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Structural Health Monitoring using Non-Destructive Testing and Retrofitting of Old Structures

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ABSTRACT: Concrete is frequently utilized in construction. Reinforced cement concrete (RCC) has grown in popularity as a favoured building material during the past century. In India, RCC has been used extensively during the past five to six decades. During this time, a significant amount of infrastructure assets, such as buildings, bridges, towers, and other structures, have been built. A durable and rigid structure will result from a solid design. It is crucial to understand the true health of an old building or structure. It guarantees the security and safety of the structure and its surroundings. Verifying whether or not the structure is secure is helpful. It provides all the crucial details on the types of slabs, walls, beams, floors, foundations, and other structural components that are necessary to verify that any building complies with safety regulations. RCC decoration is a natural occurrence that has begun to appear in many different structures; to address this issue, a systematic method is required. locating the area of degradation, examining it, and using an affordable repair technique

KEYWORDS: Retrofitting; Non- Destructive test; Ultrasonic Pulse Velocity; Fiber Reinforced Polymer; Reinforced Cement Concrete

I. INTRODUCTION

Concrete is a popular construction material. Reinforced cement concrete (RCC) has been a popular building material over the last century. RCC has been widely employed in India throughout the previous five to six decades, during which time we have constructed a great number of infrastructure assets such as buildings, bridges, towers, and other structures. RCC decoration is a natural occurrence that has begun to appear in a large number of structures; a systematic strategy is required in dealing with such problems, such as identifying the case of degradation and the subsequent investigation and cost-effective repair procedure.

Structural health monitoring is at the forefront of structural and materials research. Engineers and inspectors can use structural health monitoring systems to obtain material information on buildings and structural components. Such data can be collected using ultrasonic techniques in structural monitoring programmes, which is especially valuable given that material properties can be inferred from wave properties. This method of testing can be used to determine the homogeneity and relative quality of the concrete, to detect voids and cracks, and to assess how well crack repairs worked. In addition, it can be used to assess the degree of degradation or cracking in a structure and to indicate changes in the properties of concrete. Ultrasonic wave speed reductions over time can indicate the beginning of degradation before obvious defects become apparent. This enables engineers and inspectors to carry out repair recommendations before small flaws become a safety risk.

The first step in successful repair and treatment is a precise diagnosis. Non-destructive testing techniques are described. Numerous non-destructive testing (NDT) procedures used to analyse concrete have their origins in the examination of more homogenous metallic systems. Although these procedures have a solid scientific base, the variability of concrete makes interpretation difficult. A variety of factors can influence measurement results, including materials, mixes, craftsmanship, and ambient influences. The results of the initial testing utilising the NDT technique will be a crucial factor in the structure's further testing.

Building retrofitting, maintenance, and strengthening is not only necessary for construction and management in metropolitan areas, but it also presents a challenge for structural engineering in property management disciplines.

Retrofitting is the process of modifying an already-existing structure, such as a building or bridge, to make it stronger. Strength of the building is generated for the structural dimension, material, shape and no of structural element.

STRUCTURAL AUDIT AND RETROFITTING

The inspection or examination of a building to determine its strength in order to improve its service life, safety, and efficiency is known as structural audit. The overall health and performance of a building are dependent on its quality and maintenance, and exposure to the environment can have a substantial impact on the health of the building.

1) Non-Destructive Testing

In addition to Visual Inspection and Tapping Observation, different Non-Destructive Tests can be used to verify the quality and strength of structural components. Various NDT instruments are utilised in concrete members to determine the current strength and quality of the concrete. The end product is useful in locating The treatment to be applied to structural members and the many types of tests available on the market are listed below.

2) Retrofitting

Retrofitting is the process of enhancing or changing current buildings, systems, or machinery to increase their functionality or energy efficiency.

II. RELATED WORK

- Address:Sahara A-26, G+2 BuildingNear Advent Electronics InternationalPvt. Ltd., Opp. VIIT College, Hagawane Nagar, Lane No. 6, Kondhwa Bk., Pune 411048.
- Age of Building: 12 Years Old.



Fig 1: Site Details

PRELIMINARY SURVEY

The building was examined flat by flat for observation and external area of the structure. Some of the column, beam and slab inside the section were inspected for a variety of defects such as cracks, spalls, seepage, all flaws marked on the observation with approximate area.

The most effective quantitative approach of evaluating structural soundness and identifying typical distress symptoms as well as the accompanying problem is visual assessment of the structure.

This gives an experienced engineer crucial information on the most effective quantitative approach to retrofitting structural soundness and detecting the usual discomfort symptoms as well as the accompanying problems through a visual evaluation of the structure.



Table :1 Position and Preliminary survey of site

Sr.No.	Description	Remark	Grade
A	Settlement		
1	Column	No Settlement	8
B	Cracks		
1	Column	Diagonal cracks and minor cracks	4
2	Beams	Hair cracks	7
3	Slab	Hair Cracks	7
C	Deflection		
1	Beam	NO deflection	8
2	Slab	NO deflection	9
3	Cantilever Deflection	NO deflection	9

Table 2: Criterion for Concrete Quality Grading (As Per Is 13311(Part 1): 1992

UPV Value km/sec. (V)	Concrete quality
Greater than 4.00	Excellent
Between 3.50 and 4.00	Good but porous
Between 3.00 and 3.50	Medium
Between 2.50 and 3.00	Poor
Between 2.00 and 2.50	Very poor and low integrity
Less than 2.00	No integrity, large void suspected

Ultrasonic pulse velocity test on concrete is a recognized NDT to assess the homogeneity of concrete with this ultrasonic test on concrete, following can be assessed

Quantities assessment or strength of concrete its gradation in different location of structural member and plotting the same. An ultrasonic instrument is a convenient, battery-operated, and transportable tool used to evaluate the quality of concrete or its elastic qualities.

III. PROPOSED METHODOLOGY

1. Condition survey:

Concrete is examined as part of a condition survey to find and define areas of distress.

2. Stages: -

Stages for carrying out condition survey largely depend on field condition.

This survey of building or structure generally undertaken in four different to identify the actual problem:

- Preliminary inspection
- Visual observation
- Destructive test observation
- NDT test observation



IV. DESCRIPTION OF THE PROPOSED ALGORITHM

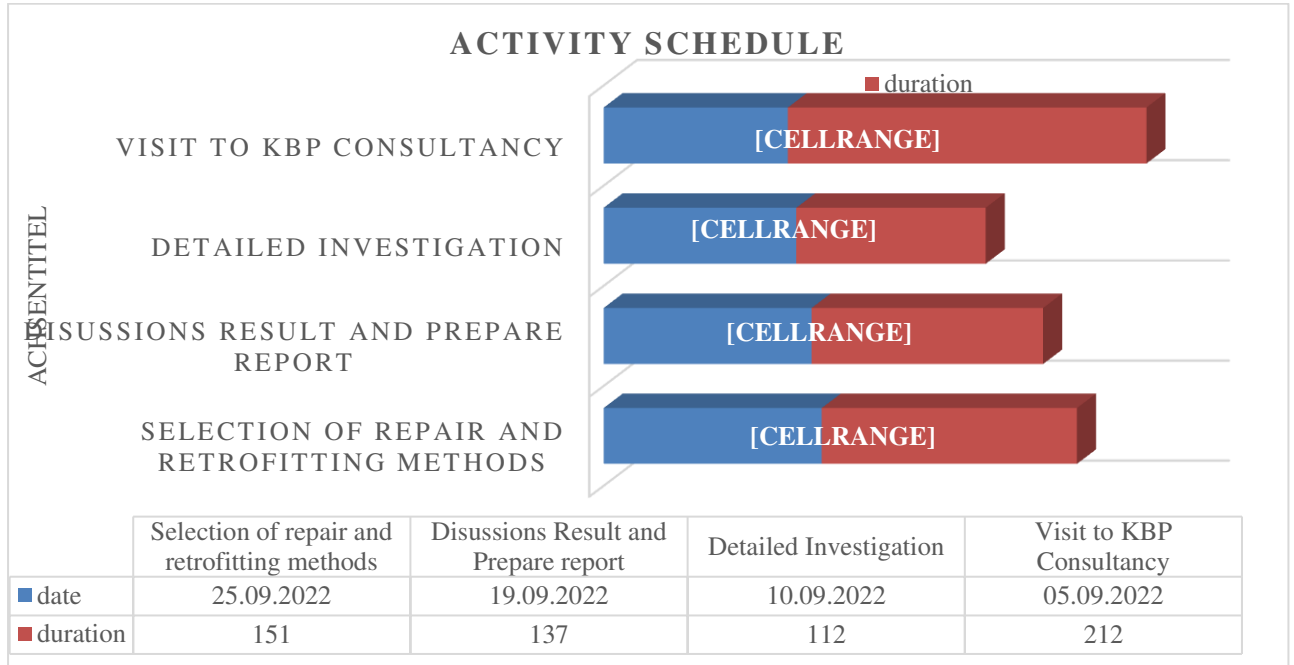


Fig 1: Site Details

Table 3: Schedule of activities done on site

Position	Start Date	End Date	Activity/Milestone
01	5/9/2022	20/2/2023	Visits to KBP Consultancy
02	10/09/2022	10/03/2023	Detailed Investigation
03	19/09/2022	24/03/2023	Discussions on Results And Preparation of Report
04	25/09/2022	10/04/2023	Selection of Repairing Process and Retrofitting methods
05	10/04/2023	20/04/2023	Completion Of Work

V. TEST RESULTS

Table 3: Rebound Hammer Number for Result for Slab

Sr. No.	Slab Level	Hammer position	Rebound No	Comp. Strength
1	S1	Vertically Up	29	10
2	S2	Vertically Down	20	10
3	S3	Vertically Down	22	10
4	S4	Vertically Down	26	11
5	S5	Vertically Down	24	12
6	S6	Vertically Down	20	10
7	S7	Vertically Down	26	11



In Rebound Hammer Test for slabs the results are by observed results the rebound hammer number is more at vertically up and Low at vertically down. Locations having verylow rebound numbers indicate weak surface concrete and may be affected by corrosion

Table4: Rebound Hammer Number for Column

Sr. No.	Column No	Column Size	Position	Rebound No	Avg	Hammer Position	C.S
1	C1	300X450M	BOTTOM	10	10.67	Horizontal	10
			MID	12		Horizontal	
			TOP	10		Horizontal	
2	C2	300X450M	BOTTOM	32	29.00	Horizontal	12
			MID	31		Horizontal	
			TOP	24		Horizontal	
3	C3	300X450M	BOTTOM	34	31.33	Horizontal	9.80
			MID	34		Horizontal	
			TOP	26		Horizontal	
4	C4	300X450M	BOTTOM	27	29.00	Horizontal	10.80
			MID	30		Horizontal	
			TOP	30		Horizontal	

In Rebound Hammer Test for column the results are by observed results the rebound hammer number is more at bottom, Average at mid and Low at top.

Table 5: Rebound Hammer Number for Beam

Sr. No.	Beam	Beam size	Position	Rebound No	Avg	Hammer Position	C.S
1.	B1	230X400	START	30	30.67	Vertically Up	10
			MID	30		Vertically Up	
			END	32		Vertically Up	
2.	B2	230X400	START	32	21.33	Vertically Up	8.20
			MID	20		Vertically Up	
			END	12		Vertically Up	
3.	B3	230X400	START	26	21.67	Vertically Up	8.60
			MID	20		Vertically Up	
			END	19		Vertically Up	
4.	B4	230X400	START	31	30.67	Vertically Up	9.60
			MID	29		Vertically Up	
			END	32		Vertically Up	
5.	B5	230X400	START	30	31.7	Vertically Up	9.85
			MID	31		Vertically Up	
			END	34		Vertically Up	

In Rebound Hammer Test for beam the results are by observed results the rebound hammer number is more at end, Average at mid and Low at start.



Table 6: Ultrasonic Pulse Velocity Test

Component	No.	Pulse velocity (km/sec)	Avg pulse velocity (km/sec)	Remark
Beam	1	3.1	3.3	Satisfactory But loss of integrity Is suspected
	2	3.5		
	3	3.3		
Column	1	3.7	3.7	Good to very good, slight porosity may exist
	2	3.5		
	3	3.9		
Slab	1	3.1	3.1	Satisfactory but loss of integrity is suspected
	2	3.0		
	3	3.3		

In Ultrasonic Pulse Velocity Test, the results are observed results the Average pulse velocity (km/sec) is more in column, average in beam and low in slabs.

IV. CONCLUSION AND FUTURE WORK

1. According to the visual inspection, the building exhibits a variety of minor damages and distresses, but considering the nature and extent of these issues, their condition can be classified as structurally stable, requiring only minor repairs to keep it in usable condition.

2. We have come to the conclusion that structural members or components are experiencing class three damage, which refers to observations such structural fractures, seepage, etc. To stop additional structural degradation, it is important to begin the major repairs as soon as feasible.

3. To keep the structure in excellent shape, necessary repairs and retrofitting should be carried out in accordance with standards.

4. The useful life of the structure might be extended by up to 10 years if the civil and structural repairs proposed in the suggestions are carried out using the right techniques, the right materials, and regular maintenance tasks.

5. In order to ensure adequate treatment of the parts that might display distress over its remaining usable life, timely maintenance is crucial.

6. The ability of beams and columns to carry axial loads and moments is improved using the RC retrofitting approach. The retrofitting technique therefore increases the axial load and moment bearing capacity of columns and beams, respectively.

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