International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 04 | Apr 2019 www.irjet.net p-ISSN: 2395-0072

Critical Analysis of Regular Building on Sloping Ground Amlibari, Nandurbar (Maharashtra)

Md Zaid[1], Hafiz Ashraf Alam[2], Khan Imran[3], Mohammed Ibrahim Gori[4], Saddam Hussain[5], Huzefa Shaikh[6]

[1,2,3,4&5] *Final Year Civil Engineering, Jamia Institute of Engineering & Management Studies, Akkalkuwa, K.B.C. North Maharashtra University, Maharashtra, India*

[6] *Professor Dept. of Civil engineering & Jamia Institute of Engineering & Management Studies, Akkalkuwa, K.B.C. North Maharashtra University, Maharashtra, India*

Abstract:- *The hilly areas in north east India contained seismic activity. Due to hilly areas building are required to be constructed on sloping ground due to lack of plain ground. The buildings are irregularly situated on hilly slopes in earthquake areas therefore many damages occurred when earthquake are affected, this may be causes lot human disaster and also affect the economic growth of these areas. The structures are generally constructed on level ground; however, due to scarcity of level grounds the construction activities have been started on sloping grounds. There are two types of configuration of building on sloping ground, the one is step back and the other is step back setback. In this study, G+4 storeys RCC building and the ground slope is 14^0. A comparison has been made with the building resting on level ground. The modelling and analysis of the building has been done by using structure analysis tool STAAD-PRO (v8i), to study the effect of varying height of the column in bottom storey at different position during the earthquake. The seismic analysis was done by the response spectrum analyses have been carried out as per IS: 1893 (part 1): 2002. A RCC Medium rise building of (G+4) storey with floor height of 3m is analyzed using Response Spectrum method on 14°slope ground. The Plan of the building shown to carry out the study i.e. the dimension of building is 18m x 12m x 13.3m.*

Key Words: STAAD-PRO, Sloping Ground, Step Back Building, Seismic, Soil Testing, Structure Analysis, Number of Bays.

1. INTRODUCTION

India has track record of catastrophic earthquakes, at various regions, which left behind loss of many lives and heavy destruction to property and economy. Analysis of buildings in hill region is somewhat different than the buildings on leveled ground, since the column of the hill building rests at different levels on the slope. Such buildings have mass and stiffness varying along the vertical and horizontal planes resulting the center of mass and center of rigidity do not coincide on various floors, hence they demand torsional analysis, in addition to lateral forces under the action of earthquakes. Earthquakes themselves do not kill people, rather the colossal loss of human lives and properties occur due to the destruction of structures. Building structures collapse during severe earthquakes, and cause direct loss of human lives. Numerous research works have been directed worldwide in last few decades to investigate the cause of failure of different types of buildings under severe seismic excitations. Massive destruction of high-rise as well as low rise buildings in recent devastating earthquake proves that in developing counties like India, such investigation is the need of the hour. Hence, seismic behavior of asymmetric building structures has become a topic of worldwide active research. 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.

Now days, rapid construction is taking place in hilly areas due to scarcity of plain ground. As a result the hilly areas have marked effect on the buildings in terms of style, material and method of construction leading to popularity of structures in hilly regions. Due to sloping profile, the various levels of such structures step back towards the hill slope and may also have setback also at the same time. These structures become highly uneven and asymmetric, due to variation in mass and stiffness distributions on different vertical axis at each floor. Such construction in earthquake prone areas makes them to attract greater shear forces and torsion compared to normal construction. The process in which behavior of soil affects the motion of the structure and motion of the structure affects the behavior of soil is termed as soil-structure interaction (SSI). Buildings were analyzed for different soil conditions using STAAD Pro software idealized by equivalent springs. It was found that as time period increases, response reduction factor decreases but was found to be the same after certain time period. India having a great arc of mountains consisting of the Himalayas defines the northern Indian subcontinent. These were formed by the on-going tectonic collision of the Indian and Eurasian plates where housing densities of approximately 62159.2 per Sq. Km are around as per 2011 Indian census. Hence there is a requirement to research to be done on the seismic safety factor and designing of these structures on terrain plane. Slope is an important component in scientific, military and civilian analyses. Various methods exist for calculating slope. Manual slope generation, based upon contour line information, is a long established and generally acceptable method.

2. LITERATURE REVIEW

2.1.1 Vrushali S. Kalsait, Dr. Valsson Varghese:-

In this paper the structural analysis software STAAD Pro v8i' is used to study the effect of sloping ground on multistoried building performance during earthquake. The purpose of the paper is to perform linear static analysis of medium height RC buildings and investigate the changes in structural behavior due to consideration of sloping ground.

2.1.2 Sujit Kumar, Dr.Vivek Garg, Dr. Abhay Sharma:-

The author emphasize for proper planning and construction practices of multistoried buildings on sloping ground. However, in normal design practice the designers generally ignore the effect of sloping ground on the structural behavior of the building. The seismic analysis of a G+4 storey RCC building on varying slope angles i.e., 7.5° and 15° is studied and compared with the same on the flat ground.

2.1.3 Mohammed Umar Farooque Patel, A.V.Kulkarni, Nayeemulla Inamdar:-

The Buildings on hill differ from other buildings. The various floors of such building steps back towards the hill slope and at the same time buildings may have setbacks also. Buildings situated in hilly areas are much more vulnerable to seismic environment. In this study, 3D analytical model of eight storied buildings have been generated for symmetric and asymmetric building Models and analyzed using structural analysis tool E-tabs to study the effect of varying height of columns in ground storey due to sloping ground and the effect of shear wall at different positions during earthquake. Seismic analysis has been done using Linear Static, Linear Dynamic method and evaluated using pushover analysis.

2.1.4 Ajay K SREERAMA and Pradeep K Ramancharl:-

In this paper, the study of the behavior of a G+3 building on varying slope angles i.e., 15°, 30°, 45°and 60° is studied and compared with the same on the flat ground. Building is designed as per IS 456 and later subjected to earthquake loads. It was observed that as the slope angle is increasing, building is becoming stiffer. Two types of analyses were conducted viz., lateral load analysis and incremental dynamic analysis. It was observed from the initial results that the columns on the higher side of the slope i.e., short columns were subjected to more shear force then longer columns on the lower side. Finite element method is used to study the static behavior where as Applied Element Method (AEM) is used to perform incremental dynamic analysis.

2.1.5 Nagargoje S.M., Sable K.S:-

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. 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. The buildings situated on hill slopes in earthquake prone areas are generally irregular, torsionally coupled & hence, susceptible to serve damage when affected by earthquake ground motion. Such buildings have mass & stiffness varying along the vertical & horizontal planes, resulting the center of mass & center of rigidity do not coincide on various floors, hence they demand torsional analysis, in addition to lateral forces under the action of earthquakes. These unsymmetrical buildings require great attention in the analysis & design. Analysis of hill buildings is somewhat different than the buildings on leveled ground, since the column of hill building rests at different levels on the slope. The shorter column attracts more forces & undergoes damage, when subjected to earthquakes.

2.2 Site Study:-

When we study about site on March end then we observe that temperature of the area is almost 38^0 to 42^0 C, and topography of ground is 14^0 Sloping is observed and also saw that soil type is Black cotton gravel soil which shows some difficulties for high rise building. So we design only for G+4. Moisture content present in the soil is 7-10%. And wind intensity is high as compare to other region so we face many problems at the time of designing.

Fig (1) Site Survey

2.3 Collection of Sample and Their Analysis:-

Firstly we collected the soil for checking of Moisture content, liquid limit and plastic limit.

After that we collect the sample in pycnometer for testing of specific gravity and we also find out the density of soil by core cutter and sand replacement method both. And we also survey the site and plotting the ground and find out the area of plot and decide the numbers of columns and analysed other requirement as per designing.

3. METHODOLOGY

3.1 Density of Soil:-

- Measure the inside dimension of the core cutter and calculate its volume. Weigh the core cutter accurate to 1 gm.
- Expose the small area, about 30cm square to be tested and level it. Put the dolly on the top of the core cutter and drive the assembly into the soil with help of the rammer unit the top of the dolly protrude about 1.5 cm above the surface.
- Dig out the container from the surrounding soil and allow some soil to project from the lower end of the cutter. With the help of the straight edge, trim flat the end of the cutter. Take out the dolly and also trim flat the other end of the cutter.
- Weight the cutter full of the soil.
- Keep some representative specimen of soil for water content determination.
- Repeat the test at two or three location nearby and get the average dry density.

3.2 Specific gravity of the soil by pycnometer:-

- Clean the pycnometer and dry it. Find the mass of the pycnometer, brass cap and washer, accurate to one gm.
- Take about 200 to 400gm of oven dried soil and put it in the pycnometer. Find the mass of the pycnometer plus soil etc.
- Fill t5hwe pycnometer to half its height with distilled water and mix it thoroughly with glass rod add more water and stirrer it. Replace the screw top and fill the pycnometer flush with hole in the conical cap dry the pycnometer from outside, and find the mass.
- Empty the pycnometer cleans it thoroughly and fills with distilled water to the hole of the conical cap and find the mass.
- Repeat step 2 to 4 for two more determination of specific gravity.

3.3 Plastic limit of soil:-

- Take about 20 gm. of air dried soil from the thoroughly mixed portion of the material passing 420 micron IS sieve. Mix it on a marble plate with sufficient distilled water to make it plastic enough to be shaped into a ball. Leave the plastic soil mass for some times ton mature. Some fat clays the plastic soil mass to be left to stand for 24 hours to allow water to permit throughout the soil mass.
- Take about 8 gm. of plastic soil, make a ball of it, and roll it on the marble plate with hand with just sufficient pressure to roll the mass into a thread of uniform diameter throughout its length. When the diameter of the thread has decreased to 3mm, the specimen is kneaded together and rolls out again.

Continue the process until thread just crumbles 3mm diameter.

- Collect the crumbled soil thread in the air tight container and keep it for water contain determination the taste is repeated twice more thus three readings are obtained for the determination.
- Also, determine the natural water content of the soil sample obtained from the field.

3.4 Liquid limit of soil:-

- Take about 120 gms of soil sample on a glass plate passing through 425 micron sieve.
- Add distilled water and mix it thoroughly and is left for a suitable maturing time, generally 15 to 30 mins for an average soil.
- Take a small portion of the paste in the cup and leveled it with a spatula to give a maximum depth of 10 mm.
- Cut a straight groove, by using grooving tool, through the paste. ASTM tool is used for sandy soil and casagrande tool is used for clay soil.
- Turn the handle of the apparatus at a rate of 2 revolutions per sec until the edges of the groove come in contact for length of approximately 10 mm along the groove. Note down the number of revolution from the counter.
- Take about 10 to 15 gms of the soil from the cup to a container for water content test.
- This process is repeated at least 3 times with increased water content. Number of revolution obtained in all the tests should lie between15 to 35.
- A graph is drawn in a semi-log graph paper with water content as ordinate on linear scale and number of revolution/blows as abscissa on log scale.
- Tine water content corresponding to 25 blows is read as liquid limit of the soil sample.

3.5 Analysis and Modeling by (STAAD PRO) :-

- Study of Indian design code provision for analysis of building on sloping ground.
- Select a building model for the case study.
- A RCC Medium rise building of (G+4) storeys with floor height of 3m subjected to earthquake loading is analyzed by using Response Spectrum Analysis in STADD PRO.
- Effect of sloping angle of the ground on behavior of structural frames is to be analyzed. Displacement, axial forces and bending moment have to be calculated for different columns.
- The Plan of the building shown has to be considered to carry out the study the dimension of building is 18m x 12m x 13.3m.

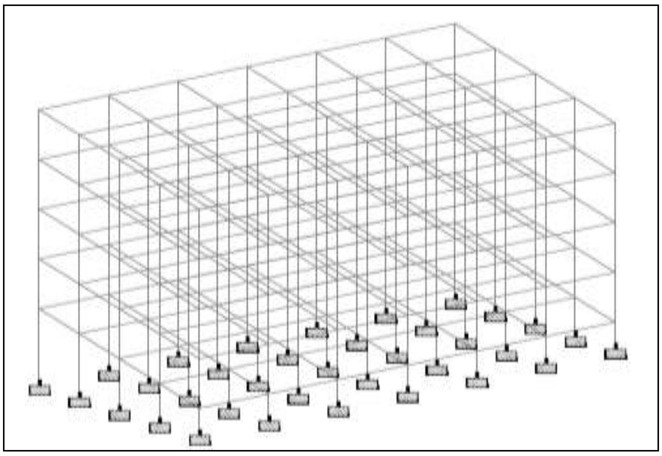


Fig (a) 3D view

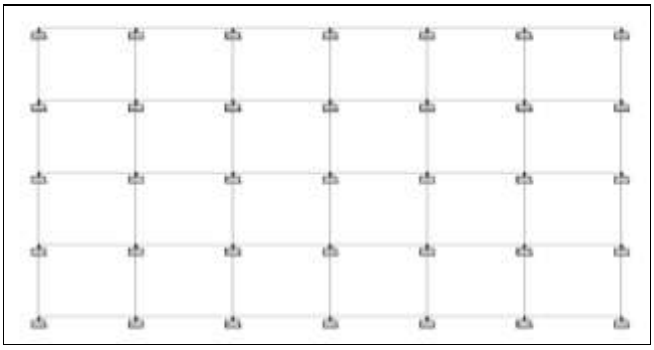


Fig (b) Plan of Building

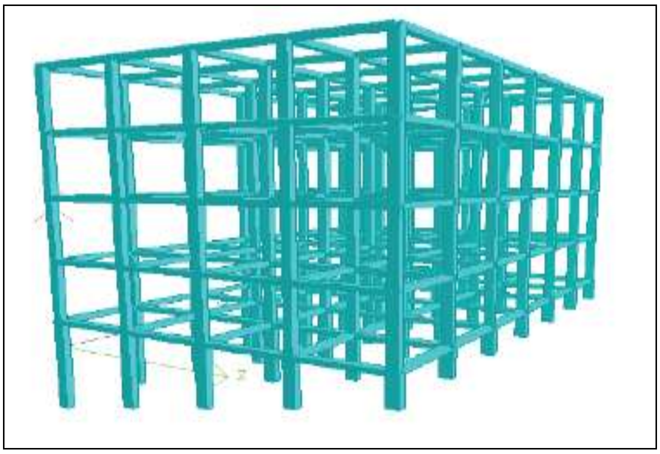
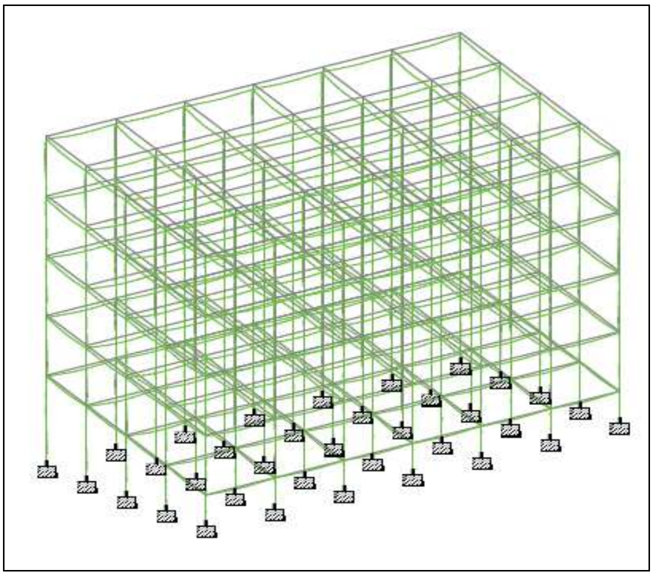
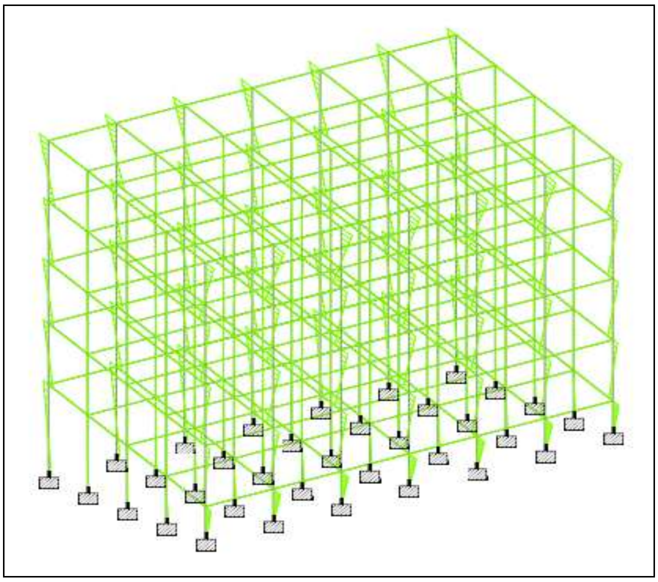


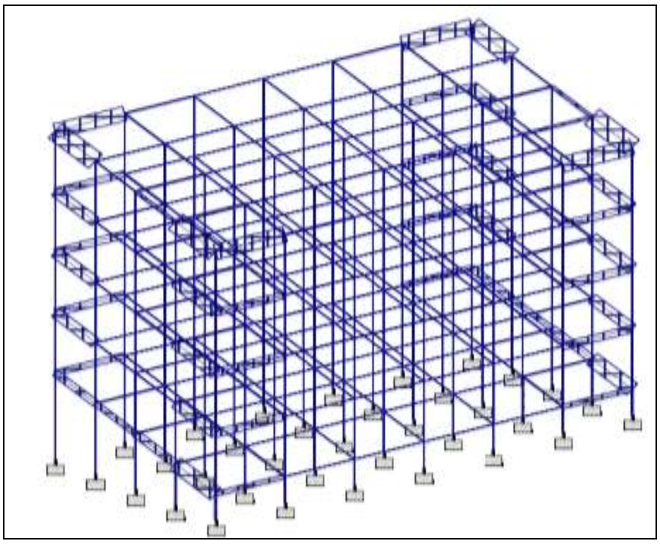
Fig (c) 3D Render View



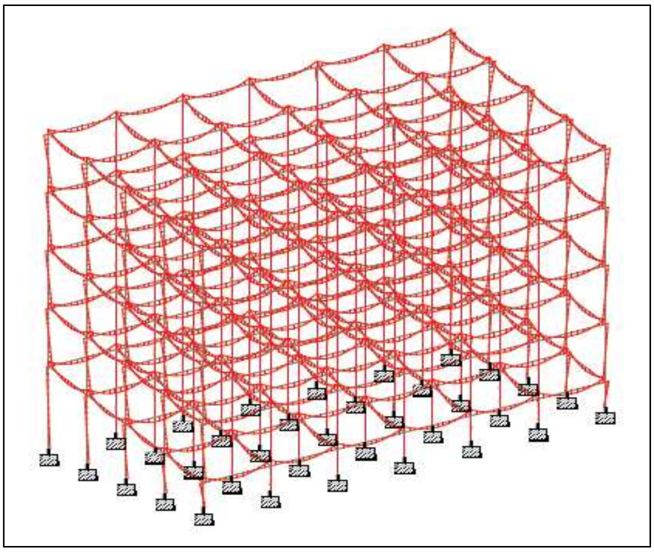
Fig(d) Displacement



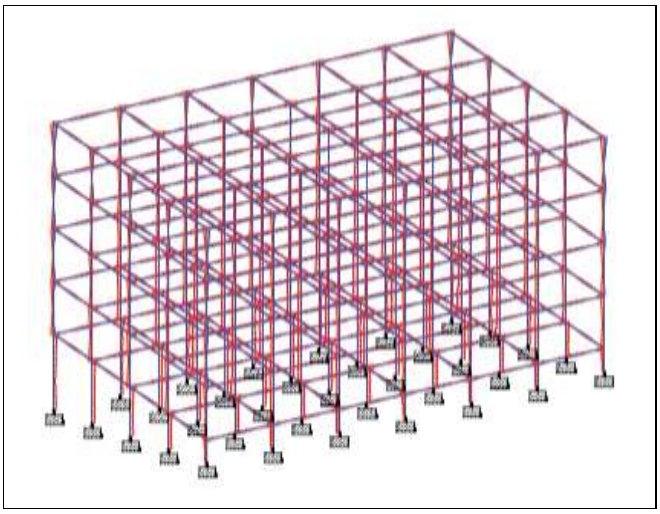
Fig(f) Bending Y



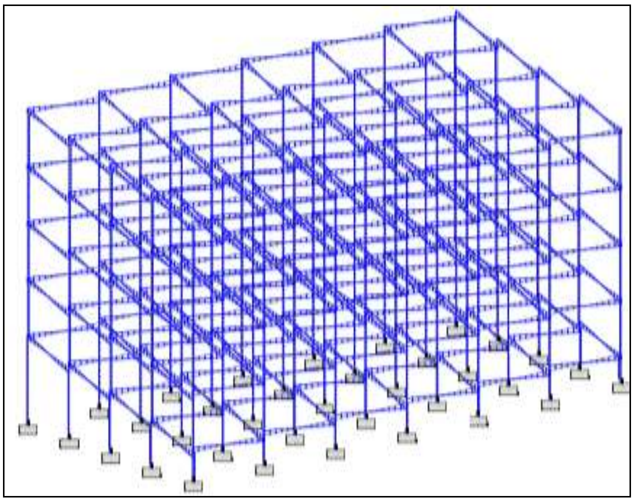
Fig(e) Torsion



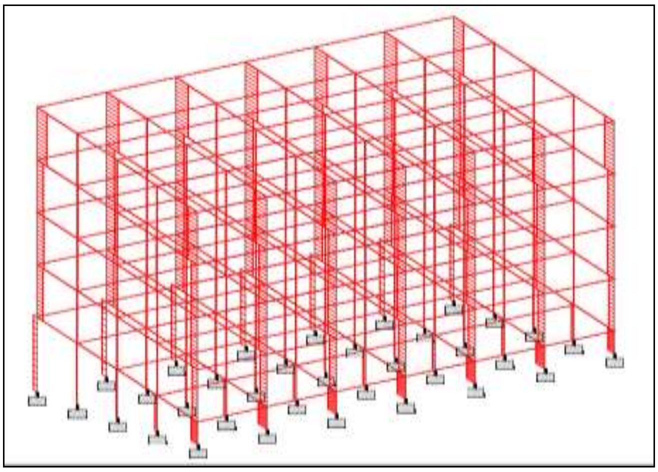
Fig(f) Bending Z



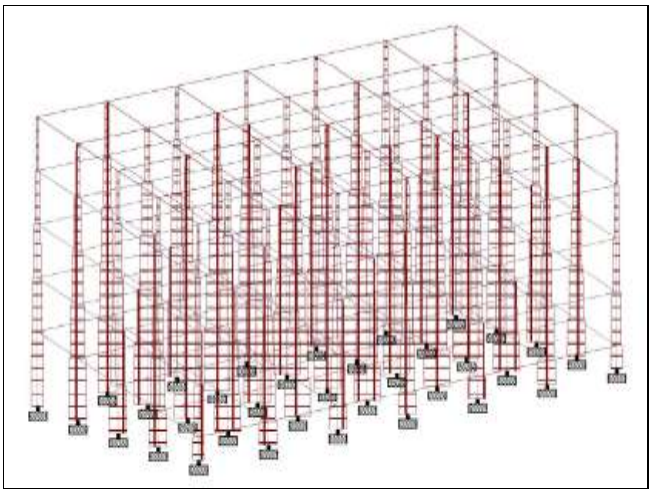
Fig(f) Beam Stress



Fig(g) Shear Y

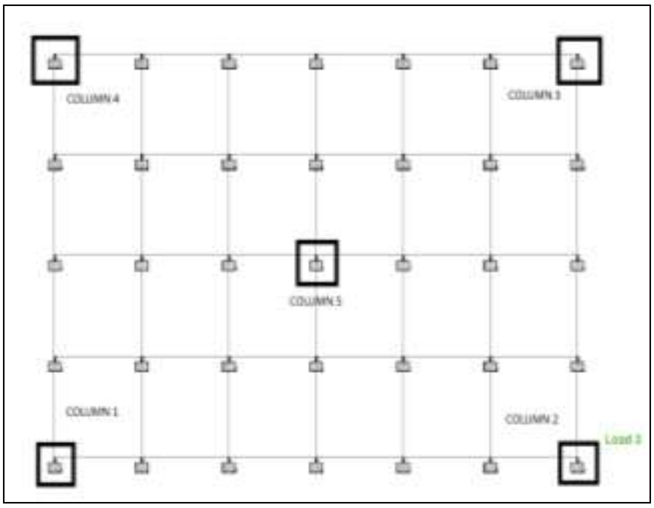


Fig(h) Shear Z



Fig(I) Axial Force

4. RESULTS



Fig(j) Different Position of Column in Plan

Table -1: Results for Axial Force, Shear in "Y" & Shear in "Z"

COLUMN	Axial Force kN	Shear-Y kN	Shear-Z kN
59	251.864	-6.673	-3.607
	-247.637	6.673	3.607
65	251.864	6.673	-3.607
	-247.637	-6.673	3.607
104	575.744	0	-0.481
	-584.848	0	0.481
115	250.522	-1.31	-2.066
	-264.471	1.31	2.066
121	250.522	1.31	-2.066
	-264.471	-1.31	2.066
122	207.331	-3.645	3.633
	-200.015	3.645	-3.633
128	207.331	3.645	3.633
	-200.015	-3.645	-3.633
139	466.536	0	-0.251
	-459.221	0	0.251
150	204.471	-2.924	-3.147
	-197.155	2.924	3.147
156	204.471	2.924	-3.147
	-197.155	-2.924	3.147
215	155.698	-3.624	4.045
	-148.382	3.624	-4.045
221	155.698	3.624	4.045
	-148.382	-3.624	-4.045
232	350.017	0	-0.156
	-342.701	0	0.156
243	153.69	-3.511	-3.914
	-146.374	3.511	3.914
249	153.69	3.511	-3.914
	-146.374	-3.511	3.914
308	103.443	-3.57	3.811
	-96.127	3.57	-3.811
314	103.443	3.57	3.811
	-96.127	-3.57	-3.811
325	233.413	0	-0.15
	-226.098	0	0.15
336	102.17	-3.377	-3.637

	-94.855	3.377	3.637
342	102.17	3.377	-3.637
	-94.855	-3.377	3.637
401	50.274	-5.104	5.858
	-42.958	5.104	-5.858
407	50.274	5.104	5.858
	-42.958	-5.104	-5.858
418	116.644	0	-0.186
	-109.329	0	0.186
429	49.734	-4.874	-5.672
	-42.418	4.874	5.672
435	49.734	4.874	-5.672
	-42.418	-4.874	5.672

Table -2: Torsion, Moment in"Y" & Moment in "Z"

COLUMN	Torsion kNm	Moment-Y kNm	Moment-Z kNm
59	-0.032	-1.828	-2.567
	0.032	6.517	-6.107
65	0.032	-1.828	2.567
	-0.032	6.517	6.107
104	0	0.102	0
	0	1.245	0
115	-0.006	5.629	-3.74
	0.006	3.233	-1.879
121	0.006	5.629	3.74
	-0.006	3.233	1.879
122	0.003	-5.332	-5.592
	-0.003	-5.567	-5.344
128	-0.003	-5.332	5.592
	0.003	-5.567	5.344
139	0	0.404	0
	0	0.35	0
150	0.007	4.321	-4.084
	-0.007	5.12	-4.688
156	-0.007	4.321	4.084
	0.007	5.12	4.688
215	0.001	-5.997	-5.342
	-0.001	-6.139	-5.531
221	-0.001	-5.997	5.342
	0.001	-6.139	5.531
232	0	0.226	0
	0	0.243	0
243	0.001	5.844	-5.232
	-0.001	5.898	-5.3
249	-0.001	5.844	5.232
	0.001	5.898	5.3
308	-0.001	-5.928	-5.489
	0.001	-5.504	-5.22
314	0.001	-5.928	5.489
	-0.001	-5.504	5.22
325	0	0.226	0
	0	0.222	0
336	-0.001	5.663	-5.185
	0.001	5.249	-4.947
342	0.001	5.663	5.185
	-0.001	5.249	4.947
401	-0.003	-7.402	-6.672
	0.003	-10.171	-8.641
407	0.003	-7.402	6.672
	-0.003	-10.171	8.641
418	0	0.248	0
	0	0.311	0
429	-0.003	7.174	-6.364
	0.003	9.841	-8.257
435	0.003	7.174	6.364
	-0.003	9.841	8.257

5. CONCLUSIONS

- The critical axial force in columns increases as slope increases.
- Shear force is found maximum in column of shorter length at front side of earthquake direction.
- Torsion is very critical in higher slopes in the front direction when the Earthquake force is considered from hill to ground.
- At the middle column the torsion is critical at various floor levels and for back side column the torsion is normally critical at higher floor levels.
- When the torsion is considered in Z direction the torsion pattern is erratic in all columns however column placed in middle are subjected to higher level of torsion than that of lower level of floor.

- After comparing both the results of analysis by changing configuration the torsion gets reduced with respect to the floor.
- When the Torsion is considered while comparison the torsion pattern is erratic in all columns however column placed in front are subjected to higher level of torsion than that of lower level of floor.

6. FUTURE SCOPE

- Analysis can be done with different soil conditions.
- Instead of regular building we can analyze irregular building for different sloping angles
- We can analyze by using other different software's such as SAP 2000, ETAB etc.
- Different positions of Shear wall can be placed while analysis of regular building.
- Analysis can be done with different seismic zone.

7. REFERENCES

- Vrushali S. Kalsait, Dr.Valsson Varghese, "Design of Earthquake Resistant Multistoried Building On A Sloping Ground" IJISET - International Journal of Innovative Science, Engineering & Technology,Vol. 2 Issue 7, July 2015.
- Sujit Kumar, Vivek Garg, Abhay sharma, "Effect Of Sloping Ground On Structural Performance Of Rcc Building Under Seismic Load" ISSN: 2348-4098 ,VOLUME 2 ISSUE 6 AUGUST 2014 (VER II), INTERNATIONAL JOURNAL.
- Nilesh B. Mevawala, Atul K. Desai, "Seismic Non-Linear Time History Analysis of Building Resting On Sloping Ground with Special Study on Nepal Earthquake", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 13, Issue 3 Ver. I (May-Jun. 2016), PP 60-66

- Mohammed Umar Farooque Patel, A.V. Kulkarni, Nayeemulla Inamdar, "A Performance study and seismic evaluation of RC frame buildings on sloping ground" Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X PP 51-58 www.iosrjournals.org International Conference on Advances in Engineering & Technology – 2014 (ICAET-2014)
- B.G. Birajdar, S. S. Nalawade, "Seismic analysis of buildings resting on sloping Ground" 13th World Conference on Earthquake Engineering Vancouver, B.C., Canada. August 1-6, 2004 Paper No. 1472.
- Pandey A.D, Prabhat Kumar, Sharad Sharma, "Seismic soil structure interaction of buildings on hill slopes" INTERNATIONAL JOURNAL OF CIVIL AND STRUCTURAL ENGINEERING Volume 2, No 2, 2011.
- S. A. Halkude, M. G. Kaly , "Seismic Analysis of Buildings Resting on Sloping Ground with Varying Number of Bays and Hill Slopes."International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 12, December – 2013 IJERTIJERT ISSN: 2278-0181 anshetti2, Mr. V. D. Ingle3.
- Y. Singh & Phani Gade, D.H. Lang & E. Erduran NORSAR , Seismic Behavior of Buildings Located on Slopes – An Analytical Study and Some Observations From Sikkim Earthquake of September 18, 2011 .
- S.M. Nagargoje and K.S. Sable, "Seismic performance of multi-storeyed building on sloping ground", S.M.Nagargoje et al./ Elixir Elec. Engg. 53 (2012) 11980-11982.