DESIGN AND MODAL ANALYSIS OF SHIP HULL WITH DAMPING TREATMENT

A Project report submitted in partial fulfillment of the requirements
for the award of the degree of

Bachelor of Technology

in

Mechanical Engineering

Submitted by

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APRIL 2023

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CERTIFICATE

This is to certify that the Project Report entitled **“DESIGN AND MODAL ANALYSIS OF SHIP HULL WITH DAMPING TREATMENT”** being submitted by xx to the Department of Mechanical Engineering, ANITS is a record of the bonafide work carried out by DASARI S R V ARUN TEJESH (319126520177),SHAIK AARIF HUSSAIN (320126520L36) ,GAMINI KRISHNA VAMSI (319126520178) ,CHINTALAPUDI VENKATA SIVA SAI KARTHIK (319126520176) , PADALA AJAY (319126520197) , under the esteemed guidance of **Dr. M PRASANTH KUMAR.** The results embodied in the report have not been submitted to any other University or Institute for the award of any degree or diploma.

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ACKNOWLEDGEMENTS

It is a privilege for us to submit a project report on DESIGN AND MODAL ANALYSIS OF SHIP HULL WITH DAMPING TREATMENT" in partial fulfillment for the award of Bachelor Of Technology in Mechanical Engineering, - Anil Neerukonda Institute Of Technology And Sciences.

We would like to express our profound gratitude and sincere indebtedness to our esteemed guide **Dr. M. Prasanth Kumar** associate professor Dept. of Mechanical Engineering, Anil Neerukonda Institute of Technology And Sciences, for his inevitable support, timely guidance and time he has devoted towards us in doing this project.

We intend to express our sincere thanks with our obedience to our Principal Prof.**K. Sri Rama Krishna** , Head of the Mechanical Engineering Department prof. **Dr. B . Naga Raju.** We also convey our sincere thanks to our Department faculty and non-teaching staff for their kind cooperation and motivation.

Finally we thank one and all who directly as well as indirectly helped us in the completion of this project.

ABSTRACT

This research project aims to investigate the natural frequencies of ship hulls builded with various materials like Structural Steel , Aluminium Alloy and a Fibre Reinforced Polymer like Vinyl Ester . And also compare the results for the natural frequency of the ship hull having a layer of damping material like Neoprene material.

The methodology adopted to find the natural frequency of the ship hull is by analysing the ship hull model by performing the modal analysis in Ansys workbench and generating the results for different modes of the ship hull to know their resonant frequencies.

The research work has concluded that the mechanical properties are directly related to natural frequency and vibration mode shapes. The results of Modal Analysis show that the Natural frequencies of the ship hull made up of Fibre Reinforced fiber have the highest value in comparison with other other two materials ie: Aluminium Alloy and Structural Steel. Also the value of the resonant frequencies is increased when a layer of Damping material is added on the inner surface of the ship hull.

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NOMENCLATURE

A	Area , mm^2
GPa	Giga Pascal
MPa	Mega Pascal
Hz	Hertz
mm	Millimeter
m	Meter
°C	centigrade
ft	feet
%	Percentage elongation
gm/cm^3	Density
W/m-k	Thermal conductivity

CHAPTER 1

INTRODUCTION

1.1 About Ship Hull

Ship structure design and analysis has always been a very important and active field of scientific research in an effort to make those structures more reliable and cost effective. The simplest structural description of a ship is that its hull is a beam designed to support the numerous weights that rest upon it (including its own weight), to resist the local forces produced by concentrated weights and local buoyant forces, and to resist the several dynamic forces that are almost certain to occur.Therefore the hull of a ship is the most notable structural entity of the ship.

To define the hull, it can be said that it is the watertight enclosure of the ship, which protects the cargo, machinery, and accommodation spaces of the ship from the weather, flooding, and structural damage. The hull of a ship is typically divided into several sections, such as the bow, stern, port, and starboard sides. The bottom of the hull is called the keel, which runs the length of the ship and provides a foundation for the rest of the structure. The sides of the hull are usually shaped like a curved, streamlined surface to reduce drag and increase speed.

Fig 1.1: ship hull

There are several types of ship hulls, each designed for specific purposes. For example, a displacement hull is designed to move through the water at a slower speed, while a planing hull is designed to ride on top of the water at higher speeds. Additionally, some hulls are designed to be more stable in rough seas, while others are designed to be more agile and flexible . The shape and design of a ship's hull can greatly affect its performance, including its speed, fuel efficiency, and flexibility. As a result, hull design is an important consideration in the construction of any vessel.

1.1.1 Types of ship hulls:

The hull is the lower part of a vessel that comes in direct contact with the water and is generally waterproof. It is one of the most essential parts of a ship that determines the motion of the ship and other factors, all of which depend on its size, shape and form.

There are a variety of hull forms used for different ships, each designed to suit the capacity, stability, hydrodynamics, functionality and appearance required for the shipHulls may be designed based on the type of lift used to keep it afloat, namely dynamic lift, buoyant lift and powered lift. Vessels like hydrofoils employ a dynamic lift, vessels like a catamaran may employ a buoyant lift and vessels like a hovercraft employ a powered lift.

Hulls based on the type of lift used are:

a) Displacement Hulls b)Planing Hulls c)Semi-displacement or Semi-planing Hulls

a) Displacement Hulls

Large ships, some trawlers and traditional recreational sailboats have displacement hulls. They are slower moving but quite steady under way and are capable of carrying large loads with relatively small propulsion units. Displacement hulls are usually round on the bottom with ballast placed low in the center. At rest, round hulls tend to roll with the waves and swells.

Fig 1. 2 Displacement Hulls

b) Planing Hulls:

Most powerboats and personal watercraft have planing hulls that ride on the water at higher speeds. They behave like displacement hulls at low speed but pop up onto a plane usually around 15-16 MPH depending on the design and load .

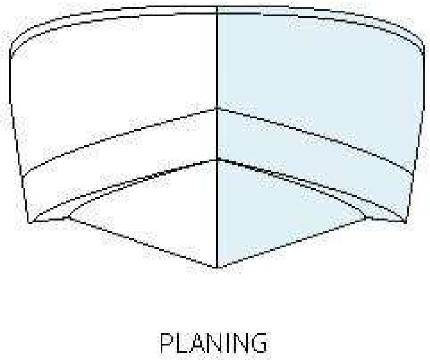

Fig .1.3 Planing Hulls

- **Flat Bottom :**

Flat-bottomed boats are very stable and can carry a heavier load. They require only a small engine to get on a plane but can ride rough and wet in chop or heavy weather. Small aluminum or fiberglass bay and fishing boats often benefit from flat hulls, which have a shallow draft.

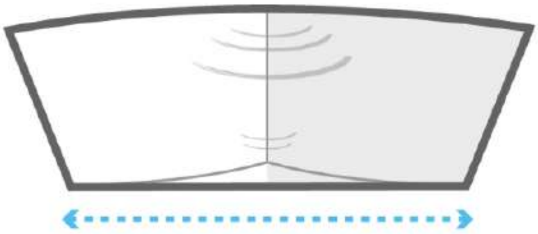

Fig 1.4 Flat bottom

- **V-Bottom:**

Deep V hulls cut through waves and ride smoothly in chop. They take a bit more power to push up onto a plane, tend to roll or bank in sharp turns and due to the angle of the hull, have less interior volume for stowage or accommodations. Fast, distance fishing boats like center consoles tend to have a V bottom so they can run fast on open water to get to the fishing grounds quickly.

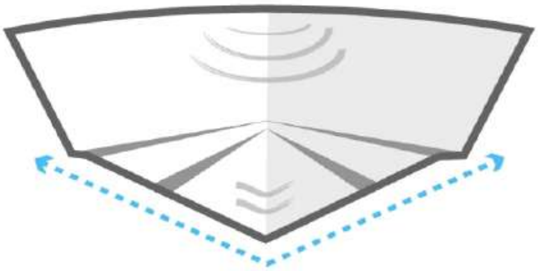

Fig 1.5 V bottom

- **Tri-Hull or Tunnel Hull :**

Popular with fisherman as well as with sport boat enthusiasts, tri-hulls, also called cathedral hulls, have a combination M-shaped bottom. They’re quite buoyant and stable and they get on plane quickly. They offer good volume below and significant deck space above. At speed, they tend to pound when they encounter choppy water so they’re ideal for lakes of calm bays.

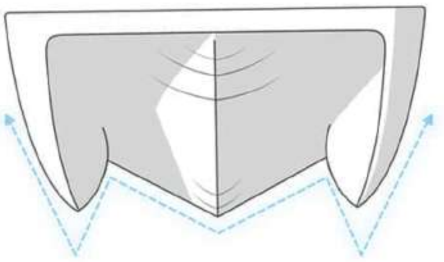

Fig 1.6 Tri hull

- **Pontoon :**

Pontoon boats ride on (typically) aluminum tubes. Traditional pontoons have two tubes but newer designs have three and are called tritoons.The newer tritoons can large outboards and so they've become planing boats capable of towing for water sports or reaching distant fishing spots.

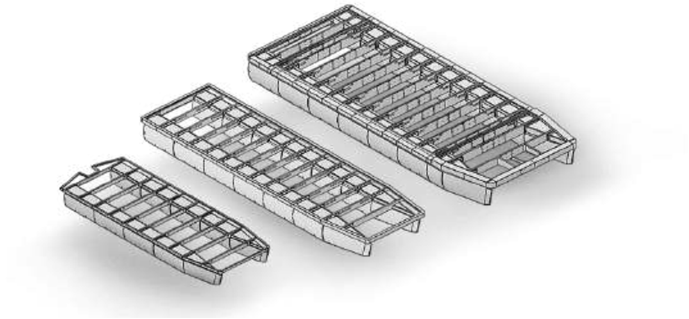

Fig 1.7 Hull structure

c) Semi-Planing / Semi-Displacement Hull:

Cruise ships and luxury yachts are the best examples of semi-planing or semi-displacement boats. The design range is quite diverse, so the specs will depend on your particular needs. But the idea is that the hull has a composite surface to facilitate the various sailing features.

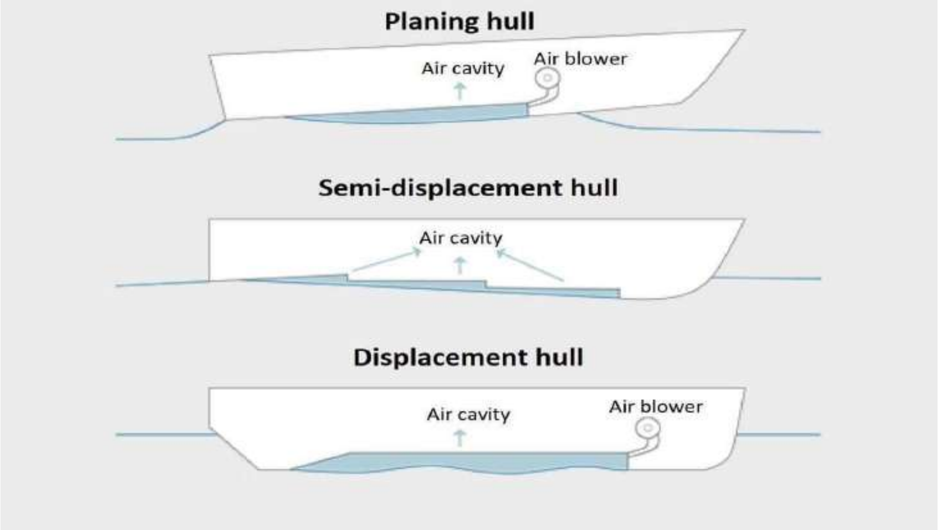

Fig 1.8 Semi displacement hull

For example, you need speed between destinations, and maneuverability as you dock at every port.Massive storage space is essential for the passengers, their gear, and their … by-products. You also want a boat that stays stable as it faces deep-sea currents and creatures.

The draft (that’s the section of the hull that stays submerged) has straight bits, angular bits, and curved bits to allow for all this. Ocean trawlers and container ships can also have a semi-planing hull. These semi boats have Vs and wedges at the front and get rounder at the stern.

1.1.2 Nomenclature of Ship Hull:

The hull form of a ship may be defined by a number of dimensions and terms which are often referred to during and after building the vessel. An explanation of the principal terms is given in fig 1.9 for reference to understand the basic dimensional parameters.

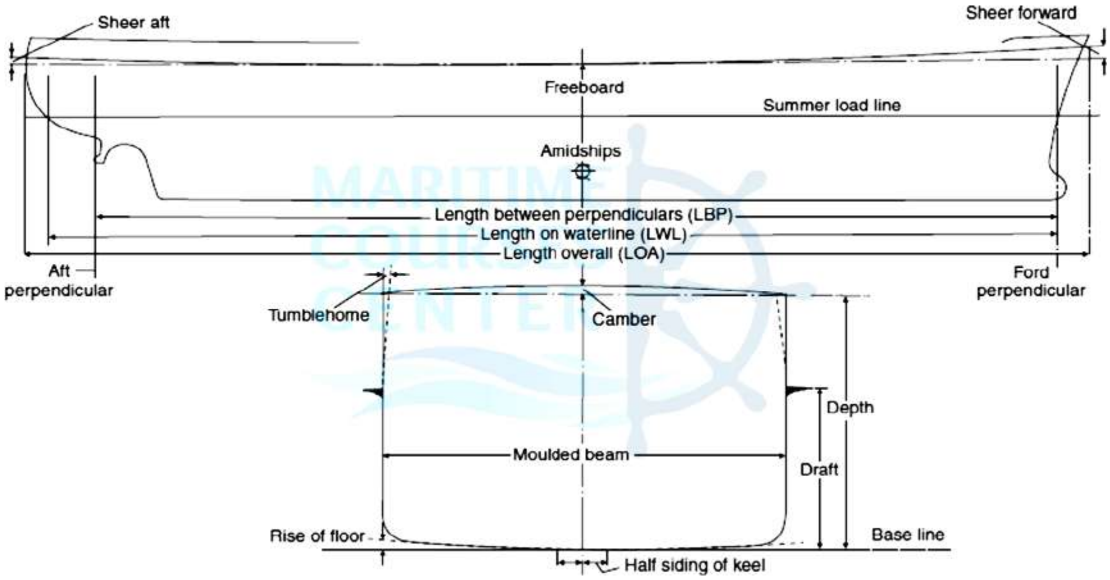

Fig 1.9 Nomenclature of ship hull

a) **Bow and Stern:**

The forward most contour of the ship's hull is called the bow, and the aft-most, its stern. The stem is the forward most contour part of the Bow.

b) **Base Line:**

A horizontal line drawn at the top of the keel plate. All vertical moulded dimensions are measured relative to this line. Moulded Beam: Measured at the midship section is the maximum moulded breadth of the ship

c) **Moulded Draft:**

Measured from the base line to the summer load line at the midship section.

d) **Moulded Depth:**

Measured from the base line to the heel of the upper deck beam at the ship's side amidships.

e) **Extreme Beam:**

The maximum beam taken over all extremities.

f) Extreme Draft:

Taken from the lowest point of keel to the summer load line.

g) Forward Perpendicular:

If a perpendicular is drawn at the point where the bow intersects the waterline, this imaginary perpendicular line is called the forward perpendicular. For most of the hydrostatic calculations, the forward perpendicular is used as the forward reference of the hull.

h) Aft Perpendicular:

Depending on the designer, the aft perpendicular can be the perpendicular drawn through the aft side of the rudder post or through the center-line of the rudder pintles. The aft perpendicular is the aft reference line for all hydrostatic calculations.

i) **between Perpendiculars**:

The length between the forward and aft perpendiculars is the length between perpendiculars. The LBP is a very important parameter in all stability calculations, hence calculation of the LBP at various drafts becomes an important step in carrying out stability analyses.

j) Sheer:

The upward curve formed by the main deck with reference to the level of the deck at the midship, is called sheer. It is usually given to allow flow of green water from the forward and aft ends to the midship and allow drainage to the bilges. The forward sheer is usually more than the aft sheer to protect the forward anchoring machinery from the waves.

k) **Length of Waterline**:

The length of the ship's hull at the summer load line is the length of waterline for the ship. This length plays an important role in the calculation of hydrostatics of the ship, as well as propeller design calculations.

l) Length Overall:

The length between the forward-most and aft-most point of the ship's hull is its overall length. This length plays a major role in designing the docking and undocking plans of the ship. In shipyards where multiple building docks are available, the overall length, beam, and depth of the ship is a deciding factor in choosing a suitable building block for the ship.

1.2 Materials used in building of a ship hull:

Generally four main materials are mostly used in the designing of a ship hull which are categorized below:

1.2.1 Steel:

Steel is the most popularly used material for construction of ship hulls and has been the material for choice over the last century due its high strength, durability and resistance to abrasion.

But the weight of steel is very high in comparison with other materials which are used for the construction of ship hulls.

Table no 1.1 : Properties of Structural Steel

Young's Modulus	2e+11 Pa
Poisson's Ratio	0.3
Bulk Modulus	1.667e+11 Pa
Shear Modulus	7.6923e+10 Pa
Isotropic Coefficient of Thermal Expansion	1.2e-0.5 1/°C
Compressive Ultimate Strength	0 Pa
Compressive Yield Strength	2.5e+08 Pa

1.2.2 Aluminium Alloy:

Aluminum is preferred by a lot of ship manufacturers on account of its being lightweight, especially when compared with the steel. Aluminum ship hulls are also more stable and can travel faster due its reduced weight. This means that the ships will get better mileage for the same quantity of fuel.It has better properties like chemical and corrosion resistance and tendency for plastic deformation makes aluminum a strong option for ship hull building.aluminium is more soft and also can be recycled like steel.
But due its cost is expensive we won't see more ships of aluminum in comparison with the structural steel.

Table no 1.2 : Properties of Aluminum Alloy

Young's Modulus	7.1e+10 Pa
Poisson's Ratio	0.33
Bulk Modulus	6.9608e+10 Pa
Shear Modulus	2.6692e+10 Pa
Isentropic Coefficient of Thermal Expansion	2.3e-0.5 1/ °C
Compressive Ultimate Strength	0 Pa
Compressive Yield Strength	2.8e+08 Pa

1.2.3 Fibre Reinforced Plastic (FRP):

Fibre Reinforced Plastic has come to heavily dominate the ship hull material sector over the past few decades as this material has light , speedy , strong , watertight, durable and corrosion free makes it a great option for use in the shipbuilding industry. One of the most important factor on the selection of FRP for ship hull is because it will not create any adverse effects on the marine ecosystem

Table No 1.3 : Properties of FRP - Vinyl Ester

Density	1.7-1.8 (gm/cm^3)
Tensile Strength	30.3 - 993 Mpa
Young's Modulus	3.72 - 94.5 Gpa
Poisson's ratio	0.3 - 0.33
Thermal conductivity	0.300 - 46.2 W/m-k

1.2.4 Polyethylene:

The polyethylene has high strength to weight ratio and has greater buoyancy and impact resistance making it suitable for ship construction. But the major disadvantage is it is not structurally very stiff as compared with aluminum and fiberglass. Also it cannot withstand higher temperatures and becomes brittle with time.

Table no 1.4 :Properties of Polyethylene

Young's Modulus	1000 Mpa
Shear modulus	750 Mpa
Tensile strength	26 Mpa
Elongation	590 %
Fatigue	19 Mpa
Bending strength	32.5 Mpa
Hardness	63.5 shore
Impact Strength	5.85 J/cm

1.3 Types of forces exerted on the Ship Hulls :

A ship is subjected to stresses from a complex system of forces and the structure must be braced and supported to withstand any reasonable combinations of load at a given time. The cost and weight in the construction of a ship must be balanced against strength, rigidity, sea worthiness and cargo capacity. The structure of a ship is subject to two basic types of force, namely Static and Dynamic forces. The former is produced by gravity, i.e. the forces exerted by weight and water pressure. The latter are produced by such actions as rolling, pitching and heaving.

1.3.1.longitudinal stresses:

There are four main types of longitudinal stresses:

a) **Sagging**.

Sagging stresses are caused by the uneven distribution of weight and buoyancy in the length of the hull. If a ship is supported on either end by the crest of a wave, the stress exerted by the waves on the buoyancy of the vessel would tend to lift the ends, whilst the center of the vessel would suffer a loss of buoyancy and tend to sag. This type of stress is known as sagging.

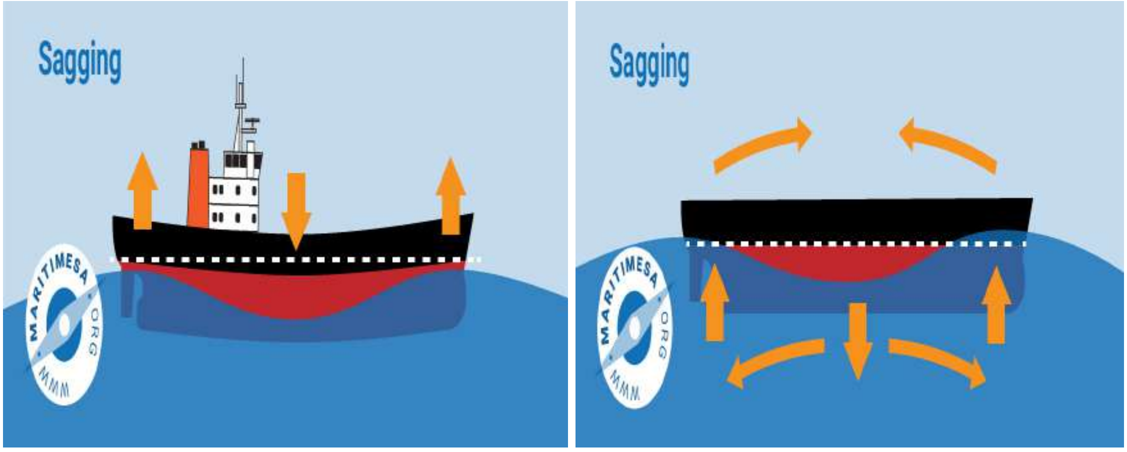

Fig 1.10 Sagging

b) **Hogging**

When the wave passes the reverse situation results, i.e. the middle of the vessel is supported on the crest whilst the two ends hang over the crest on either side. This action is known as hogging.

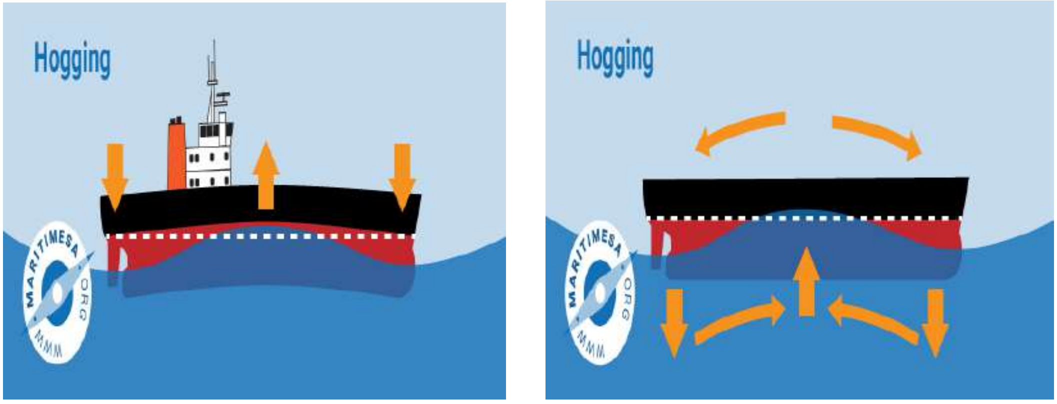

Fig 1.11 Hogging

c) **Vertical shear forces:**

Because a merchant vessel has a number of compartments along the length of the hull, there may be a difference in the loading of these compartments. The forces of gravity and buoyancy would then tend to differ from compartment to compartment and where transverse bulkheads are situated one would experience vertical shear forces.

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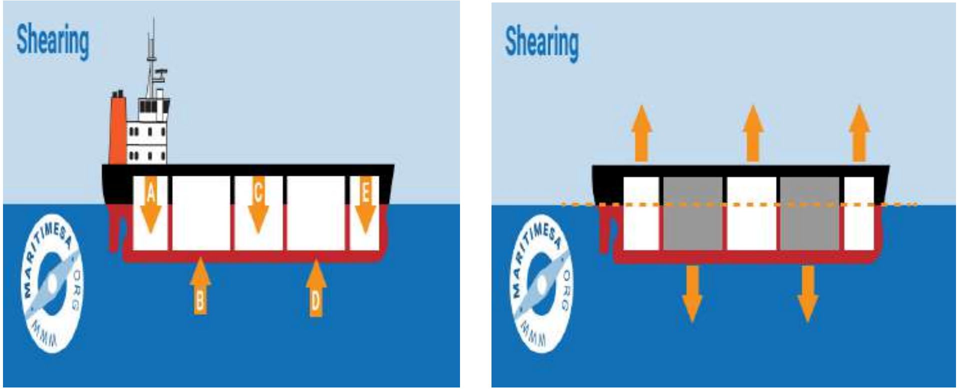


Fig 1.12 Shearing

d) **Torsional forces**:

If a vessel is subjected to pitching and rolling at the same time, ie taking the wave on either bow, the vessel tends to twist longitudinally. These are known as torsional stresses or forces.

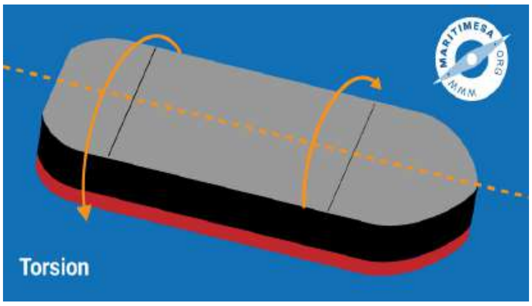


Fig 1.13 Torsion

1.3.2 Transverse stresses:

There are three main types of transverse stresses:

Racking:

When a vessel is rolling in a seaway the transverse section will try to distort corners due to racking stresses.

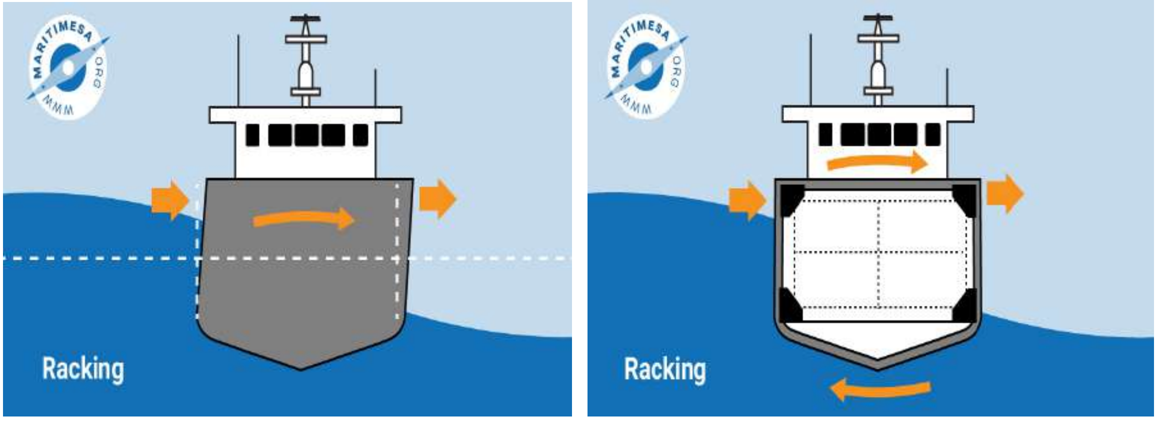


Fig 1.14 racking

Water pressure: Water acts perpendicular to the surface of the submerged hull and increases with depth.Hull should resist this stress.

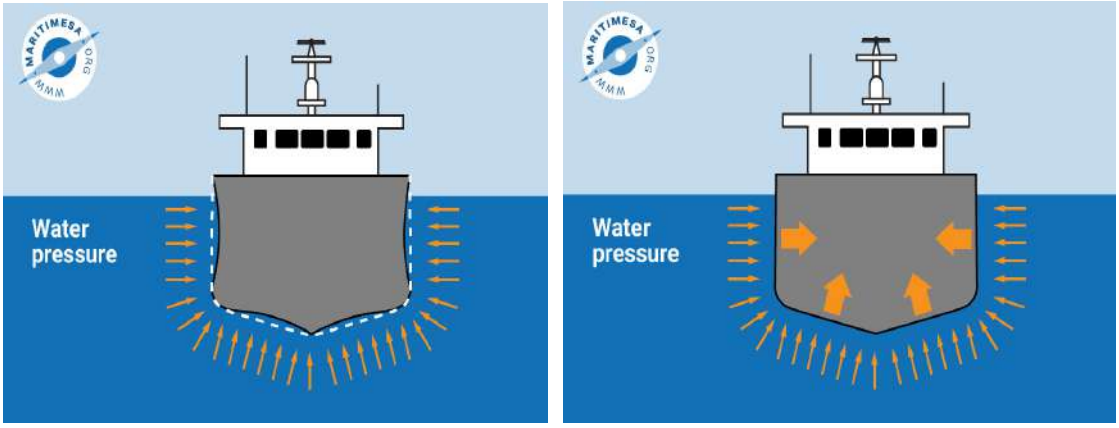


Fig 1.15 water pressure

Docking stresses :

When a ship is dry docked the thrust from the water is removed. The hull on either side of the keel strake tends to sag downwards and the beams are in tension. Keel blocks, bilge blocks and side shores are needed to support the ship. The arrangements of keel and bilge blocks are different for each class of ship. Side shores (wooden balls of timber) also differ from ship to ship.

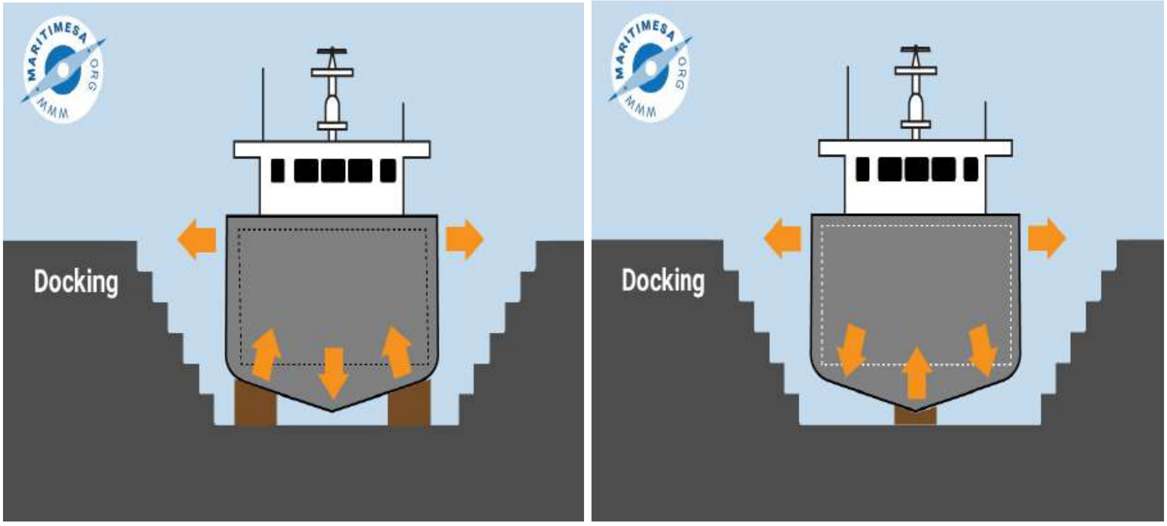


Fig 1.16 docking

1.3.3. Local stresses:

Again there are three main types of local stress:

a) **Panting**:

When the ship is under way in a seaway, she is subjected to changes in pressure caused by the waves and the pitching of the ship. The variation of pressure at the ends causes the ship to vibrate due to panting stresses. Panting has a concertina type of effect on the hull.

b) **Pounding**:

As the ship pitches into a head sea excessive pounding may occur in the forward section of the hull if the vessel is not fully loaded.occurs at the bottom plating of a ship near the bow during excessive pitching.

c) Middle weight stresses:

The concentration of heavy weights along the centerline of the hold causes the sides to tend to collapse inwards.

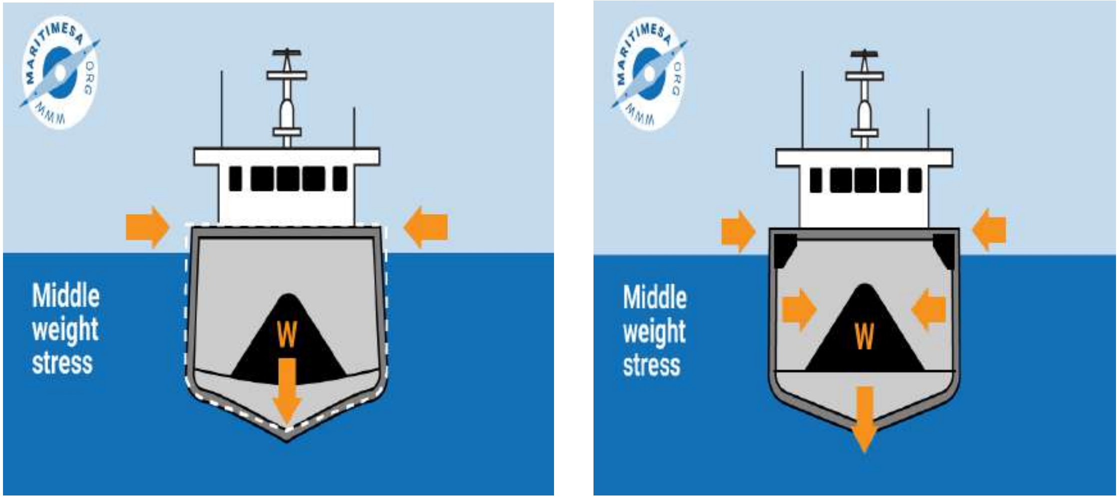


Fig 1.17 Middle weight Stresses

1.3.4 Wave excitations :

Waves can excite hull girder vibrations either through slamming impacts, also known as whipping, or through resonance between the encounter frequency of the waves and one of the hull girder natural vibration modes (springing). Whipping is more transient in nature compared to springing, but both phenomena can be avoided by changing the speed and or heading of the vessel and they usually do not cause major structural or habitability issues. The exception may be when slender installations exist on the deck of the vessel, such as the flare tower on ship shaped hydrocarbon production and process systems that are not able to change their speed or heading. Vertical whipping vibrations of the hull girder can, under certain circumstances, cause resonance of slender installations and subsequent fatigue issues

1.3.4 Propeller Excitations:

Excitation from the propeller is transmitted to the rest of the ship structure through the shell plating above the propeller (surface forces) and through the shaft line (bearing forces). Both propeller surface and bearing forces are significantly exacerbated by hull wake nonuniformity. If the propeller disc fluid inflow is circumferentially uniform, propeller-induced vibrations would not have to be considered during the ship design. Therefore, attention should be paid to the design of the after-body and appendages to achieve a uniform wake field to the greatest extent possible.

1.3.5 PROPELLER SURFACE FORCES :

Propeller surface forces are the predominant propeller excitations, especially for cavitating propellers. They account for approximately 90 percent of propeller caused ship vibrations. They act mainly in the vertical direction on the horizontal part of the ship’s bottom above the propeller.

Therefore, they directly affect the vertical vibrations of the stern (“fan-tail mode”), and consequently, the fore and aft superstructure vibrations by way of rotation. However, propeller surface forces are generally incapable of exciting the global hull girder modes to significant levels. The largest component of the propeller surface forces is a harmonic oscillation at the blade rate frequency. Harmonics at twice the blade rate frequency have, in general, half of the amplitude of the blade rate harmonic.

Higher blade rate harmonics will have even smaller amplitudes. A full power blade rate harmonic has a frequency typically in the range of hull girder natural vibration modes with seven or more nodes. Surface pressure amplitudes of the full power blade rate harmonic more than eight kPa can be considered as high and those below two kPa considered as low.

1.4 Vibrations on Ship Hulls:

1.4.1 Introduction to Vibration:

Before we go into the types of vibration, it's essential to understand what vibration is. "A vibratory motion is produced when elastic bodies are displaced from their equilibrium position by external forces and subsequently released".

1.4.2 Types of Vibration:

Understanding the several types of vibration is necessary to comprehend vibratory motion, which can be desirable or undesirable depending on the situation. There are three different types of vibration.

- Free or Natural Vibration
- Forced Vibration
- Damped Vibration

- **Free or Natural Vibration**

It is considered free or natural vibration when no external force operates on the body after it has experienced an initial displacement. Free vibration occurs when a mechanical system is started in motion with an initial input and allowed to vibrate freely.The amplitude appears to be diminishing over time.

Types of Free Vibration:

There are mainly three types of free vibration that an object may experience.

a) Longitudinal Vibration

b) Transverse Vibration

c) Torsional Vibration

a)Longitudinal Vibrations:

The vibrations are known as longitudinal vibrations when the particles of the shaft or disc travel parallel to the shaft's axis. In this situation, the shaft is alternately lengthened and shortened, causing tensile and compressive stresses to be created in the shaft.

b)Transverse Vibrations:

The vibrations are known as transverse vibrations when the particles of the shaft or disc move approximately perpendicular to the shaft axis. In this scenario, the shaft is straight and bent, causing bending stresses in the shaft.

c)Torsional Vibrations:

Torsional vibrations occur when the particles of the shaft or disc move in a circle around the shaft's axis, as seen in the figure. The shaft is twisted and untwisted alternatively in this scenario, causing torsional shear stresses.

- **Forced Vibrations**

Forced vibration occurs when a mechanical system is subjected to a time-varying disturbance (load, displacement, velocity, or acceleration). A periodic and steady-state input, a transient input, or a random input can all be used as disturbances.

The frequency of the steady-state vibration response resulting from the application of a periodic, harmonic input is equal to the frequency of the applied force or motion for linear systems, with the size of the response being dependent on the particular mechanical system.

- **Damped Vibration:**

Vibrations are considered to be damped when the energy of a vibrating system is progressively absorbed by friction and other resistances. The vibrations progressively decrease in frequency or intensity or stop altogether, and the system returns to balance.

1.4.3 About Vibration on Ship Hull:

As the size, power and speed of marine structures increase and their structures are becoming more optimized,vibration related problems are becoming more frequent. Recent design trends of locating machinery and accommodation spaces further aft and the predominant use of low-speed direct drive main diesel engines contribute to the increase of vibration related issues.Excessive structural vibration levels usually lead to three main types of problems:

a) Fatigue cracks in local structural elements

b) Decrease in habitability and comfort

c) Malfunction of installed machinery and electrical instruments

It is important to consider vibration at a vessel’s early design stage when significant improvements of the design are still possible at a relatively modest cost and make the system a safe design.

1.4.4 Ship Vibration Analysis:

The purpose of vibration analysis is to estimate the resonant frequency of the ship hulls at which the system starts vibrating.The approach for analysis of ship vibration as shown below in the flow chart:

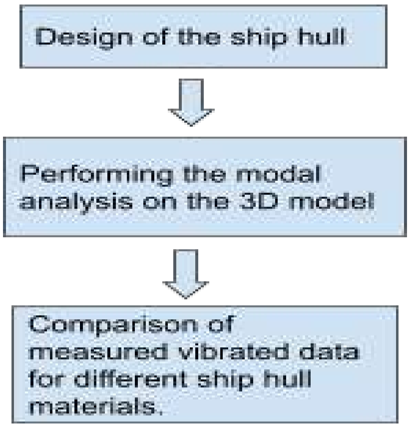


Fig 1.18 Ship vibrational analysis flowchart

Regardless of the ship design stage, vibration analysis methods can be divided into two main types:

- Free Vibration Analysis
- Forced Vibration Analysis

Free Vibration Analysis solves the equations of motion of an undamped system without any excitation forces. It seeks to identify the natural frequencies (also called eigenvalues or eigenfrequencies) of vibration of the structure at which it will tend to vibrate if disturbed. Associated with every natural frequency is its natural mode (also called eigenmode) which represents the relative deflection shape of the structure as it vibrates at a particular natural frequency. It is important to note that the free vibration analysis does not calculate the response of the structure to any particular excitation in absolute terms. It only identifies the natural frequencies of the structure, while its associated natural modes represent the structure's deflection shapes in relative terms. These mode shapes are usually scaled so that the largest amplitude of vibration in the structure is one unit. Damping in the structure has a minor influence on its natural frequencies and is usually neglected during the free vibration analysis.

Forced Vibration Analysis solves the equations of motion of the damped system with acting excitation forces or moments. There are two main subtypes of forced vibration analysis depending on the type of the excitation forces:

- Transient Response Analysis (TRA)
- Frequency Response Analysis (FRA)

Forced Vibration Analysis can be performed at any stage of the ship design process. However, it is normally performed at the detailed design level or after construction to determine the root cause of vibration problems. The uncertainty regarding the ship structure and its excitation forces at the concept design stage usually does not justify the use of advanced forced vibration analysis.

Therefore summarizing the ship vibration analysis :

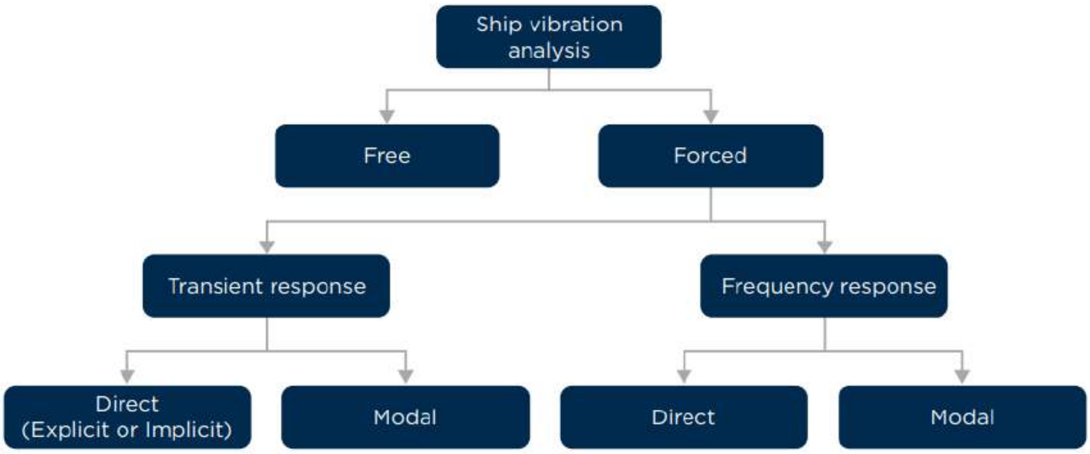


Fig 1.19 Summary of ship vibrational analysis

1.4.5 Main Elements influencing the ship vibration

Figure 1.22 shows the main elements influencing ship vibrations. Therefore, vibration mitigation measures can be taken by modifying any subset of these elements in such a way as to minimize the negative impact of vibrations on humans, ship structure, or machinery.

Fig 1.20 element influencing ship vibration

1.4.6 Effects of vibrations on ship hulls

One of the most common and dreaded problems onboard ships is high levels of vibration. The two most noticeable effects this vibration has on the ship is structural fatigue and discomfort of crew/passengers,Torsional failure of the shaft

Due to the thrust generated by the propeller shaft and blades may get damaged and due to eccentricity the whirling of the shafts takes place.

So due to the low speed diesel engines and machinery equipment of the ship hulls there will be some unbalanced forces developing on the internal structure of the system and causes periodic thrust due to which the components of the system may get damaged and machine system will start vibrating before its failure which effects in structural damage , loss of money , more amount of fuel consumption .

Therefore, fatigue and impact failures of the component take place on the grider system , machinery malfunctions .

CHAPTER 2

LITERATURE REVIEW

Y. LAKSHMI PRASANNA[1], DR. AMAR NAGESWARA RAO[2] [1] discussed that The ship, during operation experiences complex loading conditions, which is generally divided into few categories: Linear Static and Dynamic Loads, Thermal Loads and Complex Non-Linear Dynamic Loads. Generally the loading on the ship is a combination of some or all of the load categories mentioned above, depending on the type of the ship. This is dedicated to Modal and Static Analysis. Static Analysis is usually done to find the overall strength of the structure. For this, different load conditions etc. are also considered. In the domain of Modal Analysis and Static Analysis is done for ship shell to check the stability of its structure. In this different mode shapes at natural frequencies and at different load conditions the ship structure deformations and stresses are evaluated.

J. SURESH BABU[1], R. MAHESH[2], DR. D. RAVIKANTH[3] [2] Discussed that The objective of the present thesis is to study the structural behaviour of a ship hull structures subjected to bending, shearing and torsion by using finite element solutions. And one of the most active fields of ship hydrodynamics research today is the development of methods for computing the drag coefficient of the steady, free-surface, viscous flow around a ship hull. Experimental tests are often used as a reliable method for the prediction of ship performance. Nowadays, with the development of new numerical tools, advancements in computer technology and improved data processing capabilities, Computational Fluid Dynamics (CFD) has made remarkable progress. This has allowed ship designers to create a computer-generated model of a ship and check its performance, at various speeds, in a simulated environment, for subsequent optimization processing. The results from the CFD simulations are necessary to understand the complicated flow characteristics for an optimal hull design and to establish low drag and high propulsive efficiency. This allows the designers to predict if the total resistance of the ship is at an acceptable level. This project describes a Computational Fluid Dynamics (CFD) Analysis of a ship hull design

Ye Lu ,[1] Juan Liu,[2] Bei Teng,[3] [3] discussed that that a 20,000 TEU container ship with an overall length of about 400m is designed as a target ship to investigate ship hydroelastic characteristics in the joint industry project (JIP) of CSSRC-20,000 TEU. A set of systematic model tests are carried out in the seakeeping wave basin of CSSRC. The large-scale ship model data for hydroelastic experiments are presented with the determination of modal features. The modal test of the containership model is the premise of the hydroelastic analysis. The test of the natural frequency and modal shape of the ship model can be used to corroborate the accuracy of the finite element modeling. A three-dimensional. A finite element model (FEM) of the ship is employed to carry out modal analysis in a vacuum and provide modal parameters to decide the large-scale ship model data for hydroelastic experiments. Through the analysis of hydroelasticity, the wet frequency corresponding to the motion of each elastic mode is obtained. Only when the numerical calculations of the dry and wet modes are consistent with the experimental results, the containership model's calculated motion responses and structural loads are comparable to the experimental results. Therefore, examining the modal tests is extremely important for hydroelastic analysis. As the input data, the FEM will be shared with JIP members for further comparative studies of linear and nonlinear hydroelastic analyses. e experiments help provide reliable and accurate benchmark model test data for comparative studies using numerical software and methods.

Alice Mathai[1] , George John P.[2] , Jini Jacob[3] [4] discussed that the Direct Strength Analyses are meant for evaluating the yield strength and buckling strength using net dimensions of primary strength members of the container carrier. The paper deals about the automation of direct strength analysis procedures using ANSYS. The stresses at different locations are calculated due to internal cargo load, ballast load, and the external hydrodynamic sea pressure for specific load cases. The still water bending moment (SWBM) has been picked from loading manuals. The wave bending moments (WBM) are calculated from JBP Rules. The effects of SWBM & WBM are applied to the structure with proper load combination factor and local hull girder moment correction. The results are extracted using a general post-processor of ANSYS for checking yielding, buckling and ultimate strength. The overall safety of the vessel is checked.

Andrea Alaimo[1], Alberto Milazzo[2] , Davide Tumino[3],c[5] discussed that . In this paper a structural Finite Element analysis of a 50 ft pleasure vessel is presented. The study is performed under different loads conditions: modal analyses have been done in order to find the natural frequencies of the vessel, structural analyses to verify the strength of the vessel to design loads. The design loads for the vessel considered are computed according to RINA rules for the construction and classification of pleasure vessels [1]. Two different composites are used for the lamination: one is a monolithic sequence of short fibre and balanced glass lamina, used for the bottom of the vessel and for structural reinforcements, the other is a sandwich made of glass fibre composite skins and a PVC core, used for the main deck and sides of the vessel. All the analyses are performed by using Patran/Nastran™ finite element commercial software in order to identify critical areas where possible reinforcement or redesign needs to be considered.

Adil Yucel & Alaeddin Arpaci [6] With increases in ship size and speed, shipboard vibration becomes a significant concern in the design and construction of vessels. Excessive ship vibration is to be avoided for passenger comfort and crew habitability. In addition to the undesired effects on humans, excessive ship vibration may result in the fatigue failure of local structural members or malfunctioning of machinery and equipment. The propeller induces fluctuating pressure on the surface of the hull, which induces vibration in the hull structure. These pressure pulses acting on the ship hull surface above the propeller are the predominant factor for vibrations of ship structures are taken as excitation forces for forced vibration analysis. Ship structures are complex and may be analyzed after idealization of the structure. Several simplifying assumptions are made in the finite element idealization of the hull structure. In this study, a three-dimensional finite element model representing the entire ship hull, including the deckhouse and machinery propulsion system, has been developed using solid modeling software for local and global vibration analyses. Vibration analyses have been conducted under two conditions: free–free (dry) and in-water (wet). The wet analysis has been implemented using acoustic elements. The total damping associated with overall ship hull structure vibration has been considered as a combination of the several damping components. As a result of the global ship free vibration analysis, global natural frequencies and mode shapes have been determined. Moreover, the responses of local ship structures have been determined as a result of the propeller-induced forced vibration analysis.

MUHAMM ED SHAHID ALI[1] , Dr.C.G NANDAKUMAR[2][7] Vibration is the oscillatory motion of a structure which is influenced by various excitation forces on it. Vibration of a passenger boat may cause passenger discomfort, structural damage etc. If the frequency of excitation coincides with any of the system's natural frequency, resonance occurs. So the estimation of vibration is important in any passenger vessel. In this paper, the natural frequency of a passenger boat SWTD 75 is determined using a finite element beam model. The comparison has been carried out with classical methods. Suitable boundary conditions have been selected for approximating wave and still water conditions. Free vibration analysis of the boat has been carried out in various load conditions. This may be helpful to determine the condition in which the system vibrates unsafely. ANSYS, finite element software is used for analysis.

Ahmet Ergin[1] ,Levent Kaydıhan[2] and Bahadır Ugurlu[3][8] This paper presents a hydroelastic analysis of a 1900 TEU container ship using finite element and boundary elements. The method of analysis is separated into two parts. In the first part, the in vacuo dynamic properties of the container ship were obtained by using a standard finite element method. In the second part of the analysis, the ship structure was assumed vibrating in its vacuum modes when it is in contact with fluid, and the pressure distribution on the wetted surface was calculated separately for each mode. The fluid-structure interaction effects were calculated in terms of the generalized added mass terms. The wetted surface of the container ship was idealized by using appropriate boundary elements , referred to as hydrodynamic panels. A higher order panel method (linear distribution) was adopted for the calculations. In a further analysis, the wet calculations were repeated using a finite element software (ABAQUS). The wet frequencies calculated from the both analyses were compared, and a very good comparison.

CHAPTER 3

AIM & SCOPE

So we have understood that the design process of a ship hull includes various conditions to follow. The engineers must look into different factors that affect the hull system due to different internal and external excitations which cause some vibrations on the system that result in failure of the body. So we need to find the safe condition for any vibrating body in order to make a safe design. Therefore, in this study we are performing the modal analysis on the ship hull to determine its natural frequency at which the body tends to vibrate. Also performing and comparing the modal analysis results for following materials like Structural steel , Aluminium alloy and Fibre Reinforced plastic (ie: Vinyl ester) and comparing these results by applying a damping material called neoprene rubber on the inner surface of the hull evaluate the both results to know which material has high resonant frequency . so with these results we can build ship with best suitable material mentioned above after performing the analysis which can help marine engineers and naval architects to make research more on damping material to apply on the surface of ship hulls to reduce some vibration level to make the ship hull system safe and can be able to withstand the vibrations caused by the internal and external excitations.

CHAPTER 4

MODELING AND PROPOSED APPROACH

4.1 Introduction to Catia:

CATIA is a powerful Computer-Aided Design (CAD) software developed by Dassault | Systems. It is widely used in industries such as automotive, aerospace, and industrial design for creating 3D models, engineering drawings, and simulations.

CATIA stands for Computer-Aided Three-dimensional Interactive Application and it was first released in 1977. It is a multi-platform software that runs on Windows and UNIX operating systems. The software suite includes various modules such as CATIA Part Design, CATIA Assembly Design, CATIA Generative Shape Design, CATIA Sheet Metal Design, CATIA Drafting, CATIA Kinematics, and CATIA FEA.

CATIA allows designers and engineers to create 3D models from scratch, modify existing designs, and simulate product performance. It is a robust software that can handle complex designs and assemblies with ease. The software is used by various industries including automotive, aerospace, defense, and consumer goods to design and manufacture products. With its powerful tools and features, CATIA helps organizations to reduce product development costs, improve product quality, and speed up time to market.

4.1.1 Steps involved in modeling:

The modeling is done by the following steps:

Step 1: Initially the Line design of Victoria ship hull has been taken as the reference for ship hull modeling.The figure of the line diagram is shown in the next page for reference.

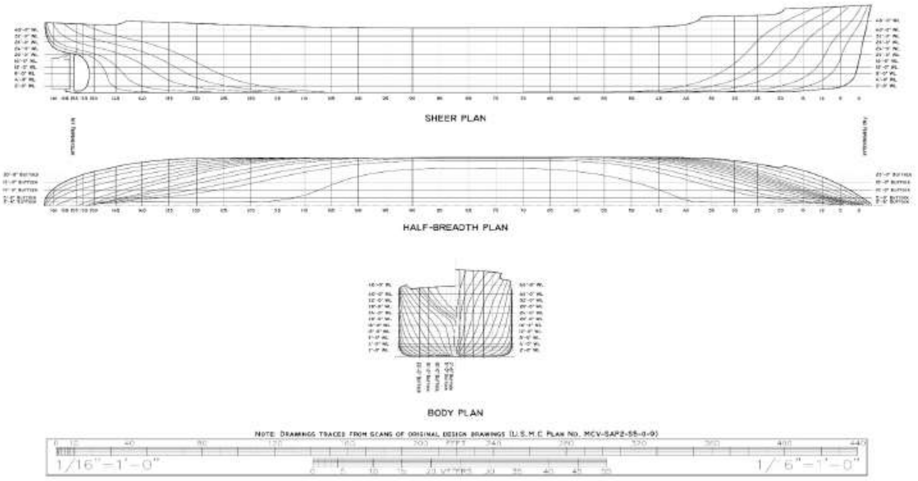


Fig 4.1 Line diagram of of victoria ship

Step 2: Importing the Line design into the Catia Shape Modelling workbench

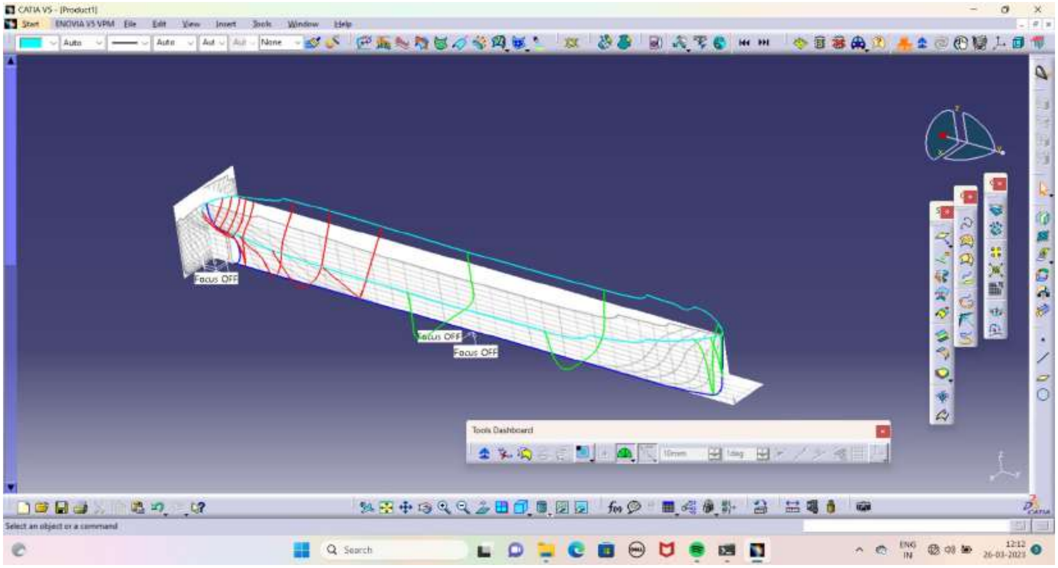


Fig 4.2 Line design of hull in CATIA

Using the 3D curves option from shape modeling workbench . We projected the lines and curves of the line diagram for the ship hull and the following pictures show the line traces and using the shape modeling options the ship hull has been designed and the following images in the next page will show you how the drafted line diagram is converted into a surface modeled entity.

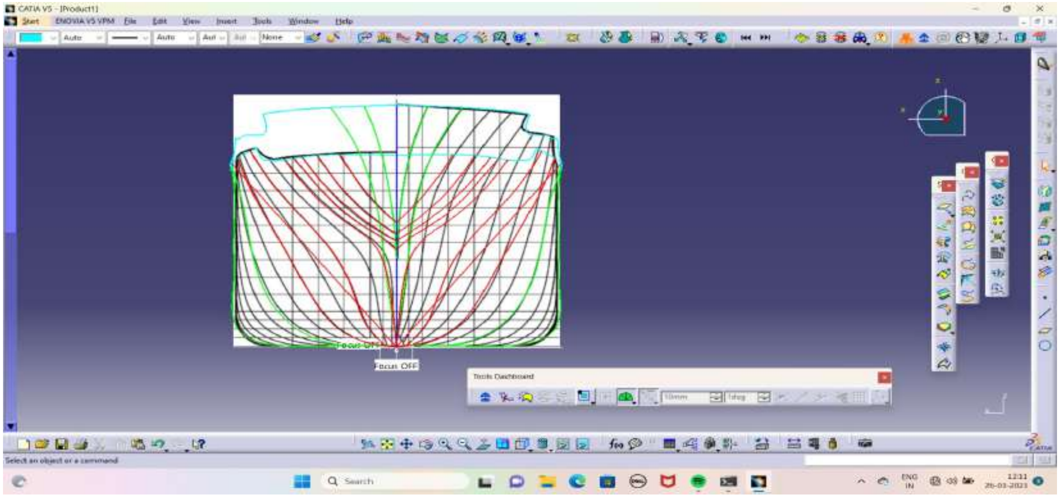


Fig 4.3 surface modeling design

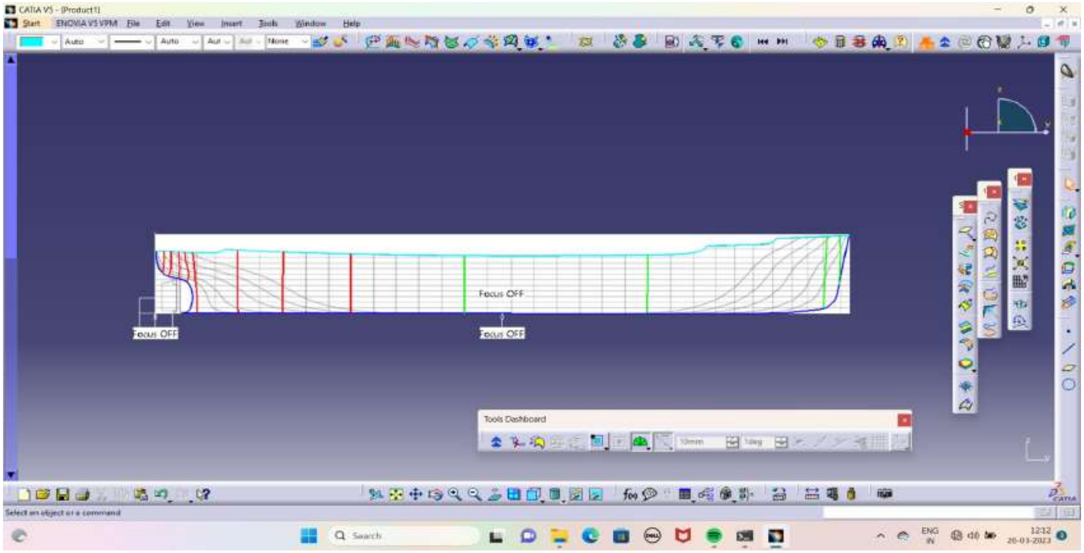


Fig 4.4 building of ship hull curves

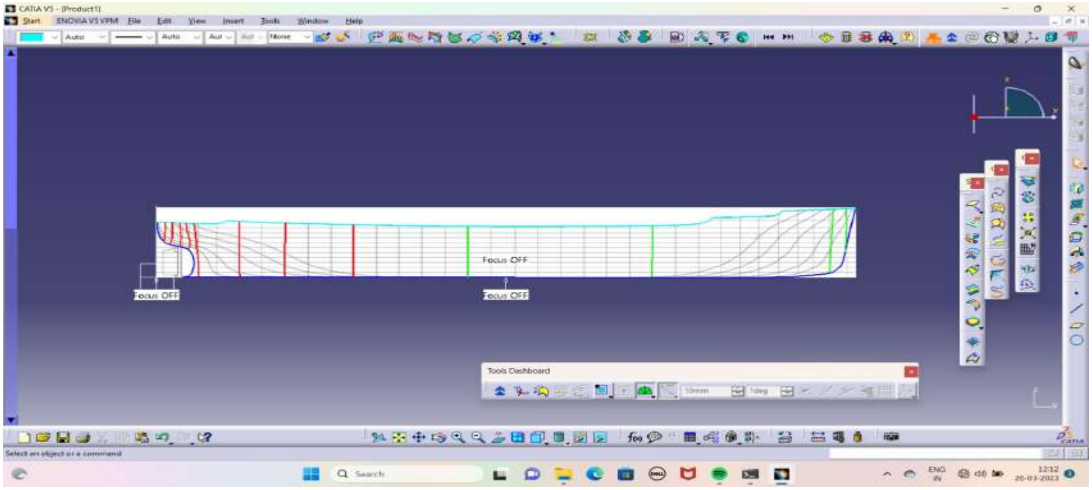


Fig 4.5 tools used in building ship hull model

Now using the fill option we extruded the line modeling into a surface modell

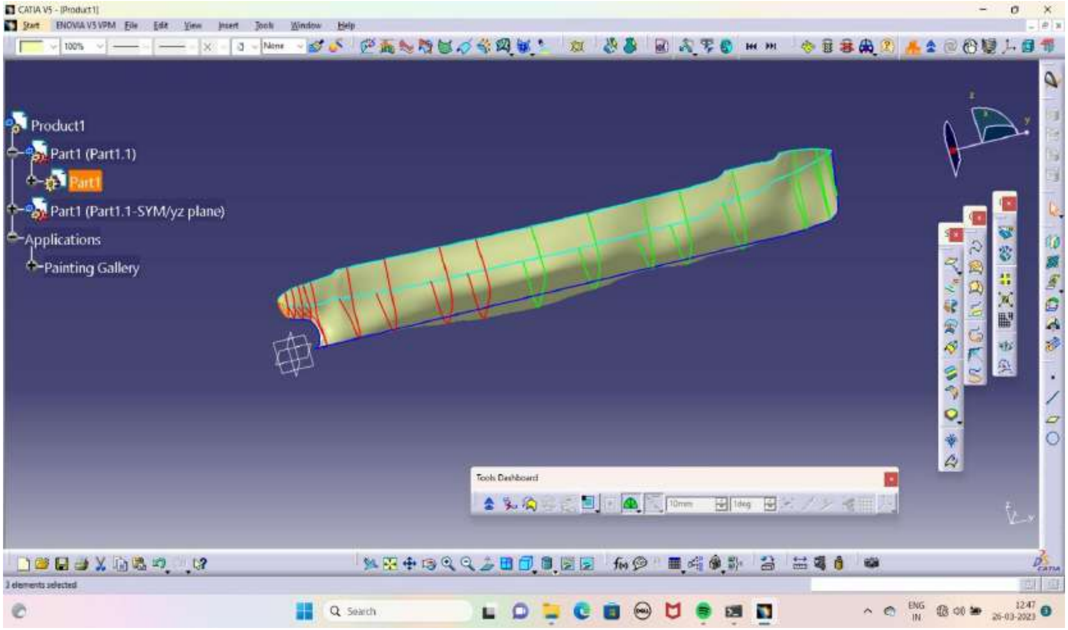


Fig 4.6 Extrude surface model

The final 3 dimensional view of the ship hull :

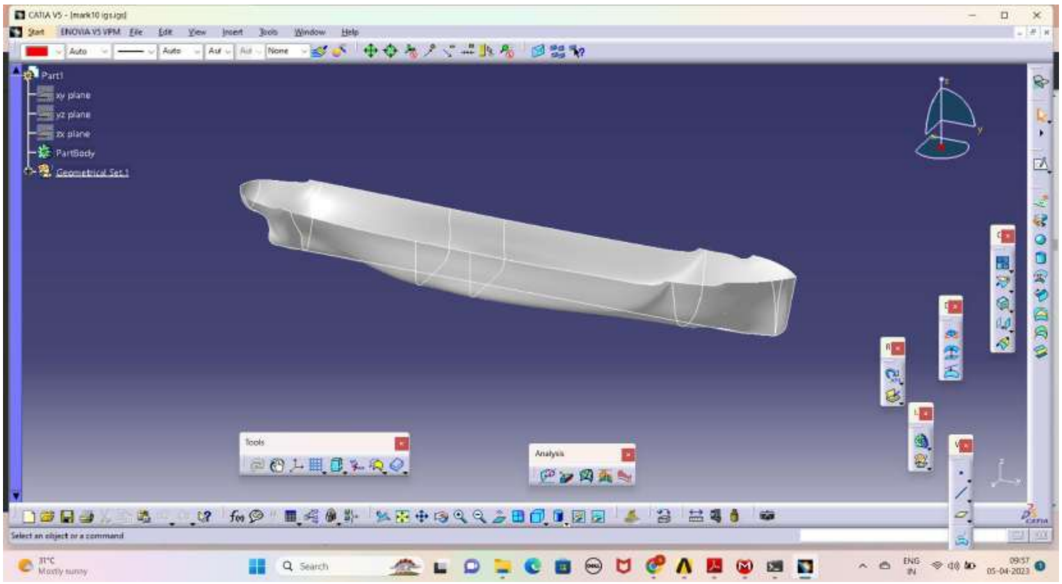


Fig 4.7 3D view ship hull

4.1.2. Dimensions of the ship hull

The sketch shows the principal dimensions of the cargo ship as shown in Fig. . The length can be overall length(LOA) and length between the perpendiculars (LOP). The depth (D) is measured from keel to the upper continuous deck. The draft (d) is measured from keel to the water line of the loaded ship. The beam (W) is the width of the ship as shown in Fig 4.8, Fig 4.9 and Fig 4.10.

LBP=442 ft

W=62 ft

D=52 ft

d = 24 ft

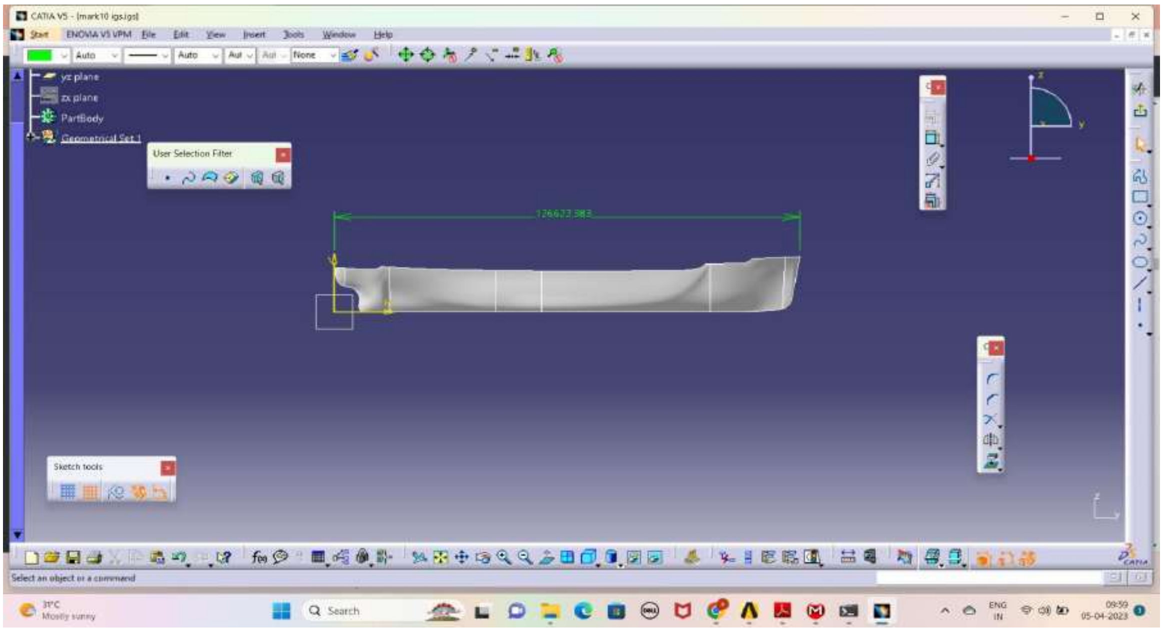
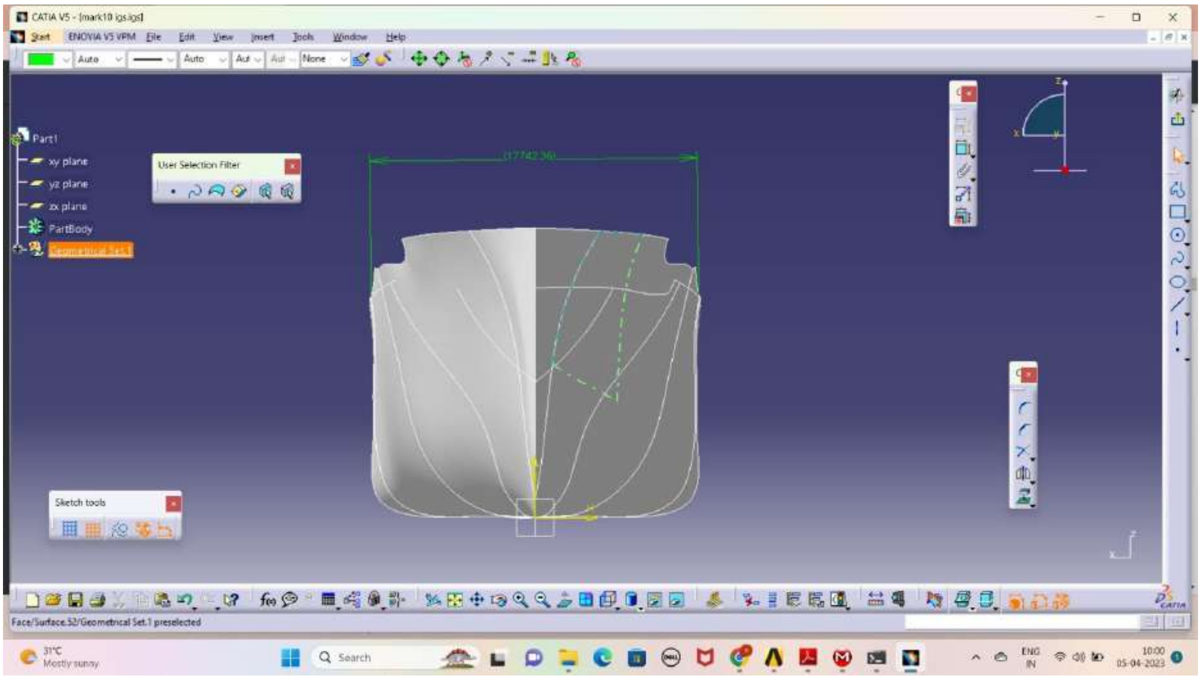
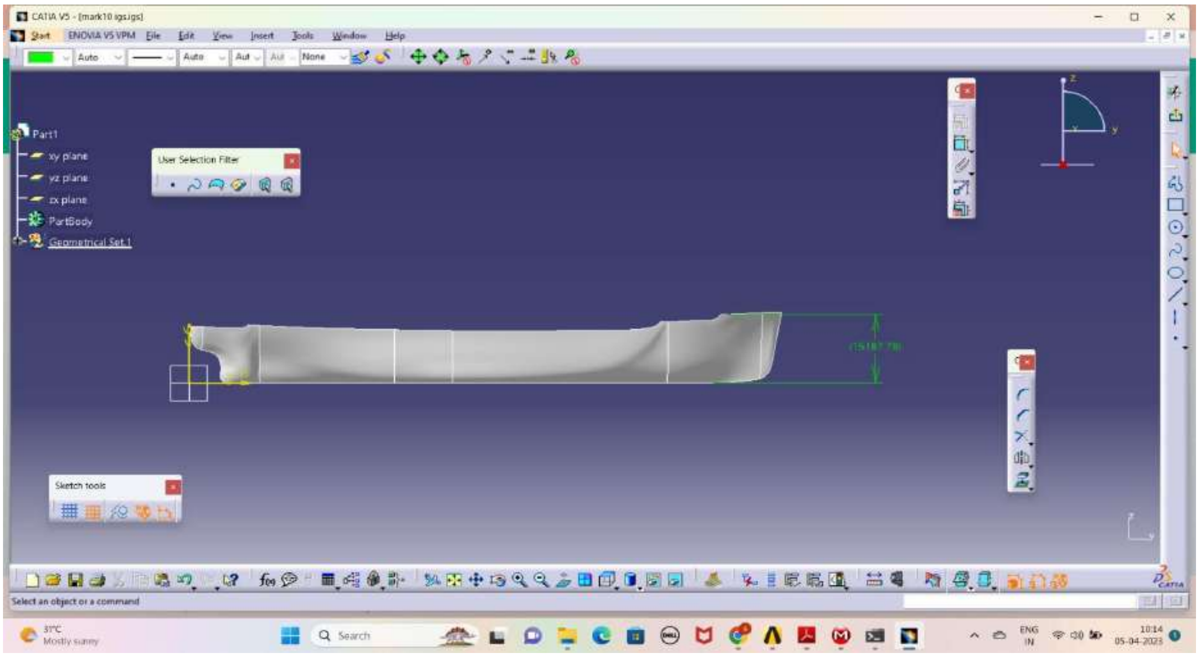


Fig 4.8 length of the hull



Face/Surface.52/Geometrical Set.1 preselected

Fig 4.9 Width of hull



Select an object or a command

Fig 4.10 Depth of hull

4.2 History of ansys

ANSYS, Inc. is an American computer aided engineering software developer headquartered south of Pittsburgh in Cecil Township, Pennsylvania, and United States. ANSYS publishes engineering analysis software across a range of disciplines including finite element analysis, structural analysis, computational fluid dynamics, explicit and implicit methods, and heat transfer.

The company was founded in 1970 by John A. Swanson as *Swanson Analysis Systems, Inc.* (SASI). Its primary purpose was to develop and market finite element analysis software for structural physics that could simulate static(stationary), dynamic (moving) and thermal (heat transfer) problems. SASI developed its business in parallel with the growth in computer technology and engineering needs. The company grew by 10 percent to 20 percent each year, and in 1994 it was sold to TA associates. The new owners took SASI's leading software, called ANSYS, as their flagship product and designated ANSYS, Inc. as the new company name.

4.2.1 Introduction to ANSYS workbench

ANSYS Mechanical is a finite element analysis tool for structural analysis, including linear, non-linear and dynamic studies. This computer simulation product provides a finite element to model behavior, and supports material models and equation solvers for a wide range of mechanical design problems. ANSYS Mechanical also includes thermal analysis and coupled physics capabilities, involving acoustics, piezoelectric, thermal-structural and thermoelectric analysis.

This type of analysis is typically used for design and optimization of a system far too complex to be analyzed by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations.

ANSYS is the standard FEA teaching tool within the Mechanical Engineering Department at many colleges. ANSYS is also used in Civil and Electrical Engineering, as well as Physics and Chemistry Departments.

ANSYS provides a cost-effective way to explore the performance of the products or process in a virtual environment. This type of product development is termed virtual prototyping. With virtual prototyping techniques, users can iterate various scenarios to optimize the product long before the manufacturing is started. This enables a reduction in level of the risk, and in the cost of ineffective designs. The multifaceted nature of ANSYS also provides a means to ensure that users are able to see the effects of design on the whole behavior of the product, be it electromagnetic, thermal, mechanical etc

4.3 Proposed Approach:

As the hull is continuously in contact with water, it is under the effect of different types of forces acting at the same time. Not only that, a hull requires high durability and resistance to prevent structural damage in case of collision or grounding. When considering the load features where the load is transmitted gradually and continuously. So to know the vibrating frequency ie: Resonance Frequency of the system is very important in order to make a safe design . so in this project we are determining the Natural frequency of the ship hulls made up of different materials using Modal Analysis technique from Ansys Workbench and also compare the results of modal analysis with natural frequencies of the ship hull having Neoprene Layer inside the hull to know whether the Neoprene is suitable for Damping Treatment for ship hull to increase their resonant frequency.

So that these results then can be presented in tabular or graphical forms.

4.3.1 Steps involved in analysis of the ship hull:

Step 1: Open the Catia Surface modeled in the ansys workbench using import geometry option as shown in fig 4.11

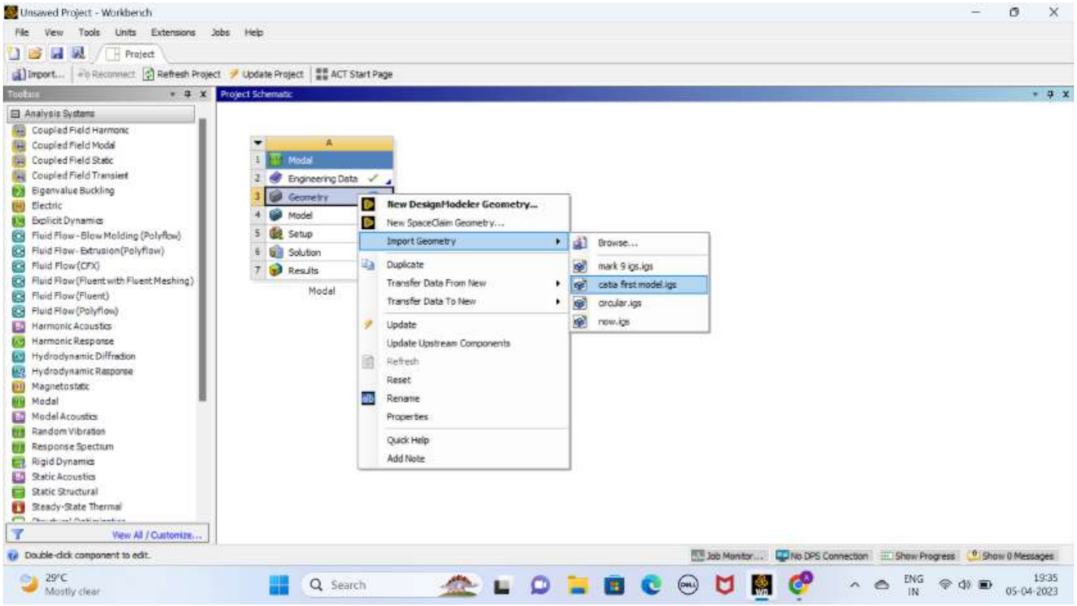
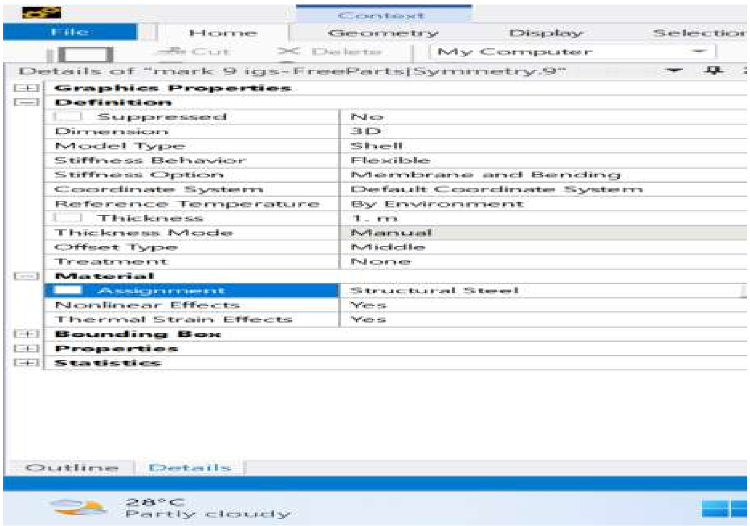


Fig 4.11 Import geometry

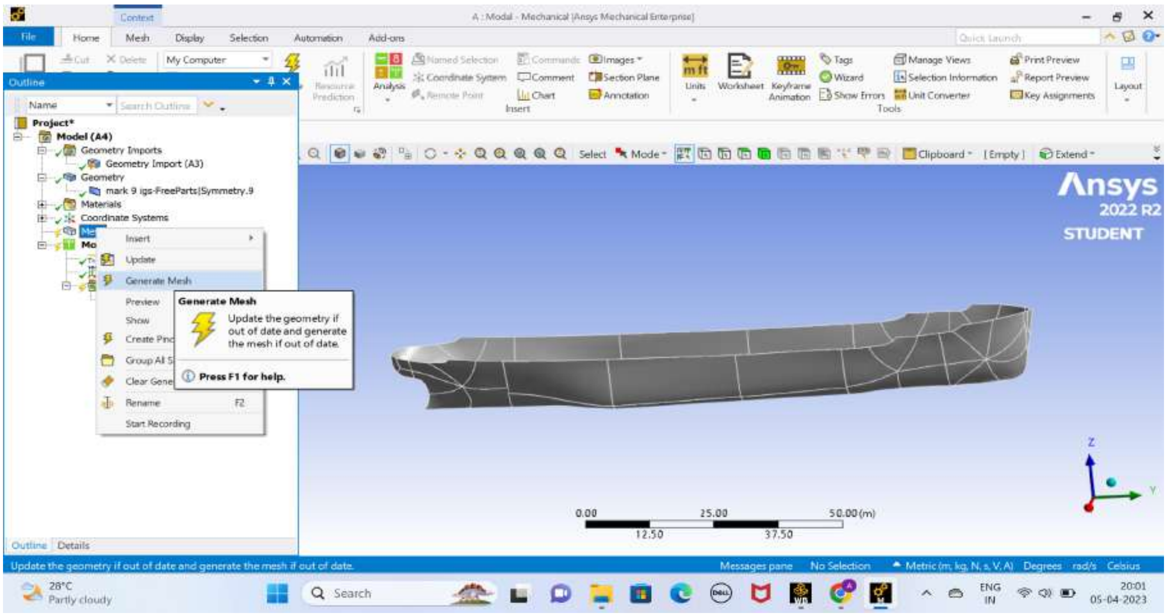
Step 2: After importing of the igs file in Ansys workbench.Now go to the geometry imports option and assign the Material and thickness to the geometry


Details of "mark 9 igs-FreeParts|Symmetry.9"

Graphics Properties	
Definition	
Suppressed	No
Dimension	3D
Model Type	Shell
Stiffness Behavior	Flexible
Stiffness Option	Membrane and Bending
Coordinate System	Default Coordinate System
Reference Temperature	By Environment
Thickness	1. m
Thickness Mode	Manual
Offset Type	Middle
Treatment	None
Material	
Assignment	Structural Steel
Nonlinear Effects	Yes
Thermal Strain Effects	Yes
Bounding Box	
Properties	
Statistics	

Fig 4.12 Material assignment

Step 3 : Now generate the mesh for body with default sizing element size of 1.0413 m The generated meshed body with fine grain structure is shown in the figure 4.13.



Generate Mesh

Update the geometry if out of date and generate the mesh if out of date.

Press F1 for help.

Update the geometry if out of date and generate the mesh if out of date.

Fig 4.13 Generate mesh

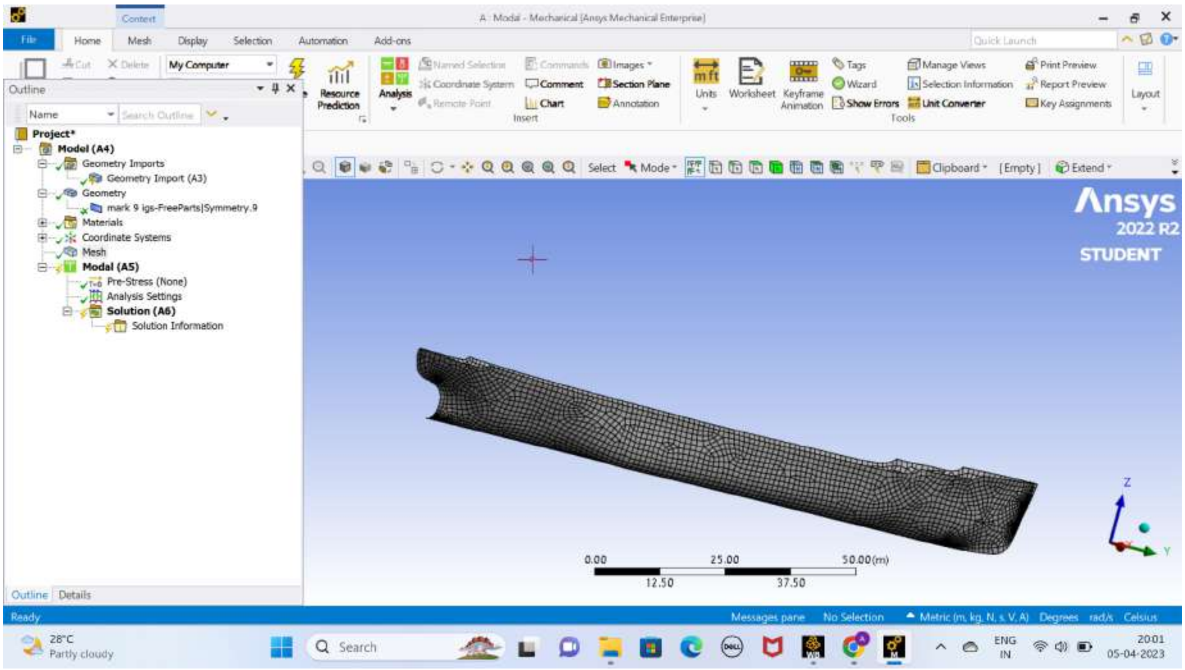
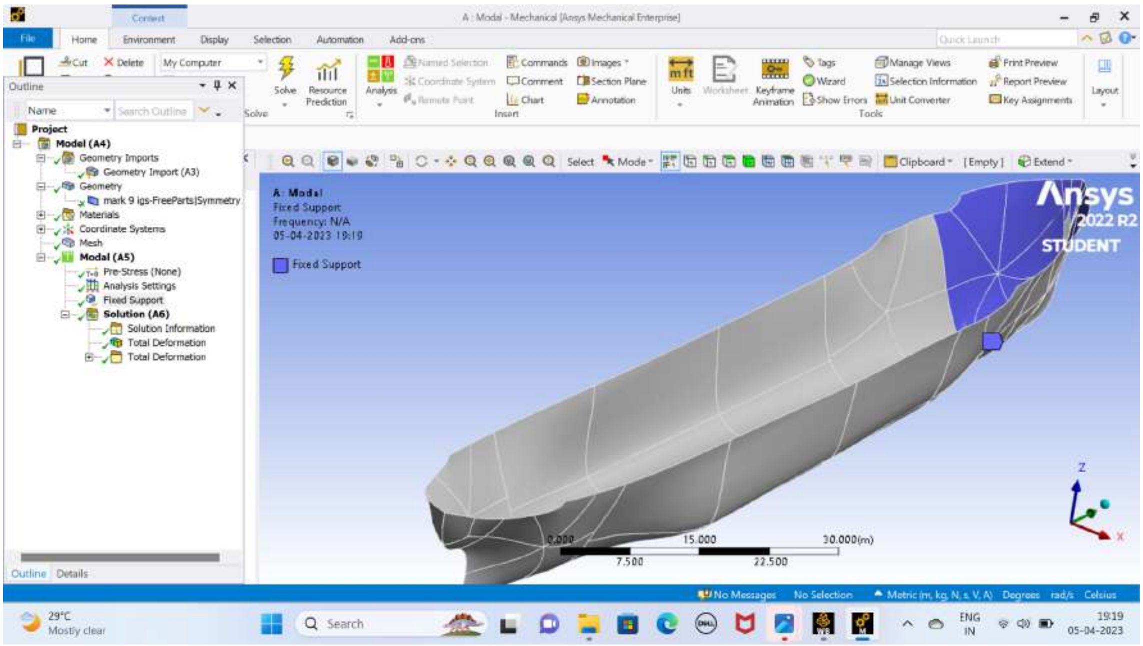


Fig 4.14 Meshed body

Step 4 : Now go into the insert option to add the fixed support. Here in this case we considered the ship hull as a fixed support as shown in figure 4.15

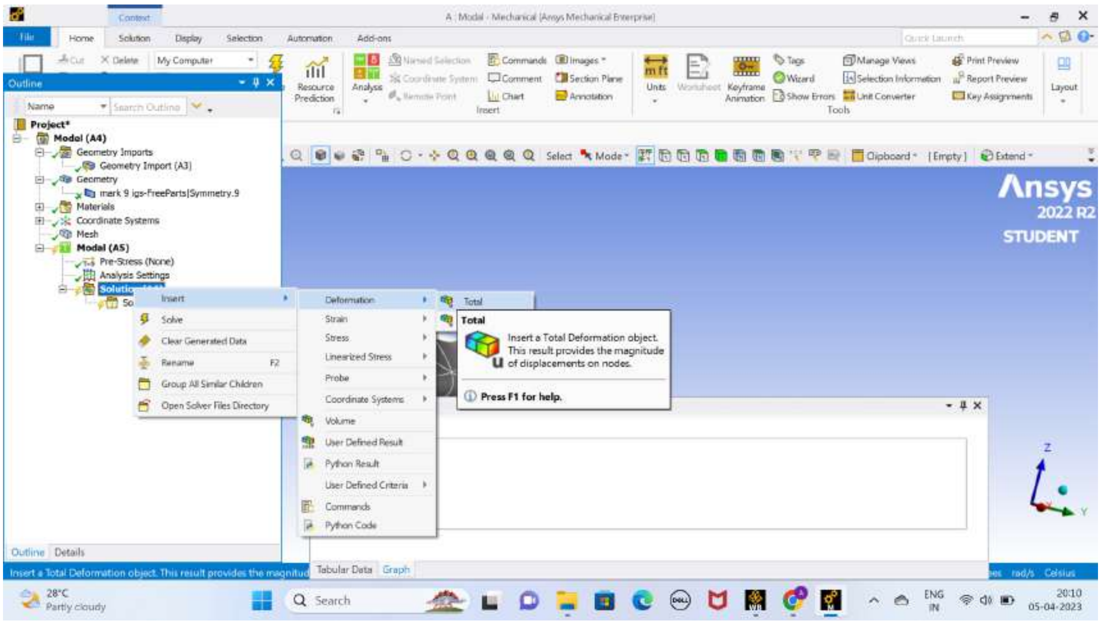


A: Modal
Fixed Support
Frequency: N/A
05-04-2023 19:19

Fixed Support

Fig 4.15 Fixed support for hull

Step 5 : Select the Total Deformation of the body for different modes of the system.



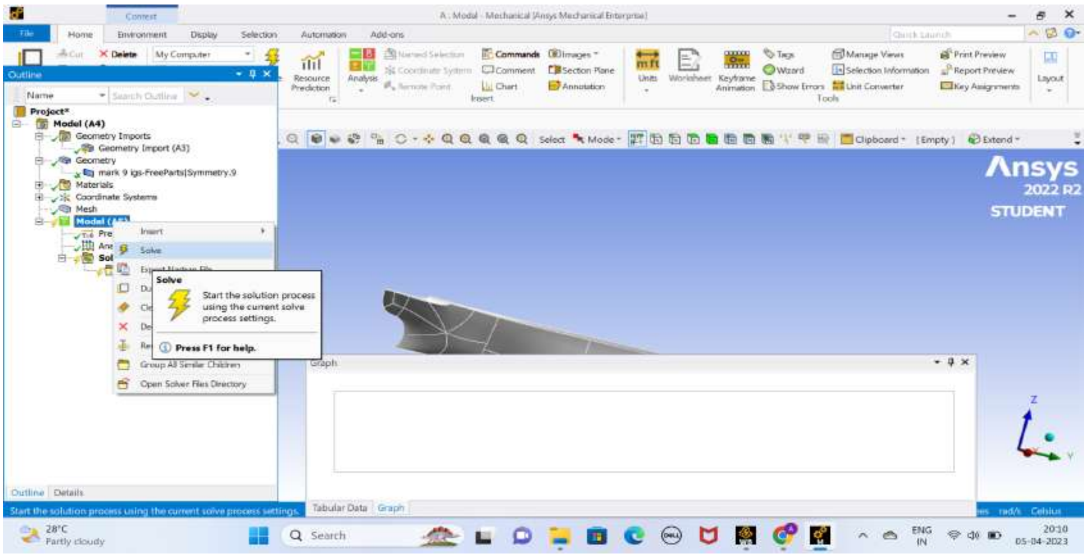
Total

Insert a Total Deformation object. This result provides the magnitude of displacements on nodes.

Press F1 for help.

Fig 4.16 Total deformation tool in ansys

Step 6 : Finally solve and evaluate the results for the meshed body.



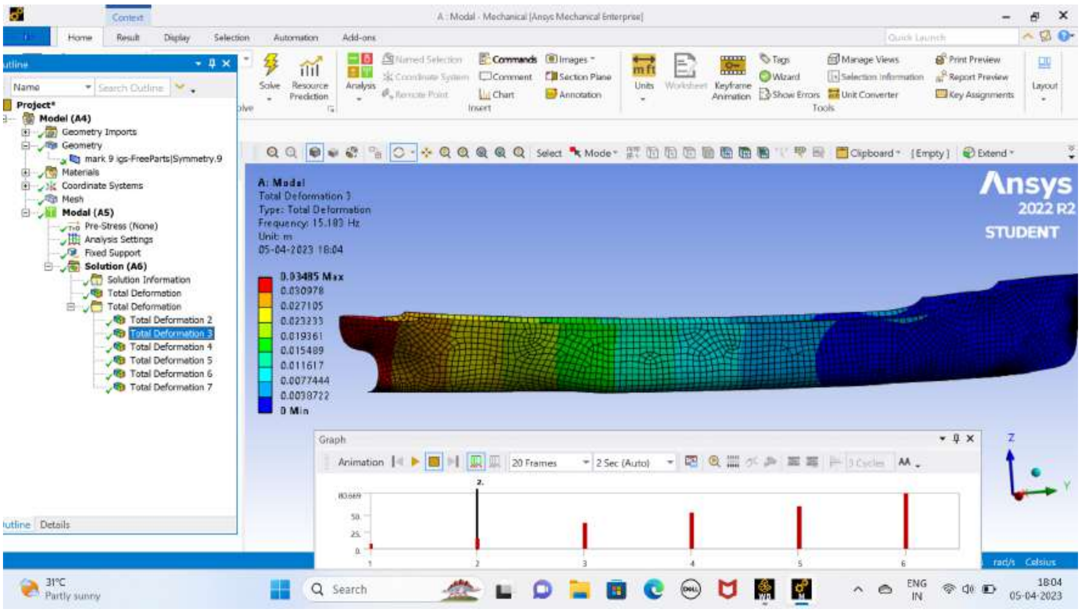
Solve

Start the solution process using the current solve process settings.

Press F1 for help.

Start the solution process using the current solve process settings.

Fig 4.17 solve tool in ansys



A: Modal
Total Deformation 3
Type: Total Deformation
Frequency: 15.183 Hz
Unit: m
05-04-2023 18:04

0.03485 Max
0.030978
0.027105
0.023233
0.019361
0.015489
0.011617
0.0077444
0.0038722
0 Min

Fig 4.18 Result for deformation of Ship Hull after solving and evaluating

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Modal analysis Results - without Neoprene rubber:

After the analysis the results of the natural frequencies are compared for different modes to the following materials which are as listed below:

5.1.1 structural steel

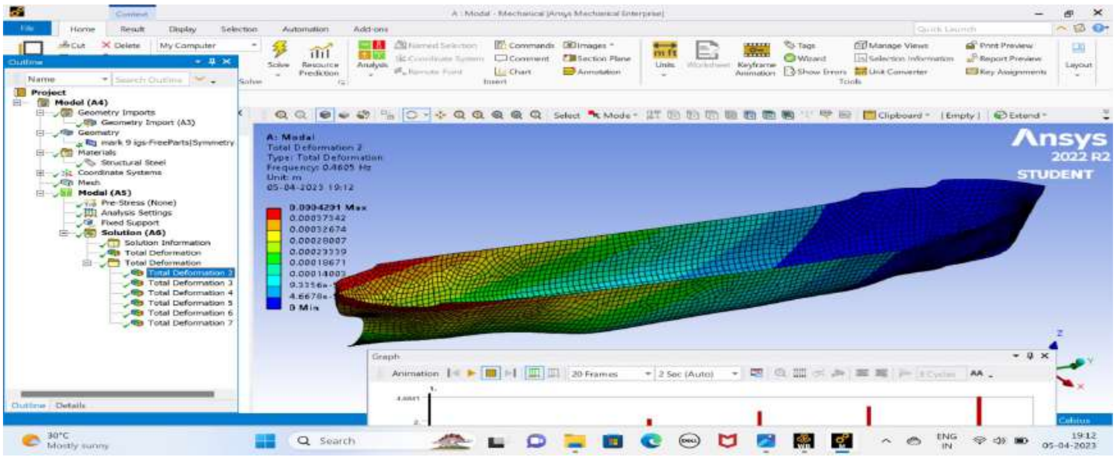


Fig 5.1 Structural steel-deformation in mode 1

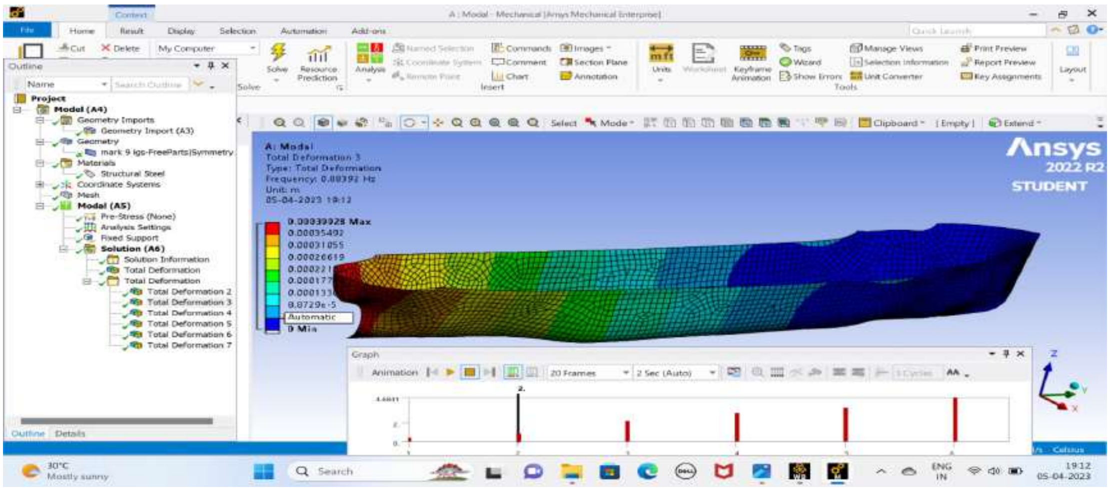
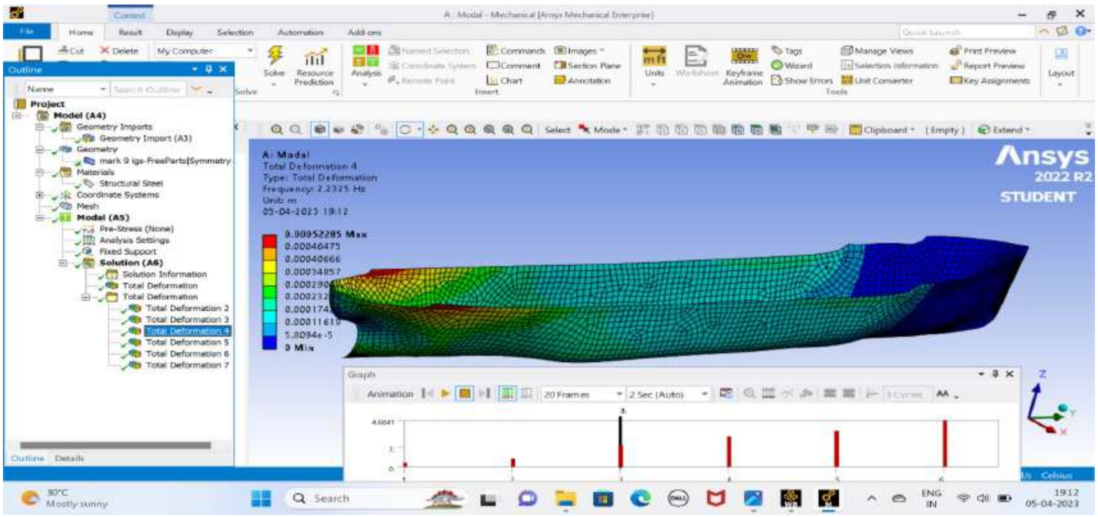
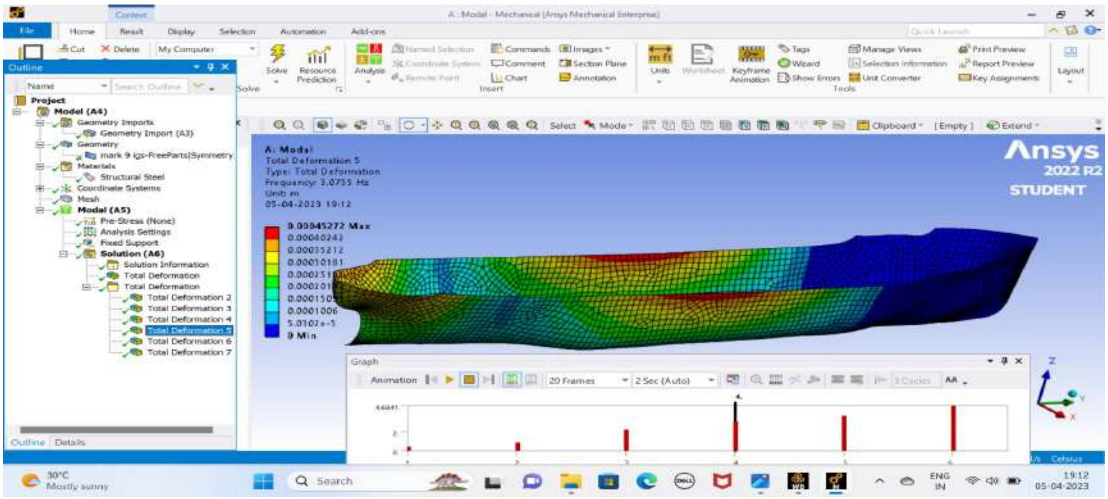


Fig 5.2 Structural steel-deformation in mode 2



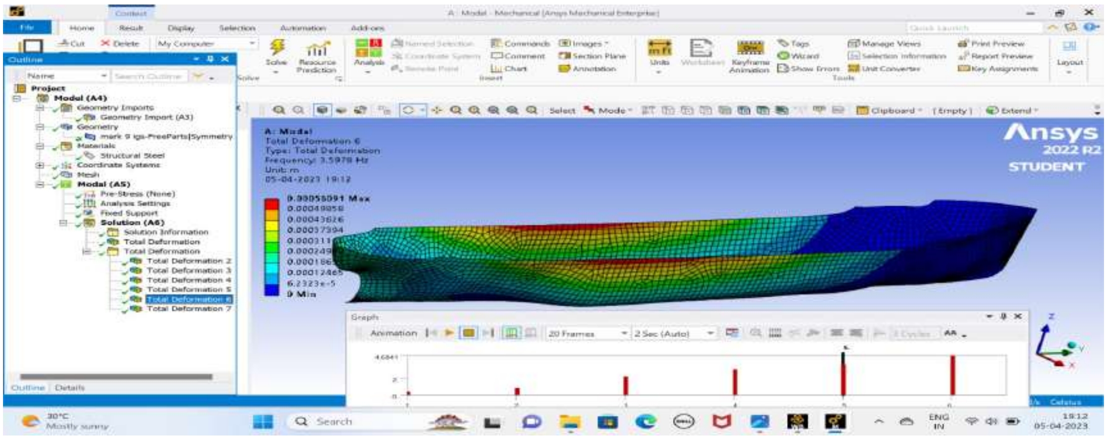
A: Modal
Total Deformation 4
Type: Total Deformation
Frequency: 2.2325 Hz
Unit: m
05-04-2023 19:12

Fig 5.3 Structural steel-deformation in mode 3



A: Modal
Total Deformation 5
Type: Total Deformation
Frequency: 3.0755 Hz
Unit: m
05-04-2023 19:12

Fig 5.4 Structural steel-deformation in mode 4



A: Modal
Total Deformation 6
Type: Total Deformation
Frequency: 3.5978 Hz
Unit: m
05-04-2023 19:12

Fig 5.5 Structural steel-deformation in mode 5

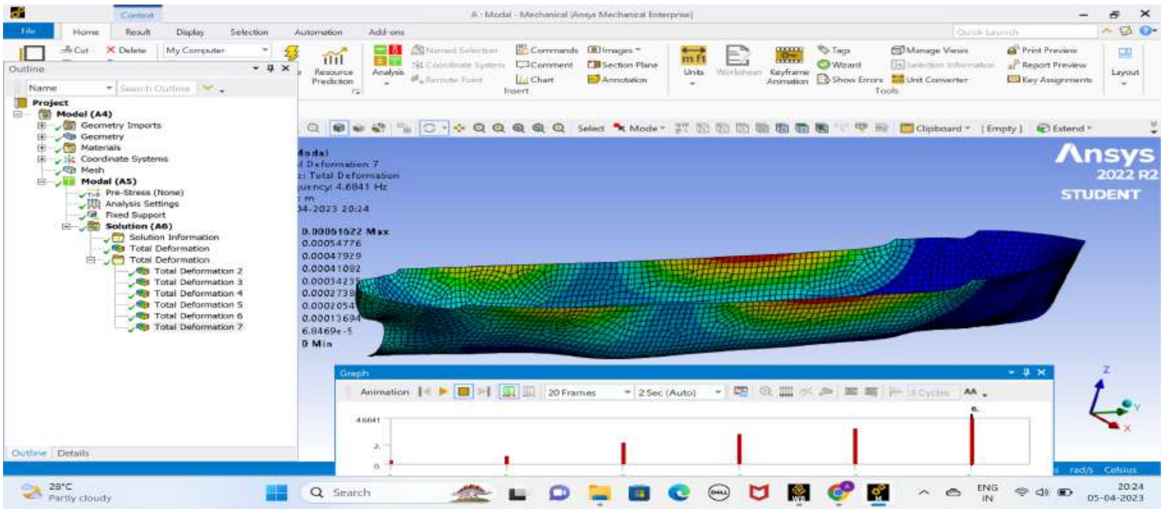
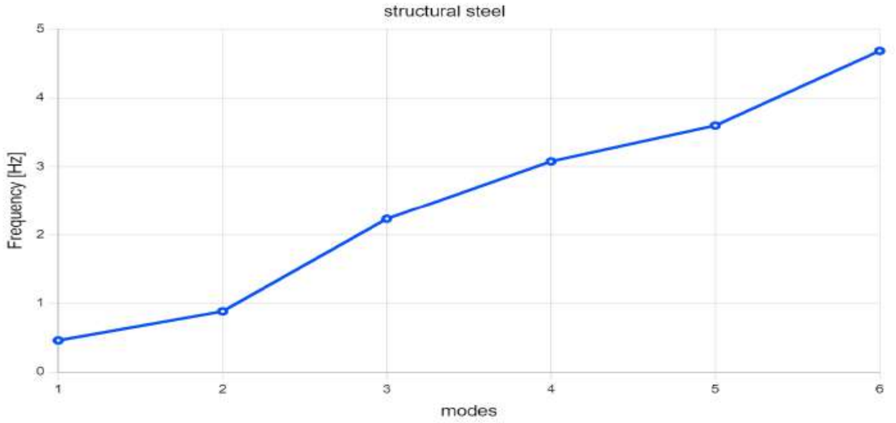


Fig 5.6 Structural steel-deformation in mode 6

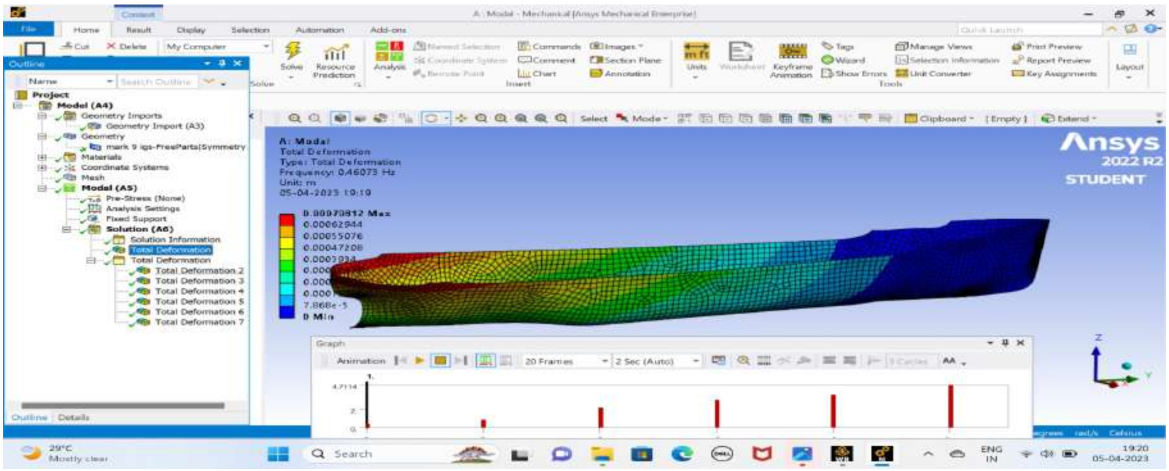
Table no 5.1 : Tabular data for structural steel

MODE	FREQUENCY(Hz)
1	0.4605
2	0.88392
3	2.2325
4	3.0755
5	3.5978
6	4.6841

Graph no 5.1 : For structural steel

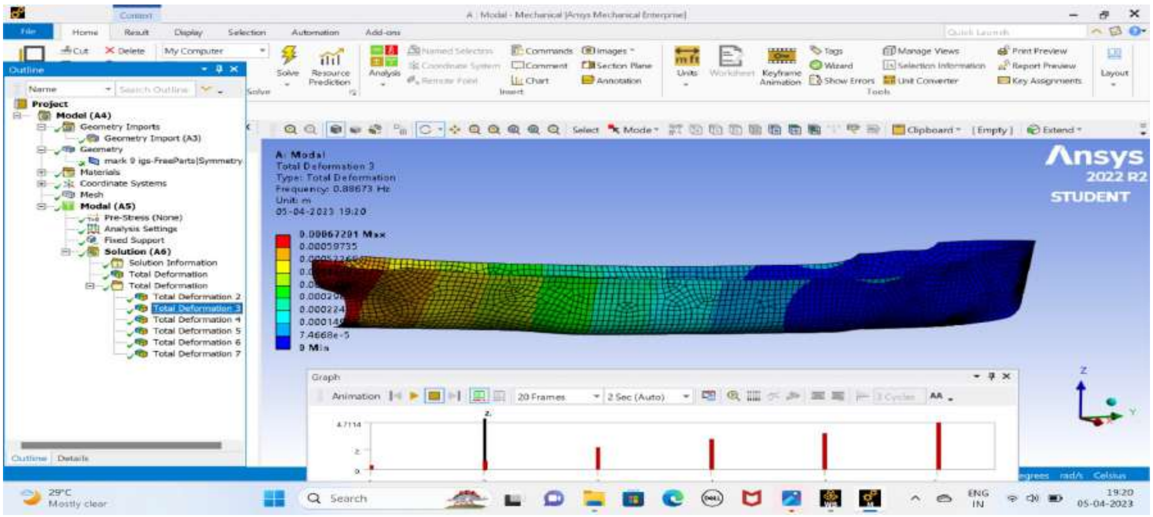


5.1.2 For aluminum:



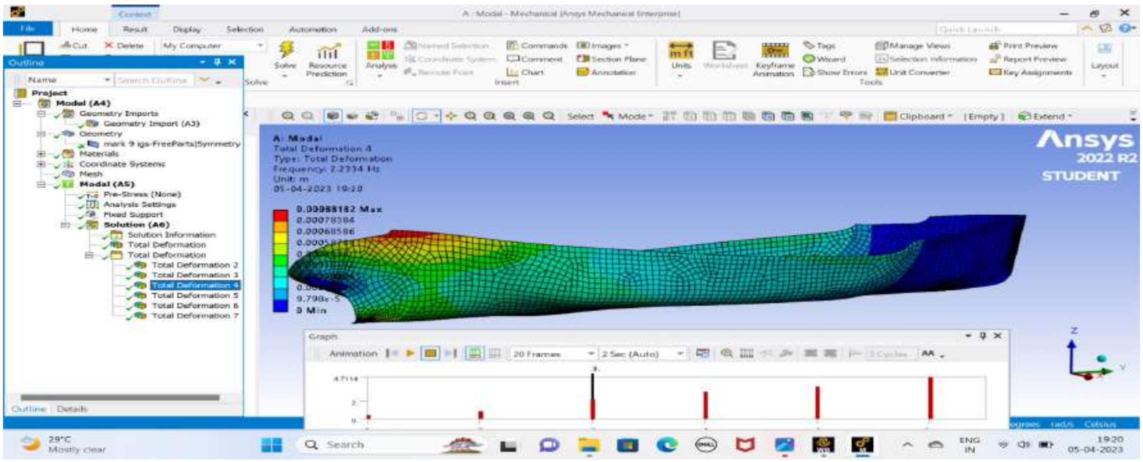
A: Modal
Total Deformation
Type: Total Deformation
Frequency: 0.46073 Hz
Unit: m
05-04-2023 19:19

Fig 5.7 Aluminum-deformation in mode 1



A: Modal
Total Deformation 3
Type: Total Deformation
Frequency: 0.88673 Hz
Unit: m
05-04-2023 19:20

Fig 5.8 Aluminum-deformation in mode 2



A: Modal
Total Deformation 4
Type: Total Deformation
Frequency: 2.2334 Hz
Unit: m
05-04-2023 19:20

Fig 5.9 Aluminum-deformation in mode 3

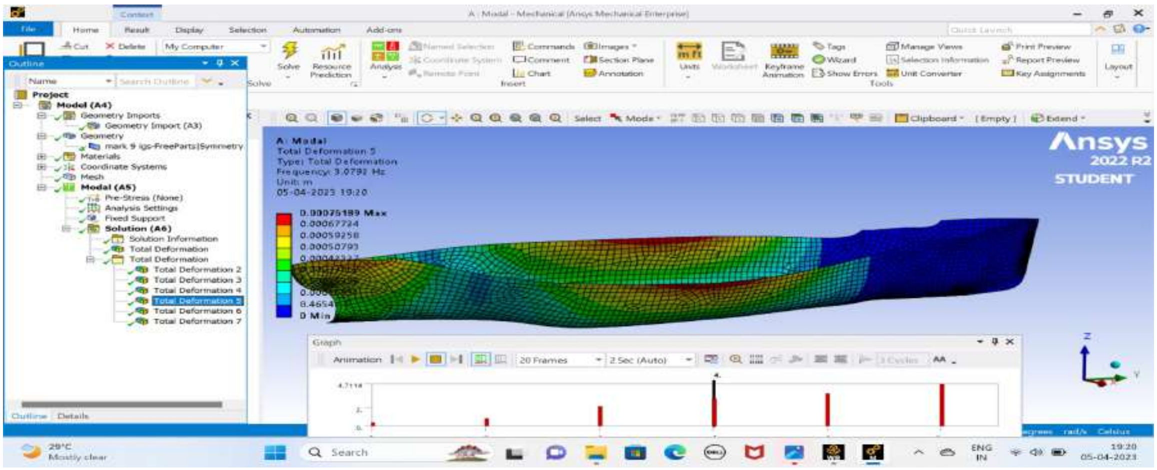

A: Modal
Total Deformation 5
Type: Total Deformation
Frequency: 3.0792 Hz
Unit: m
05-04-2023 19:20

Fig 5.10 Aluminum-deformation in mode 4

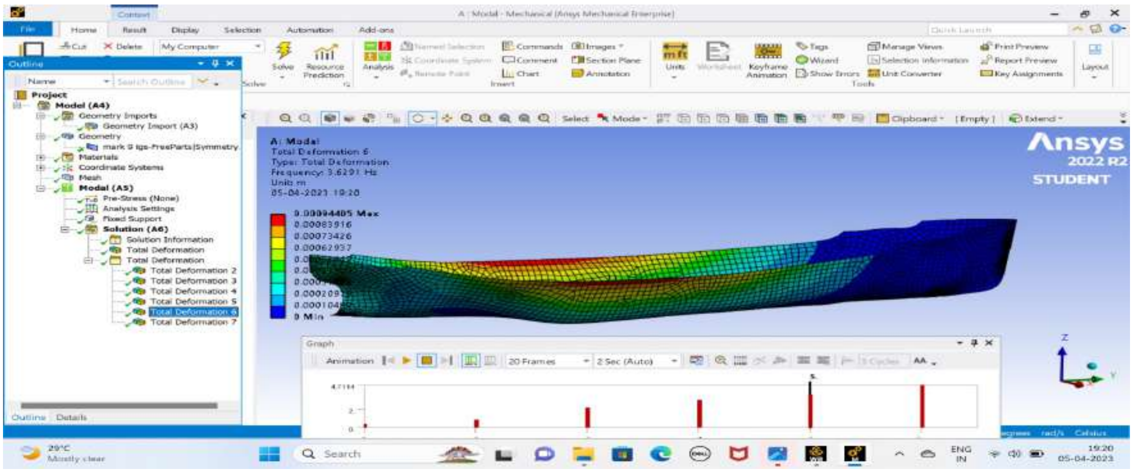

A: Modal
Total Deformation 6
Type: Total Deformation
Frequency: 3.6291 Hz
Unit: m
05-04-2023 19:20

Fig 5.11 Aluminum-deformation in mode 5

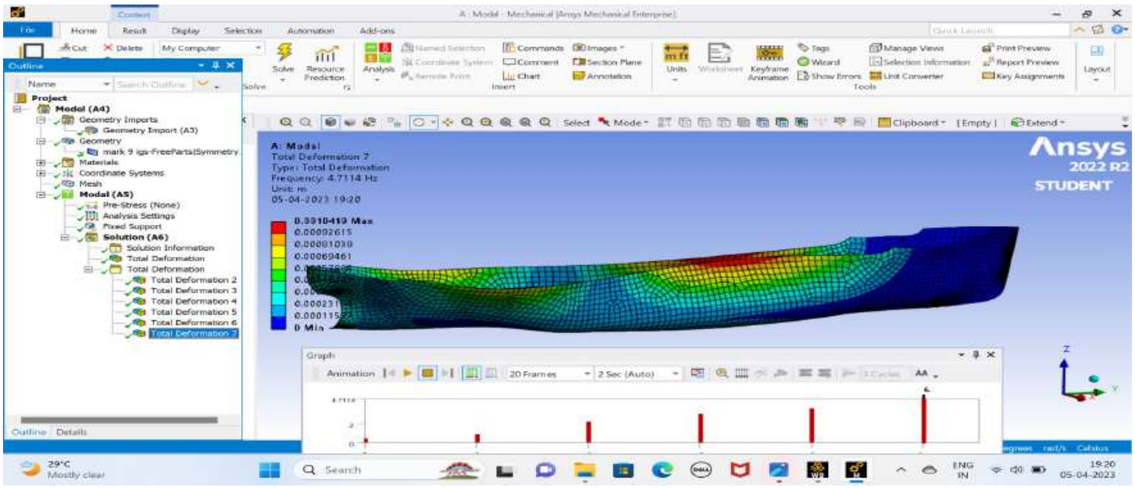
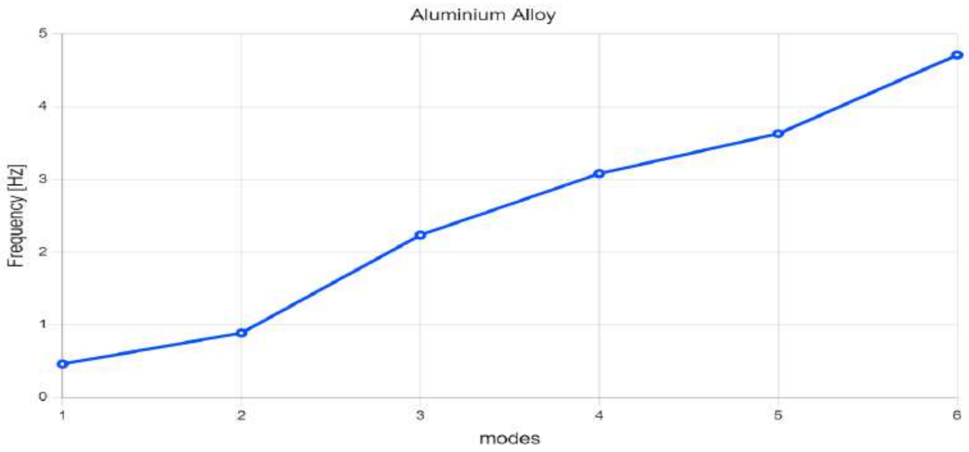

A: Modal
Total Deformation 7
Type: Total Deformation
Frequency: 4.7114 Hz
Unit: m
05-04-2023 19:20

Fig 5.12 Aluminum-deformation in mode 6

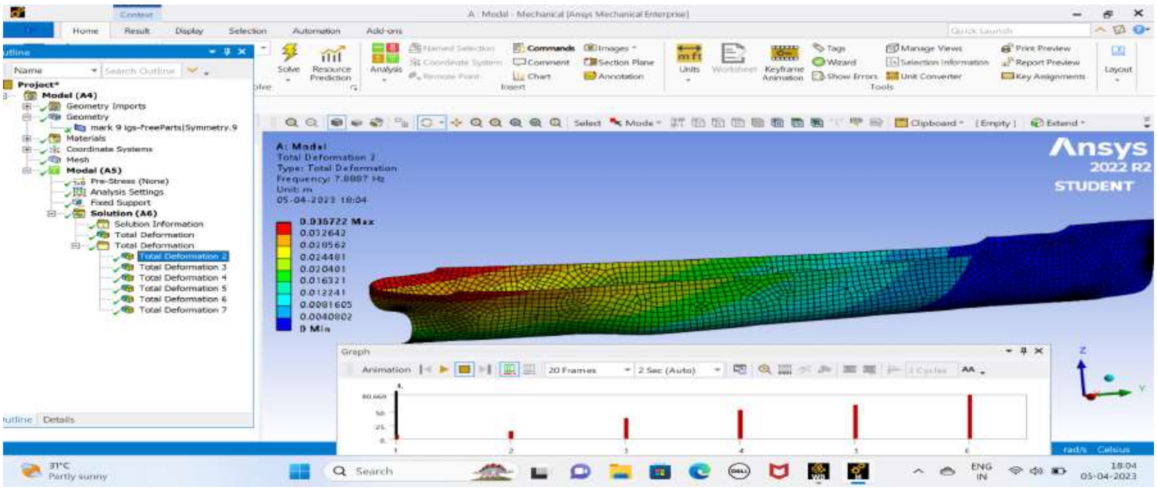
Table no 5.2 : Tabular data for aluminum alloy

MODE	FREQUENCY(Hz)
1	0.46073
2	0.88673
3	2.2334
4	3.0793
5	3.6291
6	4.7114

Graph no 5.2 - For Aluminium Alloy

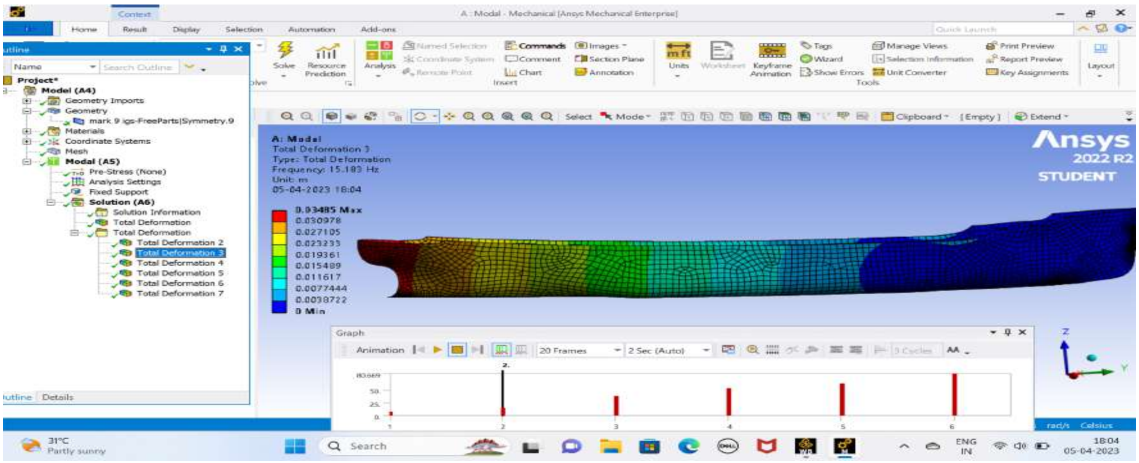


5.1.3 For FRP(Fiber Reinforced Plastic-vinyl ester):


A: Modal
Total Deformation 2
Type: Total Deformation
Frequency: 7.8887 Hz
Unit: m
05-04-2023 18:04

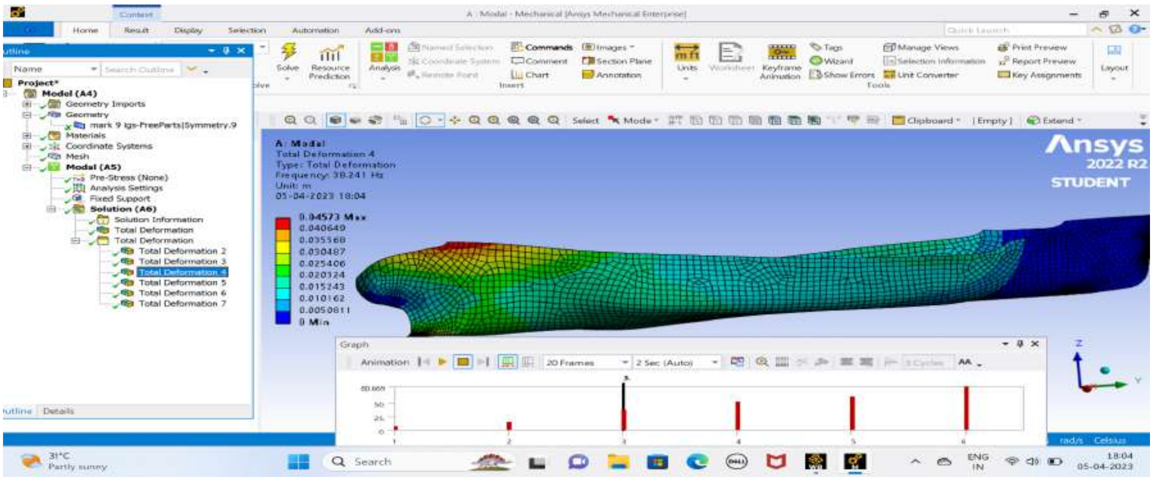
0.036722 Max
0.032642
0.028562
0.024481
0.020401
0.016321
0.012241
0.0081605
0.0040802
0 Min

Fig 5.13 FRP-deformation in mode 1


A: Modal
Total Deformation 3
Type: Total Deformation
Frequency: 15.183 Hz
Unit: m
05-04-2023 18:04

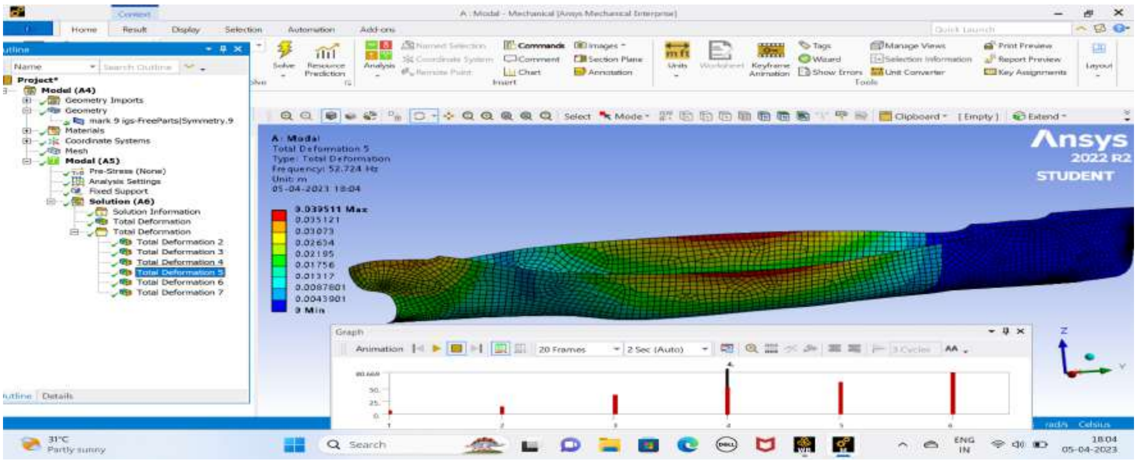
0.03485 Max
0.030978
0.027105
0.023233
0.019361
0.015489
0.011617
0.0077444
0.0038722
0 Min

Fig 5.14 FRP-deformation in mode 2


A: Modal
Total Deformation 4
Type: Total Deformation
Frequency: 38.241 Hz
Unit: m
05-04-2023 18:04

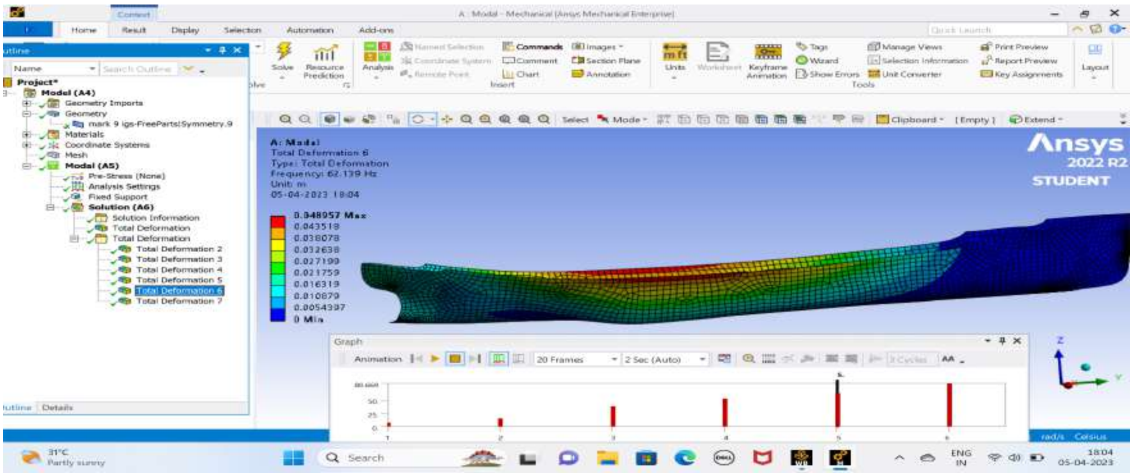
0.04573 Max
0.040649
0.035568
0.030487
0.025406
0.020324
0.015243
0.010162
0.0050811
0 Min

Fig 5.15 FRP-deformation in mode 3



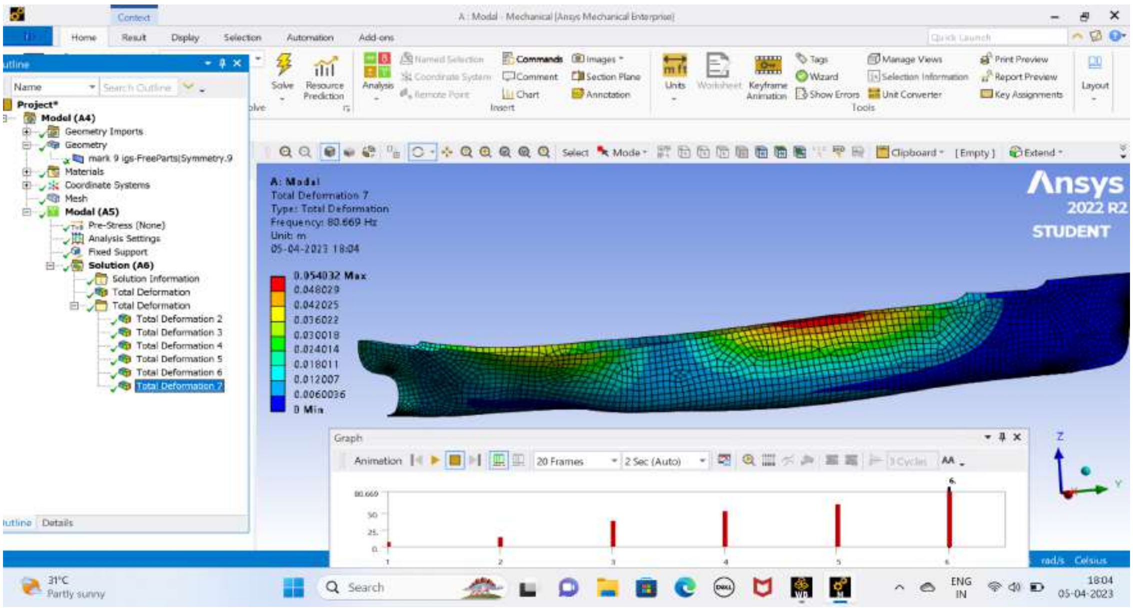
A: Modal
Total Deformation 5
Type: Total Deformation
Frequency: 52.724 Hz
Unit: m
05-04-2023 18:04

Fig 5.16 FRP-deformation in mode 4



A: Modal
Total Deformation 6
Type: Total Deformation
Frequency: 62.139 Hz
Unit: m
05-04-2023 18:04

Fig 5.17 FRP-deformation in mode 5



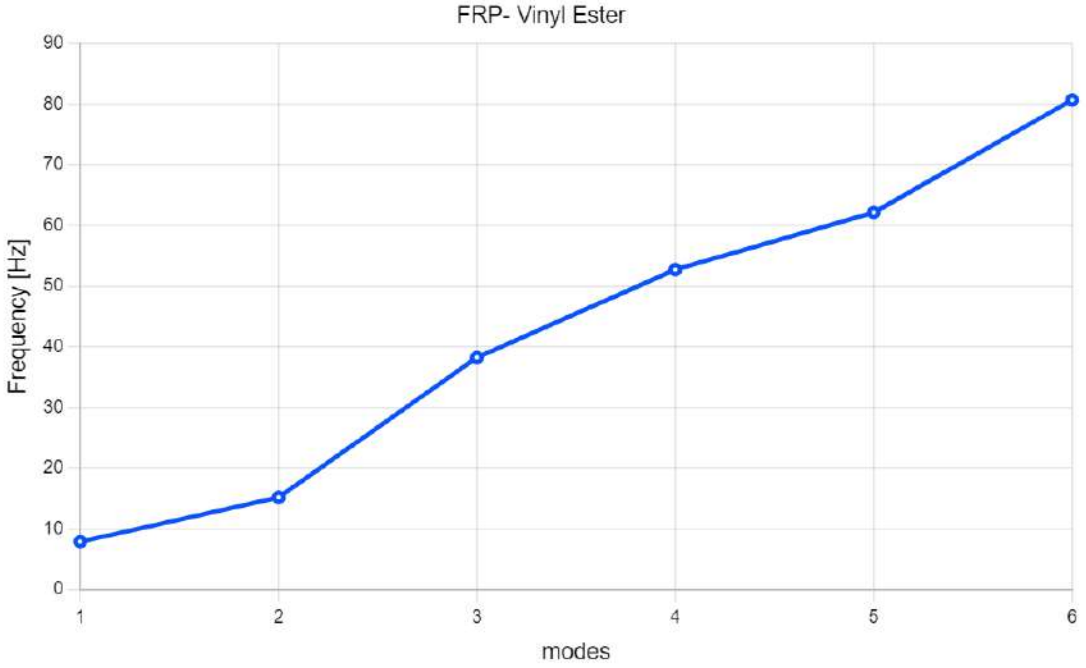
A: Modal
Total Deformation 7
Type: Total Deformation
Frequency: 80.669 Hz
Unit: m
05-04-2023 18:04

Fig 5.18 FRP-deformation in mode 6

Table no 5.3 : Tabular data for FRP- Vinyl Ester

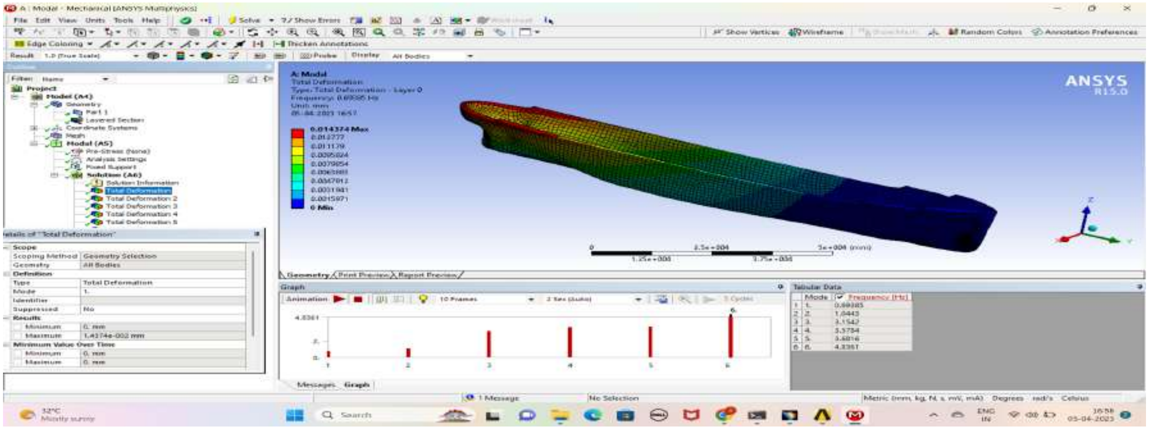
MODE	FREQUENCY(Hz)
1	7.8887
2	15.183
3	38.241
4	52.724
5	62.139
6	80.669

Graph no 5.3 - FRP - Vinyl Ester



5.2 Modal analysis results - With neoprene rubber

5.2.1 For structural steel with neoprene



A: Modal
Total Deformation
Type: Total Deformation - Layer 0
Frequency: 0.69385 Hz
Unit: mm
05-04-2023 16:57

0.014374 Max
0.012777
0.011179
0.0095824
0.0079854
0.0063883
0.0047912
0.0031941
0.0015971
0 Min

Project
Model (A4)
Geometry
Part 1
Layered Section
Coordinate Systems
Mesh
Modal (A5)
Pre-Stress (None)
Analysis Settings
Fixed Support
Solution (A6)
Solution Information
Total Deformation
Total Deformation 2
Total Deformation 3
Total Deformation 4
Total Deformation 5

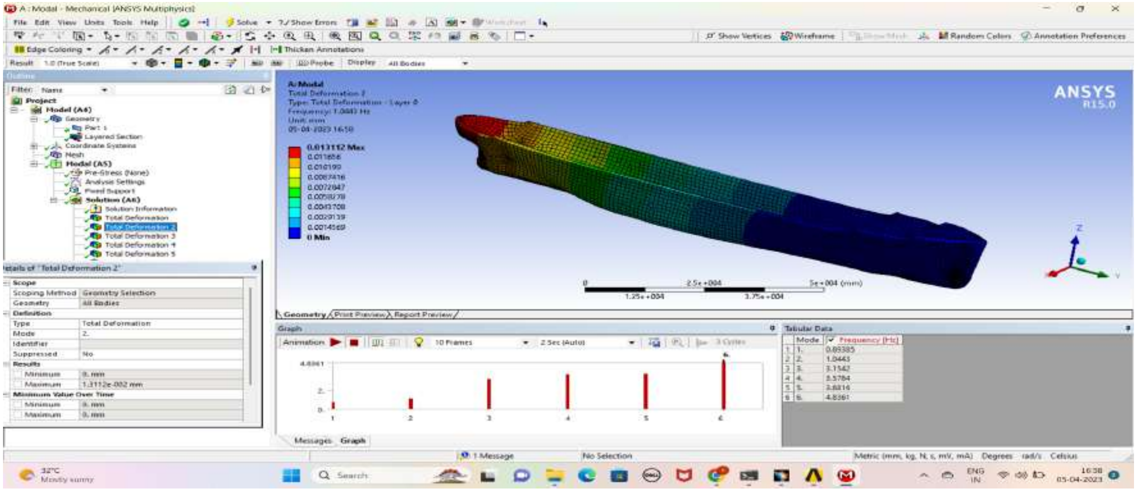
Details of "Total Deformation"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	1.
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	1.4374e-002 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

Tabular Data

	Mode	✓ Frequency [Hz]
1	1.	0.69385
2	2.	1.0443
3	3.	3.1542
4	4.	3.5784
5	5.	3.6816
6	6.	4.8361

Fig 5.19 Structural steel with neoprene rubber- deformation in mode 1



A: Modal
Total Deformation 2
Type: Total Deformation - Layer 0
Frequency: 1.0443 Hz
Unit: mm
05-04-2023 16:58

0.013112 Max
0.011656
0.010199
0.0087416
0.0072847
0.0058278
0.0043708
0.0029139
0.0014569
0 Min

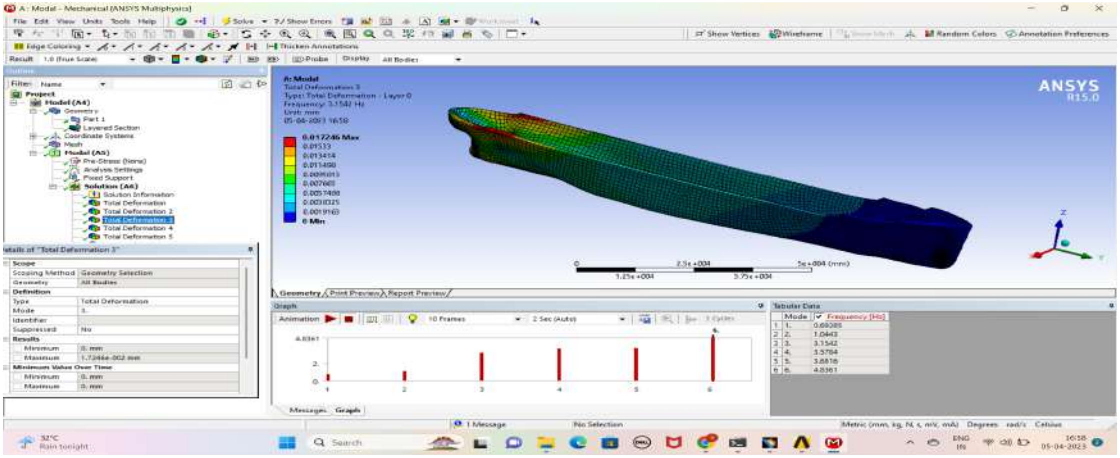
Details of "Total Deformation 2"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	2.
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	1.3112e-002 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

Tabular Data

	Mode	✓ Frequency [Hz]
1	1.	0.69385
2	2.	1.0443
3	3.	3.1542
4	4.	3.5784
5	5.	3.6816
6	6.	4.8361

Fig 5.20 Structural steel with neoprene rubber- deformation in mode 2



A: Modal
Total Deformation 3
Type: Total Deformation - Layer 0
Frequency: 3.1542 Hz
Unit: mm
05-04-2023 16:58

0.017246 Max
0.01533
0.013414
0.011498
0.0095813
0.007665
0.0057488
0.0038325
0.0019163
0 Min

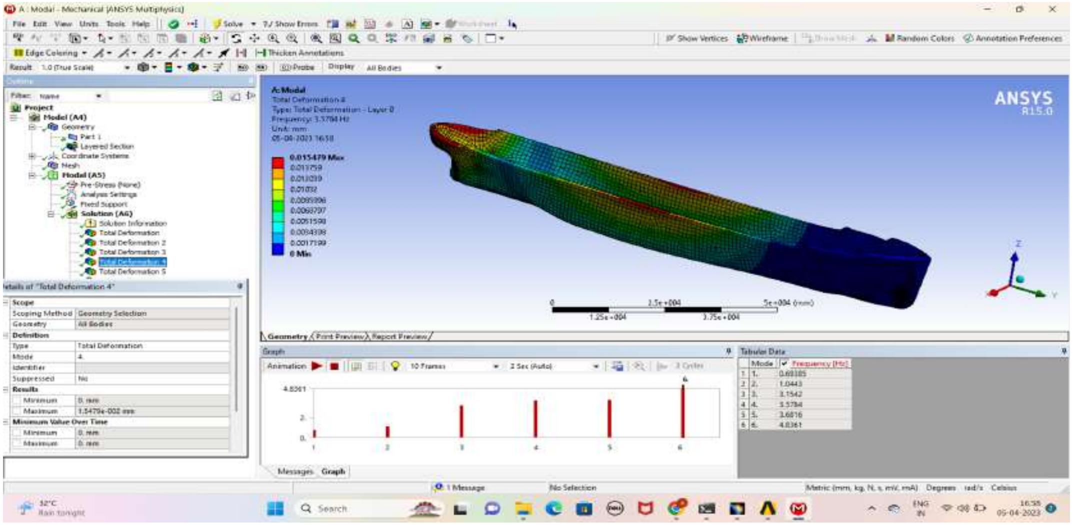
Details of "Total Deformation 3"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	3.
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	1.7246e-002 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

Tabular Data

	Mode	✓ Frequency [Hz]
1	1.	0.69385
2	2.	1.0443
3	3.	3.1542
4	4.	3.5784
5	5.	3.6816
6	6.	4.8361

Fig 5.21 Structural steel with neoprene rubber- deformation in mode 3



A: Modal
Total Deformation 4
Type: Total Deformation - Layer 0
Frequency: 3.5784 Hz
Unit: mm
05-04-2023 16:58

0.015479 Max
0.013759
0.012039
0.01032
0.0085996
0.0068797
0.0051598
0.0034398
0.0017199
0 Min

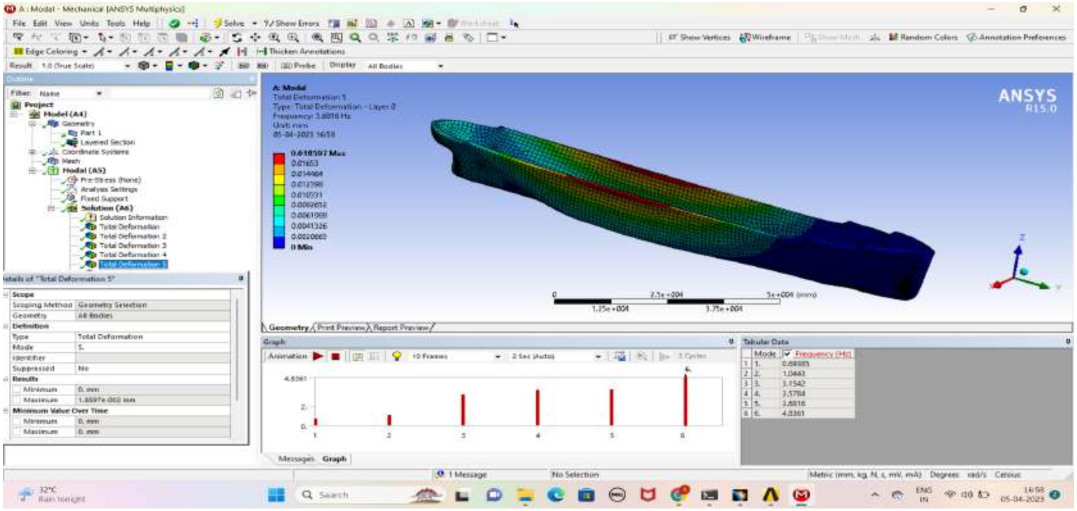
Details of "Total Deformation 4"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	4.
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	1.5479e-002 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

Tabular Data

	Mode	✓ Frequency [Hz]
1	1.	0.69385
2	2.	1.0443
3	3.	3.1542
4	4.	3.5784
5	5.	3.6816
6	6.	4.8361

Fig 5.22 Structural steel with neoprene rubber- deformation in mode 4



A: Modal
Total Deformation 5
Type: Total Deformation - Layer 0
Frequency: 3.6816 Hz
Unit: mm
05-04-2023 16:58

0.018597 Max
0.01653
0.014464
0.012398
0.010331
0.0082652
0.0061989
0.0041326
0.0020663
0 Min

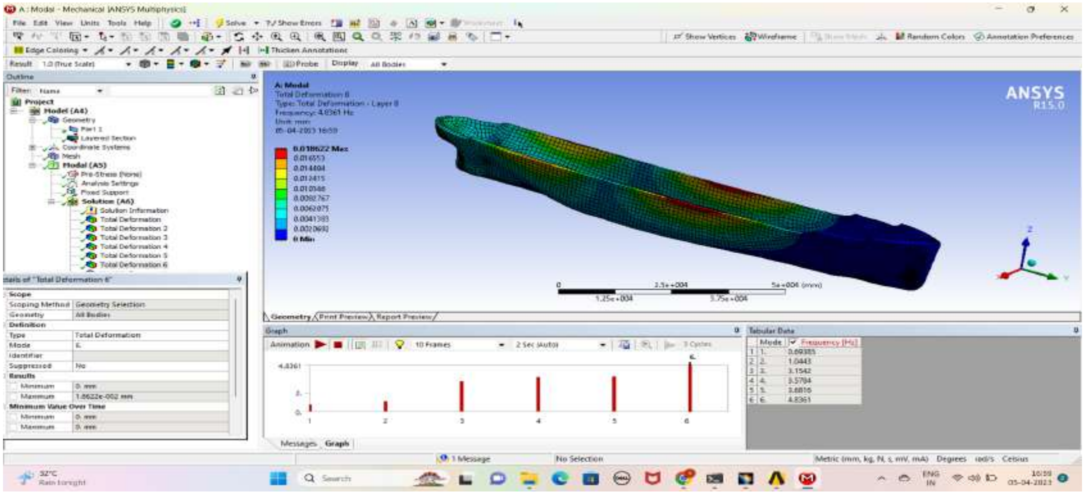
Details of "Total Deformation 5"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	5.
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	1.8597e-002 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

Tabular Data

	Mode	✓ Frequency [Hz]
1	1.	0.69385
2	2.	1.0443
3	3.	3.1542
4	4.	3.5784
5	5.	3.6816
6	6.	4.8361

Fig 5.23 Structural steel with neoprene rubber- deformation in mode 5



A: Modal
Total Deformation 6
Type: Total Deformation - Layer 0
Frequency: 4.8361 Hz
Unit: mm
05-04-2023 16:59

0.018622 Max
0.016553
0.014484
0.012415
0.010346
0.0082767
0.0062075
0.0041383
0.0020692
0 Min

Details of "Total Deformation 6"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	6.
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	1.8622e-002 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

Tabular Data

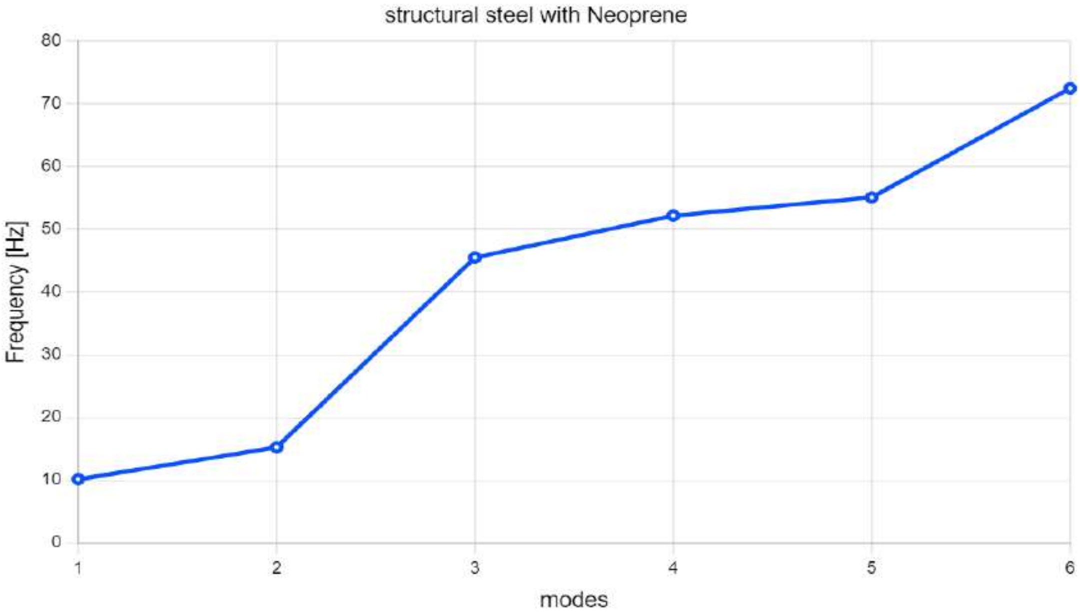
	Mode	✓ Frequency [Hz]
1	1.	0.69385
2	2.	1.0443
3	3.	3.1542
4	4.	3.5784
5	5.	3.6816
6	6.	4.8361

Fig 5.24 Structural steel with neoprene rubber- deformation in mode 6

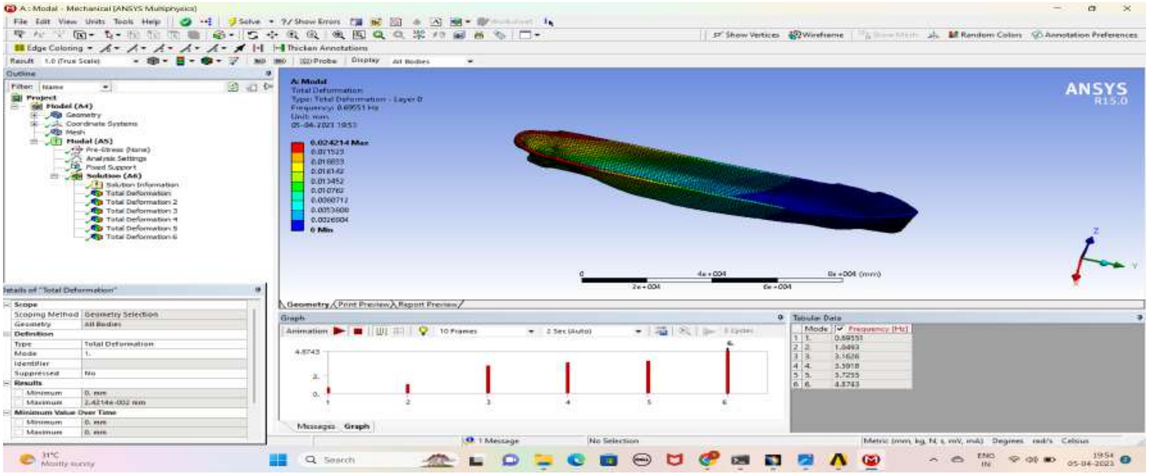
Table no 5.4 : Tabular data for Structural steel with Neoprene

Modes	Frequency[Hz]
1	10.172
2	15.256
3	45.507
4	52.192
5	55.085
6	72.484

Graph No 5.4 - Structural steel with Neoprene



5.2.2 For Aluminum alloy with neoprene


A: Modal
Total Deformation
Type: Total Deformation - Layer 0
Frequency: 0.69551 Hz
Unit: mm
05-04-2023 19:53

0.024214 Max
0.021523
0.018833
0.016142
0.013452
0.010762
0.0080712
0.0053808
0.0026904
0 Min

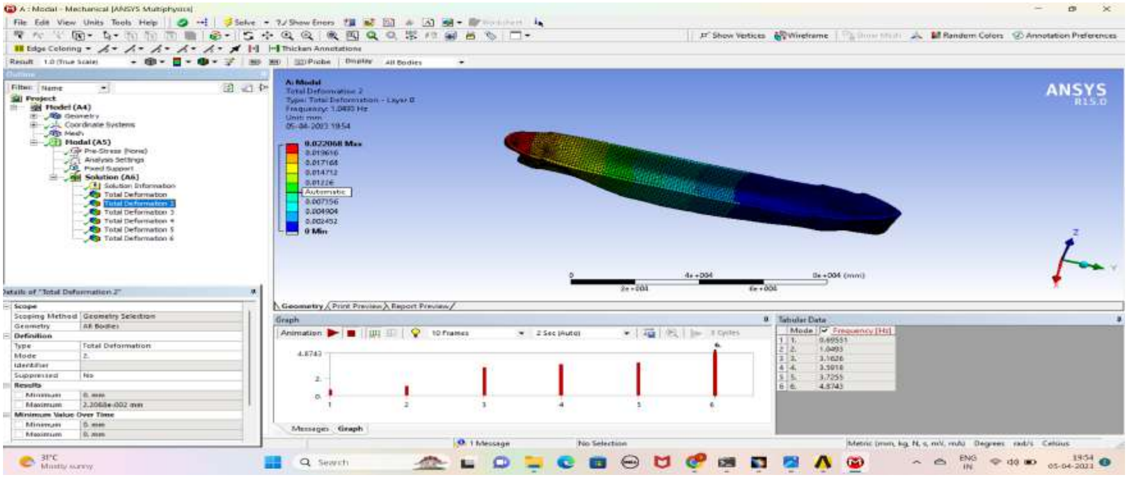
Details of "Total Deformation"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	1.
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	2.4214e-002 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

Tabular Data

	Mode	Frequency [Hz]
1	1.	0.69551
2	2.	1.0493
3	3.	3.1626
4	4.	3.3918
5	5.	3.7255
6	6.	4.8743

Fig 5.25 Aluminum with neoprene rubber-deformation in mode 1


A: Modal
Total Deformation 2
Type: Total Deformation - Layer 0
Frequency: 1.0493 Hz
Unit: mm
05-04-2023 19:54

0.022068 Max
0.019616
0.017164
0.014712
0.01226
Automatic
0.007356
0.004904
0.002452
0 Min

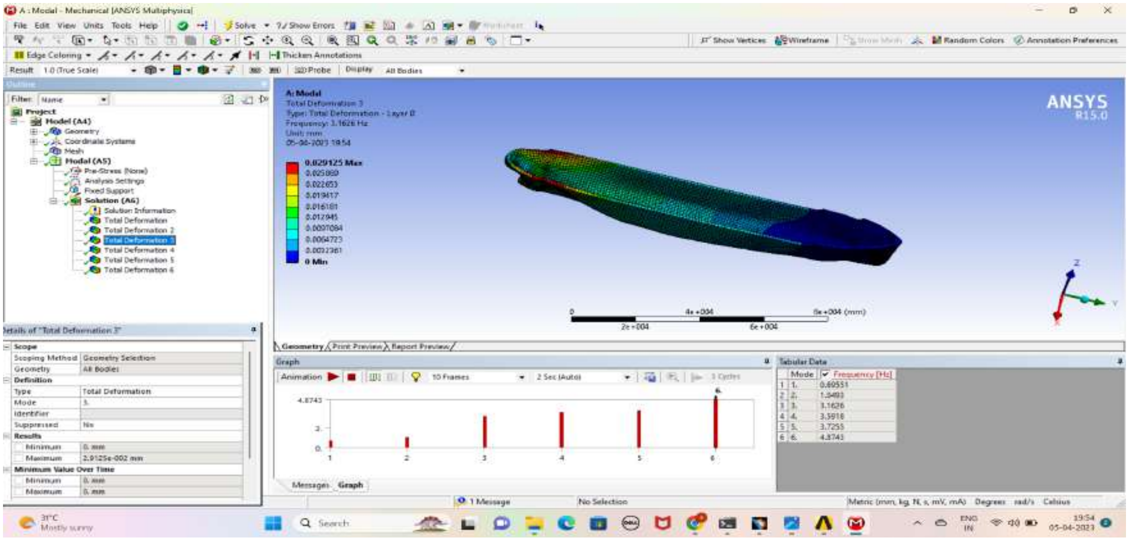
Details of "Total Deformation 2"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	2.
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	2.2068e-002 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

Tabular Data

	Mode	Frequency [Hz]
1	1.	0.69551
2	2.	1.0493
3	3.	3.1626
4	4.	3.3918
5	5.	3.7255
6	6.	4.8743

Fig 5.26 Aluminum with neoprene rubber-deformation in mode 2


A: Modal
Total Deformation 3
Type: Total Deformation - Layer 0
Frequency: 3.1626 Hz
Unit: mm
05-04-2023 19:54

0.029125 Max
0.025889
0.022653
0.019417
0.016181
0.012945
0.0097084
0.0064723
0.0032361
0 Min

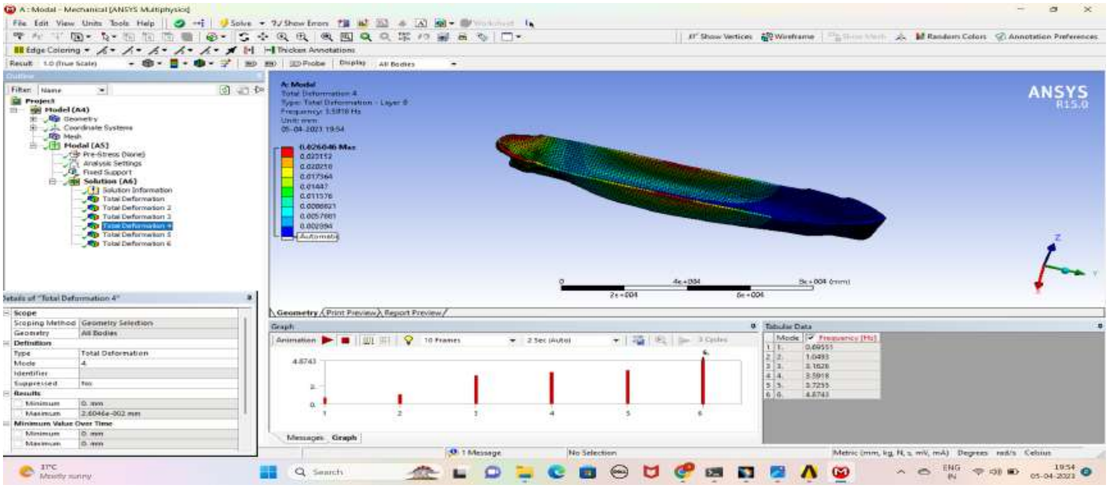
Details of "Total Deformation 3"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	3.
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	2.9125e-002 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

Tabular Data

	Mode	Frequency [Hz]
1	1.	0.69551
2	2.	1.0493
3	3.	3.1626
4	4.	3.3918
5	5.	3.7255
6	6.	4.8743

Fig 5.27 Aluminum with neoprene rubber-deformation in mode 3



A: Modal
Total Deformation 4
Type: Total Deformation - Layer 0
Frequency: 3.5918 Hz
Unit: mm
05-04-2023 19:54

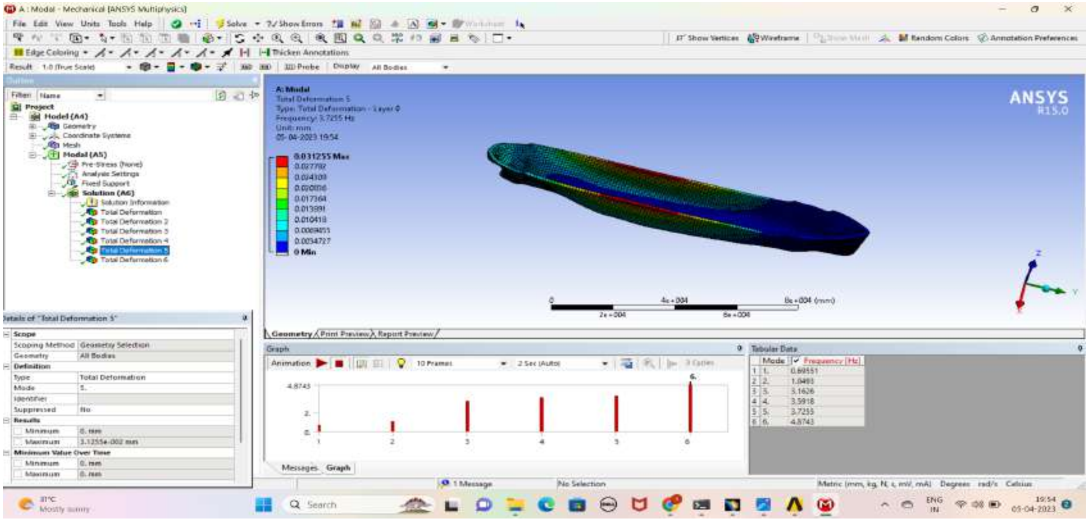
Details of "Total Deformation 4"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	4.
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	2.6046e-002 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

Tabular Data

	Mode	☑ Frequency [Hz]
1	1.	0.69551
2	2.	1.0493
3	3.	3.1628
4	4.	3.5918
5	5.	3.7255
6	6.	4.8743

Fig 5.28 Aluminum with neoprene rubber-deformation in mode 4



A: Modal
Total Deformation 5
Type: Total Deformation - Layer 0
Frequency: 3.7255 Hz
Unit: mm
05-04-2023 19:54

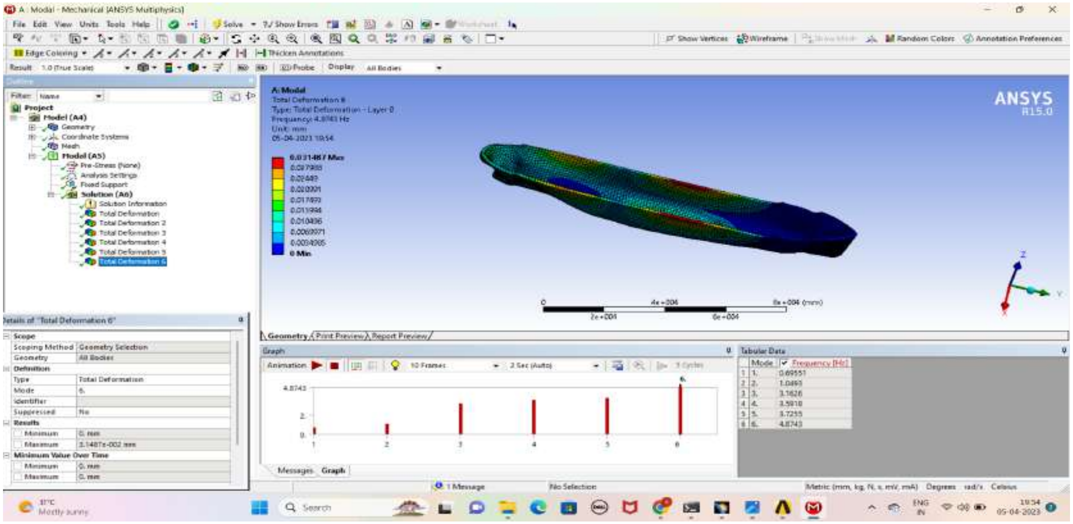
Details of "Total Deformation 5"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	5.
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	3.1255e-002 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

Tabular Data

	Mode	☑ Frequency [Hz]
1	1.	0.69551
2	2.	1.0493
3	3.	3.1628
4	4.	3.5918
5	5.	3.7255
6	6.	4.8743

Fig 5.29 Aluminum with neoprene rubber-deformation in mode 5



A: Modal
Total Deformation 6
Type: Total Deformation - Layer 0
Frequency: 4.8743 Hz
Unit: mm
05-04-2023 19:54

Details of "Total Deformation 6"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	6.
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	3.1487e-002 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

Tabular Data

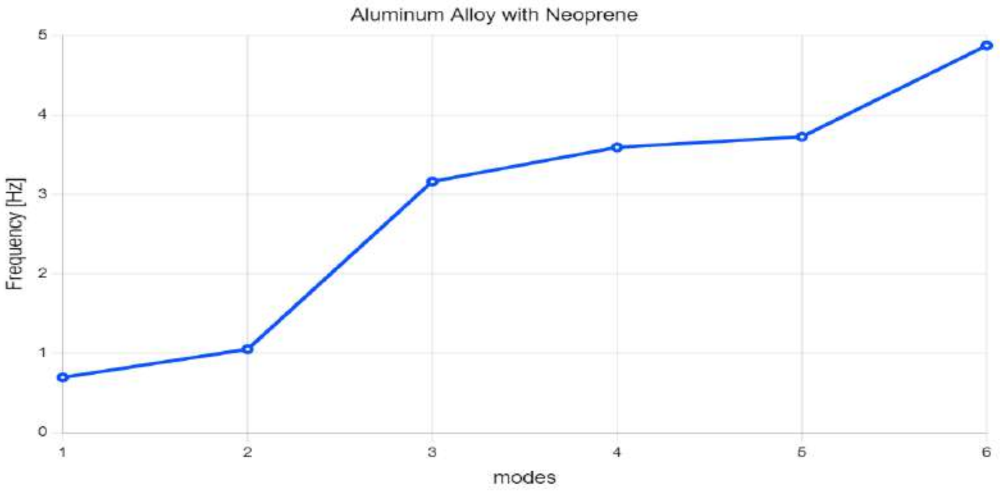
	Mode	☑ Frequency [Hz]
1	1.	0.69551
2	2.	1.0493
3	3.	3.1628
4	4.	3.5918
5	5.	3.7255
6	6.	4.8743

Fig 5.30 Aluminum with neoprene rubber-deformation in mode 6

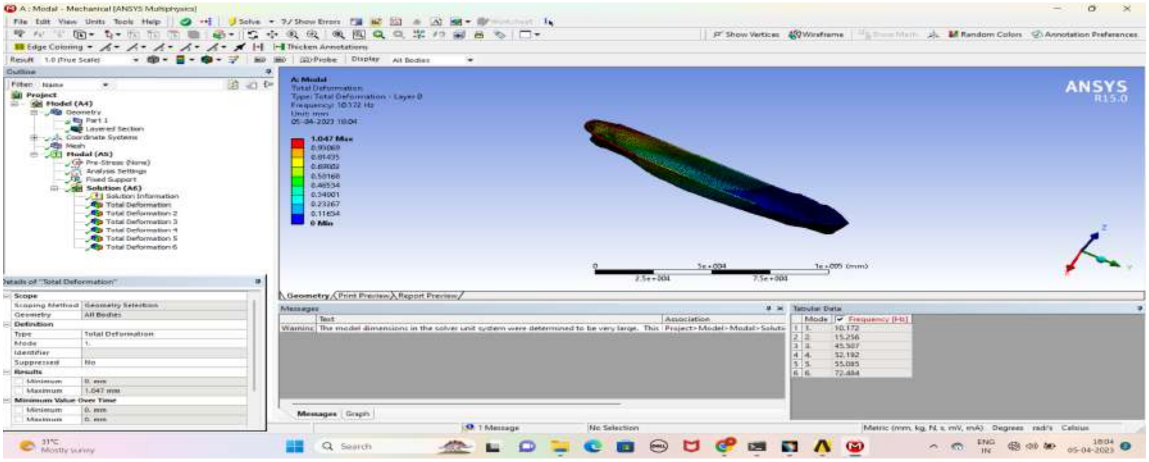
Table no 5.5: Tabular data for Aluminum Alloy with Neoprene

Modes	Frequency[Hz]
1	0.69551
2	1.0493
3	3.1626
4	3.5918
5	3.7255
6	4.8743

Graph No 5.5 - Aluminium Alloy with Neoprene



5.2.3 For FRP - Vinyl Ester with neoprene



A: Modal
Total Deformation
Type: Total Deformation - Layer 0
Frequency: 10.172 Hz
Unit: mm
05-04-2023 10:04

1.047 Max
0.93069
0.81435
0.69802
0.58168
0.46534
0.34901
0.23267
0.11634
0 Min

Details of "Total Deformation"

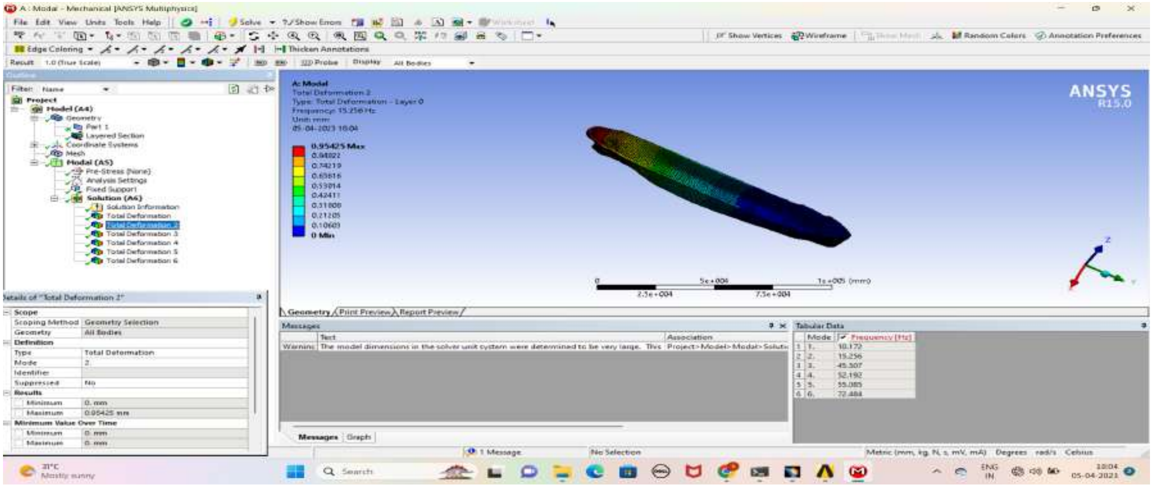
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	1.
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	1.047 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

	Text	Association
Warning	The model dimensions in the solver unit system were determined to be very large. This	Project>Model>Modal>Soluti

Tabular Data

	Mode	Frequency [Hz]
1	1.	10.172
2	2.	15.256
3	3.	45.507
4	4.	52.192
5	5.	55.085
6	6.	72.484

Fig 5.31 FRP with neoprene rubber-deformation in mode 1



A: Modal
Total Deformation 2
Type: Total Deformation - Layer 0
Frequency: 15.256 Hz
Unit: mm
05-04-2023 10:04

0.95425 Max
0.84822
0.74219
0.63616
0.53014
0.42411
0.31808
0.21205
0.10603
0 Min

Details of "Total Deformation 2"

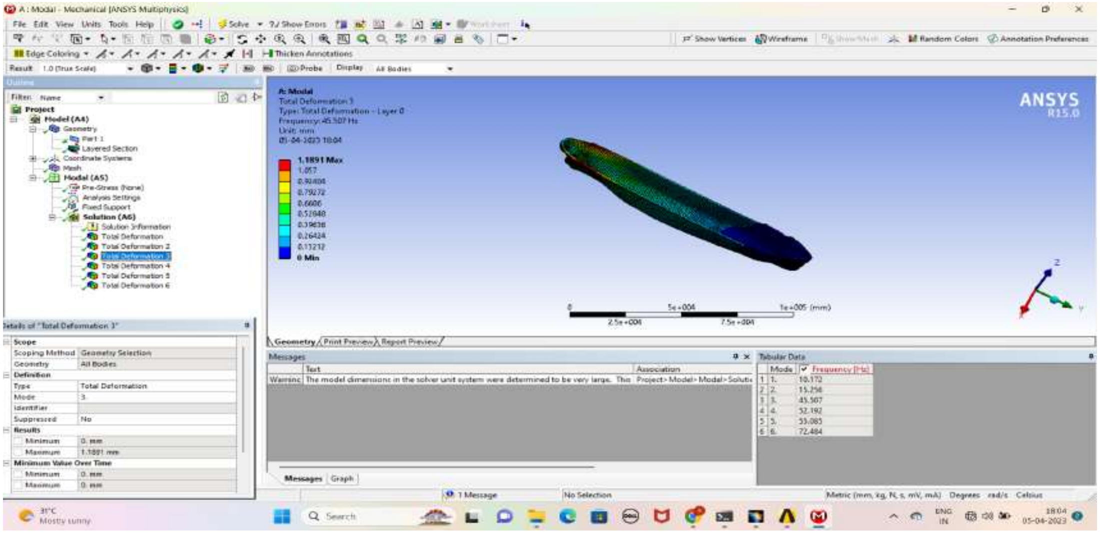
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	2.
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	0.95425 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

	Text	Association
Warning	The model dimensions in the solver unit system were determined to be very large. This	Project>Model>Modal>Soluti

Tabular Data

	Mode	Frequency [Hz]
1	1.	10.172
2	2.	15.256
3	3.	45.507
4	4.	52.192
5	5.	55.085
6	6.	72.484

Fig 5.32 FRP with neoprene rubber-deformation in mode 2



A: Modal
Total Deformation 3
Type: Total Deformation - Layer 0
Frequency: 45.507 Hz
Unit: mm
05-04-2023 10:04

1.1891 Max
1.057
0.92484
0.79272
0.6606
0.52848
0.39636
0.26424
0.13212
0 Min

Details of "Total Deformation 3"

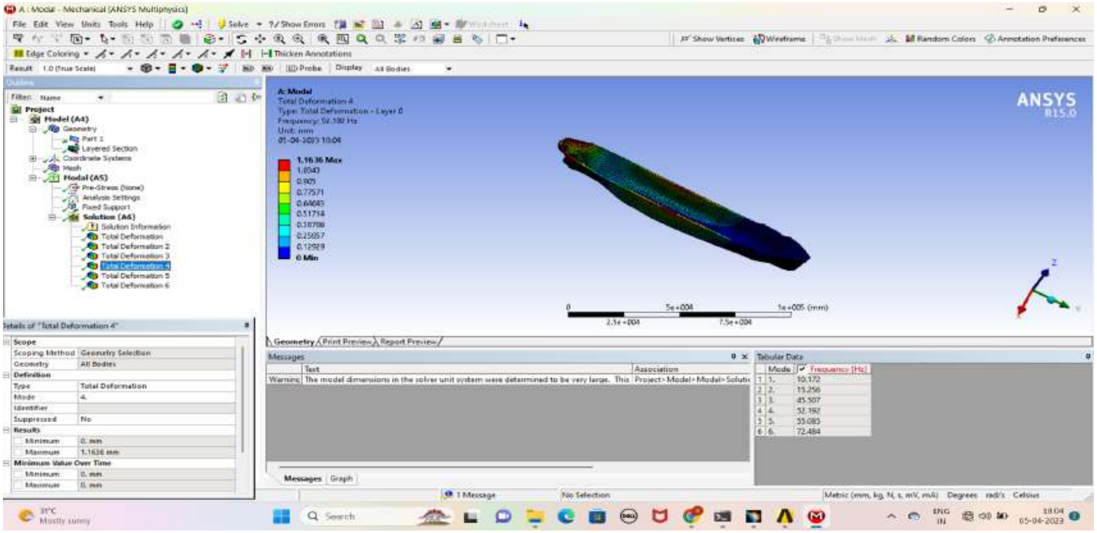
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	3.
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	1.1891 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

	Text	Association
Warning	The model dimensions in the solver unit system were determined to be very large. This	Project>Model>Modal>Soluti

Tabular Data

	Mode	Frequency [Hz]
1	1.	10.172
2	2.	15.256
3	3.	45.507
4	4.	52.192
5	5.	55.085
6	6.	72.484

Fig 5.33 FRP with neoprene rubber-deformation in mode 3



A: Modal
Total Deformation 4
Type: Total Deformation - Layer 0
Frequency: 52.192 Hz
Unit: mm
05-04-2023 18:04

Project
Model (A4)
Geometry
Part 1
Layered Section
Coordinate Systems
Mesh
Modal (A5)
Pre-Stress (None)
Analysis Settings
Fixed Support
Solution (A6)
Solution Information
Total Deformation
Total Deformation 2
Total Deformation 3
Total Deformation 4
Total Deformation 5
Total Deformation 6

Details of "Total Deformation 4"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	4.
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	1.1636 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

Messages

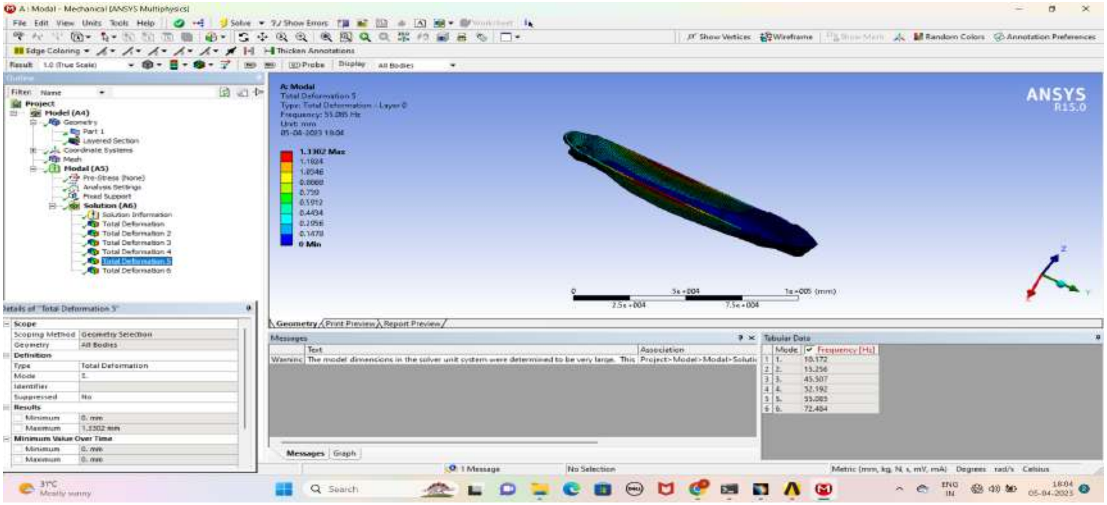
	Text	Association
Warning	The model dimensions in the solver unit system were determined to be very large. This	Project>Model>Modal>Soluti

Tabular Data

	Mode	Frequency [Hz]
1	1.	10.172
2	2.	15.256
3	3.	45.507
4	4.	52.192
5	5.	55.085
6	6.	72.484

1 Message
No Selection
Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius

Fig 5.34 FRP with neoprene rubber-deformation in mode 4



A: Modal
Total Deformation 5
Type: Total Deformation - Layer 0
Frequency: 55.085 Hz
Unit: mm
05-04-2023 18:04

Project
Model (A4)
Geometry
Part 1
Layered Section
Coordinate Systems
Mesh
Modal (A5)
Pre-Stress (None)
Analysis Settings
Fixed Support
Solution (A6)
Solution Information
Total Deformation
Total Deformation 2
Total Deformation 3
Total Deformation 4
Total Deformation 5
Total Deformation 6

Details of "Total Deformation 5"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	5.
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	1.3302 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

Messages

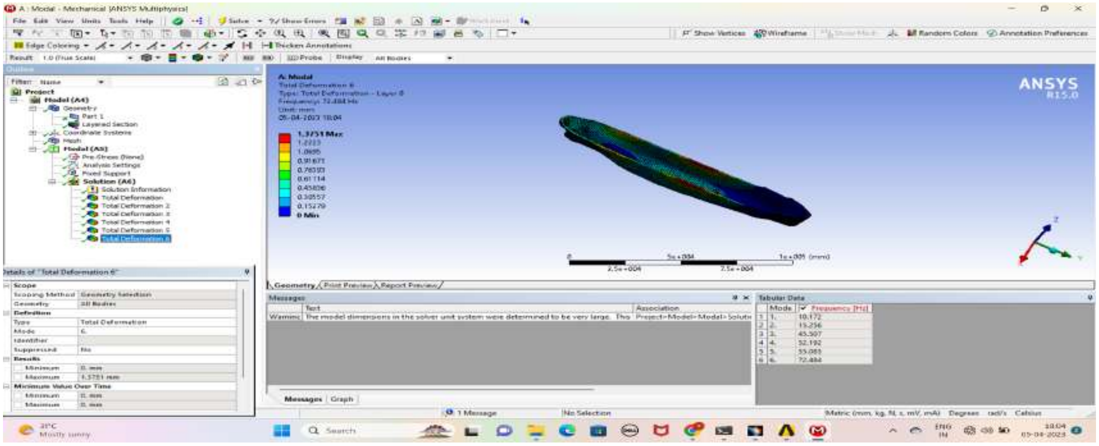
	Text	Association
Warning	The model dimensions in the solver unit system were determined to be very large. This	Project>Model>Modal>Soluti

Tabular Data

	Mode	Frequency [Hz]
1	1.	10.172
2	2.	15.256
3	3.	45.507
4	4.	52.192
5	5.	55.085
6	6.	72.484

1 Message
No Selection
Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius

Fig 5.35 FRP with neoprene rubber-deformation in mode 5



A: Modal
Total Deformation 6
Type: Total Deformation - Layer 0
Frequency: 72.484 Hz
Unit: mm
05-04-2023 18:04

Project
Model (A4)
Geometry
Part 1
Layered Section
Coordinate Systems
Mesh
Modal (A5)
Pre-Stress (None)
Analysis Settings
Fixed Support
Solution (A6)
Solution Information
Total Deformation
Total Deformation 2
Total Deformation 3
Total Deformation 4
Total Deformation 5
Total Deformation 6

Details of "Total Deformation 6"

Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Definition	
Type	Total Deformation
Mode	6.
Identifier	
Suppressed	No
Results	
Minimum	0. mm
Maximum	1.3751 mm
Minimum Value Over Time	
Minimum	0. mm
Maximum	0. mm

Messages

	Text	Association
Warning	The model dimensions in the solver unit system were determined to be very large. This	Project>Model>Modal>Soluti

Tabular Data

	Mode	Frequency [Hz]
1	1.	10.172
2	2.	15.256
3	3.	45.507
4	4.	52.192
5	5.	55.085
6	6.	72.484

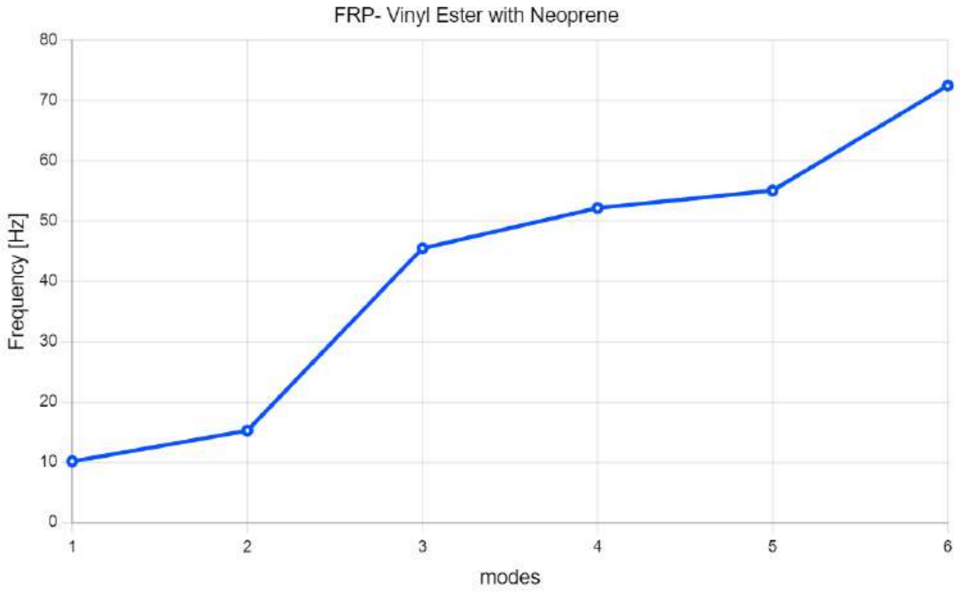
1 Message
No Selection
Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius

Fig 5.36 FRP with neoprene rubber-deformation in mode 6

Table no 5.6 : Tabular data for FRP- Vinyl Ester with Neoprene

Modes	**Frequency[Hz]**
1	10.172
2	15.256
3	45.507
4	52.192
5	55.085
6	72.484

Graph No 5.6 - FRP -m Vinyl Ester with Neoprene



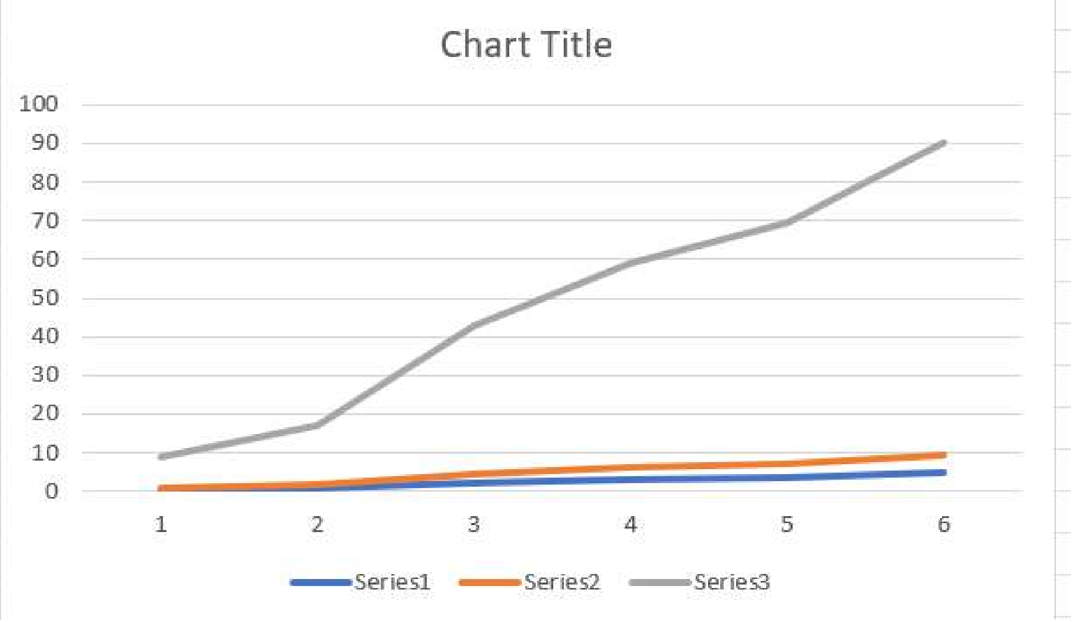
5.3 Comparison of Natural Frequencies of Steel, Aluminium and FRP-Vinyl Ester material.

5.3.1 without neoprene comparison

Table 5.7 tabular data of all three materials without a layer neoprene

modes	Structural steel	Aluminum alloy	FRP
1	0.4608	0.46073	7.8887
2	0.88392	0.88673	15.183
3	2.2325	2.2334	38.241
4	3.0755	3.0793	52.724
5	3.5978	3.6291	62.139
6	4.6841	4.7114	80.669

Graph 5.7 comparing three materials without a layer neoprene

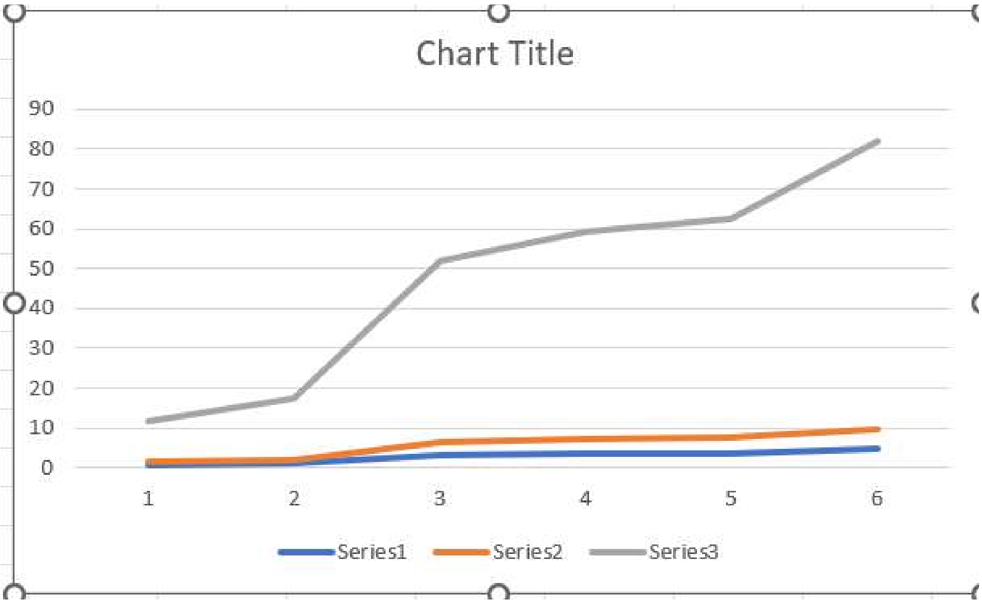


5.3.2 with neoprene comparison

Table 5.8 comparing three materials with a layer of neoprene

modes	Structural steel	Aluminum alloy	FRP
1	0.69385	0.69551	10.172
2	1.0443	1.0493	15.256
3	3.1542	3.1626	45.507
4	3.5784	3.5918	52.192
5	3.6816	3.7255	55.085
6	4.8361	4.8743	72.484

Graph 5.8 comparing three materials with a layer of neoprene



CHAPTER 6

CONCLUSIONS

6.1 Conclusion

The research work has concluded that the mechanical properties are directly related with natural frequency and vibration mode shapes because as the material assignment to the ship hull is changed we can observe from the modal analysis results that there is a change in the resonant frequency of the system.Therefore, when we evaluate the results for the first 6 modes of the deformed ship hull system with different materials like Structural Steel, Aluminium Alloy, Fibre reinforced Polymer. We then observed that the natural frequencies of the Fibre reinforced Polymer - Vinyl Ester is having the highest Resonant Frequency due it's high impact and fatigue strength properties with compared to the Structural steel and Aluminium Alloy.Also when we apply a layer of damping material to the interior portion of the ship Hull it was observed that there is an increase in the resonant frequency values for all the materials without Neoprene Rubber in comparison with all the three materials with neoprene rubber. Therefore, the materials with neoprene rubber layer showing the highest Natural frequencies.

So with this research it will be helpful for the marine engineers and Naval Architect's to make safer design to reduce the vibrations on the ship hulls to some extent by using different damping materials and it can also further create more research work for damping materials for ship hulls

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