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STRUCTURAL AUDITING OF RCC BUILDING

Arsalan A. Shaikh[1], Prof. Prashant M. Kulkarni[2], Prof. Swapnil B. Walzade[3]

[1]Post graduate student, Department of Civil Engineering, Trinity College of Engineering and Research, Pune, India.
[2]Professor, Department of Civil Engineering, Trinity College of Engineering and Research, Pune-411048, India.

Abstract – *Structural Auditing is nothing but the overall health and performance checkup of the building just like a doctor examines a patient. This process to create awareness in the 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 resulted in construction of new multi-storey concrete apartments which are now in the age of thirty plus years. There are many buildings during this period and earlier that have reduced in strength in due course of time because of structural deficiency, material deterioration, unexpected over loadings or physical damage. lf further use of such deteriorated structure is continued it may endanger the lives of occupants and surrounding habitation. In this project work, an attempt has been made to carry out the structural audit of a (G + 4) residential building at Jalgaon City. Various significant tests are carried out on the building to assess the health of the building & software modeling is also done*.

Key Words: Structural Audit, NDT Tests, Staad pro

1. INTRODUCTION

Reinforced cement concrete (RCC) as a construction material has come into use for the last one century. In India, RCC has been used widely in the last 50-60 years. In this period of time, we have created large number of structures such as buildings, bridges, sports stadium etc., which are lifeline for the civilized society. These have been created with huge investment of resources. We cannot even dream of recreating such assets out of limited national resources. It is, therefore, essential to maintain them in functional condition. Since, deterioration of reinforced concrete is a natural phenomenon and has happening in huge number of structures, a proper and systematic approach is needed in order dealing with such kind of problem. Determination of the reasons of deterioration and consequent rehabilitation/ repair strategy at optimum cost require a scientific evaluation and solution. The first step in repairs and rehabilitation is the proper diagnosis for successful rehabilitation works. It deals with non-destructive evaluation techniques, laboratory tests and condition.

1.1 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

1.2 Bye-Laws for Structural Audit

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

2. OBJECTIVES OF RESEARCH WORK

The objectives of this research work are to study:

- To Perform preliminary inspection of the building.
- To Prepare of architectural, structural plan of the building.
- To Perform of NDT tests.
- Software modelling of the building.
- To find actual strength of the structural members of building.
- To identify any alteration and addition in the structure, misuse which may result in overloading?
- To assess the damage to the existing structures under distress and suggest the remedial measures for strengthen or repairs and rehabilitation.
- To comply with Municipal requirements

3. METHODOLOGY AND RESULT

3.1 Steps involved

Steps involved in structural audit carried out is as follows.

Step 1: Preparation of structural plan of the building. Architectural and structural plans are helpful in structural

calculation, identifying or highlighting critical areas in the building.

Step 2: Making assumption of load based on the intended use of the building i.e whether it is commercial, residential. Finding which code requirement has been met.

Step 3: Preliminary inspection of the building:

This inspection involves

a. Visual inspection

b. Tapping observation

1. Visual Inspection: In this building is thoroughly inspected from flat to flat noting cracks, spells, crazing, seepage etc. Highlighting critical area of investigation and repair same is marked on the plan of the building

2. Tapping observation: During this observation some of the structural members area subjected to hammer tapping and tapping sound is noted i.e. whether it is hollow or dence.

Step 4: Test recommendation

After highlighting critical area in the building next step is to recommend the appropriate test to evaluate the structure which may include Non-destructive tests like

a. Rebound hammer test

b. Ultrasonic-pulse velocity test

c. Half-cell potential meter test

d. PROFOMETER TEST

Step 5: On the basis of testing Identify the failing Members

Step 6: Software Modelling

Step 7: Recommendation of remedial or retrofitting methods for the suitable structural Members.

Step 8: Preparation of structural audit report.

Step 9: Conclusion

3.2 Preliminary Inspection

Table-1 Building Details

Location of building	Jalgaon district
Year of construction	1988
Age of Building	31 years
Number of storey	G+4
Type of building	Residential Building
Effects of monsoon	yes
Grade of concrete	M20
Grade of Steel	Fe415
Earthquake Zone	2
Number of Units	8(Ground Floor Parking)
Type Apartment	3BHK
Area of Each Apartment	246 sq.m

Table-2 Structural details

Length of Building	30.0m
Width of Building	20.0m
Height	G+4 @ 3m=15m
Live Load on the Floor	3.0 KN/m2
Grade of Concrete	M20
Steel	Fe 415
Column Size	0.5m x 0.5m
Beam Size	0.3m x 0.4m
Slab Thickness	230mm

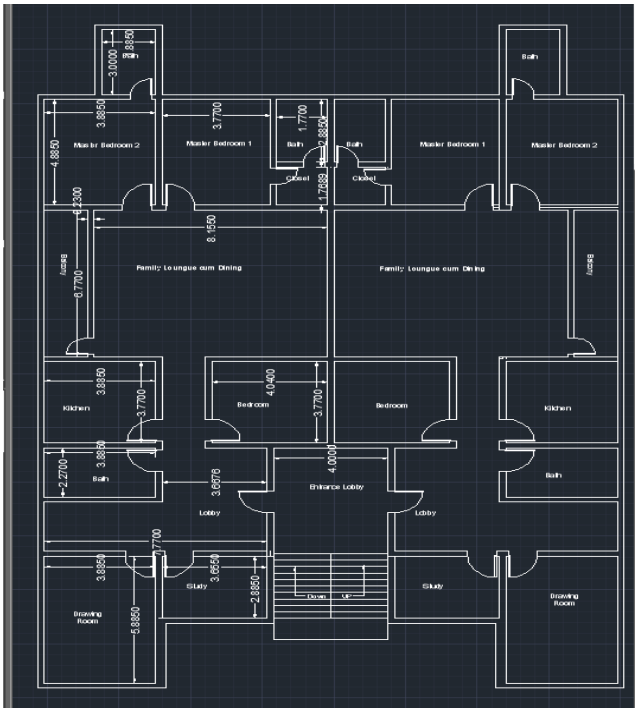

Fig-1: Architectural Plan of building

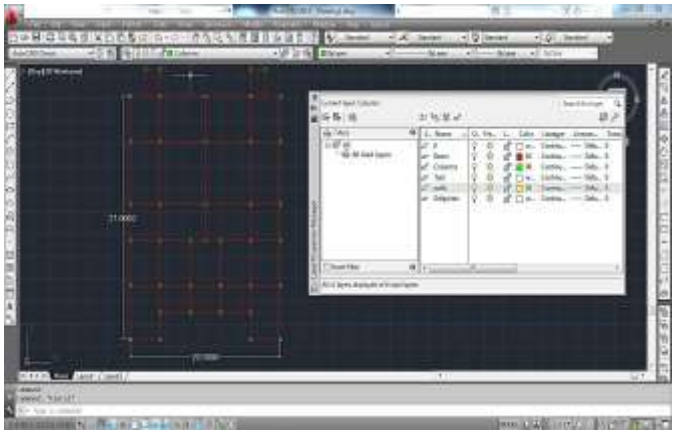

Fig-2: AutoCAD Plan

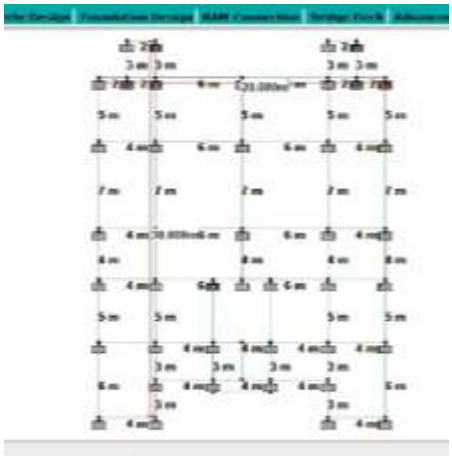

Fig-3: Column Orientation

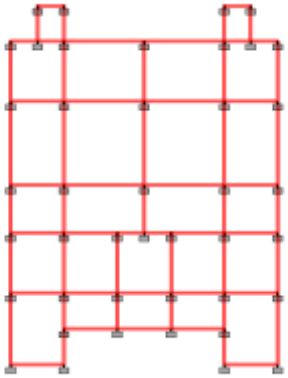

Fig-4: Beam Orientation

3.4 Rebound Hammer Test

Fig-5: Rebound Hammer Test

3.4.2 Components of a Rebound Hammer are

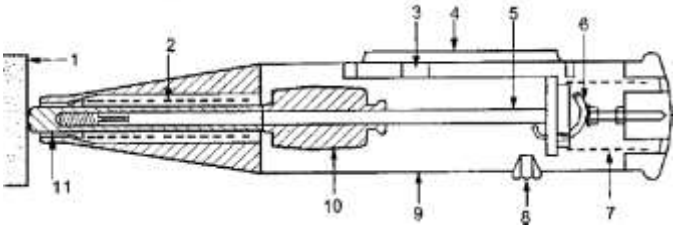

Fig-6: Components of a Rebound Hammer

1) Concrete surface
2) Impact spring
3) Rider on guide rod
4) Window and scale
5) Hammer guide
6) Release catch
7) Compressive spring
8) Locking button
9) Housing
10) Hammer mass
11) Plunger

3.4.3 Procedure for Rebound Hammer Test

- Prepare instrument for the test, remove the plunger from lock position by pushing the plunger on the surface and push it slowly against the surface
- Hold the plunger perpendicular to the testing surface
- As the body is pushed, the main spring connecting the hammer mass to the body is stretched. When the body is pushed to the limit, the latch is automatically released and the energy stored in the spring propels the hammer mass towards the plunger tip. The mass impacts the shoulder of the plunger rod and rebounds
- This rebound distance is measured on the graduated scale and is termed as rebound number.

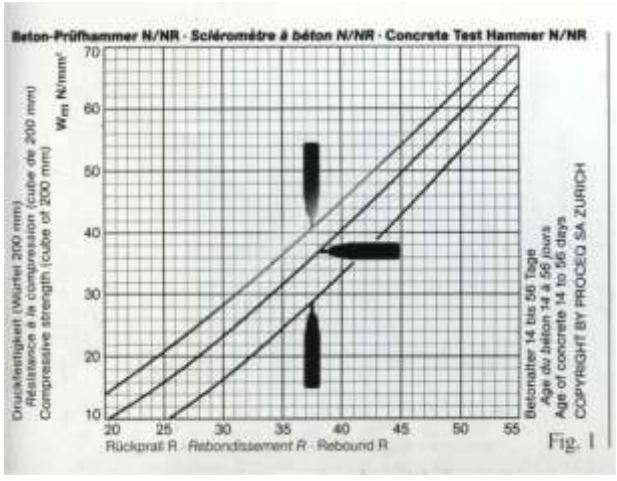

Fig-7: Relationship Between Strength and the Rebound Number

Table-3: Rebound hammer test for Columns

C No	B	M	T	avg	Position	C.S
C189	28	27	28	27.66	Horizontal	20
C190	24	22	26	24	Horizontal	14
C191	26	21	22	23	Horizontal	13
C192	29	26	27	27.33	Horizontal	18

Table-4: Rebound hammer test for Beams

B.No	S	M	E	avg	Position	C.S
B298	37	32	35	34.66	Vertically	24
B299	28	31	28	29	Vertically	15
B300	37	34	38	36.33	Vertically	26

Table-5: Rebound hammer test for Slabs

S.No	R NO	Position	C.S
S117	23	Vertically Down	18
S118	22	Vertically Down	16
S119	25	Vertically Down	20

3.5 Ultrasonic Pulse Velocity Test (UPV)

Pluse velocity calculated by

Pulse velocity = (Path length / Travel time)

Table-6: Standard Values of UPV

PULSE VELOCITY	CONCRETE QUALITY
>4.0 km/s	Very good to excellent
3.5 – 4.0 km/s	Good to very good, slight porosity may exist
3.0 – 3.5 km/s	Satisfactory but loss of integrity is suspected
<3.0 km/s	Poor and loss of integrity exist.

Table-7: UPV test for Column

Column No.	DISTANCE (mm)	TIME (µsec)	VELOCITY (km/sec)	Remark
C189	500	156.25	3.20	Medium
C190	500	173.61	2.88	Doubtful
C191	500	184.50	2.71	Doubtful
C192	500	157.23	3.18	Medium

Table-8: UPV test for Beams

Beam No.	DISTANCE (mm)	TIME (µsec)	VELOCITY (km/sec)	Remark
B294	400	135.13	2.96	Doubtful
B295	400	125.39	3.19	Medium
B296	400	121.58	3.29	Medium
B297	400	120.85	3.31	Medium
B298	400	113.63	3.52	Good
B299	400	138.40	2.89	Doubtful
B300	400	113.63	3.52	Good

Table-9: UPV test for Slabs

Sr. No.	DISTANCE (mm)	TIME (µsec)	VELOCITY (km/sec)	Remark
S117	230	72.32	3.18	Medium
S118	230	77.18	2.98	Doubtful
S119	230	75.40	3.05	Medium

3.6 Half Cell Potentiometer Test

Table-10: Half Cell Potentiometer test Result

floor	Member	- Volts	- Volts	- Volts	- Volts	- Volts
Ground	C30	0.341	0.357	0.386	0.403	0.411
Ground	C31	0.36	0.397	0.397	0.379	0.361
Third	C153	0.396	0.38	0.328	0.408	0.38
Fourth	C190	0.444	0.367	0.369	0.365	0.401
Fourth	C191	0.326	0.31	0.368	0.394	0.351
Third	C151	0.354	0.36	0.354	0.344	0.356
Ground	B47	0.324	0.365	0.347	0.368	0.45

4. MODELS

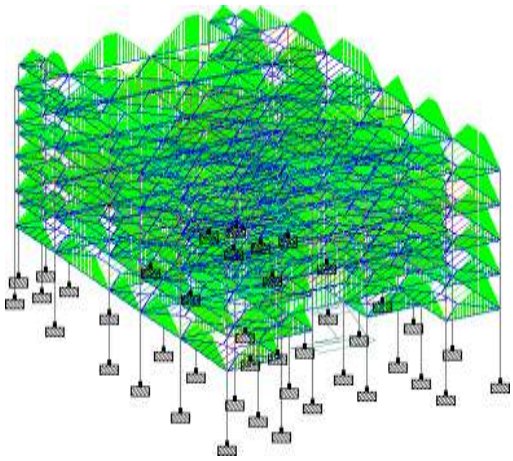

Fig-8: Relationship between Strength and the Rebound Number

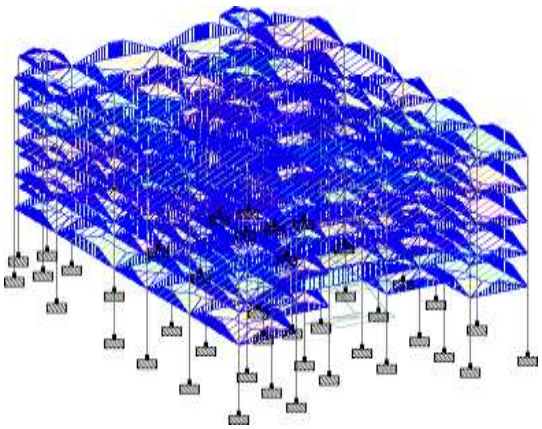

Fig-9: Relationship between Strength and the Rebound Number

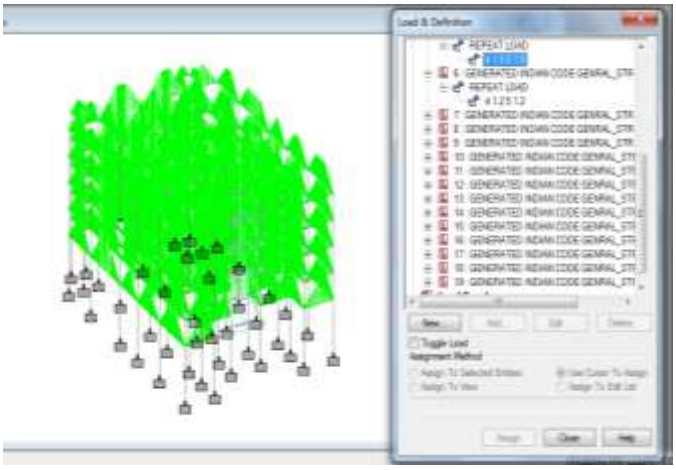

Fig-10: Relationship between Strength and the Rebound Number

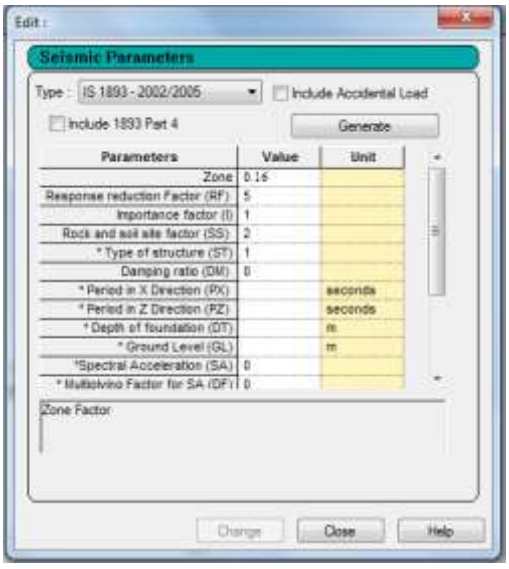

Fig-11: Relationship between Strength and the Rebound Number

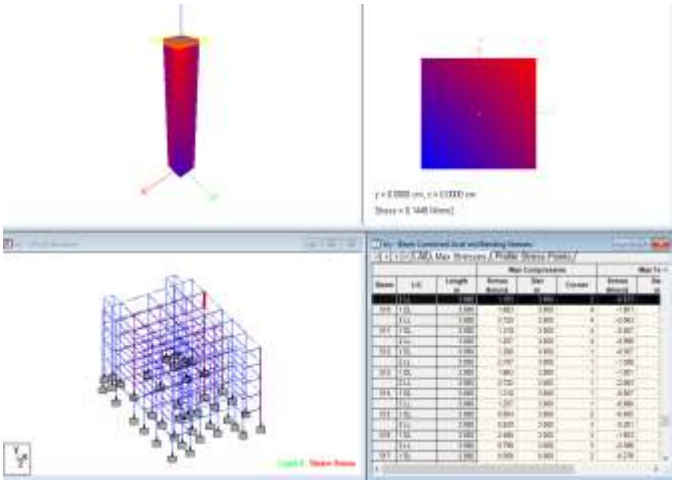

Fig-12: Max Stress in C31

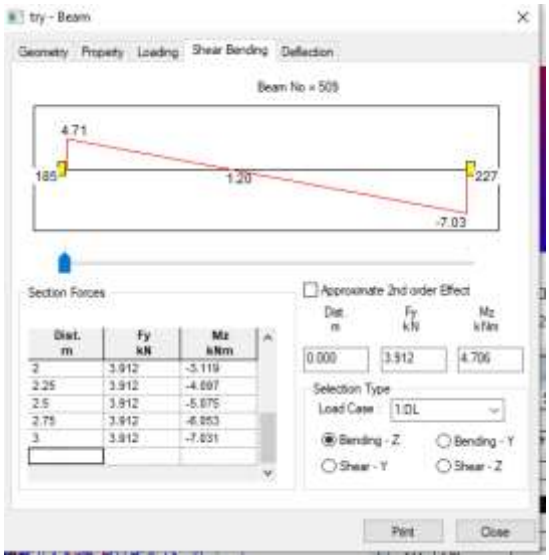

Fig-13: Deflection of Beam 509

Table-11: Grouping of Beams in x-direction

Beams In X-direction	
7m	39, 40, 41, 42, 43, 57, 58, 60, 61
6m	1, 3, 13, 14
5m	18, 19, 20, 21, 22, 23, 48, 49, 50, 51, 52
4m	30, 32, 33, 34
3m	3, 7, 10, 17

Table-12: Grouping of Beams in y-direction

Beams In Z-direction	
6m	54, 45, 36, 37, 48, 55,
4m	53, 44, 35, 24, 4, 2, 16, 15, 29, 38, 47, 56, 11, 8, 5, 25, 19, 6, 9, 12
2m	59, 63, 26, 77

Table-13: Grouping of Columns

Columns	
G. F	C1 to C40
F. F	C41 to C80
S. F	C81 to C120
T. F	C121 to C160
F. F	C161 to C200

Table-14: Grouping of Slabs

Slab	
G. F	S1 to S24
F. F	S25 to S48
S. F	S49 to S72
T. F	S73 to S96
F. F	S97 to S120

5. CONCLUSIONS

We approached Precedence Construction Pvt. Ltd. Company so as to complete auditing of 2018-2019 of RCC building. With this company we carried out three NDT tests. Tests we carried out were Rebound hammer test, Ultrasonic Pulse Velocity, Half Cell Potentiometer.

- In Rebound hammer test we observed that C31, C30, B259, S118 are un safe.
- In Ultrasonic Pulse Velocity test we observed C31, C30, B290, B259, S118 are with poor quality of material.
- Half-cell potentiometer is used to determine the corrosion activity in steel reinforcement. The potential as measured by the copper half-cell indicates the phase of the corrosion activity occurring in steel reinforcement. The potential values in all the structural members were greater than -350mV which indicates that corrosion activity is occurring positively in the concrete members.
- After knowing failure, we did software modelling for the validation.
- The approximate cost of the project is 1 lac 20 thousand
- For RCC 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 15 years structural audit should be carried out once in three years
- For structure older than 15 years structural audit should be carried out once in three years
- Government also make compulsory for structural audit for buildings which are more than 30 years old in Maharashtra
- It is observed that main cause of damage of the structural members is due to the leakage of water tank, corrosion and ageing. Corrosion in structural members is observed due to dampness and leakage from the slabs, cracks in walls ect
- Columns C30 and C31 are not safe due to leakage of water from water tank and over loading of water tank
- Reinforcement provided is in very bad condition and lost its Strength due to corrosion.
- Any delay in the structural repair work will result in more deterioration & quantity of work will become more.

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