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Seismic Analysis of Buildings Resting on Sloping Ground and Considering Bracing System

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Abstract:- **Most of the constructions in hilly regions are constrained by local topography which results in the adoption of either a step back or step back &set back configuration. Due to this the structure is irregular by virtue of varying column heights leading to torsion and increased shear during seismic ground motion. The dynamic analysis is carried out using response spectrum method to the step back and step back & set back building frames. The dynamic response i.e. fundamental time period, storey displacement & drift, and base shear action induced in columns have been studied for buildings of different heights. These results show that the performance of step back & set back building frames are more suitable in comparison with step back building frames. But after considering bracings to the step back building frames, a better performance can be observed when compared with step back & set back building frames.**

Keywords – Hill slope angle, number of bays, Static analysis, response spectrum analysis, step back frames, step back & set back frames, step back with bracings.

1. INTRODUCTION:

The economic growth & rapid urbanization in hilly region has accelerated the real estate development. Due to this, population density in the hilly region has increased enormously. The adobe burnt brick, stone masonry & dressed stone masonry buildings are generally made over level ground in hilly regions. Since level land in hilly regions is very limited, there is a pressing demand to construct buildings on hill slope. Hence construction of multi-storey R.C .Frame buildings on hill slope is the only feasible choice to accommodate increasing demand of residential & commercial activities.

2. SIGNIFICANCE OF STUDY:

It is observed from the past earthquakes, buildings in hilly regions have experienced high degree of demand leading to collapse though they have been designed for safety of the occupants against natural hazards. Hence, while adopting practice of multi -storey buildings in these hilly & seismically active areas, utmost care should be taken, making these buildings earthquake resistant. In these areas buildings with step back configuration frames may some times give worst results so bracing system is used for the these buildings and comparing the results with other configuration.

3. SCOPE OF STUDY:

Three dimensional space frame analysis is carried out for two different configurations of buildings ranging from 8 to 10 storey's resting on sloping and plain ground under the action of seismic load by using Etabs software. And also considering bracing system
to step back building configuration. Dynamic response of these buildings, in terms of base shear, fundamental time period and displacement is presented, and compared within the considered configuration as well as with other configurations. At the end, a suitable configuration of building to be used in hilly area is suggested.

The effects of the supporting foundation medium on the motion of structure gives soil structure interaction, but this may not be considered in the seismic analysis for structures supported on rock or rock like naterials.

4. BUILDING CONFIGURATION:

In the present study, two groups of building (i.e. configurations) are considered, and these two are resting on sloping ground. The slope of ground is 27 degree with horizontal, which is neither too steep or nor too flat. The height and length of building in a particular pattern are in multiple of blocks (in vertical and horizontal direction), the size of block is being maintained at 7 m x 5 m x 3.5 m. The depth of footing below ground level is taken as 1.75 m where, the hard stratum is available. And two bays are considered.

The buildings shown in figure 4.1, having step back configuration are labeled as STEP 8 to STEP 10 for 8 to 10 storey. Step back -Set back configuration of buildings is shown in figure 4.2, are designated as STEP 8 to STEP 10, according to height of building. .The building with equal number of storey's/bays have same floor area in two configurations.

Sr. N	Types of Frames	No. of Store	Column Size (mm)	Beam Size (m
1	Step back frames	STEP 8	300 x	230 x 500
		STEP 9	400 x	
		STEP 10	400 x 8	
2	Step back & set back frames	STEP SET 8	300 x 6	230 x 500
		STEP SET 9	400 x 8	
		STEP SET 10	400 x 8 0	
3	Bracings	STEP 8,9,10		230x300

In the present study, three groups of building (i.e. configurations) are considered, out of which two are resting on sloping ground and third one is on plain ground. The first two are step back buildings and step back-setback buildings; and third is the set back building. The slope of ground is 27 degree with horizontal, which is neither too steep or nor too flat. The height and length of building in a particular pattern are in multiple of blocks (in vertical and horizontal direction), the size of block is being maintained at 7 m x 5 m x 3.5 m. The depth of footing below ground level is taken as 1.75 m where, the hard stratum is available.

Geometrical properties of members for different configurations of building:

4.1 LOADINGS:

Live load	4 kN/m²
Floor finish	1.5 kN/m²
Wall weight	13.8 kN/m
	6.9 kN/m on roof
Seismic loading:	IS 1893
Zone factor	0.36 (zone V)
Soil type	I
Importance factor	1.5
Response reduction, R	5
Ecc. Ratio	0.05

Seismic analysis of different configurations of buildings is carried out by Response Spectrum as per IS 1893 (Part I): 2002. The buildings located in Zone V (0.36) with Importance Factor as 1.5. Damping is 5% and Response Reduction Factor considered is 5.0 for special RC moment resisting frame.

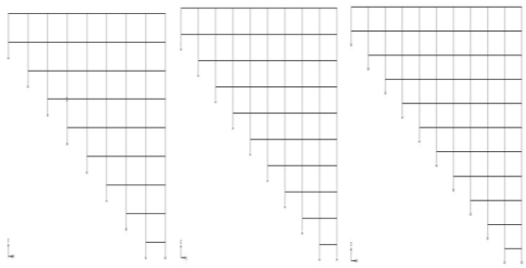


Fig: 1 Step back frames of 8 storey, 9 storey and 10 storey buildings

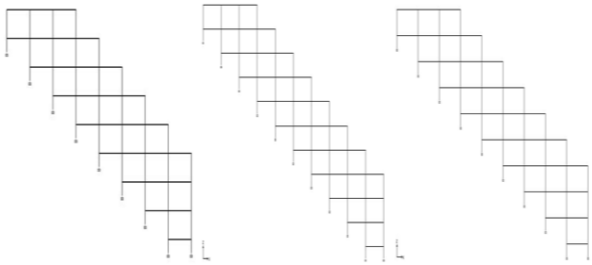


Fig: 2 Step back & set back frames of 8 storey, 9 storey and 10 storey buildings

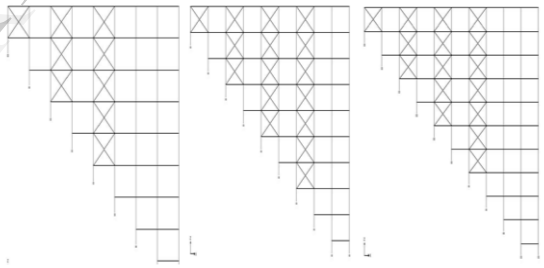


Fig: 3 Step back frames of 8 storey, 9 storey and 10 storey buildings with bracings:

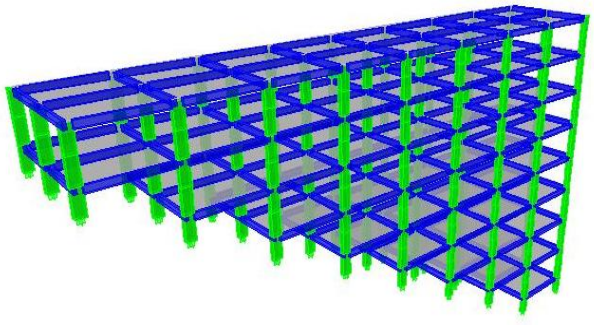


Fig: 4 Shows typical 3D view of Step back building frame.

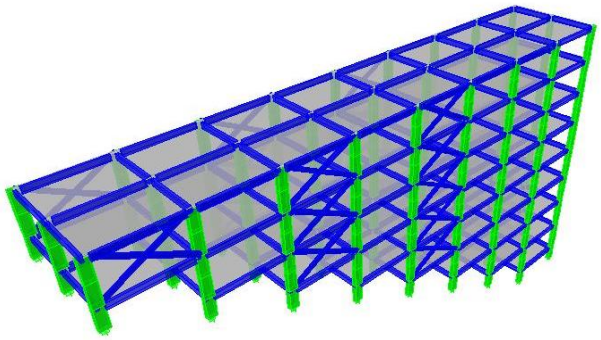


Fig: 5 Shows a typical 3 D view of Step back building frame with bracings.

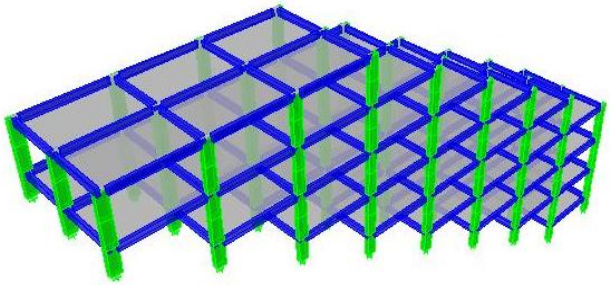


Fig:6 Shows a typical 3D view of Step &set back building frame.

PARAMETRIC STUDY:

A study of seismic behavior of a hill buildings resting on level ground and on sloping ground is done considering different configurations. These buildings are in the range of 8 to 10 storey with maximum height of buildings restricted to 35 m. The location of these building is in Seismic zone V. Bay width of frame is 7.0 m x 5.0 m and in general story height considered as 3.5 m. The depth of footing below ground level is considered about 1.75 m below ground surface.

5. RESULTS AND DISCUSSION:

Results are divided in to two parts, Both types of building frames such as step back and step back set back frames are compared and also step back with bracings and step back & set back frames are also compared under seismic loading using response spectrum method. The results obtained are expressed in terms of base shear, time period & top storey displacement.

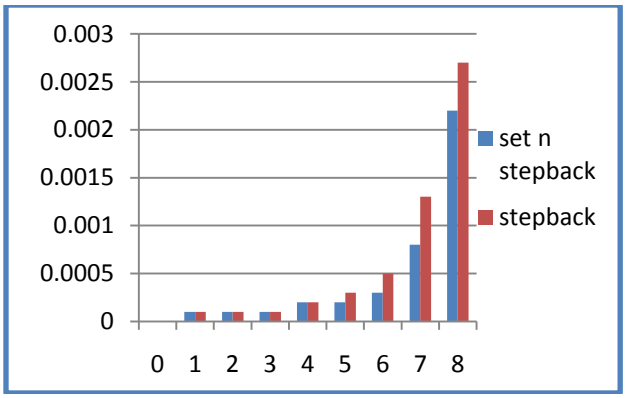
5.1 Comparison of Step back and Step back & Set back building frames:

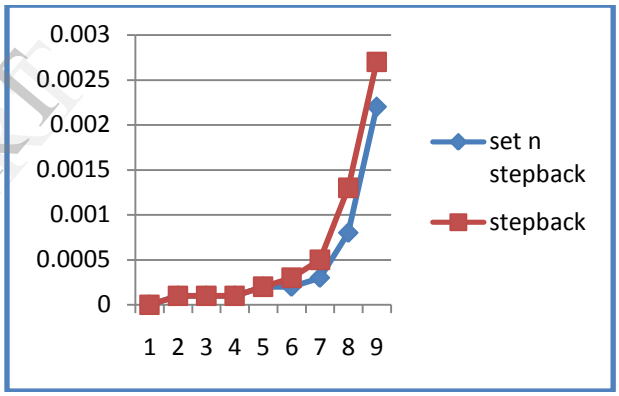
Analysis is carried out on these above mentioned configurations of building frames by considering different number of stories varying from 8 storey's to 10 storey's and results obtained are discussed in further sections.

5.1.1 Displacement variation of step back and step back & set back frames :

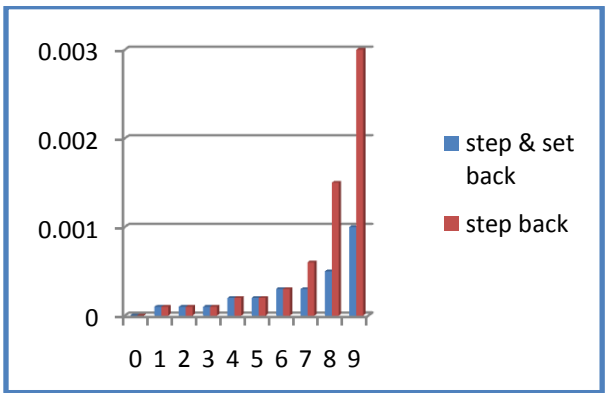
The variation of displacement for different number of storey's and configurations of building frames is shown below:

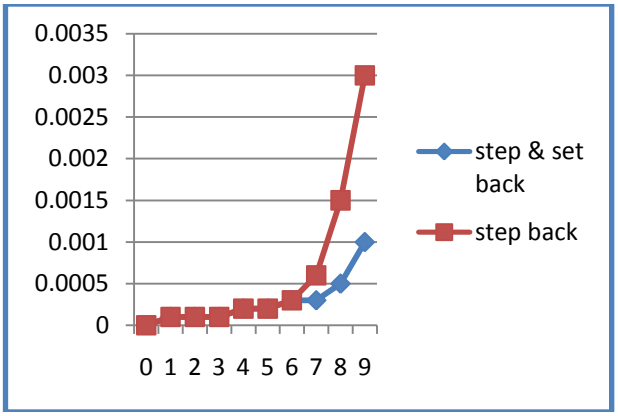
5.1.1.1 Comparison of displacements between step back and step back & set back frames of 8 storey building:



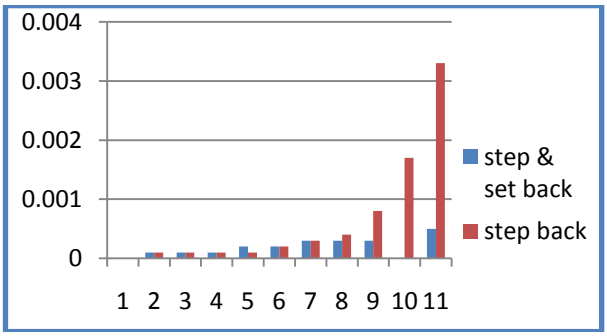


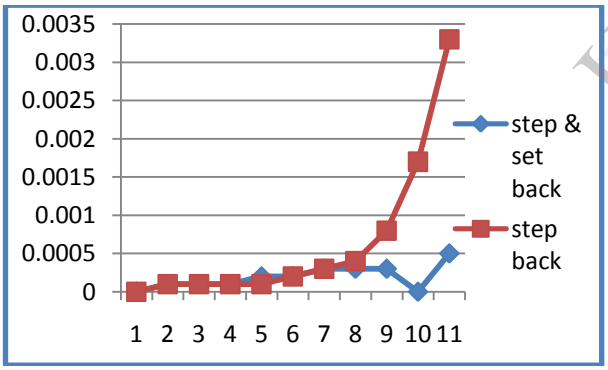
5.1.1.2 Comparison of displacements between step back and step back & set back frames of 9 storey building:





5.1.1.3 Comparison of displacements between step back and step back & set back frames of 10 storey building:



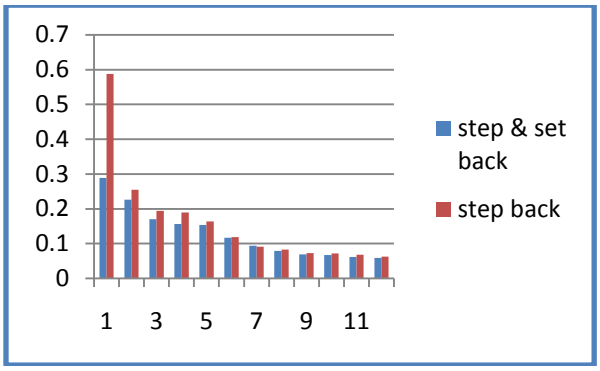


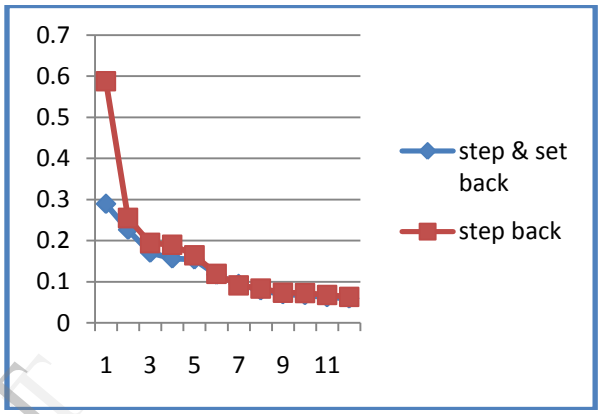
From the above graphs the displacement for top stories of step & set back and step back buildings shows that; the displacement in step back buildings are more compared to step & set back building frames. The nature of variation observed is non linear for all number of stories.

5.1.2 Time period variation of step back and step back & set back frames:

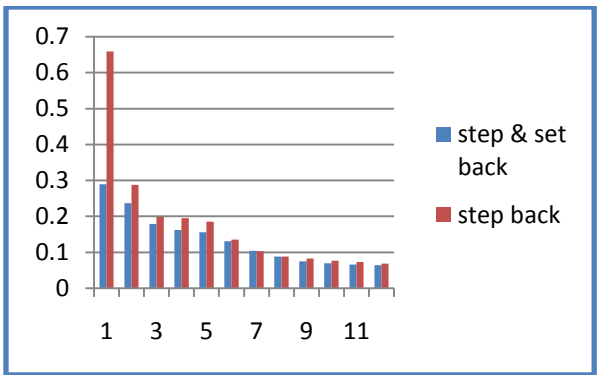
The time period variation for different number of storey's and configurations of building frames is shown below by considering 12 modes.

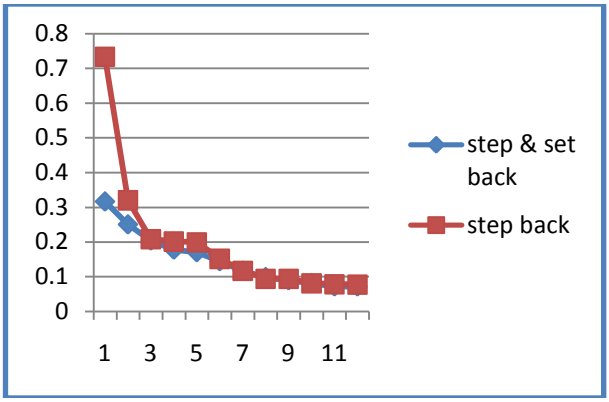
5.1.2.1 Comparison of time period between step back and step back & set back frames of 8 storey building:





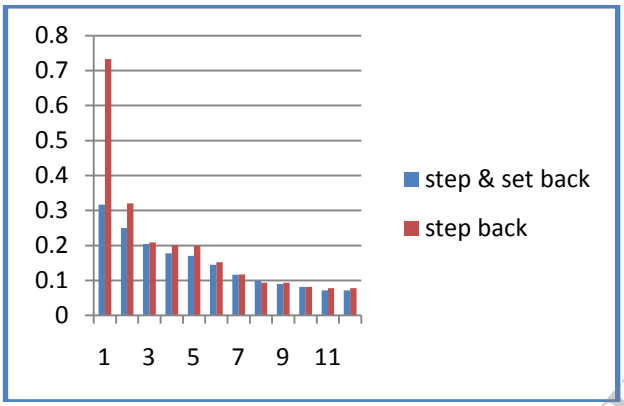
5.1.2.2 Comparison of time period between step back and step back & set back frames of 9 storey building:

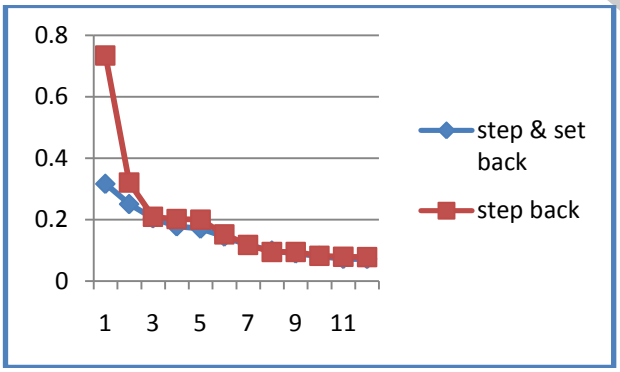




Storey	step & set back(Vx)	step back(Vx)
Base	38.83	39.42
1	19.33	16.09
2	125.7	111.2
3	299.24	266.87
4	362.86	455.16
5	342.03	610.87
6	260.69	625.94
7	600.64	1550.7
8	392.99	1027.03

5.1.2.3 Comparison of time period between step back and step back & set back frames of 10 storey building:



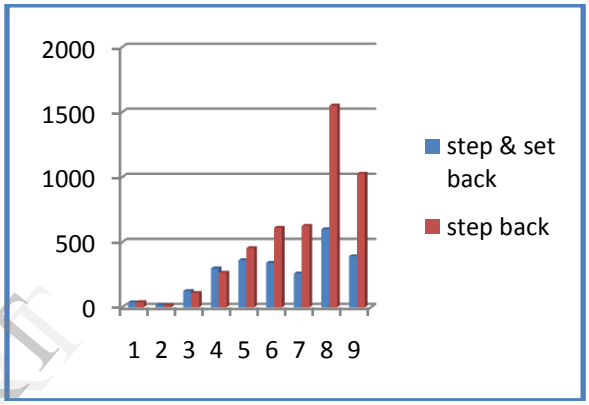


From the above graphs time period for Step back frames are more when compared with Step & Set back frames. However time period for 9 and 10 storey building frames are nearly similar.

5.1.3 Comparison of Storey Shear for different configurations:

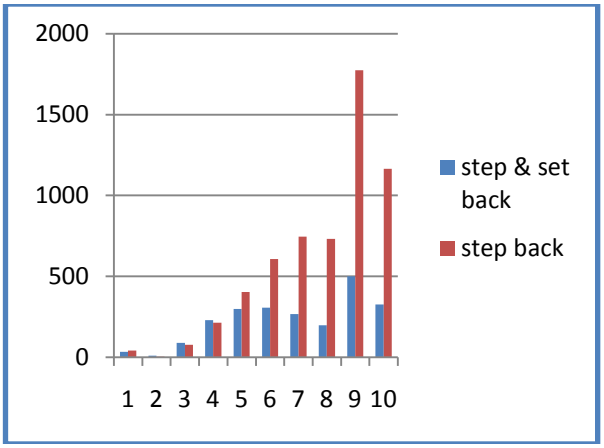
The storey shear for different storeys of different configurations is compared.

5.1.3.1 Comparison of storey shear between step back and step back & set back frames of 8 storey building:



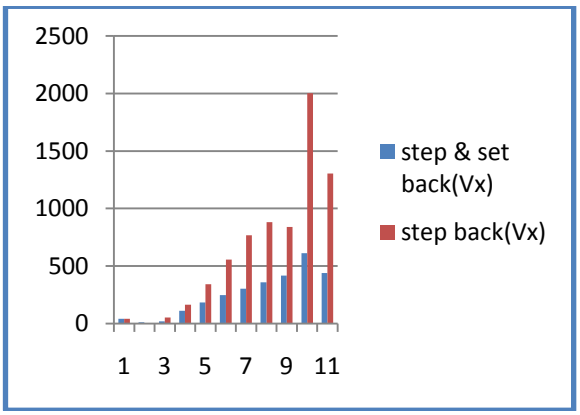
5.1.3.2 Comparison of storey shear between step back and step back & set back frames of 9 storey building:

storey	step & set back(Vx)	step back(Vx)
Base	33.14	40.8
1	10.09	4.9
2	88.54	77.56
3	228.61	214.47
4	297.9	403.99
5	305.95	607.74
6	266.37	746.49
7	196.97	731.14
8	499.62	1773.58
9	326.77	1164.93



5.1.3.3 Comparison of storey shear between step back and step back & set back frames of 10 storey building:

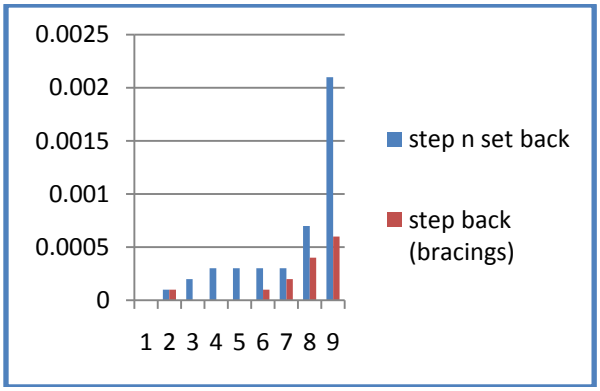
storey	step & set back(Vx)	step back(Vx)
0	41.31	41.09
1	11.46	0.74
2	19.21	53.07
3	110.07	163.81
4	184.08	341.54
5	246.73	557.59
6	304.42	769.4
7	359.53	881.08
8	417.23	838.94
9	612.9	2002.22
10	438.41	1304.62

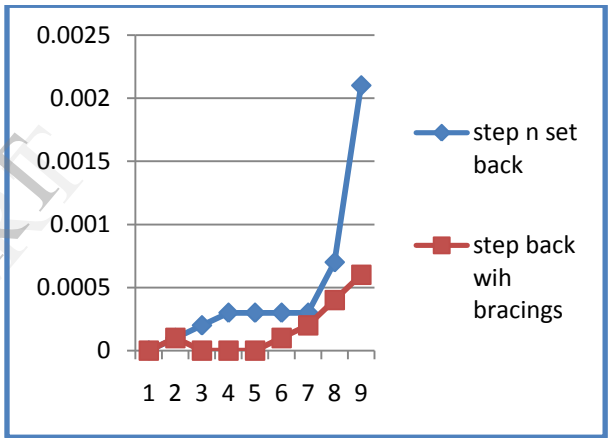


From above graphs storey shear at base is more for Step back building frames when compared with Step & Set back frames. But for 10 storey building frame the storey shear at base is approximately similar but shear for other storey's are differ.

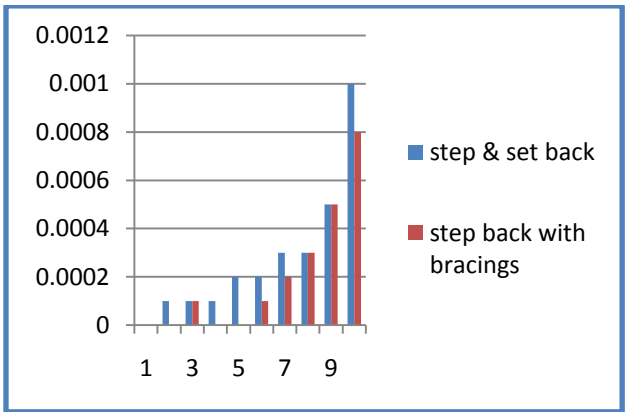
5.2 Comparison of Step back with bracings and Step & Set back Frames:

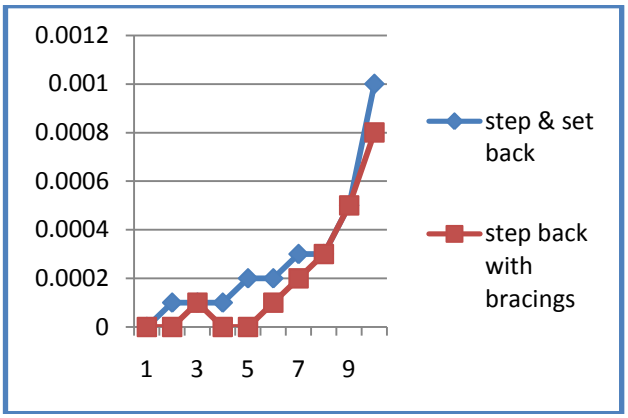
5.2.1 Comparison of displacement between step back with bracings and step back & set back frames of 8 storey building:



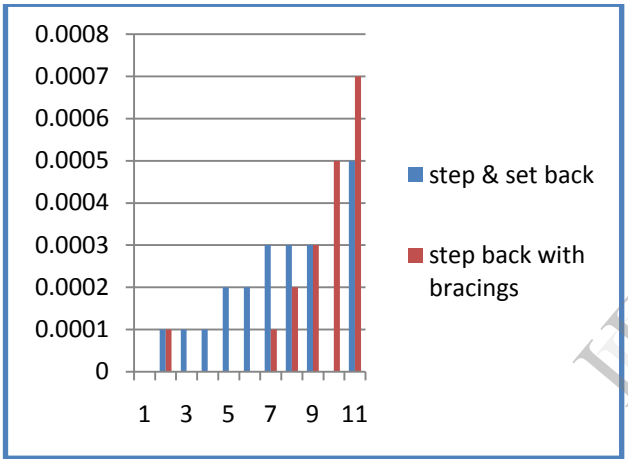


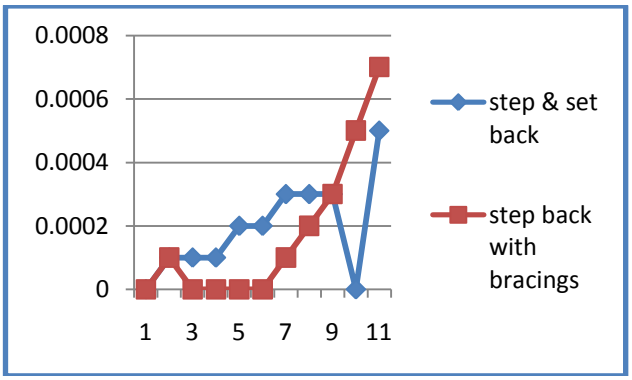
5.2.2 Comparison of displacement between step back with bracings and step back & set back frames of 9 storey building:





5.2.3 Comparison of displacement between step back with bracings and step back & set back frames of 10 storey building:





By comparing the Displacements between Step & Set back frames and Step back frames with bracings, can say that the displacements are much decreased for Step back frames as bracings are considered.

6. CONCLUSION:

From the above data due to the seismic analysis for the structures with different loading combinations the following conclusions are drawn:

1. As per IS 1893-2002 buildings with dual system consist of shear walls or bracing frames so that these are designed to resist the total design lateral force in proportion to their lateral stiffness. So Step back frames without bracings produce higher base shear as compared with step back & set back frames.
2. The step back building frames without bracings give higher values of time period as compared with step back & set back frames.
3. The step back building frames without bracings give higher values of top storey displacement as compared with step back & set back frames.
4. The performance of step back frames without bracings during seismic excitation can be effected more than other configurations of building frames. Hence, step back building frames without bracings on sloping ground are not desirable. However, it may be adopted by providing bracing system to control displacements.
5. Step back & set back frames produces less torsion effects as compared to step back frames. In case step back building frames are proposed, then step back frame shall be designed for higher moments induced in columns due to earthquake.
6. As number of storey's increases time period & top storey displacement also increases.
7. Step back frames with bracings gives less displacements compared with Step back frames with out bracings and also Step & Set back frames.

7. REFERENCES:

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