Wind Analysis on Sloping Ground Building

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Abstract— The hilly areas of North East India contains seismic activities. Due to such 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 occurs when earthquake arives, this may cause a lot of human disaster and also affect the economic growth of these areas... In this paper I analyzed using Staad.Pro Software comparison between sloping ground, with different slope and plain ground building as per IS 1893-2000. The dynamic analysis, Axial forces, Bending moment in X and Y direction and Twisting moment in Z direction in columns of buildings are analyzed with different configurations of sloping ground.

Keywords: Seismic, Sloping Ground, Staad.Pro Software, Axial Forces, Bending Moment, Twisting Moment

I. INTRODUCTION

India has record of catastrophic earthquakes, at various regions, which leave behind loss of many lives, property and economy. Analysis of buildings in hilly region is somewhat different than the buildings on leveled ground, since the column of the hill building rest at different levels on the slope. Such building 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. The unsymmetrical building require a lot of attention in the analysis and design under the action of seismic design. Past earthquake in which, buildings located near the edge of a stretch of hills or on sloping ground suffered serious damages. The shorter column at attracts more forces and undergoes damage, when subjected to earthquakes. The other problems associated with hill buildings, additional lateral earth pressure at various levels, slope instability, different soil profile yielding unequal settlement of foundation.

Earthquake is the most disastrous phenomenon of nature. 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 and hence to the occupants and the property. Mass destruction of the low and high rise buildings in the recent earthquakes leads to the investigation especially in a developing country like India. Structure subjected to seismic forces are mostly 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 due to increased lateral forces on short columns on uphill side and thus leads to the formation of plastic hinges. Structures on slopes differ from those on plains because they are irregular horizontally as well as vertically. In north and northeastern parts of India have large scale of hilly terrain which fall in the category of seismic zone IV and V.

A. *Objectives:*

Numerous irregular designed structures with various establishment levels are built with locally accessible conventional material in sloped ground because of absence of plain land in uneven areas. As a result of populace density, demand of such kind of working in uneven inclines has increased. The investigation of earthquake safe expanding on slants is required to keep the loss of life, property amid earthquake ground movement.

B. *Main Objectives of this Study are:*

- To observe the effect of earthquake considering dynamic analysis method on sloping ground.
- To observe the effect of soft soil on the high-rise building frame.
- To observe the variation in beam and column forces and stability due to sloping ground.

II. METHODOLOGY AND PROBLEM FORMULATIONS

This study shows a comparative study on a high-rise building frame (G+10) considering seismic zone (V)with soft soil strata and different slopes of ground considered are 0^o, 5^o, 8^o ,10^o and 12^o. Under the seismic effect as per IS 1893-(part I)-2002 (dynamic analysis) has been carried out. Comparison is done in terms of:- maximum bending moment, axial force, twisting moment.

1) STEP 1:- Firstly I have done a modeling of G+10 building without any sloping criteria, the size of that building was length of 20m. divided in 4 equal division of 5m.each, Height of 33m. divided in 11 equal divisions of 3m each, and width was of 16m. in 4 equal division of 4m. each.
2) STEP 2 :- After modeling of that G+10 building I have given properties on that building of two different sized rectangle first one is of size .45 m. to .40 m. which is assigned for the columns in Y direction, and the other one is of size .45 m. to .30 m. which is assigned for the beams in X and Z direction an given plate thickness of 0.125 m for whole structure.
3) STEP 3:- Now I have given support on the bottom side of building.
4) STEP 4:-After providing support I have gone to load and deflection area and I have provided seismic load in which I have taken zone factor of zone 5 whose value of Z= 0.36 and taken response reduction as ordinary moment resisting frame (OMRF) and soil type as soft soil and damping ratio as 0.5 and added a self weight factor on it and generated it.
5) STEP 5:- After that I have given seismic load in eqx and eqz direction and given seismic load according to the direction of x and z respectively. and after that provided the self weight on whole building through dead load and provided floor load in live load and after that I have

performed analysis on that building and gone to processing and in that processing field I have found out the max. bending moment, twisting moment and max. axial forces in positive and negative directions and wrote down it in a excel sheet as result.

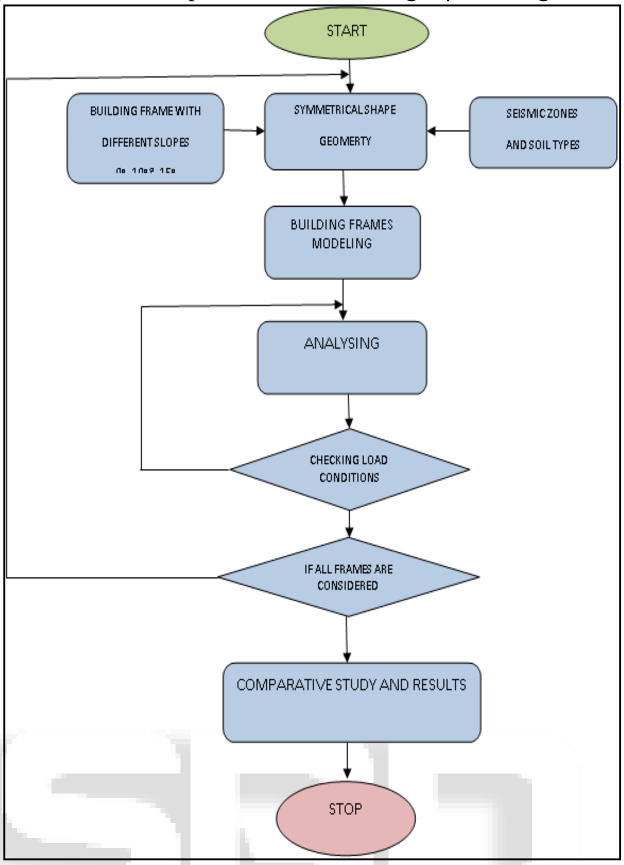
I have also designed these building for concrete under IS 13920.and provided the load combination for whole structure but taken combination of 1.2 Dead load+ 1.2 Live load+ 1.2 Earthquake load for further result for Generation 7 as it is giving a positive load combination.

6) STEP 6:- Now in this step I have taken sloping building of 5,8,10 and 12 degree angles by the same dimension which was taken in the previous building of length 20m. height 33m. and width as 16m. respectively.
7) STEP 7:- In this step I have provided the same properties and also the same type of support and loading condition as that of previous G+10 building and analysed that building now after this I have skewed the buildings in different angles of 5, 8, 10, 12 degree respectively and gone to geometry to highlight that portion of building from where it is given the angles and intersected that building and now I have removed the part which came beyond the intersected line after that I have analysed that building and found No Error on it.
8) STEP 8:- After getting no error I have gone to postprocessing and in that I have gone to reports and in beam end forces I have found out max. bending moment, max. shear force, max. Axial force and torsional force but taken Max. Axial force, Max. Bending moment in x and y direction and twisting moment in z direction respectively for further results and I have taken 3 columns one on the top most areas last column and second on middle column of horizontal direction and third one is the middle column in vertical direction and finally note down that obtain result in excel sheet.
   I have taken below three column for obtaining results.
9) STEP 9:- Now for comparison purpose I have provided lateral ties on 10 degree sloped building at the bottom to decrease length of long column and check forces in it for column 1.

III. WIND LOAD ANALYSIS OF BUILDING FRAME

A. Modeling Of Building Frames Using Staad Pro Software

1) Procedure Adopted While Modelling Of Building Frame



B. Material and Geometrical Properties:

Following material properties has been taken in modelling:-
Density of RCC: 25 kN/m^3
Density of Masonry: 18.5 kN/m^3

The foundation depth is considered at 1.50m below sloping ground level and the typical storey height floor to floor is 3.0m. The sections of columns are considered of 450mm x 400mm, and the section of beam size is 450mm x 350mm.

C. Loading Conditions

Following loading is adopted for analysis:-
1) Dead load: - Self wt. of slab considering 125mm thick.

masonry load					Remark
For storey height 3 m each	=	0.21 m x (3.0 - 0.40) m x 18.2kN/m^3	9.74	kN/m	Assume 10 kN/m
Parapet wall	=	0.21 m x (1.0) m x 18.2 kN/m^3	3.8	kN/m	4.0

Slab load					
Slab Load	=	0.12 m x 25kN/m^3	3.0	kN/m^2	slab thick. 125 mm assumed
Floor Finish	=		1.0	kN/m^2	

Total Load	=		4.00	kN/m^2	

S.No.	Parameter	Value
1	Zone (V)	0.36
2	Importance factor	1
3	Dynamic reduction	3
4	Soil site factor	Soft soil
5	Damping ratio	5 %

ANALYSIS RESULT

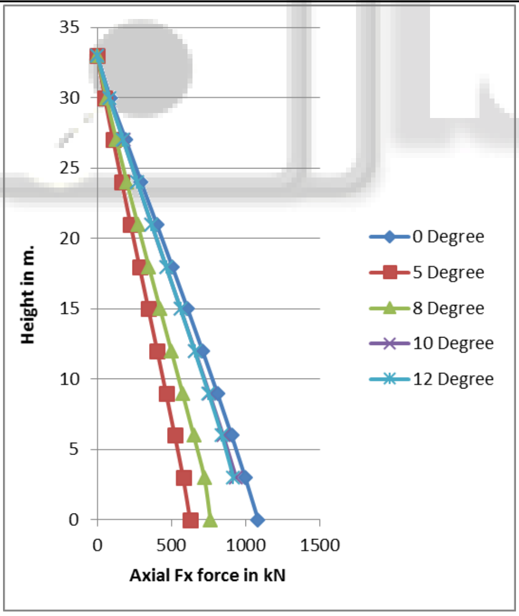
ANALYSIS RESULT IN TERMS OF AXIAL FORCE, BENDING MOMENT AND TWISTING MOMENT IN DIFFERENT CASES FOR LOAD COMBINATION (1.2 DEAD+1.2 LIVE +1.2 EARTHQUAKE LOAD) FOR GENERATION 7

FOR COLUMN 1 (LAST COLUMN FROM TOP RIGHT HAND SIDE END)

AXIAL FORCE:-

AXIAL FORCE Fx (kN)

Height m.	0 Degree	5 Degree	8 Degree	10 Degree	12 Degree
0	1084.578	625.824	762.633		
3	998.28	579.18	721.799	936.05	918.164
6	905.943	522.233	649.684	848.635	840.086
9	809.784	463.839	575.186	755.142	750.181
12	710.526	404.461	499.48	659.128	656.594
15	608.876	344.492	423.379	561.799	560.878
18	505.526	284.315	347.498	463.889	463.896
21	401.174	224.356	272.521	366.213	366.572
24	296.527	165.075	199.192	269.63	269.859
27	192.383	107.002	128.405	175.179	174.892
30	88.416	50.162	60.288	82.838	81.572
33	0	0	0	0	0



a) Load Combination Adopted:

Load case no.	Load cases
1	D-L
2	L-L
3	EQ_X
4	E.Q._Z
5	1.5(D-L+L-L)
6	1.5(D-L+E.Q.+X)
7	1.5(D-L-E.Q.+X)
8	1.5(D-L+E.Q.+Z)
9	1.5 (D.L-E.Q.+Z)
10	1.2(D.L+L.L+E.Q.+X)
11	1.2 (D.L+L.L-E.Q.+X)
12	1.2 (D.L+L.L+E.Q.+Z)
13	1.2 (D.L+L.L-E.Q.+Z)

2) Live Load on typical floors:- -3.00 kN/m^2

Live Load seismic calculation:-0.5 kN/m2

3) Wind load: Calculation of wind load as per as per is-code 875 (part-III):1987

All the building frames are analyzed for 5th wind zones whose value is 0.39.

4) Earth Quake Loads:

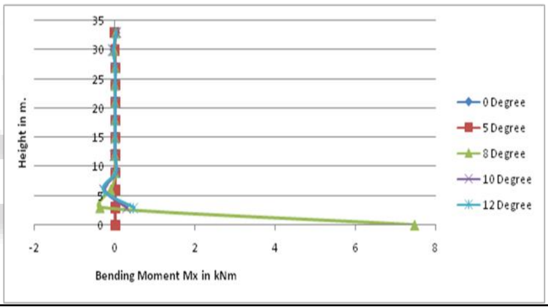
All frames are analyzed for 5th earthquake zones.

The seismic load calculation are as per IS: 1893 (part-1)-2002.

BENDING MOMENT:-

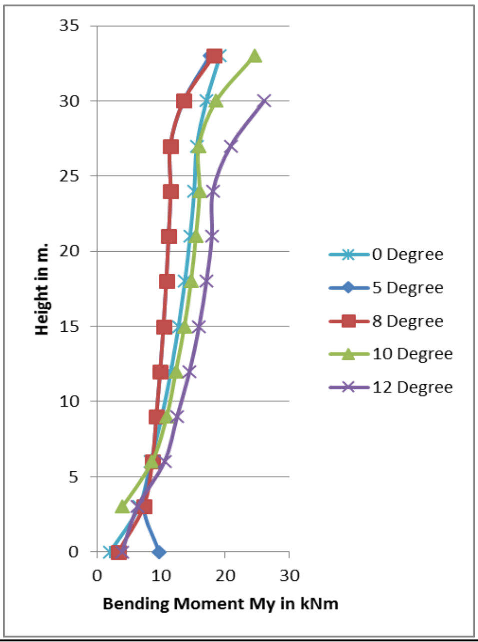
BENDING MOMENT Mx (kNm)

Height m.	0 Degree	5 Degree	8 Degree	10 Degree	12 Degree
0	0.006	0.008	7.476		
3	-0.003	0.01	-0.371	0.299	0.471
6	0.002	0.011	-0.104	-0.262	-0.284
9	0.003	0.012	0.009	0.026	0.016
12	0.004	0.014	-0.003	-0.006	-0.003
15	0.005	0.016	0	0	0.001
18	0.006	0.017	-0.001	-0.001	0.001
21	0.006	0.018	0	0	0.001
24	0.007	0.017	-0.001	-0.002	0.002
27	0.01	0.012	0.007	0.011	0.002
30	-0.014	0.006	-0.026	-0.05	-0.034
33	0.014	-0.006	0.026	0.05	0.034



BENDING MOMENT My (kNm)

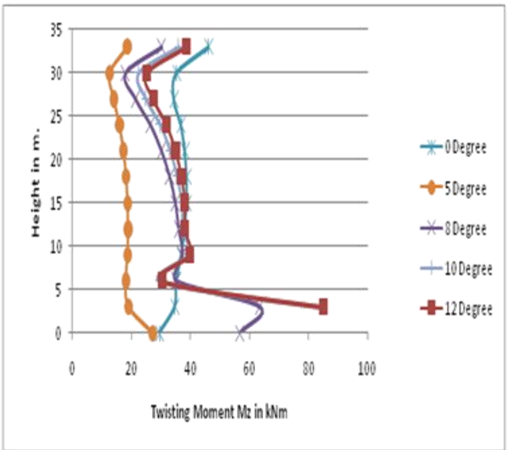
Height m.	0 Degree	5 Degree	8 Degree	10 Degree	12 Degree
0	2.06	9.7001667	3.311		
3	6.578	7.277	7.277	3.992	3.923
6	8.395	8.647	8.647	8.6	6.342
9	10.115	9.259	9.259	10.893	10.546
12	11.546	9.867	9.867	12.302	12.514
15	12.744	10.383	10.383	13.648	14.451
18	13.734	10.823	10.823	14.674	15.941
21	14.537	11.178	11.178	15.439	17.081
24	15.18	11.502	11.502	16.007	17.928
27	15.578	11.438	11.438	15.891	18.088
30	17.072	13.528	13.528	18.6	20.858
33	19.211	17.61	18.192	24.546	26.091



TWISTING MOMENT:-

TWISTING MOMENT Mz (kNm)

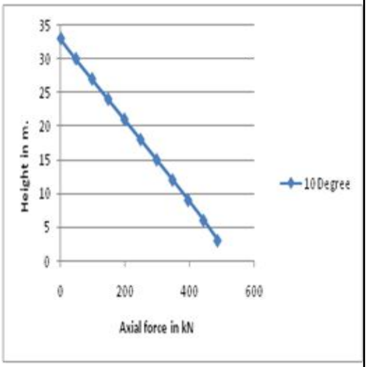
Height m.	0 Degree	5 Degree	8 Degree	10 Degree	12 Degree
0	29.475	27.187	56.807		
3	34.624	19.072	63.374	84.28	85.114
6	35.147	18.14	35.074	29.804	30.297
9	36.865	18.727	37.237	39.246	39.763
12	37.98	18.893	35.926	37.338	38.024
15	38.59	18.772	34.826	36.95	38.058
18	38.617	18.273	32.892	35.459	36.931
21	38.002	17.351	30.105	33.089	34.911
24	36.749	15.973	26.4	29.746	31.894
27	34.322	14.057	21.32	24.893	27.34
30	35.248	12.69	17.945	22.363	25.102
33	46.022	18.619	30.199	36.025	38.557



FOR COLUMN 1:- Result of the forces in 10 degree building frame with lateral ties.

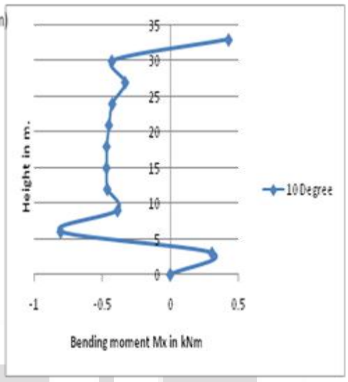
AXIAL FORCE Fx (kN)

Height m.	10 Degree
0	
3	486.684
6	442.823
9	395.363
12	346.825
15	297.54
18	247.697
21	197.512
24	147.214
27	97.047
30	46.956
33	0



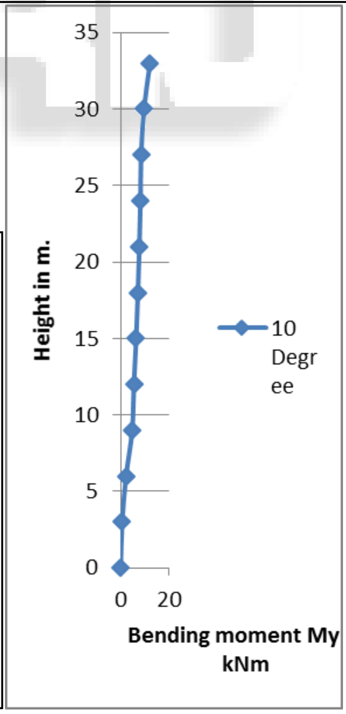
BENDING MOMENT Mx (kNm)

Height m.	10 Degree
0	0
3	0.308
6	-0.809
9	-0.389
12	-0.465
15	-0.471
18	-0.47
21	-0.453
24	-0.428
27	-0.333
30	-0.431
33	0.431



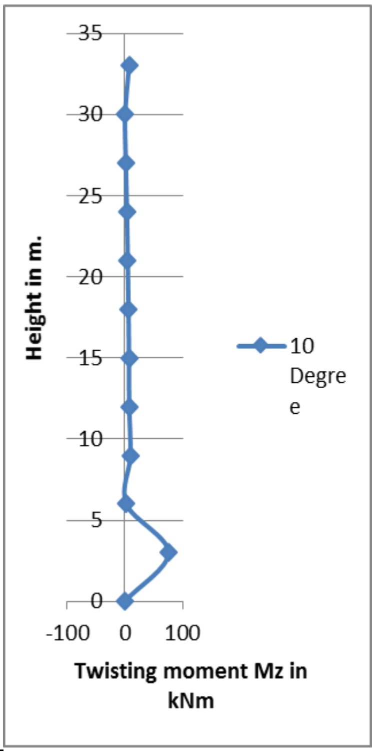
TWISTING MOMENT Mz (kNm)

Height m.	10 Degree
0	0
3	75.368
6	2.654
9	9.683
12	7.553
15	7.192
18	6.308
21	5.141
24	3.569
27	1.785
30	0.555
33	7.527



BENDING MOMENT My (kNm)

Height m.	10 Degree
0	0
3	0.629
6	2.24
9	4.758
12	5.496
15	6.433
18	7.157
21	7.759
24	8.225
27	8.496
30	9.675
33	12.186



IV. CONCLUSION AND SCOPE FOR FUTURE WORK

Following are the conclusions as per study:-

1) When the bending moment of the building on plain ground and with slopes were compared the bending moment had an increment up to 20 % on 10o slope and 40 % on 12o slope for all three columns.
2) It was observed from that the higher side of the slope, short columns were subjected to more value of forces and moment than longer column on the lower side and variation of forces I first column is more than other two column.
3) After providing lateral ties there is approximately 40% decrease in axial force and around 56-60% decrease in Bending Moment in X and Y direction and Twisting moment also decreased by 65%.

So, it would be good to provide lateral ties at the bottom in sloped buildings to decrease length of short column and provide cost effective building

V. FUTURE SCOPE OF THE STUDY

1) In this study sloping ground of 0 degree, 5 degree, 8 degree, 10 degree and 12 degree.
2) In this study G + 10 symmetrical structures has been considered. The study can be extended to more tall structures
3) This study performs dynamic analysis and in further study wind load or time history analysis can be included.

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