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STRUCTURAL AUDIT OF RCC STRUCTURE

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Abstract
Civil engineering plays important role in the life of human being. To know the life of structure and to save human life structural audit is important. Structural audit is the health check-up of building. It gives an idea about structure's condition and their life. The health examination of concrete structure is called as "Structural Audit". Structures which age have a more than 30 years have reduced their strength due to material deterioration, that's why government agencies like-municipal Corporations are responsible for ensuring the safety of old buildings by conducting structural audits. Generally, buildings that are more than 30 years old are required to undergo mandatory structural inspection. The condition and durability of a structure depend largely on regular maintenance and timely evaluation. Even buildings older than 15 years can be considered for structural assessment to identify possible deterioration or damage. To evaluate the strength and quality of concrete, different testing techniques are used. These techniques are mainly classified into destructive and non¬destructive tests. In destructive testing, concrete samples are crushed in a laboratory to measure their compressive strength. Non-destructive tests, such as the Rebound Hammer Test and Ultrasonic Pulse Velocity (UPV) Test, are widely used on site to estimate the strength and quality of concrete without causing damage to the structure.
Keywords: Structural Audit, Structural Condition Assessment, Concrete Strength Evaluation, Non-Destructive Testing (NDT), Ultrasonic Pulse Velocity Test, Rebound Hammer Test.

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I. Introduction

Concrete is the most common material used for the construction. Concrete as a material has high adaptability to satisfy many aspects in structures, such as functional, economy, maintenance, aesthetic acceptability, protection against corrosive environments, protection against fire, explosion resistance, and provide better control

It gives an idea of current condition of building and as well as the life of building. In this case study we have conducted test on 3 structures to get better understanding of the strength of structure based on age of concrete and importance of maintenance of building. We have conducted two Nondestructive tests on structure i.e. Rebound Hammer and UPV Test.

II. Literature Survey

1] A.B. Mahadik This paper deals to create awareness among the civil engineers, resident at owners of building towards the health examination existing concrete building. To find out the

strength and durability of building so as to enhance its life duration or service life span. Structural audit generally done periodically by professional expert act immediately through recommendation provided in audits reports. The success of repair and retrofit is always based on types of problem, nature of problem and environmental conditions.

2] Shah I. H. has stated structural audit is an important tool for knowing the real status of the old buildings. The audit should highlight and investigate all the risk areas, critical areas and whether the building needs immediate attention. If the building has changed the user, from residential to commercial or industrial, this should bring out the impact of such a change. This Publication gives step by step guidelines for carrying out structural audit of old buildings.

3] Sachin Rambhau Shelke, Prof. Darshana Ainchwar This paper deals with a structural auditing & health monitoring of RCC building of G+22 floors which is located at Mumbai. The age of building was 18 years. The building was observed flat by flat. They observed defects like cracks, spells, crazing. Seepage, corrosion etc. They conducted ultrasonic pulse velocity test. For structural health monitoring applications, they used capacitance-based sensor to detect micro cracks.

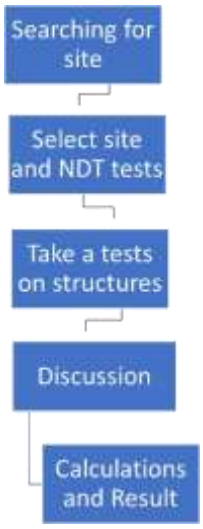
4] Sanket Sanjay Suryawanshi, Vaibhav Vishnu Vishe, Deepak Premchand Sah, Reetika Sharan In this paper, authors were tried to find out the faulty mechanism in structure to prevent the failure of building. The age of building was 28 years and also seen any damage or cracks on the structures. We used over deflection, etc. The structure gets older by the time it needs periodic check up to prevent future damages. The audit helps to investigate the problem in the structure. The health examination of concrete structures called as “structural audit”, is an overall health check-up of whole building. Structural audit is a technical survey of the building in order to check its strength and stability. The weather effect is present. They performed Rebound Hammer Test, Ultrasonic Pulse Velocity Test & carbonation test to check the performance of the structural components like beams, slabs, columns, internal & external walls.

5] Mostafa Kazemi in this study estimate the compressive strength of recycled aggregate concrete by using rebound hammer test. Rebound hammer test helps to identify relative surface weakness in cover concrete and to determine relative compressive strength of concrete. Casting cubes were tested under the controlled condition.

III. Methodology

Structural audit is done by using the non-destructive method. In this non-destructive method there are two tests are commonly using Rebound Hammer and Ultrasonic Pulse Velocity test. Visual Inspection is also method which is used for the structural audit. Rebound hammer test, used to evaluate the surface hardness of concrete and by using the Ultrasonic pulse velocity testing measure the sound velocity of the concrete and hence the compressive strength of the concrete. As regarding permissions for the tests which is performing on the structure as well as the availability of test apparatus, we selected the non¬destructive method. We performed a test on two types of RCC structures in that there is two water tanks and one residential building these two structures are existing structures.

Flow Chart:



to audit this structure because of these structures are 30 years old as per data we collected from the local authority and research papers.

Rebound Hammer Test:

Different types of rebound hammers are available with impact energies ranging from 0.07 kgm to 3.0 kgm. Hammers with higher impact energy are generally used for testing mass concrete structures, road pavements, and airport runways, while hammers with lower impact energy (0.07–0.09 kgm) are suitable for small structural elements and low-strength materials. Before conducting the test, the concrete surface should be clean and smooth. The hammer is pressed against the surface, and readings are recorded. Generally, six test readings are taken from each structural member to obtain reliable results. For example, in the case of a water tank, six readings are taken on both the inner and outer columns. Similarly, for a building structure, the test is usually carried out on the columns. During testing, the hammer is mostly held in a horizontal position, and the readings are noted based on the rebound value displayed by the instrument.

Ultrasonic Pulse Velocity (UPV) Test:

The Ultrasonic Pulse Velocity (UPV) method is a useful and reliable non-destructive testing technique used to evaluate the internal condition of concrete without causing any damage. The main objective of this method is to measure the speed of ultrasonic longitudinal waves passing

through the concrete. The velocity of these waves depends on the properties of concrete such as density, elastic characteristics, and overall mechanical strength.

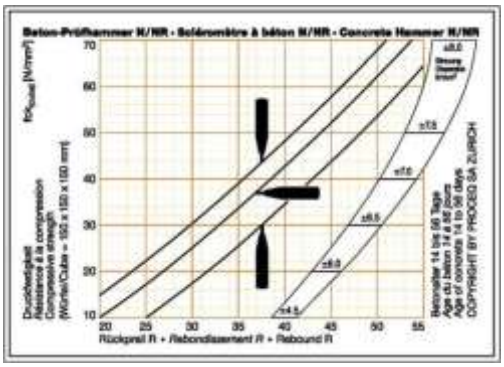
The UPV testing equipment mainly consists of a transmitter and a receiver. The transmitter generates ultrasonic pulses that travel through the concrete and are detected by the receiver. A signal or beep indicates the transmission of the pulse. The time taken by the pulse to travel from the transmitter to the receiver is recorded, and based on this time, the pulse velocity is calculated. This test helps in assessing the quality and uniformity of concrete and in detecting internal defects such as cracks, voids, honeycombing, or segregation. There are three common methods used for measuring ultrasonic pulse velocity in concrete: direct transmission, semi-direct transmission, and indirect

Visual Inspection:

For existing structures, presence of some feature requiring further investigation is generally indicated by visual inspection, such as weathering, chemical attack, mechanical damage, physical deterioration, abuse, construction deficiencies or faults and many others. Visual inspection is done by open eyes, while visual inspecting for the structures we don't have

IV. Result and Comparison

- **Rebound Hammer test:**



Rebound graph

Impact energy for rebound hammer as per IS: 516(Part 6/ Section4):2020

Average Rebound Number	Quality of Concrete
>40	Very Good Hard Layer
30 – 40	Good layer
20 – 30	Fair
<20	Poor

- **Ultrasonic Pulse Velocity Test:**

(surface) transmission. In many field conditions, the indirect transmission method is commonly used for testing concrete structures.

Result of Rebound Hammer Test for Tank 1

Sr. No.	Test Locations Tank-1	Angle of test	Rebound No. 1	2	3	4	5	6	Avg. Re-bound No.	Strength Of Concrete N/mm²	REMARK
	Column										
1.	Column-1	0	54	44	48	47	36	44	46	52	Good
2.	Column-2	0	50	46	47	44	40	43	45	50	Good
3.	Column-3	0	46	48	40	42	44	44	44	48	Good
4.	Column-4	0	52	44	48	40	44	47	46	52	Good
5.	Column-5	0	48	42	40	48	52	47	46	52	Good
6.	Column-6	0	54	48	47	44	48	40	47	54	Good
	Beam										
1.	Beam-1	0	50	44	44	48	42	45	46	52	Good
2.	Beam-2	0	46	42	40	44	48	48	45	50	Good
3.	Beam-3	0	44	48	42	47	44	40	44	48	Good

Result of Rebound Hammer Test for Tank 2

Sr. No.	Location Tank-2	Angle of test	Rebound No. 1.	2.	3.	4.	5.	6.	Avg. Re-bound No.	Strength Of Concrete N/mm²	REMARK
	Column										
1.	Column-1	0	54	49	48	48	46	50	49	57	Good
2.	Column-2	0	52	44	46	48	49	48	48	55	Good
3.	Column-3	0	48	46	48	52	44	50	48	55	Good
4.	Column-4	0	49	53	50	48	50	54	50	61	Good
5.	Column-5	0	52	48	50	46	52	49	49.5	58	Good
6.	Column-6	0	46	50	48	49	46	52	48	55	Good
	Beam										
1.	Beam-1	0	48	46	48	44	42	47	46	52	Good
2.	Beam-2	0	46	44	45	40	42	44	44	48	Good
3.	Beam-3	0	47	42	44	40	46	42	43	46	Good

Result of Ultrasonic Pulse Velocity Test for Tank2
Velocity criterion for Concrete Quality Grading as per IS 516 (Part 5/sec1): 2018

Sr. No.	Pulse Velocity by Cross Probing (Km/Sec)	Concrete Quality Grading
1.	Above 4.40	Excellent
2.	3.75 to 4.40	Good
3.	3.00 to 3.75	Doubtful
4.	Below 3.00	poor

Result of Rebound Hammer Test for RCC building

Sr. No.	Locations Building	Angle of test	Rebound No. 1.	2.	3.	4.	5.	6.	Ave Re-bound No.	Strength Of Concrete N/mm²	REMARK
	Column										
1.	Corner Column-1	0	31	41	31	35	36	46	37	36	Good
2.	Corner Column-2	0	34	32	44	36	40	35	37	36	Good
3.	Middle Column-1	0	32	36	42	40	33	36	36	34	Good
4.	Middle Column-2	0	35	37	42	38	32	38	39	39	Good

Result of Ultrasonic Pulse Velocity Test for Tank1

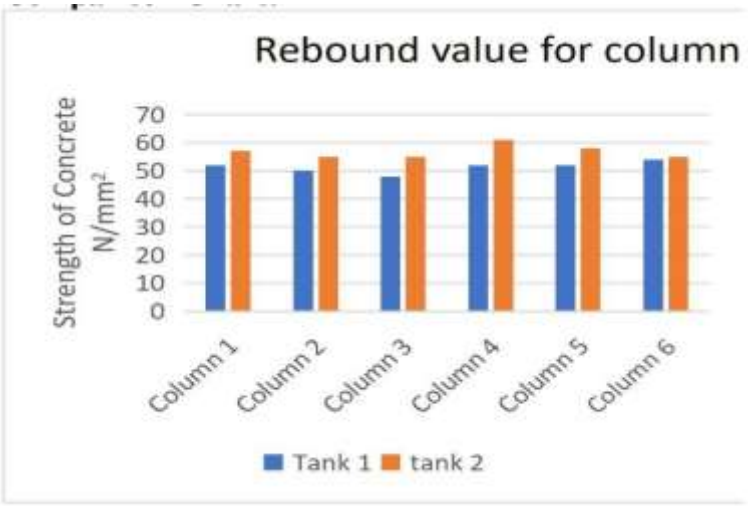
Sr. No.	Location Tank-1	Mode Of Test (Direct/ Indirect/ Semi Direct)	Path Length (mm)	Transit Time (Micro second)	Pulse Velocity (Km/ Sec)	Quality Of Concrete Based on Test Result
	Column					
1.	Column-1	Indirect	400	101.0	3.960	Good
2.	Column-2	Indirect	400	96.0	4.166	Good
3.	Column-3	Indirect	400	99.0	4.040	Good
4.	Column-4	Indirect	400	101.0	3.960	Good
5.	Column-5	Indirect	400	98.0	4.081	Good
6.	Column-6	Indirect	400	102.0	3.921	Good
	Beam					
1.	Beam-1	Indirect	400	104.0	3.846	Good
2.	Beam-2	Indirect	400	99.0	4.040	Good
3.	Beam-3	Indirect	400	101.0	3.960	Good

Sr. No.	Location Tank-2	Mode Of Test (Direct/ Indirect/ Semi Direct)	Path Length (Mm)	Transit Time (Micro second)	Pulse Velocity (Km/Sec)	Quality Of Concrete Based on Test Result
	Column					
1.	Column-1	Indirect	400	104.0	3.84	Good
2.	Column-2	Indirect	400	101.1	3.96	Good
3.	Column-3	Indirect	400	106.0	3.77	Good
4.	Column-4	Indirect	400	103.0	3.88	Good
5.	Column-5	Indirect	400	105.0	3.80	Good
6.	Column-6	Indirect	400	104.1	3.84	Good
	Beam					
1.	Beam-1	Indirect	400	101.0	3.960	Good
2.	Beam-2	Indirect	400	99.0	4.040	Good
3.	Beam-3	Indirect	400	102.0	3.921	Good

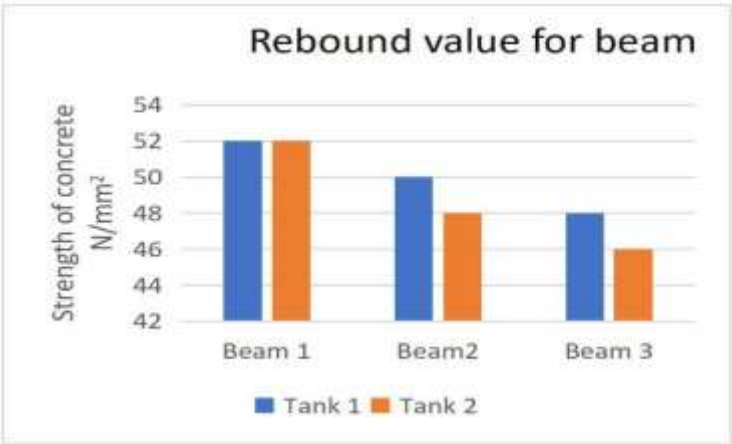
Result of Ultrasonic Pulse Velocity Test for RCC building

Sr. No.	Location / Building	Mode Of Test (Direct/ Indirect/ Semi Direct)	Path Length (Mm)	Transit Time (Micro second)	Pulse Velocity (Km/Sec)	Quality Of Concrete Based on Test Result
1.	Corner Column-1	Indirect	400	106	3.77	Good
2.	Corner Column-2	Indirect	400	104	3.846	Good
3.	Middle Column-1	Indirect	400	109	3.669	Doubtful
4.	Middle Column-2	Indirect	400	101	3.960	Good

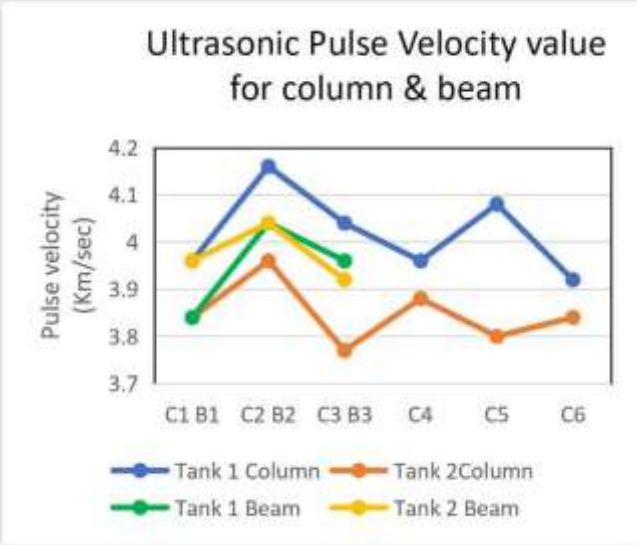
Comparison Chart:



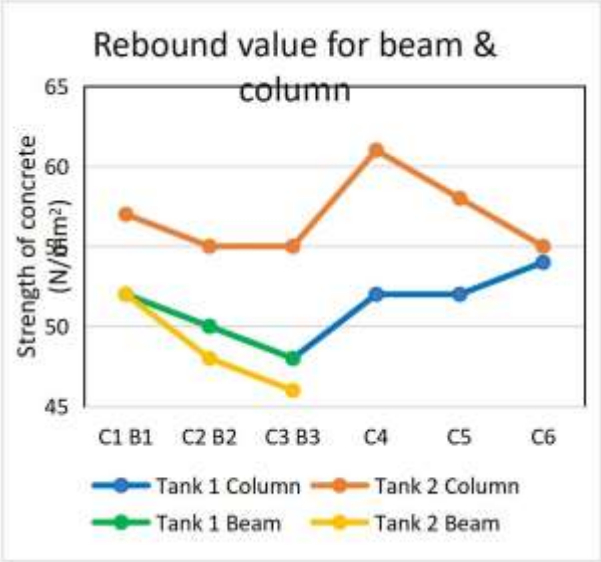
Rebound value comparison of column



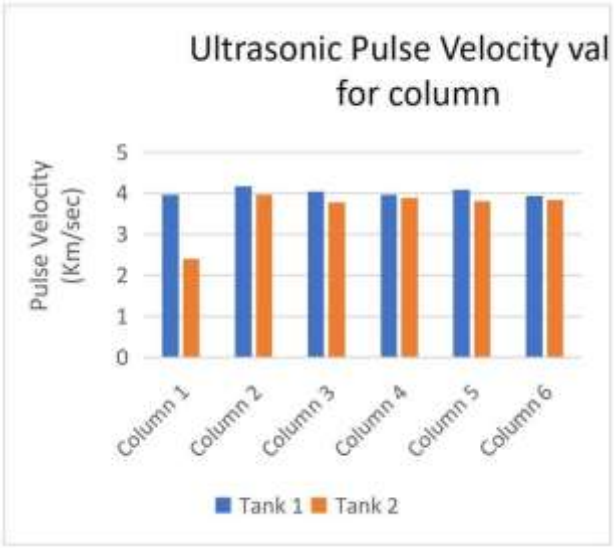
Rebound value comparison of beam and column



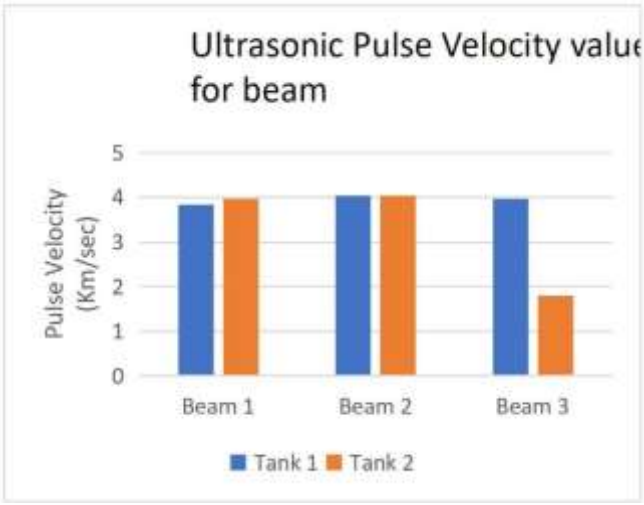
UPV value comparison of column & beam



Rebound value comparison of beam and column

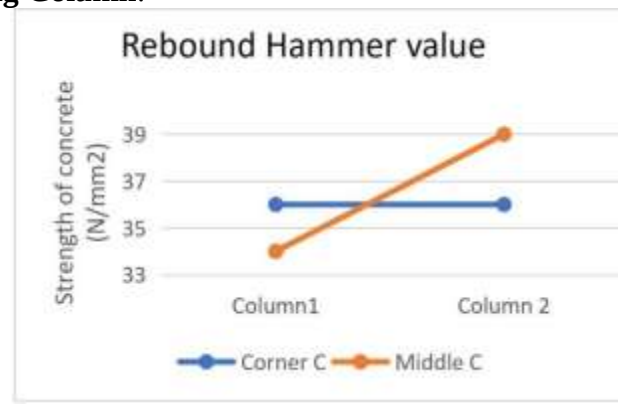


UPV value comparison of column

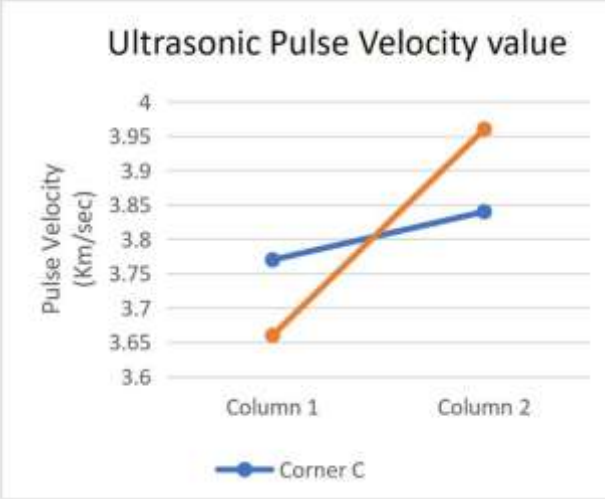


UPV value comparison of beam

Comparison of Building Column:



Rebound value comparison of building column



UPV value comparison of building column

V. Conclusion

- Rebound hammer and UPV was used to assess the quality. It was observed that concrete of structure component tested at site using rebound hammer showed the quality of both tanks tank 1 and tank 2 was good and it is fits for the stability of the structure.
- UPV test results for the same showed internal quality of concrete for both tanks were good. The rebound hammer test conducted at the site showed the quality of concrete used for column and beam for both tanks were good and it also fits for the stability of structure. For both tanks there is no necessary for repair as per the test results, but in visual inspection we seen cracks in plaster of the beam so it requires minor repairing.
- From the test result of rebound hammer for building, it was observed that compressive strength of concrete material for columns tested on site showed the quality of concrete was good and for ultrasonic pulse velocity showed quality of concrete vary between good to doubtful. Hence it can be concluded from present study the quality of concrete for construction or assessment of strength of existing building cannot be decided by results obtained from rebound hammer or ultrasonic pulse velocity only, for better assessment the result should be checked with the results from other advance instruments.

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