FORESHOCK EFFECT ON ELEVATED WATER TANK

A

PROJECT REPORT

Submitted in partial fulfilment of the requirements for the award of the Degree

of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision

of

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT SOLAN-173234

HIMACHAL PRADESH INDIA

MAY, 2022

STUDENT'S DECLARATION

We hereby declare that the work presented in the Project report entitled **"Foreshock Effect on Elevated Water Tank** "submitted for partial fulfilment of the requirements for the degree of Bachelor of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision of '**Dr.Tanmay Gupta'.** This work has not been submitted elsewhere for the reward of any other degree/diploma. We are fully responsible for the contents of my project report.

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"Foreshock Effect On Elevated Water Tank** "in partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat**is an authentic record of work carried out by **Aditya Chauhan (181633) and Vishal Garg (181610)** during a period from July 2021 to May 2022, under the supervision of **Dr.Tanmay Gupta** (Assistant Professor), Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

Date: 14 May 2022

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JUIT, Waknaghat	JUIT, Waknaghat	

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We gratefully acknowledge the Management and Administration of Jaypee University of Information Technology, Waknaghat for providing us the opportunity and the environment to initiate and complete our project now.

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ABSTRACT

Elevated water tanks must should be designed to withstand all the types of forces that are expected to act throughout their lifetime. Taking into consideration seismic load is one of the most essential parts of constructing and designing an elevated water tank. Many water tanks were damaged and collapsed during earthquakes all over the world. The failures of the water tank are due to collapse of supporting systems rather than any other factor. It is also seen that the damage takes place due to improper maintenance of the supporting systems and without considering the sloshing effect, demand of seismic forces and improper arrangement of the supporting elements. Consequently, this analytical study is to analyse the elevated water tank considering the sloshing effect, base isolation and analysing the elevator water tank in empty condition. It also highlights some important results based on sloshing effect and base isolation that must be considered before and after designing and construction of an elevated water tank.

Keywords: Earthquakes, Collapsed, Elevated Water Tank, Sloshing, Base isolation

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Many disasters have occurred in most of the states or union territories of the Indian subcontinent. Most of the casualties and immeasurable property loss every year are due to natural calamities like earthquake, flood, cyclones have resulted in collapse of many structures or superstructures . Hence it becomes important to learn from these situations and to work accordingly. More than 60% of Indian regions are prone to earthquakes as per data given by IS 1893-2002 Part-I. Property loss can always be recovered to some extent after an earthquake, but life loss can never be recovered. The main fact behind life loss is the collapse of a structure by an earthquake. Hence it becomes important for every engineer to analyse and design structure properly as per seismic requirement.

Liquid storage tanks are essential structures in the oil, water and gas industry and their behaviour during an earthquake is more important than its economic value. According to recent research results during the last decade, there were several places in India, where the zones were upgraded. Hence, the seismic evaluation of existing water tanks or important structures should be done to reduce risk for the environment and population.

Elevated water tanks consist of slender staging columns with huge water mass at the top which becomes more critical during earthquakes for failure. It is observed from past earthquakes, taking in view the Bhuj earthquake of 26 January 2001, most of the damage occurred in support of structures because of lack of knowledge about the supporting systems. So it becomes urgent to pay some attention for seismic safety of these structures or superstructures with suitable modifications in designing and regular maintenance of these structures.

1.2. Water Storage Tanks(Elevated)

Elevated water tanks also known as water towers and are constructed at a height sufficient to pressurise a water distribution system. The main purpose is to achieve proper distribution and to maintain constant pressure and flow, at the time of the discharge and when the water comes downward from a certain height it has a sufficient upraise in the pressure that is making it serve at a fixed rate in almost every outlet.

These tanks are used for different purposes and needs to be stored for the ready access like household water storage, commercial usage and beverage preparation, irrigation, agriculture, fire suppression, and industrial manufacturing. All use the water storage tanks to streamline flow delivery. The primary reason for the elevation of these tanks is to create more water pressure to deliver water with more force.

Figure 1: An overview of elevated water tank located at Jubbal, Shimla District, (HP)

1.3. Advantages of elevated water tanks

1.3.1 Easy Maintenance

The tanks that are located above the ground level provide much more easy access than those which are below ground level. However these tanks are more prone to damage than the below ground tanks. If these tanks are properly installed and maintained the damage can easily be spotted which can either be on tank, pipe, pump or at any other spot.

1.3.2 Easy to install

Large PE storage tanks should be installed on a concrete or asphalt base. Because GRP tanks are less flexible and can shatter if they move they will require a firm level foundation. If it is determined that the systems storage capacity needs to be increased at a later date adding another above ground tank is usually quite simple in most of the cases.

1.3.3 Varieties and area

The variety of above ground water tanks is much more as compared to below. Tanks exist in a variety of style, shape, size ranging from simple round barrels to intricate columns and even thin boxes that resemble fence panels. Because of the enormous range there is typically something that will fit..

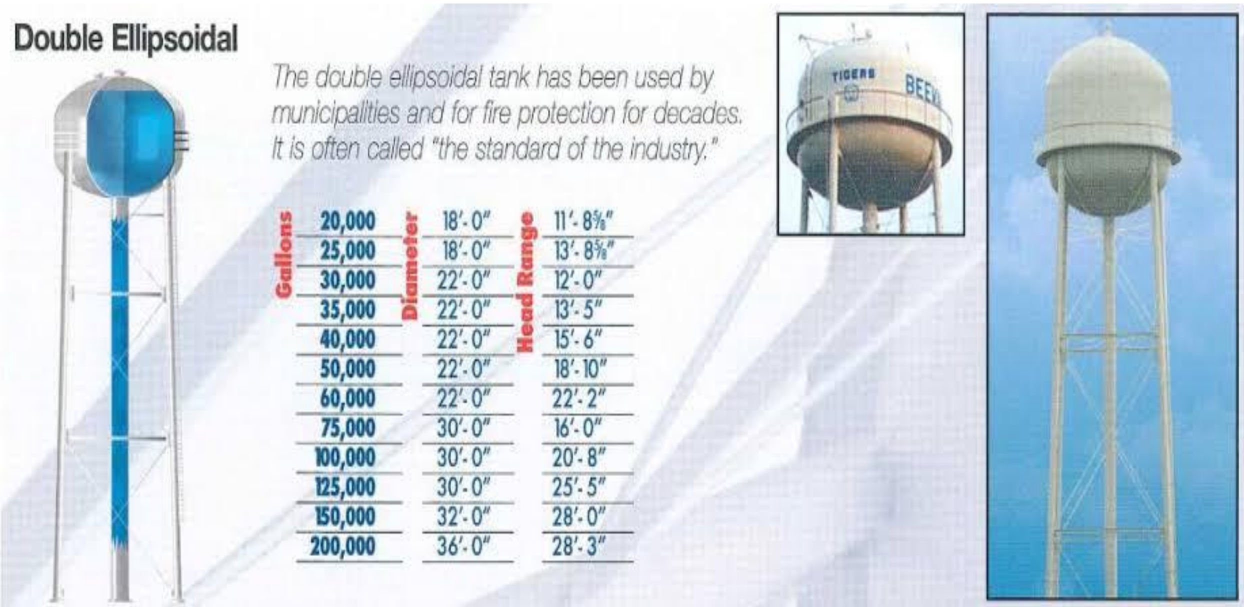
1.4. Disadvantages of Above Ground Tanks

The extremes of the climates are directly faced by the above tanks. There is always a risk of freezing of pipe work and pumps so a good and proper insulation is needed. In some cases when the water is only used sometimes, the water can completely be drained to avoid the damages and prevent failures. In summers the above water tanks are exposed to the sun directly so this increases the chances to development of cracks and degrades the quality of plastering.

1.5. Elevated water tank types:

Tank builders often make elevated water storage tanks out of carbon steel, which is inexpensive to fabricate and extremely robust. Steel elevated tanks have been proven to endure up to 60 years since carbon steel is easy to be maintained. Therefore below mentioned are some of the most commonly used above ground tanks with their respective figures.

1)Double Ellipsoidal: Double ellipsoidal storage tanks are commonly regarded as the conventional tank form, with steel beams and columns supporting a cylinder side wall welded to ellipsoid top and bottom. The following twin ellipsoidal storage tank sizes are available from Pittsburgh Tank & Tower:



Gallons	Diameter	Head Range
20,000	18'-0"	11'-8 5/8"
25,000	18'-0"	13'-8 5/8"
30,000	22'-0"	12'-0"
35,000	22'-0"	13'-5"
40,000	22'-0"	15'-6"
50,000	22'-0"	18'-10"
60,000	22'-0"	22'-2"
75,000	30'-0"	16'-0"
100,000	30'-0"	20'-8"
125,000	30'-0"	25'-5"
150,000	32'-0"	28'-0"
200,000	36'-0"	28'-3"

Figure 2: Double Ellipsoidal elevated water tank

Figure 3: Front view of double ellipsoidal tank

2) Elevated Toro: The Toro spherical tank design gives these storage tanks their name. These tanks are typically used for applications that require lot of pressure. The following size and column configurations are available in elevated Toro tanks.

Figure 4: Elevated Toro water tank

3) Sphere: Elevated sphere water tanks are popular because of their streamlined designsand aesthetical appeal. For a stable sphere water tank erected on single pedestal the following dimensions are available.

Gallons	Shapes	Diameter	Head Range
25,000	Sphere	19'- 6"	15'- 6"
30,000	Sphere	20'- 6"	16'- 3"
40,000	Sphere	22'- 0"	20'- 0"
50,000	Sphere	24'- 0"	21'- 3"
60,000	Sphere	25'- 0"	22'- 9"
75,000	Sphere	27'- 0"	25'- 0"
100,000	Sphere	30'- 0"	26'- 0"
125,000	Sphere	32'- 0"	29'- 6"
150,000	Sphere	34'- 0"	31'- 4"
200,000	Sphere	37'- 6"	34'- 0"
250,000	Sphere	44'- 0"	31'- 0"
300,000	Sphere	46'- 6"	32'- 6"
400,000	Sphere	51'- 6"	35'- 0"
500,000	Sphere	55'- 6"	37'- 6"

Figure 5: An overview of Sphere water tank

Figure 6: Front view of Sphere water tank

4) PED Cone: PED Cone tanks are distinguished by distinctive look, which features a single cone-shaped base that supports a raised spherical tank. The following are the PED-Cone tanks

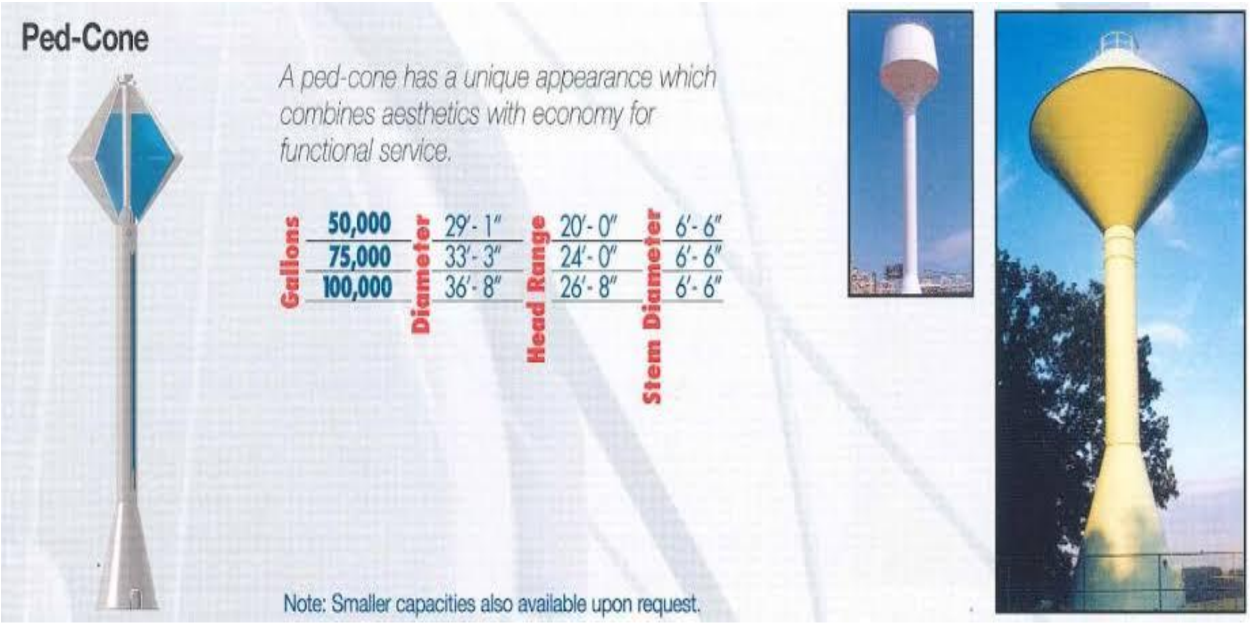


Figure 7: An overview of Ped-Cone water tank

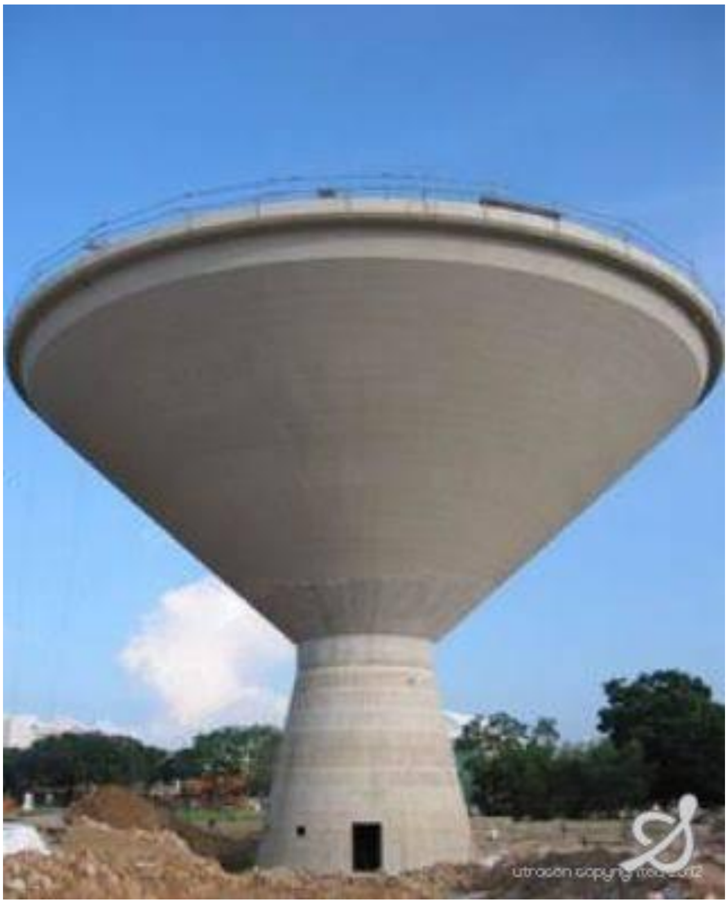


Figure 8: Front view of Ped-cone water tank

5)Fluted-Pillar: Fluted-pillar elevated tanks have plenty of room inside the fluted shaft for pump equipment, storage and other things, as well as lot of water storage. Dimensions are as follows:

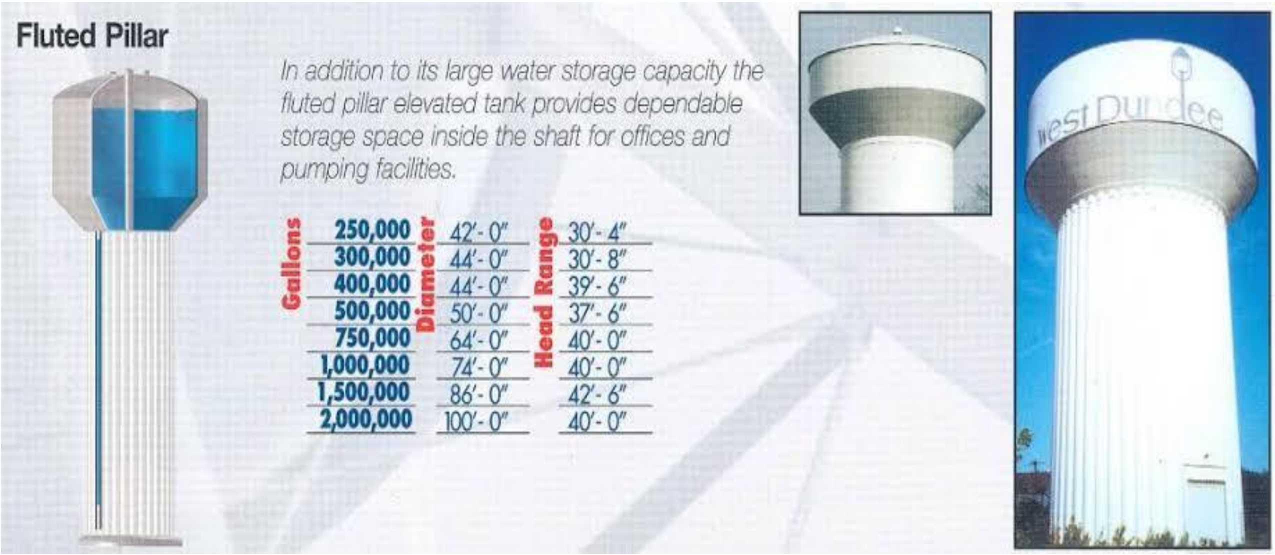


Figure 9: An overview of Fluted Pillar water tank

Figure 10: Front view of Fluted pillar water tank

1.6 Elevated Water Tank Selection

When selecting the best elevated water tank for your application, it is important to consider the height, construction, capacity, size and shape, and cold protection requirements. Installation of the correct elevated water tank ensures reliable and efficient water flow throughout the distribution area.

1. **Height:** Water pressure is impacted directly by the height of above water tank. Towers should offer a minimum of 20 psi of water pressure to users within the distribution system at all the times, though standard pressure is much higher—typically between 60 and 70 psi. The height of the elevated tank must be sufficient to ensure constant minimum pressure to all points within the distribution area.

2. **Size and Capacity:** The expected use and storing capacity should be considered and it should be according to the size of the community. Projections for water usage, including community growth and emergency usage, are necessary to ensure that the elevated water storage tank has sufficient capacity.

3. **Construction:** Some factors must be considered the intended use, water quality, pressure requirements, and environmental impact. The area's soil quality and consistency, potential seismic activity, high winds, and extreme temperatures will all influence material selection and design elements. Also consider the installation site and how field erected tanks may present challenges.

4. **Cold Resistance Importance:** There is always a risk of freezing of above water tanks in below zero temperatures, which in turn could leave the community without a reliable water source. A variety of water tank heating methods may be implemented to prevent freezing, including gravity circulation, steam coils, and or the direct steam discharge.

Figure 11:Cold resistance of water tank

1.7. APPLICATIONS

Elevated Water Storage Tank Applications-

Apart from municipal works the elevated water tanks are mostly used for the following works

1. Protection from fire
2. To regulate and process the water
3. Cooling of the super-structures

1.8. MAINTENANCE:

Maintenance of elevated tanks :

To ensure water quality a regular maintenance is must for the elevated tank. The standards established by the AMERICAN WATER WORKS ASSOCIATION (AWWA) and most regulations by state and Federal govt. Ensure a proper check in every 3-5 years.

the tank's coating, fixtures and foundations are examined by inspectors to ensure that everything is in good working condition. Any flaws or inconsistencies discovered during the examination should be addressed immediately to avoid increasing issues including leakage, loss of pressure, and contamination inside tank.

. To avoid particle build-up and probable contamination from loose, leaking, or damaged tank components, we must examine water quality on a routine basis.

1.9. Various Load Cases for Elevated Water Tanks

1.9.1 SLOSHING

Any disturbance to partially filled liquid containers causes it. The free liquid surface can experience various kinds of motion depending on the type of disturbance and container shape, including simple planar, no planar, rotational, irregular beating, symmetric, asymmetrical, semi, and messy motion. The free liquid surface can exhibit fascinating kinds of motion in the form of energy exchange between engaging modes when engaging with an elastic container or its support system.

When unrestricted motion interacts with the elastic support structural dynamics in the proximity of internal resonance conditions, the outcome is a modulated free surface.

The surface tension of the liquid is dominant in a low gravity field, as well as the liquid may be positioned randomly within the tank based on the tank wall's wetting characteristics. The estimation of hydrodynamic pressure distribution, forces, moments, and natural frequencies of the free-liquid surface is at the heart of the liquid sloshing dilemma. The dynamic stability and performance of movable containers are directly influenced by these factors.

In general, there really are two separate components to the hydrostatic forces of liquids in moving rigid containers. One component is proportional to the tank's displacement. This element is caused by a portion of fluid travelling at the same speed as that of the tank. The second type of pressure is known as "convective" pressure, and it depicts free-surface liquid motion. Sloshing parts are usually modelled using mechanical models such as mass-spring-dashpot or pendulum systems.

EFFECTS:

Effect on global effects, such as shear force, bending moments, and time frame, as well as local influences, such as member pressures and joint separations.

Houser (1963) proposed two mass model systems: impulsive mass and convective mass, both of which exert hydraulic pressures.

The height of the liquid column in relation to the diameter of the container determines the severity of the adversity.

The fraction of total mass that sloshes increases as the ratio decreases.

Dent, yielding (thus the crack), pipeline separation, and excessive joint displacements are all possible outcomes.

LIMITATIONS:

Although the effect of sloshing is roughly expected, the approach ignores the following.

- Compressibility of the fluid
- Viscosity of fluid
- Fluid structure interaction
- Elasticity of the container
- Thermal stress induced

1.9.2BASE ISOLATION

One of the most popular ways of protecting a structure against seismic force is seismic base isolation, often known as base isolation or base isolation system. It is a series of structural elements intended to dissociate a superstructure from its base, which is lying on the ground, and therefore guarantee the integrity of a building or non-building structure.

Figure 12: LA city hall retrofitted with base isolation

One of the most effective earthquake resistant tools in terms of passive structural vibration control methods is base isolation. Various approaches, such as rubber bearings, friction bearings, ball bearings, spring systems, and other ways, can be used to provide isolation. Its purpose is to ensure that a building or non-building material can withstand a potentially devastating earthquake by proper initial design or subsequent changes. The use of base isolation can enhance both the seismic performance and the seismic sustainability of a structure in specific instances.

The base isolation system consists of isolation units with or without isolation factors, where:

Isolation units are the fundamental components of a basic isolation system, and their function is to deliver the decoupling effect mentioned above to a structure or non-building construction.

Figure 13: Base isolators under the Utah state capitol

Shear or sliding units can be used as isolation units. Both new structural design and seismic retrofit can benefit from this approach. Some of the most prominent US landmarks, such as Pasadena City Hall, San Francisco City Hall, Salt Lake City and County Building, or LA City Hall, were mounted on isolation system devices as part of the seismic retrofit process. It necessitated the construction of stiffness diaphragms and moats encircling the structures, as well as measures for overturning and the P-Delta Effects.

Smaller scale base isolation is also used, sometimes down to a single room in a structure. To protect critical equipment from earthquakes, isolated raised-floor systems are deployed. The technique has been used to safeguard sculptures and other works of art, such as Rodin's Gates of Hell in Tokyo's Ueno Park's National Museum of Western Art.

1.10. Organisation of Thesis

This analysis shows the behaviour of an elevated water tank during an earthquake or seismic activity considering the sloshing dynamics and base isolation.

Chapter 2 discusses about various research papers related to our analysis. It is focusing on reviewing the related studies and shows that how our work is different for other works.

Chapter 3 provides a description about our analytical model and its complete dimensions. It shows impact on our model under different force profiles and it also shows the sloshing effects and base isolation on elevated water tanks.

Chapter 4 provides the conclusions for this analysis in which we analysed the sloshing effect and base isolation for an elevated water tank considering the 3 phases that were the the empty tank phase, half-full tank phase, full tank phase.

CHAPTER 2

LITERATURE REVIEW

2.1 REVIEWS

Prashant Abansode: In his review work, Prashant Abansode titled seismic study of raised water tank with various staging configurations. He investigated the behaviour of several staging systems under various tank conditions, utilising staad-pro v8i 2007 to conduct Response Spectrum Analysis on three different types of bracing systems of elevated water tanks for various types of zones. He compared the base shear and nodal displacement of an elevated water tank while it was empty and full. In his research, he discovered the following: Because the bracing system adds additional mass to the structure, the base shear value increases as the level of bracing increases. As the level of bracing is increased, the base moment is found to increase. Lateral repositioning

Cherukupally Rajesh and SudipJha: The behaviour of elevated water tank for variable staging height was the subject of a review study written by Cherukupally Rajesh and SudipJha. They concentrated their research on the behaviour of raised tanks under various loads and the creation of structures that are safer. They looked at how elevated tanks responded to variations in wind load, taking into account reactions such base shear and base displacement. Finally, the study reveals the significance of an appropriate supporting arrangement for the elevated water tank to sustain high damage during wind stress conditions. Excitation of responses such as base shear force, overturning moment, and roof displacement is caused by wind load characteristics with differing two fundamental wind speeds.

S.S.Quandri: "Seismic Analysis of RC Elevated Water Tank Using Different Staging Pattern," by S.S.Quandri, is a review paper. He took into account various factors such as water storage capacity, water tower height, variation in the number of segments h/d ratio, staging arrangements such as normal staging, hexagonal staging, cross staging, and radial staging with central column, and staging arrangements such as normal staging, hexagonal staging, cross staging, and radial staging with central column. He constructed 36 models for empty tank, half tank, and full tank conditions after taking into account all of these parameters. They worked on FEM-based staad-pro software. Each water tower's response to the others will be examined for base shear, axial force, bending moment, and lateral displacement. Graphs are used to describe the behaviour of water. Because of the structure,

Hardik V. Patel:.In his article, Analysis of elevated square water tanks with various staging systems, Hardik V. Patel. He used SAP 2000 to do seismic analysis of RCC Square raised tanks in his research. The result of the basic reaction, joint displacement, is compared with different staging systems using response spectrum analysis. He investigated the frame kind of construction in his study. Columns and braces are the basic components of frame staging. On the periphery of the frame, staging columns are positioned, and they are joined inside by bracing at various levels. The demand for water distribution in high water tank heads is met by altering the height of the staging piece.

Pranjali N Dhage: In her review paper, study on dynamic analysis of RCC elevated water tanks, Pranjali N Dhage. In her work, she looked at two scenarios where the tank capacity was the same but the geometric feature of the container changed in response to an increased water tank. In her conclusion, she discovered that the scale value of the static reaction was higher than that of the dynamic response. It happens when distinct time periods and hydrodynamic elements are overlooked during the analysis, resulting in the structure collapsing.

George W Housner: In his study, George W Housner (1963) identified three basic conditions for water tank analysis. He first considered a fully filled water tank with no free board, disregarding the sloshing impact; next he considered an empty water tank, disregarding the sloshing effect because water is not present. The water tank behaves as a single mass structure when it is full and empty, but when it is partially filled, the effect of sloshing must be considered. He concluded from the three situations that a fully filled tank is viewed at maximum force compared to a half-filled tank. He came to the conclusion that the greatest force applied to a half-full tank might be much less than half that applied to a full tank.

1.2. SUMMARY AND GAPS IN EXISTING LITERATURE

According to Prashant A Bansode's review, base shear increases as the level of bracing increases because the bracing system adds mass to the structure, causing the base shear value to grow. As the level of bracing rises, the base moment increases as well. The research by Cherukupally Rajesh and Sudip Jha reveals the need of having an appropriate supporting arrangement to avoid substantial damage to an elevated water tank during a windstorm. According to S.S Quandri's research, the stiffness of the structure increases as it is fixed at the base and free at the top, and the amplitude of lateral displacement base shear changes. Hardik V. Patel researched the frame structure type. Columns and braces are the primary components of frame staging. In her conclusion, Pranjali N Dhage found that the static reaction has a higher scale value than the dynamic response. This is due to differing time period selections and hydrodynamic elements being overlooked throughout the analysis, which will result in the structure collapsing. Three basic requirements for water tank analysis were explored by George W Housner in his research. He came to the conclusion that the greatest force a half-full tank can withstand is likely to be less than half that of a full tank.

In the above mentioned literature there was no proper consideration of sloshing effect so a proper analytical study is done so as to put some light in this direction. In these studies there was no proper mention of base isolation for seismic effect so a detailed analysis is being done so as to put some light on this issue.

1.3. OBJECTIVES

1. Analysis of elevated water tank considering sloshing effect.
2. Analysis of elevated water tank considering base isolation.
3. Analysis of elevated water tank in empty condition.

CHAPTER 3

ANALYTICAL STUDY ON MODEL

3.1. GENERAL

The total effective weight of the tank and the stiffness of the staging determine the horizontal and vertical components of the seismic forces. As a result, in seismically active places, overhead tanks should be assessed and designed for seismic forces both while full and when empty. When the tank is empty, the effective weight of the tank system employed in the study is made up of the tank's dead weight and one-third of the weight of staging. When the tank is full, the weight of the contents is added to the weight under tank empty conditions. The design horizontal seismic coefficient is calculated as follows, according to IS: 1893:

$\alpha h = \beta \ I \ F0 \ Sa/g$

I = 1.5, F0 = 0.4 (for seismic zone V) (for water towers)

β = 1 (for raft foundation)

Average acceleration coefficient (Sa/g)

The period of free vibration determines the average acceleration coefficient (T). Concrete structure dampening The damping factor is considered to be 5% for reinforced concrete.

$T = Ct\sqrt{\frac{w \times hx^2}{EsAg}}$

Ct = coefficient depending upon the slenderness ratio , the slenderness Ratio, given in table 6 of IS: 1893

h = height of structure above base

A = area of cross section of column

Es = modulus of elasticity of concrete

g = acceleration due to gravity

W = Weight of the structure above base.

3.2. Analysis model

This is the analytical model that we have made using staad- pro software and its dimensions are mentioned in table No.1. In this we are going to study and observe the sloshing effect and base isolation for this respective model.

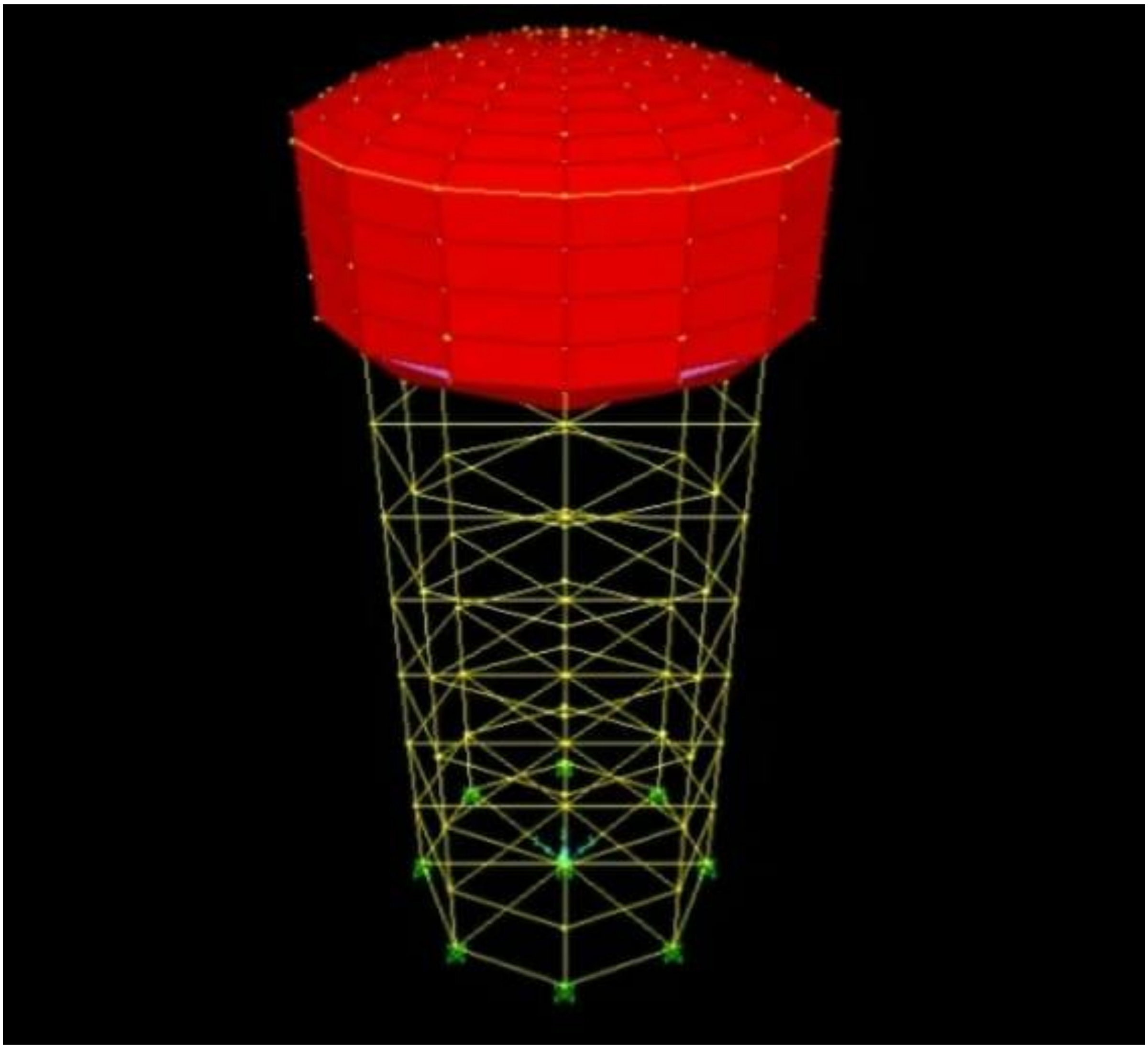


Figure 14: Analysis Model

Table 1. Measurements of the structure	
Diameter of tank	11m
Depth of tank	4m
Capacity of tank	565486 L
Tanks Shell thickness	240mm
Elevation of base slab from the ground	20m
Column numbers	9(8-peripheral and 1- central)
Pattern of bracing	Radical bracing
Bracing level	6 levels at every 3m interval
Column diameter	400mm
Measure of the columns	230mm X 300mm
Base slab thickness	300mm

3.3. FORCE PROFILE

- Bending moment

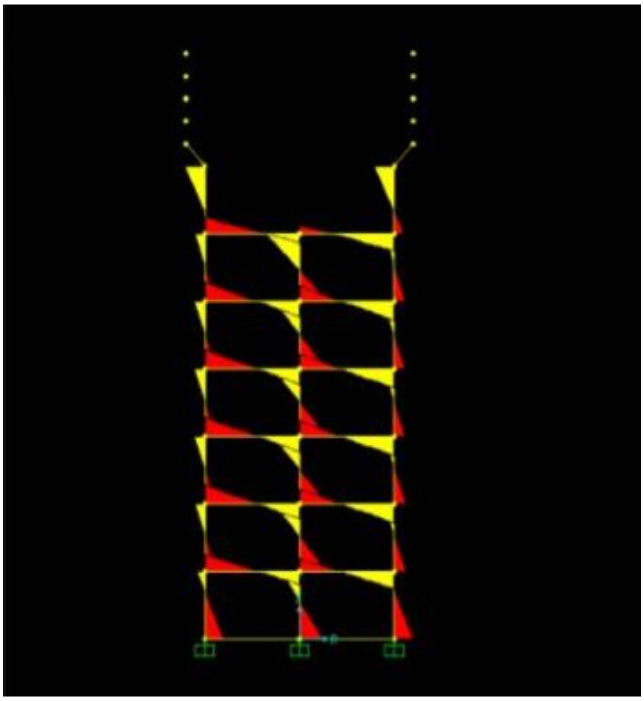


Figure 15: El-Centro at step 18 or 1.8s

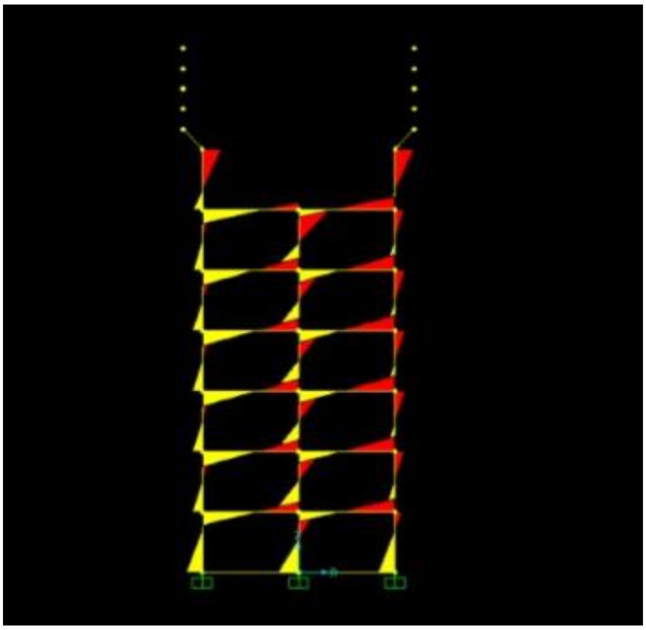


Figure 16: El-Centro at step 28 or 2.8s

- Shell Stress

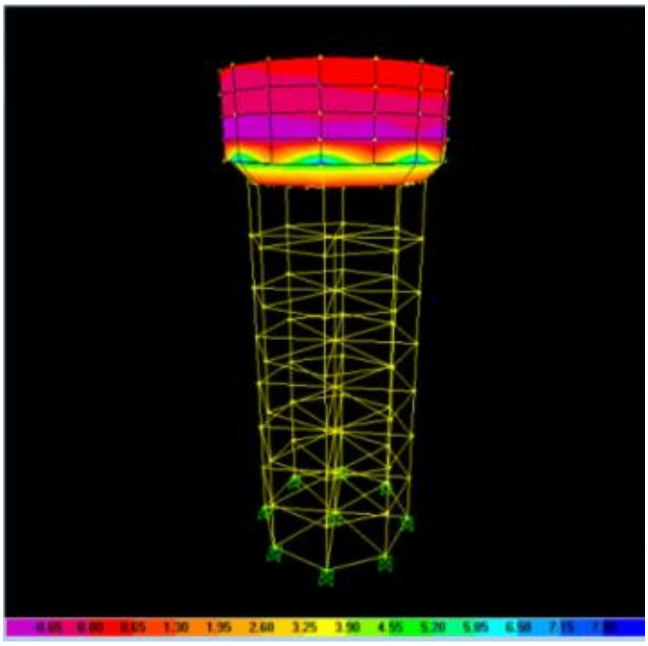


Figure 17: Resultant forces for water load

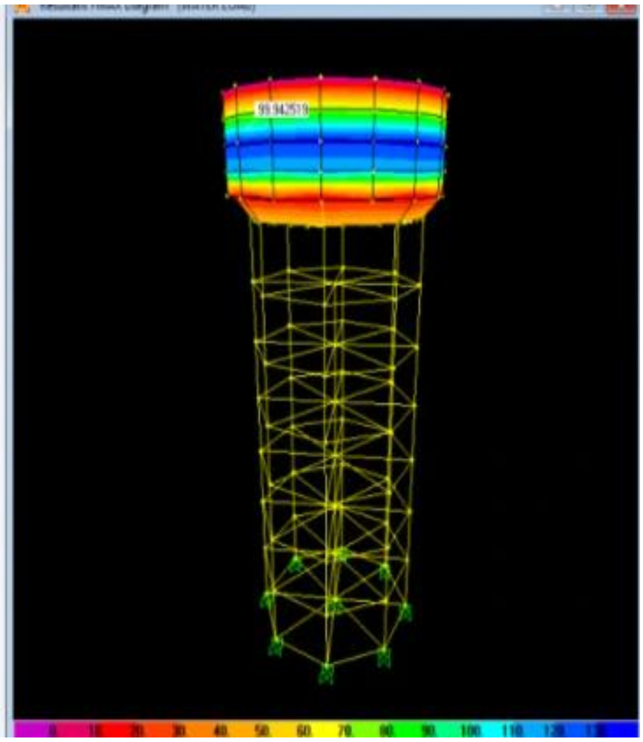


Figure 18: Resultant moment for water load

3.4. DESIGN COMPONENTS OF INTZE TYPE TANK

3.4.1. Tank portion

1. Top Roof Dome- The roof at the top is normally 100mm to 150mm thick, with reinforcement at the meridian and latitudes. Typically, the increase is 1/5th of the span.

2. Ring Beam-The ring wire is required to resist the dome's horizontal thrust component. The ring beam will be made to withstand hoop tension.

3. Circular Wall-This must be built to withstand hoop tension created by horizontal water pressure as well as bending moments induced by liquid load on the wall.

4. The bottom slab will be constructed to support the overall load above it. In addition, the slab will be constructed to support the whole load above it. The slab will also be constructed to span in width.

. 5. Bottom Beams-A continuous bottom beam will be built to transfer all of the load above it to the columns.

3.4.2. Staging Portion

1. Braces and Columns

Columns-These must be built to withstand the overall load that will be applied to them. The columns will be reinforced at regular intervals and must be built to withstand wind and seismic loads.

Braces-The braces are the components that join the columns at their mid-height. It is used in slender columns to increase the weight carrying capability of the column.

2. Foundation

A combination footing or raft footing with or without tie beam or raft is required by IS11682-1985. All supporting columns should have a solid foundation.

3.5. DOMES

A dome is a narrow shell formed by the rotation of a regular curve around one of its axes. The type of curve and the direction of the revolution axis determine the shape of the dome. Domes can be found on the roofs of circular regions, circular tanks, hangers, exhibition halls, auditoriums, and the bottoms of tanks, bins, and bunkers, among other buildings. Dome structures can be made of masonry, steel, wood, or reinforced concrete. However, reinforced domes are more widely utilised nowadays since they can span huge distances.

Membrane theory for the analysis of revolution shells can be established by ignoring the effects of bending, twisting, and shear and assuming that loads are conveyed entirely by axial stresses. The domes are designed by calculating the merdional thrust and circumferential forces. However, on both sides of the dome, a minimum of 0.3 percent steel should be given.

Membrane Theory of shell revolution

The illustration depicts a typical shell of revolution, on which the equilibrium of an element, as determined by the intersection of meridian and latitude, is shown. Forces around the circumference are called meridional stresses, while forces at right angles to the meridian plane and along the latitude are called hoop stresses, and are represented by. ignoring differences in magnitudes of, because extremely small,

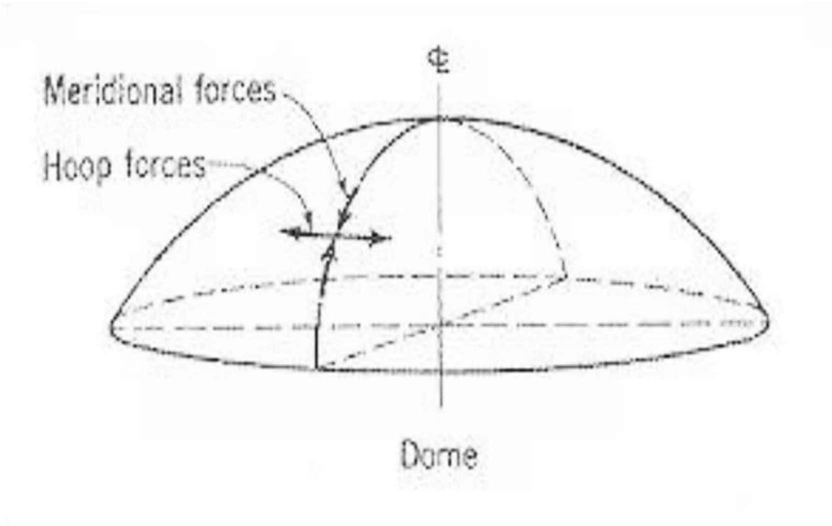


Figure19: A Typical shell revolution

All around the circle, force N acts tangentially to the surface, while force N acts radially. The magnitude of hoop stress is calculated as follows:

Nθ = WR ($\frac{1}{1+COSØ}$– cosØ)

Nθ = $\frac{WR}{1+COSØ}$

Where,

W = Total load on the dome in KN/m2

R = Radius of curvature

And, Ø = cos $\frac{R-1}{R}$

3.6. CYLINDRICAL WALL

Circular wall tanks are generally more economical than those having other shape. The tanks are subjected to uniformly varying load due to hydrostatic forces increasing from zero at the free water surface to the water surface to the maximum at the bottom. In the circular tank, the lateral pressure causes hoop tension in the wall. The magnitude of the hoop tension depends on nature of joint between wall and bottom slab Two types are generally considered in the design:

I. Flexible joint between base and wall in flexible joint, the deflection at the bottom of the wall is unrestricted. For the height H of the liquid in the tank. The maximum lateral pressure at the base is γw H.

This will cause hoop tension of $\gamma w \, H \times D/2$.

II. In rigid joint, the wall is rigidly fixed with the base hence; deflection at the bottom of the joint is not possible. The upper part of the wall will predominantly have a hoop tension, while the lower part will bend like a cantilever fixed at the base. Thus, a part of the load will be carried by the hoop tension and a part by cantilever action. Following methods have been suggested for the design of this type of tank,

i. Reissner’s method

ii. IS: 3370 (Part IV) method

iii. Carpenter’s method

iv. Approximate method

The method provided in this project is IS: 3370 (part IV). This approach calculates hoop tension and bending moment at various heights, as well as shear at the base. This approach uses coefficients at various heights of the wall to calculate hoop tension, bending moment, and shear at various heights.

CHAPTER 4

CONCLUSIONS FROM ANALYTICAL STUDY

4.1. GENERAL

In this analysis we analysed the sloshing effect and base isolation for an elevated water tank considering the 3 phases that were the the empty tank phase, half-full tank phase, full tank phase. Therefore the following results and conclusions were drawn from this analysis study on Foreshock effect on elevated water tanks. In today's world, water storage in the form of tanks for drinking and washing, swimming pools for exercise and recreation, and sewage sedimentation tanks are becoming increasingly important. We use rectangular water tanks for small capacities and circular water tanks for larger capacities. The Intze tank is a circular tank with some modifications. Because the lower dome in this design resists horizontal force, the Intze tank is built to save money on the project. The design of an Intze water tank is a time-consuming process. The entire structure was hand-built with M30 concrete. This project covers a large amount of knowledge in a short amount of time. This project was mainly based on studying and analysing the sloshing effect and base isolation for the elevated water tanks. The sloshing effect has never been taken into consideration, so this project mainly highlights the sloshing effect. The base isolation is also kept aside while the designing and construction of elevated water tanks so our project describes base isolation in brief so that the future elevated tanks could resist the seismic effect.

4.2. RESPONSE QUANTITIES UNDER SLOSHING

The procedure in finding the response quantities is from IS 1893:2002

Table 2: Under sloshing conditions, dynamic response quantities				
Response quantity		Tank empty	Half tank	Tank full
Time period (seconds)	Impulsive	5.64	8.37	9.07
	Convective	N.A	3.43	2.88
Base shear (kN)		339.5	919.77	685.97
Overturning moment (kN.m)		5394.37	2133.45	14917.77

In the half-full condition, the base reactions are substantially higher than in the tank-full condition.

The fraction of convective mass approaches unity as the height of the liquid column drops.

4.3. IMPACT OF BASE ISOLATION

• Bearings are used to isolate the base from the ground.

• The amplitude and dispersion of lateral forces are reduced.

• High energy dissipation and horizontal flexibility

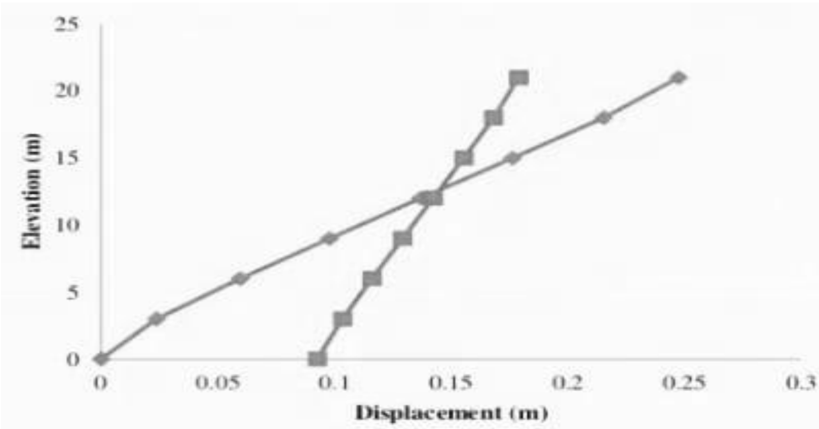
• The former of the two types of isolation bearings – spring-like and sliding-like – is employed for analysis.

• The fundamental time period has been increased from 7.65 seconds to 8.19 seconds.

Table 3. Impact of base isolation		
Support	Global Fx	Global My
	kN	kN-m
Fixed base	618.891	13302.885
Isolated base	217.322	4692.93

65 percent reduction in base shear and overturning moment

4.4 Displacement of different levels



Absolute displacement against elevation of various levels is represented on a line chart.

Reduced storey drift but increased absolute displacement; nonetheless, this must not result in pounding with neighbouring structures. Apart from that, the number of base reactions has decreased. Isolation of the base. Sloshing reduced joint displacement and base reaction by 64.8 and 64.7 percent, respectively. Half-full reactions are substantially greater than full reactions.

4.5 Scope for future study

This project provides a detailed analysis and review about sloshing dynamics and base isolation of elevated water tanks. Study on constructional feasibilities of elevated water tanks can always be done in future. Study on stresses due to the friction and temperature variations can be studied in future. Effect of PH value of water also needs to be studied along with the alkalinity of water.

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