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A STUDY ON RESPONSE REDUCTION FACTOR OF RC WATER TANK

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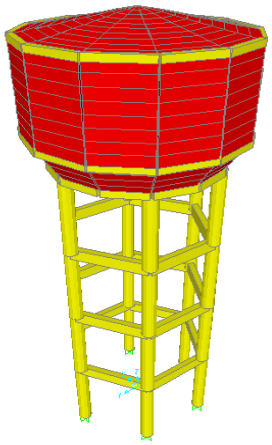
Abstract —***the main purpose of earthquake resisting design is that the structure should not permit to collapse but damage is allowed during earthquake. Water tank is important structure. Staging type of tanks is generally collapse during earthquake, so it is required to calculate earthquake load perfectly. Past evidence had shown that the elevated tanks are vulnerable due to earthquake. The tanks are designed based on linear elastic methods which are considered only elastic range. Factor shows the reserved strength of water tank.in IS 1893-2002(part-2) value of R factor for RC elevated shaft supported tank is 1.8 and for column supported 2.5. One constant R-value for elevated water tank cannot reflect the expected inelastic behavior of all elevated water tanks located in different seismic zone and having different staging pattern. So it is required to find out perfect value of R factor for various type of RC elevated tank individually. The present study efforts are made to evaluate the response reduction factor of RC framed staging elevated water tank having varying staging height, capacities, staging type and zones. The main objective of this study is to verify the R factor of most common designed Elevated Intze tank through comparing the assumed R factor during design to actual R factor obtained from non-linear*** *analysis.*



Keywords*-SAP2000, R-Factor, Time Period, Ductility Factor, Redundancy Factor*

I INTRODUCTION

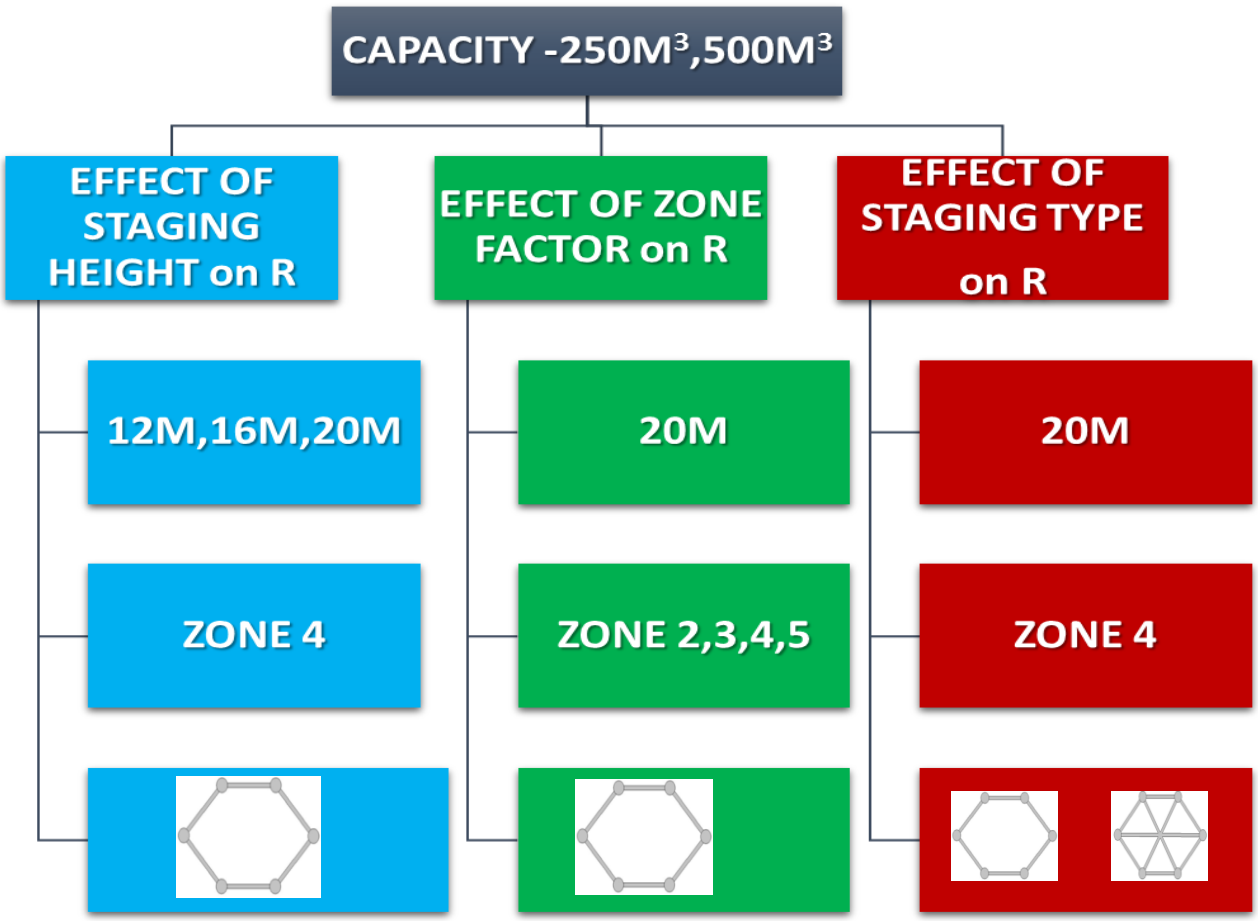
Water Is Considered As the Source of Every Creation And Is Thus A Very Crucial Element For Humans To Live A Healthy Life. High Demand of Clean and Safe Drinking Water Is Rising Day By Day As One Can Not Live Without Water. It Becomes Necessary To Store Water. Water Is Stored Generally In Concrete Water Tanks and Later On It Is Pumped To Different Areas To Serve The Community.

1.1 Need of Study:

Generally staging support system type causes over Head Tanks Collapse in Earthquake. It Is Very Important To Consider Earthquake Load In Design Of Elevated Tank. Response Reduction Factor (R) Is Very Important To Find Out Earthquake Load. The Response Reduction Factor Reflects The Capacity Of Structure To Dissipate Energy By Inelastic Behavior. The Values Of Response Reduction Factor(R) Of RC Elevated Water Tank Are Given In Is 1893 Draft Code, Which Is Arrived At Empirically Based On Engineering Judgment. The Value Of R-Factor Is Fixed 2.5 For Frame Supported RC Elevated Tank. One Constant R-Value For Elevated Water Tank Cannot Reflect The Expected Inelastic Behavior Of All Elevated Water Tanks Located In Different Seismic Zone And Having Different Capacities. So It Is Required To Find Out Perfect \ Value Of R Factor For Various Type Of Rc Elevated Tank Individually.

1.2 Objectives:

The Main Objective Of This Study Is To Verify The R factor Of Most Common Designed Elevated Intze Tank Through Comparing The Assumed R Factor During Design To Actual R Factor Obtained From Non-Linear Analysis. In this study, 250000 and 500000 litters of water tanks are taken for the study of response reduction factor.



II CONCEPT OF RESPONSE REDUCTION FACTOR:

The Concept Of R factor Is Based On The Observations That Well Detailed Seismic Framing Systems Can Sustain Large Inelastic Deformations Without Collapse And Have Excess Of Lateral Strength Over Design Strength. Response Reduction (R) Factors Are Essential Seismic Design Tools, Which Are Typically Used To Describe the Level of Inelasticity Expected In Lateral Structural Systems During An Earthquake. The Response Reduction Factor (R) Is Depends On Over Strength (Rs), Ductility (Rμ), Redundancy (Rr). Over Strength Factor (Rs) Accounts For The Yielding Of A Structure At Load Higher Than The Design Load Due To Various Partial Safety Factors, Strain Hardening, Oversized Members, Confinement Of Concrete. Non-Structural Elements Also Contribute To The Over Strength. Ductility Factor (Rμ) Is A Ratio Of Ultimate Displacement Or Code Specified Permissible Displacement To The Yield Displacement. Higher Ductility Implies That The Structure Can Withstand Stronger Shaking Without Collapse. Redundancy Factor (Rr) Depends On The Number Of Vertical Framing Participate In Seismic Resistance. Yielding At One Location In The Structure Does Not Imply Yielding Of The Structure As A Whole. Hence The Load Distribution, Due To Redundancy Of The Structure, Provides Additional Safety Margin.

- SAP software is used to perform the nonlinear static pushover analysis.
- The RC beams and columns are modeled as 3-D frame elements with centerline dimension.
- Wall and domes are modeled as shell elements.
- Column foundations are assumed to be fixed.
- Default hinges are considered for analysis
- Flexure moment (M3), axial biaxial moment (P-M2-M3) and axial compressive shear force (V) hinges are assigned at the face of beam, column, and bracing respectively using the static pushover analysis.

III RESULTS

3.1 For 250000 litters:

Variation in height:

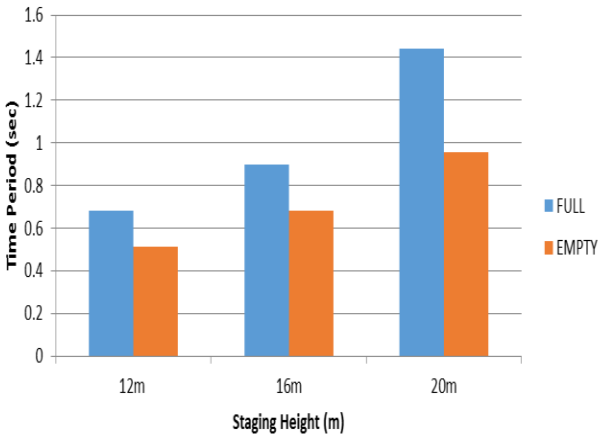
TANK TYPE:INTZ TANK	COLUMN SIZE:650MM DIA	
STAGING TYPE6 COL CIRCULAR	ZONE IV	
12M	FULL	EMPTY
TIME PERIOD	0.68	0.51
BASE SHEAR	311	329
DUCTILITY FACTOR	1.202	2.68
REDUNDANCY FACTOR	0.86	0.86
OVERSTRENGTH FACTOR	1.83	3.15
R	2.77	4.65

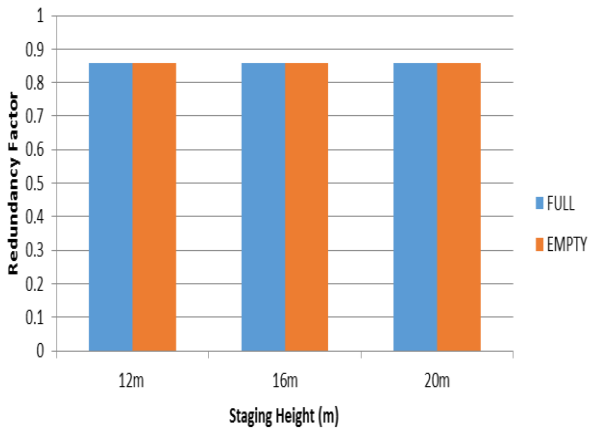
TANK TYPE:INTZ TANK	COLUMN SIZE:650MM DIA	
STAGING TYPE6 COL CIRCULAR	ZONE IV	
16M	FULL	EMPTY
TIME PERIOD	0.9	0.68
BASE SHEAR	280	278
DUCTILITY FACTOR	0.83	2.22
REDUNDANCY FACTOR	0.86	0.86
OVERSTRENGTH FACTOR	2.36	1.94
R	1.7	3.71

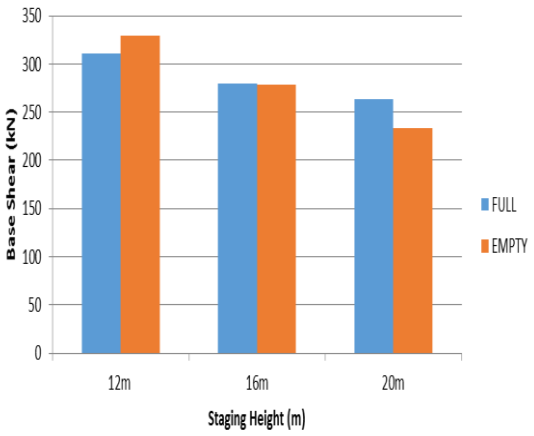
TANK TYPE:INTZ TANK	COLUMN SIZE:650MM DIA	
STAGING TYPE6 COL CIRCULAR	ZONE IV	
20M	FULL	EMPTY
TIME PERIOD	1.44	0.955
BASE SHEAR	263	233
DUCTILITY FACTOR	0.8	1.61
REDUNDANCY FACTOR	0.86	0.86
OVERSTRENGTH FACTOR	1.94	1.93
R	1.34	2.68

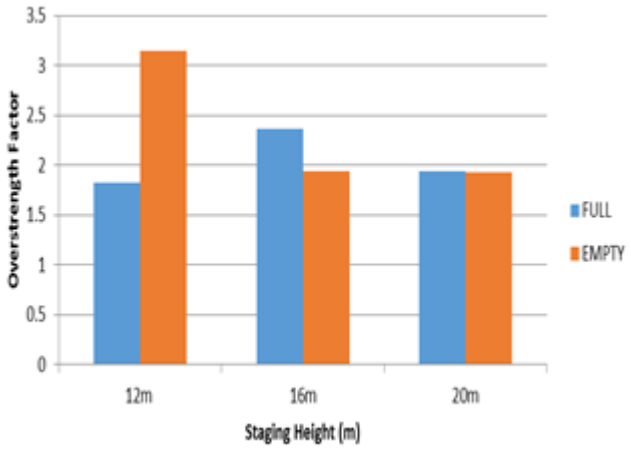
Variation in zone:

COLUMN SIZE:650MM DIA		COLUMN SIZE:650MM DIA		COLUMN SIZE:650MM DIA	
COLUMN STEEL:		COLUMN STEEL:		COLUMN STEEL:	
ZONE II		ZONE III		ZONE V	
FULL EMPTY	EMPTY	FULL	EMPTY	FULL	EMPTY
1.25223	0.955	1.25223	0.955	2.01	0.955
101	87	161	141	280	316
2.41	2.44	2.41	2.44	0.5344	2.44
0.86	0.86	0.86	0.86	0.86	0.86
1.84	3.79	1.87	2.31	2.42	1.28
3.99	7.9	3.2	4.86	1.23	2.68









TANK TYPE:INTZ TANK		COLUMN SIZE:650MM DIA	
STAGING HEIGHT 12M		COLUMN STEEL: 10 -20mm	
STAGING TYPE6 COL CIRCULAR		ZONE IV	
	Staging Height	FULL	EMPTY
TIME PERIOD	12m	0.68	0.51
	16m	0.9	0.68
	20m	1.44	0.955
	Staging Height	FULL	EMPTY
BASE SHEAR	12m	311	329
	16m	280	278
	20m	263	233
	Staging Height	FULL	EMPTY
DUCTILITY RATIO\	12m		
	16m		
	20m		
	Staging Height	FULL	EMPTY
DUCTILITY FACTOR	12m	1.283	1.3
	16m	0.7645	1.03
	20m	0.799	0.84
	Staging Height	FULL	EMPTY
REDUNDANCY FACTOR	12m	0.86	0.86
	16m	0.86	0.86
	20m	0.86	0.86
	Staging Height	FULL	EMPTY
OVERSTRENGTH FACTOR	12m	1.83	3.15
	16m	2.36	1.94
	20m	1.94	1.93
	Staging Height	FULL	EMPTY
R Factor	12m	2.77	4.65
	16m	1.7	3.71
	20m	1.34	2.68

3.2 For 500000 Litters:

TANK TYPE:INTZ TANK	COLUMN SIZE:650MM DIA	
STAGING TYPE6 COL CIRCULAR	ZONE IV	
12M	FULL	EMPTY
TIME PERIOD	1.46	0.58
BASE SHEAR	401	369.25
DUCTILITY FACTOR	2.23	2.29
REDUNDANCY FACTOR	0.86	0.86
OVERSTRENGTH FACTOR	1.827	1.28
R	3.51	2.52

TANK TYPE:INTZ TANK	COLUMN SIZE:650MM DIA	
STAGING TYPE6 COL CIRCULAR	ZONE IV	
16M	FULL	EMPTY
TIME PERIOD	1.68	0.82
BASE SHEAR	356.17	298
DUCTILITY FACTOR	1.11	2.54
REDUNDANCY FACTOR	0.86	0.86
OVERSTRENGTH FACTOR	1.92	1.89
R	1.83	4.13

TANK TYPE:INTZ TANK	COLUMN SIZE:650MM DIA	
STAGING TYPE6 COL CIRCULAR	ZONE IV	
20M	FULL	EMPTY
TIME PERIOD	2.015	1.05
BASE SHEAR	304.5	237
DUCTILITY FACTOR	1.49	1.83
REDUNDANCY FACTOR	0.86	0.86
OVERSTRENGTH FACTOR	1.45	1.91
R	1.87	3.01

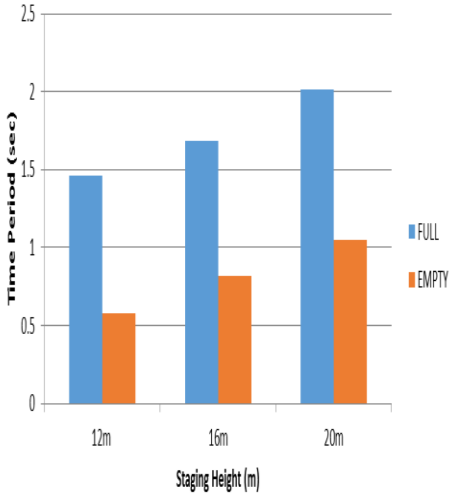
VARITION IN ZONE 20M:

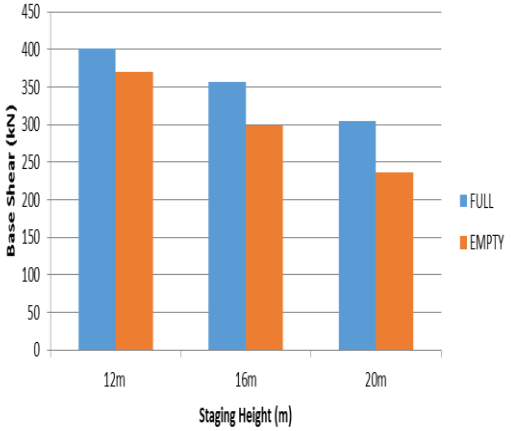
COLUMN SIZE:650MM DIA	
COLUMN STEEL:	
ZONE II	
FULL EMPTY	EMPTY
2.015	1.05
126.85	99.12
0.89	3.083
0.86	0.86
4.722	2.96
3.61	7.877

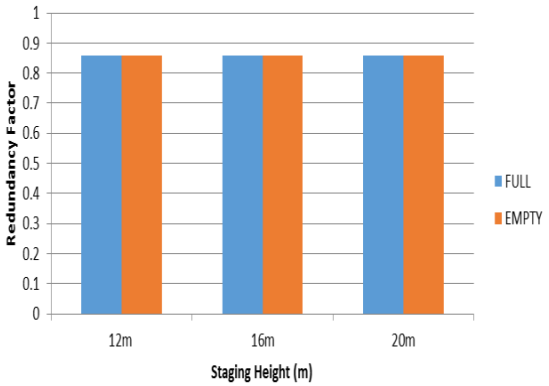
COLUMN SIZE:650MM DIA	
COLUMN STEEL:	
ZONE III	
FULL	EMPTY
2.015	1.05
202.96	158
0.89	1.87
0.86	0.86
2.44	2.84
2.24	4.61

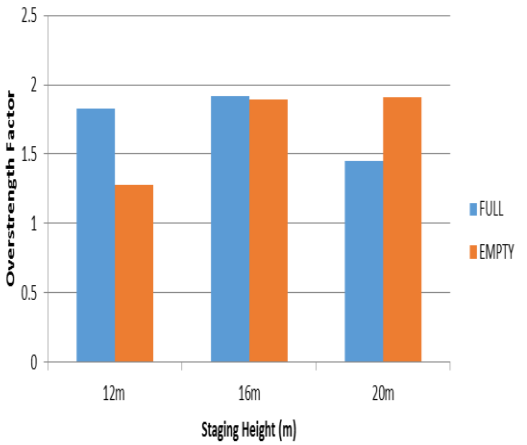
COLUMN SIZE:650MM DIA	
COLUMN STEEL:	
ZONE V	
FULL	EMPTY
2.05	1.05
456.68	356.77
0.89	1.88
0.86	0.86
1.3	1.26
1.01	2.04

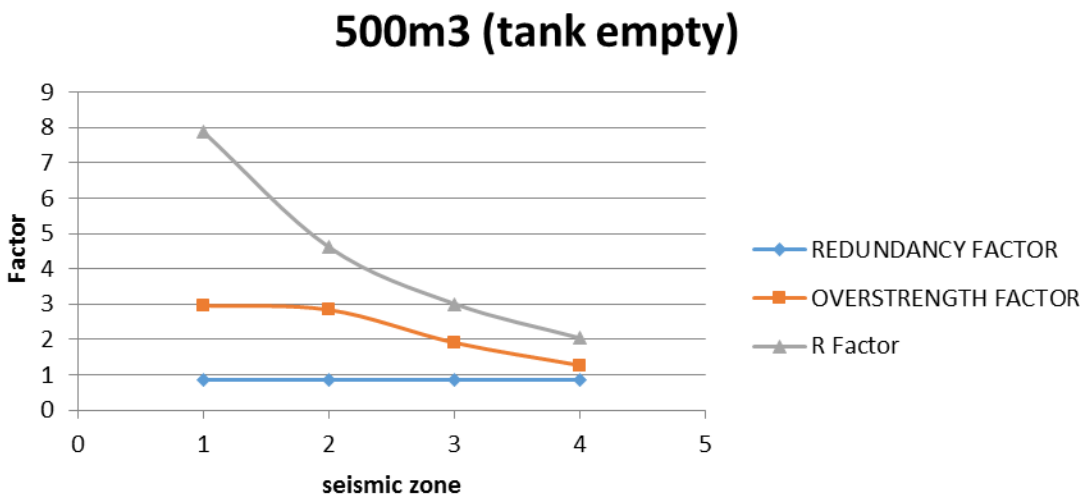
TANK TYPE:INTZ TANK		COLUMN SIZE:650MM DIA	
STAGING HEIGHT 12M		COLUMN STEEL: 10 -20mm	
STAGING TYPE6 COL CIRCULAR		ZONE IV	
	Staging Height	FULL	EMPTY
TIME PERIOD	12m	1.46	0.58
	16m	1.68	0.82
	20m	2.015	1.05
	Staging Height	FULL	EMPTY
BASE SHEAR	12m	401	369.25
	16m	356.17	298
	20m	304.5	237
	Staging Height	FULL	EMPTY
DUCTILITY RATIO\	12m		
	16m		
	20m		
	Staging Height	FULL	EMPTY
DUCTILITY FACTOR	12m	1.283	1.3
	16m	0.7645	1.03
	20m	0.799	0.84
	Staging Height	FULL	EMPTY
REDUNDANCY FACTOR	12m	0.86	0.86
	16m	0.86	0.86
	20m	0.86	0.86
	Staging Height	FULL	EMPTY
OVERSTRENGTH FACTOR	12m	1.827	1.28
	16m	1.92	1.89
	20m	1.45	1.91
	Staging Height	FULL	EMPTY
R Factor	12m	3.51	2.52
	16m	1.83	4.13
	20m	1.87	3.01

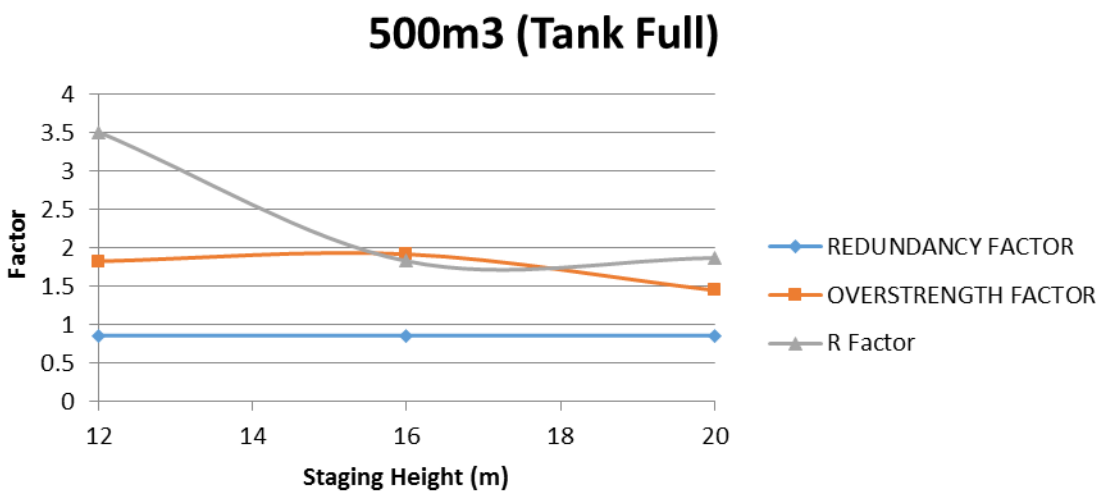


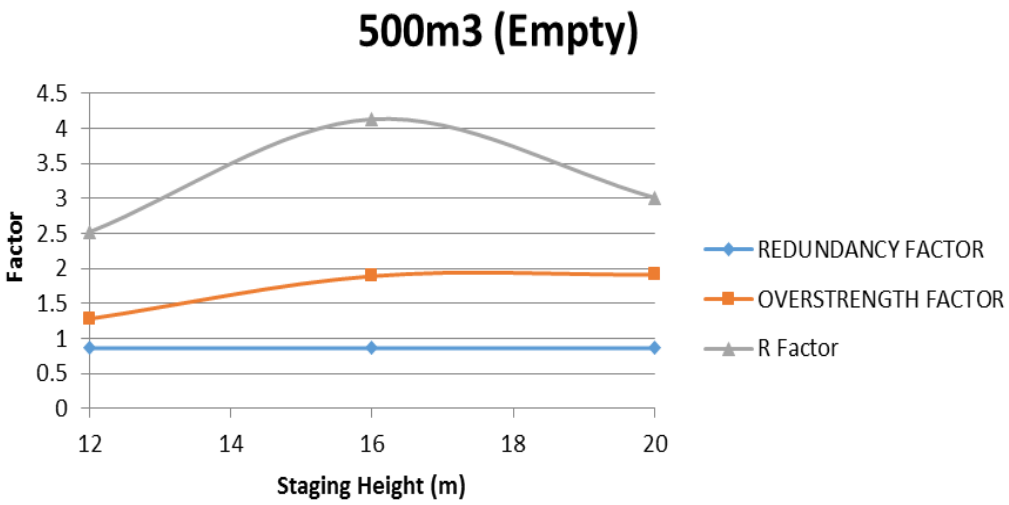


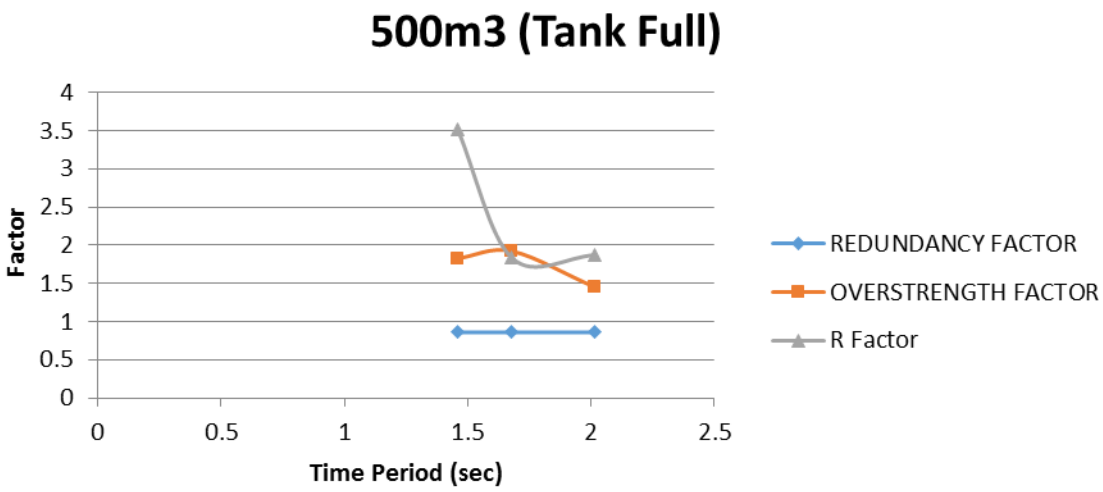


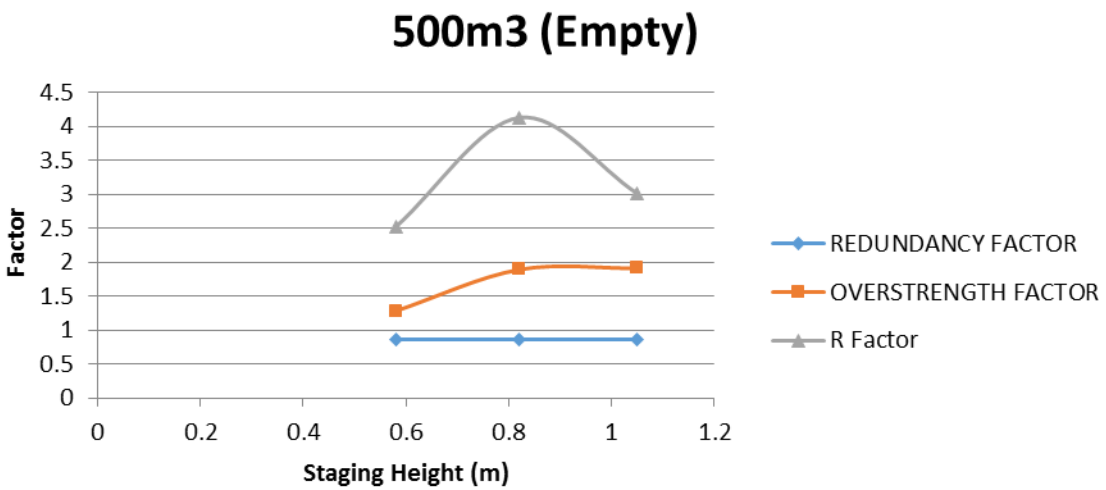


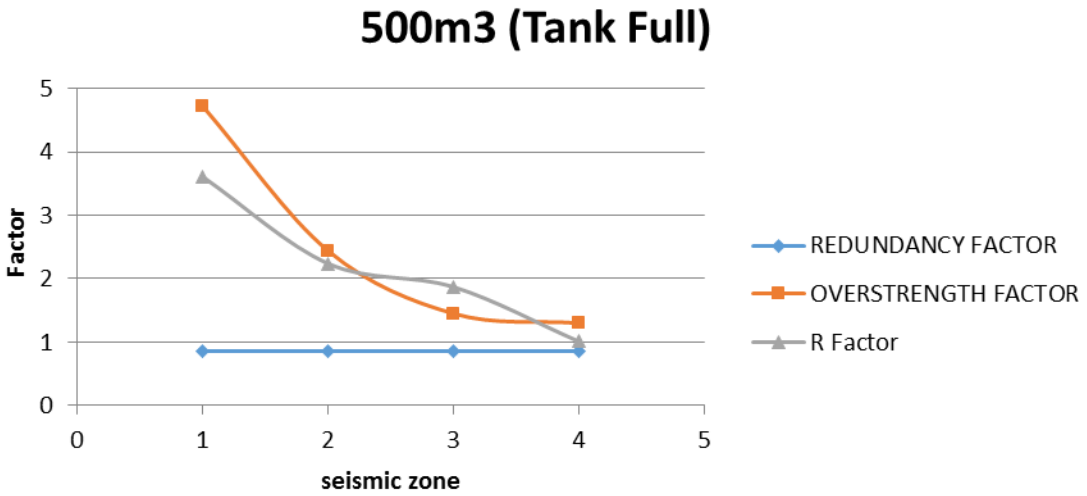


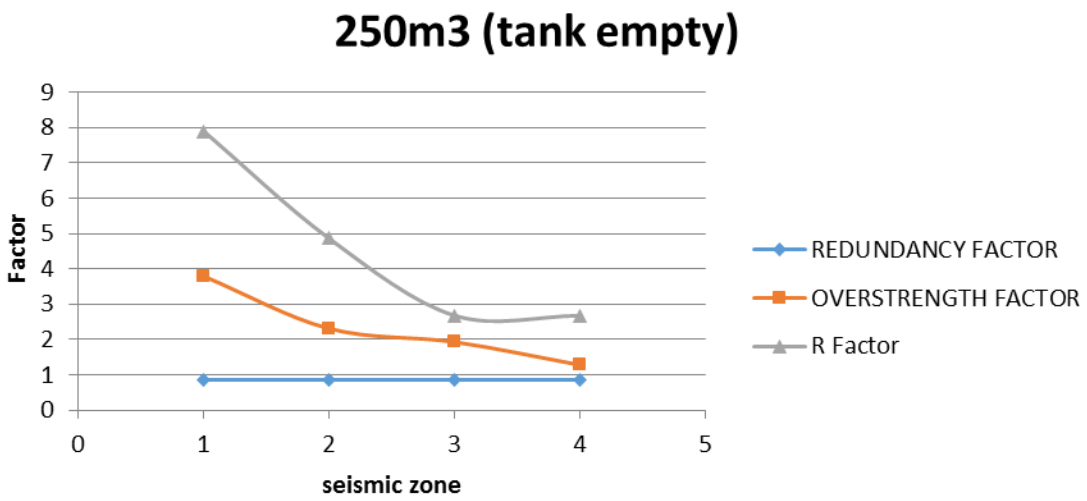


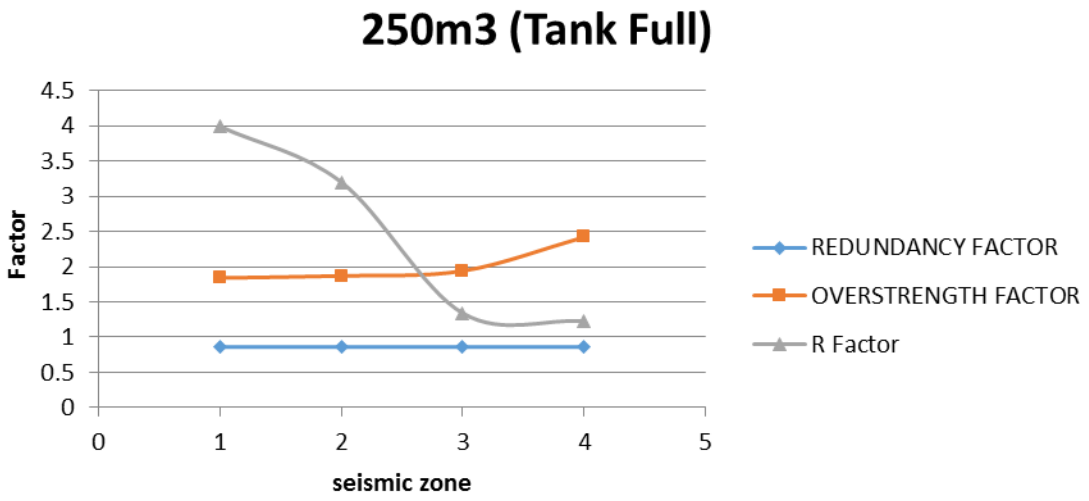


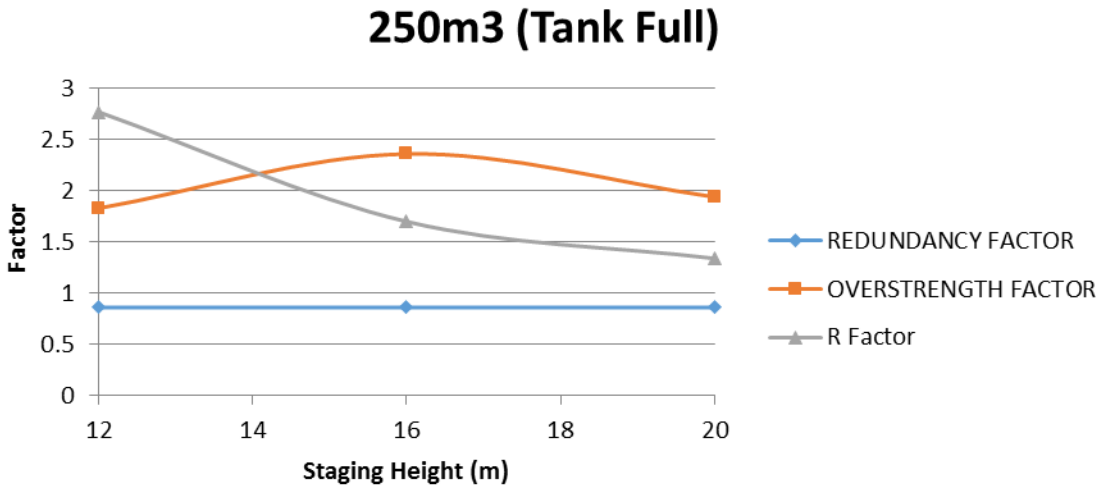


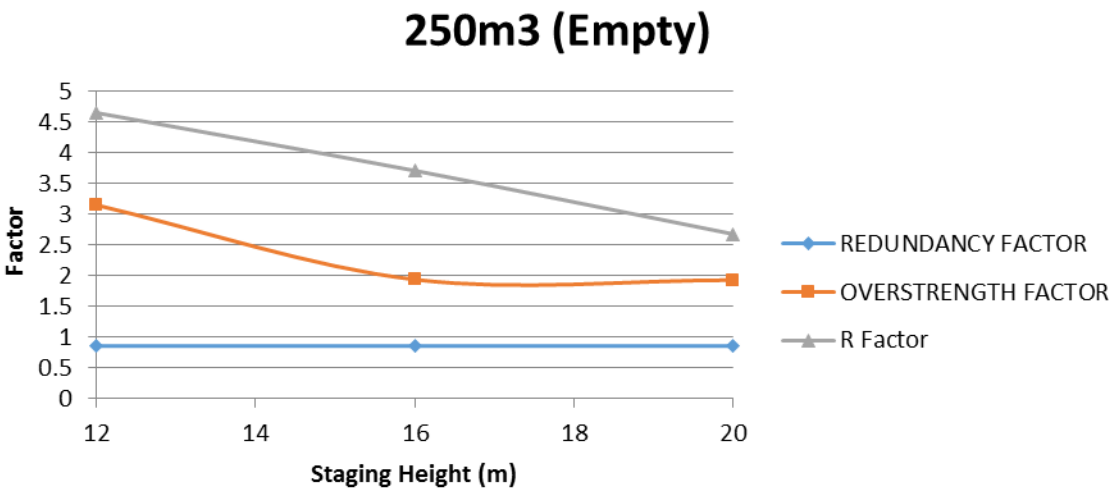


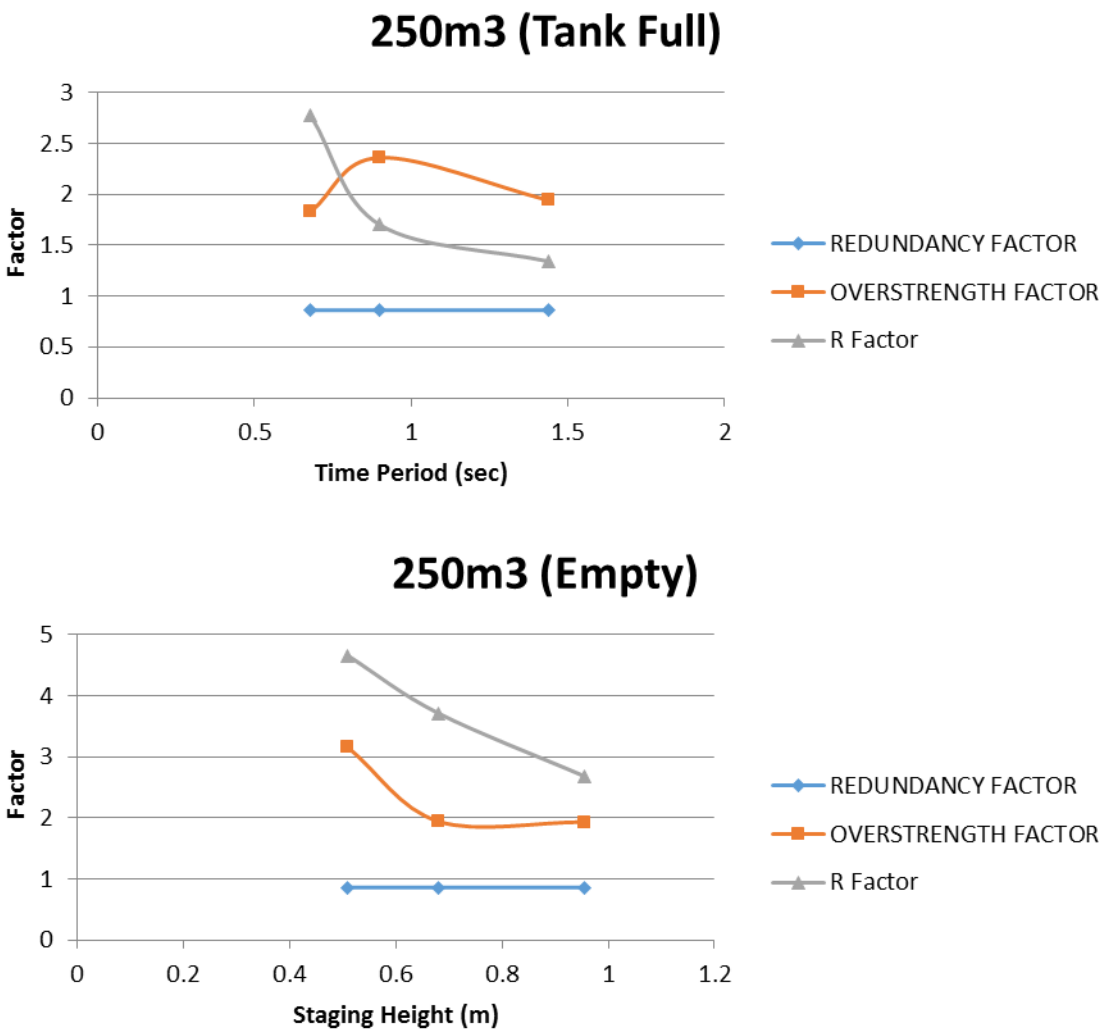












IV CONCLUSION

The elevated tanks Fundamental time period increases with increase in tank staging height. Also time period increases with the tank filling condition. Base shear decreases as the staging height increases that is due to increase in Time period and the dispersion of base shear is increased when the percentage of the filling in the storage tanks are increased. The response reduction factor is considerably affected by the fundamental time period of water tanks. It reduces as the fundamental time period increases. Estimation of response reduction factor with exact analysis will help in an economical design.

REFERANCE

1. IITK-GSDMA GUIDELINE FOR WATER TANK
2. IS 3370:2009 CONCRETE STRUCTURES FOR STORAGE OF LIQUIDS - CODE OF PRACTICE
3. ATC 19 STRUCTURAL RESPONSE MODIFICATION FACTOR
4. CRITERIA FOR DESIGN OF RCC STAGING FOR OVER HEAD TANK
5. REVIWE OF CODE PROVISION ON DESIGN SEISMIC FORCE FOR LIQUIDE STORAGE TANK

