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CONSIDERING THE EFFECT OF SEISMIC FORCES ON HIGH RISE STRUCTURES IN SLOPING AREA.

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ABSTRACT

As most of the northern zone of India is situated in mountainous region, there is a lack of plain surface. (India is number two in population in the world there fore to settle this population there is a high demand of high rise structure). But in areas where plain ground is not available therefore high rise structures are to be built on sloping ground subsequently, the primary target of this study is to decide the effect of seismic forces on the high rise structures. Situated on a sloping ground for which in this dissertation slopes of 0 degree, 8 degree and 12 degree is considered with different soil conditions to find out the effect of different soils too. Comparative study have been made on unsymmetrical plan of G+9 floors considering all the four seismic zones as per I.S. 1893 part 1 2002. For analyzing and modeling purpose STAAD. Pro programming is utilized and study is done on the premise of maximum storey displacement, axial forces, shear forces, maximum bending and displacement in X and Z direction.

In this study we adopt 13 loading combination in each case as per Indian Standards and dimensions of column (450 mm x450 mm) and beam (400 mm x300 mm) in all the cases. We observed the result of all the cases in the same manner, Soft soil shows maximum values in all parameters, medium soil shows moderate result and hard soil shows minimum.

Keywords:

1. Seismic forces
2. Sloping Grounds
3. High Rise Structures
4. Reduction factor
5. IS:1893
6. STAAD Pro

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INTRODUCTION

Slope structures are not the same as those in fields; they are exceptionally sporadic and unsymmetrical in level and vertical planes, and torsion ally coupled. Consequently, they are defenseless to extreme harm at the point when influenced by earthquake ground movement. Seismic powers acts more separate in sloping areas because of the auxiliary anomaly. Likewise it has been contemplated that the earthquake activities are inclined in sloping ranges. In India, for movement on slanting ground bringing about different vital structures, for example, strengthened instance, the north-east states. The shortage of plain ground in sloping ranges forces development cement surrounded doctor's facilities, universities, inns and workplaces laying on uneven slants. The conduct of structures amid earthquake relies on the dissemination of mass and firmness in both even and vertical planes of the structures. In sloping locale both these properties differs with inconsistency and asymmetry. Such developments in seismically inclined territories make them presented to more prominent shears and torsion.

North and northeastern parts of India have huge sizes of uneven territory, which are ordered under seismic zone IV and V. In this area the development of multistory RC encircled structures on slope inclines has a prevalent and squeezing request, because of its monetary development and quick urbanization. This development in development movement is adding to gigantic increment in populace density. While development, it must be noticed that Hill structures are unique in relation to those in fields i.e., they are exceptionally unpredictable and unsymmetrical in flat and vertical planes, what's more, torsion ally coupled. Since there is lack of plain ground in uneven regions, it commits the development of structures on inclines.

In our study we have taken 36 cases in sloping ground at 0^0 , 8^0 and 12^0 in all the four seismic zones in soft, medium and hard soil types and analyze the G+9 unsymmetrical structure using STAAD . Pro V8i software and study the variations in Bending Moment, Shear Force, maximum Displacement in X and Z Direction and Storey Displacement in all the floors in both X and Z direction.

EARTHQUAKE

It has been seen in past seismic tremors that the structures on slants serve more fiendishness and fold. Shudders cause valid harm to structures, for case, disappointment of individuals in the building and if the power of tremor is high it prompts breakdown of the structure. In past years populace has been developed undeniably and as a consequence of which urban zones and towns began spreading out. In light of this reason different structures are being inborn slanting zones. India has a broad shoreline bleeding edge which is secured with mountains and inclinations. Different resorts are being delivered in uneven zones to give strategies to visitors. The structures in these zones are made on slanting grounds. An enormous part of the harsh reaches in India go under the seismic zone II, III and IV zones in such case working in perspective of inclining grounds are exceedingly slight against seismic tremor. This is an eventual outcome of the way that the bits in the ground floor contrast in their statures as appeared by the inclination of the ground. Sections toward one side are short and on flip side are long, by virtue of which they are exceedingly fragile. Seismic powers acts more separate in sloping areas because of the auxiliary anomaly. Likewise it has been contemplated that the earthquake activities are inclined in sloping ranges. In India, for instance, the north-east states. The shortage of plain ground in sloping ranges forces development movement on slanting ground bringing about different vital structures, for example, strengthened cement surrounded doctor's facilities, universities, inns and workplaces laying on uneven slants. The conduct of structures amid earthquake relies on the dissemination of mass and firmness in both even and vertical planes of the structures. In sloping locale both these properties differs with inconsistency and asymmetry. Such developments in seismically inclined territories make them presented to more prominent shears and torsion.

OBJECTIVES

Many irregular configured buildings with different foundation levels are constructed with locally available traditional material in hilly slopes due to lack of flat land in hilly regions. Because of population density, demand of such type of building in hilly slopes is increased. The study of earthquake resistant building on slopes with different type of soils is required to prevent the loss of life, property during earthquake ground motion

Main objectives of this study are:

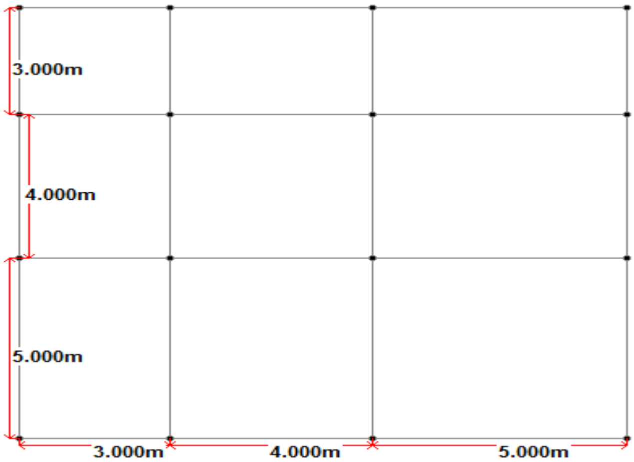
- To determine the effect of seismic zones on sloping ground.
- To determine the effect of different type of soils on the structure.
- To determine the variation due to sloping angels.

2. RESEARCH METHOD

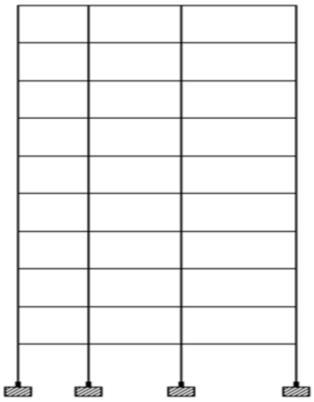
This study shows comparative study of high rise structures G+9 building frame considering different seismic zones with three different soil types and different slope of ground as 0^0, 8^0 and 12^0. Under the seismic effect as per IS 1893(part I) -2002 static analysis. A comparison of analysis results in terms of displacements, bending moment, Storey displacement, shear force has been carried out.

This study is attempted in following steps:

Step-1 Selection of building geometry with three different type of soil, unsymmetrical 3 bays of 3-4-5 meters G+9 story of 3D frame. Fig. 3.1.1



Step-2 Selection of ground conditions as per sloping 0, 8 and 12 degrees.



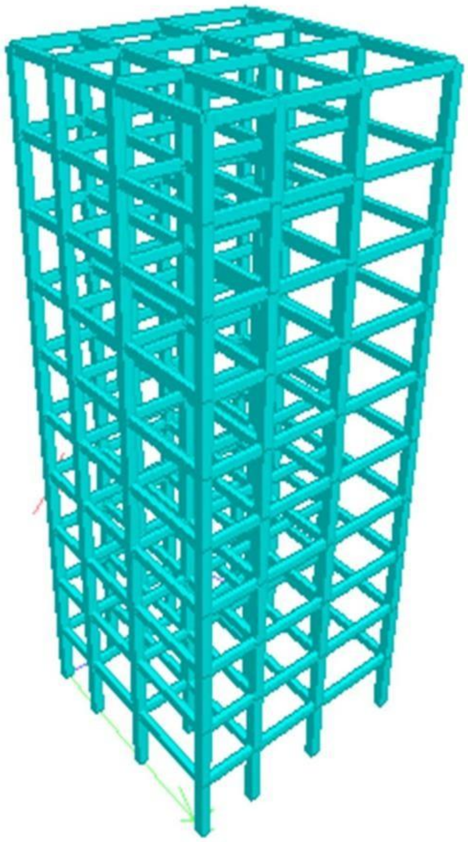
Step-3 Selection of Seismic zones (Zone II, III, IV and V) as per IS- 1893(part I) -2002.

Seismic Zone.	**II**	**III**	**IV**	**V**
Seismic intensity.	Low.	Moderate.	Severe.	Very Severe.
Z	0.10	0.16	0.24	0.36

Step-4 Load combination

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

Step-5 3-d Modeling of building frames using STAAD.Prov8i.



Step-6 Analysis considering different types of sloping ground frames considering different seismic zones. Fig 3.6 shows seismic load in x & Fig 3.7 shows seismic load in z direction.

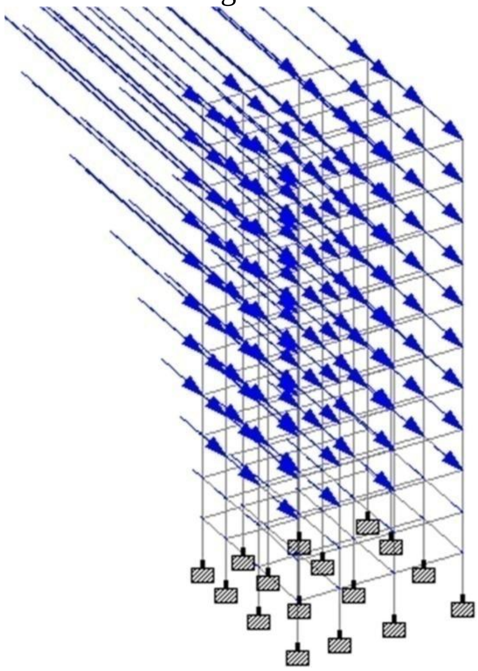


Fig.3.6

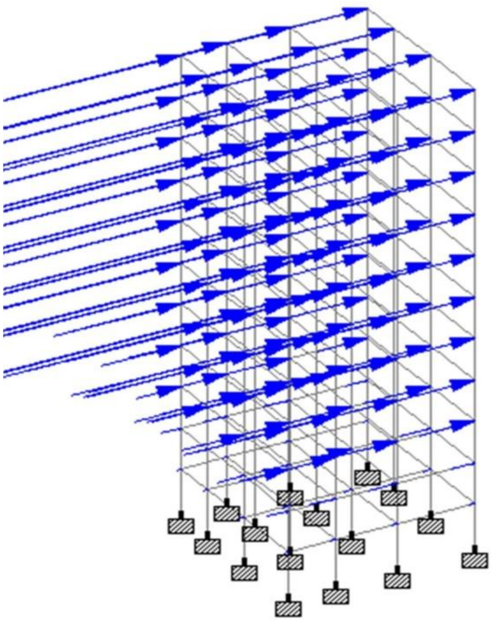
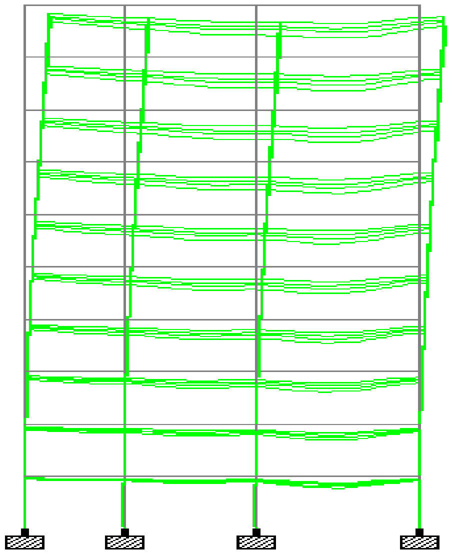


Fig 3.7

Step-7 Comparative study of results as Maximum bending moments, Maximum displacements, story wise displacement, Maximum shear force.

Following figure shows the deflection in sloping ground conditions:



Geomerical Properties

Following geometrical properties has been considered with materials in modeling:- Density of RCC: 25 kN/m3, Density of Masonry: 20 kN/m3

The structural plan in X direction is 3.0x4.0x5.0 meters (12.0 m) respectively and in Z direction is 3.0x4.0x5.0 meter (12.0 m) respectively, the storey height of each floor is 3 m. The sections of columns are considered of 450 mm x 450 mm and the section of beam size is 400 mm x 300 mm.

Loading Conditions

Following loading is adopted for analysis:-

(a) **Dead Loads**: as per IS: 875 (part-1) -1987.

Details of Dead Load

Brick Masonry Wall Load					Remark
For floor height 3 m	=	0.245 m x (3.0 - 0.40) m x 20kN/m^3	12.75	kN/m	
Parapet wall	=	0.23 m x (1.0) m x 20kN/m^3	4.6	kN/m	
Floor Load					
Slab Load	=	0.15 m x 25kN/m^3	3.75	kN/m^2	slab thick. 150 mm assumed
Floor Finish	=		1.0	kN/m^2	
Total Load	=		4.75	kN/m^2	

(b) **Live Loads:** as per IS: 875(par2)1987. Live Load on typical floors = 4.75kN/m^2 Live Load seismic calculation = 0.70kN/m^2.

(c) **Earth Quake Loads:** All frames are analyzed for all the 4 earthquake zones.

S.No.	Parameter	Value	As per code
1	Zone factor (II, III, IV and V)	0.10, 0.16, 0.24 and 0.36 .	Table -2
2	Importance factor	1.5	Table -6
3	Response reduction	3	Table -7
4	Soil site factor	Soft, medium and hard	Fig- 2
5	Damp ratio	-	Table -3

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

3. Results and Analysis # Results of Analysis in 0^0 Sloping Ground

Maximum bending moment (kN-m) in 0^0 slant.

Soil Type	Maximum Bending Moment (kN-m) in 0^0 sloping ground			
	Zone-II	Zone-III	Zone-IV	Zone-V
Soft	150.307	227.571	337.745	507.936
Medium	131.377	189.154	274.561	413.159
Hard	115.192	145.209	206.503	303.096

It is observed that maximum bending moment is in Soft soil and minimum in hard soil, therefore hard soil is comparatively more stable and decreases reinforcement requirement.

Maximum Shear Force (kN) in 0^0 Slant

Soil Type	Shear force (kN) in 0^0 slope			
	Zone-II	Zone-III	Zone-IV	Zone-V
Soft	120.92	170.92	237.77	338.05
Medium	105.17	146.10	200.54	282.20
Hard	87.85	117.47	157.31	217.35

It is observed that maximum shear force is seen in soft soil whereas minimum in hard soil, therefore hard soil is considered better.

Maximum axial force (kN) in 0^0 slope

Soil type	Axial force kN in 0^0 degree slope			
	Zone-II	Zone-III	Zone-IV	Zone-V
Soft	2990.928	2990.928	2990.928	3486.254
Medium	2990.928	2990.928	2990.928	3129.163
Hard	2990.928	2990.928	2990.928	2990.928

Informality in axial forces is observed in zones except zone IV and V. which shows gradual increase in axial forces at higher zones With respect to soil type.

Maximum displacement (mm) in 0^0 slant

Soil Type	Maximum Displacement (mm) in 0^0 Sloping Ground.			
	Zone-II	**Zone-III**	**Zone-IV**	**Zone-V**
Soft	67.456	106.455	158.455	236.454
Medium	55.39	87.15	129.497	193.017
Hard	41.378	64.731	95.869	142.575

It is observed that maximum displacement occurs in soft soil whereas minimum in hard soil type, thus hard soil is more stable.

 # Results of Analysis in 8^0 Sloping Ground

Maximum bending moment (kN-m) in 8^0 slope

Soil Type	MaxBending Moment (kNm) in 8^0 sloping ground			
	Zone-II	**Zone-III**	**Zone-IV**	**Zone-V**
Soft	285.717	457.302	686.082	1029.251
Medium	232.632	372.365	558.677	838.145
Hard	170.984	273.73	410.724	616.215

Maximum bending moment It is observed that maximum bending moment is in Soft soil and minimum in hard soil, therefore hard soil is comparatively more stable and decreases reinforcement requirement.

Maximum Shear Force (kN) in 8^0 Slant

Soil Type	Shear force (kN) in 8^0 slope			
	Zone-II	**Zone-III**	**Zone-IV**	**Zone-V**
Soft	231.42	360.13	531.76	789.19
Medium	191.59	296.42	436.18	696.76
Hard	145.35	222.43	325.19	479.34

It is observed that maximum shear force is seen in soft soil whereas minimum in hard soil, therefore hard soil is considered better.

Maximum Axial Force

Soil type	Axial force kN in 8 degree slope			
	Zone-II	**Zone-III**	**Zone-IV**	**Zone-V**
Soft	3000.783	3000.783	3443.708	4388.194
Medium	3000.783	3000.783	3093.061	3862.223
Hard	3000.783	3000.783	3000.783	3251.418

Informality in axial forces is observed in zones except zone IV and V. which shows gradual increase in axial forces at higher zones With respect to soil type.

Maximum displacement (mm) in 8^0 slant

Soil Type	Maximum Displacement (mm) in 8^0 Sloping Ground			
	Zone-II	**Zone-III**	**Zone-IV**	**Zone-V**
Soft	90.176	143.648	214.945	321.89
Medium	73.632	117.179	175.241	262.334
Hard	54.421	86.44	129.133	193.172

It is observed that maximum displacement occurs in soft soil whereas minimum in hard soil type, thus hard soil is more stable.

 # Results of Analysis in 12^0 Sloping Ground

Maximum bending moment (kN-m) in 12^0 slope

Soil Type	MaxBending Moment (kNm) in 12^0 sloping ground			
	Zone-II	**Zone-III**	**Zone-IV**	**Zone-V**
Soft	171.675	287.806	442.648	674.91
Medium	135.746	230.32	356.419	545.566
Hard	114.142	163.562	256.282	395.361

Maximum bending moment It is observed that maximum bending moment is in Soft soil and minimum in hard soil, therefore hard soil is comparatively more stable and decreases reinforcement requirement.

Maximum Shear Force (kN) in 12^0 Slant

Soil Type	Shear force (kN) in 12^0 slope			
	Zone-II	**Zone-III**	**Zone-IV**	**Zone-V**
Soft	261.56	410.04	608.02	904.99
Medium	215.62	336.54	497.77	739.61
Hard	162.27	251.18	369.73	548.51

It is observed that maximum shear force is seen in soft soil whereas minimum in hard soil, therefore hard soil is considered better.

Maximum Axial Force in 12^0 slant

Soil type	Axial force kN in 12 degree slope			
	Zone-II	**Zone-III**	**Zone-IV**	**Zone-V**
Soft	3005.617	3005.617	3005.617	3431.136
Medium	3005.617	3005.617	3005.617	3082.366
Hard	3005.617	3005.617	3005.617	3005.617

Informality in axial forces is observed in zones except zone IV and V. which shows gradual increase in axial forces at higher zones With respect to soil type.

Maximum displacement (mm) in 12^0 slant

Soil Type	Maximum Displacement (mm) in 12^0 Sloping Ground in X dir.			
	Zone-II	**Zone-III**	**Zone-IV**	**Zone-V**
Soft	58.742	93.652	140.198	210.018
Medium	47.941	76.371	114.277	171.137
Hard	35.399	56.303	84.175	125.984

It is observed that maximum displacement occurs in soft soil whereas minimum in hard soil type, thus hard soil is more stable.

4. CONCLUSION:

Following are the conclusions as per study-

Maximum Displacement

- Maximum displacement is observed in soft soil and minimum in hard soil therefore hard soil is stable whereas soft soil is critical.
- In seismic zones, maximum displacement is measured in zone-V and minimum in zone-II hence zone-V is critical
- As comparing slopes, maximum displacement is seen in 12 degree sloping ground and minimum in 0 degree sloping ground means as slope is increasing displacement is also increasing
- In this comparative study zone-II, hard soil, 0 degree sloping is best because it is stable.

Maximum Bending Moment

- Maximum bending moment is observed in soft soil and minimal in hard soil therefore hard Soil is stable.
- In earthquake zones, bending moment maximum is observed in zone-V and minimal in Zone-II means zone-II provide better strength.
- As contrasting slopes, maximum bending moment is observed in 12 degree sloping ground and minimal in 0 degree sloping ground, means as slope is rising bending moment is also rising.
- In this comparative study seismic zone-II hard soil, 0 degree slope is cost effective as it shows lesser moment means lesser reinforcement.

Maximum Shear Force

- Maximum shear force is seen in soft soil and minimal in hard soil therefore hard soil is stable whereas soft soil is severe.
- In seismic zones, maximum shear force is observed in zone-V and minimal in zone-II means zone-II provide superior stability.
- As correlate slopes, maximum shear force is observed in 12 degree sloping ground and minimal in 0 degree sloping ground, means as slope is raising shear force is also rising.

Maximum Axial Force

- Maximum axial force is observed in soft soil, moderate is medium soil and minimal in hard soil therefore hard soil is stable whereas soft soil is severe.
- In seismic zones, maximum axial force is observed in zone-V and minimal in zone-II therefore zone-II provides better stability.
- As comparing slopes, maximum axial force is observed in 12 degree slanting ground and minimal in 0 degree sloping ground, therefore as slope is rising axial force is also rising.

FUTURE SCOPE OF THE STUDY

- In this study sloping ground of 0 degree, 8 degree and 12 degree have been provided. The study can be stretched out to further more level of slope.
- In this study G + 9 unsymmetrical structures has been considered. The study can be extended to more tall structures.
- This study performs seismic load analysis and in further study wind load analysis can be included.

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