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Structural Audit of Buildings

A.B. Mahadik[1] and M.H. Jaiswal[2]

[1]Structural Engineer, Structural Department, MWH Global, Bajaj Brand View, Wakdewadi, Pune, Maharashtra, India.
[2,] Structural Engineer, Structural Department, MWH Global, Bajaj Brand View, Wakdewadi, Pune, Maharashtra, India.

Abstract

This paper deals to create awareness amongst the civil engineers, residents and owners of building towards the health examination of existing concrete buildings called as Structural Audit. The need of structural audit is for maintenance and repairs of existing structures whose life has exceeded the age of 30 years to avoid any mishaps and save valuable human life. The concrete is widely used as construction material being inexpensive, easy for construction, applications and because of it high strength-cost ratio. More than ever, the construction industry is concerned with improving the social, economic and environmental parameters of sustainability. In India, from 1980 onwards the infrastructure industry witnessed stepping up of public investment and growth in infrastructure industry which results in construction of new multistory concrete apartments which are now in the age of thirty plus years. There are many buildings during this period and earlier have reduced strength in due course of time because of structural deficiency, material deterioration, unexpected over loadings or physical damage. If, further use of such deteriorated structure is continued it may endanger the lives of occupants and surrounding habitation. 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 diagnosis for health of existing buildings is thus utmost important for finding the present serviceability and structural viability of structures. The structural audit must be carried out following auditing norms, methods of non-destructive testing and code provisions. The structural

auditing will help to implement maintenance and repair work timely which leads to prolonged life of the building and safety of the occupants.

Keywords: Structural Audit; Non Destructive Testing; Repair; concrete.

1. Introduction

In India there are many old buildings which have reduced strength in due course of time. If further use of such deteriorated structure is continued it may endanger the lives of the occupants and surrounding habitation. Appropriate actions should then be implemented to improve the performance of structures and restore the desired function of structures. Thus, it is utmost important to perform structural audit of existing buildings and to implement maintenance/ repair work timely which will lead to prolonged life of the building and safety of the occupant. To act more responsible and preemptive towards the dilapidated buildings, the municipal corporation must issue notices to the buildings and co-operative societies which are more than 30 years old to carry out mandatory structural audit and submit the audit report. Structural audit should highlight and investigate all critical areas and recommend immediate remedial and preventive measures. It should cover the structural analysis of existing frame and find critical elements for all types of loadings. It also helps in delivering a strong building structure with cost effective solutions and appropriate maintenance program. This paper deals with study of different parameter of structural audit including visual inspection, non-destructive testing, core sampling and testing. It also emphasizes on different repairs and retrofitting measures to be used for buildings after structural audit.

2. Structural Audit

2.1 What is Structural Audit?

Structural Audit is an overall health and performance checkup of a building like a doctor examines a patient. It ensures that the building and its premises are safe and have no risk. It analyses and suggests appropriate repairs and retrofitting measures required for the buildings to perform better in its service life. Structural audit is done by an experienced and licensed structural consultant.

2.2 Purpose of Structural Audit

- To save human life and buildings
- To understand the condition of building
- To find critical areas to repair immediately
- To comply with statutory requirements
- To enhance life cycle of building by suggesting preventive and corrective measures like repairs and retrofitting

2.3 Bye-Laws

As per clause No.77 of revised Bye-Laws of Cooperative Housing Societies: "The Society shall cause the 'Structural Audit' of the building as follows:

- For building aging between 15 to 30 years once in 5 years
- For building aging above 30 years Once in 3 years

3. Stages in Carrying Out Structural Audit

3.1 Study of architectural and structural drawings, design criteria, design calculations, structural stability certificate of existing structures

3.2 If architectural and structural drawings are not available, as built drawings can be prepared by an engineer

3.3 Visual Inspection

3.3.1 Need of visual inspection

- to recognize the types of structural defects
- to identify any signs of material deterioration
- to identify any signs of structural distress and deformation
- to identify any alteration and addition in the structure, misuse which may result in overloading

3.3.2 Scope of visual inspection

The inspection report should reveal the following listings along with photographs and sketches.

a) General information of the building

- Name and address of the building
- Number of stories in each block of building
- Description of main usage of building viz. Residential, commercial, institutional
- Maintenance history of the building

b) Structural System of the building

- Sub structure: Settlement of columns or foundations, Settlement of walls and floors, Deflection and cracks in Retaining wall, Soil bearing capacity through trial pits or from adjacent soil data
- Super structure: Materials used and framing system of structure, identification of the critical structural members like floating columns, transfer beams, slender members, rusting of exposed steel and its extent.
- Mention the status of all building elements like beams, slabs, columns, balconies, canopy, false ceiling, chajja, parapet and railings with respect to parameters deflection, cracks, leakages and spalling of concrete.

- Likewise, verify 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 in walls
- Identify the leakages in Terrace, toilets, plumbing lines, drainage lines and overhead tanks.

3.4 Non Destructive and Destructive Testing

In addition to visual inspection, the real strength and quality of a concrete structure need to be checked with non-destructive tests. A number of non-destructive tests (NDT) for concrete members are available to determine present strength and quality of concrete. Some of these tests are very useful in assessment of damage to RCC structures subjected to corrosion, chemical attack, fire and due to other reasons. These tests have been put under four categories depending on the purpose of test as under:

3.4.1 Concrete Strength

- Rebound Hammer Test: To measure surface hardness of concrete
- Ultrasonic Pulse Velocity Test: To assess homogeneity of concrete, to assess strength of concrete qualitatively, to determine structural integrity
- Core Sampling and Testing: To measure strength, permeability, density of concrete.

3.4.2 Chemical Attack

- Carbonation Test: To assess depth of carbonation and pH of concrete
- Chloride Test: To assess total water/acid soluble chloride contents
- Sulphate Test: To assess total water/water soluble sulphate contents of concrete

3.4.3 Corrosion Potential Assessment

- Cover Meter: To measure cover of reinforcement, diameter of reinforcement and spacing of reinforcement
- Half Cell Method: To assess probability of corrosion in the embedded steel
- Permeability Test: To assess permeability of concrete due to water and air

3.4.3 Homogeneity and integrity Assessment

- Ultrasonic pulse velocity for determination of cracks and discontinuities

3.5 Core Testing

This is direct method of assessing strength of concrete. In this method cylindrical core samples are taken from existing structures. The cores are visually inspected and tested in laboratory to check its compressive strength.

3.6 Pushover Analysis

Generally Push over analysis is used to understand the existing capacity of structure for seismic and gravity loading which will show different occupancy levels like immediate occupancy, life safety and collapse prevention. The seismic evaluation of existing buildings compares their capacity against earthquake demand at specific site and concerns the potential earthquake-caused risk to building systems and elements that are closely related to human life safety.

3.7 Identification of critical areas in building

Based on the above inspection, analysis and test results, the report should conclude the critical areas that need immediate repairs and retrofitting. For example: number of columns requiring immediate repair and strengthening, repair of critical slab and beams, water proofing of terrace, toilet blocks, cracks in walls or structural elements etc.

4. Post Structural Audit

4.1 Repairs

Based on the audit findings and recommendations different measures of repairs and strengthening are carried out. According to ACI 546R-04, to repair is to replace or correct deteriorated, damaged, or faulty materials, components, or elements of a structural system. From this point of view, repair may be divided into structural repair and serviceability repair. The former refers to the restoration of lost sectional or monolithic properties of damaged members, while the later refers to the restoration of structural surfaces to a satisfactory operational standard.

Obviously, poor design, poor construction, poor maintenance, incorrect usage, new environmental influences or an intended increase of the loading or extension of the structure’s lifespan can make repair and/or strengthening necessary.

Excluding technical considerations, the ultimate choice of method of repair and strengthening of a concrete structure may also be influenced by factors like overall quality of repairs and the size of individual repairs, access for repair, relative cost, ease of application, available labor skills and equipment and client requirements including future maintenance and economic considerations

4.2 Strengthening and Retrofitting

Strengthening is the process of restoring the capacity of damaged components of structural concrete to its original design capacity, or increasing the strength of structural concrete. Strengthening of a concrete structure may be required due to several reasons:

- Change of usage which may cause over-stress in the structural member.
- Serious materials and structural deteriorations which cause structural members to be no longer able to carry the imposed loads with an adequate factor of safety
- To increase the capacity for seismic resistance if the building is not designed for it or the structure does not fulfill current design requirement corresponding to seismic zones, R factor or so.

Strengthening of structural members can be achieved by replacing poor quality or defective material with better quality material, by attaching additional load-bearing material, such as high quality concrete, additional steel, thin steel plates, various types of fiber reinforced polymer sheets, and so on, and by the redistribution of the load such as by adding a steel supporting system. The purpose of strengthening is to increase the load-carrying capacity or stability of a structure with respect to its previous condition.

5. Conclusion

The structural diagnosis is vast, important and highly responsible job which is connected with lives of human beings. It is mandatory and advisable to carry out the periodical structural audit of the buildings by professional experts and act immediately through recommendations provided in audit report. The success of repairs and restoration is always based on thorough knowledge, correct diagnosis and in-depth studies of problems in building, proper repair practices and finally socio-economic considerations. The effective implementation of auditing enhances the life span of structure, prevents deterioration of building leading to sustainability.

References

[1] M. J. Monteiro and N. J. Pathak (2011), Article in International Journal of Earth Sciences and Engineering, ISSN 0974-5904,
[2] 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.