Analysis & Design of A G+10 Residential RCC Building Under Various Seismic Responses

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Abstract- *The design process of structural planning and design requires not only imagination and conceptual thinking but also sound knowledge of science of structural engineering besides the knowledge of practical aspects, such as recent design codes, bye laws, backed up by ample experience, intuition and judgment. The purpose of standards is to ensure and enhance the safety, keeping careful balance between economy and safety.*

In the present analysis of G+10 building under various seismic response system and designed (Slabs, Beams, Columns and Footings) using AUTOCAD software.

Thereafter, the loads are calculated namely the dead loads, which depend on the unit weight of the materials used and the live loads, which according to the code books. Footings are designed based on the safe bearing capacity of soil.

Designing of slabs depends upon whether it is a one way or a two way slab, the end conditions and the loading. From the slabs, the loads are transferred to the beam. Thereafter, the loads (mainly shear) from the beams are taken by the columns. Finally, the sections must be checked for all the four components with regard to strength and serviceability.

In this project, the columns, beams and loads are analysis done in Staad Pro Software. And the footings and slabs are analysis done in prepared MS Excel.

Many important Indian cities fall under high risk seismic zones, hence strengthening of buildings for lateral forces is a prerequisite. In this ANALYSIS the aim is to analyze the response of a high-rise structure to ground motion using Response Spectrum Analysis. Different models, that is, bare frame, brace frame and shear wall frame are considered in Staad Pro. and change in the time period, stiffness, base shear, storey drifts and top-storey deflection of the building is observed and compared.

Keywords- Beams, columns, footings, slabs, bare frame, brace frame and shear wall frame, Structural Designing.

I. INTRODUCTION

A Residential Apartment building was designed in such a way that each floor consists of five flats with a configuration of G+10 in the site area of 1313 *Square meter*. The loads are calculated namely the dead loads, which depend on the unit weight of the materials used and the live loads, which according to the code books. Footings are designed based on the safe bearing capacity of soil. For this purpose, frame analysis is done by limit state method.

Reinforced Concrete frames are the most common construction practices in India, with increasing numbers of high-rise structures adding up to the landscape. There are many important Indian cities that fall in highly active seismic zones. Such high-rise structures, constructed especially in highly prone seismic zones, should be analyzed and designed for ductility and should be designed with extra lateral stiffening system to improve their seismic performance and reduce damages. Two of the most commonly used lateral stiffening systems that can be used in buildings to keep the deflections under limits are bracing system and shear walls.

The use of steel bracing system is a viable option for retrofitting a reinforced concrete frame for improved seismic performances. Steel braces provide required strength and stiffness, takes up less space, easy to handle during construction, can also be used as architectural element and is economic. Steel braces are effective as they take up axial stresses and due to their stiffness, reduce deflection along the direction of their orientation. Shear walls are structural system consisting of braced panels, also known as Shear Panels. Reinforced concrete Shear walls transfer seismic forces to foundation and provide strength and stiffness.

OBJECTIVES

a. To analyze the building with different ground motions, namely, IS code compatible ground motion, Imperial Valley ground motion .
b. To perform dynamic analysis of the building using response spectrum method.

c. To model building with different lateral stiffness systems and study the change in response of the building
d. To compare and get a better and efficient lateral stiffness system

II. LITERATURE REVIEW

Viswanath K.G (2010) investigated the seismic performance of reinforced concrete uildings using concentric steel bracing. Analysis of a four, eight, twelve and sixteen storied building in seismic zone IV was done using Staad Pro software, as per IS 1893: 2002 (Part-I). The bracing was provided for peripheral columns, and the effectiveness of steel bracing

Chavan, Jadhav (2014) studied seismic analysis of reinforced concrete with different bracing arrangements by equivalent static method using Staad Pro. software. The arrangements considered were diagonal, V-type, inverted V-type and X-type. It was observed that lateral displacement reduced by 50% to 60% and maximum displacement reduced by using X-type bracing. Base shear of the building was also found to increase from the bar

Esmaili et al. (2008) studied the structural aspect of a 56 stories high tower, located in a high seismic zone in Tehran. Seismic evaluation of the building was done by non-linear dynamic analysis. The existing building had main walls and its side walls as shear walls, connected to the main wall by coupling of beams. The conclusion was to consider the time-dependency of concrete. Steel bracing system should be provided for energy absorption for ductility, but axial load can have adverse effect on their performance. It is both conceptually and economically unacceptable to use shear wall as both gravity and bracing system.

III. METHODOLOGY ADOPTED

As discussed in the scope of the work, the entire work is divided into four parts:

- Analysis of the beams and columns with out bare frames.
- Analysis of structure with bare frame.
- Analysis of structure with braced frames.
- Analysis of the frame with shear wall
- Structural analysis by Limit state method

For analysis a 10 stories high building is modeled in Staad Pro as a space frame. The building is does not represent any real existing building. The building is unsymmetrical with the span more along Z direction than along X direction. The building rises up to 33m along Y direction and spans 24.76 m along X direction and 29.3 m along Z direction .The building is analyzed by Response Spectrum Analysis, which is a linear dynamic analysis. Dynamic Analysis is adopted since it gives better results than static analysis.

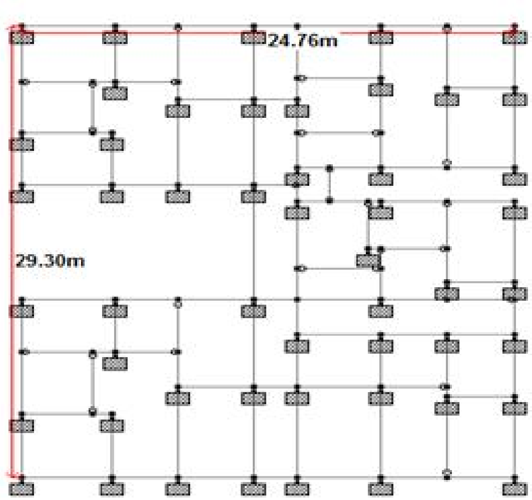


Fig. 4 Plan of the building

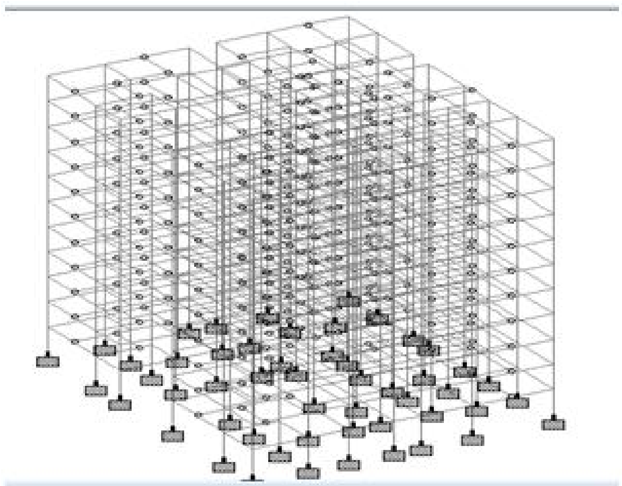


Fig. 5 Model of the building

Response Spectrum Analysis

Response Spectrum is a linear dynamic analysis. Response spectrum is a plot of the maximum response of a SDOF system to a ground motion versus time period. It is derived from time history analysis of ground motion by taking the maximum response for each time period.

In Staad Pro, Response Spectrum Analysis is done as follows:

1. After preparing the bare model, seismic definition for IS 1893-2002 was created by giving the required input of time period, zone factor, R factor, etc. Then under seismic definition self-weight and floor weights of 2.5kN/m2 and 2.575 kN/m2 were given.
2. Under Load Definition Earthquake load, Dead load, Live load and various load combinations were created.
3. Under Earthquake load, after assigning self-weight, floor load and live load in X, Y and Z directions, Response Spectra was defined. For Indian Code compatible earthquake already defined IS 1893-2002 is chosen. For Imperial Valley Earthquake and San Francisco Earthquake the response spectrum values are entered. Acceleration values for the corresponding time periods of the building for Imperial Earthquake and San Francisco earthquake has been taken by multiplying 9.81* Sa/g of their respective response spectrum. The Sa/g is the response spectrum values that were taken from the results of EXCEL prepared sheat.
4. The load combinations that were considered were according to IS 1893-2002 (Part-1)

MODELING OF BRACED FRAME

For braces angle section ISA 80 X 50 X 8 is used. There are four trial locations in the building where braces are placed and analyzed for their effect on lateral stiffness. Braces are modeled as axial force members having pinned end connections. Bracings are of X-type modeled throughout the height of the building. The four locations are as follows:

1. Bracing at the exterior side of the frame along X-direction.
2. Bracing at the exterior side of the frame along Z-direction.
3. Bracing at the exterior side of the frame along X and Z-direction.
4. Bracing at the exterior side of the frame around the corners

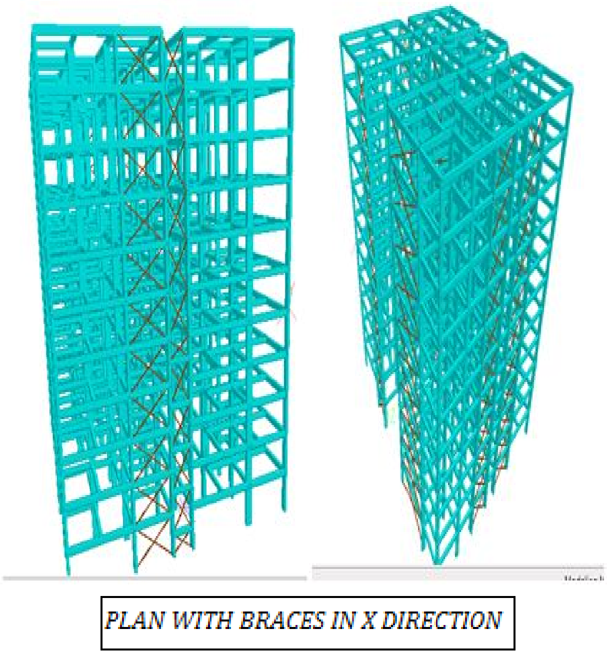


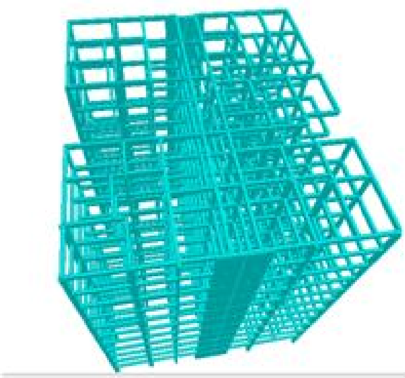
Fig.6 Bracings in X-direction Bracings inin in X&Z-direction EDGES

MODELING OF SHEAR WALL FRAME

Shear Wall considered is of 230mm thickness, and placed along the entire height of the structure. Shear wall has been modelled as rectangular column section by increasing width to spacing of the bay i.e, the spacing between two columns. The shear walls are placed in the exact locations as that of bracings, and the analysis is done.
The three locations are as follows:

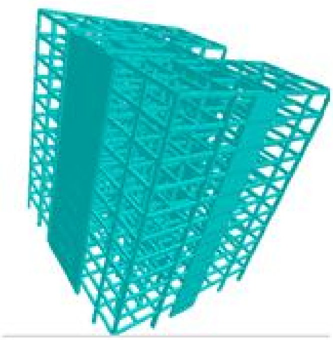
1. Shear wall at the exterior side of the frame along X-direction.
2. Shear wall at the exterior side of the frame along Z-direction.
3. Shear wall at the exterior side of the frame along X and Z-direction.

The figures of the models with different locations of shear walls are given below :



Shear Wall in X direction

Z-Direction



X-Z Direction
Fig 10.

IV. RESULTS AND DISCUSSION

The result is based on the responses of the bare frame model and the changes in the responses after using bracings and shear wall. The results include changes in time periods, base shear, inter-storey drifts and top-storey deflections for ground motions along X and Z direction considered individually. The results of time period, base shear, inter-storey drifts and top- storey deflection for bare frame, braced frame and shear wall frame were then compared with each other and a conclusion was then drawn.

Comparison of Inter-Storey Drift for ground motion in X-direction

Table 5. Inter-Storey Drift for ground motion in X- direction

Storey	Bare Frame In mm	Bracing in X	Bracing in Z	Bracing in XZ	Bra cing ED GE	Shear Wall X	Shear Wall Z	Shear Wall EDGE
1	0	0	0	0	0	0	0	0
2	8.423	7.946	6.51	6.498	5.667	7.882	3.288	3.079
3	13.611	13.65	10.441	10.424	8.938	14.066	5.344	5.912
4	14.317	14.361	10.828	10.815	9.321	14.88	5.716	6.757
5	13.722	13.771	10.468	10.465	9.089	14.34	5.975	7.054
6	12.716	12.763	9.862	9.861	8.653	13.728	6.462	7.291
7	9.973	11.626	9.182	9.182	8.172	12.62	6.697	7.418
8	12.424	10.462	8.492	8.49	7.698	11.309	6.847	7.481
9	9.236	9.269	7.774	7.771	7.205	9.883	6.989	7.46
10	6.65	7.977	6.958	6.954	6.611	8.412	6.915	7.212
11	9.584	6.506	5.96	5.965	5.824	6.681	6.53	6.684

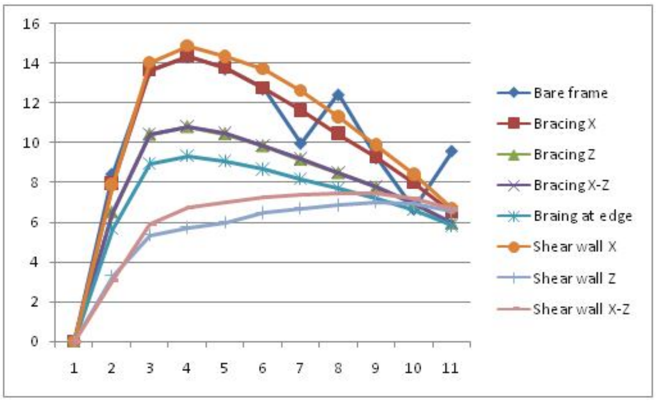


Fig 16. Variation of Inter-Storey Drift for ground motion in X direction

Comparison of Inter-Storey Drift for ground motion in Z-direction

Inter- storey drifts in bare frame was found to exceed this limit of 13mm. By using bracings it was found that there was no reduction in drift in Z direction but frame with shear wall showed remarkable reduction in the drift. Inter storey drift decreases remarkably in case of shear walls.

Table 6. Inter-Storey Drift for ground motion in Z- direction

Storey	Bare Frame In mm	Bracing in X	Bracing in Z	Bracing in XZ	Bracing EDG E	Shear Wall X	Shear Wall Z	Shear Wall EDGE
1	0	0	0	0	0	0	0	0
2	8.423	7.946	6.51	6.498	5.667	7.882	3.288	3.079
3	13.611	13.65	10.441	10.424	8.938	14.066	5.344	5.912
4	14.317	14.361	10.828	10.815	9.321	14.88	5.716	6.757
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6	12.716	12.763	9.862	9.861	8.653	13.728	6.462	7.291
7	9.973	11.626	9.182	9.182	8.172	12.62	6.697	7.418
8	12.424	10.462	8.492	8.49	7.698	11.309	6.847	7.481
9	9.236	9.269	7.774	7.771	7.205	9.883	6.989	7.46
10	6.65	7.977	6.958	6.954	6.611	8.412	6.915	7.212
11	9.584	6.506	5.96	5.965	5.824	6.681	6.53	6.684

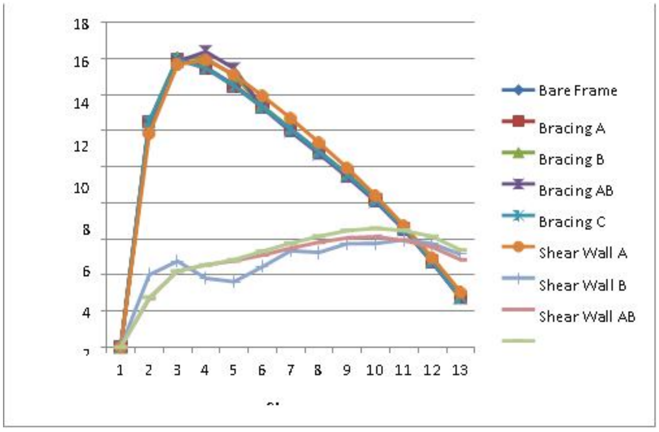

Fig 17. Variation of Inter-Storey Drift for ground motion in Z direction

Comparison of Top-Storey Deflection for ground motion in X- direction

There is reduction in top-storey deflection in the frame due to bracing and shear wall. Reduction is more in case of Bracing at edges and Shear Wall in X-Z . For ground motion in X- direction Shear Wall Z is ineffective since in Shear Wall Z case shear wall is present in Z-direction not in X-direction.

Table 7. Top-Storey Drift for ground motion in X- direction

Cases	Top- Storey Deflection (mm)
Bare Frame	102.456
Bracing X	96.465
Bracing Z	104.571
Bracing X-Z	92.459
Bracing Edges	83.858
Shear Wall X	68.833
Shear Wall Z	118.927
Shear Wall X-Z	75.927

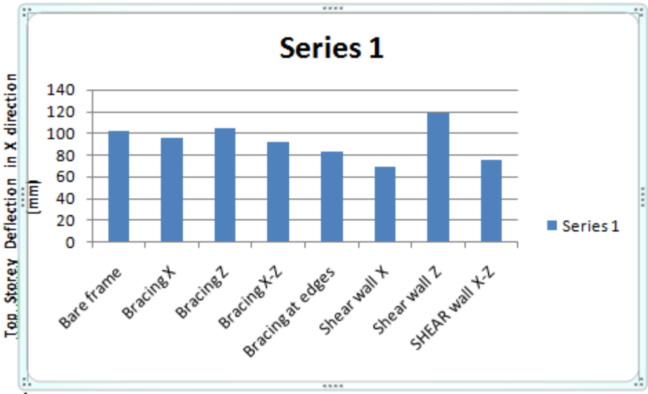

Fig 19 Staad Pro results for top-storey deflection in X direction

V. CONCLUSION

This project work was a small effort towards perceiving the how introducing bracing or a shear wall in a building can make in difference in protecting the building in earthquakes. Almost all the buildings in India are RC frame, and earthquake tremors are felt every now a then in some or the other part of the country. Hence through this project it was tried to appreciate the effectiveness and role of this small extra structural elements that can save both life and property, at least for most of the earthquakes.

The following conclusions were drawn at the end of the Analysis :

- There is a gradual reduction in time periods of the bracing and shear wall systems from the time period of bare frame, indicating increase in stiffness.
- Time Period in case of Shear Wall X-Z is the highest, hence is the most stiff and better option for strengthening the structure.
- Base Shear produced in the Bare Frame is maximum for Imperial Valley Earthquake.
- In case of bracing system, Bracing System at edges (with braces at the corners) are the most effective one than other bracing systems, effectively reducing top-storey drift and inter storey drifts in both X- and Z-directions.
- There is hardly any reduction in drift along Z-direction due to Bracing B, for all the ground motions.
- Shear Wall X is effective in reducing drifts along X-direction only, and Shear Wall Z is effective in reducing drifts along Z- direction only, for all the ground motions.
- Above all Shear Wall X-Z is the best in all the stiffening cases considered.

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