

Structural audit of new Rajendra Vihar & estimation of Repairs

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Abstract - Structural Audit is defined as a preliminary technical survey of a building to assess its general health as a civil engineering structure. It is usually initiated as the first step for repair.

A methodology for Structural Audit was first presented by the Indian Society of Structural Engineers. Structural Audit is an important tool for knowing the real status of the old building.

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.

This paper defines the structural audit of the residential building and also the suggestions for the repair that will enhance the life of the building.

1. INTRODUCTION

A financial audit - a professional CA who examines the accounting procedures, the controls, the finances of the "board/association and its fiscal strength. Similarly, structural audit is the examination of the structural strength and functioning of the building.

Structural Audit: -

1. Structural Audit is -defined as a preliminary technical survey of a building to assess its general health as a civil engineering structure. It is usually initiated as the first step for repair. A methodology for Structural Audit was first presented by the Indian Society of Structural Engineers.
2. Conducting Structural Audit is similar to Annual Health Monitoring & so it is advisable to do structural audit every 10 years. Mumbai Municipal Corporation makes it mandatory every

3 years for residential buildings more than 30 years old.

2. LITERATURE REVIEW

J. Bhattacharjee, et.al. (1) {1999} Mr. Bhattacharjee 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 bldg. 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. Monteria, J., Pathak, N.J. {2001} They have estimated the soundness of existing structures whose life has crossed the age of thirty years. Concrete constructions are generally expected to give trouble free service throughout its intended design life. The deterioration of buildings can be a result of various factors including fire damage, frost action, chemical attack, corrosion of steel etc. during the life span of the structure. The investigation of soundness is thus essential for finding the present serviceability of the structure and its scope for future developments or for the change in its utilization.

Kishor Kunal, et. al. (2014) This paper talks about how visual inspection of cracks can be helpful in order to identify and categorize them with respect to various parameters by taking case study of an institutional building. He has concluded that some prevention could be taken care of during the construction process itself. Any lack of attentiveness can lead to a cause for damage in the building in its future, which can also lead to the failure of structure. Cracks may occur due

to various reasons, as discussed earlier. The occurrence of cracks cannot be stopped but particular measures can be taken to restrict them to reduce the level and degree of consequences. Generally speaking, for causes and prevention of cracks in any particular case it is necessary to make careful observations and to collect detailed information in the form of a checklist

Sanket.S.Suryavanshi.et al (2018) The paper gives a complete study on structural repair report carried by author. As per the author, Building was inspected as per each flat internally as well as externally. Defects were observed in columns, slabs, beams, walls and conditions of structural components were return in the sheet. At the same time photographs were taken by the author to collaborate with defects visually. By the investigations surveys they came to know that health condition of building is fair. With the NDT's conducted it was concluded that structural members are suffering from class 3 damage. According to CPWD (Central public works department) class 3 damage stands for observation like spalling of concrete cover, structural cracks etc., in which principal repairs are required. So as per observations, Principal repairs were needed to be started as early as possible to avoid further deterioration of the structure. Quality of RCC found was poor as per the result of rebound test and UPV test performed at various locations, so the recommendation was to start repair work which included strengthening of column, plastering works of defected areas and water proofing, etc. Also, rectification of leakage should be in various location of top floors Delay in works could increase the quantity of work due to continuous deterioration the structure

B.H Chafekar, O.S Kadam, K.B Kale.et al (2014) Gives us the methods to inspect a building. Also, they have focused mainly on Visual inspection of a building. The points to be taken into consideration for visual inspection of a building. The various points have been listed to check the building. The paper also talks about the purpose of carrying out the audit of a building for various reasons like to save lives and property, to know the future life of the building and for municipal bylaws consideration.

K.R. Sonawane, Dr. A.W. Dhawale had stated the general health and performance of building depends on its quality of maintenance. As a building grows old ageing, use (misuse) an exposure to the environment

can affect the health of building significantly. Therefore, it is advisable to monitor it periodically by taking professional opinion Structural Audit is preliminary technical survey of building to assess its general health as a civil engineering structure. It is usually initiated as the first step for repair this is similar to periodic health checkup recommended for older people.

3. OBJECTIVE

Structural audit heavily focused on the safety for personnel and product that are intended to identify conditions requiring repair, structural efficiencies, corrosion that affects the structural integrity, fall protection deficiencies, ladder, platform and all the building deficiencies.

Objectives of our project are:

1. To study the type of structural defects.
2. To identify any sign of deterioration in the material.
3. To perform proper Non-Destructive Test on a structure and to estimate areas of critical repairs.
4. Performing appropriate repairs based on tests result conducted and estimation of repairs cost.
5. Estimation of cost for remedial measures which are to be taken for repairing of the structure and increase its value.

4. METHODOLOGY

Structural Audit is a preliminary technical survey of a building to assess its general health as a civil engineering structure. It is usually initiated as the first step for repair. The format of auditing changes from structure to structure and also from auditor to auditor. We have adopted a basic format which covers the essential parts of the structural auditing of a framed RCC structure in this project.

Visual inspection: -

Visual inspection is a careful and critical examination, especially for flaws. The term itself derives from the Latin inspection, meaning to examine carefully or look closely into. In fact, inspection is typically a deliberate, in-depth, exacting process that requires more than mere looking or scanning. The inspection process may be done using such behavior as looking, listening, feeling, smelling, shaking, and twisting.

Tapping Observation: -

Some of the columns & beams inside the building were subjected to Tapping by hammer, Visual and Non-Destructive testing methods. The hollow sound was recorded in the observation sheets as damages.

4.1 Types of Testing's

A. Destructive Testing

Test 1 Concrete Core Test

To measure strength, permeability, density of concrete.

Application:

These tests are primarily done to obtain the compressive strength of the concrete sample, in addition, the density of the concrete sample is also obtained.

Concrete Core tests are done-In accordance with Indian standards IS: 1199 and IS: 516

Procedure:

1. The exact position from where the core can be extracted from the concrete member is determined using a rebar mapping device so as to avoid the reinforcing bars within the concrete member.
2. Concrete core of diameter of at least three times the maximum nominal size of coarse aggregate to obtained using 2 core cutting machine.
3. The obtained cores are capped on both sides in the laboratory using epoxy mortar. The capped surfaces shall be at right angles to the axis of the specimen and shall not depart from a plane by more than 0.05 mm.
4. The core fs then placed in water at a temperature of 24° to 30°C for 48 hours before testing.
5. The core is then subjected to compression forces on a compression testing machine. The breaking point is observed & noted.
6. The obtained compressive strength is converted to equivalent cube strength and is reported after applying suitable correction factors. In accordance with the Indian standards.

B. Non-Destructive Testing

Test 1 Rebound hammer test

It is a device to measure the elastic properties or strength of concrete or rock, mainly surface hardness and penetration resistance.

Application

These tests are primarily done to assess:

1. The likely compressive strength of concrete
2. The uniformity of concrete

Rebound Hammer tests are done in accordance with Indian standards IS: 13311 (Part 2).

Procedure

1. The concrete surface is cleaned properly.
2. The hammer is pressed against the concrete surface and released.
3. Six readings are taken and an average is taken.
4. Correlate the average with the compressive strength.

Test 2 Ultrasonic pulse velocity test

It is used to determine the integrity of structural concrete by measuring the speed and attenuation of an ultrasonic wave passing along a specific test path in the element being tested.

Application:

These tests are primarily done to establish:

1. The homogeneity of concrete.
2. Presence of cracks, voids and other imperfections.
3. Changes in quality of concrete over time.
4. This test does not establish compressive strength of tested concrete.

UPV Tests are done in accordance with Indian standards IS: 13311 (Part 1)

Procedure:

1. The concrete surface where probes are to be applied is cleaned properly.
2. Grease is applied on the test surfaces.
3. The probes are pressed on the surface of the structural element to remove air gaps.
4. Distance between the two probes is: noted.
5. Read time taken for the ultrasonic pulse from the instrument.
6. Calculate Velocity = distance / time.

Sr. No	Pulse velocity by cross probing	Concrete Quality Grading
1	Above 4.5 km/s	Excellent
2	3.5 km/s to 4.5 km/s	Good
3	3 km/s to 3.5 km/s	Medium
4	Below 3 km/s	Doubtful

Test 2 Carbonation test

When there is no change in color of concrete, it means that the area is affected by carbonation. The carbonation test is performed by extracting the cores of in-situ concrete. The carbonation test is also performed by drilling a hole on the concrete surface to the different depth up to concrete cover.

Application

These tests are used to assess the probability of corrosion reinforcement.

Carbonation tests can also be done on extracted cores by applying the chemical on the core and measuring the depth till which the carbonation has taken place.

Procedure

1. Identify test location & drill a hole in the concrete to reach the reinforcement.
2. Inject chemical & Insert steel rod.
3. The color change determines till what depth carbonation has taken place.

Carbonation tests can also be done on extracted cores by applying the chemical on the core and measuring the depth till which the carbonation has taken place.

Test 3 Half-cell potentiometer test

It is used to determine the probability of corrosion within the rebars in reinforced concrete structures.

Application

HCP Tests are done in accordance with ASTM C876 standard.

Procedure

1. Identify test location & drill a hole in the concrete to reach the reinforcement.
2. Establish electric contact with the reinforcement.
3. Place the half cell at various locations on the concrete surface & measure voltage. In the voltmeter.
4. Correlate the obtained voltages to probability of corrosion as per ASTM standard.

Test 3 Chemical Test

Application

These tests of concrete are used to assess the pH level, Chloride (Ci) content and SO₃ content of Concrete. A higher pH value or a higher content of chloride or SO₃, than permitted by Indian standard Codes shows the presence of an environment where corrosion of

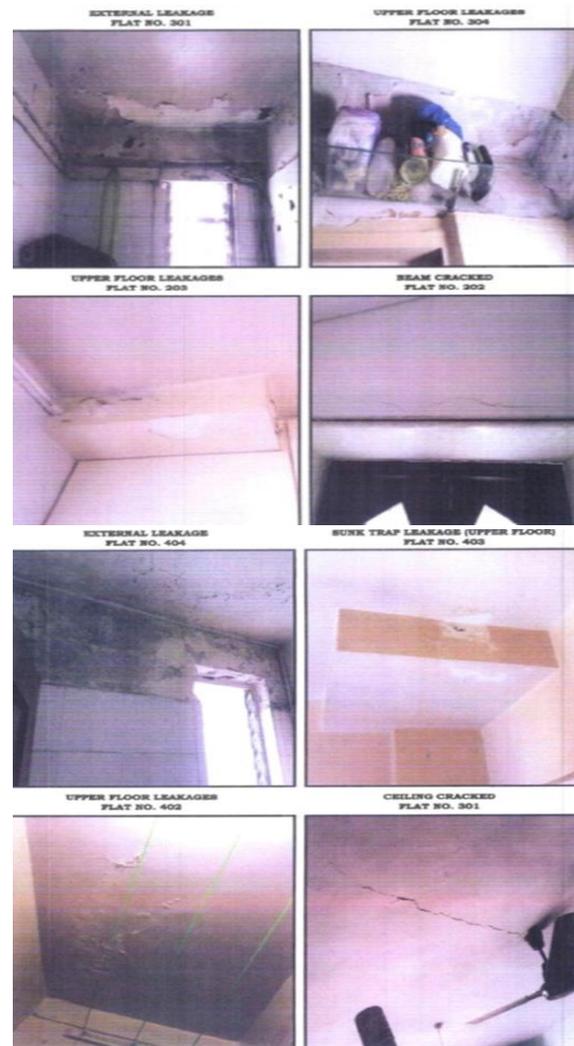
reinforcement has much higher probability than normal.

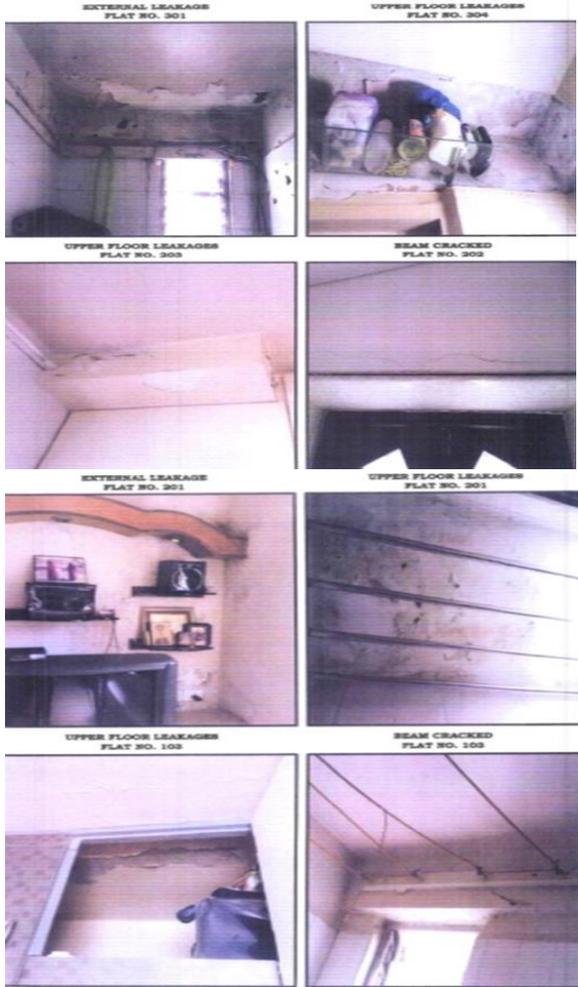
Procedure

1. The chemical tests are conducted on powdered concrete samples collected from the site.
2. The powdered samples are tested in the lab using test kits from reputed manufacturers.
3. The obtained results are correlated with the permissible limits given by IS 456: 2000 code and reported.

Permissible limit

Ph	Not less than 8
Cl (kg/m ³)	For PCC, maximum 3 kg of chloride per cubic meter of concrete.
	For RCC, maximum 6 kg of chloride per cubic meter of concrete.
SO ₃ (%)	Less than 4% by mass of cement in the concrete mix.





Repairs to be done: -

Water Proofing	Chemical coating on terrace
External Plaster	Re-plastering in two coats
Column jacketing	PCM/ Micro concrete
Slab Recasting	Not required
RCC cover to be placed	Not Required
Beam recasting	Not Required
Partial Evacuation during repairs needed	Not Required
Propping	Required

Types of Defects

- Based on inspection & availability of the outside as well as inside of the flats and staircase of the building, the structural frame of the building appears in MODERN DEGREE condition. However, at few areas cracks and structural defects were noticed during our inspection, which need to be rectified with appropriate methods.
- Internal conditions of flats & shops observed during the survey are found in satisfactory condition overall. However internal flats very few places' cracks on beams were observed.
- Most of RCC structural members in head room & Stilt area beams with columns were found major cracked & damaged; hence it is suggested to repair the cracked & damaged RCC structural members with proper propping structural repair method immediately.
- During our survey, the non-structural members (Viz. RCC Sunshades, Balcony paradi etc.) are found cracked / damaged at a few places and need to be repaired with non-polymer treatment to restore extensive damage in these non-structural members of the building.
- At the same time all kinds of leakages (internal as well as external) must be rectified completely.
- Some of the supporting structural members of Head room & Overhead water tank are found cracked and need to be repaired with appropriate treatment.
- Due to the interior / furniture work done in some flats, some of the structural members were not made available for our inspection at this stage. We suspect there may be a few structural members, which might have undergone some kind of structural damage, but perforce could not be visually inspected.

5. CONCLUSION AND RECOMMENDATION

Condition of: -

Internal Plaster	Structurally Satisfactory
External Plaster	Re-plastering required
Plumbing	Bad
Drain lines/Chamber	Fair

Observations: -

Major cracks in Columns/beam	Yes (silt area)
Seepages/leakages	Yes
Staircase area	Structurally Satisfactory
Lift walls	Structurally Satisfactory
U.G. tank	Fair
OHT	Structurally Satisfactory
Parapet at Terrace	Re-Plastering required
Common Areas	Compound pavement need repair

Corrosion

- Rusting of Iron and steel is the most common process of corrosion. The following equations describe the formation process of rust.

$$2 \text{ Fe} + \text{H}_2\text{O} + 1/2 \text{ O}_2 \text{ ---} 2 \text{ FeO (OH)}$$
- Concrete is permeable to water and solution of chloride & sulphate. Penetration of the solution of these chemicals can produce a gradual change in the condition within the concrete ultimately leading to Corrosion of Steel and deterioration of concrete loses its alkalinity. Major constituents like Carbon dioxide, Sulphates, Sulphur dioxide etc. cause the loss of alkalinity in concrete.
- Any corrosion of reinforcement results in the formation of rust, which occupies a volume of about 2.2 times that of iron from which it is formed. This corrosion product has literally no place to go so that it produces large internal pressure as high as 1 ton /square inch around the concrete resulting in longitudinal cracks in the concrete parallel to main reinforcement bars.

6. RESULT

SUMMARY OF ESTIMATED COST OF THE REPAIR		
Sr. No.	DESCRIPTION	AMOUNT
A	PREPARATORY WORKS	142,200
B	SERVICE ITEMS	228,750
C	CIVIL WORKS	1,949,000
D	STRUCTURAL REPAIRS	898,000
E	WATERPROOFING WORKS	285,000
F	PLUMBING WORKS	532,350
G	PAINTING WORKS	2,142,450
GRAND TOTAL		6,177,750

7. FUTURE SCOPE

By structural audit of structure its life span and strength can be calculated. This is the initial stage of structural audit of building. Non-Destructive Tests is necessary. By these test results the strength of different components can be calculated.

8. CONCLUSION

The structural diagnosis is vast, important and highly responsible job which is connected with the 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 defects of structural members are due to combined effects of carbonation, corrosion and effect of continuous drying and wetting.

1. Useful for insurance claims.
2. Helps to understand exact nature of distress before undertaking the structural repairs.
3. Useful for loan application to bank, useful for insurance claim.
4. Additional proof of sound structure before purchase or sale flat.
5. Members can understand the exact status condition of their individual flat.
6. Easier to convince, to get co-operation and fund from members.
7. To produce if required by registrar or BMC or any other Govt. Dept.
8. Even members can visualize the extent of repairs during work and can experience.
9. Helps contractors to understand the exact nature of distress before touching the structure for repairs, so chances of increasing the work/cost is minimum.

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