Analytical Study on Storey Displacement and Drift Ratio of H Shape and Step Back Set Back Multistoried Buildings on Sloping Ground

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Abstract **- Framed structures constructed on hill slopes shows different structural behavior than that on the plain ground. Since these buildings are unsymmetrical in nature, hence shows unequal distribution due to varying column height and length. In the present study, the multi storied building is considered for the study. The seismic analysis of different structural configuration such as step back set back structure and H shape structure is considered. Based on different structural configurations, the responses have been studied and analyzed by using latest application software. The study is carried by using time history method. The past three severe earthquakes occurred in India are studied. It is observed that the Step back set back structure performs better as compared to H shape structure for without shear wall. It is also observed that the H shape structure with internal as well as external shear wall performed better as compared to Step back set back structure.**

Index Terms **- Multistorey building, Hill Slope angle, Step back set back structure, H shape structure, Shear wall, Time history analysis.**

I.INTRODUCTION

Our country has a track record of catastrophic earthquakes, at various regions, which left behind loss of many lives and heavy destruction to property and economy. Bhuj earthquake on January 26, 2001, was one of such catastrophic earthquakes in which several buildings in Ahmadabad, Kutch, and Bhuj were collapsed, some were severely damaged and subsequently demolished and with more than 35000 people were dead. The 1999 Chamoli earthquake occurred on 29 March in the Chamoli district in the Indian state of Uttar Pradesh (now in Uttarakhand). Approximately 103 people died in the earthquake. The 20 October 1991 Uttarkashi earthquake killed over a thousand people and caused extensive damage to property in the Garhwal Himalaya region.

The most common bracing methods for resisting lateral forces in buildings include moment frames, shear walls, and braced frames. Step back set back building are found to be more suitable on sloping ground [(2)]. Step back Set back building frames are found to be more suitable on sloping ground as comparison with Step back building frames [(5)]. Step back set back configuration performed better than step back configuration [(7)]. It is found that limited study has been carried out on the structures on sloping grounds. Also, studies related to multi storied structure on sloping ground with shear wall at different location for seismic analysis are rarely seen. Therefore, more study on structure on sloping ground with shear wall at different location is necessary for understanding behaviour of such structure.

II. OBJECTIVE OF THE STUDY

1) To perform the seismic analysis of different structural configuration such as step back set back structure and H shape structure & to study the behaviour of multi storied building on sloping ground with shear wall at different locations for improved performance of structure.
2) To investigate the different structural parameters such as displacement, drift ratio, storey shear, base shear, storey stiffness.
3) To arrive at suitable structural configuration for multi storey building resting on sloping ground.

III. DESCRIPTION OF BUILDINGS

A study of seismic behaviour of hill building on sloping ground is conducted considering different configurations as shown in figure 1,2,3,4,5. The slope of the ground is considered 28.07˚ which is neither too steep nor too flat. Plan dimension of the block is 6.0 m x 5.0 m. and a story height of 3.2 m. The size of R.C.C beams and column shows in below table no.1.

Table 1 Size of R.C.C Beams and Column used in buildings

Building Height	Column Size mm x mm	Beam Size mm x mm
27.2 m	600 X 600	300 X 600

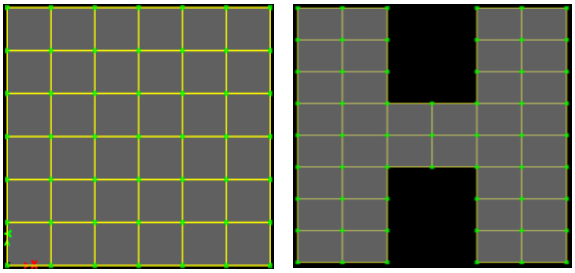


Figure 2 Plan of H- Shape Structure with shear wall 1(left) and shear wall 2(right)

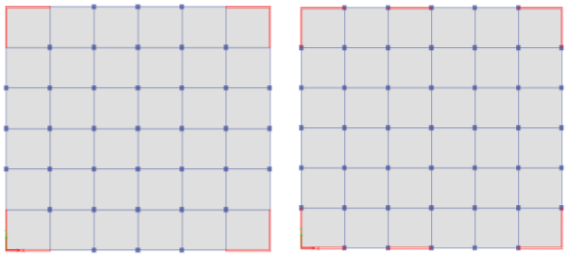


Figure 3 Plan of Step Back Set Back Structure with shear wall 1(left) and shear wall 2(rig

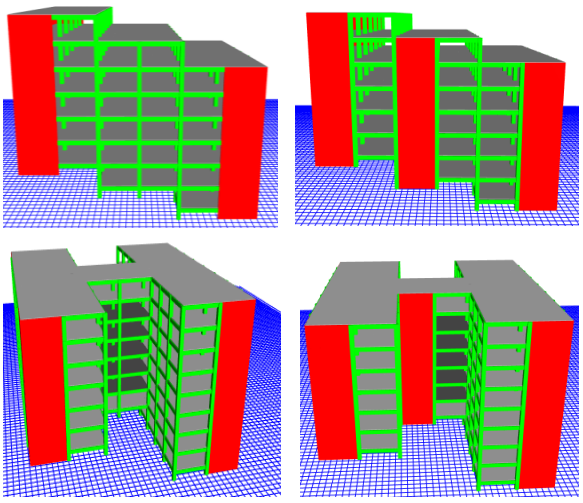


Figure 4 Elevation of H Shape Structure & Step Back Set Back Structure

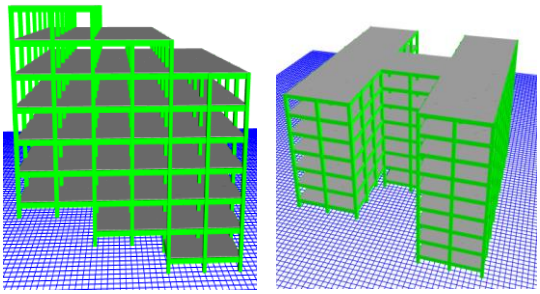


Figure 5 Elevation of H Shape Structure & Step Back Set Back Structure

IV. METHODOLOGY

In the present study, the seismic analysis of different structural configurations such as Step back set back structure and H shape structure is considered. The multi storied building is considered for the study. Analysis is done by using ETABs software. Time History Analysis is used to carry out the analysis as per IS 1893:2016. From this analysis the structural parameters such as displacement, drift ratio has been studied and presented accordingly. For carrying out linear time history analysis on the structures Bhuj, Uttarkashi, and Chamoli earthquake data is used. The shear wall 1 structure in H shape as well as step back setback structure as shown in fig 2,3,4 has walls on the exterior corners of the structures, whereas in configuration of shear wall 2 additional shear walls have been provided at the internal sides as shown in the figures.

Seismic analysis of different configurations of buildings is carried out by the Time History Analysis. In table 2 showing the parameters of building.

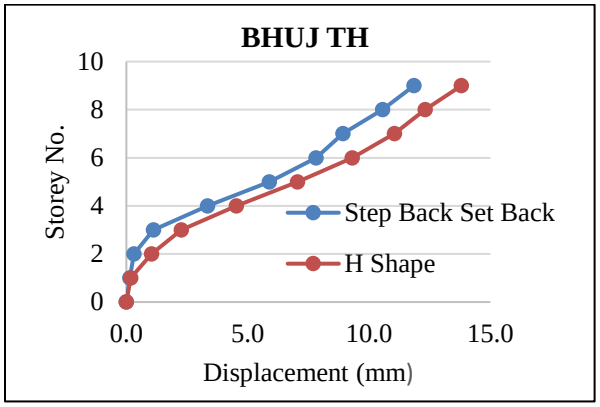
Table 2 Parameters used

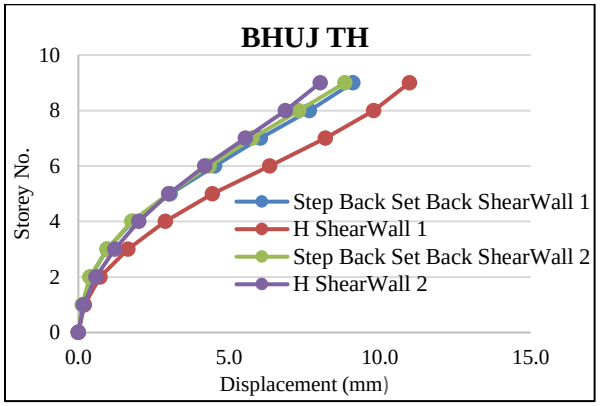
Parameters	Values
Soil type	Hard
Importance Factor	1.2
Zone Factor	IV
Damping Ratio	0.05
Reduction Factor	5
Live Load	3 kN/m²
Floor Finish	1.5 kN/m²
Wall Load	13.00 kN/m

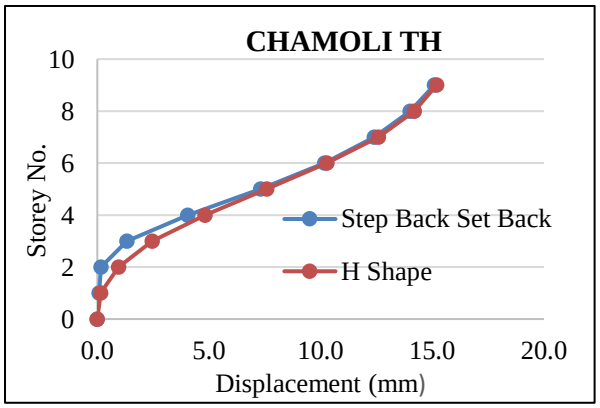
V. RESULTS AND DISCUSSION

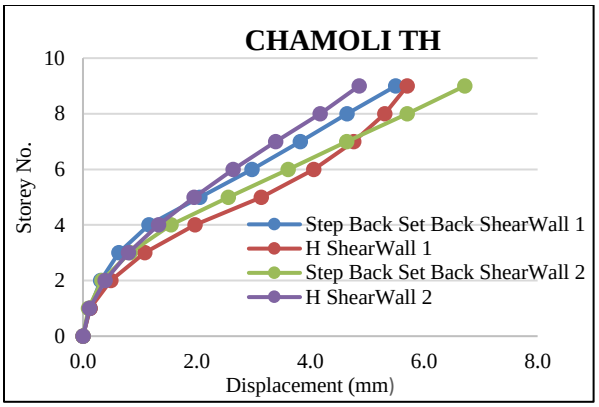
The time history analysis was carried out on the structures for 27.20 m. The time histories used were Bhuj, Uttarkashi, and Chamoli as given in the previous chapter. The time histories were matched with response spectra as a function of Time domain. The results for displacement were as shown in fig below.

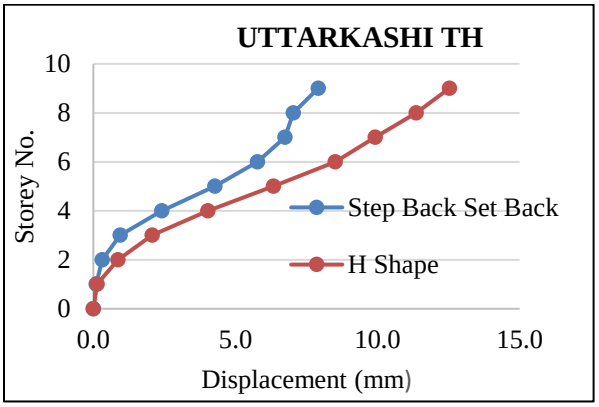
a. DISPLACEMENT:











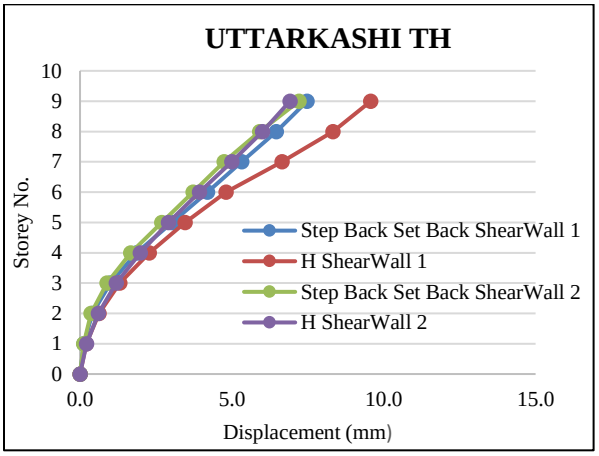


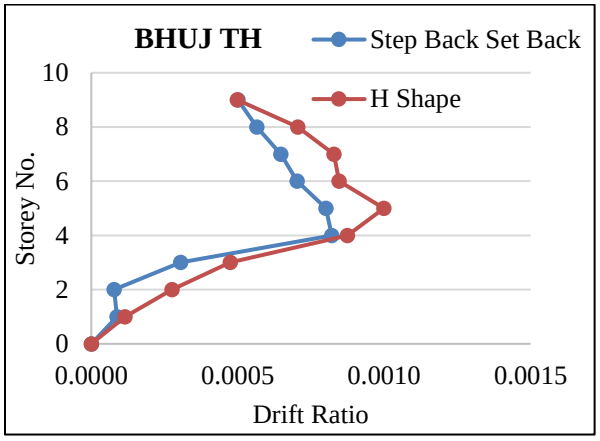
Figure 6 Displacements under Time History Analysis

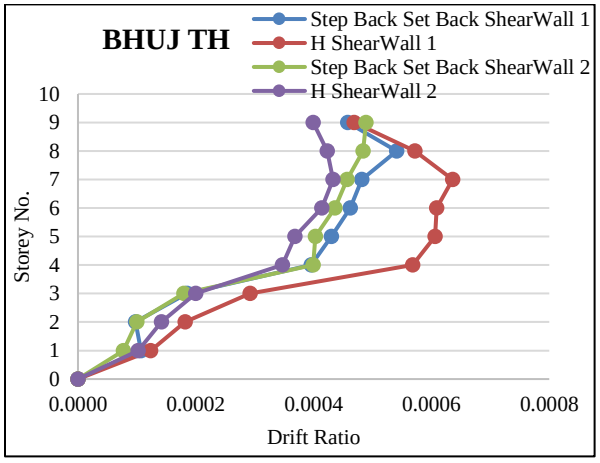
Story displacement is the lateral displacement of the story relative to the base. It was seen from above fig.no.6 the displacement under Bhuj and Chamoli earthquake were somewhat similar for the H shape structure and Step back set back structure. The displacements observed for Chamoli Time History were maximum as it was a very short span earthquake with highest peak acceleration. The displacements observed in Bhuj were higher than that in the Uttarkashi. As the time histories are along the

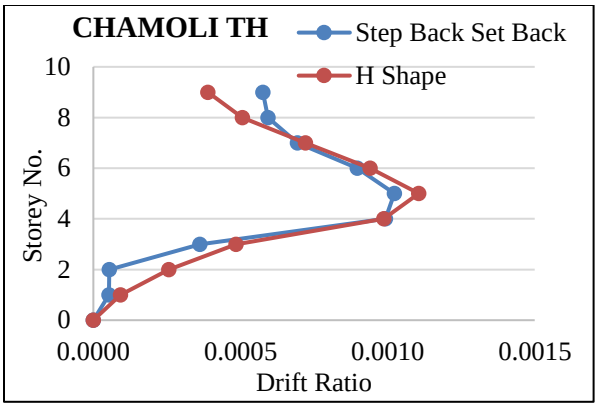
direction of the slope, the configuration of H shape & Step back set back with shear walls at external and internal location in that direction performed better, in terms of displacement than the configuration having shear walls at the external faces only.

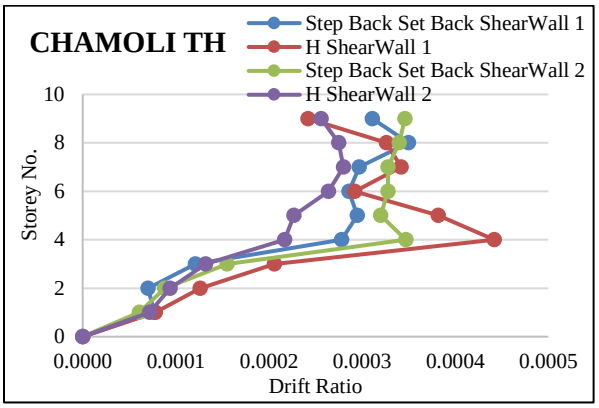
b. DRIFT RATIO:

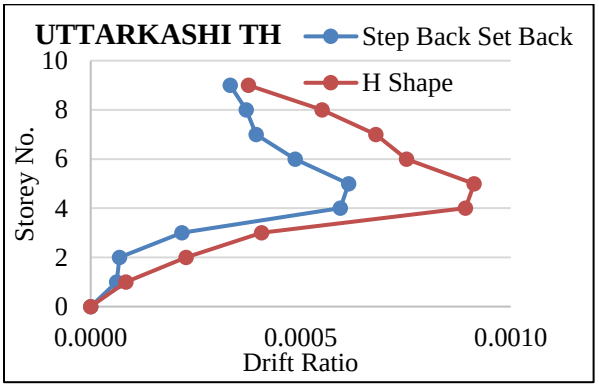
The drift ratio is defined as the ratio of maximum lateral drift to total height of the specimen. The results of H-Shape structure & Step back set back structure are similar in nature, it was seen that in fig.no.7 the drift ratio was within the limits of permissible limit (Not exceed 0.004 times the storey height). The H shape structure shows maximum drift ratio as compared to Set back step back structure. From all three-time history it is observed that the H shape structure shows maximum drift ratio as compared to Set back step back structure. In terms of drift the H shape building with internal as well as external shear wall performed efficient than the rest of structures for all time histories.











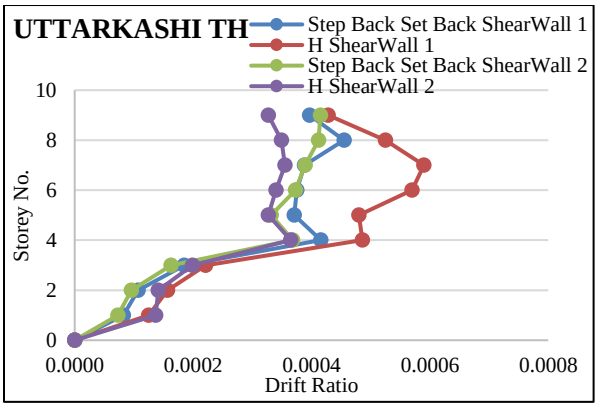


Figure 7 Drift ratio under Time History Analysis

The Table 3,4,5 shows the summarized results for H-Shape structure and Step back set back structure under the response spectrum analysis (RSA) and time history analysis (THA).

Table 3 Summary for Time History Analysis of 27.2 m Ht of Buildings without Shear Wall

Types of configurations	RSA Displace. (mm)	RSA Drift ratio (Storey Drift/Storey Ht)	Bhuj THA	
			Max Storey Displace. (mm)	Max Drift Ratio (Storey Drift/Storey Ht)
H Shape Structure on slope	19.151	0.00136	13.804	0.00099
Step back set back structure on slope	14.004	0.00090	11.853	0.00082
			Chamoli THA	
H Shape Structure on slope	19.151	0.00136	15.194	0.00110
Step back set back structure on slope	14.004	0.00090	15.094	0.00102
			Uttarkashi THA	
H Shape Structure on slope	19.151	0.00136	12.527	0.00091
Step back set back structure on slope	14.004	0.00090	7.912	0.00061

Table 4 Summary for Time History Analysis of 27.2 m Ht of Buildings with Shear Wall (1)

Types of configurations	RSA Displace. (mm)	RSA Drift ratio (Storey Drift/Storey Ht)	Bhuj THA	
			Max Story Displace. (mm)	Max Drift Ratio (Storey Drift/Storey Ht)
H Shape Structure on slope	9.416	0.00052	10.979	0.00063
Step back set back structure on slope	8.455	0.00055	9.098	0.00054
			Chamoli THA	
H Shape Structure on slope	9.416	0.00052	5.707	0.00044
Step back set back structure on slope	8.455	0.00055	5.505	0.00035
			Uttarkashi THA	
H Shape Structure on slope	9.416	0.00052	9.574	0.00059
Step back set back structure on slope	8.455	0.00055	7.477	0.00045

Table 5 Summary for Time History Analysis of 27.2 m Ht of Buildings with Shear Wall (2)

Types of configurations	RSA Displace. (mm)	RSA Drift ratio (Storey Drift/Storey Ht)	Bhuj THA	
			Max Story Displace. (mm)	Max Drift Ratio (Storey Drift/Storey Ht)
H Shape Structure on slope	7.745	0.00039	8.023	0.00043
Step back set back structure on slope	7.527	0.00040	8.84	0.00048
			Chamoli THA	
H Shape Structure on slope	7.745	0.00039	4.858	0.00028
Step back set back structure on slope	7.527	0.00040	6.718	0.00034
			Uttarkashi THA	
H Shape Structure on slope	7.745	0.00039	6.911	0.00036
Step back set back structure on slope	7.527	0.00040	7.21	0.00041

VI. CONCLUSION

1. From all three-time history it is observed that the H Shape structure without shear wall experiences more drift ratio as compared to step back set back structure.
2. The Step back set back structure without shear wall shows less displacement as compared to H Shape structure without shear walls.
3. The H Shape structure when considered with external as well as internal shear walls shows less drift ratio as compared with externally located shear walls.
4. The H Shape structure considered with external as well as internal shear walls shows less storey displacement as compared to step back set back structure considered with external as well as internal shear walls.
5. The configuration of H shape & Step back set back with shear walls at external and internal

location in that direction performed better as compared to shear wall at external location.

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