

Structural Auditing of residential building

Gourav S. Shinde¹ Dr S.J.Arwikar²

P.G Students¹, Department of Civil Engineering, Annasaheb dange college Of engineering Ashta, Sangli, Maharashtra, India.
HOD² Department of Civil Engineering, Annasaheb dange college Of engineering Ashta, Sangli, Maharashtra, India.

Abstract: This paper covers the study of Structural Auditing of Residential Building. Now a days structural Auditing is necessary because of the poor quality of construction, carelessness in supervision during construction, use of poor quality of materials, carelessness by labors 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. Now while performing the audit of a residential building and we have conducted nondestructive testing on this building like Rebound hammer and ultrasonic Pulse velocity meter test after getting test results we have decided the building is safe or not and if it is not safe then remedial measures will be provided to increase the life of the building.

Index Terms- Structural Audit, NDT Methods, Structural Engineering, Rehabilitation. Building inspection, repairs and control

I. INTRODUCTION

In our country, there are so many old buildings which have reduced strength due to its age. If further use of such damaged structure is continued it might dangerous to the lives of the occupants and the surrounding area. We seriously must take actions to implement to improve the strength of structures and restore the desired function of structures. Thus, it is seriously required to do a structural audit of existing buildings and to implement maintenance and repair work to regain its original strength of the building.

To act more responsible and preemptive towards the very damaged buildings, the municipal corporation must issue notices as early as possible to the buildings and co-operative societies which are nearly 30 years old it is mandatory to carry out structural audit and submit the report. The structural audit should investigate all deteriorate areas and recommend immediate remedial measures.

II. LITERATURE REVIEW

Sachin Shelke, Darshana Ainchwar (2018) [1] 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.

Peteris Drukis, Liga Gaile and Leonids Pakrastins (2017) [2] Safety of buildings is very important in all aspects. A commercial building at Riga collapse due to damages caused was very serious and 54 people were died. Safety of structure is the practice of designing, constructing, operation, maintaining and removing structure in ways that no any loss of human or injuries. This paper tells us risk based assessment system of commercial building with target to classify this in common way. The outcome of this paper is exact assessment of the structure and the effect of that risk factor to the safety of public buildings.

A.B. Mahadik and M.H. Jaiswal(4) (2014) [3] This paper create awareness amongst the civil engineering structure and health examination of the concrete structure called as Structural assessment. The need of assessment is for maintenance and repair of existing structures whose life has exceed the age of 15 years according to standard guidelines and to save valuable loss of human life and also the collapse of structure. peculiarities. For example, the head margin in this template measures proportionately more than is customary. This measurement and others are deliberate, using specifications that anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations.

B.H Chafekar, O.S Kadam, K.B Kale, S.R Mohite, P.A Shinde, V.P Koyle (2013-14) [4] In a framed structure building, frame which is the heart of building. This frame is design by structural engineer taking in to consideration of factors and various codes which necessary. Different techniques used to assess of frames of old structure. Visual inspection non-destructive test are used to access frame of structure is made.

D.M. McCann, M.C. Forde (2001) [5] This paper reviews the state of non-destructive testing (NDT) methods as applied to the civil engineering industry in the Millennium Year, 2000. The basic principles of NDT methods are described with particular reference to the five major factors that influence the success of a survey: depth of penetration, vertical and lateral resolution, contrast in physical

properties, signal to noise ratio and existing information about the structure. The main NDT methods used in engineering investigations are discussed and illustrated with brief case histories from the literature. The integration of NDT surveys into the investigation of structures is described. The underlying reasons why NDT methods are perceived as 'not working' by the structural engineer are identified as: a lack of understanding of variability of both the construction materials used and NDT methods themselves.

III. PROBLEM STATEMENT- Presently visit to residential building which are more than 30 years old and to take various tests which are required for structural audit. After analysis of that building we will check the weak members and give the remedies or new design of that weak member for increased strength of that building.

IV. NEED OF STRUCTURAL AUDIT

1. Increase life of the building.
2. To save life of lives in the building.
3. To find damaged area of the building and to repair immediately.
4. To know the real condition of the building whether it is safe for dwelling or not.
5. To feel safe for occupants and surrounding peoples.

V. OBJECTIVES

1. To study the types of structural defects.
2. To identify any signs of material deterioration.
3. To identify any signs of structural damage .
4. To identify any changes in the structure.
5. To give remedies for improving structure.

VI. METHODOLOGY –

An old apartment located at Sangli which is about 40 years old have been selected for the structural auditing. The following research methodology have been adopted-

1. Performing preliminary inspection of the residential building.
2. Visual inspection to highlight critical area.
3. Performance of NDT tests.
4. Finding actual strength of the building.
5. Suggesting remedial measures.

VII. CASE STUDY OF RCC BUILDING.

A. Visual Inspection-

This building is a residential type and located in Sangli city. While visual observing this building it has been shows that material deterioration in every structural as well as non-structural member has gone to an extreme point and steel has been corroded, and some of the reinforcements which are totally disappeared. The column has gone large vertical cracks in huge manner which is easily observed by human eyes. Dampness problem is everywhere due to leakage in slab

Observation on case study,

1. Large cracks to columns.
2. Condition of slab is extremely poor and steel of the slab is completely rusted due to water. At the current situation it can be fall at any time.
3. Large amount of cracks produced on water tank columns.

4. Detachment of bond between wall and beam.
5. Seeping of water from wall.
6. The growing of weeds, small plants on building due to dampness or moisture present in walls.
7. The plants and trees growing periphery of building. Due to this causes cracks problems.
8. Large cracks on compound walls.
9. Plasters of some places are getting separated from its position.
10. Plumbing lines & drainage lines are leaking.
11. Water enters in the room from windows.
12. Electric Wiring in some rooms has problems.
13. The overall maintains of the building is very poor.
14. The wall joint with column is not proper and this shows the separation of wall with column by cracks.
15. The cover of beam has fallen down and steel is exposed to atmosphere.
16. Plaster on RCC member and on brickwork acts as skin but this plaster has fallen down most of the part.

Some photos of structural members like column slab of building which clearly shows that material deterioration reaches at extreme point.

1. Slab



Fig.1– Totally damaged slab

From above photos we can clearly see that condition of slab is extremely poor and steel of the slab is completely rusted due to water. At the current situation it can be fall at any time. Slab is heavily damaged because of poor quality of concrete, workmanship and careless supervision during the construction Even proper cover is not provided during the construction of slab.

2. columns-



Fig.2– Totally damaged Column

The fig shows us that the cracks on column are caused because of seepage of water inside the column through cracks and continued to increase column damage. The vital reason of columns being cracked is leakage. The concrete has totally separated from steel and column also the main bars along with stirrups are rusted. The concrete has no hardness as it has become in the powder form. This has caused poor appearance to columns and reduced strength.



Fig.3– Rusted steel of column

The above fig shows that steel has corroded totally and has lost its strength. While performing rebound hammer test the steel specimen had come out. Appearance looks like wood due to corrosion caused by leakage.

3. Water tank columns –



Fig.4– Cracks in water tank column

In this photo we can clearly see that the large amount of cracks are produced in water tank columns. The cracks are induced in the column because of swelling action of concrete takes place ultimately the diameter of steel inside the column get increased.

B. Tapping Observation-

While tapping on the Structural members of the building with hammer the hollow sound was recorded. This clearly shows that large amount of voids are present in those members.

C. Carbonation test –

The powder of concrete is obtained through structural members. Then the collected powder from structural members is made moist & then phenolphthalein indicator is dropped on the moist powder it to check any colour change. If the moist powder colour changes to pink indicate that concrete is not affected by carbonation & if there is no colour change is detected then it indicates that concrete is affected by carbonation.

VIII. NDT TESTS

Inspection & Testing:-

The main aim of rebound hammer testing is to get the general quality of concrete, rather than evaluating each RCC members in detail. On site few RCC members at random were tested. Ultrasonic pulse velocity (UPV) measurements were taken on Beam, column, and slab.

Corrosion:-

Rusting of reinforcement in structure is very common. Any corrosion of reinforcement which may cause serious damage to the structure if this damage to the structure is not repaired within time then loss of structure and loss of life may cause.

Usually the corrosion occurs due to the exposed steel to the atmosphere, this exposed steel if remain for long time rusting occurs. Due to poor workmanship at the time of casting RCC members the voids remain in concrete which may further lead to removal of concrete cover and due to wear and tear the steel exposed to atmosphere.

Some of the members of the building were subjected to test by Ultrasonic pulse velocity and Rebound Hammer test and reading were recorded which were evaluated further for remedial measures.

We have used following instruments

A. Rebound Hammer - Rebound hammer test is the most useful testing methods for comparing the relatively weaker and stronger areas of structural members.

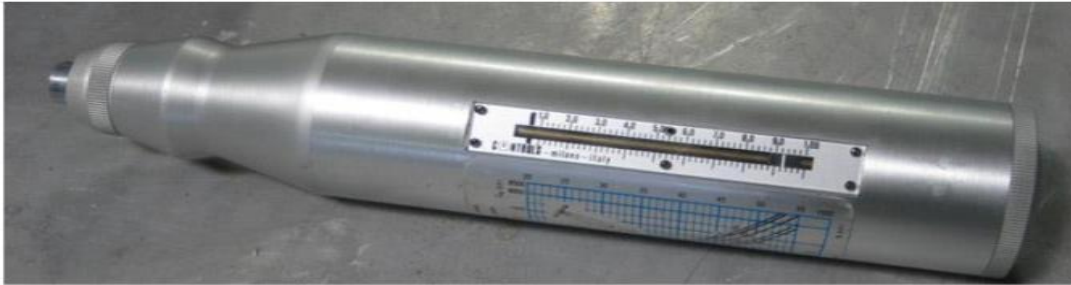


Fig.5- Rebound Hammer

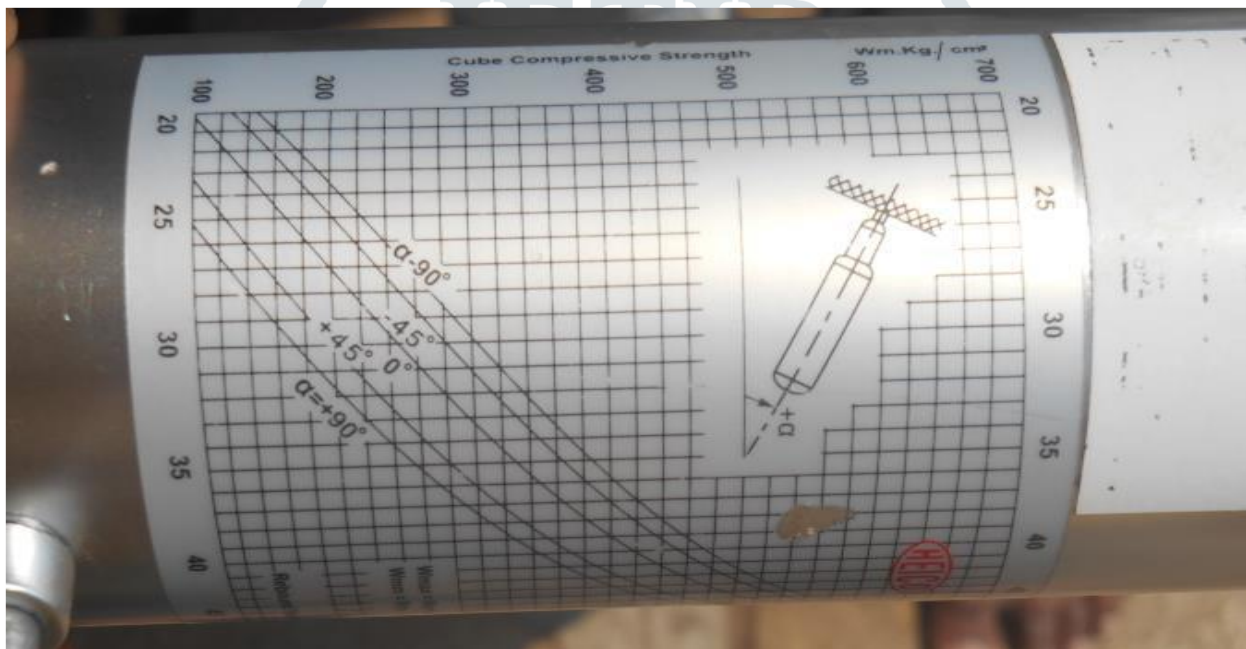


Fig.6- Rebound Hammer graph

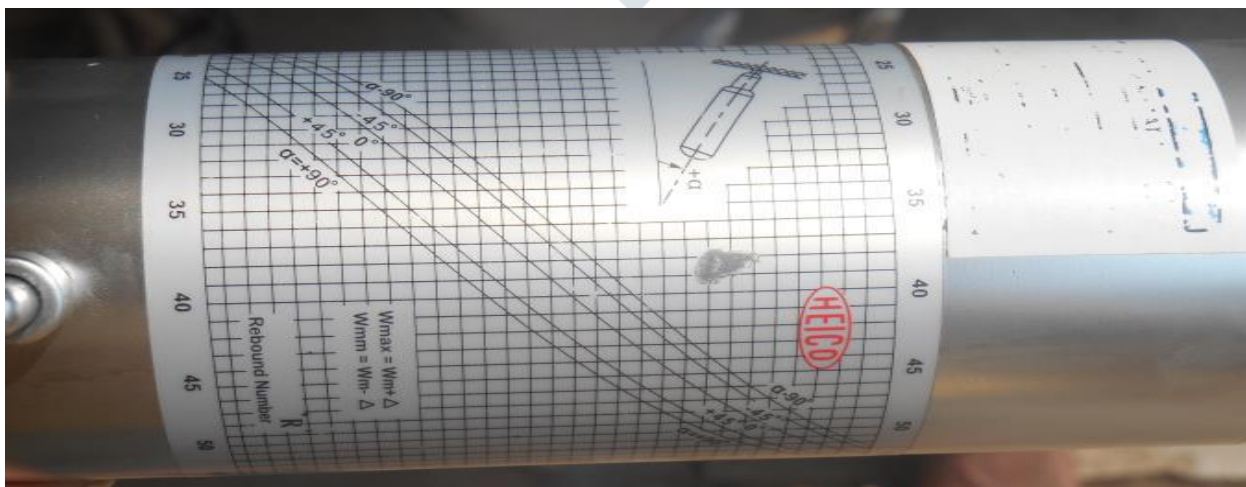


Fig.7- Rebound Hammer graph

Results of rebound hammer

Table I. Rebound Hammer Test Results (Column)

Rebound Value	Average	Compressive Strength Kg/cm ²
For Columns		
25		
20	22	120
21		
42		
36	36.7	340
32		
20		
24	20.7	110
18		
20		
25	23	140
22		
20		
23	23	140
26		
30		
28	28	220
26		
35		
28	31	260
30		

Table II. Rebound Hammer Test Results (Slab And Beam)

Rebound Value	Average	Compressive Strength Kg/cm ²
For Slab		
36		
42	39.5	330
40		
35		
36	34.5	210
32		
For Beam		
27		
29	28	220
28		
27		
29	29	230
31		

B. Ultrasonic Pulse Velocity –

This test is used for assess the quality of concrete by ultrasonic pulse velocity method as per IS: 13311 (Part 1) – 1992

The underlying principle of this test is –

The method consists of measuring the time of travel of an ultrasonic pulse passing through the structural members. Comparatively higher velocity is obtained when concrete quality is excellent in terms of density, uniformity, homogeneity etc. Here are the results of ultrasonic pulse velocity meter test on structural members



Fig.8- Ultrasonic pulse velocity meter



Fig.9- Ultrasonic pulse velocity meter calibration rod

Table III . Ultrasonic Pulse Velocity Meter

TEST RESULTS (COLUMN SLAB AND BEAM)

Sr No.	Velocity (m/s) For Columns	Concrete quality grading
	For Columns	
1	409	Doubtful
2	1533	Doubtful
3	1439	Doubtful
4	642	Doubtful
5	1075	Doubtful
6	1996	Doubtful
	For Slab	
1	589	Doubtful
2	1519	Doubtful
	For Beams	
1	4123	Good
2	1143	Doubtful
3	230	Doubtful

IX. REMEDIES

1. For Columns-

There are 4 Columns which have large Vertical cracks which is dangerous. For extra safety of columns and also increase load bearing capacity of columns reinforced concrete jacketing method can be used in which old column will be covered by new column.

2. For Slabs-

The advanced composite materials especially Fiber Reinforced polymer (FRP) systems in the field of structural engineering. FRP composites as construction materials have been largely used in civil engineering recently. FRP composites are lightweights, which have high strength and this is non-corrosive as well as non-magnetic materials. FRP has extensive use of recent, current and potential applications of these materials that cover both new and existing structures.

3. For overhead water tank-

Large cracks are produced on water tank columns so it's better to dismantle that overhead water tank and provide GI sheets on top staircase to protect staircase from Rain and heat.

4. Detachment of bond between wall and beam-

There is detachment of bond between wall and beam and cracks invariably develop at RCC and brick joints. You need to cut a groove in the plastering in such locations. If you want to seal the developed cracks along the wall and beam, then take it chip of width about 5mm and also equally deep. Purchase crack seal compounds from the market. Follow the instructions given by the manufacturer, seal

the cut grooves with the compounds purchased from the market. At times chances of developing crack again along the old crack but it will be of smaller width. Repeat the process.

5. Seeping of water from wall-

Good quality paints: The paint used for the building is of bad quality, maximum chances of moisture tend to seep through the concrete, thereby damaging the walls. Modern-day high-quality paints are resistant to water and contain silicon that offers the wall extra strength.

Filling up of cracks: Mortar is a dense and cohesive material that is waterproof. It could be used to seal the cracks on the wall. Structural cracks, as well as damaged wall tiles or roof, can be fixed using putty (white cement). That would prevent the paint from chipping during monsoons.

Proper drainage: Check out the house drainage system, as leaky water tanks cause in-wall dampness due to the moisture. Install sturdy water pipes and ensure the joints are well-sealed.

6. Improper maintains-

Some of the room in the apartment are improperly maintained so improve its appearance proper plastering must be provide and after providing plastering good quality painting must be provide.

7. Growing of plants-

Plants are grown near to plumbing pipes so as early as possible plants must remove from that place to avoid damage to structural members and after removing roots empty space of roots must fill by concrete mortar.

8. Cracks on compound wall-

Due to poor soil bearing capacity the soil has settled and leading to unequal load distribution of column and wall on soil leading to cracks so it's better to reconstruct compound wall from hard strata to avoid settlement of soil.

9. Uncleaned Site area of building-

There is large problem of vegetation periphery of building. This can be removed by acids.

10. Another Remedies-

Plaster at some places is getting separated from its position at such places by using cement paste or white cement it can be curable.

Plumbing lines & drainage lines are leaking hence required hence required.

Water enters in the room from windows hence proper water proofing is required.

Electric Wiring in some rooms have problems which must be cure.

X. RECOMMENDATION

1. Looking into all aspects of the building maintenance and as per our detailed survey, we suggest that the building needs to be thoroughly repaired and painted in a planned manner.
2. For any RCC framed structure the RCC components are like the bones in a body and hold the entire load of the body and any damage to the same has to be rectified immediately and cannot be left unattended for long period of time.
3. To bring the RCC components to their near original strength the same have to be repaired by polymer modified mortar method.
4. The RCC members originally deteriorated due to ingress of water and to prevent it happening again all sources of leakages must be stopped completely.
5. Plaster acts like a skin to the bones in a RCC structure, but the skin also needs to have a raincoat and the same is provided by a good quality resin based coating.
6. To stop the ingress of water the proper arrangement should be done
7. Structural Repairs (Wherever Necessary).
8. External Plaster (Patch).
9. Crack Filling/Joint Filling.
10. External Drain down take Plumbing (Wherever Necessary).
11. Terrace waterproofing by using nondestructive method.
12. Dead wall / Internal Terrace parapet wall plaster repairs.

XI. RESULTS

As per above rapid survey or by visual inspection building condition is not fair. That means over all structural condition of existing building under inspection is not fair. The said structure is about 40 years old. The plaster of Column and beam and slab spall out. General maintenance required to total structure our structural opinion says that the whole structure is not safe for occupants but they have to do the general routine maintenance.

By phenolphthalein indicator test we got some results which show that the concrete is affected by carbonation.

By NDT test we got some result by rebound hammer test and ultrasonic test we can conclude that the building is not safe.

The report states that the building is not safe so it is suggested to demolish the structure. But if we implement the remedies as stated in the report to the building the building life span may increase up to certain years but the implementation of remedies becomes uneconomical.

XII. CONCLUSION

For a framed structure structural assessment is necessary so that appropriate remedial measures can be recommended for all type of structural defects. This assessment of any structure gives extra life span to the structure by applying appropriate remedies suggested in assessment report.

From above observation we conclude that the structural defects are due to the faulty workmanship, poor quality of material used at the time of construction and no any specific supervision at the time of construction carried out. The reinforcement provided in members are corroded and there is loss in strength of the member, this loss is due to leakage of water from slab. Also there are combined effects of carbonation, corrosion, and effects of continuous drying and wetting.

So the strength and serviceability of structure can be extended by taking necessary measures such as waterproofing walls and slab to stop seepage of water in to structural members to stop corrosion of reinforcement. Providing polymer mortar treatment. Recasting of slab.

XIII. REFERNCES

1. Sachin Shambhau Shelke, Prof. Darshana Ainchwar: Structural health monitoring, Audit Repair andrehabilitation of building in construction industry. International Journal of Engineering Technology Science and research, ISSN 2394-3386, Vol, 05 Issue 3, March 2018
2. P Druķis¹ , L Gaile, K Valtere, L Pakraŗtiŗņš and V Goremikins : Study of structural reliability of existing concrete structures , IOP Conf. Series: Materials Science and Engineering 251 (2017) 012087 doi:10.1088/1757-899X/251/1/012087
3. A.B. Mahadik and M.H. Jaiswal,: Structural Audit of Building, IJCER, ISSN 2278-3652 Vol, 05 pp. 411-416, (2014)
4. B.H. Chafekar, O.S Kadam, K.B Kale, S. R. Mohite, P,A Shinde, V.P Koyle:Structural Audit, IJCER, Vol, 01 Issue1, pp. 42-46, October 2013-2014
5. D.M. McCann, M.C. Forde,: Review of NDT methods in the assessment of concrete and masonry structures, NDT & E International, pp. 71-84 (2001)
6. Malcom K. Lim,: Combining multiple NDT methods to improve testing effectiveness. Construction and Building Materials, pp.1310-1315 (2013)
7. Ravi Ranade Non Destructive Testing of Concrete Structures (NDT, Repair / Rehab. Consultant, Concrete Technologist)