Seismic Analysis of Multi-Storey R.C.C. Structures Resting on Hilly Sloping Grounds and Considering Steel Bracings

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Abstract— In hilly areas most of the engineering structures are constructed by considering local topography that is on sloping grounds results in the using of a step back method or step & set back method. The structures are irregular due to adoption of these methods and it leads to increased shear and torsion during seismic ground motion because of its irregularity in structures and by virtue of different column heights. Using Equivalent static method and Response Spectrum method the analysis is carried out to the step & set back framed building and step back framed buildings on slope grounds with different number of storeys. The lateral displacement, storey drift, time period and base shear induced in column are studied for the different number of storey and building heights. The result shows that the step & set back type of building frames are best suitable for sloping ground or in hilly areas as compared with step back type of building frames. By considering steel bracings to step back types of framed buildings, a better performance can be observed.

Key words: Steel Bracings, Steel Bracings

I. Introduction

In the world, some parts in hilly areas are seismic active for example north regions in India. In these hilly areas the grounds are in slops hence scarcity of plane ground occurs due to this most of the important structures like reinforced concrete framed offices, hotels, hospitals, colleges are resting on sloping grounds of hills. Since, the behaviour of multi storey RCC structural buildings during earthquake depends on the mass distribution and the stiffness in both vertical and horizontal planes of the buildings, and vary in buildings with sloping grounds with asymmetrical and irregularity due to step & set back frame and step back frame configuration. The structures constructed in these hilly and seismic active areas induce increased shears and torsion as comparison with structures constructed conventionally. In the hilly areas, population has increased due to this the rapid urbanization and economic growth has accelerated real estate development and increased in the cost of land. Hence on hilly region the multi storied RC buildings are in demand. In the past earthquakes, it is seen that the structures in hill areas are highly damaged and collapsed. There for the construction of multi storied RC buildings in seismic active areas and on the sloping grounds of hilly areas should be designed for earthquake resistant

II. Objectives of the Study

The following are the objectives:

- To generate 3D model of building frames with step back frames, step back frames considering bracing and step & set back frame configurations using ETABS.
- To determine the variation of top storey displacement for step back frames and step back frames considering bracing and step & set back frames using Equivalent Static method & Response Spectrum method.
- To compute the variation of time period for step back frames and step back frames considering bracing and step & set back frames.
- To evaluate the variation of storey drift, base shear and top storey forces for the step back frames and step back frames considering bracing and step & set back frames.
- To study the performances of building on slope grounds of hills.
- To compare the results of step back frames and step back frames considering bracing and step & set back frames with respect to storey displacement, storey drift, base shear, time period and top storey shear.
- To strengthening the building model during earthquake ground motion.

III. Scope of the Study

Considering the seismic loads the 3D frame model analysis is carried out for the step back frames, step back frames considering bracing and step back & set back frames of different configurations of buildings, of 10 to 12 storeys on the hilly slop grounds by using software Etabs. Dynamic response of these buildings, in terms of fundamental time period, base shear, displacement, storey drift, top story forces are computed and compared with different configurations of building which are practiced in hilly areas.

The stiffness and seismic strength of a step back frame configuration building can be increased by considering bracings. The steel bracings are commonly used as it is ease in erection & its strength to weight ratio, and it also reduces flexure and shear in column and beams. The existing RC structures are strengthening by using steel bracings.

IV. Building Configuration

In this, present study 3 types of building frame are considered which are resting on slop ground and the ground slop is 28 degree as compare to horizontal plane.

The buildings frames are maintained of blocks size 6 m x 4 m x 3.2 m. & considering 4 no. of bays. The footing depth below ground to hard stratum is 1.6 m.

Seismic analysis of the different configurations of buildings is carried out by response spectrum as per IS 1893 (Part I):2002

A. Details of the Building:

Type of structure	SMRF
Type of building	Commercial
No. of storeys	G+9, G+10, G+11
Storey height	3.2 m
Seismic zone	V
Materials properties	

Grade of concrete	
For beams	M25
For columns	M30
For slab	M25
Grade of steel	Fe 415
Grade of Steel bracing	Fe 345
Member properties	
Column size for G+9 storey	0.6X0.6 m
Column size for G+10 storey	0.65X0.65 m
Column size for G+11 storey	0.7X0.7 m
Beam size	0.3X0.6 m
Thickness of slab	0.15 m
Thickness of wall	0.23 m
Steel bracing	ISA 110X110X10 mm
Load Intensities	
Live Load	3.5 KN/sq.m
Floor finishes	1.0 KN/sq.m
Wall weight	11.385 KN/sq.m
As per IS 1893 (Part 1) :2002	
Zone factor, factor for zone V	0.36
Soil type	I
Importance factor, I	1
Response reduction factor, R	5
Ecc. Ratio	0.05

Table 1:

B. *Description of Models:*

Model -1

The building is of G+9 storeys, constructed in step back building frames configurations.

Model-2

The building is of G+9 storeys, constructed in step back building frames configurations considering steel bracings.

Model-3

The building is of G+9 storeys, constructed in step & set back building frames configurations.

Model-4

The building is of G+10 storeys, constructed in step back building frames configurations.

Model-5

The building is of G+10 storeys, constructed in step back building frames configurations considering steel bracings.

Model-6

The building is of G+10 storeys, constructed in step & set back building frames configurations.

Model-7

The building is of G+11 storeys, constructed in step back building frames configurations.

Model-8

The building is of G+11 storeys, constructed in step back building frames configurations considering steel bracings.

Model-9

The building is of G+11 storeys, constructed in step & set back building frames configurations.

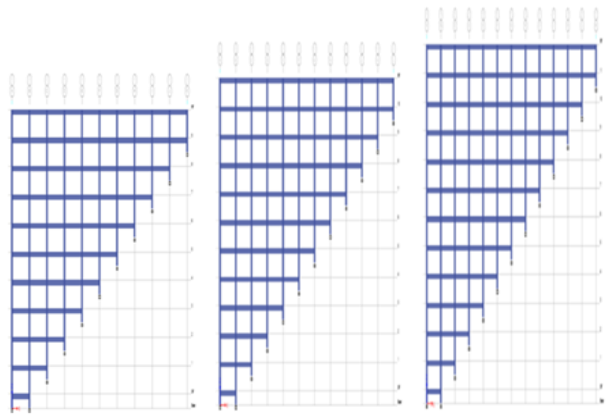

Fig. 1: Building is of G+9, G+10, G+11 storeys, constructed in step back building frames

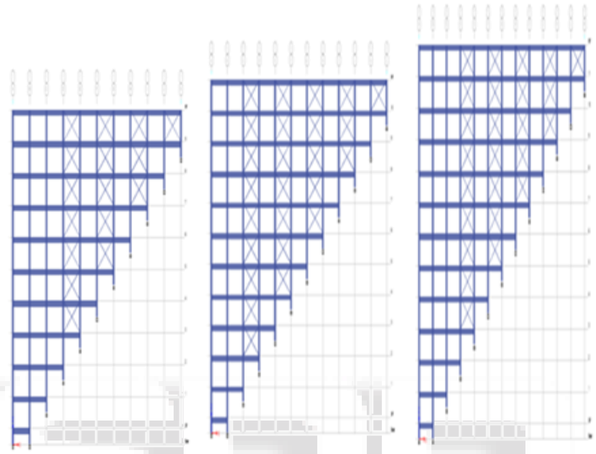

Fig. 2: Building is of G+9, G+10, G+11 storeys, constructed in step back building frames considering steel bracings

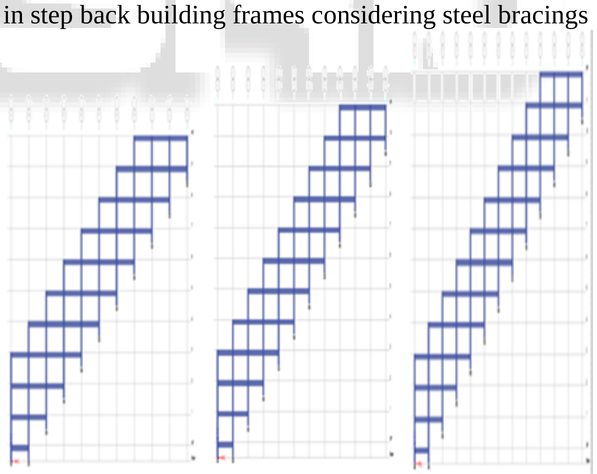

Fig. 3: Building is of G+9, G+10, G+11 storeys, constructed in step & set back building frames configurations

V. RESULTS & DISCUSSION

A. *Lateral Displacement:*

The Lateral displacements of each floor are determined by using Equivalent Static Method and Response Spectrum Method.

1) Comparison Of Displacements Between Step Back Frames, Step Back With Bracing Frames And Step & Set Back Frames Of G+9 Storeys Building Along X Direction

Storey no.	Step back frames	Step back considering bracing	Step & set back frames

	UX	UX	UX
RF	2.0	1.7	1.2
9	1.2	1.1	0.5
8	0.6	0.7	0.2
7	0.5	0.5	0.3
6	0.5	0.5	0.4
5	0.4	0.4	0.4
4	0.3	0.3	0.3
3	0.2	0.2	0.2
2	0.1	0.1	0.1
1	0.1	0.1	0.1
GF	0.01	0.01	0.01

Table 2:

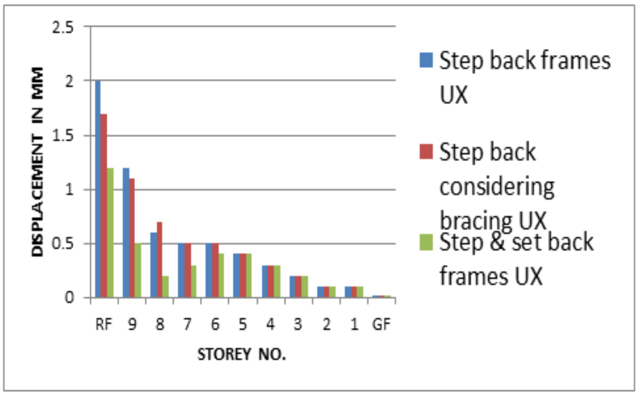

Fig. 4:

2) Comparison Of Displacements Between Step Back Frames, Step Back With Bracing Frames And Step & Set Back Frames Of G+9 Storeys Building Along Y Direction

Storey no.	Step back frames	Step back considering bracing	Step & set back frames
	UY	UY	UY
RF	12.1	11.8	3.1
9	11.3	10.9	3.1
8	10.2	9.8	2.9
7	8.7	8.4	2.7
6	7.0	6.8	2.5
5	5.3	5.2	2.3
4	3.7	3.7	2.0
3	2.2	2.3	1.7
2	1.1	1.3	1.0
1	0.4	0.5	0.4
GF	0.1	0.1	0.1

Table 3:

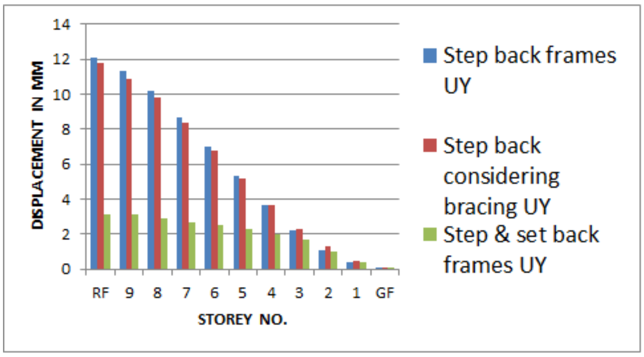

Fig. 5:

3) Comparison Of Displacements Between Step Back Frames, Step Back With Bracing Frames And Step & Set Back Frames Of G+10 Storeys Building Along X Direction:

Storey no.	Step back frames	Step back considering bracing	Step & set back frames
	UX	UX	UX
RF	1.8	1.5	1.0
10	1.0	1.0	0.4
9	0.5	0.6	0.2
8	0.5	0.5	0.2
7	0.5	0.4	0.3
6	0.4	0.4	0.3
5	0.3	0.3	0.3
4	0.2	0.2	0.2
3	0.1	0.1	0.2
2	0.1	0.1	0.1
1	0.03	0.04	0.04
GF	0.01	0.01	0.01

Table 4:

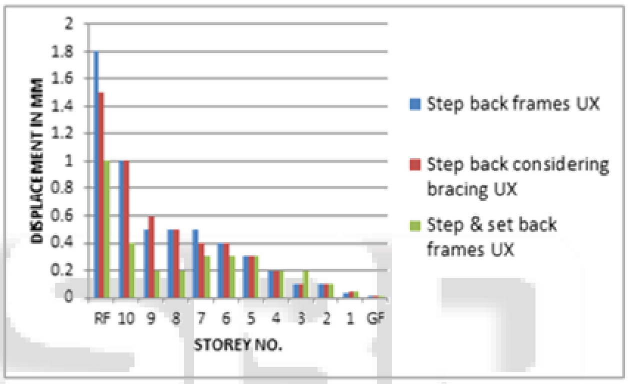

Fig. 6:

4) Comparison of displacements between step back frames, step back with bracing frames and step & set back frames of G+10 storeys building along Y direction:

Storey no.	Step back frames	Step back considering bracing	Step & set back frames
	UY	UY	UY
RF	12.5	12.2	2.8
10	11.7	11.4	2.7
9	10.6	10.3	2.5
8	9.2	9.0	2.3
7	7.6	7.5	2.0
6	6.0	5.9	1.8
5	4.4	4.4	1.6
4	3.0	3.0	1.4
3	1.7	1.9	1.2
2	0.9	1.0	0.7
1	0.3	0.4	0.3
GF	0.03	0.1	0.04

Table 5:

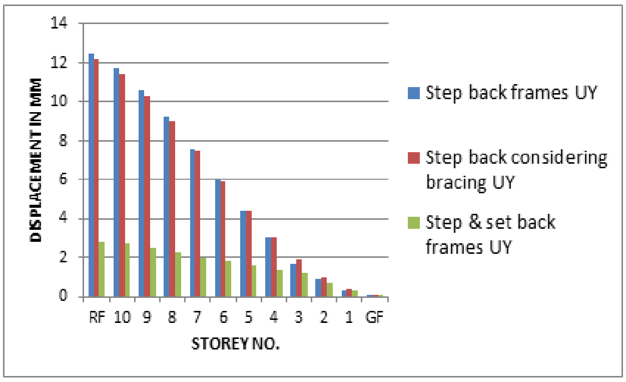

Fig. 7:

5) Comparison Of Displacements Between Step Back Frames, Step Back With Bracing Frames And Step & Set Back Frames Of G+11 Storeys Building Along X Direction:

Storey no.	Step back frames	Step back considering bracing	Step & set back frames
	UX	UX	UX
RF	1.8	1.4	0.9
11	1.0	0.9	0.3
10	0.5	0.5	0.1
9	0.5	0.4	0.2
8	0.5	0.4	0.2
7	0.4	0.3	0.2
6	0.3	0.3	0.2
5	0.2	0.2	0.2
4	0.2	0.1	0.2
3	0.1	0.1	0.1
2	0.1	0.1	0.1
1	0.02	0.02	0.02
GF	0	0	0

Table 6:

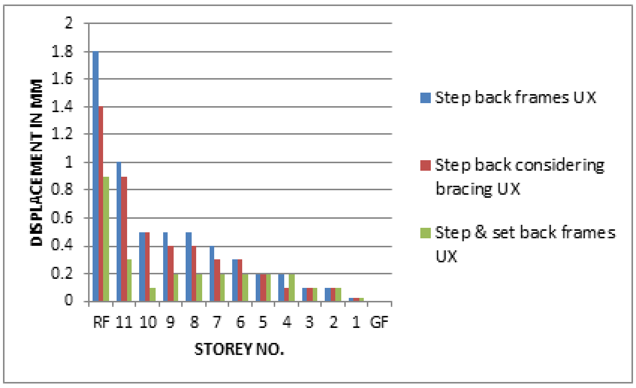

Fig. 8:

6) Comparison Of Displacements Between Step Back Frames, Step Back With Bracing Frames And Step & Set Back Frames Of G+11 Storeys Building Along Y Direction

Storey no.	Step back frames	Step back considering bracing	Step & set back frames
	UY	UY	UY
RF	12.9	12.7	2.6
11	12.1	11.8	2.5
10	11.0	10.8	2.2
9	9.7	9.5	1.9
8	8.2	8.1	1.7
7	6.6	6.5	1.5
6	5.1	5.1	1.4
5	3.6	3.7	1.2
4	2.4	2.5	1.1
3	1.4	1.5	0.9
2	0.6	0.7	0.5
1	0.2	0.3	0.2
GF	0.02	0.04	0.03

Table 7:

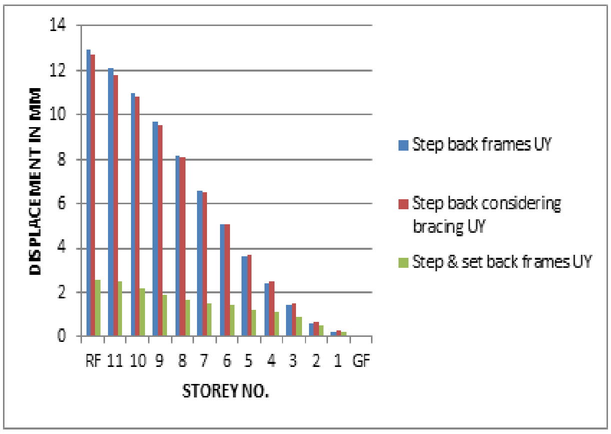

Fig. 9:

On comparing the displacement results of building models on slope ground, the lateral displacements in step back building frames are of higher values as compared with the step back building frames considering bracing. Hence the use of bracings in step back building frames in slop grounds is suggested for strengthening the building

B. Base Shear:

The design seismic base shear (VB) along any principal direction may be calculated by using the formula

VB = Ah X W

Where, Ah = Design horizontal acceleration spectrum value using the fundamental natural period T in the considered direction of vibration

W = seismic weight of the structure

The Ah is calculated by using the following expression:

$$A_h = \frac{Z\ I\ S_A}{2\ R\ g}$$

1) Comparison of Base Shear for Different Models by Equivalent Static Method Along X & Y Direction:

Model no.	Equivalent static method	
	EQ X in KN	EQ Y in KN
1	8386.31	4772.53
2	8395.94	4957.70
3	5046.30	5046.30
4	10157.35	5651.85
5	10170.86	5836.03
6	5719.70	5719.70
7	12178.31	6622.59
8	12192.12	6800.80
9	12918.27	6459.13

Table 8:

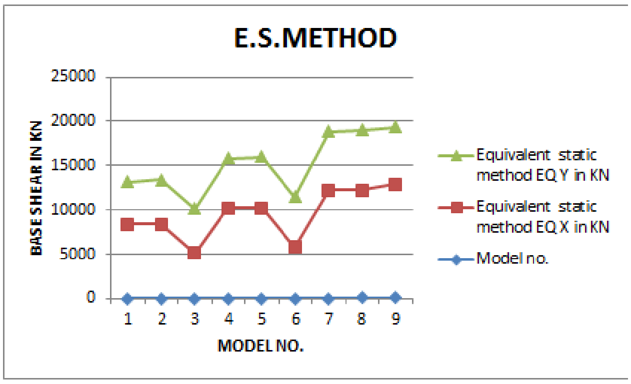

Fig. 10:

2) Comparison of Base Shear for Different Models by Response Spectrum Method along X & Y Direction:

Model no.	Response Spectrum method	
	RS X in KN	RS Y in KN
1	4923.85	2973.58
2	5098.85	3121.51
3	3670.84	3115.73
4	5817.68	3522.45
5	6007.70	3664.08
6	4245.96	3404.19
7	7587.06	4072.80
8	6971.77	4249.43
9	4607.99	3627.71

Table 9:

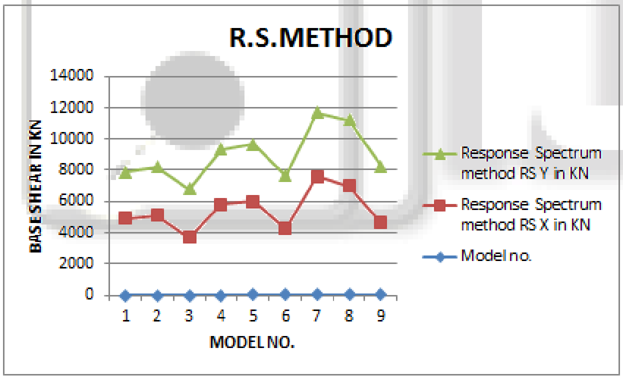

Fig. 11:

C. Storey Drift:

The displacement of one level relative to the other level below or above is known as storey drift. The permissible limit for storey drift is 0.004 times of the storey height so as to minimise the damages which can occurs during the earthquake ground motion.

The analysis of building models shows permissible limits of storey drifts. The storey drifts of each model are computed and tabulated in below tables and the results are compared.

Comparison Of Storey Drift Between Step Back Frames, Step Back With Bracing Frames And Step & Set Back Frames Of G+9 Storeys Building Along X & Y Direction

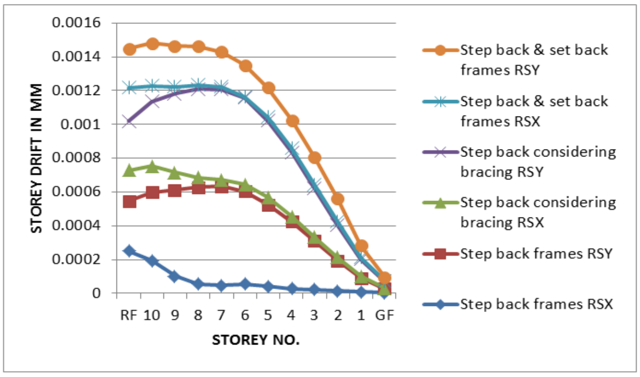

Fig. 12:

1) *Comparison of Storey Drift between step back frames, step back with bracing frames and step & set back frames of G+10 storeys building along X & Y direction*

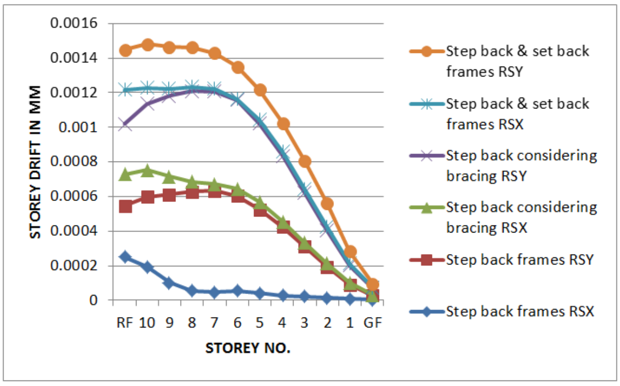

Fig. 13:

2) Comparison of Storey Drift between step back frames, step back with bracing frames and step & set back frames of G+11 storeys building along X & Y direction

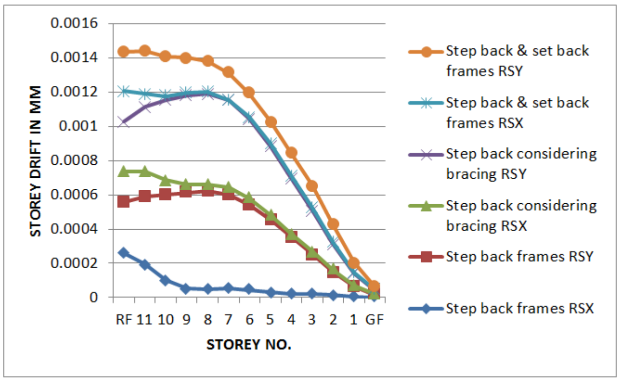

Fig. 14:

The drifts are in the permitted limits given by the codes (0.004*h=12.0mm). The storey drift in bottom storeys are less and the story drift in upper storeys are more when compared. Therefore it is acceptable for structures.

D. Time Period:

The time period variation of different types of building frames configurations and different no. of storeys are shown below considering 12 modes.

1) Comparison of Time Period between step back frames, step back with bracing frames and step & set back frames of G+9 storeys building

Mode no.	Step back frames	Step back frames considering bracings	Step & set back frames
1	0.703	0.677	0.291
2	0.313	0.283	0.246
3	0.236	0.220	0.188
4	0.202	0.177	0.177
5	0.156	0.142	0.144
6	0.146	0.141	0.130
7	0.146	0.127	0.115
8	0.121	0.116	0.113
9	0.112	0.099	0.106
10	0.103	0.098	0.095
11	0.090	0.083	0.094
12	0.088	0.081	0.082

Table 10:

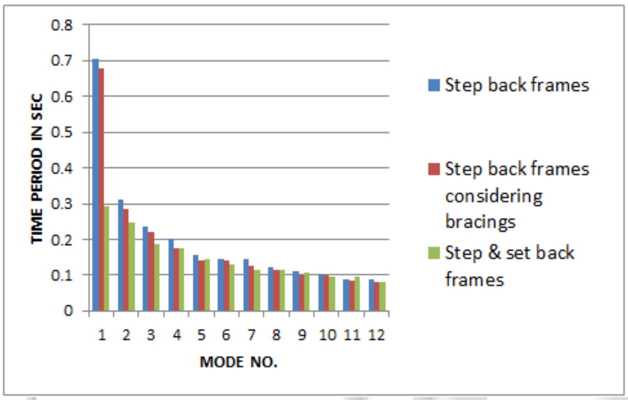

Fig. 15:

VI. CONCLUSION

1) The displacements are less in step back building frames considering bracings as comparison with step back building frames without considering bracings.
2) The time period values are higher in step back frames without bracings as comparison with step & set back frames.
3) The base shear is high in step back frames considering bracings as comparison with step back & set back frames.
4) On the slope grounds step back framed buildings without bracings are not desirable
5) The top storey displacements in step back frames without bracings are higher values as comparison with step & set back frames.
6) The torsion effects produced are less in set and step back building frames as comparison with step back framed buildings.
7) The top storey displacements & time period increases as the no. of storey increases.
8) The storey drifts of building frames are found within the specified limit.

REFERENCES

[1] Satish Kumar and D.K. Paul, "Hill building configurations from seismic considerations", Journal of structural engineering, vol. 26, No. 3, Oct. 1999.

[2] S.S. Nalawade., "Seismic Analysis of Buildings on Sloping Ground," M.E. Dissertation, University of Pune, Pune Dec-2003

[3] Vishwanath k.G., Prakash K.B. and Anant Desai, "Seismic analysis of Steel braced Reinforced concrete frames", International journal of civil and structural engineering volume 1, No 1, pp 114-121, 2010.

[4] IS: 1893 – 2002 (Part-1) "Criteria for Earthquake Resistant Design of Structures", Bureau of Indian Standard, New Delhi, India