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Seismic Analysis of Elevated Water Tank on Different Sloping Angle of Ground with Different Height and Capacity

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Abstract – *In this paper work an attempt have been made to study the behavior of the R.C.C elevated water tank of capacity 1 lakh, 5 Lakh and 10 Lakh liters and a comparison is made in between the model kept on sloping ground and different type of sloping angles with considered different height of elevated water tank and the analysis is carried out using SAP2000 Softwer.Taking following things in consideration water level i.e. Fully Condition and Empty Condition of Tank. Earthquake Zone V & III (As per IS-1893-2002). After the completion of the analysis a comparative study is carried out with respect to Base shear ,Shear Force & bending moment variation about left , Middle , right Column as well as earthquake are be tabulated .Following value are compared in between & Sloping ground surface.*

***Key Words*: - Square Tank ,Seismic Zone, Height, Water Capacity, Sloping Degree, Displacement, Base Shear, Shear Force, Bending Moment, Response spectrum Method, SAP2000.**

1. INTRODUCTION

There are large number of storage tanks around the world, most of which are used for water and oil storage facilities. They also play an important role in municipal water supply, fire fighting systems and in many industrial facilities for storage of water. In order to provide the head of water required for a water supply process, water tanks are usually installed on a supporting tower, thereby instead of requiring heavy pumping facilities, the necessary pressure can be obtained by gravity. In the last decade most of these studies have concentrated upon the elevated tanks. In the past earthquakes including Bhuj earthquake of 26 January 2001, damages had been observed widely in the support structures, which is typical of the damage sustained to a large number of water tanks of capacities ranging from 80 m3 to 1,000 m3 and as far away as 125 km from the epicenter (Rai, 2001).

2. Modeling of Structure

Here the study carried out for the Seismic Behavior of Different Height and Water Capacity for Elevated Water Tank. The analysis of the Elevated Water Tank by RSM (Response Spectrum Method) by which it gives the seismic response of the structure by considering the various seismic zones such as Zone III and Zone V with different Height and Water Capacity (Fully & Empty Condition) with Different Slopping Ground. In this study, different research parameters like displacement, Shear force and Bending Moment, Base shear are analyzed. The analysis is done by using SAP2000 V15 software.

3. Elevated Water Tank Plane and Dimension Details

Dimension of various structure element present in elevated R.C.C. water tank are fixed as fallow:

1. Storage capacity = 1 Lakh Litre / 10,15 Lakh Litre
2. Grade of Concrete = M 25
3. Grade of Steel = Fe 415

About Tank

4. Thickness of Top Slab = 100mm
5. Thickness of Bottom Slab = 150mm
6. Thickness of side Wall = 200mm
7. Depth of Tank = 3m / 3.6m
8. Size of Tank = 6.3m x 5.3m

About Beam

9. Size of top Ring Beam = 300mm x 250mm
10. Size of Bottom Ring Beam = 600mm x 300mm
11. Size of Bracing Beam = 300mm x 300mm
12. Size of Columns = 450mm x 450mm
13. No. of Columns = 9
14. Height of Water Tank = 9m/12m/15m

15. Slope of Ground = 1. 10 Degree
    2. 20 Degree

About Earthquake Zone

16. Seismic Zone = 1. 0.36 (V)
    2. 0.16 (III)
17. Type of Soil = Loose Soil
18. Load = Live load (1.5 KN/ m^2)
19. Response Reduction Factor = 2.5
20. Importance Factor = 1.5
21. Damping = 0.05

Table -1: Analysis of Elevated Water Tank Details of Modeling data and different considered parameters.

Water Capacity	Height	Slopping Degree	Zone
1 Lakes Liter	9m,12m, and 15m	Normal Ground 10 degree Slopping 20 degree Slopping	V & III
5 Lakes Liter	9m,12m, and 15m	Normal Ground 10 degree Slopping 20 degree Slopping	V & III
10 Lakes Liter	9m,12m, and 15m	Normal Ground 10 degree Slopping 20 degree Slopping	V & III

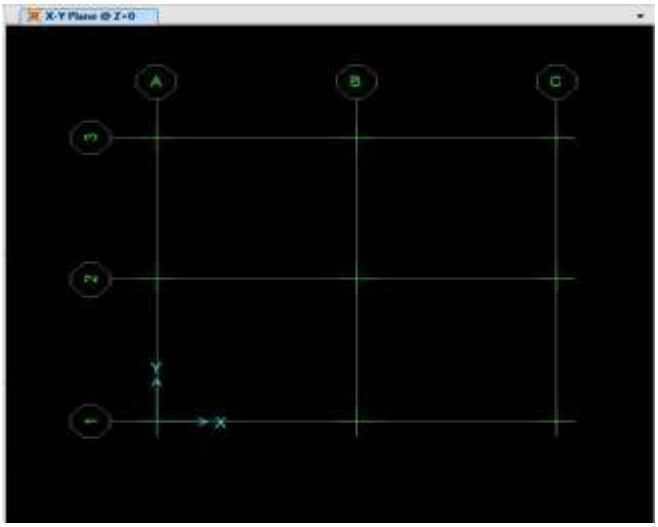


Fig :-1 Plan for 9m, 12m, 15m height

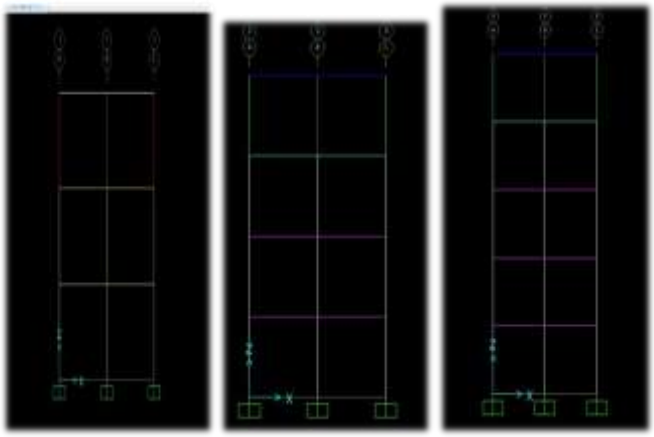


Fig:-2 Section for Levelled Ground for 9m, 12m, 15m height

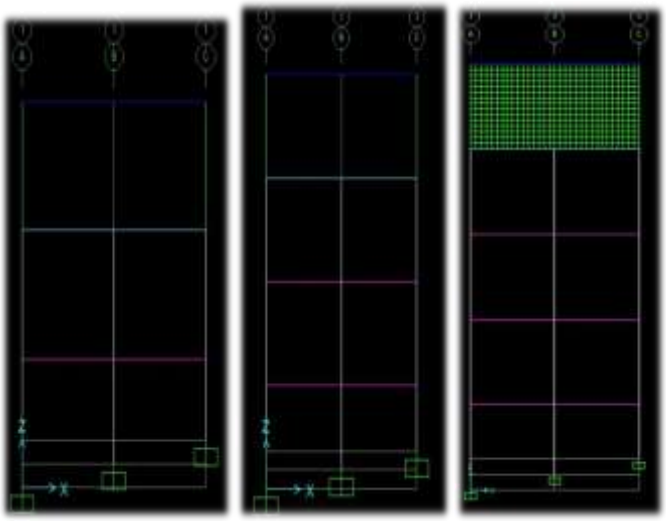


Fig:- 3 Section for 10 Degree Slope for 9m, 12m, 15m height

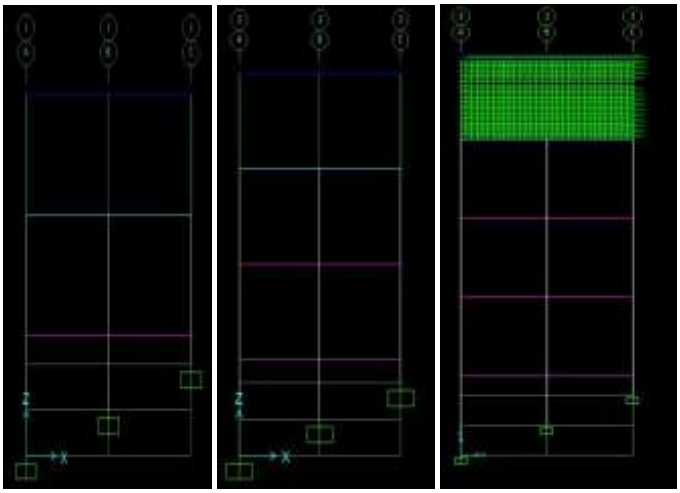


Fig :- 4 Section for 20 Degree Slope for 9m, 12m, 15m height

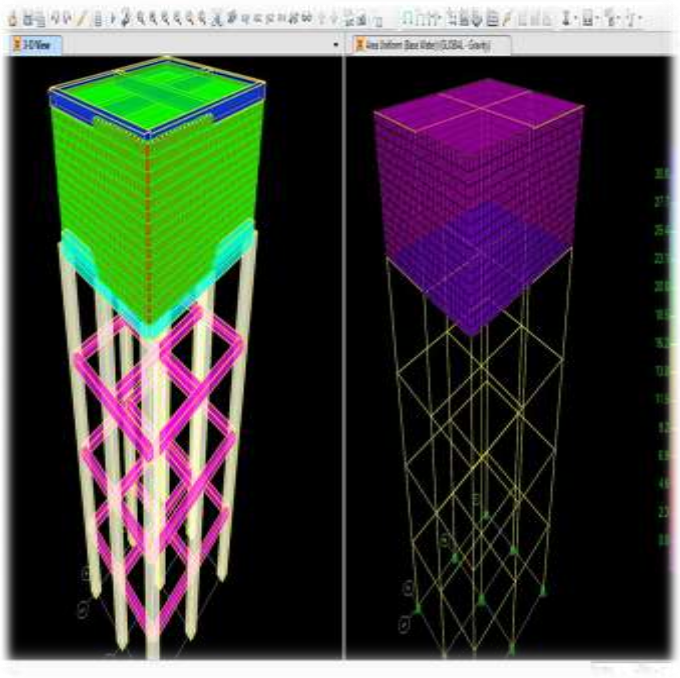


Fig :-5 Elevation of Fully Elevated Water Tank

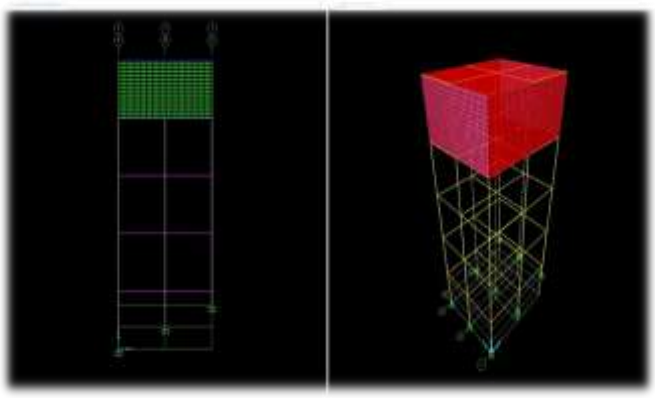


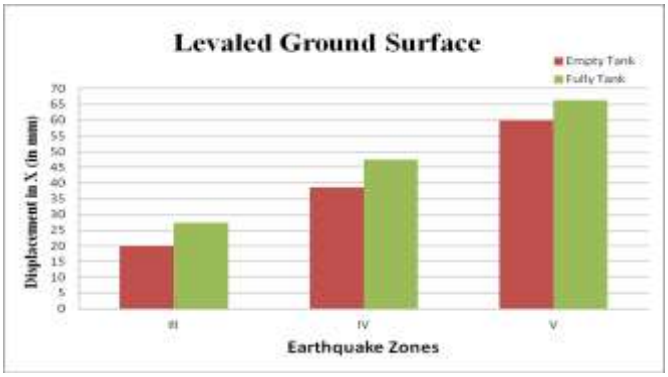
Fig :-6 Elevation of Empty Elevated Water Tank

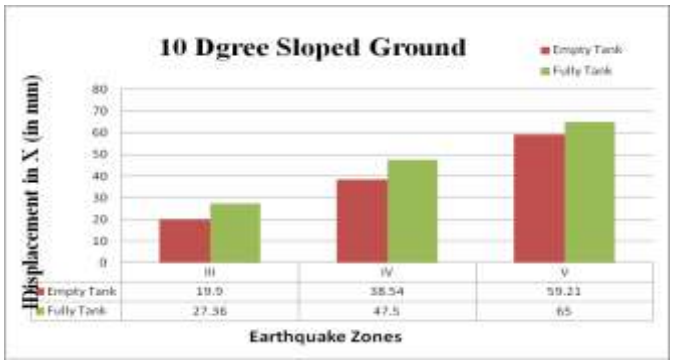
4. RESULTS AND DISCUSSIONS

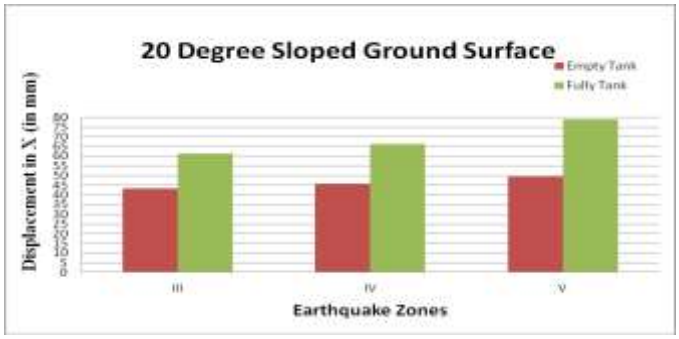
The parameter of this study are Base shear, Shear Force And Bending moment on Column , Node Displacement due to lateral forces like earthquake on tank comparing the result in between the model kept on Different sloping & Leveled ground surface.

5. For 9 Meter Height of Elevated water tank

- **Displacement**







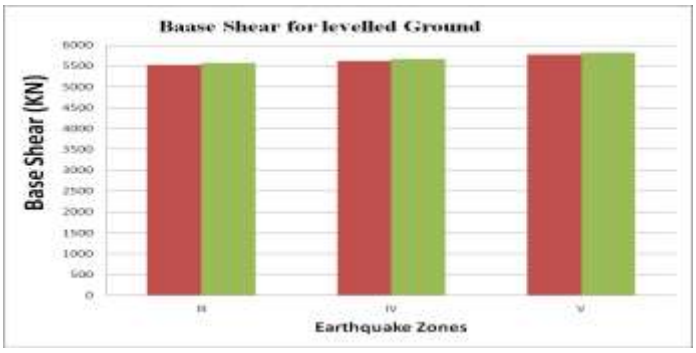
❖ **Shear Forces**

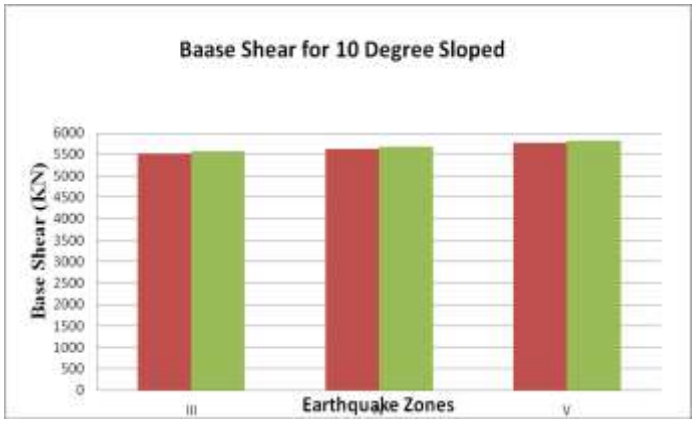
			S.F (KN)			
9M HEIGTH			Staging	Left Colu.	Mid.Colu.	Right colu.
	Level G.L	Empty Tank	1St	626.13	809.05	626.13
			2nd	636.74	645.63	636.74
		Fully Tank	1St	627.18	756.76	627.18
			2nd	549.62	751.14	549.62
	10 Degree Slope	Empty Tank	1st	-486.59	-435	-386
			2nd	-149.35	-473.82	-822.2
		Fully Tank	1st	-336.03	-385	-254
			2nd	-120.14	-339.67	615.13
	20 Degree Slope	Empty Tank	1st	-778.43	-728.27	-782.06
			2nd	170.76	-92.45	-2573
		Fully Tank	1st	-140.8	29.28	2320.65
			2nd	627.38	744.18	633.61

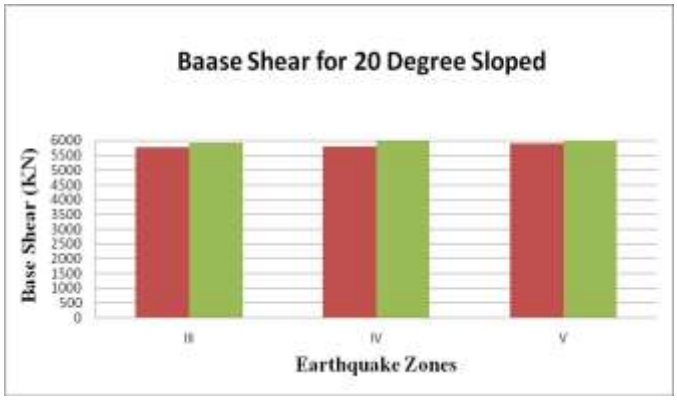
❖ **Bending Moment**

			B.M (KN.M)			
9M HEGTH			Staging	Left Colu.	Mid.Colu.	Right colu.
		Empty Tank	G.L	1574.54	1750.44	1574.54
			1ST	-308	-678	-306
			2ND	-1557.77	-1369	-1557.77
		Fully Tank	G.L	-1556.89	-1683.25	-1556.89
			1ST	325.12	587.47	325.12
			2ND	1329.31	1601.79	1329.31
	10 Degree Slope	Empty Tank	G.L	-520.4	-915.12	-1361.32
			1ST	-72.34	180	-330
			2ND	1016	860	933
		Fully Tank	G.L	-402.69	-682	-1044
			1ST	-321	260	281
			2ND	684	787.2	811.29
	20 Degree Slope	Empty Tank	G.L	-35.91	-482	-2327
			1ST	-532	-303	-864.85
			2ND	1444	1239	1481.32
		Fully Tank	G.L	37.71	403.5	2054.57
			1ST	458	931	400
			2ND	-1113.7	-1362	-1157

❖ **Base Shear**

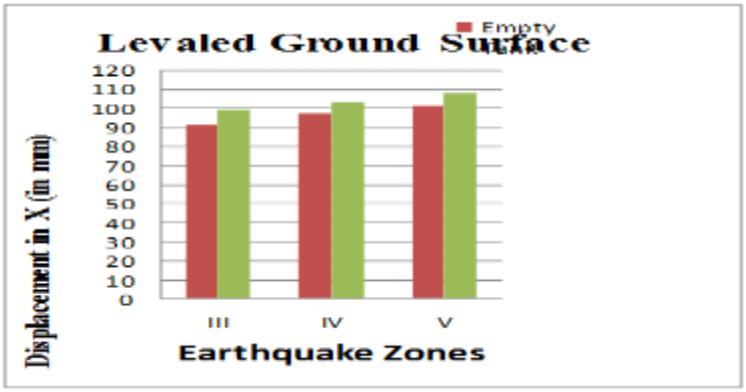


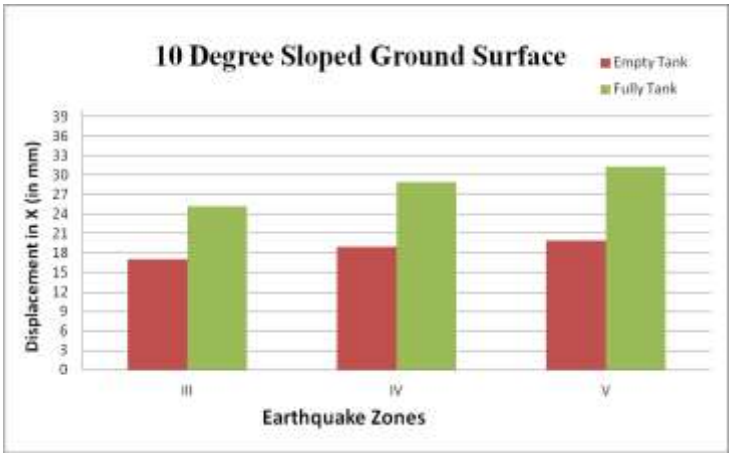


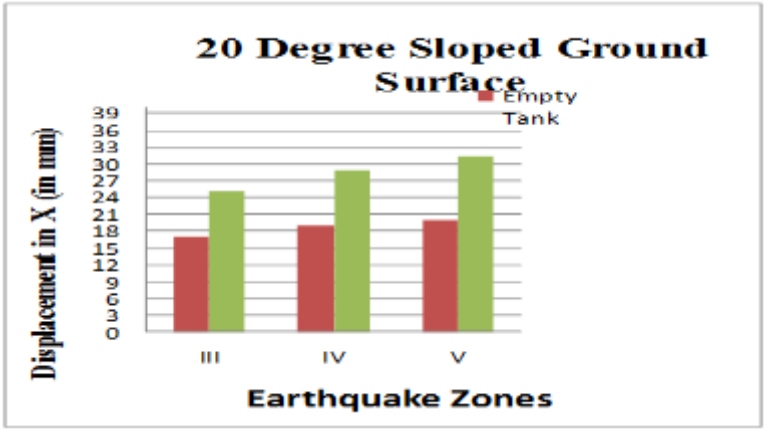


6. For 12 Meter Height of Elevated water tank

- **Displacement**







❖ **Shear Forces**

			S.F (KN)			
			Staging	Left Colu.	Mid Colu.	Right colu.
12M HEIGTH	Level G.L	Empty Tank	1st	-270.9	-341.14	-270.9
			2nd	-232.47	-385.77	-232.47
			3rd	-248.36	-256.29	-248.36
		Fully Tank	1st	-266.31	-340	-266.31
			2nd	-235.92	-368	-235.92
			3rd	-212.54	-31.05	-212.54
	10 Degree Slope	Empty Tank	1dt	35.94	121.93	241.98
			2nd	106.17	147.71	81.29
			3rd	105.26	100.35	92.68
		Fully Tank	1st	-24.08	-80.89	-156.93
			2nd	-67.68	-89.78	-52.54
			3rd	-56.9	-73.51	-48.26
	20 Degree Slope	Empty Tank	1st	-70.14	-30.06	783.19
			2nd	164.26	234.58	170.85
			3rd	173.4	167.08	152.51
		Fully Tank	1st	-1.27	7.1	105.29
			2nd	12.24	21.51	19.09
			3rd	9.68	6.65	-2.89

❖ **Bending Moment**

			S.F (KN)			
			Staging	Left Colu.	Mid Colu.	Right colu.
12M HEIGTH	Level G.L	Empty Tank	1st	-270.9	-341.14	-270.9
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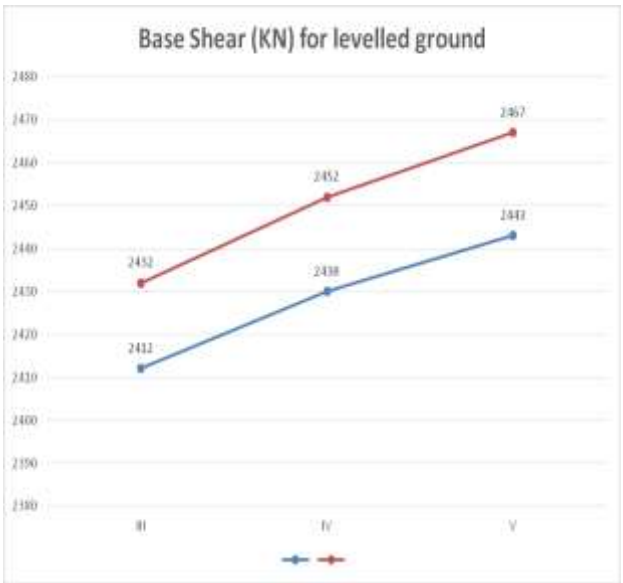
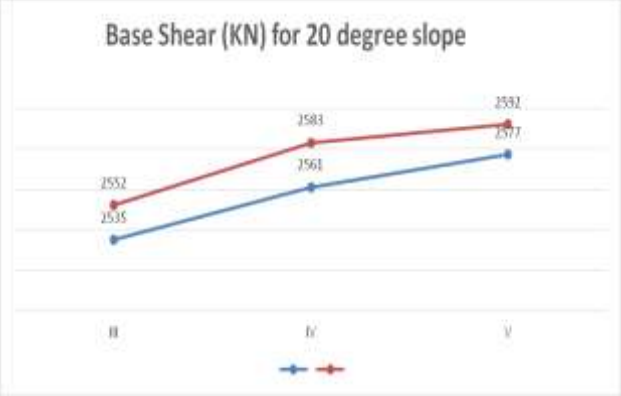
			2nd	12.24	21.51	19.09
			3rd	9.68	6.65	-2.89

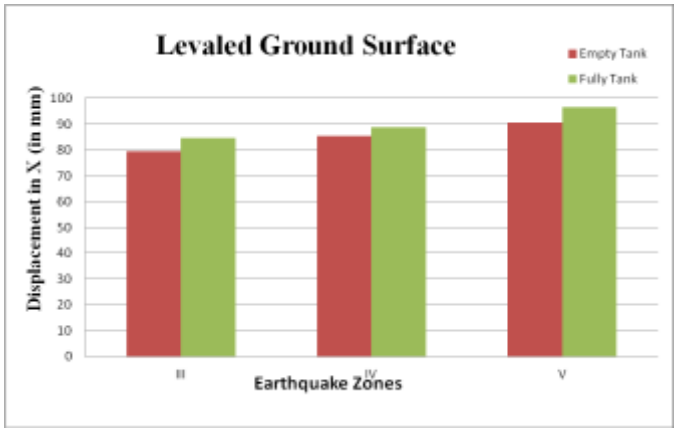
❖ **Base Shear**

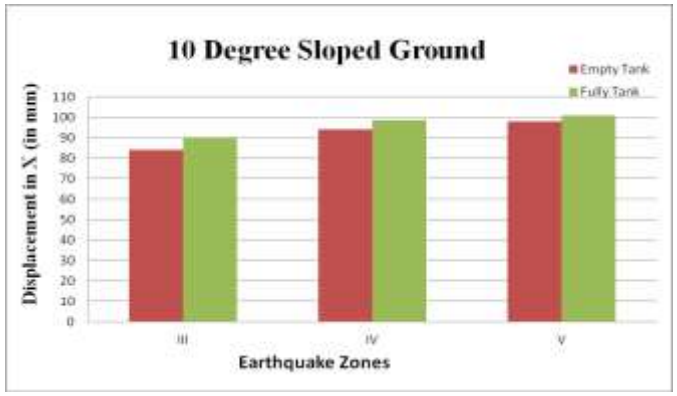


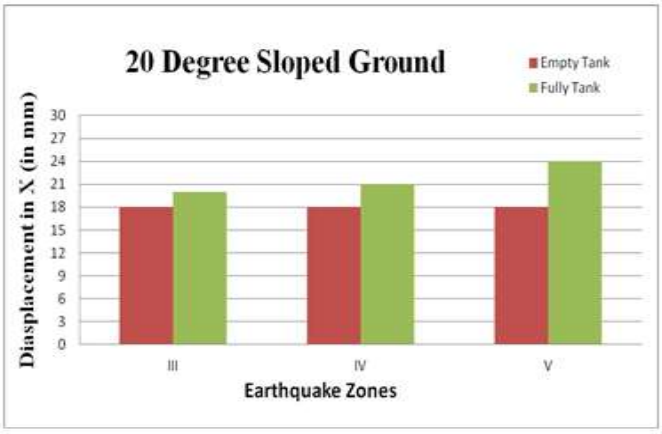


7. For 15 Meter Height of Elevated water tank

- **Displacement**







❖ **Shear Forces**

			S.F (KN)			
			Staging	Left Colu.	Mid.Colu.	Right colu.
15M HEIGTH	Level G.L	Empty Tank	1st	156.98	204.29	156.98
			2nd	139.8	232.04	139.8
			3rd	124.29	221.18	124.29
		Fully Tank	1st	156.28	202.8	156.28
			2nd	138.28	232.48	138.28
			3rd	127.08	212.86	127.08
	10 Degree Slope	Empty Tank	1dt	-28.16	-179.33	-375.81
			2nd	-182.04	-258.76	-141.28
			3rd	-141.61	-253.22	-147.49
		Fully Tank	1st	-28.2	-177.63	-373.64
			2nd	-180.04	-259.02	-139.4
			3rd	-144.69	-243.48	-150.44
	20 Degree Slope	Empty Tank	1st	-29.69	-11.8	326.39
			2nd	66.01	96.12	66.72
			3rd	47.09	43	41.17
		Fully Tank	1st	21.97	6.33	-255.72
			2nd	-50.5	-69.74	-51.39
			3rd	-34.1	-32.7	-32.69

❖ **Bending Moment**

			S.F (KN)			
			Staging	Left Colu.	Mid.Colu.	Right colu.
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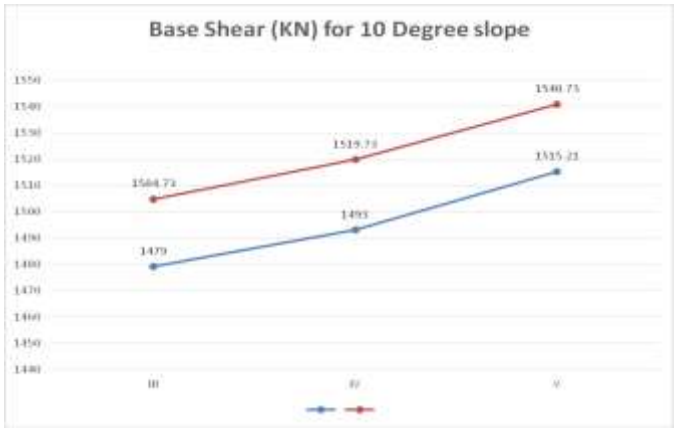
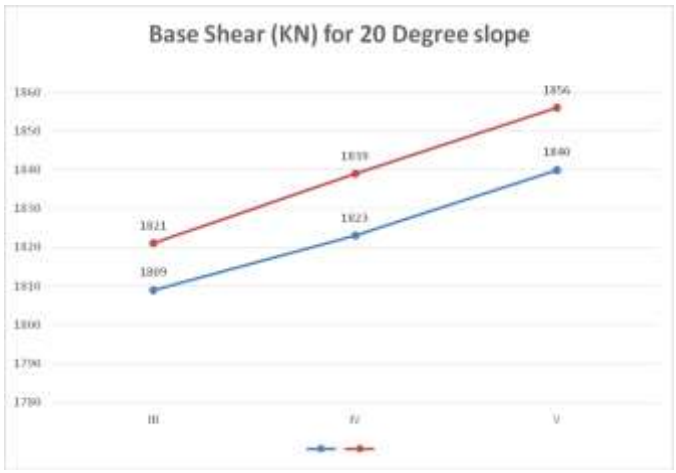
			3rd	47.09	43	41.17
		Fully Tank	1st	21.97	6.33	-255.72
			2nd	-50.5	-69.74	-51.39
			3rd	-34.1	-32.7	-32.69

❖ **Base Shear**





8. CONCLUSIONS

- From the graph it is seen that as the displacement for the node go on increasing for all cases of both the sloped & leveled goes increasing with earthquake zones.
- As we move from right to left column i.e. (from lower side to higher side of sloping ground) the shear force increases.
- This shows that as the height of staging increases shear force increases.
- As we move from right to left column i.e. (from lower to higher side) the bending moment increases .This shows that as the height of staging increases bending moment decreases.

- From the plotted graph is can be clearly seen that the changes in the base shear found to be going on increasing as we keep on increasing zone factor i.e from zone-III, IV & V for all the case i.e Full tank, empty tank levels.

- In the model that's on the level ground surface, from the graph it is seen as the graph seen increasing , from zone-III, IV & V for all the case i.e Full tank, empty tank levels.

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