Comparative Study of Seismic Performance of a Building with Bottom Rigid Storey along with Different Types of Shear Walls using Moment Transfer Beams

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Abstract— The G+20 multi storey irregular building is taken for present study. This building is modeled and analyzed by using ETABS V9.7.4. Assuming the material property as linear and nonlinear. The performance of the building is studied by comparing the base shear, displacement, storey drift in different analysis. Multi-storey 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 behavior of the columns at ground level of multi-storey buildings with soft ground floor as satellite bus stop and moment transfer beams in all storey subjected to earthquake loading. The structural action of masonry infill panels of upper floors has also been taken into account by modeling 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 modeled with different shapes of shear wall with top and bottom soft storey.

Key words: Soft Storey, Equivalent Diagonal Strut, Moment Transfer Beams, Shear Wall

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. Reinforced concrete building can adequately resist both horizontal and vertical load. Whenever there is requirement for a multistory 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 behavior 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 ETABS 2015.

II. Literature Review

A. A Seismic Analysis of RC High Rise Structural Building with Multiple Soft Storey at Various Level using Etabs [Syed Mohammad Zakir Ali]

M. Tech Student (Structural Engineering) & Amaresha Assistant Professor Department of Civil Engineering Veerappa Nisty Engineering College, Shorapur 585224, Dist. Yadgir Md. Zakir Ali’s paper describes that increasing worldwide Development of metro cities in India there is increasing demand in High Rise Building and the effect of masonry infill panel on the response of RC frame subjected to seismic action is widely used. In his study the effect of masonry wall on high rise building is studied, as it is essential to consider the effect of masonry infill for the seismic evaluation of moment resistant reinforced concrete frame. Linear analysis on high rise structure with different arrangement is carried out and for analysis G+9 framed building is modelled. Soft stories are subjected to larger lateral loads during earthquakes and under lateral loading. This lateral force cannot be well distributed along the height of the structure. This situation causes the lateral forces to concentrate on the storey having larger displacement. The lateral force distribution along the height of a building is directly related to mass and stiffness of each storey

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When a multistory building is subjected to lateral load, each floor will drift with respect to adjacent floors as each floor mass acts independently. Thus the distribution of horizontal shear will be distributed across floors as building frame act in flexible manner. In presence of infill wall and column as in mass of the upper floors to act together as a single mass, as relative drift between adjacent floors is restricted. Natural time period for the model having on column in the ground storey is more than the model having both column and shear wall in the ground storey. Thus this indicates that the model with only columns is not appropriate for analysis as compared to other model having both wall and column in the ground storey. The presence of wall sin upper storey makes the much stiffer than open ground storey. Hence the upper storey move almost together as a single block and most of the horizontal displacement of the building occurs in the soft ground storey itself.

C. Objectives of the Present Work

– To study the effect of soft-story in multistory buildings.

- To know proper modeling technique of masonry infill.
- To know the behavior of the building with ground and top soft-storey.
- To study the influence of moment transfer beams on structural behavior of multistory building.
- To study the effect of drift, acceleration, displacement, story shear, and infill in multi-story building.
- To check the results with software ETABS, with different models, parameters.

III. MODEL DESCRIPTION

In the present study 9 different models of 21 storey which is having 4 bays of 10m in x- direction and 13 bays of 10 m in y direction with the plan dimension of 40m X 130m and a storey height of 10m, 2m and 3m of storey 1, storey 11 and 21 and remaining all storey respectively. Following type of structure such as bare frame, both ground and intermediate floor as soft storey are considered, L, Box, swastika and I pattern shear wall are provided at corner of the plan. Providing equivalent diagonal strut of 300 mm width in place of masonry infill panel. The building is considered in zone 5 and medium strength soil. Modulus of elasticity of brick masonry is 3500x10^{3}kN/m^2 density of brick masonry is20kN/m^3, grade of concrete(for beams and slabs) is 25 N/mm^2, grade of concrete(for columns and shear walls) is 30 N/mm^2, floor finishes is 1kN/m^2, imposed loads is 3.5 KN/m^2, wall load of 12kN/m2 .Slab thickness of 0.150m and thickness of slab of 200 beneath swimming pool exerting a pressure of 29kN/m2 on slab .Column size of 1.2mx1.5m , Moment Transfer beam of .4mx.6m in x –direction , beam at first storey of .6mx1.2m and rest of the beams as .4mx.6m. Beam size, from storey 1to storey7= 0.4m x 0.8 m, thickness of slab = 0.23m thickness of concrete wall= 0.23m.

IV. MODELS CONSIDERED FOR ANALYSIS

Following 9 models are analyzed by equivalent static method response spectrum method using ETABS software.

1) Model 1: Bare frame model, however masses of brick masonry infill walls (230mm thick) are included in the model.
2) Model 2: Building model is same as model 1 with L-type shear wall at corners.
3) Model 3: Building model is same as model 1 with Box-type shear at the corners.
4) Model 4: Building model is same as model 1 with Swastik-type shear wall at corners.
5) Model 5: Building model is same as model 1 with I-type shear wall at corners.
6) Model 6: Building model is same as model 2 with full diagonal strut that replaces brick masonry infill of 230mm thick in all the stories excluding soft storey.
7) Model 7: Building model is same as model 3 with full diagonal strut that replaces brick masonry infill of 230mm thick in all the stories excluding soft storey.
8) Model 8: Building model is same as model 4 with full diagonal strut that replaces brick masonry infill of 230mm thick in all the stories excluding soft storey.
9) Model 9: Building model is same as model 5with full diagonal strut that replaces brick masonry infill of 230mm thick in all the stories excluding soft storey

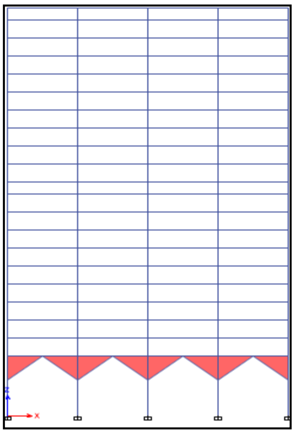
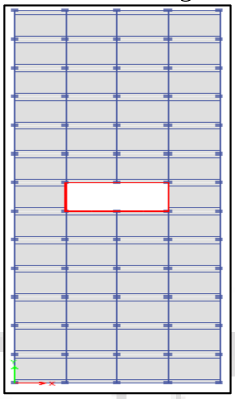
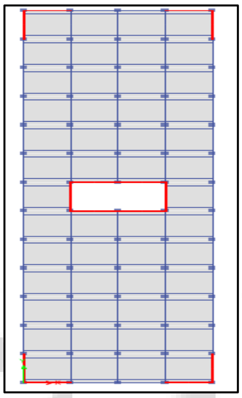


Fig. 1: Front view of building

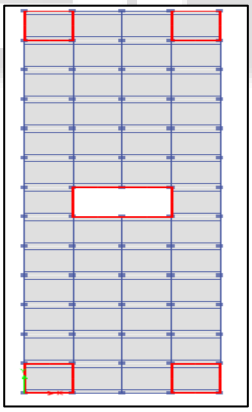
The above figure shows how beams and columns in the ground storey are connected by the use of a triangular reinforced concrete wall in order to provide extra stability and increase the resistance against seismic forces.



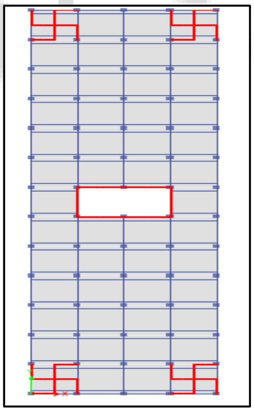
Model 1



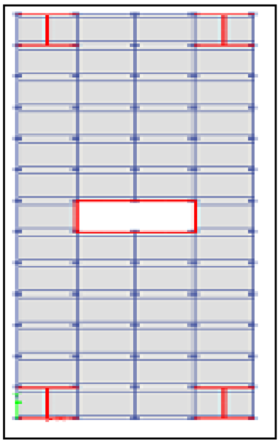
Model 2



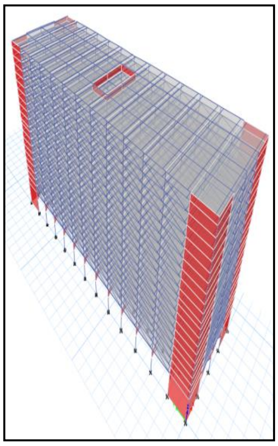
Model 3



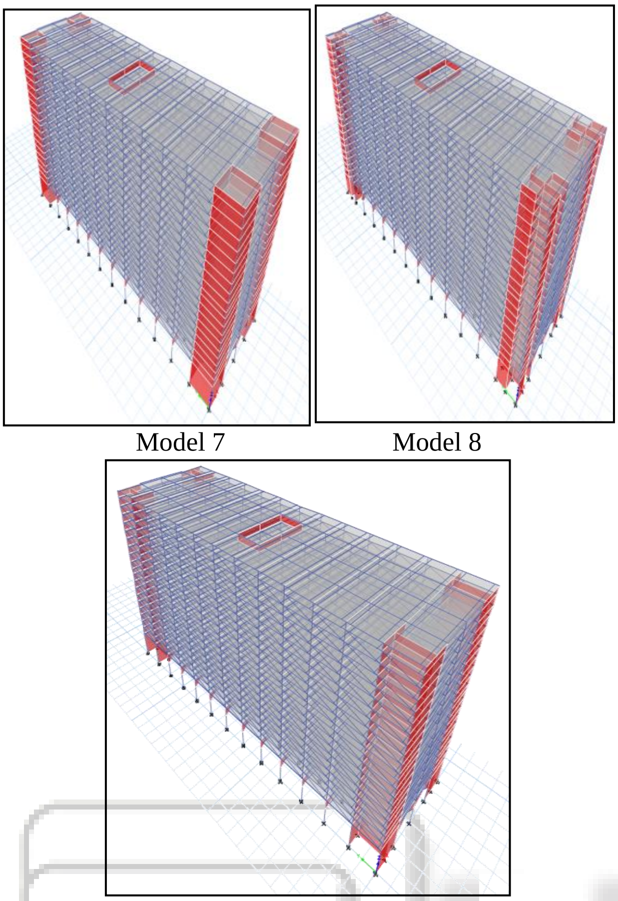
Model 4



Model 5



Model 6



Model 7 Model 8

Model 9

Fig. 2: Models

V. RESULTS AND DISCUSSION

The results obtained from the ETABS analysis of G+20 model for ESA, RSA and THA methods are tabulated and discussed for the parameters such as base shear, storey drift and storey displacement. The comparison between ESA, RSA and THA methods are shown and reported.

A. *Time Period*

When the ground shakes, the base of a building moves with respect to the ground, and the building swings back and forth. The building will oscillate back-and-forth horizontally and after some time come back to the original position these oscillations are periodic. The time taken (in seconds) for each complete cycle of oscillation (i.e., one complete back-and-forth motion) is the same and is called Fundamental Natural Period T of the building.

Fundamental time period in Sec	
Model No.	Time in Sec
1	7.406
2	2.565
3	1.918
4	2.138
5	2.029
6	2.29
7	1.863
8	2.007
9	1.877

Table 1: Time Period for ESA, RSA and THA.

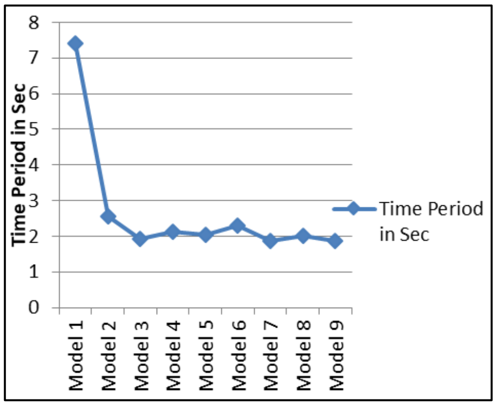


Fig. 3: Time Period for ESA, RSA and THA.

B. *Base Shear*

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure

Base Shear (kN)			
Model No.	ESA	RSA	THA
1	12858.74	12864.83	24098.67
2	21669.39	25012.65	60965.75
3	28830.37	34638.24	72748.34
4	26238.71	30832.11	64547.34
5	23308.8	27602.85	53277.43
6	26838.66	26431.17	78617.55
7	33194.86	35480.59	72725.23
8	30741.77	30832.11	72618.51
9	29672.31	25073.32	53517.77

Table 2: Base Shear for ESA, RSA and THA.

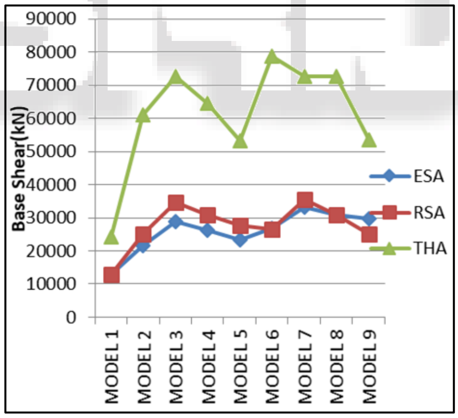


Fig. 4: Base Shear for ESA, RSA and THA.

C. *Storey Displacement*

It is the important factor, when the structure is affected by seismic forces and wind force. It mainly depends on the height of the structure, tall structures are more flexible for lateral loads. Displacement values will be higher at the top storey and less at bottom storey.

The storey displacement for ESA, RSA and THA methods are given in the Table 3 and the graphical representation is shown in Fig 5.

Storey Displacement(mm)			
Model No.	EESA	RRSA	TTHA
1	362.6	149.9	379.3
2	70.4	54.5	135.5
3	52.9	41.2	96.5
4	58.4	45.9	109.8

5	58.3	47.5	96.6
6	62.4	49.3	114.4
7	50	39.1	100.8
8	54.6	36.1	103.8
9	57.2	37.8	95.9

Table 3: Storey Displacement for ESA, RSA and THA.

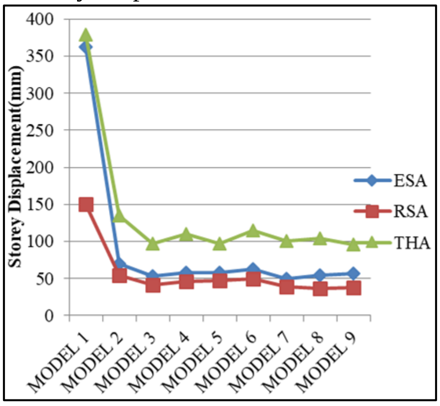


Fig. 5: Storey Displacement for ESA, RSA and THA.

D. Storey Drift

It is nothing but the difference between storey displacements of one storey with respect to the other storey. As per codes its value should not exceed the limit of 0.004 of height of the storey. Its value is usually maximum at mid stories.

The storey drift for ESA and RSA methods are given in the Table 4 and the graphical representation is shown in Fig 6.

Storey Drift			
Model No.	ESA	RSA	THA
1	0.008315	0.003468	0.009052
2	0.001482	0.001275	0.003651
3	0.001115	0.00097	0.002407
4	0.001213	0.001057	0.003036
5	0.001177	0.001	0.002356
6	0.001276	0.001124	0.002948
7	0.001042	0.000917	0.002389
8	0.001118	0.000819	0.002796
9	0.00121	0.000871	0.002304

Table 4: Storey Drift for ESA, RSA and THA.

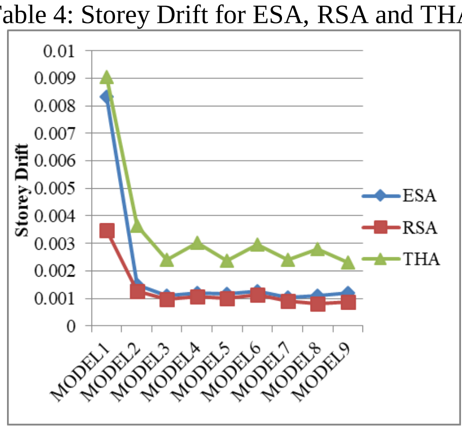


Fig. 6: Storey Drift for ESA, RSA and THA.

E. Storey Stiffness

Storey Stiffness determines whether the storey is soft storey or not. As per IS 1893-2002, A soft storey is one in which the lateral stiffness is less than 70% of that in the storey above or less than 80% of the average lateral stiffness of the three storeys above.

Storey Stiffness(kN/m)		
Model No.	ESA	RSA
1	3272321	6179616
2	16179668	21497699
3	26630647	35797063
4	21471989	27532902
5	20971458	28978190
6	18554196	22674863
7	28631714	37292751
8	23416743	28248847
9	23117496	29268488

Table 5: Storey Stiffness for ESA and RSA.

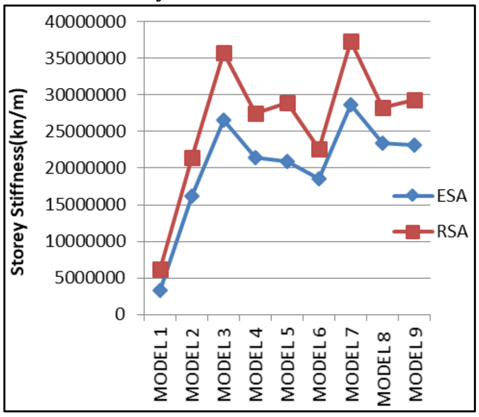


Fig. 7: Storey Stiffness for ESA and RSA.

VI. CONCLUSIONS

1) Fundamental time period decreases when the effect of masonry infill wall and concrete shear wall is considered.
2) The RC frame Model 1(bare frame) having highest value of time period compared to model with shear wall and diagonal strut.
3) As the number of soft stories increases the fundamental time period also increase, therefore existence of soft story can make the structure very much flexible.
4) The time period obtained for Model 7 with shear wall (Box type shear wall) and equivalent diagonal strut has got least value as compared with bare frame model, hence it has high stiffness which is good for design purpose.
5) The storey drifts are found within the limit as specified by the code IS 1893(Part-1):2002.
6) Higher storey drift values are dangerous to the building in our study Model 3 has shown least drift by ESA, Model 8 by RSA and Model 9 by THA.
7) Considerable amount of reduction in storey displacement observed by introduction of any type of shear wall.
8) Displacement is found to be minimum for Model 7 in case of ESA, Model 8 for RSA and Model 9 for THA method. Considerable amount of storey displacement is reduced using any type of shear wall.
9) The soft story effect is less at intermediate location of the building because of increased stiffness. A service storey of lesser height can be safer for building at higher level.
10) In case of base shear, Model 2 with L type shear wall offers least in case of ESA and RSA, whereas Model 5 with I type shear wall in case of THA.
11) Coming to the stiffness point of view, Model 7 with Box type shear wall including equivalent diagonal strut has

found to be maximum which indicates it can withstand large amount of seismic forces

12) All models with different type of shear wall and models with shear wall with diagonal strut are giving good results compared to bare frame model. So it is recommended to use any type of shear wall depending on the site condition and the convenience of designer.
13) By making the bottom storey rigid as shown in Fig1 it has provided considerable stiffness and improved its resistance against seismic forces.
14) A secondary beam helps to reduce span of the large slab and keep check on slab depth. It avoids load concentration and helps in redistribution of bending moments from main beams.

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