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# Essential Inspection of Kolhapur City's RCC Building

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***ABSTRACT***
*A structural audit is required for framed structures in order to determine the proper corrective actions for different types of structural flaws and shortcomings. so that it can continue to meet the requirements for appropriateness and longevity. A structural audit needs to be done on any kind of structure at least once every five years. Every three years, a structural audit should be completed for buildings that are more than fifteen years old. It appears that the primary causes of structural member deterioration are aging and corrosion. There are several reasons why structural elements corrode, such as wall cracks, moisture, slab leaks, and more. Therefore, the building's appropriateness and strength can be strengthened by completing the following tasks: installing slabs to stop water damage.*

***Keywords:*** *inspection, building, water, slabs, visual testing, measures*

## I. INTRODUCTION

### 1.1 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 retro fitting measures required for the buildings to perform better in its service life. Structural audit is done by an experienced and licensed structural consultant.

### 1.2 Need of Structural

Structural Audit Structural audit is carried out in order to

1) To increase life of property.
2) To know the health of building and its expected life.
3) To check actual reliability of the structure.
4) In order to recommend rehabilitation techniques.
5) In order to highlight the critical areas and repair the immediately
6) For structural audit certificate required by municipality and other authorities.

### 1.3 Structural Audit by-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:

1. For building aging between 15 to 30 years once in 5years
2. For building aging above 30years once in 3year. D. Objectives of structural audit
1. Performing preliminary inspection of the building.
2. Preparation of architectural, structural plan of the building.
3. Visual inspection to highlight critical area.
4. Performance of NDT tests.
5. E-TABS modeling of the building.
6. Finding actual strength of the building.
7. Suggesting remedial measures
8. Noting of all visible defects, deterioration and its quantification.
9. These are marked on floor drawings from which he estimates is worked out.

10. Diagnosis of damages
11. Suggest remedial measures
12. Submission of the conditions survey and structural audit report, priority wise estimate for rehabilitation, condition survey drawings, photographs.
13. Necessity of non destructive testing will be decided after inspection of structure.

**Scope of the Work**

1. Surveyingthepremisesfromtheinsides&outsidesi.e.eac h&everypremisestobe surveyed to get a proper idea of its present structural condition. This physical survey will be carried out with hammer tapping on the RCC members to ascertain the degree of distress.
2. Identifying and noting allied problems pertaining to leakages & Seepages & any Additions/ Alterations carried out in the premises (which may be detrimental to the present health of the structure)
3. Identifying the nature of damages, extent of damages and its severity.
4. Carrying out NDT test's at required locations
5. Analyzing various defects observed, identifying the likely causes of all such damages.
6. Finally suggesting remedial measures to be adopted to restore the Structural health of the presently diseased Structure with a view to enhance its Structural Stability and Durability as per the priorities required.
7. Submitting detailed Survey Report containing our observations, suggestions, recommendations and photographic log.

## II. LITERATURE REVIEW

**ShahI. H**. has stated structural audit is an important tool for knowing the real statusof 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. haschanged 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. 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.Thedeteriorationofbuildingscanbearesultofvariousfactorsin cludingfiredamage,frostaction,chemicalattack,corrosionofsteel etc.duringthelifespanofthestructure. 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

**Balayssac J.-P., Laurens S.,** has stated the management and maintenance of the buil the ritage is one of the main concerns of the owners of concrete structures. Combining NDT methods is currently considered as one of the most appropriate ways to improve the quality of the diagnosis of concrete structures. This paper describes a French project named SENSO (Strategy of non-destructive evaluation for the monitoring of concrete structures) devoted to developing a methodology for the non-destructive evaluation of concrete based on a multi-technique approach

**Villain Geraldine Sbartai, Zoubir Mehdihave,** implement ted non-destructive techniques (NDTs) for surveying concrete structures in marine environments, non-destructive measurement results must be correlated with concrete durability indicators such as porosity and water and chloride contents. For this purpose, tests introducing two electromagnetic methods (GPR and the capacitive technique), as well as the impact-echo method, were run on six different concrete mixes containing various porosities, with five water content values and three chloride concentrations.

## III. VISUAL INSPECTION

### A. Introduction

Visual testing is probably the most important of all non-destructive tests. It can often provide valuable information to the well trained eye. Visual features may be related to workmanship, structural serviceability, and material deterioration and it is particularly important that the engineer is able to differentiate between the various signs of distress which may be countered. These include for instance, cracks, pop-outs, palling, disintegration, colour change, weathering, staining, surface blemishes and lack of uniformity. Extensive information can be gathered from visual inspection to give a preliminary indication of the condition of the structure and allow formulation of a subsequent testing program.

The visual inspection however should not be confined only to the structure being investigated. It should also include neighboring structures, the surrounding environment and the climatic condition. This is probably the most difficult aspect of the whole structural investigation or any diagnostic works since what appears obvious tone may not be so to another. The importance and benefits of a visual survey should not is underrated. Often the omission of what appears to be insignificantevidencecanleadtoawrongconclusionbeingmade.T headvantageofatrainedeyeisbestdescribedbySherlockHolmesw henhewrote:―Iseenomorethanyoubut I have trained myself to notice what I see.

**B. Tools and Equipments for Visualization**

An engineer carrying outa visualsurvey shouldbe well equipped with tools to facilitate the inspection.Theseinvolveahostofcommonaccessoriessuchasmea suringtapesorrulers,markers,thermometers,anemometersandot hers.Binoculars, telescopes, borescopes and endoscopes or the more expensive fibre scopesmay be useful where access is difficult. A crack width microscope or a crack widthgauge is useful, while a magnifying glass or portable microscope is handy for close upexamination. A good camera with the necessary zoom and micro lenses and otheraccessories, such aspolarized filters,facilitatespictorial documentationof defects,andaportablecolourchartishelpfulinidentifyingvariation inthecolourofthe concrete. A complete set of relevant drawings showing plan views, elevations andtypicalstructural detailsallows recordingofobservations to bemade.

**C. General Procedure for Visualization**

Before any visual test can be made, the engineer must peruse all relevant structural drawings ,plansandelevations to become familiar with the structure.Availabledocumentsmustalsobe examinedandthese include technicalspecification,pastreports of tests or inspection made, construction records, details of materials used,methodsand dates ofconstruction,etc.

The survey should be carried out systematically and cover the defects present, the current and past use of the structure,the condition of adjacentstructuresandenvironmental condition. All defects must be identified, the degree classified, similartothose used for fire damaged concrete and, where possible, the causesidentified.The distribution and extent of defects need to be clearly recognized. For examplewhether the defects are random or appear in a specific pattern and whether the defectisconfined to certainlocations of membersor is presentall overthestructure.

Visual comparison of similar members is particularly valuable as a preliminary totesting to determine the extent of the problems in such cases. A study of similarstructures or other structures in the local area constructed with similar materials canal so be helpful inproviding casestudy‘evidence, particularlyifthoseotherstructures vary in age from the one under investigation. There is a need to identifyassociated or accompanying defects, especially which particular defect predominates. Segregation or excessive bleeding at shutter joints may reflect problems with theconcrete mix, as might plastic shrinkage cracking, whereas honeycombing may be anindicationofalowstandardofconstructionworkmanship.Lacko fstructuraladequacy may show itself by excessive deflection or flexural cracking and this mayfrequentlybethereason foran insitu assessment ofastructure.

Long term creep defections, thermal movements or structural movements may cause distortion of door frames,crackingofwindows,orcrackingofastructureoritsfinishes . Material deterioration is often indicated by surface cracking of the concreteand examination of crack patterns may provide a preliminary indication of the cause. Systematic crack mapping is a valuable diagnostic exercise when determining the causes and progression of deterioration. Observation of concrete surface texture and colour variations may be a useful guide to uniformity. Colour change is a widely recognized indicator of theexten to ffiredamage.Visualinspectionisnotconfined to the surface but may also include examination of bearings, expansion joints, drainage channels and similar features of a structure. Any misuse of the structure canbeidentifiedwhencomparedtotheoriginaldesignedpurposeof thestructure.Anassessment may also need to be made of the particular environmental conditions to which each part of the structure has been exposed.

In particular the wetting and drying frequency and temperature evariation tha tanelement is subjected to should be recorded because these factors influence various mechanisms of deterioration in concrete. For example, in marine structures it is important to identify the splash zone. Settlement of surrounding soil or geotechnical failures need to be recorded.Account must also betaken of climatic and other external environmental factors at the location, since factors such as freeze thaw conditions maybe of considerable importance when assessing the cause sofdeterioration. A careful and detailed record of all observations should be made as thein spection proceeds. Drawings can be marked, coloured or shaded to indicate the localseverityof each feature.Defects that commonlyneed recordinginclude.

- Cracking which can vary widely in nature and style depending on the causative mechanism
- Surface pitting and spalling
- Surfaces taining
- Differential movements or displacements
- Surface voids
- Honey combing
- Bleed marks
- Constructional and lift joints
- Exudation of efflorescence.

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**D. Application of Visual Inspection**

For existing structures, presence of some feature requiring further investigation isgenerally indicated by visual inspection, and it must be considered the single mostimportantcomponentofroutinemaintenance.Itwillalsoprov idethebasisforjudgments relating to access and safety requirements when selecting test methods and testlocations. Asmentionedearlier,avisualinspectionprovidesaninitialindi cationofthecondition of the concrete to allow the formulation of a subsequent testing programme.It is also through suchinspectionsthatproperdocumentationofdefectsandfeaturesi n the concrete structure can be effected. With a trained eye, visual inspection can reveal substantial information regarding the structures uchas the construction methods, weathering, chemical attack, mechanical damage, physical deterioration, abuse, construction deficiencies or faults and many others. In this building is thoroughly inspected from flat to flat noting racks, spells, crazing, seepage etc. Highlighting critical area of investigation and repair same is marked on the plan of the building.

**E. Need of Visual**

1) To inspectionTorecognizethetypesofstructuraldefects
2) To identifyanysigns ofmaterialdeterioration.
3) To identify any signs of structural distress and deformation.
4) To identify any alteration and addition in the structure, misuse this may result in over loading.

**E. Structural System of 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 orfromadjacent 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.

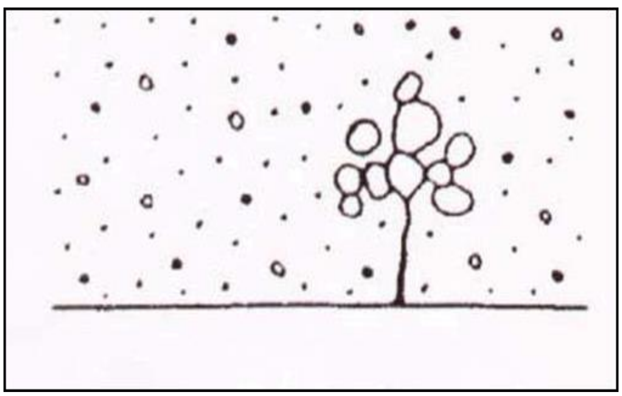

**Figure 1:** Sketch of exposed aggregate

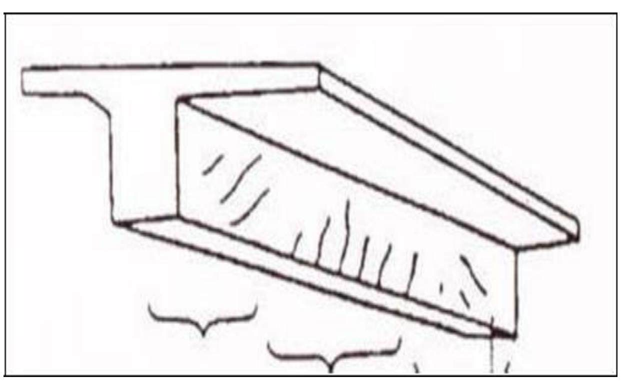

**Figure 2:** Cracks due to bending and share stresses

**F. Field Test**

After high lighting critical area in the building extstep is to recommend the appropriatetest to evaluate the structure which may include like .

1. DestructiveTesting
2. Non-DestructiveTesting

**1. Destructive Testing**

Destructive testing are carried out to understand the specimen's failure, specimensperformance or material behaviour under different loads. These tests are generallymuch easier to carry out, yield more information, and are easier to interpret than non-destructive testing. Destructive testing is most suitable, and economic, for objects which will be mass-produced, asthecost of destroying small number of specimens is negligible. It is usually not economical to do destructive testing where only one orvery few items are to be produced. Analyzing and documenting the destructive failuremode is often accomplished using a high-speed camera recording continuously until the failure is detected.

Detecting the failure can be accomplished using a sound detector or stress gaugewhich produces a signal to trigger the high-speed camera. These high-speed camerashaveadvancedrecordingmodestocapturealmostanytype ofdestructivefailure.After the failure the high-speed camera willstop recording. The captureimagescanbe played back in slowmotion showing precisely what happen before,during andafter thedestructiveevent, image by image. Sometypes of destructivetestingare.

1. Stress Tests
2. Hardness test
3. Crash Tests
4. Metallographic Tests

**2. Non-Destructive Testing**

Non-destructive testing (NDT) is a wide group of analysis techniques used in scienceand technology industry to evaluate the properties of a material, component or systemwithout causing damage. The terms Non-destructive examination, Non-destructiveinspection and Non-destructive evaluation are also commonly used to describe thistechnology, because NDT does not permanently alter the component being inspected,itisahighly valuabletechniquethatcansavebothmoney and time in product evaluation, trouble shooting, and research.

Analyzing and documenting a non-destructive failure mode can also be accomplished using a high-speed camera recording continuously (movie-loop) until the failure isdetected. Detecting the failure can be accomplished using a sound detector or stressgauge which produces a signal to trigger the high-speed camera. These high-speed cameras have advanced recording modes to captures omenon-destructivefailures. After the failure the high-speed camera willstoprecording.The captureimages can be played back in slow motion showing precisely what happen before,duringand after thenon-destructiveevent, image by image.

NDT tests are applicable in testing the condition of the bridges, highways, buildingetc.NDT allows users to determine following properties of the object.

1) Strength
2) Durability
3) Density
4) Moisture content
5) Elastic properties
6) Extent of visible crack

The final benefit of non-destructive testing may be hard to quantify, but it‘s the most important of all. Knowing that your equipment is functioning the way it should (and that future accidents can be prevented with simple check-ups) adds years to the life of a beleague.

**Non-destructive Test**

1) Ultra-sonic pulse velocity method
2) Rebound hammer test
3) Bar locator/Cover meter

# IV. CASE STUDY

| S N | Description | Details |
|---|---|---|
| **1** | Building name | Shri Vishwanath co. housing society, E ward Kolhapur |
| **2** | Date of starting structural audit | 23/11/2017 |
| **3** | Year of construction | 1979 |
| **4** | No. of building | Total-7<br>A-type 2No.<br>B-type 3No.<br>C-type 2No. |
| **5** | Area of plot | 4023.70 Sq.m |
| **6** | Existing floor area | 3760.30 Sq.m |
| **7** | Total built up area | 4015.60 Sq.m |
| **8** | Structure | RCC framed structure |
| **9** | Foundation | Simple footing, Pile foundation |
| **10** | Plaster | Cement plaster with dry distemper and water proof cement paint |
| **11** | Flooring | Rooms–plane cement tiled Kitchen-1.5inchblackkadappastone |
| **12** | Skirting Dado | Whiteglazedtiled5 inch forallrooms |
| **13** | Doors | Main entrance – Teak wood panelled<br>All internal doors – Nova teak wood<br>Any other sustainable material paneled with MS angle frame |
| **14** | Windows | MS glazed with 3/8 inch square barsasa security bars |
| **15** | Year of last repair | Generally 4 to 5 years ago |
| **16** | Details of last repair<br>Structure repaire<br>Roof of any other waterproofing<br>External finish( paint)<br>Plumbing | -None<br>-Done for some of the buildings<br>-Done for all buildings<br>-Done for all buildings |
| **17** | Plan and Drawing<br>Architectural Plan<br>Structural Plan<br>Building plan | -Yes<br>-No<br>-Yes |
| **18** | Mode of inspection<br>Visual Inspection<br>Field test(NDT) | -Yes<br>-Yes |

**1. Visual Inspection of Buidings**

**Wing A**

- Leakage from slab
- Diagonal cracks near opening
- Dampness in walls and slab
- Uneven settlement in flooring
- Separation of balcony
- Separation of balcony(Gap)
- Separation of balcony
- Separation of balcony

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**Wing B**

- Reinforcement is visible
- Cover removal of slab
- Diagonal cracks to wall
- Major cracks to below of staircase cap
- Leakage from pipes
- Major leakage
- Settlement of floor
- Reinforcement is visible

**Wing C**

- Slab detached out in balcony
- Diagonal cracks above opening
- Major Dampness in wall
- Major leakage
- Major horizontal cracks above window
- Plaster damage
- Patches removed

## V. REMEDIAL MEASURES

**1. Grouting**

Grouting in civil engineering refers to the injection of pumpable materials into a soilor rock formation to change its physical characteristics. It is one of the ways in whichground water can be controlled during civil engineering works. Grouting is suitablewhere soil permeability would create a heavy demand on pumping or where groundconditionsmean it maybeeconomicallyinefficient to borewells.

**2. Injection Method**

Typically, grouting is carried out is by driving pipes or boring holes into the ground, and then pumping the grout solution at high pressure through inserted tubes. The extent of grouting required for a particular area is determined through investigation of ground conditions and the calculation of a drilling pattern. This considers the size, spacing and depth of the holes required. The type of grout and the particular ground conditions will influence the spacing of the holes.

**3. Grouting Material**

There are several different types of material used for grouting:

**a) Cement Grouting**

Cement (or cementitious grout) is used for grouting materials with a high permeability. Neat cement and water or a mixture of sand (4 parts) to cement (1 part)is the usual composition. Holes are bored in a radius around the area to be excavated before being injected with a thin grout, the viscosity of which is then increased byreducing the water-cement ratio. If required, secondary holes are bored between the primary holes to ensure the complete grouting of the area.

**b) Bentonite Grouting**

Bentonite is produced from clay which has thixotropic properties, meaning it forms ahighly water-resistant gel which, when mixed with additives, can create a permanent barrier to water flow. This is used where soil particles are too small for cement grouting, most commonly to combat seepage in alluvial soils beneath the foundations of dams or other water-bound structures.

A Fiber Reinforced Polymer (CFRP) composite is defined as a polymer (plastic) matrix, either thermo set or thermoplastic, that is reinforced(combined)with a fibre or other reinforcing material with a sufficient aspect ratio to provide a discernablere in forcing function in one or more directions. FRP composites are different from traditional construction materials such as steel or Aluminum. FRP composites are an isotropic where as steel oral. Aluminum is isotropic (uniform properties in all directions, independent of applied load). Therefore, FRP composite properties are directional, meaning that the best mechanical properties are in the direction of the fiber placement.

Reinforced concrete buildings may be vulnerable to progressive collapse due to a lack of continuous reinforcement. Carbon fiber reinforced polymer (CFRP) may be used to retrofit existing reinforced concrete beams and provide the missing continuity needed to resist progressive collapse. A Fiber Reinforced Polymer (FRP) composite is defined as a polymer (plastic)matrix, either thermo set or thermoplastic, that is reinforced (combined) with a fiber or other reinforcing material with a sufficient aspectratio(length to thickness) to provide a discernable reinforcing function in one or more directions.

## VI. CONCLUSION

For framed structure structural audit is necessary so that appropriate remedial measures can be recommended for all types of structural defects and damages .So that it continues to serve strength and serviceability requirement. For any structure it is necessary to carry out structural audit at least once In the five years. For structure older than 15years structural audit should be carried out once in 3years.

From above observation we conclude that even though heavy reinforcement is provided for the structural members and demand to capacity ratio is less than one for all structural members. Reinforcement provided is in very bad condition and lost its Strength due to corrosion. Due to corrosion there is reduction in the cross section of the reinforcement resulting on deflection under their own weight therefore unsafe to carry any further load.

It is observed that main cause of damage of the structural members is due to corrosion and ageing. Corrosion in structural members is observed due to dampness and leakage from the slabs, cracks in walls etc. So the strength and serviceability of the building can be increased by taking necessary measures such as: Water proofing slabs and walls to stop seepage of water into structural members so as to avoid further corrosion. Providing polymer mortar treatment recasting of slab etc

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