IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 7, May 2023

Structural Audit of RCC Building

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Abstract: *Civil engineering forms the backbone of all structures that provide comfort to human life. Buildings have a finite lifespan during which they need to be maintained to remain in good serviceable condition. However, over time, all structures experience wear and tear, resulting in cracks, rusting of steel, and other signs of aging. To ensure the safety of the building and its occupants, it is essential to conduct regular structural audits using non-destructive testing (NDT) methods and adhering to Indian Standard (IS) codal provisions. Negligence during supervision, the use of substandard materials, and environmental factors can shorten a building's useful life. Therefore, a structural audit should be conducted every five years to preserve and renovate the existing structure, thereby increasing its safe life. This is a cost- effective way to extend the lifespan of a building instead of constructing new ones. NDT testsprovide information on the structure's current strength and other factors, such as rusting of steel, which is the most common reason for structural damage. Regular maintenance, including addressing wetness, leakages, and other environmental factors, is necessary to enhance the building's serviceability. Failure to maintain structures older than 30 years can endanger the lives of occupants and surrounding structures. Thus, structural auditing is essential to determine the current strength and serviceability of existing structures and carried out in accordance withestablished norms and standards.*

Keywords: Structural auditing, SHM, NDT tests, HRI, Rebound Hammer test.

I. INTRODUCTION

In India RCC has been used extensively since last 50-60 years. After the independence a rapid development in multi-storied infrastructure is seen. Also, after the independence, the construction activity in India has been increasing geometrically.Structural audit was first introduced by Indian society of structural engineers from 1975. Due to increase in population, peoplemigrating from village to cities therefore the population in cities increasing & number of people living in building are more than the actual design consideration. In India there are many old buildings which have reduced strength due to low quality material, improper techniques used in construction, the chances of failure of building are increased. The first step inrepairing process of building is structural audit. Structural auditing is the process in which health of building is checked. Structural audit also highlights and investigate risk areas, critical areas of building & also suggests if any urgent attention is required or not. Every structure has its own service life. Due to maintenanceof the structure health of the building increases. The building constructed usuallyreduces its strength when the building becomes older. Therefore, it is compulsoryfor all building to carry out structural auditing once in 5 years whose age is 15 to30 years & also for 3 years for building older than 30 years. If the structural condition gets bad, we can go earlier for structural auditing. The need of audit is to save life and building. The major issues that occurs in structural audit is that the people are not aware about the structural audit & its importance.

1.1 Structural Audit

A structural Audit is done to check the performance and serviceability of the structure over its usable life span. It assures the structure is safe without any risk. It looks and recommends suitable suggestions to maintain and renovate the existing building.It is necessary for a building to perform wellin its usable life span.

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1.2 Necessity of Structural Audit:

1. To enhance the usable life period of thestructure.
2. To identify the serviceability of the building.
3. To anticipate the life of the building.
4. To check the current strength of the structure.
5. To recommend the reclamation method.
6. To save human lives from any accidents.
7. To examine the critical member of the structure.

1.3 Objectives of Structural Audit:

1. To identify any structural weaknesses ordefects in the building that may compromise its stability or integrity.
2. To evaluate the current condition of the building and identify any signs of distress or damage that may require repairs or maintenance.
3. Execution of NDT tests.

II. LITERATURE SURVEY

"Structural Audit For An Educational Building", Abhinav Kale, Mahesh Gond, Pallavi Kharat

In this paper, authors were carried out the structural auditing of Sant. Tukaram Maharaj Vidyalaya which is located at Lohegaon, Pune. The shape of building is L-shaped, which RCC framed structure with two storied. The internal and external walls are made up of bricks. The authors were inspected external building faces, staircase, lobby, passage, rooms etc. From visual inspection and Rebound Hammer Test, they concluded that the building will require major repairs and the remainingmembers of the building need major up- gradation.

"Structural Audit of RCC Building", 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 structure. The authors carried out the structural auditing of RCC building i.e. Vidhata apartment of G+4 floors which is located at Thane. The age of building was 28 years and also the weather effect is present. They performed Rebound HammerTest, Ultrasonic Pulse Velocity Test & carbonation test to check the performance of the structural components like beams, slabs, columns, internal & external walls. They concluded that principle repairs are required at various levels, all the vegetation should be removed, minor cracks should be repaired by injection of Epoxy or by using grouting method, deteriorated plaster surface must be removed & plastering should be done with mortar proportions 1:3, corroded steel must be replaced wherever necessary.

"Structural Auditing with a CaseStudy", J.M. Sadamate, Dr. G.A. Hinge

This paper deals with a case study of RCC building i.e. Renuka Residency with G+8 floors which is located at Katraj. From visual inspection, they said that there is no serious problem in settlement of components, corrosion of steel and deflection of components. Also the seriouspart observed is leakage problems, dampness & even cracks. They conducted Rebound Hammer test, core cutting test, carbonation test. From carbonation test, they concluded that there will be chances of corrosion in near future. Also, they suggested some repairs in masonry work, waterproofing & tiling floorings. From visual inspection and NDT tests, it is cleared that repairs are required the buildings. At the time of performing NDT tests, it was observed that various columns and beams whose quality and strength is doubtful, jacketing should be done. From core tests, for first level slab, concrete should be classified as of M25 grade and M30 grade for first second level slab.

"Structural Audit: A Case Study of Nashik Residential Building, Maharashtra, India", K.R. Sonawane, Dr. A.W. Dhawale

The authors carried out the structural auditing of Malti-Vinayak building which is residential building & located at Lokmanyanagar, Gangapur Road, Nashik. They carried out visual inspection using scale, tape etc. They inspected external building faces, terrace etc. They carried out Rebound Hammer test & from that they concluded that the compressive strength of column (C2, C3, C4, C8, C10) and beam (B2, B3, B5, B7, B10, B11) is poor. Due to

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environment effect, spalling of concrete hasoccurred. Also there is corrosion of reinforcement in chajja & column (C6). From overall inspection, the authors suggested that the building should be repaired.

"Structural Audit, Repair and Rehabilitation of Building", Rohit Newale, Yogesh Sartape, Ashish Remane, Shreya Telrandhe, Sachin Vairal, Prof. Girish Joshi

This paper studied the present state of structure and major areas where improvement is needed during its service life stage for sustainable development and also the method of carrying out repair, rehabilitation and retrofitting. They carried out the structural auditing of RCC buildingof G+4 floors which is located at Pune. Theage of building was 27 years & there is effect of mansoon on building. The buildingwas visually inspected flat by flat. They carried out cover meter test, half cell potential test, ultrasonic pulse velocity test, petrography test, core test, water permeability test, chloride sulphate test & porosity test. The condition of the buildingappeared to be quite bad.

"Structural Health Monitoring, Audit and Rehabilitation of Building in Construction Building", 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. Overall study showed defects are due to combined effectsof carbonation, corrosion and effect of continuous drying & wetting.

III. METHODOLOGY

Literature survey for selection of topic

For final selection of topic thorough literature survey was done on the initial topics decided, and the already existing research work done on these topics were studied.

Problem statement

Determining the main problem anddeciding the method to deal with it.

Selection of topic for the Project

Final discussion on the topics was done and what new can be done was discussed and the final topic was decided.

Literature survey supporting topic ofproject

Thorough literature survey supporting the topic of project was done which made it very clear about the topic and what weshould do.

Study of plan of building

After deciding the topic study structural plan of the building. If the structural plan is not available, the same can be prepared by any Engineer.

Visual inspection

The visual inspection of a structure is the most effective qualitative method of evaluation of structural soundness & identifying the typical distress symptoms together with associated problems. The various points should be checked on inspection like settlement in the foundation,detect dampness in wall, cracks in column,beams, slab & walls, any sign of material deterioration, the various addition & alternation made, status of balconies- sagging, deflection, cracks, electrical wiring from main connection to all rooms, leakages from terrace & toilet block etc.

Identification of critical areas

Based on visual inspection the report should conclude the critical areas that needimmediate repairs and retrofitting.

NDT tests

To perform NDT tests depending upon defects in structure.

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Results

After performing NDT tests obtain theresults.

Site Photographs

After obtaining the results, we will analyze and final report of the project work will be prepared.Reference photos can be seen below

Fig. 1 – Spalling of paint

Fig. 2 – Horizontal Cracks

Fig. 3 – Cracks on wall

IV. EXPERIMENTAL RESULTS & DISCUSSION

General Information of Building

Basic Information	
Name of Building	Saraswati Complex
Address	Hadapsar, 411028
Building Survey	

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Name	Saraswati Complex
Mode of Use	Residential
Type of Structure	RCC Frame Structure
No. of stories	4
No. of lifts	1
Previous structural audit	This is first structural audit
Description of Building	
Floor height	3m
External walls	Bricks
Internal walls	Bricks
Survey	
Mode of survey	Visual inspection using scale & tape
Area Inspected	Ext. building faces, terrace, etc.

Table 1 – General Information of Building

Health Rating Index from Visual Inspection

Sr. No.	Description	VB	B	F	G	VG
A	**External Building Faces**					
1	**Columns & beam Cracks, bulging, corrosion**		**4**			
2	**Drainage & Rainwaterpipes Leaking, broken**				**8**	
3	**Water supply pipes**				**8**	
4	**Paint Weathering, fading**			**6**		
B	**Staircase, Lobby & Passage**					
5	**Columns, beams, slabs,parapets Cracks, dampness,vegetation**				**8**	
6	**Paint Weathering, fading**				**8**	
C	**Terrace**					
7	**Terrace slab Seepage into flats below**			**6**		
8	**Loading Overloading**				**8**	

Table 2 – HRI from Visual Inspection

Where,
VB: Very Bad – 2B: Bad - 4
F: Fair - 6 G: Good - 8
VG: Very Good - 10

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From visual inspection, the ratings are given as 2, 4, 6, 8 & 10. Add the scores and divide it by8 to get Health Rating Index (HRI).

HRI = (4+8+8+6+8+8+6+8)/8 = 56/8HRI = 7.0

As per visual inspection HRI becomes 7.0 that means condition of building under visualinspection is good

Rebound Hammer Test

Rebound Hammer test is a Non-destructive testing method of concrete which provides a convenient and rapid indication of the compressive strength of the concrete. The rebound hammer is also called a Schmidt hammer that consists of a spring-controlled mass that slides on a plunger within a tubular housing. A concrete with low strength and low stiffness will absorb more energy to yield a lower rebound value.

Sr. No.	Location			Rebound Value	Quality of Concrete
	Member	Identification Mark	Position		
1	Column	A10	Top	38.00	Good
2	Column	A10	Bottom	33.00	Good
3	Column	B3	Top	25.00	Fair
4	Column	B3	Bottom	21.00	Fair
5	Column	B7	Middle	26.00	Fair
6	Column	B9	Top	29.00	Fair
7	Column	B9	Bottom	28.00	Fair
	First Slab – Beams				
8	Beam	A3 - B3	North	20.00	Fair
9	Beam	A3 - B3	South	25.00	Fair
10	Beam	A9 - B9	North	25.00	Fair
	First Slabs				
11	Slab	A7, A8, B8	S1	29.00	Fair
12	Slab	A6, A7, B6	S2	30.00	Fair

.Table 3 – Rebound Hammer Values

Fig. 5 – Rebound Hammer

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

Table 4 – Quality Standards

V. CONCLUSION

After conducting a visual inspection and non-destructive testing (NDT) on the building, it has been concluded that repairs are required. Minor cracks should be repaired through injection of epoxy or grouting. The building is classified as having class 3 damage, which includes observations such as structural cracks and seepage. However, the Health Rating Index indicates that the overall condition of the building is good. During NDT testing, various columns, beams, and slabs were found to have doubtful quality and strength, as shown in tables 3 and 4. To address this issue, jacketing

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should be done. The core extraction test shows that the strength of the concrete is in good condition, and the carbonation test indicates that the building is not suffering from corrosion activity. Proper repairs and retrofitting should be carried out in accordance with specifications to maintain the building's healthy condition.

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