Analytical Study on Storey Shear and Base Shear 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.**

Keyword: **Multistorey building, Hill Slope angle, Step back set back structure, H shape structure, Shear wall, Time history analysis.**

I. INTRODUCTION

RC framed structures constructed on hill slopes show different structural behaviour than on the plain ground. 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 storey shear, base shear, story 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

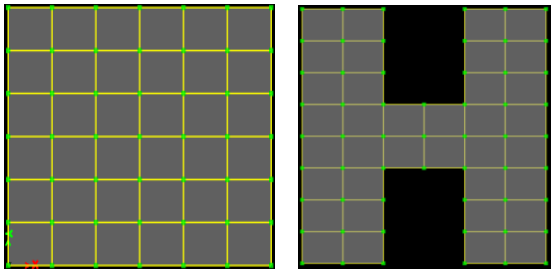


Figure 2 Plan of H- Shape Structure with shear wall 1(left) and shear wall 2(right)

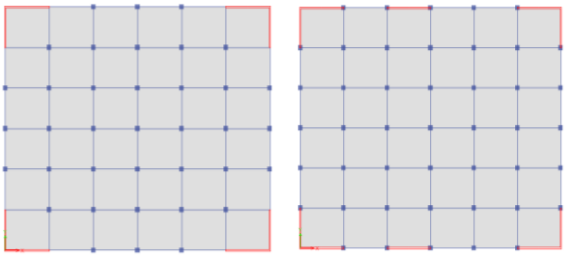


Figure 3 Plan of Step Back Set Back Structure with shear wall 1(left) and shear wall 2(rig

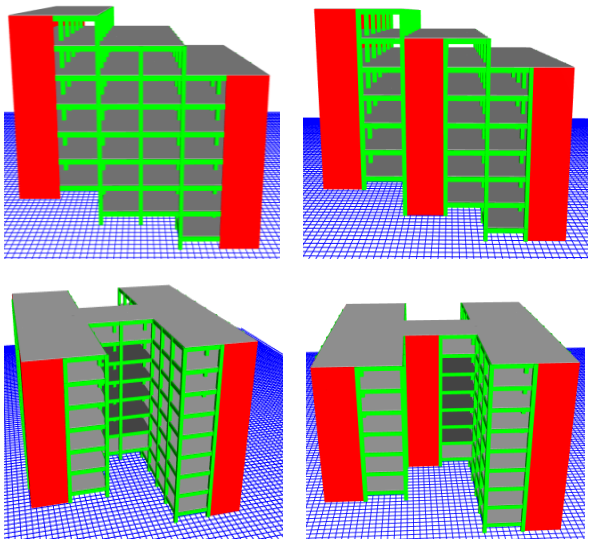


Figure 4 Elevation of H Shape Structure & Step Back Set Back Structure

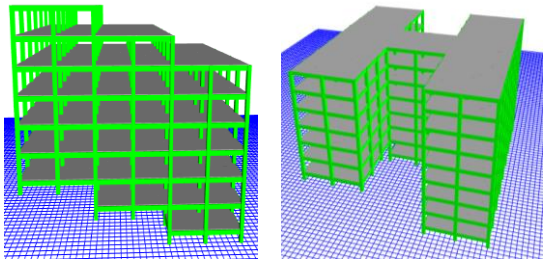


Figure 5 Elevation of H Shape Structure & Step Back Set Back Structure

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 storey shear, base shear 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

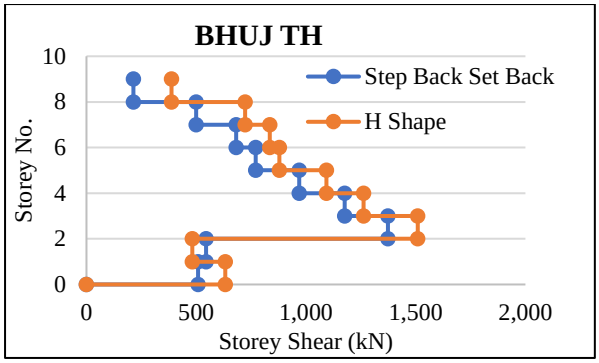
Parameters	Values
Soil type	Hard
Importance Factor	1.2
Zone Factor	IV
Damping Ratio	0.05
Reduction Factor	5
Live Load	3 kN/m²
Floor Finish	1.5 kN/m²
Wall Load	13.00 kN/m

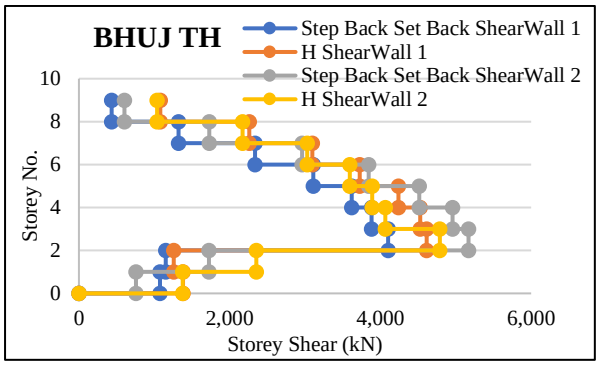
V. RESULTS AND DISCUSSION

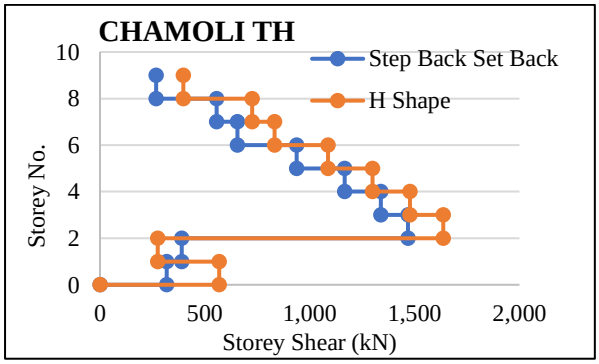
The time history analysis was carried out on the structures for 27.20 m. The time histories used were Bhuj, Uttarkashi, and Chamoli as given in the previous chapter. The time histories were matched with response spectrum as a function of Time domain.

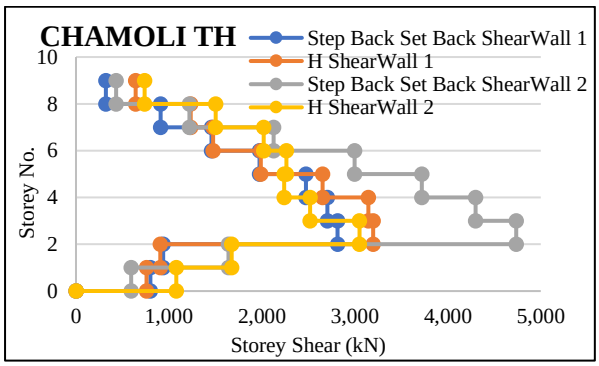
a. STOREY SHEAR:

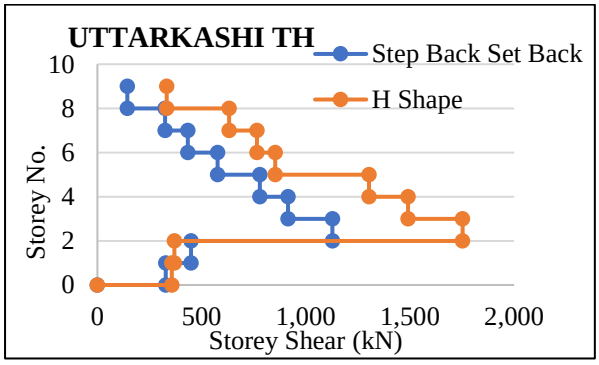
It is the lateral force acting on a storey due to the forces such as seismic and wind force. Buildings having lesser stiffness attract lesser storey shear and vice versa. It can be seen from figure 6 a sudden rise in shear can be seen at the topmost column on the slope, where most of the seismic forces are attracted. The story shear observed higher under Uttarkashi time history. Maximum storey shear was found on the configuration of step back set back structure with shear wall. Thus, shear walls at this location were found to be efficient in H shape as well as step back set back buildings.











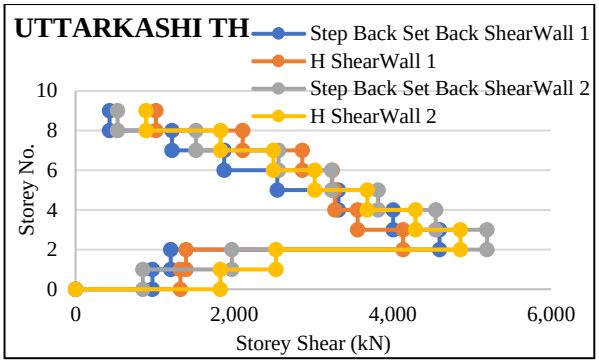


Figure 6 Storey Shear under Time History Analysis

b. Base Shear:

Base shear is the force that is generated at the base of the structure especially due to seismic forces. It can be seen from the figure 7(a) shows that the step back setback structure is less base shear as comparison with H shape structure for without shear wall. The 7(b) shows that the H shape structure is less base shear as compared to Step back set back structure for with shear wall.

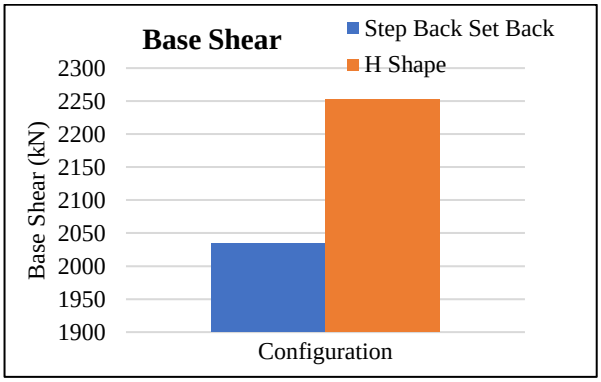


Figure 7(a) Base Shears without Shear Wall

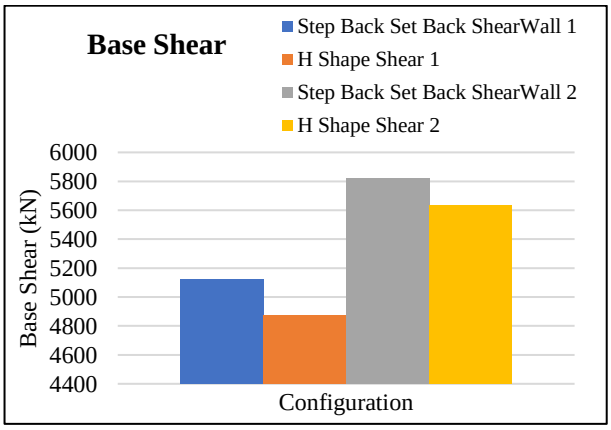


Figure 7 (b) Base Shears with Shear Wall

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 Storey Shear (kN)	RSA Storey stiffness (kN/m)	Bhuj THA	Base Shear (kN)
			Max Storey Shear (kN)	
H Shape Structure on slope	1622	3056709	1509.4	2253
Step back set back structure on slope	1287	3532252	1373.6	2034
			Chamoli THA	
H Shape Structure on slope	1622	3056709	1636.6	2253
Step back set back structure on slope	1287	3532252	1468.4	2034
			Uttarkashi THA	
H Shape Structure on slope	1622	3056709	1752.6	2253
Step back set back structure on slope	1287	3532252	1127.6	2034

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

Types of configurations	RSA Storey Shear (kN)	RSA Storey stiffness (kN/m)	Bhuj THA	Base Shear (kN)
			Max Storey Shear (kN)	
H Shape Structure on slope	4644	9195427	4788.4	4873
Step back set back structure on slope	4079	8715908	4102.3	5123
			Chamoli THA	
H Shape Structure on slope	4644	9195427	3196.6	4873
Step back set back structure on slope	4079	8715908	2813.3	5123
			Uttarkashi THA	
H Shape Structure on slope	4644	9195427	4134.9	4873
Step back set back structure on slope	4079	8715908	5193.8	5123

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

Types of configurations	RSA Storey Shear (kN)	RSA Storey stiffness (kN/m)	Bhuj THA	Base Shear (kN)
			Max Storey Shear (kN)	
H Shape Structure on slope	4644	9955351	4788.4	5632
Step back set back structure on slope	4808	8671520	5168.9	5820
			Chamoli THA	
H Shape Structure on slope	4644	9955351	4858.4	5632
Step back set back structure on slope	4808	8671520	5193.8	5820
			Uttarkashi THA	
H Shape Structure on slope	4644	9955351	4858.4	5632
Step back set back structure on slope	4808	8671520	5193.8	5820

VI. CONCLUSION

1. From all three-time history it is observed that the H Shape structure without shear wall experiences more storey shear as compared to step back set back structure.
2. The Step back set back structure without shear wall shows less base shear 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 storey shear as compared with externally located shear walls.
4. The H Shape structure considered with external as well as internal shear walls shows less storey base shear 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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