NATIONAL INSTITUTE OF OCEAN TECHNOLOGY ENERGY AND FRESH WATER FACILITY

Internship Report On

A Mechanical Analysis of Beam Materials for Structural Applications at NIOT

Submitted by

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ACKNOWLEDGEMENT

We would like to thank the **Director of NIOT** and **Project Director and Head EFW** for giving us the golden opportunity to do an internship at the esteemed institution.

We express our thanks and gratitude to our guide **Mr. V. Samson Packiaraj, Scientist – E** and **Mr. Karthikeyan Avudaiyappan, Scientific officer Grade II** for their guidance and support throughout the internship.

We express our sincere thanks **to Ms. Anulekha Majumdar, Scientist -D** and **Mr. Loga Prasanna S, Project scientist I** for their guidance for the project.

We owe our sincere thanks to the Energy and Freshwater (EFW) team members for giving us access to various components available in the lab and experimental data for completing our intern work.

We are thankful for our university management, for providing us an opportunity to take up this internship; **Dr. P. Prathap, Professor and Head (Mechanical Engineering** for being a motivation for taking up new opportunities.

ABSTRACT

This report presents a comprehensive study conducted during an internship at the National Institute of Ocean Technology (NIOT), focusing on the mechanical analysis of beam materials for structural applications and the integration of advanced technologies in Ocean Thermal Energy Conversion (OTEC) and Low-Temperature Thermal Desalination (LTTD) systems. Additionally, the report delves into the role of winch systems in the energy and freshwater sectors, highlighting their significance in the deployment and maintenance of oceanographic equipment.

The mechanical analysis involved evaluating the performance of simply supported and cantilever beams made from structural steel, aluminum alloy, and grey cast iron under point load and uniformly distributed load (UDL) conditions. software. Results showed structural steel exhibited the highest strength and lowest deformation, making it suitable for high load-bearing applications. Aluminum alloy displayed moderate strength and higher deformation, suitable for weight-sensitive applications, while grey cast iron showed the highest stress and deformation, making it suitable for applications requiring good compressive strength and vibration damping.

The study also explored the potential of OTEC and LTTD systems as sustainable solutions for energy and freshwater production. OTEC systems utilize the temperature difference between warm surface seawater and cold deep seawater to generate electricity. In an open-cycle OTEC, warm seawater boils in a low-pressure container, producing steam that drives a turbine, enriching surface water with nutrients from the ocean floor. LTTD systems exploit the same temperature difference to produce fresh water, where warm seawater evaporates in a vacuum flash chamber and is condensed using cold deep seawater.

The report highlights the crucial role of winch systems in the energy and freshwater sectors. Winch systems are essential for the precise deployment, retrieval, and maintenance of oceanographic equipment in OTEC and LTTD plants. They provide accurate control, ensuring the safe and efficient handling of instruments. The benefits of winch systems include enhanced operational efficiency, improved safety, and reduced environmental impact, making them indispensable for OTEC and LTTD operations.

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Chapter 1

1.1 Ocean Thermal Energy Conversion (OTEC) System:

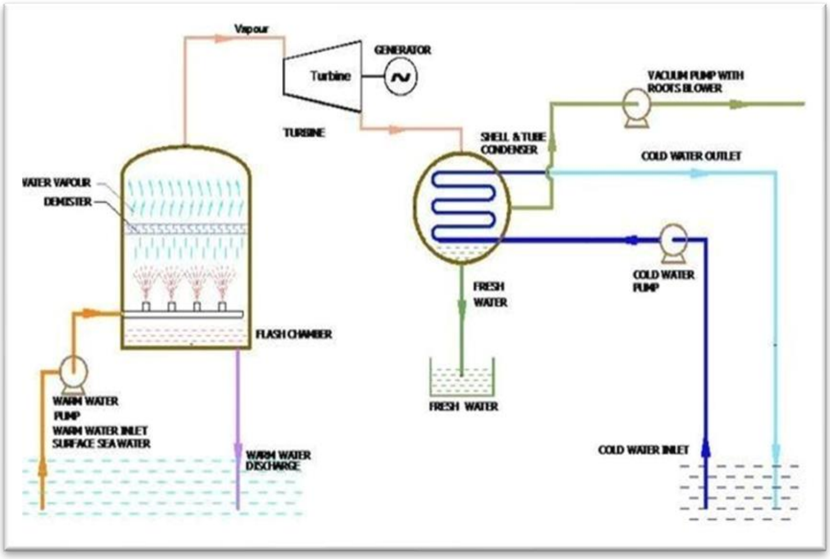
An Ocean Thermal Energy Conversion (OTEC) system uses warm surface seawater as its working fluid. In an open-cycle OTEC, warm surface seawater is placed in a low-pressure container, causing the water to boil and produce steam. The expanding steam drives a turbine, generating electricity.

OTEC is a promising candidate for future energy sources due to its minimal environmental impact. The process involves mixing deep and shallow seawater, which enriches the surface water with nutrients from the ocean floor. These deep waters are rich in nitrates and can be beneficial for agricultural purposes.
Working Principle:

An Ocean Thermal Energy Conversion (OTEC) system utilizes the temperature difference between warm surface seawater and cold deep seawater to generate electricity. Here's a step-by-step breakdown of how the OTEC system works:

- Warm Surface Seawater Intake: Warm surface seawater, typically around 25-30°C, is pumped into a low-pressure evaporator.

- Evaporation: In the low-pressure environment of the evaporator, the warm seawater boils and turns into steam.
- Steam Expansion: The steam produced is used to drive a turbine connected to a generator, producing electricity.
- Condensation: The steam is then condensed back into water by using cold deep seawater, typically around 5°C, pumped from depths of around 1000 meters.
- Water Discharge: The condensed water, now desalinated, can be used for various purposes, including drinking water, agriculture, or returned to the ocean.



Benefits of OTEC:

- Renewable Energy Source: OTEC harnesses the thermal energy stored in the ocean, a virtually inexhaustible resource, making it a sustainable energy solution.
- Environmental Impact: The environmental impact of OTEC is negligible. It does not produce greenhouse gases or other pollutants.
- Nutrient Upwelling: The mixing of deep, nutrient-rich seawater with surface water promotes marine life growth and supports aquaculture.
- Agricultural Benefits: The nitrates brought up from deep water can be used as fertilizers, enhancing agricultural productivity.

Conclusion:

OTEC systems offer a renewable, environmentally friendly energy source with additional benefits for marine ecosystems and agriculture. As technology advances, OTEC could play a significant role in the global energy landscape.

1.2 Low-Temperature Thermal Desalination (LTTD) System:

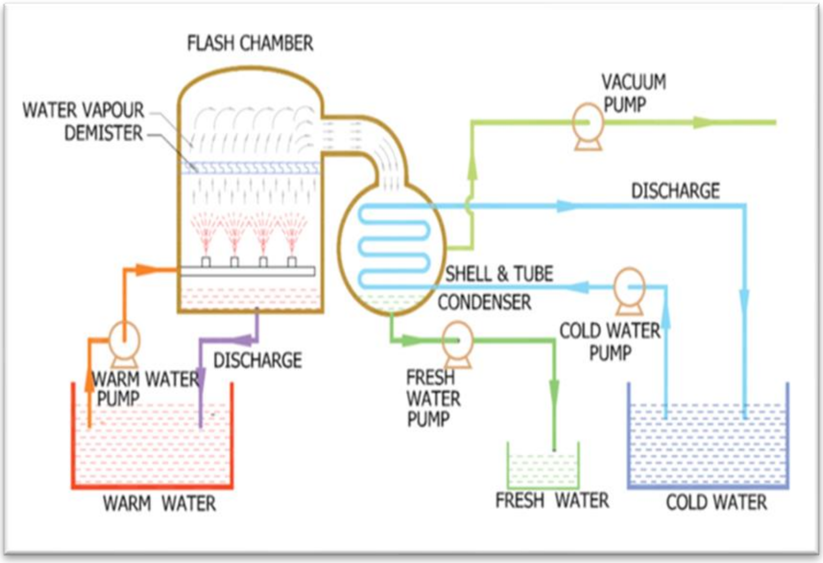
A Low-Temperature Thermal Desalination (LTTD) system utilizes the temperature difference between warm surface seawater and cold deep seawater to produce fresh water. In an LTTD system, warm surface seawater is evaporated in a low-pressure container, creating vapor. This vapor is then condensed using cold deep seawater, resulting in the production of fresh water.

LTTD is a promising technology for desalination due to its low environmental impact and energy efficiency. By leveraging the natural thermal gradients in the ocean, LTTD provides a sustainable solution for producing potable water, especially in coastal and island regions.

Working Principle:

Low-Temperature Thermal Desalination (LTTD) is a process that exploits the temperature difference between warm surface seawater and cold deep seawater to produce fresh water. Here’s how LTTD works:

- Warm Surface Seawater Intake: Warm surface seawater, typically around 25-30°C, is pumped into a vacuum flash chamber.
- Evaporation: In the vacuum chamber, the warm seawater evaporates at low temperatures due to the reduced pressure, producing water vapor.
- Cold Deep Seawater Intake: Cold deep seawater, typically around 5°C, is pumped from depths of about 1000 meters.
- Condensation: The water vapor is then condensed by passing it over the cold deep seawater in a heat exchanger, turning it into fresh water.
- Fresh Water Collection: The condensed fresh water is collected and can be used for drinking, irrigation, or industrial processes.
- Brine Discharge: The remaining seawater, now slightly more saline, is returned to the ocean.



Benefits of LTTD

- Sustainable Water Source: LTTD harnesses the thermal energy available in the ocean, providing a virtually inexhaustible and renewable source of fresh water.
- Environmental Impact: The environmental impact of LTTD is minimal. It does not involve chemical additives or produce harmful byproducts.
- Energy Efficiency: LTTD operates at low temperatures, reducing the energy required for the desalination process compared to conventional methods.
- Nutrient Upwelling: Similar to OTEC, the process of mixing deep, nutrient-rich seawater with surface water can enhance marine life growth and support aquaculture.
- Agricultural Benefits: The byproduct of LTTD, nutrient-rich seawater, can be utilized in agriculture, improving soil fertility and crop yields.

Conclusion:

LTTD systems offer a sustainable, environmentally friendly solution for desalination with additional benefits for marine ecosystems and agriculture. As technology advances, LTTD could play a vital role in addressing global water scarcity, particularly in regions with access to oceanic thermal gradients.

Chapter 2

Winch System in Energy and Fresh Water Sector at NIOT:

A winch system is a crucial mechanical device used extensively in the energy and fresh water sectors, particularly in oceanographic applications managed by the National Institute of Ocean Technology (NIOT). This system is essential for the deployment, retrieval, and maintenance of deep-sea equipment utilized in Ocean Thermal Energy Conversion (OTEC) and Low-Temperature Thermal Desalination (LTTD) plants.

Working Principle of Winch System:

The winch system operates by winding and unwinding a cable, rope, or wire around a drum. This mechanism is powered by motors which can be electric, hydraulic, or pneumatic, depending on the specific requirements of the operation. The winch system provides precise control over the deployment and retrieval of equipment, ensuring safe and efficient handling.

- Deployment of Equipment: The winch system lowers equipment, such as pipes, sensors, and other devices, into the ocean. This process requires accurate control to ensure the equipment reaches the correct depth and position.
- Retrieval of Equipment: The system retrieves the deployed equipment, which is

essential for maintenance, data collection, and analysis.

- Maintenance Operations: The winch system plays a vital role in the regular maintenance of oceanographic equipment, facilitating the inspection and repair of devices used in OTEC and LTTD operations.

Benefits of Winch System in Energy and Fresh Water Sector:

- Precision and Control: The winch system allows for precise control over the deployment and retrieval of equipment, ensuring accurate positioning and safe handling.
- Enhanced Efficiency: By automating the process of lowering and raising equipment, the winch system increases operational efficiency, reducing the time and effort required for manual handling.
- Safety: The winch system enhances the safety of operations by providing reliable control mechanisms, reducing the risk of accidents during the deployment and retrieval of heavy or delicate equipment.
- Versatility: Winch systems can be adapted to various oceanographic applications, making them essential for the versatile operations of OTEC and LTTD plants.
- Reduced Environmental Impact: The controlled operations of the winch system minimize the disturbance to marine environments, supporting the sustainable practices of NIOT.

Conclusion:

The winch system is an indispensable component in the energy and fresh water sectors, particularly in the operations of OTEC and LTTD plants managed by NIOT. Its precision, efficiency, and safety features make it essential for the successful deployment, retrieval, and maintenance of oceanographic equipment. As technology advances, the winch system will continue to play a critical role in supporting sustainable and efficient operations in harnessing ocean resources for energy and fresh water.

Chapter 3

3.1 **Introduction**:

Beam analysis is crucial in structural engineering to ensure safety and reliability. This report focuses on simply supported and cantilever beams subjected to point load and UDL, examining their behavior when made of different materials.

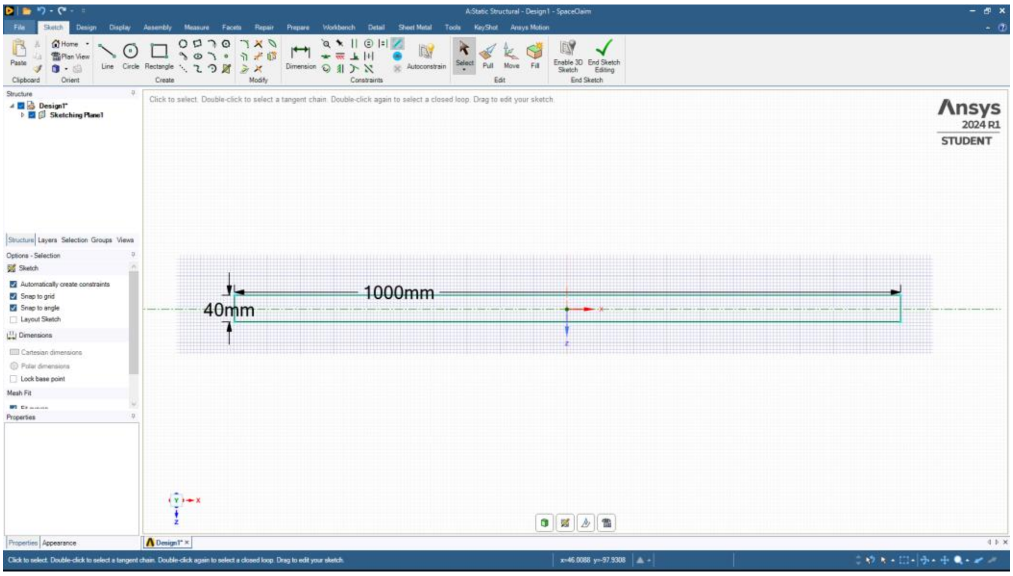
3.2 **Objectives**:

- Analyze the behavior of simply supported and cantilever beams under point load and UDL.
- Compare stress and deformation in beams made of Structural steel, Aluminum Alloy, and Grey Cast iron.

3.3 **Methodology**:

The analysis involves:

- Defining beam geometry.



- Selecting Structural steel, aluminum alloy, and Grey cast iron as materials
- Setting up point load and UDL cases.
- Simulating using ANSYS.

3.4. **Beam Analysis:**

- Simply Supported Beam:

  A beam supported at both ends without restraint at the supports. It can freely rotate and has no moment resistance at the supports.

- Cantilever Beam:

  A beam fixed at one end and free at the other, providing support through moment and shear force at the fixed end.

3.5. **Load Cases:**

- **Point Load**:

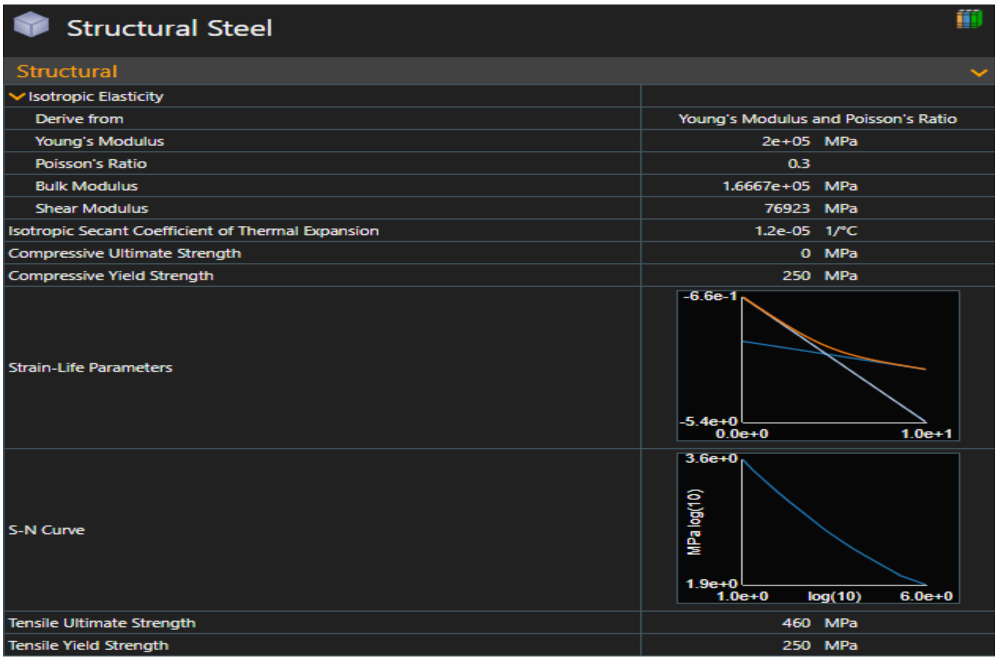
  A concentrated load applied at the mid-span of the beam.

- **Uniformly Distributed Load (UDL)**:

  A load spread evenly along the length of the beam.

3.6. **Materials:**

- Structural Steel:



Structural Steel

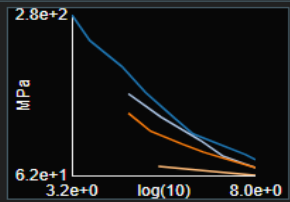
Structural

Isotropic Elasticity	
Derive from	Young's Modulus and Poisson's Ratio
Young's Modulus	2e+05 MPa
Poisson's Ratio	0.3
Bulk Modulus	1.6667e+05 MPa
Shear Modulus	76923 MPa
Isotropic Secant Coefficient of Thermal Expansion	1.2e-05 1/°C
Compressive Ultimate Strength	0 MPa
Compressive Yield Strength	250 MPa
Strain-Life Parameters	-6.6e-1 -5.4e+0 0.0e+0 1.0e+1
S-N Curve	3.6e+0 MPa log(10) 1.9e+0 1.0e+0 log(10) 6.0e+0
Tensile Ultimate Strength	460 MPa
Tensile Yield Strength	250 MPa

- Aluminum Alloy:

Aluminum Alloy

General aluminum alloy. Fatigue properties come from MIL-HDBK-5H, page 3-277.

Density	2.77e-06 kg/mm³
Structural	
Isotropic Elasticity	
Derive from	Young's Modulus and Poisson's Ratio
Young's Modulus	71000 MPa
Poisson's Ratio	0.33
Bulk Modulus	69608 MPa
Shear Modulus	26692 MPa
Isotropic Secant Coefficient of Thermal Expansion	2.3e-05 1/°C
Compressive Ultimate Strength	0 MPa
Compressive Yield Strength	280 MPa
S-N Curve	
Tensile Ultimate Strength	310 MPa
Tensile Yield Strength	280 MPa

- Grey Cast Iron

Gray Cast Iron

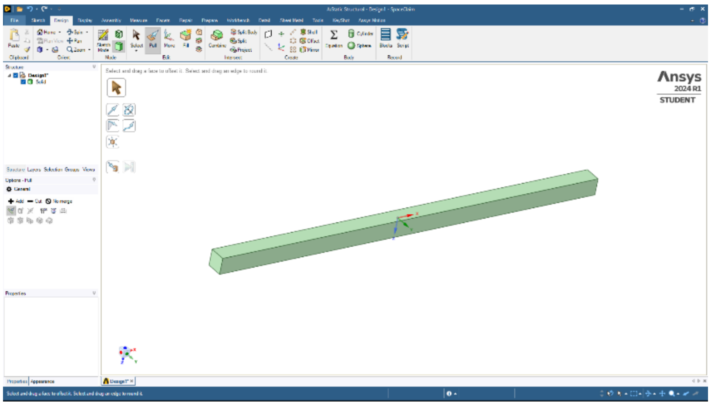
Density	7.2e-06 kg/mm³
Structural	
Isotropic Elasticity	
Derive from	Young's Modulus and Poisson's Ratio
Young's Modulus	1.1e+05 MPa
Poisson's Ratio	0.28
Bulk Modulus	83333 MPa
Shear Modulus	42969 MPa
Isotropic Secant Coefficient of Thermal Expansion	1.1e-05 1/°C
Compressive Ultimate Strength	820 MPa
Compressive Yield Strength	0 MPa
Tensile Ultimate Strength	240 MPa
Tensile Yield Strength	0 MPa

3.7. **ANSYS Simulation:**

The ANSYS simulation involves several crucial steps to ensure accurate results for the stress and deformation analysis of the beams. The steps are as follows:

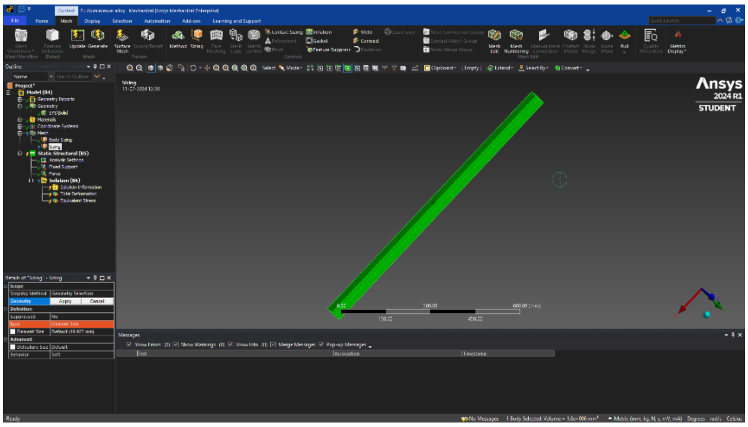
- **Model Creation**:

The geometry of the beams is created using ANSYS. The beams are modeled with the following dimensions:
Length: 1000 mm
Cross-section: 40 mm x 40 mm
The beam is modeled as a solid structure, ensuring that the dimensions are precise and consistent across different simulations.



- **Meshing:**

A fine mesh is applied to the beam geometry to ensure accurate simulation results. The meshing parameters are carefully chosen to balance computational efficiency and result accuracy. The mesh is refined near the areas where loads are applied and at the supports to capture the stress concentration accurately.



- **Boundary Conditions:**

The boundary conditions for the beams are defined as follows:

- Simply Supported Beam:
    - The beam is supported at both ends, allowing rotation but not translation in the vertical direction.
    - Supports are placed at the extremities (0 mm and 1000 mm) along the length of the beam.
- Cantilever Beam:
    - The beam is fixed at one end (0 mm) and free at the other end (1000 mm).
    - The fixed end has both translational and rotational constraints to simulate the fixed support condition.

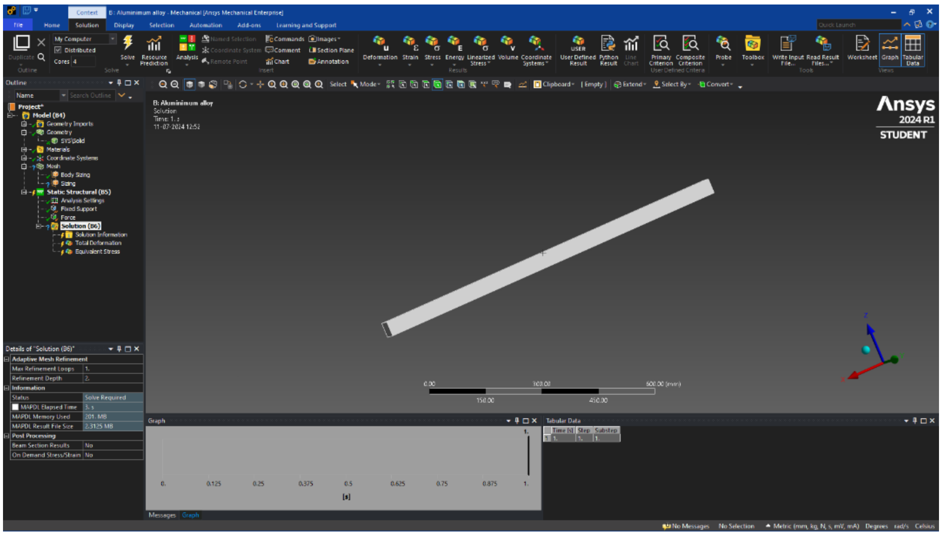
- **Loads**:

Two types of loads are applied to the beams:

- Point Load:
- A concentrated load of -2000 N is applied at the mid-span of the beam (500 mm from either end).
- This load simulates a scenario where a heavy object is placed at the center of the beam.
- Uniformly Distributed Load (UDL):
- A load of -2000 N is distributed evenly along the entire length of the beam (1000 mm).
- This load represents a uniform load distribution, such as the weight of the beam itself or other uniformly distributed loads

- **Simulation**:

  The simulation is run using ANSYS, and the results are extracted for stress distribution and deformation patterns. The following results are obtained for each beam type and load case.



<u>3.8 Results and Discussion:</u>

<u>Stress Distribution for Simply Supported beam with point load</u>:

➢ Structural Steel:

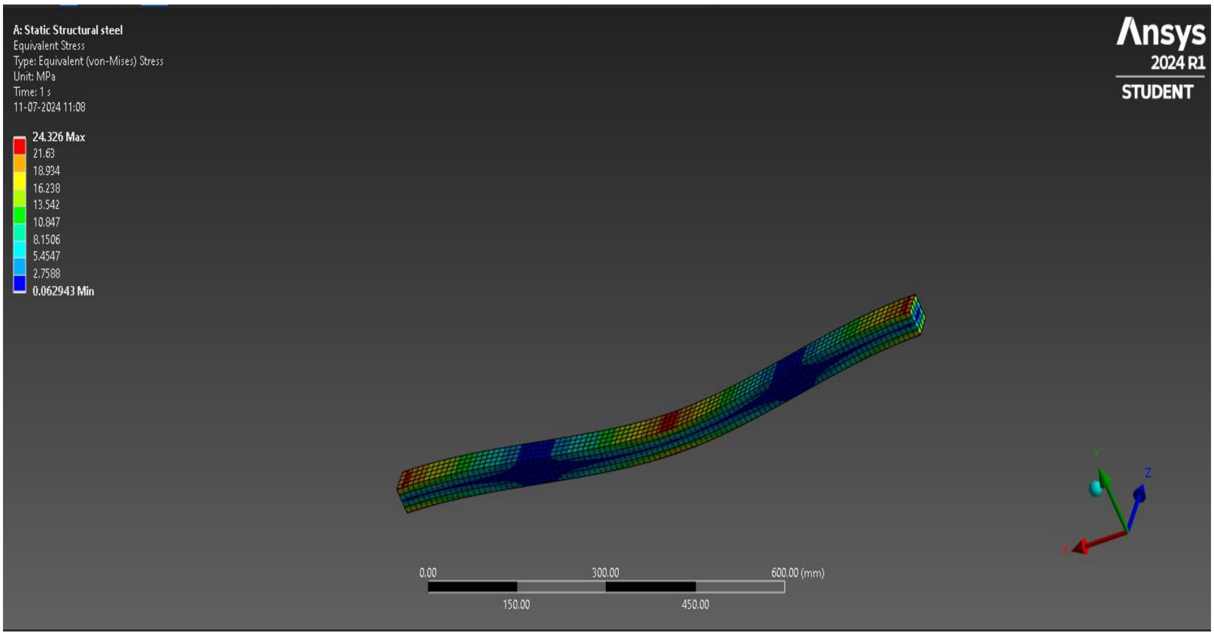


Fig :01

➢ Aluminum Alloy:

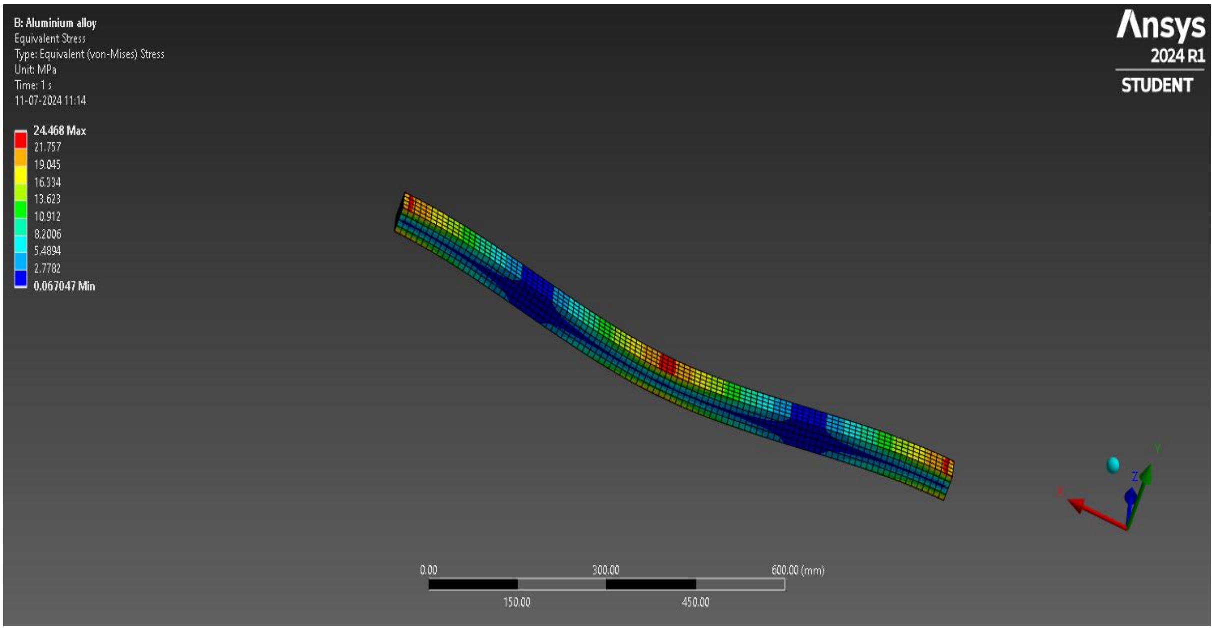


Fig:02

➢ Gray Cast Iron:

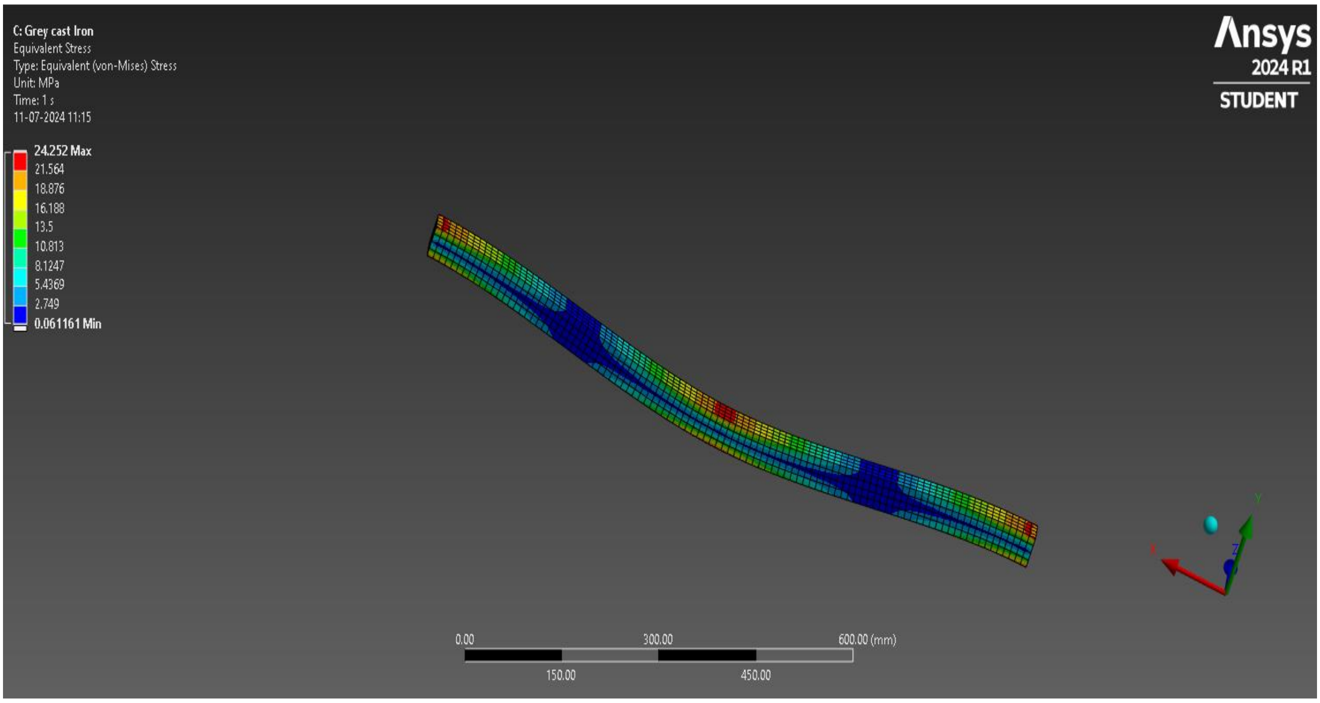


Fig :03

Deformation for Simply Supported beam with point load:

- Structural Steel:

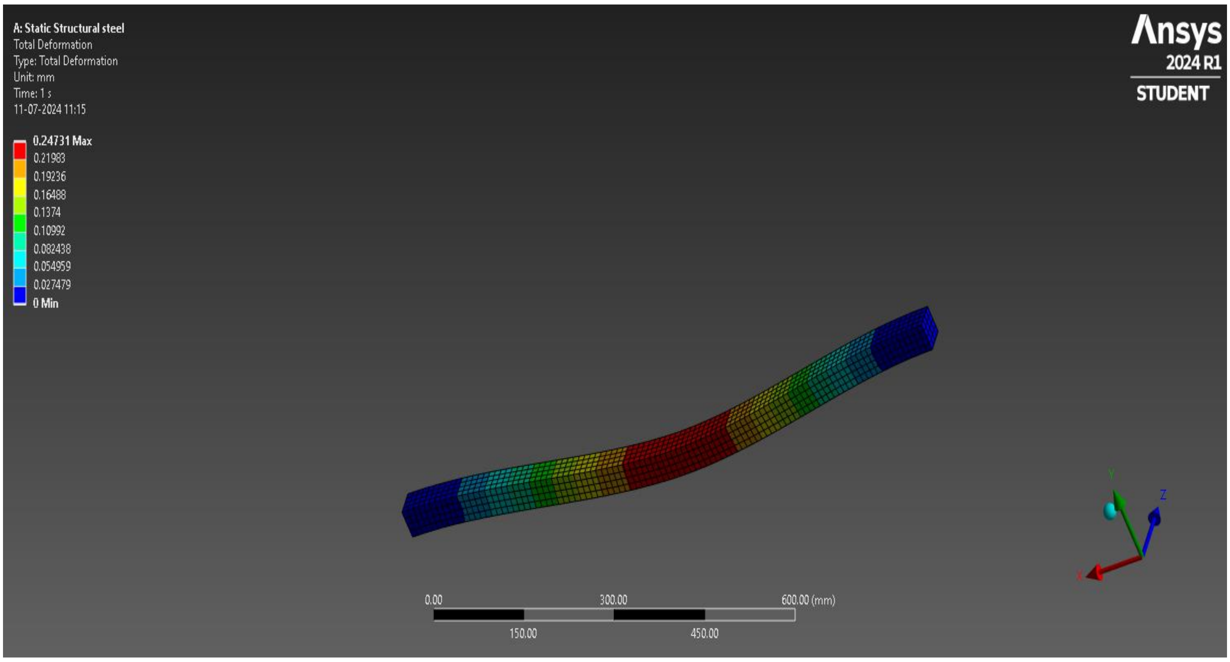


Fig :04

- Aluminum Alloy:

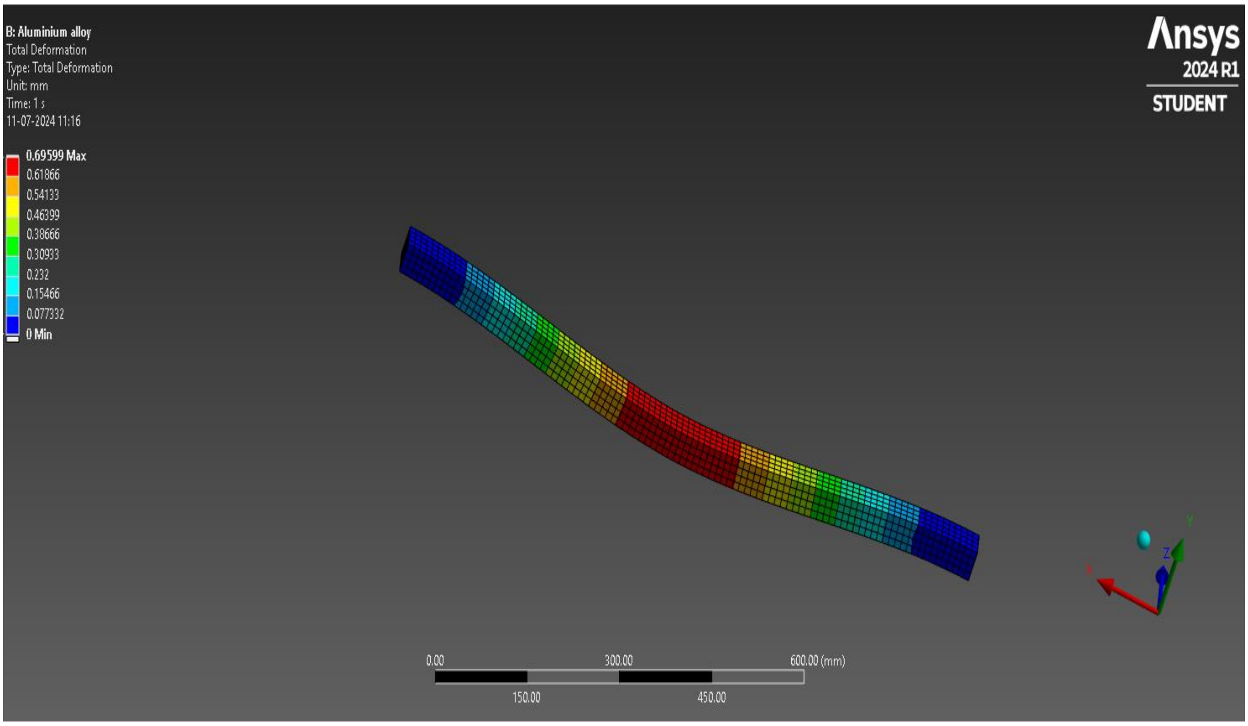


Fig:05

- Gray Cast Iron:

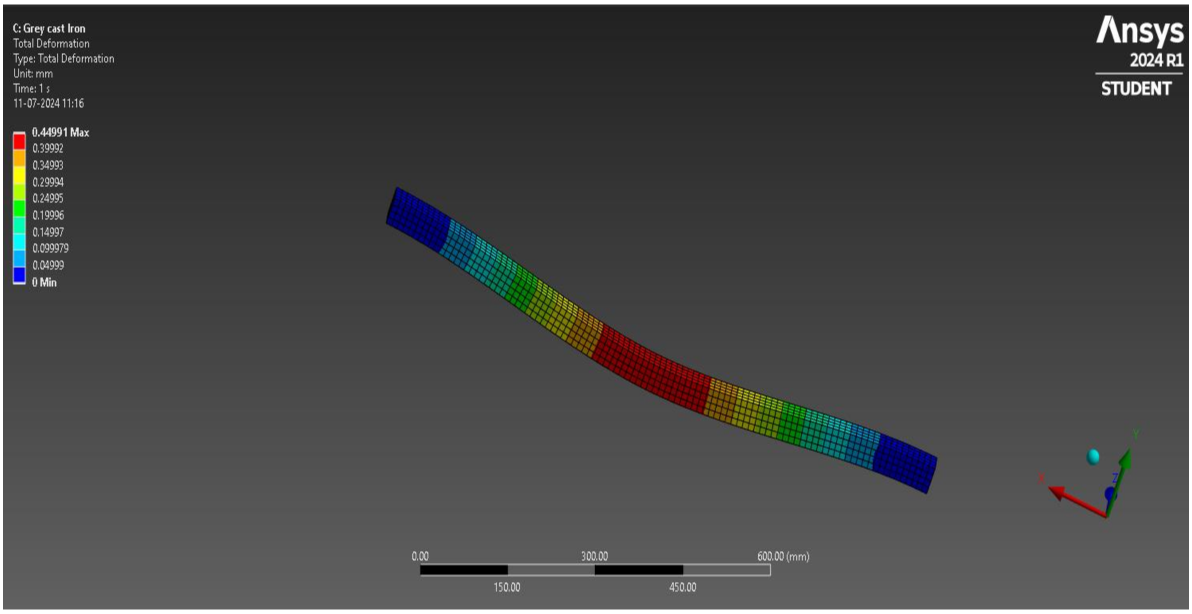


Fig :06

<u>Tabulation of Max Stress and deformation of Simply supported Beam with point load</u>

Material	Max Stress	Deformation
Structural Steel	24.326 MPa	0.247 mm
Aluminum alloy	24.468 MPa	0.695 mm
Grey Cast Iron	25.542 MPa	0.449 mm

Table :1

Stress Distribution for Simply Supported beam with UDL:

➢ Structural Steel:

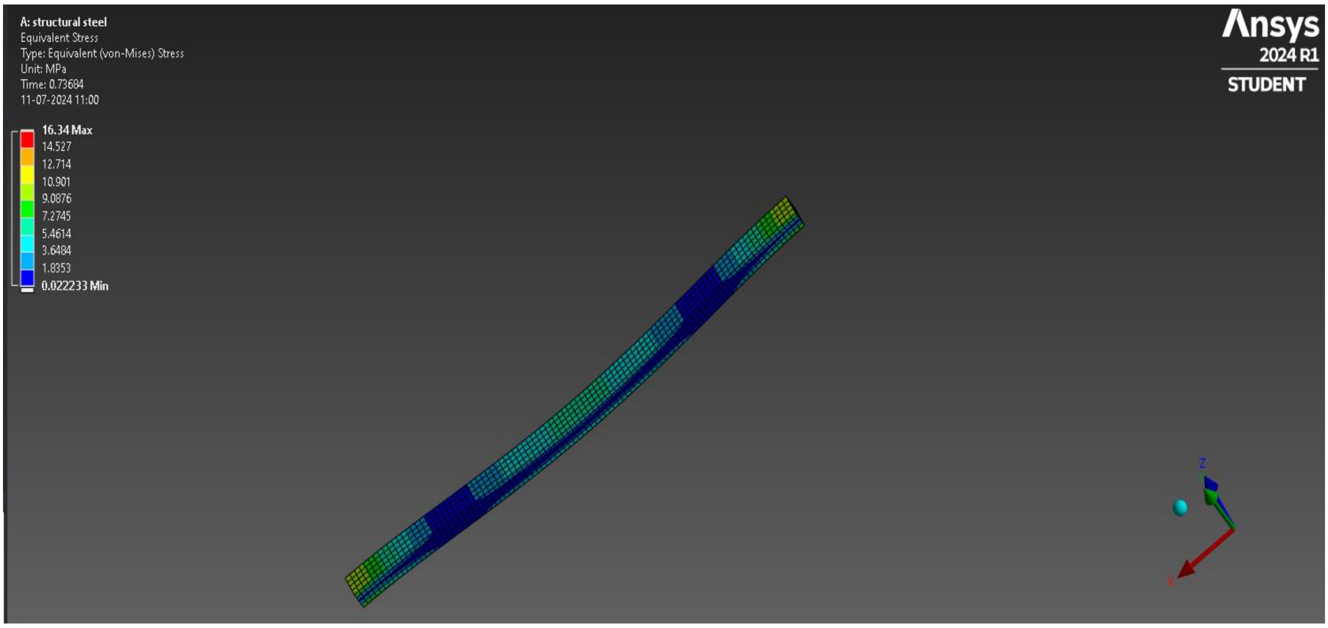


Fig :07

➢ Aluminum Alloy:

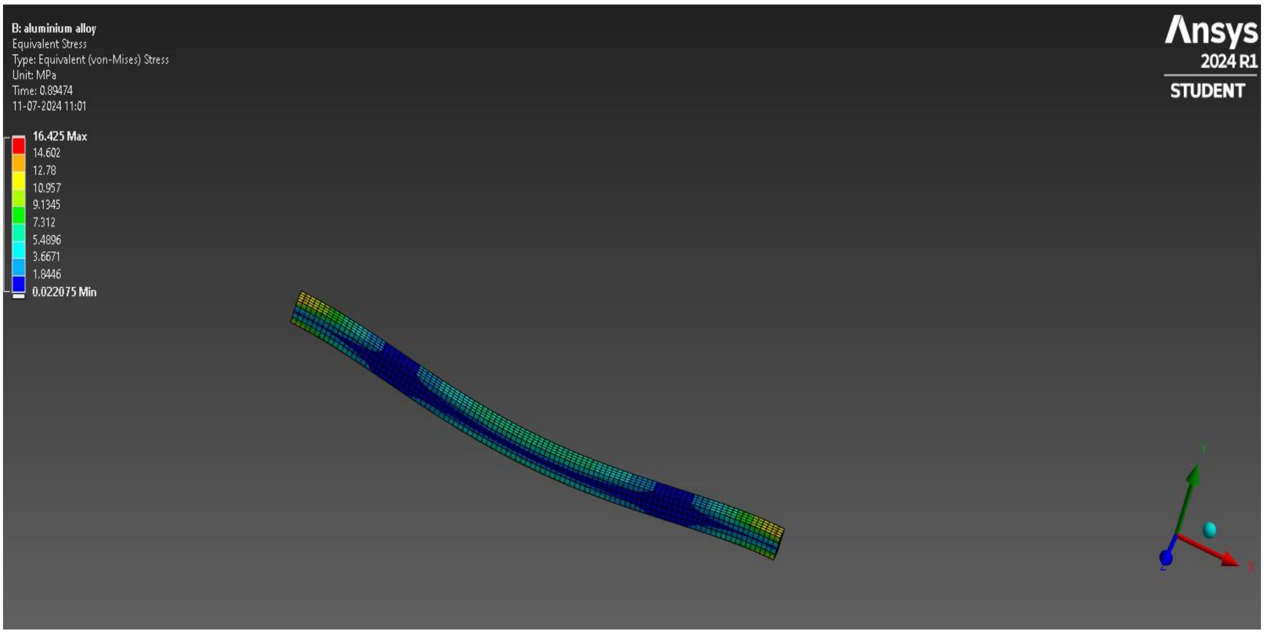


Fig :08

➢ Gray Cast Iron:

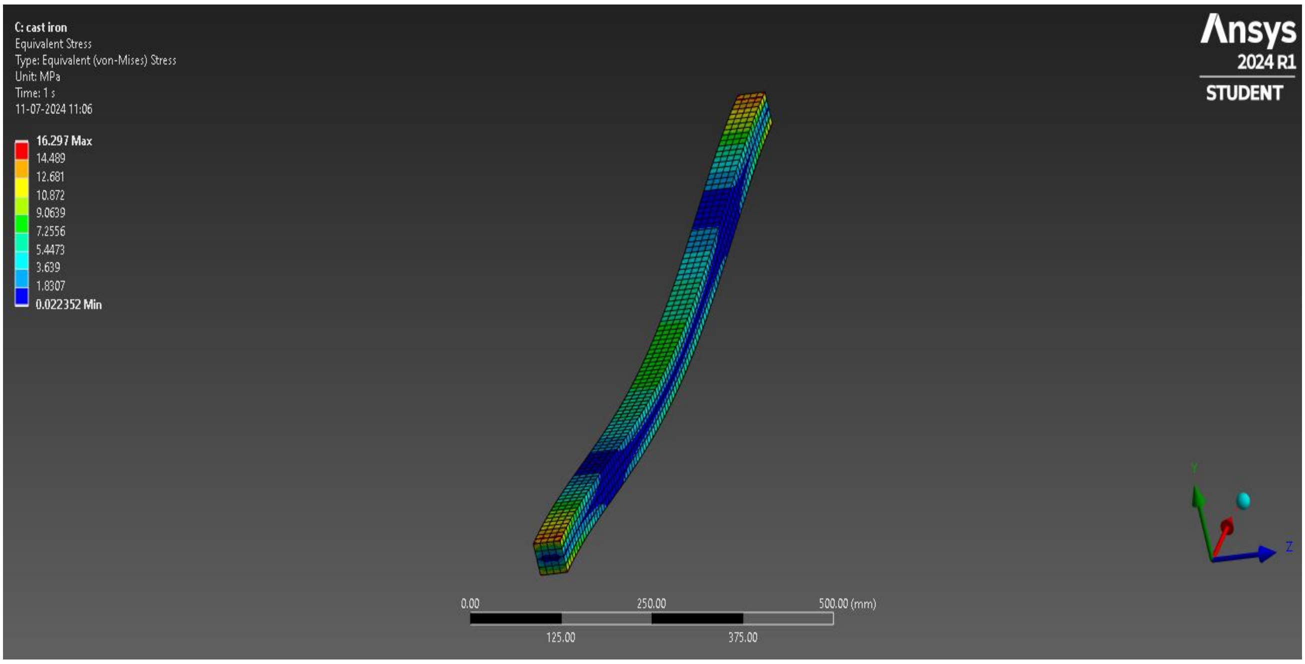


Fig :09

Deformation for Simply Supported beam with UDL:

➢ Structural Steel:

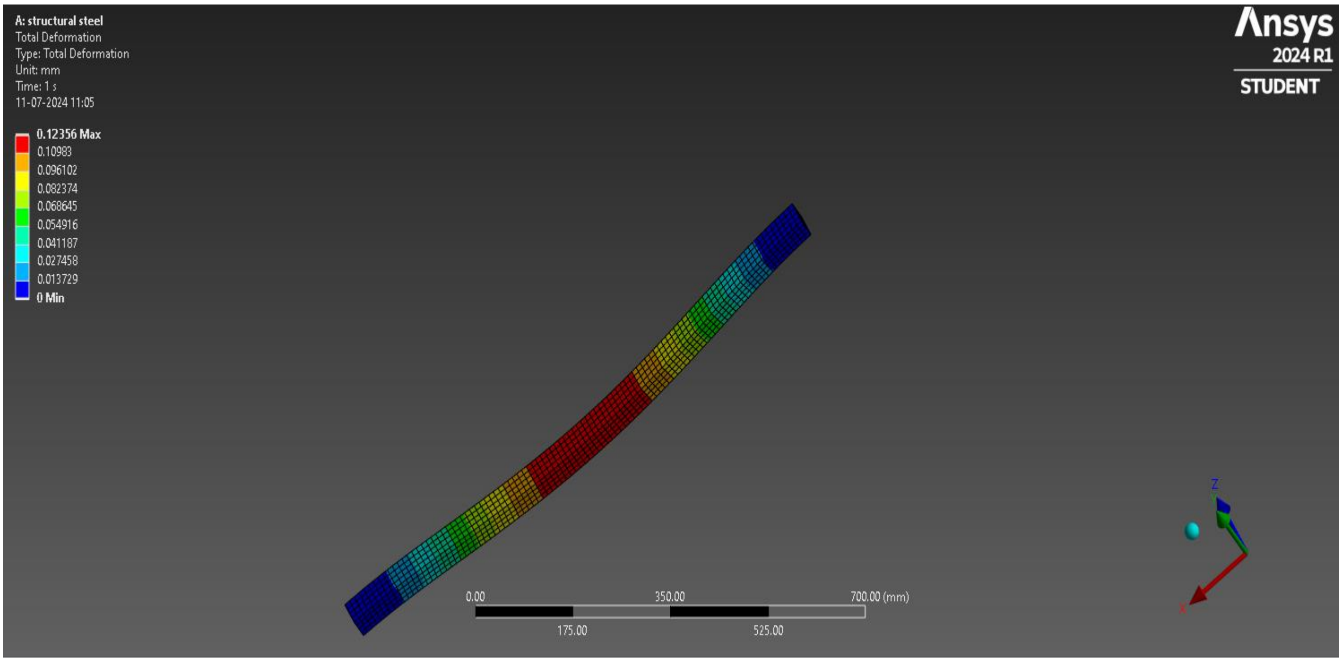


Fig :10

- Aluminum Alloy:

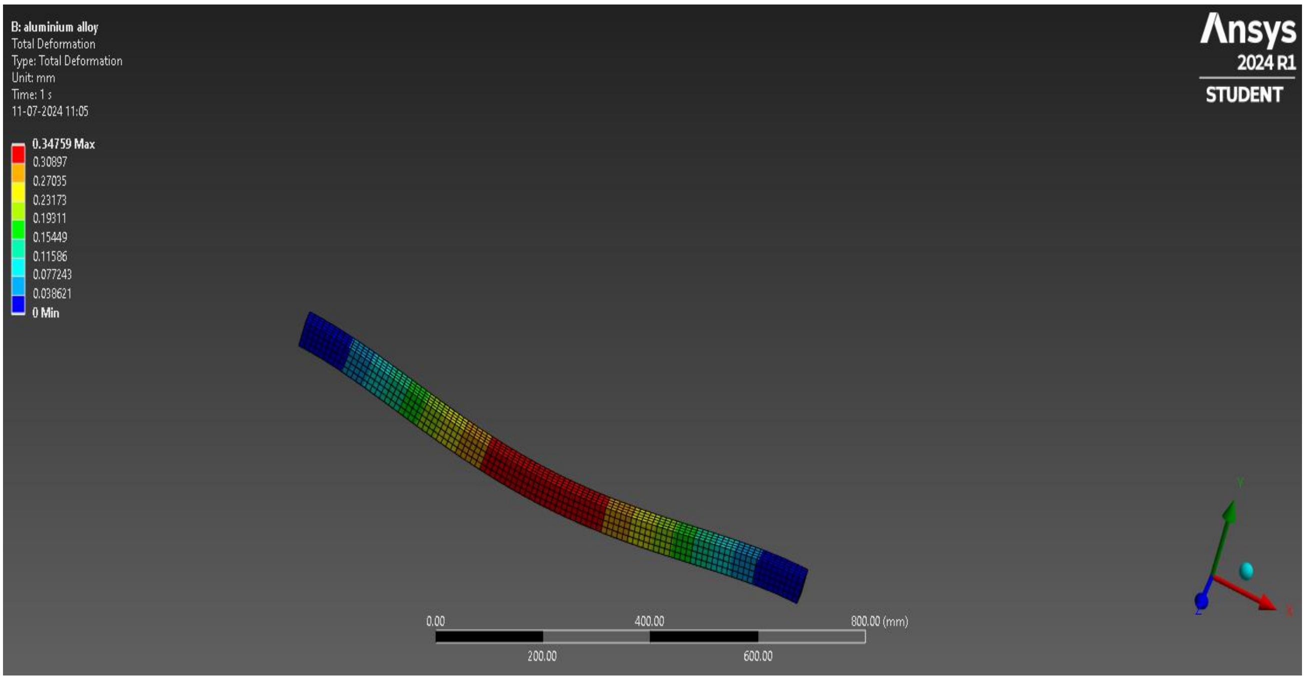


Fig :11

- Gray Cast Iron:

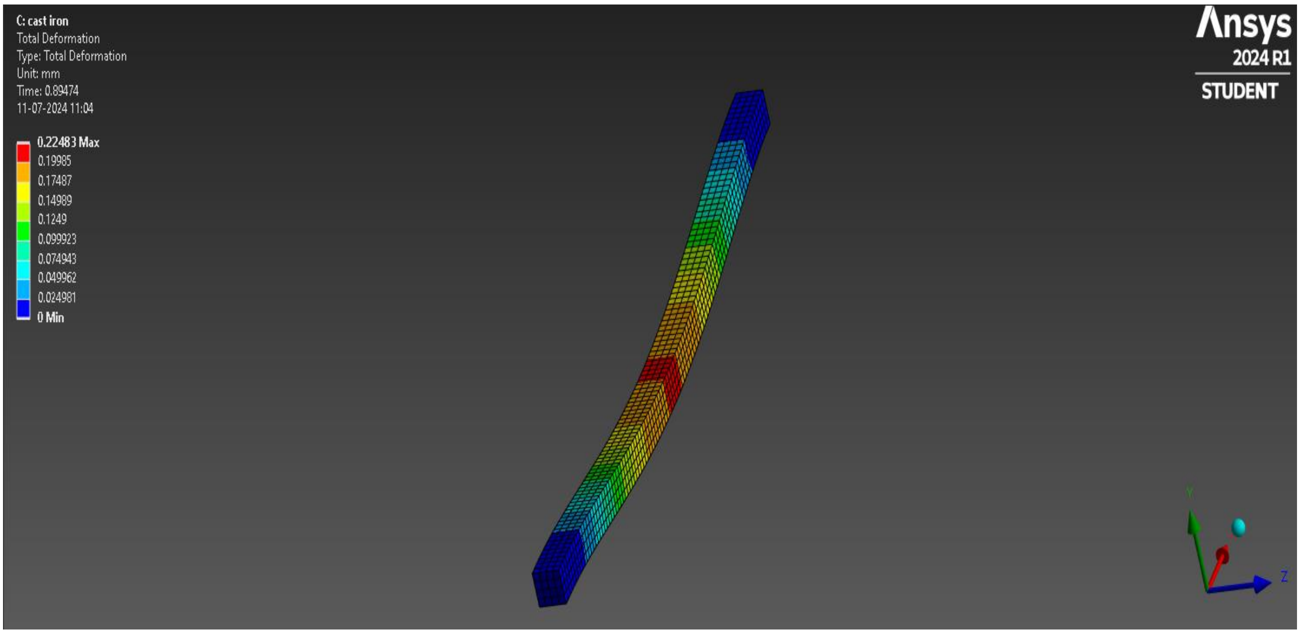


Fig :12

Tabulation of Max Stress and deformation of Simply supported Beam with UDL

Material	Max Stress	Deformation
Structural Steel	16.34 MPa	0.123 mm
Aluminum alloy	16.42 MPa	0.347 mm
Grey Cast Iron	16.29 MPa	0.224 mm

Table :2

Stress Distribution for Cantilever beam with point load:

- Structural Steel:

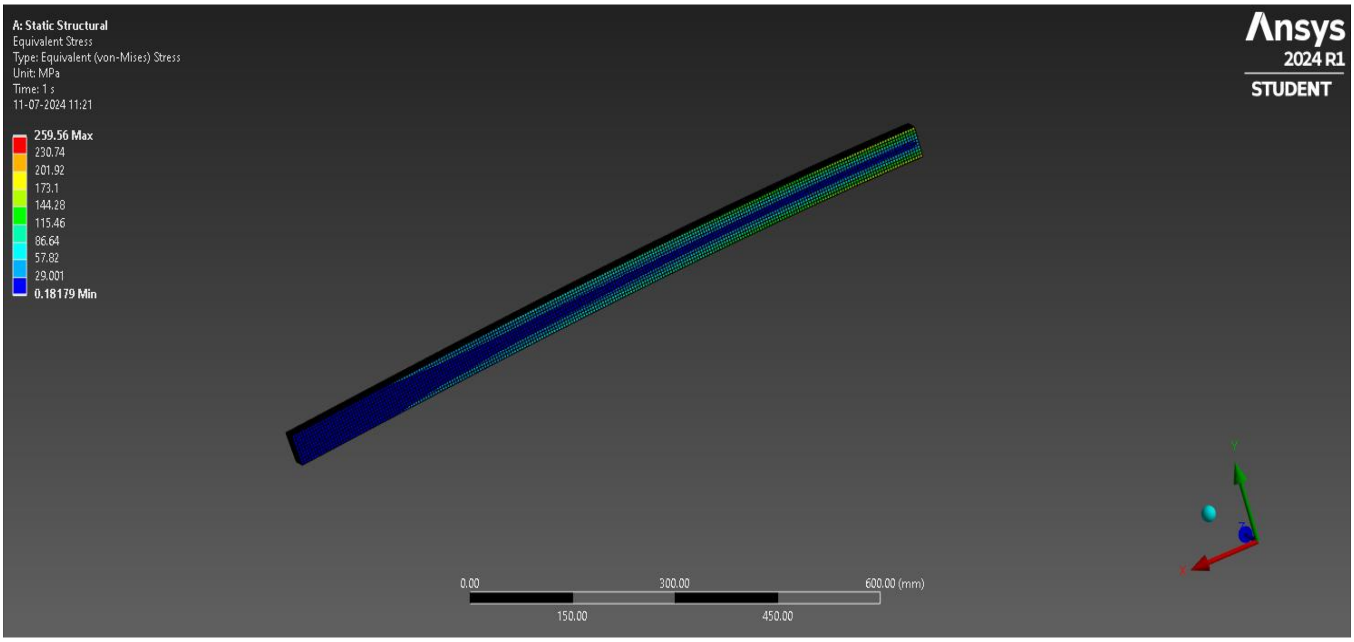


Fig :13

- Aluminum Alloy:

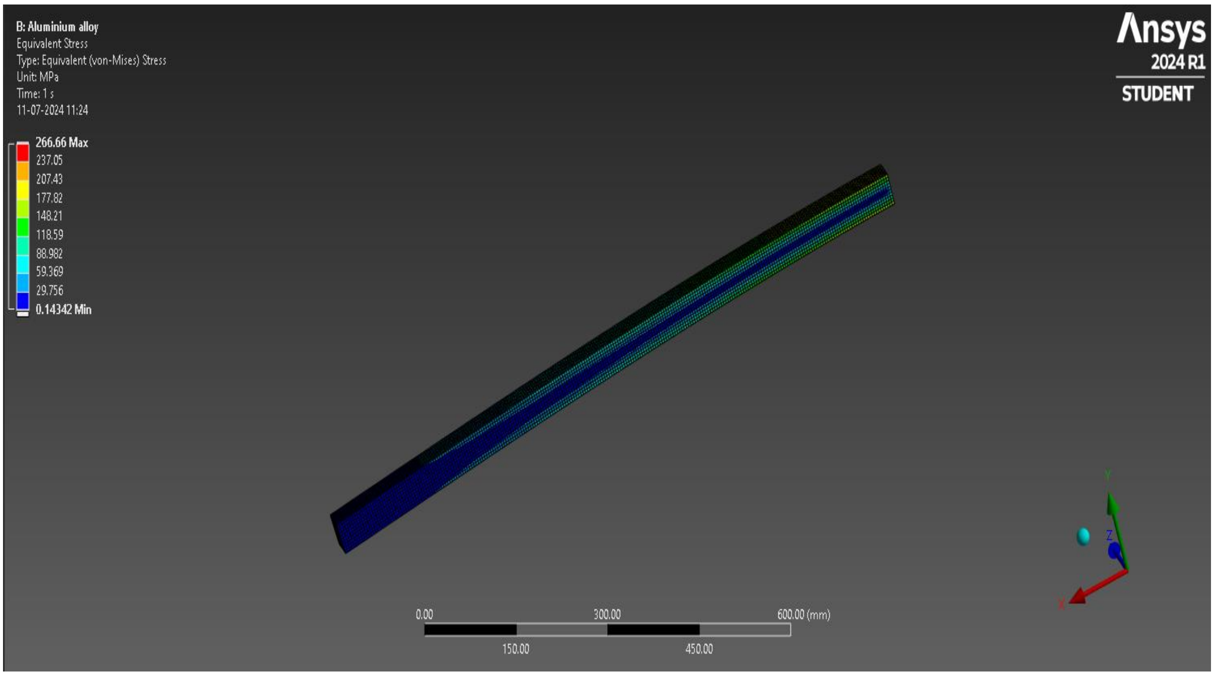


Fig :14

- Gray Cast Iron:

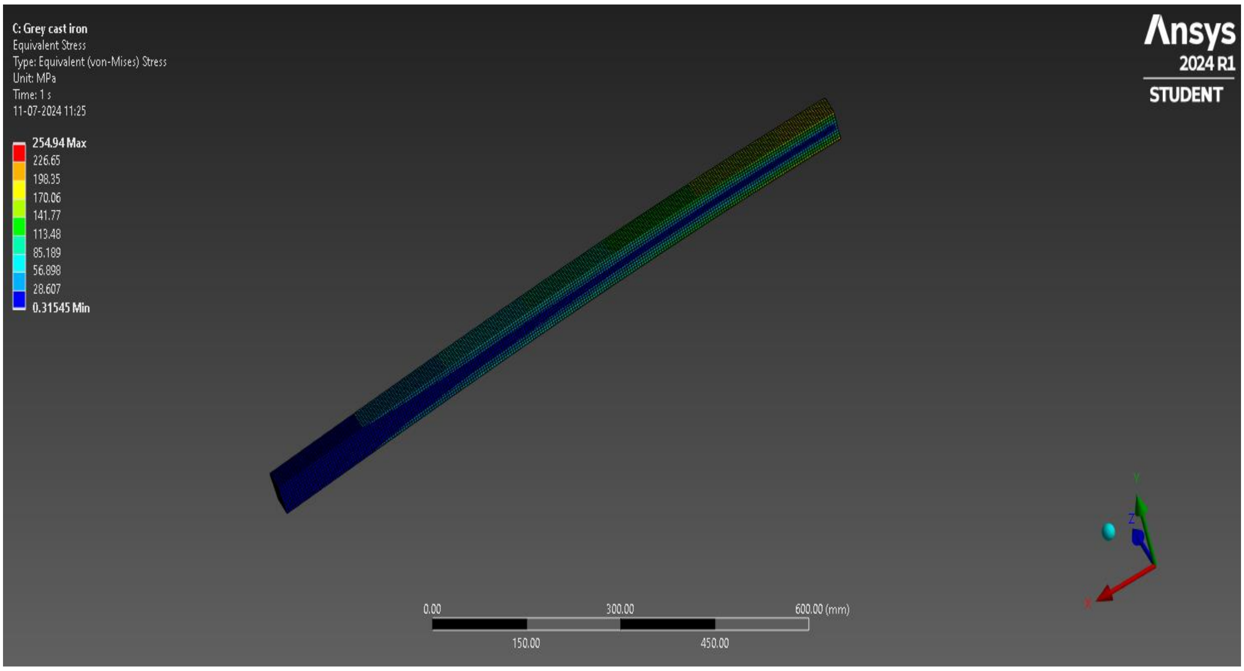


Fig :15

Deformation for Cantilever beam with point load:

- Structural Steel:

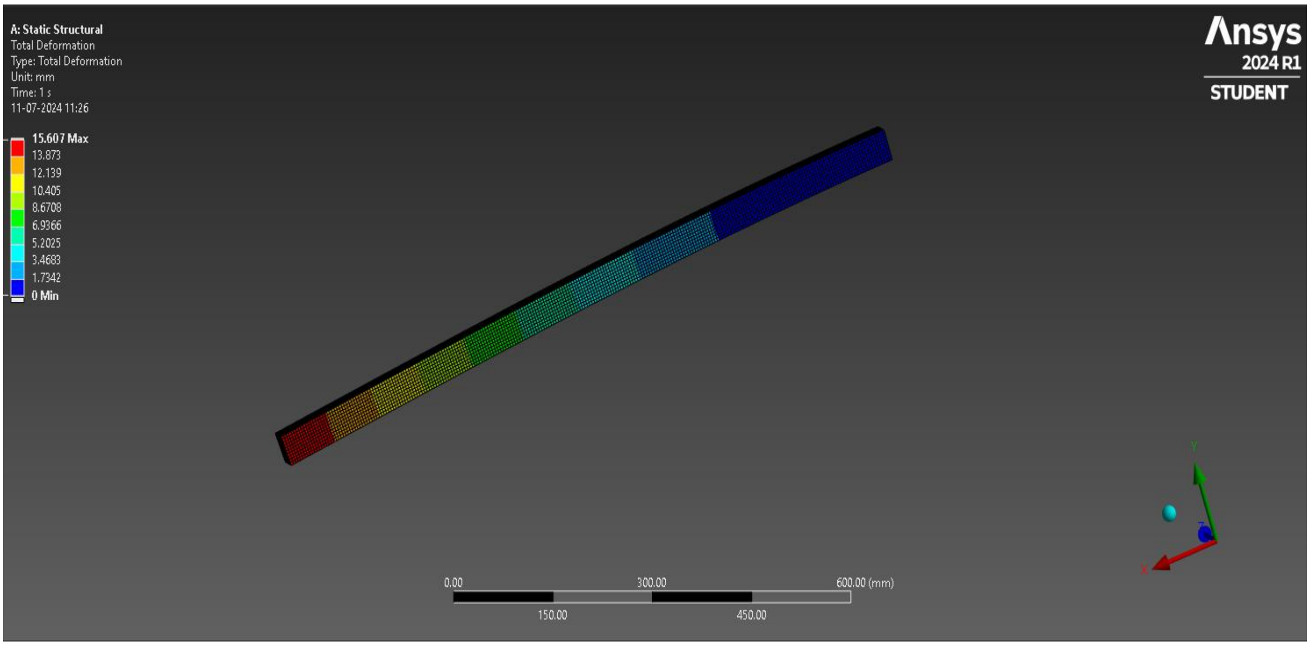


Fig :16

- Aluminum Alloy:

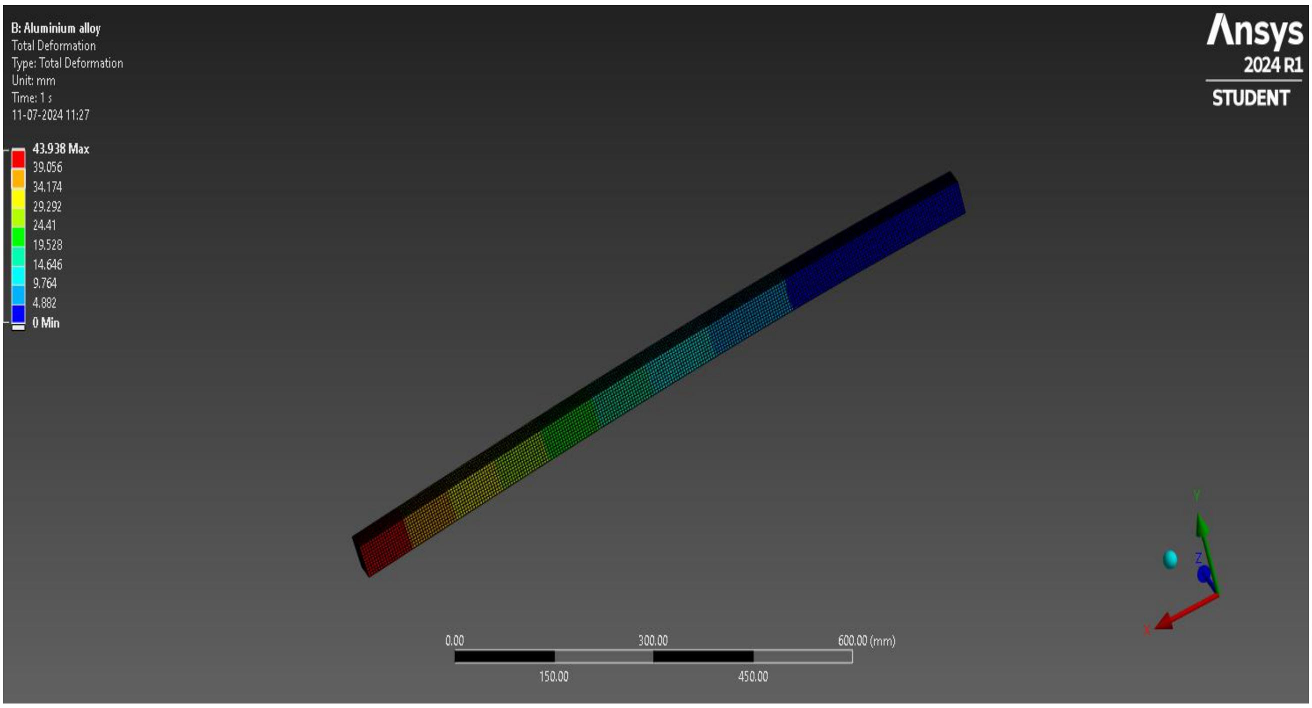


Fig :17

- Gray Cast Iron:

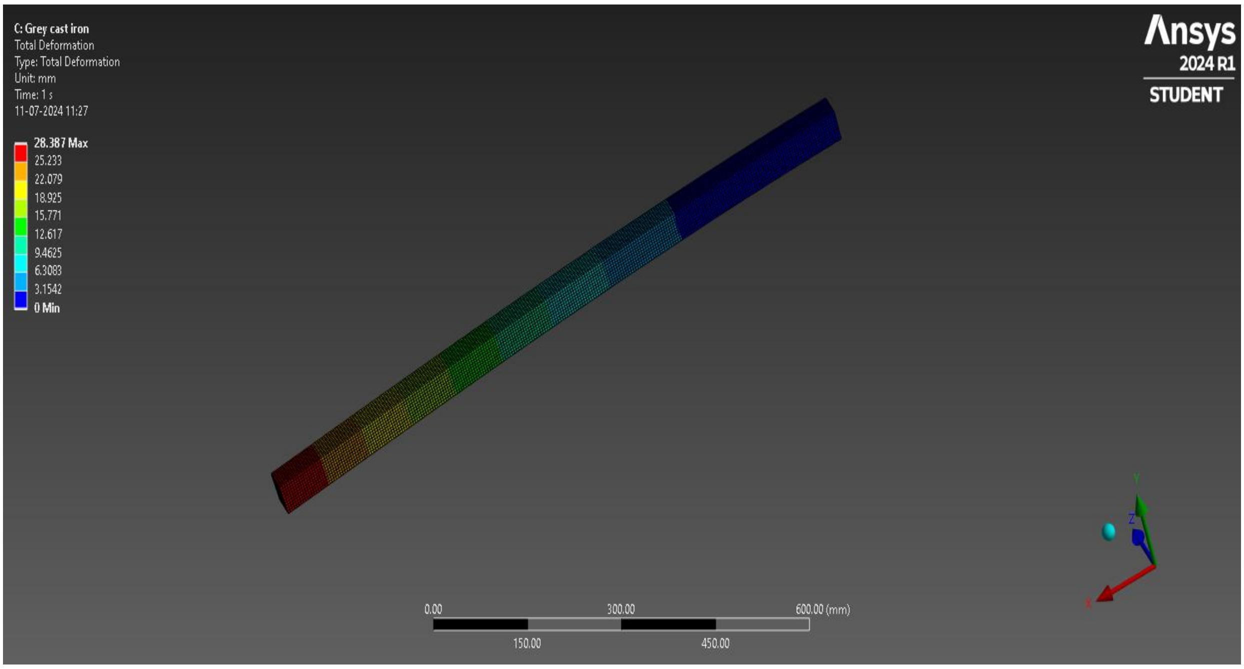


Fig :18

<u>Tabulation of Max Stress and deformation of Cantilever beam with point load</u>

Material	Max Stress	Deformation
Structural Steel	259.56 MPa	0.123 mm
Aluminum alloy	266.66 MPa	0.347 mm
Grey Cast Iron	254.94 MPa	0.224 mm

Table :3

Stress Distribution for Cantilever beam with UDL:

- Structural Steel:

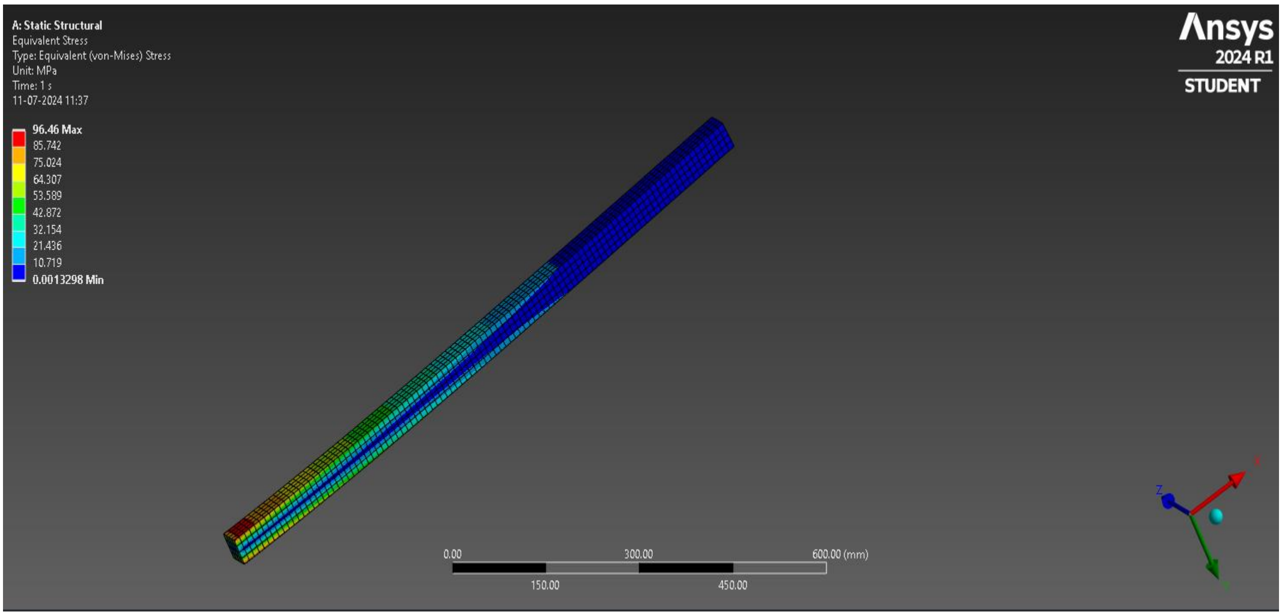


Fig :19

- Aluminum Alloy:

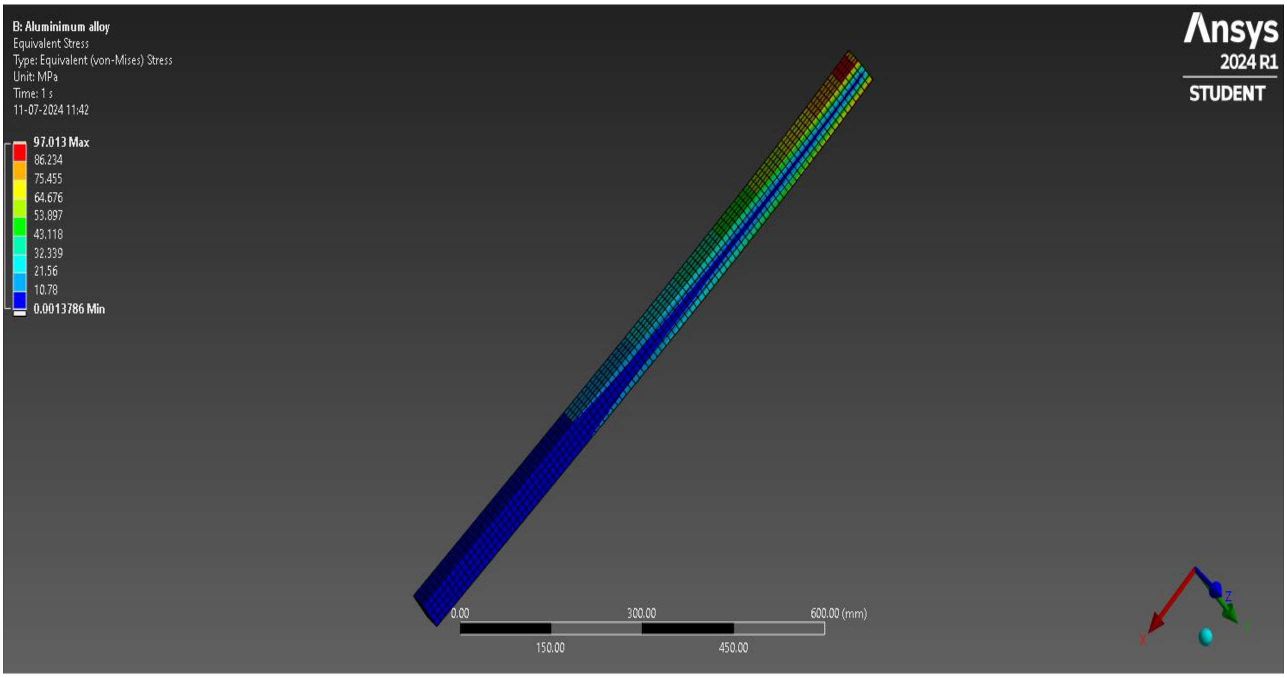


Fig :20

➢ Gray Cast Iron:

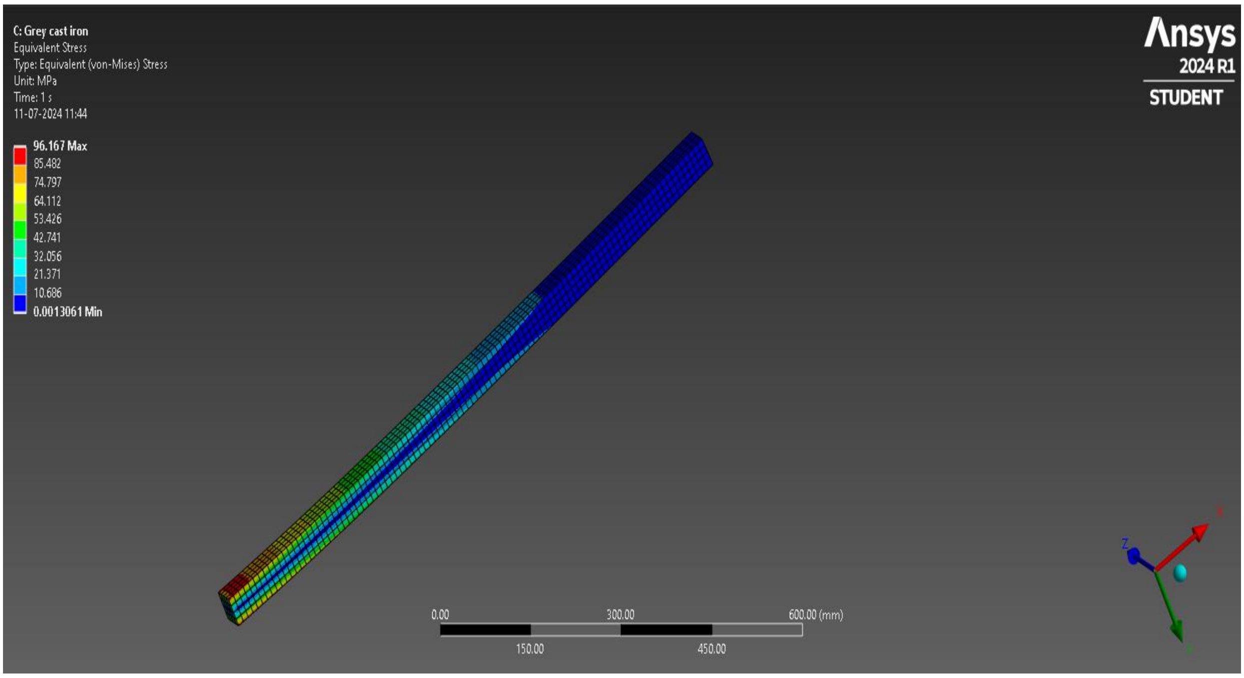


Fig :21

Deformation for Cantilever beam with UDL:

➢ Structural Steel:

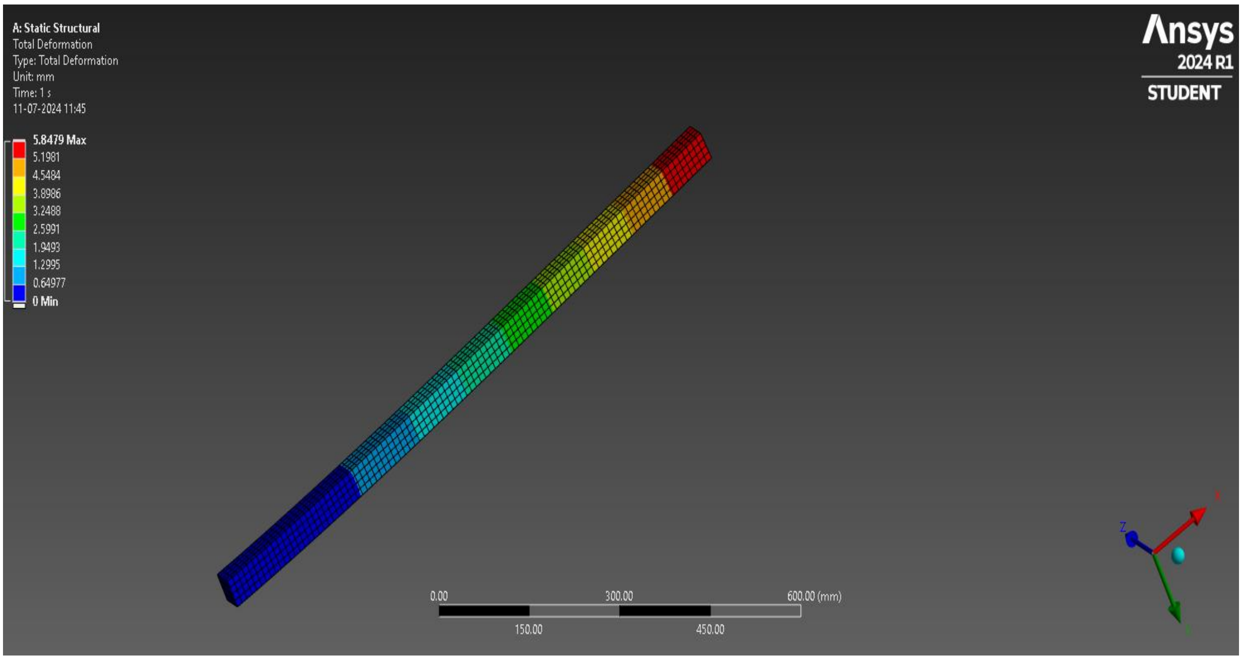


Fig :22

➢ Aluminum Alloy:

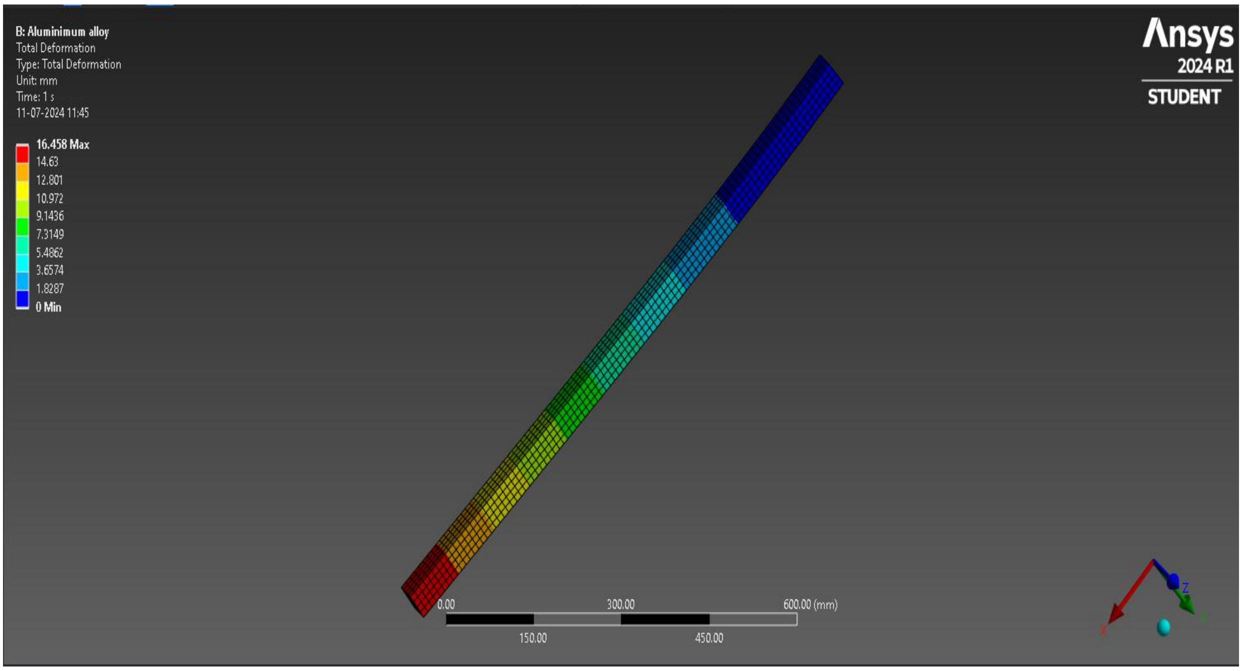


Fig :23

➢ Gray Cast Iron:

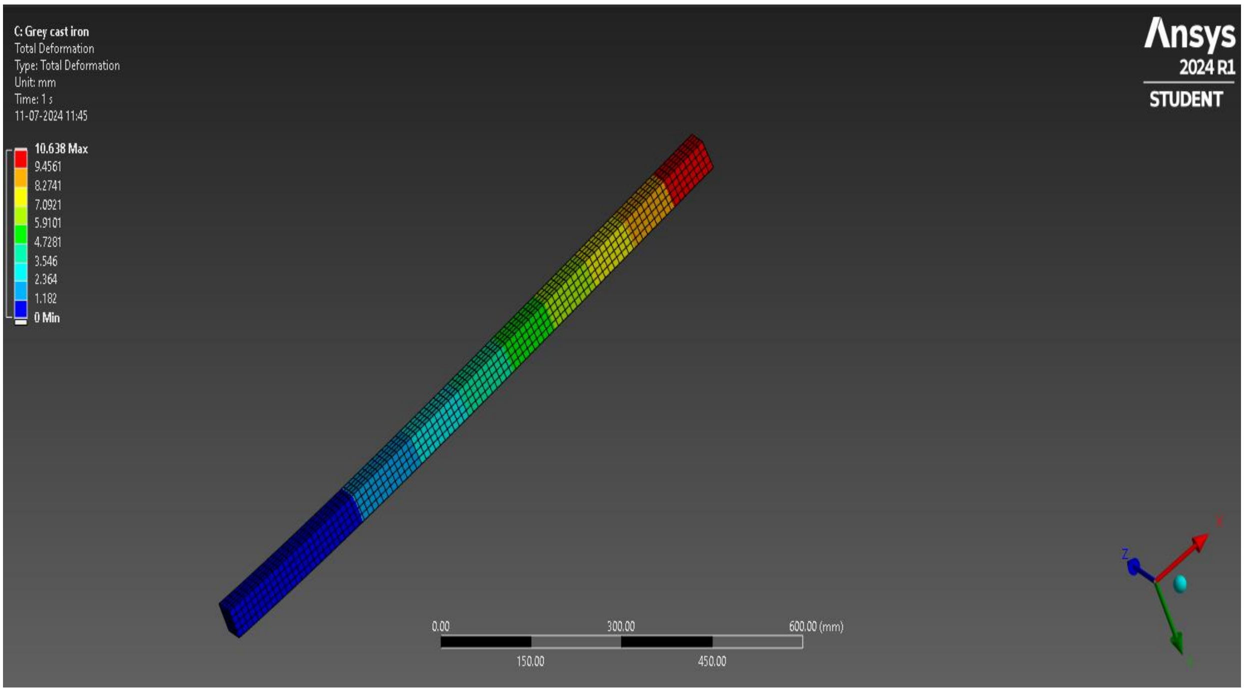


Fig :24

Tabulation of Max Stress and deformation of Cantilever beam with UDL

Material	Max Stress	Deformation
Structural Steel	96.46 MPa	5.84 mm
Aluminum alloy	97.01 MPa	16.45 mm
Grey Cast Iron	96.17 MPa	10.63 mm

Table :4

3.9. Conclusion:

The analysis of simply supported and cantilever beams under both point load and uniformly distributed load (UDL) using structural steel, aluminum alloy, and grey cast iron provides insights into the mechanical performance of these materials:

- Structural Steel: Structural steel beams exhibit the highest strength and lowest deformation under both point load and UDL conditions. This makes structural steel the most suitable material for applications requiring high load-bearing capacity and minimal deformation. It is ideal for construction and infrastructure projects where durability and safety are paramount.

- Aluminum Alloy: Aluminum alloy beams demonstrate moderate strength and higher deformation compared to structural steel. While not as strong as steel, aluminum's lightweight nature and good deformation characteristics make it suitable for applications where weight reduction is critical, such as in aerospace, automotive, and certain architectural applications.

- Grey Cast Iron: Grey cast iron beams show the highest levels of stress and deformation under both loading conditions compared to structural steel and aluminum alloy. Due to its brittleness and lower tensile strength, grey cast iron is less suitable for applications involving dynamic or heavy loads. However, its good compressive strength and vibration damping properties make it useful in specific applications like engine blocks and machinery bases.

3.10. References:

Gere, J. M., & Timoshenko, S. P. (2001). Mechanics of Materials. Brooks/Cole.
ANSYS, Inc. (2023). ANSYS Mechanical User's Guide.