FINITE ELEMENT ANALYSIS OF UNDERGROUND STORAGE TANK
A PROJECT REPORT

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

degreeof

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision

of

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HIMACHAL PRADESH, INDIA

MAY-2022

STUDENT'S DECLARATION

I hereby declare that the work presented in the project report entitled **"Finite element analysis of underground storage 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 **Mr.Kaushal Kumar**. this work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

Signature of Student

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Roll no-181645, 181634

Department of Civil Engineering

Jaypee University of Information Technology, Waknaghat, India

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"Finite element analysis of underground storage 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 **Amish Kartik(181645), Priyanshu Sharma(181634)** during a period from January 2022 to May 2022 under the supervision of **Mr. Kaushal Kumar** Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat. The above statement is correct to the best of our knowledge.

Signature of Supervisor

Mr. Kaushal Kumar
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Signature of HOD

Prof. (Dr.) Ashish Kumar
Professor & Head of Department
Department of Civil Engineering
JUIT Waknaghat

ACKNOWLEDGMENT

I would like to thank so many people who have helped in every possible way in successful completion of this project. Firstly, I would like to express my gratitude to my project guide **Mr. Kaushal Kumar**, who have provided me an opportunity to do this project under his guidance. He has provided valuable ideas and support during the course of this work. This work would not have been possible without his support. I would like to thank our project coordinator and all other faculty members and technical staff of Department of Civil engineering of Jaypee University of Information Technology for providing valuable input throughout the course of this work. I would like to thank all who helped me during my project at **Jaypee University of Information Technology, Waknaghat** for their support and help in the work and analysis and finally my Institute Jaypee University of Information Technology.

“

CONTENT

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ABSTRACT

Underground garage tanks (USTs) normally have a diameter of 1.2 to 3. 7 meters and a period of 1.eight to 22 meters. External loadings and the load of its fluid capability ought to be accommodated with the aid of using the traits and thickness of the UST. On-web website online dimension will become a massive trouble in the end plumbing has been built, and overall performance tracking facts is rare. On the opposite hand, finite detail analysis (FEA) affords a brief and correct manner to forecast the outcomes of complex loadings on strong structural deformation strain and stress conduct. The three-D laptop assisted design (CAD) of a full-scale, half-symmetry UST version is investigated on this take a look at the usage of FEA tools, specifically ANSYS and ABAQUS. A chopped-strand-mat composite UST is uncovered to a chain of related static structural loadings as soon as the subsurface surroundings is translated into boundary inputs. The maximum detrimental occasions are decided the usage of simulated deformation and von-Mises strain. With and with out the limiting rope, collection of analyses had been conducted. The findings shed mild at the conduct of a UST gadget whilst subjected to a predetermined set of loading conditions. From the perspective of those FEA tools, the simulation and analytical facts had been frequently in agreement. Keywords: Underground garage tank; finite detail analysis; chopped strand mat

CHAPTER 1

1.0 INTRODUCTION

Traditional metallic UST tank failure has lengthy been due to corrosion and leaking. For years, a malfunctioning UST might be leaking its chemical contents into the encircling soil with out inflicting any seen seepage till close by water wells or streams end up poisoned. Since 2010, there was an boom withinside the quantity of incidents of surprising and brief corrosion of UST components, in particular sump pumps, risers, submersible turbine pumps, and air flow pipes, in at the least 9 US states [1]. Sowards and Mansfield located that metallic corrodes an order of significance quicker than copper in underground fuel garage tank structures uncovered to ethanol and acetic acid. The findings confirmed that when localized corrosion attack commences, harm can arise at appreciably better quotes than a standard corrosion-price version may want to anticipate [2]. The use of fiber strengthened polymer composites (FRPC) withinside the manufacturing of UST is a end result of technological advancements. Despite the truth that FRPC facilitates save you corrosion, tank screw ups can nevertheless arise because of wrong installation, insufficient piping connections, a loss of tracking and inspection, operational extremes, mechanical harm over time, and a lot of soil conditions [3, 4]. The truth that it's far almost hard to acquire facts from a buried UST with out digging it out (uninstalling it) and reburying it withinside the ground (reinstalling it) is a massive hassle in analyzing its behaviour and performance. Repeating the un-set up and reinstalation cycles might weaken the soil and jeopardise the UST and piping's basis support. The influences of quite a number situations regarding soil species, gasoline concentration, and buoyancy on UST stress have been tested the use of finite detail evaluation on this work.

1.1 tank classification:

In this phase, the various types of water tanks are described in detail. Water tanks come in a variety of shapes and sizes, depending on their function, floor level, and other factors. Water tanks are categorised into three kinds based on their positioning and location. Those are,

a) Underground tanks

b) Tanks resting on ground

c) Overhead water tanks

The shape of the subterranean and on-ground tanks is usually circular or rectangular, but the shape of the overhead tanks is determined by the aesthetics of the surroundings and the design.

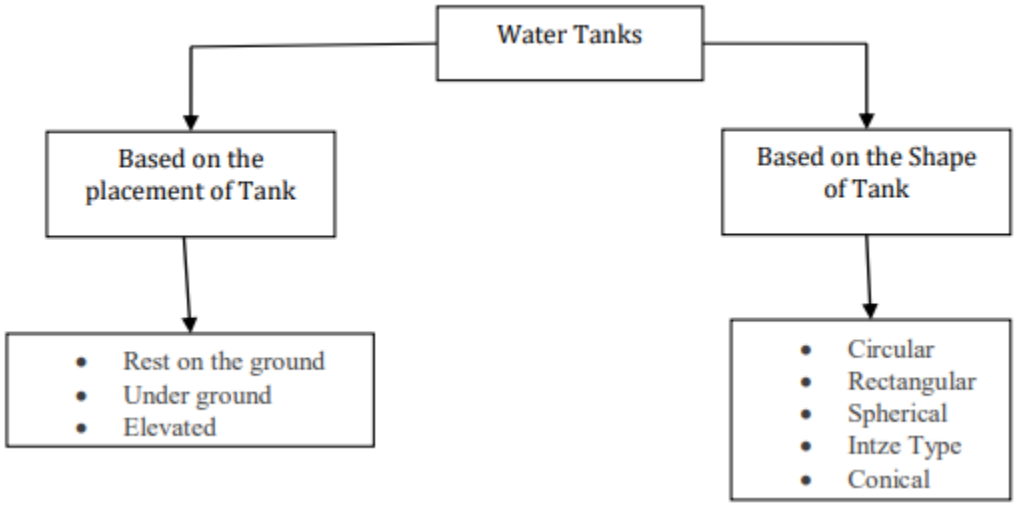


Figure 1: Classification of water tank

1.1.1 Underground storage tank

A storage tank that is buried underground is known as an underground storage tank (UST). There are three types of underground storage tanks:

-Steel/aluminum tank produced by manufacturers in most states and meeting Steel Tank Institute specifications.

-A metal tank (aluminum/steel) was overwrapped with filament windings such as glass fiber/aramid or carbon fibre or a plastic compound for corrosion protection and to create an interstitial space.

- Tanks having a metal liner constructed of composite material, fibreglass/aramid, or carbon fibre (aluminium or steel).

Underground water storage tanks are used to store potable drinking water, wastewater, and collected rainwater. So whether you name it a water tank or a water cistern, these are the storage tanks for you if you're storing water underground. Concrete cisterns can be replaced by plastic underground water

Figure2 : underground storage tank

tanks (cisterns).

1.1.2 Tanks resting on ground

In this area, we will only look at tanks that are physically supported on the ground, such as clear water reservoirs, settling tanks, and aeration tanks. Pressure is applied to the walls of these tanks, and the weight of water is applied to the base. The shape of these tanks is rectangular or round.

1.1.3. Overhead water tanks

Overhead water tanks come in a variety of shapes and sizes, and can be used as service reservoirs, balancing tanks in water delivery schemes, and for replenishing tanks for various reasons. Reinforced concrete water towers have particular advantages in that they are not impacted by climate

variations, are leak-proof, have more rigidity, and can be customised to fit any shape.

Water tanks are classed into types based on their shape. These are they:

a) Circular tanks

b) Conical or funnel shaped tanks

c) Rectangular tanks

d) Intze type

e) Spherical type

a) Circular tanks

Circular tanks are ideal for storing big amounts of material. Because the side walls are fastened to the floor slab at the junction, they are intended for circumferential hoop tension and bending moment. Because it is more cost effective, the bottom slab is normally flat.

Figure 3: Circular type tank

b) Conical or funnel shaped tanks

This tank is the best in terms of architectural features and aesthetics. It also has the advantage of being appropriate for high staging because of its hollow shaft. It may be built cheaply and quickly using slip from the casting process. Pre-cast concrete parts can also be used to construct them.

Figure 4: Conical Type water tank

c) Rectangular tanks

The Rectangular tank's walls are subjected to bending moments in both the horizontal and vertical directions. Because water pressure causes a triangular load on the walls, analysing the moment in the wall is challenging. The magnitude of the moment will be determined by various parameters, including the tank's length, breadth, and height, as well as the state of the wall's support at the top and bottom edges. If the wall's length is greater than its height, the moment will be primarily vertical, causing the panel to bend

Figure 5 : Rectangular type

like a cantilever. If the height is more than the length, however, the moments will be horizontal, and the panel will bend like a thin slab supported on the edges. As a result, both bending moment and direct tension will be applied to the tank's wall.

d) Intze type tank

The INTZ water tank is a circular water tank with a spherical top and a conical slab with a spherical dome at the bottom. The inward forces from the conical slab counteract the outward forces from the bottom dome in this form of water tank, resulting in reduced stress on the water tank's concrete bottom slab. Because of the reduced stresses, the thickness of the concrete bottom slab decreases, lowering the amount of concrete required and lowering the cost of the water tank.

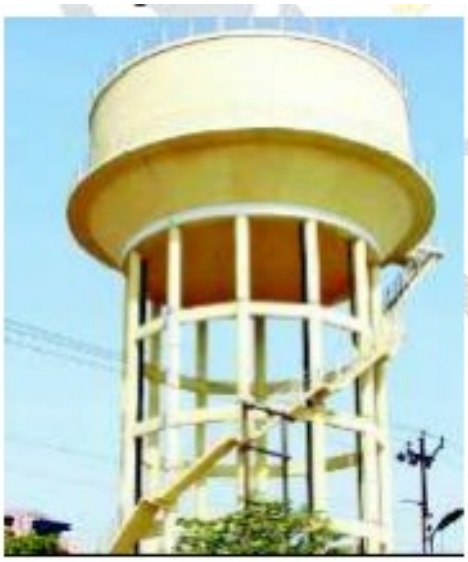


Figure (6): Intze type Water tank

e) Spherical type

High-pressure fluids are best stored in this sort of storage tank. A spherical is an extremely durable structure. There are no weak places on the sphere's surfaces due to the uniform distribution of loads both internally and externally. Spheres, on the other hand, are far more expensive to make than cylindrical or rectangular tanks. Spherical storage tanks have a smaller surface area per unit volume than any other type of tank, which is a benefit. As a result, the amount of heat transferred from warmer surroundings to the liquid in the sphere will be lower than in cylindrical or rectangular storage vessels.

Figure (7): Spherical type water tank

1.2 OBJECTIVE

1.Development of finite element model of underground water tank using ABAQUS software.

2.To study the behavior of underground water tank for varying fuel content and varying buoyancy force.

CHAPTER 2

LITERATURE REVIEW

1. V. Drazan kozak[1]

and so forth offered labored on Overloading Effect at the Carrying Capacity of Cylindrical Tank with Torispherical Heads for the Underground Storage of Petrol, Horizontal cylindrical double pores and skin metal tank with torispherical heads for the underground garage of petrol has been manufactured, Before exploitation it must be examined with stress of two bars in accordance EN 12285-1 norm. During the pressurization out of control stress growing happens. Effects in this overloading were analyzed with the aid of using the usage of of finite detail method.

2. Anshuman Nimade et al. 2018

"An Informative Review on Underground Storage Reservoir System" The finite detail technique has been used withinside the parametric assessment of outcomes of underground water tank is the most important a part of their study. In introduction, they have got furnished facts approximately underground water tank used for diverse functions tot shop water for waste water rainwater series and roof catchments are the first-rate exercise to shop water in underground tanks via way of means of channeling.

3. Chirag Patel et al. 2012

Tapering of increased water tank is referred to of their paintings via way of means of concluding the diameter aspect partitions and via way of means of the use of staging. They have taken into consideration their studies as in step with Gujarat catastrophe control authority. Mass dashpot version is the ideal

manner describe the water tank, consequently they used this mass dashpot version of their paintings. For staging's, they used diverse tiers with spacing's among them to aid the water tank. Results and end component have merged to explain the spot paintings

4. Chirag Patel et al. 2012

Using software program tool, the principal a part of their paintings became correctly finished include evaluation paintings, designing paintings with evaluation of underground square water tank. In advent part, they've proven the significance of water tank and their three kinds of classifications with the use of every of them. Tank with staging are used and analyzed with the assist of Staad Pro software program. Two layout instances have utilized in underground water tank. They concluded concrete tanks that may be changed with the aid of using plastic tanks. Dead hundreds ought to be extra than uplift hundreds for the duration of upkeep paintings concluded with the aid of using their uplift check. Allowable strain ought to be extra than strain on soil simply after creation paintings concluded with the aid of using looking at strain on soil.

5. Suraj P. Shinde 2018

The paintings is only primarily based totally on layout manually and in comparison with software program Staad and SAP 2000. He mentioned the targets primarily based totally on Indian trendy suggestions with evaluation and its layout. Axial forces and deflection has analyzed with an technique to get and make secure RCC water tank. Dynamic kind of water tank loading has mentioned complete and empty conditions. After discussing the classifications, the writer summarized the stairs regarding choice of tank size, calculation of shear forces, bending moment, deflection and axial forces withinside the tank. Results concerned withinside the paintings concludes

that it has now no longer viable to get the deflection manually, it has simplest to be achieved through software program technique and each the software program values are almost same. The permissible fee of 7000 KN/ sq. m. has made in empty and complete water situation as in keeping with shell stresses.

6. W. O. Ajagbe et al.

The paintings on underground water tank that has designed and analyzed withinside the case of completely submerged via way of means of the usage of precept of beam resting on elastic basis has been mentioned on this paintings. MESDA Pro evaluation software has used and with the assist of unfold sheet, this precept has carried out and evaluation has performed thoroughly. Case examine of three Australian towns become investigated first then literature survey paintings has performed. Manual evaluation has additionally positioned a further attempt withinside the paintings ends in evaluation of second in distinctive water tanks with modulus of sub grade response, second in distinctive tanks with top of tank. Their recommendation, indicates it ought to be price powerful together with its length choice and the modulus of sub grade response ought to be decided in lab first earlier than its production procedure

7. Dowd, Richard M.

"Leaking underground garage tanks." Environmental Science & Technology 18, no. 10 (1984): 309A-309A. Since mid-1983, the EPA has been reading the troubles related to leaking underground garage tanks (LUST). An envisioned 10-30% of the 3. five million or extra underground tanks now used to save petroleum products, chemicals, risky wastes, and different drinks can be leaking their contents to the surrounding environment. For example, Provincetown, Mass., sued a chief oil organization and others for $25 million as a result of a gasoline leak that disrupted the town's consuming water supply.

8. Kass, M.D., Theiss, T.J., Janke, C.J. and Pawel, S.J., 2012.

Analysis of Underground Storage Tank System Materials to Increased Leak Potential Associated with E15 Fuel. *ORNL/TM-2012/182, July*.

The USEPA Office of Underground Storage Tanks commissioned a study at ORNL to evaluate whether or not an extended cap potential for leaking of USTs will stand up at the same time as moving from E10 to E15 gasoline. The authentic aim has become to bring together a probabilistic failure assessment tool to estimate the increase in releases, if any, if E15 modified E10 in regulated UST systems. A key part of this way has become to solicit evaluations from a panel of organization and regulatory experts to select out crucial variables that impact failure probability estimates. However, the shortage of data at the general overall performance of gift UST systems with E15 precluded the possibility that state/organization experts should speculate on E15's impact to UST systems. Therefore, the task aim has become redirected to address the delivered leak cap potential (or incompatibility) of UST device materials at the same time as moving from E10 to E15. Potential leak locations, collectively with pipe couplings were identified, and the elastomers and sealants applied in couplings and turning into a member of were additionally studied.

Sowards, Jeffrey W., and Elisabeth Mansfield.

"Corrosion of copper and metallic alloys in a simulated underground garage-tank sump surroundings containing acid-generating bacteria." Corrosion technological know-how 87 (2014): 460-471.[9] they simulate corrosion located in underground gas garage tank structures with the aid of using headspace and aqueous publicity to biotic natural acid. Carbon metallic and

copper have been uncovered to Acetobacter sp. inoculated into aqueous-ethanol answers over a length of about 30 days. The metallic alloy exhibited pitting corrosion and the copper alloy exhibited pitting and intergranular corrosion because of acetic acid produced with the aid of using the microbes. Corrosion charges have been depending on formation of corrosion merchandise and are ranked as follows so as of growing magnitude: Copper-aqueous < Steel-aqueous < Copper-headspace < Steel-headspace. The laboratory check technique advanced right here reproduces corrosion located in practice.

9. **Sheng, Ooi Ching, Wai Keng Ngui, Hui Kar Hoou, Lim Meng Hee, and Mohd Salman Leong.**

"A review of strategies for monitoring the condition of subterranean storage tanks." 02009 in MATEC Web of Conferences, vol. 255. 2019 EDP Sciences [10]

This article seeks to provide a complete overview of underground storage tank condition monitoring approaches (UST). Because of its huge capacity and low floor area demand, the UST has long been a popular dangerous substance reservation mechanism. The complicated cylindrical-shaped system and its surrounding environment have recently come under scrutiny due to contamination caused by unintentional subsurface leaking. Numerous efforts have been focused on the damage repair process and fault detection practice, according to studies on relevant countermeasures; nonetheless, there are doubts in current technical complexities affecting the effectiveness of corrective methods.

10. **Damen, Kay, André Faaij, and Wim Turkenburg.**

"Health, protection and environmental dangers of underground CO2 garage–review of mechanisms and cutting-edge expertise. Climatic Change 74, no. 1

(2006): 289-318. CO2 seize and garage (CCS) in geological reservoirs can be a part of a approach to lessen international anthropogenic CO2 emissions. Insight withinside the dangers related to underground CO2 garage is wanted to make sure that it may be carried out as secure and powerful greenhouse mitigation option. This paper goals to offer a top level view of the cutting-edge (gaps in) expertise of dangers related to underground CO2 garage and studies regions that want to be addressed to boom our information in the ones dangers. Risks resulting from a failure in floor installations are understood and may be minimised via way of means of danger abatement technology and protection measures. The dangers resulting from underground CO2 garage (CO2 and CH4 leakage, seismicity, floor motion and brine displacement) are much less nicely understood. Main R&D goal is to decide the tactics controlling leakage through/alongside wells, faults and fractures to evaluate leakage fees and to evaluate the outcomes on (marine) ecosystems. Although R&D sports presently being undertaken are running on those issues, it's far anticipated that similarly demonstration tasks and experimental paintings is wanted to offer information for extra thorough danger assessment.

11. **Chang, James I., and Cheng-Chung Lin.**

A observe of garage tank injuries." Journal of loss prevention withinside the manner industries 19, no. 1 (2006): 51-59.[11] This paper critiques 242 injuries of garage tanks that befell in business centers over ultimate forty years. Fishbone Diagram is carried out to research the reasons that result in injuries. Corrective moves also are supplied to assist working engineers managing comparable conditions withinside the future. The consequences display that 74% of injuries befell in petroleum refineries, oil terminals or garage. Fire and explosion account for 85% of the injuries. There have been eighty injuries (33%) resulting from lightning and 72 (30%) resulting from human mistakes together with bad operations and maintenance. Other reasons have been system failure, sabotage, crack and rupture, leak and line

rupture, static electricity, open flames etc. Most of these injuries could were averted if exact engineering were practiced.

12. **Bajic, Stanley J., Siquan Luo, Roger W. Jones, and John F. McClelland.**

"Analysis of underground garage tank waste simulants via way of means of Fourier remodel infrared photoacoustic spectroscopy. Applied spectroscopy 49, no. 7 (1995): 1000-1005. Underground garage tank waste sludge from nuclear gas procedures is hard to investigate due to the intense heterogeneity, chemical reactivity, and radioactivity of the waste. Conventional techniques of evaluation generally require large pattern managing approaches both to skinny the pattern or to split additives previous to evaluation. These approaches are time consuming, require radiation containment cells, and growth the chance of radiation publicity to lab employees due to the large managing. In this paper a way making use of Fourier remodel infrared photoacoustic spectroscopy to investigate unsafe underground garage tank waste with a minimum quantity of pattern and pattern managing is mentioned. The technique become advanced with the usage of waste tank simulants that have been acquired from the Westinghouse Hanford Company. Emphasis become located at the willpower of disodium nickel ferrocyanide, sodium nitrate, and sodium nitrite due to the priority for the capability of exothermic reactions taking place among oxidizers and ferrocyanide-containing compounds. This technique additionally lets in for the evaluation of different ions of hobby in waste procedures which includes sodium sulfate. A easy pattern practice technique is likewise mentioned which makes use of freeze drying to dispose of water from the simulants at the same time as retaining a uniform pattern for evaluation.

13. **Van der Meer, L. G. H.**

"Computer modelling of underground CO2 garage." Energy Conversion and Management 37, no. 6-8 (1996): 1155-1160. This paper provides the findings of a have a look at to envision the realistic abilities of industrial to be had

reservoir simulators to are expecting the consequences of CO2 injection underground and the garage ability of a extensive variety of underground environments. Three simulation principals formerly used for CO2 garage are carried out on a unmarried take a look at problem. The predictive outcomes of those simulations are compared. Possible enhancements to the simulation techniques are suggest.

14. **Sacile, Roberto.**

"Remote real-time monitoring and control of contamination in underground storage tank systems of petrol products." Journal of Cleaner Production 15, no. 13-14 (2007): 1295-1301.[12] A tool to show and to control contamination withinside the soil, further to withinside the aquifer is presented. Specifically, the tool is suitable to show continuously, remotely, and in real-time the soil surrounding underground storage tank (UST) systems, which incorporates in petrol issuer stations. The tool has moreover talents for remediation, due to the possibility to be configured as a soil venting tool. A prototype has been on foot for extra than three years in a petrol issuer station in Genova, Italy. Results show that, in every day work, not unusual place small-medium leakages also can moreover occur, which may be related to several events, the most not unusual place of this is the delivery of petrol products to the USTs. In the one's cases, the tool can diagnose the leakage and start remediation with the resource of the use of a particular soil venting process. Some problems on the cost/advantage evaluation of this era and on the software program to insert it as a crucial step to assure zero emissions to the soil in connection with petrol product storage and manufacturing are discussed.

CHAPTER 3

3.1 AUTOCAD

AutoCAD is a business programming application for 2D and 3D CAD after plan computer aided design and drafting open starting around 1982 as an action words on and beginning around 2010 as versatile web and cloud based application advance as AutoCAD 360 created made and showcased through autodesk AutoCAD was first delivered in December 1982 running on miniature PC with inside portrayals regulator before the presentation of autocad most business programs on brought together server species or little PC with every computer aided design shopper working at an other sensible terminal AutoCAD is utilized over white extent of and different by coordinators project both expert visual originator and unmistakable expert it is kept up with by 750 informative focus point by and large start in 1994 is auttocad lead thinking the Walk 1986 auto get his change into the most all inclusive card program overall starting around 2014 AutoCAD is in its 29th period and aggregate with all its assortment constant turning into the majority of the most piece of utilized computer aided design program all through the greater part of the world.

3.1.1 HISTORY

AutoCAD was gotten from a program of in 1997 and discharge in 1979 called webcad additionally imployed in early autodes document and little skilled CAD which was formed going before orthodest by then Marine chip program associates course of action by means of autodesk individual advocate Mike riddle the essential structured by the orthodox association was appeared at 1982 comics and discharge that December 2016 release exhibit the 30th note note were the least of the AutoCAD for windows

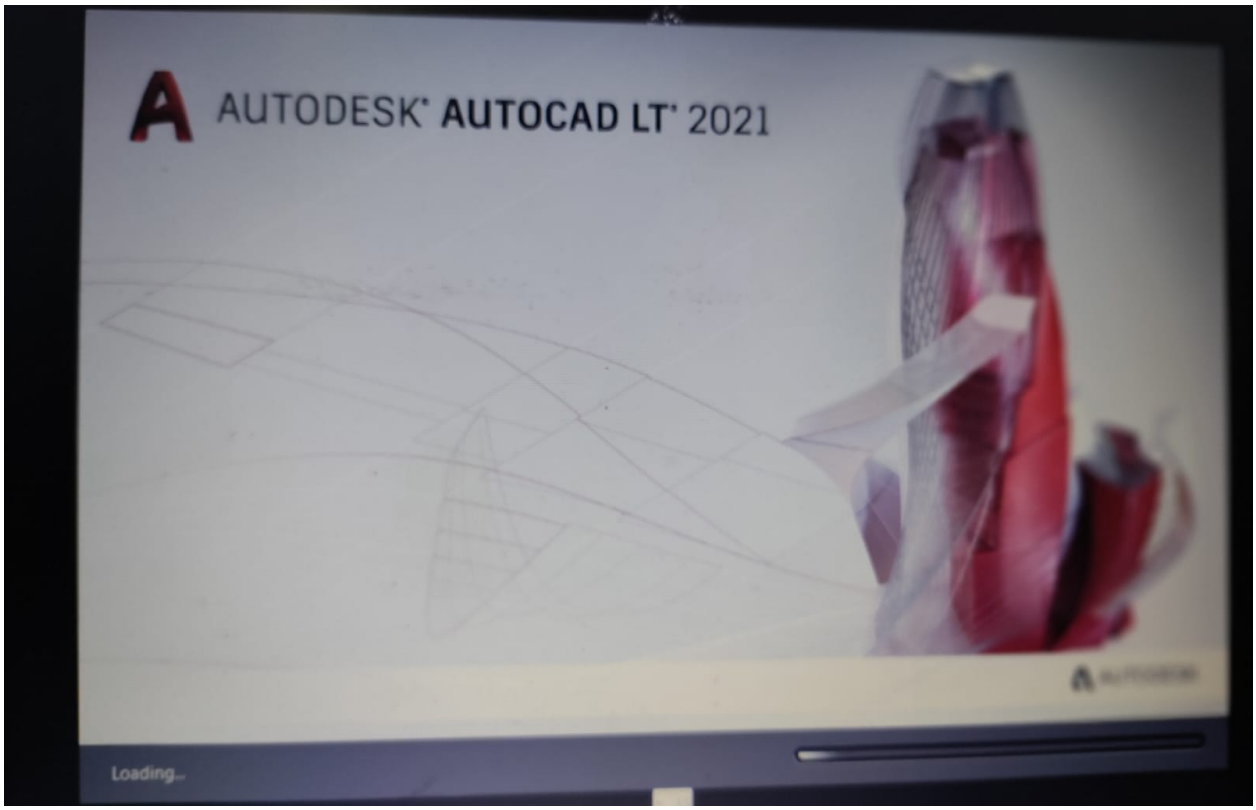
.The 2014 release features the fourth consecutive year for AutoCAD for Mac.

autocad is basically used for three things:

1.) 2d modelling

2.) 3d modelling

3.) drafting and annoation



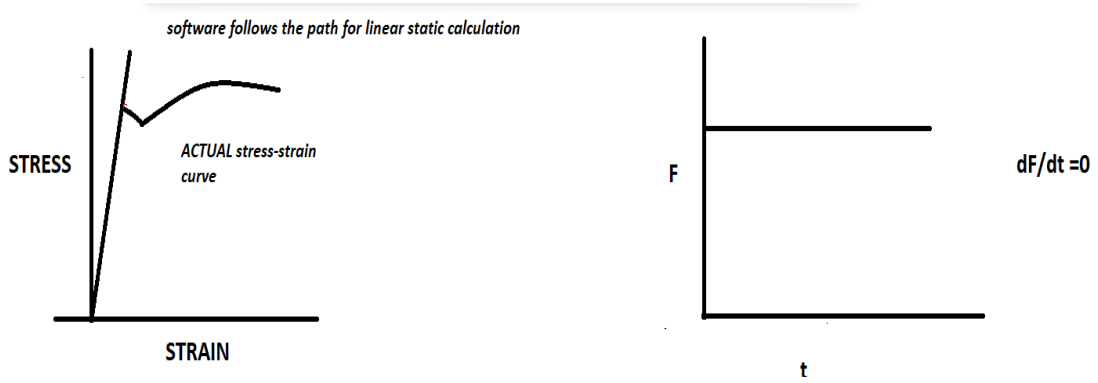
3.2 **ABAQUS**

Abaqus is one of the most widely used finite element analysis software in the world development by Dassault Systems. It is used almost all types of industries including automobile aerospace electromechanical heavy machinery sector and it is also known as the best non linear solver in the world.

TYPES OF PROBLEMS IN ABAQUS IN FINITE ELEMENT ANALYSIS

1. LINEAR STATIC ANALYSIS
2. NON-LINEAR STATAIC ANALYSIS
3. DYNAMIC ANALYSIS
4. BUCKLING ANALYSIS
5. THERMAL ANALYSIS
6. FATIGUE ANALYSIS
7. OPTIMIZATION
8. CFD ANALYSIS
9. CRASH ANALYSIS
10. NVH ANALYSYS

3.2.1 LINEAR STATIC ANALYSIS



The force is static i.e there is no variation with respect to time (dead weight)(LINEAR STATIC ANALYSIS GRAPH]

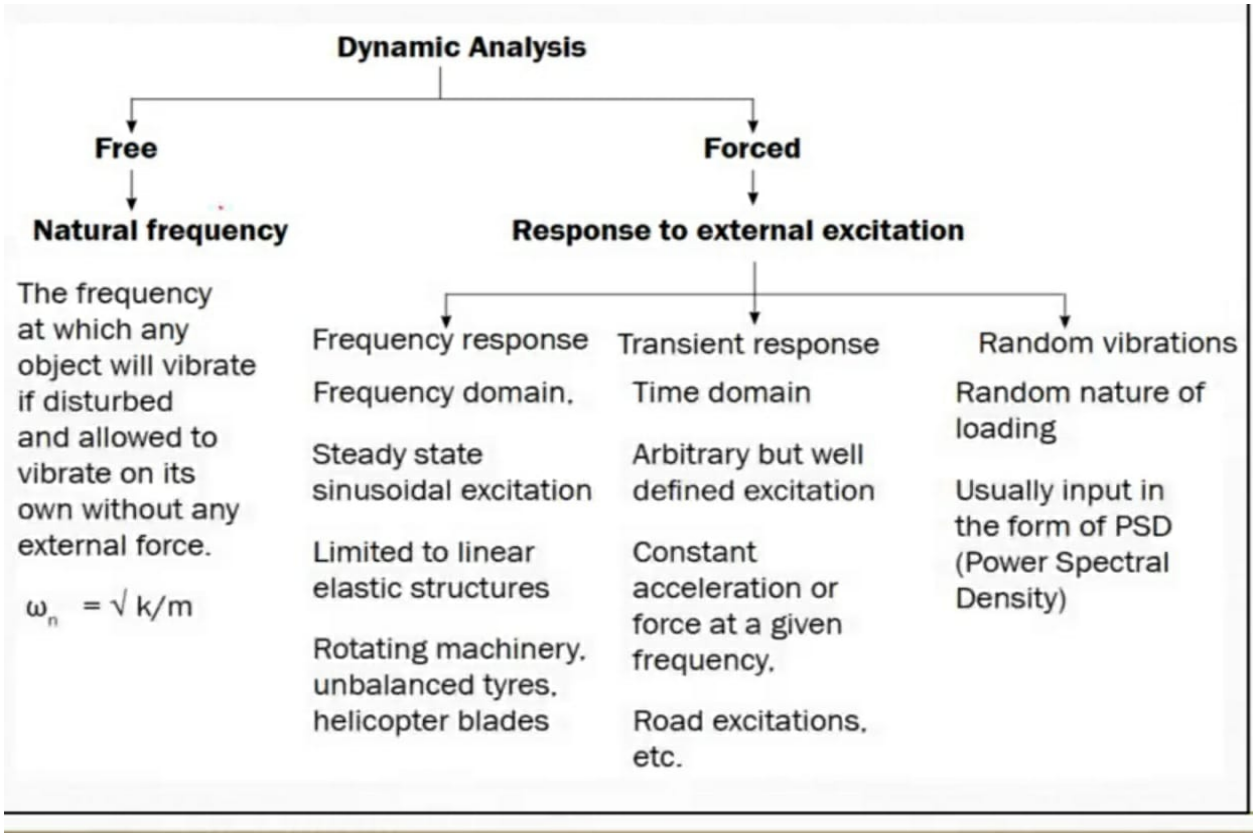
3.2.2 DYNAMIC ANALYSIS

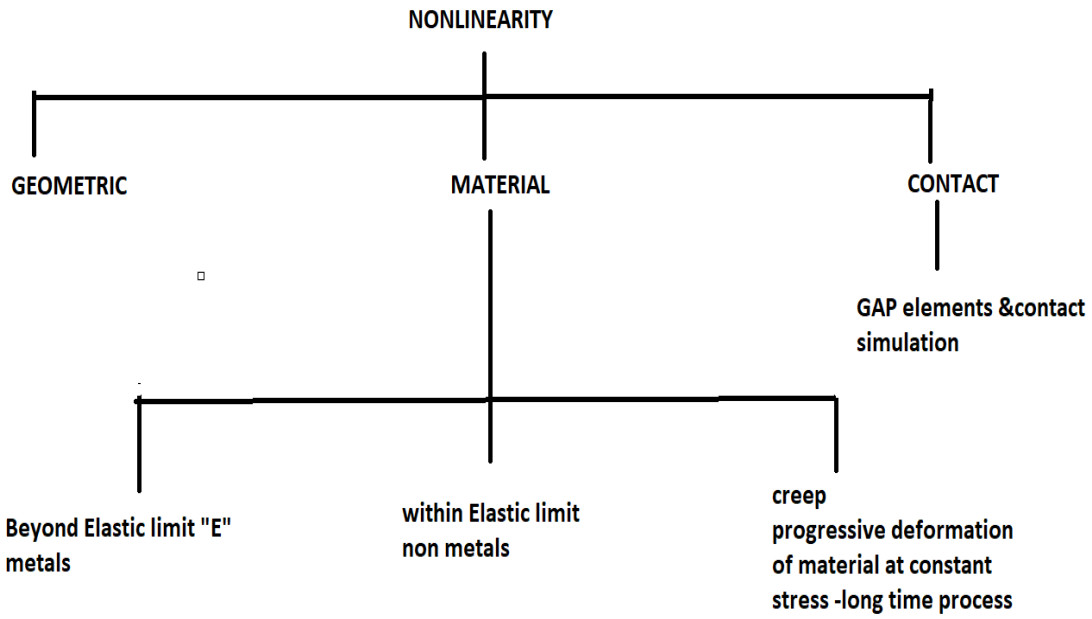
1.Forces varies with parameters such as position and velocity ,time.

2.vibrations in mechanical systems.

3.Impact analysis.

4. Drop test.

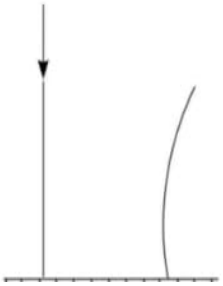



NONLINEARITY
GEOMETRIC
MATERIAL
CONTACT
GAP elements &contact simulation
Beyond Elastic limit "E" metals
within Elastic limit non metals
creep progressive deformation of material at constant stress -long time process

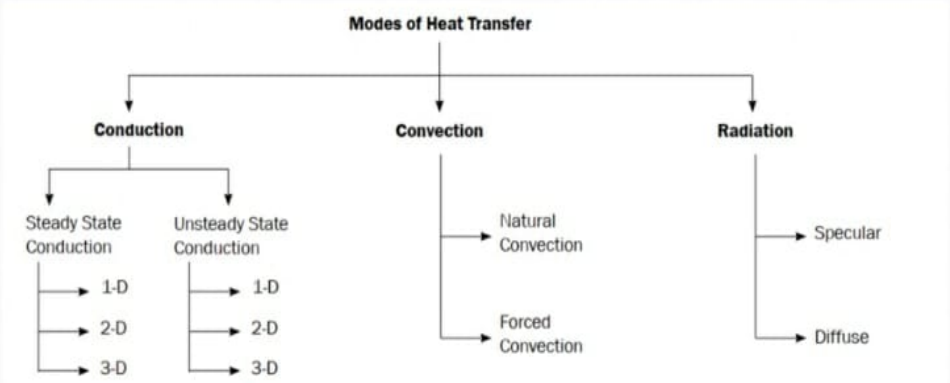
Linear Buckling Analysis

Some key aspects:

- Applicable for only compressive load
- Slender beams and sheet metal parts
- Bending stiffness <<< Axial stiffness
- Large lateral deformation



Thermal Analysis



3.2.3 FATIGUE ANALYSIS

1. Fatigue is the progressive and loacalized structural damage that occurs when a material is subjected to cyclic load.
2. Fatigue analysis,using S-N (stress-life)and E-N(strain-life) approaches for predicting the life (number of loading cycles)

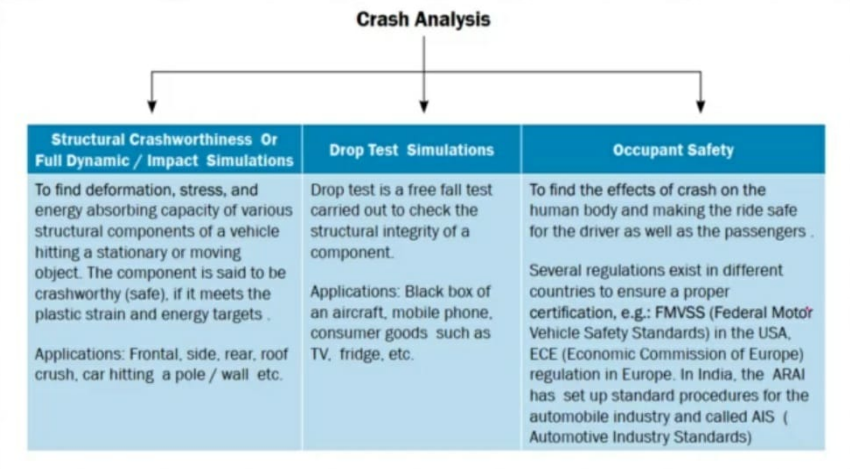
3.2.4 Optimization

1. Optimizing the design of the body depending upon the results from FEA analysis.
2. Reduce cost
3. Reduce materials
4. Providing ribs&support etc.

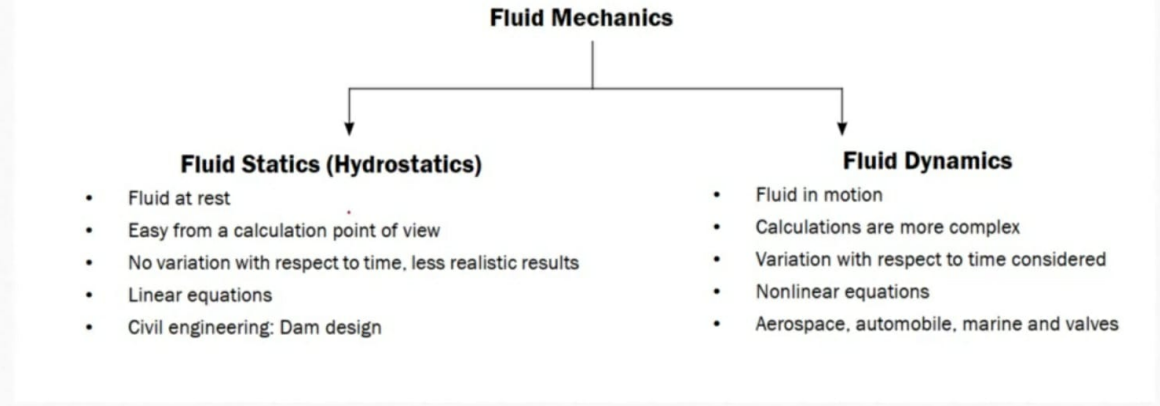
Noise, Vibration And Harshness, NVH

Sound Radiation Or Scattering Or Uncoupled Problems	Coupled Or Vibroacoustics Problems
This predicts how much sound pressure level is felt by a vibrating source at a certain distance as a function of the solid angle. A typical example is how much sound level is felt due to a horn or a silencer vibrating at a certain distance. These problems are solved by Boundary Element Method.	This is when there is a clear interaction of a structure and fluid cavity. A typical example is when there is a noise level felt at the driver's right ear due to the engine vibration in an idle condition. These problems are solved by Finite Element Method.

Crash Analysis



Computational Fluid Dynamics (CFD)



CHAPTER 4

4.1MATERIAL & MODEL

4.1.1 Composite UST

The current study utilised a UST made of polymer-based chopped strand mat fibre reinforced composite. Because of the random orientation of cut ped glass strings, the model assumes a homogenous and isotropic mechanical property. The mechanical parameters of the chopped strand mat FRPC were defined using the input dat a, an o b t obtained from a local composite UST provider in Malaysia, as shown in Table 1.

Young's modulus , E	8.069 x 10^9 Pa
Poisson's ratio, u	0.2
Shear modulus, G	2.979 x 10^9 Pa
Density, p	48 kg/m^3

Table 1. Mechanical properties of the composite UST.

4.1.2 FEA Model

ANSYS Workbench 12 is used to create the CAD geometry of a three-D 1/2 of symmetry version of the UST, that's then loaded into ABAQUS for analysis. The version blanketed a riser, tank frame, tank coverings, and reinforcement ribs, which have been all designed capabilities of the UST. As illustrated in Figure 1, the tank version is much like a capsule, with a cylindrical frame and semi-ellipsoid covers at each ends. The cylindrical riser connects the tank to the floor floor and serves as a fluid transmission route, with ribs introduced to enhance the hoop's strength. Because the riser is fixed to the cylindrical fixture above floor, its pinnacle floor is totally limited, and symmetry boundary situations have been implemented to the version's symmetrical plane. Restraining straps/ropes are commonly wrapped over the tank frame at some stage in UST set up to counteract buoyancy and distribute a number of the deformation stresses. Four restraining straps have been tied round particular ribs, such as the second one ribs on each facets and ribs

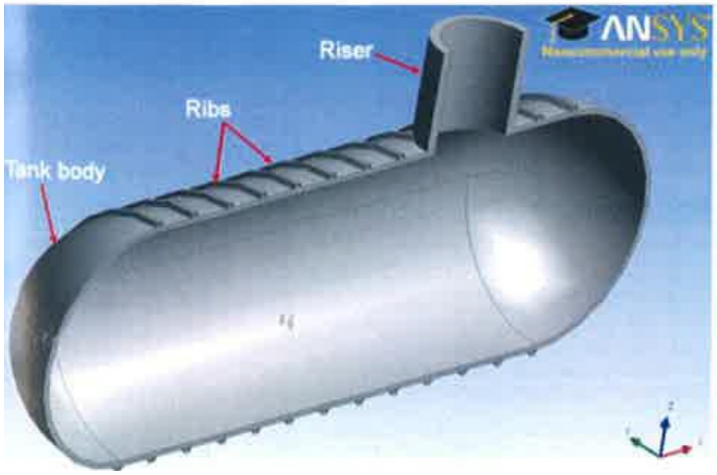


Figure 8. Half symmetry model of the UST

beside the centre ribs. Figure 2 suggests how those straps are connected to the tank and the way touch changed into taken off at 30 levels from the horizontal axis' centre.

The restraining straps are considerably stiffer than the UST in practise, therefore they have been categorized as inflexible frame in the version. Tangential floor to floor touch with out slide became described because the interplay characteristics among the strap and the ribs. A general of 20,804 continuum 3-d tetrahedral factors have been used to mesh the UST .

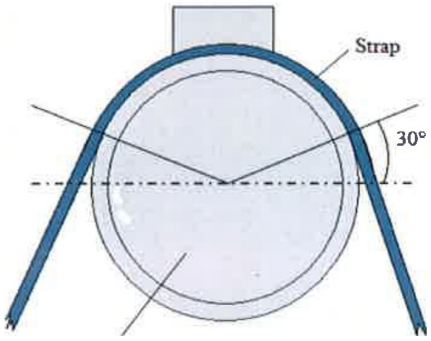


Figure 9. The attached strap layout .

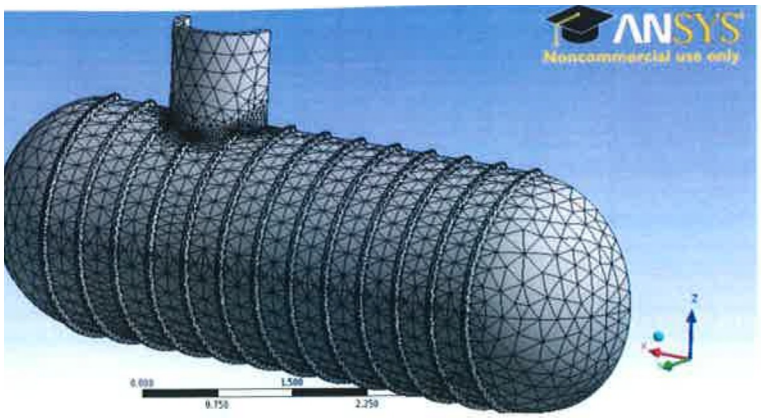


Figure 10. Tetrahedral mesh density of the UST.

Within the simulation, 3 principal styles of loading have been considered: pinnacle, backside, and inner loads. The pinnacle load is described because the made of the soil quantity and density, i.e. 297.6 kN for concrete soil, performing downward at the tank's higher floor, as proven in Figure 4. The buoyancy pressure of subsurface water in the soil reasons backside load, which lifts the tank's backside floor upwards [5]. The calculation changed into carried out the use of Pascal's theorem, which yielded 154.7 kN for a completely submerged tank [6, 7]. Internal loading is due to the load of the fluid content material in the UST performing downwards at the internal floor, i.e. 109.6 kN for a complete tank of petrol.

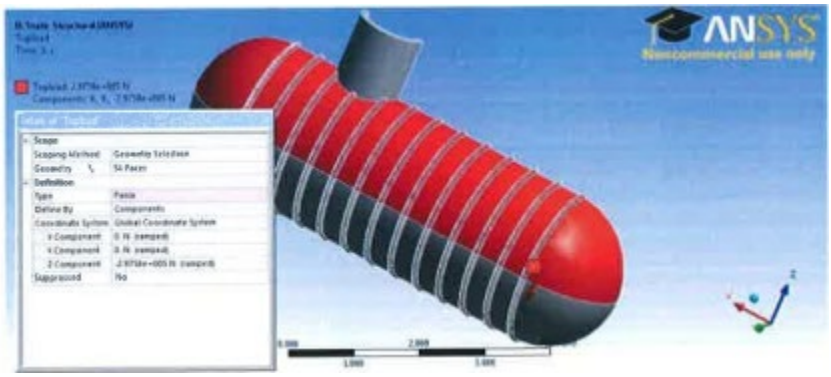


Figure 11. UST with applied top load.

Within the static structural analysis, the loadings have been assumed to be constant, and 3 output variables have been calculated: I the von-Mises stress,

which takes into consideration all 3 additives of fundamental stresses and derives a most cost primarily based totally at the yield power formula, (ii) the overall deformation to analyze the significance and course of tank motion, and (iii) the overall stress to assess the inner stretches at the tank body.

CHAPTER 5

5. RESULT AND DISCUSSION

The simulated results from ANSYS Workbench 12 and ABAQUS 6.9- 2 are shown in this section.

5.1 ANSYS Workbench 12

The maximum and minimum von-Mises stress, total deformation, and total strain from the requested output of ANSYS Workbench 12 were shown in Table 2, while the respective contour plots were shown in Figures 5 to 7.

	Minimum	Maximum
von-Mises stress (Pa)	19556	1.4794 X 108
Total deformation (m)	0	0.12071
von-Mises strain	2.4236 X **10-6**	1.1834 X **10-2**

Table 2. Output request of ANSYS .

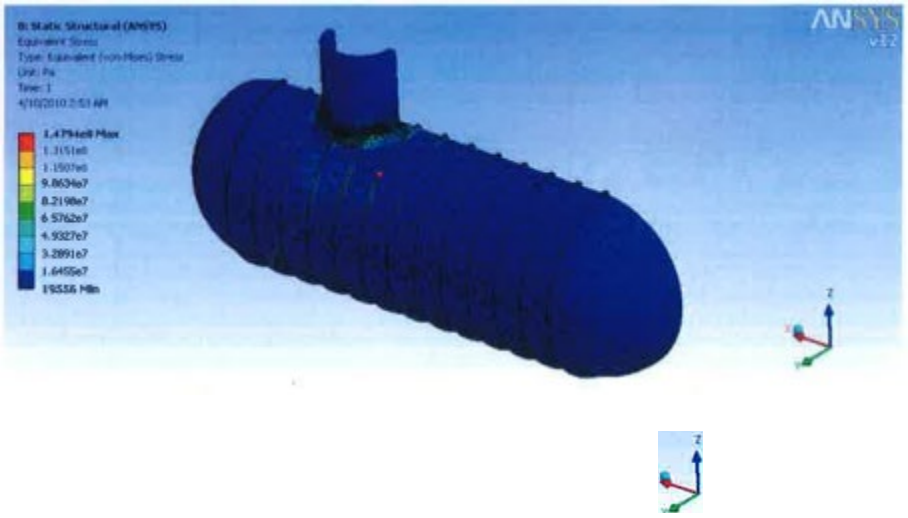


Figure 12. von-Mises stress in ANSYS.

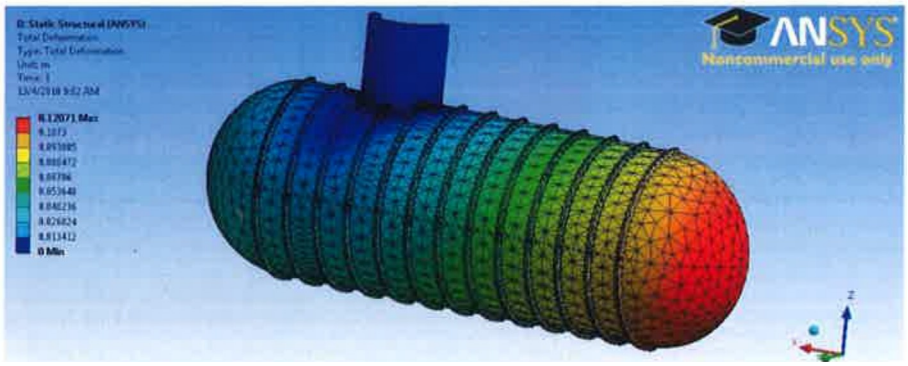


Figure 13. Total deformation in ANSYS.

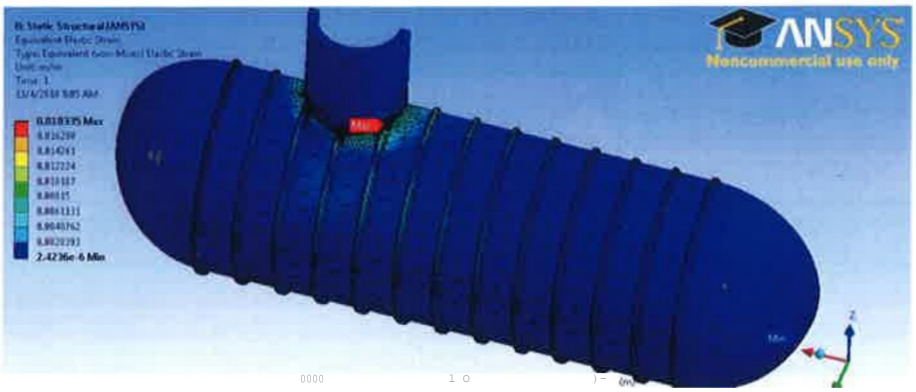


Figure 14. von-Mises strain in ANSYS

5.2 ABAQUS 6.9-2

Table 3 shows the greatest or the minimum von-Mises stress, total deformation, and total strain output created by ABAQUS.

	Minimum	Maximum
van-Mises stress (Pa)	22523	1.3867 X 108
Total deformation (m)	0	0.13821
van-Mises strain	5.5496 X 10-6	2.1982 X 10· 2

Table 3. Output request of ABAQUS.

The strap is created in ABAQUS and attached to the designated ribs. Because the straps are defined as rigid bodies within the model, there is no strain or deformation. Table 4 shows increment in the van-Mises stress on the UST with strap reinforcement, and Figure 8 shows the corresponding contour plot. When restraining straps were fitted, the UST received significantly less stress.

	Minimum	Maximum
van-Mises stress (Pa)	6048	7.4813 X 10 7

Table 4 von- mises stress of the UST with restraining straps installed

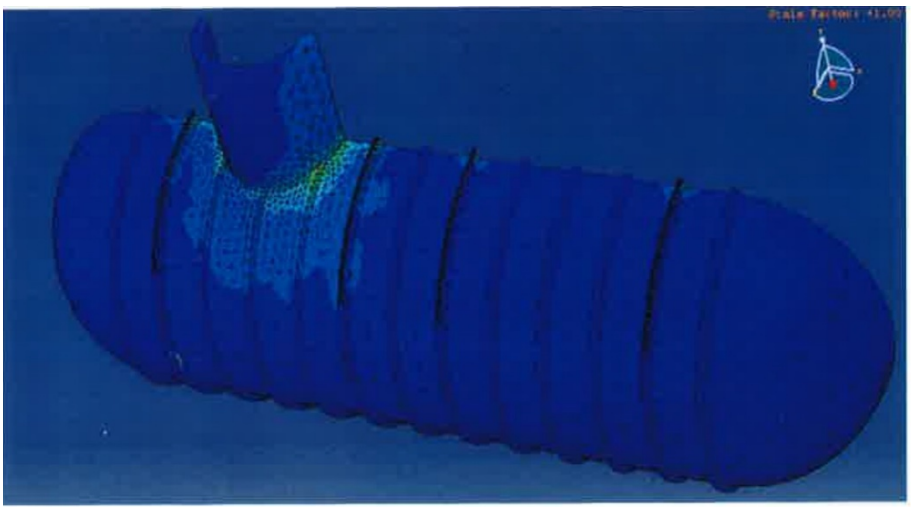


Figure 15. van-Mises stress with restraining straps installed (ABAQUS).

All consequences examined that the maximum strain and strain get up at the brink connecting to the riser and tank body, e.g. at location of most strain concentration. Elements at the outer wall professional tensile deformations while inner wall elements professional compressive deformations, causing the element a extrade of shape and as a end result the following maximum strain and strain. The ribs toward the maximum strain location showed higher strain and acted as reinforcement to share partial of the load. Although the ground location affected is wide, the strain degree remains very low and insignificant. The surrender location that is furthest to the riser enjoy greater deformation than the adjacent surrender, most like a rotation with center at the intersection of riser and tank body's crucial axes. The tank shape turn out to be maintains without any distortion or shear during the deflection. The computed van-Mises strain without restraining straps is spherical 139 - 148 MPa and the maximum strain reduced to 74.eight MPa with the straps installed. The computed outputs are in contrast through a root imply

rectangular analysis, Equation 1, and the consequences are showed in Table 5. It can be determined that thesimulated consequences agreed well in term of van-Mises strain and typical deformation. The identical strain showed a distinctly massive percentage difference way to the small strain price professional through manner of manner of the UST beneathneath the prescribed loadings, in which a small model withinside the computed strain offer rise to a massive percentage difference withinside the RMS calculation , e.g. a 1.2% strain in ANSYS and a 2% strain in ABAQUS produced some 46% RMS error.

$$Root\ Mean\ Square\ Error = \frac{\sqrt{(x_1 - x_2)^2}}{x_1} \times 100\% \qquad (1)$$

	von-Mises Stress (%)	Total Deformation(%)	Equivalent Strain (%)
ABAQUS VsANSYS	6.7	14.5	46.2

Table 5. RMS error of computed outputs

5.3 Effects of Varying Submerged Level

$$Total\ Top\ Soil\ Load = \rho_s V_s g$$
$$Bottom\ Load = m_w g = \rho_w V g$$
$$Internal\ Loading = m_f g = \rho_f V g$$

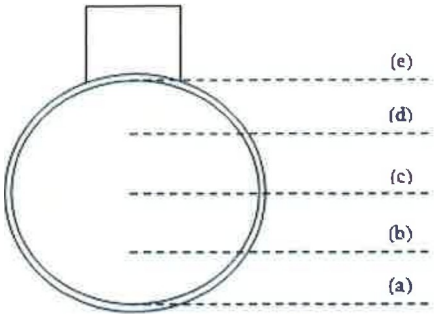
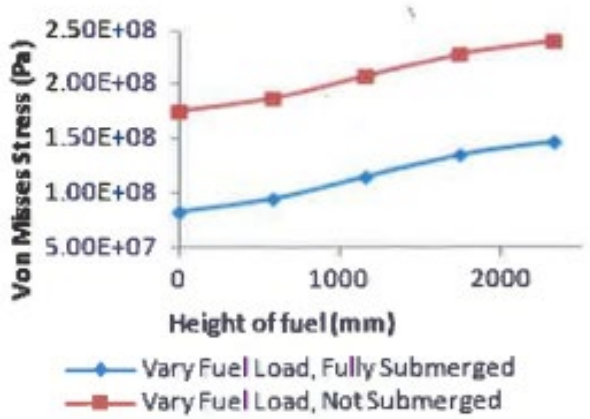
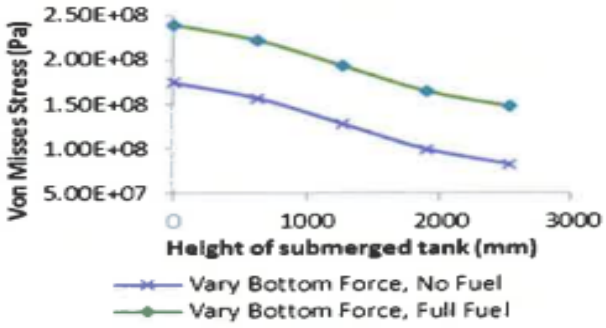


Figure 16. van-Mises stress with restraining straps installed (ABAQUS).

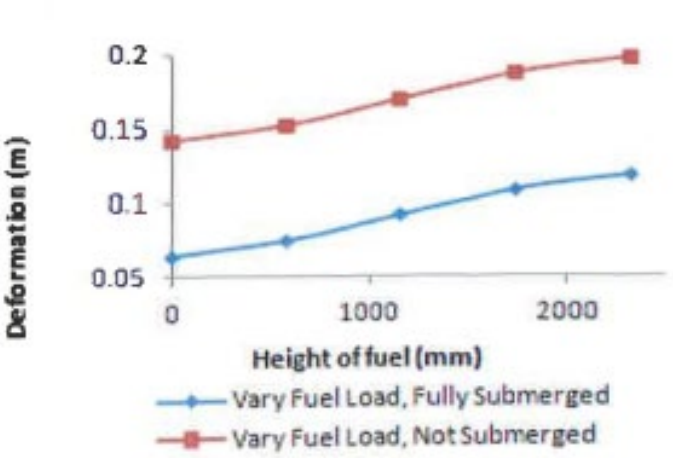
Figures 10 to 15 show the findings from ANSYS Workbench 12 plotted against the height of the gasoline or the height of the submerged tank. The volume fluctuations in these locations are bigger as it approaches the centre of the cylindrical cross-section tank, resulting in a larger gradient in the second and third quarters.



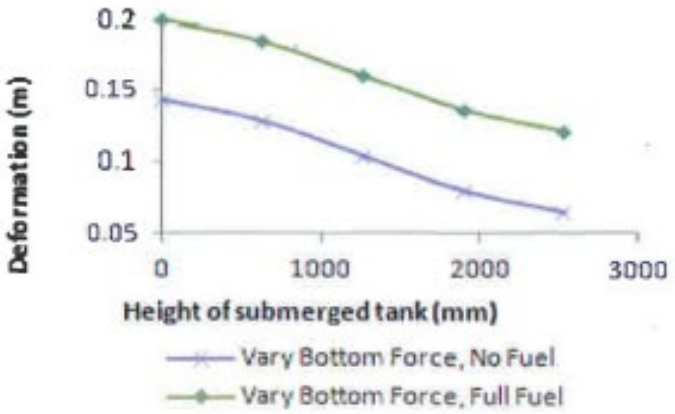
GRAPH1. von-Mises stress on varying fuel conte nt .



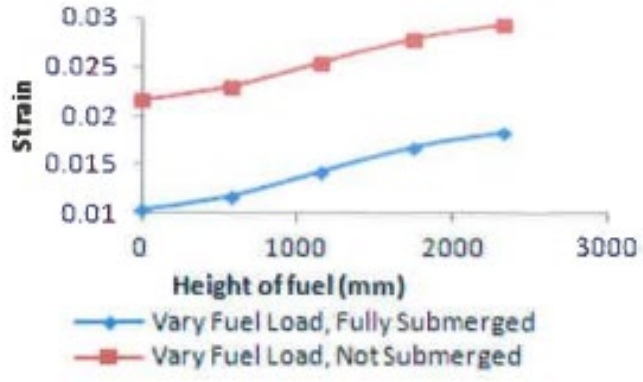
Graph 2- .von-Mises stress on varying bouancy force.



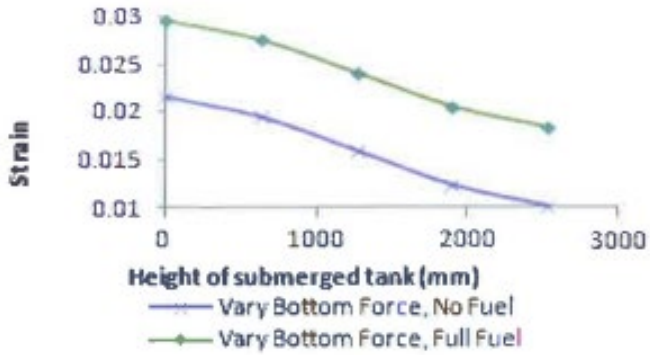
Graph 3- . Deformation on varying fuel conte nt



Graph4 -. Deformation on varying bouancy



Graph 5- .Von-Mises train on varying fuel content.



Graph 6-. von-Mises strain on varying buoyancy force.

5.4 Effect of Loadings on von-Mises Stress

The pressure stage is proportional to the pinnacle and indoors loadings, however inversely proportional to the lowest load, as may be shown. Deformation and pressure relationships seem to comply with a comparable trend. Under complete load and now no longer submerged conditions, the maximum negative condition (most von-Mises pressure) occurs, ensuing in 240 MPa, 0.2 min overall deformation, and three percentage nominal pressure. The least destructing scenario, on the opposite side, turned into reached whilst the UST turned into definitely submerged with out fuel, yielding eighty three MPa, 0.06 m, and 1% correspondingly.

5.5 Thick Wall Cylinder Calculation

When pressure is applied both inwardly, Pi, and outwards, Pa, a cylindrical tank experiences axial, σ_a, circumferential, σ_c, and radial, σ_r, stresses, as shown in Equations 2 to 4.

$$\sigma_a = \frac{\left(P_i r_i^{\,2} - P_o r_o^{\,2}\right)}{r_o^{\,2} - r_i^{\,2}} \tag{2}$$

$$\sigma_c = \frac{\left(P_i r_i^{\,2} - P_o r_o^{\,2}\right)}{r_o^{\,2} - r_i^{\,2}} - \frac{r_o^{\,2} r_i^{\,2}\left(P_o - P_i\right)}{r^2\left(r_o^{\,2} - r_i^{\,2}\right)} \tag{3}$$

(4) $$\sigma_r = \frac{\left(P_i r_i^{\,2} - P_o r_o^{\,2}\right)}{r_o^{\,2} - r_i^{\,2}} + \frac{r_o^{\,2} r_i^{\,2}\left(P_o - P_i\right)}{r^2\left(r_o^{\,2} - r_i^{\,2}\right)}$$

Po is described as pinnacle load over place of element, and Pi is described as indoors loading over place of element, wherein ro and ri are the outer and internal radius, respectively. The length of the tetrahedral factors allocated to the tank stages from one hundred fifty to two hundred mm. The pinnacle and inner loadings, which might be positioned on the neck connecting the riser and the tank body, have an impact on the vicinity wherein maximum pressure occurs. The out of doors wall surface, at r = 1.22 m, is the vicinity wherein the 3 thing stresses (axial σa, circumferential σc, and radial σr) are calculated, as proven below.

Axial stress, σ_a = -100.39 MPa

Circumferential stress, σ_c = -186.50 MPa

Radial stress, σ_r,. = -14.29 MPa

The von-Mises stress, σ_{vm}, can then be calculated through Equation 5.

$$\sigma_{vm} = \sqrt{\frac{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_1 - \sigma_3)^2}{2}} \qquad (2)$$

σ_{vm} = 149.13 MPa

Deformation, Δx, can be obtained through Hooke's Law (Equation 6) as showed below.

$$\Delta x = \frac{\sigma_{vm}}{E}(x_0) \qquad (6)$$

$$\Delta x = 0.1375 \text{ m}$$

The preliminary undeformed geometry is x0, and the Young's modulus is E.

It may be visible that the computed van-Mises pressure and deformation of 149.thirteen MPa and 0.1375 m are inside a 10% tolerance of the simulated most pressure and deformation, respectively.

CHAPTER 6

CONCLUSION

Maximum van-Mises strain turned into calculated to be among 139 and 148 MPa, most deformation turned into 0.121-0.138 m, and most stress turned into 1.18 and 2.20 percentage. The phase in which the riser attaches to the tank frame skilled the maximum strain and stress. Under the blended strain, the tank deforms in a rotating fashion. The UST turned into determined to be bolstered through restraining straps, which decreased the most van-Mises strain to 74.eight MPa. Under complete gasoline load and now no longer submerged conditions, the maximum damaging circumstance turned into observed, with 240 MPa, 0.2 min general deformation, and three percentage nominal stress.

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