International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 7, July-2018

SEISMIC ANALYSIS OF MULTISTORIED BUILDING ON SLOPING GROUND WITH GROUND SOFT STOREY AND TOP SOFT STOREY

Abu Zafar Mohammed Irfan[1], Prof. Vishwanath B Patil[2]

[1]P.G.Student, Department of Civil Engineering, Poojya Doddappa Appa college of Engineering, Gulbarga,

[2]Associate Professor, Department of Civil Engineering, Poojya Doddappa Appa college of Engineering, Gulbarga, 585102

Abstract— India is the developing country it's population increases day by day and the density of population is overcrowded in cites due to this human are migrated towards in any direction regardless of ground conditions. In grounds type sloping ground is very unstable in any condition. In sloping ground regions if the earthquake is triggered damages are unaccountable to humans and human shelters, there is chance of total loss of everything, for this reason design and constructions required extra care on sloping ground apart from flat ground's design and constructions. In this study G+21 building analysis and comparison is carried out on sloping ground and flat ground with the help of analysis software E-Tabs. It is observed that sloping ground with ground soft story having height of soft story is increases compare to typical stories, shows lesser value of base shear at base of the building compare to flat ground buildings. Seismic analysis studied by linear static (ESA) and linear dynamic (RSA) method is used.

Keywords— Earthquake, Sloping Ground, E-Tabs, ESA, RSA.

I. INTRODUCTION

Sikkim earthquake of September 18, 2011 was the first trembling in India which uncovered the RC frame buildings on hill slopes to ground trembling and performance of such structures in this rather sensible ground trembling was far from satisfactory. Due to scarcity of flat land in hilly areas, majority of the buildings is constructed on the hill slopes with regular structural configuration having foundations at different levels. Such structures pose special structural and constructional problems. Dynamic characteristics of hill structures (the term has been used in this paper for buildings located on hill slopes) are significantly different from the buildings resting on flat topography, as these are regular and symmetrical in both horizontal and vertical directions. The variation of stiffness and mass in vertical as well as horizontal directions, results in canter of mass and centre of stiffness of a story not coinciding with each other and not being on a vertical line for dissimilar floors. When subjected to lateral loads, these structures are generally subjected to weighty torsional response.

A large portion of India is susceptible to damaging levels of seismic hazards. Hence, it is indispensable to take in to account the seismic load for the design of structures. In structures the lateral loads due to earthquake are a matter of concern. These lateral forces can produce critical stresses in the structure, induce undesirable stresses in the building, induce undesirable vibrations or cause excessive lateral sway of the structure.

1.1 Need of the study

India covers of countless arc of highlands which consists of Himalayas in its northern part which was formed by on-going tectonic collision of plates. Due to the scarcity of the plain terrain in this region there is an obligation of the construction of the houses on the sloping ground. Hence there is need of study of seismic safety and the design of the structures on slopes.

The response of a sloped building depends on frequency content of the earthquake as it affects its performance when it is subjected to ground motion. In this research work study is done by variable sloping angle.

1.2 Objectives

The present work aims at the study of following objectives.

- To Analyse the performance of the regular RCC building resting on slope ground i.e. (10%,15%,20% & 25%) and flat ground consists of Soft story at ground and top of the building under linear dynamic analysis (response spectrum) method in zone IV earthquake region.
- To study numerous responses such as Base shear, Inter storey drift, Displacement, Time-Period,etc.of buildings.
- Comparison of building Responses by considering buildings on different hill slope with flat ground surface building.

1.3 Scope of Study

The analysis is carried out by considering RC framed structures located in seismic zone IV with response reduction factor of 5, importance factor of 1.5, damping of 5%, zone factor 0.24, soil is medium stiff, linear static analysis has been carried out for high rise structures with different slopes with Soft storyes for structure are considered as 10^o, 15^o ,20^o and 25^o degrees. Seismic forces have been applied abiding to the conventions of IS 1893-2002(Part 1) load patterns on the sloped buildings. The principal objective of the analysis is to predict the behavior of the structure using E-tabs software which is based on finite elements and Performance levels of the structure under different conditions are obtained by detailed study of the results from analysis.

I. MODEL DESCRIPTION

2.1 Design Data

Number of Stories	22	Grade of Concrete	M30 (Column, Beams, Slabs and Walls)
1^{st} Floor Height	7.92 m	Grade of Steel	415 Mpa
2^{nd} Floor Height	4.27 m	Live Loads for Other Floors	5 kN/m^2
21^{st} Floor Height	2.44 m	Live Loads for Lift Slab	3 kN/m^2
Typical Floor Height	3.35 m	Super Dead Load	5 kN/m^2
No of Bay in X- Direction	4	Floor Finish Load	1.5 kN/m^2
No Of Bay in Y- Direction	8	Density of RCC	25 kN/m^3
Spacing in X-Direction	12.19 m	Density of Brick Masonry	20 kN/m^3
Spacing in Y-Direction	9.14 m	Beam Size	300 X 1219.2 mm
Columns Size	1828.8 X 1828.8 mm	Slab Thickness	150 mm

2.2Model Description

MODEL NUMBER	DESCRIPTION
MODEL-1	Building on flat ground (0 degrees slope) with Bare Frame (Figure2)
MODEL-2	Building on flat ground (0 degrees slope) with Masonry infills (Figure 3)
MODEL-3	Building On flat ground (0 degrees slope) with Corner shear wall (Figure 4)
MODEL-4	Building on Sloping ground (10 degrees slope) with Bare frame (Figure 5)
MODEL-5	Building on Sloping ground (10 degrees slope) with Masonry Infills (Figure 6)
MODEL-6	Building on Sloping ground (10 degrees slope) with Corner shear wall (Figure 7)
MODEL-7	Building on Sloping ground (15 degrees slope) with Bare frame (Figure 8)
MODEL-8	Building on Sloping ground (15 degrees slope) with Masonry Infills (Figure9)
MODEL-9	Building on Sloping ground (15 degrees slope) with Corner shear wall (Figure 10)
MODEL-10	Building on Sloping ground (20 degrees slope) with Bare frame (Figure 11)
MODEL-11	Building on Sloping ground (20 degrees slope) with Masonry Infills (Figure 12)
MODEL-12	Building on Sloping ground (20 degrees slope) with Corner shear wall (Figure 13)
MODEL-13	Building on Sloping ground (25 degrees slope) with Bare frame (Figure 14)
MODEL-14	Building on Sloping ground (25 degrees slope) with Masonry Infills (Figure 15)
MODEL-15	Building on Sloping ground (25 degrees slope) with Corner shear wall (Figure 16)

2.3 Analysis Methods

Two types of Analysis method are used:-

1. Equivalent Static Method
2. Response Spectrum Method

Equivalent Static Method :-(According to SP-22)

In this method, mass of the structure multiplied by design seismic coefficient, acts statically in a horizontal direction. It is also assumed here that the magnitude of the coefficient is uniform for the entire members of the structure. Design shears at different levels in a building shall be computed from the assumption of linear distribution horizontal accelerations, varying from zero at the base of the structure to a maximum at the top. For important and complicated structures this method is not adequate.

Response Spectrum Method:-(According to SP-22)

It is a dynamic method of analysis. In the calculation of structural response (whether modal analysis or otherwise), the structure should be so represented by means of an analytical or computational model that reasonable and rational results can be obtained by its behavior.

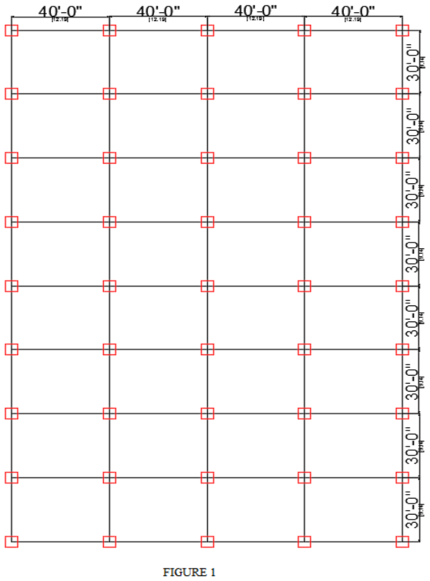


FIGURE 1: Showing details of Plan

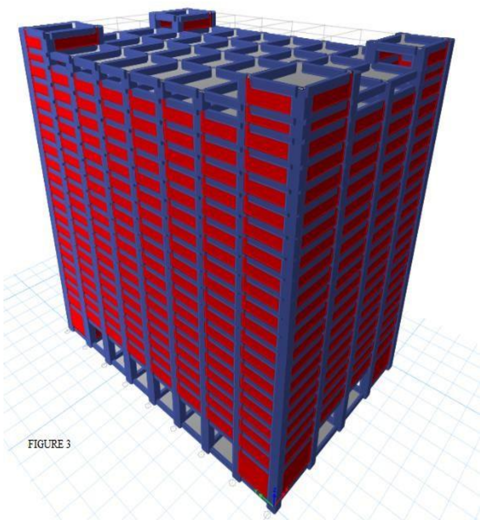


FIGURE 2

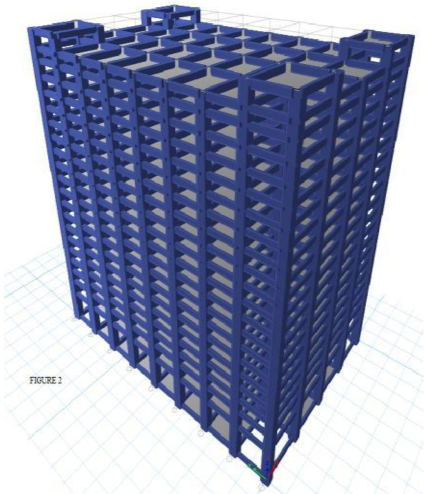


FIGURE 3

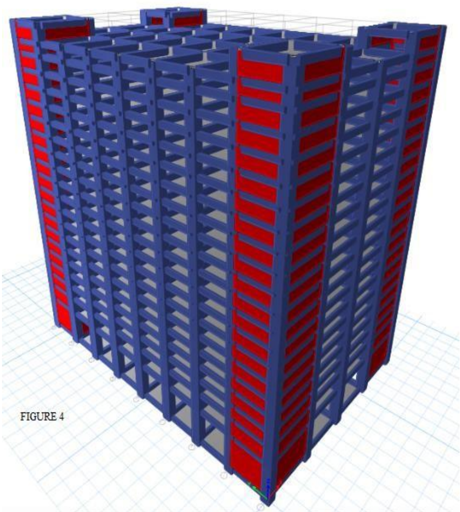


FIGURE 4

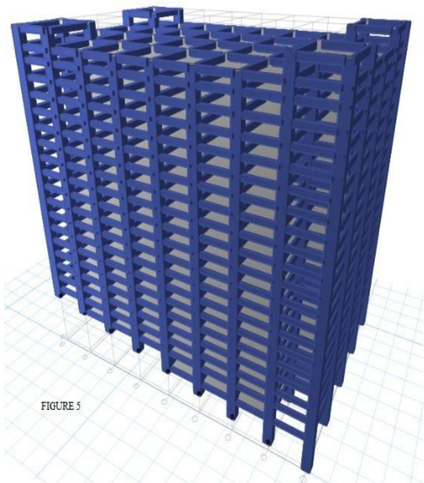


FIGURE 5

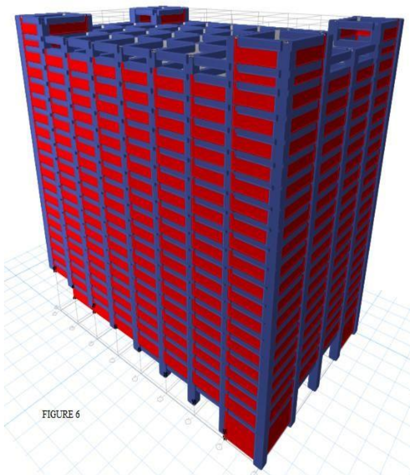


FIGURE 6

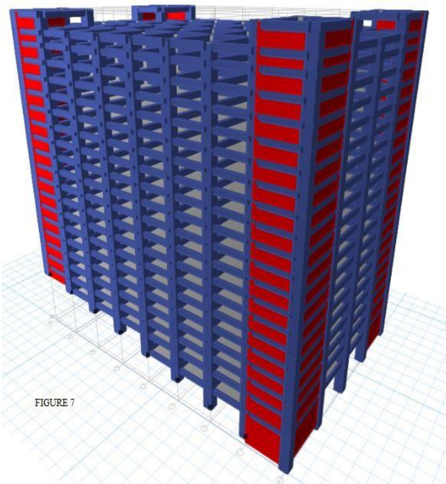


FIGURE 7

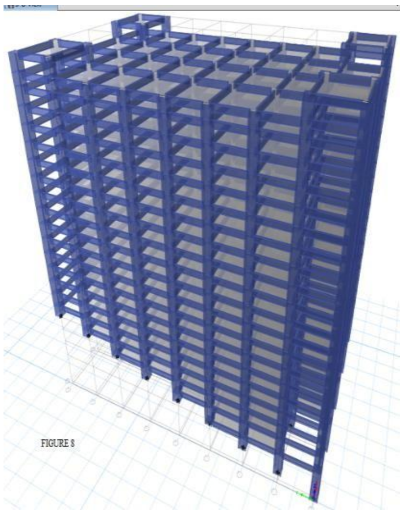


FIGURE 8

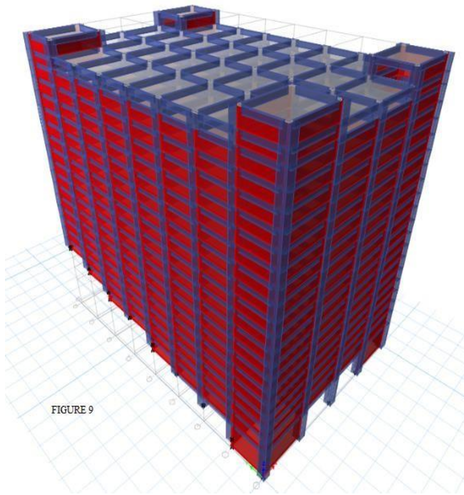


FIGURE 9

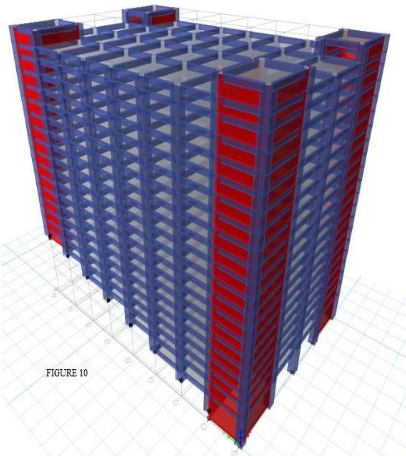


FIGURE 10

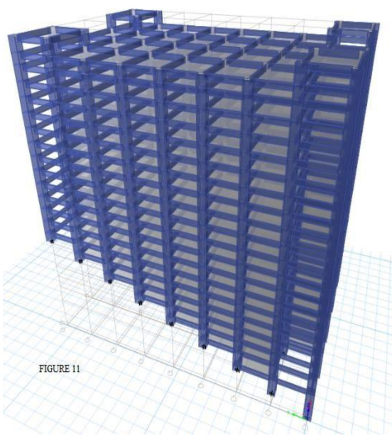


FIGURE 11

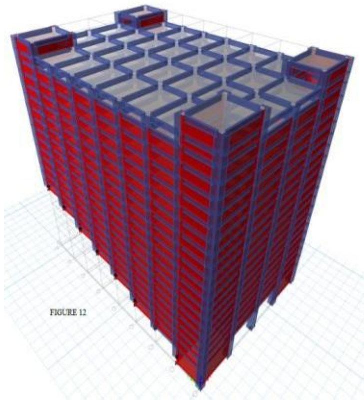


FIGURE 12

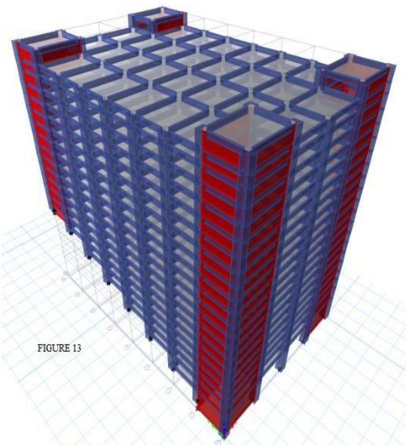


FIGURE 13

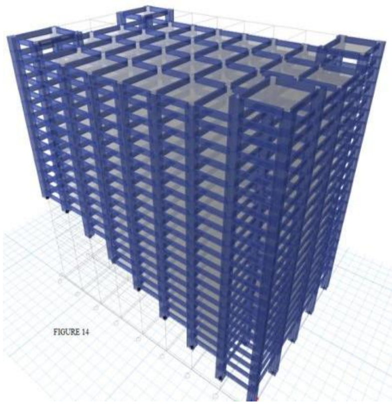


FIGURE 14

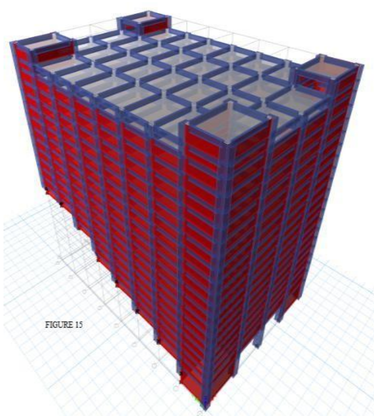


FIGURE 15

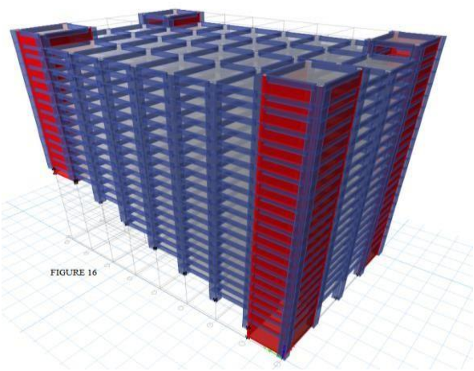
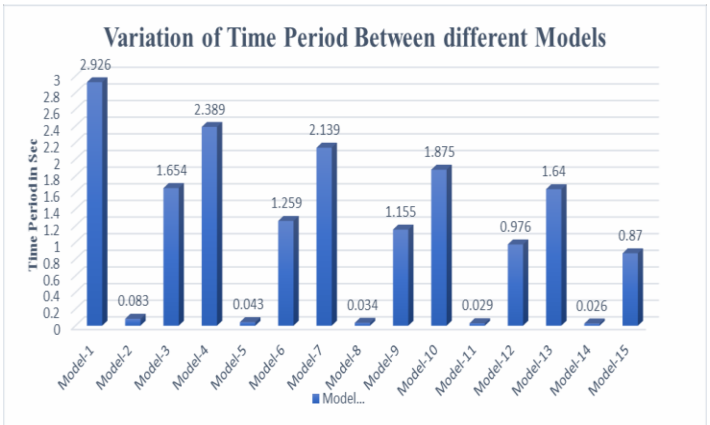


FIGURE 16

II. RESULTS AND DISCUSSION

Table: 1 Fundamental Time Period (Sec)

Model Number	Time Period (Sec)
Mode-1	2.926
Mode-2	0.083
Mode-3	1.654
Mode-4	2.389
Mode-5	0.043
Mode-6	1.259
Mode-7	2.139
Mode-8	0.034
Mode-9	1.155
Mode-10	1.875
Mode-11	0.029
Mode-12	0.976
Mode-13	1.64
Mode-14	0.026
Mode-15	0.87



The fundamental time period as perIS: 1893:2002 Part(I), are evaluated and are presented in the table-1 and Figure-17 for comparison of results. The max value for time period is at model-1 for flat ground model as compared to sloping models. Time period for the flat building is 2.926 sec similarly for 10^{o,} 15^{o}, 20^{o}, 25^{o} is 2.389, 2.139, 1.875, 1.64 sec respectively. Model-4 (10 degree) bare frame model has highest value of time period in all the sloping models. The minimum value of time period is for the model 5,8,14 which has masonry infill. Time period for the masonry model 10^{o,} 15^{o}, 20^{o}, 25^{o} is 0.043, 0.034, 0.029, 0.026 sec respectively.

FIGURE 17: Fundamental Time Period (Sec)

Table: 2 Lateral displacement (mm)

Model No.	EQ-X (mm)	EQ-Y (mm)	RS-X (mm)	RS-Y (mm)
Mode-1	69.3	58.4	54.4	46.47
Mode-2	0.3	0.3	0.3	0.3
Mode-3	39.6	44.1	30.2	33.2
Mode-4	61.2	49	54.4	40.3
Mode-5	0.1	0.1	0.1	0.1

Mode-6	36.2	34.6	33.6	29.8
Mode-7	57	44.6	55.1	38.3
Mode-8	0.1	0.1	0.1	0.1
Mode-9	31.8	31.9	34.8	29.3
Mode-10	51.8	39	54.6	35.9
Mode-11	0.1	0.1	0.1	0.1
Mode-12	27.2	27.1	32.6	26.7
Mode-13	45.4	34.6	49.7	33.9
Mode-14	0.04658	0.04878	0.1	0.1
Mode-15	26.6	23.7	33.1	24.3

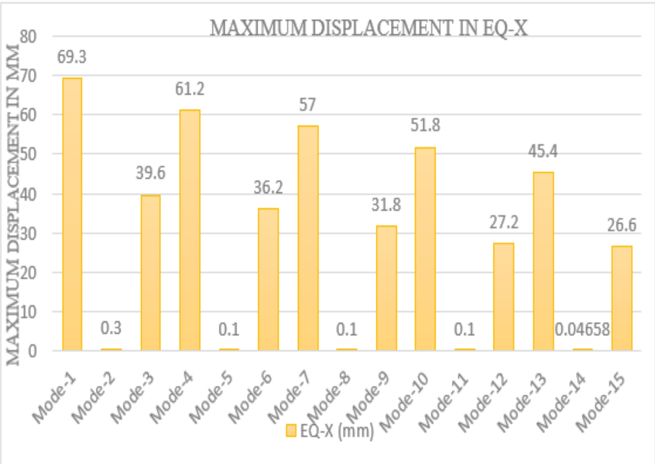


FIGURE 18: Lateral Displacement (mm) in EQ-X

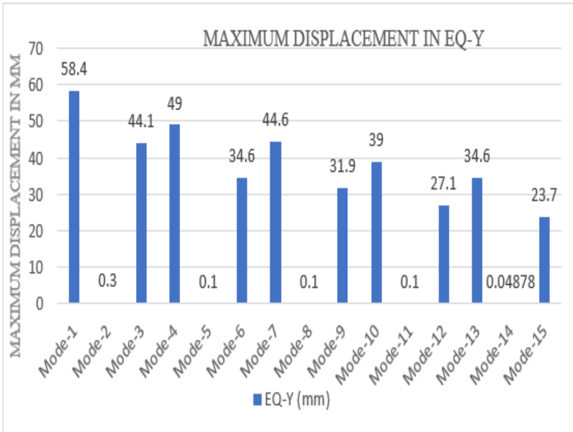


FIGURE 19: Lateral Displacement (mm) in EQ-Y

Displacement results are shown in Table-2 and also in figure-18 to Figure-21 and compare them to get the behaviour of the various buildings. 10-degree bare frame model has highest value of displacement compare to another sloping model of bare frame. Model-1 (0-degree slope) has highest value of displacement compare to all models. Model-14 has least value of displacement compare to all models. Models which contains brick-infills shows lesser displacement values compare to models which contains corner shear walls.

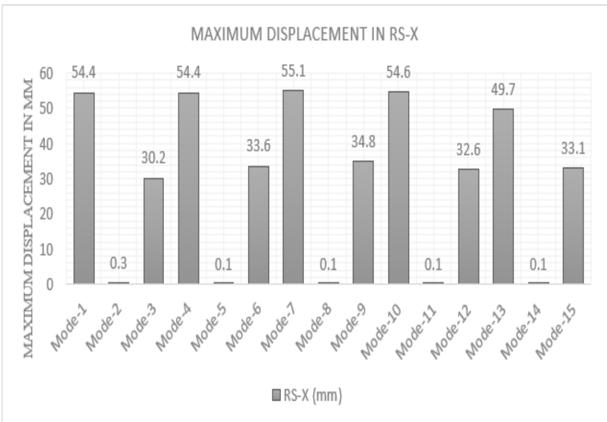


FIGURE 20: Lateral Displacement (mm) in RS-X

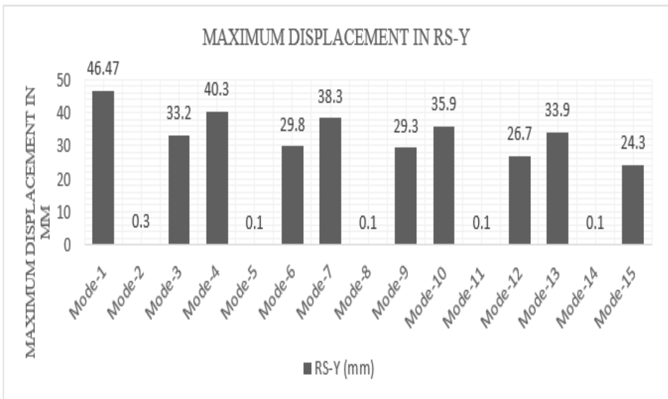


FIGURE 21: Lateral Displacement (mm) in RS-Y

Table 3: Base Shear (kN)

F

Model No.	EQ-X (kN)	EQ-Y (kN)	RS-X (kN)	RS-Y (kN)
Mode-1	17584.6952	20394.0173	17598.7312	20403.1402
Mode-2	138713	138713	138828.8618	138812.2164
Mode-3	38371.6469	31962.0315	38392.483	31537.2995
Mode-4	19734.1898	23450.4259	19723.9513	23444.0788
Mode-5	126939	126939	126922.5433	126922.5433
Mode-6	31009.523	29402.688	31039.373	29418.9119
Mode-7	20895.4194	25165.4261	20889.4415	25155.2275
Mode-8	121154	121154	121262.0182	121252.8633
Mode-9	47306.7567	39826.6227	47287.7059	39825.126
Mode-10	21970.2217	27176.5404	21968.2462	27196.1077
Mode-11	111502	111502	111503.5697	111614.8387
Mode-12	51749.7308	43440.3608	51737.613	43483.5497
Mode-13	23319.5623	28492.1749	23335.0706	28521.0078
Mode-14	103422	103422	103519.4579	103533.1534
Mode-15	48020.4212	45300.6486	48057.9762	45332.0502

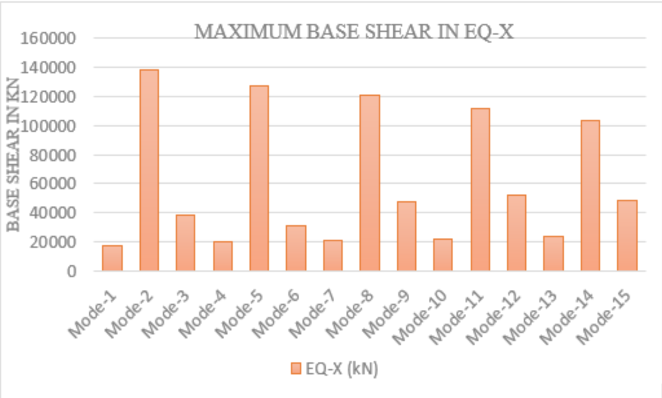


FIGURE 22: Base Shear(kN) in EQ-X

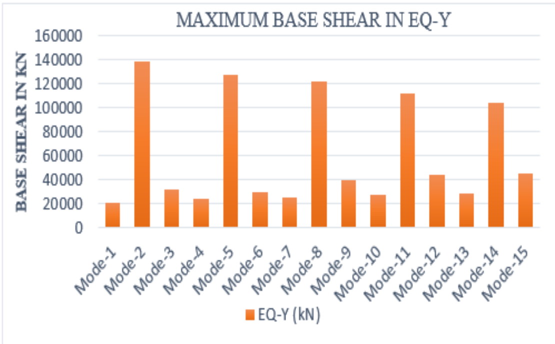


FIGURE 23: Base Shear (kN) in EQ-Y

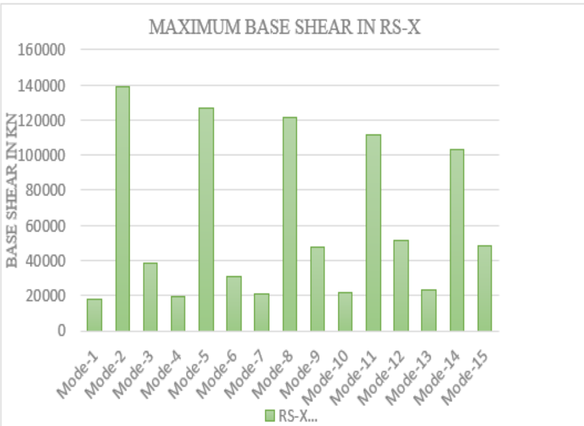


FIGURE 24: Base Shear (kN) in RS-X

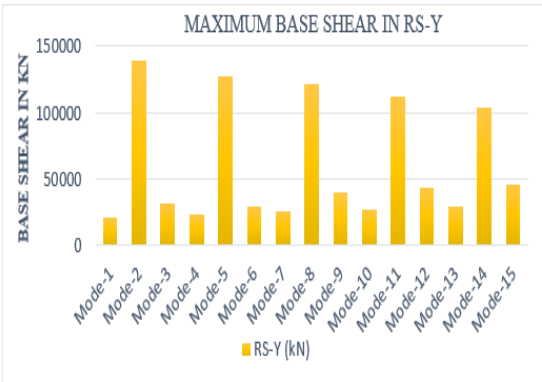


FIGURE 25: Base Shear (kN) in RS-Y

The result for the base shear are shown in the Table-3 and Figure-22 to 25. Model-2 shows highest value of base shear compare to other 0-degree models. Model-5 shows highest value of base shear compare to other 15°, 20°, 25° sloping models. 0-Degree model has highest value of base shear compare to sloping ground models. Models containing brick infills on sloping ground shows highest value of base shear compare to all the configurations models on sloping ground. Models containing corner L-type shear walls shows lesser values of base shear compare to the models containing brick infills walls. It can be suggested that L-type shear walls can be used on sloping ground.

Table 4: Story Drift (m)

Model No.	EQ-X (mm)	EQ-Y (mm)	RS-X (mm)	RS-Y (mm)
Mode-1	0.001251	0.001056	0.001056	0.000934
Mode-2	0.000008	0.00002	0.000008	0.00002
Mode-3	0.000641	0.000702	0.000488	0.000533
Mode-4	0.001273	0.001086	0.001184	0.000937
Mode-5	0.000003	0.000005	0.000003	0.000003
Mode-6	0.000655	0.000648	0.000605	0.000561
Mode-7	0.001284	0.001098	0.001285	0.000974
Mode-8	0.000003	0.000005	0.000003	0.000003
Mode-9	0.000629	0.000674	0.000693	0.000625
Mode-10	0.001269	0.001092	0.001366	0.001021
Mode-11	0.000002	0.000005	0.000002	0.000005
Mode-12	0.000603	0.000653	0.000727	0.000649
Mode-13	0.001226	0.001067	0.001365	0.001052
Mode-14	0.000002	0.000004	0.000002	0.000005
Mode-15	0.000566	0.000627	0.000712	0.000647

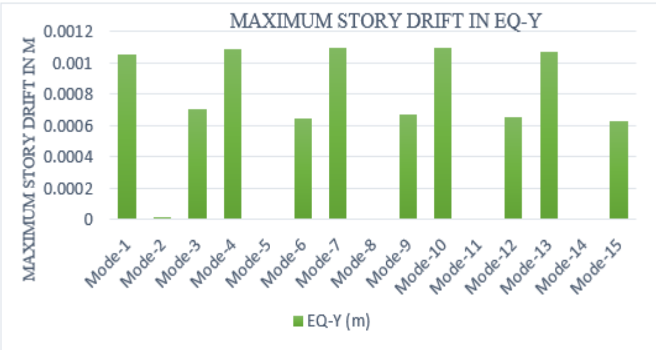


FIGURE 26: Story Drift (m) in EQ-X

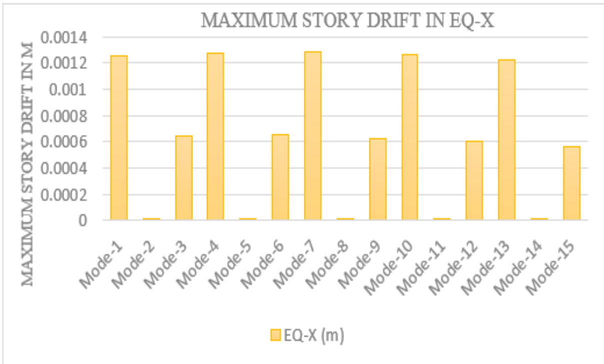


FIGURE 27: Story Drift (m) in EQ-Y

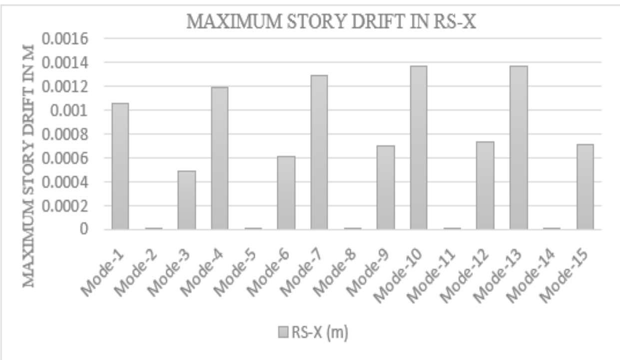


FIGURE 28: Story Drift (m) in RS-X

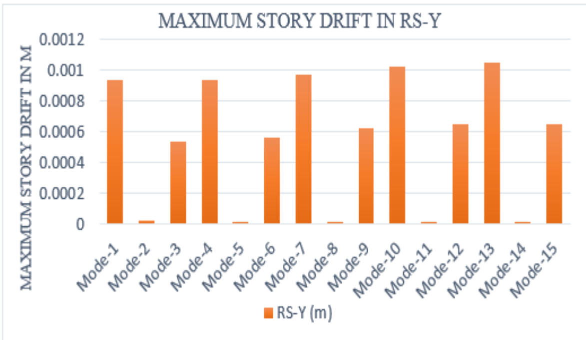


FIGURE 29: Story Drift (m) in RS-Y

Results for inter story drift is shown in Table-4 for all cases of hill sloped buildings and flat surface building and also comparison in Figure-26 to Figure-29. Masonry model has less story drift as compared to bare frame and shear wall model because the stiffness of the brick infill model is more. Bare frame model has more story drift compared to other configuration of model as the structure is more flexible. Story drift decreases for L-type shear wall model considerably as compared to bare frame.

III. CONCLUSIONS

From the above study the following conclusions are inscribed.

1. It has been seen that the value of time-period is slightly changes when slopes of the building changes i.e. time-period decreases with increase in slope.
2. Of all the models the masonry model has least value of time-period because of increase in stiffness of the structure as compared to bare frame and shear wall structure.
3. As the slope of the building increases, displacement is decreases.
4. It's concluded that as the slope of the building increases displacement value decreases and we can achieve lesser displacement by using brick infills.
5. The results show that building with brick infills on 25-degree slope is stable compare to other combinations on sloping ground.
6. As the slope of the building increases the value of base shear decreases.
7. Models containing brick infills on sloping ground shows highest value of base shear compare to all the configurations models on sloping ground.
8. Models containing corner L-type shear walls shows lesser values of base shear compare to the models containing brick infills walls. It can be suggested that L-type shear walls can be used on sloping ground.
9. Masonry model has less story drift as compared to bare frame and shear wall model because the stiffness of the brick infill model is more.
10. Bare frame model has more story drift compared to other configuration of model as the structure is more flexible.
11. Story drift decreases for L-type shear wall model considerably as compared to bare frame.
12. As the sloping of the ground increases the story drift also increases for bare frame models.

REFERENCES

1. Abu Zafar Mohammed Irfan, Vishwanath B Patil. "Review On Seismic Analysis Of Multistoried Building On Sloping Ground". Volume: 05 Issue: 01 ,Jan-2018 www.irjet.net e-ISSN: 2395-0056 p-ISSN: 2395-0072.
2. A.R. Chandrasekaran and D. S. Prakash Rao (2002), A seismic Design of Multi-storied RCC Buildings.
3. Birajdar.B.G,"Seismic analysis of buildings resting on sloping ground", 13thWorld Conference on Earthquake Engineering, Vancouver, B.C., Canada, Paper No. 1472, 2004.
4. Y. Singh and Phani Gade "Seismic Behavior of Buildings Located on Slopes" - An Analytical Study and Some Observations From Sikkim Earthquake of September 18, 2011. 15th World Conference on Earthquake Engineering Journal 2012.
5. Ravikumar C M,*, Babu Narayan K S "Effect of Irregular Configurations on Seismic Vulnerability of RC Buildings" Architecture Research2012,2(3):20-26DOI: 10.5923/j.arch.20120203.01.
6. S.M.Nagargoje and K.S.Sable," Seismic performance of multi-storeyed building on sloping ground", Elixir International Journal, 7 December 2012.
7. Y. Singh and Phani Gade "Seismic Behavior of Buildings Located on Slopes" - An Analytical Study and Some Observations From Sikkim Earthquake of September 18, 2011.15th World Conference on Earthquake Engineering Journal 2012.
8. N. Jitendra Babu, K .Y.G.D Balaji "pushover analysis of unsymmetrical framed structures on sloping ground" International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD) ISSN 2249- 6866 Vol. 2 Issue 4 Dec - 2012 45-54.
9. Ajay Kumar Sreerama, Pradeep Kumar Ramancharla (2013), Earthquake behavior of reinforced concrete framed buildings on hill slopes. iternational Symposium on New Technologies for Urban Safety of Mega Cities in Asia (USMCA 2013) Report No: IIIT/TR/2013/-1.

10. Dr. S. A. Halkude et al "Seismic Analysis of Buildings Resting on Sloping Ground With Varying Number of Bays and Hill Slopes" International Journal of Engineering Research and Technology ISSN:2278-0181,Vol.2 Issue 12, December-2013.

11. Prashant D, Dr. Jagadish Kori G " Seismic Response of one way slope RC frame building with soft storey" International Journal of Emerging Trends in Engineering and Development Issue 3, Vol.5 (September 2013).

12. Rayyan-Ul-Hasan Siddiqui and , H. S. Vidyadhara "Seismic Analysis of Earthquake Resistant Multi Bay Multi Storeyed 3D – RC Frame" International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 2 Issue 10, October – 2013.

13. Sujit kumar, Dr. Vivek garg, Dr. Abhay sharma (2014), "Effect Of Sloping Ground On Structural Performance Of Rcc Building Under Seismic Load", ISSN: 2348-4098 VOLUME 2 ISSUE 6 AUGUST 2014 (VER II).

14. Mohammed Umar Farooque Patel et al "A Performance study and seismic evaluation of RC frame buildings on sloping ground" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X-, PP 51-58,2014.

15. Shivanand.B, H.S Vidyadhara "Design of 3D RC Frame on Sloping Ground" International Journal of Research in Engineering & Technology eISSN-2319-1163 pISSN :2312-7308 Volume 3 Issue:08 Aug 2014.

16. G.Suresh, and E.Arunakanth, "Seismic Analysis of Buildings Resting on Sloping Ground and Considering Bracing System",International Journal of Engineering Research and Technology, Vol. 3,pp. 2278-0181, 2014.

17. Dr. R. B. Khadiranaikar1 and Arif Masali2 Seismic performance of buildings resting on sloping ground. IOSR J Mech Civ Eng (IOSR-JMCE) 11(3):12–19.

18. Prasad Ramesh Vaidya, "Seismic Analysis of Building with Shear Wall on Sloping Ground". International Journal of Civil and Structural Engineering Research ISSN 2348-7607 (Online) Vol. 2, Issue 2, pp: (53-60), Month: October 2014 - March 2015, Available at: www.researchpublish.com.

19. S.K.Deshmukh, and F.I.Chavan "Seismic Analysis of R.C.C. Building Resting on Sloping Ground", International Journal of Pure and Applied Research in Engineering and Technology, Vol. 3, pp.119-133, 2015.

20. A.S.Swathi, G.V. Rama Rao, R. A. B. Depaa "Seismic Performance Of Buildings On Sloping Grounds". IJIREST volume 4, special issue 6, (May2015).

21. Narayan Kalsulkar And Satish Rathod " Seismic analysis of RCC building resting on sloping ground with varying number of bays and hill slopes". IJCET journal volume 5.No.3 (june 2015) paper No 2063.

22. R. Nagarjuna, and S.B.Patil, "Lateral Stability of Multistorey Building on Sloping Ground", International Research Journal of Engineering and Technology, Vol.02, pp.2395-0072, 2015.

23. Paresh G. Mistry, Hemal J. Shah. "Seismic Analysis of Building on Sloping Ground Considering Bi-Directional Earthquake". International Journal of Scientific Development and Research (IJSDR) www.ijsdr.org. ISSN: 2455-2631 © April 2016 IJSDR | Volume 1, Issue 4.

24. Likhitharadhya Y R, Praveen J V, Sanjith J, Ranjith A. "Seismic Analysis of Multi-Storey Building Resting On Flat Ground and Sloping Ground". IJIRSET, (An ISO 3297: 2007 Certified Organization) Vol. 5, Issue 6, June 2016.

25. Shivakumar Ganapati, Shivaraj Mangalgi. "pushover analysis of rc frame structure with floating column on sloping ground". (IRJET) e-ISSN: 2395-0056 Volume: 04 Issue: 08 | Aug -2017 www.irjet.net p-ISSN: 2395-0072.

26. Ravindra Navale, Dr. Sandeep Hake, Pramod Kharmale. "analysis of unsymmetrical building resting on sloping ground by dividing in 2d frame". (IRJET) e-ISSN: 2395-0056 Volume: 04 Issue: 07 | July -2017 www.irjet.net p-ISSN: 2395-0072.

27. Naveen Kumar S M, Vasipalli Vamsi Krishna Reddy, Supriya C L. "Analysis and Comparison of Step Back RC Frame Building on Sloping Strata and Plain Strata". © 2017 IJRTI | Volume 2, Issue 9 | ISSN: 2456-3315.