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Study of destructive and non destructive test for codal base minimum grade of concrete

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Abstract —*A numerous methods of destructive and non-destructive testing have been carried out in the Laboratory. The need of evaluation the in-situ mechanical properties of the concrete together with the seismic vulnerability assessment were the reasons of carrying out such amount of test. As non-destructive testing, the surface hardness methods, the ultrasonic methods and the combined methods have been chosen for the purposes of quality control and in-situ concrete strength estimation. As destructive methods to determine the strength estimation. As destructive methods to determine the strength of the in –situ concrete, the extraction of cylindrical specimens (core) from some structural element has been employed. After having briefly described the structure under test and having presented the result of the testing campaign, we investigate the following aspects: the variation of the mechanical properties of the in-situ concrete, the reliability of the combined methods, the need to calibrate the resistance obtained Non destructive methods with the strength of cylindrical specimens (cores) extract from some structural elements in the proximities of the Non-destructive test.*

Keywords- *UG Nondestructive and Destructive test*

I. INTRODUCTION

An important feature of non- destructive test is that they permit re- testing at the same, or nearly the same, location so that changes with time can be monitored. The use of non – destructive tests leads to increased safety and allows better scheduling of construction, thus making it possible to progress faster and more economically. Broadly speaking, these tests can be categorized into those that assess the strength of the concrete in situ, and those that determine other characteristics of the concrete such as voids, cracks, and deterioration. With respect to strength, it should be noted that it can be only assessed, that not measured, because the non destructive test are, the most part, comparative in nature. Thus it is useful to established an experimental relation between the property being measured by a given test and the strength of the test specimens or cores from the actual concrete ; there after this relation can be used to converted the non destructive test results into strength value. An understanding Of the physical relation between the given non destructive the results and strength is essential. This relation for the various test will be discuss in what follows. One more general comment about the interpretation of the results of non destructive test is necessary. The test rarely given a number which can be unequivocally interpreted engineering judgment is necessary. Thus if the testing arises from a dispute between the parties involved in the construction the full test programmed should be determined in advanced and the interpretation of possible test result bearing in mind there variability, should also be agreed .Otherwise there is risk that one part is or another will seek addition test and the dissipate about the concrete in the structure will be compounded by a dissipate about the testing. Helpful advise about planning non-destructive testing is given in BS 1881:Part 201:1986,and BS 6089:1981 give a guide to the assessment of concrete strength in existing structure.

II. OBJECTIVES OF INVESTIGATION

- Assessing the likely compressive strength of concrete with the help of suitable correlation between rebound index and compressive strength.
- The main object of ultrasonic pulse velocity method is to be established the homogeneity of the concrete.
- Impact echo can be used to determine the location and extend of flaws such as cracks, delimitations, voids, honeycombing and deboning.
- Determine in-situ compressive strength of the concrete.

III MIX MATERIALS

A. Cement

The cement used in this experimental work is "Ulttratech 53 grade Ordinary Portland Cement". All properties of cement are tested by referring IS 12269 - 1987 Specification for 53 Grade Ordinary Portland Cement.

B. Water:

Potable water available in laboratory is used for mixing & curing of concrete.

C. Fine Aggregate

Locally available fine aggregate used was 4.75 mm size confirming to zone II with specific gravity 2.66. The testing of sand was conducted as per IS: 383-1970.Water absorption and fineness modulus of fine aggregate was 1.35% and 2.80 respectively.

D. Coarse Aggregate

Coarse aggregate used was 20mm and less size with specific gravity 2.70. Testing of coarse aggregate was conducted as per IS: 383-1970. Water absorption and fineness modulus of coarse aggregate was 0.7% and 6.01 respectively.

E. Fly Ash

Fly Ash (FLA) is available in dry powder form and is procured from Dirk India Pvt. Ltd., Nasik. It is available in 30Kg bags, color of which is light gray under the product name "Pozzocrete 60".

IV. EXPERIMENTAL WORK AND TEST

A. Destructive test conducted on Concrete:

In present study cube compression test, flexural test on beams and Cylindrical split tensile test on self compacting concrete with constant fraction of steel fiber were carried out.

Compressive Strength Test:

A cube compression test is performed on standard cubes of size 150 x 150 x 150 mm after 3, 7 and 28 days of immersion in water for curing. The compressive strength of specimen is calculated by the following formula:

fcu = Pc /A

Where

Pc = Failure load in compression, KN

A = Loaded area of cube, mm2

Split Tensile Test:

The split tensile test is well known indirect test used to determine the tensile strength of concrete. Due to difficulties involved in conducting the direct tension test, a number of indirect methods have been developed to determine the tensile strength of concrete. In these tests, in general a compressive force is applied to a concrete specimen in such a way that the specimen fails due to tensile stresses induced in the specimen.

p

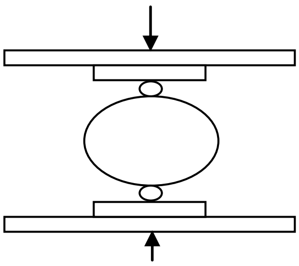


Fig 1 Cylinder split tensile test setup

The split tensile strength of cylinder is calculated by the following formula,

$$ft = 2P / \pi LD$$

Where,

ft = Tensile strength, MPa

P = Load at failure, N

L = Length of cylinder, mm

D = Diameter of cylinder, mm

Flexural Test:

Standard beams of size 150 x 150 x 700mm are supported symmetrically over a span of 400mm and subjected two points loading till failure of the specimen. The deflection at the center of the beam is measured with sensitive dial gauge on UTM. The two broken pieces (prisms) of flexure test are further used for equivalent cube compressive strength.

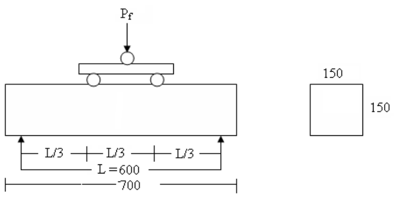


Fig 2 Two point loading setup in flexure test

(All Dimensions are in mm)
The flexural strength is determined by the formula

$$f_{cr} = \text{Pf L / bd2}$$

Where,

f_{cr} = Flexural strength, MPa
Pf = Central point through two point loading system, KN
L = Span of beam, mm
b = Width of beam, mm
d = Depth of beam, mm

B. Non Destructive test conducted on Concrete:

Rebound Hammer:

The most commonly used surface hardness procedure is the standard rebound hammer test. The test was developed in 1948 by Swiss engineer Ernst Schmidt and is commonly referred to as the Schmidt Rebound Hammer (Kolek, 1969). Upon impact with the concrete surface, the rebounded hammer records a rebound number which presents an indication of strength properties by referencing established empirical correlations between strength properties of concrete (compressive and flexural) and the rebound number.

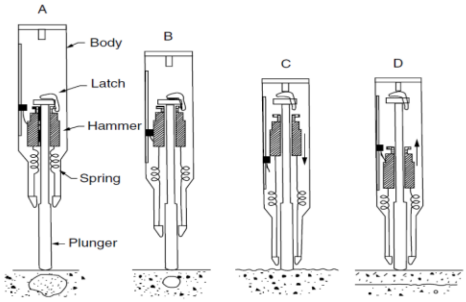


Fig 3 Rebound hammer

Ultrasonic Pulse Velocity Methods:

The method is based on measuring the velocity of compression stress waves P-waves. The pulse velocity is related to Young's modulus of elasticity by the well known law

$$Vp=\sqrt{\frac{Ed}{\rho}}\, f[v]$$

Where

Vp = velocity of compressional stress waves
Ed = dynamic Young's modulus of elasticity;
ρ = mass density
υ = Poisson's ratio
f (v) = function dependent on the shape and dimensions of the solid

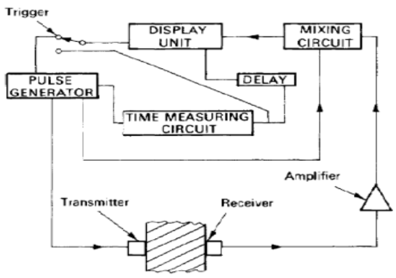


Fig 4 Typical UPV Testing Equipment

Pull-Out Bond Test:

Pull-out resistance methods measure the force required to extract standard embedded inserts from the concrete surface. Using established correlations, the force required to remove the inserts provides an estimate of concrete strength properties. The two types of inserts, cast-in and fixed-in-place, define the two types of pull-out methods. Cast-in tests require an insert to be positioned within the fresh concrete prior to its placement. Fixed-in-place tests require less foresight and involve positioning an insert into a drilled hole within hardened concrete.

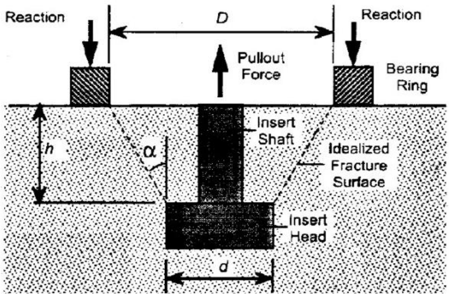


Fig 5 Pull out test

Advantages:-

The relationship between pullout strength and compressive strength is needed to estimate in place strength. Studies suggested that for a given test system there is a unique relationship. Therefore, the recommended practice is to develop the strength relationship for the particular concrete to be used in construction. A large number of correlation studies have reported that compressive strength is linear function of pull out strength. The locations and number of pullout tests in a given placement should be decided very carefully. The inserts should be located in the most critical portions of the structure and sufficient number of tests should be conducted to provide statistically significant results. The test is considered superior to the rebound hammer and the penetration resistance test, because large volume and greater depth of concrete are involved in the test.

Carbonation Test:

This test is carried out to determine the depth of concrete affected due to combined attack of atmospheric carbon dioxide and moisture causing a reduction in level of alkalinity of concrete. A spray of 0.2% solution of phenolphthalein is used as pH indicator of concrete.[23]Carbonation is the reaction of carbon dioxide in the environment with the calcium hydroxide in the cement paste. This reaction produces calcium carbonate and lowers the pH to around 9. At this value the protective oxide layer surrounding the reinforcing the steel breaks down and corrosion becomes possible. The most favorable condition for the carbonation reaction is when there is sufficient moisture for the reaction but not enough to act as a barrier.

V. CASTING AND TESTING

A. Compressive strength test for cube:

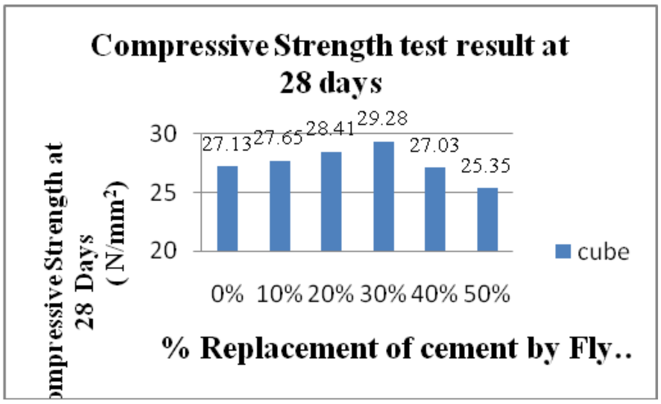
Photo No. 1 Compressive strength test for cube

Tab. No. 1 Compressive strength test for cube 28 Days

Sr. No.	% of Fly Ash	C/s Area (mm^2)	Load (kN)	Compressive Strength (N/mm^2)	Avg. Compressive Strength (N/mm^2)
1.	0%	22500	612.55	27.2	27.13
2.			618.05	27.4	
3.			603.00	26.8	
4.	10%	22500	624.10	27.73	27.65
5.			622.35	27.66	
6.			620.15	27.56	
7.	20%	22500	636.55	28.29	28.41
8.			642.25	28.54	
9.			639.65	28.42	
10.	30%	22500	656.00	29.15	29.28
11.			658.20	29.25	

12.			662.45	29.44	
13.	40%	22500	610.30	27.12	27.03
14.			606.75	26.96	
15.			608.00	27.02	
16.	50%	22500	604.05	26.84	25.35
17.			600.25	26.66	
18.			508.00	22.57	

Graph 1 Graph for Compressive Strength of Cube

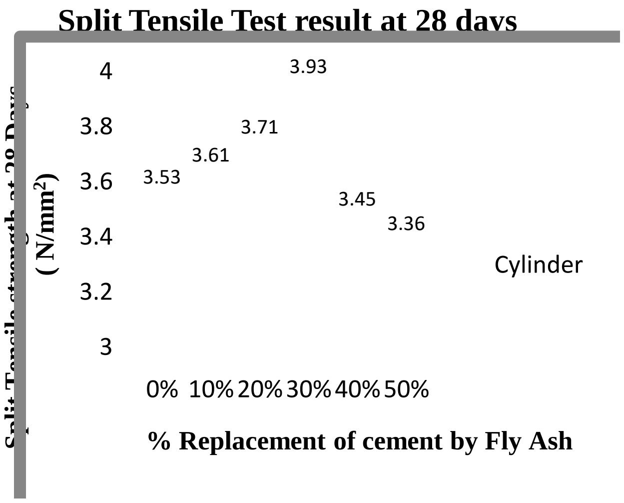


B. Split Tensile Test for cylinder:

Tab No. 2 Split Tensile Test for cylinder 28 Days

Sr. No.	% of Fly Ash	Load at Failure (kN)	Tensile Strength(N/ mm2)	Average Tensile Strength(N/mm2)	Remark
1.	0%	252	3.56	3.53	As per clause no.6.2.2 page no. 16 of IS: 456-2000 Split Tensile Strength of M20 grade concrete is **3.13 Mpa**
2.		250	3.53		
3.		248	3.50		
4.	10%	254	3.59	3.61	
5.		256	3.62		
6.		258	3.64		
7.	20%	260	3.67	3.71	
8.		262	3.70		
9.		266	3.76		
10.	30%	278	3.93	3.93	
11.		276	3.90		
12.		280	3.96		
13.	40%	246	3.48	3.45	
14.		244	3.45		
15.		242	3.42		
16.	50%	240	3.39	3.36	
17.		238	3.36		
18.		236	3.33		

Graph 2 Graph for split tensile Strength of cylinder

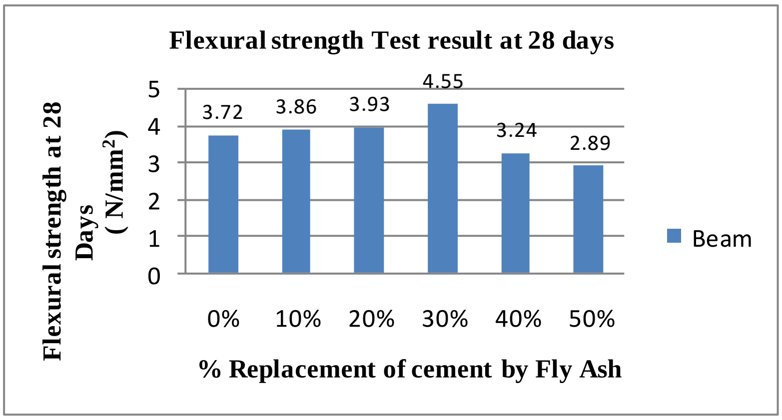


C. Flexural Test on beam

Tab No. 3 Flexural Test on beam 28 Days

Sr. No.	% of Fly Ash	Load at Failure (kN)	Flexural Strength (N/mm2)	Average Flexural Strength (N/mm2)	Remark
1.	0%	18	3.73	3.72	As per clause no.6.2.2 page no. 16 of IS: 456-2000 Flexural Strength for M20 grade concrete is **3.13MPa**
2.		20	4.14		
3.		16	3.31		
4.	10%	19	3.94	3.86	
5.		20	4.14		
6.		17	3.52		
7.	20%	22	4.56	3.93	
8.		16	3.31		
9.		19	3.94		
10.	30%	20	4.14	4.55	
11.		22	4.56		
12.		24	4.97		
13.	40%	15	3.11	3.24	
14.		18	3.73		
15.		14	2.90		
16.	50%	14	2.90	2.89	
17.		16	3.31		
18.		12	2.48		

Graph 3 Graph for flexure Strength of beam



D. Rebound Hammer Test:

Tab No. 4 Rebound Hammer Test

Photo no. 2 Rebound hammer test on cube

Sr. No.	% of Fly Ash	Rebound No.	Comp. Strength (N/mm^2)	Avg. Comp. Str. (N/mm^2)
1.	0%	37	28	26.66
2.		36	26	
3.		36	26	
4.	10%	39	32	30.00
5.		38	30	
6.		37	28	
7.	20%	40	33	31.66
8.		38	30	
9.		39	32	
10.	30%	42	38	37.00
11.		40	33	
12.		43	40	
13.	40%	35	24	25.33
14.		34	22	
15.		32	20	

16.	50%	34	22	22.00
17.		32	20	
18.		35	24	

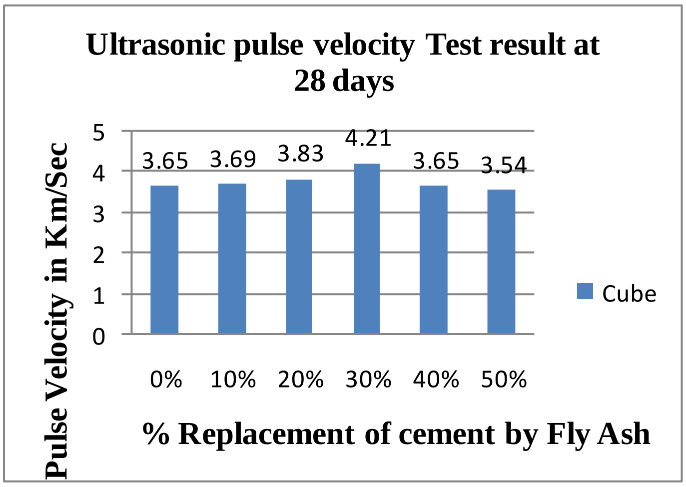
E.Ultrasonic Pulse Velocity Methods:

Photo No.3 Ultrasonic Pulse Velocity

Tab No. 5 *Ultrasonic Pulse Velocity* Test

Sr. No	% of Fly Ash	Transit Time In Micro Sec	Path Length In mm	Pulse Velocity By Cross Probing	Avg. Pulse Velocity (km/Sec)
1.	0%	41	150	3.65	3.65
2.		40	150	3.75	
3.		42	150	3.57	
4.	10%	40	150	3.75	3.69
5.		38	150	3.94	
6.		44	150	3.40	
7.	20%	44	150	3.40	3.83
8.		38	150	3.94	
9.		36	150	4.16	
10.	30%	35	150	4.28	4.21
11.		38	150	3.94	
12.		34	150	4.41	
13.	40%	40	150	3.75	3.65
14.		41	150	3.65	
15.		42	150	3.57	
16.	50%	42	150	3.57	3.54
17.		44	150	3.40	
18.		41	150	3.65	

Graph 6 Graphs for Ultrasonic Pulse Velocity Test



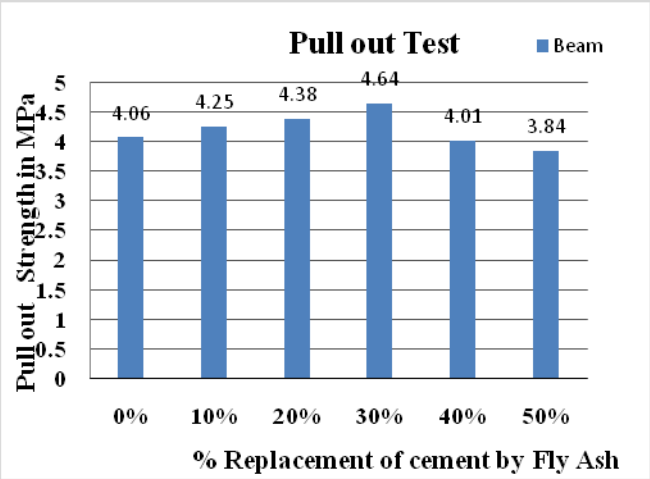
F. Pull out Test:

Photo No. 4 Pull out Test on beam

Tab No. 6 Pull out Test

Sr. No.	Specimen	% of Fly Ash	Load (kN)	Pull Out Strength (N/mm²)
1	Cube	0 %	128	4.06
2		10%	134	4.25
3		20%	138	4.38
4		30%	146	4.64
5		40%	126	4.01
6		50%	124	3.84

Graph 7: Graphs for Comparative Pull out Test



G. Carbonation Test:

Tab No. 7 Carbonation Test:

Sr. No.	% of Fly Ash	Indicator Used	Colour Changes To	Concrete Health
1.	0%	Phenolphthalein	Pink	Good
2.			Pink	
3.			Pink	
4.	10%	Phenolphthalein	Pink	Good
5.			Pink	
6.			Pink	
7.	20%	Phenolphthalein	Pink	Good
8.			Pink	
9.			Pink	
10.	30%	Phenolphthalein	Pink	Good
11.			Pink	
12.			Pink	
13.	40%	Phenolphthalein	Pink	Good
14.			Pink	
15.			Pink	
16.	50%	Phenolphthalein	Pink	Good
17.			Pink	
18.			Pink	

VI. CONCLUSION

1. Non Destructive material testing is extremely effective means for the manufacturer or operator of a technical plant to quickly draw a firm conclusion about the quality of his product or the condition of his plant.
2. This allows quality defects to be detected early and to prevent weaknesses causing disturbances of plant operation up to severe damage including unwelcome downtimes cause by component failure.
3. Using combine method of ultrasonic pulse velocity and rebound hammer gives better result than the only ultrasonic pulse velocity method.
4. The replacement of cement by fly ash in concrete also increases the rebound hammer test strength of concrete. It is clear that Compressive strength obtained from the rebound hammer test is excellent and increases with increment of Fly Ash up to 30%.
5. Velocity of an ultrasonic pulse passing through the concrete is more than 3.5 km/second which suggest that concrete quality is good. Due to good filling effect voids from the concrete reduces which increases velocity of ultrasonic pulse fly ash concrete.
6. The pull-out strength increases with the percentage increase of fly ash in concrete Beam. An increase of 4.67%, 7.88% and 14.28% strength was observed for 10%, 20% and 30% replacement of cement with fly ash respectively.
7. Use of Phenolphthalein indicator changed the color of hardened concrete to pink which indicates that concrete was not affected by the atmospheric carbon dioxide.

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