Effect of Shear Wall Sections on Multistorey Building with Satellite Bus-Stop having Floating Columns with Top Soft Storey

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Abstract

Multi-storeyed buildings with open (soft) ground floor are inherently vulnerable to collapse due to earthquake load, even then their construction is still widespread in the developing nations. An investigation has been performed to study the behaviour of the columns at ground level of multi-storeyed buildings with soft ground floor as satellite bus stop and floating columns in the upper stories subjected to earthquake loading. The structural action of masonry infill panels of upper floors has also been taken into account by modelling them as diagonal struts. Shear wall is one of the most commonly used lateral load resisting in high rise building. In this study building is modelled with different shapes of shear wall with top and bottom soft storey. Static and dynamic analysis is carried out by using ETABS 2013. The comparison of these models for different parameters like Storey drift and storey acceleration is carried out.
Keywords: Soft Storey, Equivalent Strut Width, Floating Columns, Shear Wall, Water Pressure

I. INTRODUCTION

Earthquakes are natural hazards under which disasters are mainly caused by damage or collapse of buildings. Objective of seismic analysis is stated as the structure should be able to endure minor shaking intensity without sustaining any damage, thus leaving the structure serviceable after the event. Lateral forces can produce the critical stresses in a structure and in addition cause lateral sway of the structure. Many buildings constructed in recent times have a special feature that the ground stories are left open for the purpose of parking, reception etc. Such buildings are often called open ground storey buildings or buildings on stilts. The strength demand on the column in the first storey for these building is large, upper stories move almost together as a single block and most of the horizontal displacement of the building occurs in the soft ground storey. However in the upper stories the forces in the columns are effectively reduced due to presence of brick infill walls which share the forces.

Reinforced concrete building can adequately resist both horizontal and vertical load. Whenever there is requirement for a multistorey building to resist higher value of seismic forces, lateral load resisting system such as shear wall should be introduced in a building. Vertical plate like RC wall introduced in building in addition to beam, column and slab are called shear wall. Shear walls are incorporated in building to resist lateral Forces and support the gravity loads. RC shear wall has high in plane stiffness. Positioning of shear wall has influence on the overall behaviour of the building. For effective and efficient performance of building it is essential to position shear wall in an ideal location. Many researchers have investigated on changing position of shear wall location to determine parameter like Storey shear, time period, storey acceleration and displacement. This analysis is done by using ETAB. It was observed that placing shear wall away from the centre of gravity resulted in increase in most of member forces.

The main Objectives of the present study is

- Effect of soft story on structural behaviour of high rise building.
- To observe the structural performance of the building having equivalent diagonal strut and floating columns with soft storey when subjected to lateral loads.
- To know the effect of water pressure in the top soft storey of the building.
- Seismic response of soft story structure with different shapes of shear wall.

II. DESCRIPTION OF STRUCTURAL MODEL

The plan layout for all the building models is same as shown below. Study has been done on ten different models of a twelve storey building. Out of them one is bare frame model, fully infilled frame (only outer face), top soft storey, bottom and top soft storey and other six models with different shapes of shear wall. The member size at respective floors with grade of concrete is shown in below table 1.

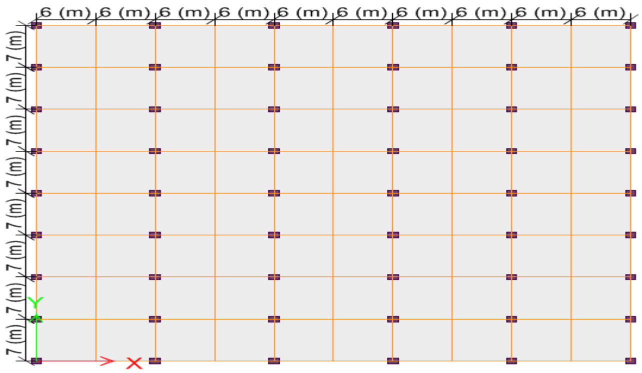

Fig 1: Plan at storey 1

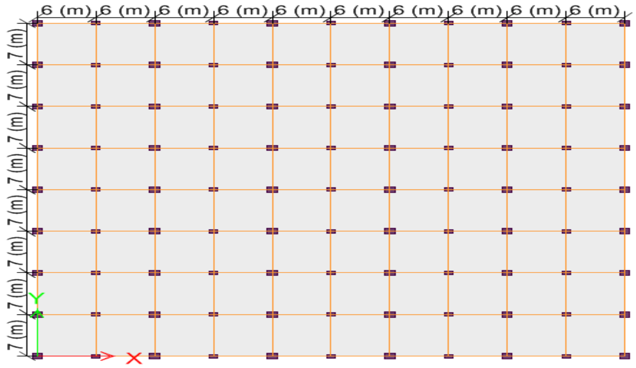

Fig 2: Plan from storey 2 to 12

Table – 1
Member sizes

Grade of concrete	*Member*	*Size in mm*	*Storey*
M35	*Column*	*900x1000*	*1st & 2nd*
M35	*Column*	*700x900*	*3 to 9*
M35	*Column*	*500x700*	*10 to 12*
M35	*Floating column*	*300x500*	*2 to 12*
M35	*Beam*	*900x1000*	*1st*
M35	*Beam*	*300x500*	*2 to 11*
M35	*Beam*	*300x400*	*12th*
M25	*Slab*	*150 mm thick*	*All storey*

In the top storey swimming pool is modeled with member properties as given below
L = 24m, B = 14m , H = 2.7m , h = 2.3m
Thickness of wall (t_w) = 0.3m
Thickness of slab (t_s) = 0.3m
Hydrodynamic pressure:
Pressure on wall=16.67 KN/ m²
Pressure on slab=22.563 KN/ m²
Following data is used in the analysis of the RC frame building models:
Material Properties:
Density of Reinforced Concrete = 25kN/m³
Modulus of elasticity of brick masonry= 4.66x106 kN/m²
Density of brick masonry = 20kN/m³
Poisson’s Ratio of concrete = 0.2
Assumed Dead load intensities:
Floor finishes = 1.5kN/m²
Live load intensities:
Imposed loads = 4KN/ m²
Roof live =1.5 KN/ m²
Thickness of wall = 0.23m
Design Spectrum
Zone –V
Zone factor, Z (Table2 of IS 1893-2002) – 0.36
Importance factor, I (Table 6 of IS 1893-2002) – 1.0
Response reduction factor, R (Table 7 of IS 1893-2002) – 5.00
Soil type (figure 2 of IS 1893-2002) – Type II (Medium soil)
Storey heights: Bottom storey = 8m, 2nd to 11th storey = 3.7m, Top storey =2.7m

III. MODEL CONSIDERED FOR ANALYSIS

Following ten models are analyzed in ETABS 2013 as special moment resisting frame using equivalent static analysis, response spectrum analysis and time history analysis.

1) Model 1: Bare frame model with floating columns and swimming pool (at top storey), however masses of brick masonry infill walls(230 mm) thick are included in the model.
2) Model 2: Building model has full brick masonry infill in the form of diagonal strut only on the outer face.
3) Model 3: Building model is same as model 2, but there is no infill in the top storey.

4) Model 4: Building model has no brick masonry infill in ground and top storey, but has full brick masonry infill in the form of diagonal strut only on the outer face in rest of all storeys.
5) Model 5: Building model is same as model 4, further L shape shear wall is provided at corners.
6) Model 6: Building model is same as model 4, further T shape shear wall is provided at corners.
7) Model 7: Building model is same as model 4, further swastika shape shear wall is provided at corners.
8) Model 8: Building model is same as model 4, further channel section shear wall is provided at corners.
9) Model 9: Building model is same as model 4, further I section shear wall is provided at corners.
10) Model 10**:** Building model is same as model 4, further plane shear wall is provided at centre of outer face building.

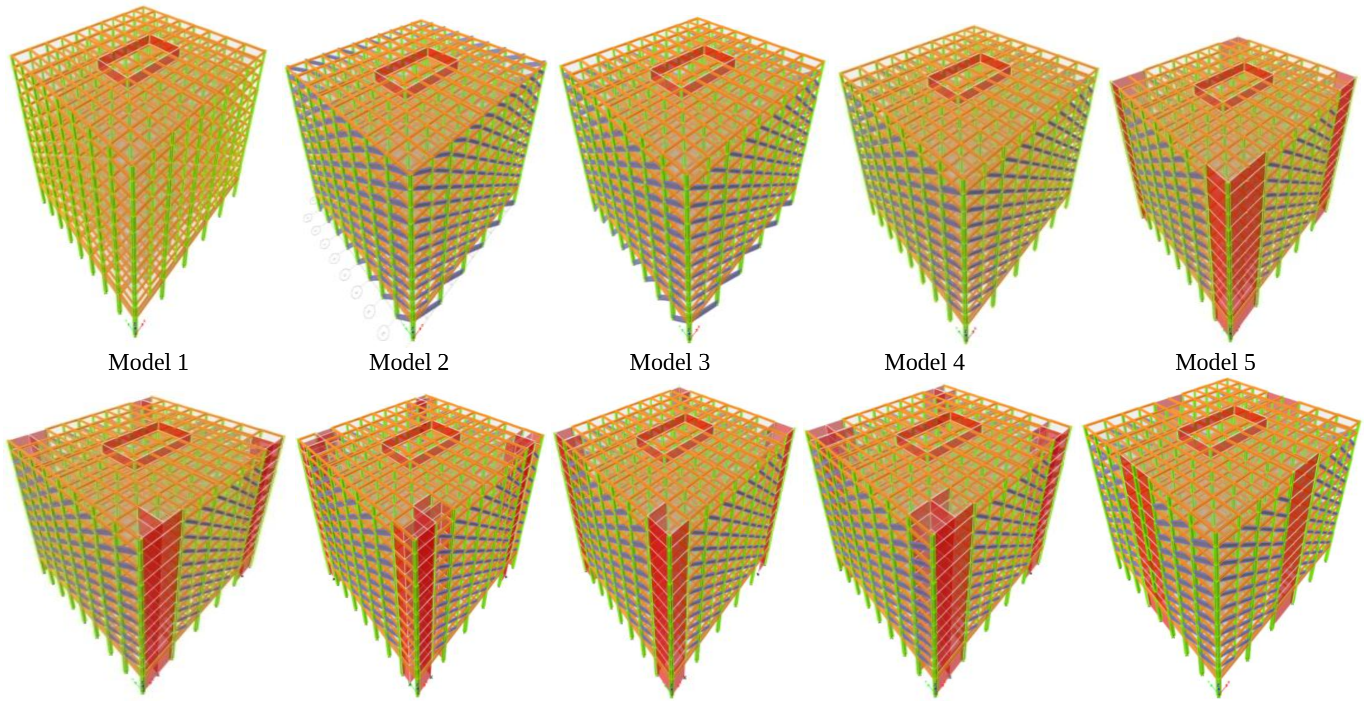

Fig 3: 3D Building Models

IV. RESULTS AND DISCUSSIONS

Response spectrum analysis(RSA) and Time history analysis(THA) has been performed for each model in ETABS 2013 software. From the obtained results below charts has been drawn in X direction. Similar variation is observed in Y direction.

A. Storey Drift

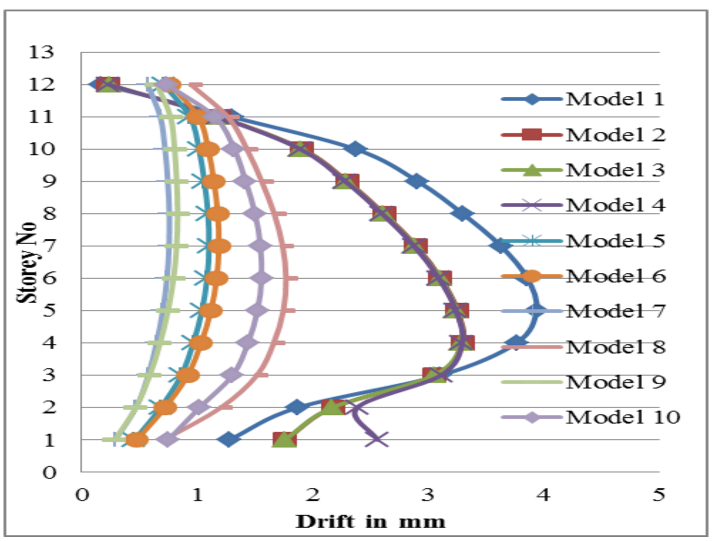

Fig. 4: Chart 1: Comparison of storey drift between various models for ESA along X direction

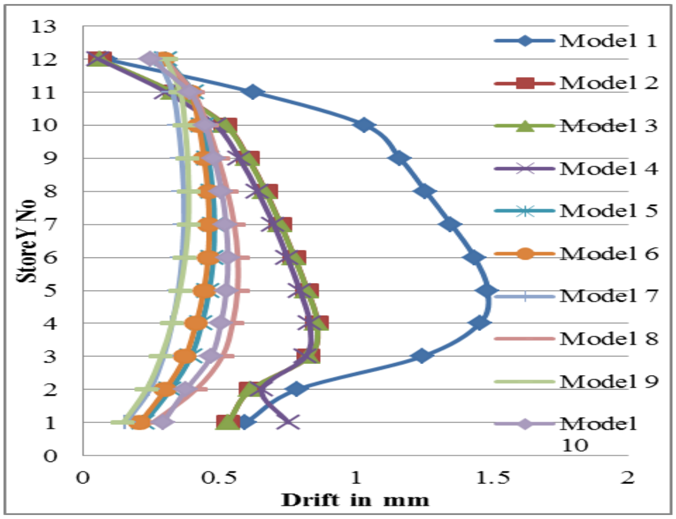

Fig. 5: Chart 2: Comparison of storey drift between various models for RSA along X direction

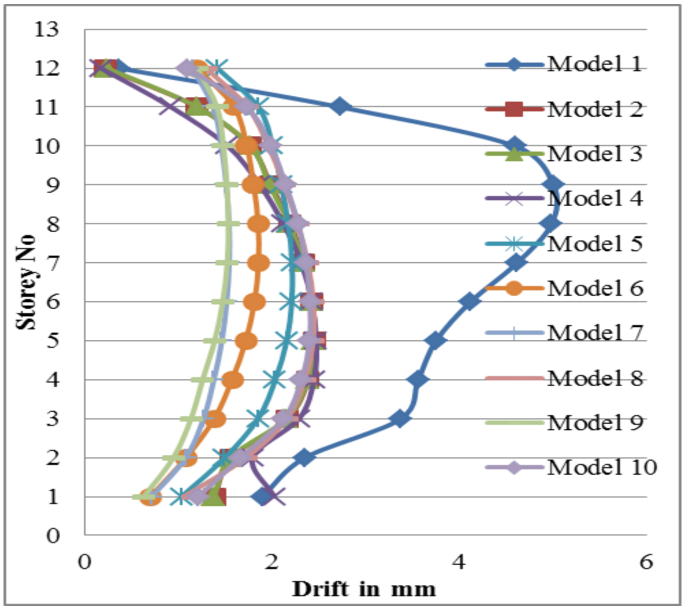

Fig. 6: Chart 3: Comparison of storey drift between various models for THA along X direction

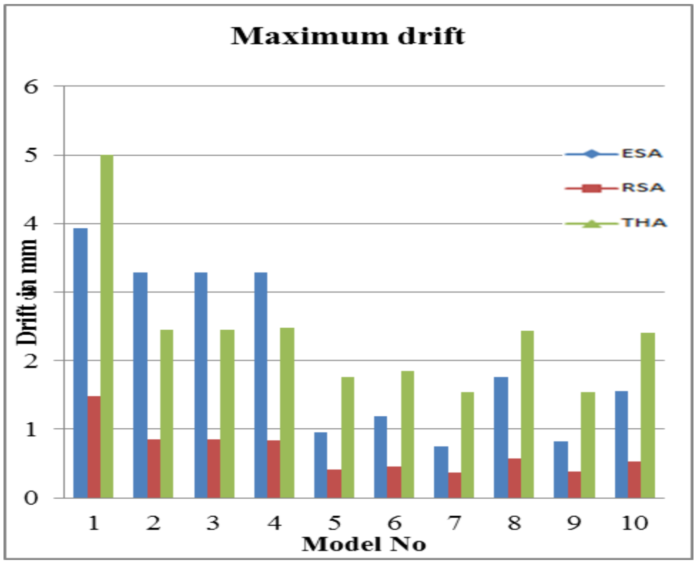

Fig. 7: Chart 4: Comparison of Maximum Drift between various Models for ESA,RSA and THA along X Direction

All the results of storey drifts obtained from all three analysis are plotted in respective charts. From these charts it is clearly observed that bare frame model (Model 1) yields higher drift values as compared to other models. Also it is clearly observed from these charts that the storey drifts gradually increase from storey level 2 to certain storey level(4,5,6) and then gradually decreases to top storey. When the effect of soft storey is considered in Model 4 at bottom and top storey the drift first takes S shape pattern reaches maximum value then goes on decreasing up to top storey. Even though top storey is soft storey there is no effect in drift. Also Model 4 has the maximum drift in the bottom storey compared to all other models due to soft storey effect.

When shear wall is considered in remaining models(5,6,7,8,9,10) there is considerable reduction in drift compared to Model 4. Also the storey drift in both the directions satisfy the permissible limit i.e. 0.004*h=0.004*3.7=14.8mm. From chart 4 it can be seen that RSA results are in between ESA and THA. Model 1 has the maximum drift and it goes on reducing for other models. Considering ESA there is 16.29% reduction in maximum storey drift for Model 2 when compared to Model 1, 0.24% reduction for Model 3 compared to Model 2 and the percentage reduction when shear wall is considered for models 5,6,7,8,9,10 compared to Model 4 are 70.77%,63.97%,77%,46.3%,74.8%,52.76% in X direction. Similarly the average percentage reduction in maximum storey drift for models with shear wall when compared to Model 4 for RSA and THA is 45.15% and 22.2%. From chart 4 it is observed that Model 7 has least drift compared to other models in both the directions.

A. Storey Acceleration

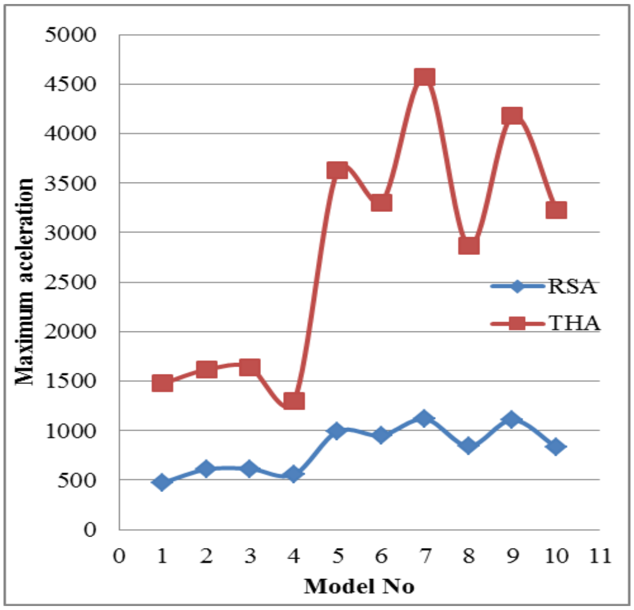

Fig. 8: Chart 5: Comparison of Maximum acceleration between various models for RSA and THA along X direction

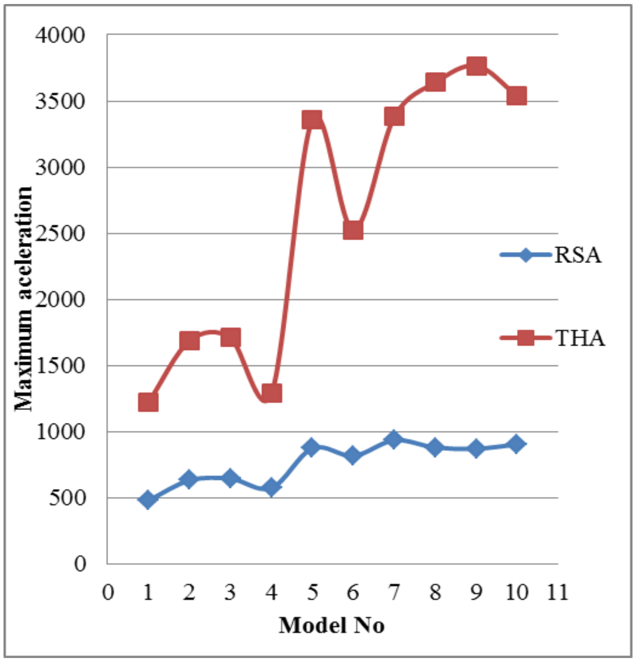

Fig. 9: Chart 6: Comparison of Maximum acceleration between various models for RSA and THA along Y direction

During an earthquake, the building can amplify its motion, resulting in peak floor accelerations higher than the peak ground acceleration. Maximum acceleration is observed in the top storey compared to below storey levels. Chart 5 and 6 shows the comparison of maximum acceleration in top storey between various models for RSA and THA along X and Y direction. From these charts it is observed that models with shear wall yields higher storey acceleration and particularly swastika shape shear wall showed better performance in storey acceleration compared to other models.

V. CONCLUSIONS

- Bare frame model (Model 1) yields higher drift values as compared to other models.
- Model with bottom soft storey have got highest storey drift values at soft stories levels, which leads to dangerous sway mechanism. Therefore providing shear wall is essential so as to avoid soft storey failure.
- There is considerable reduction in drift for models with shear wall when compared to Model 4.
- It is observed that swastika shape shear wall (Model 7) has least drift compared to other models in both the directions for all three analysis.
- Building with top soft storey does not showed any effect in drift when subjected to seismic loading.
- Storey drifts are found within the limit as specified by code (IS 1893-2002 Part-1).
- Effect of water tank at top soft storey is very much less during seismic lateral loading.
- Storey acceleration is maximum for model 7 along X direction for RSA and THA.
- It is concluded that inclusion of masonry infill and concrete shear wall will increase the strength and stiffness of the structure.

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