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Seismic Analysis of Intze Water Tank for Different Bottom Dome Deviation Angle & Bracing

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Abstract—*This paper concern on the seismic analysis of RCC intze elevated water tank which is subjected to live load, dead load, seismic load as per IS codes. But in past issues maximum water tank damages occur due to the earth quakes. So the seismic analysis of water tank is important as well as wind analysis. The reason for damage of the water tank is due to lack of knowledge about staging or bracing part of the tank which play important part during earth quake. The staging or bracing plays a very important role which provides more stiffness and safety to structure and as well as to control the storey displacement of the structure. Angle of dome is also play important role in the seismic analysis, hence this paper also concern with the study of bottom dome angle deviation in which the angle of bottom dome selected are 35 and 50 degree for same capacity of water tank 1000 m^3. So the elevated intze water tank is analyzed for all seismic zones as per IS: 1893 and also analysis with different staging pattern like octagonal, octagonal and plus, octagonal and cross with under different filling conditions, analysis has been done using STAAD.Pro software.*

Keywords—*Seismic analysis, staging of tank, intze tank, deviation angle, STAAD.Pro.*

I. INTRODUCTION

Tanks are the storage structures which are used to store the important liquids and other important things like grains etc. As we know that water is a most important liquid in human life. So depending on requirement of storage, capacity of tank is also important. There are different type of liquid storage tanks normally used in practice are underground, rested on the ground, and elevated tanks. Out of all these types elevated is most valuable tank and play very important role to full fill the demand of public or industries because of its large capacity of tank [1].

Liquid storage structure is most valuable structure, so the seismic analysis and design of tank plays important role because most of damages occur due to lack of knowledge about design method of tank. In liquid storage structure generally adopted WSM method as compare to LSM method because in WSM has more serviceability as compare to LSM also extend the life span of the structure.

Intze tank: In case of large diameter elevated circular tanks, thicker floor slabs are required resulting in uneconomical designs. In such cases intze type tank with conical and bottom spherical domes provides an uneconomical solution. The proportions of the conical and spherical dome are selected so that the outward thrust from the bottom dome balances the inward thrust due to the conical domed part of the tank floor [2] as shown in figure 1

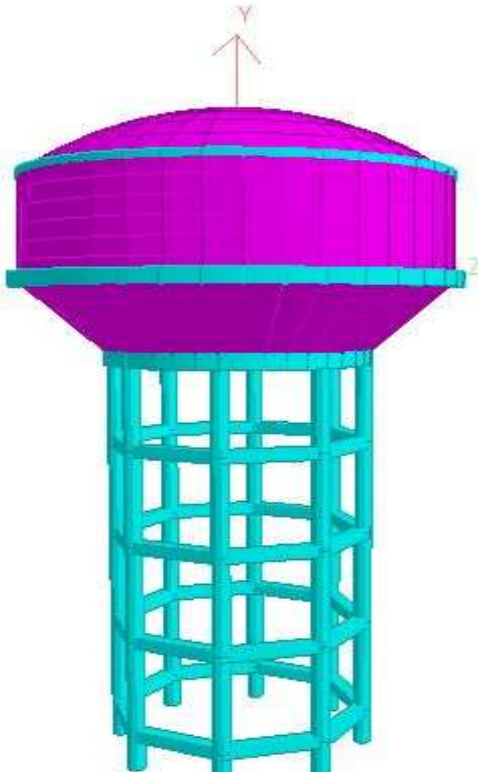


Figure 1: Intze Water Tank

II. Materials Required

Intze water tank is constructed using concrete a building material which is obtained by combining cement, water and inert materials. The inert materials are fine aggregate and coarse aggregate. The quality and quantity of the aggregates should be as per the IS: 456-2000 [10]. The minimum cement content should be 360 kg/m^3 and maximum should be 560 kg/m^3 [10]. The inert materials should be well graded [10]. Water using for mixing should be palatable water [10]. And the

minimum grade of concrete should be M30 [11].

III. Methodology

➢ **Equivalent Static Method or Two Mass Idealization Method**

Equivalent static analysis of elevated water tank is the conventional analysis method which is based on the conversion of seismic load into equivalent static load. The seismic weight of each floor is calculated as its full dead load plus the appropriate amount of imposed load. The equivalent lateral base shear force procedure or equivalent static method was given in IS:1893-2002 for seismic loading for all structures. Historically or traditionally, seismic load were taken as equivalent static accelerations which were modified by various factors, depending up on the location of structure according to seismic zone, soil properties, the natural frequency of the structure. Elevated Water tank has to be analyzed for conditions i.e, tank full condition and tank empty condition.

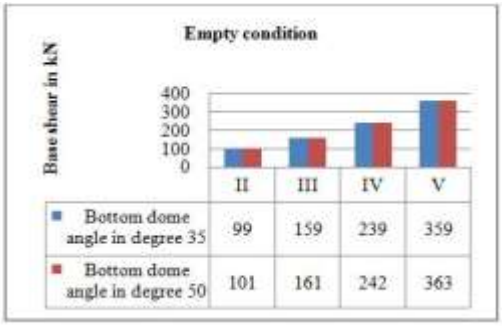
Analysis & Design of elevated water tanks against earthquake effect is of considerable importance. These structures must remain functional even during and after an earthquake. Most elevated water tank are never completely filled with water. Hence, a two- mass idealization of the tank is more appropriate as compared to one-mass idealization.[9]

Table -1 Design Parameters of Intze Tank

SI. No	Particulars	Size/value	Size/value
1	Bottom dome angle in degrees	35^0	50^0
2	Capacity of tank in m^3	1000	1000
3	Unit weight of concrete in kN/ m^3	25	25
4	Grade of concrete in Mpa	M30	M30
5	Grade of steel in Mpa	Fe500	Fe500
6	Thickness of top dome in mm	100	100
7	Rise of top dome in m	2.72	2.72
8	Diameter of tank in m	15	15
9	Height of cylindrical wall in m	4.28	4.46
10	Thickness of cylindrical top in mm	150	150
11	Thickness of cylindrical bottom in m	250	250
12	Size of Top ring beam in m	0.3 x 0.3	0.3x 0.3
13	Rise of conical dome in m	3	3
14	Thickness of conical dome in mm	400	400
15	Rise of bottom dome in m	1.41	2.09
16	Thickness of bottom dome in mm	300	300
17	Number of columns	8	8
18	Size of bottom ring beam in m	1 x 0.6	1x 0.6
19	Total height of staging in m	16	16
20	Size of columns in m	0.6 x 0.6	0.6x 0.6
21	Size of bracing in m	0.5 x 0.5	0.5 x 0.5

Table -2

Base Shear in KN								
Bottom dome angle	35^0				50^0			
Seismic Zones	II	III	IV	V	II	III	IV	V
Empty	99	159	239	359	101	161	242	363
Half	151	242	364	545	182	292	438	657
Full	202	323	485	728	266	425	637	956



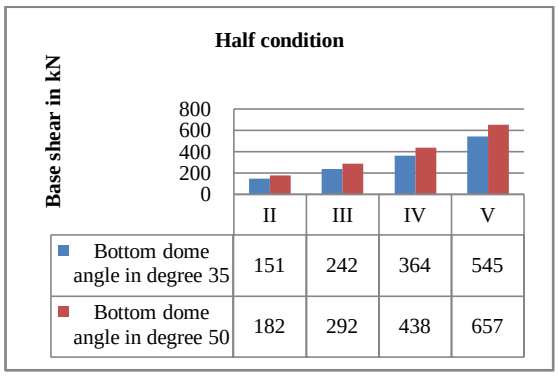


Table-3

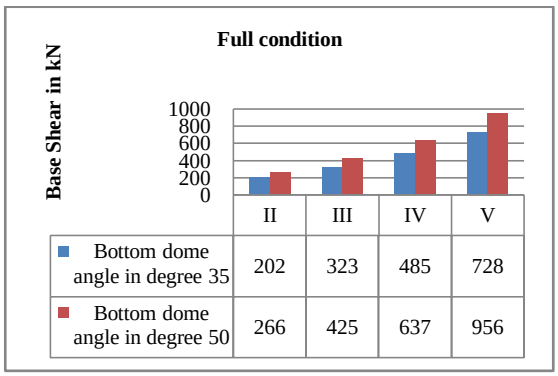


Table-4

Storey displacement for Zone II in mm			
Storey level in m	Angle in degree	35^0	50^0
16m	Empty	6.26	6.32
	Half	9.58	11.59
	Full	12.85	16.93
12m	Empty	5.13	5.16
	Half	7.76	9.42
	Full	10.36	13.74
8m	Empty	3.37	3.41
	Half	5.13	6.37
	Full	6.86	9.30
4m	Empty	1.59	1.61
	Half	2.42	2.92
	Full	3.23	4.25
0m	Empty	0.15	0.15
	Half	0.23	0.27
	Full	0.30	0.40

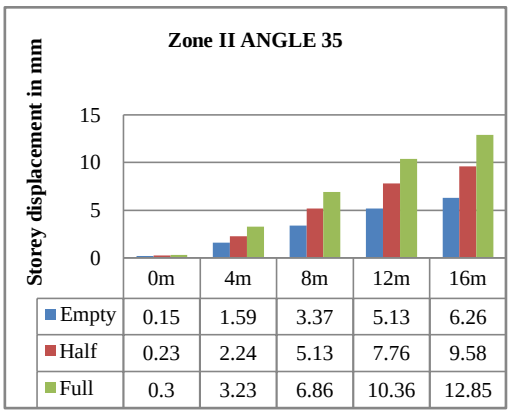
Table-5

Storey Displacement for Zone III in mm			
Storey level in m	Angle in degree	35^0	50^0
16m	Empty	10.11	10.27
	Half	15.33	18.51
	Full	20.56	27.11
12m	Empty	8.18	8.25
	Half	12.48	15.02
	Full	16.70	21.87
8m	Empty	5.40	5.45
	Half	8.22	9.92
	Full	10.99	14.45
4m	Empty	2.55	2.57
	Half	3.87	4.68
	Full	5.17	6.80
0m	Empty	0.24	0.24
	Half	0.36	0.44
	Full	0.49	0.64

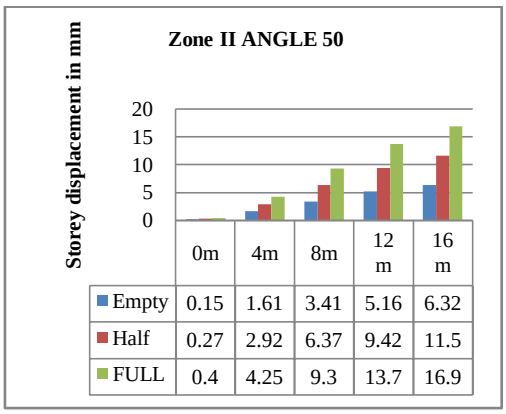
Table-6

Storey Displacement for Zone IV in mm			
Storey level in m	Angle in degree	35^0	50^0
16m	Empty	15.17	15.40
	Half	23.01	27.83
	Full	30.86	40.63
12m	Empty	12.27	12.37
	Half	18.73	22.59
	Full	25.08	32.92
8m	Empty	8.10	8.18
	Half	12.32	14.89
	Full	16.46	21.67
4m	Empty	3.38	3.61
	Half	5.38	6.79
	Full	7.76	10.20
0m	Empty	0.36	0.36
	Half	0.55	0.66
	Full	0.73	0.97

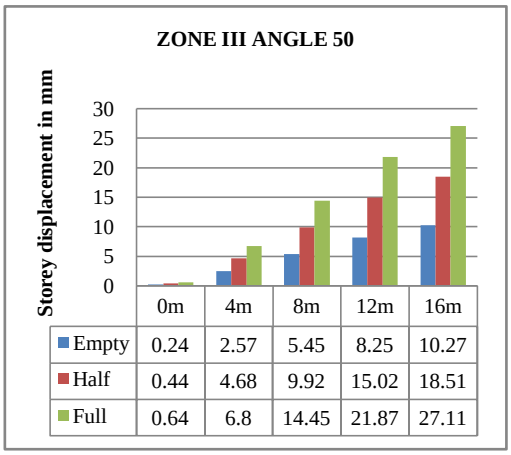
Storey Displacement for Zone v in mm			
Storey level in m	Angle in degree	35^0	50^0
16m	Empty	22.55	22.76
	Half	34.51	41.32
	Full	46.26	58.59
12m	Empty	18.40	18.57
	Half	28.03	33.93
	full	37.49	49.46
8m	Empty	12.16	12.27
	Half	18.50	22.15
	full	24.72	32.51
4m	Empty	5.74	5.82
	Half	8.73	10.53
	Full	11.65	15.31
0m	Empty	0.55	0.55
	Half	0.83	0.99
	full	1.10	1.45



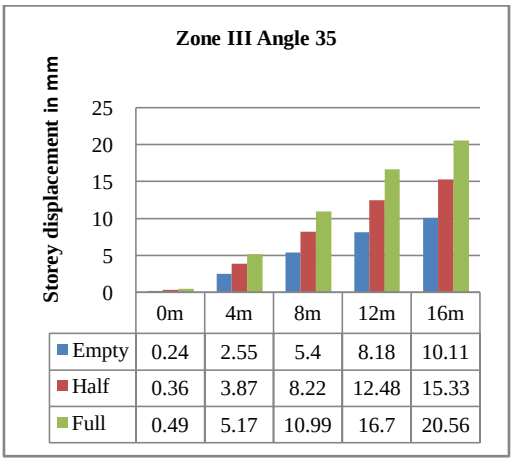
	0m	4m	8m	12m	16m
Empty	0.15	1.59	3.37	5.13	6.26
Half	0.23	2.24	5.13	7.76	9.58
Full	0.3	3.23	6.86	10.36	12.85



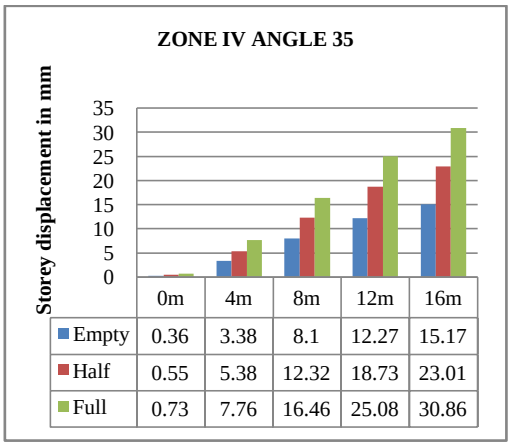
	0m	4m	8m	12 m	16 m
Empty	0.15	1.61	3.41	5.16	6.32
Half	0.27	2.92	6.37	9.42	11.5
FULL	0.4	4.25	9.3	13.7	16.9



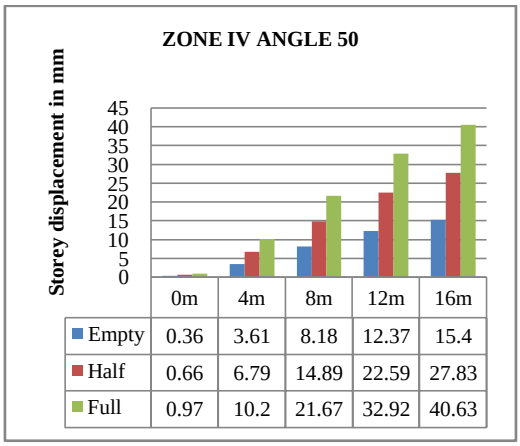
	0m	4m	8m	12m	16m
Empty	0.24	2.57	5.45	8.25	10.27
Half	0.44	4.68	9.92	15.02	18.51
Full	0.64	6.8	14.45	21.87	27.11



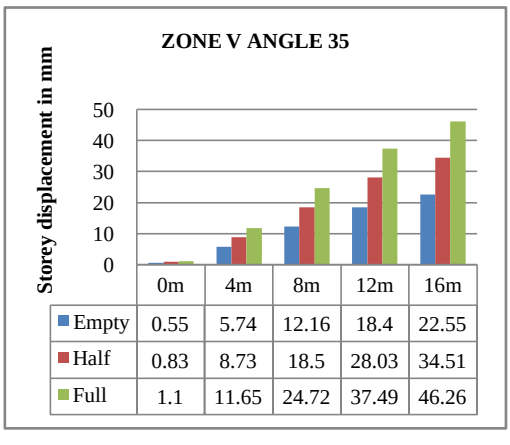
	0m	4m	8m	12m	16m
Empty	0.24	2.55	5.4	8.18	10.11
Half	0.36	3.87	8.22	12.48	15.33
Full	0.49	5.17	10.99	16.7	20.56



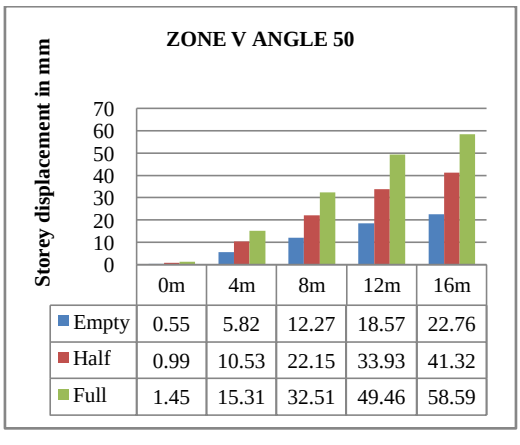
	0m	4m	8m	12m	16m
Empty	0.36	3.38	8.1	12.27	15.17
Half	0.55	5.38	12.32	18.73	23.01
Full	0.73	7.76	16.46	25.08	30.86



	0m	4m	8m	12m	16m
Empty	0.36	3.61	8.18	12.37	15.4
Half	0.66	6.79	14.89	22.59	27.83
Full	0.97	10.2	21.67	32.92	40.63



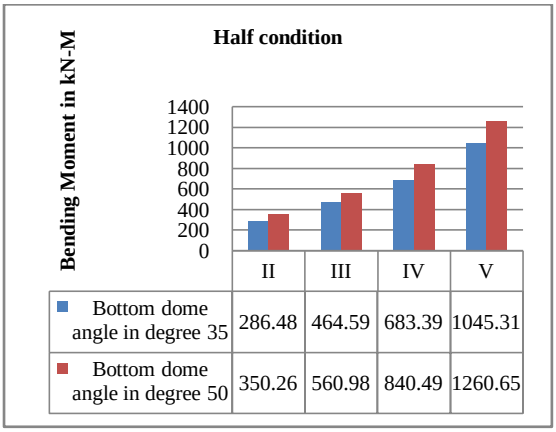
	0m	4m	8m	12m	16m
Empty	0.55	5.74	12.16	18.4	22.55
Half	0.83	8.73	18.5	28.03	34.51
Full	1.1	11.65	24.72	37.49	46.26

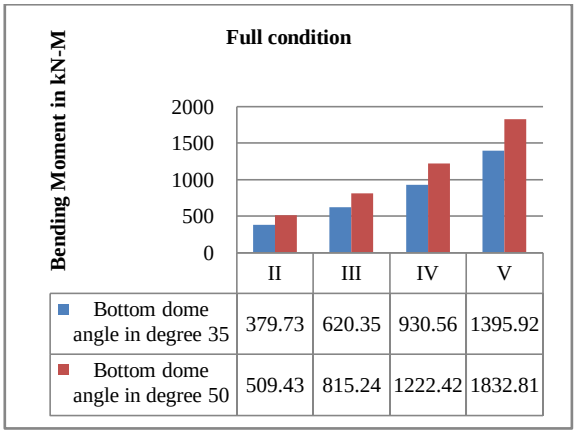


	0m	4m	8m	12m	16m
Empty	0.55	5.82	12.27	18.57	22.76
Half	0.99	10.53	22.15	33.93	41.32
Full	1.45	15.31	32.51	49.46	58.59

Table-7

Max. bending moment at base (summation of all columns) in KN-M								
Bottom dome angle in degree	35^0				50^0			
ZONES / Water level	II	III	IV	V	II	III	IV	V
Empty	191.22	306.16	459.41	688.91	193.52	309.21	463.73	690.86
Half	286.48	464.59	683.39	1045.31	350.26	560.98	840.49	1260.65
Full	379.73	620.35	930.56	1395.92	509.43	815.24	1222.42	1832.81
Total Load on Foundation (All Zones) in KN								
Bottom dome angle in degree / Water level	35^0				50^0			
Empty	780				791			
Half	1564				2104			
Full	2348				3417			





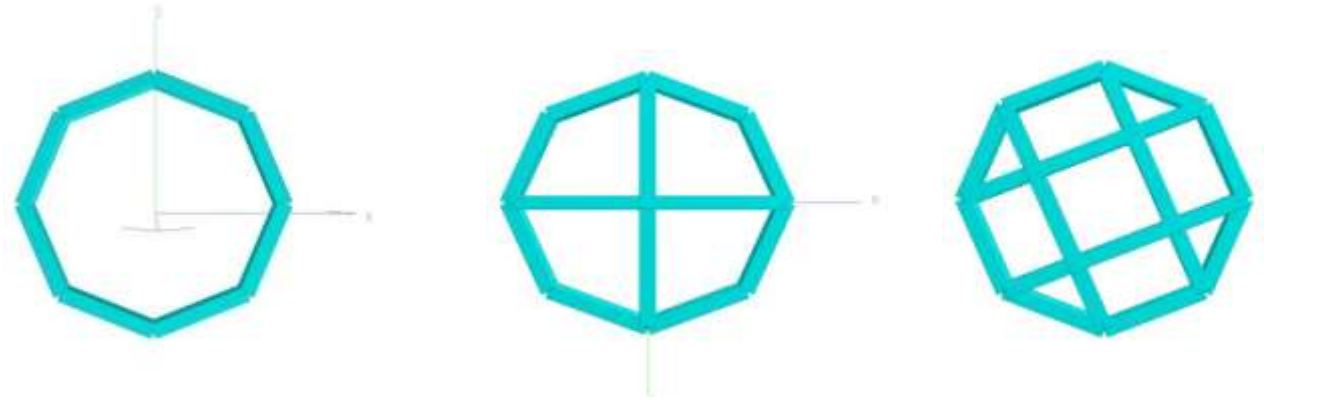
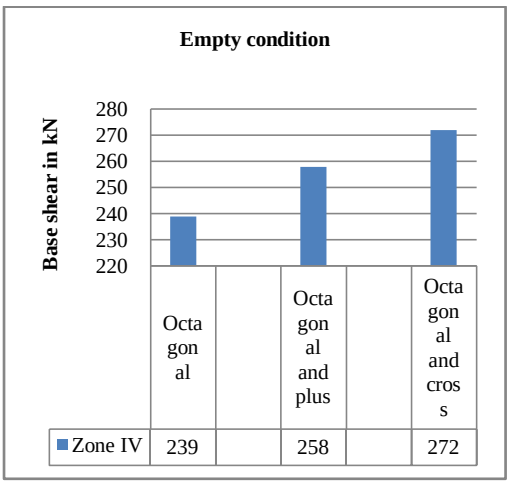


Figure 2 Showing Different Type of Bracing

Table-8

Base Shear in KN for Zone-IV			
Bottom dome angle in degree	35^0		
Bracing system	Octagonal	Octagonal and plus	Octagonal and cross
Empty	239	258	272
Full	485	502	516



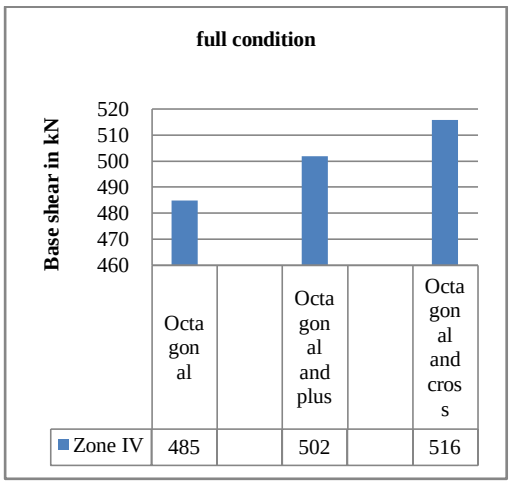
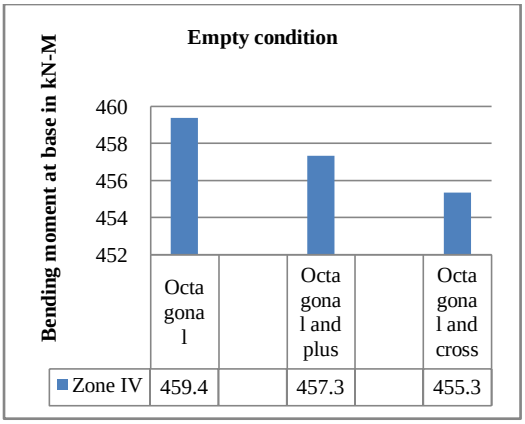


Table-9

Max. bending moment at base (summation of all columns) in KN-M			
Bottom dome angle 35 degree			
Bracing type / Water level	Octagonal	Octagonal and plus	Octagonal and cross
Empty	459.41	457.34	455.38
Full	930.56	902.87	876.92
Total Load on Foundation (Sum of All columns) in KN			
Bracing type / Water level	Octagonal	Octagonal and plus	Octagonal and cross
Empty	6240	6664	7024
Full	18784	19208	19568



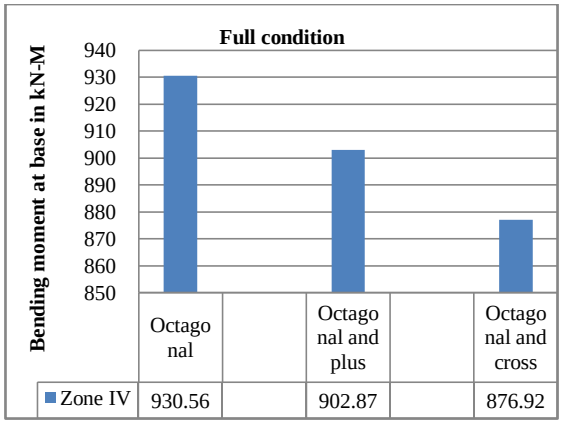
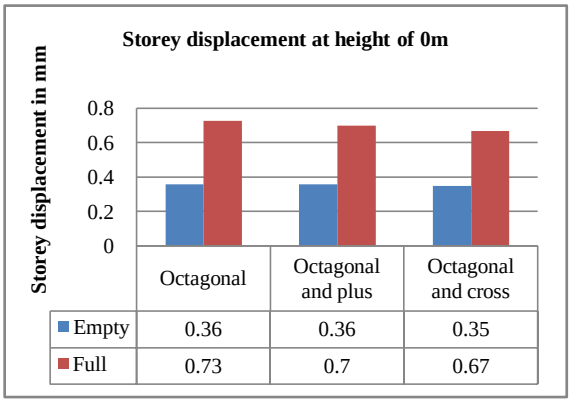
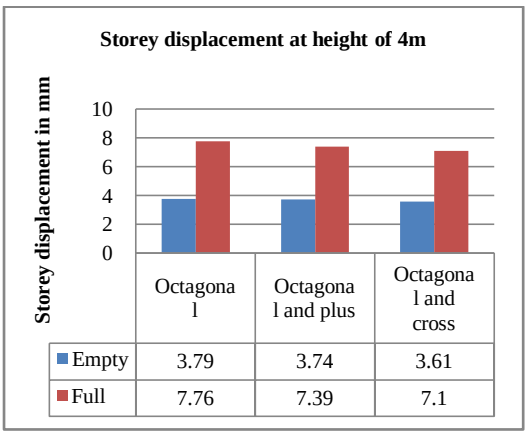
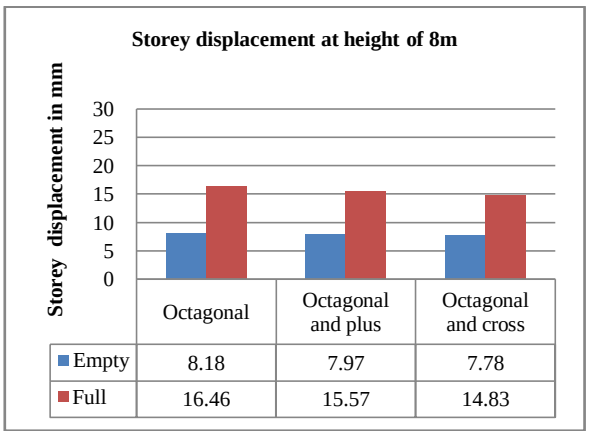


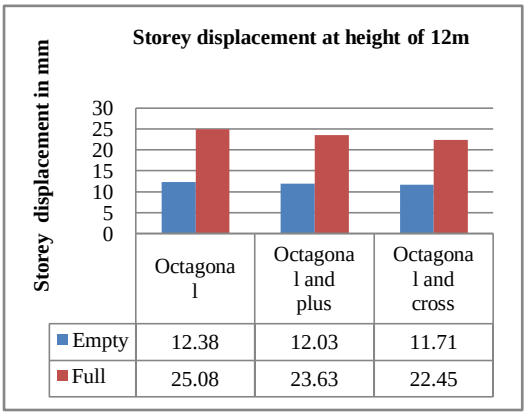
Table-10

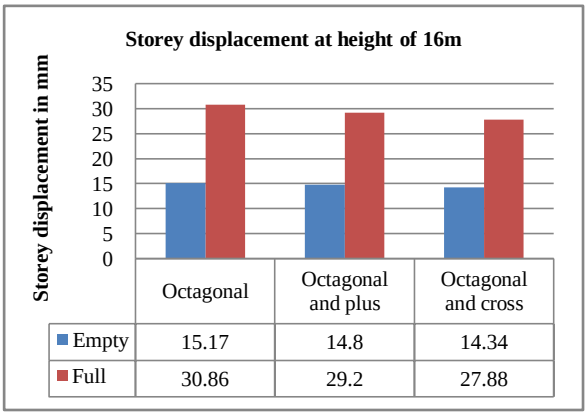
Storey displacement in mm				
Bottom dome angle 35^0				
Bracing type / Storey level	Water level	Octagonal	Octagonal and plus	Octagonal and cross
16m	Empty	15.17	14.80	14.34
	Full	30.86	29.20	27.88
12m	Empty	12.27	12.03	11.71
	Full	25.08	23.63	22.45
8m	Empty	8.10	7.97	7.78
	Full	16.46	15.57	14.83
4m	Empty	3.79	3.74	3.61
	Full	7.76	7.39	7.10
0m	Empty	0.36	0.36	0.35
	Full	0.73	0.70	0.67











Conclusion and Discussion

From base shear variation it is concluded that when the height of storey level increases base shear is also increases. We also found that there is more base shear in full condition tank as compare to empty or half condition. Base shear is also increases as the zone increases form II to V. There is more base shear in zone v as compare to zone II III IV. There is more base shear and max. bending moment at base in water tank with bottom dome angle 50 degree as compare to water tank with dome angle 35 degree..Base shear and max. bending moment at base is also increases with bottom dome angle of water tank is increases due to mass moment of inertia of intze water tank. From the above result we conclude that Intze Water tank with bottom dome angle 35 degree is more appropriate as compare to bottom dome angle 50 degree. Because the value of base shear, storey displacement and max. bending moment at base is more in 50 degree bottom dome angle as compare to bottom dome angle 35degree . And these values are also more in case of water tank with full condition as compare to empty or half condition. Hence full tank case is considered for seismic analysis.

When we used different type of bracing like simple octagonal bracing, octagonal with cross bracing and octagonal with plus bracing there is increase in base shear and decreases the storey displacement and max. bending moment at base respectively. So the octagonal with plus bracing is more useful as compare to simple octagonal bracing, and octagonal with cross bracing.

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