International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 07 | July - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Retrofitting of Earthquake damaged R.C.C Structure using various Retrofitting techniques.

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Abstract - The aim of this study is to retrofit an earthquake damaged structure using different materials. The structure is named as model A which is 5 storey's. Model A was designed for gravity loads but when analyzed for seismic loads using STADD Pro v8i, columns of ground storey failed which means the structure cannot withstand future earthquakes. The loading of the building is kept the same, but it is retrofitted using 3 materials that are steel, concrete, fibre reinforced polymer. Nomenclature of building is done as when bracing is done in middle columns of all exterior portion of building it is termed as MODEL 'B' as shown in figure .When steel bracing is provided in all edges of building as shown in figure it is termed as MODEL 'C', when bracing is provided central columns of building in XY direction, and in corner in YZ direction it is termed as MODEL 'D' as shown in figure. Three types of steel bracing are used: ISMC 225, ISMC 350, and ISMC 300. 11 models were analyzed, 9 for steel bracing, 1 for FRP plate, 1 for concrete jacketing. The displacements, Storey drift, axial forces were compared between original structure and retrofitted model.

***Key Words*:** Repair, Restoration, Retrofitting,Steel Bracing,Jacketing and Fiber Reinforced Polymer(FRP).

1.INTRODUCTION

Retrofitting ,repair ,rehabilitation of R C C buildings are done which are unfit to take the revised load,occupancy has been changed, performed poorly during the earthquake or need to be strengthened .

Various retrofitting techniques are implemented like jacketing of beam and column,bracing of columns,widening of columns & beams,installation of FRP .

2. DETAILS OF STRUCTURE

HEIGHT OF 1ST FLOOR FROM GROUND FLOOR = 3.6 m

HEIGHT OF 2ND FLOOR FROM GROUND FLOOR = 7.2 m

HEIGHT OF 3RD FLOOR FROM GROUND FLOOR =10.8m

HEIGHT OF 4RD FLOOR FROM GROUND FLOOR =14.4 m

HEIGHT OF 4RD FLOOR FROM GROUND FLOOR =18.0 m

DISTANCE BETWEEN COLUMNS = 4 m

SIZE OF COLUMNS= 300 × 300 mm

SIZE OF BEAMS = 300 × 300 mm

THICKNESS OF SLAB = 110 mm

DEPTH OF FOUNDATION =1500 mm

3.SEISMIC DESIGN FACTORS

Various seismic design factors used in this paper are as follows:

Response reduction factor (RF):- The response reduction factor R for the buildings in this thesis is taken as 5.0 i.e. special RC Moment Resisting Frame (SMRF) has been considered as these are the basic common structural elements being used in earthquake resistant structures.

- Importance factor (I) :- The importance factor I is taken as 1.5 for all models.
- Zone factor (Z) :- The zone factor Z for all models is taken as 0.24 for zone 4.
- Damping Ratio: - The critical damping for the models is assumed to be 5% as specified for concrete by IS: 1893 (Part 1):2002.
- Soil type:-The soil type assumed for design acceleration spectrum is type 2 soil i.e. Medium soil.
- Imposed load: - An imposed uniformly distributed floor load of has been considered for analysis purpose in present study.
- Percentage reduction of imposed load for earthquake: - The design imposed load for

earthquake has been reduced to 50% as per the codal provisions.

4.LOAD CASES APPLIED

The following load combinations have been accounted for in these models:

1 Primary Seismic load in X Direction

2 Primary Seismic load in Z Direction

3 Primary Dead Load

4 Primary Live Load

5 Combination DL +LL

6 Combination 1.5(DL+LL)

7 Combination 1.5(DL+EQ X DIR)

8 Combination 1.5(DL-EQ X DIR)

9 Combination 1.5(DL+EQ Z DIR)

10 Combination 1.5(DL-EQ Z DIR)

11 Combination 1.2(DL+LL+EQ X DIR)

12 Combination 1.2(DL+LL-EQ X DIR)

13 Combination 1.2(DL+LL+EQ Z DIR)

14 Combination 1.2(DL+LL-EQ Z DIR)

15 Combination (0.9DL+1.5EQX)

16 Combination (0.9DL-1.5EQX)

17 Combination (0.9DL+1.5EQZ)

18 Combination (0.9DL-1.5EQZ)

5 Analysis

The analysis is performed and the details which are obtained from the analysis are mentioned here and some of the results are attached below:

- Member End Force
- Support Reaction
- Max And Min Support Reaction
- Beam End Force
- Beam Force Details (Max Shear Force)
- Beam Relative Displacement Details
- Beam Combined Area And Bending Stresses
- Maximum Stresses

5.1 RETROFITTED MODELS USING DIAGONAL BRACING IN VARIOUS DIRECTIONS.

5.1.1 Model **"B"** which is a retrofitted model. ISMC 225 was used to retrofit the structure which was not safe for future earthquakes.

Retrofitting material used-ISMC225 DOUBLE CHANNEL BACK TO BACK.

In model "**B**" diagonal bracing is provided in the columns lying at the center of the exterior grid.

Table -1: COLUMN BEAM BRACING SIZES

Elements	Material	Dimensions
Columns	Concrete	300mm*300mm
Beams	Concrete	300mm*300mm
Bracing	Steel	ISMC 225 Double angle.

5.1.2 Model **"C"** which is a retrofitted model. ISMC 225 was used to retrofit the structure which was not safe for future earthquakes.

Retrofitting material used-ISMC225 DOUBLE CHANNEL BACK TO BACK.

In model "**C**" diagonal bracing is provided in the columns lying at the edges of the exterior grid.

5.1.3 Model **"D"** which is a retrofitted model. ISMC 225 was used to retrofit the structure which was not safe for future earthquake.Retrofitting material used –ISMC 225 DOUBLE CHANNEL BACK TO BACK.

In model "**D**" bracing is provided in the central columns of the building in XY direction, and in the corner in YZ direction.

5.2 Retrofitting Material Used- Fibre Reinforced Polymer. Model With Fibre Reinforced Polymer Wrapped At The Ground Floor Columns.

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Material Constants:-For modeling

A. Concrete: Density= 25kN/m^3
Elasticity= 2.5x10^7kN/m^2
Poisson's Ratio=0.15

B. Steel Density= 78.5kN/m^3
Elasticity= 2.1x108 KN/m^2
Poisson's Ratio=0.15

C. FRP: Density= 16kN/m3
Elasticity= 3.6 x10^7kN/m2
Poisson's Ratio=0.17

TABLE:2

Elements	**Material**	**Dimensions**
Columns	Concrete	300mm*300mm
Beams	Concrete	300mm*300mm
Ground floor columns	FRP installed	Plates of 1mm on all four sides of the column.

5.3 MODEL "F".

Width of concrete jacketing at ground floor column-200 mm.

Width of concrete jacketing at ground floor column-150 mm.

MODEL WITH COLUMN JACKETING WITH CONCRETE.

Table -3:

ELEMENT	**MATERIAL**	**DIMENSION (in mm)**
COLUMNS GROUND FLOOR.	CONCRETE	500*500
COLUMNS FIRST FLOOR TO THIRD FLOOR.	CONCRETE	450*450
COLUMNS THIRD FLOOR TO FOURTH FLOOR.	CONCRETE	300*300

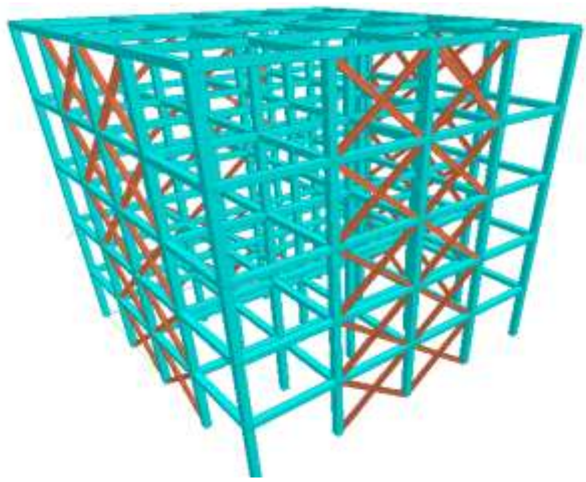

Fig 1: DIAGONAL BRACING FOR MODEL "B"

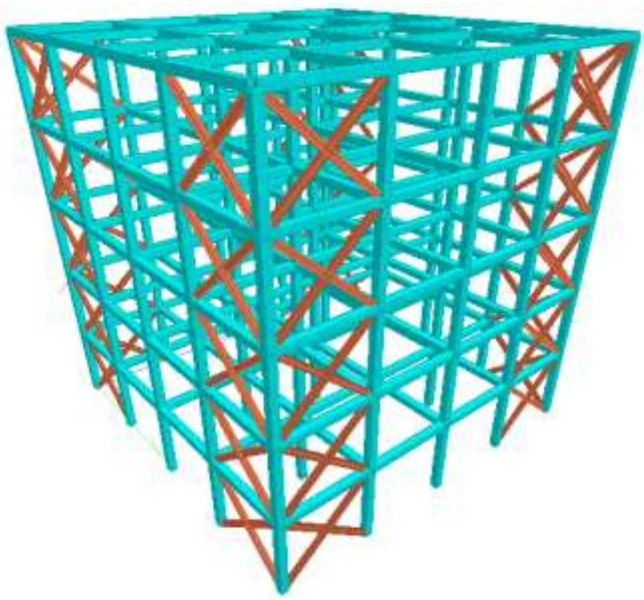

Fig 2: DIAGONAL BRACING FOR MODEL "C".

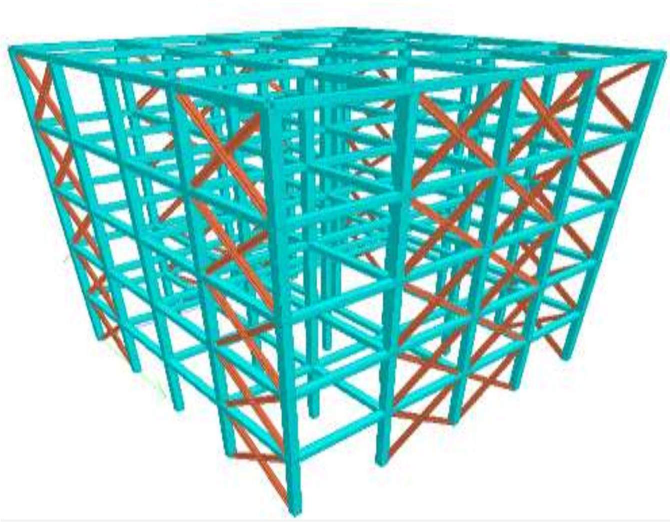

Fig 3: DIAGONAL BRACING FOR MODEL "D".

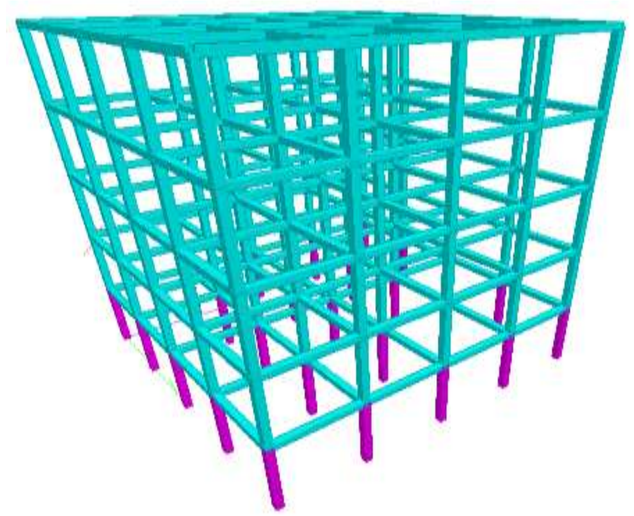

Fig 4: FRP INSTALLED AT GROUND FLOOR COLUMNS.

6 CONCLUSIONS

Comparative study of results of different models on building with or without retrofitting materials has been made for original structure and retrofitted structure. The result of various parameters e.g. storey shear, base shear, storey drift, lateral displacement and axial force in original model and earthquake damaged retrofitted model.

6.1 COMPARISON OF AXIAL FORCES COLUMNS DAMAGED DUE TO EARTHQUAKE LOAD.

The bar chart 1 for maximum axial force in column 7,8,9,12,14,17,18,19 is observed before and after retrofitting using bracing. It is seen that the axial force in all columns was more in the original structure than in the retrofitted model. For column 18 the axial force is least. The maximum axial force observed is 1144.927KN and minimum is 1128.994 KN.

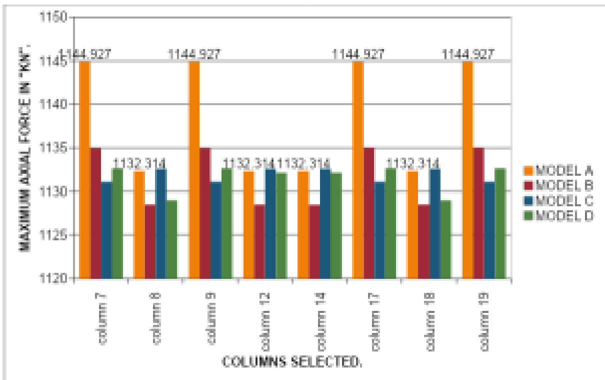

Chart1:Bar Chart Showing Maximum Axial Force In Columns (In Y Direction) Before And After Retrofitting.

6.2 COMPARISON OF AXIAL FORCES IN ALL MODELS.

From the bar chart 2 it is seen that the maximum axial force in model A(earthquake damaged building) has maximum axial force as compared to all other retrofitted models. Maximum axial force in members decreases by using Steel braces of ISMC 225. Model C shows least axial force which implies that this retrofitted model will withstand future earthquakes.

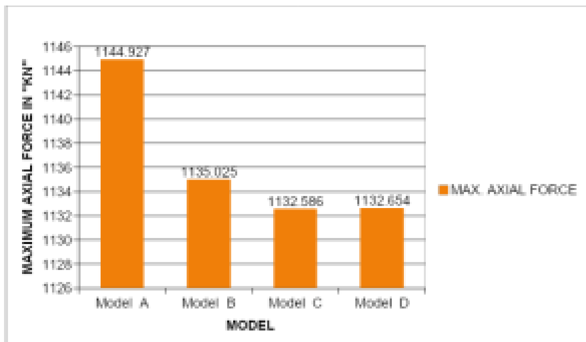

Chart 2:Bar Chart Showing Maximum Axial Forces In Columns Before And After Retrofitting (In Kilonewtons).

6.3 COMPARISON OF DISPLACEMENT OF RETROFITTED MODEL A USING FRP LAMINATE WITH ORIGINAL MODEL.

From CHART 3- It is seen that when an earthquake damaged structure is retrofitted using fibre reinforced polymer then the displacement in structure decreases hence that was the aim for which FRP was installed.

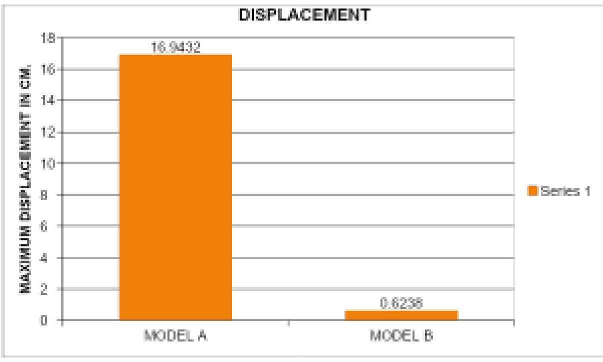

Chart 3:Comparison Of Displacement Of Retrofitted Model A Using Frp Laminate With Original Model.

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