Research Article Impact Factor: 4.226 ISSN: 2319-507X
S. K. Deshmukh, IJPRET, 2015; Volume 3 (8): 119-133 IJPRET

INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

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SPECIAL ISSUE FOR
NATIONAL LEVEL CONFERENCE
"SUSTAINABLE TECHNOLOGIES IN CIVIL ENGINEERING"

SEISMIC ANALYSIS OF R.C.C. BUILDING RESTING ON SLOPING GROUND

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Accepted Date: 13/03/2015; Published Date: 01/04/2015

Abstract – The aim of study is to analyze the RCC building sloping ground ,as such building are different from those in plains, they are irregular variation along the vertical and horizontal planes. The Experimental method used over here for Seismic analysis is Linear static method for seismic analysis of G+6 storey plain building as well as inclined building. In these case the analysis of structure is carried out computationally by using STAADPRO. Initially plain they are very irregular and unsymmetrical in horizontal and vertical planes and subjected to torsion and twisting forces, this leads to, severe damage when subjected by Earthquake ground motion due to mass and stiffness building G+6 storey with plan dimension of 20m x 9m has been analyzed which is later on compared with analysis of similar building resting on sloping ground. The Comparison is done with respect to shear force, Moment, displacement and base shear. It is found that the building with G+6 storey inclined slope at 11^{o} is less resistive against lateral force. the top storey displacement is very high. The short column effects are produce due to inclined slope in building attracting more forces during Earthquake. From thr comparison it is clear that, the maximum rotational displacements are found in seismic building resting on sloping ground as compare to the RCC plain building. In Building resting on Sloping ground, the shear force goes on increasing whereas in plain seismic building shear force variation is small. The moments are found maximum, in case of sloping ground building as compare to plain building. From all the observations made, for maximum displacement values, max. reaction values, forces values, drift values, nodal displacement along edge, flow pattern of moment at base ,it is clear that out of two cases, that is building with uniform column at base (case I) and building inclined at base, the moment develop is more in Case no. II, when building is subjected to lateral forces or seismic forces. This values further reinforce the concept of short column effect as well as torsion and twisting develop in structure due to uneven height of column

Keywords- Sloping ground, irregular, unsymmetrical, torsionally coupled, shear force moment, displacement, drift, seismic forces, short column effect, twisting

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Access Online On:

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How to Cite This Article:

S. K. Deshmukh, IJPRET, 2015; Volume 3 (8): 119-133

PAPER-QR CODE

INTRODUCTION

Hill buildings are different from those in plains; they are very irregular and unsymmetrical in horizontal and vertical planes, and torsionally coupled. Hence, they are susceptible to severe damage when affected by earthquake ground motion. Past earthquakes [e.g. Kangra (1905), Bihar- Nepal (1934 & 1980), Assam (1950), Tokachi-Oki-Japan (1968), Uttarkashi-India (1991)], have proved that buildings located near the edge of stretch of hills or sloping ground suffered severe damages. 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. Seismic analysis for lateral vibration of such buildings are somewhat different than the buildings on level ground since the columns of the building rest at different levels on the slope. Such buildings are also unsymmetrical in elevation and plan which demand torsional analysis; in addition to lateral forces under the action of earthquakes.

Every property is different, and slopes present special challenges to Engineer. But sloped properties can be particularly attractive because they often offer beautiful views. Building on slopes and know the challenges to be mastered by the structural design and floor plan. But we also know the many interesting options created by clever use of such a property. For example, a house on a slope can have two ground floors, if desired. And an intelligently placed terrace or garage can turn a house on a slope into something very special. So there is no need to be afraid of sloped properties. The RCC framed buildings having different configurations can be constructed on flat and sloping grounds. The buildings on flat ground may have regular or setback configurations. The buildings on a sloping ground may have setback or combination of stepback and setback configurations.

Buildings on hill slope differ from those in plains. The floors of such buildings step back towards the hill slope and at the same time building may also have setbacks. A setback is a sudden change in plan dimension or a sudden change in stiffness along the height of a building. Stepping back of building towards hill slope may result into unequal column heights at the same floor.

1 OBJECTIVES AND SCOPE OF PAPER

i)To study the various parameters which influence the Building on plane ground, considering seismic forces for Zone III.

i)To study the various parameters which influence the Building on Sloping ground, considering seismic forces for Zone III.

iii)To do Analysis and Comparative study of Buildings on Sloping and Plane Ground.

iv)Analysis of Buildings on Sloping Ground with angle Of 11^0 considering seismic forces for Zone III.

2 CASE CONSIDERATION UNDER SEISMIC ANALYSIS

Case No.I

1:Experimental investigation on seismic plane building

1) Two 2G+6 storey building with a plan dimension 20m X 9m have been chosen for the analysis purpose the model are developed and analysis by using STAAD.Pro 2008 one of the model is plane seismic building of which input parameters are as follows.

Zone factor -0.16(zone 111)

Response reduction factor -3

Important factor -1

Soil factor -2

Grade of concrete M25

Grade of reinforcing steel Fe415

Size of beam = 230 X 450 mm

Size of column = 230 X 600 mm

LOADING CONSIDERATION

For analysis of structure the following loads are taken from IS875 part 1 and Part 2

Dead load = 4.625KN/M2

Live load =3KN/M2

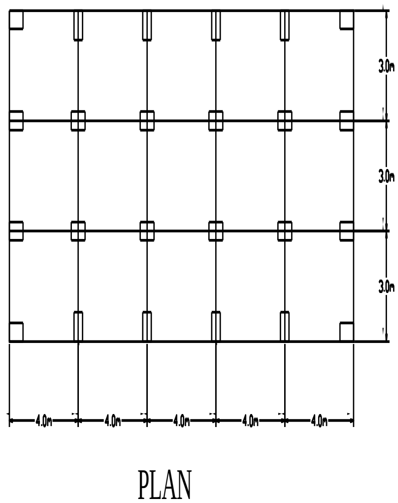
Earthquake load

Combination 1 :1.5(DL+LL)

Combination 2:1.2(DL+-EL)

Combination 3:(0.9DL+-1.5EL)

Combination 4 :1.2DL+0.3LL+EL)



G+6plainBuilding

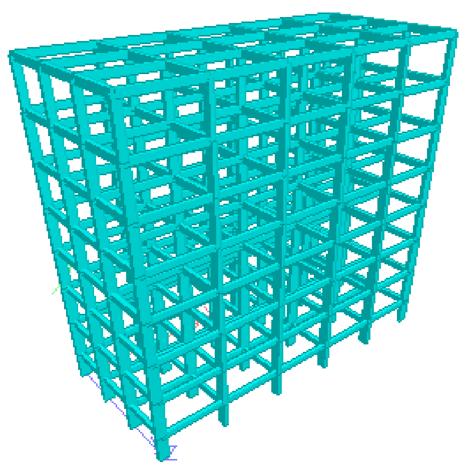


Fig 4.1: 3D rendered view G+6 plain building

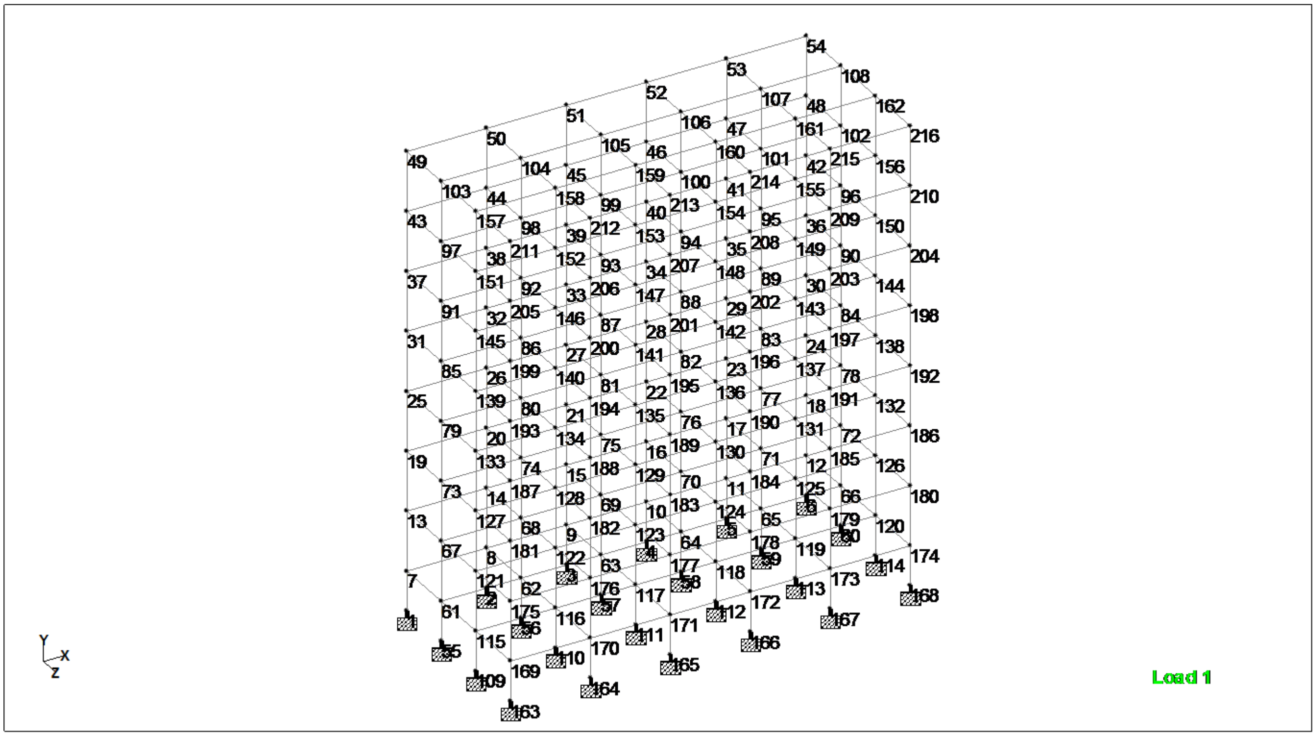


Fig 4.2: Node nos of entire frame

STAAD.Pro Report

To:	From:			
Copy to:	Date:	30/11/2014 20:04:00	Ref:	ca/ Document1

Job Information

	Engineer	Checked	Approved
Name:			
Date:	23-Nov-14		

Structure Type	SPACE FRAME

Number of Nodes	216	Highest Node	216
Number of Elements	496	Highest Beam	496

Number of Basic Load Cases	7
Number of Combination Load Cases	13

Included in this printout are data for:

All	The Whole Structure

Included in this printout are results for load cases:

Type	**L/C**	**Name**
Primary	4	LOAD CASE 4 EQX
Primary	5	LOAD CASE 5 -EQX
Primary	6	LOAD CASE 6 EQZ
Primary	7	LOAD CASE 7 -EQZ
Primary	1	DL
Primary	2	LL
Primary	3	RLL
Combination	8	COMBINATION LOAD CASE 8 (1.5D.L.+1.5L.L.+1.5RLL)
Combination	9	COMBINATION LOAD CASE 9 (1.5D.L.+1.5EQX)
Combination	10	COMBINATION LOAD CASE 10 (1.5D.L.-1.5EQX)
Combination	11	COMBINATION LOAD CASE 11 (1.5D.L.+1.5EQZ)
Combination	12	COMBINATION LOAD CASE 12(1.5D.L.-1.5EQZ)

CASE NO, 2:

2 Experimental investigations on seismic R.C.C building inclined at 11^0

1) Two 2G+6 storey building with a plan dimension 20m X 9m have been chosen for the analysis purpose the model are developed and analysis by using STAAD. Pro 2008 one of the model is seismic R.C.C building inclined at 20^0 of which input parameters are as follows.

Zone factor -0.16(zone 111)

Response reduction factor -3

Important factor -1

Soil factor -2

Grade of concrete M25

Grade of reinforcing steel Fe415

Size of beam = 230 X 450 mm

Size of column = 230 X 600 mm

LOADING CONSIDERATION

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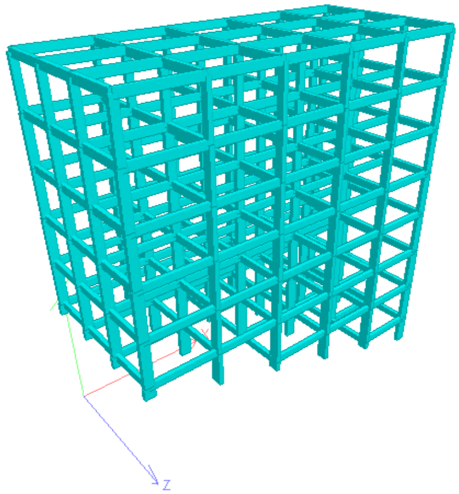

3.Observations & Remarks

Table No 5.1: Maximum Forces values Summary for Case I and Case II

Type	Node no		Lodind combination		Values	
	CaseI	Case II	CaseI	Case II	CaseI	Case II
Max Fx	1	181	10	10	14.335	21.935
Min Fx	4	73	9	17	-14.335	-`15.437
Max Fy	74	74	8	8	1625.175	1627.57
Min Fy	2	1	6	6	-39.755	-38.824
Max Fz	1	1	12	12	24.296	24.8
Min Fz	181	181	11	11	-24.296	-24.8
MaxMx	1	4	12	1`2	24.833	28.195
MinMx	181	184	11	11	-24.833	-28.195
MaxMy	181	182	9	11	.035	0.515
MinMy	1	2	9	12	-.035	-.515
MaxMz	4	109	9	9	12.714	19.207
MinMz	1	181	10	10	12.714	-19.155

1) **Table No. 5.2 Drift Values For Inclined Buildings**

Node No.	Story Drift
213	1.28
209	
205	2.71
201	3.027
197	3.393
193	3.873
187	4.451
185	7.04

Table No 5.3: Maximum Displacement Values Summary for Case I And Case II

Type	Node No		Loading Comb.		Case I	Case II
	Case I	Case II	Case I	Case II	mm	Mm
Max.x	105	141	9	9	25.852	27.396
Min.x	108	144	10	18	-25.852	-23.749
Max.y	34	144	6	5	0	-16.734
Min.y	106	107	8	8	.012	2.583
Max.z	34	36	11	11	.009	2.961
Min.z	214	216	12	12	.009	2.961
Max.rx	10	10	11	11	-.003	1.068
Min.rx	190	190	12	12	-.003	5.646
Max.ry	180	190	10	12	-25.617	5.646
Min.ry	177	10	9	11	25.617	5.646
Max.rz	12	192	10	10	-7.719	-7.572
Min.rz	9	189	9	9	7.719	8.709
Max Rst	106	107	9	9	25.838	27.368

Table No 5.4: Maximum Reaction values for inclined building

Support	X (KN)	Y(KN)	Z(KN)	M_X(KN-M)	M_Y (KN-M)	M_Z (KN-M)
1	-10.833	-37.797	0.003	0.004	0.010	-12.323
2	-5.871	4.064	-0.000	-0.001	0.004	7.719
3	-2.511	-2.025	0.000	0.000	0.003	4.501
4	-0.334	35.766	-0.001	-0.002	0.005	1.923
5	-10.934	-38.321	0.004	0.003	0.011	12.436
6	-5.923	4.108	0.000	0.000	0.005	7.788
7	-2.533	-2.050	0.000	0.000	0.004	4.541
8	-0.337	36.259	-0.001	0.002	-0.005	1.894
9	-11.002	-38.661	0.001	0.001	0.004	12.513
10	-2.511	-2.025	0.000	0.000	0.003	4.501
11	-2.548	-2.065	0.000	0.000	0.002	4.569
12	-0.339	36.583	0.001	0.001	0.002	1.923
13	-11.002	-38.661	0.001	0.001	0.004	12.513
14	-5.959	4.137	0.000	0.000	0.002	7.835
15	-2.548	-2.065	0.000	0.000	0.002	4.569
16	-0.339	36.583	0.001	0.001	0.002	1.923
17	-10.833	37.797	0.003	0.004	0.010	12.323
18	-5.923	4.108	0.000	0.000	0.005	7.788
19	-2.533	-2.050	0.000	0.000	0.004	4.541
20	-0.337	36.259	-0.001	0.002	-0.005	1.894
21	-10.833	37.797	0.003	0.004	0.010	12.323
22	-5.871	4.064	-0.000	-0.001	0.004	7.719
23	-2.511	-2.025	0.000	0.000	0.003	4.501
24	-0.334	35.766	0.001	0.002	0.005	1.894

When the comparison for both the cases is done for max. Forces developed, it is observed that in case II the forces in the direction is greater as compared to that in case I by 50%

However in vertical direction the forces are almost same which further indicate no gravity design, to be changed. The case is same for even Z-direction as seismic loading is assigned in X-direction.

Whereas, there is a noticeable change in moment development in Z – direction by almost 65% incremental value in case II, which indicates development of comparatively strong moment twist in inclined building.

However, the value is not so significantly change for moment in X and Y directions.

When the values of max. and min. displacement are compared for both the cases , it is observed that the values of displacement in vertical direction is more in case II as compared in case I.

Similarly rotational displacement values for X and Y directions are 100 times more in case II as that of case I, which indicates high twist torsion causing moment in building with slope at base.

This high amount of rotational displacement further reinforce the concept of failure of short column in structure.

When the observation is made for the nodal displacement values as mention in table no. 5.4 the simplified story to story drift values based on resultant are tabulated in table no. 5.3

From this values, when compared can be observed that the drift values are more in case no.II i.e. inclined building also. It is observed the value is min. at top floor, then it is more comparatively and later on so increasing till base node.

This drift value indicate story to story direction induce in both case and thus more drift or displacement is present in inclined building.

From this table 5.2, it is observed that the reaction or support to be provided to resist forces maximum in X and Y directions axial in nature.

Further, the resisting against moment development in Z-direction is needed to be provided as compared to other two directions i.e. X and Y . When the flow pattern are values of moment in X-direction is observed for case I , it is clear that value is more at end corner nodes with decrement in second row and is almost constant in middle rows with same reflecting values for bottom half pattern.

When the same flow is observed for case II , it is clear that the magnitude of nodal value got increased.

The moment develop in direction for both the cases are almost same.

When comparison is being done for moment development in Z-direction, it is clear that value is more at corner rows , whereas min. along middle rows in case I

When this comparison is done for case II , it is observed that the rows got incremented to high extend . Along with that the values are more in left column node as compared to right column node.

Which reflects uneven distribution and moment at corners of building and those may give rise to torsion and twisting effect.

CONCLUSION:

From all the observations made, for max. Displacement values, max. reaction values, forces values, drift values, nodal displacement along edge, flow pattern of moment of base, it is clear that out of two cases that is of building with uniform column at base (case I) and building inclined at base, the moment develop is more in case no. II, when building is subjected to lateral or seismic forces.

From the study, it is observed that the building which are resting on sloping ground are subjected to short column effect , attract more forces and are worst affected during seismic excitation. Hence form design point of view, special attention should be given to the size, orientation, and ductility demand of short column . it is also found that the hill slope building are subjected to significant torsional effects due to uneven distribution of shear force in the various frames of building suggest development of torsional movement which is found to be higher on a sloping ground building. This values further reinforce the concept of short column effect as well as torsion and twisting develop in structure due to uneven heighted column.

Thus the structure with uneven column height needs more attention to overcome this torsion twisting forces development and is thus , if neglected is more liable for seismic hazard.

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