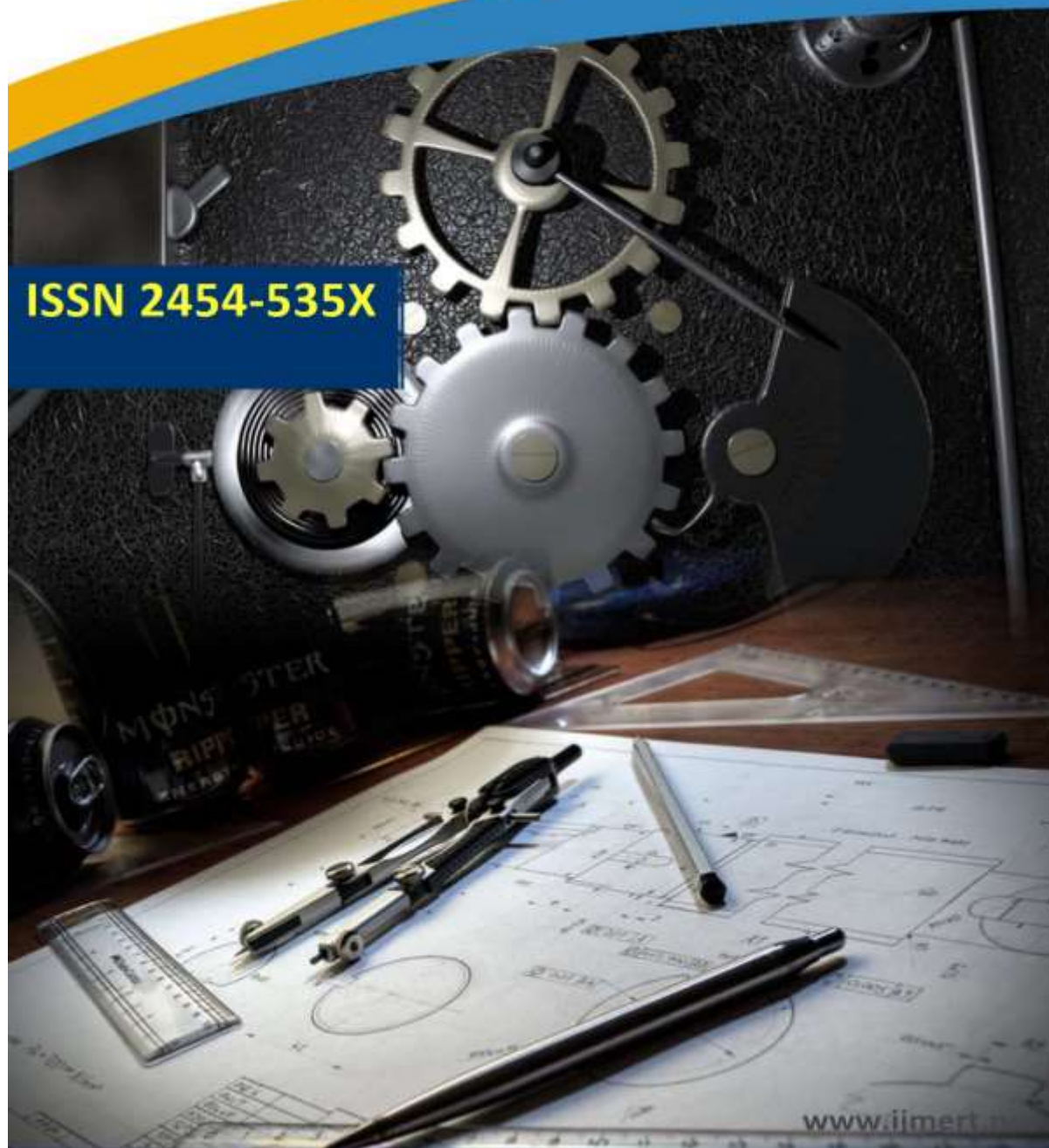




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MODELLING AND ANALYSIS OF CANTILEVER BEAM WITH VARIOUS PARAMETERS

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Abstract

The fundamental goal is to examine the deformation of cantilever beam of mild steel and grey cast iron. The 3D model of cantilever beams with rectangular and circular cross sections will be drawn with the use of space claim software. The model sare then used to simulate the performance of the beam in workbench dyna under various loading conditions and element formulations namely reduced integration and fully integrated analyzer. The relative investigation was done between the Analytical and simulation results to identify the most significant design parameters and their optimal values. The project aims to provide valuable insights into the design optimization of cantilever beams and demonstrate the capabilities of Workbench Dyna software in conducting complex simulations for structural analysis.

Keywords: Deformation, Space claim, Workbench dyna, fully integrated, Reduced integrated

Introduction

Cantilever beams are a type of structural element commonly used in various fields of engineering, including civil engineering, mechanical engineering, and aerospace engineering. They provide a simple and efficient way to support loads and can be found in various structures and machines. Cantilever beams are characterized by their fixed support at one end, while the other end is free and protrudes into space, making them a type of "overhanging beam." The load is applied to the free end of the beam, which creates a bending moment that causes the beam to deform. The shape and size of the beam and the magnitude and direction of the applied load determine the deflection and stress levels of the cantilever beam. Cantilever beams can be used in various applications, such as bridges, cranes, and aircraft wings. They offer advantages such

as high load-carrying capacity, structural simplicity, and low cost of manufacturing. However, the design of cantilever beams requires careful consideration of several factors, including material properties, cross-section dimensions, load conditions, and the environment in which they will operate. The design optimization of cantilever beams involves finding the most efficient and effective design that meets the necessary constraints and requirements. Simulation software such as Workbench Dyna can be used to analyze the performance of cantilever beams under different conditions and optimize their design parameters to achieve the best results. Overall, cantilever beams are an essential structural element that plays a critical role in various engineering applications.

Statement of the Problem

The problem statement involves identifying the most significant design parameters that affect the performance of the cantilever beam, such as the beam's shape, load, material, and element formulations, and optimizing their values to achieve the best possible performance. The optimization process involves finding the right combination of design parameters that minimize the deflection of the cantilever beam while maximizing its load-carrying capacity and meeting other design requirements such as weight, cost, and safety. The problem statement also involves demonstrating the capabilities of Workbench Dyna software in conducting complex simulations for

structural analysis and design optimization. The software's ability to model various design parameters and simulate the behavior of the cantilever beam under different conditions is essential to the success of the project. By addressing the problem statement, the project aims to provide valuable insights into the design optimization of cantilever beams and contribute to the advancement of structural engineering and design optimization.

Objectives of the study

- To analyze the performance of the cantilever beam under different design parameters such as beam shape, load, material, and element formulations.
- To identify the most significant design parameters that affect the performance of the cantilever beam and their optimal values.
- To optimize the design parameters to achieve the highest performance while meeting the necessary

constraints and requirements.

- To provide valuable insights into the design optimization of cantilever beams.
- To contribute to the advancement of structural engineering and design optimization.

Review of Literature

In a study by A solid-beam finite element and non-linear constitutive modelling J. Frischkorn and S. Reese [1] done analysis on cantilever beam. The study investigated the effect of material properties such as Young's modulus and Poisson's ratio on the deflection and stress levels of the cantilever beam. In another study of Strength of Material by S. Ramamrutham[2] done simulation on cantilever beam with various materials. The study considered design parameters such as beam length, height, width, and material properties to minimize the deflection. Furthermore Timoshenko[3] investigated the behavior of cantilever beam study compared the performance of rectangular, circular, and triangular cross-section cantilever beams and found that triangular cross-section beams had the lowest deflection. Lengvarsky et al. [4] done an analysis of Modal Analysis Of Titan Cantilever Beam Using Ansys And Solid Work. In a study of Roberto Raiteri [5] examined Microcantilever cantilever-based biosensors, The study investigated the effect of material properties such as Young's modulus and Poisson's ratio on the deflection and stress levels of the cantilever beam. In another study of Monika Chaudary [6] investigated Microcantilever based sensors, Furthermore Suryansh Arora[7] and Sandeep Kumar Vashist[8] considered design parameters such as beam thickness, width, and length to minimize the deflection and stress levels of the cantilever beam while meeting constraints on weight and safety factors.

Research Methodology

Since the beam undergoes deformation when different loads are applied, it is necessary to determine which type of material is suitable for designing of beam. the three physical parameters we took into consideration are type of load applied, material of the beam, and shape of the

For Point load : $\Delta_{\max} = (FL^3)/(3EI)$

For Uniformly distributed load: $\Delta_{\max} = (FL^4)/(3EI)$

Where

F= magnitude of the load

L=length of the beam

E=modulus of elasticity of the beam material

I=moment of inertia of the beam's cross sectional area

Explicit dynamics is a numerical simulation technique used to solve problems in the field of structural and solid mechanics, especially those involving large deformations, and non-linear material behavior. It is a computational method used to solve time-dependent problems that involve dynamic loading conditions and rapid changes in deformation behavior. In explicit dynamics, the

beam were taken into consideration. Also two element formulations namely fully integrated and reduced integrated are selected while simulation to check which material and element formulation is suitable for designing of the beam.

The maximum deflection of the beam is given by:

equations of motion are integrated forward in time using a time step approach, where the system response is calculated at discrete intervals of time. This analysis is carried on the cantilever beam based on the different parameters considered and the obtained results are analyzed and compared with the corresponding theoretical results. This analysis will provide better material and suitable element formulation for the beam in the design.

The boundary conditions of the beam represented in above figures [1-3] and meshing of the beam represented in above figures [4-7]

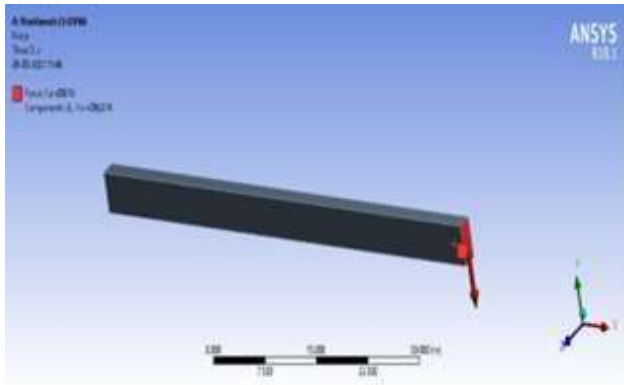


Fig.1: Rectangular beam with point load.

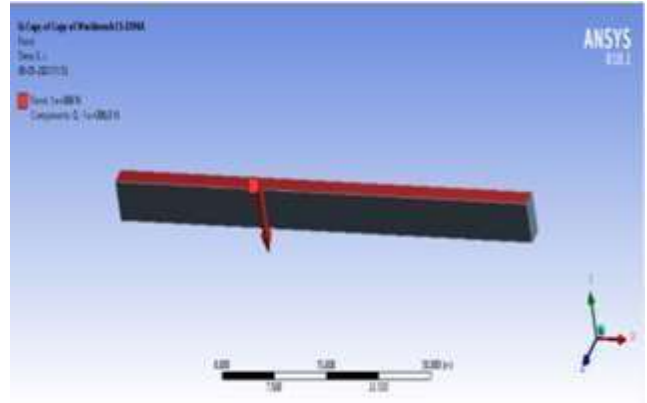


Fig.2: Rectangular beam with UDL

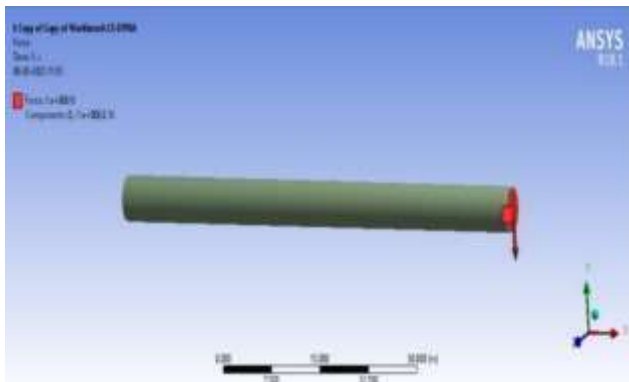


Fig.3: Circular beam with point load

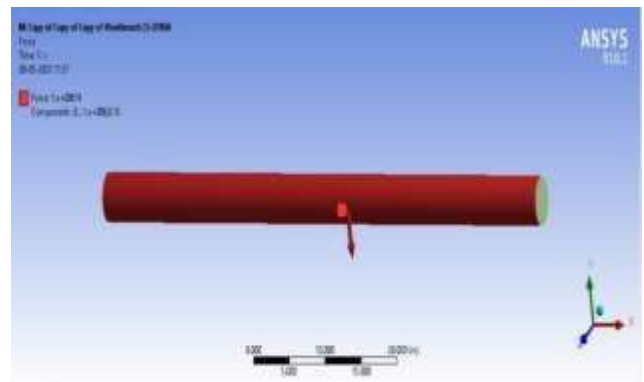


Fig.4: Circular beam with UDL

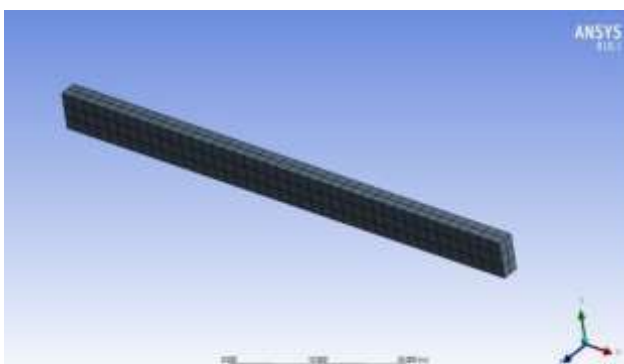


Fig.4: Rectangular beam with reduced integrated mesh

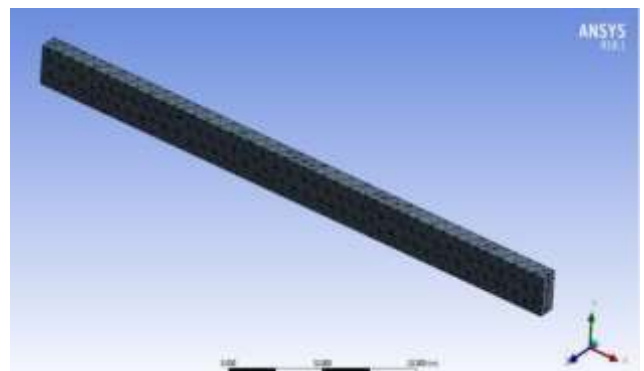


Fig.5: Rectangular beam with fully integrated mesh

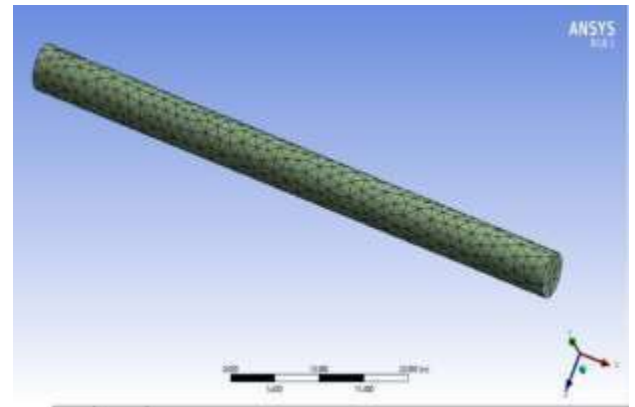
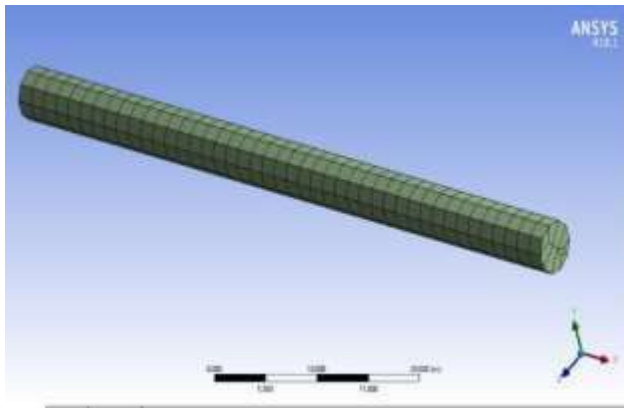


Fig.6: Circular beam with reduced integrated mesh Fig.7: Circular beam with fully integrated mesh

Material properties of mild steel represented in below tabular data (table-1) and Material properties of grey cast iron represented in below tabular data (table-2)

	A	B	C	D	E
1	Property	Value	Unit		
2	Material Field Variables	Table			
3	Density	7830	kg m ⁻³		
4	Isotropic Elasticity				
5	Derive from	Young's ...			
6	Young's Modulus	2E+11	Pa		
7	Poisson's Ratio	0.29			
8	Bulk Modulus	1.5873E+11	Pa		
9	Shear Modulus	7.7519E+10	Pa		

Table-1: Material properties of mild steel

	A	B	C	D	E
1	Property	Value	Unit		
2	Material Field Variables	Table			
3	Density	7200	kg m ⁻³		
4	Isotropic Elasticity				
5	Derive from	Young's Modulus and Poisson...			
6	Young's Modulus	1.1E+11	Pa		
7	Poisson's Ratio	0.28			
8	Bulk Modulus	8.3333E+10	Pa		
9	Shear Modulus	4.2969E+10	Pa		
10	Isotropic Thermal Conductivity	52	W m ⁻¹ C ⁻¹		
11	Specific Heat	447	J kg ⁻¹ C ⁻¹		

Table-2: Material properties of grey cast iron

Results and Discussion

The simulation results are shown in the figures below with their corresponding parameters

Fig (9-11) represents of deformation of rectangular beam and point load acting on it with different materials and element formulations

Fig (12-15) represents of deformation of circular beam and point load acting on it with different materials and element formulations

Fig (16-19) represents of deformation of rectangular beam and UDL acting on it with different materials and element formulations

Fig (20-23) represents of deformation of circular beam and UDL acting on it with different materials and element formulations

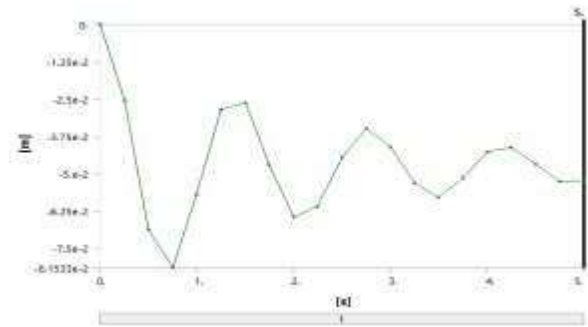
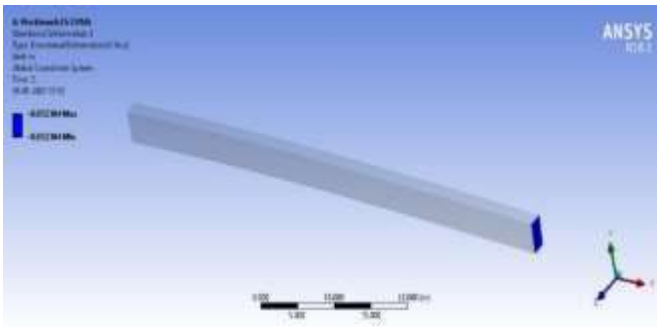


Fig.8: rectangular cross section; mild steel; point load; reduced integrated

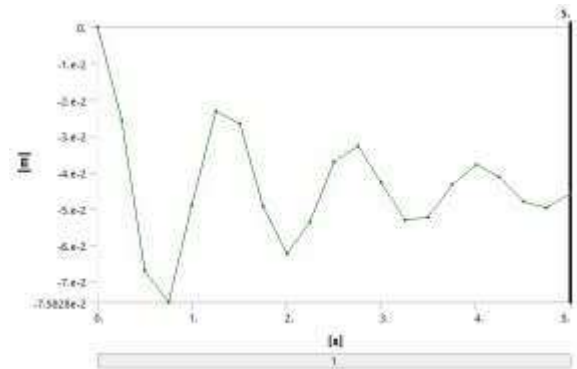
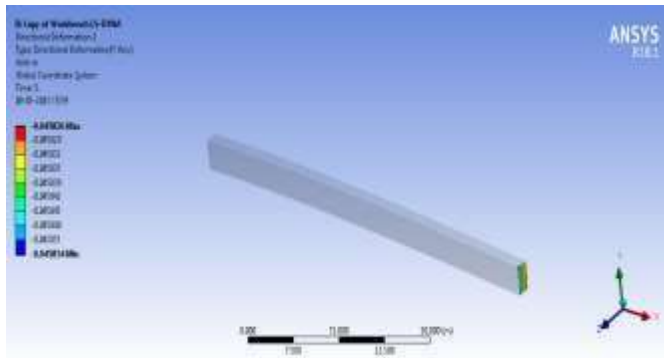


Fig.9 : rectangular cross section; mild steel; point load; fully

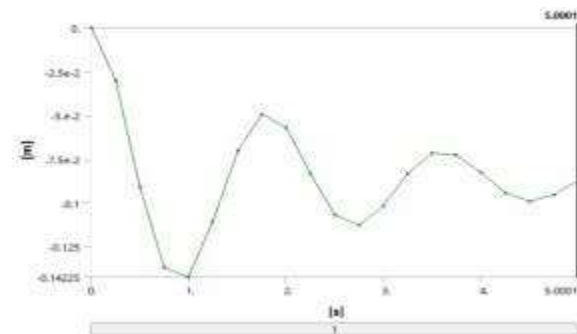
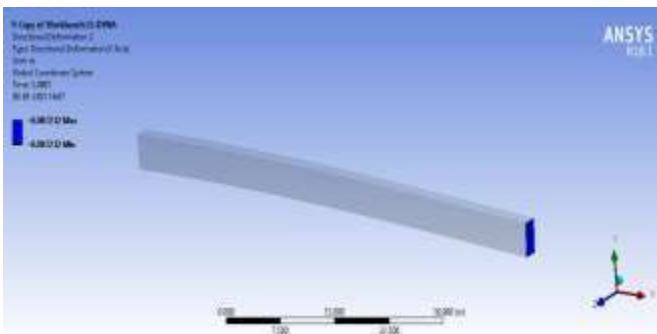


Fig.10: rectangular cross section; grey cast iron; point load; reduced integrated

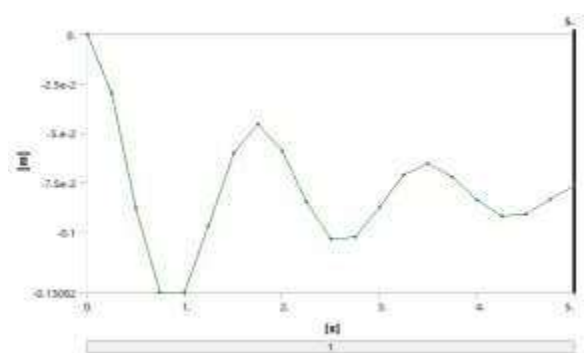
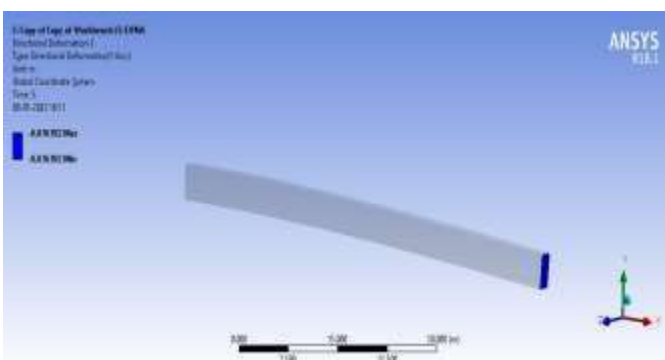


Fig.11: rectangular cross section; grey cast iron; point load; fully integrated

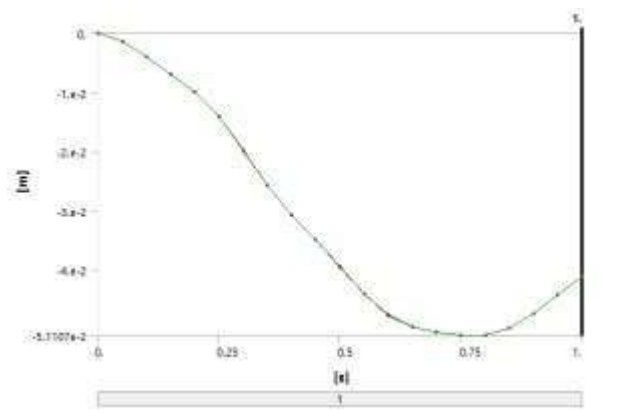
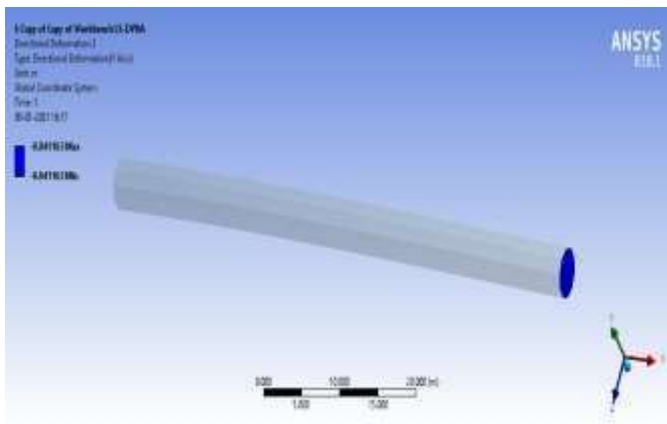


Fig.12: circular cross section; mild steel; point load; reduced integrated

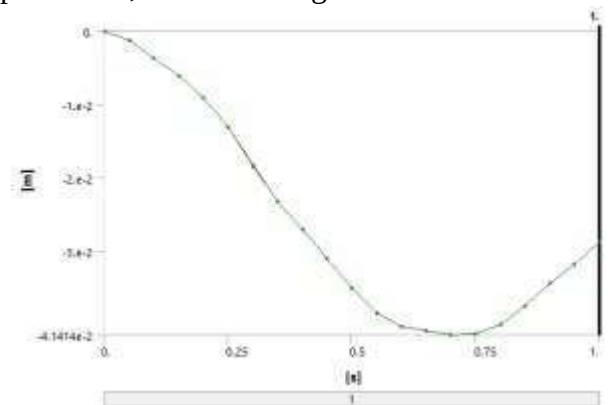
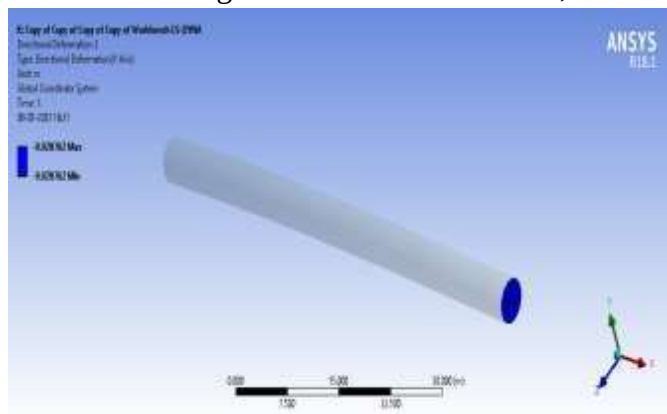


Fig.13: circular cross section; mild steel; point load; fully integrated

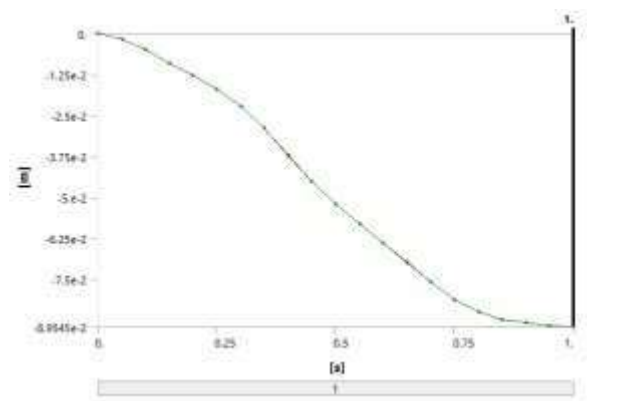
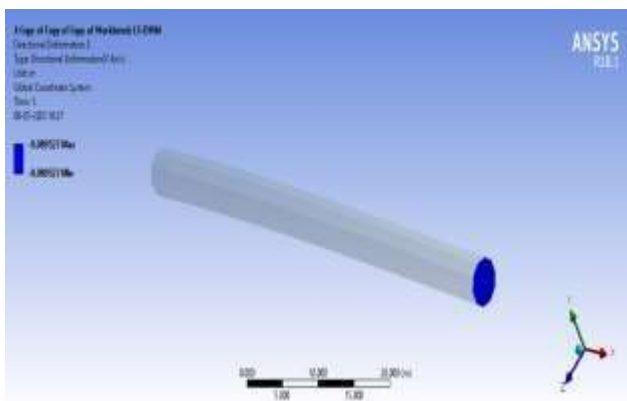


Fig.14 :circular cross section; grey cast iron; point load; reduced integrated

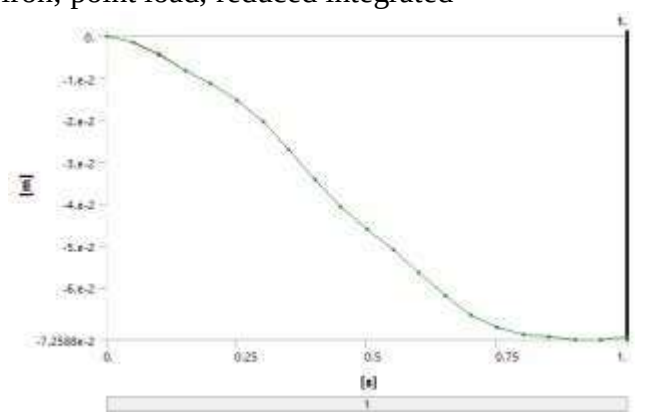
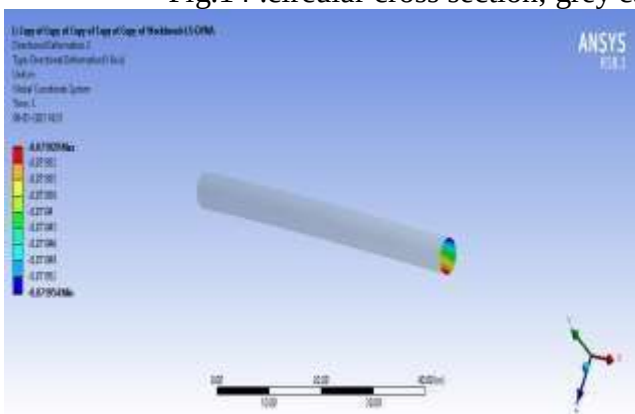


Fig.15 : circular cross section; grey cast iron; point load; fully integrated

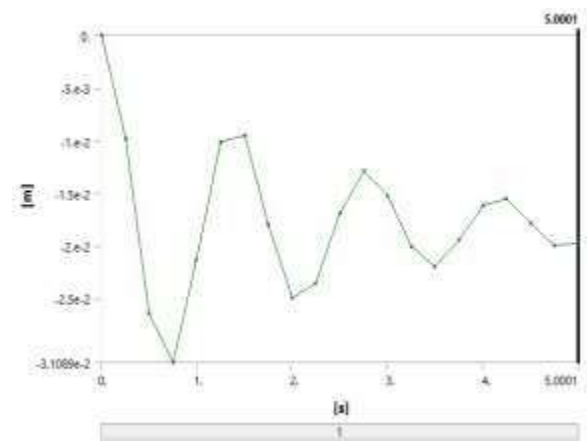
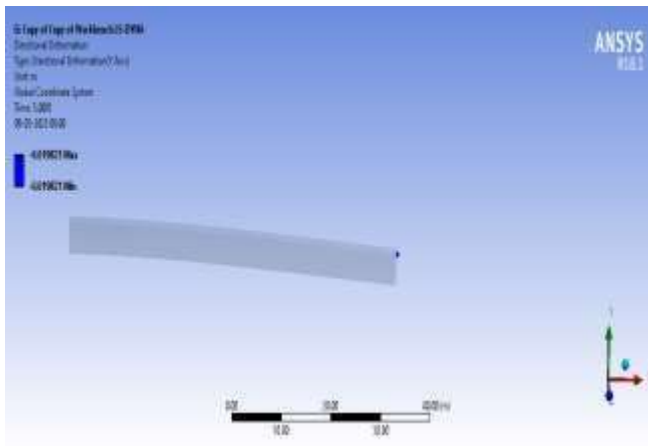


Fig.16 : rectangular cross section; mild steel; UDL; reduced integrated

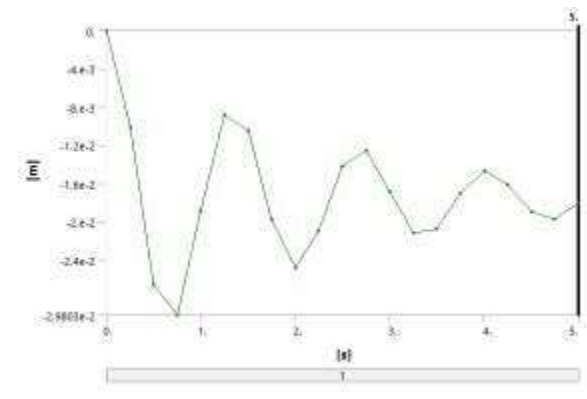
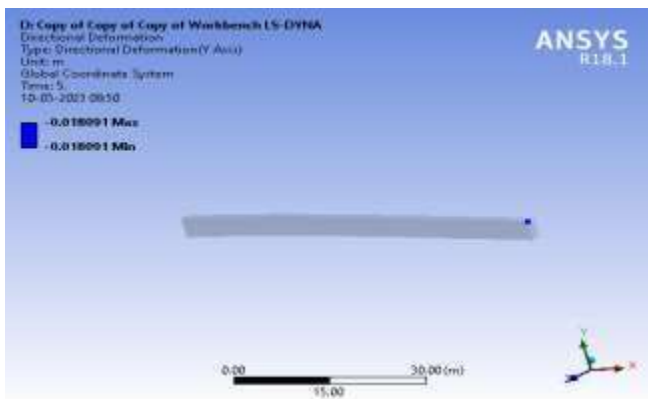


Fig.17 : rectangular cross section; mild steel; UDL; fully integrated

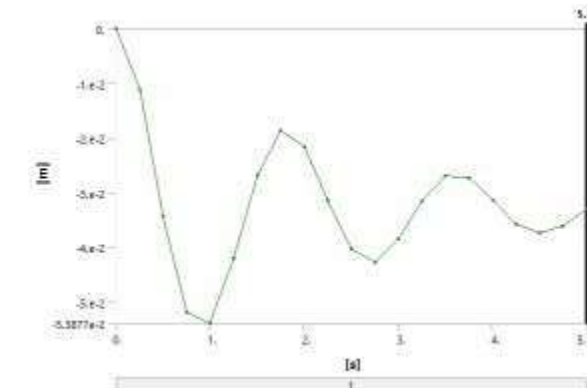
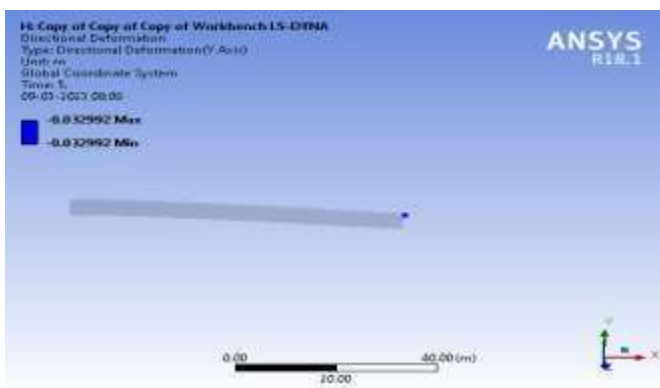


Fig.18: rectangular cross section; grey cast iron; UDL; reduced integrated

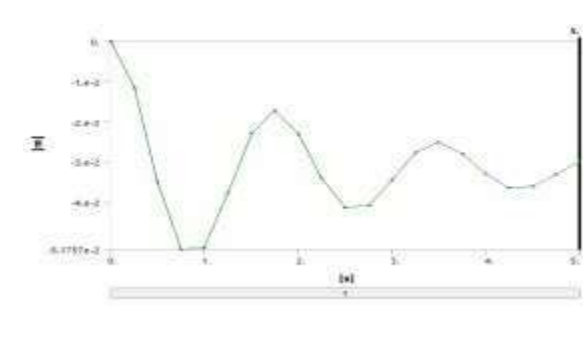
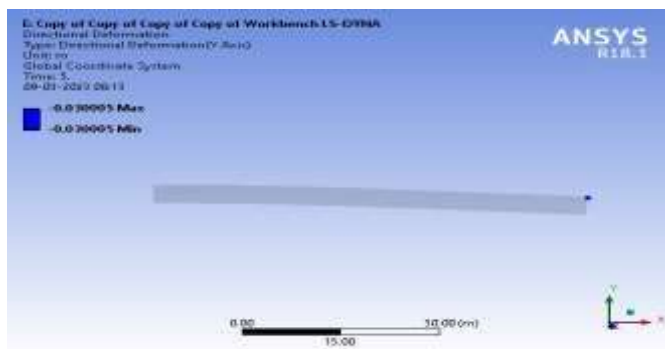


Fig.19: rectangular cross section; grey cast iron; UDL; fully integrated

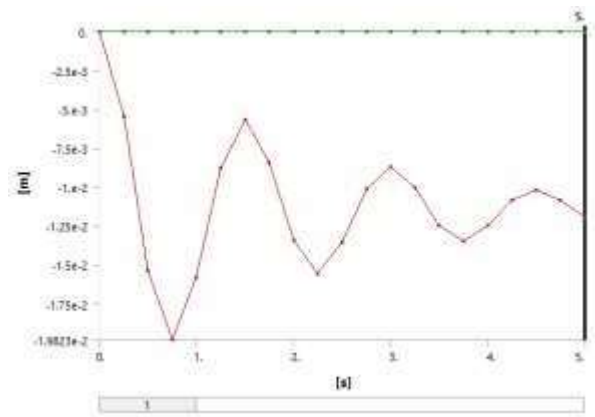
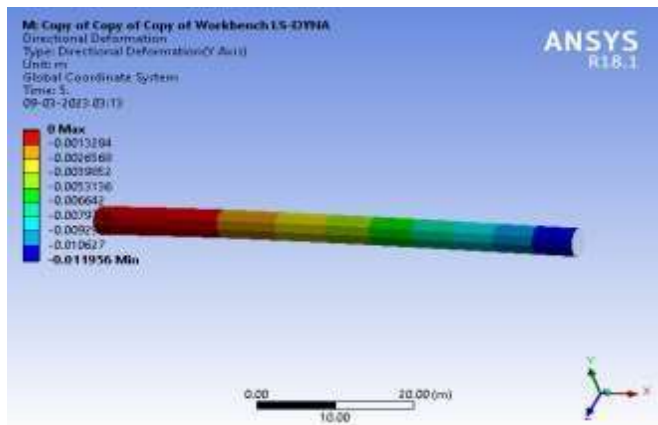


Fig.20: circular cross section; mild steel; UDL; reduced integrated

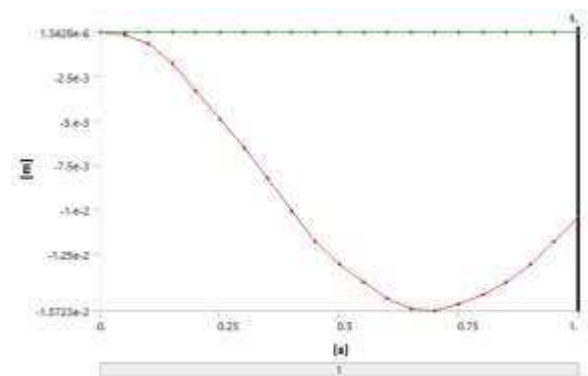
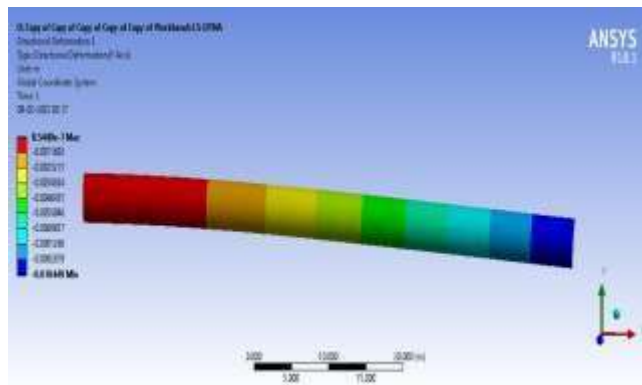


Fig.21: circular cross section; mild steel; UDL; fully integrated

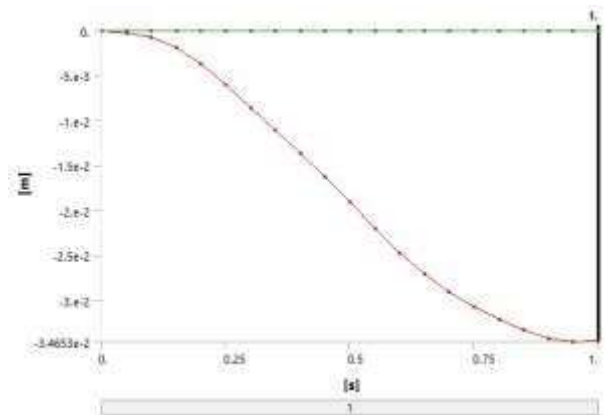
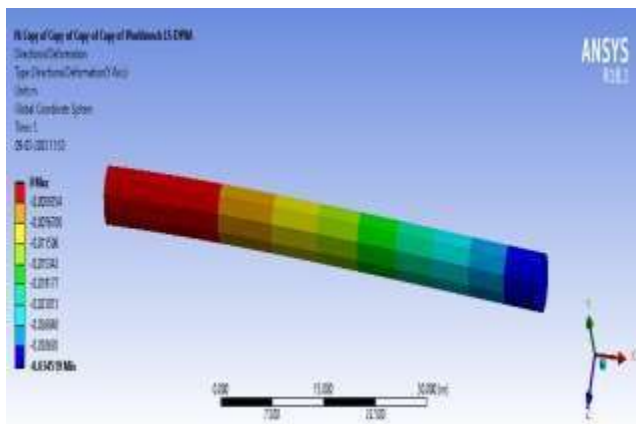


Fig.22: circular cross section; grey cast iron; UDL; reduced integrated

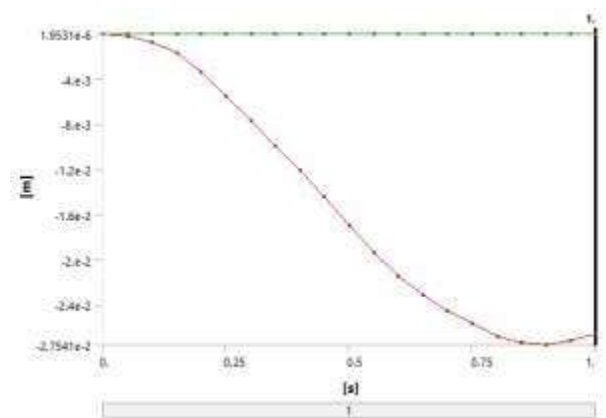
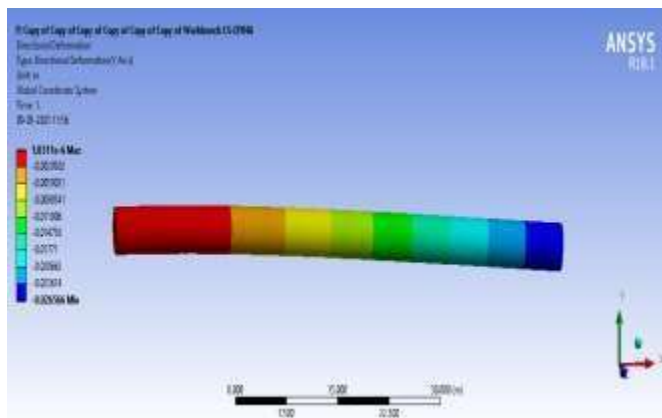


Fig. 23 : circular cross section; grey cast iron; UDL; fully integrated

The simulation results of the beam with various parameters are shown in above figures.

RESULTS

The results of this project are presented in the form of graphs, which show the relationship between different parameters and the deformation of the cantilever beam. These graphs provide valuable insights into the behavior of the beam under different conditions and can be used to optimize the design of cantilever beams for specific applications.

The simulation results between different materials and element formulations are represented in below graphs.

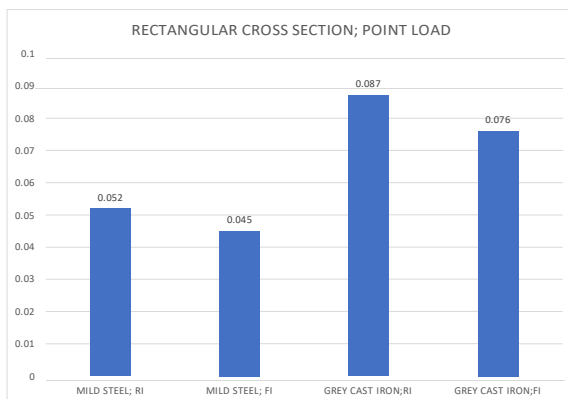
graph 1 represents comparison between

mild steel and cast iron with reduced integration and fully integration of rectangular beam with point load acting

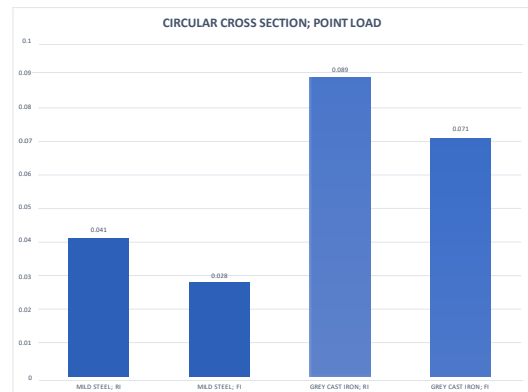
graph 2 represents comparison between mild steel and cast iron with reduced integration and fully integration of circular beam with point load acting

graph 3 represents comparison between mild steel and cast iron with reduced integration and fully integration of rectangular beam with UDL acting

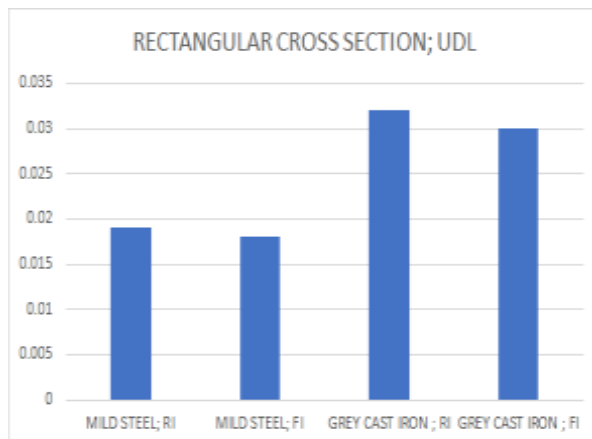
graph 4 represents comparison between mild steel and cast iron with reduced integration and fully integration of circular beam with UDL acting



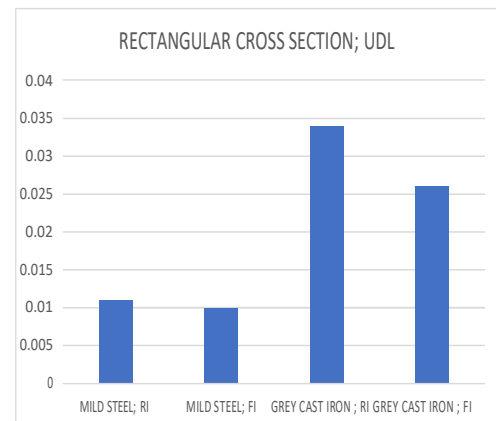
graph 1



graph 2



Graph 3



graph4

Conclusion

The analysis of cantilever beams is an important area of research for engineers and researchers working in the field of structural mechanics. This project aimed to investigate the behavior of cantilever beams with different parameters such as load, shape, material, and element

formulations using Workbench Dyna software. The focus was on deformation only, and mild steel and grey cast iron materials were compared using reduced and fully integrated element formulations. The results of the analysis indicated that mild steel and fully integrated element

accurate results among the different combinations tested. This implies that mild steel and fully integrated element formulations can be a suitable combination for cantilever beam applications. The study has highlighted the significance of considering various parameters when designing and analyzing cantilever beams. Advanced software tools like Workbench Dyna can assist engineers in simulating the behavior of these structures and provide valuable insights into their design and performance. In summary, this project has provided a better understanding of the behavior of cantilever beams and emphasized the importance of choosing the right combination of material and element formulations for optimal performance. This can be useful for engineers working in the design and analysis of cantilever beams for various applications.

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