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"STUDY ON INFLUENCE OF INVERTED V AND W-FRAME COLUMN SUPPORT ON DYNAMIC BEHAVIOUR OF HYPERBOLIC COOLING TOWER UNDER SEISMIC LOADING"

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Abstract - *Hyperbolic cooling tower is a structure its main function is to cool down the water from different plants and removes the waste heat to the atmosphere with avoiding pollution to the environment. These cooling towers are used in various power plants such as nuclear, atomic, petrochemical, natural gas refineries etc.These are the very large structures with shell elements and columns at the base. In this present study the existing cooling tower of height 124.80mts is taken as reference tower. In this study the boundary condition taken is top end of the tower is free and bottom end of the tower is fixed condition. By varying different thicknesses along constant height with inverted V-frame and W-frame column support condition under seismic loading are modeled and method of finite element analysis is done using the software named SAP2000.From the analysis results the parameters like maximum stress, deflection and frequency of the different modes. Lastly the comparison for minimum thickness for both column supports and maximum thickness for both column supports are carried on. These values are tabulated and plotted in graphs and differences in them are noted and optimum cooling tower with suitable column supports are determined.*

Key Words**: cooling tower, V and W-frame column support, Seismic loads, SAP, Deflection.**

1. INTRODUCTION

Cooling tower is a part of the structure in the power plants which is used to remove the waste heat from the structure to the atmosphere by cooling the water stream in low temperature condition. The hyperbolic shaped cooling towers are commonly used in the nuclear power plants, petrochemical plants, thermal power plants, petroleum refineries, atomic power plants, natural gas processing plants, food processing plants etc. The cooling tower are huge structures which are greatly affected by wind and earthquake loads. The main purpose of working of cooling tower is to remove the heat from the water which is ejected by plants structures either by atmospheric air or by mechanical equipments and release the waste heated air or water of lower temperature to outside environment without causing any harm to the living bodies. As it is most significant structure in thermal, nuclear and petrochemical plants, it should be frequently checked for the strength and stability under self-weight, and dynamic loads like wind load and earthquake load. Therefore, self-weight analysis, static method of wind analysis and both nonlinear and linear analysis under seismic loading of cooling tower with different column supporting systems are conducted for the analysis of cooling tower. The general working method of cooling tower is it may be natural draught or mechanical draught cooling tower, first the heated water from plants are pumped to the certain height depending upon the height of the cooling tower then they inlet to the pipes of nozzles and water is distributed in this way by system of piping. Then the water in the pipes are sprayed on the surfaces of fillers first the water sprays in the form of small droplets of water on surface then they flow in the way of pack of layers where either by atmospheric natural air or by mechanical equipments the water is exposed to air for more time and cooling of water takes place.

2. LITERATURE REVIEW

T. Sithara et.al (2016), this paper deals with the effect of the static and dynamic loads on hyperboloid shape of shell structure. By taking an existing cooling tower of height 143.50 m from Bellary Thermal Power plant station. These towers are analyzed using ANSYS software. In analysis of method transient the post failure condition is possible where as in method of response spectrum it is not possible. so we can conclude that method of Transient analysis is better than Response spectrum analysis. C.R. Athira et.al (2016), in this paper the cooling tower performance is checked by varying parameters such as thickness and height of the tower shell and also to study the effect of these parameters on structural behavior of cooling tower. The modeling of the cooling tower is carried out by using the software STAAD.Pro and to analyze and design the cooling tower using the software SAP2000NL.From this we can conclude that Time history method of analysis gives the structural responses of the cooling towers more accurately than other methods of analysis.Ashok.P.Ponath et.al(2016), In this paper two existing cooling towers with different heights are analyzed. Both the towers have varying thickness throughout the height. ABAQUS 6.14 is used to analyze the cooling towers.

The analyses are done both for buckling and static conditions and stress concentration and buckling behavior of both towers are analyzed and compared. Both the towers show the least stresses near the top and relatively higher stresses near the throat.

3. DESCRIPTION OF PRESENT WORK

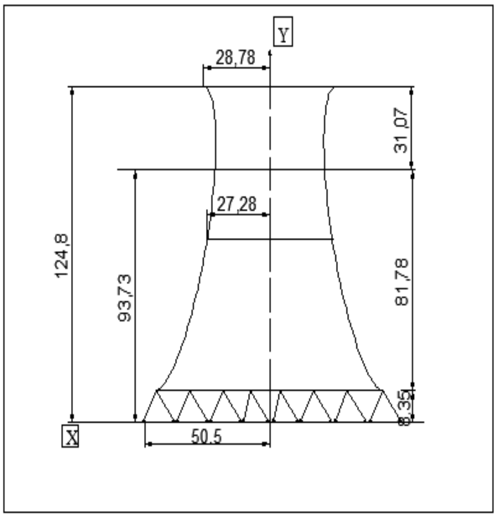

Fig-1: Geometry of hyperbolic cooling tower

Table -1: Parameters considered

Description of parameter	For inverted V and W type of columns
Total height of tower	124.80m
Throat diameter	55.490m
Bottom diameter	101.00m
Top diameter	57.568m
Column diameter	750mm
Throat height from bottom	93.73m

The main work of this study is to compare the dynamic properties of Hyperbolic shape of cooling tower which are supported on W-frame and Inverted V-frame column supports and to suggest the optimum cooling tower under weak soil condition in zone-4 and zone-5.

PROPERTY OF MATERIAL

- Modulus of elasticity=31Gpa
- Concrete grade=M30
- Steel grade=Fe 415
- RCC density=25KN/m^3
- Poisson ratio=0.15

For the Calculation of the Design Spectrum, the following Factors were considered as per IS 1893 (Part I) 2002

Zone factor: For Zone 4 = 0.24

For zone 5 = 0.36

Importance factor (I) = 1.0

Response reduction factor (R) = 3.00

Poisson's ratio = 0.15

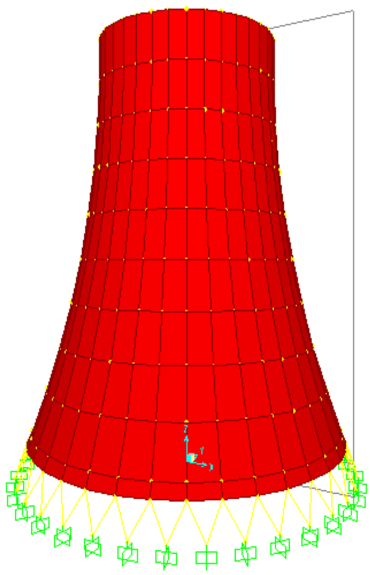

Fig-2: Hyperbolic cooling tower with inverted V-frame column support.

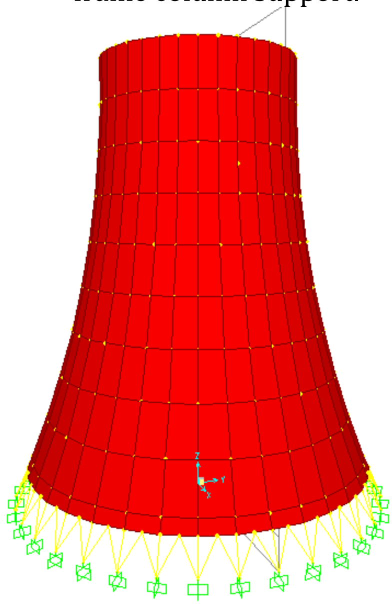

Fig-3: Hyperbolic cooling tower with W-frame column support.

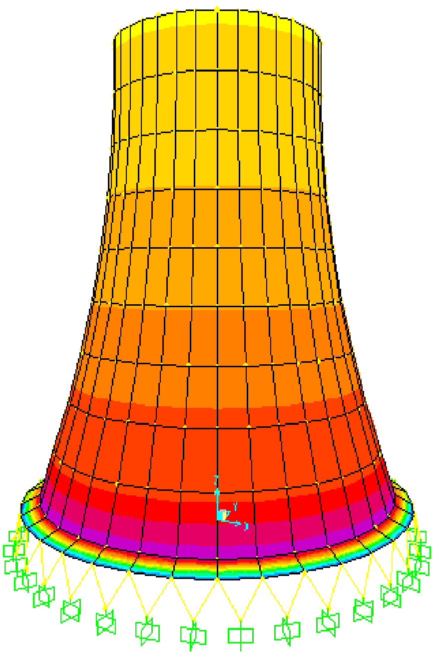

Fig -4: Maximum stress for inverted V-frame column support for zone-4.

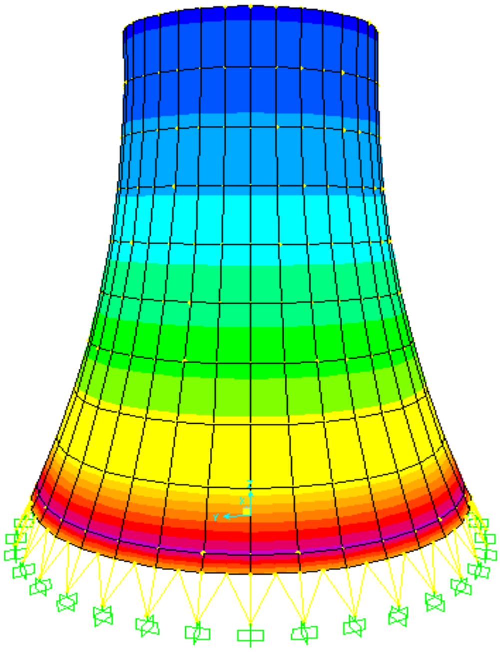

Fig-6: Maximum stress for W-frame column support for zone-4

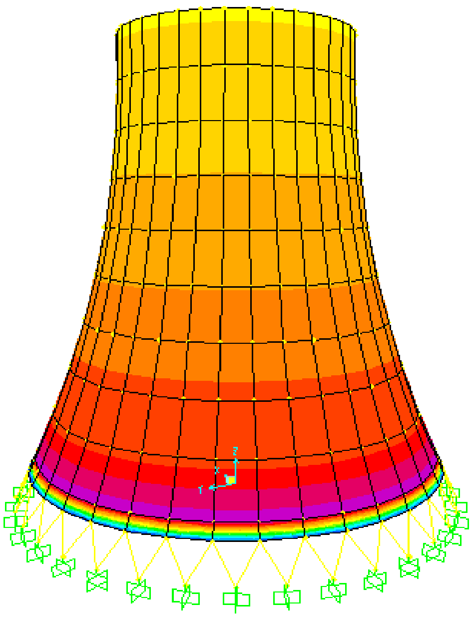

Fig -5: Maximum stress for inverted V-frame column support for zone-5

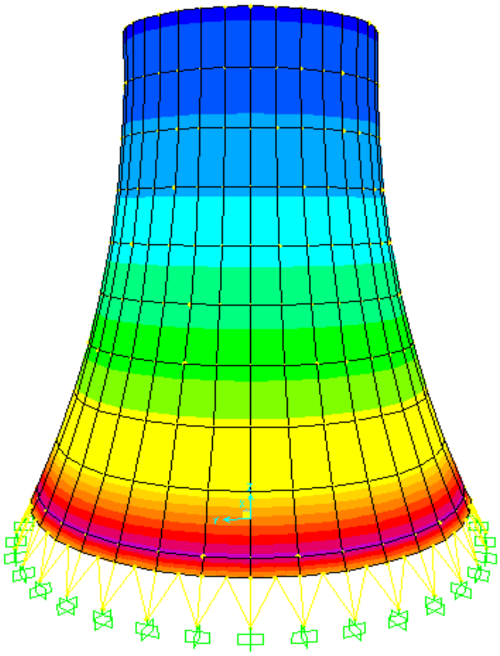

Fig-7: Maximum stress for W-frame column support for zone-5

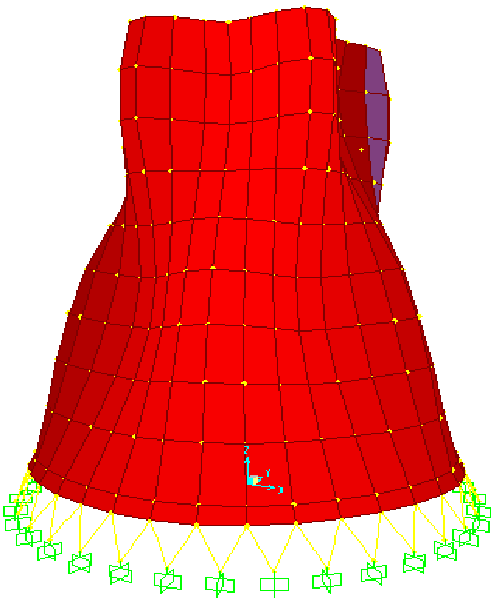

Fig-8: Deflection for inverted V-frame column support for zone-4 in mode-1

4 RESULTS AND DISCUSSIONS

Table-3: Inverted V-Frame column support for Zone-4

Thickness (mm)	Modes	Frequency (Hz)	Deflection (m)	Maximum stress (Mpa)
200	1	1.164	0.0199	0.0022
	5	1.237	0.0196	0.0022
	10	1.264	0.0191	0.0020
300	1	1.232	0.0156	0.0022
	5	1.328	0.0153	0.0020
	10	1.502	0.0146	0.0019
400	1	1.25	0.0135	0.0015
	5	1.436	0.0123	0.0014
	10	1.49	0.0122	0.0014
500	1	1.277	0.0122	0.0016
	5	1.41	0.0115	0.0016
	10	1.617	0.011	0.0015
600	1	1.308	0.0105	0.0017
	5	1.442	0.0098	0.0017
	10	1.783	0.0095	0.0015

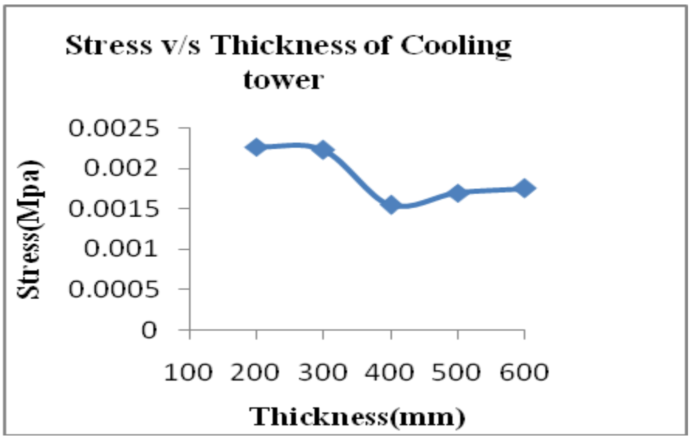

Chart -1: Graphical Representation of Stress v/s Thickness of cooling tower for Mode-1 for Inverted v-frame column support

From the table 3 it is observed that the maximum stress for 200mm thickness of cooling tower under mode-1 is 0.00226Mpa.Then as the thickness increases from 200 to 400mm the stress decreases by 3%.This indicates that as the thickness of shell element of cooling tower goes on increasing the stability of structures increases and maximum stress of the structure decreases.

Table-4: W-Frame column support for Zone-5

Thickness (mm)	Modes	Frequency (Hz)	Deflection (m)	Maximum stress (Mpa)
200	1	1.164	0.0199	0.002268
	5	1.237	0.0196	0.002235
	10	1.264	0.0191	0.002005
300	1	1.232	0.0156	0.002226
	5	1.328	0.0153	0.002005
	10	1.502	0.0146	0.001944
400	1	1.25	0.0135	0.001548
	5	1.436	0.0123	0.001489
	10	1.49	0.0122	0.001471
500	1	1.277	0.0122	0.001697
	5	1.41	0.0115	0.001656
	10	1.617	0.011	0.001517
600	1	1.308	0.0105	0.001755
	5	1.442	0.0098	0.001751
	10	1.783	0.0095	0.001596

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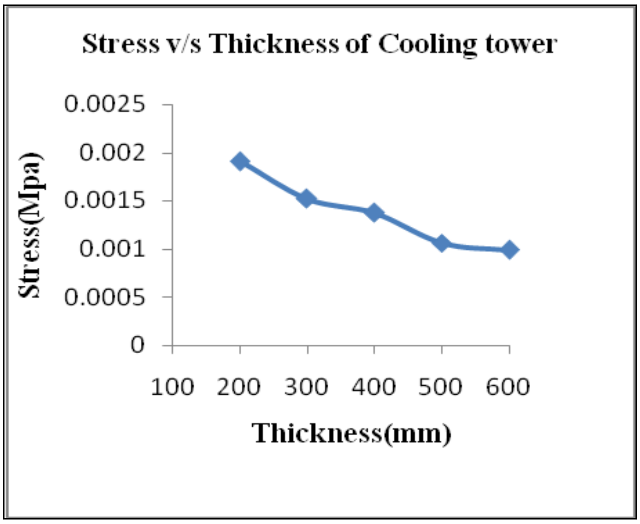

Chart- 2: Graphical Representation of Stress v/s Thickness of Cooling tower for Mode 1 for zone-5 of W-frame column support

From the table 4 it is observed that the maximum stress for 200mm thickness of cooling tower under mode-1 is 0.001911Mpa of zone-5.Then as the thickness increases from 200 to 600mm the stress decreases by 48%.This indicates that as the thickness of shell element of cooling tower goes on increasing the stability of structures increases and maximum stress of the structure decreases.

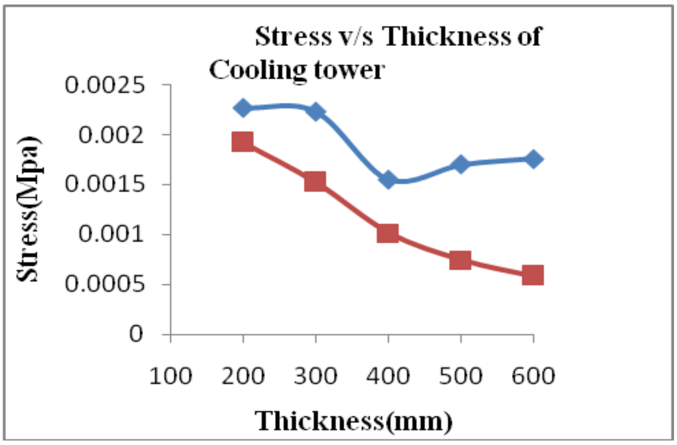

Chart-3: Comparison between Inverted V-frame column support and w-frame column support for mode-1 of zone -4

From the fig 5 it is observed that the maximum stresses for 200mm thickness under mode-1 of zone-4 is 0.00268 and 0.001915Mpa of inverted V-frame and W-frame column supports of cooling tower. It indicates that as the thickness goes on increasing the stress value decreases more in w-frame column support than inverted v-frame column support.

Table-6: Comparison between Inverted V-frame column support and W-frame column support for least thickness in zone-4.

	Thick (mm)	Freq (Hz)	Deflections (m)	Maximum stress(Mpa)
Inverted V-Frame column support	200	1.164	0.0199	0.00226
W-Frame column support	200	0.669	0.0196	0.00191

From the table 6 it is observed that the maximum stress value, deflection and frequency value for least 200mm thickness under mode-1 of zone-4 for both inverted v-frame column support and w-frame column support

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Table-7: Comparison between Inverted V-frame column support and W-frame column support for maximum thickness in zone-4.

	Thick (mm)	Freq (Hz)	Deflections (m)	Maximum stress(Mpa)
Inverted V-Frame column support	600	1.308	0.0105	0.001755
W-Frame column support	600	0.567	0.0221	0.000585

3. CONCLUSIONS

The present study of work is carried on for to study the dynamic behavior of the hyperbolic cooling tower with inverted V-frame and W-frame column support under earthquake loading on soft soil condition.

- The maximum stress of cooling tower as the shell thickness increases it is observed that there is a decrease of stress in W-frame column support than the inverted V-frame column support of cooling tower in zone-4 and zone-5 condition.

- The deflection under loading condition is greater for W-frame column support than the inverted V-frame column support of cooling tower.
- The frequency for mode-1 is more for inverted V-frame when compared to W-frame column support.
- For the minimum thickness of 200mm the maximum stress, deflection and frequency is greater for inverted V-frame than W-frame column support of cooling tower.
- For the maximum thickness of 600mm the maximum stress, deflection and frequency is more for inverted V-frame column support when compared to W-frame column support of cooling tower.

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