https://dx.doi.org/10.22161/ijaers.5.8.35 ISSN: 2349-6495(P) | 2456-1908(O)

Investigation of Seismic Parameters of R.C. Building on Sloping Ground

Mohd. Arif Lahori[1], Sagar Jamle[2]

[1] M Tech Scholar, Department of Civil Engineering, Oriental University, Indore, India
Email: ariflahori1991@gmail.com
[2] Assistant Professor, Department of Civil Engineering, Oriental University, Indore, , India
Email: sj.sagarjamle@gmail.com

Abstract ***—*** *As we all know that the R.C. structures which are constructed on slope of mountains are commonly asymmetrical in shape in downward gradient and when these are in contact with earthquake effects, exposed to massive destruction. When considering the horizontal and vertical planes of these R.C. structures, it shows dissimilar floor stiffness along with floor mass. The objective of this investigation is to compare the outcomes from dynamic method of earthquake analysis performed on R.C. structures with five different configurations like, regular building, Step back building 20^0, Step back building 30^0, Step back Set back 20^0 building and Step back Set back 30^0 building are presented. Analysis containing storey displacement in X and Z directions along with the storey drift, storey shear and time period has carried out by using Response Spectrum Method.*
Keywords— Earthquake effects, Multistory building, Response spectrum, Sloping Ground, Step back, Step back set back.

I. INTRODUCTION

Since as per seismic history of India, I.S. 1893 shows the seismic zones where earthquake occurred and it is detected that most of them have been occurred in northern and north-eastern states of India especially in hilly region. Since there had been a problem of construction space limitation, a demand to construct buildings on hill slope has now the main attention. Since the shortage of plain earth in hilly area forces the construction activity on sloping ground.

The solution for this problem is to construct buildings on hill slope that is only feasible choice to put up the growing demand for commercial along with residential living space. However, adopting the construction activity of multi-storey structures in these earthquake prone areas, special attention should be given when designing these buildings earthquake resistant.

II. OBJECTIVES OF THE PRESENT STUDY

It was witnessed from the earlier seismic activities that the buildings which are situated over hilly regions have greater extent of failure due to earthquakes along with a mass factor which has supposed to be projected at a decline angle towards the valley. Hence for this active region extreme care should be taken for making these multistory structures seismic proof.

The objectives of this work are as follows:

1. Use of response spectrum method in step back, step back set back and plain ground multistoried structure.
2. To compare the analytical results of 20^0 and 30^0 step back and step back set back structure.
3. To calculate maximum displacement and drift values for the comparison of all the 5 cases.
4. To compare base shear, time period along with mass participation factor shows dynamic response result of the 5 cases used.
5. To find out the most economical structural design on sloping ground using Staad pro software.

III. METHODOLOGY AND MODELLING APPROACH

This examination contains G + 8 storey residential building having 6 bays in x direction and 6 bays in z direction for a total of 5 cases that are mentioned in table 1 and figure 1-2. According to various cases, 20^0 along with 30^0 sloping structure were made. Using Indian Standard code 1893 (part 1): 2002, various parameters are taken, assuming the structure is to be located in seismic zone V and on rested over medium soil.

Several data used in this study for modeling and loadings are as follows:

- Length of building = 18 m along with a projection of 3 m of 12 m in width.
- Width of building = 18 m along with a projection of 3 m of 12 m in width.
- Height of each storey = 3.66 m.
- Dead load as per IS 875 part I = 12 KN/m^2 (intermediate floors).

https://dx.doi.org/10.22161/ijaers.5.8.35 *ISSN: 2349-6495(P) | 2456-1908(O)*

- Dead load as per IS 875 part I = 10 KN/m^2 (roof).
- Live load as per IS 875 part II = 2 KN/m^2.

Design parameters for Zone V are as follows:

- Zone factor Z=0.36 (ZONE V)
- Importance factor I = 1
- Response reduction factor R = 5
- The fundamental natural period (Ta) for moment resisting frame building with brick infill panels:-

$$T_a = \frac{0.09h}{\sqrt{d}}$$

Total 5 Cases are used in this work and these models are prepared in Staad Pro software.

Table.1: Different Cases with respect to building configurations

S. No.	CASES	Building Configurations
1	CASE 1	Regular building on plane ground
2	CASE 2	Step back building 20 degree
3	CASE 3	Step back building 30 degree
4	CASE 4	Step back Set back building 20 degree
5	CASE 5	Step back Set back building 30 degree

Table 2: Geometrical properties of members for different Cases

<table>
<tr><th>CASES</th><th>Size of Beam</th><th>Size of Exterior Column</th><th>Size of Interior Column</th><th>Thickness of Slab</th></tr>
<tr><td>CASE 1</td><td rowspan="5">500 mm x 300 mm</td><td rowspan="5">450 mm x 450 mm</td><td rowspan="5">450 mm x 450 mm</td><td rowspan="5">125 mm</td></tr>
<tr><td>CASE 2</td></tr>
<tr><td>CASE 3</td></tr>
<tr><td>CASE 4</td></tr>
<tr><td>CASE 5</td></tr>
</table>

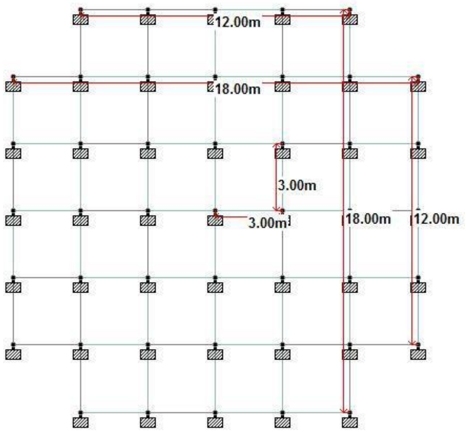


Fig.1: Plan of multistoried structure

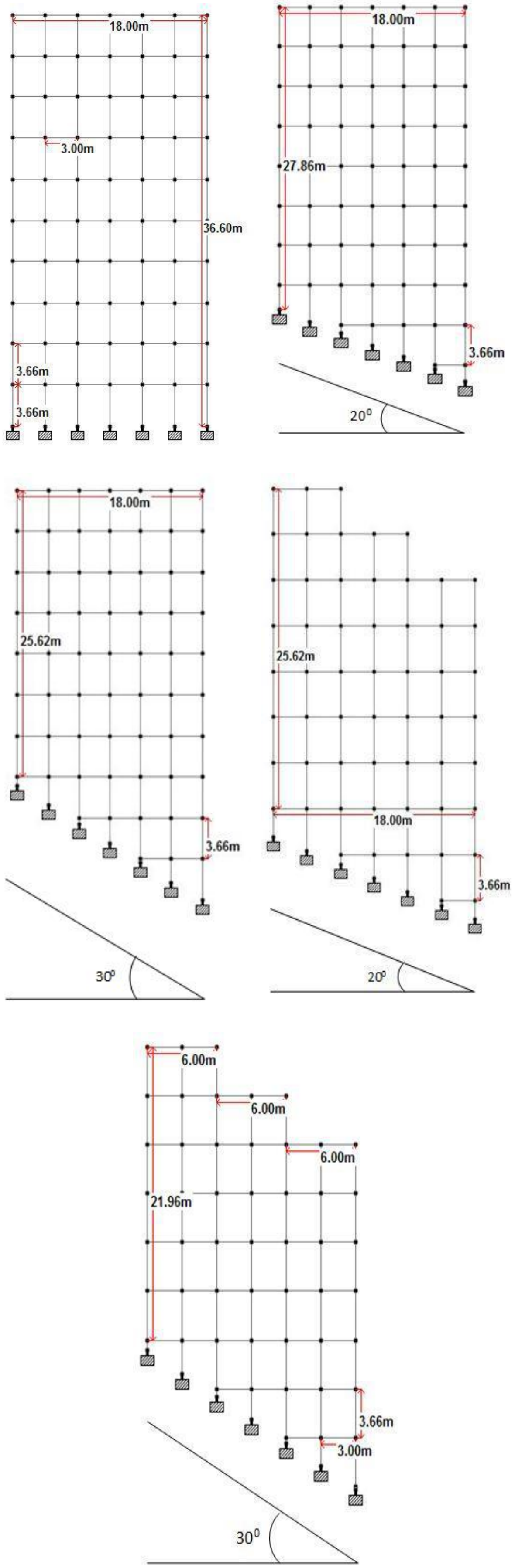


Fig.2: Elevation of various cases of multistoried structure

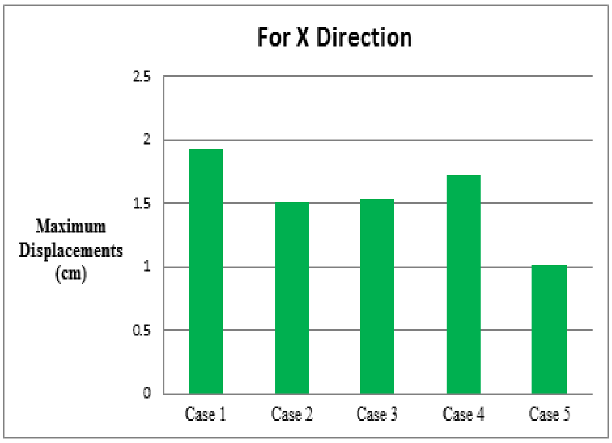
https://dx.doi.org/10.22161/ijaers.5.8.35 ISSN: 2349-6495(P) | 2456-1908(O)

IV. RESULTS ANALYSIS

Since for the analysis of seismic effects, all the cases of the structures have been analyzed for seismic shake for longitudinal along with transverse direction. Various loads along with load combinations applied on all the cases and reflective result parameters have been analyzed with each other to determine the efficient case. Results are shown both in tabular form as well as graphical form.

Table.3: Maximum Displacement in X direction of R.C.C. for all 5 cases in Zone V

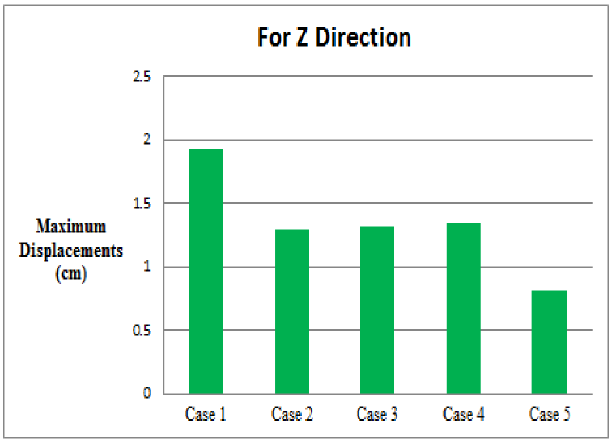
S. No.	Height (m)	Maximum Displacement (cm) For X Direction				
		CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
1	0	0	0	0	0	0
2	3.66	0.1782	0.0011	0.0020	0.0011	0.0001
3	7.32	0.4201	0.0182	0.0044	0.0178	0.0018
4	10.98	0.6684	0.1698	0.0461	0.1648	0.0043
5	14.64	0.9150	0.4127	0.3005	0.3953	0.0365
6	18.3	1.1535	0.6561	0.5768	0.6198	0.2257
7	21.96	1.3766	0.8878	0.8407	0.8247	0.4194
8	25.62	1.5757	1.0988	1.0812	0.9993	0.5874
9	29.28	1.7409	1.2788	1.2878	1.1311	0.7158
10	32.94	1.8615	1.4169	1.4494	1.2656	0.8478
11	36.60	1.9308	1.5054	1.5379	1.7217	1.0121



Graph 4: Maximum Displacement in X direction of R.C.C. for all 5 cases in Zone V

Table.4: Maximum Displacement in Z direction of R.C.C. for all 5 cases in Zone V

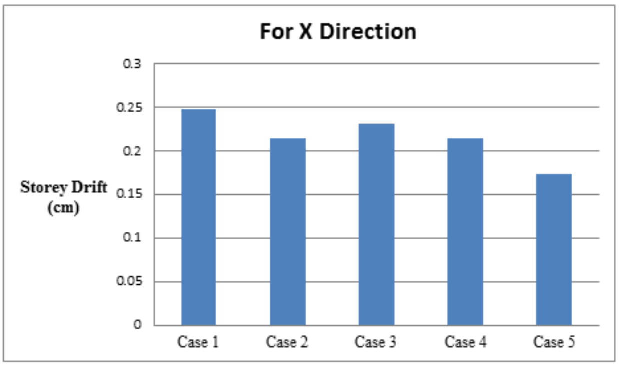
S. No.	Height (m)	Maximum Displacement (cm) For Z Direction				
		CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
1	0	0	0	0	0	0
2	3.66	0.1782	0.0002	0	0.0002	0
3	7.32	0.4201	0.0223	0.0089	0.0208	0
4	10.98	0.6684	0.1668	0.0850	0.1622	0.0067
5	14.64	0.9150	0.3821	0.3024	0.3763	0.0640
6	18.3	1.1535	0.5968	0.5337	0.5876	0.2331
7	21.96	1.3766	0.7992	0.7511	0.7826	0.4062
8	25.62	1.5757	0.9803	0.9443	0.9507	0.5567
9	29.28	1.7409	1.1302	1.1032	1.0783	0.6714
10	32.94	1.8615	1.2379	1.2168	1.1884	0.7622
11	36.60	1.9308	1.2962	1.3173	1.3457	0.8135



Graph 2: Maximum Displacement in Z direction of R.C.C. for all 5 cases in Zone V

Table.5: Storey Drift in X direction of R.C.C. for all 5 cases in Zone V

S. No.	Height (m)	Storey Drift (cm) For X Direction				
		CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
1	0	0	0	0	0	0
2	3.66	0.1782	0.0002	0	0.0002	0
3	7.32	0.2419	0.0221	0.0089	0.0206	0
4	10.98	0.2483	0.1445	0.0761	0.1414	0.0067
5	14.64	0.2466	0.2153	0.2174	0.2141	0.0573
6	18.3	0.2385	0.2147	0.2313	0.2113	0.1691
7	21.96	0.2231	0.2024	0.2174	0.195	0.1731
8	25.62	0.1991	0.1811	0.1932	0.1681	0.1505
9	29.28	0.1652	0.1499	0.1589	0.1276	0.1147
10	32.94	0.1206	0.1077	0.1136	0.1101	0.0908
11	36.60	0.0693	0.0583	0.1005	0.1573	0.0513

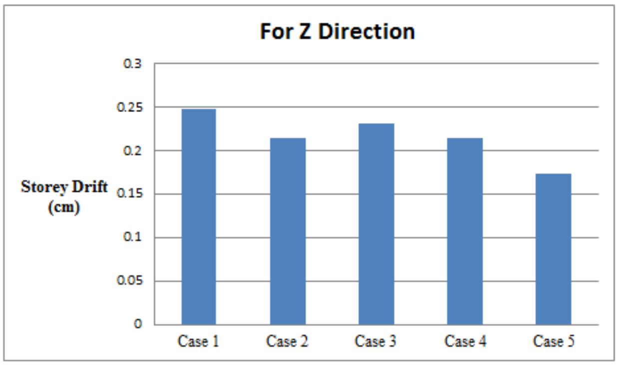


Graph 3: Storey Drift in X direction of R.C.C. for all 5 cases in Zone V

https://dx.doi.org/10.22161/ijaers.5.8.35 ISSN: 2349-6495(P) | 2456-1908(O)

Table.6: Storey Drift in Z direction of R.C.C. for all 5 cases in Zone V

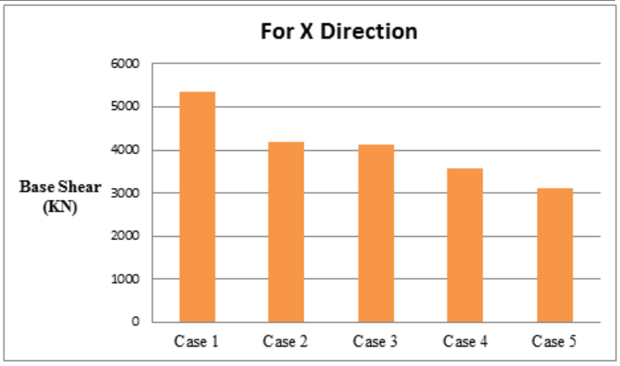
S. No.	Height (m)	Storey Drift (cm) For Z Direction				
		CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
1	0	0	0	0	0	0
2	3.66	0.1782	0.0002	0	0.0002	0
3	7.32	0.2419	0.0221	0.0089	0.0206	0
4	10.98	0.2483	0.1445	0.0761	0.1414	0.0067
5	14.64	0.2466	0.2153	0.2174	0.2141	0.0573
6	18.3	0.2385	0.2147	0.2313	0.2113	0.1691
7	21.96	0.2231	0.2024	0.2174	0.195	0.1731
8	25.62	0.1991	0.1811	0.1932	0.1681	0.1505
9	29.28	0.1652	0.1499	0.1589	0.1276	0.1147
10	32.94	0.1206	0.1077	0.1136	0.1101	0.0908
11	36.60	0.0693	0.0583	0.1005	0.1573	0.0513



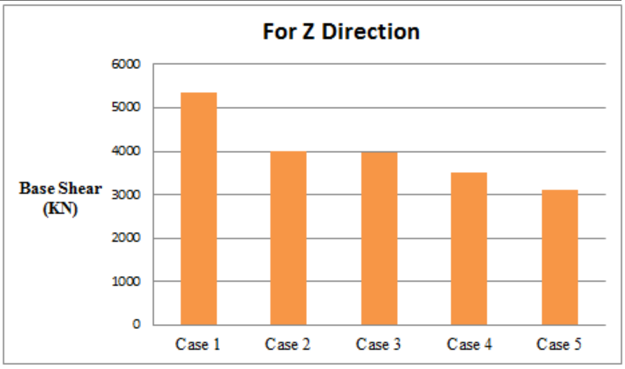
Graph 4: Storey Drift in Z direction of R.C.C. for all 5 cases in Zone V

Table.7: Base shear comparison for X direction

CASES	Base Shear (KN)	
	X direction	Z direction
CASE 1	5341.73	5341.73
CASE 2	4188.78	3988.71
CASE 3	4129.45	3977.33
CASE 4	3561.91	3520.29
CASE 5	3116.92	3098.08



Graph 5: Base shear comparison for X direction



Graph 6: Base shear comparison for Z direction

Table.8: Time Period and mass participation factor for case 1

Mode No.	Time Period (Seconds)	Participation X %	Participation Z %
	CASE 1		
1	1.713	0.006	81.723
2	1.713	81.723	0.006
3	1.495	0	0
4	0.563	0	10.447
5	0.563	10.447	0
6	0.495	0	0

Table.9: Time Period and mass participation factor for case 2

Mode No.	Time Period (Seconds)	Participation X %	Participation Z %
	CASE 2		
1	1.371	0	71.91
2	1.347	74.291	0
3	1.172	0	3.079
4	0.449	0	9.158
5	0.441	9.598	0
6	0.387	0	0.412

Table.10: Time Period and mass participation factor for case 3

Mode No.	Time Period (Seconds)	Participation X %	Participation Z %
	CASE 3		
1	1.293	0	66.408
2	1.247	66.984	0
3	1.099	0	2.799
4	0.422	0	8.743
5	0.405	8.474	0
6	0.363	0	0.321

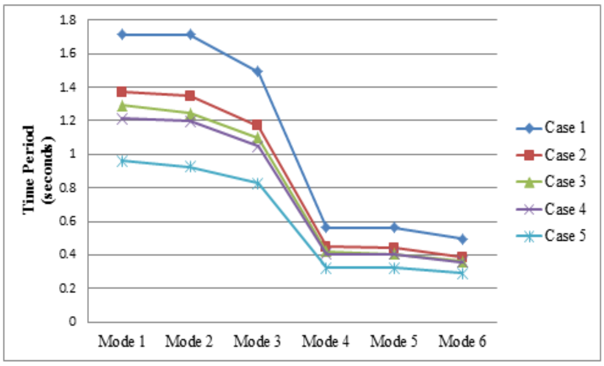
https://dx.doi.org/10.22161/ijaers.5.8.35 ISSN: 2349-6495(P) | 2456-1908(O)

Table.11: Time Period and mass participation factor for case 4

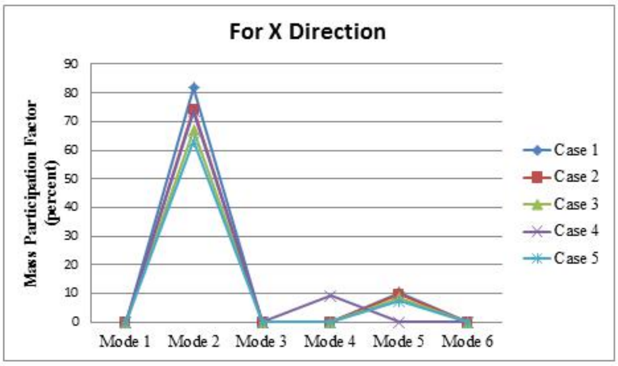
Mode No.	Time Period (Seconds)	Participation X %	Participation Z %
	CASE 4		
1	1.215	0	73.544
2	1.199	73.56	0
3	1.049	0	0.928
4	0.405	9.101	0
5	0.404	0	9.097
6	0.357	0	0.213

Table.12: Time Period and mass participation factor for case 5

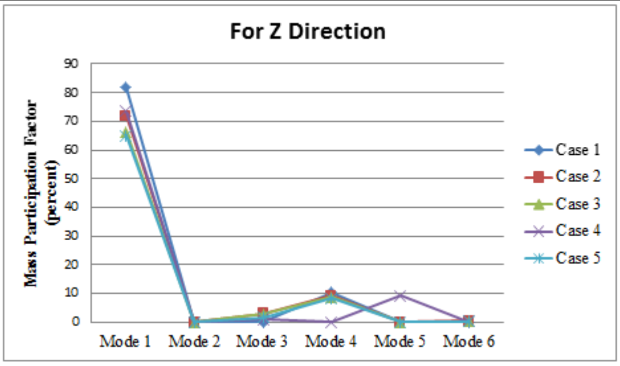
Mode No.	Time Period (Seconds)	Participation X %	Participation Z %
	CASE 5		
1	0.962	0	64.885
2	0.926	63.165	0
3	0.829	0	1.558
4	0.323	0	8.201
5	0.322	7.298	0
6	0.291	0	0.242



Graph 7: Time Period for total 5 cases



Graph 8: Mass participation factor for X direction of total 5 cases



Graph 9: Mass participation factor for Z direction of total 5 cases

V. CONCLUSION

The following conclusion has been investigated by different model configurations are as follows:-

1. At height of floors i.e. 3.66 m, the maximum displacement in longitudinal direction has a maximum value of 1.19308 cm for case 1 and minimum value of 1.0121 cm obtained for case 5. Transverse direction shows a maximum value of 1.9308 cm for case 1 and minimum value of 0.8135 cm obtained for case 5.
2. Storey drift seems to be greatest for case 1 with a value of 0.2483 cm and for transverse direction, maximum value seems to be 0.2485 cm for case 1.
3. Base shear values seem to be greatest for case 1 with a value of 5341.73 KN in longitudinal direction and least value seem to be in case 5 with a value of 3098 KN.
4. Time period along with participation factor seems to be acting mostly in case 1 and 2.
5. The most economical section for sloping ground when comparing all 5 cases has observed to be case 5 that is step back set back 30 degree model.

ACKNOWLEDGEMENTS

I extend my deepest gratitude to ***Mr. Sagar Jamle, Assistant Professor,*** Department of Civil Engineering, Oriental University, Indore, (M.P.) for providing all the necessary facilities and feel thankful for his innovative ideas, which led to successful completion of this work.

REFERENCES

[1] Roser J. Robert, Ranjana M. Ghate (2016), "Seismic Analysis of Multistoried RCC Building on Sloping Ground", International Journal For Research In Emerging Science And Technology, ISSN: 2349-7610, Vol. 03, Issue 12, pp. 40-45.

[2] G Suresh, Dr. E Arunakanthi (2014), "Seismic Analysis of Buildings Resting on Sloping Ground and Considering Bracing System", International Journal of Engineering Research & Technology, ISSN: 2278-0181, Vol. 03, Issue 09, pp. 1107-1113.

https://dx.doi.org/10.22161/ijaers.5.8.35 *ISSN: 2349-6495(P) | 2456-1908(O)*

[3] Shivanand B, H. S. Vidyadhara (2014), "Design Of 3d RC Frame on Sloping Ground", International Journal of Research in Engineering and Technology, ISSN: 2319-1163, Vol. 03, Issue 08, pp. 307-317.
[4] Satish Kumar, D.K. Paul (1999), "Hill buildings configuration from seismic consideration", Journal of Structural Engineering, Vol. 26, Issue 03, pp. 179-185.
[5] I.S. 1893 (Part 1) - 2002, Criteria for earthquake resistant design of structure, general provision and building, Bureau of Indian standards, New Delhi.
[6] IS 456 - 2000, Plain and Reinforced Concrete-Code of Practice.