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

DASARI S R V ARUN TEJESH319126520177SHAIK AARIF HUSSAIN320126520L36GAMINI KRISHNA VAMSI319126520178CHINTALAPUDI VENKATA SIVA SAI KARTHIK319126520176PADALA AJAY319126520197

Under the Esteemed Guidance of

Dr. M. PRASANTH KUMAR M.Tech. Ph.D. Associate Professor



DEPARTMENT OF MECHANICAL ENGINEERING

ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES (A) (Permanently Affiliated to Andhra University, Approved by AICTE, Accredited by NBA Tier-I, NAAC) Sangivalasa, Visakhapatnam (District) Andhra Pradesh -India– 531162.

APRIL 2023

DEPARTMENT OF MECHANICAL ENGINEERING ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY & SCIENCES (UGC Autonomous & Permanently Affiliated to Andhra University)



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.

Project Guide

Dr. M. Prasanth Kumar Associate Professor Dept. of Mechanical Engineering, ANITS Head of the Department

Dr. B. NAGA RAJU Professor Dept. of Mechanical Engineering ANITS

THIS PROJECT IS APPROVED BY THE BOARD OF EXAMINERS:

INTERNAL EXAMINER:

EXTERNAL EXAMINER:

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.

TABLE OF CONTENT

n P	Page No.
LEDGEMENT	i
Т	ii
F CONTENTS	iiii
ABLES	vi
IGURE	vii
RAPHS	X
LATURE	xi
R 1. INTRODUCTION	1
	,1
out ship hull	1
.1 Types of ship hull	2
.2 Nomenclature of ship hull	6
erials used in building of a ship hull	9
2.1 steel	9
2.2 Aluminium alloy	10
2.3 Fiber reinforced plastic	10
2.4 polyethylene	11
es of forces exerted on the ship hull	12
.1 Longitudinal stress	12
.2 Transverse stress	14
.3 local stress	15
.4 wave excitations	16
.5 propeller excitations	17
rations on ship hull	18
	LEDGEMENT T

	1.4.1 Introduction to vibration
	1.4.2 types of vibration
	1.4.3 About vibration on ship hull
	1.4.4 ship vibration analysis
	1.4.5 main elements influencing ship vibration
	1.4.6 effect of vibration on ship hull
СНА	PTER 2: LITERATURE REVIEW
СНА	PTER 3: AIM AND SCOPE 29
СНА	PTER 4: MODELING AND PROPOSED APPROACH
	4.1 Introduction to Catia
	4.1.1 Steps involved in modeling
	4.1.2 Dimensions of ship hull
	4.2 History of ansys
	4.2.1 introduction to Ansys workbench
	4.3 Proposed Approach
	4.3.1 steps in analysis of ship hull
СНА	PTER 5 ; RESULTS AND DISCUSSIONS
5.1	modal analysis without neoprene rubber
	5.1.1 structural steel
	5.1.2 aluminum alloy45
	5.1.3 FRP -vinylester
5.2	modal analysis results with neoprene rubber
	5.2.1 structural steel with neoprene rubber
	5.2.2 aluminum alloy with neoprene rubber
	5.3.3. FRP with neoprene

5.3	comp	parison of natural frequencies of steel, aluminum and FRP	. 60
	5.3.1	without neoprene comparison	.60
	5.3.2	with neoprene comparison	.61
CHA	PTER	6: CONCLUSION	.62
	REFE	RENCES	64

LIST OF TABLES

Table No.Title of the Table

Page No.

Table 1.1	properties of structural steel	9
Table 1.2	properties of aluminum alloy	10
Table 1.3	properties of FRP- vinyl ester	11
Table 1.4	properties of polyethylene	11
Table 5.1	Tabular data for structural steel	44
Table 5.2	Tabular data for Aluminium Alloy	.47
Table 5.3	Tabular data for FRP -vinyl ester	50
Table 5.4	Tabular data for Structural steel with Neoprene	. 53
Table 5.5	Tabular data for aluminum alloy with neoprene	. 56
Table 5.6	Tabular data for FRP with neoprene	. 59
Table 5.7	Tabular data of all three materials without a layer neoprene	60
Table 5.8	tabular data of all three materials with a layer of neoprene	61

LIST OF FIGURES

Figure No.	Figure Caption	Page No.
Figure 1.1	Ship hull	1
Figure 1.2	Displacement hull	3
Figure 1.3	Planning	3
Figure 1.4	Flat bottom	4
Figure 1.5	V bottom	4
Figure 1.6	Tri hull	5
Figure 1.7	Hull structure	5
Figure 1.8	Semi displacement hull	6
Figure 1.9	Nomenclature of ship hull	7
Figure 1.10	Sagging	12
Figure 1.11	Hogging	13
Figure 1.12	Shearning	
Figure 1.13	Torsion	14
Figure 1.14	Racking	14
Figure 1.15	Water Pressure	14
Figure 1.16	Docking	
Figure 1.17	Middleweight Stresses	16
Figure 1.18	Ship vibrational analysis flowchart	
Figure 1.19	Summary of ship vibrational analysis	
Figure 1.20	element influencing the ship vibration	
Figure 4.1	line diagram of victoria ship hull	
Figure 4.2	line design of hull in catia	
Figure 4.3	surface modeling design	32
Figure 4.4.	Building of ship hull curves	
Figure 4.5	tools used in building ship hull model	

Figure 4.6	extruded surface model
Figure 4.7	3D viewshiphull
Figure 4.8	length of the hull
Figure 4.9	width of hull
Figure 4.10	depth of hull
Figure 4.11	import geometry
Figure 4.12	material assignment
Figure 4.13	generate mesh
Figure 4.14	meshed body
Figure 4.15	fixed support of hull40
Figure 4.16	total deformation tool in ansys
Figure 4.17	solve tool in ansys
Figure 4.18	results for deformation after solving
Figure 5.1	Structural steel-deformation in mode 1
Figure 5.2	Structural steel-deformation in mode 2
Figure 5.3	Structural steel-deformation in mode 3
Figure 5.4	Structural steel-deformation in mode 4
Figure 5.5	Structural steel-deformation in mode 5
Figure 5.6	Structural steel-deformation in mode 6
Figure 5.7	Aluminum-deformation in mode 145
Figure 5.8	Aluminum-deformation in mode 245
Figure 5.9	Aluminum-deformation in mode 345
Figure 5.10	Aluminum-deformation in mode 446
Figure 5.11	Aluminum-deformation in mode 546
Figure 5.12	Aluminum-deformation in mode 646
Figure 5.13	FRP-deformation in mode 1
Figure 5.14	FRP-deformation in mode 2
Figure 5.15	FRP- deformation in mode 3
Figure 5.16	FRP-deformation mode 4
Figure 5.17	FRP- deformation in mode 5

Figure 5.18	FRP - deformation in mode 6	
Figure 5.19	Structural steel with neoprene-deformation in mode 1	51
Figure 5.20	Structural steel with neoprene-deformation in mode 2	51
Figure 5.21	Structural steel with neoprene-deformation in mode 3	51
Figure 5.22	Structural steel with neoprene-deformation in mode 4	
Figure 5.23	Structural steel with neoprene-deformation in mode 5	
Figure 5.24	Structural steel with neoprene-deformation mode 6	
Figure 5.25	Aluminum alloy with neoprene-deformation in mode 1	54
Figure 5.26	Aluminum alloy with neoprene-deformation in mode 2	54
Figure 5.27	Aluminum alloy with neoprene-deformation in mode3	54
Figure 5.28	Aluminum alloy with neoprene-deformation in mode 4	55
Figure 5.29	Aluminum alloy with neoprene-deformation in mode 5	55
Figure 5.30	Aluminum alloy with neoprene-deformation in mode 6	55
Figure 5.31	FRP with neoprene-deformation in mode 1	57
Figure 5.32	FRP with neoprene-deformation in mode 2	57
Figure 5.33	FRP with neoprene-deformation in mode 3	57
Figure 5.34	FRP with neopren- deformation in mode 4	58
Figure 5.35	FRP with neoprene- deformation in mode 5	58
Figure 5.36	FRP with neoprene- deformation in mode 6	

LIST OF GRAPHS

Graph 5.1 : For structural steel	44
Graph 5.2 - For Aluminium Alloy	47
Graph 5.3 - FRP - Vinyl Ester	.50
Graph 5.4 - Structural steel with Neoprene	53
Graph 5.5 - Aluminium Alloy with Neoprene	56
Graph 5.6 - FRP -m Vinyl Ester with Neoprene	59
Graph 5.7 comparing three materials without a layer neoprene	.60
Graph 5.8 comparing three materials with a layer of neoprene	.61

NOMENCLATURE

А	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.

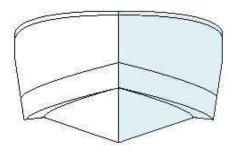
2





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 .



PLANING

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.

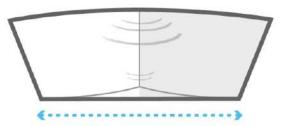


Fig 1.4 Flat bottom

• 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.

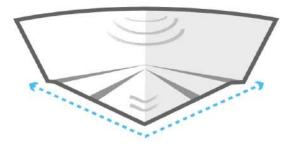


Fig 1.5 V bottom

• 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.

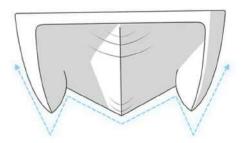


Fig 1.6 Tri hull

• 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.

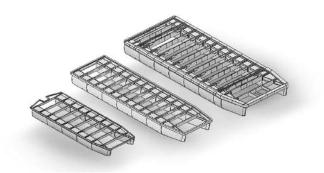


Fig 1.7 Hull structure

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.

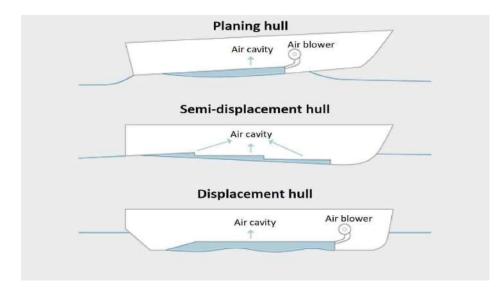


Fig 1.8 Semi displacement hull

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.

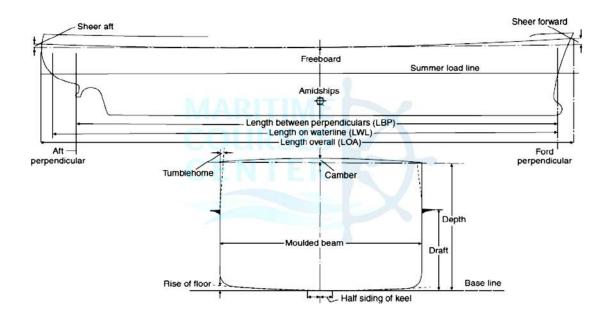


Fig 1.9 Nomenclature of ship hull

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.

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.

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

Table no 1.2 : Properties of Aluminum Alloy

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

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

Table No 1.3 : Properties of FRP - Vinyl Ester

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.

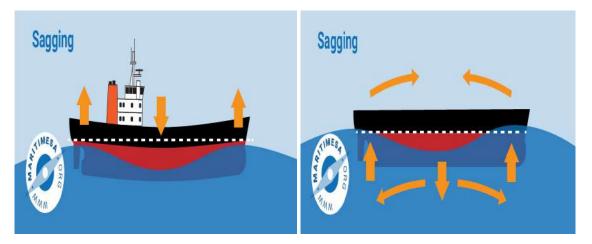


Fig 1.10 Sagging

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.

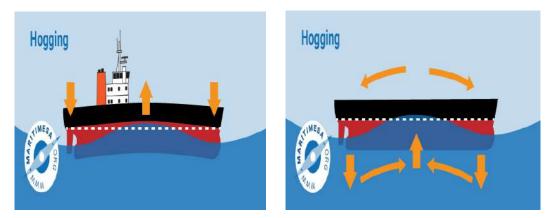


Fig 1.11 Hogging

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.

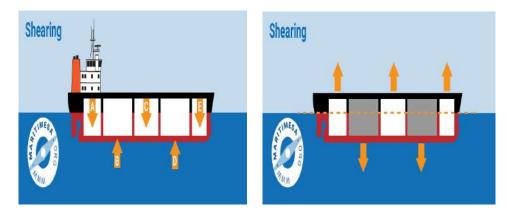


Fig 1.12 Shearing

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.

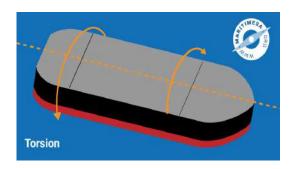


Fig 1.13 Torsion

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.

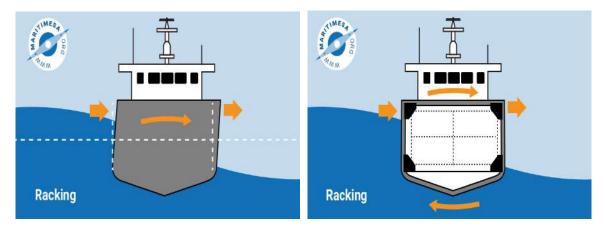


Fig 1.14 racking

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

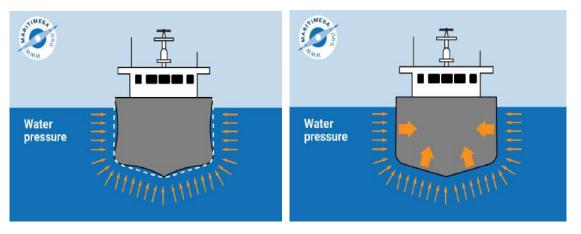


Fig 1.15 water pressure

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.

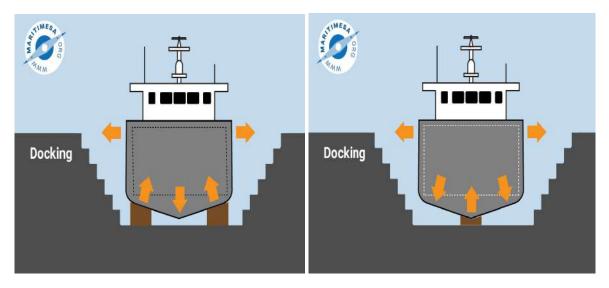


Fig 1.16 docking

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.

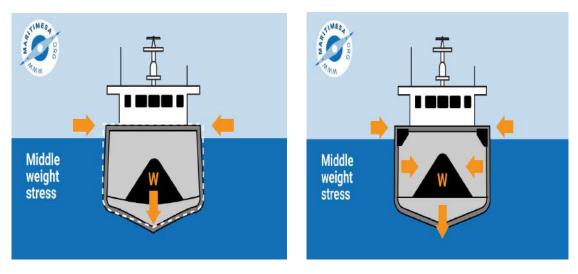


Fig 1.17 Middle weight Stresses

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:

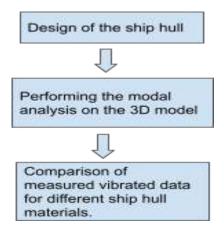


Fig 1.18 Ship vibrational analysis flowchart

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

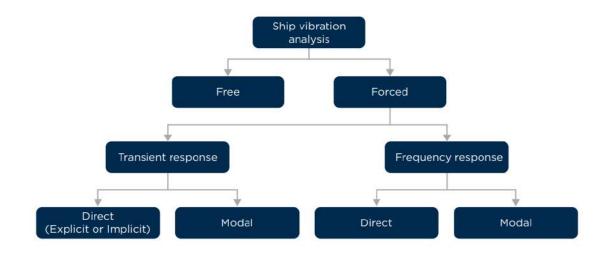
- Free Vibration Analysis
- Forced Vibration Analysis

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 PRASANNA¹, DR. AMAR NAGESWARA RAO² [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 BABU¹, **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 Mathai¹, George John P.², Jini Jacob³ [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 Alaimo¹, Alberto Milazzo², Davide Tumino³,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/NastranTM 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 ALI¹, **Dr.C.G NANDAKUMAR²[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 Ergin¹, Levent Kaydıhan² and Bahadır Ugurlu³[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 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.

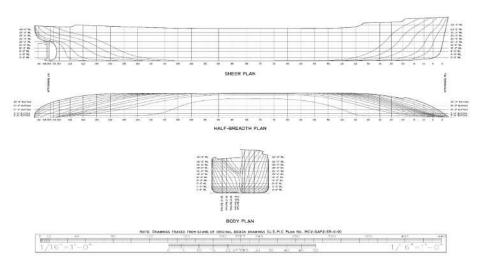


Fig 4.1 Line diagram of of victoria ship

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

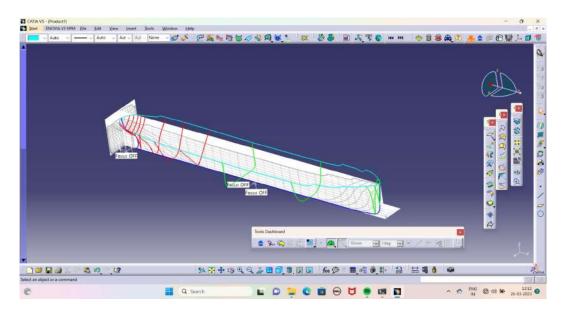


Fig 4.2 Line design of hull in CATIA

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.

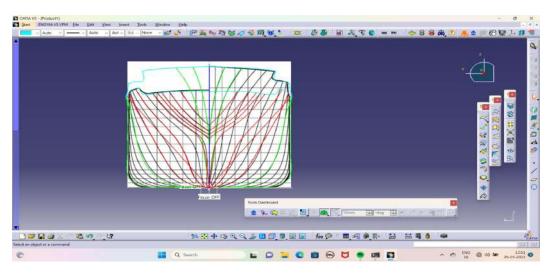


Fig 4.3 surface modeling design

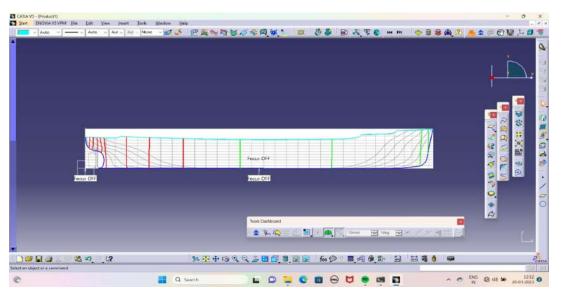


Fig 4.4 building of ship hull curves

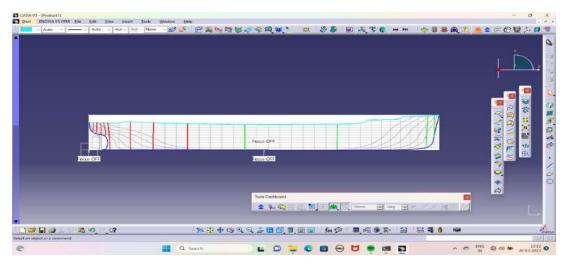


Fig 4.5 tools used in building ship hull model

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

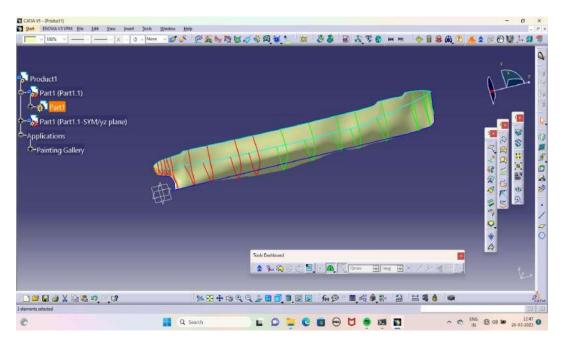


Fig 4.6 Extrude surface model

The final 3 dimensional view of the ship hull :

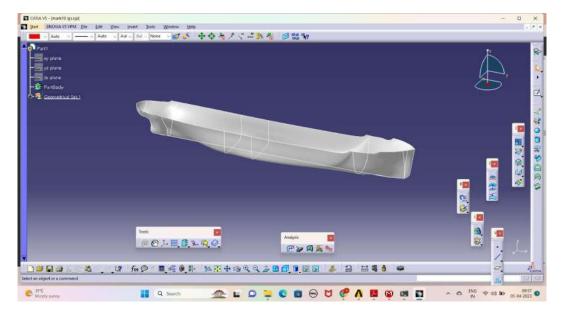


Fig 4.7 3D view ship hull

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

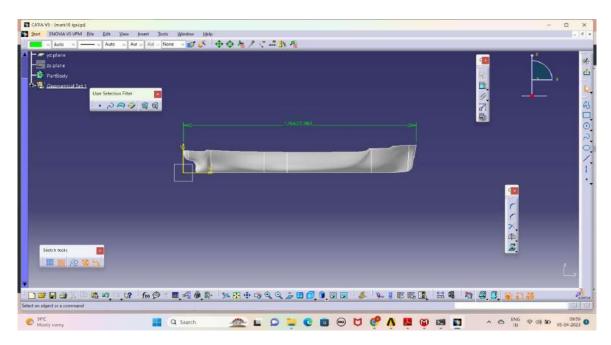


Fig 4.8 length of the hull

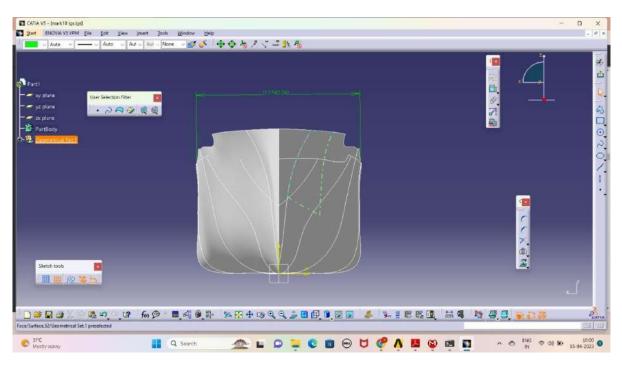


Fig 4.9 Width of hull

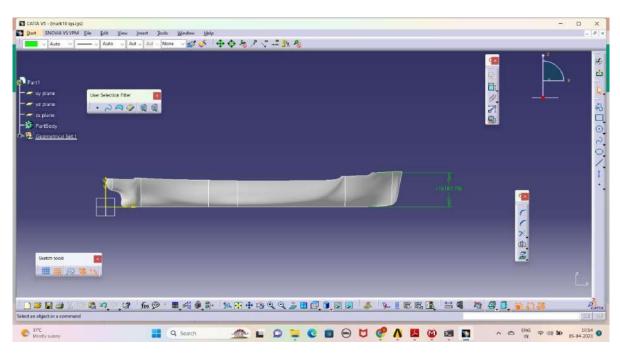


Fig 4.10 Depth of hull

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

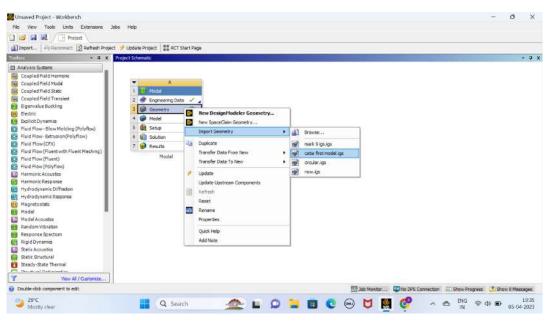


Fig 4.11 Import geometry

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

	File Home	Geometry Display Selec	tior
	-Cut XD	elete My Computer -	
De	stails of "mark 9 igs-Fre	eParts Symmetry.9" - 4	
Gerl	Graphics Properties		
	Definition		
1	Suppressed	No	
1	Dimension	3D	
	Model Type	Shell	
1	Stiffness Behavior	Flexible	
	Stiffness Option	Membrane and Bending	
1	Coordinate System	Default Coordinate System	
1	Reference Temperature	By Environment	
	Thickness	1. m	
1	Thickness Mode	Manual	
[Offset Type	Middle	
1	Treatment	None	
	Material		
	Assignment	Structural Steel	-
1	Nonlinear Effects	Yes	
	Thermal Strain Effects	Yes	
CE1	Bounding Box		
(III)	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.

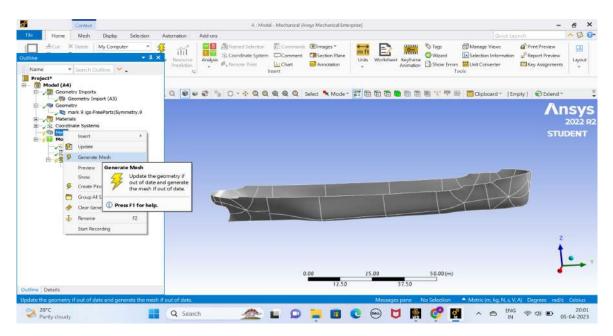


Fig 4.13 Generate mesh

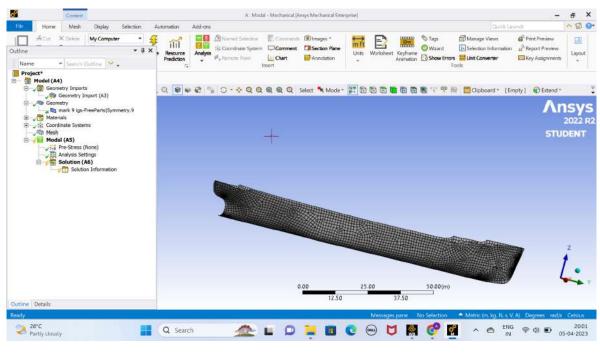


Fig 4.14 Meshed body

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

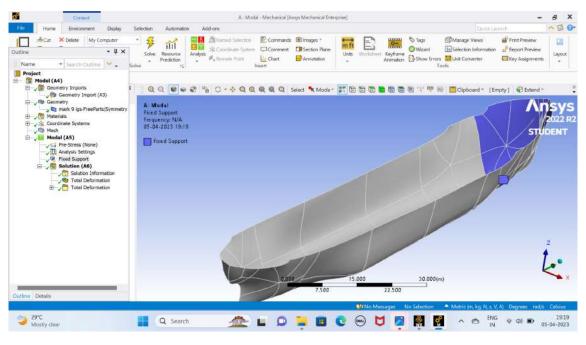


Fig 4.15 Fixed support for hull

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

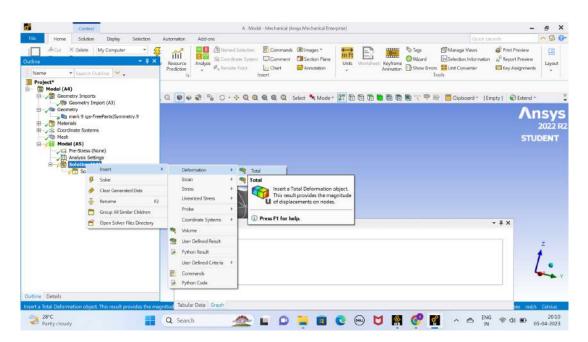


Fig 4.16 Total deformation tool in ansys

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

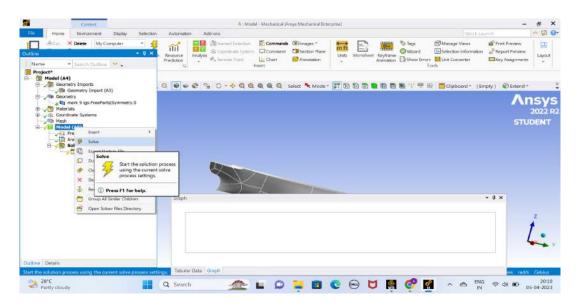


Fig 4.17 solve tool in ansys

Home Result Display Selection	on Automation	Add-ons					neli	~ 13
Model (A4)	- 🤧 👬 Solve Precistion	Acadysis	tion Commands Dimages Saum Command III Section Lichart SAnnotat Insert	Plane mft Eg min	Wizard []	Manage Views Selection Information	Print Preview Report Preview	Laycort
Contexty Imports Contexty Imports Contexty Contexts Contexts	Q Q @	tion 3 formation 193 Hz 9:04	R Q Q Soloct 🥆 N	ode- # D D D D D D		Cipboard *- {Em	۸n	1 24 4 6
→ 0 Total Deformation 5 → 2 0 Total Deformation 5 → 2 0 Total Deformation 7	0.011617 0.007744 0.0038721 0 Min		Z. 20 Frames *	2 Sec (Auto) - 🖾 🕲 🎬	(** = =)	* 3 Code M.	• # × Z	•
		25						

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

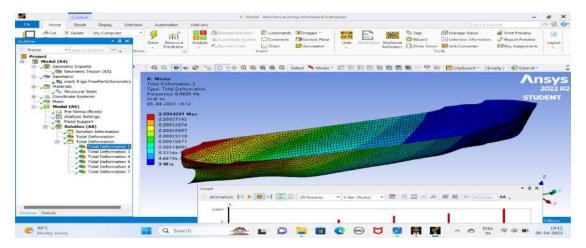


Fig 5.1 Structural steel-deformation in mode 1

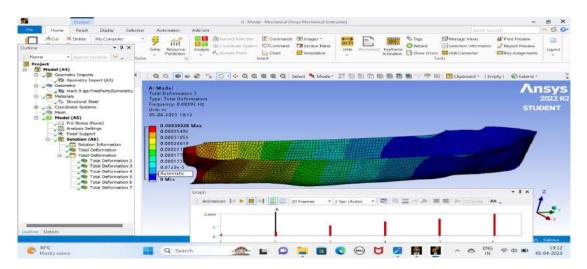
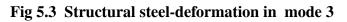


Fig 5.2 Structural steel-deformation in mode 2

Home Result Display Selection	Automation Add-or						Contra	Laurah -	10	121
Inne - Scart II Cultima - Scart	Solve Resource Prediction	St Consciouts System . Recourt Fold	Sertion Pane		Keyframe Animation		Manage Views	Prant Preview Prepart Preview		Layout
Project Model (A4) Gametry Imports K	00.000		 							
Geometry Import (A3) Geometry Materials Materials Structural Steel Structural Steel Structural Steel Mesh	A: Madal Total Deformation 4 Type: Total Deformation Frequency: 2,2325 Hz Unds m	6							101 20	022
Model (A5) Trail Performation Trail Deformation	03-04-2023 19:12 0.00052285 Max 0.000246473 0.000240666 0.000230 0.000230 0.000232 0.000174 0.000174 0.000174 0.000174 0.000174							7		
Hodel (AS) V. For Stress (Vicine) V. For Stress (Vicine) V. FaceS Support Solution Information V. Total Deformation	02-04-023 19:12 0.00052628 Mix 0.0005465 0.00073457 0.00073457 0.00073457 0.00073457 0.00073457 0.00073457 0.00073457 0.00073457 0.0007457 0.0007457 0.0001657 0.000157 0.0001657 0.000157 0.000057 0.00000000000000000000000000000000000		ames 7 25%	er (Auto)	e a:)	1	
Model (A5) Vor Area Stress (Norme) Vor Analysis Settings Vor Analysis Settings Vor Need Sectors Solution (A6) Vor Total Deformation 3 Vor Total Deformation 5 Vor Total Deformation 5 Vor Total Deformation 5	02-04-2023 19:12 0.00052285 Max 0.00046475 0.000290 0.00014857 0.0001761 0.0001761 0.0001761 0.0001761 0.0001761 0.0001465 0.000145 0.0000145 0.0000000000000000000000000		ames † 250	sc (Auto) =	e a:	1 × 4 =)	ž	•



Context	K. Modal - Mechanical (Arrige Mechanical Interprine)		- 63
Home Result Display Selection	Automation Add-one On-Ide Laurenh		. PO
Anne - Solve Solve	Image: Stress Figure 2 Image: Stress Figure 2<	eview	Layos
hoject Model (A4) Casmetry Imports - star Geometry Import (A3) - star marks - star is tigs-freeParts(Symmetry) - star is tigs-freeParts(Symmetry)	다. Insert Teds Q.Q. 응 속 상 1% [고·승 Q.Q.Q.Q.Q.Q.Select 및 Moder 227 전 전 전 전 전 전 전 전 전 전 전 전 전 전 전 전 전 전	۸ns	
H	Type: Fool D Friematon Frequency: 30/351 4c2 Shift in 0.0004/323 10/12 0.0004/327 Max 0.00001/31/2 0.00001/31 0.000001/31 0.000001/31 0.00000000000000000000000000000000000	STUD	

Fig 5.4 Structural steel-deformation in mode 4

Context			Anchemical (Areps Marchanical Entr	(c)prove (-	-19
Home Result Display Selection	Automation Add-on					Christian Christian		~ [2]
Anne Secon Come . Store	Solve Rescurpt Prediction	Stationartionie Spreen 💭	Commands III) Images * Comment III Section Plane Chart III Annotation	and the second sec	Taps Witcard Witcard	Manage Views	 Print Preview ¹⁰ Report Preview EDKey Assignments 	Layos
Project Modul (A4)								
(A3)	A Mudal	ାଠାର୍କର୍ଷ୍ୟର୍	🔍 🔍 Select 🌂 Mode '	· #1 05 05 45 46 00		f 🛄 Clubboard * 1 &m		٦SV
Signature Sign-FreeParts Symmetry	Total Deformation 6 Type: Total Deformation						~~~	202
Structural Steel Jic Coordinate Systems Zin Mesh	Frequency: 3.5978 Hz Unit:m						STU	DEN
JAG REAL	05-04-2023 19:12							
III) Analysis Settings	0.00055091 M+x					-		
Fire Stress (Nene) III Analysis Settings Fixed Support Solution (A6)								
	0.00049056 0.00049056						-	
In the Strings Industry Settings Industry Industry	0.00050091 M+x 0.00049058 0.00049526 0.00057394 0.0003110005						7	
Ciril Pres Eleress (Kenet) Ciril Analyses Settings Ciril Analyses Settings Ciril Solution (AG) Ciril Solution (AG) Ciril Deformation	0.00050091 M+x 0.00049056 0.00037394 0.0003110 0.000249 0.0001586 0.0001586 0.0001586 0.0001586						7	
Viti Pre-Strong (Nune) Viti Analysis Settings Viti Analysis Settings Viti Solution Information Viti Solution Information Viti Total Deformation 2 Viti Total Deformation 3 Viti Total Deformation 4	0.00030091 Max 0.00049056 0.00037024 0.00037024 0.00037024 0.000114 0.000249 0.000188 6.23238-5 0 Min						7	
Construction	0.00058091 M+x 0.00048056 0.00054926 0.00057394 0.00057394 0.0001965 0.0001965 0.0001965 0.0001965 0.0001965 0.0001965 0.0001965 0.0001965 0.0001965 0.00058000 0.00057594 0.0005750000000000						/	z
Construction	0.0001952091 Max 0.00019526 0.00019526 0.00019526 0.00019526 0.00019526 0.00019526 0.0001952 0.000195 0.00000000000000000000000000000000000	mation 1+ > (=) +1						į.
	0.0001952091 Max 0.00019526 0.00019526 0.00019526 0.00019526 0.00019526 0.00019526 0.0001952 0.000195 0.00000000000000000000000000000000000	instan 14 🕨 🔲 🖬						Ĺ
Construction	0.0001952091 Max 0.00019526 0.00019526 0.00019526 0.00019526 0.00019526 0.00019526 0.0001952 0.000195 0.00000000000000000000000000000000000	AND						Ļ

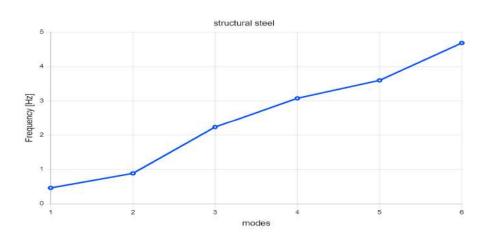
Fig 5.5 Structural steel-deformation in mode 5

Control	A : Modal - Mechanical (Annys Mechanical Interpress) -	- 8	
Home Result Display Selectio	tion Automation Add-ons Ourick Lativich	200	12
My Computer	Constants	1.	iyou
Project (A4)	(a) (1005		
Geometry Imports Geometry Geometry	🔍 📦 📽 🖓 🤹 📿 🔆 🔍 🔍 🍳 🍭 🍳 Select 🔧 Mode * 💱 🗈 🖄 🛅 🛅 🖏 🖏 🖤 👾 📾 🗖 Opboard * (Smpty) 🕹 Extend	*	
Materials Source Systems	dautai A	ns	
	a Deformation 7 zi Total Deformation	207	
Here Modal (A5)	urreg 4.6841 Hz STT	UDE	
Rixed Support	4-2023 20:24		
Solution (A6)			
	0.00051622 Max		
Solution Information	0.00054776		
Total Deformation	0.00014776		
Total Deformation Total Deformation Total Deformation 2 Total Deformation 3	0.00014776 0.000417829 0.00041082 0.00041082		
Solution Information Total Deformation Total Deformation 2 Total Deformation 3 Total Deformation 3 Total Deformation 4 Total Deformation 4 Total Deformation 5	0.0004776 0.00047829 0.00041082		
	0.00014776 0.000147929 0.00014292 0.00014292 0.00014293 0.0007054 0.0007054		
Solution Information Total Deformation Total Deformation 2 Total Deformation 3 Total Deformation 3 Total Deformation 4 Total Deformation 5 Total Deformation 5	0.00014776 0.000147829 0.0001423 0.0001423 0.0002735		
Control Deformation Control Deformation	0.005/47/6 0.0001/929 0.0000/929 0.0000/92000/92000/92000/92000/92000/92000/92000/92000/92000/92000/92000/92000/92000/9200000000		
	0.00014776 0.0001929 0.0001929 0.0001929 0.0001929 0.0001950 0.0000000000000000000000000000000000	z	
	0.00017929 0.00017929 0.0001492 0.00014929 0.00014929 0.00014929 0.00014929 0.00014929 0.00014929 0.00014929 0.00014929 0.00014929 0.00014929 0.000014929 0.000014929 0.000014929 0.00014929 0.00014929 0.00014929 0.00014929 0.00014929 0.00014929 0.00014929 0.00014929 0.00014929 0.000014929 0.000014929 0.000014929 0.0000000000000000000000000000000000	ť	
	0.00014776 0.0001929 0.0001929 0.0001929 0.0001929 0.0001950 0.0000000000000000000000000000000000	Ĺ	
	0.00014776 0.0001929 0.0001929 0.0002735 0.0002735 0.0002735 0.0002735 0.0002735 0.0002735 0.0002735 0.0002735 0.00015604 0.0000000000000000000000000000000000	Ľ	•
	0.00014776 0.0001929 0.0001929 0.0002735 0.0002735 0.0002735 0.0002735 0.0002735 0.0002735 0.0002735 0.0002735 0.00015604 0.0000000000000000000000000000000000	ž	•

Fig 5.6 Structural steel-deformation in mode 6

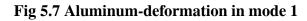
MODE	FREQUENCY(Hz)
1	0.4605
2	0.88392
3	2.2325
4	3.0755
5	3.5978
6	4.6841

Graph no 5.1 : For structural steel



5.1.2 For aluminum:

A Cut X Dahlar My Computer V August Links My Computer X August Links Manage V August Links Manage V August Links Manage V August Links V August Manage V August Links V August Manage V August	File Home Beauth Display Selection	A Model - Mechanical (Anays Mechanical Emergine) Automation Additions Coll-A Laurente	
Product (A) Construction (Diports)	Ticle X Delete My Computer	Figure 2 Manuage Verse Concretence Concretence	sus Preview
Coop Total Deformation a Total Deformation a Tot	Valid Genetry The Prevents Systems Verse Prevents Systems Verse Sys	A: Muda: Total Defamation Type: Total Defamation Progency: 0.46073 Hz Unit: m 05:04:203 T0:10 B.08079124 Max 0.00052766 0.00001720F 0.00001720F	Ansy 2022



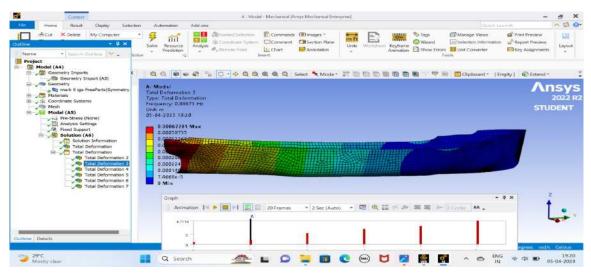


Fig 5.8 Aluminum-deformation in mode 2

Certext	A : Modal - Mischanical (Proge Mechanical Unteranne)	- 19
in Home Result Display Selection	n Automotion Add-ons	~ E
Africut X Delete My Computer -	Miningset Optimized Environ Conversals C	
Project Model (A4) Seconstry Importa Cocometry Import (A3) Cocometry Import (A3) Import (A	QQQ ●● 4 0 + 4 QQQQQ Select N Mode - 27 日 日 日 日 日 日 日 日 日 日 日 日 日 日 日 日 日 日	nsy
B - ik Coordinate Systems	Type: Total Deformation Frequency, 22134 Hs Unit m 01-64-2021 Hs28	2022 UDEN
Tread Business Tread Business Tread Deformation	B.00088122 Max B.000081596 B.00008159 B.0008159 B.0	

Fig 5.9 Aluminum-deformation in mode 3

			I - Mechanical (Ansys Mechanical	the second se				-	-
Home Result Display Selection	on Automation Add-					Chutzž La		0.6	9
Aff Curt X Delete My Computer	Solve Resource Anal	All Coordinate System Rumana Parti	Commands Collimages * ClConvinent Section Pla Chart Annotation	ma ha	Vitane Show Error	Manage Vews	 ^A Print Preview ^A Report Preview Key Assignments 	Laye	-04
Project									
E Geometry Imports K Geometry Import (A3)	000000	" ■ ○ • ◆ Q Q	🔍 🔍 Q Select 🌂 Mos			🕾 🛄 Clipboard * [En	mpty1 10 Edend *	-	
Geometry Geometry mark 9 igs-FreeParts Symmetry Materials	A Madal Total Deformation 5 Type: Total Deformatio						۸r	15	
E Coordinate Systems	Frequency 3.0792 Hz	in .					100000		
🗄 Jiii Modal (A5)	Units m 05-04-2023 19:20						STU	IP1=N	
110 Pre-Stress (None)	Contraction of the contract								
	- 0.00075189 Max								
Fixed Support									
Solution (A6)	0.00057724					States of the local division of the			
Solution (A6)	0.00059258 0.00059258 0.00050793								
Solution (A6)	0.00057724								
Solution (A6) Solution Information Total Deformation Total Deformation Total Deformation 2	0.00067724 0.00059258 0.00050793 0.00050793 0.00042327								
Solution (A6)	0.00067724 0.00059258 0.00059793 0.00050793 0.00050793 0.0005793						J		
Solution (A6) Solution (A6) Solution Information Total Deformation Total Deformation 2 Total Deformation 2 Solution Deformation 4 Solution	0.00067724 0.00059258 0.00050793 0.00050793 0.00042327						J		
Solution (A6) Solution (A6) Solution Information Total Deformation Total Deformation Total Deformation Total Deformation Solution Total Deformation Solution Solution	0.2006/7924 0.2005/9250 0.2005/293 0.2015/293 0.2015/293 0.2015/293 0.2015/293 0.2015/293 0.2015/293 0.2015/293 0.2015/293 0.2015/293						J	7.	
Solution (A6)	0.00067258 0.00050258 0.00050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.00507258 0.0050725 0.005070000000000000000000000000000000						**	zia	
Solution (A6)	0.00067258 0.00050258 0.00050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.00507258 0.0050725 0.005070000000000000000000000000000000		20 Frames * 2 Sec. (A	uto) - P Q III			**	-	
Solution (A6)	C. 00067224 C. 00059258 C. 00050293 C. 0005029 C. 0005000000000000000000000000000000000		20 Frames + 2 Sec (A	uto) - 2 Q III -			** 1		
Solution (A6)	0.00067258 0.00050258 0.00050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.0050793 0.00507258 0.0050725 0.005070000000000000000000000000000000		20 Frames + 2 Sec (A	uto) - R Q III -			** 1	Ļ	
Solution (A6)	C. 00067224 C. 00059258 C. 00050293 C. 0005029 C. 0005000000000000000000000000000000000		20 Frames + 2 Sec (A	uto) - = = = = =			** 1	ŀ	



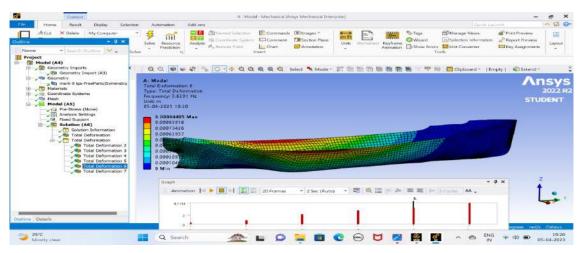


Fig 5.11 Aluminum-deformation in mode 5

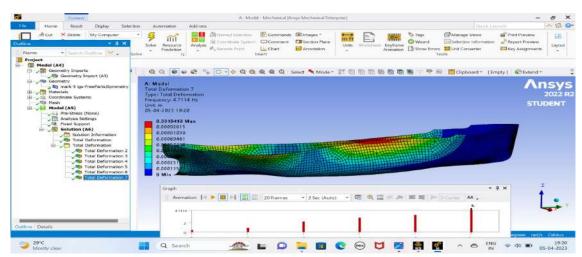
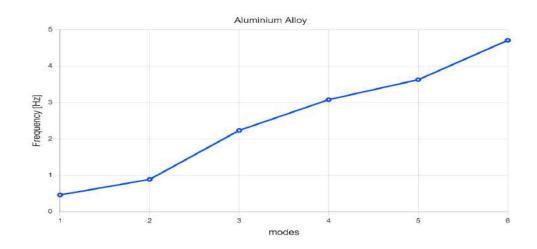


Fig 5.12 Aluminum-deformation in mode 6

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

Table no 5.2 : Tabular data for aluminum alloy

Graph no 5.2 - For Aluminium Alloy



Home Result Display Select	on Automation	Add-ons		al (Ansys Mechanical Erh			(Galacta	unde	6	×
ama • Search Outline • • • • •	Solve	Analysis	Rute System Comm	ands @Timages * ant @Esection Plane @Annotation	Units Workshee	Keyfrane Animation	Manage Views Selection Information Selection Information Selection Information Selection Information Selection Information	Print Preview ¹ ¹⁰ Report Preview Key Assignments	Layo	out
Geometry Imports Geometry Imports Geometry Geometry	A: Madsi Total Deformat Type: Total De Frequency: 7.8 Dats m	oan J fermetion 097 Hz	÷00000) Select 🦜 Mode 1		8 6 6 8 7 9 1	🖶 🛅 Clipboard * (En	۸r	15 202	2
Read Support Read Support Solution (AB) Solution (AB) Total Deformation	05-04-2023 18 0.036722 0.032642 0.020562 0.024481 0.020401 0.016321									
	0.0091605 0.0040502 D Min	raph		Frames * 2 Sec	c (Auto) * 😨	Q	I = Icyalas Ar.	- # ×		
		80.660 541 -			140				-	•

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



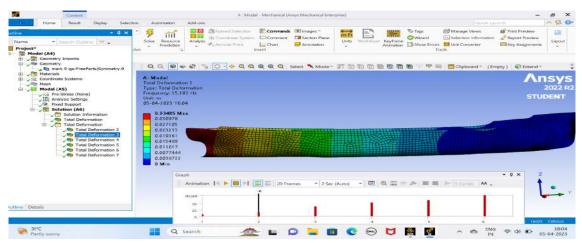


Fig 5.14 FRP-deformation in mode 2

Context Home Result Display Sele	A Misibili Mechanisal (Annys Mechanisal Enterpode)	dick Laurers	- 13
ame = Search Outline > , roject* @ Model (A4)		n all Print Preview	Layout *
Coordinate Systems Coordinate System	Q Q @ @ @ ¹	۸n	2022
Reed Support Sublam. Information Sublam. Information Sublam. Information Total Deformation 2 Total Deformation 3 Total Deformation 4 Total Deformation 7 Total Deformation 7	0-04-2021 19:04 0.04050 0.03050 0.03010 0.03010 0.03010 0.03010 0.03010 0.03010 0.03010 0.03010 0.00000 0.0000000 0.000000 0.00000000		

Fig 5.15 FRP-deformation in mode 3

	ion Automation	Add-ons	al - Mechanical phrays Mechanical Erro					~ 53
Home Result Display Select Home Basent Dutline	Show Predictor	Analysis Analysis Analysis	Commande El Images - Comment Section Plane Hourt Annaution	Griss Washerert Keyfraere Antimation	Waard 1958	anage Views lectors Information	 Print Preview Report Preview Key Assignments 	Layo
→ million Geometry → million Geometry → mark 9 isos-freeParts[Symmetry.9 → million → million → million Coordinate Systems → million → million → million Model (AS) → million → million	A: Modal Total Deformation Type: Total Defor Frequency: 52,72/	15 mation	🙊 🔍 🔍 Select 🦜 Mode ។	27 6 6 6 6 6 6	8 7 9 8 8	Clipboard * Emp	۸n	2022
Comparison of the section of th	Unit m 05-04-2021 18:04 0.0395112 10 0.0305121 0.02053 0.02195 0.02195 0.02195 0.03195 0.03195 0.03195							
Total Deformation 7	0.0043901			A CONSIGNATION OF THE OWNER OWNER OF THE OWNER OWN				
Total Deformation 7		n Animation (4 > [6] (-1)	😰 🕮 20 Frames 🔹 2 Sec	(Auto) - 🖾 🔍 🖽 d	< 24 36 36 24		- # ×	<u>.</u>

Fig 5.16 FRP-deformation in mode 4

Connect Horse Result Daplay Select	A Model - Mechanical (Ange Mechanical Entergrave)	- 12
anne - Semich Quilfere -	Name Name Commands Com	Layes
Concentry Imports Concentry Amplitude States Concentry Concentry Concentrate Systems Concentrate Systems Con	QQQ C C C C C C C C C C C C C C C C C C	
Manipus Settrops Manipus Settrops Golden Support Solution (C6)	05-04-2012 19:04 0.44057 /Mar. 0.310703 0.07109 0.01709 0.01709 0.01709 0.01709 0.01709 0.01079	
Construction C	05-04-2013 19:04 19:48057 Max 0,0405719 0,012589 0,027199 0,021799 0,01513 0,016579	•

Fig 5.17 FRP-deformation in mode 5

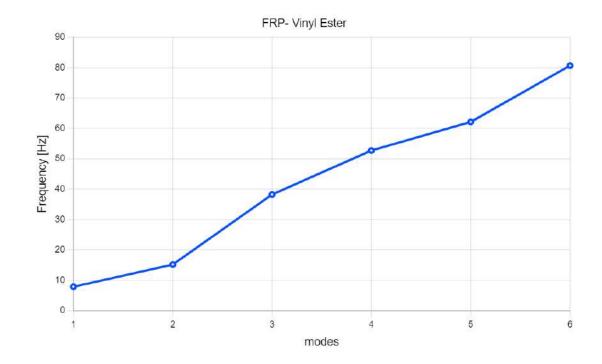
Home Result Display Selection	ten Automation Add-ons Divisi Launch	
- # X me - Search Guilline 😪 .	Entry Address Commands Entry Commands Commands Entry Commands Commands	v Lava
roject* Model (A4) Genemetry Imports Genemetry Imports Genemetry Imports Genemetry Genemetry Genemetry Genemetry Genemetry Genemetry Mach Genemetry Mach Genemetry Mach Genemetry Mach Genemetry Genemetry Mach Genemetry Genemet	here r Inort Tools Q Q Q Q Q Q Q Q Q Q Q Q Q Q Q Q Q	
Total Deformation 5 Total Deformation 6 Total Deformation 7	0.019611 0.012007 0.0060036 0 Min	
Total Deformation 5	0.012007 0.0060036	ž.

Fig 5.18 FRP-deformation in mode 6

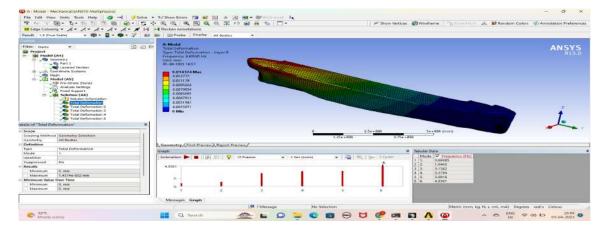
MODE	FREQUENCY(Hz)
1	7.8887
2	15.183
3	38.241
4	52.724
5	62.139
6	80.669

Table no 5.3 : Tabular data for FRP- Vinyl Ester

Graph no 5.3 - FRP - Vinyl Ester



5.2 Modal analysis results - With neoprene rubber



5.2.1 For structural steel with neoprene

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

	5-16 16 10 🖬 🐠 S	◆ Q、 Q、 ● 図 Q、 Q、 第 12 副 巻 多 □・ グ Show Vertices (20)Wireframe **]:===================================	Random Colors 😪 Annotation Preference
In cape coloring .	6- 1- 1- 1- 1- 1- 1- 1- 1- 1-1		
esuit 1.0 (True Scale)	- @- <u>-</u>	a mar (BDProbe Display all bodies +	
Filter Name -	• ଅ ଏ	Ar Model Total Environmentation 2	ANSYS
Project		Tupo Determination / Tupo Text Determination : Lager &	ANSIS
(8A) IsboH (86)		Freedomers V. (2001) Her	
E . fip fiermetry		Unit www	
Part 1		05-04-2020 16-19	
Coordinate	ed Section		
Ap Nesh	Polyaramana and a second secon	0.611112 Max	
- IT Hedal (AS	0		
	tress (Hane)	Economic Contraction	
Andyr Andyr	sis Settings		
, SIL Parti	Degapor t		
🖽 🦛 Solut	tion (AE)		
	Solution Information Total Deformation		
	Tudal Definition 2	LODIASED	
	Total Deformation 3		
	Total Deformation 4	0.00	•
	Total Deformation 5		
alla of "Total Deformation	m2* 9		
		A DECEMBER OF STREET	· · · ·
scope	and formation	0 25+004 5+004 (mm)	
icope icoping Method Geome		0 2.5x+004 (9mm) 1.29x+004 1.75x+004	
icope icoping Method Geome Geometry All Stro		1.35++004 1.75++004	
icope icoping Method Geomy Geometry All Stor Definition	dies	1.25+634 1.75+604 Cenametry_(Print Praview) Regist Praview/	
icope Scoping Method Geome Cesmetry All Sind Definition Type Total C		1.55+054 1.75+054 Generatry (Print Pranses) Report Provides / Graph 0 Telako Data	
Icope Icoping Mitthed Gramo Geametry All Bind Definition Type Total D Mode 2.	dies	1.55 + 604 3.75 + 604 Generativy_First Flavion_} Report Provises/ ● Graph ● Telefore ● Animation ● Determine ● Model [** Treasmont [*t]]	
kcope iccoping Method Geams Geamstry All End Definition Total E Mode 2. dentifiar	dies	1.55 + 004 1.75 + 004 1.55 + 004 1.75 + 004 Generatry (Print Presence) Brook Brook 0 Brook Br	
icope icoping Mitthed Gram esanity All Sad befinition ype Total C dots 2. dentitier uppressed No	dies	1.25x - 034 1.25x - 034 Compty (Print Process), Regard Process) Graph This late Data Animution (Print Process), Regard Process) 2.55x - 034 This late Data Animution (Print Process), Regard Process) 2.55x - 034 This late Data Animution (Print Process), Regard Process) 2.55x - 034 This late Data Animution (Print Process), Regard Process) 2.55x - 034 This late Data Animution (Print Print Pr	
Iscope Scoping Method Geomo Geometry All Sind Definition Type Total D Hode 2. dentifier Suppressed Ho	diet Deformation	125+4001 3/5+4001 Genmetry/(Print Parsine), Bryont Provine)/ 0 Graph 0 Addet 10 Addet 10 Addet 10 Addet 10	
cope coping Method Geom- exemetry all Sed befailtion ype Total E date Z. demtifier uppressed No besuits B. mm	diet Defoimation	1.57x + 054 1.57x + 054 Company / Print Provincy / Provincy / Company Province / Company Province / Company Animution ► III / III ♥ 10 Promes 2 Sec Bullin III / III ♥ 10 Promes Address III / III ♥ 10 Promes 2 Sec Bullin III / III ♥ 10 Promes Address III / III ♥ 10 Promes 2 Sec Bullin III / III ♥ 10 Promes	
cope coping Method Geom- exemetry all Sed befailtion ype Total E date Z. demtifier uppressed No besuits B. mm	dies Deformation De 002 mm	1.5% + 004 1.7% + 004 Columetry (Print Process), Regard Process 0 Second Process 2.5% + 004 Adart 1.7% + 004 Adart 1.7% + 004 Adart 1.7% + 004 2.8 1.7% + 004 2.8 1.7% + 004 2.8 1.7% + 004 2.8 1.7% + 004 2.8 1.7% + 004 2.8 1.7% + 004 2.8 1.7% + 004 2.8 1.7% + 004 2.8 1.7% + 004	
cope coping Mitthod Geomy commung All Sad Sefaultion Type Total C dentifier dentifier Uppersoid No lesselfs Maximum 5, 21122	dies Deformation te 002 mm ref	1.5% + 004 Generatry (Prist Process) Report Process/ Graph Ø Titiske Data Advention ■ 100 (00 (00 (00 (00 (00 (00 (00 (00 (00	
cope coping Method Great coping Method Great alf End adfailen rpin Total C total 2. Sentifier Minimus 0.mm Minimus 0.mm Minimus 0.mm	dies Deformation De 002 mm ne	1.5% + 054 1.5% + 054 1.5% + 054 1.5% + 054 Crash Animution ► 0 100 + 004 Animution ► 100 + 004 100 + 004	
copie coping Mitthod Geromi jeamstry All Smi isfination pps Total E lodie 2. termfrier upprissed No. espits Minimum 8.mm Minimum 1.1112 Minimum Value Over Tim	dies Deformation De 002 mm ne	1.5% + 004 Generatry (Prist Process) Report Process/ Graph Ø Titiske Data Advention ■ 100 (00 (00 (00 (00 (00 (00 (00 (00 (00	
cope coping Method Great coping Method Great alf End adfailen rpir Total C total 2. Sentifier Minimus 0.mm Minimus 0.mm Minimus 0.mm	dies Deformation De 002 mm ne	1.25x + 054 1.25x + 054 Comparison // Provide	
cope coping Method Great coping Method Great alf End adfailen rpir Total C total 2. Sentifier Minimus 0.mm Minimus 0.mm Minimus 0.mm	dies Deformation De 002 mm ne	1.5% + 054 1.5% + 054 1.5% + 054 1.5% + 054 Crash Image: Crash of the second se	

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

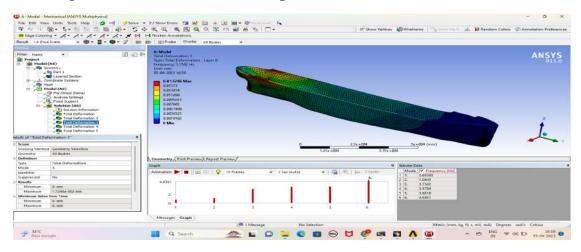


Fig 5.21 Structural steel with neoprene rubber- deformation in mode 3

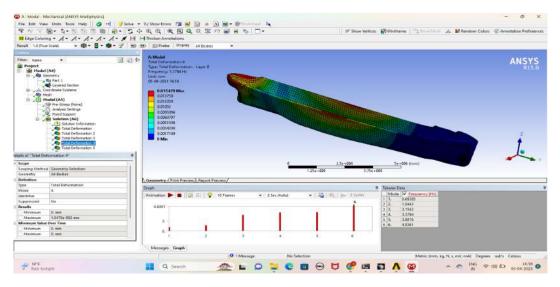


Fig 5.22 Structural steel with neoprene rubber- deformation in mode 4

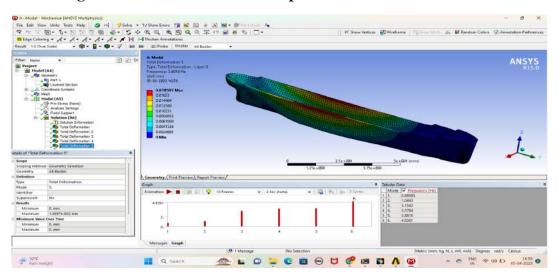


Fig 5.23 Structural steel with neoprene rubber- deformation in mode 5

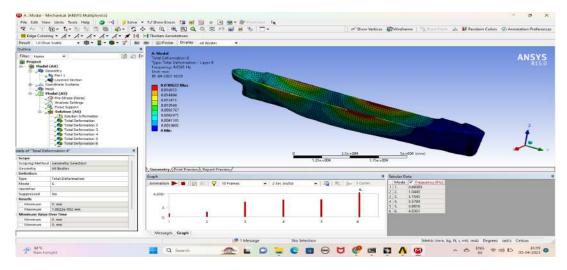
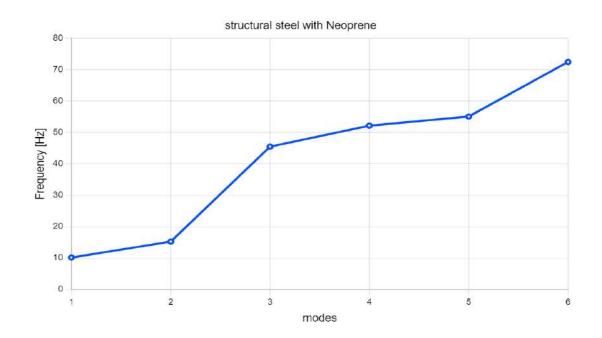


Fig 5.24 Structural steel with neoprene rubber- deformation in mode 6

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

 Table no 5.4 : Tabular data for Structural steel with Neoprene





5.2.2 For Aluminum alloy with neoprene

	🔞 - 🔖 - Hù Hù 🕅 🗰 🚳 - H 🖕 -	💠 🚯 🔍 🔍 🖉 🔍 🔆 75 🗃 🖷 🏠 🔲 -	votation Preference:
	no - A - A - A - A - A - A - 1-1		
teasift 1.0 (Trus			
lutine			
filber: Hame	- S - C + C + C + C + C + C + C + C + C + C	Total Defurmation	ANSYS
I Project		Taper Tetal Deformation - Layer 0	DIA
- in Pladel	(64)	Englanding 0.00551 Hz	
- 1 Ca		Units many	
AD Me	sor devete Systems	05-04-2021 1951	
	undad (AS)	- 0.024214 Mar	
1	No Pro-Etrosa (Faire) Aralysis Settings Proved Support	0.071523	
	Analysis Settings	A DISERT	
	Plant Support Di Solution (Afi)	2011A2	
	Solution (AB)	6.013452	
	Total Deformation	5.01076J	
	Total Deformation 2	6.0060711	
	Total Deformation 3	0.0033608	
	- Total Deformation 1	0.0326904	
	Tutal Deformation 5	0 Palm	Z
	- Total Deformation 6		
			Too too
		0 4++004 B++004 (mm)	
ulte of "Social De	darmeksen" #	2e+004 Ee+004	1 mar
коре		Geometry / Print Preview / Report Preview /	1
cope coping Metho	d Geometry Selection	2e+004 Ee+004	
cope coping Metho econetry		Accessity / Print Preview / Report Previ	
cope coping Metho iconetry lefinition	d Degraetry Selection All Reduct	74+004 64+004 Generatry (Print Preview)/Itspert Preview/ 9 Graph 9 Assimulting (Print Preview)/Itspert Preview/ 11 Main adding 11 11 14	1 m
cope (oping Methor cometry Infinition Int	d Seametry Selection all Bodies Total Deformation	Zer+001 Gr-004 Graph 9 Tables 10 Factors Arritoria 10 Factors	1
cope coping Methor isometry Sefinition (pt fode	d Degraetry Selection All Reduct	Jaccountry (Point Previous) Report Previous) 0 </td <td>1</td>	1
rope coping Methos ecaletry efinition pe tode catifier	d Gesinetry Selection All Bodoei	24 + 604 Generating / Port Prevines / Report Prevines / Object Object P Tender Data Astronation Image: Colspan="2">Image: Colspan="2" Image: Colspan="2" Image	<u></u>
cope coping Metho econetry edinitism pe hode contilier uppressed	d Seametry Selection all Bodies Total Deformation	24 + 001 6 + 004 Graph Braine Data Graph Braine Data Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2" Graphic Data Colspan="2" Descent Colspan="2" Colspan="2" Descent Colspan="2" Descent Colspan="2" Colspan= 2 Descent Colspan="2" Descent Colspan="2" Colspan= 2 Descent Colspan="2" Descent Colspan="2" Descent Colspan="2"	£
rope coping Melho ecosety effection pre tode antilier uppressed	d Gesinetry Selection All Bodoei	Jaccountry (Print Provine), Regist Provine) 0 <td><u></u></td>	<u></u>
ope oping Melhos sosteby obsidion pe ode emblier opprissed esuits	6 Desinity Striction All Redue Talat Octomation L. No	24 + 001 6 + 004 Graph Braine Data Graph Braine Data Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2">Colspan="2" Graphic Data Colspan="2" Descent Colspan="2" Colspan="2" Descent Colspan="2" Descent Colspan="2" Colspan= 2 Descent Colspan="2" Descent Colspan="2" Colspan= 2 Descent Colspan="2" Descent Colspan="2" Descent Colspan="2"	<u> </u>
rope coping Methor ecaseby efficition pr lode centifier uppresent exults Minimum Maximum	d Deenstry SteleCopy All Books Lot Deformation L. Kee D. mm J. June D. June	Jaccountry (Print Provine), Regist Provine) 0 <td>f</td>	f
rópe coping Methor isometry edinition roc hode tentifier upprésent seuts Abinimum Maximum	d Deenstry SteleCopy All Books Lot Deformation L. Kee D. mm J. June D. June	Zet 4001 Cardod Generating, // Point Review, // Report Preview, // ReportPreview, // Report Preview, // Report Preview, // Report	f
cope coping Metho ecastry befinition pet tode dantilier uppressed besufts Minimum Maximum Maximum	d Dennetry Schellen All Bolonie Teal Deformation L. Bolonie Bolonie Deffection Lefther Officeron Derer Team	Jaccountry (Print Provine), Regist Provine) 0 <td></td>	

Fig 5.25 Aluminum with neoprene rubber-deformation in mode 1

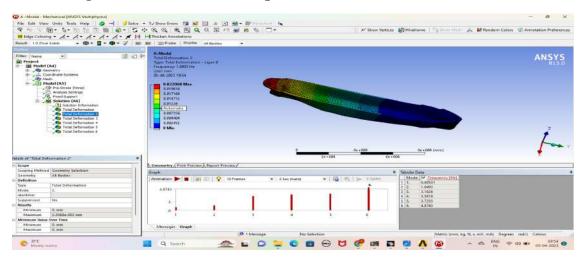


Fig 5.26 Aluminum with neoprene rubber-deformation in mode 2

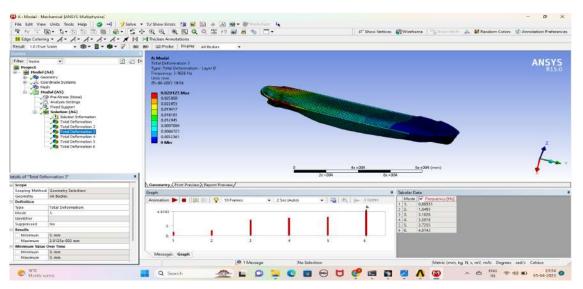


Fig 5.27 Aluminum with neoprene rubber-deformation in mode 3

幸た可聞・な・回回回員 () - ()	🕻 李 仪 氏 《 图 文 只常 19 🙀 画 🥎 🔲 • 👘 👘 👘 👘 👘 👘 👘 👘 👘 👘 👘 👘 👘
Edge Coloring + K+ K+ K+ K+ K+ #	Pricken Avendation
esuit 1.0 (frue Scale) - 🕲 - 🚦 - 🙂 - 🛫 🗌	ND ND Finder Display All Bodies .
and the second of the second se	
The Traject region	ANSYS
- CB Tubai Cenfermation 2 - CB Tubai Cenfermation 2 - CB Tubai Cenfermation 5 - CB Tubai Denfermation 6	
→ (P) Table Deformation 3 → (P) (Satel Deformation 4 → (P) Table Deformation 5 → (P) Table Deformation 6 → (P) Table Deformation 6	0 44-104 (k-10)
	2 0.05/991 2 0.05
Table Deformation 3 Table Deformation 3 Table Deformation 4 Table Deformation 4	0 44-104 (k-10)
	0 0005/001 000<
for fair Defaustors for a defaustors f	
	Construction
Total Deformation 2 Total Deformation 2 Total Deformation 4 Total Deformation 4	0.005/091 0.005/091 2 4+:004 2 4+:004 Commetry (Prior Private), Engant Private) 0 Service 0 </td
for Definition of a second secon	
A faile Deformation 2 A faile Deformation 2 A faile Deformation 4 A faile deformation 4 A faile deformation A faile deformation A faile deformation A faile deformation Frail deformation	0 0.005/WP 0.005/WP 0.005/WP 0 0 0.005/WP 0.005/WP 0 0.005/WP 0.005/WP 0.005/WP
frie Definition of a frie Definition of a frie Definition of a frie Definition fried Definition fried Definition fried Definition fried Definition	0 005/091 2 + -204 (b+ -204 from -2) 2 + -204 (b+ -204 from -2) Concentry (Prior Processo/ Seguet Processo/ Seguet A 4240 4-244 4-240 4-240 5 + -204 (b+ -2) 5 + -2
Price Definitions on 2 Price Definitions on 2 Price Definitions on 2 Price Definitions on 4 Price Definitions	0.05/001 0<
Total Deformation 2 Total Deformation 2 Total Deformation 4 Total Deformation 4 Total Deformation 4 Total Deformation	0 005/091 2 + -204 (b+ -204 from -2) 2 + -204 (b+ -204 from -2) Concentry (Prior Processo/ Seguet Processo/ Seguet A 4240 4-244 4-240 4-240 5 + -204 (b+ -2) 5 + -2
Annum D. Annu	0.05/001 0<
Point Contraction Point Point Contraction Point Point Contraction Point P	0.005/091 0.005/091 0.005/091 0.005/091 0.005/091 0.005/091 24+004 0e-004 Statute Date 0e-004 Statute Date 0e-004 Annumber 0 0.005/091 4.0141 0e-004 2.000 0.005/091 0.000 0.005/091 0.000 0.005/091 0.000 0.005/091 0.000 0.005/091 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
Control Control Control Control Control Contro Control Control Con	3 4x+004 5x+001 (cmm) 4 5x+001 (cmm) 5x+001 (cmm) 3 4x+004 5x+001 (cmm) 3 4x+004 5x+001 (cmm) 3 4x+004 5x+001 (cmm) 4 5x+001 (cmm) 5x+001 (cmm) 3 5x+001 (cmm) 5x+001 (cmm) 4 5x+001 (cmm) 5x+001 (cmm) 4 5x+001 (cmm) 5x+001 (cmm) 5 5x+001 (cmm) 5x+001 (cmm) 6 5x+001 (cmm) 5x+001 (cmm) 7 5x+001 (cmm) 5x+001 (cmm) 6 5x+001 (cmm) 5x+001 (cmm) 7 5x+001 (cmm) 5x+001 (cmm) 8 5x+001 (cmm) 5x+001 (cmm)

Fig 5.28 Aluminum with neoprene rubber-deformation in mode 4

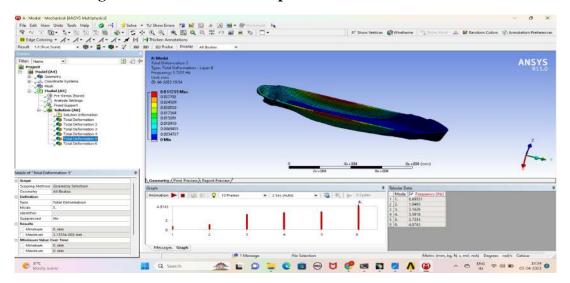


Fig 5.29 Aluminum with neoprene rubber-deformation in mode 5

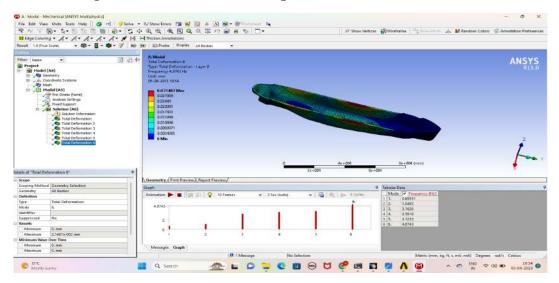
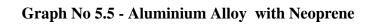
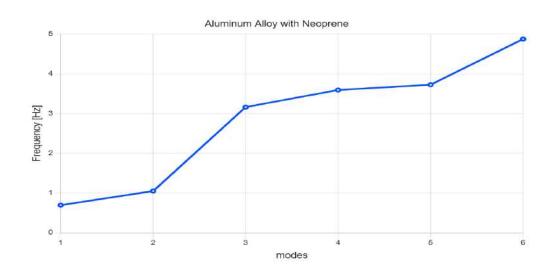


Fig 5.30 Aluminum with neoprene rubber-deformation in mode 6

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

Table no 5.5: Tabular data for Aluminum Alloy with Neoprene





5.2.3 For FRP - Vinyl Ester with neoprene

	• 7/Show Errors 🚛 🔐 🖄 💩 🛆 🗺 • 🕪 Analysis 🗛	In the second		
* 化学 喧・キ・防防防衛 ● ●・154	○我我我的我的我们常行前面为□-	Fr Show Vertices	🛛 Wireframe 👘 👘 👘 Marin 🦂 🖬 Random Color	rs Annotation Preference
Edge Columny - 1 - 1 - 1 - 1 - 1 - 1				
tesydt 1.0 (True Scale) 🔹 🔞 🕶 🦉 🖷 👘 🕶 🛒 🕬	180 GDProbe Display All Bodies +			
utine				
Filten Itama * 🔅 🖒	A: Mudal Total Deformation			ANSYS
i Project	Type: Total Deformation + Layer D			R15.0
Sel Hodel (A4)	Enquercy 10/122 Hz			
m . Connetry	Unit mm 01-04-2022 18/04			
- Lawer Section	01-04-2023 10:04			
	1.047 Max			
All Menh	0.93069	and the second		
G Pre-Stress (Mare)	0.01495			
Arefysis Settings	- 0.630012			
- JR. Fixed Support	0.50168			
III _ Sit Solution (A6)	0.46534	and the second se		
Solution Information	0.34001			
Total Deformation	0.11454			
Total Deformation 3	0 Min			
Total Deformation 4	- K den			
- Total Deformation S				
Total Deformation 6				6
		34+004	1e + 005 (mm)	
			Te vedo ummo	
uls of "Sotal Deformation" #		3.5++301 7.5e+001		
ils of "Solal Deformation" 8 kope	Geometry (Print Preview) Report Preview/	2.5e+001 7.5e+003		
Rope Loging Method Semetry Selection			fatoviar Data	
cope coping Nethod Beametry Selection Secondry All Bodies	Geometry (Print Previum) Report Previum/	4.4.5		
Coper destinat deametry Xelection .	Messages	Amociation	Mode (Finguency (Ht))	с и
cope coper district diseasety Selection exercity All Bolite: etitizion pe Total Defunyation	Messages Text	Amociation	Mode (Finguency (Ht))	
cope copen control descentry Neterlation terretry All Bothet befinition type Tufal Deformation type 1.	Messages Text	Amociation	Mode (Finguency (Ht))	
copin coping Veteration coping Veteration exercises electrons tetration table to table table to table table to table to table to table to table table to tab	Messages Text	Amociation	Mode (Finguency (Ht))	
COPY Contract Contractor Services Contractor	Messages Text	Anacistice Anacistice opt. This: Project>Model>Model>Solute	Mode I# Frequency (Ht) 1 50.172 2 2 31.526 2 3 2 4.526 4 4.507 4 5 5505 5	
oper concept Mathewal (desavariary Setrentium - exemetry Al Bouldes execution - settabon - oper - Total Cetanovalisan - concert operand No - senate	Messages Text	Anacistice Anacistice opt. This: Project>Model>Model>Solute	Mode (Finguency (Ht))	
cope company Mathada Lideanatary Netreations economy and the second se	Messages Text	Anacistice Anacistice opt. This: Project>Model>Model>Solute	Mode I# Frequency (Ht) 1 50.172 2 2 31.526 2 3 2 4.526 4 4.507 4 5 5505 5	
reger anna Martina a lansaarty Sataktina exemuty a All Bagdets exemuty a All Bagdets exemuty a status and a status and a status exemutian a status and a status and a status and a status and a status and a status and a status based and a status and a status and a status and a status based and a status and a status based and a status	Messages Text	Anacistice Anacistice opt. This: Project>Model>Model>Solute	Mode I# Frequency (Ht) 1 50.172 2 2 31.526 2 3 2 4.526 4 4.507 4 5 5505 5	
orger comp Motional Exercisity Setabilities bernetity Alt Boltes bernetity Internetities per Internetiti	Noteinergen Officiality The model dimension in the cable and cytem ones determined to be very be	Anacistice Anacistice opt. This: Project>Model>Model>Solute	Mode I# Frequency (Ht) 1 50.172 2 2 31.526 2 3 2 4.526 4 4.507 4 5 5505 5	
Incess Composition descenting Stretching Descenting Mathematical Descenting Mathematical Des	Messages Text	Anacistice Anacistice opt. This: Project>Model>Model>Solute	Mode I# Frequency (Ht) 1 50.172 2 2 31.526 2 3 2 4.526 4 4.507 4 5 5505 5	

Fig 5.31 FRP with neoprene rubber-deformation in mode 1

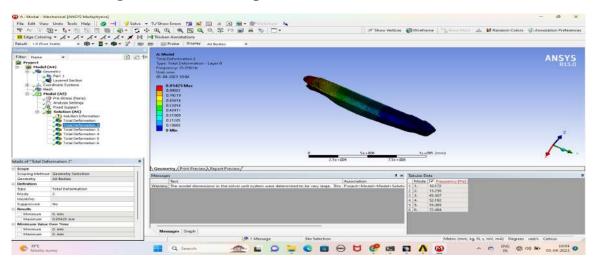


Fig 5.32 FRP with neoprene rubber-deformation in mode 2

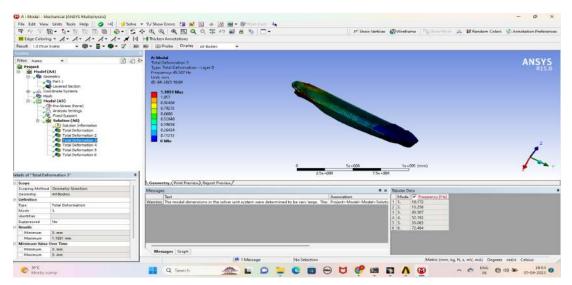


Fig 5.33 FRP with neoprene rubber-deformation in mode 3

		File Edit Verv Units Tools Help ②		
Edge Colorio	· A. A. A. A. A. A.			
landt 1.0 mile		B Dorbe Duplay At Sodiet		
ande 1.0 (Pade	scard	The state of the s		
		A: Model		
3 mm	Anti Part I Layeed Scon Antibas Systems dat (AS) ProcEsse (Deco) Antipas Estings Find Seport Estings (AS) Diskto Estings Diskto Esti	Total Constraints # Type: Flatid Streamtion = Lays & Type: Ty		ANSYS 815.0
	Total Deformation 6		-	K
	Total Deformation 5	0 5++00	1e-005 (mm)	K
tells of "fotal Def	Total Deformation 6 Total Deformation 6			K
	Total Deformation 6 Total Deformation 6	0 <u>5++004</u> 2.51+-004 7:54+30		K
Scope	Se list is in the medium of the first interview of the list is in the first interview of the list	<u>ا 5++004</u> ک.5++004 ک.5++004 ک.5++004	D4	K
Scope Scoping Method	Control Control Control Control Total Control Control Total Control Total Control Contro Control Control Contro Control Control C	0 5++000 2.57+-004 Xissingei 0 x x	54 × Tebular Data	K
Scope Scoping Method Geometry	Se list is in the medium of the first interview of the list is in the first interview of the list	0 5+100 2.5x+004 7.5x+00 Accountry (Front Preview) Report Preview/ # Messinger # > Text Association	<	Å
Scope Scoping Method Geometry Definition	Construction C	0 5++000 2.57+-004 Xissingei 0 x x	54 Tabular Data (Mode) [77 <u>Frequency [14]</u> 14] 1. 0.172	4
Scope Scoping Method Geometry Definition Type	Construction	0 5+100 2.5x+004 7.5x+00 Accountry (Front Preview) Report Preview/ # Messinger # > Text Association	94 < Tabular Data Mode [77 Freesame: [15]] ist [1], 10,172 2]2, 13,256	4
Scope Scoping Method Geometry Definition	Construction C	0 5+100 2.5x+004 7.5x+00 Accountry (Front Preview) Report Preview/ # Messinger # > Text Association	94 < Tabular Data Mode [77 Freesame: [15]] ist [1], 10,172 2]2, 13,256	~
Scope Scoping Method Geometry Definition Type Mode Identifier	Constant of the second se	0 5+100 2.5x+004 7.5x+00 Accountry (Front Preview) Report Preview/ # Messinger # > Text Association	94 < Tabular Data Mode [77 Freesame: [15]] ist [1], 10,172 2]2, 13,256	~
icope Icoping Method Jeometry Meterition Vp+ Mode Jentifier Luppresed	Construction	0 5+100 2.5x+004 7.5x+00 Accountry (Front Preview) Report Preview/ # Messinger # > Text Association	9 C Theodel D Info Decess (7 Frequences (Ht)) 1 2 3 - 11350 2 3 - 11350 4 4 - 32,597 4 5 - 32,605	~
icope Icoping Method Jeometry Sefection Vyok Wode Jentifier Coppressed IesuRs	Construction C	0 5+100 2.5x+004 7.5x+00 Accountry/Front Preview/ 0 Messinger 0 Test Association	94 < Tabular Data Mode [77 Freesame: [15]] ist [1], 10,172 2]2, 13,256	~
Scope Scoping Method Decentry Definition Type Mode Identifier Dupproced Results Minimum	Control C	0 5+100 2.5x+004 7.5x+00 Accountry/Front Preview/ 0 Messinger 0 Test Association	9 C Theodel D Info Decess (7 Frequences (Ht)) 1 2 3 - 11350 2 3 - 11350 4 4 - 32,597 4 5 - 32,605	~
kope coping Method Sconetry Sefection Myse dentifier Coppensed Results Minimum Maximum	Control C	0 5+100 2.5x+004 7.5x+00 Accountry/Front Preview/ 0 Messinger 0 Test Association	9 C Theodel D Info Decess (7 Frequences (Ht)) 1 2 3 - 11350 2 3 - 11350 4 4 - 32,597 4 5 - 32,605	~
Scope Scoping Mithod Decinitiy Definition Type Mode Schriftler Schriftler Schriftler Machinan Machinan Machinan Michiman Value	Control C	0 5+100 2.5x+004 7.5x+00 Accountry/Front Preview/ 0 Messinger 0 Test Association	9 C Theodel D Info Decess (7 Frequences (Ht)) 1 2 3 - 11350 2 3 - 11350 4 4 - 32,597 4 5 - 32,605	~
Scope Scoping Method Sconetry Definition Type Mode Sentifier Suppressed Results Minimum Maxeman	Control C	0 5+100 2.5x+004 7.5x+00 Accountry/Front Preview/ 0 Messinger 0 Test Association	9 C Theodel D Info Decess (7 Frequences (Ht)) 1 2 3 - 11350 2 3 - 11350 4 4 - 32,597 4 5 - 32,605	4

Fig 5.34 FRP with neoprene rubber-deformation in mode 4

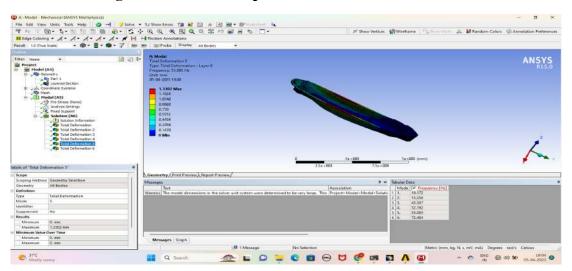


Fig 5.35 FRP with neoprene rubber-deformation in mode 5

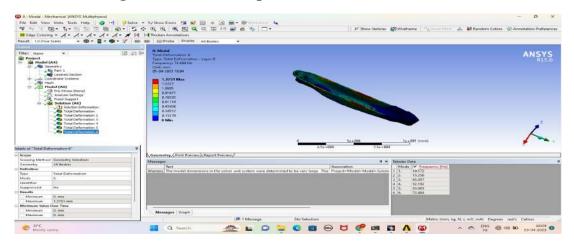
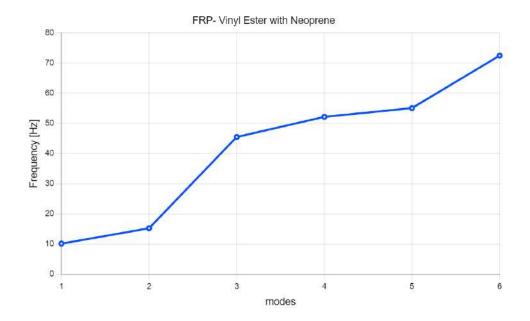


Fig 5.36 FRP with neoprene rubber-deformation in mode 6

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

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

Graph No 5.6 - FRP -m Vinyl Ester with Neoprene



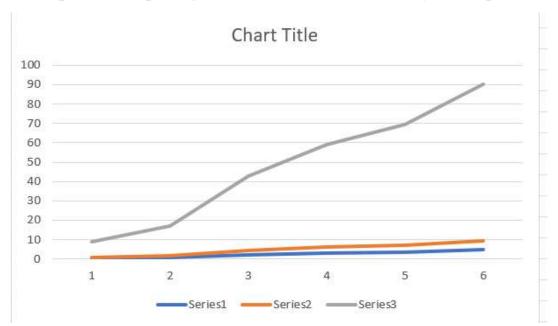
5.3 Comparison of Natural Frequencies of Steel, Aluminium and FRP-Vinyl Ester material.

5.3.1 without neoprene comparison

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

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

Graph 5.7 comparing three materials without a layer neoprene

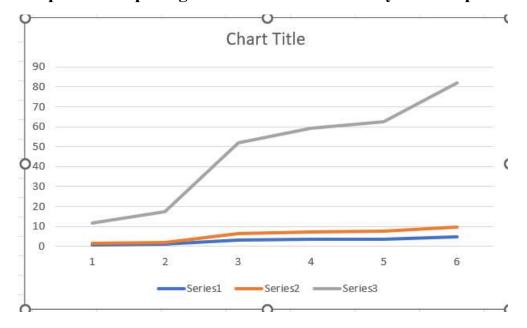


5.3.2 with neoprene comparison

Table 5.8 comparing three materials with a layer of heoprene							
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				

Table 5.8 comparing three materials with a layer of neoprene

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

References

[1]Y. LAKSHMI PRASANNA1, DR. AMAR NAGESWARA RAO2 Ship Hull

Structure Analysis in ANSYS ,Vol.04 ,Issue.33, August-2015,

[2]**J. SURESH BABU¹, R. MAHESH², DR. D. RAVIKANTH** Design And Analysis of a Ship Hull, IRE Journals, Volume 5, Issue 1, JUL 2021.

[3]**Ye Lu**,¹**Juan Liu**,²**Bei Teng**,³ Modal Investigation on a Large-Scale Container Ship Model for Hydroelastic Analysis, Hindawi Shock and Vibration Volume 2022, Article ID 2539870, 11 pages https://doi.org/10.1155/2022/2539870

[4]Alice Mathai¹, George John P.², Jini Jacob³, Direct Strength Analysis of Container Ships www.ijerd.com, Volume 6, Issue 5, March 2013, PP. 98-106

[5]**MUHAMM ED SHAHID ALI¹**, **Dr.C.G NANDAKUMAR**²FREE VIBRATION ANALYSIS OF PASSENGER BOAT ,ISSN 0976 – 6995 (Print) ISSN 0976 – 7002

(Online) Volume 5, Issue 3, September - December (2014), pp. 01-07

[6] Ahmet Ergin¹, Levent Kaydıhan² and Bahadır Ugurlu³ Hydroelastic Analysis of a
1900 TEU Container Ship Using Finite Element and Boundary Element Methods, TEAM
2007, Sept. 10-13, 2007, Yokohama, Japan

,https://www.researchgate.net/publication/325402629

[7]**Prof. M. Mukhopadhyay** "Vibration analysis and Structural system" ,Dept. of OENA IIT Kharagpur. [2]"Hydro elasticity of ships" by R E D Bishop and W G Price.

[8]**A. D. Papanikolaou and T. E. Schellin**, "A three-dimensional panel method for motions and loads of ships with forward speed," Journal for Research in Shipbuilding and Related Subject, vol. 39, no. 4, pp. 145–156, 1992.

[9] Y. Welaya, T. M. Ahmed, and H. S. Wahab, "A linear three dimensional frequency-domain numerical model for the prediction of ship motions in regular/irregular seaways," Towards Green Marine Technology and TransportTaylor & Francis Group, Milton Park, Oxfordshire, UK, pp. 167–174, 2015.

[10]**J. Jiao, S. Huang, S. Wang, and C. Guedes Soares,** "A CFD–FEA two-way coupling method for predicting ship wave loads and hydroelastic responses," Applied Ocean Research, vol. 117, Article ID 102919, 2021.