# "Structural Diagnosis, Repair and Retrofitting of RCC Structure"

**SHARIKMASLAT ABUTURAB. S[1], Dr. S. N. TANDE[2],**

*[1] PG Student, Dept. of Civil Engineering, Walchand College of Engineering, Sangli, Maharashtra, India, 416415*
*[2] Associate Professor, Walchand College of Engineering, Sangli, Maharashtra, India, 416415*

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**Abstract -** *In the modern world, there are many different types of structures, including ones made of steel, reinforced concrete, and composite materials. These structures must be able to sustain loads from gravity, earthquakes, wind, etc. during the course of their design lives. Nevertheless, many current structures might degrade or need to be upgraded. When upgrading an existing structure, for example, it may be more cost-effective to apply retrofitting techniques to strengthen the existing building rather than demolishing it and starting from scratch. The behavior of G+1 story R.C. frame buildings is the subject of the study. The frame structure's characteristics are defined along with it. The structure is diagnosed visually, using any NDT testing that was done on it, and by taking into account the data that was produced after inspection. In order to pinpoint the crucial structural components and suggest repair and retrofitting, models are made using the ETABS software.Modification of the building's use in accordance with the needs of the client, etc. In some circumstances, such as when modifying an existing structure, it is more cost-effective to use retrofitting techniques to strengthen the current structure rather than tearing it down and building a brand-new one.*

***Key Words***: Diagnosis1, NDT2, Repair3, Retrofitting4, ETABS5

## 1. INTRODUCTION

For over a century, reinforced cement concrete (RCC) has been used in building. Over the past 50–60 years, RCC has seen widespread use in India. Buildings, bridges, sports stadiums, and other infrastructure assets that are essential to the survival of a civilized society have been built in significant numbers during this time. These have involved a significant expenditure of resources. With our limited national resources, we cannot even imagine attempting to recreate such assets. Therefore, it is crucial to keep them in good working order. Since RCC deterioration is a natural occurrence and has begun to show up in many structures, a systematic method is required to deal with such issues. Identifying the degradation and ensuing repair at the lowest possible cost requires.

The diagnosis of a concrete structure includes not only determining its current state but also making predictions about the reasons for deterioration and the structure's remaining life. Therefore, correct diagnosis of the concrete's is essential to extending both its current life and the life of the structure as a whole. It can be economically feasible to restore the damaged structure and extend its remaining life if the cause of deterioration is identified and the structure is properly assessed. Before beginning any repair work, NDT tests must be performed to determine the severity of the distress and damages in the concrete structure as well as to determine the quality and strength of the concrete. In order to pinpoint the crucial structural components and suggest repair and retrofitting, models should be made and analyze using the ETABS software.

### 1.1 PURPOSE OF PROJECT.

A vast number of existing buildings in India are dangerously vulnerable to earthquake effects, and the number of such structures is continually increasing. This was underscored by the recent earthquake. Retrofitting any existing building is a complex process that demands competence; retrofitting RC buildings is more difficult due to the complex behavior of the RC composite material. The behavior of buildings during an earthquake is influenced not only by the size of the members and the amount of reinforcement, but also by the placement and detailing of the reinforcement. Construction techniques in India produce serious construction faults, making retrofitting even more challenging. Appropriate maintenance extends the life of a structure and can be utilized to prevent such damages, which can help to avoid failures caused by these damages. Higher operational loads, complexity of design, and longer life time periods placed on civil constructions make monitoring their health increasingly critical..

### 1.2 OBJECTIVES OF PROPOSED WORK.

The objectives of the work are as follows:

1) Formulation of the problem statement, development of methodology and possible validation with research articles.
2) Performing primary inspection of RCC structure by NDT test.
3) Software modelling of building and Evaluation of strength parameter with respect to the type of structural defects, any signs of material deterioration and deformation
4) To recommend life enhancing preventive and corrective measures like repairs and retrofitting for RCC structure.

## 2. THE VARIOUS STAGES INVOLVED IN STRUCTURAL DIAGNOSIS.

### 2.1 Study of plan and Site Description.

### 2.2 .Visual inspection.

The various points should be checked on inspection.

- Any settlement in the foundation.
- Detect dampness in wall.
- Any sign of material deterioration.
- The various addition and alteration made.
- Status of balconies – sagging, deflection, crack.
- Survey And Data Collection.

### 2.3 Non-destructive testing.

In addition to the visual inspection the quality of the member can be determined by the use of various non-destructive test. There are various instrument (NDT) used in the concrete members to determine the present strength and quality of the concrete. The result of these is useful in finding out the treatment to be given to the structural members. There are various types of the test available in the market. The instrument used depends upon the type of the audit carried out, age of the building, type of the structure, surrounding condition, atmospheric condition etc. some to the instrument are listed below.

- Rebound Hammer Test:- To measure surface hardness of concrete.
- Ultrasonic Pulse Velocity Test:- To assess homogeneity of concrete, to assess strength of concrete qualitatively, to determine structural integrity.

### 2.4 .Identification Of Critical Areas In Building.

Based on the above inspection, test results and analysis by ETABS software modelling , the report should conclude the critical areas that recommended to repairs and retrofitting.

## 3. CASE STUDY.

### 3.1 Site Description

| | |
|---|---|
| Name Of Site | Royal Avenue |
| Location | Ichalkaranji |
| Year Of Construction | 1990 |
| Type Of Structure | RCC |
| Zone | II |
| Number Of Stories | G+1 |
| Storey Height | 3 m. |
| Thickness of slab | 150 mm |
| Size of all columns | 230 × 450mm, 230 x 375mm, 300 x 450mm, 450 x 450 mm. |
| Size of all beams | 230 × 450mm, 300 x 600mm. |

### 3.2 Study Of Architectural and Structural Plans.

At the planning stage, field planning documents are created. These field recordings are essential for figuring out the pattern and kind of damage. The structural members are also divided into several types based on similar exposure situations in order to effectively identify the source of distress.

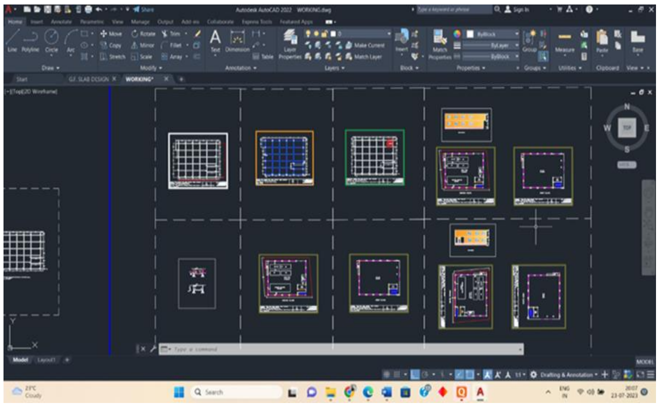

Fig 3.2.1 Architectural and Structural Plans.

Table 3.2.2 Column Sizes.

| Column Number | Column Size |
|---|---|
| C9, C11, C14, C17 | 230X375 |
| C1, C7, C15, C16, C22 | 230X450 |
| C6, C8, C10, C13 | 230X450 |
| C2, C3, C4, C5, C12, C21 | 300X450 |
| C18, C19, C20 | 450X450 |

### 3.3 Condition Assessment.

A thorough examination of the building was conducted to search for any flaws like seepage, crazing, or cracks. Significant issues that require investigation and repair were identified by the inspection. Investigated were several locations discovered during visual examination that require urgent repair owing to detoriation and corrosion of steel reinforcements.

3.3.1. Major Cracks and Spalling of concrete.

Fig 3.3.1.1 Defects At Building.

3.3.2 Seepage / Leakage through concrete.

Fig.3.2.2.1 Seepage At Wall Of Building.

3.3.3 Structural cracks of concrete

Fig 3.3.3.1 Structural cracks of concrete

**3.4 Performing Non-destructive Testing.**

Table 3.4.1 Rebound Hammer Test Readings

| SR NO | COLUMN NUMBER | COLUMN SIZE | Average Compressive Strength (Mpa) |
|---|---|---|---|
| 1 | C1 | 230 x 450 | 26.5 |
| 2 | C2 | 300 x 450 | 28 |
| 3 | C3 | 300 x 450 | 21.5 |
| 4 | C4 | 300 x 450 | 20.5 |
| 5 | C5 | 300 x 450 | 22 |
| 6 | C6 | 230 x 450 | 26 |
| 7 | C7 | 230 x 450 | 24 |
| 8 | C8 | 230 x 450 | 22.25 |
| 9 | C9 | 230 x 375 | 20.5 |
| 10 | C10 | 230 x 450 | 23 |
| 11 | C11 | 230 x 375 | 27.25 |
| 12 | C12 | 300 x 450 | 28.20 |
| 13 | C13 | 230 x 450 | 26.5 |
| 14 | C14 | 230 x 375 | 28 |
| 15 | C15 | 230 x 450 | 26.25 |
| 16 | C16 | 230 x 450 | 28.5 |
| 17 | C17 | 230 x 375 | 25.5 |
| 18 | C18 | 450 x 450 | 21.25 |
| 19 | C19 | 450 x 450 | 22 |
| 20 | C20 | 450 x 450 | 23.5 |
| 21 | C21 | 300 x 450 | 24.5 |
| 22 | C22 | 230 x 450 | 27.5 |

**4. DESIGNING AND ETABS ANALYSIS OF STRUCTUR.**

The structure is idealized as a 3-D space Frame model using the software ETABS. The masonry wall is used as filler wall and not cast monolithically with structure. Hence this is not modelled in the analysis In this slab loads are applied as a floor door Slab loads are applied as a floor loads. Wall loads are applied as UDL on beams. Self- weight is added in the software to have member loads.

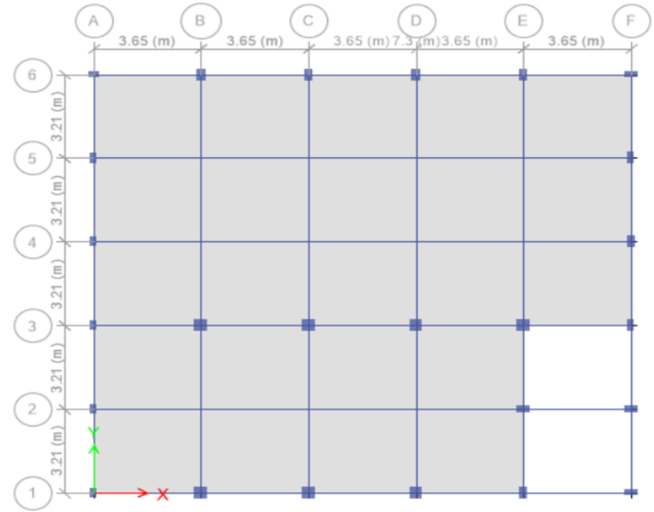


Fig 4.1 a) Planned View of ETABS Model

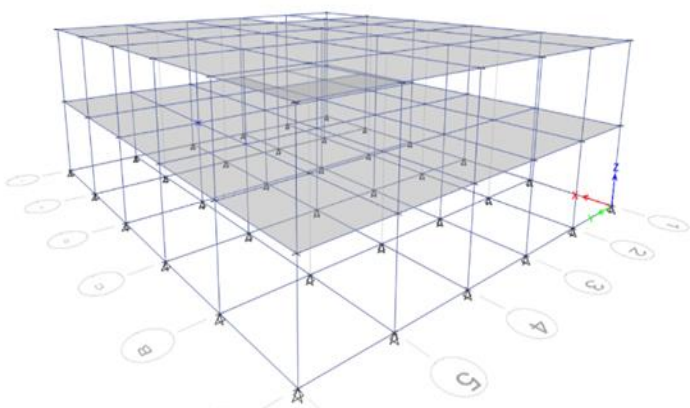

Fig 4.1 b) Planned View of ETABS Model

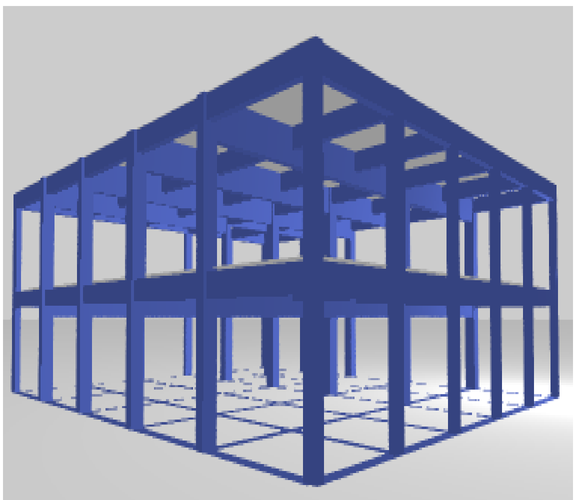

Fig 4.2 a) 3d Frame Generated In ETABS

## 5. STRUCTURAL ANALYSIS RESULTS.

5.1 Demand and capacity ratio Comparison.

Table 5.1 Representing the difference in strength of column before strengthening and after strengthening

| SR NO | COL NO. | D/C RATIO BEFORE STRENGTHENING | D/C RATIO AFTER STRENGTHENING |
|---|---|---|---|
| 1 | C1 | 0.943 | 0.570 |
| 2 | C2 | 0.892 | 0.680 |
| 3 | C3 | 1.162 | 0.660 |
| 4 | C4 | 1.219 | 0.668 |
| 5 | C5 | 1.136 | 0.710 |
| 6 | C6 | 0.961 | 0.558 |
| 7 | C7 | 1.040 | 0.758 |
| 8 | C8 | 1.123 | 0.719 |
| 9 | C9 | 1.216 | 0.561 |
| 10 | C10 | 1.086 | 0.610 |
| 11 | C11 | 0.917 | 0.466 |
| 12 | C12 | 0.886 | 0.456 |
| 13 | C13 | 0.943 | 0.228 |
| 14 | C14 | 0.892 | 0.481 |
| 15 | C15 | 0.952 | 0.454 |
| 16 | C16 | 0.877 | 0.374 |
| 17 | C17 | 0.980 | 0.228 |
| 18 | C18 | 1.176 | 0.560 |
| 19 | C19 | 1.136 | 0.620 |
| 20 | C20 | 1.063 | 0.580 |
| 21 | C21 | 1.020 | 0.625 |
| 22 | C22 | 0.909 | 0.590 |

Table 5.2 Table Showing Decrease in Demand capacity ratio of critical column after strengthening.

| SR NO | COL NO. | D/C RATIO BEFORE STRENGTHENING | D/C RATIO AFTER STRENGTHENING |
|---|---|---|---|
| 3 | C3 | 1.162 | 0.66 |
| 4 | C4 | 1.219 | 0.668 |
| 5 | C5 | 1.136 | 0.71 |
| 7 | C7 | 1.040 | 0.758 |
| 8 | C8 | 1.123 | 0.719 |
| 9 | C9 | 1.216 | 0.561 |
| 10 | C10 | 1.086 | 0.610 |
| 18 | C18 | 1.176 | 0.560 |
| 19 | C19 | 1.136 | 0.620 |
| 20 | C20 | 1.063 | 0.580 |
| 21 | C21 | 1.020 | 0.625 |

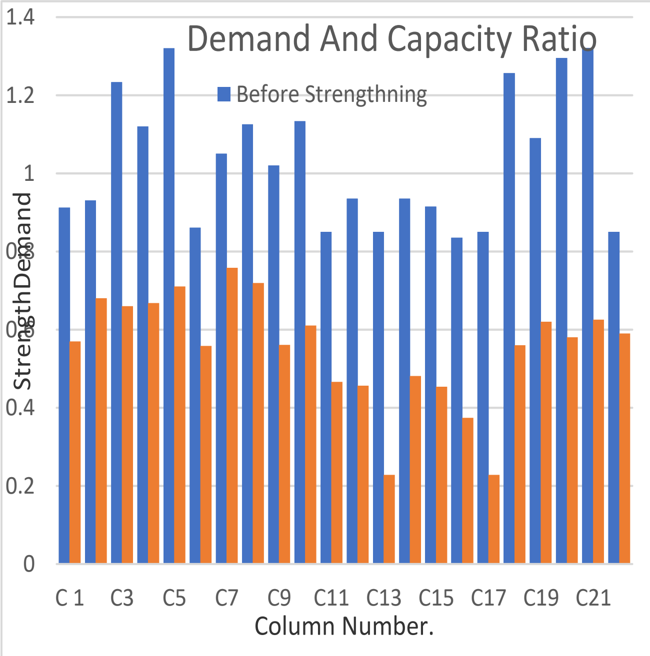


Fig 5.3 Graphical Representation of Demand And Capacity Ratio

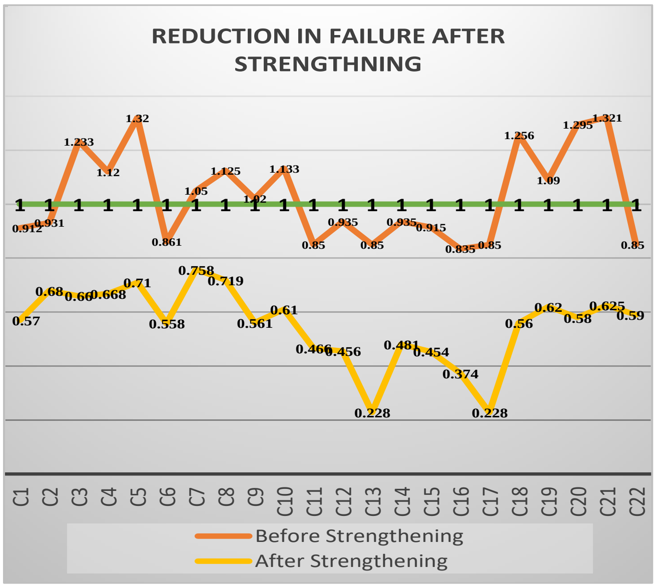


Fig: 5.4 Graphical representation of reduction in failure after strengthening.

### 5.2 Story Response.

In general, as a structure's height increases, it also increases its lateral load (such as wind and earthquake).When this type of response gets significant enough that the influence of lateral load must be explicitly considered in design. Thus the story drift of our structure is generated with the help of ETABS.

#### 5.2.1 Story Drift Before Strengthening.

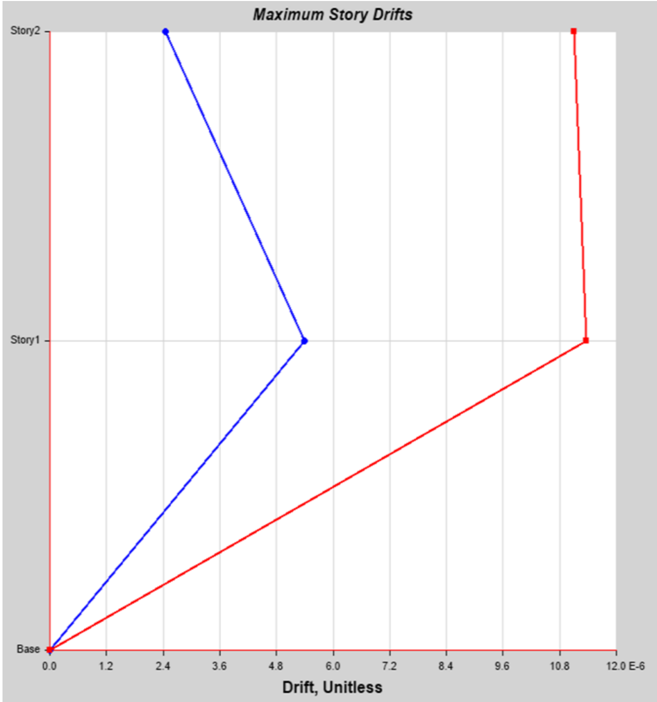


Fig:5.3.1 Story Drift Response Before Strengthening

#### 5.2.2 Story Drift After Strengthening.

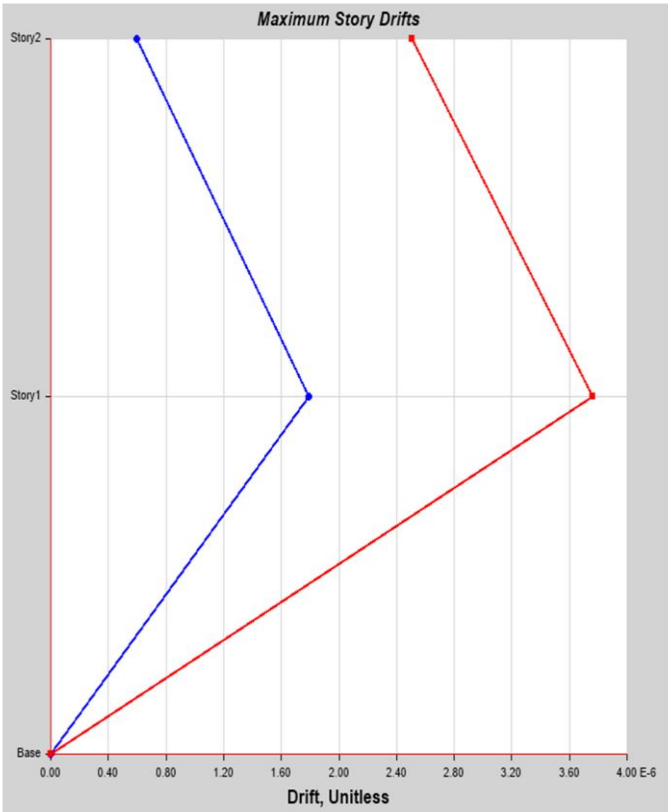


Fig:5.3.2 Story Drift Response After Strengthening.

## 6. CONCLUSIONS

1. Various columns and beams whose quality and strength were in question are discovered during NDT testing, and it is determined that repairing should be done for these beams and columns.

2. Thus, certain members were found to be severely damaged and required rapid strengthening according to the research performed using both experimental and software analysis. We continued to apply strengthening to the appropriate members using ETABS, and we saw significant results in terms of strength recovery.

3. Using an interaction curve and ETABS analysis, this finding was examined in relation to the D/C ratio. The outcomes and corresponding graphs are displayed above.

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