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Investigation on Structure of Building and Life of Structure

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Abstract: *In Our country there are as many as old aged structures which have reduced the capability of performance day by day as the result of climatic adverse actions and distinct weathering moves however nearby upcoming use of such deteriorating structural elements may be very drastically harmful for the living being staying out there because the overall strength of elements went down notably. As a consequence the structural audit of such structural elements becomes too much important. In this project, condition of the existing structure is assessed using NDT'S and it is proposed to extend the structure. During the construction stage, there are many tests available to assess the excellence of concrete. In the case of existing structures, to check the quality of concrete destructive tests are not possible, meanwhile, concrete quality will be assessed by using non-destructive testing (NDT) techniques such as rebound hammer test. In this present study, an attempt has been made to check the quality of concrete in an existing building using non-destructive testing methods such as rebound hammer test use and for the purpose of Structural assessment, Structural Audit can be carried out. This paper deals with the various factors related with the structural audit of the structures. But the audit contains various factors which are not similar for every structure. 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: Non-Destructive Test (NDT), deteriorating structure, Structural Audit, Rebound Hammer, Structural assessment

I. 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 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. A safety audit process involves inspection, testing and suggestion for remedial work of deteriorating structures due to increasing life span of structural elements. In addition to that audit provides evaluation of the enterprise's building or any residential building protection against failure and some other important necessary safety reports and documentation to decide that shall we or shall we not restore health of structures on which testing has been done. Structural Audit is an important tool for knowing the real status of the old buildings. The Audit should highlight & investigate all the risk areas, critical areas and whether the bldg. needs immediate attention. It should also cover the structural analysis of the existing frame and pinpoint the weak structural areas for static, wind & earthquake loads. The structural audit ensures that the structure is safe and has no risk.it is conducted by a professional.

II. LITERATURE REVIEW

[1] Bhairavi Pawar, Dhiraj Phapale, Akash Suryavanshi, Vikas Shinde, Swati Bhangale (2022), Civil Engineering Industry is one of the oldest diligences which gives an introductory structure to all mortal beings. Every structure has its own service life and it should stand forcefully on its position during its complete service life. Over a period of time, as

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these structures come aged, we find in them certain declination or deterioration with attendant torture manifested in the form of cracking, disjoining, delaminating, corrosion etc. Similar deteriorated structures can be rehabilitated and retrofitted by using varied types of compounds & modernistic repair accouterments. The paper brings out the current state of concrete structures & the considerable areas where enhancement is demanded during its service life stage for sustainable expansion & so the approachof carrying out Repair, Rehabilitation & Retrofitting.

[2] Abhishek Argade, S.S. Motegaonkar (July 2022), In Our country there are as many as old aged structures which have reduced the capability of performance day by day as the result of climatic adverse actions and distinct weathering moves however nearby upcoming use of such deteriorating structural elements may be very drastically harmful for the living being staying out there because the overall strength of elements went down notably. As a consequence the structural audit of such structural elements becomes too much vital. Structural audit can result in extended existence of those deteriorating structural elements and as a result in increasing probability of safety of structure and the people staying there. If the age of the structural elements constructed is about twenty five years then the regulating municipal organization files the legal form of written document for structural audit of such particular structural elements for structural audit also provides the affected place of faults and additionally offers corrective form of few remedial & repair measures for prevention of similarly probable occurrence of strain in structure. After performing audit priority for the repair should be given according to the severity of defect found.

[3] Sanket Sanjay Suryawanshi, Vaibhav Vishnu Vishe, Deepak PremchandSah, Reetika Sharan (2018), The paper states the faultymechanism in the structure and different measures to overcome them. It states that the structure can be residential, commercial or historical monument. The ancient structures had huge impact on life because of its long-life span. But nowadays the structures become less efficient and lose their strength before the design period. So, to prevent any further damage, regular check-ups and health examination of the building is carried. For co-operative housing society, buildings older than 15 years must have a structural audit carried out every 5 years to know the remaining life of the building. The model bylaw no-77 also states that structural audit is necessary. It states that if a building is 15-30 years old, then audit is carried out every 5 years and if the building has completed 30 years or above that, then audit is taken place after every 3 years.

[4]R.Saravanakumar,K.S.Elango,S.Gnana Venkatesh b,S.Saravanaganesh (June 2024), This paper mainly dealt with the evaluation of the structural stability of four storied building using non destructive on-destructive testing methods. During the construction stage, there are many tests available to assess the excellence of concrete. The quality of concrete mainly depends on the quality of materials, concrete grade, and water-cement ratio. In the case of existing structures, to check the quality of concrete destructive tests are not possible, meanwhile, concrete quality will be assessed by using non-destructive testing (NDT) techniques such as rebound hammer, ultrasonic pulse velocity (UPV) etc. In this present study, an attempt has been made to check the quality of concrete in an existing four-storied building using non-destructive testing methods such as rebound hammer test and ultrasonic pulse velocity test. Moreover, the stability of the structure was also assessed. Non-destructive testing method was chosen since existing information of the structure was unavailable. Test results showed that the basement (B1) was susceptible to corrosion, and the compressive strength was not in the recommended range. Ultrasonic pulse velocity (UPV) results also proved that the average quality of the concrete was poor. Hence, significant suggestions were given for necessary retrofitting measures to improve the stability of the structure.

[5] Malkin et al. (2018), Precise Non-destructive estimation of engineering structures using Ultrasonic immersion imaging requires accurate representation in the surface of the structure. In this research, the relationship between surface geometry, surface measurement error Ultrasonic Ranges and Total Focusing Method (TFM) and how it affects the ability to paint a feature. The component was investigated. Shaped surfaces sinusoids that cover a set of surface wavelengths and amplitudes are studied. It can also be observed that it is very poor. The results are achieved if the surface gradient is excessively steep.

[6] Swapnil U. Biraris (2017), Structural audit is an overall health and performance check-up of buildings. It is important to the building to check their safety and they have no risk. It is process of analyses of building and this process. suggest a appropriate repairs and retrofitting measures required for the buildings to perform better in its service life structural audit is an important tool for knowing the real health status of the old buildings.

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[7] Sachin Shelke, Darshana Ainchwar (2018), Structures are the assemblies of beam, column, & slab which safely transfer the superimposed load to the foundation. Concrete is an integral material used for construction purposes. Thus, to know the strength of this concrete we used the technique Nondestructive testing. The rebound hammer test is a hardness test and it is based on principle that the rebound of an elastic mass depends on the hardness of the surface against which the mass impinges. The assessment of any old structure by which we can extend the life of the structure by suggesting remedies for repair. The ultrasonic pulse velocity test is conducted which gives quality of concrete.

III. STRUCTURAL AUDIT

3.1 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. Structural audit is nothing but the checking of the health of the existing structure.It is important to know the current status of the structure, to know the remaining life or if any repairs are needed or there is a need of redevelopment of the structure. By carrying the structural audit human life as well as a lot of economy can be saved.

3.2 Purpose of Structural Audit-

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

3.3 Objectives of study-

- To study the types of structural defects.
- To identify any signs of material deterioration.
- To identify any signs of structural damage.
- To identify any changes in the structure.
- To give remedies for improving structure.

3.4 Need of Structural Audit-

- Increase life of the building.
- To save life of lives in the building.
- To find damaged area of the building and to repair it immediately.
- To know the real condition of the building whether it is safe for dwelling or not.

3.5 Aim

To study and perform structural audit of a building.

IV. METHODOLOGY

An old building of age in the range of 20 to 30 years will be selected. The research methodology will consist as follow-

1. Performing preliminary inspection of the residential building.
2. Preparation of architectural, structural plan of the residential building.
3. Visual inspection to highlight critical area.
4. Performance of NDT tests.
5. Finding actual strength of the building.

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6. Suggesting remedial measures.

4.1. Experimental Investigation-

Non Destructive Testing (NDT) Techniques (An Overview)- In existing structures, the quality of concrete can be easily accessed by various techniques. In addition, NDT techniques are being used in evaluating the quality of plastics, composites, metals etc. The parameters such as internal voids, porosity, cracks, surface cavities, delamination, and weld quality are also Monitored. The term 'non-destructive' emphasizes that these tests do not compromise the intended performance of the structural elements under investigation. The field of non destructive evaluation is broadly categorized into two main groups: 'in-situ field tests' and 'laboratory tests.' These categories encompass a range of techniques designed to provide valuable insights into the condition of concrete members without causing any harm to their structural integrity.

4.2 Rebound Hammer Test-

A rebound hammer test confirming to IS 13311 (Part 2) is performed to assess the structural stability of four storied building. A few activities are to be verified before performing the test. The activities like preparation of surface to be tested, calibration of equipment, identification and marking, execution of tests, and recording results are to be checked. Before execution, the surface of the concrete is to be cleaned and it should be free from loose particles, dust, oil, or any other contaminants that may affect the test results. Furthermore, the calibration of the equipment is to be verified and it should be within the acceptable range before proceeding with the test. The rebound hammer test provides a quick and simple way to estimate the strength of the concrete surface. It consists of a spring-loaded mass when released it impacts the surface of the concrete. The rebound distance of the hammer is measured and correlated to the concrete's compressive strength. Harder the concrete, the higher the rebound value. It is particularly useful in the field for assessing the uniformity of concrete strength across a structure or for identifying areas of potential concern. However, it's essential to note that the test provides only an estimate of the concrete strength at the surface and may not represent the overall strength of the entire structure.

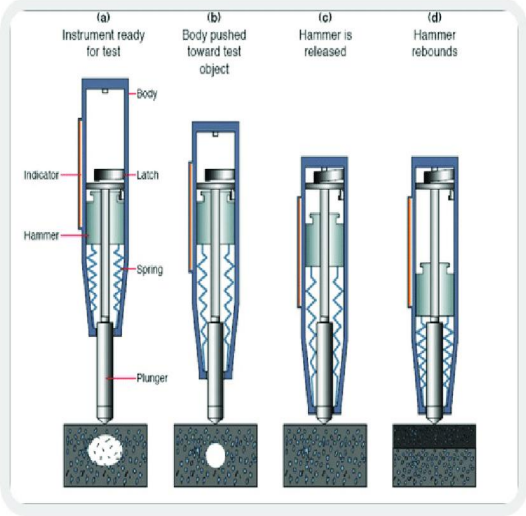

Fig. Rebound Hammer Test

V. STRUCTURAL AUDIT OF EXISTING BUILDING THROUGH VISUAL OBSERVATION AND CHECK OF COMPRESSIVE STRENGTH BY NDT

CASE I : VISUAL OBSERVATION OF ENGINEERING SCIENCE DEPARTMENT BUILDING-

A Report is prepared by visual inspection, engineering judgement, interviewing the management corporation, owners and users, and checking the drawings available at site.

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General Information of the Building

1. Name of the building: Science building
2. Address of the building: Z. P. School Building, Jalgaon, And District: Jalgaon Maharashtra.
3. Number of storey : G+1 (Ground and First Floor)
4. Description of main usage of the building: Building Constructed for Industrial Purpose.
5. Type of Structure: RCC Frame Structure.
6. Year of Construction: 1984
7. Dates of inspection: 20th January 2025

Structural System of the Building

1. Description of the structural form,: At present Footing, Column, Beam, Slab, walls and Staircase of Ground and First Floor has been constructed on Site.
2. Systems and materials used in different parts of the building e.g. reinforced concrete, concrete, Brick work in walls with mortar.
3. Foundation system: RCC (Long and Short span Structure).

Actual Visual Inspection at site

Visual inspection was conducted on 11th and 12th January 2025, for observation and assessment of structural steel and material of the building. It had been observed that there are following things :

1. Partly broken slab and beams.
2. Cracked broken staircase .
3. Damaged column with cracking.

1. GROUND FLOOR:

1. Strength of slab are reduced in tension zone as observed from NDT test reading
2. Various places at bottom sides of slab cracks are formed Strength measure uneven at various places.
3. Observed strength of column at position of entry found to be zero.
4. Observed structural cracks at entrance beam and exposed reinforcement recorded very low strength at end of beam.
5. Column at Entry of compound is having deep structural crack at entire height of column and strength recorded at many places is zero, while adjacent column is damaged at bottom with reinforcement visible and corroded.
6. Various places observed reading zero or not measurable as per NDT testing record.

2. FIRST FLOOR:

1. All RCC Chajjas are weak & partly opening of reinforcement & spalling of RCC material, as result strength observed is zero. Strength of columns are weak in compression, at various places.
2. Major structural cracks are formed opening, of columns front & both two sides, rusting of reinforcement showing strength are zero.
3. Strength of slab beams are showing average.
4. In walls minors cracks are formed it seen outer side of projection, spalling of plasters are many places.
5. Observed junction joints of beam and columns are corrugated at various positions so strength are less measurable.

3. TERRACE FLOOR

1. Strength of inverted beam is varying in different places abruptly.
2. Terrace slab are weak in tension, showing NDT reading extremely low.
3. Cracks are formed on walls of toilet units of terrace.
4. Opening of reinforcement at bottom of slab, rusting of all reinforcement it weakened Structural members in tension.
5. Structural cracks observed on walls and beams of staircase units.
6. All waist slabs are seen damaged, concreting material are spalling & deterioration at various places.
7. Strength of riser & tread are reduced due to waist slab thickness damaged.
8. R.C.C pardi of stair case unit showing average strength.

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9.Columns are showing varying strength up to parapet level minor cracks are formed so strength are less as per test records.

VI. RESULT AND DISCUSSION

NEED OF STRUCTURAL STRENGTHENING:

• Load increases due to higher live loads, increased wheel loads, installations of heavy machinery, or vibrations.
• Damage to structural parts due to aging of construction materials or fire damage, corrosion of steel reinforcement, and/or impact of vehicles.
• Improvements in suitability for use due to limitation of deflections, reduction of stress in steel reinforcement and/or reduction of crack widths.
• Modification of structural system due to elimination of walls/columns and/or openings cut through slabs.
• Errors in planning or construction due to insufficient design dimensions and/or insufficient reinforcing steel.

Repairs:

The main purpose of repairs is to bring back the architectural shape of the building so that all services start working and the functioning of building is resumed quickly. Repair does not pretend to improve the structural strength of the building and can be very deceptive for meeting the strength requirements of the next earthquake. The actions will include the following:

• Patching up of defects such as cracks and fall of plaster.
• Repairing doors, windows, replacement of glass panes.
• Checking and repairing electric wiring.
• Checking and repairing gas pipes, water pipes and plumbing services.
• Re-building non-structural walls, smoke chimneys, boundary walls, etc.
• Re-plastering of walls as required.

VII. CONCLUSIONS

1. Structural Audit is an important tool for knowing the real status of the old buildings. The Audit highlights & investigate all the risk areas, critical areas and whether the bldg. needs immediate attention.
2. If building is more than 15 years old. It is important that structural audit is necessary once in 5 years.
3. It ensures that the building and its premises are safe and have no risk.
4. It analyses and suggests appropriate repairs and retrofitting measures are required for the buildings to perform better in its service life.
5. Strength in lower columns were extremely low while at upper floor it is moderate.
6. Strength reduction reason is mainly observed as corrosion of reinforcement due to moisture impact.
7. Age of the building is also facto as more strengthening need to be required by retrofitting and by treating all cracks.

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IS- Codes Used-
Indian Standard: 13311:1992 (Part 1) NDT methods of Test- Ultrasonic Pulse Velocity.
Indian Standard: 13311:1992 (Part 2) NDT methods of Test- Rebound Hammer.
Indian Standard: 456: 2000- Plain and Reinforced Concrete – Code of Practice (Fourth Revision).
Indian Standard: 516: 1959- Method of test for strength of concrete.