-5.447926595} \dots 2$$

In comparison, combining the two methods by using the SONREB data gives a significantly higher correlation coefficient of 0.441 as we have seen. From figure no 3 we can say that the regression equation of the SONREB has a greater accuracy than the previous two equations. Correlation coefficient 0.003 is obtained from figure no. 1, when the rebound values use for strength estimation and as well as correlation coefficient 0.352 is obtained from figure no 2, when the UPSV values use for strength estimation. As Rebound Index exceeds, Ultra sonic pulse velocity value decreases

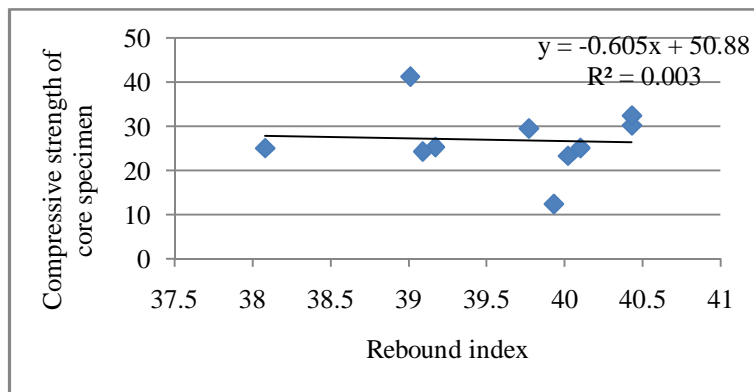


Fig 1: Rebound number vs. compressive strength of core specimen

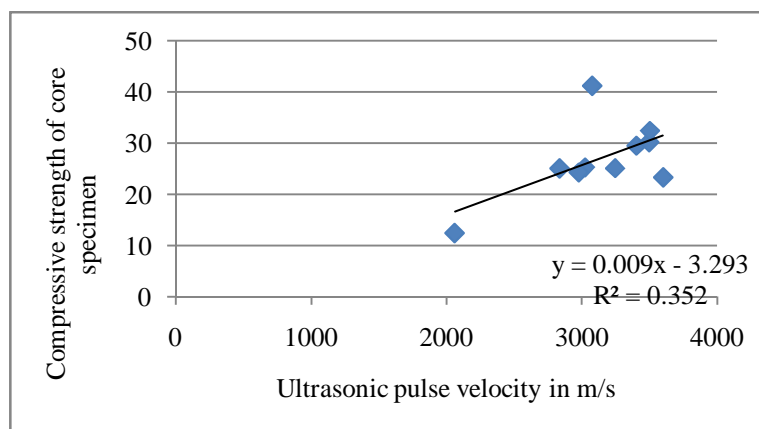


Fig 2: Ultrasonic pulse velocity vs. compressive strength of core specimen

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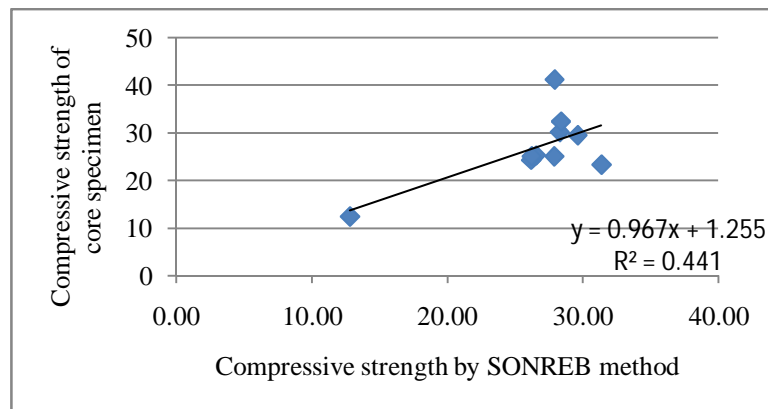


Fig 3: Compressive strength by SONREB method vs. compressive strength of core specimen

V. CONCLUSION

1. The comparison carried out shows how the use of known destructive methodologies (cores), associated with a non-destructive method (SONREB) allows to obtain a higher level of knowledge and a greater accuracy on the estimation of the concrete compressive strength if the relationship is calibrated on the individual building
2. Correlation coefficient 0.003 is obtained, when the rebound values use for strength estimation and as well as correlation coefficient 0.352 is obtained, when the UPSV values use for strength estimation. As Rebound Index exceeds, Ultra sonic pulse velocity value decreases.
3. Higher correlation coefficient of 0.441 is obtained, when combination of the two methods by using the SONREB method. We can find more accurate compressive strength by the application of this correlation of combined method.
4. Just by knowing the Rebound Hammer Number and UPV, strength can be calculated.

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