STRUCTURAL HEALTH MONITORING OF CONCRETE STRUCTURE USING NDT

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ABSTRACT

Structures are gatherings of load carrying members capable of safely shifting the superimposed loads to the foundations. Their main and most observed after things is the strength of the material that they are made of. Concrete, as we all know, is an primary material used for construction devotions. Thus, strength of concrete used, is crucial to be 'known' before starting with any kind of investigation. In the present preceding, several methods and techniques, called as Non-Destructive Evaluation (NDE) techniques, are being used for Structural Health Monitoring (SHM). The attentiveness of nondestructive testing (NDT) is to achieve material properties of in place specimens without the damage of the specimen nor the structure from which it is taken. However, one problem that has been main 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. For most cast-in-place concrete structures, construction provisions require that test cylinders be cast for 28-day strength determination. Usually, demonstrative test specimens are cast from the same concrete mix as the larger structural elements. The rebound hammer test is classified as a hardness test and is based on the principle that the rebound of an elastic mass be determined by on the hardness of the surface against which the mass impinges. The energy absorbed by the concrete is correlated to its strength. There is no exceptional relation between hardness and strength of concrete but experimental data relationships can be obtained from a given concrete. Though, the term "nondestructive" is given to any test that does not damage or affect the structural behavior of the elements and also leaves the structure in a suitable condition for the client. The consumption of the ultrasonic pulse velocity tester is presented as a device to monitor basic initial cracking of concrete structures and hence to present a threshold limit for likely failure of the structures.

***Keywords* -** NDT, Structural Health Monitoring, Audit, Repair, Rehabilitation.

1. INTRODUCTION

The definition shows the comparison between two systems in which one assume to represent the initial state and also and undamaged state. This type of issue is mainly focuses on the study of the identification of the damage in the structure. Therefore it can be concluded that the damage will affect the change in material and geometric properties of the structure which includes changes the boundary conditions and the connectivity's of the system which can effects badly the present and future performance of the structure.

To maintain the safety of the structure, structural durability and also the performance of the structure in the work that the efficient system of structural monitoring is instantly required. the quality and quantity of the structure during and after construction of the any new infrastructure and also for the renovated structure the characteristics of material properties and life span of structure is become very serious reason of worry. The NDT is the biggest and easiest solution for this kind of SHM issue. The NDT are generally used in many industries. In advance NDT methods are useful for the existing structures are available for every type of concrete structure. Therefore the objective of this research study is the availability, relevance, handiness, complexness, and the limitations of NDT. There are many methods that are currently being research for NDT. So this chapter is mainly gives attention on the NDT methods for the examination and checking of the concrete material.

2. Structural health monitoring:

Based on the past concrete structure ultrasonic testing theory, S transform time-frequency analysis methods were recognized. From the study, several assumptions can be drawn by Juncai Xu and Hai Wei (2019) are as follows: The S-transform algorithm is humble and easy to implement. Future work will be conducted on successful the applicability of the method in practice. Saman Farhangdoust and Armin Mehrabi (2019) study included a comprehensive literature review with a focus on NDT methods applicable to health monitoring of ABC closure joints. Lingzhu Zhou (2019) studied smart aggregate (SA) transducers, which can be used as both actuator and sensor, are employed to categorize the structural damage mechanism of basalt-FRP (BFRP) bars reinforced concrete beams. Time reversal method is accepted for increasing the signal-to-noise ratio (SNR), which is aimed at obtaining clear ampli- tude of focused signal. Joyraj chakraborty(2019) presents the investigations on the opportunity of utilizing autoregressive model, where the velocity of ultrasonic wave in a medium is needy on the operational state. Xinlin Qing (2019) paper conveys a brief suggestion of piezoelectric transducer-based SHM system technology established for aircraft applications in the past two decades. Development trend of SHM technology is also discussed. Bin Wang et.al. (2019) research gives information of, electro mechanical impedance based method, an imperative technique in structural health monitoring, was assumed to detect the bonding damage of carbon fiber reinforced polymer plate-strengthened steel beam by using lead zirconate titanate (PZT) transducers. Various methods are used for the analysis of the ultrasonic signals this study is done by Joyraj Chakraborty in2019.

Study of Wongi S Na(2016) proposes a new concept of employing UAV for structural health monitoring of civil infrastructures, using a vibration-based NDE method. Review paper by Divya P. Goswami (2016) Investigates why and how nondestructive testing (NDT) measurements can be used in order to evaluate on site strength of concrete. Kondapalli Harshada (2015) studied the objective of work is to take-out Structural Health Monitoring based on Non Destructive Testing. Darshak kumar Mehta (2015) studies the method of conducting structural health monitoring varies extremely with the type and usage of structures which needs to be examined. Dustin Pieper (2014) work focuses on the design and implementation of an embedded FSS sensor for detection of strain and buckling during displacement load testing of a novel steel-tube reinforced concrete column. Structural health monitoring is an essential characteristic of the transportation and infrastructure industries. Won-Jae Yi (2013) says that Critical structures such as aircrafts, bridges, dams and buildings need periodic inspections to guarantee safe operation. The experimental investigation using NDT methods showed that a good correlation occurs between compressive strength, SRH and UPV is studied by Mohammadreza Hamidian (2011). In this lesson, after a brief overview of the basic SHM concepts, the main fiber optic methods available for this application are reviewed; underlining the four most successful ones is reviewed by José Miguel (2011). It has been shown that defects such as disbands, delaminations and voids may be modeled as a spring beneath which is the sound structure whose belongings are unaffected studied by Wai Yie LEONG (2009).

3. Experimental investigations and Results:

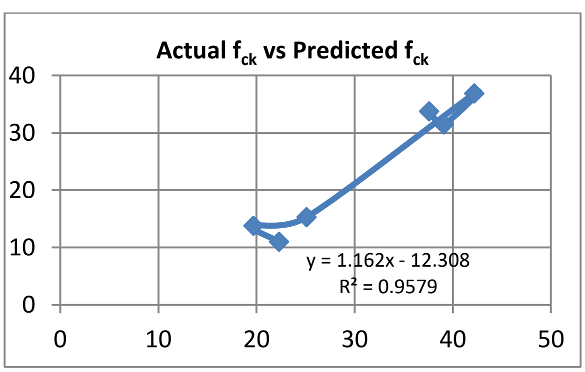
Rebound Hammer Test: The rebound hammer is very simple and handy to which we can used to deliver suitable and quick suggestions of the compressive strength of concrete. The rebound hammer has the spring control mass which slides on a plunger inside a tubular housing. This test gives the hardness of concrete which is based on the opinion that the rebound of a specimen is rest on the hardness of the surface against which the mass is imposes. The energy gain by the concrete is related to nothing bird its strength. There are some problems occurs during the rebound hammer test which may involves problem of impact which is related to stress wave propagation.

Ultrasonic Pulse Velocity test: The ultrasonic test method is established on the opinion that the velocity of ultrasonic pulse awesome over any material is dependent on the density, modulus of elasticity and poisons ratio of the material. Relative Lee the concrete quality is good in terms of density consistency and regularity if the velocity is higher. The ultrasonic pulse velocity is generally produced by and transducer. The pulses are as true into the concrete by using that transducers it experiences multiple reflections at the boundaries of different materials within the concrete. The Waves passing through the materials develops compressive wave transverse waves as well as surface waves.

Test results of Rebound Hammer Number:

Sr No	R_1	R_2	R_3	R_4	R_5	R_6
1	19	19	24	42	36	38
2	25	20	25	42	37	38
3	23	20	26	41	40	37
4	22	19	26	42	37	37
5	23	19	26	42	39	38
6	22	20	25	42	40	38
7	22	19	25	43	40	37
8	22	21	24	43	41	37
9	23	21	25	43	40	38
10	22	19	25	42	41	37
Mean	22.3	19.7	25.1	42.2	39.1	37.6
D.L.	150	150	150	150	150	150
B.L.	247	311.5	365.5	830	710	760
F_{ck}	11	13.8	15.3	36.88	31.5	33.8

Table 1: Rebound Hammer Testing Result

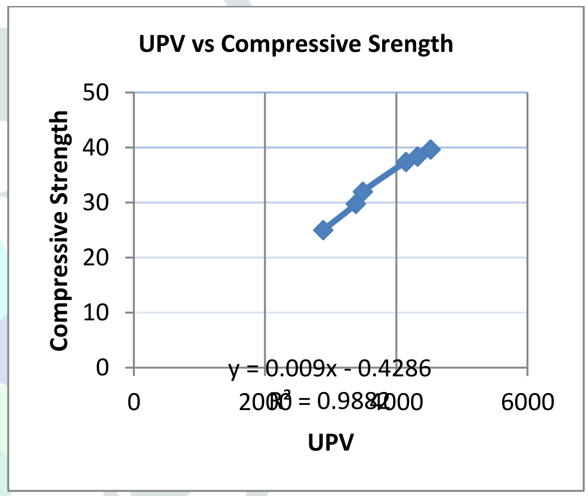


Graph 1: Calibration Graph for Rebound Hammer with its Equation

Test Results of Ultrasonic Pulse Velocity Test:

Sn	V	V	V	Mean	D.L.	B.L.	F_{ck}
1	2825	2916	2913	2884.67	150	562.5	25
2	3350	3585	3218	3384.33	150	669.8	29.77
3	3625	3632	3218	3491.66	150	720	32
4	4241	4213	4007	4146.33	150	841.5	37.4
5	4411	4444	4117	4324	150	875.5	38.4
6	4625	4525	4417	4522.33	150	893.2	39.7

Table 2: Ultrasonic Velocity Testing Result



Graph 2: Calibration Graph for Ultrasonic Pulse Velocity

Testing Results of Hall 2 and Hall 7

1. Beam 1 of hall 2:

Sr no	R.N.	Mean	UPV	F_{ck}
1st support	26	27	2620	20.3
	28			
	27			
Mid span	25	26.33	2729	20
	27			
	27			
2nd support	26	27	2645	20.3
	28			
	24			

Table 3: Readings of Beam 1 of Hall 2

2. Beam 2 of Hall 2:

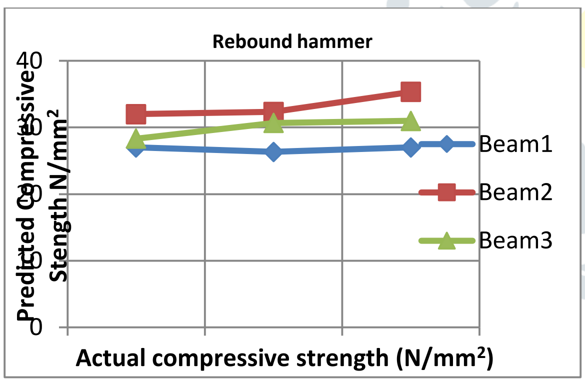
Sr no	R.N.	Mean	UPV	F_{ck}
1st support	26	27	2620	20.3
	28			
	27			
Mid span	25	26.33	2729	20
	27			
	27			
2nd support	26	27	2645	20.3
	28			
	24			

Table 4: Readings of Beam 2 of Hall 2

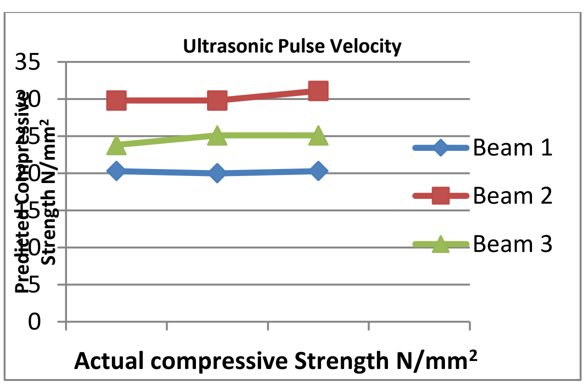
3. Beam 3 of Hall 2:

Sr no	R.N.	Mean	UPV	F_{ck}
1st support	28	27	2620	20.3
	28			
	27			
Mid span	25	26.33	2729	20
	27			
	27			
2nd support	29	27	2445	20.3
	28			
	24			

Table 5: Readings of Beam 3 of Hall 2



Graph 3: Rebound Test Result for Hall No 2 Beam



Graph 4: Ultrasonic Pulse Velocity test Result for Hall No 2 Beam

4. Slab 1 of Hall 2:

Sr no	R.N.	Mean	UPV	F_{ck}
Edge	47	45.33	5710	47.9
	45			
	44			
Mid Span	48	47	5764	49.3
	49			
	44			
Centre of slab	53	50.67	6229	52.6
	51			
	48			

Table 6: Result of slab 1 of Hall 2

5. Slab 2 of Hall 2:

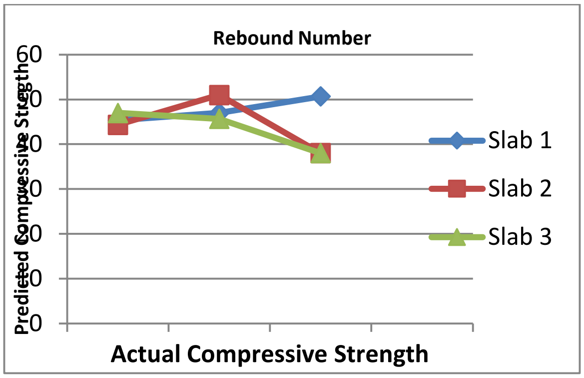
Sr no	R.N.	Mean	UPV	F_{ck}
Edge	47	44.33	4122	47.8
	42			
	44			
Mid Span	58	51	3890	52.4
	47			
	58			
Centre of slab	38	38	2667	40.5
	36			
	40			

Table 7: Result of slab 2 of Hall 2

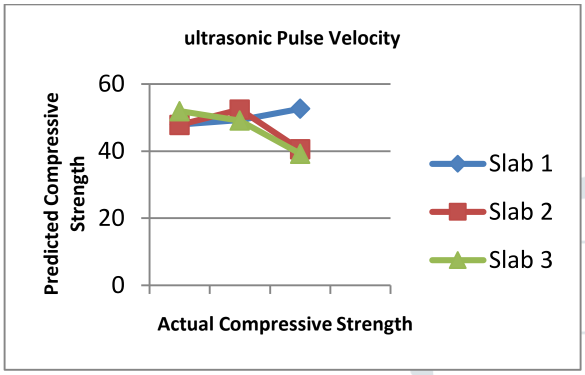
6. Slab 3 of Hall 2:

Sr no	R.N.	Mean	UPV	F_{ck}
Edge	45	47	5846	51.9
	46			
	50			
Mid Span	45	45.67	5760	49.1
	45			
	47			
Centre of slab	42	38	4832	39.1
	39			
	33			

Table 8: Result of slab 3 of Hall 2



Graph 5: Rebound Test Result for Hall No 2 slab



Graph 6: Ultrasonic Pulse Velocity test Result for Hall No 2 slab

7. Column 1 of Hall 7:

Sr no	R.N.	Mean	UPV	F_{ck}
Bottom	28	28.67	3313	22.52
	29			
	29			
Middle	13	13.67	2187	13.41
	14			
	14			
Top	15	15.33	1943	14.19
	16			
	15			

Table 9: Results of column 1 of hall 7

8. Column 2 of Hall 7

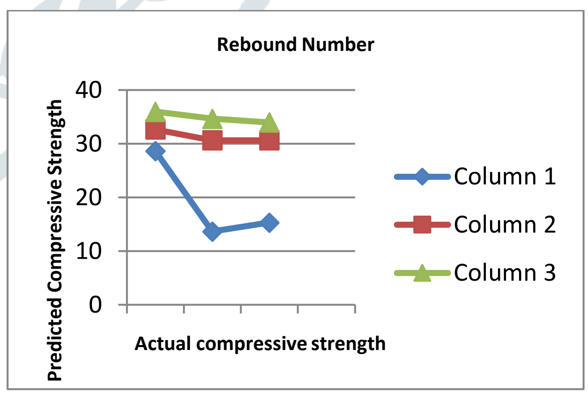
Sr no	R.N.	Mean	UPV	F_{ck}
Bottom	32	32.67	3754	31.3
	33			
	33			
Middle	30	30.67	3531	30.1
	32			
	30			
Top	31	30.67	3255	30.1
	31			
	30			

Table 10: Results of column 2 of hall 7

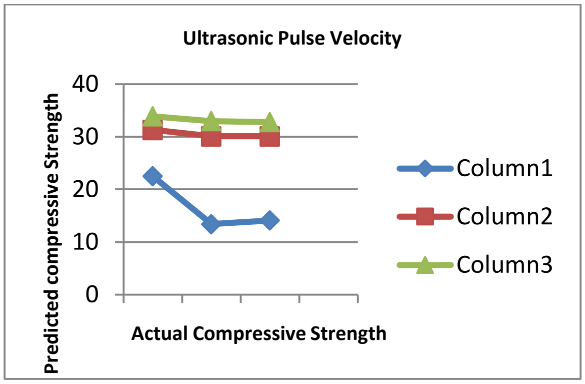
9. Column 3 of Hall 7:

Sr no	R.N.	Mean	UPV	F_{ck}
Bottom	36	36	3744	33.9
	36			
	36			
Middle	34	34.67	3828	33
	35			
	35			
Top	33	34	3614	32.8
	34			
	35			

Table 11: Results of column 3 of hall 7



Graph 7: Results of rebound number of columns of Hall 7



Graph 8: Result of Ultrasonic Pulse Velocity test of columns of Hall 7

10. Beam 1 of Hall 7:

Sr no	R.N.	Mean	UPV	F_{ck}
1st support	40	39	4468	39.9
	40			
	37			
Mid span	32	32.67	3455	29.9
	32			
	34			
2nd support	34	34.33	3480	30.8
	34			
	35			

Table 12: Results of beam 1 of hall 7

11. Beam 2 of Hall 7:

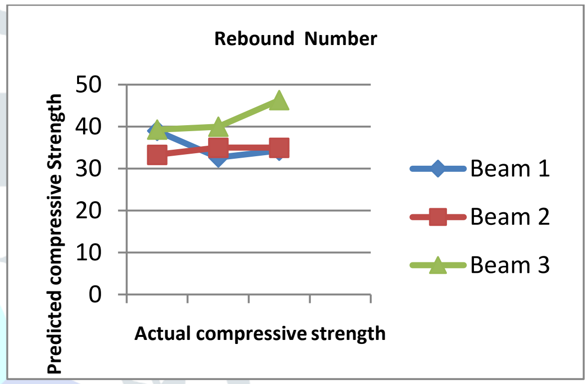
Sr no	R.N.	Mean	UPV	F_{ck}
1st support	33	33.33	3655	30.5
	35			
	32			
Mid span	34	35	3845	31.6
	35			
	36			
2nd support	34	35	3440	31.6
	37			
	34			

Table 13: Results of beam 2 of hall 7

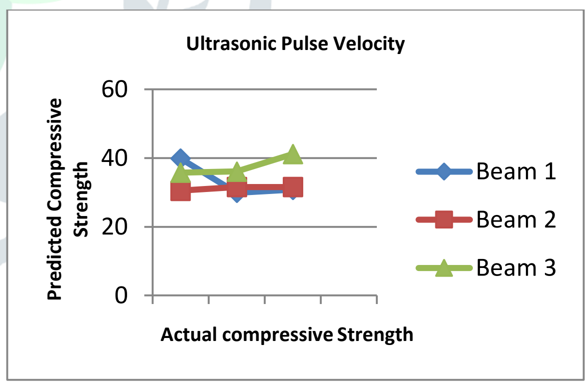
12. Beam 3 of Hall 7:

Sr no	R.N.	Mean	UPV	F_{ck}
1st support	43	39.33	4505	35.8
	39			
	36			
Mid span	38	40	4533	36.1
	45			
	37			
2nd support	45	46.33	4861	41.2
	49			
	44			

Table 14: Results of beam 3 of hall 7



Graph 9: Results of rebound number of beams of Hall 7



Graph 10: Result of Ultrasonic Pulse Velocity test of beams of Hall 7

13. Slab 1 of Hall 7:

Sr no	R.N.	Mean	UPV	F_{ck}
Edge	38	38.67	4257	34.3
	39			
	39			
Mid Span	36	35.67	3966	32.7
	35			
	35			
Centre of slab	34	34	3850	31.8
	34			
	34			

Table 15: Results of slab 1 of hall 7

14. Slab 2 of Hall 7:

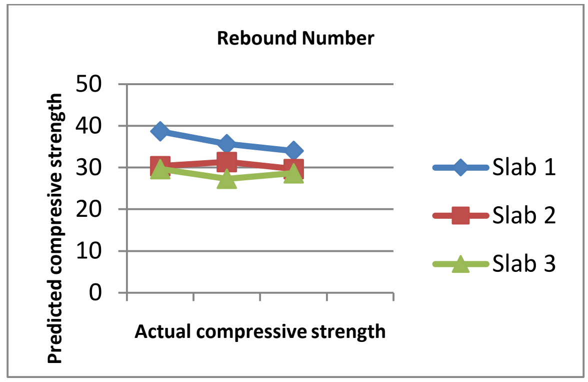
Sr no	R.N.	Mean	UPV	F_{ck}
Edge	33	30.33	4122	26.5
	30			
	28			
Mid Span	32	31.33	3890	27.2
	31			
	31			
Centre of slab	29	29.67	2855	25
	30			
	30			

Table 16: Results of slab 2 of hall 7

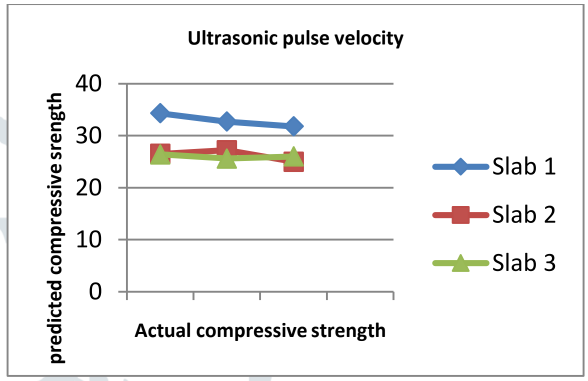
15. Slab 3 of Hall 7:

Sr no	R.N.	Mean	UPV	F_{ck}
Edge	30	29.67	4005	26.4
	33			
	28			
Mid Span	28	27.33	3825	25.6
	28			
	27			
Centre of slab	30	28.67	3988	26.4
	29			
	27			

Table 17: Results of slab 3 of hall 7



Graph 11: Results of rebound number of slabs of Hall 7



Graph 12: Result of Ultrasonic Pulse Velocity test of Slabs of Hall 7

Rebound Number	Concrete quality grading
45-50	Excellent quality
40-45	Good quality
30-40	Medium quality
20-30	Poor quality

Table 18: criteria for concrete quality grading of rebound hammer test

Sr no	Pulse velocity (km/sec)	Concrete quality grading
1	Above 4.5	Excellent quality
2	3.5 to 4.5	Good quality
3	3.0 to 3.5	Medium quality
4	Below 3.0	Poor quality

Table 19: criteria for concrete quality grading of ultrasonic pulse velocity test

4. Conclusion

For proper understanding of structural health the various NDT test are carried out depending upon the age of structure and the type of structure to predict the reliability of structure. in recent years the rebound hammer test and ultrasonic pulse velocity test are carried out on concrete structure to find out the standards of concrete and suitability of structure before applying the load on structure.

Act of formation of NDTV it will shows us the results of the structural health and it will show us the repair conditions for the structure. Do the categories for repair are different for different conditions and it may vary by different techniques and cost of repair.

From rebound hammer test results it shows that the various slabs shows the medium compressive strength which is up to 30N/mm^2 to 40 N/mm^2 which is required to be repaired extend or increase the strength of structure. And the results for beams and columns have an adequate compressive strength.

From the ultrasonic pulse velocity test some of the columns shows the results of velocity up to 3000 m/s which is ok but it will affect because of grading quality of concrete. The building shows the adequate strength.

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