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Performance Analysis of Braced Reinforced Concrete Building in Sloped Terrain

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Abstract: ***The Buildings on the hills differs from other buildings constructed in plain terrain. Each floor of building steps back towards the hill slope and at the same time buildings may have designed with setbacks configuration also. Buildings constructed in hilly areas are more vulnerable to seismic environment. This study is on generating a 3D analytical model of multi-storey buildings analyzed using structural analysis tool 'ETABS" to study the effect of varying height of columns due to sloping ground and the effect of bracing at different positions in a different configuration of the building during an earthquake. Seismic analysis has been done using the response spectrum method. The performance of the buildings on the sloping ground is highly vulnerable to earthquake on each storey level. Buildings resting on sloping ground with step back configuration are compared to buildings resting on the plain ground with same type load applied to each of the structure. From this study entire modelling the behaviour of normal ten storey building, step back, set-step back ten storey building is studied, it is found that the displacement and base shear value shows the performance of step back building and set-step back building. This is research also focus on effective placement of bracing with different types and in different positions. The displacement values show better performance by providing X bracing in the lateral direction.***

Keywords: Earthquake, Sloping Ground, Response Spectrum Method, Stability of Slopes, Bracing, ETABS.

I. INTRODUCTION

Buildings constructed in sloped terrain are more vulnerable to earthquake and other lateral forces. The main reason for the effect is the variation in the column height on the ground floor. There are around three types of configuration they are normal structure, step back structure and set- step back structure. These three configurations are used to be constructed in sloped terrain and hilly regions. Dynamic character of the structure changes because of variation in the column height. Due to the change in the column height the stiffness of the structure changes short column effect also occurs in that structure. Mostly hilly area comes seismic zone. While acting to lateral load the short column which may act to compression will be heavily damaged than that of the slender column. The dynamic characteristic of the building in hills and sloped terrain differs from the plain structure.Bracing which is used to resist lateral load is being provided in a different position and four different bracing are used to modelled and analyzed. The models are being generated as if in the zone IV and V. multi-storey structure of the same configuration and features and loading condition on lateral and longitudinal are modelled and analyzed . Due to the tremendous increase in the population in the hilly area, there are needs for constructing high rise structure in that area by considering the safety and security of the human being.

Variation of stiffness and mass in horizontal and vertical direction results in the Centre of stiffness and mass of the structure. The displacement and base shear value of the structure are compared for the results for three models with different bracing in different positions.

II. MODELING AND ANALYSIS

In the present study lateral load analysis as per the seismic code for the bare Frame, step back and set step back frame with four different types of bracing at six different orientation or position is carried out and an effort is made to study the effect of seismic loads on them and thus assess their seismic vulnerability by performing linear static and response spectrum. The analysis is carried out using ETABS. ETABS helps in modelling many models with different configuration by easy pick tools and modelling options and provides exact results by which Columns and beams are modelled. Slabs are modelled as rigid diaphragms. The beam and column joints are to be rigid. Different building components are modelled as described below Using Software, three distinct analyses are carried on G+10 storied building models on plain ground and on sloping ground, and loading pattern is as followed by the IS code provision and analysed by Response Spectrum Analysis method.

III. DESCRIPTION AND FEATURE

A. Description of the structure

The structure is placed in sloped terrain is modelled with three different configuration compared with bracing in different position with same loads and components. The modelled structure is used for analysis.

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Table-I: Describtion And Features Of Structure

Floor height	3.5 m
Number of Storey	10
No of bay in X direction	4
No of bay in Y direction	3
Spacing in X direction	3.7 m
Spacing in Y direction	3.6 m
Beam sizes	450×300 mm
Column sizes	600×450 mm
Slab thickness	200 mm
Thickness of wall	230
Live Load	4 kN/m^2
Dead Load	1 kN/m^2
Grade of concrete	M35
Grade of Steel	Fe500
Earthquake parameters	
Type of frame	OMRF
Response Reduction Factor	3
Importance Factor	1
Earthquake zone	IV
Wind zone	II

The Table-I Describe the feature dimension of the structure which is being modelled and analysed using ETABS.

B. Plan and elevation of structure

The Fig. 1.represents the plan of the structure. It contains 4 bays on the lateral direction and 3 bay in the longitudinal direction with total storey height of 32 m

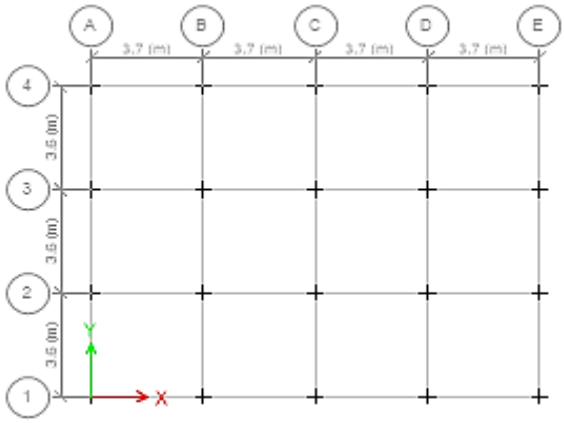

Fig.1 Plan Of Building

The Fig. 2. given below describe the model elevation view of the normal ten storey building created, assigned with load in ETABS this structure is used as reference model for providing bracing.

The Fig. 3 describe the step back structure which is used as a model for applying bracing and for analysing of step back configurated structure.

The Fig. 4 describe the set-step back structure which is used as a model for applying bracing and for analysing of step back configurated structure.

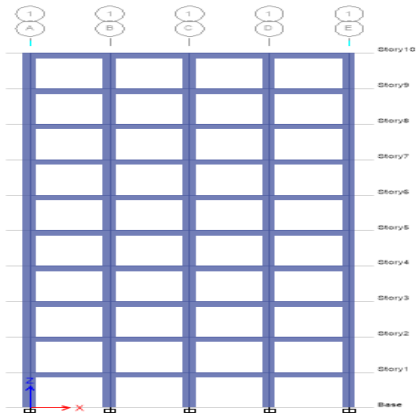

Fig. 2. Normal Buildings Without Bracing

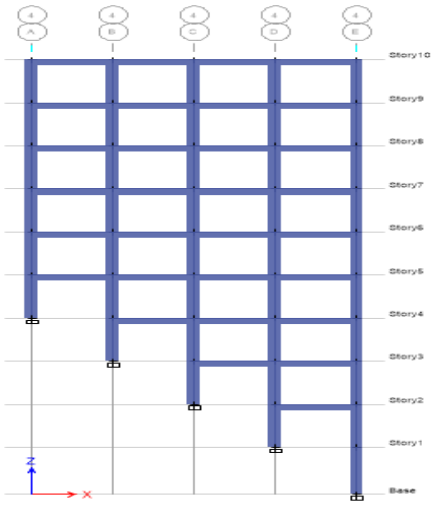

Fig. 3. Step Back Buildings Without Bracing

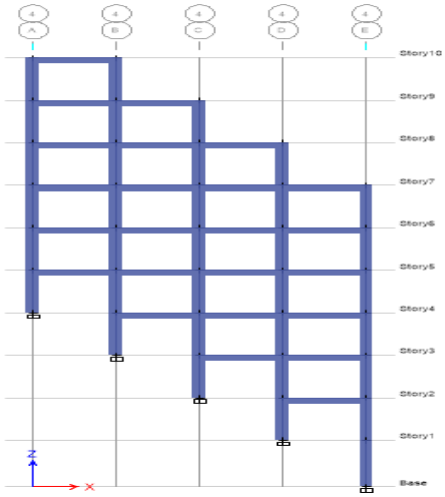

Fig. 4. Set- Step Back Buildings Without Bracing

C. Postion of bracing placed in the structure

The figure given below explaines the arrangement of bracing placed in the structure with different configuration. Arround four different types of bracing named as X, V, Inverted –V and Eccentric bracing are placed in these six different configuration.

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The Fig. 5 denotes the plan of building where bracing are placed in the centre of the structure

Fig. 5. Bracing In Centre of the Structure

The Fig. 6. denotes the plan of building where bracing are placed in the core of the structure

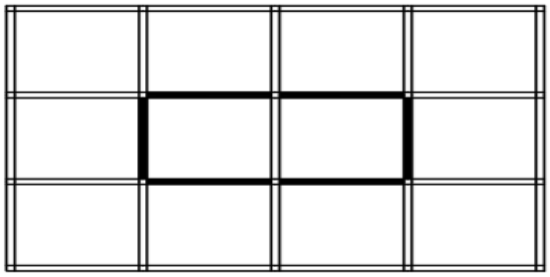

Fig. 6. Bracing In Core of the Structure

The Fig. 7 denotes the plan of building where bracing are placed in the edges of the structure

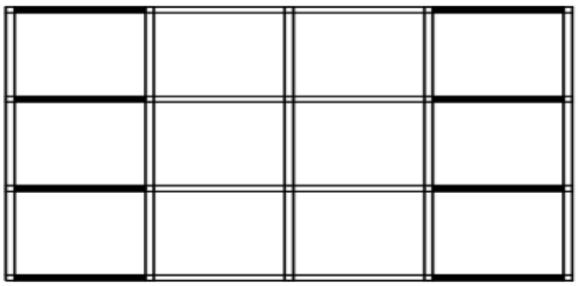

Fig. 7. Bracing In Edges of the Structure

The fig. 8 denotes the plan of building where bracing are placed in the lateral direction of the structure

Fig. 8. Bracing In Lateral Direction of the Structure

The Fig. 9 denotes the plan of building where bracing are placed in the outer wall of the structure

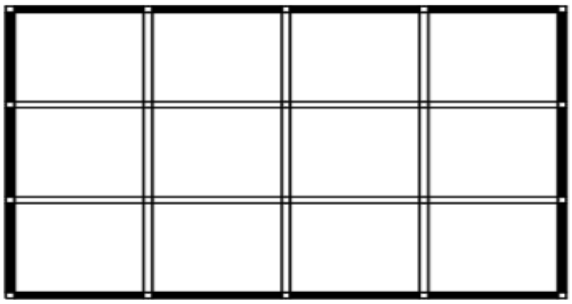

Fig. 9. Bracing In Centre of the Structure

The Fig. 10 denotes the plan of building where bracing are placed in a pattern

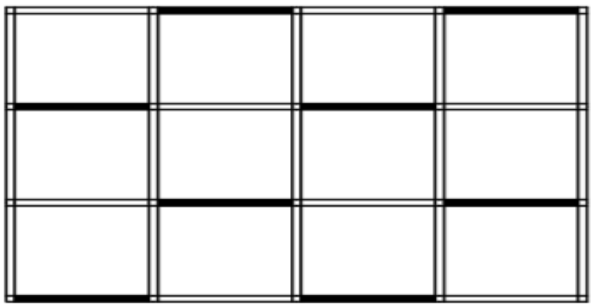

Fig. 10. Bracing In pattern of the Structure

IV. RESULT AND DISCUSSION

The present study involves the analysis of multistoried building (G+10) of three different configuration and four different types of bracing placed in six different position in sloped ground by using ETABS. The reactions at the base of the building and top storey displacement were taken for the analysis of slope. The following are the results obtained from the analysis.

A. Displacement for plain building

The results shows the displacement graph for three configured building which are bare frame without any difference in column height ,step back building and set –step back building. The graph results shows that the plain structure without any configuration shows large value of displacement in it. The set-step back and step back shows better performance in displacement and base shear.

The Fig. 11. Gives the graph comparison of displacement for Normal. Step back and set-step back building without bracing

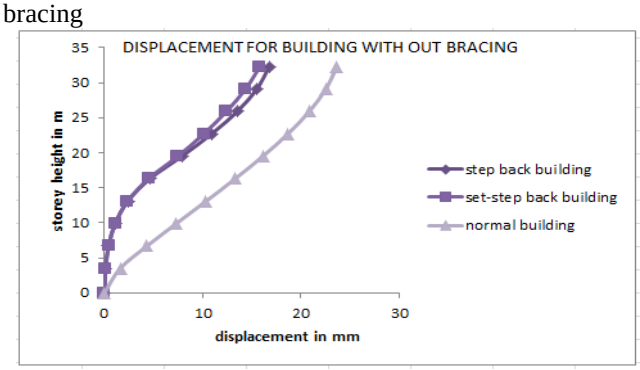

Fig. 11. Displacement For Buildings Without Bracing

B. Displacement for plain building with bracing

The graph given below gives the result for displacement of structure placed in plain terrain which is affected by the Same force acting in sloped terrain. The structure is Equipped with different types of bracing in different position.

The fig. 12. Gives the graph comparison of displacement for building with V- bracing

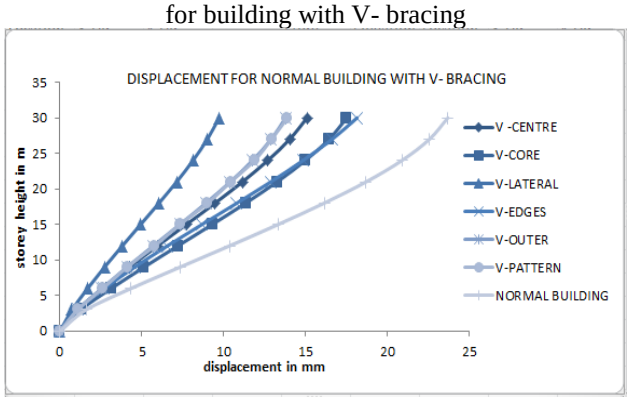

Fig. 12. Displacement For Building With – V Bracing

The Fig. 13. Gives the graph comparison of displacement for building with X- bracing

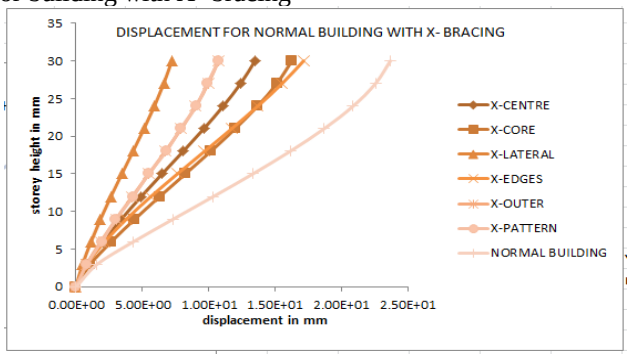

Fig. 13. Displacement For Building With x-Bracing

The Fig. 14. Gives the graph comparison of displacement for building with inverted v- bracing.

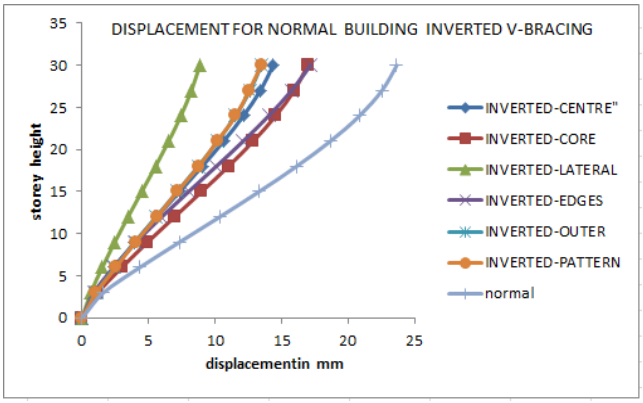

Fig. 14. Displacement For Building With inverted v-Bracing

The Fig. 15. Gives the graph comparison of displacement for building with Eccentric- bracing

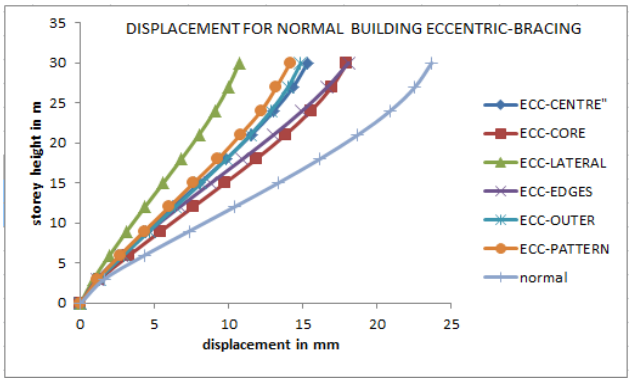

Fig. 15. Displacement For Building Without Eccentric Bracing

With the comparition of the four graphs for braced structure placed in plain terrain it shows that the bracing gives better results than structures without bracing similarly x-bracing adopted in lateral direction and bracing placed in lateral direction are effective than others.

C. Displacement for plain Step back building with bracing

The results comparison presented below explains that in x,v and inverted v- bracing placed in lateral direction shows better performance. In eccentric-bracing the bracing placed on the outer surface of the structure shows good results.

The Fig. 16. Gives the graph comparison of displacement for step back building with v- bracing

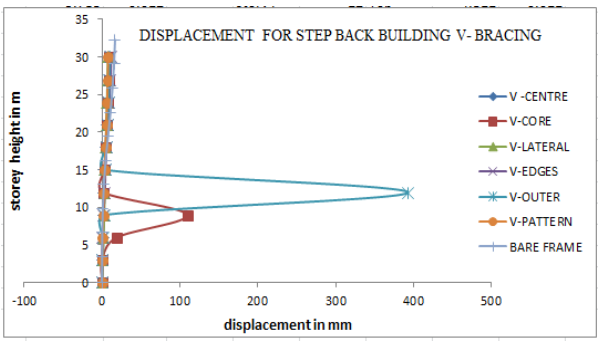

Fig. 16. Displacement For step back Building With v-Bracing

The Fig. 17. Gives the graph comparison of displacement for step back building with v- bracing.

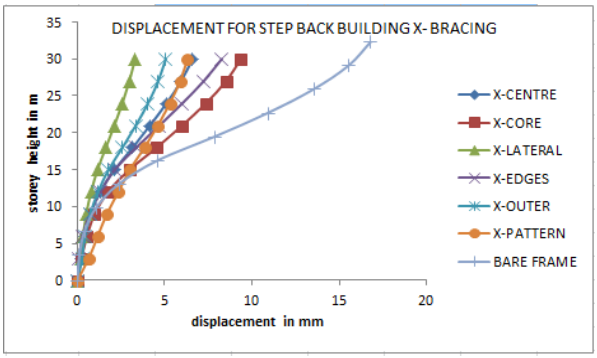

Fig. 17. Displacement For step back Building With x-Bracing

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The fig. 18. Gives the graph comparison of displacement for building with inverted v- bracing

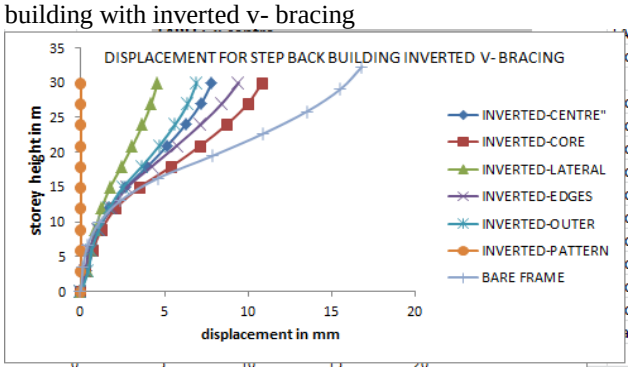

Fig. 18. Displacement For step back Building With inverted v- Bracing

The Fig. 19. Gives the graph comparison of displacement for step back building with eccentric- bracing

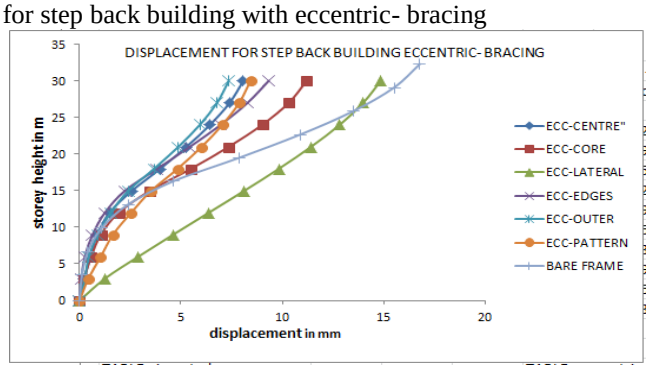

Fig. 19. Displacement For step back Building With eccentric Bracing

D. Displacement for plain Set-Step back building with bracing

The results comparison presented below explains that in x,v and inverted v- bracing placed in lateral direction shows better performance. Bracing placed in the edges give poor performs and create worse situation for the structure

The Fig. 20. Gives the graph comparison of displacement for building with v- bracing

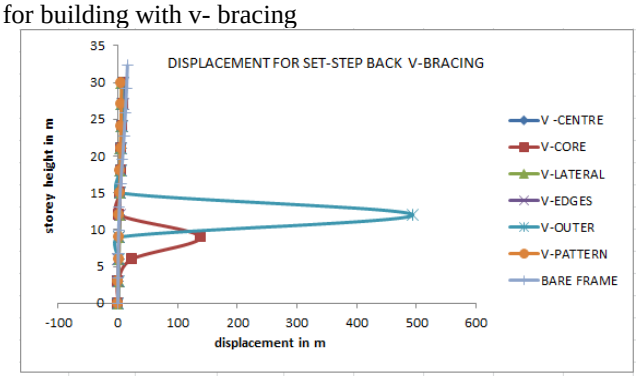

Fig. 20. Displacement For set-step back Building With V-Bracing

The Fig. 21. Gives the graph comparison of displacement for set-step back building with x- bracing

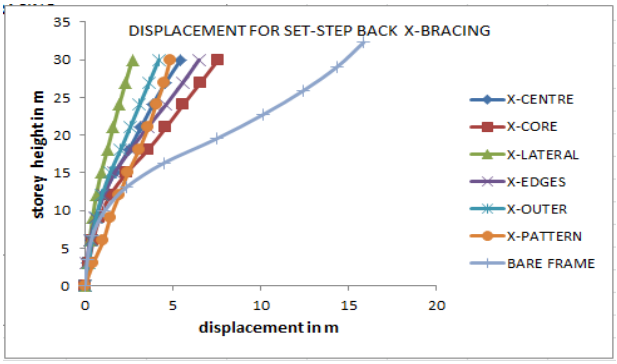

Fig. 21. Displacement For set-stepBuilding With x-Bracing

The Fig. 22. Gives the graph comparison of displacement for building with inverted v-bracing

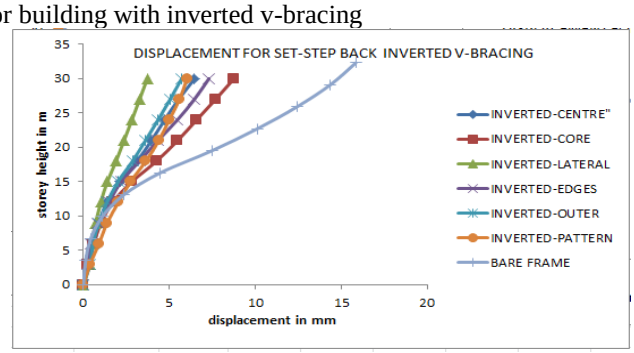

Fig. 22. Displacement For set-step back Building With Inveted V-Bracing

The Fig. 23. Gives the graph comparison of displacement for set-step back building with eccentric bracing

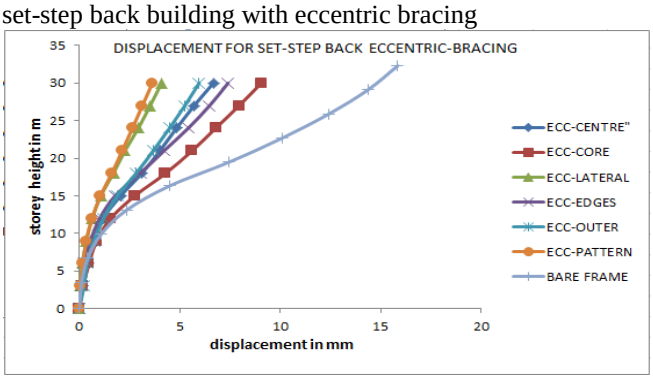

Fig. 23. Displacement For set-step back Building With eccentric Bracing

The graphical results of set-step back building shows the same results like plain building and step-back building they shows better response when placing bracing in lateral direction and even more effective when appling x-bracing.

V. CONCLUSION

The performance of step back building and set step back building proves more effective in seismic zone than normal configuration building. Bracing placed in lateral direction resist more effect to the building than the other position where the bracing are placed. Bracing which is configured like X prove more resistance towards lateral loads and effect to the structure than the other bracing. Building with bracing gradually reduces the top storey displacement and base shear considerably when compared to structure without bracing.

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