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Seismic Behavior of Overhead Circular Water Tank with Shear Wall using STAAD PRO

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Abstract: Dynamic analysis of circular elevated water tank is a complex procedure involving fluid structure interaction. The circular elevated tank supports large water mass at the top of slender staging. In case of circular elevated tank the resistance against lateral forces exerted by earthquake is largely dependent of supporting system. Staging is considered to be a critical element as far as lateral resistance is concern. Satisfactory performance of staging during strong ground shaking is crucial. In this project we are going to study seismic behaviour of circular elevated water tank in view point of their supporting system(SHEAR WALL) is evaluated using finite element software STAAD PRO. The main objective is to evaluate effect of shear wall on distribution of lateral forces for circular elevated water tank using equivalent linear static method software STAAD PRO. Total twelve combinations were analysed using DYNAMIC ANALYSIS and results are presented. The parametric study is performed on model with different staging system to evaluate their performance with regard to lateral stiffness, displacement, seismic base shear, moment, deflection, time period etc.
Keywords: Elevated water tank, Shear wall, Dynamic Analysis, STADD PRO.

I. INTRODUCTION

An elevated water tank is a large water storage container constructed for the purpose of holding water supply at certain height to provide sufficient pressure in the water distribution system. Liquid storage tanks are used extensively by municipalities and industries for storing water, inflammable liquids and other chemicals. Industrial liquid tanks may contain highly toxic and inflammable liquids and these tanks should not lose their contents during the earthquake. These tanks have various types of support structures like RC braced frame, steel frame, RC shaft, and even masonry pedestal. The frame type is the most commonly used staging in practice. The main components of the frame type of staging are columns and braces. The staging acts like a bridge between container and foundation for the transfer of loads acting on the tank. Thus Water tanks are very important for public utility and for industrial structure.

Elevated water tanks consist of huge water mass at the top of a slender staging which are most critical consideration for the failure of the tank during earthquakes. Elevated water tanks are critical and strategic structures and the damage of these structures during earthquakes may endanger drinking water supply, cause to fail in preventing large fires and substantial economic loss. Since, the elevated tanks are frequently used in seismic active regions hence; seismic behavior of them has to be investigated in detail. Due to the lack of knowledge of supporting system some of the water tanks were collapsed or heavily damaged. So there is need to focus on seismic safety of lifeline structure with respect to alternate supporting system which are safe during earthquake and also to withstand more design forces. The frame support of elevated water tank should have adequate strength to resist axial loads, moment and shear force due to lateral loads. These forces depend upon total weight of the structure, which varies with the amount of water present in the tank container. An analysis of the dynamic behavior of such tanks must take into account the motion of the water relative to the tank as well as the motion of the tank relative to the ground. The aim of the present work is to compare the seismic performance of elevated water tank considering different staging system and at different heights

II. LITRETURE REVIEW

A. Ayazhussain M.Jabar et al (2012) studied the Behavior of supporting system under different earthquake time history record with SAP 2000 software. They compared various systems such as redial bracing and cross bracing with basic supporting system for various fluid level condition. They considered water mass in two parts as impulsive and convective as per GSDMA guidelines. They found results shows that structure responses are influenced by the presence of water, the earthquake characteristics and staging pattern. Presence of water; at empty condition base shear stresses& moments are moderate while as in half full presence they are minimum and at full maximum Staging pattern: at basic condition base shear stresses & moments are maximum, at radial bracing condition base shear stresses & moments are minimum and at crossing bracing condition base shear stresses & moments are moderate

B. Krishna Rao et al (2015) studied by seismic analysis of overhead circular water tank carried out in according to I.s.1893-1984 & 1893-2002 Part -2. In this they are taken Capacity 1000 cubic meter capacity located in 4 different seismic Zone (Zone-II, Zone-III, Zone-IV, Zone-V) and on three different soil condition and three different tank water condition (Tank full , Tank 50% , Empty Tank) by using sap 2000. The parameter compared base shear base moment, convective hydrodynamic pressure on Tank wall and base slab. The results shows that the increase in base shear stresses & moments, hydrodynamic pressure and time period with increase in zone factor in all conditions such as soil types, tank fill conditions.

C. Urmila Ronald et al(2016) Studied seismic Behavior of cylindrical liquid storage tank was carried out by performing dynamic response spectrum analysis using finite element method base software (ETABS) As per I.S 1893-2002 .they also carried out analysis for elevated circular water tank for empty and full tank condition under different soil condition and different Zone. The results show that when the tank is full the base shear is more. If the water tank is located in high seismic zone then base shear and base moment's increases. They also found that the base shear and base moment changes with soil types/conditions.

D. S.K.Jangave(2014) et al studied the seismic behavior of elevated water tank with consideration and modeling of impulsive and convective water masses inside the container as one mass model and two mass model as per 1893-2002 Under different time history recorded using FEM software sap 2002. The results shows that the structure response is influenced by different capacities of water tank and their one mass model and two mass model and earthquake under four different time history have been compared in this method they also used frame type staging They found that displacement for two base models is more than one base model as well existing model

E. By Pravin K. Malohtra (2010)In there Research paper they have provided the theoretical background of simplified seismic design procedure for cylindrical ground supported tank. They considered impassive and convective action of liquid in flexible still or concrete taken fixed to rigid foundation. The responses like base shear, overturning moments are calculated by performing simple calculations (Dynamic Analysis).

III. METHODOLOGY

A. Model Description

Circular overhead tank is selected for the study. Four models are to be prepared having different staging configurations. The following model are generated with varying height of water tank such as 5m, 10, 20m, with empty, half, full water level condition.

Model I- Overhead circular water tank with radial staging system (5 m, 10 m, 20 m) with tank empty, half, full tank conditions.

Model II - Overhead circular water tank with double strut staging system (5 m, 10 m, 20 m ,) with tank empty, half, full tank conditions.

Model III - Overhead circular water tank with shear wall on six side(5 m, 10 m, 20 m ,) with tank empty, half, full tank conditions.

Design Parameter Of Overhead Circular Water Tank

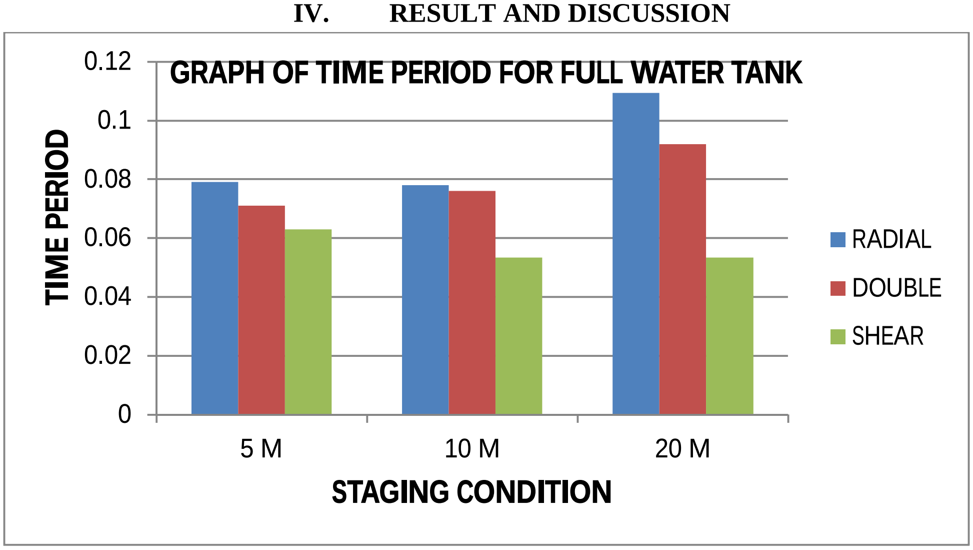
DIAMETER OF TANK	10.5 m
HEIGHT OF TANK	4 m
FREE BOARD	1.5 m
Rise of dome	0.5 m
DIAMETER OF BOTTEM RING	8.5 m

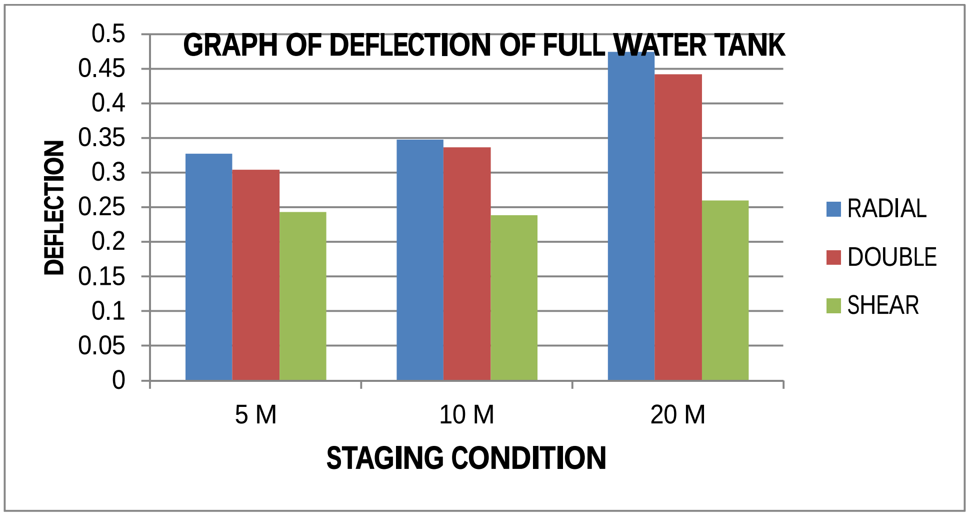
THICKNESS OF ROOF	0.1 m
THICKNESS OF WALL	0.17 m
TICKNESS OF BASE SLAB	0.45 m
DENSITY OF CONCRETE	24 kn/m^3
DEPTH OF FOUNDATION	1.5 m

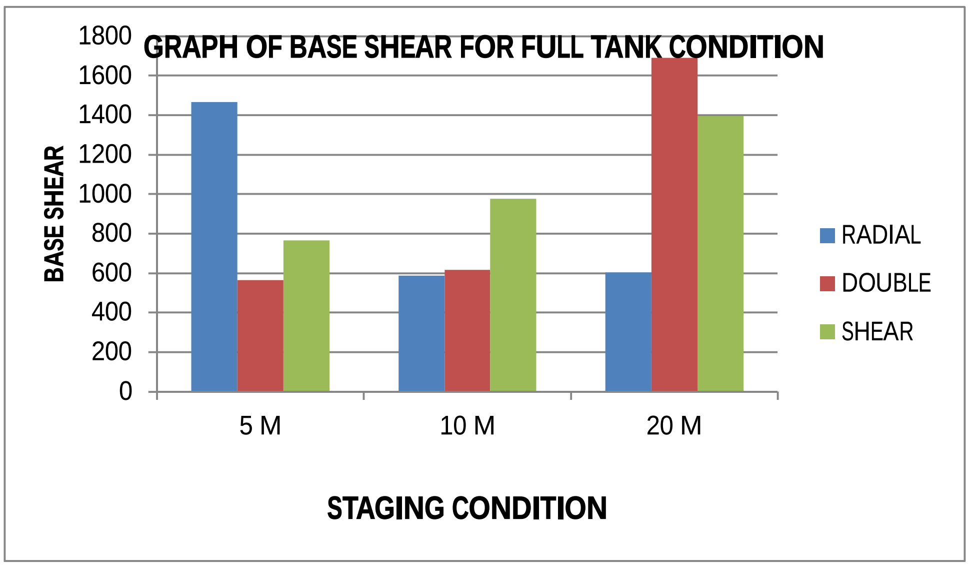
TANK STAGING PROPERTY	
NO. OF COLUMNS	6
COLUMN SIZE	0.3 X 0.6 m
RING BEAM SIZE	0.8 X 0.5 m
COULMN HEIGHT	5 m , 10 m , 20 m
BRACING INTERVEL : FOR 5 m FOR 10 m For 20 m	FROM TOP 2.5 m , 5 m 2 m , 6 m , 10 m 4 m , 8 m , 12 m , 16 m , 20 m
BRACING BEAM SIZE	0.3 X 0.3 m
DOUBLE STRUT SIZE	0.3 X 0.3 m
NUMBER OF SHEAR WALL	6
THICKNESS OF SHEAR WALL	0.6 M

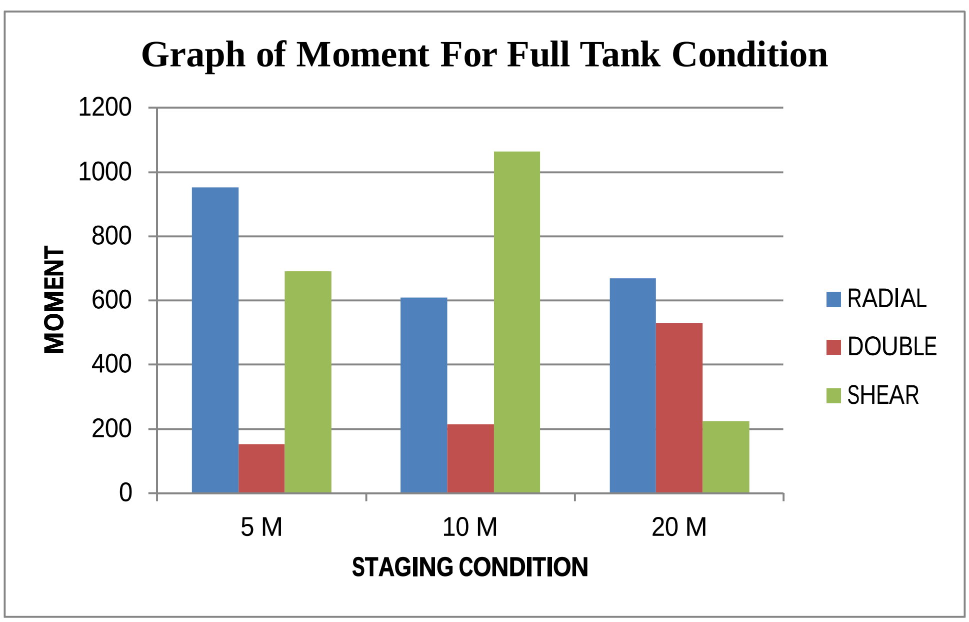
Seismic data	
ZONE	v
ZONE FACTOR	0.36
RESPONSE REDUCTION FACTOR	5
IMPORTANCE FACTOR	1.5
DAMPING RATIO	5 %
TIME PERIOD IN X - DIRECTION	0.11
TIME PERIOD IN Y - DIRECTION	3.53

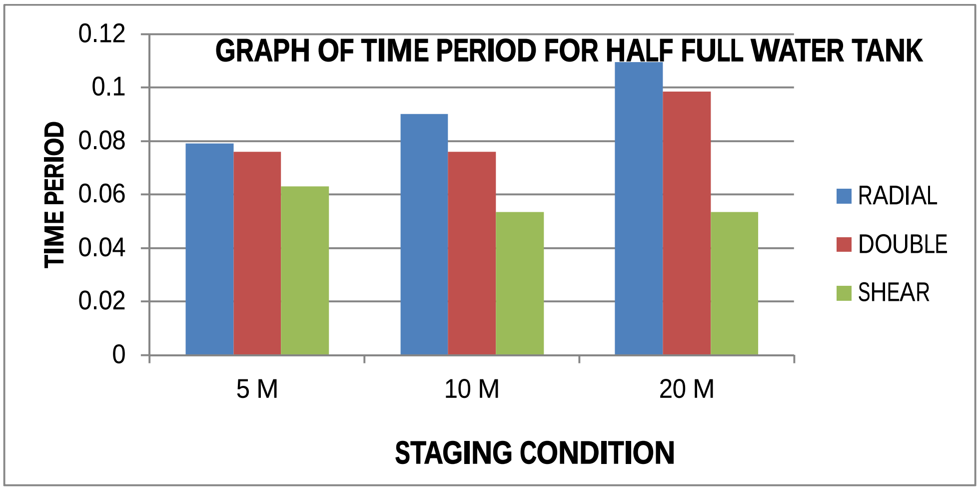
IV. RESULT AND DISCUSSION

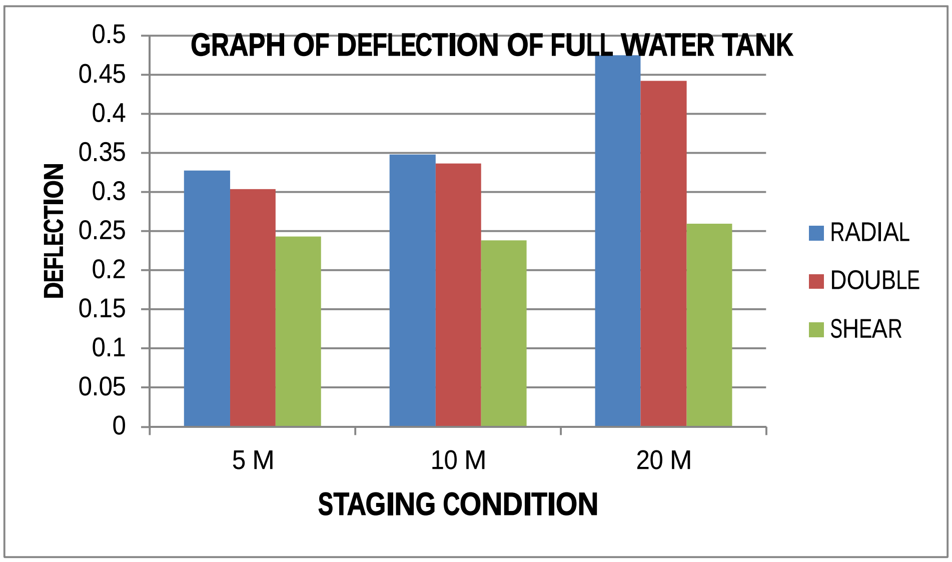


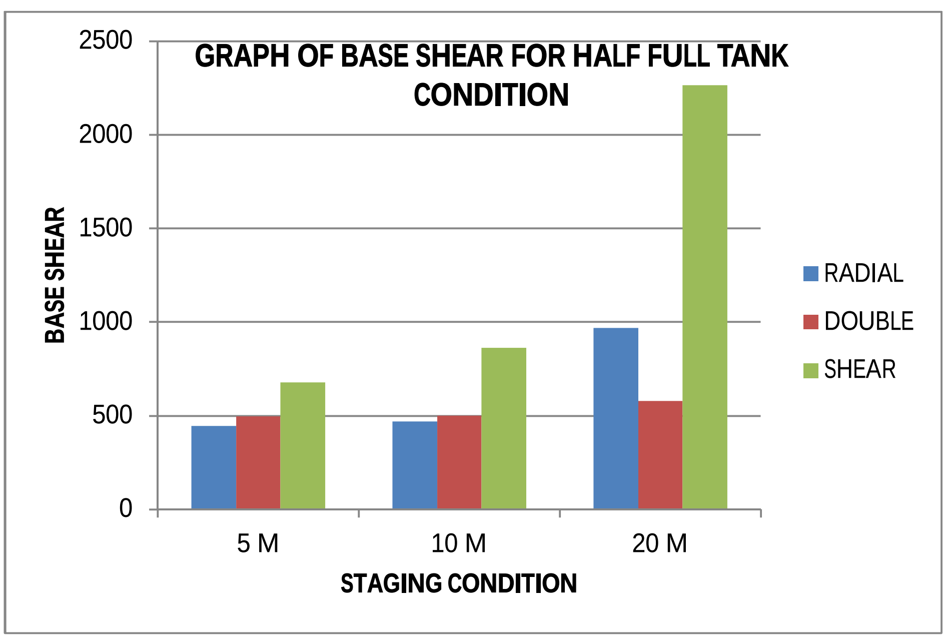

GRAPH OF DEFLECTION OF FULL WATER TANK
DEFLECTION
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
5 M
10 M
20 M
STAGING CONDITION
RADIAL
DOUBLE
SHEAR

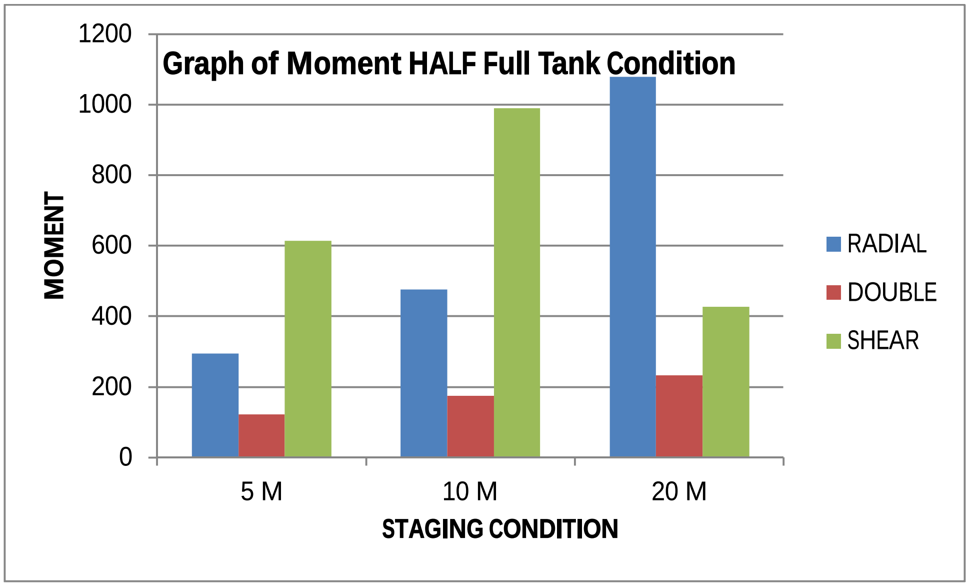

GRAPH OF BASE SHEAR FOR FULL TANK CONDITION
BASE SHEAR
1800
1600
1400
1200
1000
800
600
400
200
0
5 M
10 M
20 M
STAGING CONDITION
RADIAL
DOUBLE
SHEAR

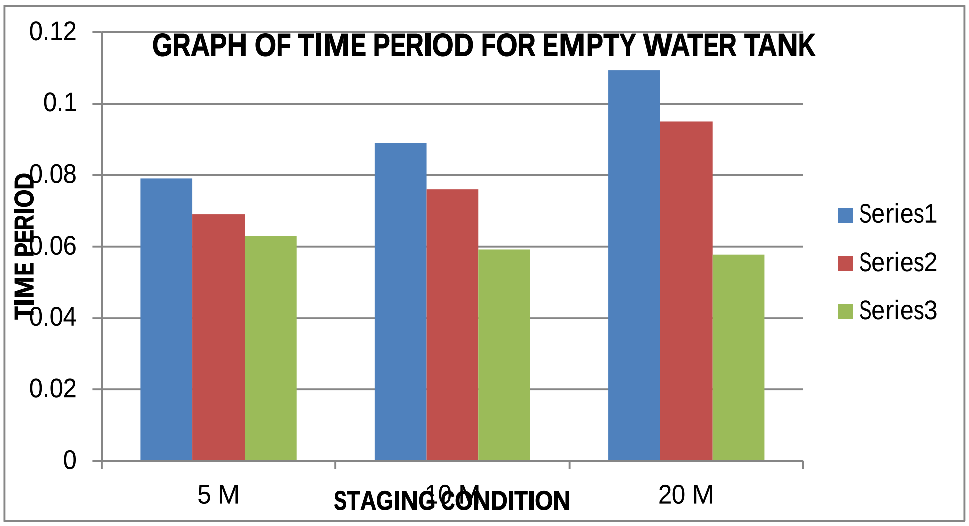

Graph of Moment For Full Tank Condition
MOMENT
1200
1000
800
600
400
200
0
5 M
10 M
20 M
STAGING CONDITION
RADIAL
DOUBLE
SHEAR

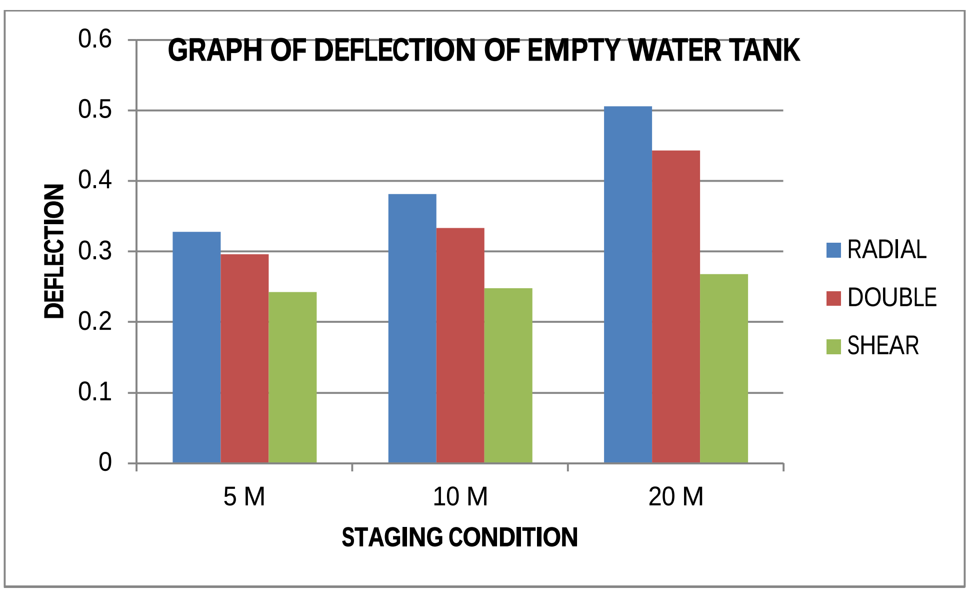

GRAPH OF TIME PERIOD FOR HALF FULL WATER TANK
TIME PERIOD
0.12
0.1
0.08
0.06
0.04
0.02
0
5 M
10 M
20 M
STAGING CONDITION
RADIAL
DOUBLE
SHEAR

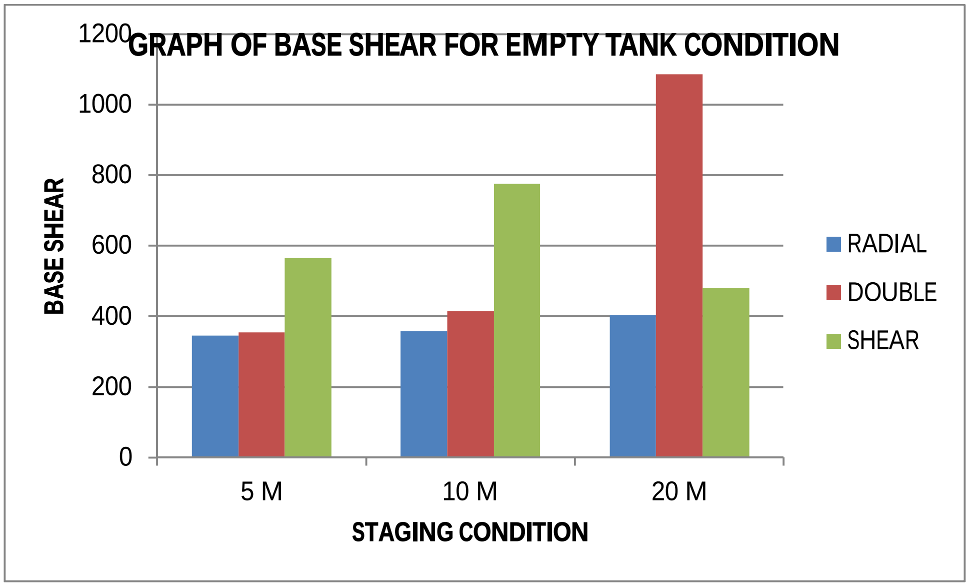

GRAPH OF DEFLECTION OF FULL WATER TANK
DEFLECTION
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
5 M
10 M
20 M
STAGING CONDITION
RADIAL
DOUBLE
SHEAR

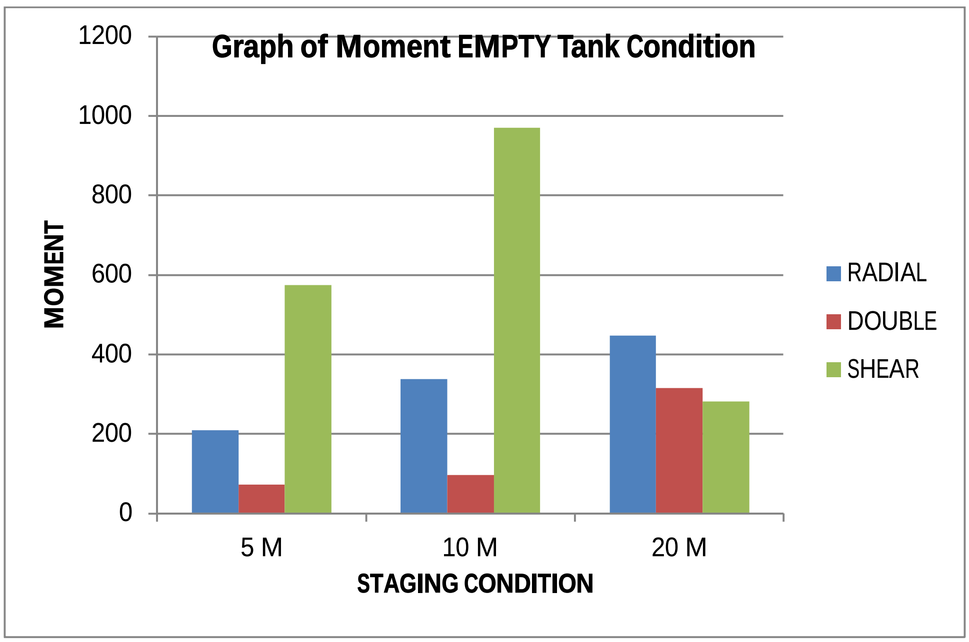

GRAPH OF BASE SHEAR FOR HALF FULL TANK CONDITION
BASE SHEAR
2500
2000
1500
1000
500
0
5 M
10 M
20 M
STAGING CONDITION
RADIAL
DOUBLE
SHEAR


Graph of Moment HALF Full Tank Condition
MOMENT
1200
1000
800
600
400
200
0
5 M
10 M
20 M
STAGING CONDITION
RADIAL
DOUBLE
SHEAR


GRAPH OF TIME PERIOD FOR EMPTY WATER TANK
TIME PERIOD
0.12
0.1
0.08
0.06
0.04
0.02
0
5 M
10 M
20 M
STAGING CONDITION
Series1
Series2
Series3


GRAPH OF DEFLECTION OF EMPTY WATER TANK
DEFLECTION
0.6
0.5
0.4
0.3
0.2
0.1
0
5 M
10 M
20 M
STAGING CONDITION
RADIAL
DOUBLE
SHEAR





V. CONCLUSION

A. *We have Concluded from Above Result and Discussion,*

1) As the height of tower increases time period also increases, In case of shear wall with height increases time period is decreases and also the time period is minimum as compared to radial and double strut staging condition
2) As the height of tower increases the deflection of the tower increases, In case of shear wall deflection is minimum as compare to radial and double strut staging condition.
3) *As the height increases,*
   a) For radial staging condition base shear decrease at some level and again increase in some amount.
   b) For double strut staging condition base shear continuously increases.
   c) For shear wall base shear is also increases.
4) As the height of tower increases displacement also increases, In case of shear wall displacement is minimized as compare to radial and double strut.

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A. Code books

[1] IS 1893 (Part 1):2002 Criteria for earthquake resistant design of structures.
[2] IS: 1893(Part II) (2005) Draft Criteria for Earthquake Resistant Design of Structure (Liquid Retaining Tanks), in this draft two mass modal is illustrate for analysis of liquid storage tank.
[3] IS: 3370 (part II-IV)-1965 Code of practice for concrete structures for the storage of liquids, in this code general requirement and stress for design of liquid storage tank is illustrated.
[4] IS: 3370 (Part II) – 1965 code of practice for concrete structures for the storage of liquids
[5] IS: 456-2000 plain and reinforced concrete code of practice, in this code all design parameter for RCC design of different component of elevated water tank. SP 64 (S & T): 2001, "Explanatory Handbook on Indian Standard Code of Practice for Design Loads (other than earthquake) for Buildings and Structures (IS 875 Part 3-Wind Loads)", BIS, New Delhi.

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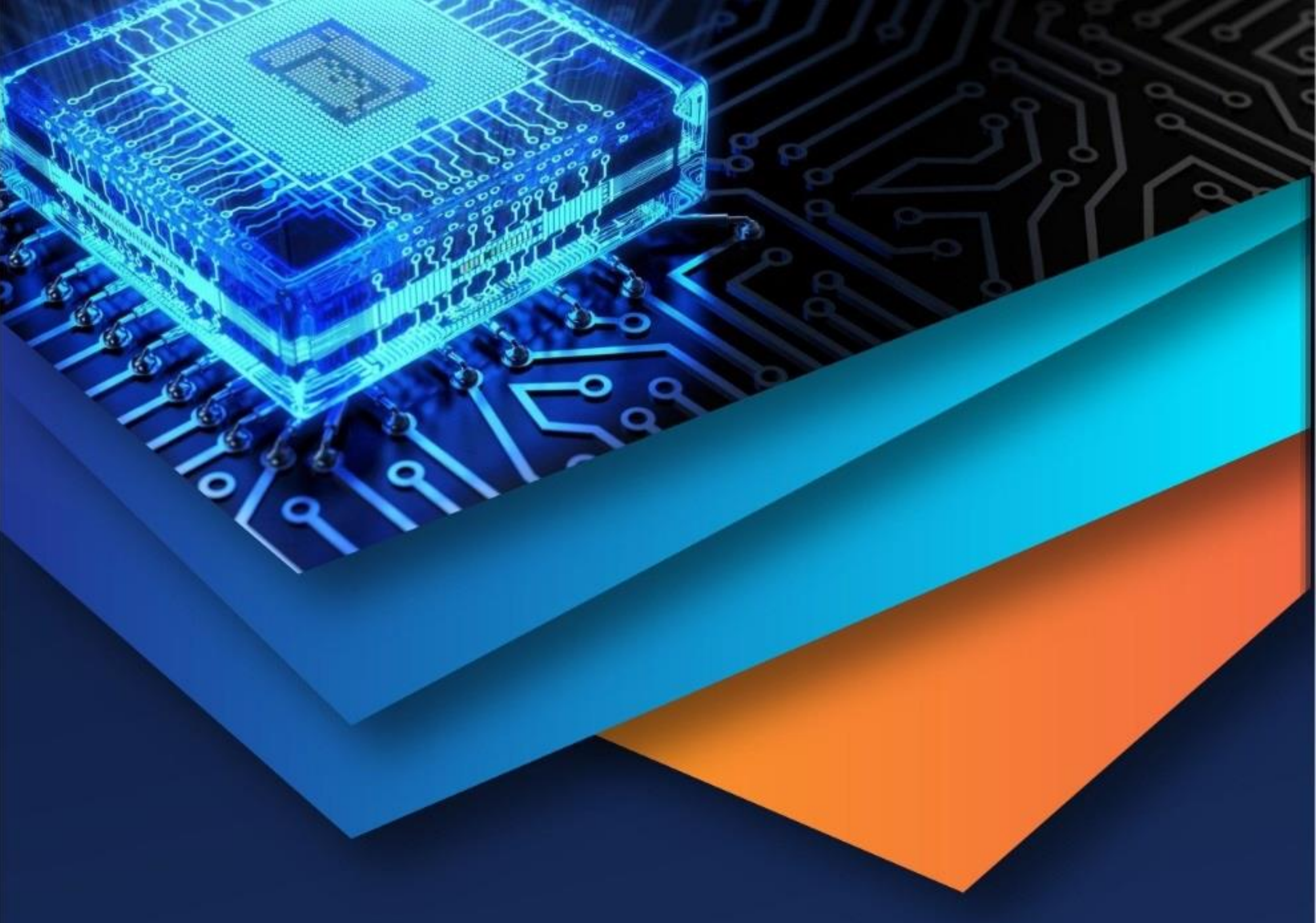
[2] S,K Duggal; Earthquake resistant design of structure



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