"SEISMIC ANALYSIS OF ELEVATED WATER TANK BY USING VARIOUS TYPES OF BRACING AND STAGING PATTERN"

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Abstract

Water tanks and especially the elevated water tanks are structures of high importance which are considered as main lifeline elements that should be capable of keeping the expected performance i.e. operation during and after earthquakes. Thus researchers, in recent years, have focused on studying seismic behaviours of these tanks Analysis of hydrodynamic structure such as elevated concrete water tank is quite complicated when compared with other structures. From the very upsetting experiences of few earthquakes, like Bhuj earthquake (2001) in India R.C.C elevated water tanks were heavily damaged or collapsed. This was might be due to the lack of knowledge regarding the proper behaviour of supporting system of the tank due to the dynamic effect and due to improper geometrical selection of staging.

The main aim of this study is to understand the behaviour of different staging, under different loading conditions and strengthening the conventional type of staging, to give better performance during earthquake. Equivalent Static Analysis, for different types of bracing systems, applied to the staging of elevated circular water tank in zone IV, is carried out using STAAD Pro. Comparison of base storey shear and nodal displacements of the container of Circular water tank in X, Y and Z direction for empty, half-filled and full condition is done.

After calculating base shear and nodal displacements for empty, half filled & full condition of container applying with different types of bracing system in staging then from

economy point of view project study will suggest such type of bracing which gives minimum base shear as well as considerable displacement for measure earthquake zones.

Keywords: Elevated circular water tank, Staging, Bracing, Earthquake Resistance

Introduction

Water is human basic needs for daily life. Sufficient water distribution depends on design of a water tank in certain area. An elevated water tank is a large water storage container constructed for the purpose of holding water supply at certain height to pressurization the water distribution system. Many new ideas and innovation has been made for the storage of water and other liquid materials in different forms and fashions. There are many different ways for the storage of liquid such as underground, ground supported, elevated etc. Liquid storage tanks are used extensively by municipalities and industries for storing water, inflammable liquids and other chemicals. Thus, Water tanks are very important for public utility and for industrial structure.

Indian sub-continent is highly vulnerable to natural disasters like earthquake, draughts, floods, cyclones etc. According to IS code 1893(Part 1):2016, more than 60% of India is prone to earthquakes. The earthquake of 26 January 2010 in Gujarat was unprecedented for the entire country, then public learnt first time that the scale of disaster could have been far lower had the construction in the region compiled with codes of practice for earthquake prone regions. These natural calamities are causing many casualties and innumerable property loss every year. After an earthquake the loss which cannot be recovered are the life loss. Collapse of structures causes people to life loss. Hence badly constructed structures kill people more than earthquake itself. Hence it becomes important to analyse the structures properly.

Elevated tanks should remain functional in the post-earthquake period to ensure water supply is available in earthquake-affected regions. Never the less, several elevated tanks were damaged or collapsed during past earthquakes. Due to the fluid–structure–soil/foundation interactions, the seismic behaviour of elevated tanks has the characteristics of complex phenomena. Therefore, the seismic behaviour of elevated tanks should be known and understood, and they should be designed to be earthquake-resistant. Some general programs have been carried out, which cover large amounts of data; these programs include STAAD PRO etc.

This paper presents the Importance of the supporting system of water tanks here this is considered different type of bracing and staging patterns. In this paper we concluded that the where there is high risk of seismic force the Diamond bracing pattern may be used for Providing

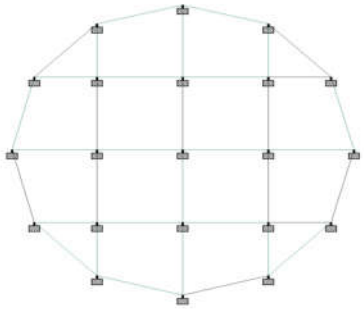
better supporting system lumped mass model and two mass model methods. It can be observed from the analyses that elevated water tank with frame type of staging perform better by following draft code IS: 1893 (Part-2) guidelines than earlier guidelines due to the following characteristics. And concluded that Total base shear and base moment obtained for tank full condition are more than tank empty condition by 47% and 51% respectively. Hence design will be governed by tank full condition. Lateral force is more in tank full condition when compared to tank empty condition and hence tank full case is considered for seismic analysis. Base shear obtained by two mass models is found to be increased by 36% when compared to lumped mass model method. The maximum value of forces and moments obtained from STAAD Pro tells the maximum load to which the tank is subjected and thus critical. The check for critical members from STAAD Pro also reveals that the tank is stable for maximum forces and moments.

Methodology

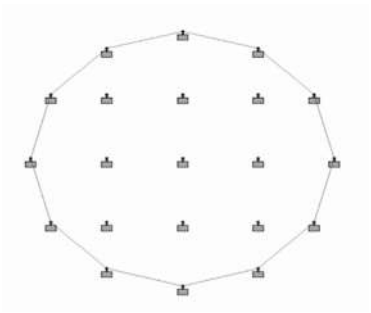
For present work seismic analysis is carried out for Elevated Storage Reservoir having different staging and bracing patterns situated in zone IV for various storage conditions. The analysis is carried out using STAAD PRO.

Four types of Models are considered in the study, which are

ESR with Cross Pattern.



ESR with Normal Pattern



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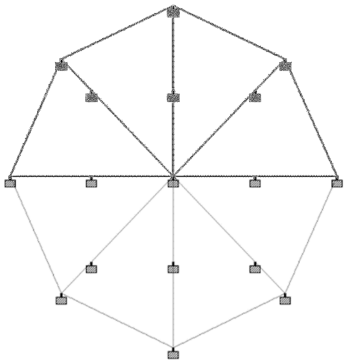
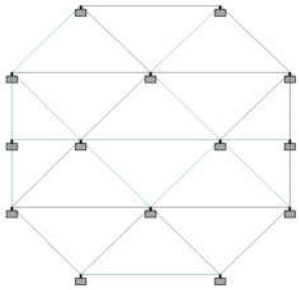
ESR with Radial Pattern.



ESR with Diamond Pattern.



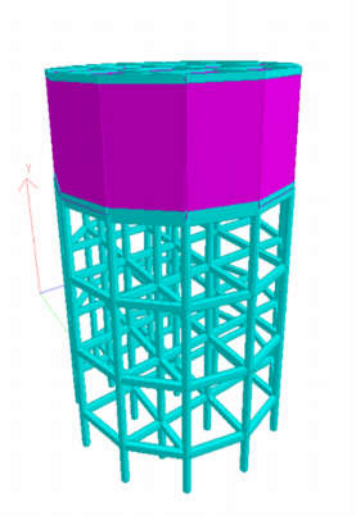
STAAD.Pro.v8i is the most popular structural engineering software product for 3D model generation, analysis and multi-material design. It has an intuitive, user-friendly GUI, visualization tools, powerful analysis and design facilities and seamless integration to several other modeling and design software products. For static or dynamic analysis of bridges, containment structures, embedded structures (tunnels and culverts), pipe racks, steel, concrete, aluminum or timber buildings, transmission towers, stadiums or any other simple or complex structure, STAAD.Pro has been the choice of design professionals around the world for their specific analysis needs

Specifications of Water Tank

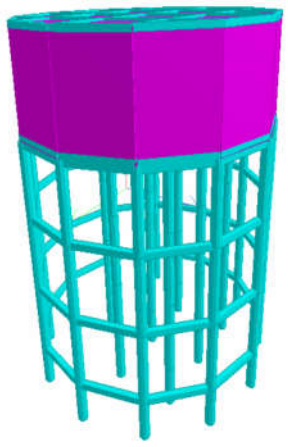
SR. NO.	Parameters	Values			
		Cross	Normal	Diamond	Radial
1	Capacity of Tank(m^3)	1500	1500	1500	1500
2	Diameter of Tank(m)	18.4	18.4	18.4	18.4
3	Height of Cylindrical Wall(m)	6.3	6.3	6.3	6.3
4	Thickness of Cylindrical Wall at Top(mm)	250	250	250	250

5	Thickness of Cylindrical Wall at Bottom(mm)	400	400	400	400
6	Height of Staging(m)	17	17	17	17
7	Number of Columns	21	21	14	17
8	Diameter of Column(mm)	600	750	760	700
9	Diameter of Submerged Column(mm)	350	350	350	350
10	Size of Beam(mm)				
	A) Cover Slab	300X350	300X350	300X350	300X350
	B) Ring Beam	400X750	400X750	400X750	400X750
	C) Bracing	400X400	400X400	460X460	425X425
13	Thickness of Cover Slab(mm)	150	150	150	150
14	Thickness of Base Slab(mm)	380	380	380	380
15	Density of Concrete(KN/m^3)	25	25	25	25

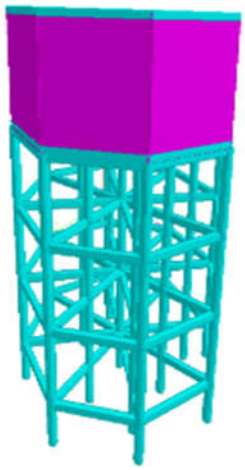
3D Modelling of ESR



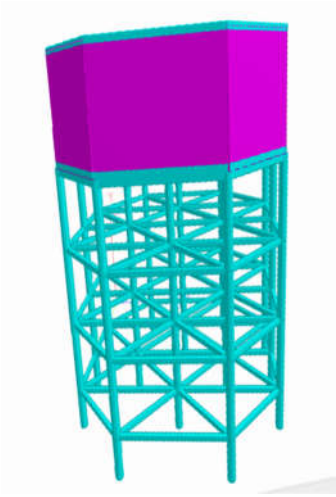
CROSS BRACING



NORMAL BRACING



DIAMOND BRACING

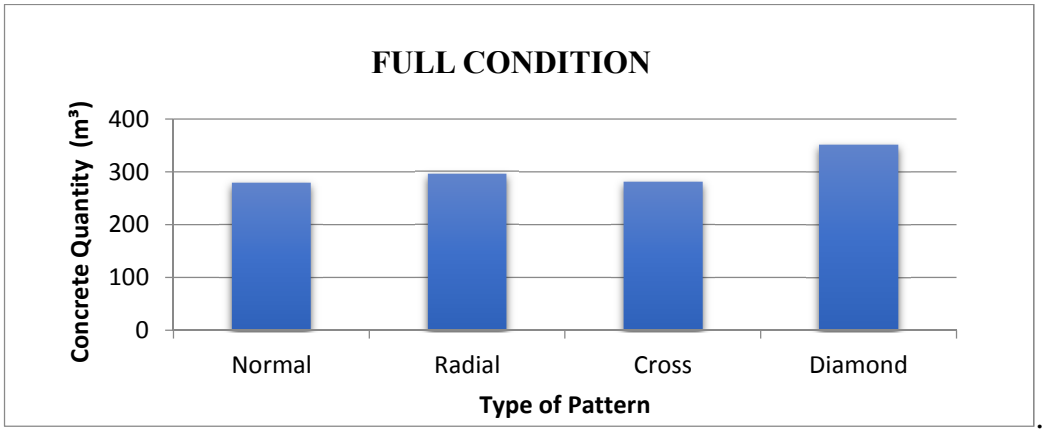


RADIAL BRACING

RESULT

Concrete Quantity (m^3): -

Sr. No.	Pattern Types	Tank Fill Condition		
		Empty	Half	Full
1	Normal	279.1	275.6	279.1
2	Radial	295.3	291.8	295.3
3	Cross	280.9	257.4	280.9
4	Diamond	351.8	348.7	351.8



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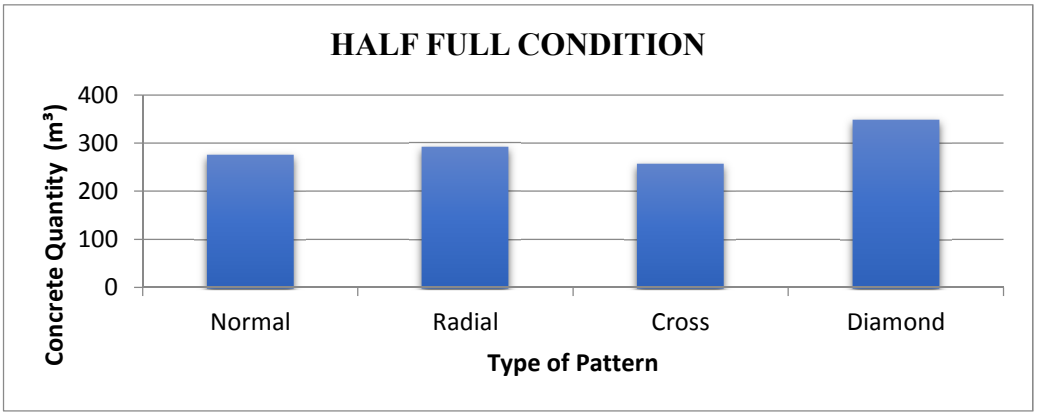
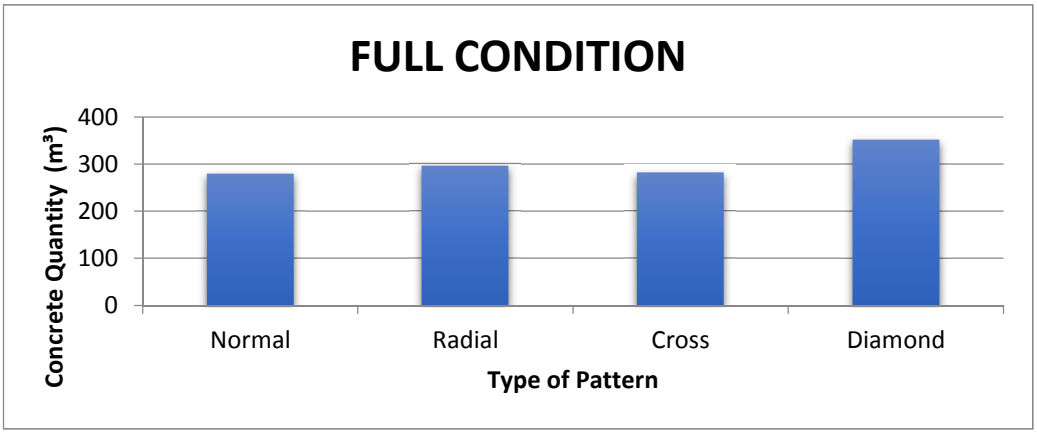
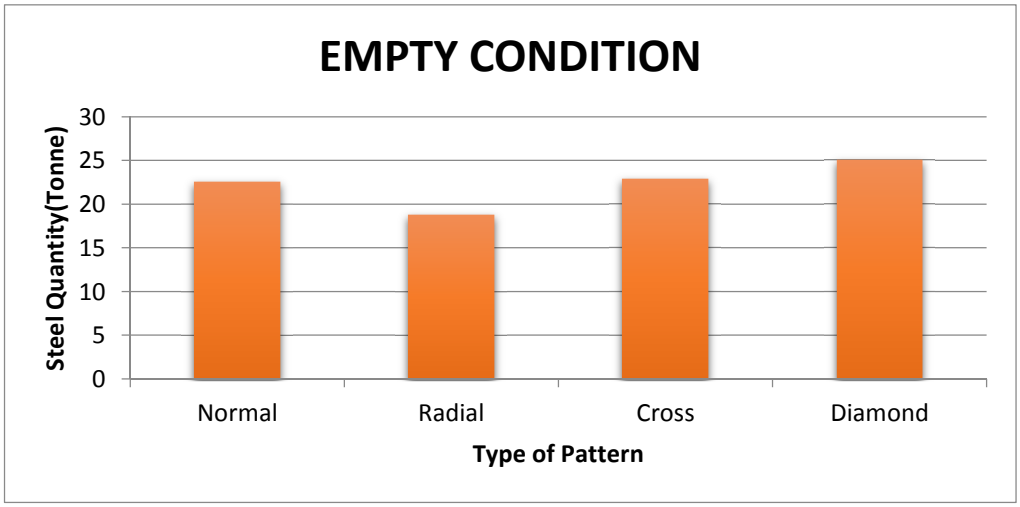
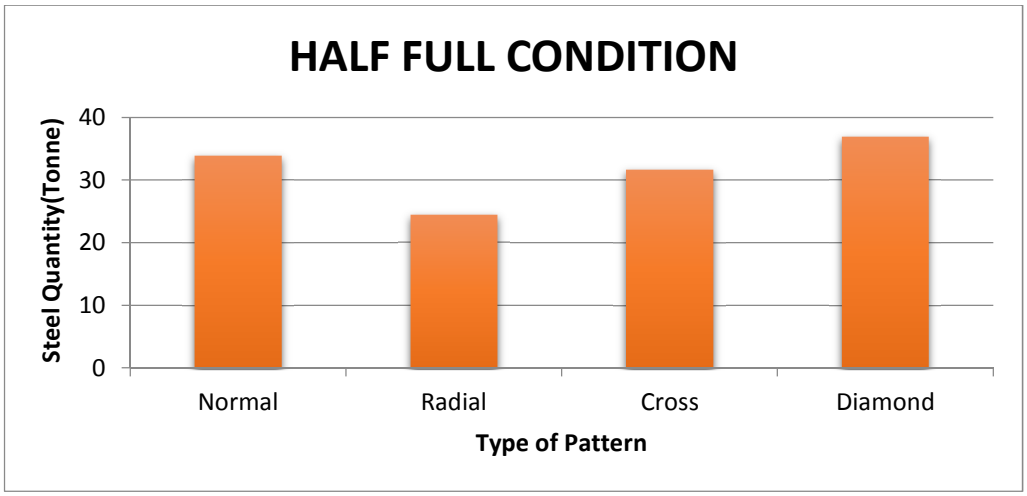


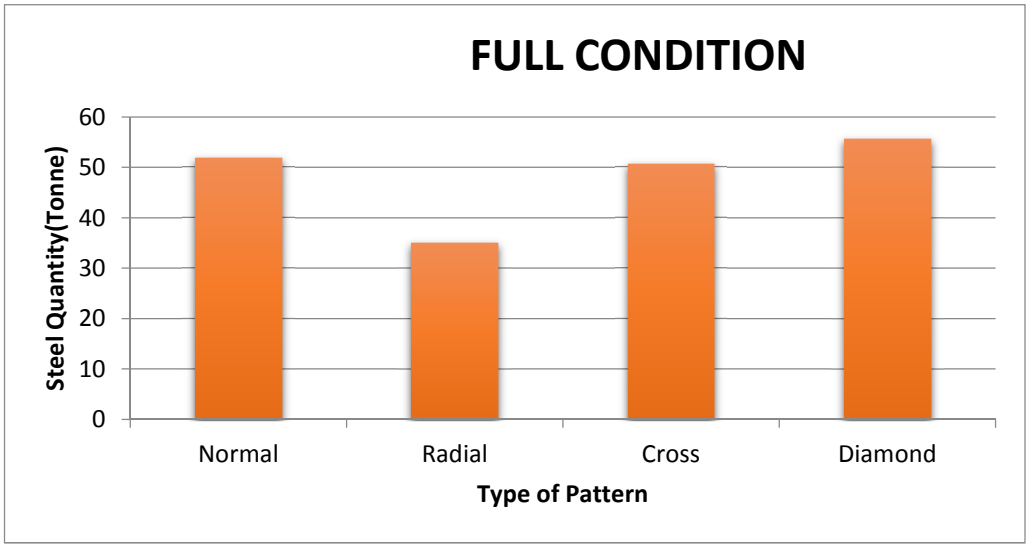


Steel Quantity(ton): -

Sr. No.	Pattern Types	Tank Fill Condition		
		Empty	Half	Full
1	Normal	22.59	33.85	51.83
2	Radial	18.8	24.37	35.03
3	Cross	22.87	31.67	50.58
4	Diamond	25.03	36.86	55.67

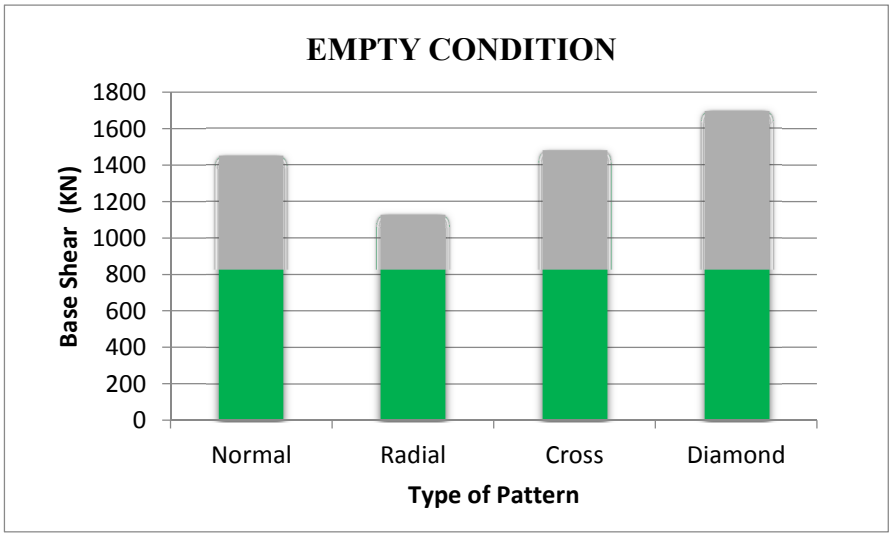

EMPTY CONDITION
Steel Quantity(Tonne)
30
25
20
15
10
5
0
Normal
Radial
Cross
Diamond
Type of Pattern

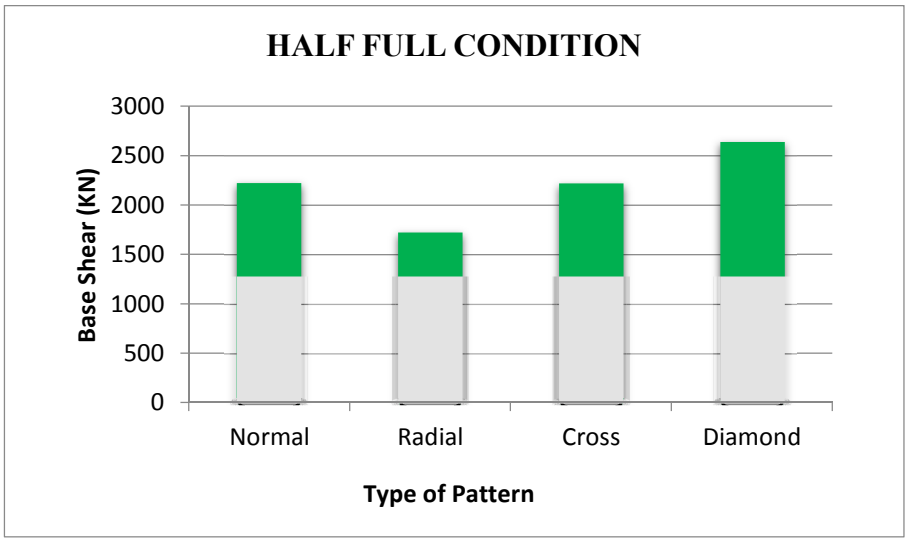

HALF FULL CONDITION
Steel Quantity(Tonne)
40
30
20
10
0
Normal
Radial
Cross
Diamond
Type of Pattern

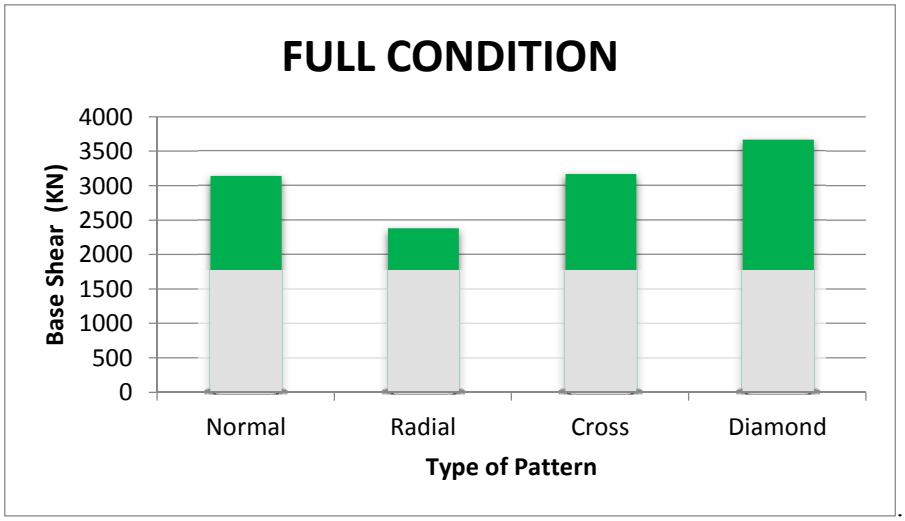

FULL CONDITION
Steel Quantity(Tonne)
60
50
40
30
20
10
0
Normal
Radial
Cross
Diamond
Type of Pattern

Base Shear (KN):-

Sr. No.	Pattern Types	Tank Fill Condition		
		Empty	Half	Full
1	Normal	1450.47	2225.97	3137.78
2	Radial	1127.67	1727.73	2382.07
3	Cross	1480.45	2222.08	3167.77
4	Diamond	1696.17	2642.8	3664.81

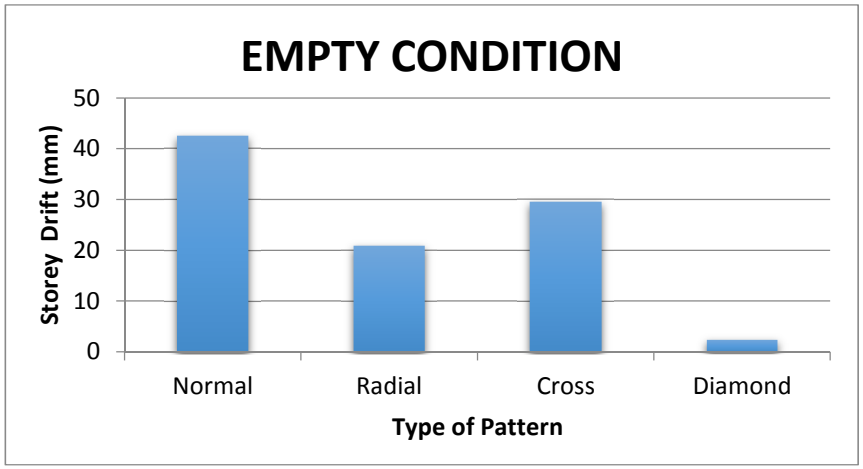


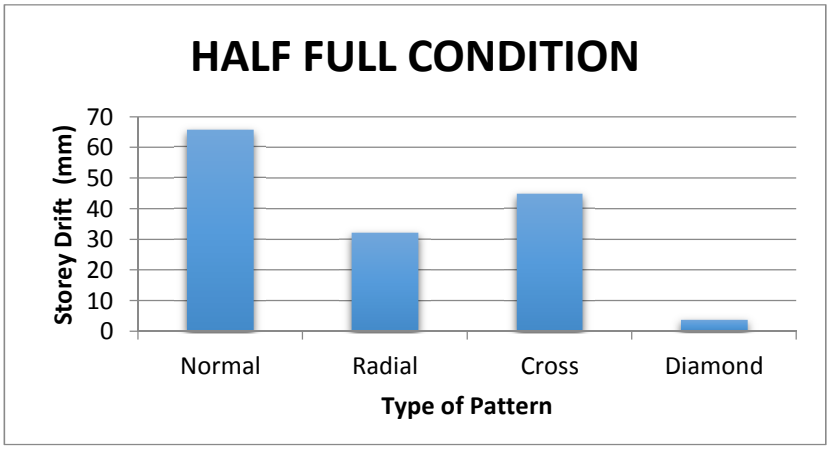


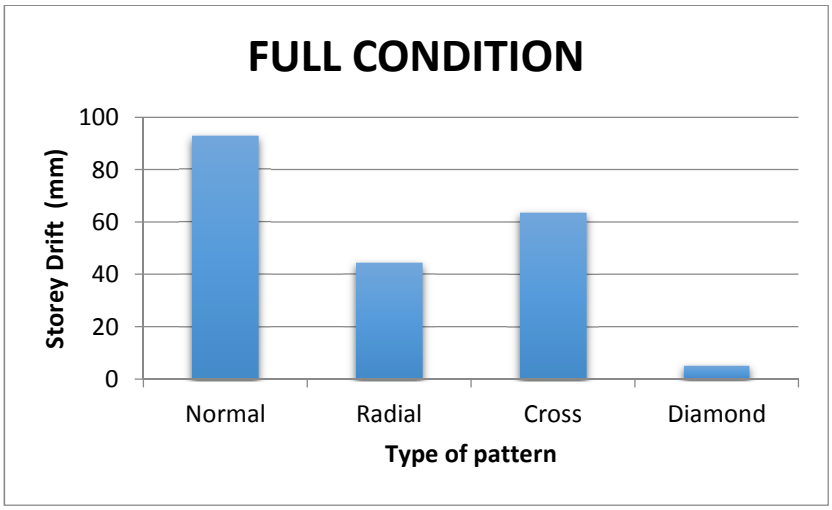


4) Storey Drift (mm):-

Sr. No.	Pattern Types	Tank Fill Condition		
		Empty	Half	Full
1	Normal	42.5	65.51	92.67
2	Radial	20.85	32.1	44.48
3	Cross	29.52	44.75	63.6
4	Diamond	2.4	3.73	5.19







- ## Conclusions

The above study demonstrates the considerable change in various load behaviour of elevated tanks with consideration of responses like base shear, storey displacement etc. when supporting system is used with appropriate modifications. Finally, study discloses the importance of suitable supporting configuration to remain withstand against heavy damage/failure of elevated water tanks during various conditions.

In our research an attempt has been made for the analysis of an elevated water tank using STAAD.Pro V8i. The following conclusions are drawn on the basis of research and analysis done through STAAD.Pro as described below: -

- From the comparison between displacement for different bracing system and displacement for different alternate bracing it is conclude that new bracing pattern gives the minimum value of displacement. For new bracing pattern storey displacement value is

much more less than cross, normal and radial patterns. New pattern is superior over other patterns in relation to storey displacement and storey displacement is reducing by about 90%.

- Parametric study is carried out for different bracing patterns of an elevated water tank. It is clear that the base shear value increases for new bracing pattern in staging. Base shear value is more for full tank condition than half full and empty tank condition.
  This is apparent because of the increase of overall stiffness of the structure.

- New types of supporting systems are effective but not economical.

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