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Earthquake Resisting Techniques on A G+10 Storey Building with the Help of Shear Walls & Bracings, using Software

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Abstract: From the beginning of life on Earth it is evident that natural catastrophes cause a lot of destruction to human life and property. One of the major natural phenomena is the Earthquake. Sudden shaking of ground is a difficult challenge to any structure standing on earth. Due to Improper design of the structure without seismic resistance many buildings have collapsed and lives have lost during earthquakes. Different shapes & materials of buildings have been used to achieve the strength required to withstand the earthquake. In modern era, lots of seismic force resisting techniques are being used to make a structure/building earthquake resistant. These techniques include introducing Shear walls, Bracings, base isolation, column jacketing etc. to enhance the structure. In this paper, I present a Comparative analysis of earthquake resisting techniques on a G+10 story building with the help of different types of Shear walls & Bracings, using software. The comparison is done between: an un-Resisting structure, parallel shear walls, L-shaped shear wall, diagonal bracings, X-shaped bracings & V-shaped bracings. The use of shear walls and bracings helps to strengthen then structure to make it more Earthquake resistant. The analysis in done on a G+10 building for seismic zone III as per IS 1893:2002 codal provisions. The software that I have used to carry out this analysis is Staad pro v8. It is found out that shear walls and bracing contribute largely in reducing the deflection by increasing the strength and stiffness of the building. The results of this project can further be used to enhance the seismic strength of buildings using combination of seismic resistance techniques.

Keywords: Shear Walls, Bracings, Comparative analysis, High Rise Building, Earthquake resistant.

I. INTRODUCTION

From ancient times earthquake has been a cause of major destruction of structures. Due to this reason, various techniques have been employed to tackle this problem. Earthquake is defined as a sudden shaking of ground due to a fault or slip in the tectonic plates. This fault or slip that takes place within the tectonic plates causes energy to be released which sets off various forms of waves from the epicenter in all directions. The various types of waves are: P waves, S waves, Rayleigh waves, love waves that can be measured as per their intensity and the magnitude.

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This vigorous shaking of ground is then transferred to the structure and if the structure is not seismically resistant it can cause a structure to fail. In India various previous examples can be noted including Bhuj 2005 where thousands of lives got suffered and thousands of structures got destroyed because of earthquake.

Hence there was a need to make the structure earthquake resistant in order to minimize the destruction of structures and human life these various techniques are being implemented on structure to make them seismically resistant or earthquake resistant. These techniques include addition of various structural elements like share walls, bracings, base isolation dampers etc. In this paper I am discussing the comparative analysis of various earth quake resistant techniques on a 10-story building using software.

II. SEISMIC RESISTANCE TECHNIQUES

A. Addition of Shear walls

Shear wall is a seismic restraint member used to oppose lateral forces parallel to the wall. Shear wall opposes the loads due to Cantilever Action. So, Shear walls are vertical components of the horizontal or lateral force resisting system.

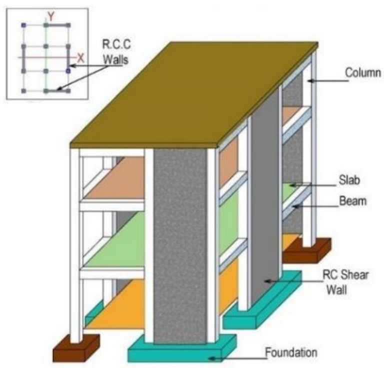


Figure-1: Shear Wall

B. Addition of Bracing

A braced frame is a framework used in structures to resist horizontal loads, for example, wind and seismic pressure. They are commonly made of basic steel, which when exposed both tension and compression, work efficiently. The beams and columns that form the frame carry vertical loads, and the bracing system carries the lateral loads. The shafts and sections that structure the frame convey vertical burdens, and the propping framework conveys the sidelong loads.

Figure-2: Cross Bracings

There are various types of bracings, but the type that will be dealt with in this project is Diagonal Bracing & Cross Bracing.

III. ANALYSIS TECHNIQUES USED ON STAAD PRO

A. Max deflection

Max deflection can also be called the Top deflection of the structure. It is the maximum extent to which the structure displaces in X & Z direction under earthquake loads in both perpendicular directions.

B. Story drift

Story displacement is the absolute value of displacement of the storey under action of the lateral forces

C. Story shear

The design seismic force to be applied at each floor level is called storey shear.

D. Maximum Axial force

The Axial Force is generally defined as the Force acting along the axis of a member.
The maximum axial force is mostly experienced at the base of the structure, at the bottom most columns.

IV. BUILDING MODELLING

A. General

In this project I have used is a G+10 storey building with same floor plan with 4 bays having same lengths of 4 m along the longitudinal and the transverse direction as shown in figure. This building is designed as per the Indian Code of Practice for Seismic Resistant. Design of buildings story heights of buildings are assumed to be constant including the ground story. The buildings are modelled using software "STAAD-PRO V8i 3.1 Dimensions

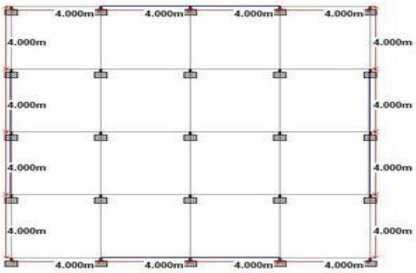


Figure-3: Plan of the Structure (Top view)

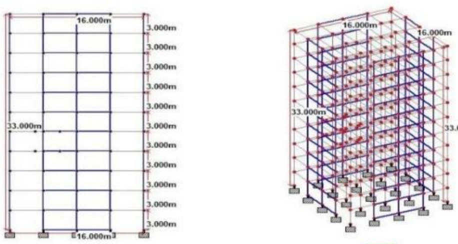


Figure-4: Dimensions (side view,isometric view)

B. Input Data

- Type of structure: multi-storey fixed jointed plane frame.
- Number of stories 11 (G+10).
- Floor height 3 m.
- Seismic zone III (IS 1893 (part 1):2002).
- Materials Concrete (M 35) and Reinforcement (Fe415).
- Bay sizes in the X-direction: 4m, 4m, 4m & 4m - 4 bays.
- Bay sizes in the Z-direction: 4m, 4m, 4m &4m-4bays.
- Column 300 x 400 mm (for all columns).
- Beam 300 x 300 mm (for all beams).
- Type of soil medium soil.
- Response spectra as per IS 1893.

C. Loading Details

- Dead Load
  Slab Thickness assume = 125 mm
  Floor Finish = 75mm
- Live Load-
  1. All Floor = 5 kN/m^2
  2. Earthquake Zone = Zone III
  3. Zone Factor = 0.16
  4. Earthquake Resistance Design of Structure = IS 1893 (Part 1) 2002
  5. Safe Bearing Capacity of Soil = 250 kN/m3
  6. Floors = G.F. + 10 Upper Floors
  7. Ground Floor Height = 3 m
  8. Assumed Thickness of Wall
     External wall = 230mm
     Internal wall = 115mm
  9. Grade of Concrete for column and other = M20
  10. Grade of Steel = Fe415

D. Load Combination

The analysis has been done for the dead load (DL), live load (IL), & earthquake load(EL) in all the directions i.e. sway to left (-EL) and sway to right (EL) by using software Staad pro. The combination of loads has been made according to cl 6.3 of IS 1893 (Part 1) Load Combination for Earthquake Design

Table-1:Load Combination for Earthquake Design

Load Case	Details of Load Cases
1.	1.5 (DL + LL+RLL)
2.	1.5 (DL + EQX)
3.	1.5 (DL – EQX)
4.	1.5 (DL + EQX)
5.	1.5 (DL – EQZ)
6.	(1.2DL+0.6LL+1.2EQX)
7.	(1.2DL+0.6LL-1.2EQX)
8.	(1.2DL+0.6LL+1.2EQZ)
9.	(1.2DL+0.6LL-1.2EQZ)
10.	0.9 DL + 1.5 EQX
11.	0.9 DL - 1.5 EQX
12.	0.9 DL + 1.5 EQZ
13.	0.9 DL - 1.5 EQZ

E. Earthquake Loads

Loadsarecalculatedas per IS 1893:2002 (Part 1) Seismic parameters considered for analysis are

Table-2: Seismic Intensity

Seismic Zone	V
Zone factor (Z)	0.36
Response ReductionFactor (R)	5
Importance factor (I)	1
Soil type	Medium soil
Damping	5 %

The design horizontal seismic coefficient Ah for the structure shall be calculated as follows, (IS:1893- 2002, Cl.6.4.2)

V. ANALYSIS

Analysis of building is one using STAAD Pro.The models were prepared in the STADD Pro. Software by using different types of RC shear wall viz. Parallel Shear wall and Cornered shear wall and these are located at different location such as along periphery and at corner. And also, analysis is done by modelling structure with Diagonal and Cross type Bracings.

A. Base Structure (without seismic restraints)

A base structure is modelled only with the use of columns and beams, and no additional seismic restraints are used. This the plain or base structure that will be further used for comparison with other models with additional seismic restraints.
The following structure is a G+10 story building designed on staad pro having no seismic restraints.

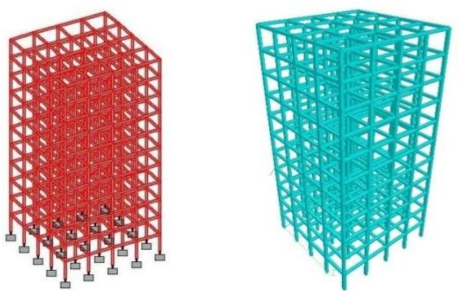


Figure-5: Base structure (without seismic restraints)

B. Parallel Shear Walls

Model is prepared using staad pro software where the high-rise structure is embedded & supported with shear wall on all four sides. The plan dimensions the shear wall is given as (8m x 0.200m) from the base to the roof i.e. 33 m. As the Shear walls are in parallel direction with respect to the two directions of earthquake EQX &EQZ, it is names as Parallel Shear walls.

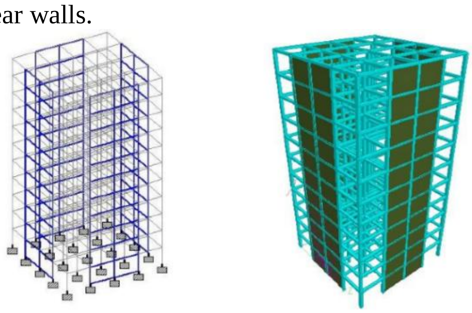


Figure-6: Parallel Shear Walls

C. Corner Shear Walls

Model is prepared using staad pro software where the high rise structure is embedded & supported with shear wall on all four Corners of the building .The shear wall installed here is a L-Shaped shear wall with plan dimensions given as (4m x 0.200m)+(4m x 0.200m) from the base to the roof i.e. 33 m.

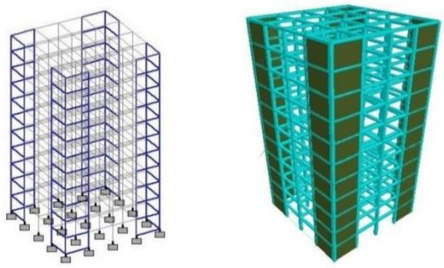


Figure-7: Corner shear walls

D. Bracings-Diagonal

Model is prepared using staad pro software where the high-rise structure framework is embedded & supported with steel bracings. The steel bracing used is an angle section having dimensions ISA 100x100x10. The bracings are connected diagonally throughout the framework from one column beam joint to another.

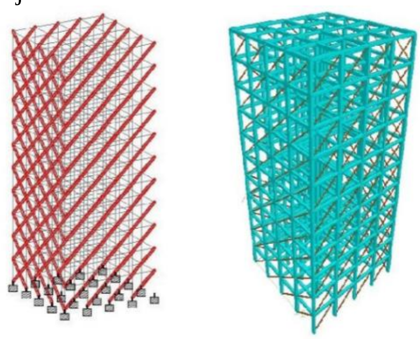


Figure-8: Bracings-Diagonal

E. Bracing- Crossed

Model is prepared using staad pro software where the high-rise structure framework is embedded & supported with steel bracings. The steel bracing used is an angle section having dimensions ISA 100x100x10. The bracings are connected diagonally throughout the framework from one column beam joint to another.

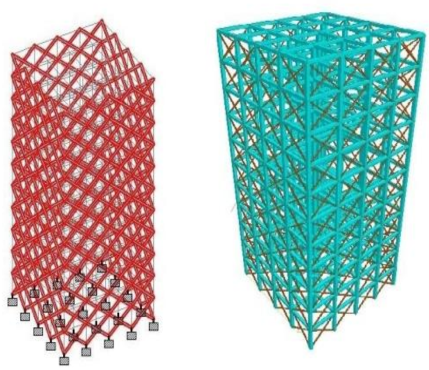
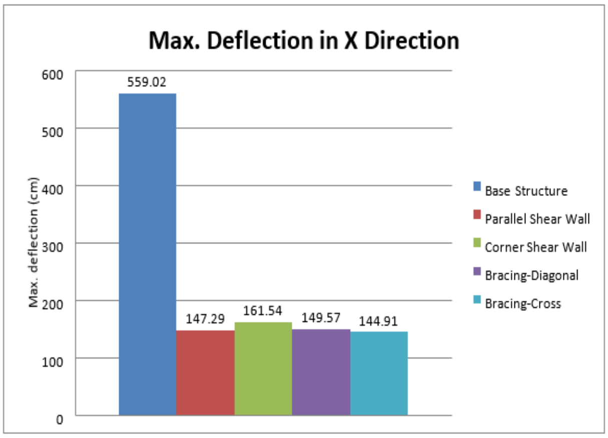


Figure-9: Bracings- Crossed

VI. COMPARITIVE ANALYSIS

A. Max. Deflection in X Direction Comparison



Graph-1:Max Deflection in X direction

Discussion

Here, the max deflection signifies the maximum lateral displacement of the nodes of the model under seismic loads. It is also called Top Deflection as the top of the structure experiences Max displacement.

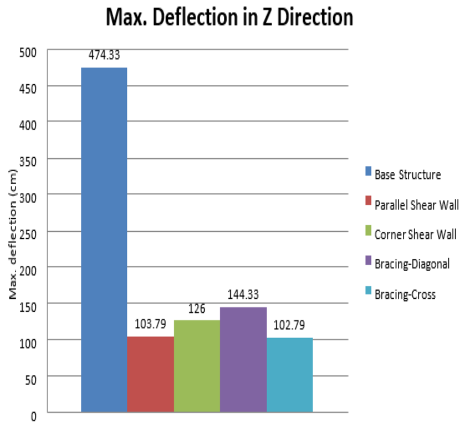
Base structure (without Seismic Restraints) has the highest maximum node displacement i.e. 559 cm in X direction.

It can also be denoted as +559 cm & -559 cm in both the parallel directions.

The models with shear walls & bracings show significant decrease in Max displacement, signifying increase in stiffness.

The least Max. displacement can be noted in Cross braced Model, which is the most earthquake resistant techniques in this test among these models.

B. Max. Deflection in Z Direction Comparison:



Graph-2: Max deflection in Z direction

Discussion

Here, the max deflection signifies the maximum lateral displacement of the nodes of the model under seismic loads. It is also called "Top Deflection" as the top of the structure experiences Max displacement.

Base structure (without Seismic Restraints) has the highest maximum node displacement i.e. 474.33 cm in Z direction.

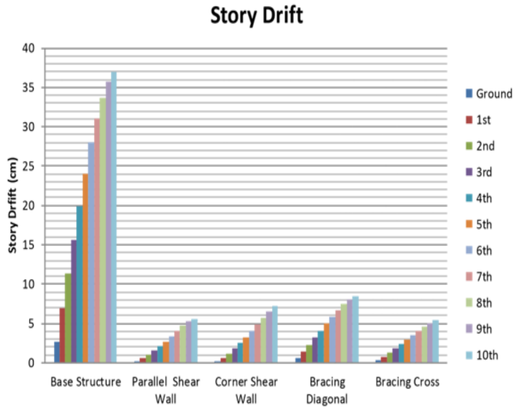
It can also be denoted as +474.33 cm & -474.33 cm in both the parallel directions.

The critical load combination under which max displacement is achieved is 1.5(DL+EQZ).

The models with shear walls & bracings show significant decrease in Max displacement, signifying increase in stiffness.

The least value of Max. displacement can be noted in Cross braced Model as, which is the most earthquake resistant techniques in this test among these models.

C. Story Drift Comparison



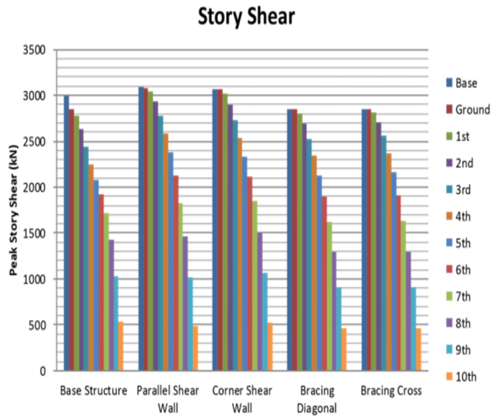
Graph-3: Story drift comparison

Discussion

Story displacement is the absolute value of displacement of the stories under action of the lateral forces.

The various story displacements are represented separately i.e. from ground to top of the structure (0-33m), a Total of eleven stories. The base structure has the highest value of story displacement as represented by the graph. The use of seismic restraints significantly decreases the movement of the structure of reducing the story shear of all the stories.

D. Story Shear Comparison

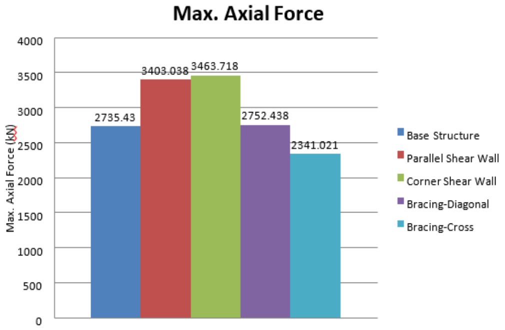


Graph-3: Story Shear Comparison

Discussion

Story Shear is the lateral force acting on a storey due to the forces such as seismic and wind force. It is calculated for each storey, changes from minimum at the top to maximum at the bottom of the building. Base shear is the total lateral force acting on the building at its base, which is equal to storey shear of the bottom storey. Highest Peak story shear can be seen in Structures with shear wall because of high weight. Lowest peak shear can be seen in model with cross bracings.

E. Maximum Axial Force Comparison



Graph-4: Maximum Axial Force Comparison

Discussion

Max axial force represent the axial force through columns at the base of the structure.

The more the weight of the structure the more is the force on the columns i.e. Max Axial force.

The max axial force is observed in the model with corner shear walls and least ids observed in the Model with cross bracings further signifying that cross-bracing g is the best Seismic resistant supplement member, as it is light in weight and gives high seismic resistance to building.

VII. CONCLUSION

1. Four RC framed models have been observed and analyzed by introducing various earthquake resisting members, like: Parallel shear walls, Corner Shear walls, Diagonal Bracings & Cross Bracings.
2. It is observed from the above analysis that the displacement observed in the models, which are without shear walls & bracings is more as compared to the models having shear walls and bracings at different locations.
3. It has been observed that the Max deflection is significantly reduced after providing the shear walls or bracings in the RC frame in X-direction as well as in Z-direction.
4. It is also been observed that Story shear effectively decreased by introducing Shear Walls and Bracings at different locations.
5. The best location of shear wall in multi-storey building is parallel shear walls. And the best type of bracings that can be used is cross bracing.
6. The lateral deflection of column for building with cross bracing is reduced maximum as compared to all models.
7. The least story shear is found in the model with cross bracing. The shear force is maximum at the ground level & the bending moment is maximum at roof level.
8. By providing shear walls and bracings to the high-rise structure, seismic behavior will be affected to a great extent and also the stiffness and the strength of the buildings is increased.
9. Finally, it is concluded that, optimization using cross bracings is the best procedure, in present work mode for maximum earthquake resistance.

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