REHABILITATION OF STRUCTURE

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***Abstract*—** the life cycle of building can be broadly divide into four phases i.e. architectural planning, structural design, construction, maintenance. In most of building at most care is taken in first three cases but maintenance is forgotten. Ignorance to maintenance causes severe structural distress in building over period of time. Most of the building constructed in last 23 to 30 years is in severe structural distress and needs to repair, hence these building needs a periodical survey from structural point of view to asses from structural health. Based on this survey a decision regarding the structural health of building and repair required can be taken. This project with methods of estimating the audit of existing structures whose life has crossed the age of 30 years. Such an investigation can be carried out using the following methods: a) Visual examination b) Non Destructive Testing c) Partial Destructive Testing. This project covers the study of Structural Auditing of Residential Building .Now a days structural Auditing is necessary because of poor quality of construction, carelessness in supervision during construction use of poor quality of materials, carelessness by labours during work because of such reasons the quality of the building goes down and then automatically life of the building goes down. Now a days life of the building comes 60 years from 100 years because of such reasons we need to do Structural Auditing of the building after 15 years to check whether it is safe or not if not then remedial measures to be provided.

Keywords- Structural audit, Structural Engineering, NDT method, Structural Evaluation Program

I. INTRODUCTION

Large stocks of existing structures and infrastructure are deteriorated with use and time and might have passed their design life and require retrofitting and rehabilitation. The cost of retrofitting various infrastructures is estimated in the lakhs of rupees. To overcome the ill effects caused by these deteriorated buildings Repair and Rehabilitation works are carried out from time to time. Many of the existing structures were designed to codes that have since been modified and upgraded. Change in use or higher loads and performance demands require modifications and strengthening of structural elements. Concrete construction is generally expected to give trouble free service throughout its intended design life. However, these expectations are not realized in many constructions because of structural deficiency, material deterioration, unanticipated over loadings or physical damage. Premature material deterioration can arise from a number of causes, the most common being when the construction specifications are violated or when the facility is exposed to harsher service environment than those expected during the planning and design stages.

1.1. PROBLEM STATEMENT

1. To increase life of the building.
2. To know the health of the structure and its expected life.
3. To check the actual reliability of the structure
4. To recommend rehabilitation techniques
5. To highlight the critical areas and repairs them immediately
6. To save life of lives in the building.
7. To know the real condition of the building whether it is safe for dwelling or not.

1.2. OBJECTIVE

1. To recognize the types of structural defects.
2. To identify any signs of material deterioration.
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.
5. To identify any signs of material deterioration.
6. To identify any signs of structural distress and deformation.
7. To identify any alteration and addition in the structure.
8. Remedies for the restoration of the structure

1.3. SCOPE

Structural Audit is nothing but health check-up of the building to know building. After knowing the real condition of the building we give remedial measures to increase service life of the building.

II. LITERATURE SURVEY

[1] Rajendra P. Srivastava et.al. (1999) -This article performs two types of analysis using dempster-shafer theory of belief functions for evidential reasoning. The first analysis deals with the impact of the structure of audit evidence on the overall belief at each variable in the network, variables being the account balance to be audited, the related transaction streams, and the associated audit objectives. The second analysis deals with the impact of the relationship (logical "and" and "algebraic relationship") among various variables in the network on the overall belief, for our first analysis, we change the evidential structure from a network to a tree and determine its impact.

[2] Constantinos A. Balaras et.al. (2005) – A total of 349 residential building audits were performed in seven European countries to collect data on the degradation of building elements (architectural and installations). The buildings cover typical architectural typologies, sizes, constructions and installations, at different states of deterioration. The data was collected based on a standardized methodology for building audits. Follow up analysis revealed the most important influencing factors on the deterioration of existing residential buildings throughout Europe and estimated service lives of various building architectural elements and electromechanical installation.

[3] B.H Chafekar et. al.(3) (2013-14) - Before going in detail about the structural audit is necessary to know about the structure. A structure is a system of inter connected elements to carry loads safely to underground earth. The health examination of concrete building called as structural audit. The author shows different methods in paper:

[4] A.B. Mahadik et.al.(4) (2014) –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.

[5] Francesca Ceronia(5) (2015) - A synergic approach for the investigations of the historical building performances - with reference to both the structural behaviour and the energy performances for the space heating and cooling - is presented. The historical masonry building “Palazzo Bosco Lucarelli”, located in Benevento, has been chosen as case study. The structural and energy analyses are carried out in parallel, especially during the identification of the building characteristics through tests and surveys in-situ.

[6] Mohammad Ismail (6) (2016) - The paper presents research findings on the deteriorating conditions of abandoned residential projects due to environmental factors of degradations . Sampling was made from two hundred and sixty-one abandoned housing projects. Structural degradations associated with the uncompleted buildings were studied. In a similar manner, a small-scale reinforced concrete structure was erected in an open and critically monitored for defects caused by environmental factors of degradations. The selected uncompleted buildings were assessed for surface salt deposits, crack formations and reinforcement corrosion. However, the small-scale structure was evaluated for performance degradations through destructive and non-destructive strength tests, steel tensile strength test and corrosion test. Results show that there is an alarming decrease in structural integrity and durability functions in abandoned reinforced concrete buildings with time.

[7] Swapnil U Biraris(8) (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.

[8] Shah I. H.(9) 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.

[9] Monteria. J., Patha ,N. J(8) 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.

III. RESEARCH METHOLOGY

Steps to be followed in Structural Auditing

STEP 1: It is imperative that we must have Architectural and Structural plans 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 any Engineer.

STEP 3: Inspection of the Building - A detailed inspection of the building can reveal the Following:

1. Any settlements in the foundations.
2. Cracks in columns, beams and slabs.
3. Concrete disintegration and exposed steel reinforcements photographs can be helpful.
4. Slight tapping using hammer can reveal deterioration in concrete.
5. Corrosion in reinforcement.
6. Status of Balconies – sagging, deflection, cracks.
7. Status of Architectural features viz. Chhajjas.
8. Cracks in walls indicating swelling in R.C.C. members or deflection or corrosion.
9. Leakages from terrace & Toilet blocks.
10. Leakages & dampness in walls resulting into cracks and corrosion.

11. Status of repairs & last repaired.

12. What was repaired?

13. Who was the Agency?

14. How much was spent for repairs?

15. Building plans are available? When approved?

STEP: 4 Preparation of Audit Report: On the basis of inspection of building an Audit Report is prepared.

STEP 5: Tests Recommended: It is important that various tests are carried out in the old buildings. This will give an idea about the extent of corrosion, distress and loss of strength in concrete & steel.

STEP 6: Highlight the critical areas and how to go for repairs.

IV. PROPOSED SYSTEM

DEVELOPMENT MODEL

A Norm According to the model bye-law no. 77 for co-operative housing societies, it is mandatory that if the age of a building is 15 to 30 years, a structural audit must be carried out once in five years and for buildings older than 30 years it should be carried out once in three years. One may, however, go for it even earlier if one suspects the condition of the building to be bad. Perhaps monsoon/ post monsoon is the best time to commission a structural audit since the seepage is more evident at that time. The certificate, issued by a structural engineer registered with BMC, will have to be submitted within a year after a building completes 30 years. For any corrective repairs suggested by the commissioner, the owner or occupants will be asked to submit the structural stability certificates again after a specific period suggested by him. If found unsafe, he has been given the authority to issue a notice to the owner to submit a structural stability certificate within 30 days from the date of notice . It will be binding on owners to carry out corrective repairs to the satisfaction of the commissioner. The certificate, issued by a structural engineer registered with BMC, will have to be submitted within a year after a building completes 30 years. For any corrective repairs suggested by the commissioner, the owner or occupants will be asked to submit the structural stability certificates again after a specific period suggested by him. If found unsafe, he has been given the authority to issue a notice to the owner to submit a structural stability certificate within 30 days from the date of notice . It will be binding on owners to carry out corrective repairs to the satisfaction of the commissioner.

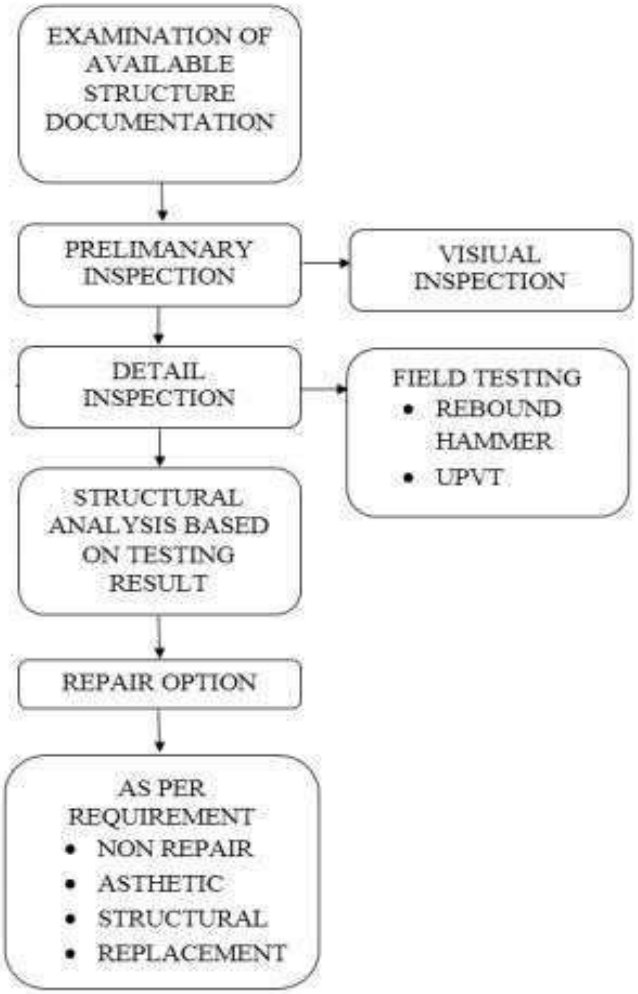


Fig 1: System Architecture

VI.RESULT

Convolution is the first layer to extract features from an input image (image). Convolution preserves the **Structural audit report of Case Study**

Table -1: Case Study- Basic Information of RCC Building.

Sr. No.	Building/Structure	Details
1	Name of Building / Structure	SAI Apartment
2	Address	Pune [MH] [INDIA]
3	-Mode of Use -Type of Structure	Residential Building RCC Structure
4	No. of Stories	G+4
5	Year of Construction	1990 [29 yrs old]
6	Previous Structural Audit	None
7	Floor Height	3.6 m
8	External Wall	Brick Wall

9	Internal Wall	Brick Wall
10	Balconies	3 Nos. [West Zone Side]
11	Mode of Survey	Visual Inspection , Tapping Observation , Non-Destructive Test.
12	Inspected Area	External Wall, Internal Wall, Terrace, Beams, Columns, All Class Rooms. [In case ofCivil ,Mechanical and ElectricalEngineering point of View]
13	Units Locked	None
14	Survey Disallowed in Units	None
15	Miscellaneous /Special Things	None

Table -2: Visual Inspection Report

Sr. No.	Inspected Components	Remarks
A]	SUB- STRUCTURE	-------
1	Foundation Strata	Soft Strata observed on 2.20m and Hard Strata Observed on 2.40m depth
2	Settlement of Footing And Column	No Settlement of Footing and Column Found
3	Cracks in Column , Walls ,Joints	Minor Cracks are found on Column, Walls.
B]	PLINTH-LEVEL	-------
1	Joint at plinth	Minor Cracks Found
2	Swelling Problem	Not Found
C]	SUPER- STRUCTURE	-------
1	Cracks in Columns / Rusting of Steel / Exposed Steel	Normal Rusted steel, Broken reinforcement, and cracks in column is visible below slab ,balcony and junction of beam and column
2	Cracks in External Walls	Minor Inclined cracks are developed

3	Cracks in Internal Walls	Minor Vertical cracks are developed
4	Leakages and Dampness in External and Internal Walls	Normal dampness observed on inside wall
5	Slab	Some cracks and Leakages are found on slab
6	Overhead Water-Tank	Found Normal Leakage
		and rusted steel
7	Color of Building	Found Fade
8	Tiles , Skirting and Dados	Major Breakages found
9	Condition of Plumbing system	Some Leakages found near the junction of pipes
10	Electrical Wiring	Open Fitting found in poor condition
11	Condition of Doors Windows , Ventilators , and fasteners	Found good in operating condition
12	Electrical Equipment's like, Fans, Tube-Light, Exhaust Fans, Switches, Electrical Boards. etc	Overall performance of all mentioned items are found Good and Satisfactory
13	Condition /Performance of Lift.	Lift not available
14	Condition of Rain Water Harvesting System [RWH]	Not Available
15	Condition of Sewage Treatment Plant [STP]	Not Available
16	Under Ground Water Tank	Found Minor plaster Cracks.
17	Sanitary Facility Condition	Satisfactory
18	Building Last Repair details	Before 1 yr.
19	Cost of Repair	5.0 Lac
20	Items Repaired	Coloring , Drainage system, Plumbing System, Water Proofing for slab, Underground water tank cracks repairing

Fig 2: Visual Inspection of Cracks and Damages of Plaster in Building.

FIG 3: VISUAL INSPECTION OF LEAKAGE IN BUILDING

Table -3 Non -Destructive Test [NDT]

Components	No.	Strength of Component in Mpa	Avg. Strength in Mpa	Remark
COLUMN	C1	34	36 Mpa	Very Good Layer
	C2	33		
	C3	37		
	C4	35		
	C5	37		
	C6	40		
BEAM	B1	32	30 Mpa	Good Layer
	B2	36		
	B3	22		
	B4	30		
	B5	32		

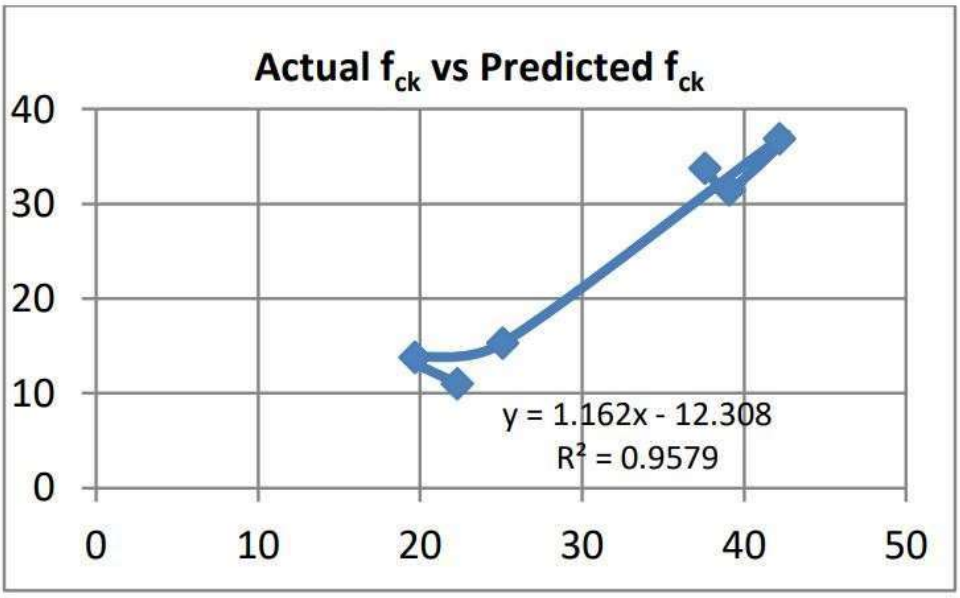
	B6	30			
SLAB	S1	22	25 Mpa	od Layer	

Fig 4: Non-Destructive Test [NDT] on Column and Slab in Building

Test results of Rebound Hammer Number:

Table 4: Rebound Hammer Testing Result

Sr No	R_1	R_2	R_3	R_4	R_5	R_6
1	19	19	24	42	36	38
2	25	20	25	42	37	38
3	23	20	26	41	40	37
4	22	19	26	42	37	37
5	23	19	26	42	39	38
6	22	20	25	42	40	38
7	22	19	25	43	40	37
8	22	21	24	43	41	37
9	23	21	25	43	40	38
10	22	19	25	42	41	37
Mean	22.3	19.7	25.1	42.2	39.1	37.6
D.L.	150	150	150	150	150	150
B.L.	247	311.5	365.5	830	710	760
F_{ck}	11	13.8	15.3	36.88	31.5	33.8



Graph 1: Accurecy Graphs

CONCLUSION

From the consideration of all the above points we conclude that the defects of structural members are due to combined effects of carbonation, corrosion & effect of continuous drying and wetting. The result of visual survey prompt us to conclude the distress is wide spread and is an ongoing process and so needs to be stopped at this stage so as to avoid complete collapse of the structure. There for Rehabilitation of the RCC members and will constitute the following steps

- Periodic maintenance of structures is essential.
- Each and every problem should be properly analyzed and then the appropriate repair methods undertaken.
- Primary design of the building reflects its performance in long run.
- Each repair technique is suitable only for the particular application for which it is meant for.
- Cost should not be significant planning factor in rehabilitation though it is a deciding factor.
- Due to moisture, walls get patch off and brick walls losses its strength, so the mentioned repair works for bricks and plaster of walls is well recommended.
- Due to some adverse conditions cracks will form in walls and slab which disturbs the functioning of structure, so the earlier mentioned methods are very useful for repair of cracks and rehabilitation of structure.
- Propping the structure wherever necessary
- Removing loose/disintegrated concrete
- Cleaning the affected steel
- Adding steel wherever necessary
- Applying Passivator coat to the steel
- Applying Bond Coat and doing Polymer /Micro
- Concrete treatment depending on the requirements

Finishing with new plaster

- For proper understanding of structural health the various NDT test are carried out depending upon the age of structure and the type of structure to predict the reliability of structure. in recent years the rebound hammer test and ultrasonic pulse velocity test are carried out on concrete structure to find out the standards of concrete and suitability of structure before applying the load on structure.
- Act of formation of NDTV it will shows us the results of the structural health and it will show us the repair conditions for the structure. Do the categories for repair are different for different conditions and it may vary by different techniques and cost of repair
- From rebound hammer test results it shows that the various slabs shows the medium compressive strength which is up to 30N/mm2 to 40 N/mm2 which is required to be repaired extend or

increase the strength of structure. And the results for beams and columns have an adequate compressive strength.

- From the ultrasonic pulse velocity test some of the columns shows the results of velocity up to 3000 m/s which is ok but it will affect because of grading quality of concrete. The building shows the adequate strength.

Structural Defects:

The defects of structural members are due to combined effects of carbonation, corrosion & effect of continuous drying and wetting. The result of visual survey prompt us to conclude the distress is wide spread and is an ongoing process and so needs to be stopped at this stage so as to avoid complete collapse of the structure. There for Rehabilitation of the RCC members and will constitute the following steps

- Propping the structure wherever necessary
- Removing loose/disintegrated concrete
- Cleaning the affected steel
- Adding steel wherever necessary.
- Applying Passivator coat to the steel
- Applying Bond Coat and doing Polymer /Micro Concrete treatment depending on the requirements
- Finishing with new plaster
- The condition of the building appears to be quite bad and major structural distress is observed in some of the columns and beams of the external walls.

FUTURE WORK

- Future work will developed a energy harvesting system for gained a significant rolled and interest in recent years due to the widespread availability of inexpensive, low cost and low power RF chipsets and microcontrollers that could form the core of a wireless bridge sensor system.

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