

Structural Audit: A Need of an Hour

Rushabh Karnavat¹ Vivek Singh²

¹Structural Engineer ²C.E.O.

^{1,2}Creative Consultants, Mumbai

Abstract— Structural audit is a complete health and performance check-up of structures. The need of structural audit is for maintenance and repairs of existing structures whose age has more than of 15 years. It is important to the building or any structure to check their safety. Structural audit is an important for knowing the real health status of the heritage buildings or structure. It is process of analyses of building and this process suggest an appropriate repairs and retrofitting measures required for the better performance of the building service life. There are many buildings have reduced strength in period of long time because of structural deficiency, material deterioration, unexpected over loadings or physical damage. There is demand of appropriate actions and measures for all such building structures to improve its performance and restore the desired functions of structures which may leads to increase its functional life. The periodical structural auditing and analysis for health of existing buildings is very important for finding the present status of structures. The structural audit must be carried out auditing norms, methods of non-destructive testing and code provisions.

Key words: Structural Audit, Non-Destructive Test, repairs and controls

I. INTRODUCTION

There are many building structures which have reduced strength after the period of long time. Use of such deteriorated structure it may cause danger the lives of the surrounding habitation. Appropriate techniques should be executed to improve the better performance of structures and reestablished the desired function of structures. The health examination of concrete building called as "Structural audit"

Structural Audit is an important tool for knowing the real status of the existing building structures. Thus, it is important to perform structural audit of existing building structures and to implement maintenance/ restoration work after suitable time which will help for prolonged life of the building structure and safety of the surroundings.

It should highlight and investigate all critical portion and recommend immediate suggestive remedial and preventive measures. It also helps in carrying a strong building structure with cost effective solutions and appropriate maintenance program.

II. STRUCTURAL AUDIT

A. What is Structural Audit?:

Structural audit is a complete health and performance checkup of the building structures. Structural Audit is an important tool for knowing the real status of the existing building structures. It examines the critical portion of the structures and suggests appropriate retrofitting techniques required for the durability and serviceability point of view. It ensure that the premises of the structures are safe and have no risk.

B. Purpose of structural audit:

- To save human life and Property
- To understand the condition of building and to project the expected future life.
- To comply with municipal and statutory requirements
- To proactively assist the residents and the society to understand the seriousness of the problems and the urgency required to attend the same
- To enhance life cycle of the building structure by suggesting preventive and corrective measures
- To find critical portion to repair immediately

C. Why structural audit?:

Structural audit mainly carried out for:

- As a Statutory Requirement:-
 - After every 5 years as per Inspector of factories
 - After 30 years at every 5 years as per Municipal Act
 - After 15 years at every 5 years and after 30 years at every 3 years as per Co- operative society act
- For insurance
- For Bank-Mortgage
- For Valuation
- Structure showing Distress
- Proposed Addition, Alterations Extensions in building / structure
- For Damage assessment due to earthquake, fire, blast, vibration, corrosion etc.

D. Stages in Carrying Out Structural Audit:

- 1) Visual Inspection
 - 2) Non-Destructive Testing
- 1) *Visual Inspection:*
- a) General information of the building
 - Name and Detailed Address of building
 - Number of stories in each wings/ blocks of building
 - Year of construction of building
 - Description of main usage of building i.e. Residential, Commercial, Institutional, etc.
 - b) Structural System of the building
 - Sub structure: Settlement of columns or foundations, Deflection and cracks in Retaining wall, Soil bearing capacity through trial pits or from adjacent soil data
 - Super structure: Identification of the critical structural members like columns, transfer beams, slender members, rusting of exposed steel and its extent. Verify which materials used and framing system of structure
 - Mention the status of all building structural elements like beams, slabs, columns, likewise balconies, canopy, chajja, parapet wall and railings relating to deflection, cracks, leakages, spalling of concrete, exposure of steel, corrosion of steel etc. etc.
 - Identify the status of water tank, staircase, lift and lift machine room.

- c) Addition or Alterations in the building
 - Identification of change of occupancy
 - Alteration or addition of partition walls
 - Alteration or addition in loadings- stacking
 - Alteration or addition of toilets, water tank
 - Alteration or addition of balcony
- d) Dampness and leakages
 - Detect the dampness, seepage marks in walls
 - Identify the leakages in Terrace, toilets, plumbing lines, drainage lines and overhead water tanks.

2) Non-Destructive Testing:

Non-Destructive Testing (NDT) is a wide group of analysis techniques used in science and technology industry to inspecting, Testing, or Evaluating materials, components or assemblies for discontinuities, or differences in characteristics without destroying the serviceability of the part or system.

In other words, when the inspection or test is completed the part can still be used.

The terms Non-destructive examination, Non-destructive inspection and Non-destructive evaluation are also commonly used to describe this technology, because NDT does not permanently alter the component being inspected, it is a highly valuable technique that can save both money and time in product evaluation, troubleshooting, and research.

Types of Non-Destructive tests for RCC structure :

- 1) Ultrasonic Pulse Velocity Test (UPV)
 - 2) Rebound Hammer Test
 - 3) Half-Cell Potentiometer Test (HCP)
 - 4) Carbonation Test
 - 5) Chemical Test viz. pH, Cl₂, SO₃
 - 6) Core Cutting test
 - 7) Cover Meter test
 - 8) Permeability Test
- 3) Why N.D.T.?
- a) Concrete Strength
 - Ultrasonic Pulse Velocity Test: To evaluate homogeneity of concrete, to assess strength of concrete qualitatively, to determine structural integrity
 - Rebound Hammer Test: To measure surface hardness of concrete, to find the compressive strength
 - Core cutting Test: To calculate compressive strength, permeability, density of concrete.
 - b) Chemical Attack
 - Carbonation Test: To measure depth of carbonation
 - Chloride Test: To evaluate total water/acid soluble chloride contents
 - Sulphate Test: To assess total water/water soluble sulphate contents of concrete
 - c) Corrosion Potential Assessment
 - Cover Meter: To measure cover of reinforcement, diameter of reinforcement and spacing of reinforcement
 - Half Cell Method: To determine probability of corrosion in the implanted steel
 - Permeability Test: To assess permeability of concrete due to water and air

E. How structural Audit is carried out:

1) Steps to be followed in Structural Auditing:

Step 1: One Should Must Have All Architectural And Structural Plans/Drawings Of The Buildings. It Will Be Helpful If We Have Detailed Structural Calculations Including Assumptions For The Structural Design.

Step 2: If the Architectural plans and Structural plans are not available, the same can be prepared by Engineer by measuring the size of the building. & locating the position of the columns, beams and size of all such structural elements.

Step 3: Inspection of the Building –

A detailed visual inspection with photographic survey of the building structure externally and internally can reveal the Following:

- 1) Any settlements in the foundations.
 - 2) Status of Architectural features viz. Chajja, fins, canopies etc.
 - 3) Cracks in walls indicating swelling in R.C.C. members or deflection or corrosion.
 - 4) Cracks in R.C.C. members i.e. columns, beams and slabs etc.
 - 5) Spalling of concrete and exposed steel reinforcements
 - 6) Extent of corrosion in reinforcement.
 - 7) Slight tapping using hammer to find out deterioration in concrete.
 - 8) Status of Balconies – sagging, deflection, cracks.
 - 9) Changes carried out affecting structure. Toilet blocks - Added or changes made? Change of user – from Residential to Commercial to industrial? Change of Partition Walls?
 - 10) Leakages from terrace & Toilet blocks.
 - 11) Leakages & dampness in walls resulting into plaster cracks and corrosion.
 - 12) Status of repairs & last repaired and what was that
- Occupation Certificate available?
Structural Plans available?
Structural Stability Certificate available?
Structural Calculations available?

Step 4: Tests Recommended:

It is important that various tests are carried out in the existing buildings. This will give an idea about the extent of corrosion, distress and loss of strength in concrete & steel.

Step 5: Preparation of Audit Report:

On the basis of visual inspection and Non-Destructive testing of building, an Audit Report is prepared. Suggested remedies should be included in the structural audit report.

Step 6: Highlight the critical areas in distress mapping plans and how to go for repairs, methodology, proving Standard operating procedures (SOP)

For e.g.

- 1) No. of columns requiring immediate attention including treating rusted steel, adding new steel, jacketing of columns etc. – Repairing foundations, repairing balconies, Chajja.
- 2) Need to retrofit for beams and slabs wherever required.
- 3) Required water proofing of terrace, toilet blocks.
- 4) Attending cracks in external walls and providing good quality of paint. The critical areas highlighted need to be repair immediately.

F. General Format of the Structural Audit Report:

1) Introduction:

Sr.No.	Description	Remark
1	Type of bldg. structure	
2	Age of building	
3	No. of wings	
4	No. of stories	
5	No. of flats	
6	Mode of use	
7	Architectural Plan Available	
8	Structural Plan Available	
9	Building Plan Approval Date	
10	Occupation Certificate Date	
11	Last Repair Date/History	

Table 1:

2) Visual Observation:

Sr.no.	Description	Remarks
Sub Structure		
1.	Foundation/Footing Strata	
	Settlement of Columns	
	Settlement of Walls	
	Cracks in Columns , Walls, Joint at Plinth	
Super Structure		
2.	Super Structure Inspections	
	Cracks in columns/ rusting of steel , / exposed steel	
	Cracks in beams/ rusting of steel , / exposed steel	
	Cracks in slabs / rusting of steel, / exposed steel	
	Cracks in external walls	
	Cracks in internal walls	
3.	Leakages & dampness in external walls	
4.	Toilet leakages, cracks	
5.	Terrace water proofing inspection	
6.	Leakage & dampness on the top floor slab	
7.	Inspection of water tank above terrace	
8.	Inspection of underground water tank	
9.	Leakages & damages:-plumbing lines/waterlines, drainage lines	

Table 2:

III. CONCLUSIONS

The structural diagnosis is vast, important and highly responsible job which is connected with lives of human beings. For any load bearing or R.C.C. framed structure, structural audit is very necessary. It is mandatory and advisable to carry out the periodical structural audit of the buildings by professional experts – Consulting Civil & Structural Engineers and perform immediately through recommendations provided in their audit report to safeguard the structure. The effective implementation of suggestive remedies provided in the audit report will ultimately increases the life span of structure, prevents deterioration of building leading to sustainability. For every CHS building structure more than 15 years old structural audit is necessary once in

five years. If building older than 30 years, once in a 3 years structural audit should be done considering serviceability & durability point of view

REFERENCES

- [1] M. J. Monteiro and N. J. Pathak (2011), Article in International Journal of Earth
- [2] Sciences and Engineering, ISSN 0974-5904, Volume 04, No 06 SPL, October 2011, pp. 677-680.
- [3] J. J. Shah (2008), Article in The Indian Concrete Journal, pp. 17-26.
- [4] Indian Standard: 13311:1992 (Part 1) NDT methods of Test- Ultrasonic Pulse Velocity.
- [5] Indian Standard: 13311:1992 (Part 2) NDT methods of Test- Rebound Hammer.
- [6] ACI 546R-04 – Concrete repair guide.
- [7] ACI 562-12 - Code Requirements for Evaluation, Repair, and Rehabilitation of Concrete Buildings.
- [8] Indian Standard: 456: 2000- Plain and Reinforced Concrete – Code of Practice (Fourth Revision).
- [9] Indian Standard: 516: 1959- Method of test for strength of concrete.
- [10] Shah I.H. (2008), “Structural Audit of Existing Buildings”, Structural Audit & Suggested Formats 2008
- [11] A.B Mahadik and M.h Jaiswal, “Structural Audit of Buildings”, International Journal of Civil Engineering Research, Vol.5, Issue 4, pp: 411-416, November 2014
- [12] Building and Construction Authority, “Periodic Structural Inspection of Existing Buildings”, January 2012 Central PWD, “Handbook on repair and rehabilitation of RCC Buildings”, July 2010