Review of Seismic Response of Residential Tower with and without Shear Wall

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Abstract: ***Shear wall system are most commonly used for resisting lateral load in the high rise buildings. In seismic design of the building reinforced concrete shear walls or structural walls act as a major role as earthquake resisting member. This necessitates need for design based on seismic response by suitable method to make sure strength and stability of the structures. In the present work to study the seismic response of the fifteen storey residential tower with and without shear wall and the behavior of the building with shear walls at different locations was carried out. Shear wall effectiveness has been studied with the help of ten different models. Model one to five is regular shape structural system and model six to ten is irregular shape structural system. Model one and model six is bare frame and remaining eight models models have shear wall with different location. Earthquake load is applied to a residential tower of fifteen storey located in zone V. The comparison of these models for different parameters like displacement, storey drift and base shear has been obtainable by reinforced concrete shear wall building with and without shear wall. The software used is ETABS v15.2.***

Keywords: framed structure, Seismic analysis, time history analysis, Shear wall, multi storey, ETABS v15.2

1. Introduction

Earthquakes occur due to the development of movement in between the tectonic plates within the earth's crust. The movement between the fault lines, and the vitality discharged is transmitted through the earth as waves that causes ground movement numerous miles from the epicentre. These waves travel at various moments of time, with diverse amplitudes and convey distinctive levels of energy. At times severity of ground movement during this event can be minor, moderate with less damage and strong with permanent damage, which can be grouped by size and its severity of damage. The intensity of the earthquake can is measured by Magnitude, where intensity of any earthquake can be collected by recording the data of ground motions on seismograms. This is measured by Modified Mercalli Intensity scale (MMI scale).

The magnitude and intensities of earthquakes varies from one point to another causing low to severe damage because of its destructive powers on engineered structure in addition giving life threat and rise to great economic losses in country. To avoid this misfortune issue many countries over the world started monitoring and recording the ground motions in their regions and changing over these information into seismic zone maps in terms of Peak ground accelerations (PGA). These zone maps are regularly updated with specific data in order to anticipate future earthquakes, which will be helpful for creation and design of economical and safe earthquake resistant structures.

2. Objective

1) To attain knowledge in design of moment-resisting Frames by analysing it.
2) To study the behaviour of buildings with shear wall at different location and with bare frame.
3) To attain knowledge regarding effects of earthquake on RC building.
4) To study the seismic behaviour of buildings linear static, linear dynamic and non-linear dynamic analysis (time history analysis).
5) Evaluate the effect of G+15 storey buildings located in Zone- V with shear wall at different location subjected to ground motion.

3. Materials & Methods

For this study, a 10-story building with a 3-meters height for each story, regular in plan is modeled. These buildings were designed in compliance to the Indian Code of Practice for Seismic Resistant Design of Buildings .The buildings are assumed to be fixed at the base and the floors acts as rigid diaphragms. The sections of structural elements are square and rectangular and their dimensions are changed for different building. Storey heights of buildings are assumed to be constant including the ground storey. The buildings are modelled using software ETAB Nonlinear v 15.2.0.Four different models were studied with different positioning of shear wall in building. Models are studied zone V comparing lateral displacement, story drift and storey shear for all models.

3.1 Seismic Input

1) Mode1 **I:** Structural system of regular shape without shear wall.
2) Model **II:** Structural system of regular shape with shear wall at lift.
3) Model **III:** Structural system of regular shape with shear wall at lift and staircase.
4) Model **IV:** Structural system of regular shape with shear wall at corner of the building.
5) Model **V:** Structural system of regular shape with parallel shear wall.
6) Model **VI:** Structural system of irregular shape without shear wall.
7) Model **VII:** Structural system of irregular shape with shear wall at lift.
8) Model **VIII:** Structural system of irregular shape with shear wall at lift and staircase.
9) Model **IX:** Structural system of irregular shape with shear wall at corner of building.
10) Model **X:** Structural system of irregular shape with parallel shear wall.

Model I to V: Regular shape
Model VI to X: Irregular shape

3.2 Parameters

Response Reduction Factor 5, Seismic Zone Factor 0.36, Height of Building 45m, Thickness of Shear wall 0.23m, Beam size 0.230m x 0.50m, Column size0.230m x 0.60m, Live Load For Lobby 3, Hall 2, Balcony 3, kitchen 2 kN /m^2, Floor Finish for terrace 1.5, floor 1.2 kN /m^2

Grade of Concrete M25, Grade of Steel Fe 415 and Thickness of slab will be varying for Lobby 175mm, Hall 150mm, Balcony 100mm and kitchen 125mm

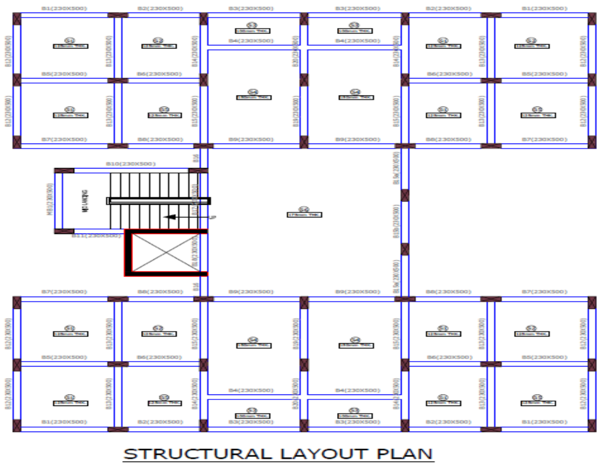

Figure 3.1: Structural layout Plan of irregular shape

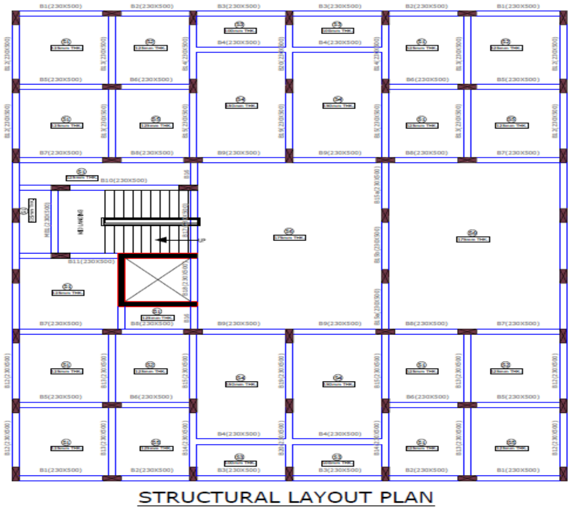

Figure 3.2: Structural layout for regular shape

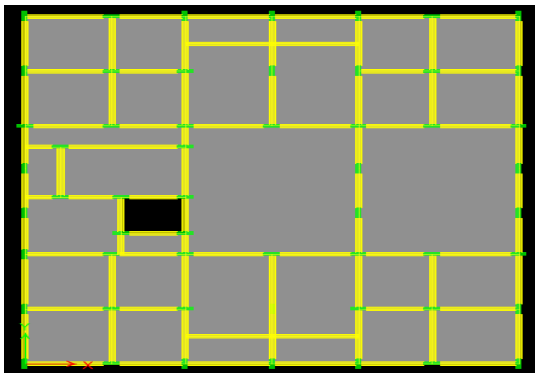

Figure 3.3: model 1

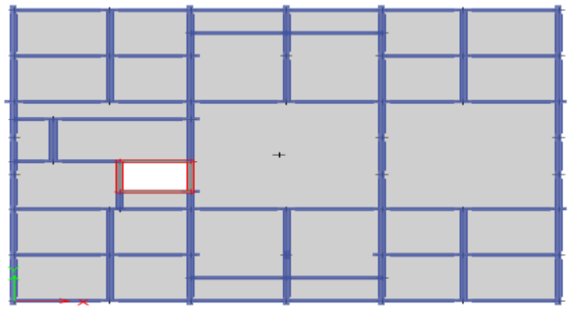

Figure 3.4: model 2

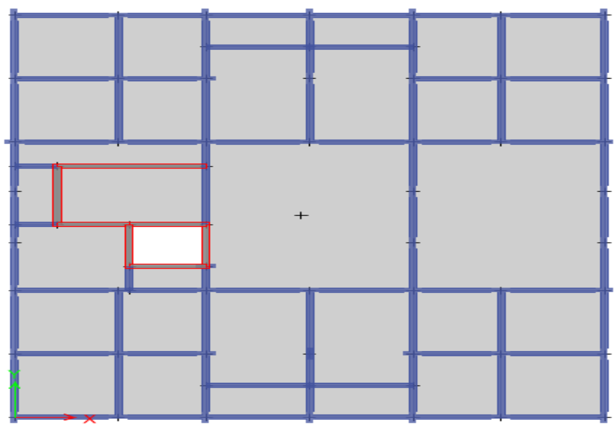

Figure 3.5: model 3

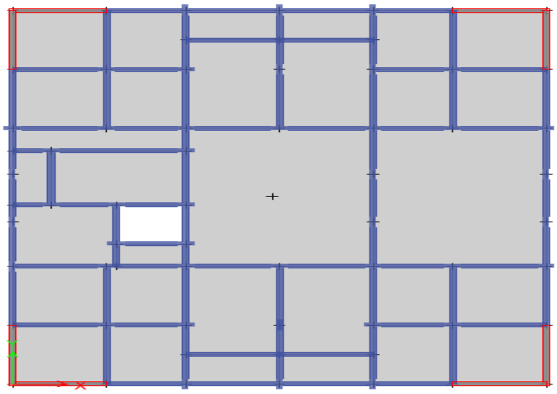

Figure 3.6: model 4

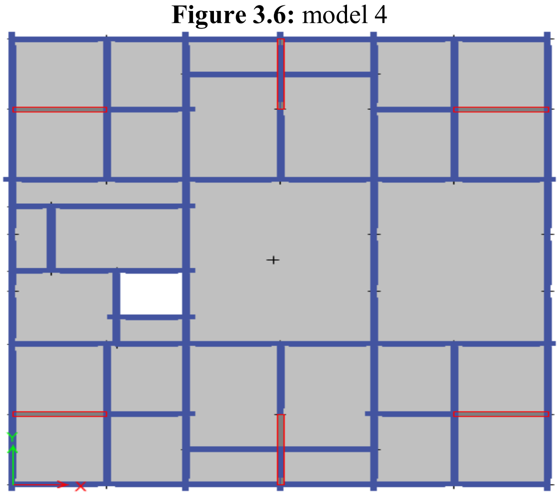

Figure 3.7: model 5

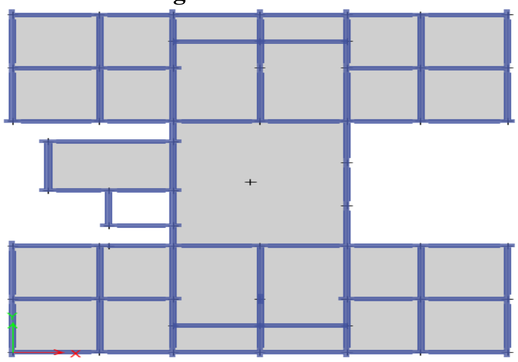

Figure 3.8: model 6

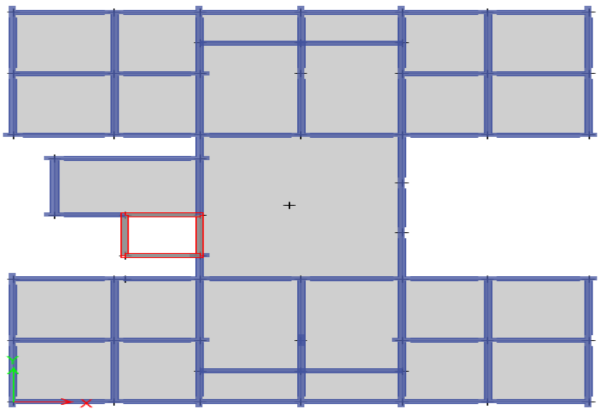

Figure 3.9: model 7

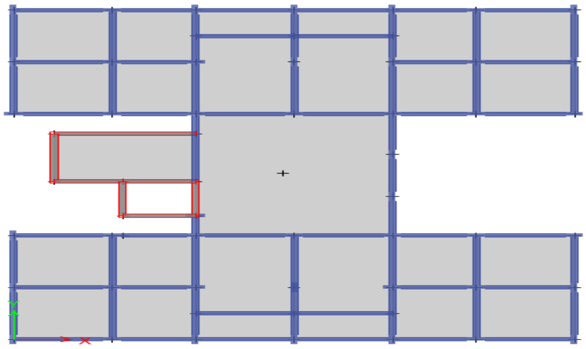

Figure 3.10: model 8

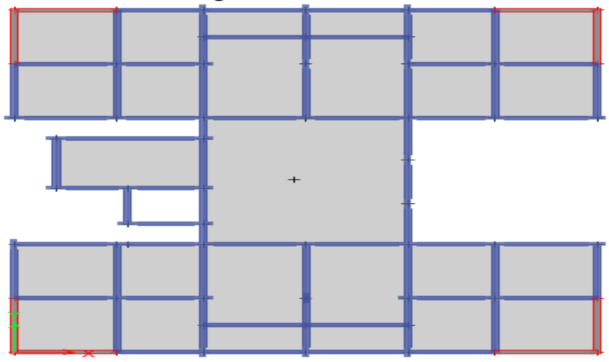

Figure 3.11: model 9

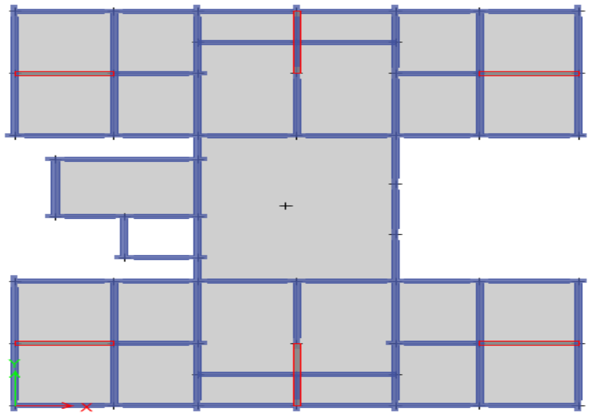

Figure 3.12: model 10

4. Results and Comparison

4.1 Lateral Displacement for Equivalent Static Method

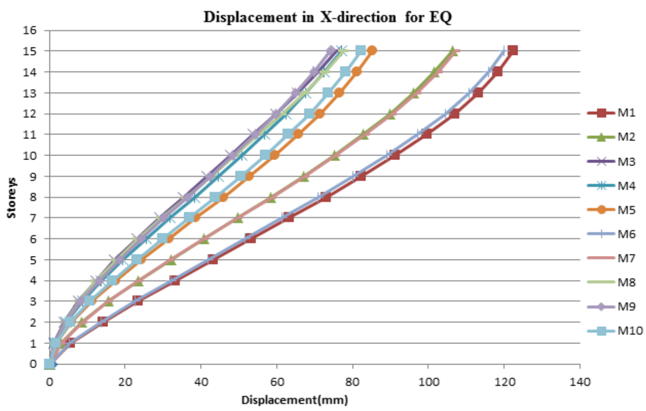

Figure 4.1: displacement along X-dir for EQX

Storey Displacement for Regular Shape Building.

- From fig 4.1 it is observed that maximum storey displacement occurs in Model 1 and minimum Storey displacement in Model 3 for X-direction.

- The percentage of lateral displacement of Model 3 has 38% less lateral displacement compared to Model 1, In comparison with Model 1 the percentage of lateral displacement decreases 13% in Model2, 36.9% in Model 4 and 30.25% in Model 5.

Storey Displacement for Irregular Shape Building.

- From fig 4.1 it is observed that maximum lateral displacement in Model 6 and minimum lateral displacement in Model 9 for X-direction..
- The percentage of lateral displacement in Model 9 has 38% less lateral displacement compared to Model 6, In comparison with Model 6 the percentage of lateral displacement decreases 11% in Model7, 35.0% in Model 8 and 31.15% in Model 10.

4.2 Lateral Displacement for Response Spectrum Method

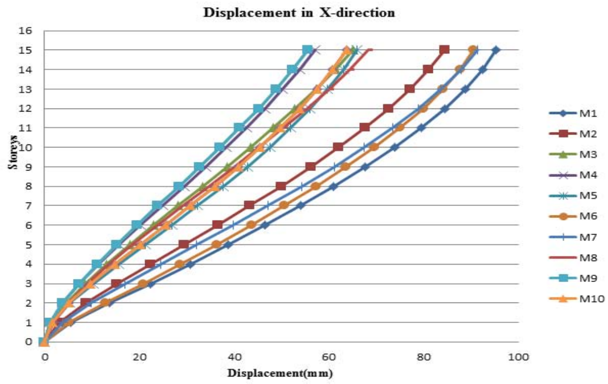

Figure 4.2: displacement along X-dir for RSX

Storey Displacement for Regular Shape Building

- From fig 4.2 it is observed that maximum lateral displacement in Model 1 and minimum lateral displacement in Model 4 for X-direction.
- The percentage of lateral displacement in Model 4 has 40% less lateral displacement compared to Model 1, In comparison with Model 1 the percentage of lateral displacement decreases 11.2% in Model2, 31.5% in Model 3 and 30.6% in Model 5.

Storey Displacement for Irregular Shape Building

- From fig 4.2 it is observed that maximum lateral displacement in Model 7 and minimum lateral displacement in Model 9 for X-direction.
- The percentage of lateral displacement in Model 9 has 39.23% less lateral displacement compared to Model 7, In comparison with Model 7 the percentage of lateral displacement decreases 1.16% in Model6, 25.35% in Model 8 and 30.27% in Model 10.

4.3 Lateral Displacement for Time History Analysis

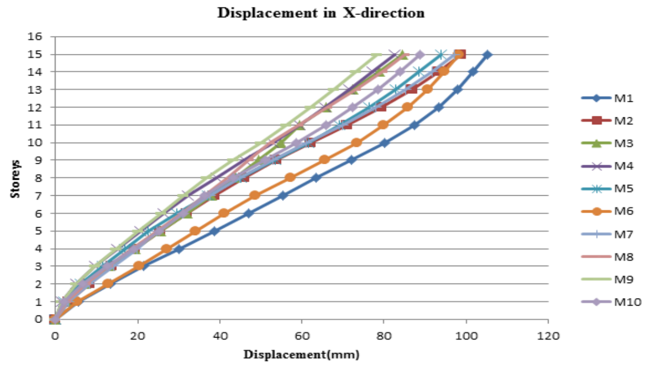

Figure 4.3: displacement along X-dir for TH

Storey Displacement for Regular Shape Building

- From fig 4.3 it is observed that maximum lateral displacement in Model 1 and minimum lateral displacement in Model 4 for X-direction.
- The percentage of lateral displacement in Model 4 has 21.38% less lateral displacement compared to Model 1, In comparison with Model 1 the percentage of lateral displacement decreases 6% in Model2, 19.7% in Model 3 and 10.75% in Model 5.

Storey Displacement for Irregular Shape Building.

- From fig 4.3 it is observed that maximum lateral displacement in Model 6 and minimum lateral displacement in Model 9 for X-direction.
- The percentage of lateral displacement in Model 9 has 20.28% less lateral displacement compared to Model 6, In comparison with Model 6 the percentage of lateral displacement decreases 1% in Model7, 13.15% in Model 8 and 9.37% in Model 10.

4.4 Inter Storey Drift for Equivalent Static Method

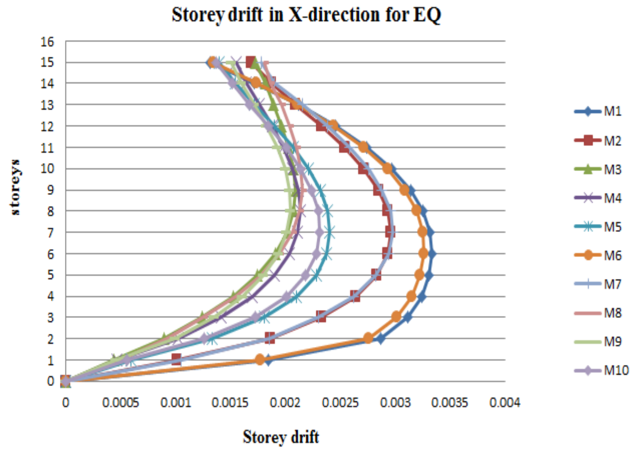

Figure 4.4: Inter storey drift along X-dir for EQX

Inter Storey Drift for Regular Shape Building.

- From fig 4.4 it is observed that maximum Inter Storey Drift in Model 1 and minimum Inter Storey Drift in Model 3 for X-direction.
- The percentage of Inter Storey Drift of Model 3 has 37.4% less Inter Storey Drift compared to Model 1, In comparison with Model 1 the percentage of Inter Storey Drift decreases 11.37% in Model2, 36.0% in Model 4 and 27.8% in Model 5.

Inter Storey Drift for Irregular Shape Building

- From fig 4.4 it is observed that maximum Inter Storey Drift in Model 6 and minimum Inter Storey Drift in Model 9 for X-direction.

4.5 Inter Storey Drift for Response Spectrum Method

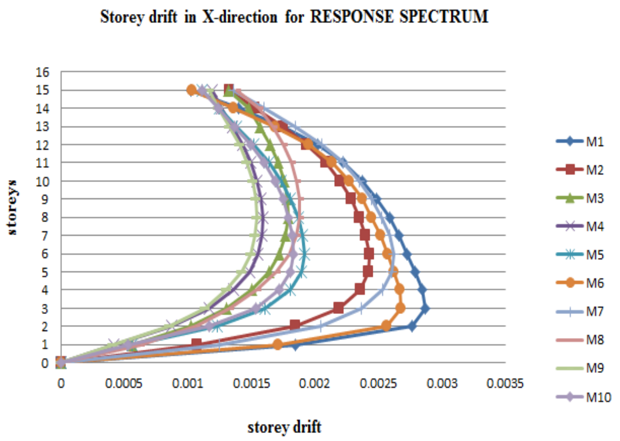

Figure 4.5: Inter storey drift along X-dir for RSX

Inter Storey Drift for Regular Shape Building

- From fig 4.5 it is observed that maximum Inter Storey Drift in Model 1 and minimum Inter Storey Drift in Model 4 for X-direction.
- The percentage of Inter Storey Drift in Model 4 has 44.6% less Inter Storey Drift compared to Model 1, In comparison with Model 1 the percentage of Inter Storey Drift decreases 15.3% in Model2, 37.6% in Model 3 and 33.1% in Model 5.

Inter Storey Drift for Irregular Shape Building.

- From fig 4.5 it is observed that maximum Inter Storey Drift in Model 6 and minimum Inter Storey Drift in Model 9 for X-direction.
- The percentage of Inter Storey Drift in Model 9 has 42.5% less Inter Storey Drift compared to Model 6, In comparison with Model 6 the percentage of Inter Storey Drift decreases 2.23% in Model7, 29.8% in Model 8 and 31.7% in Model 10.

4.6 Inter Storey Drift for Time History Analysis

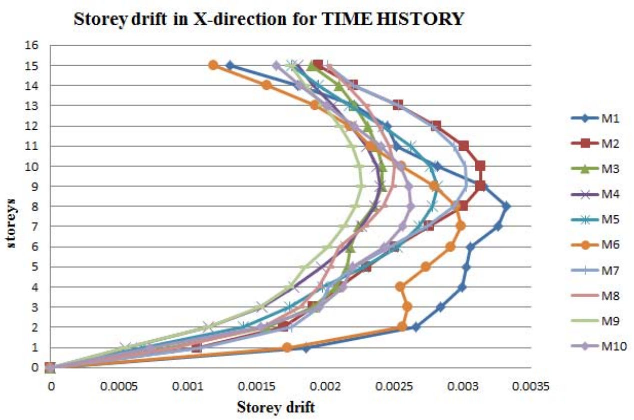

Figure 4.6: Inter storey drift along X-dir for TH

Inter Storey Drift for Regular Shape Building.

- From fig 4.6 it is observed that maximum Inter Storey Drift in Model 1 and minimum Inter Storey Drift in Model 4 for X-direction.
- The percentage of Inter Storey Drift in Model 4 has 27.7% less Inter Storey Drift compared to Model 1, In comparison with Model 1 the percentage of Inter Storey Drift decreases 5.72% in Model2, 27.1% in Model 3 and 15.0% in Model 5.

Inter Storey Drift for Irregular Shape Building.

- From fig 4.6 it is observed that maximum Inter Storey Drift in Model 7 and minimum Inter Storey Drift in Model 9 for X-direction.
- The percentage of Inter Storey Drift in Model 9 has 25.4% less Inter Storey Drift compared to Model 7, In comparison with Model 7 the percentage of Inter Storey Drift decreases 1.3% in Model6, 17.5% in Model 8 and 13.53% in Model 10

4.7 Base Shear for Equivalent Static Method

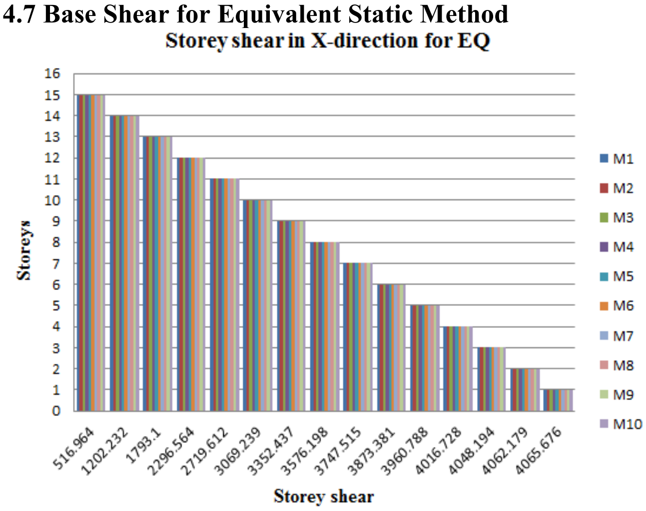

Figure 4.7: Base shear along X-dir for EQX

Base Shear for Regular Shape Building

- From fig 4.7 it is observed that maximum Base Shear in Model 5 and minimum Base Shear in Model 4 for X-direction.
- The percentage of Base Shear of Model 4 has 1.63% less Base Shear compared to Model 5, In comparison with Model 5 the percentage of Base Shear decreases 1.0% in Model1, 1.1% in Model 2 and 1.15% in Model 3.

Base Shear for Irregular Shape Building

- From fig 4.7 it is observed that the maximum Base Shear in Model 10 and minimum Base Shear in Model 9 for X-direction.
- The percentage of Base Shear of Model 9 has 1.8% less Base Shear compared to Model 10, In comparison with Model 10 the percentage of Base Shear decreases 1.12% in Model6, 1.1% in Model 7 and 1.08% in Model 8.

4.8 Base Shear for Response Spectrum Method

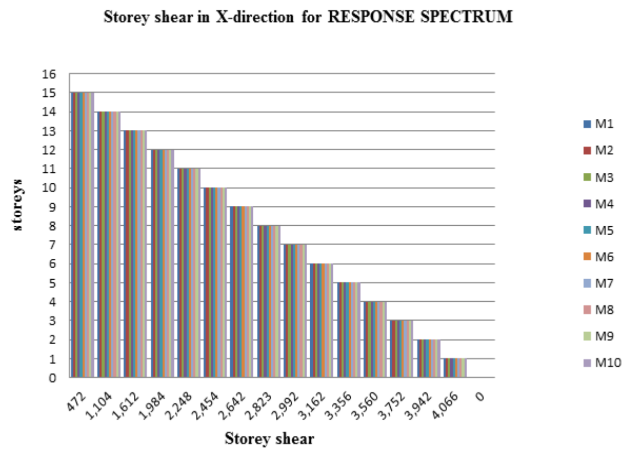

Figure 4.8: Base shear along X-dir for RSX

Base Shear for Regular Shape Building and Irregular Shape Building

In response spectrum analysis method we obtained the same base shear results for all models compared to equivalent static method, So that the base shear remains same for both cases.

4.9 Base Shear for Time History Analysis

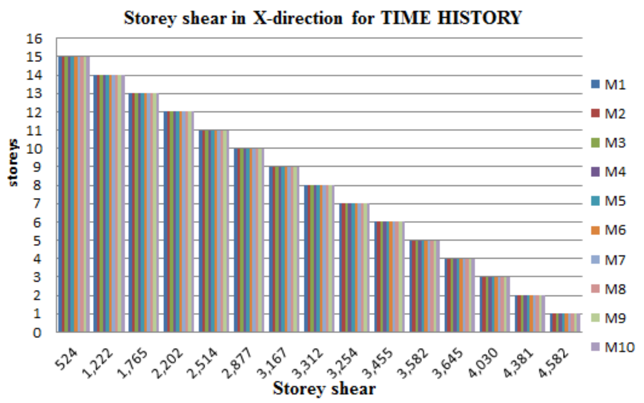

Figure 4.9: Base shear along X-dir for TH

Base Shear for Regular Shape Building

- From fig 4.9 it is observed that maximum Base Shear in Model 3 and minimum Base Shear in Model 2 for X-direction.
- The percentage of Base Shear in Model 2 has 17.6% less Base Shear compared to Model 3, In comparison with Model 3 the percentage of Base Shear decreases 16.25% in Model1, 3.3% in Model 4 and 7.65% in Model 5.

Base Shear for Irregular Shape Building

- From fig 4.9 it is observed that maximum Base Shear in Model 8 and minimum Base Shear in Model 7 for X-direction.
- The percentage of Base Shear in Model 7 has 19.5% less Base Shear compared to Model 8, In comparison with Model 8 the percentage of Base Shear decreases 19.25% in Model6, 7.61% in Model 9 and 3.77% in Model 10.

5. Conclusion

- The present work is focuses on study of seismic behavior of RC multi storey building which located in zone V, of IS 1893-2002(part-1).the behavior were renowned in terms of lateral displacement, storey drift and storey shear for the considered models. The following are the conclusions which can be concluded from present study, which are as follows.
- In equivalent static analysis it is observed that model 3 and model 9 have lesser lateral storey displacement compared with all other different models.
- In response spectrum analysis it is observed that model 4 and model 9 have lesser lateral storey displacement compared with all other different models.
- In time history analysis it is observed that model 4 and model 9 have lesser lateral storey displacement compared with all other different models.
- In equivalent static analysis it is observed that model 3 and model 9 have lesser inter storey drift compared with all other different models.
- In response spectrum analysis it is observed that model 4 and model 9 have lesser inter storey drift compared with all other different models.
- In time history analysis it is observed that model 4 and model 9 have lesser inter storey drift compared with all other different models.
- In equivalent static analysis and response spectrum analysis it is observed that model 5 and model 9 have lesser base compared with all other different models.
- In time history analysis it is observed that model 2 and model 7 have lesser base shear compared with all other different models.
- The changing of shear wall position will affect the attraction of the forces so the shear wall position must be in proper position
- It is observed that shear wall is economical and effective in the high rise building.
- If shear wall will provide at an adequate locations substantially reduces the displacement due to an earthquake

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