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SEISMIC ANALYSIS OF DIFFERENT SLOPING GROUND CONSIDERING DIFFERENT SOIL CONDITIONS.

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ABSTRACT

In the hilly region of india earthquakes are very common, due to drastic increase in population density of India tall structures are needed to be constructed on sloping ground due to shortage of plain area. Structures situated on sloping ground in seismic zone are susceptible to severe damage when affected by seismic activities. Purpose of this work is to determine the effective building frame from different sloping ground and soil conditions. In this research comparative study have been made on G+10 unsymmetrical building frame considering various sloping ground and different types of soil. So, therefore 36 problems are analysed using STAAD.Pro V8i software. Results are collected in terms of axial force, shear force,bending moment,maximum displacement, Storey Displacement which are fundamentally examined to measure the impacts of different slant of ground

KEYWORDS: sloping ground,seismic zones,structural analysis,STAAD.Pro,soil, displacement

INTRODUCTION

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. The impact of step-like slant geology on seismic ground movement has not been altogether inspected before, in spite of that there is undeniable proof of its noteworthiness even from the late 1960s. Indeed, this type of surface geography has drawn minimal consideration among researchers, when contrasted with slopes and gorge, regardless of its noteworthiness in building practice. One conceivable reason is the non-symmetric geometry of step-like inclines, which convolutes diagnostic arrangements and supports for the most part site particular numerical reproductions whose conclusions are hard to sum up. A analyses for the response of step-like ground slopes in different soils, under vertically propagating seismic waves with different sesmic zones to explore the effects of slope geometry, predominant excitation frequency and duration, as well as of the dynamic soil properties on ground motion in a parametric manner, and provide qualitative as well as quantitative insight to the phenomenon.

It is observed from past earthquakes that the buildings on slopes serve more damage and collapse Occurs. Earthquakes causes genuine harm to structures, for example, disappointment of individuals in the building and if the power of tremor is high it prompts breakdown of the structure. In late years population has been expanded definitely and because of which urban areas and towns began spreading out. Because of this reason numerous structures are being built in sloping zones. India has an expansive beach front line which is secured with mountains and slopes. The Himalayan run likewise has substantial mountains and numerous towns are spread over these mountains. Numerous resorts are being developed in uneven zones to give game plans to visitors. The structures in these zones are developed on slanting grounds. A large portion of the bumpy ranges in India go under the seismic zone II, III and IV zones in such case building based on inclining grounds are exceedingly powerless against seismic tremor. This is because of the way that the segments in the ground floor contrast in their statures as indicated by the slant of the ground. Sections toward one side are short and on flip side are long, because of which they are exceedingly powerless. Poor conduct of short sections is because of the way that short segment is stiffer when contrasted with the long segment, and it draws in bigger quake force. Stiffness of a section is the imperviousness to misshapening – the bigger is the firmness, bigger is the power required to twist it. On the off chance that a short section is not satisfactorily intended for such a substantial constrain, it can endure critical harm amid an earthquake.

In past several studies have been made to investigate the effect of motion by earthquake in hilly regions. The impact as far as Axial force, shear force, displacement, bending moment and story displaceemnt. And some prominent literature reviews are as follows:

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Dr. S. A. Halkude et al. (2013) seismic analysis performed on three different configurations viz., Step back building, Step backset back building and Set back building. 3–D analysis including torsional effect has been carried out by using response spectrum method. It has been found that combination of step back and set back building was less affected by torsion as compared to step back buildings. Hence, they observed that Step back & set back buildings are found to be more suitable on sloping ground.

SUJIT KUMAR et al. (2014) studied the behavior of sloping ground frames considering inclinations of (7.5o, 15o) under seismic forces. The comparison of sloping ground and plane ground building under seismic forces is done. Here G+ 4 storey is considered with same loading conditions and properties for its behavior and comparison. And observed that horizontal pressure and bending moment increases with increase in sloping angels whereas vertical forces remain same.

Keyvan Ramin et al. (2013) compared two four-story reinforced concrete moment resisting frame (MRF) buildings with medium deformability, one is sloped by 20 degrees and other is at 0 degrees sloped with same loading conditions and properties using software csi ETABS2000 and SAP2000 and observed that in shorter column stiffness and bending moment is more as compared so longer ones.

G Suresh et al. (2014) considered two groups of building (i.e. configurations), and these two are resting on sloping ground. The slope of ground is 27 degree with horizontal, which is neither too steep or nor too flat. The height and length of building in a particular pattern are in multiple of blocks (in vertical and horizontal direction), the size of block is being maintained at 7 m x 5 m x 3.5 m. The depth of footing below ground level is taken as 1.75 m where, the hard stratum is available. And two bays are considered. And it is observed that the displacement in step back buildings are more compared to step & set back building frames. The nature of variation observed is non linear for all number of stories. As number of storey's increases time period & top Storey displacement also increases.

Sanjaya Kumar Patro (2013) studied floor diaphragms are taken as rigid. M25 concrete was used and P-delta effects creep & shrinkage effects were not considered. Axial deformation was considered for columns. Torsional effect was considered as per IS-1893:2002.Seismic analysis was performed by Response Spectra Method as per IS1893:2002.Ordinary moment resistins frame was taken for all these types of buildings in seismic zone III. Response reduction factor and importance factor was taken as 3 and 1 respectively.5% of damping was considered. And they observed Less damage occurs in case of Set back building in flat soil. Detailed study of economic cost for leveling sloping soil and other issues need to be studied. Lateral displacement of top storey is maximum for Step back building. On sloping soil Setback- Stepback building is favored.

The main objectives of the presnt work is to determine the effect of different seismic zones, types of soil and sloping ground on building frames in terms of axial force,shear force,bending moment and displacement.

METHODOLOGY

This research paper deals with comparative study of seismic activities on G+10 unsymetrical frame with different soil types and sloping ground. The followings steps has been taken:

Step1: Selection of unsymmetrical geometry of building frames.

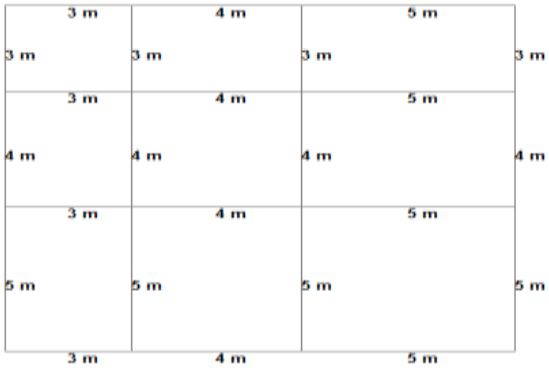

Fig.1: Plan of building

Step2. In present work we are taking sloping angels of 0^0, 10^0 and 15^0.

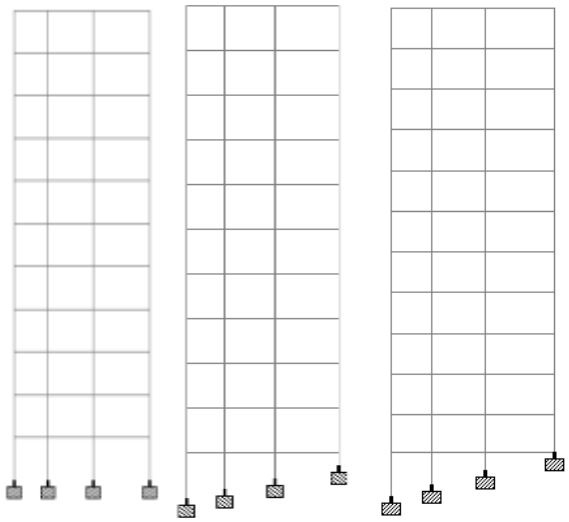

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Fig. 2: Sloping ground 0^0,10^0 and 15^0 respectively

Step 3: Selection of seismic zones IS- 1893 (part I) – 2002 in Table 2

Table 1: Various seismic zones

Seismic zone	II	III	IV	V
Seismic intensity	Low	Moderate	Severe	Very Severe
Z	0.1	0.16	0.24	0.36

Step-4 Formation of load combination

Table 2: Number of load cases details

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

Step-5 Modeling of building frames using STAAD.Pro V8i software.

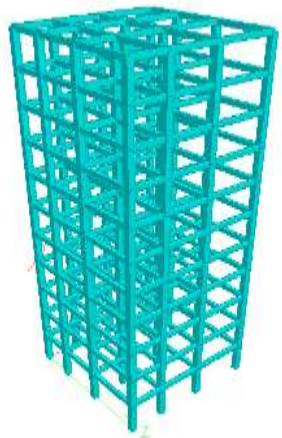

Fig. 3: 3d view

Step-6 Analysis considering different types of soil, sloping ground frame models, seismic zones with load combinations.

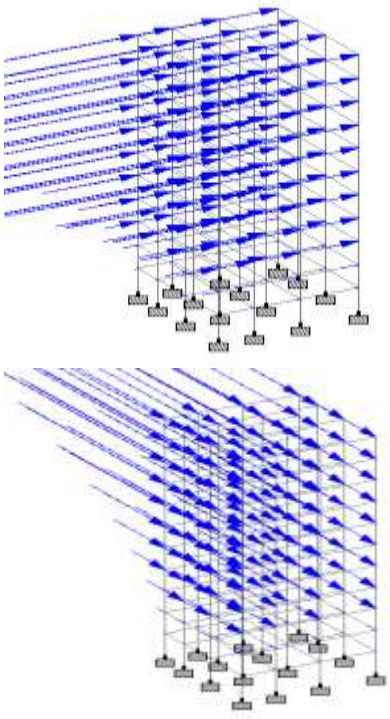

Fig. 4: seismic effect in X and Z direction.

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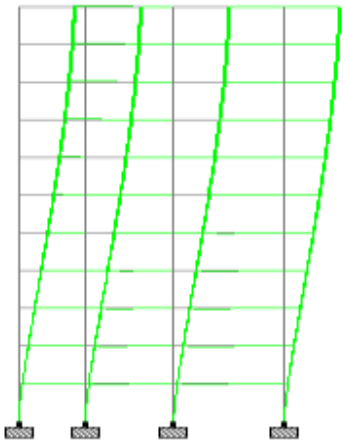
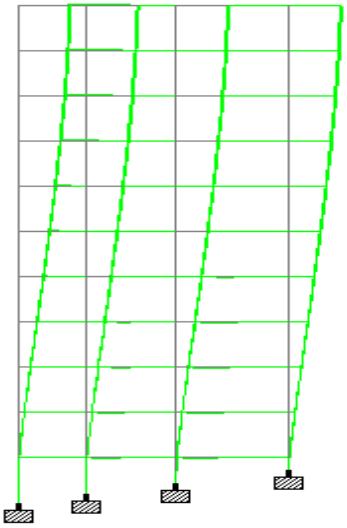
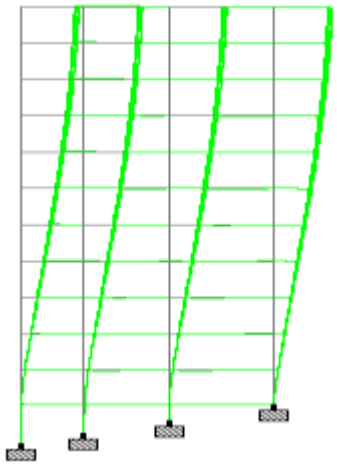
Step-7 Comparative study of results as Max bending moments, Max displacements, story wise displacement, Maximum shear force. Fig 3.5 shows deflection in 0^0 10^0 and 15^0 sloping ground.







. Fig. 5: Deflection in 0^0 10^0 and 15^0 sloping ground.

MODELLING AND PROBLEM FORMULATION

Material and geomerical properties:
Following material properties as been considered in modeling:-
Density of RCC: 25 kN/m3
Density of Masonry: 20 kN/m3
The unsymmetrical plan in x direction is 3mx4mx5m (12m) and in z direction is 3mx4mx5m (12m) the typical storey height floor to floor is 3.0m. The sections of columns are considered of 450mm x 450mm, and the section of beam size is 450mm x 250mm.

Loading conditions
Following loading is adopted for analysis:-

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Table 3. Details of dead load

Brick masonry wall load					Remark
For floor height 3 m	=	0.25 m x (3 - .45) m x 20kN/m^3	12.75	kN/m	
Parapet wall	=	0.25 m x (1) m x 20kN/m^3	5	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	kN/m^2	
Total Load	=		4.75	kN/m^2	

(b) Live Loads: as per IS: 875 (part-2) 1987

Live Load on typical floors = 3kN/m^2

Live Load seismic calculation = 0.75kN/m^2

(c) Earth Quake Loads: All Structures are analyzed for 4 earthquake zones

The earth quake calculation are as per IS: 1893 (2002)

Table 4: Earthquake force parameters for proposed problem

S. No.	Parameter	Value	As per code
1	Zone (II,III,IV,V)	0.1, 0.16, 0.24,0.36	Table – 2
5	Damping ratio	0.05	Table – 3
2	Importance factor (I)	1.5	Table – 6
3	Response reduction factor (RF)	5	Table - 7
4	Rock and soil site factor (SS)	Soft, Medium and Hard	

Period in X direction (PX): $\frac{0.09*h}{\sqrt{dx}}$ seconds Clause 7.6.2

Period in X direction (PX) = 0.09x30/12 = 0.782

Period in Z direction (PZ): $\frac{0.09*h}{\sqrt{dz}}$ seconds Clause 7.6.2

Period in X direction (PZ) = 0.09x30/12 = 0.782

Where h = height of the building

dx= length of building in x direction

dz= length of building in z direction

So, Sa/g = 2.5 (as per code).

ANALYSIS AND RESULT

The following results are carried out in different slopes:

Maximum bending moment:

Maximum bending moment in 0 degree slope

Max Bending Moment (kN-m) in 0 Degree Slope

Table 4 Bending moment in 0 degree

Soil Type	Max Bending Moment (kNm) in 0^0 sloping ground			
	Zone-II	Zone-III	Zone-IV	Zone-V
Soft	211.452	325.769	478.884	719.626
Medium	176.085	269.181	393.31	585.56
Hard	142.237	203.466	294.737	431.644

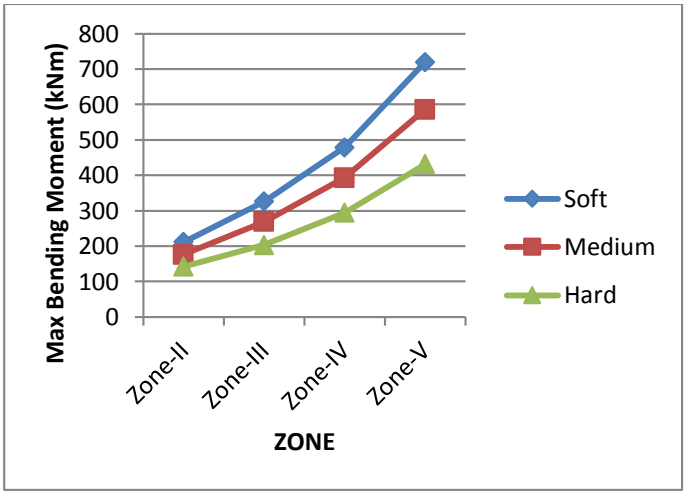

Fig. 6 bending moment in 0 degree slope

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Max bending moment (kNm) in 10 Degree Slope

Table 5 Bending moment in10 degree

Soil Type	Bending moment (kNm) in 10^0 sloping ground			
	Zone-II	Zone-III	Zone-IV	Zone-V
Soft	267.454	435.006	658.408	993.512
Medium	227.102	352.066	533.999	806.897
Hard	197.012	255.749	389.523	590.184

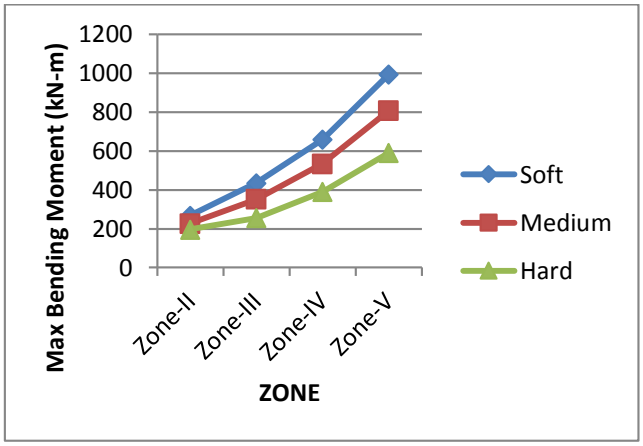

Fig. 7 bending moment in 10 degree slope

Maximum. bending moment (kNm) in 15 Degree Slope

Table 6 Bending moment in15 degree

Soil	Max bending Moment (knm) in 15^0 sloping ground			
	Zone-II	Zone-III	Zone-IV	Zone-V
Soft	255.421	360.82	544.638	820.396
Medium	229.09	298.398	442.273	666.817
Hard	199.441	249.475	323.396	488.502

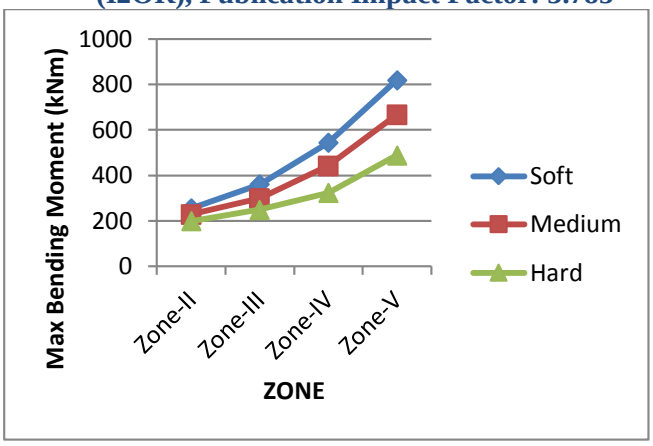

Fig. 8 bending moment in 15 degree slope

It is observed that in every case Max Bending moment is observed in Soft soil and min in Hard soil Therefore hard soil is stable and reduces reinforcement. Whereas best is 0 degree sloping ground with hard soil and zone-II condition.

Maximum shear force

Maximum shear force in 0 degree slope

Table 7 Shear force in 0 degree

Soil Type	Shear force (kN) in 0^0 slope			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Soft	159.54	232.97	330.86	477.71
Medium	136.83	196.62	276.35	395.93
Hard	110.58	154.41	213.04	300.97

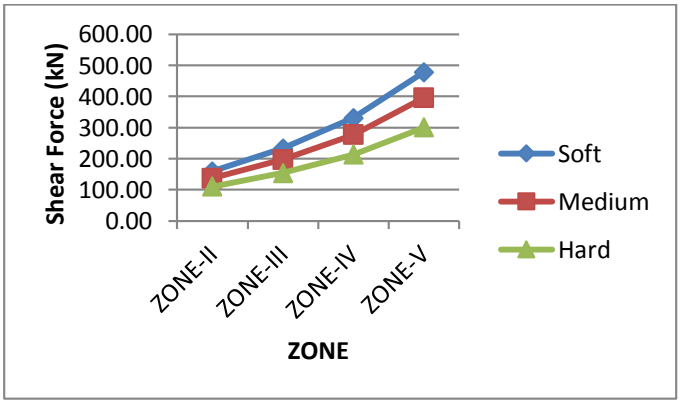

Fig. 9 Shear force in0 degree slope

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Maximum Shear Force in 10 Degree Slope

Table 8 Shear force in10 degree

Soil Type	Shear force (kN) in 10^0 slope			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Soft	301.17	462.21	680.38	1007.63
Medium	251.54	382.17	558.89	825.39
Hard	193.92	289.96	418.03	613.75

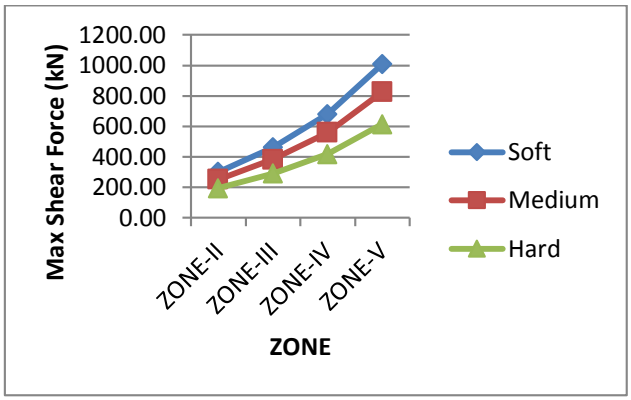

Fig. 10 Shear force in10 degree slope

Maximum Shear Force in 15 Degree Slope

Table 9 Shear force in 15 degree

Soil Type	Shear force (kN) in 15^0 slope			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Soft	177.46	249.641	351.26	503.689
Medium	156.057	213.457	294.67	418.803
Hard	131.364	172.519	229.392	320.227

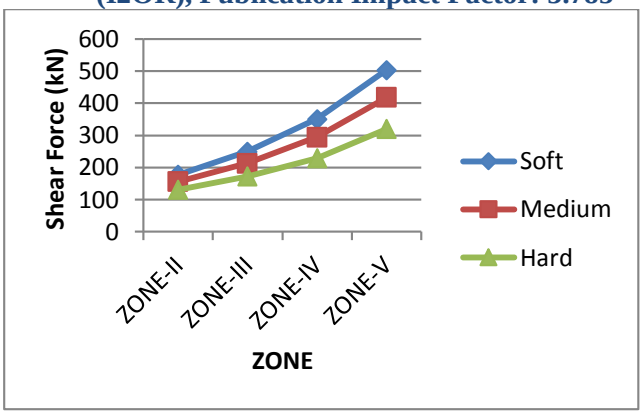

Fig. 11 Shear force in15 degree slope

It is observed that in every case Maximum Shear force is observed in soft soil and minimum in hard soil therefore hard soil is better. As it is more stable and stiff whereas the best case out of all is o degree with hard soil and zone-II

Axial force

Axial force in 0 degree slope

Table10 Axial force in0 degree

Soil type	Axial force kN in 0 degree slope			
	Zone II	Zone III	Zone IV	Zone V
Soft	3217.758	3217.758	3743.863	4762.395
Medium	3217.758	3217.758	3365.726	4195.189
Hard	3217.758	3217.758	3217.758	3536.498

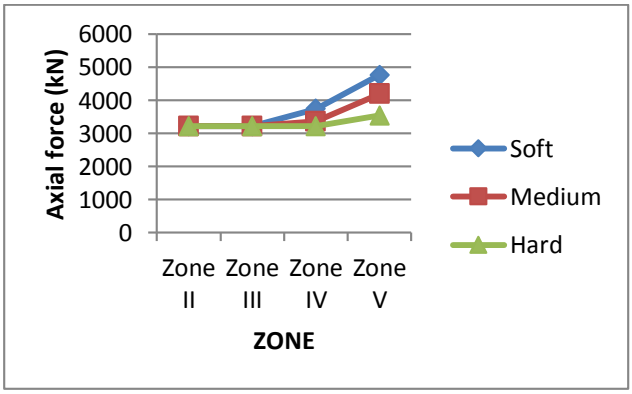

Fig. 12: Axialr force in0 degree slope

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Axial force in 10 degree slope

Table11 Axial force in10 degree

Soil type	Axial force kN in 10 degree slope			
	Zone II	Zone III	Zone IV	Zone V
Soft	4679.999	4679.999	4679.999	5328.695
Medium	4679.999	4679.999	4679.999	4766.961
Hard	4679.999	4679.999	4679.999	4679.99

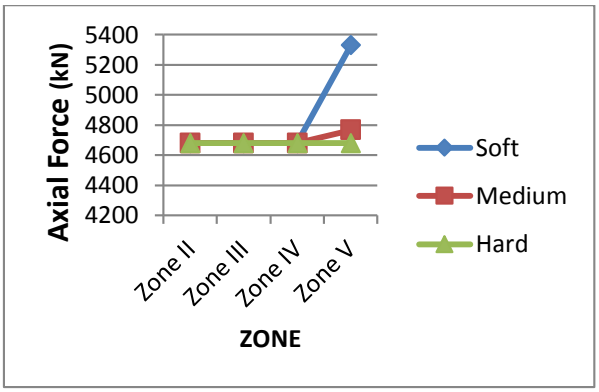

Fig. 13Axialr force in10 degree slope

Axial force in 15 degree slope

Table12 Axial force in15 degree

Soil type	Axial force kN in 15 degree slope			
	Zone II	Zone III	Zone IV	Zone V
Soft	4419.745	4419.745	4427.349	5490.262
Medium	4419.745	4419.745	4419.745	4898.34
Hard	4419.745	4419.745	4419.745	4419.745

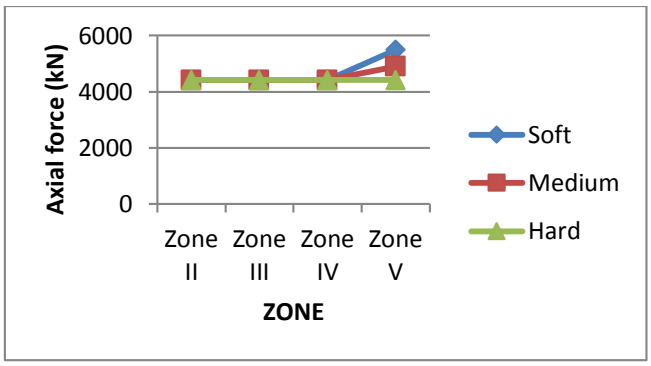

Fig. 14 Axial force in15 degree slope

It is observed that a uniformility is axial stresses in all zones except zone IV and V. which shows increase in axial forces at higher zones With respect to soil type.

Maximum displacement in X and Z direction

Maximum displacement in X and Z direction in 0 degree slope.

Table 13 maximum displacement inX direction 0 degree slope

Soil Type	Maximum displacement (mm) in 0^0 sloping ground in X dir.			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Soft	101.035	159.778	238.102	355.588
Medium	82.862	130.7	194.485	290.162
Hard	61.756	96.932	143.832	214.183

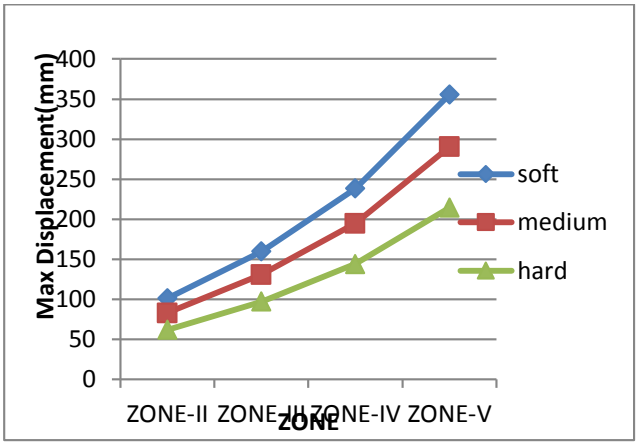

Fig. 15maximum displacement inX direction 0 degree slope

Table 14maximum displacement in Z direction 0 degree slope

Soil Type	Maximum Displacement (mm) in 0^0 sloping ground in Z direction.			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Soft	101.035	159.778	238.102	355.588
Medium	82.826	130.7	194.485	290.162
Hard	61.756	96.932	143.832	214.183

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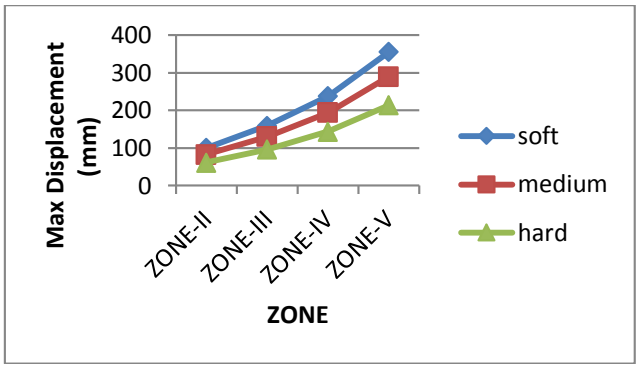

Fig. 15maximum displacement in Z direction 0 degree slope

Maximum displacement in X and Z direction in 10 degree slope.

Soil Type	Maximum Displacement (mm) in 10^0 Sloping Ground in X direction.			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
soft	93.994	148.337	220.796	329.483
medium	77.181	121.437	180.445	268.956
hard	57.656	90.197	133.585	198.668

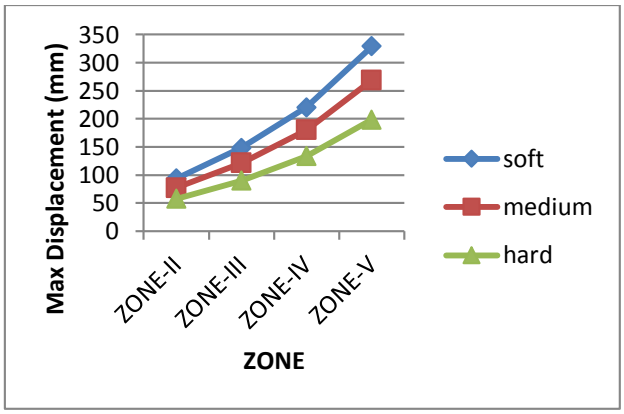

Fig. 16 maximum displacement in X direction 10 degree slope

Table 15 maximum displacement in Z direction 0 degree slope

Soil Type	Maximum Displacement (mm) in 10^0 Sloping Ground in Z Direction.			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
soft	97.205	151.959	224.965	334.473
medium	80.265	124.855	184.309	273.489
hard	60.593	93.38	137.096	202.67

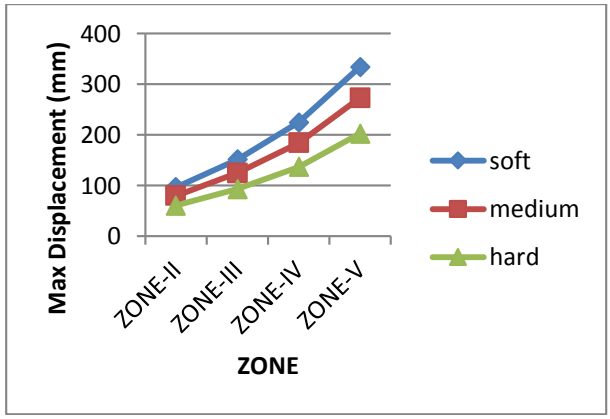

Fig. 17 maximum displacement in Z direction 10 degree slope

Maximum displacement in X and Z direction in 15 degree slope.

Table 16 maximum displacement in X direction 15 degree slope

Soil Type	Maximum displacement (mm) in 15^0 sloping ground in x direction.			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
soft	99.855	157.796	235.051	350.933
medium	81.929	129.114	192.029	286.4
hard	61.111	99.372	142.067	211.458

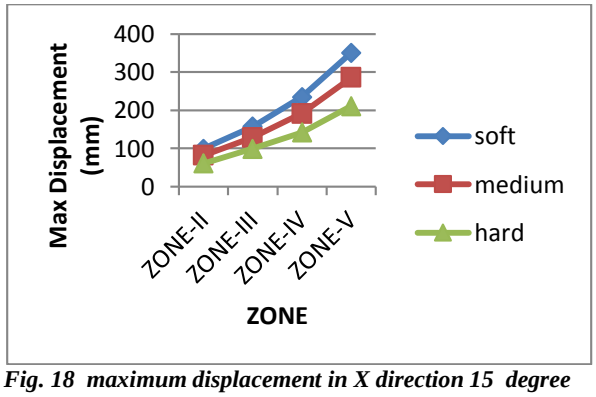

Fig. 18 maximum displacement in X direction 15 degree

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Table 17 maximum displacement in Z direction 15 degree slope

Soil Type	Maximum displacement (mm) in 15^0 sloping ground in Z direction.			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
soft	104.979	163.638	241.85	359.168
medium	86.831	134.601	198.295	293.766
hard	65.756	100.881	147.714	217.965

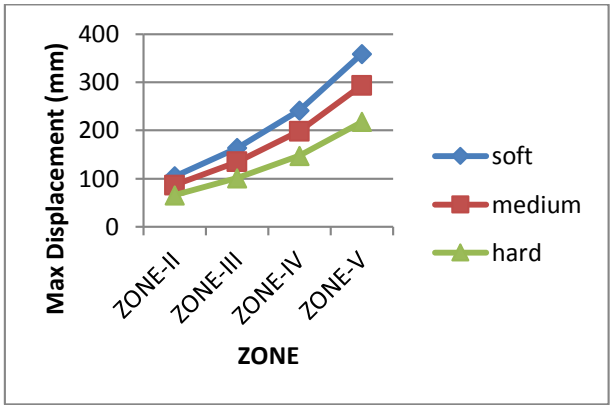

Fig. 19 maximum displacement in Z direction 15 degree

Maximum storey displacement in X and Z direction in soft,medium and hard soil.

Maximum storey displacement in in X and Z direction in soft, medium and hard soil in 0 degree slope.

Table 18 maximum storey displacement inX direction 0 degree slope

Storey	Storey Displacement (mm) in X direction in soft soil			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Base	0	0	0	0
Gf	3.843	6.149	9.224	13.835
1st Storey	10.327	16.524	24.785	37.178
2nd Storey	17.356	27.769	41.653	62.48
3rd Storey	24.451	39.122	58.682	88.024
4th Storey	31.413	50.26	75.39	113.057
5th Storey	38.07	60.912	91.368	137.051
6th Storey	44.238	70.78	106.17	159.255
7th Storey	49.71	79.537	119.305	178.957
8th Storey	54.269	86.83	130.245	195.368
9th Storey	57.701	92.321	138.481	207.722
10th Storey	59.982	95.971	143.957	215.936

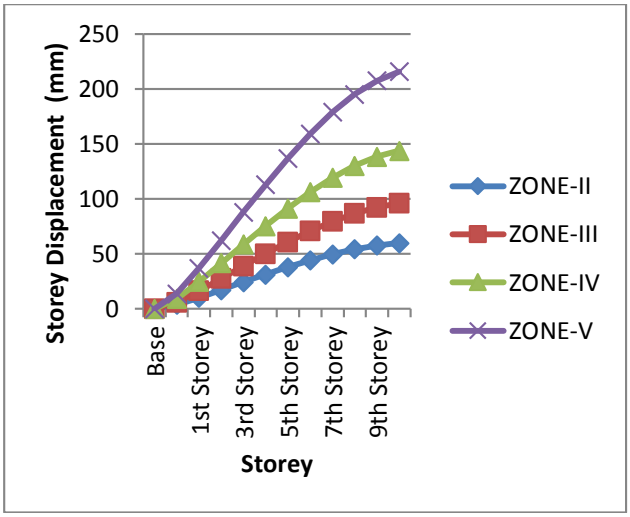

Fig. 20 maximum storey displacement in Z direction0 degree

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Table 20 maximum storey displacement in Z direction 0 degree slope

Storey	Storey Displacement (mm) in Z direction in soft soil			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Base	0	0	0	0
Gf	3.843	6.149	9.224	13.835
1st Storey	10.327	16.524	24.785	37.178
2nd Storey	17.356	27.769	41.653	62.48
3rd Storey	24.451	39.122	58.682	88.024
4th Storey	31.413	50.26	75.39	113.057
5th Storey	38.07	60.912	91.368	137.051
6th Storey	44.238	70.78	106.17	159.255
7th Storey	49.71	79.537	119.305	178.957
8th Storey	54.269	86.83	130.245	195.368
9th Storey	57.701	92.321	138.481	207.722
10th Storey	59.982	95.971	143.957	215.936

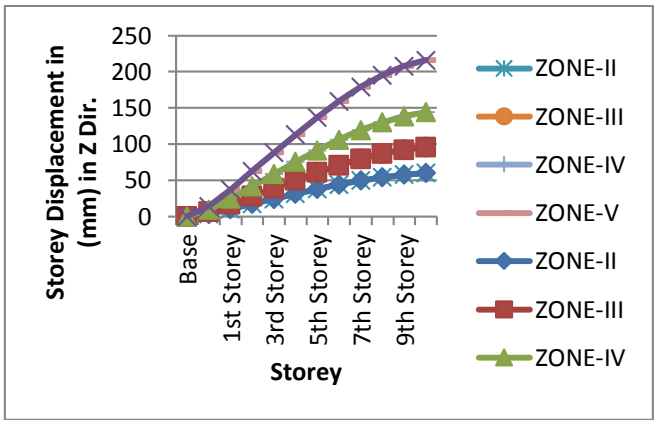

Fig. 21 maximum storey displacement in X direction 0 degree

Table 21 maximum storey displacement in X direction 0 degree slope medium soil

Storey	Storey Displacement (mm) in X direction in medium soil			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Base	0	0	0	0
Gf	3.13	5.008	7.511	11.267
1st Storey	8.41	13.456	20.185	30.277
2nd Storey	14.134	22.614	33.921	50.882
3rd Storey	19.912	31.86	47.789	71.684
4th Storey	25.581	40.93	61.396	92.093
5th Storey	31.003	49.605	74.407	111.611
6th Storey	36.026	57.641	86.462	129.693
7th Storey	40.483	64.772	97.158	145.738
8th Storey	44.195	70.712	106.068	159.102
9th Storey	46.99	75.183	112.775	169.163
10th Storey	48.848	78.156	117.235	175.852

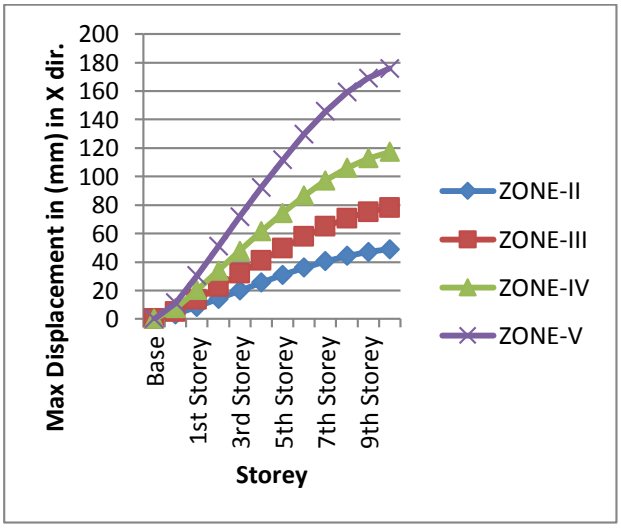

Fig. 21 maximum storey displacement in X direction 0 degree medium soil

Table 22 maximum storey displacement in Z direction 0 degree slope medium soil

Storey	storey displacement (mm) in Z dir 0 degree medium soil			
	ZONE-II	ZONE-II	ZONE-IV	ZONE-V

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Base	0	0	0	0
Gf	3.13	5.008	7.511	11.267
1st Storey	8.41	13.456	20.185	30.277
2nd Storey	14.134	22.614	33.921	50.882
3rd Storey	19.912	31.86	47.789	71.684
4th Storey	25.581	40.93	61.396	92.093
5th Storey	31.003	49.605	74.407	111.611
6th Storey	36.026	57.641	86.462	129.693
7th Storey	40.483	64.772	97.158	145.738
8th Storey	44.195	70.712	106.068	159.102
9th Storey	46.99	75.183	112.775	169.163
10th Storey	48.848	78.156	117.235	175.852

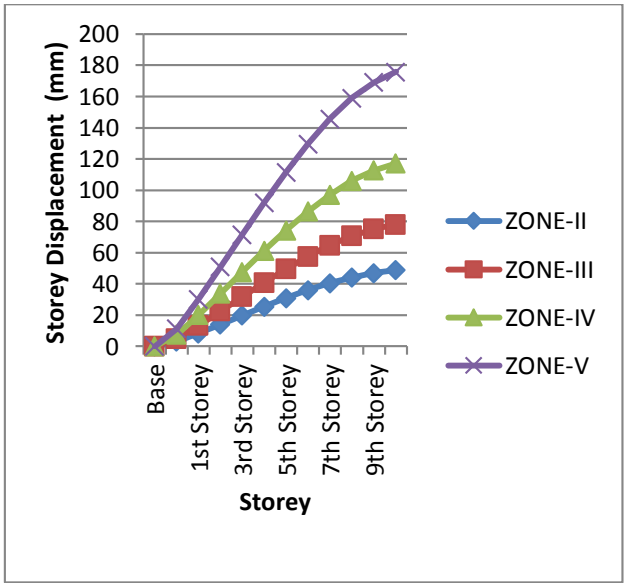

Fig. 22 maximum storey displacement in Z direction 0 degree medium soil

Table 23 maximum storey displacement in X direction 0 degree slope hard soil

Storey	Storey Displacement (mm) in X direction in hard soil			
	ZONE-	ZONE-	ZONE-	ZONE-
	II	III	IV	V
Base	0	0	0	0
Gf	2.301	3.682	5.523	8.285
1st Storey	6.184	9.894	14.842	22.262
2nd Storey	10.393	16.628	24.942	37.413
3rd Storey	14.641	23.426	35.139	52.709
4th Storey	18.81	30.096	45.144	67.716
5th Storey	22.796	36.474	54.711	82.067
6th Storey	26.49	42.383	63.575	95.363
7th Storey	29.767	47.627	71.44	107.16
8th Storey	32.496	51.994	77.991	116.987
9th Storey	34.551	55.282	82.923	124.384
10th Storey	35.917	57.468	86.202	129.303

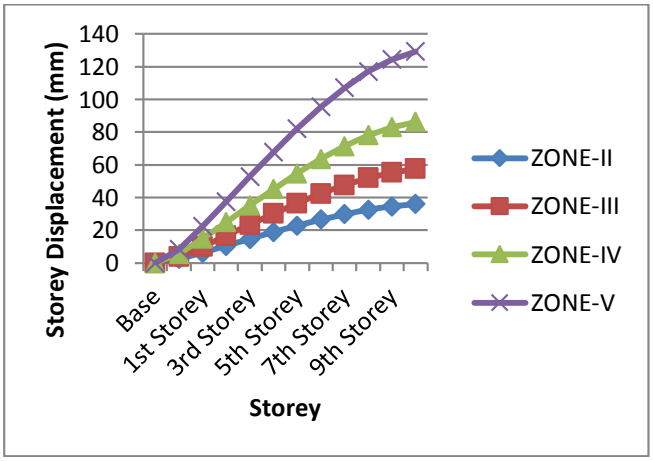

Fig. 23 maximum storey displacement in X direction 0 degree hard soil

Table 24 maximum storey displacement in Z direction 0 degree slope hard soil

Storey	Storey Displacement (mm) in Z direction in hard soil			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Base	0	0	0	0
Gf	2.301	3.682	5.523	8.285

1st Storey	6.184	9.894	14.842	22.262
2nd Storey	10.393	16.628	24.942	37.413
3rd Storey	14.641	23.426	35.139	52.709
4th Storey	18.81	30.096	45.144	67.716
5th Storey	22.796	36.474	54.711	82.067
6th Storey	26.49	42.383	63.575	95.363
7th Storey	29.767	47.627	71.44	107.16
8th Storey	32.496	51.994	77.991	116.987
9th Storey	34.551	55.282	82.923	124.384
10th Storey	35.917	57.468	86.202	129.303

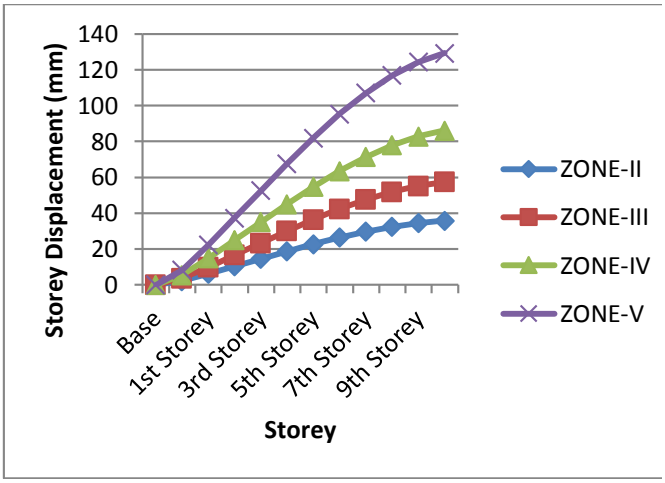

Fig. 24 maximum storey displacement in Z direction 0 degree hard soil

Maximum storey displacement in in X and Z direction in soft, medium and hard soil in 10 degree slope.

Table 25 maximum storey displacement in X direction 10 degree slope soft soil

Storey	Storey Displacement (mm) in X direction in soft soil			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Base	0	0	0	0
Gf	1.209	1.935	2.902	4.354

1st Storey	6.52	10.432	15.648	23.471
2nd Storey	13.304	21.287	31.93	47.895
3rd Storey	20.303	32.485	48.727	73.091
4th Storey	27.194	43.51	65.265	97.897
5th Storey	33.787	54.06	81.09	121.634
6th Storey	39.895	63.832	95.747	143.621
7th Storey	45.31	72.495	108.743	163.114
8th Storey	49.813	79.701	119.551	179.327
9th Storey	53.193	85.109	127.663	191.494
10th Storey	55.426	88.681	133.022	199.533

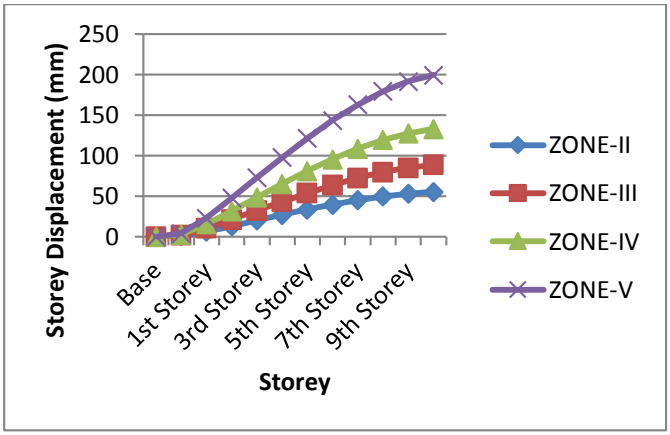

Fig. 25 maximum storey displacement in X direction 10 degree soft soil

Table 26 maximum storey displacement in Z direction 10 degree slope soft soil

Storey	Storey Displacement in Z Direction 10degree			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Base	0	0	0	0
Gf	3.428	5.485	8.228	12.342
1st Storey	9.423	15.076	22.615	33.922
2nd Storey	16.104	25.766	38.649	57.974

3rd Storey	22.957	36.732	55.098	82.647
4th Storey	29.741	47.585	71.378	107.066
5th Storey	36.259	58.014	87.021	130.531
6th Storey	42.313	67.701	101.552	152.328
7th Storey	47.692	76.307	114.46	171.69
8th Storey	52.171	83.473	125.21	187.815
9th Storey	55.537	88.859	133.286	199.934
10th Storey	57.765	92.424	138.636	207.955

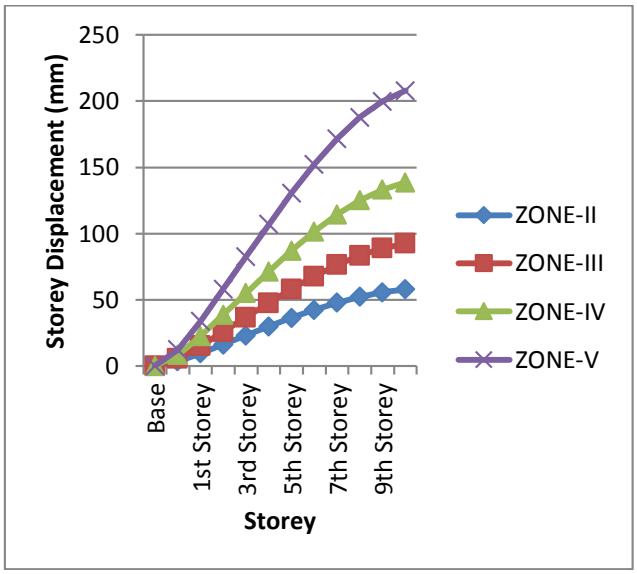

Fig. 26 maximum storey displacement in X direction 10 degree soft soil

Table 27 maximum storey displacement in X direction 10 degree mediumt soil

Storey	Storey Displacement in X Dir 10 degree Medium soil			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Base	0	0	0	0
Gf	0.985	1.576	2.364	3.545
1st Storey	5.31	8.495	12.743	19.114
2nd Storey	10.835	17.335	26.003	39.005
3rd Storey	16.534	26.455	39.682	59.523
4th Storey	22.146	35.433	53.15	79.725
5th Storey	27.515	44.025	66.037	99.056
6th Storey	32.489	51.983	77.974	116.961
7th Storey	36.899	59.038	88.557	132.836
8th Storey	40.566	64.906	97.359	146.039
9th Storey	43.319	69.31	103.965	155.948
10th Storey	45.137	72.219	108.329	162.494

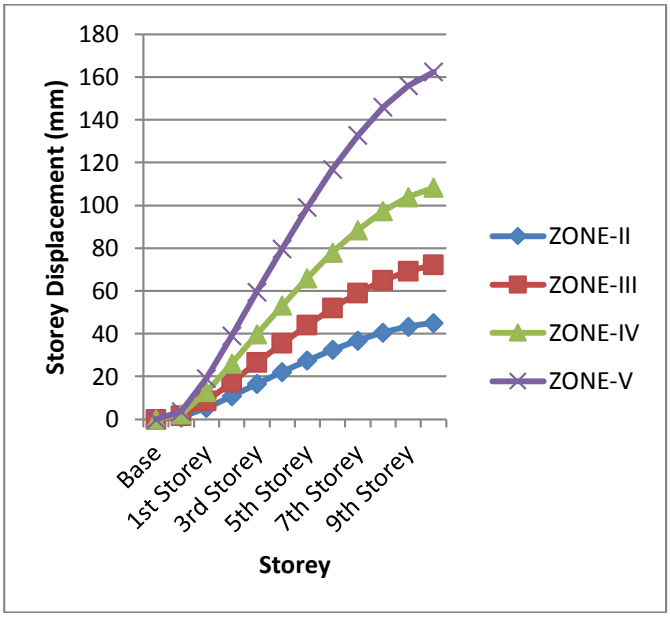

Fig. 27 maximum storey displacement in X direction 10 degree medium soil

Table 28 maximum storey displacement in Z direction 10 degree mediumt soil

Story	Storey Displacement in Z Direction 10 degree Medium soil			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Base	0	0	0	0
Gf	2.792	4.467	6.7	10.051
1st Storey	7.674	12.278	18.417	27.625
2nd Storey	13.114	20.983	31.475	47.212
3rd Storey	18.696	29.913	44.87	67.305

4th Storey	24.22	38.752	58.128	87.192
5th Storey	29.528	47.245	70.897	106.301
6th Storey	34.459	55.134	82.701	124.051
7th Storey	38.839	62.142	93.213	139.819
8th Storey	42.486	67.978	101.967	152.951
9th Storey	45.228	72.364	108.547	162.82
10th Storey	47.042	75.268	112.902	169.352

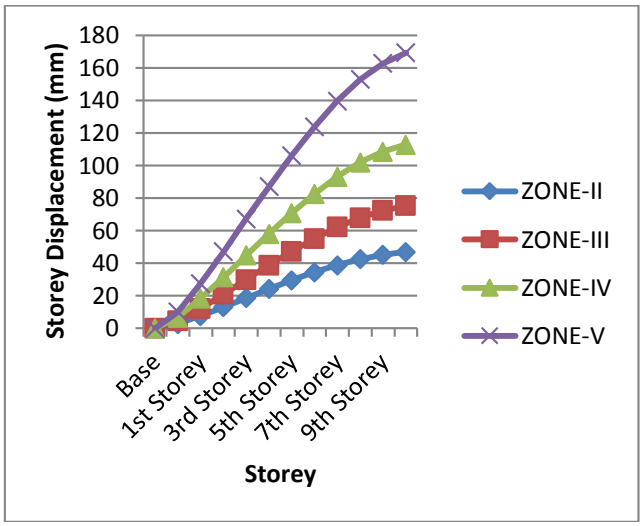

Fig. 28 maximum storey displacement in direction 10 degree medium soil

Table 29 maximum storey displacement in X direction 10 degree hard soil

Storey	Storey Displacement in X Dir 10 degree Hard			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Base	0	0	0	0
Gf	0.724	1.159	1.738	2.607
1st Storey	3.904	6.247	9.37	14.055
2nd Storey	7.967	12.747	19.12	28.68
3rd Storey	12.157	19.452	29.178	43.767
4th Storey	16.284	26.054	39.081	58.621
5th	20.232	32.371	48.557	72.835

Storey				
6th Storey	23.889	38.222	57.334	86.001
7th Storey	27.131	43.41	65.116	97.673
8th Storey	29.828	47.725	71.588	107.381
9th Storey	31.852	50.963	76.445	114.667
10th Storey	33.189	53.102	79.654	119.481

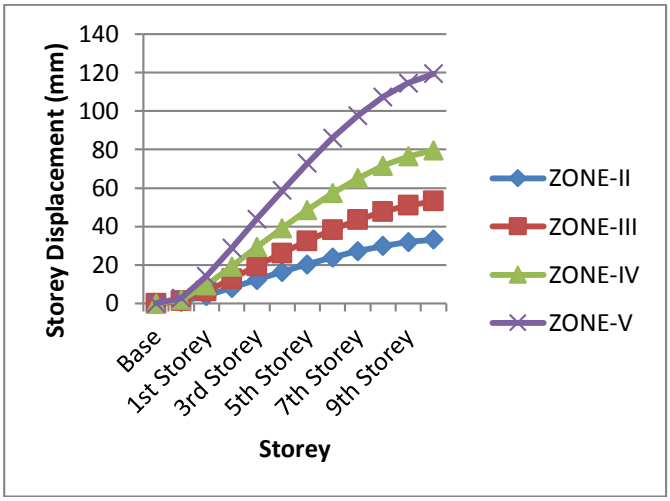

Fig. 29 maximum storey displacement in direction 10 degree hard soil

Table 29 maximum storey displacement in Z direction 10 degree hard soil

Storey	Storey Displacement in Z Direction 10 degree Hard soil			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Base	0	0	0	0
Gf	2.053	3.285	4.927	7.39
1st Storey	5.642	9.028	13.542	20.312
2nd Storey	9.643	15.429	23.143	34.715
3rd Storey	13.747	21.995	32.993	49.489
4th Storey	17.809	28.494	42.741	64.112
5th Storey	21.712	34.739	52.108	78.163
6th	25.337	40.54	60.809	91.214

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Storey				
7th Storey	28.558	45.693	68.539	102.808
8th Storey	31.24	49.984	74.976	112.464
9th Storey	33.256	53.209	79.814	119.721
10th Storey	34.59	55.344	83.016	124.524

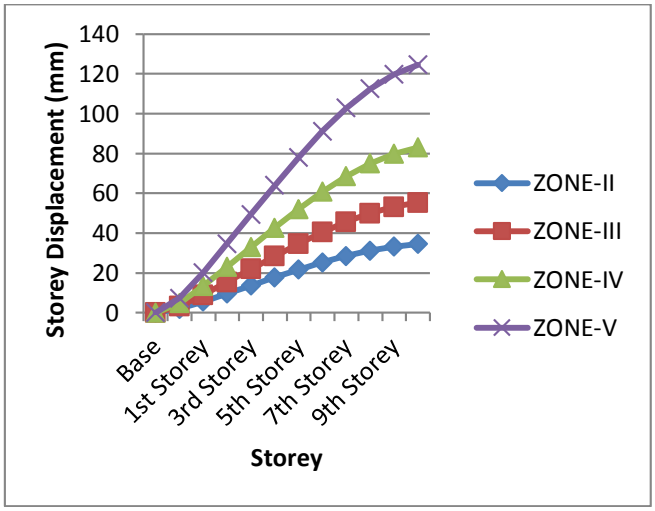

Fig. 30 maximum storey displacement in Z direction 10 degree hard soil

Maximum storey displacement in in X and Z direction in soft, medium and hard soil in 15 degree slope.

Table 30 maximum storey displacement in X direction 15 degree soft soil

Storey	Storey Displacement in X Direction in 15 degree Soft soil			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Base	0	0.904	1.356	2.033
Gf	0.565	7.067	10.601	15.901
1st Storey	4.417	17.43	26.145	39.217
2nd Storey	10.876	28.602	42.902	64.354
3rd Storey	24.856	39.774	59.661	89.491
4th Storey	31.657	50.651	75.976	113.964
5th Storey	38.111	60.977	91.466	137.199
6th Storey	44.053	70.484	105.726	158.589
7th Storey	49.3	78.88	118.32	177.479
8th Storey	53.663	85.86	128.791	193.186
9th Storey	56.96	91.136	136.704	205.055
10th Storey	59.191	94.706	142.059	213.089

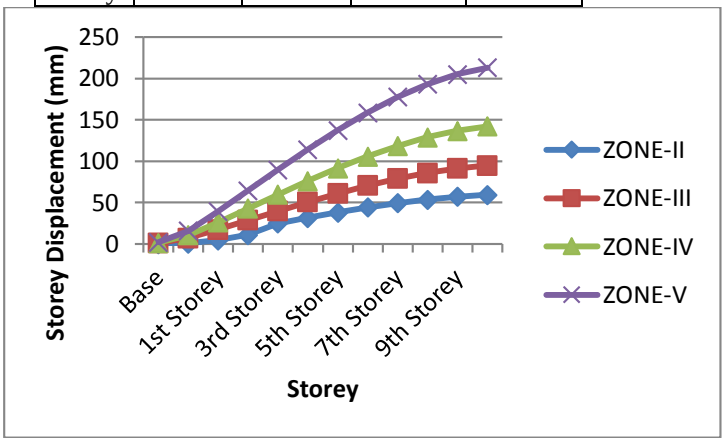

Fig. 31 maximum storey displacement in X direction 15 degree soft soil

Table 31 maximum storey displacement in Z direction 15 degree soft soil

Storey	Storey Displacement in Z Direction 15 degree Soft soil			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Base	3.631	5.81	8.716	13.073
Gf	8.718	13.298	20.922	31.383
1st Storey	15.152	24.243	36.364	54.546
2nd Storey	21.924	35.078	52.617	78.925
3rd Storey	28.744	45.991	68.986	103.479
4th Storey	35.426	56.682	85.023	127.534
5th Storey	41.798	66.876	100.314	150.472
6th Storey	47.681	76.289	114.434	171.651
7th Storey	52.887	84.619	126.929	190.393
8th Storey	57.223	91.556	137.335	206.002

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9th Storey	60.506	96.809	145.214	217.82
10th Storey	62.735	100.375	150.563	225.844

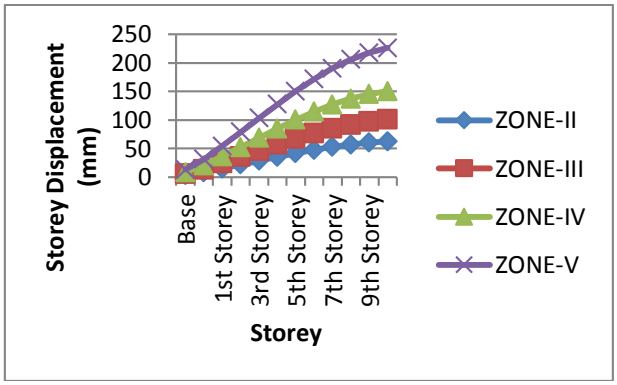

Fig. 32 maximum storey displacement in Z direction 15 degree soft soil

Table 32 maximum storey displacement in X direction 15 degree medium soil

Storey	Storey Displacement in X Direction 15 degree medium soil			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Base	0.46	5.755	1.104	1.656
Gf	3.597	14.192	8.633	12.949
1st Storey	8.872	23.292	21.292	31.938
2nd Storey	14.558	32.391	34.939	52.408
3rd Storey	20.244	41.249	48.586	72.879
4th Storey	25.78	41.249	61.873	92.809
5th Storey	31.036	49.658	74.487	111.731
6th Storey	35.875	57.4	86.1	129.15
7th Storey	40.148	64.237	96.356	144.534
8th Storey	43.701	69.922	104.883	157.325
9th Storey	46.386	74.218	111.327	166.991
10th Storey	48.204	77.126	115.689	173.534

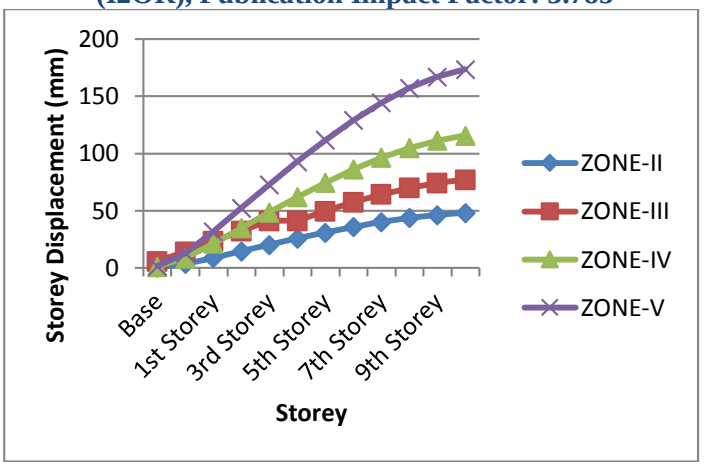

Fig. 33 maximum storey displacement in X direction 15 degree medium soil

Table 33 maximum storey displacement in Z direction 15 degree medium soil

Storey	Storey Displacement in Z Direction 15 degree medium soil			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Base	2.957	4.732	7.098	10.647
Gf	7.099	11.359	17.039	25.558
1st Storey	12.339	19.743	29.614	44.421
2nd Storey	17.854	28.566	42.85	64.274
3rd Storey	23.408	37.453	53.18	84.27
4th Storey	28.85	46.16	69.24	103.86
5th Storey	34.039	54.462	81.693	122.54
6th Storey	38.83	62.128	93.192	139.787
7th Storey	43.07	68.911	103.367	155.051
8th Storey	46.601	74.561	111.841	167.762
9th Storey	49.274	78.839	118.258	177.387
10th Storey	51.089	81.743	122.614	183.921

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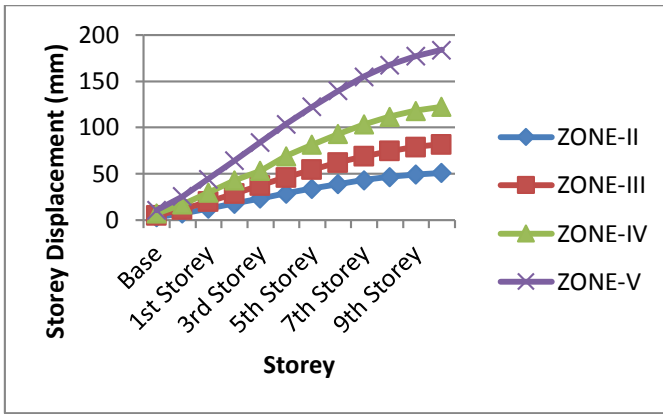

Fig. 34 maximum storey displacement in Z direction 15 degree medium soil

Table 34 maximum storey displacement in X direction 15 degree hard soil

Storey	storey displacement in X direction 15 degree Hard soil			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Base	0.338	0.541	0.812	1.218
Gf	2.645	4.232	6.348	9.522
1st Storey	6.523	10.437	15.656	23.484
2nd Storey	10.704	17.127	25.69	38.535
3rd Storey	14.885	23.817	35.725	53.587
4th Storey	18.956	30.33	45.495	68.242
5th Storey	22.821	36.513	54.77	82.155
6th Storey	26.379	42.206	63.309	94.963
7th Storey	29.521	47.233	70.85	106.275
8th Storey	32.133	51.413	77.12	115.68
9th Storey	34.108	54.572	81.858	122.788
10th Storey	35.444	56.71	85.066	127.598

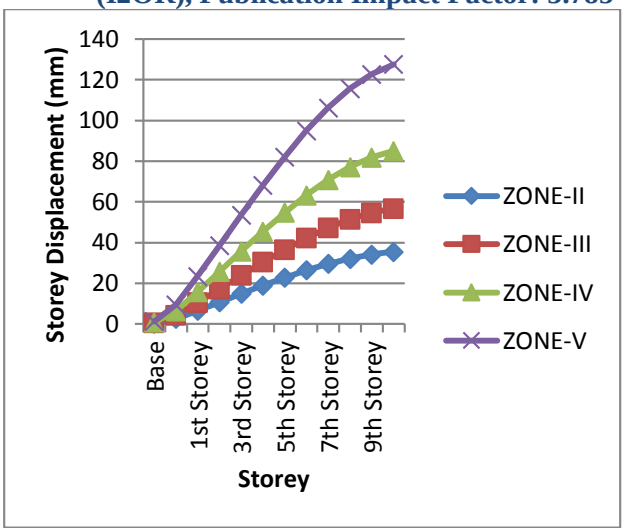

Fig. 35 maximum storey displacement in X direction 15 degree hard soil

Table 35 maximum storey displacement in Z direction 15 degree hard soil

Storey	storey displacement in Z direction 15 degree Hard soil.			
	ZONE-II	ZONE-III	ZONE-IV	ZONE-V
Base	2.175	3.479	5.219	7.828
Gf	5.22	8.325	12.528	18.792
1st Storey	9.073	14.517	21.775	32.662
2nd Storey	13.128	21.005	31.507	47.261
3rd Storey	17.212	27.539	41.309	61.963
4th Storey	21.213	33.941	50.912	76.368
5th Storey	25.029	40.046	60.068	90.103
6th Storey	28.551	45.682	68.523	102.785
7th Storey	31.669	50.67	76.005	114.008
8th Storey	34.265	54.824	82.236	123.355
9th Storey	36.231	57.969	86.954	130.431
10th Storey	37.566	60.105	90.157	135.236

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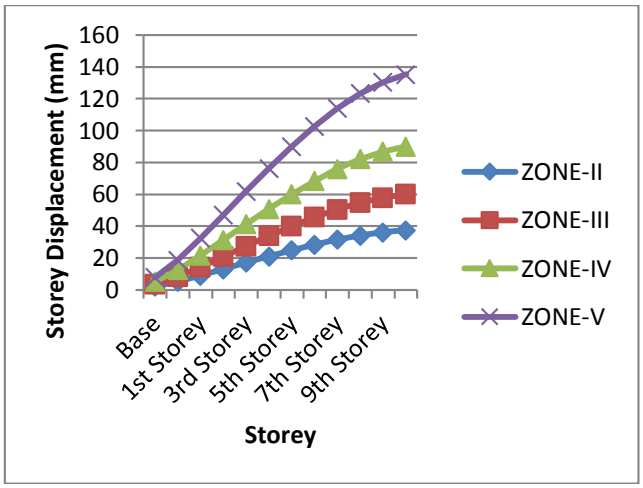

Fig. 36 maximum storey displacement in Z direction 15 degree hard soil

In the study of storey displacement in all the cases it is observed that Zone-V, soft soil shows max storey displacement whereas zone-II, hard soil shows min therefore Zone is better .

CONCLUSIONS

Following are the conclusions as per study-

Maximum displacement

- Maximum displacement is seen in soft soil, moderate is medium soil and minimum in hard soil therefore hard soil is stable whereas soft soil is critical.
- In seismic zones, maximum displacement is seen in zone-V and minimum in zone-II means zone-V is critical
- As comparing slopes, maximum displacement is seen in 15 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 and stiff.

Maximum bending moment

- Maximum bending moment is seen in soft soil and minimum in hard soil therefore hard soil is stable.
- In seismic zones, maximum bending moment is seen in zone-V and minimum in zone-II means zone-II provide better stability.
- As comparing slopes, maximum bending moment is seen in 15 degree sloping ground and minimum in 0 degree sloping ground, means as slope is increasing bending moment is also increasing.
- In this comparative study Zone-2, hard soil, o degree slope is economical as it shows less moment means less reinforcement.

Maximum shear force.

- Maximum shear force is observed in soft soil and minimum in hard soil therefore hard soil is stable whereas soft soil is critical.
- In seismic zones, maximum shear force is seen in zone-V and minimum in zone-II means zone-II provide better stability.
- As comparing slopes, maximum shear force is seen in 15 degree sloping ground and minimum in 0 degree sloping ground, means as slope is increasing shear force is also increasing.

Maximum axial force

- Maximum axial force is seen in soft soil, moderate is medium soil and minimum in hard soil therefore hard soil is stable whereas soft soil is critical.
- In seismic zones, maximum axial force is seen in zone-V and minimum in zone-II means zone-II provide better stability.
- As comparing slopes, maximum axial force is seen in 15 degree sloping ground and minimum in 0 degree sloping ground, means as slope is increasing axial force is also increasing.

Maximum storey displacement

- Maximum storey displacement is seen in soft soil, moderate is medium soil and minimum in hard soil therefore hard soil is stable whereas soft soil is critical.
- In seismic zones, maximum displacement is seen in zone-V and minimum in zone-II means zone-II provide better stability.

- As comparing slopes, maximum displacement is seen in 15 degree sloping ground and minimum in 0 degree sloping ground, means as slope is increasing displacement is also increasing.

REFERENCES

1. KUMAR SUJIT, GARG V. & SHARMA A. "Effect Of Sloping Ground On Structural Performance Of RCC Building Under Seismic Load". International Journal Of Science, Engineering And Technology, ISSN: 2348-4098 Volume 2, Issue 6. (2014)
2. **BIS (2002).** "IS 1893 (Part 1)-2002: Indian Standard Criteria for Earthquake Resistant Design of Structures", Part 1 – General Provisions and Buildings (Fifth Revision), Bureau of Indian Standards, New Delhi
3. Sarkar, P., Prasad, A. M., and Menon, D., Vertical geometric irregularity in stepped building frames, Engineering Structures 32, pp 2175–2182. (2010). Paul,
4. D.K. and Kumar, S. (1997) Stability Analysis of Slope with Building Loads. Soil Dynamics and Earthquake Engineering, **16**, 395-405
5. A.R. Vijaya Narayanan, Rupen Goswami and C.V.R. Murty, "Performance of RC Buildings along Hill Slopes of Himalayas during 2011 Sikkim Earthquake", EERI Newsletter, EERI Special Earthquake Report, February 2012, 1-14.
6. Dr. S. A. Halkude, Mr. M. G. Kalyanshetti, Mr. V. D. Ingle "Seismic Analysis of Buildings Resting on Sloping Ground with Varying Number of Bays and Hill Slopes", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 2 Issue 12, December – 2013.
7. S.S. Nalawade., " Seismic Analysis of Buildings on Sloping Ground," M.E. Dissertation, University of Pune, Dec-2003.
8. S.M.Nagargoje and K.S.Sable," Seismic performance of multi-storeyed building on sloping ground", Elixir International Journal, 7 December 2012.
9. D.K. Paul1, Simplified seismic analysis of framed buildings on hill slopes, Bulletin of the Indian Society of Earthquake Technology, Paper No. 335, vol. 30, No. 4,Dec. 1993, pp. 113-124.
10. D.K. Paul, Simplified seismic analysis of framed buildings on hill slopes, Bulletin of the Indian Society of Earthquake Technology, Paper No. 335, vol. 30, No. 4,Dec. 1993, pp. 113-124.
11. Satish Kumar and D.K. Paul3, Hill building configurations from seismic considerations, Journal of structural engineering , vol. 26, No. 3, Oct. 1999.
12. B.G. Birajdar and S.S. Nalawade5, Seismic analysis of buildings resting on sloping ground, 13th world conference on earthquake engineering, Vancuover, B.C., Canada, August 1-6, 2004, paper No. 1472.
13. Fuji, K., Nakano, Y. and Sanada, Y. (2004), "Simplified Nonlinear Analysis Procedure for Asymmetric Buildings", Proc. of the 13th World Conference on Earthquake Engineering, Vancouver, Canada, Paper No. 149
14. Sharad Sharma (2008), "Seismic soil-structure interaction in buildings on hilly slopes" M.Tech. Dissertation, Indian Institute of Technology Roorkee.
15. Dr. B.G. Naresh Kumar and Avinash Gornale Seismic Performance Evaluation of Torsionally Asymmetric Buildings International Journal of Science and Engineering Research, bVolume 3, Issue 6, June 2012.
16. 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.
17. I.S. 1893(Part 1)-2002, Criteria for earthquake resistant design of structure, general provision and building, *Bureau of Indian standards, New Delhi.*