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Retrofitting of a Structure in Chennai for Earthquake Resistance

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ABSTRACT

Worldwide earthquakes are responsible for the destruction of a large number of buildings and loss of lives. To reduce such hazards, it is important to design the buildings to resist the seismic forces. There are many structures which are constructed in the traditional manner without any intervention of Engineers and Architects. In this paper, seismic evaluation of an existing 4 storey residential building situated in Chennai, which is not designed for earthquake resistance, was done considering the forces belong to Seismic Zone III. Seismic evaluation determines the weakest components in the building and what will be the deficiencies during Earthquake. The structure was analyzed using STAAD.PRO software. There are many retrofitting strategies available like global retrofit and local retrofit. After scrutinizing the available retrofitting strategies, best retrofit strategy that is suitable, efficient and cost-effective for the existing building is proposed. Retrofit strategy adopted will increase and enhance the strength and the flexibility of the structure which will be more than the demand by an earthquake. Adopting such retrofitting strategy may be a suitable option to minimize the hazards associated with earthquakes when it strikes a building not designed as per seismic forces.

I. INTRODUCTION

In Urban India, Reinforced Concrete (RC) buildings are the most common types of construction and they are subjected to static loads (Live and Dead loads) and Dynamic loads (Wind and Earthquake Loads) during their lifespan. The industrial revolution and urbanization had lead to the construction of multi-storied buildings for both Residential as well as for Office purposes. In Seismic areas, the majority of buildings are designed only for static loads without considering the dynamic loads. If the RC structures are not properly designed for the resistance of earthquake forces, it may cause the complete failure of the RC structures and may loss human life also. These buildings needed to be reassessed and retrofitted against Seismic forces. Retrofitting an existing building is more cost-effective than constructing a new building. Seismic retrofitting upgrades the overall performance, efficiency and sustainability of an existing building against the seismic forces. There are several reasons to retrofit an existing building like: buildings not designed according to standard codes or, a subsequent update of code and design practice or up gradation of seismic zone. There are various methods of retrofitting the structure and making it earthquake resistant. In this paper, we have used a bracing system to retrofit the structure and also a comparative study has been done considering different types of bracing systems. This study focuses on seismic vulnerability assessment and retrofitting of G+4 RC frame building situated in Chennai which belongs to Seismic Zone III. The bracing system controls lateral displacements of the frame caused due to seismic forces and hence effective in increasing strength and stability of the building. We proposed bracing system as it has some advantages over others. It is relatively cost-effective, easy in application, does not significantly add to the structural weight and can be easily customized.

II. METHODOLOGY

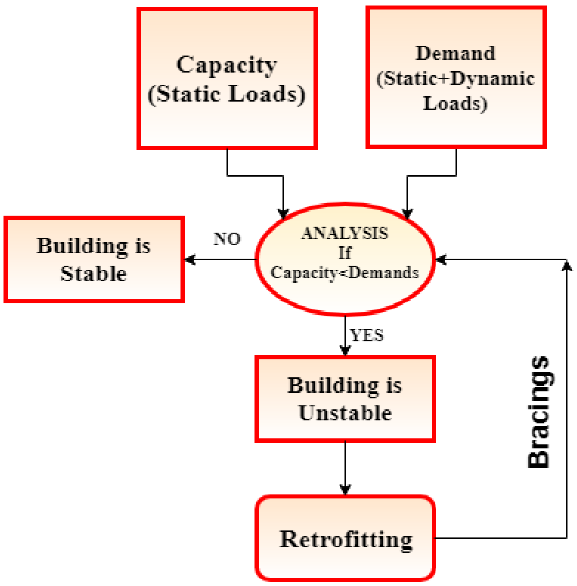
We have analyzed the framed structure using Static analysis and Dynamic analysis. As it is a low rise structure static analysis is sufficient, but for more accurate results we also did dynamic analysis. In static analysis, only one mode was considered for each direction.

1. Seismic behavior of the existing building has been determined in the presence of only static loads, termed as capacity.

2. Seismic behavior of building has been determined by using static and dynamic (earthquake and wind) loads termed as demand.

3. After analyzing, a comparative analysis has been done amongst different types of bracings, and the best one is adopted in order to retrofit the structure.

STAAD.Pro (Version V8iSS6) software is used to model the building and perform all the analysis.



Flowchart

III. Model Generation and Analysis

We considered G+4 residential building. The ground and rest of the floor had a height of 3.2 m each. The values of dead load, live load and self-weight were calculated using the specifications given in IS875 part-1 and part-2. The wind load intensities were calculated using IS875 part-3. The seismic load calculations were done using IS 1893 part-1. The depth of the foundation of one metre was provided below ground level. The soil was assumed to be of type II, medium as per IS 1893.

1 Typical floor Plan and Elevation

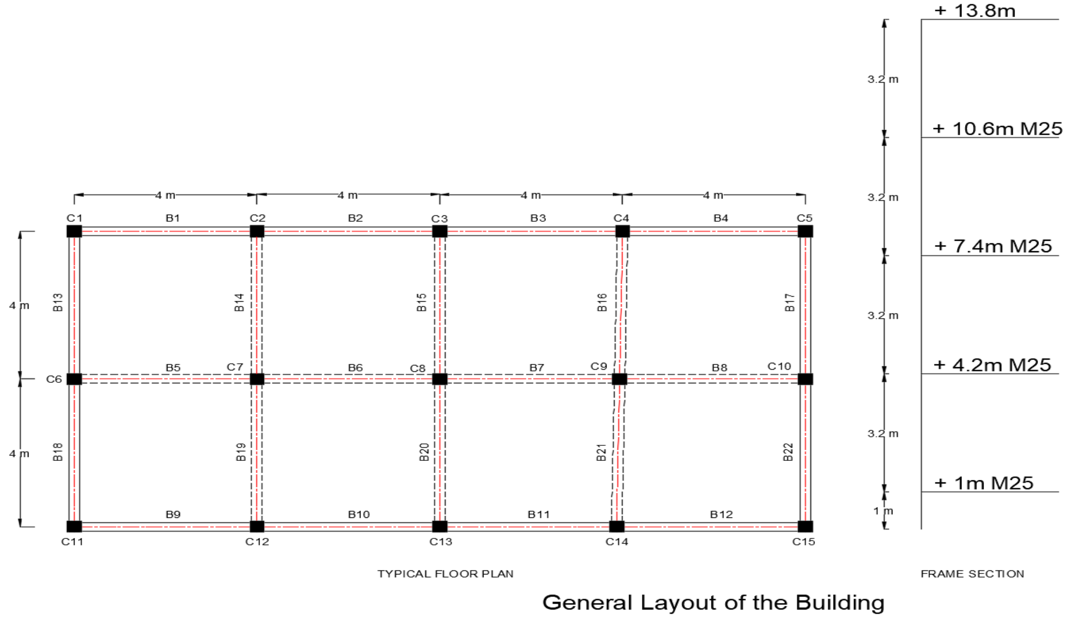


Figure-1

2. Rendered view of structure

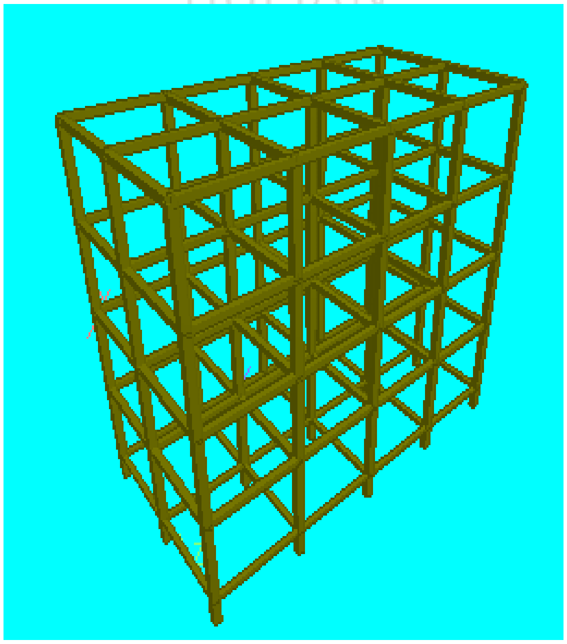


Figure - 2 Unbraced Structure

3. Building description

Table - 1

Sl. No.	Particulars	Values
1.	Plan Dimension	16 m x 8 m
2.	Height of building	12.8 m
3.	Grade of steel	Fe415
4.	Grade of concrete	M25
5.	Beam size (i) Plinth	150 mm x 200 mm
	(ii) Other beams	250 mm x 250 mm
6.	Column	300 mm x 300 mm
7.	Seismic zone	III

4. Loading-

a) **Dead load** – (i) self weight

(ii) Floor finish (typical floor) – 1 kN/m^2

(iii) Floor finish (terrace floor) – 1 kN/m^2

(iv) Waterproofing (terrace floor) – 2 kN/m^2

b) Live load –

(i) on typical floor – 4 kN/m^2

(ii) on terrace floor – 1.5 kN/m^2

c) Seismic load – in X and Z directions

Parameters :-

1. Zone factor – 0.036

2. Importance factor (I) – 1.5

3. Response reduction factor (RF) – 4

4. Damping Ratio (DM) - 0.05

5. Rock and soil site factor (SS) - 1

6. Type of structure - 3

d) Wind load

Basic wind speed of 50 m/s for Madras has been considered from the IS 875 part-3.

Bracing provided are of different types for retrofitting like K bracing, chevron bracing, diagonal bracing, cross bracings, etc. and comparison is done and the best one was adopted.

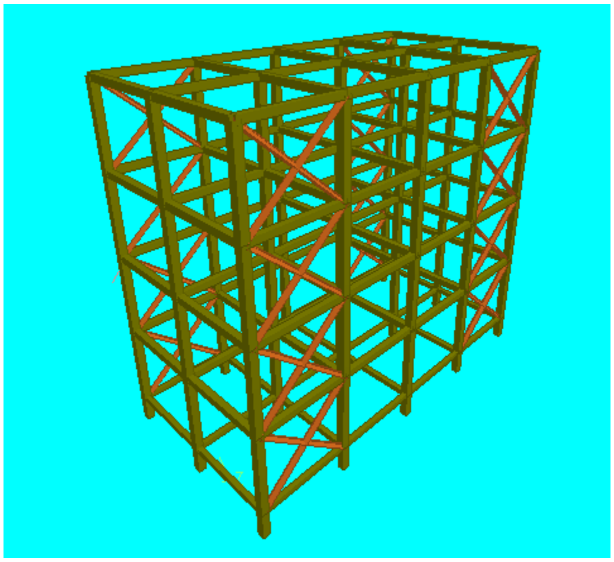


Figure - 3 Cross Bracing

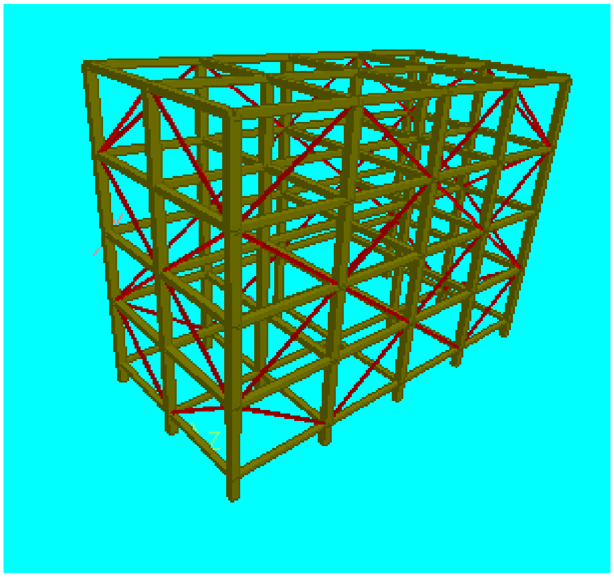


Figure - 4 Diagonal Bracing

IV. RESULT AND DISCUSSION-

From the results obtained after the analysis of building, we observe that building designed only for static loads are incapable of resisting the dynamic load (earthquake and wind loads) and therefore the structure will be unstable in the presence of seismic loads. The observed values (i.e demand) of unbraced structure were more than the capacity, therefore the structure needs to be retrofitted. After retrofitting the structure with different types of bracings, we have compared the results obtained and it was found that cross bracings are the best as the values of maximum displacement, maximum axial force, maximum shear force and maximum bending moment were the least when compared to others. We could also find that usage of cross retrofitting will affect the feasibility of the building as it will obstruct the required openings for doors and windows which will be a disadvantage for cross bracings, therefore we can also adopt chevron bracings.

Table - 2 (STAAD Pro Output)

Output Data / Loadings	Max. Displacement (mm)	Max. Axial force (kN)	Max. Shear force (kN)	Max. Bending moment (kN.m)
DL+LL	1.792	7.094	23.989	18.080
Seismic loading	26.125	154.180	36.929	39.019
Cross bracing	7.891	80.425	18.609	20.769
Diagonal bracing	8.691	84.104	19.559	27.985

V. CONCLUSION

After retrofitting the building with steel bracings, there is a significant decrease in the seismic vulnerability. On the basis of results, it is found that adding cross bracings to the structure will increase the stiffness of the RC frame. Amongst the different types of bracings, it is found that cross bracings are more advantageous in the terms of strength and stability provided to the building. In this way, retrofitting of existing buildings can be done in an efficient manner and huge losses in the terms of money and life can be minimized.

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