Student Project

A Sample Project Report of the Programme, B.E-Naval Architecture and Offshore Engineering is given below

FE ASSESSMENT OF IWO CRANE INSTALLATION

A MAJOR PROJECT

Submitted by

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For the fulfillment of the

degree

Of

BACHELOR OF ENGINEERING

In

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DEPARTMENT OF NAVAL ARCHITECTURE & OFFSHORE ENGINEERING

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BONAFIDE CERTIFICATE

This is to certify that the project entitled "**FE Assessment of IWO Crane Installation**" submitted by **T.U.V.N. Varalakshmi, Mohammed Arham Shariff and Anoop George** to the Department of Naval Architecture & Offshore Engineering, AMET, India for the award of degree of Bachelor of Engineering is a bonafide record of technical work carried out by them under my supervision. The contents of this project, in full or in parts, have notbeen submitted to any other institute or university for the award of any degree or diploma.

....	....
Signature	Signature
(HOD)	(Guide)
Dr. S.K Bhattacharya	Dr.P Sivabalan
Professor	Associate Professor
Department of Naval Architecture & Offshore Engineering	Department of Naval Architecture & Offshore Engineering

ACKNOWLEDGEMENTS

We extend our heartfelt gratitude and appreciation to all those who contributed to the realization of this achievement.

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We would like to express our gratitude to the members of the reviewer committee for their meticulous evaluation and insightful suggestions, which have greatly enriched our research.

Our profound thanks go to our families for their sacrifices and unwavering emotional support throughout our B.E. journey. We also extend our heartfelt appreciation to our parents and friends for their constant support, assistance, and encouragement.

T.U.V.N Varalakshmi
Mohammed Arham Shariff
Anoop George

Date: 20-05-2024

Place: Chennai, India.

ABSTRACT

A floating dry dock is a large, U-shaped pontoon that can be submerged to raise a ship out of the water for repair or maintenance. The dock has floodable buoyancy chambers and walls that provide stability when the floor is below water. Water is then pumped out of the dock, raising the ship out of the water.

This project report outlines the design and structural analysis of a crane installation on a floating dry dock. The primary goal was to develop a robust and safe foundation for the crane, ensuring its stability and operational efficiency. The project began with the geometric modeling of the crane foundation and floating dry dock using Rhino software. This model was then imported into ANSYS Space-Claim for refinement and preparation for simulation.

In ANSYS Workbench, we set up and performed a finite element analysis (FEA) in ANSYS Mechanical. The analysis process included generating a mesh, applying boundary conditions, and simulating various operational loads. Special attention was given to analyzing the structural response at different angles of crane operation.

The analysis revealed that while the crane foundation and floating dry dock exhibited acceptable performance under most operational conditions, the maximum load was observed at a 0-degree angle of crane operation. This finding underscores the importance of considering the crane's orientation during operation to ensure structural integrity and safety.

This report demonstrates the successful integration of Rhino and ANSYS software tools to achieve a comprehensive structural analysis for the crane installation on the floating dry dock, highlighting the critical importance of load orientation in the design process.

TABLE OF CONTENTS

TABLE OF FIGURES

CHAPTER 1

Crane Installation in a Floating Dry Dock Vessel: Literature Review

1.1 Introduction

- The installation of cranes on floating dry dock vessels is a critical component in the marine and shipbuilding industries.
- This process involves complex engineering, logistical planning, and adherence to stringent safety regulations.
- The literature on this subject spans various disciplines including marine engineering, mechanical engineering, project management, and safety protocols.
- This review synthesizes the existing research and guidelines to provide a comprehensive understanding of the crane installation process in floating dry dock vessels.

1.2 Historical Background

- The concept of floating dry docks dates back to the 19th century, primarily used for ship repair and maintenance. With technological advancements, the integration of cranes on these structures has evolved significantly.
- Early installations were rudimentary, often limited to manually operated winches. Modern installations now incorporate advanced crane technologies, including automated systems, which enhance operational efficiency and safety.

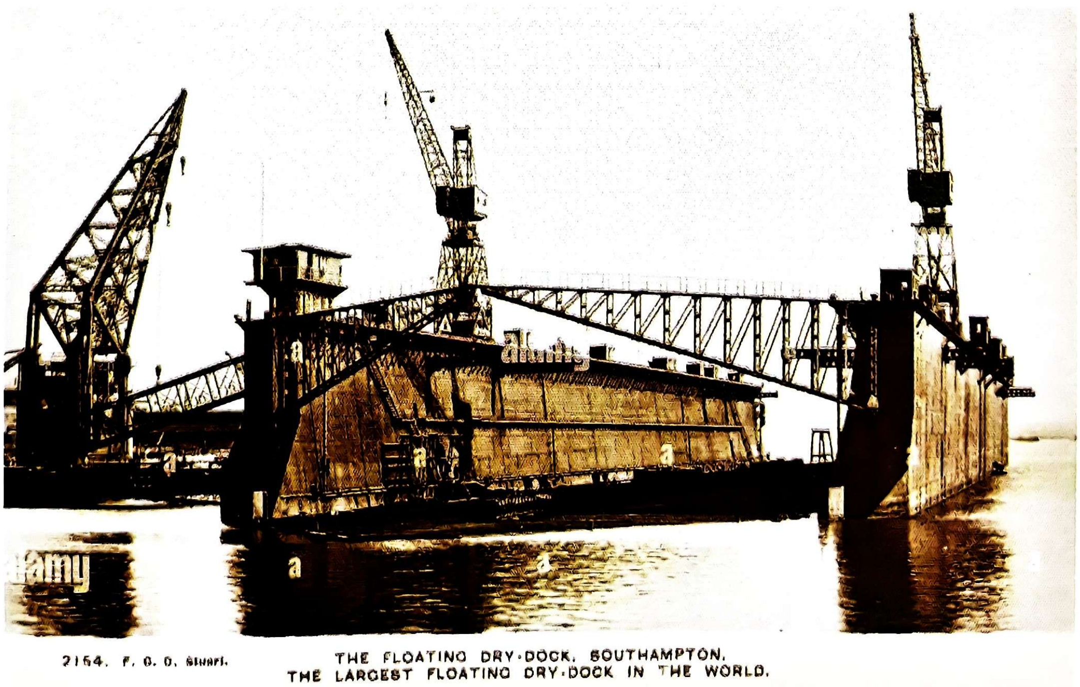


Figure 1 A Floating Dry Dock in Early 19th Century

1.3 Types of Cranes Used

Different types of cranes are employed depending on the specific requirements of the floating dry dock. Common types include:

1.3.1 Gantry Cranes:

- These are often used due to their ability to span wide areas and lift heavy loads.

Figure 2 Gantry Crane on a Floating Dry Dock

1.3.2 Jib Cranes:

- Typically used for lighter, more precise lifting tasks.

Figure 3 Jib Crane

1.3.3 Tower Cranes:

- Used in situations where height is a critical factor.

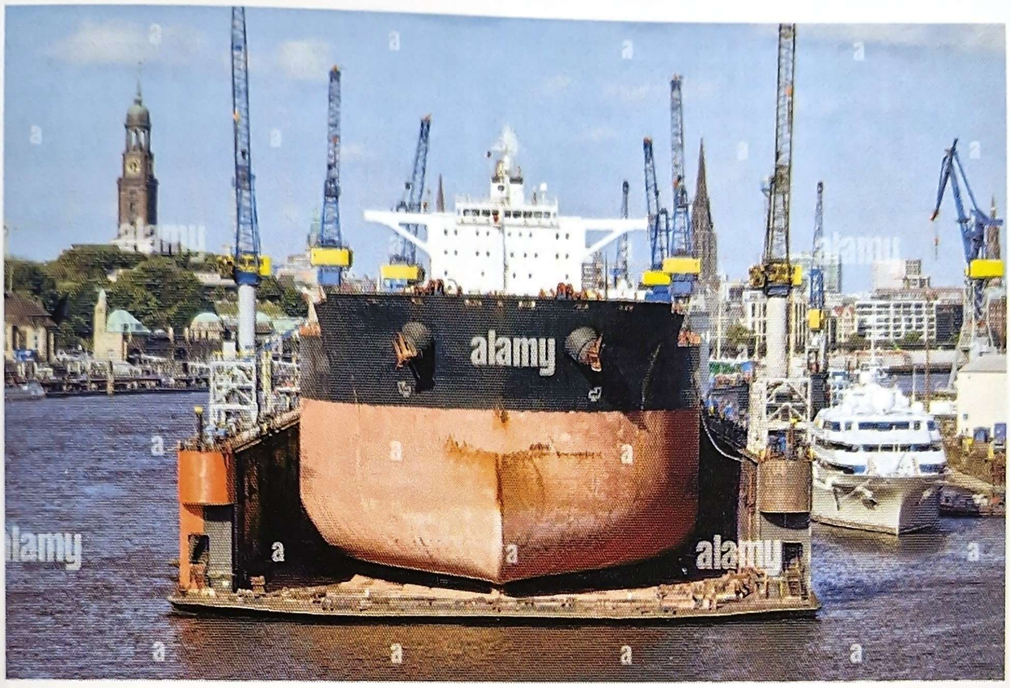


Figure 4 Tower Crane

1.3.4 Mobile Cranes:

- Offer flexibility and are often used for temporary installations.

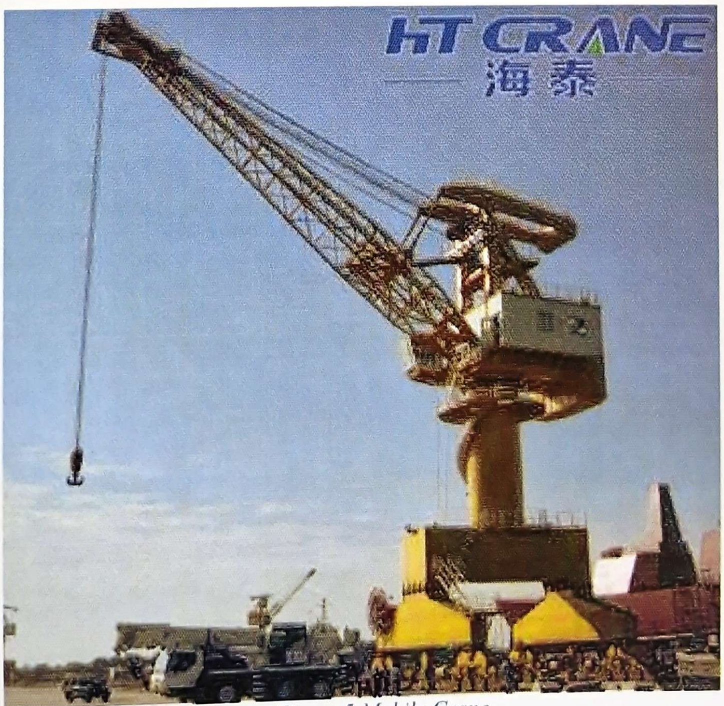


Figure 5 Mobile Crane

Each type has unique installation requirements and operational characteristics that must be carefully considered.

1.4 Installation Procedures

The installation of cranes on floating dry dock vessels involves several key steps:

1.4.1 Design and Planning:

- This phase includes a thorough analysis of the dry dock's structural capacity, environmental conditions, and operational requirements. Computer-aided design (CAD) software is commonly used to create detailed plans and simulations.

1.4.2 Structural Reinforcement:

- Depending on the weight and type of crane, the dry dock may require structural modifications or reinforcements. This ensures that the dock can safely support the crane and its load.

1.4.3 Crane Assembly and Erection:

- Cranes are often delivered in parts and assembled on-site. This process involves precise alignment and bolting of crane components. In some cases, cranes are pre-assembled on land and then transferred to the dry dock.

1.4.4 Testing and Commissioning:

- Once installed, cranes undergo rigorous testing to ensure they meet operational standards. This includes load testing, functional tests of all crane movements, and safety checks.

1.5 Safety Considerations

Safety is paramount in crane installations on floating dry docks. Key safety protocols include:

1.5.1 Risk Assessments:

- Comprehensive risk assessments to identify potential hazards and mitigate risks.

1.5.2 Compliance with Regulations:

- Adherence to international and local safety standards, such as those set by OSHA (Occupational Safety and Health Administration) and IMO (International Maritime Organization).

1.5.3 Training and Certification:

- Ensuring that all personnel involved in the installation are adequately trained and certified.

1.5.4 Emergency Procedures:

- Establishing clear emergency response procedures in case of accidents.

1.6 Challenges and Solutions

Several challenges are inherent in the installation of cranes on floating dry docks:

1.6.1 Stability of the Floating Structure:

- Floating dry docks are inherently less stable than land-based structures. Advanced stabilization techniques, such as ballast adjustments and mooring systems, are employed to counteract this issue.

1..6.2 Environmental Conditions:

- Marine environments present unique challenges such as saltwater corrosion, strong winds, and waves. Using corrosion-resistant materials and robust design solutions helps mitigate these challenges.

1.6.3 Logistical Constraints:

- The logistics of transporting large crane components to the floating dry dock can be complex. Utilizing specialized transport vessels and modular assembly techniques can streamline this process.

1.7 Case Studies

- Examining case studies of successful crane installations can provide valuable insights. For instance, the installation of a gantry crane on the USS ARD-5 floating dry dock involved extensive structural modifications and innovative engineering solutions to accommodate the crane's weight and operational demands.

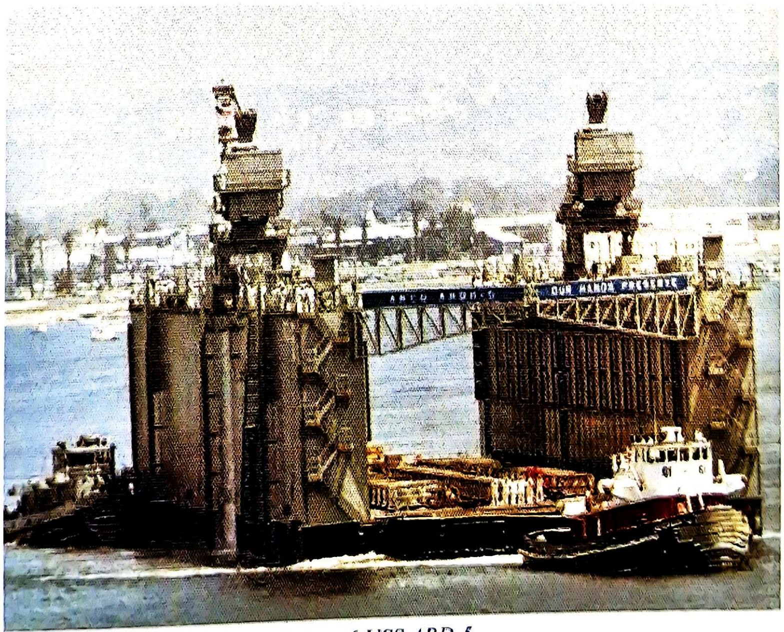


Figure 6 USS ARD-5

- Similarly, the integration of a mobile crane on the HMS Invincible dry dock highlighted the importance of flexibility and precision in the installation process.

1.8 Future Trends

The future of crane installation on floating dry docks is likely to be influenced by several trends:

1.8.1 Automation and Remote Control:

- Increasing use of automated systems and remote control technologies to enhance safety and efficiency.

1.8.2 Sustainable Practices:

- Incorporation of environmentally friendly materials and practices to reduce the ecological impact of installations.

1.8.3 Advanced Materials:

- Development and use of advanced materials such as high-strength composites to reduce weight and increase durability.

1.9 Conclusion

- The installation of cranes on floating dry dock vessels is a complex but essential process in the maritime industry. It requires meticulous planning, engineering expertise, and strict adherence to safety standards.
- As technology advances, new methods and materials will continue to improve the efficiency and safety of these installations, supporting the ever-growing demands of shipbuilding and repair activities.

1.10 References

Key sources includes

- The International Journal of Maritime Engineering,
- OSHA guidelines, and the
- IMO's safety protocols.

CHAPTER 2

ABBREVIATIONS and ACRONYMS:

FEA	-	Finite Element Analysis
FOS	-	Factor of Safety
g	-	Acceleration due to gravity; 9810 mm/s2
Fx	-	Component of Force in X-direction
Fy	-	Component of Force in Y-direction
Fz	-	Component of Force in Z-direction
Rx	-	Rotation in X-direction
Ry	-	Rotation in Y-direction
Rz	-	Rotation in Z-direction
F	-	Design Load
DF	-	Design Factor
Ax	-	Global acceleration in X-direction
Ay	-	Global acceleration in Y-direction
Az	-	Global acceleration in Z-direction
COG	-	Centre of Gravity
T	-	Ton

CHAPTER 3

INTRODUCTION

3.1 FEA- Finite Element Analysis

Finite Element Analysis (FEA) is a computational technique used to predict how a material or structure will respond to various physical conditions such as heat, vibration, fluid flow, and structural loads.
It's widely employed in engineering and physics disciplines for simulating and analysing complex systems.

3.1.1 Types of Analysis:

- Structural Analysis: Predicts how structures like beams, shells, and solids respond to loads such as forces, pressures, and thermal gradients.
- Thermal Analysis: Examines temperature distributions and heat transfer within structures and materials.
- Fluid Flow Analysis: Studies the behaviour of fluids (liquids or gases) within or around structures, predicting factors like pressure, velocity, and turbulence.
- Electromagnetic Analysis: Investigates electromagnetic fields and their interactions with structures and materials.
- Coupled Field Analysis: Considers interactions between multiple physical phenomena, such as thermo-mechanical or fluid-structure interactions.

3.1.2 Working of FEA

- Discretization: The structure or material under analysis is divided into smaller, simpler elements. These elements are often geometrically simple, like triangles or rectangles in 2D analysis, or tetrahedra and hexahedra in 3D analysis.

- Mathematical Formulation: Mathematical models, often based on principles of continuum mechanics, are applied to each individual element to describe its behaviour under various conditions such as mechanical loading, thermal gradients, or fluid flow. These models typically involve equations describing stress, strain, heat transfer, fluid flow, and other relevant physical phenomena.

- Assembly: The equations governing the behaviour of each element are then assembled into a system of equations that represents the behaviour of the entire system. This assembly process involves connecting the nodes (points where elements meet) of adjacent elements and ensuring continuity of solutions across element boundaries.

- Solution: Once the system of equations is assembled, numerical techniques are used to solve it. These techniques may include matrix methods, iterative solvers, and optimization algorithms. The solution process involves solving for the unknowns, such as displacements, temperatures, or fluid velocities, at each node of the finite element mesh.
- Analysis: After obtaining the solution, engineers can analyse the results to understand how the system behaves under different conditions. This analysis may involve determining stresses, strains, deformations, temperature distributions, fluid velocities, or other relevant parameters. Engineers can then use this information to assess the performance, safety, and reliability of the system, identify potential failure modes, and optimize the design.

3.1.3 Finite Element Analysis in Ship Structures

- Hull Structural Analysis: FEA is employed to analyse the hull structure of ships, including the main hull, decks, bulkheads, and superstructures. By modelling these components and applying loads such as hydrostatic pressure, wave loads, and loads from onboard equipment, engineers can assess the structural integrity and performance of the hull under various operating conditions.

- Fatigue Analysis: Ships are subjected to cyclic loading conditions due to wave-induced motions and operational activities. FEA can be used to perform fatigue analysis, predicting the accumulation of fatigue damage in structural components over time. This helps engineers identify critical areas prone to fatigue failure and optimize the design to enhance the vessel's fatigue resistance.

- Dynamic Analysis: FEA enables engineers to conduct dynamic analysis of ship structures, considering the dynamic response of the vessel to wave-induced motions, machinery vibrations, and other dynamic loads. Dynamic analysis helps evaluate the structural stability, dynamic amplification factors, and vibration characteristics of the ship's components.

- Impact Analysis: Ships may encounter impact loads from collisions with floating objects, grounding incidents, or accidental events. FEA can simulate such impact scenarios and assess the structural integrity of the ship's hull, assess damage tolerance, and evaluate the effectiveness of collision protection measures such as collision bulkheads and reinforced structures.

- Buckling and Stability Analysis: FEA can predict the buckling behaviour and structural stability of ship components under compressive loads. By analysing the critical buckling modes and load-carrying capacities of structural members, engineers can ensure that ship structures meet stability requirements and avoid buckling failure during operation.

CHAPTER 4

OWNER'S REQUIREMENT

Installation of Crane on Floating Dry Dock

4.1 Vessel Details

Length O. A	-	125.75 m
Beam MLD.	-	25.00 m
Depth MLD.	-	13.00 m
Class	-	IR Class

4.2 Crane Type

Electro- Hydraulic Driven Cylinder luffing, telescopic Boom type, 10T Deck Crane.

4.3 Crane Data

- Hoisting Capacity : 10T at 8m to 12.5m and 5T at 8m to 33m
- Hoisting Speed at full load : 0-10m/min (stepless control) for 10T

  0-20 m/min (stepless control) for 5T
- Maximum Lift : 50m
- Hoisting Height : 20m on installation deck
- Maximum Working radius : 33m
- Minimum Working radius : approx. 8m
- Telescopic Stroke : min retired 8m, max extend 13m
- Slewing Speed : 0-1 rpm
- Slewing angle : 360 degrees limitless
- Luffing time (from 15 to 80 deg. : approx. 220 second
- Luffing angle : 0 degree – 70 degrees
- Hoisting wire rope : Dia 20 anti-twist type, galvanized steel
- Luffing wire rope : Dia22 anti-twist type, galvanised steel
- Control : Local control on the slewing crane inside control cabin and joystick stepless crane inside control speed.
- Operation : one (1) by one (1) motion at full load & full speed or two motion simultaneously under full load & reduced speed.
- Self-weight without hyd. Oil : 65 T

- Self-weight with hyd. Oil : 68 T

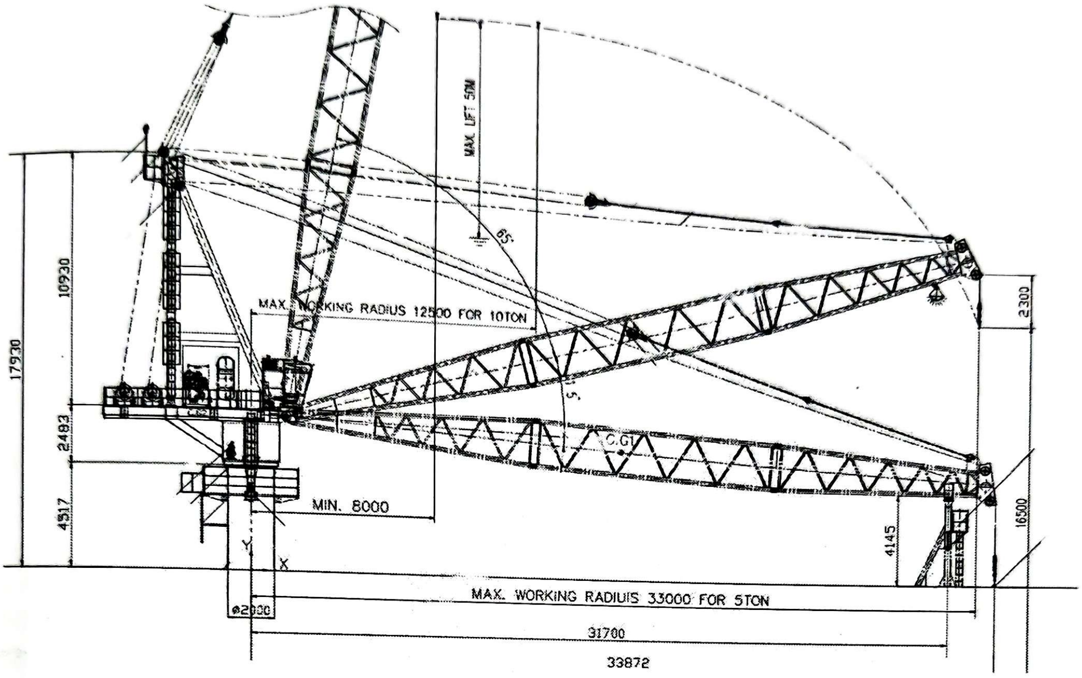


Figure 7 Crane

CHAPTER 5

5.1 Scope of Work

The scope of work is to perform design check of the crane pedestal and its supporting structure against the crane loads provided by the vendor.

5.2 Methodology & Design Approach

The crane pedestal is analysed against the crane's dynamic loads which are provided by the vendor. The structure is analysed with the design loads with boundary conditions applied as mentioned below and the stresses and deflection of the structure is within acceptable limits.

5.3 Model Description

Structural Drawing was used to prepare the model in Rhino 3D and The ANSYS 2024 R2 is used to simulate the behaviour of structural bodies under structural loading conditions. ANSYS automated FEA technologies from ANSYS Inc., is used to generate the results listed in this report.

CHAPTER 6

CHAPTER 7

3D MODEL

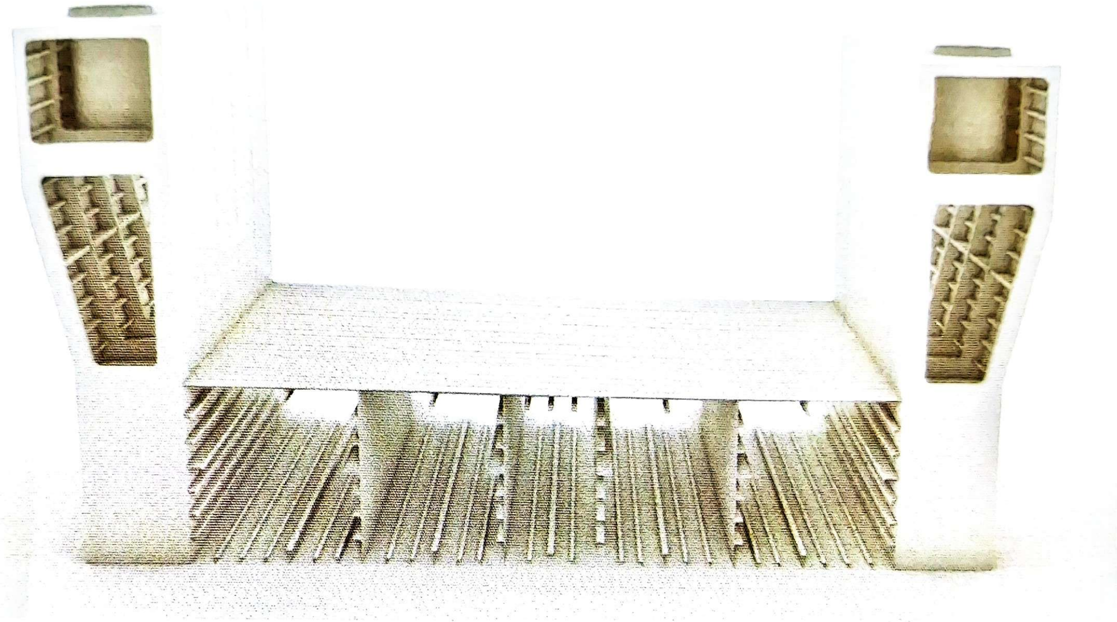


Figure 8. Floating Dry Dock

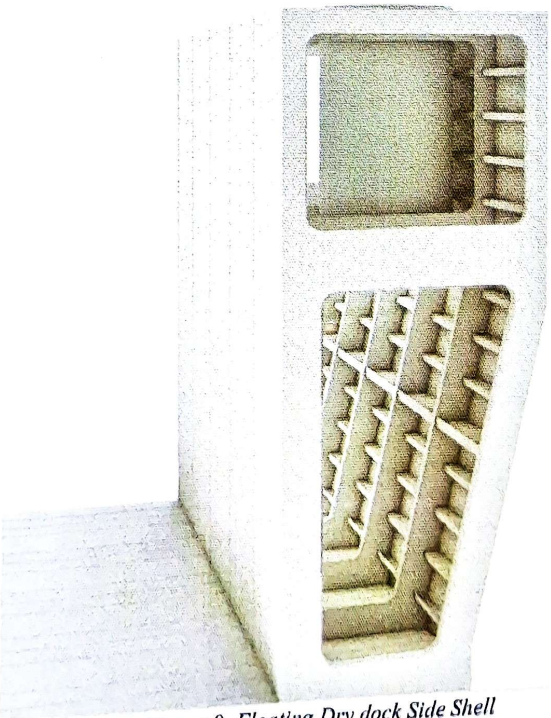


Figure 9 Floating Dry dock Side Shell

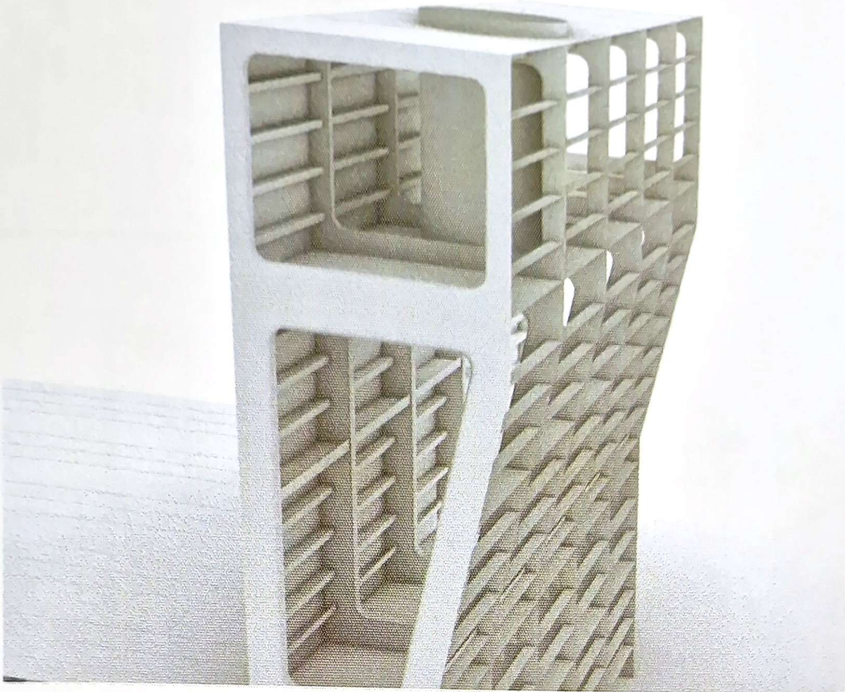


Figure 10 Floating Dry Dock Side Shell

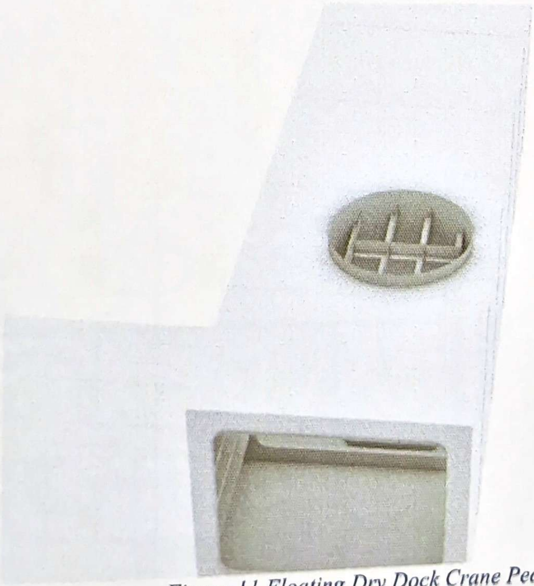
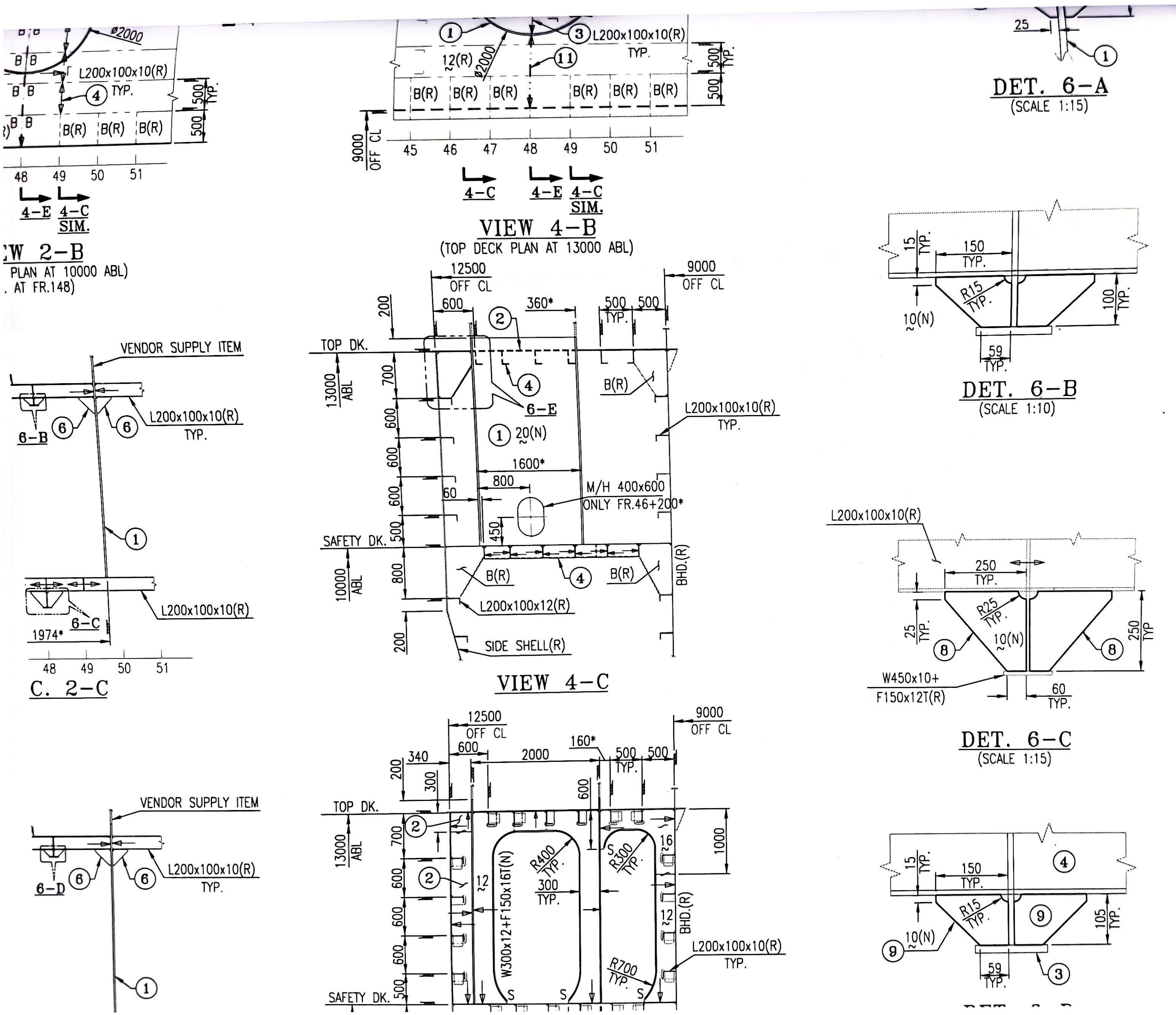


Figure 11 Floating Dry Dock Crane Pedestal



6	BRACKET PLATE 250x250x10mm THK.
7	BRACKET PLATE 150x100x10mm THK.
8	BRACKET PLATE 250x250x10mm THK.
9	BRACKET PLATE 150x10x10mm THK.
10	BRACKET PLATE 700x528*x10mm THK.
11	GIRDER W300x16+F150x16Tmm THK.
	TOTAL ESTIMATED WEIGHT

GENERAL NOTES:-

1. ALL DIMENSIONS ARE IN MM, EXCEPT AS SPECIFI
2. ALL FILLET WELDS TO BE DOUBLE CONTINUOUS I IMPRACTICABLE.
3. (*) STAR MARK DIMENSION TO BE VERIFIED ON SITE.
4. (R) - INDICATES REFRENCE STRUCTURE. (B) - INDIC
5. (N) - INDICATES NEW STRUCTURE.
6. - INDICATED DISCONTINUITY OF STRUCTURE.
7. - INDICATED CONTINUITY OF STRUCTURE.
8. ALL TRANSVERSE VIEWS ARE LOOKING FORWAR
9. ALL LONGITUDINAL VIEWS ARE LOOKING PORT.
10. BURRS AND SHARP OR RAGGED EDGES SHALL BE RE
11. CRANE BASE TO BE SUPPLIED BY THE VENDOR.
12. CONNECTION OF THE CRANE AND THE VENDOR SUPPI BE ADEQUATE ENOUGH AND ALL FLANGE CONNECTION WITHSTAND CRANE REACTION FORCES.
13. MATERIAL TO BE MANUFACTURED AND TESTED IN ACC CLASSIFICATION SOCIETY.
14. BOM IS PROVIDED FOR SINGLE CRANE

7.2 Extent of Model

- Shell element has been used for modelling of the structure.
- The extent of model is considered from Fr40 to Fr60 in longitudinal direction, inner wing walls to Side shell in Star Board and pontoon to pedestal top in vertical direction.
- No corrosion margin is considered for the model.

7.3 Element Types

The structural members have been modelled according to their shape using the following types of elements:

- Shell 4 node 181 element

7.4 Material

The material used for modelling the elements is "Grade A". The mechanical properties of the material are mentioned below:

a. Young' s modulus = 2.1 E+5 M Pa
b. Poisson's Ratio = 0.3
c. Material density = 7.85E-09 T/mm3

The 3.2m crane pedestal provided by the vendor is of material grade D36 (GEW05-6621-20000).

Steel Grade	Yield Stress (MPa)	Minimum Ultimate Tensile Strength (MPa)
Mild Steel	235	400

CHAPTER 8

8.1 Calculation Data & Design Assumptions

8.1.1 Assumptions

- All calculations are performed with the following assumptions:
  - Linear static analysis
  - Small displacements
  - Linear behaviour of material
- The welding seam has no effect on the transfer of load.
- In analysis, tertiary members like collar plates, brackets are not modelled as they are assumed to have negligible effect on the stress & deflection.
- No accidental impact load is considered.

8.1.2 Design Loads

- Dead Load (Self Weight)

Load due to gravity or self-weight of the structure is automatically taken into account by software itself. Ay= g = 9810 mm/s2

- Crane Load

The Crane loads are applied according to the document 'G.A. for Floating Dock Crane (GEW05-6621- 20000) from the vendor.

  - Vertical Load (Fy) = 80.5 Ton-M
  - Overturning Moment (Mz+y) = 445 Ton-M
  - Slewing Moment (My) = 68 Ton-M

**Note - The slewing moment is estimated because it is not specified by the crane vendor. The overturning moment has been applied in variable directions and analysed as shown below. Of these cases the critical one is mentioned in this report

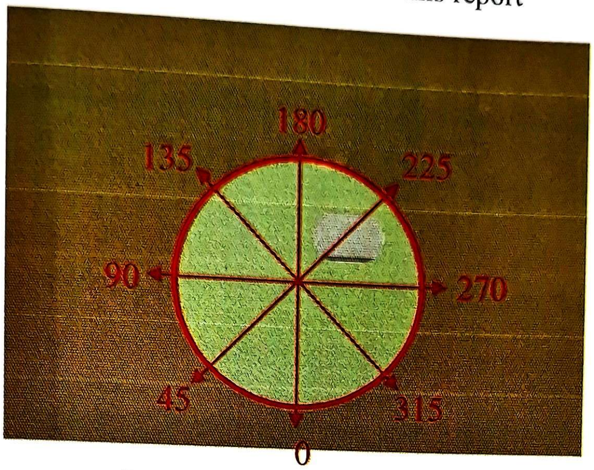


Figure 12 Overturning Moment Directions

8.2 Result Summary

- The structure was analysed with the design loads as mentioned above.
- The allowable Von-Mises stresses are calculated as per Lloyds Register rule for Lifting appliances in Marine Environment, Chapter 4 Sec 2.17.7. As per table 4.2.6 of above section a stress factor of 0.67 is selected for the analysis and for von mises stress a factor of 1.1 is applicable as mentioned in the above section of LR rules.

Stress Factor for Von-Mises stress = 0.67 x 1.1 = 0.737

8.3 Design Stress

The following table mentions the maximum Von-Misses stress.

Material	Yield stress	Stress Factor	Allowable Stress (MPa)	Von Mises Stress (MPa)
Mild Steel	235	0.737	173.2	155.5

CHAPTER 9

9.1 Model Overview

- In this section, we present visualizations of the 3D model developed using ANSYS Space-Claim software, focusing on the crane installation on a floating dry dock. The images provided depict the foundational elements necessary for the crane installation. Specifically, the model highlights the crane foundation and the structural aspects of the floating dry dock.
- The detailed renderings illustrate the spatial arrangement and structural integrity designed to support the crane, ensuring stability and operational efficiency. These visual aids serve to enhance the understanding of the setup and the engineering considerations involved in this installation project.

9.2 Key features of the model:

9.2.1 Crane Foundation:

- Detailed depiction of the crane foundation structure, showcasing the design considerations for load distribution and stability. This foundation is critical to ensuring the crane's operational safety and efficiency.

9.2.2 Floating Dry Dock Structure:

- Visualization of the floating dry dock's structural components, emphasizing the buoyancy and balance required to support the crane and its foundation. The model illustrates how the dock maintains stability under various load conditions.

9.2.3 Integration Points:

- Highlighted areas where the crane foundation interfaces with the floating dry dock. These points are crucial for understanding the mechanical connections and the distribution of forces during crane operation.

9.2.4 Material Specifications:

- Annotations indicating the types of materials used in both the crane foundation and the floating dry dock. These materials are selected based on their strength, durability, and resistance to marine environmental conditions.

9.2.5 Engineering Considerations:

- Insight into the engineering principles applied in the design, including considerations for dynamic loads, environmental factors, and safety margins.

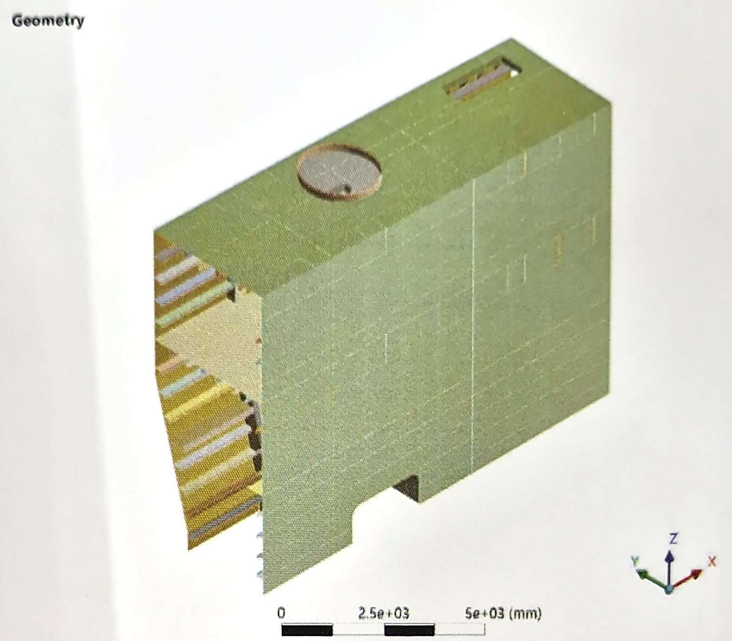


Figure 13 Isometric View

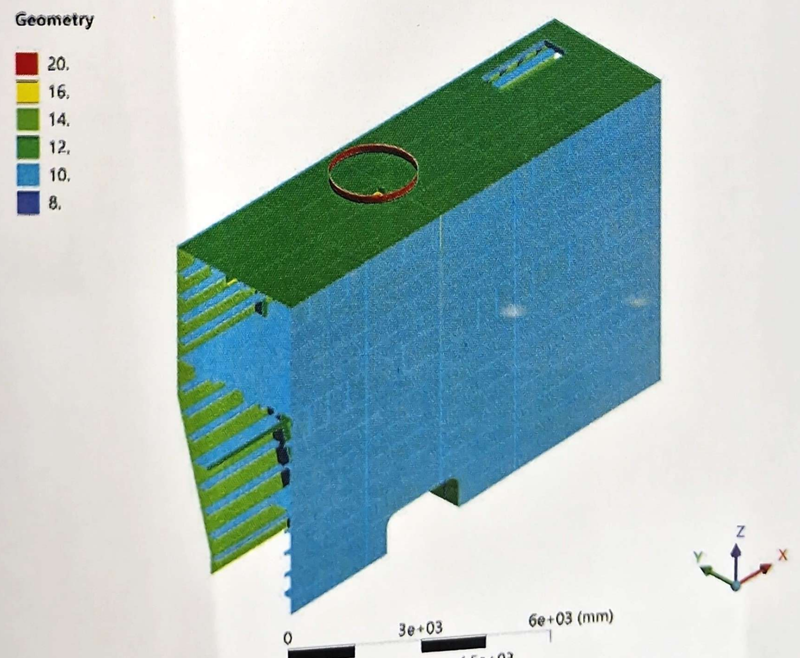


Figure 14 Shell Thickness

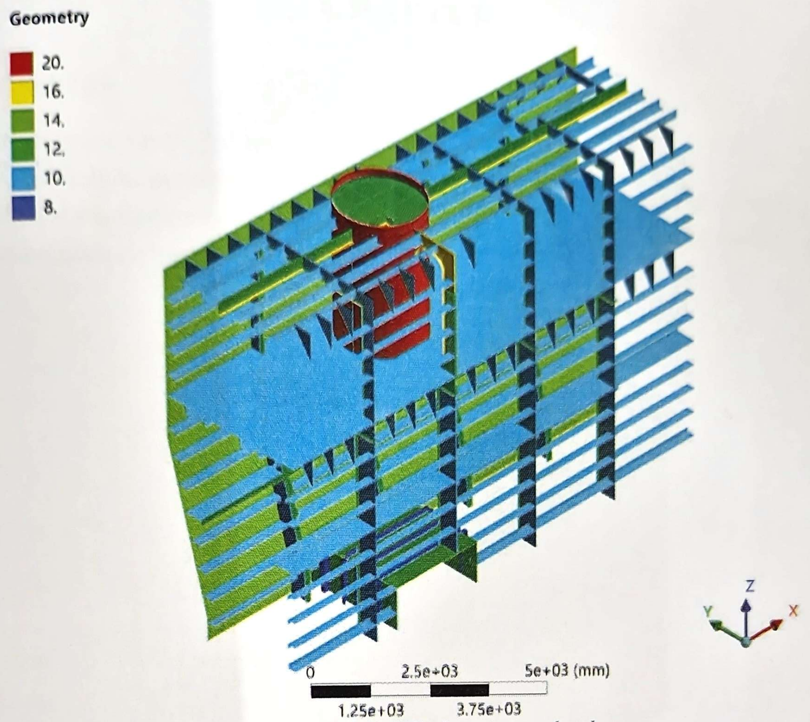


Figure 15 Shell Thickness i.w.o pedestal

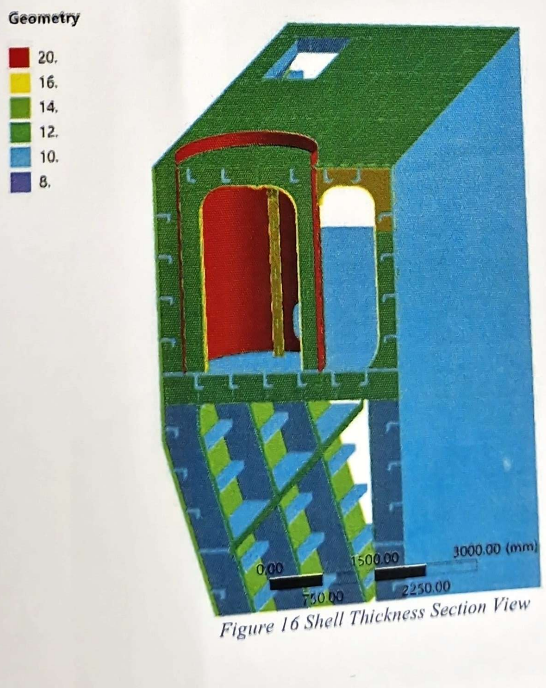


Figure 16 Shell Thickness Section View

CHAPTER 10

10.1 Meshing

- A program-controlled meshing was done.
- All structural member is meshed with Quadrilateral and triangular elements.
- Below are some mesh plots showing mesh quality and fineness of model.
- Maximum element Size: 50 mm

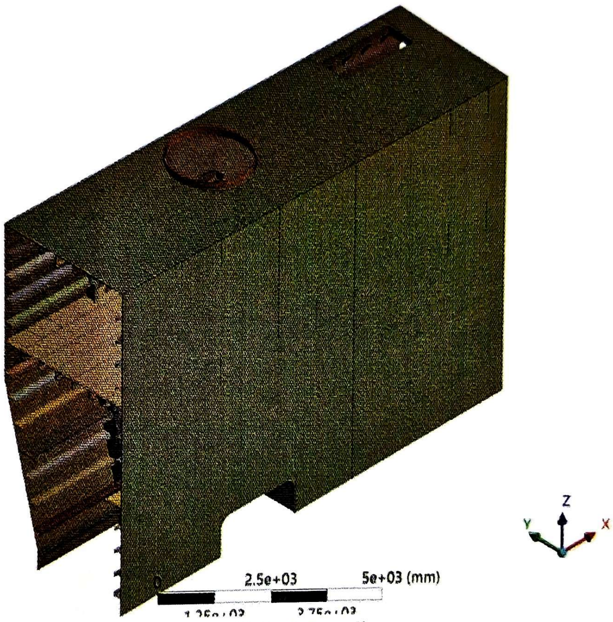


Figure 17 Mesh Overall

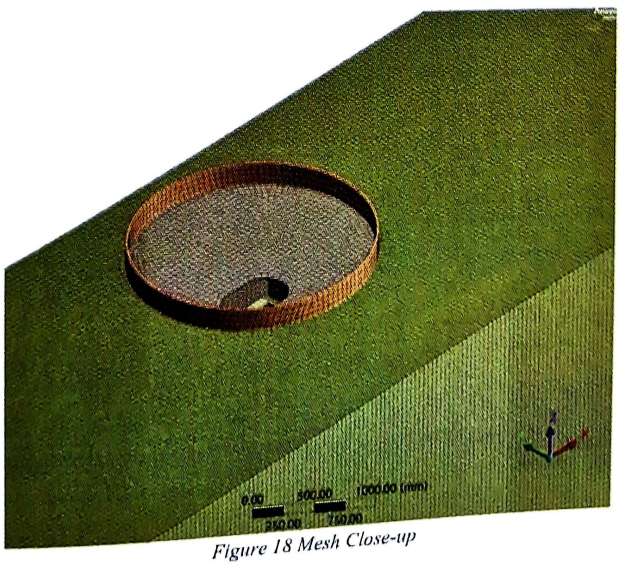


Figure 18 Mesh Close-up

CHAPTER 11

11.1 Design Load

- The loads applied comprises of the crane loads supplied by the crane vendor.
- The load is shown for typical case (Overturning moment 0 degree).

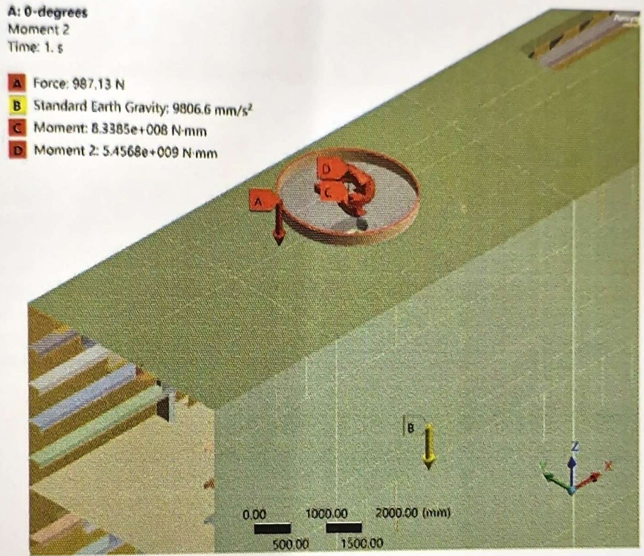


Figure 19 Operating Condition 0 degree

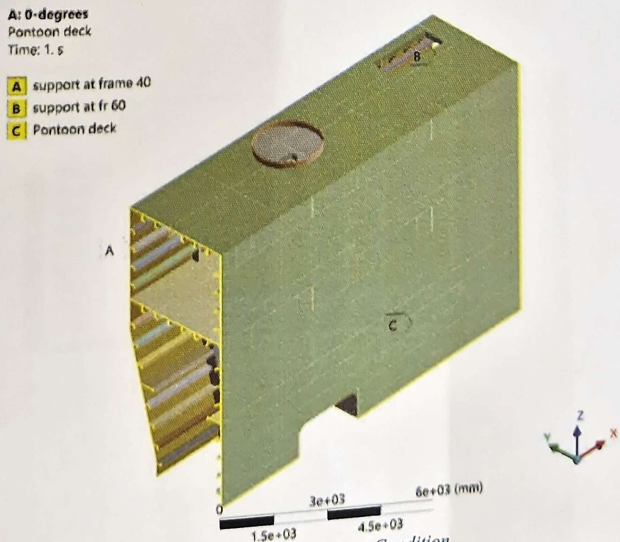


Figure 20 Boundary Condition

CHAPTER 12

12.1 Analysis Result Plot for Loading Condition

- Simulation Type is set to Static and Analysis Type is set to Linear Static Structural.
- The stress plots for the loading condition with overturning moment in 0 degree is shown below as the stress values are the highest in the same.

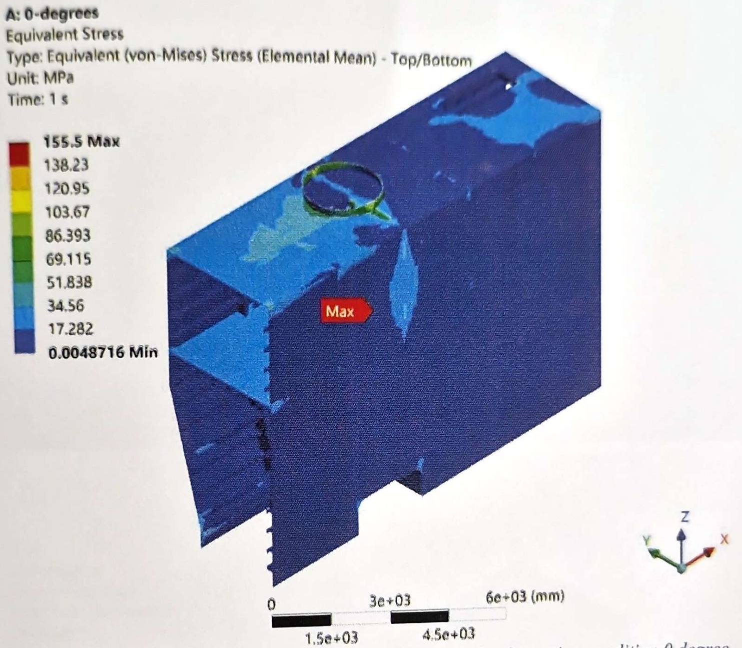


Figure 21 Equivalent Von-Mises Stress Distribution for Operating condition 0 degree

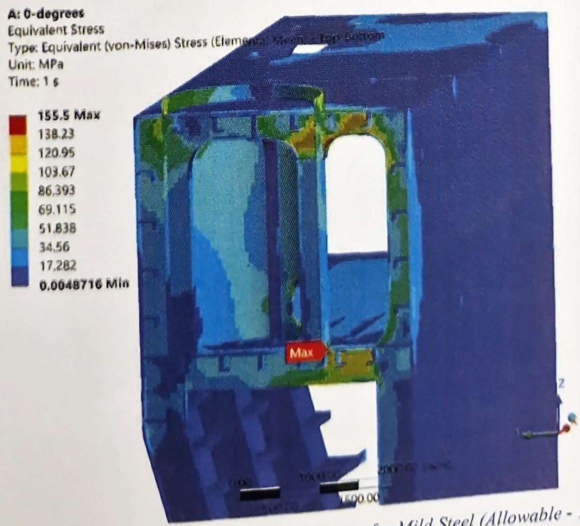


Figure 22 Equivalent Von-Mises Stress Distribution for Mild Steel (Allowable - 173.2 Mpa)

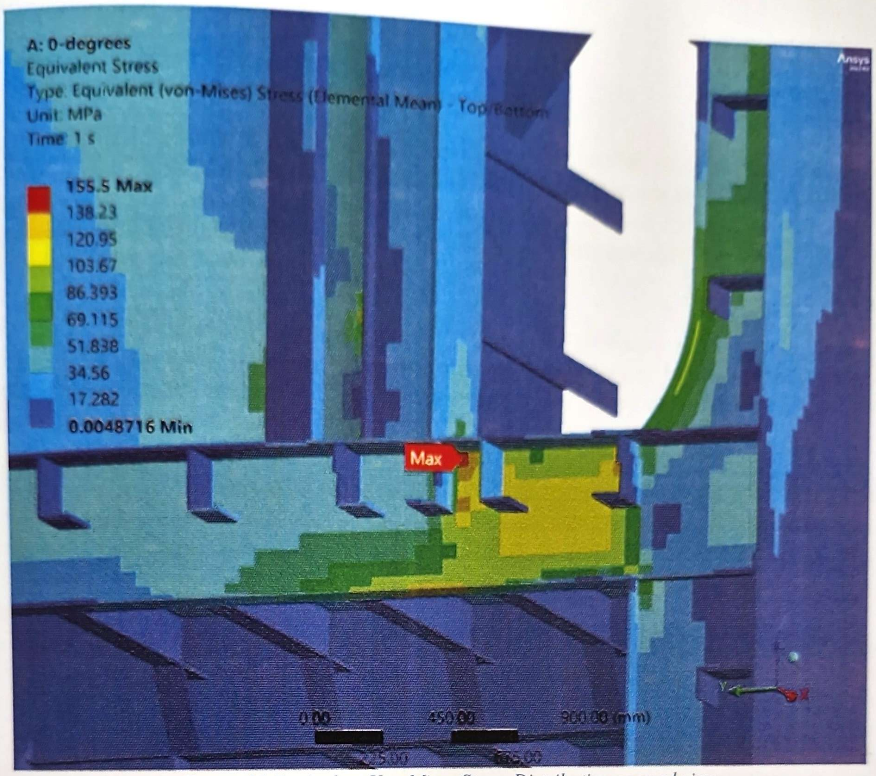


Figure 23 Equivalent Von-Mises Stress Distribution zoomed view

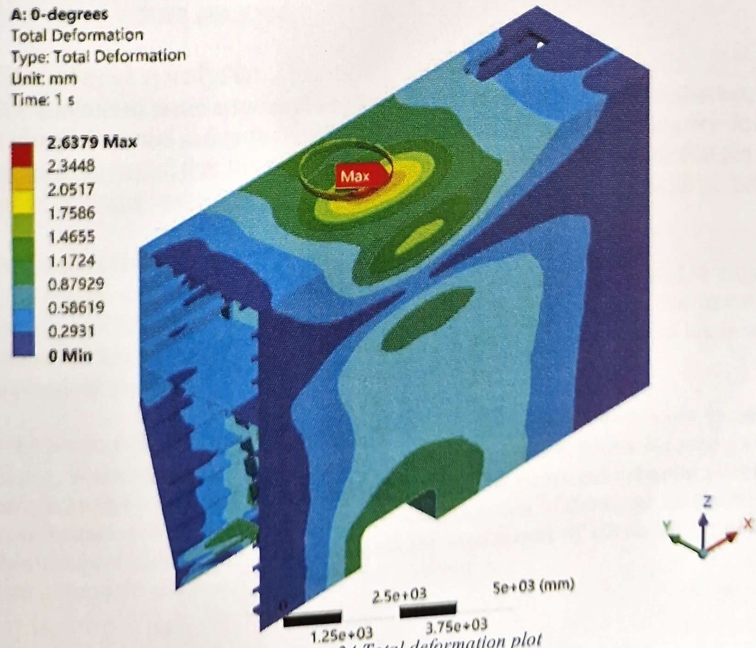


Figure 24 Total deformation plot

CONCLUSION

In this project, we successfully designed and analyzed the installation of a crane on a floating dry dock using a comprehensive approach that involved multiple advanced software tools. The initial model was created using Rhino software, which allowed for precise geometric design and structural detailing. This model was then imported into ANSYS Space-Claim for further refinement and preparation for analysis.

Within ANSYS Space-Claim, we meticulously defined the geometry of the crane foundation and the floating dry dock, ensuring that all critical elements were accurately represented. The refined model was then imported into ANSYS Workbench, where we set up the simulation environment and parameters.

In ANSYS Mechanical, we performed detailed finite element analysis (FEA) to evaluate the structural integrity and performance of the crane foundation and floating dry dock under various load conditions. The analysis process included the following key steps:

Meshing:

- We generated a high-quality mesh to discretize the model into finite elements. This step was crucial for obtaining accurate results, with careful attention to mesh density in critical areas to ensure detailed stress and strain analysis.

Boundary Conditions and Load Application:

- Appropriate boundary conditions were applied to simulate the operational environment of the floating dry dock. The maximum crane load was applied at different angles of operation, with particular focus on the 0-degree angle, where the highest loads were observed.

Static Structural Analysis:

- We conducted static structural analysis to determine the stress distribution, deformation, and safety factors of the crane foundation and floating dry dock. The analysis revealed that the maximum stress and deformation occurred at the 0-degree angle of crane operation, which was a critical finding for ensuring structural safety.

Results Evaluation:

- The results were evaluated to identify potential points of failure and to ensure that the design met all safety and operational requirements. The analysis confirmed that the crane foundation and floating dry dock could withstand the applied loads without exceeding material limits or compromising structural integrity.

Overall, the project demonstrates the effective use of ANSYS software tools, including Space-Claim, Workbench, and Mechanical, in conjunction with Rhino for model creation. The thorough analysis provided valuable insights into the structural behavior under maximum loading conditions, ensuring the safe and efficient operation of the crane on the floating dry dock. This comprehensive approach highlights the importance of advanced simulation techniques in modern engineering design and analysis.

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These references provide a comprehensive foundation for understanding the engineering, design, and technical considerations involved in the crane installation on a floating dry dock, as detailed in this project report.