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Strength Assessment & Restoration of RC Structure by Structural Health Evaluation-Case Study

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Abstract - Structures can be any kind it can be Historical, Heritage Structure, Residential building, Commercial building or an Industrial building. Every structure has its own service life, and within this service-life it should stand firmly on its position. Eg. A Taj Mahal in Agra in India which is one of the oldest structure and a Wonders of the World, and still stand on its position very efficiently. But this not a condition about the today's Structures. A collapsed mechanism has increased and today's Structures are getting collapsed before there service life is completed. Therefore, it is advisable to monitor it periodically by taking a professional opinion. Structural Audit is a preliminary technical survey of a building to assess its general health as a civil engineering structure. Apart from requiring regular maintenance, many structures require extensive Repair, Rehabilitation Retrofitting. Over a period of time, as these structures become older, we find in them certain degradation or deterioration with resultant distress manifested in the form of cracking, splitting, delaminating, corrosion etc. Such deteriorated structures can be rehabilitated and retrofitted by using various types of admixtures modern repair materials.

Keywords-Structural audit, Structural Engineering, NDT method, ETABS Modelling, Structural Evaluation Program, Rehabilitation, Retrofitting, Sustainable Development, Polymers, Admixtures.

1. INTRODUCTION

India is a heritage of old building and Structures. These structures due to continuous deterioration of material and not being timely maintained have reduced Strength. If, further use of such damage structure is continued it may cause severe loss of lives and Property. Structural Audit is an overall health and performance check-up of a building like a doctor examines a patient. Structural Audit is an important tool for knowing the real status of the old building. 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. So our initiative is to work to ensure that the building is Safe and has no risk. It also suggests some Repair to increase the Serviceability of the building. It is necessary for maintenance and Repair of Existing Structure having age more than 30 years.

3. NEED OF PROJECT

A large number of existing buildings in India is severely deficient against earthquake forces and the number of such buildings is growing very rapidly. This has been highlighted in the past earthquake. Retrofitting of any existing building is a complex task and requires skill, retrofitting of RC buildings is particularly challenging due to complex behaviour of the RC composite material. The behaviour of the buildings during earthquake depends not only on the size of the members and amount of reinforcement, but to a great extent on the placing and detailing of the reinforcement. The construction practices in India result in severe construction defects, which make the task of retrofitting even more difficult. Appropriate maintenance prolongs the life span of a structure and can be used to prevent such damages can help to avoid failures which may result due to this damages. Higher operational loads, complexity of design and longer life time periods imposed to civil structure make it increasingly important to monitor the health of these structures.

4. OBJECTIVES

- To find the critical areas which need to repair immediately & identifying any alterations and addition in the structure, misuse which may result in overloading?
- Finding existing strength of selected structure & expected future life at present condition.
- To enhance life cycle of structure by suggesting preventive and corrective measure like repairs

5. ESEARCH METHODOLOGY

We have studied the conventional NDT methods advanced methods comparatively with respect to efficiency towards good results for strength assessment of RC structure.

6. METHODOLOGY

Preliminary Data & structure details

Building is located in Indapur, it's an institutional building G+1 structure, and building is 24 years old. Other essential data given below:

- Name Of Site- Malojiraje Vyayam Shala, Indapur
- Location- Kasba, Indapur
- Year Of Construction-1995
- Present Age Of Structure- 24 Years
- Type of structure-RCC
- Zone- III
- Number of stories-G+1
- Ground storey height- 3.2 m.
- Floor to floor height-3.2 m
- Parapet wall-230 mm thick including plaster
- Wall thickness-230 mm thick including plaster
- Total depth of the slab-180 mm
- Size of all columns- 230 × 230 mm
  230 x 380mm
  230 x 450 mm
- Size of all beams- 230 × 350 mm

Fig1. Selected site for investigation

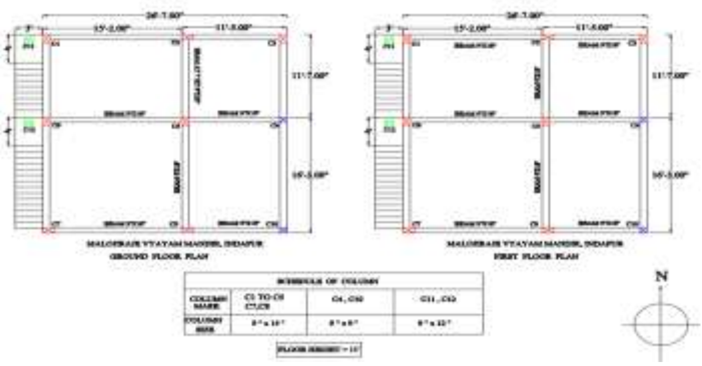


Fig2. Beam Column Layout

7. STEPS TOWARDS FULFILLMENT OF PROJECT ARE AS FOLLOWS:

Step 1: Condition survey

It is an examination of concrete for the purpose of identifying and defining area of distress.

A) To identify the causes of distress & their sources.

B) To assess the extent of distress occurred due to corrosion, fire, earthquake or any other reason and the residual strength of the structure

C) To priorities the distressed elements according to seriousness of repairs

D) To select and plan the effective remedy.

- Stages for Condition Survey:-The condition survey has following stages.
  1. Preliminary inspection.
  2. Planning
  3. Visual inspection
  4. Field testing

Step 2: Preliminary inspection of the building:

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.

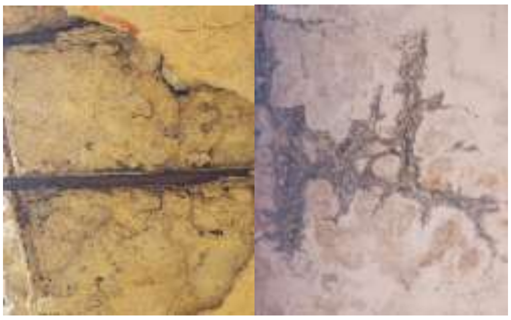


Fig3. Some areas detected during visual inspection which need immediate repair due to corrosion of steel reinforcements

2. Tapping observation: Column and beams of the building were subjected to tapping by the hammer .For some of the beams and column hollow sound was recorded. This hollow sound was due to loss of integrity between reinforced steel and surrounding concrete.

Selection of critical area for further Non-Destructive testing: Based on above observations of the ground floor was found most unsafe due to bad condition of structural elements such as beam, column and slab. Status of beams of this area is critical beams are sagging due to deflection and corrosion. There is bulging in columns due to corrosion of reinforcement and disintegration of concrete has resulted in exposure of the reinforcement to atmosphere.

Step 3: **Experimental Work**

Non Destructive Testing

Non-destructive Testing method are the method of tastings in which properties nor condition of the material is determined without damaging or making changes in the integrity of material. This methods of testing allows to test the material or component without losing its usefulness.NDT method helps in testing integrity of concrete or structural members throughout its life span.

Once the NDT tests is performed it is possible to re-test the structure. NDT tests are applicable in testing the condition of the bridges, highways, building etc. NDT methods have been in use for about 4 decades, and in this period, the development has taken place to such an extent that it is now considered as a powerful method for evaluating existing concrete structures with regard to their strength, durability and quality.

NDT allows users to determine following properties of the object

1. Strength properties at site

2. Durability

4. Moisture content

5. Elastic properties

6. Extent of visible cracks

3.1.1 Method of testing:

1. Prepare the instrument for the test, remove the plunger from lock position by pushing the plunger on the surface and push it slowly against the surface.

2. Hold the plunger perpendicular to the testing surface.

3. 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.

4. This rebound distance is measured on the graduated scale and is termed as rebound number.

Experimental Analysis Results

Table -1: For Column

Sr. No	Column No.	Column Size (mm)	Rebound No.	Hammer position	Comp Strength (Mpa)
1	C1	230x450	29	Horizontal	18.5
2	C2	450x230	31	Horizontal	21.5
3	C3	450x230	23	Horizontal	12.5
4	C4	230x230	24	Horizontal	13.8
5	C5	230x450	32	Horizontal	22
6	C6	230x450	20	Horizontal	10.3
7	C7	450x230	26	Horizontal	13
8	C9	450x230	33	Horizontal	22
9	C10	230x230	25	Horizontal	13.9
10	C11	450x230	20	Horizontal	13.3
11	C12	450x230	24	Horizontal	13.8

Table -2: For Beams

Sr. No	Beam No.	Beam Size (mm)	Hammer position	Rebound No	Comp Strength (Mpa)	Avg. (Mpa)
1	B1	230x 380	Horizontal	28	15.5	14.75
			Vertical	30	14	
2	B2	230x 380	Horizontal	24	13.8	13.15
			Vertical	28	12.5	
3	B3	230x 380	Horizontal	23	12.6	13.2
			Vertical	29	13.8	
4	B4	230x 450	Horizontal	22	12	12
			Vertical	27	12	
5	B5	230x 380	Horizontal	35	27.5	20.65
			Vertical	29	13.8	
6	B6	230x 380	Horizontal	30	20.7	17.6
			Vertical	31	14.5	
7	B7	230x 380	Horizontal	34	25	19.4
			Vertical	29	13.8	
8	B8	230x 380	Horizontal	32	22	16.15
			Vertical	24	10.3	
9	B9	230x 380	Horizontal	23	12.6	12.3
			Vertical	21	12	
10	B10	230x 380	Horizontal	30	20.7	16.6
			Vertical	28	12.5	
11	B11	230x 380	Horizontal	28	15.5	15
			Vertical	31	14.5	
12	B12	230x 380	Horizontal	29	18.5	18
			Vertical	33	17.5	
13	B13	230x 300	Horizontal	34	25	23
			Vertical	36	21	
14	B14	230x 300	Horizontal	32	22	20
			Vertical	34	18	

3.2. ETABS MODELLING & ANALYSIS

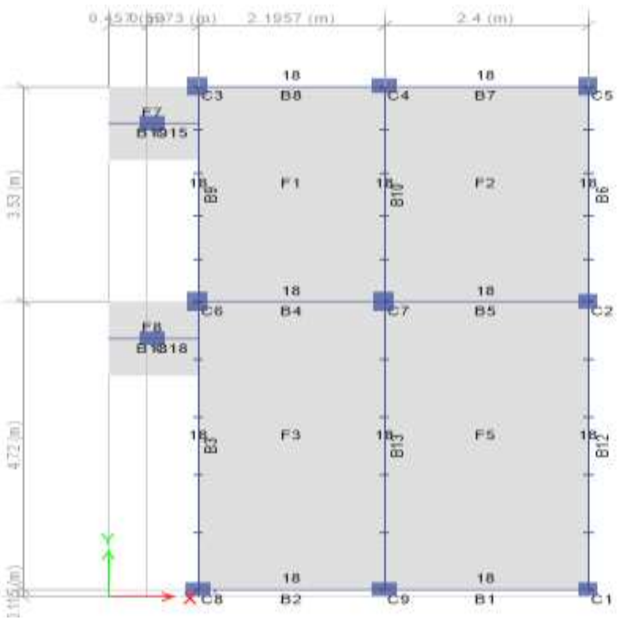


Fig.4:Planned View of Etabs Model

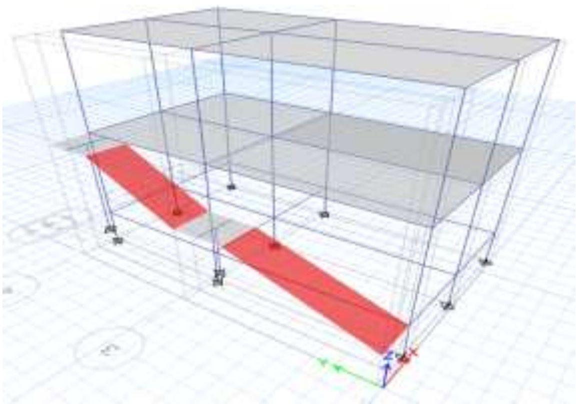
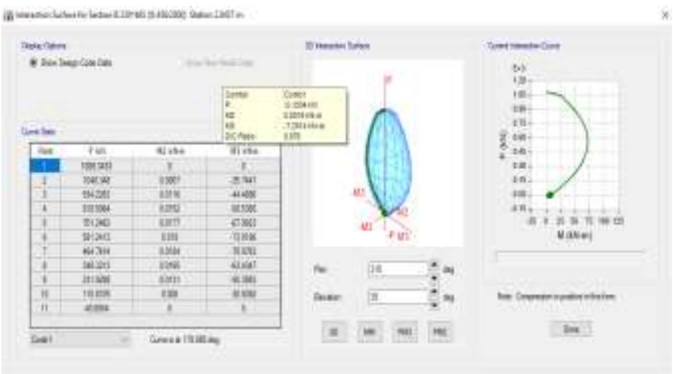


Fig.4: Planned View of Etabs Model

3D View of Etabs Model



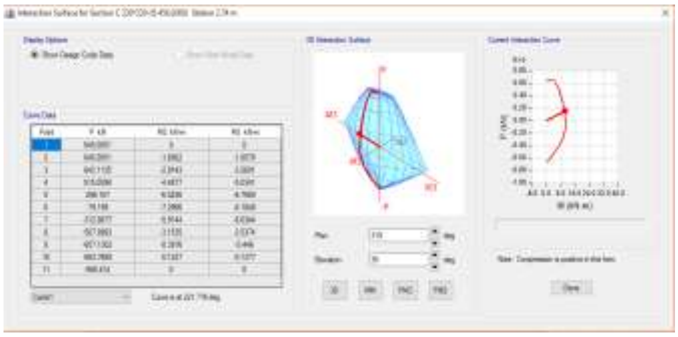


Fig.4: Planned View of Etabs Model Analysis with respect to interaction curve

3.2.1. Method

Step 1: Determine size of the structural members, actual reinforcement present in the members.

Step 2: Determine the actual load on the members using IS: 456:2000.

Step 3: Capacity of the structural members is determined using ETABS analysis of the members carried out in previous step.

Step 4: Compute demand and capacity ratio for the members and finding the members which needs immediate strengthening.

Step 5: Application of strengthening system FRP layer for the failed members.

Step 6: Analyse again with respect to demand and capacity ratio and comparing results.

Table -3: Result Comparison

Sr. No	Column No	Size	D/C Before Strengthening	D/C After Strengthening
1	C1	230x380mm	0.746	0.312
2	C2	230x380mm	0.86	0.45
3	C3	230x380mm	0.896	0.641
4	C4	230x230mm	1.071	0.71
5	C5	230x380mm	0.94	0.42
6	C6	230x380mm	1.244	0.698
7	C7	230x380mm	0.644	0.309
8	C9	230x380mm	0.918	0.64
9	C10	230x230mm	1.28	0.73
10	C11	230x300mm	1.31	0.751
11	C12	230x300mm	1.113	0.591

3.2.2. ETABS RESULT GRAPHS

3.2.2.1.Software analysis results before strengthening

Graph.1. Base Shear vs Displacement

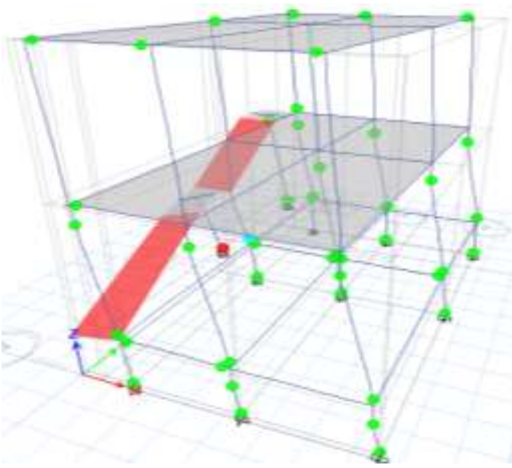


Fig.7. Hinges Located before strengthening

Graph.2. Story Drift

3.2.2.2. Software analysis results after strengthening

Graph.3. Base Shear vs Displacement

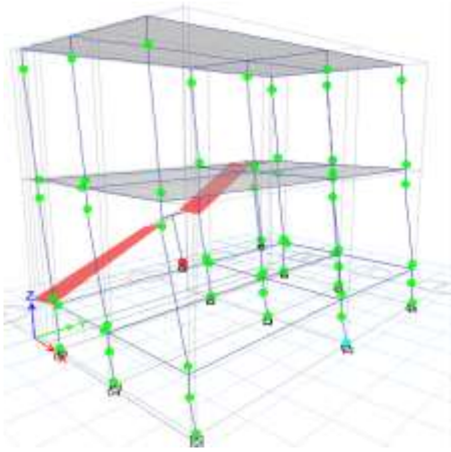
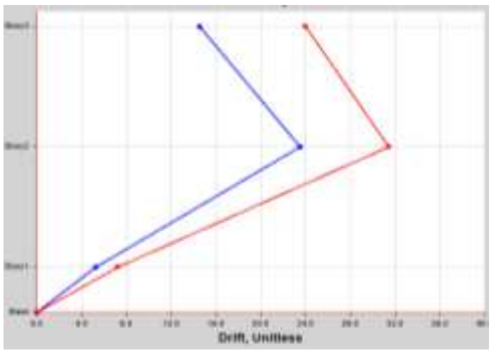


Fig.7. Hinges Located after strengthening



Graph.6. StoryDrift

Conclusion

Thus as per the analysis that made by both experimental and software analysis some members found heavily deteriorated and were needed immediate strengthening. Further we applied strengthening to respective members using ETABS and we got positive result towards strength regain. This result was analyzed by ETABS analysis with respect to D/C ratio using interaction curve. The results and respective graphs are as shown above.

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