Seismic Analysis of RCC Multi-Storey Building with Effect of Bracing Resting on Sloped Ground

Satishkumar Guttedar[1], Sujeet Patil[2]

[1]*M.Tech Student, Dept. Of Civil Engineering, PDA Institute of Technology, Kalburagi, Karnataka, India*
[2]*Professor, Dept. Of civil Engineering, PDA Institute of Technology, Kalburagi, Karnataka, India*

---***---

Abstract - *: In hilly areas buildings are built on sloping grounds. When the hilly areas come under the seismic zones the buildings are highly vulnerable to earthquakes. The dynamic analysis is carried out using response spectrum method to the step-back building and step back-set back building frames. The dynamic response that is fundamental time period, storey displacement and base shear has been studied. These results show that performance of step back-set back frames is more suitable in comparison with step-back building frames. But after considering the cross bracing(X) to the outer periphery of all models at the corner ends, A better performance can be observed in all models compare to the building without bracing. The RCC multi-storey building (G+20) analysis is carried out for different configurations with bracing and without bracing using E-tabs2018 commercial software.*

Key Words: Step-back building, Step back-Set back building, Sloped Ground, Response spectrum method, Hill slope, Bracing.

1. INTRODUCTION

Earthquake is the vibration of earth's surface caused by waves coming from a source of disturbance inside the earth. As the waves radiate from the fault, they undergo geometric scattering and reduction due to loss of energy in the rocks. Since the interior of the earth consists of heterogeneous formations, the waves undergo multiple reflections, retraction, dispersion and reduction as they travel. The seismic waves arriving at a site on the surface of the earth are a result of complex superposition giving rise to irregular motion and shaking of ground. When a structure is subjected to seismic forces it does not cause loss to human lives directly but due to the damage cause to the structures that leads to the collapse of the building. Mass destruction of the low and high rise buildings in the recent earthquakes leads to the need of investigation especially in a developing country like India. Structure subjected to seismic/earthquake forces are always vulnerable to damage and if it occurs on a sloped building as on hills which is at some inclination to the ground the chances of damage increases much more. Structures on slopes vary from those on plains grounds because they are asymmetrical horizontally as well as vertically. 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. Therefore; there is popular & pressing demand for the construction of multi - storey buildings on hill slope in and around the cities. 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.C Frame buildings on hill slope is the only feasible choice to accommodate increasing demand of residential & commercial activities.

1.1 Building Configuration

1. Step-back building (Resting on sloping ground)

2. Step back-Set back building (Resting on sloping ground)

3. Set-back building (Resting on plain ground)

1.2 Bracing systems

Bracing systems are used to resist horizontal forces like wind load, seismic action and to transmit to the foundation. The bracing members are arranged in many forms, which carry solely tension, or alternatively tension and compression. The bracing is made up of crossed diagonals, when it is designed to resist only tension. Based on the direction of wind, one diagonal takes all the tension while the other diagonal is assumed to remain inactive. One of the most common arrangements is the cross bracing. Bracings hold the structure stable by transferring the loads sideways (not gravity, but wind or earthquake loads) down to the ground and are used to resist lateral loads, thereby preventing sway of the structures.

2. OBJECTIVES OF STUDY

1. To study the seismic behavior of sloping ground building with different configuration.

2. To study the effect of bracing in RCC multi-storey buildings resting on sloping ground.

3. METHODOLOGY

The project work is divided into six Steps with following content.

Step 1: Deal with introduction of building and specific objective of the project is presented in it.

Step 2: Study the different research papers and journals on the modeling and Seismic properties.

Step 3: Mathematical modeling for different building configuration is carried out.

Step 4: It covered Response spectrum method analysis of different structure by taking earthquake data.

Step 5: Gives the comparison between with bracing and without bracing buildings.

Step 6: It covers interpret conclusion from various results.

4. MODELING AND ANALYSIS

4.1 Data considered

Type of building	Residential building
Type of frame	Special Rc moment resisting frame
Number of stories	20
Total height of building	60m
Grade of concrete	M_{40}, M_{30}
Grade of reinforced steel	HYSD 500,415(rebar). Fe345(steel)
Type of bracing	Cross bracing or X bracing ,ISNB350H
Size of column	1000 x 1500mm
Size of beam	450 x 600mm
Thickness of slab	200mm
Slope angle	45•
Zone	MMDLXIII
Type of soil	I
Importance factor (I)	1.2
Response reduction ®	5
Seismic zone factor	0.36
Damping ratio	5%
IS-code book	IS 1893-2016(Part 1)
Seismic method	Response spectrum method

Load calculations are done using Indian standards such as:-

- IS: 875(Part – 1)-1987 for Dead loads (Unit weight of Building materials and Stored materials).
- IS: 875(Part –2)-1987 for Imposed loads.
- IS: 1893(Part 1)-2016 for Seismic loads.

4.2 Load combination

1. 1.5 Dead load + 1.5 Live load
2. 1.2 Dead load + 1.2 Live load + 1.2Earthquake load
3. 1.5 Dead load + 1.5 Live load
4. 1.5 Dead load + 1.5 Earthquake load.

4.3 Method of analysis

Response spectrum method

In this method, multiple modes of response of a building to an earthquake are taken into account. The response of the different models are combined to provide an estimate of the total response of the structure using the modal combination methods such as,

- Absolute Sum (ABS) method
- Square root of Sum of Squares (SRSS)
- Complete Quadratic Combinations (CQC)

It is the maximum expected lateral force that will occur due to seismic ground motion at the base of the structure.

Vb = Ah x W

Where

Ah = Design Horizontal Acceleration Spectrum Value, using the fundamental natural period (T) in the considered direction of vibration and it can be determined by the relation.

Ah = $(Z/2) * (I/R) * (Sa/g)$

Z = Seismic Zone Factor given in table 3 of IS 1893(part 1) page 10.

I = Importance Factor

R = Response Reduction factor

Sa/g = Response Acceleration Coefficient

W = Seismic Weight of the Building

5) 3D view of different models considered for analysis

WITHOUT BRACING

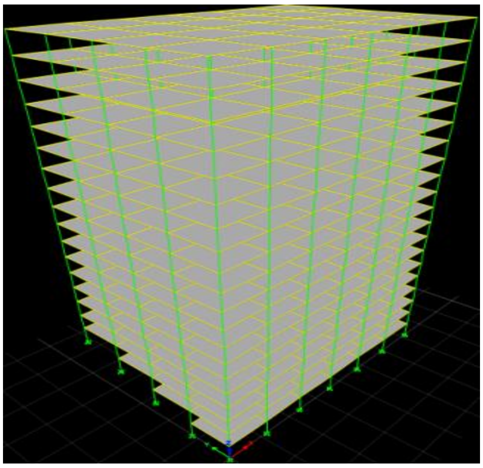


Fig.1.Step-back building

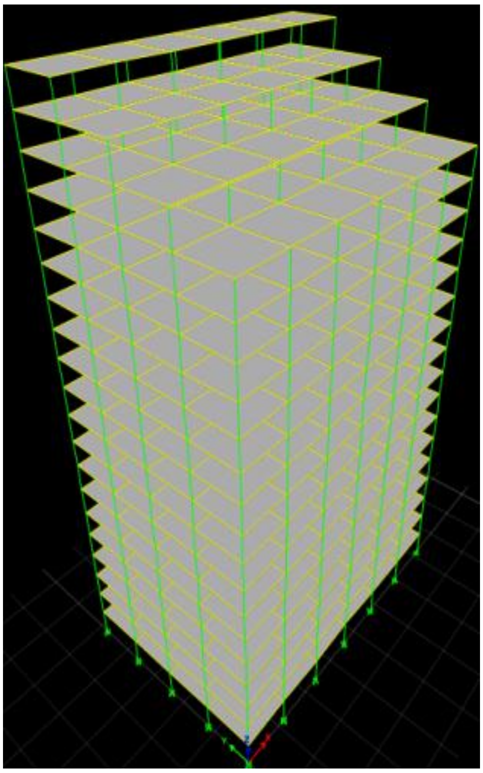


Fig.3.Set back building

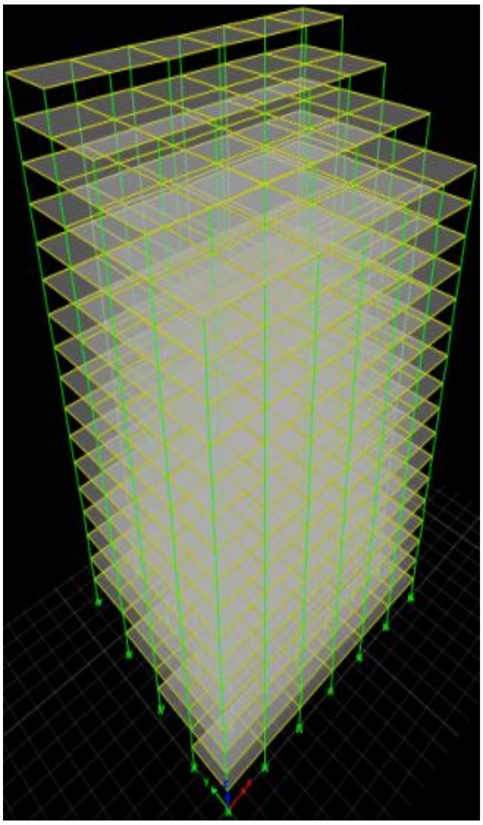


Fig.4.Step back –Set back building

WITH X BRACING OR CROSS BRACING

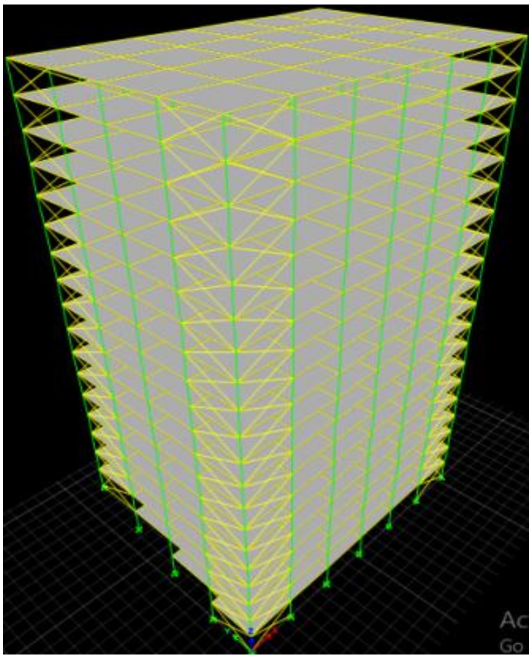


Fig.4.Step-back building with bracing

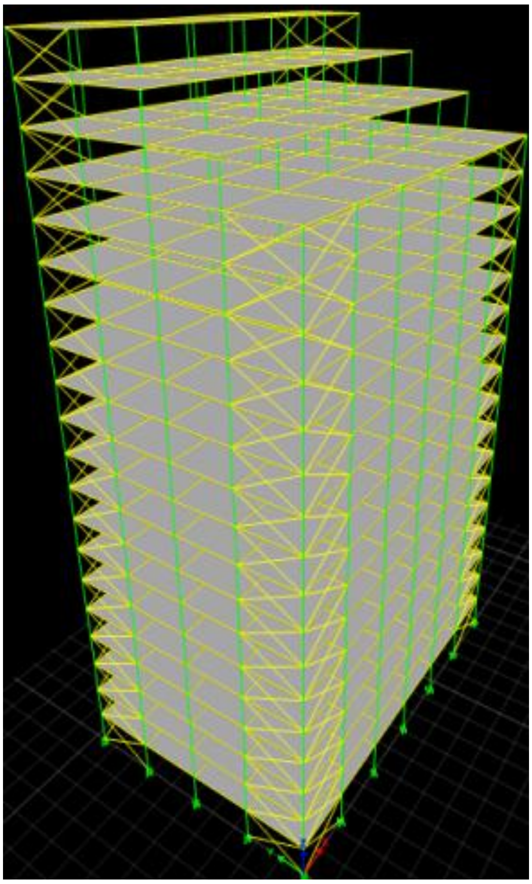


Fig.5.Set back building with bracing

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 09 | Sep 2020 www.irjet.net p-ISSN: 2395-0072

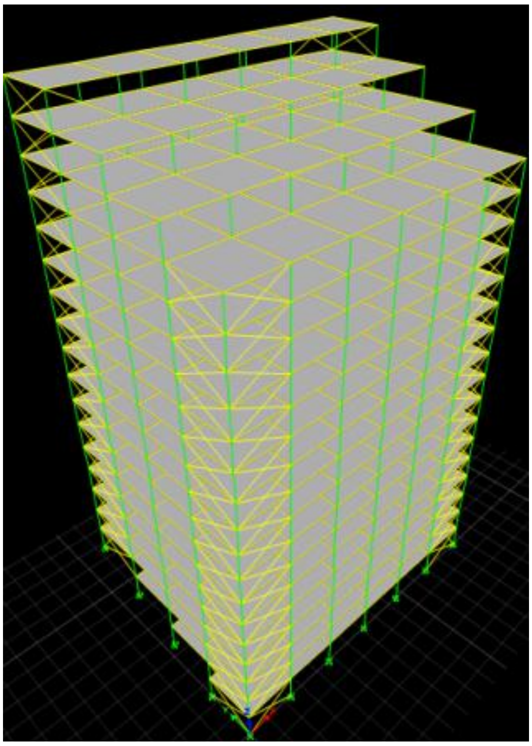


Fig.6.Step back-Set back building with bracing

6) RESULTS AND DISCUSSIONS

6.1 Time period

Figure 7 and 8 shows variation of time period for different building configuration

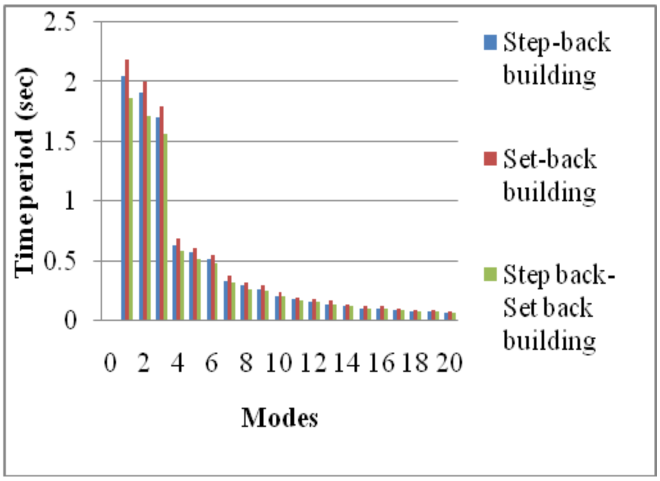


Figure 7: Shows variation of time period for buildings without bracing.

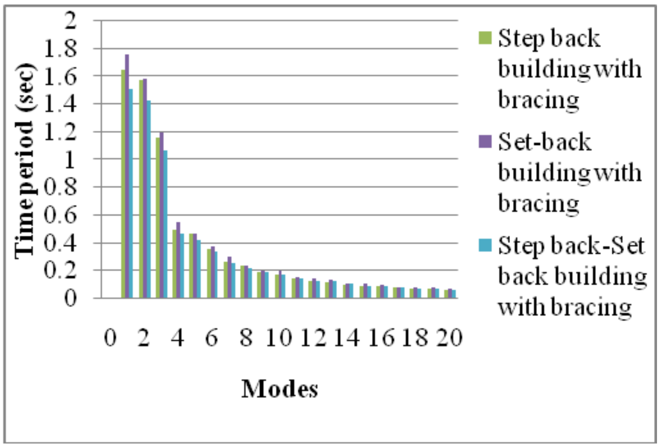


Figure 8: Shows variation of time period for buildings with bracing.

From above figure it is observed that time period in Step back-Set back building configuration is less as compare to the different configuration. It also observed that time period is decreases in case of building with bracing in all configurations. Hence use of X bracing reduces the time period of all models when compare to the models without bracing.

6.2 Storey Displacement

WITH BRACING

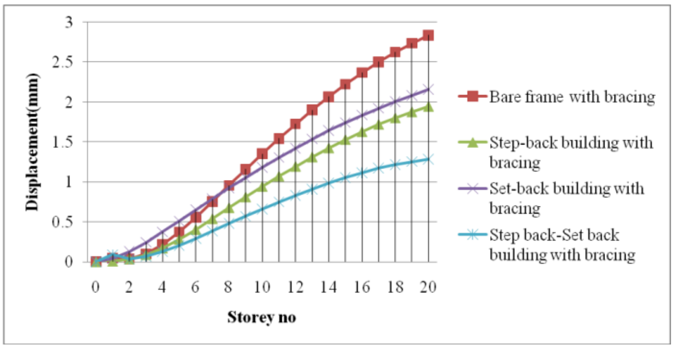
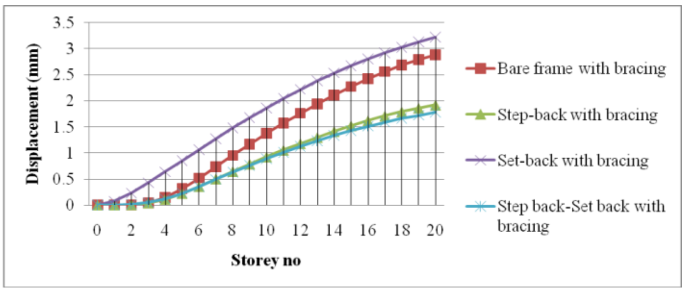


Fig 9 and 10 shows variation of storey displacement of different building models in X and Y direction.



WITHOUT BRACING

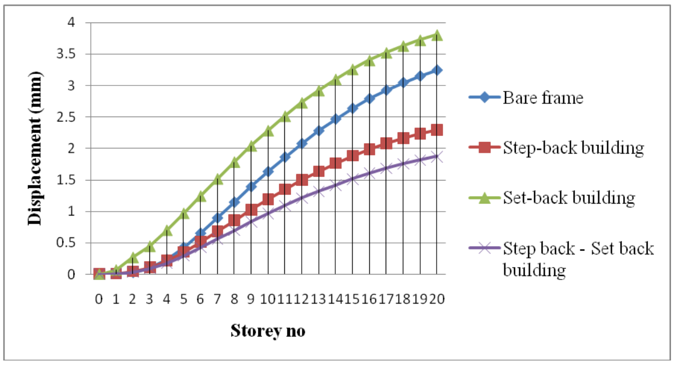


Figure 11 shows variation of Storey displacement of building with bracing in X direction.

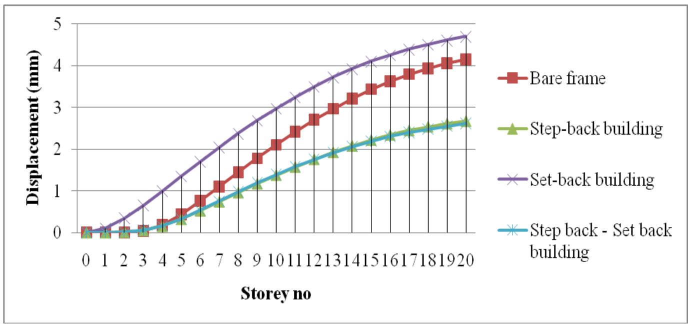
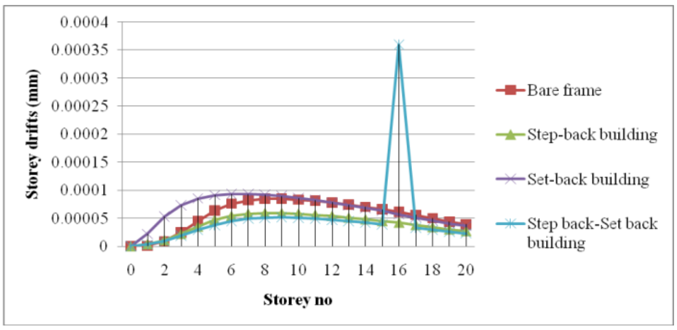


Figure 12 shows variation of Storey displacement of building with bracing in Y direction.

From above figures of storey displacement of models it is observed that due to the effect cross bracing reduces the storey displacement of all models. The presence of bracing reduces storey displacement of Step-back building in both X and Y direction respectively (17.92% in X and 39.2% in Y) When compare to the Step-back without bracing. Similarly for, the presence of bracing in Step back-Set back reduces the storey displacement in both directions i.e. 51.63% in X direction and 7.73% in Y direction has compared to the Step back-Set back building without bracing.

6.3 Storey drifts



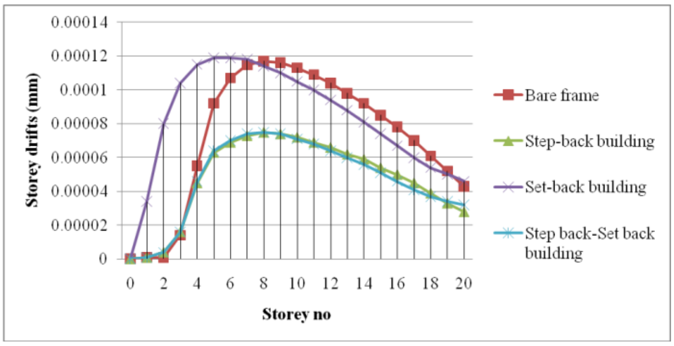


Figure 13 and 14 shows variation of Storey drifts of all models without bracing in X and Y direction

WITH BRACING

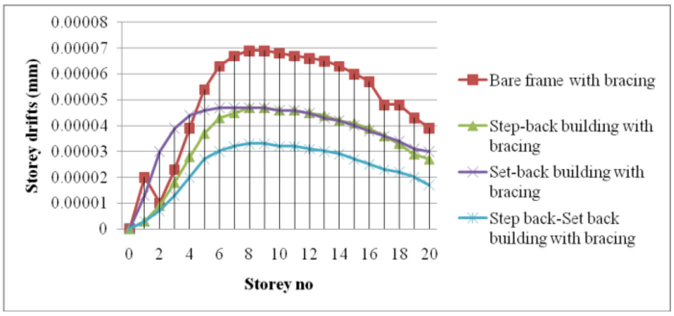


Figure15 shows variation of Storey drifts of all models with bracing in X direction.

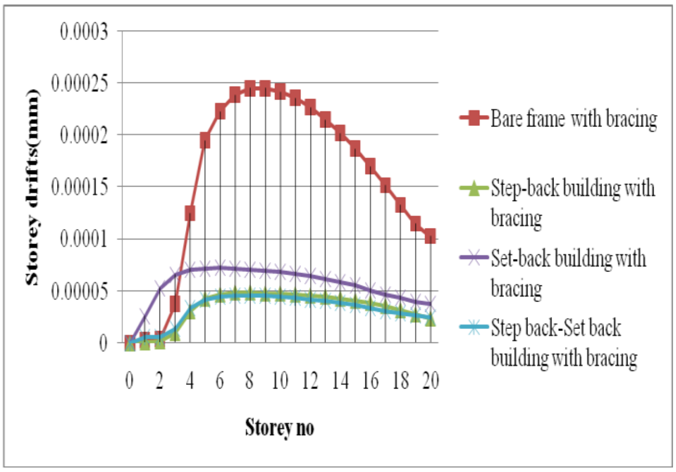


Figure 16 shows variation of Storey drifts of all models in Y direction.

From above figure it is observed that storey drifts decrease in all models due to the effect of bracing when compare to the building without bracing.

6.3 Base Shear (KN)

WITHOUT BRACING

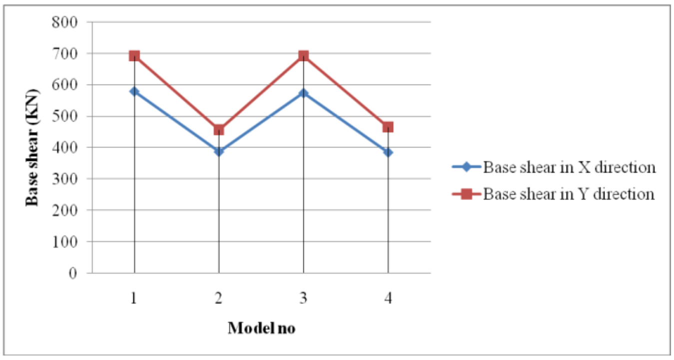


Figure 17 shows variation of base shear of different models without bracing.

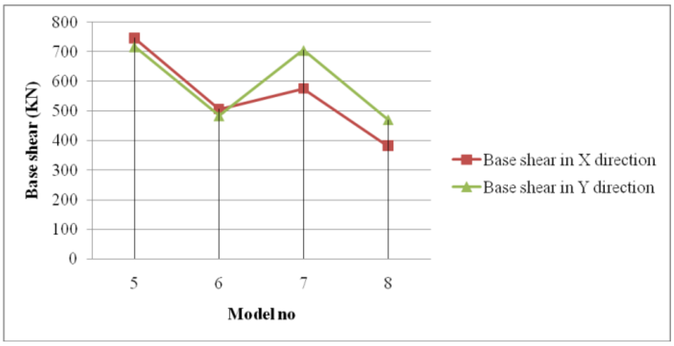


Figure 18 shows variation of base shear of different models with bracing.

From the above fig 17 and 18 shows that variation of base shear of different buildings with bracing and without bracing, it observed that the presence bracing in building increaseas base shear when compare to the building without bracing in X and Y direction.

9. CONCLUSIONS

Based on the investigation, the fallowing inferences were drawn:

1. For all buildings considered for study, the storey displacement and storey drifts values are within the permissible limit as per respective codes.

2. The top storey displacement and storey drift of Step-back building is quite high has compare to the Step back-Set back building resting on the sloping ground.

3. The performance of Step-back building frames without bracings during seismic excitation can be affected more than other configuration of building frames; however it may be adopted by providing bracing system to control displacement.

4. Step back-Set back building Configuration may be favored on sloping ground.

5. The seismic response of the building changes with inclusion of braces in structure.

6. The presence of cross bracing(x) reduces the storey displacement, storey drifts and time period of all building models resting on flat ground and sloping grounds.

7. Base shear increases by inclusion of braces. The value of maximum base shear increases in braced structure as compare to the unbraced structure. This is due to the increased stiffness of building by addition of braced member.

REFERENCES

[1] S.M.Nagargoje, K.S.sable, "Seismic performance of multi-storey building on sloping ground". Elixir, Dec 2012.
[2] Zaid Mohammad, Abdul Baqi, "Seismic response of Rc framed buildings resting on hill slopes". Sciencedirect.com, Dec 2016.
[3] Sanjith, Ranjith, "Seismic analysis of multi-storey buildings resting on flat ground and sloping ground. IJIRSET, June 2016.
[4] Ravindra Navale, Dr.sandeep Hake, "Analysis of unsymmetrical building resting on sloping ground dividing in 2D frame". IRJET, Volume04, Issue07, July 2017.
[5] Harish ks, Akash k, Amith AP, "Analysis of multi-storey building (G+4) in sloped ground".IJRASET, Volume05, Issue08, July 2017.
[6] Mr.Archin Jain, Dr.Rakesh patel, "Analysis of building constructed on sloping ground for different types of soil". IJARIT, Volume03, Issue06, August 2017.
[7] C.H. Ashok, "Seismic analysis of Step back structure on sloped ground". IJARIIT, Volume03, Dec 2017.
[8] Sindhurashmi.B.M, Bhavani Shanker, "Seismic response of Rc framed structure resting on sloping terrain". IRJET, Volume05, Issue05, July 2018.
[9] Sachinkumar Dangi, Salleem Aktar, "Seismic analysis of Rc building on sloped ground with shear wall at different position". September 2019.
[10] IS-1893-2016(part1), "Criteria for earthquake resistant design of structures". BIS New Delhi.
[11] IS 875(part1), "Code practice for dead loads".1987 BIS, New Delhi.
[12] IS 875(part2), "Code practice for imposed loads".1987 BIS, New Delhi.

BIOGRAPHIES

Satishkumar Guttedar, P,G student, Dept. of Civil Engineering, PDA Institute of Technology, kalburagi, Karnataka, India.

Sujeet Patil, Professor, Dept. of Civil Engineering , PDA Institute of Technology, kalburagi, Karnataka, India.