ES221-Mechanics of Solids

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Stress Analysis of an Euler-Bernoulli Beam

Problem Statement :

We're creating a program to analyze stress in beams. Users will input details like beam type, load positions, and magnitudes, and the program will generate diagrams showing shear and bending forces (SFD and BMD), the beam's deflection, and stress distribution using the Mohr Circle method for any point on the beam.

Objective :

- Create an easy-to-use interface where the user can input information about the beam type and details of the loads, such as the magnitude and positions of loads acting on it, and the user can get all the required particulars.
- Generate clear and accurate plots showing the Shear Force Diagram (SFD) and Bending Moment Diagram (BMD) based on the calculated stresses using the Mohr Circle method.
- Develop algorithms for the Mohr Circle method to calculate reaction forces, shearing forces, bending moments, principal stresses, and shear stresses along the beam.
- Create a visual representation of the beam's deflection under the specified loads and parameters the user enters.

Methodology :

Firstly, we discussed what problems we were going to calculate to solve our problem statement. Thus, we decided to plot the bending moment, shear force, deflection of the beam and Mohr circle diagrams. We started with writing the code for our project that inputs the various parameters and outputs shear forces, bending moments and deflections of the beam giving a better insight to people to understand the mechanics of the beam under loads.

Numerical implementation/Experimental details :

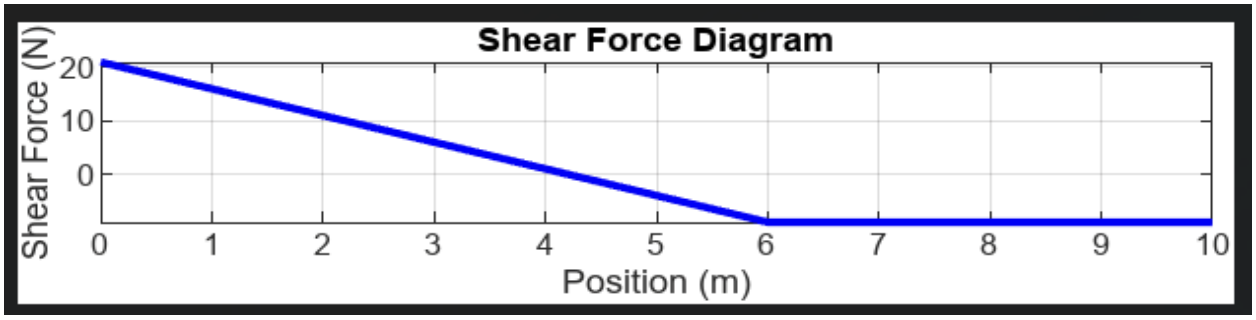
- Firstly, we are taking the load's length, magnitude and location on the beam.
- We plot the shear force and bending moment diagram from the input taken.
- Then, we plot the deflection using the formula we get from Euler-Bernoulli's theorem.
- Then we have also plotted the Mohr's circle by taking normal and shear stresses as input from the user. Link for the codes.

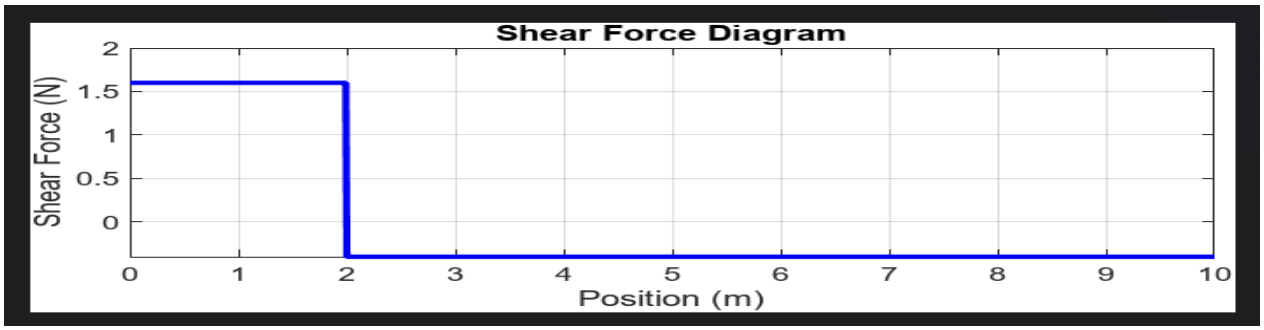
Mohr's circle :

We created the code to generate Mohr's circle for given inputs of normal and shear stresses. The code works so that users give input of the normal stresses (sigma_x and sigma_y) and the shear stress (tau_xy). By taking them as input, It calculates the radius (R) and center (C) of the Mohr Circle. Then, it computes the principal normal stresses (sigma1 and sigma2) and principal shear stresses (tau12 and tau21). It initializes a plot and draws the x and y normal stresses, shear stresses on xy and yx planes, and the line representing the given shear stress (tau_xy) across the Mohr Circle. It also marks the circle's centre (C) and plots the Mohr Circle using polar coordinates.

This gives a visual representation of stress in beams under different loading conditions.

Results and discussion:



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Enter the value of normal stress on x face (MPa) : 50
Enter the value of normal stress on y face (MPa) : -10
Enter the value of shear stress on xy plane (MPa) : 40
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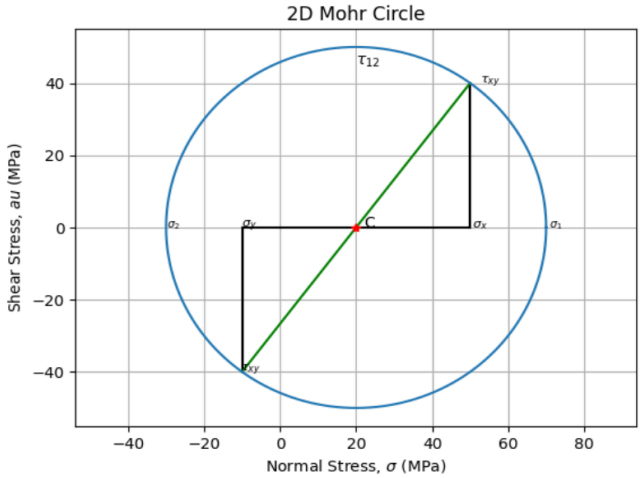

The developed structural analysis program for beams successfully integrates user-friendly input mechanisms, clear visualization tools, and robust error handling. Users can easily input key parameters such as beam type, load configuration, and material properties, facilitating efficient analysis. The program generates Shear Force Diagrams (SFD), Bending Moment Diagrams (BMD), and Mohr's circle diagrams, providing users with comprehensive insights into beam behavior and stress distributions. With accurate deflection calculations and intuitive visualization of results, engineers can make informed decisions regarding beam design and structural integrity. The

program's error-handling mechanisms effectively detect and alert users to invalid inputs, enhancing the reliability of analysis results. Overall, by prioritizing usability and functionality, the software serves as a valuable tool for structural engineers and researchers alike.

What Could We Do Better :

In our projects, we've encountered challenges stemming from conceptual errors and difficulties in formulating coding approaches. As a result, we've imposed limitations such as restricting our code to handle only simply supported beams. Additionally, we've faced obstacles in integrating Mohr's circle with the deflection code, leading us to upload the Mohr's circle code separately. To address these issues, we acknowledge the need for improvement in conceptual clarity and seamless integration of various analytical components within our projects.

Learning outcomes :

The learning outcomes from this project are :

- We understood structural mechanics properly with concepts related to beam types, load effects, reaction forces, shearing forces, bending moments, stress distributions, and beam deflection.
- Through implementing Mohr's circle, we learned how to apply this technique to calculate reaction forces, shearing forces, bending moments, and stress distributions along the beam accurately.
- By generating clear SFDs and BMD plots, we gained clear visualization and interpretation skills of the internal forces and moments within the beam.
- The visual representation of beam deflections made us understand how a beam will deflect under applied loads, giving us insights into structural integrity.
- By creating a program, we developed practical structural analysis skills, making it easier to calculate and analyze stress and beam deflections.

Overall, this project offered a comprehensive learning experience that gave us the knowledge, skills, and confidence to tackle complex structural analysis tasks.