Stresses in Beams

Mini Project 1

ME321: Mechanics of Deformable Bodies

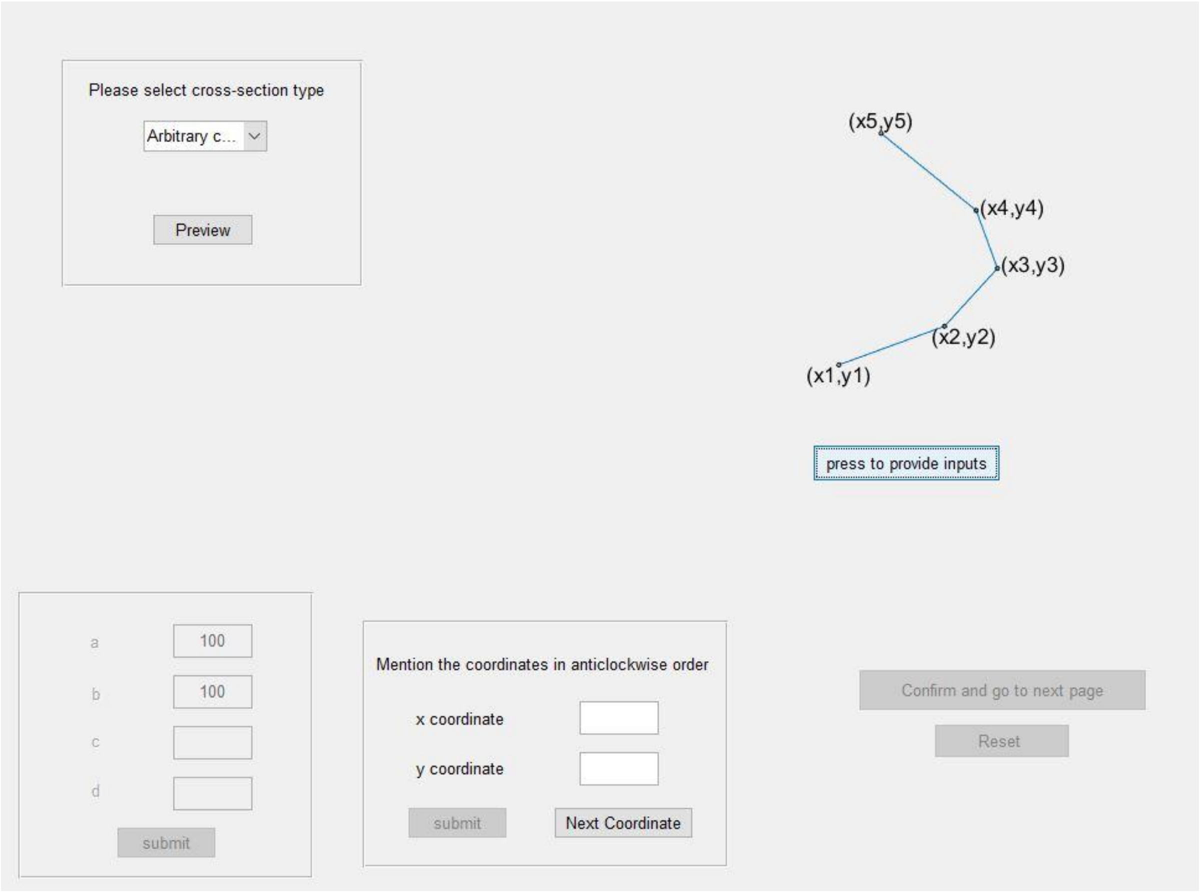
Coding

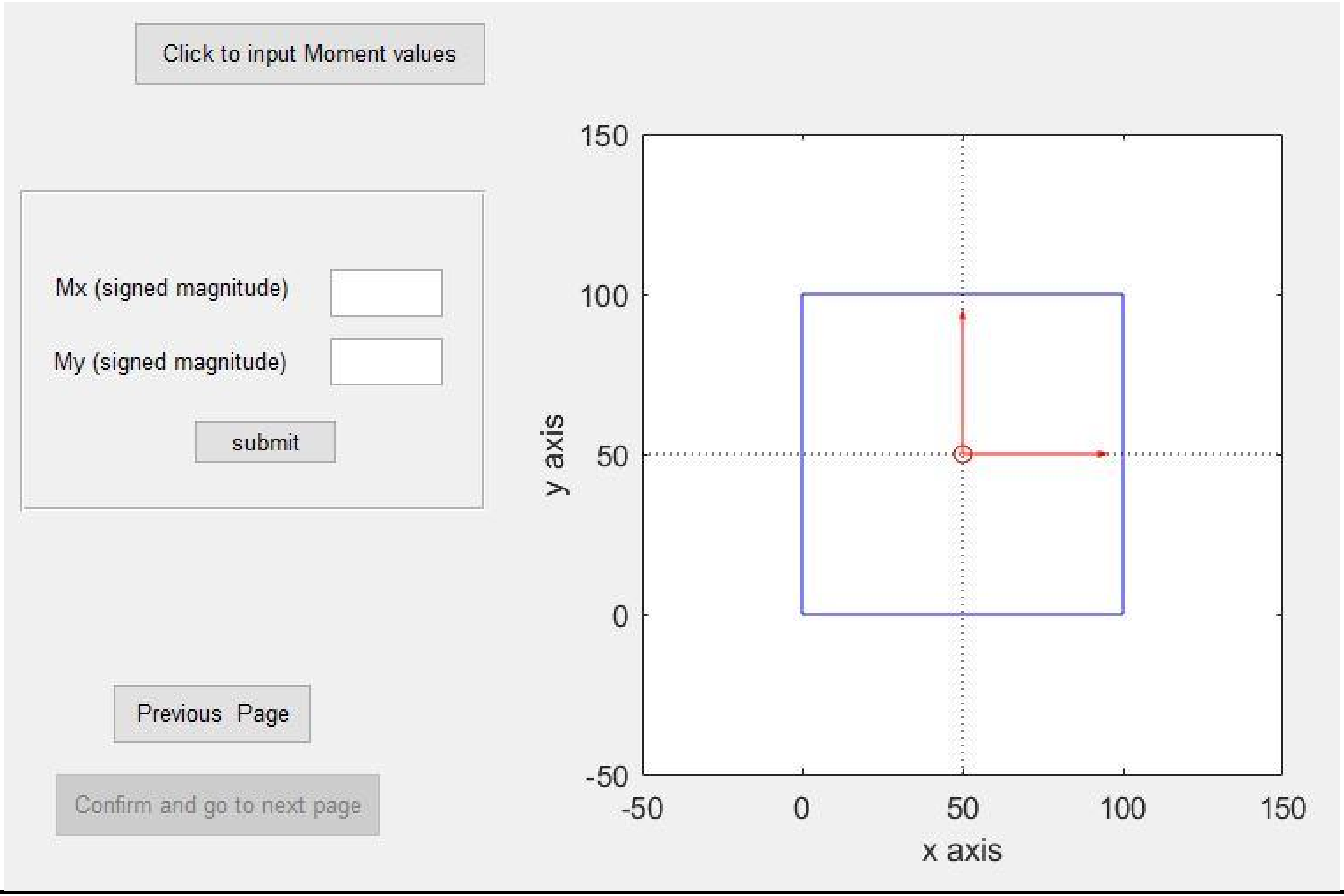
- Objective: The primary goal of the project was to determine the stress distribution on an arbitrary cross section.
- Key features of the implementation:
  - The code can calculate Second Moments of Inertia about the specified axis of cross section. It can also determine the Centroidal Moments of Inertia as well as the Principal Moments of Inertia.
  - The code requires Moment Vector(assumed to be acting on the Shear Center of the cross section) acting on the cross section in an arbitrary direction and coordinates of the cross section. It does not require information about the angle between the x-z centroidal plane of the cross section and the plane of load as we are projecting the Moment Vector along the principal axis and then using the Non Symmetrical Bending Formula mentioned in the reference text pertaining to the course to determine the Stress Induced at a particular point of the cross section.

- Drawbacks and Bottlenecks
    - The code is applicable only when the plane of load passes through the Shear Center of the cross section. Moreover it is applicable only in the Pure Bending scenario.
    - The code is applicable for any arbitrary polygonal cross section however it is not applicable for any non-polygonal cross section.
    - The code requires the Moment Vector acting on the arbitrary cross section to determine the stresses acting on the cross section.
    - In order to make the code work for arbitrary polygonal cross section we compromised with the easy inputs like web length, flange width for I section and went for coordinates of the cross section as an input.
    - Neutral Axis is not computed in the code as it is left to the user to visualize the Neutral Axis from the Visualization of the Stress Distribution on the cross section.

Visualization

- Objective: Base code generated stress values at specified points of the cross-section. Primary goal was to visualize the output obtained from base code. In addition, try to come up with a user friendly interface.
- Key features of the implementation(What can be done using the code?)
  - Base code is capable of calculating Stress values at a specified point(provided as input)
  - The Visualization code asks user to feed in the cross-section type (rectangular, triangular,I shaped,L shaped or any arbitrary polygonal cross-section), along with the Moment vector, in form of components along x and y directions.
  - Inputs for cross-section type are stored in form of vertices of selected polygon.
  - It then scans for all the points lying in the interior of convex polygon.
  - Upon identification of interior points, it uses the base code to generate stress matrix (containing stress values at discretized interior points).
  - Visualizes Stress values through appropriate graphs.


Please select cross-section type
Arbitrary c...
Preview
(x5,y5)
(x4,y4)
(x3,y3)
(x2,y2)
(x1,y1)
press to provide inputs
a
100
b
100
c
d
submit
Mention the coordinates in anticlockwise order
x coordinate
y coordinate
submit
Next Coordinate
Confirm and go to next page
Reset


Click to input Moment values
Mx (signed magnitude)
My (signed magnitude)
submit
Previous Page
Confirm and go to next page
150
100
50
0
-50
y axis
-50
0
50
100
150
x axis

Click to input Moment values

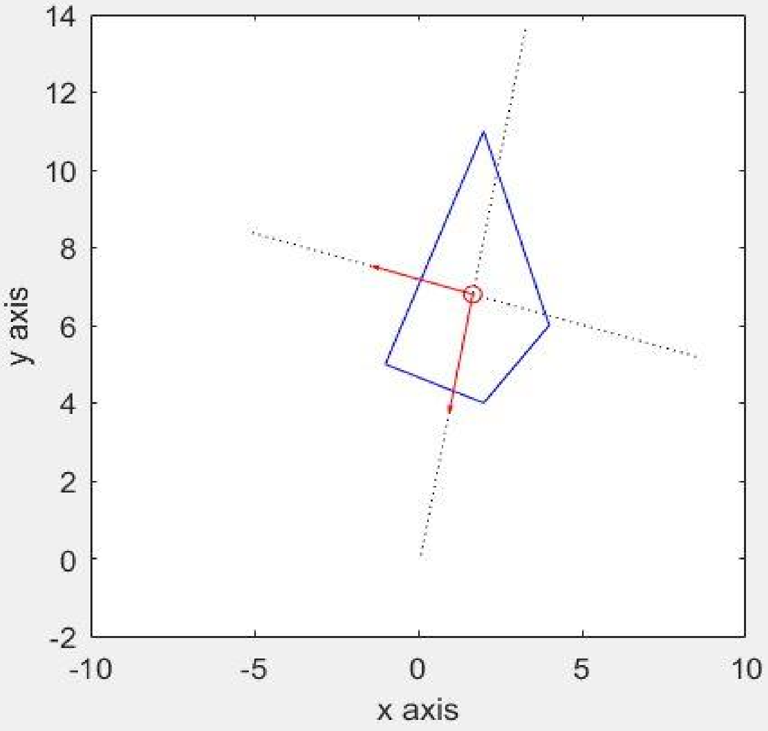
Mx (signed magnitude)

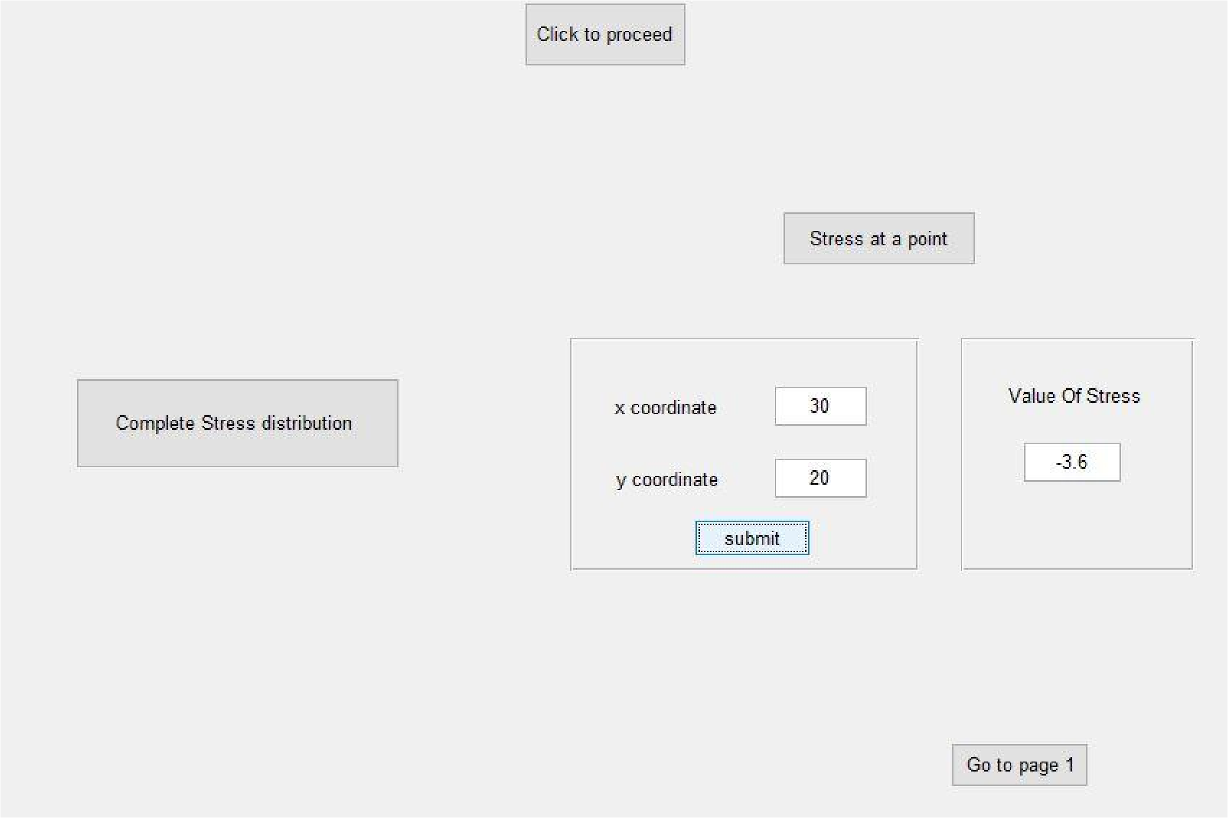
My (signed magnitude)

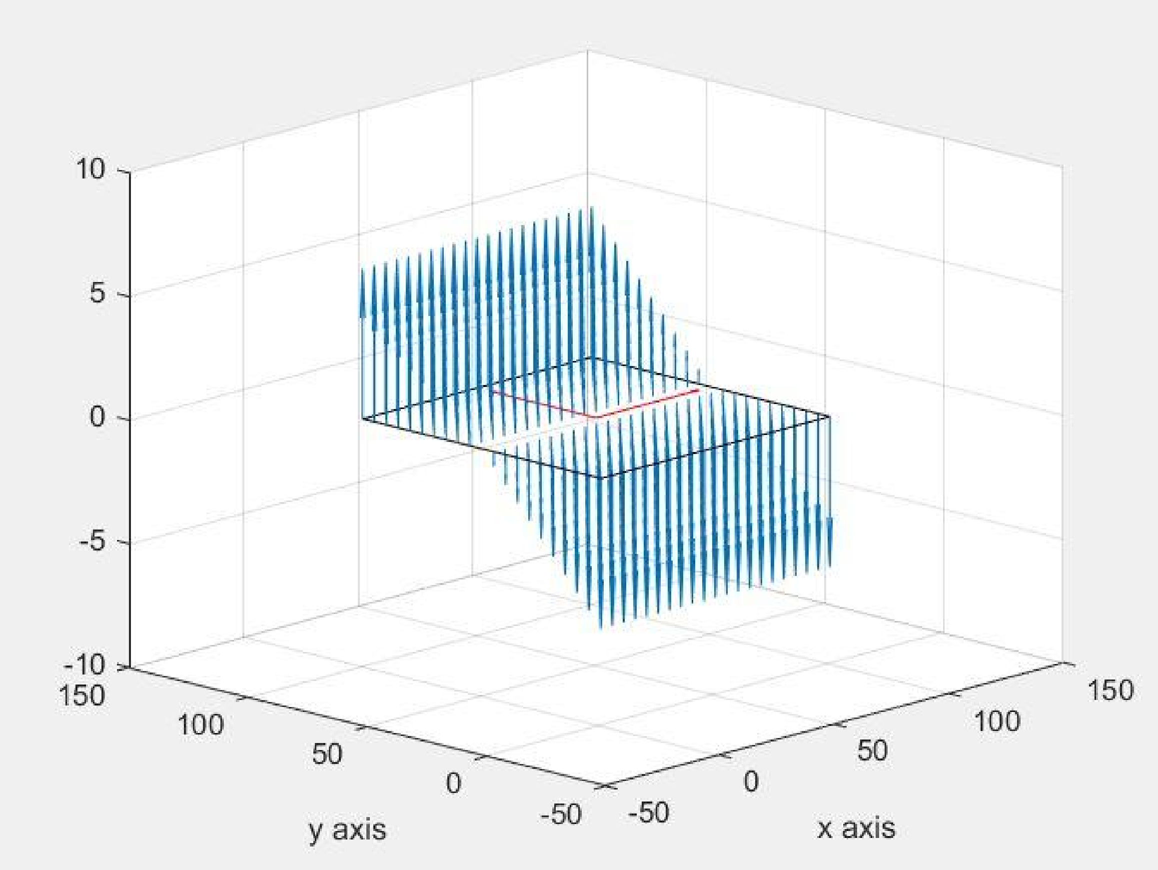
submit

Previous Page

Confirm and go to next page




Click to proceed
Stress at a point
Complete Stress distribution
x coordinate
30
y coordinate
20
submit
Value Of Stress
-3.6
Go to page 1


10
5
0
-5
-10
150
100
50
0
-50
y axis
-50
0
50
100
150
x axis

- Functionality & Scope (What can be visualized using the code?)
  - Complete stress distribution across a polygonal cross-section of beam for symmetrical and unsymmetrical bending. Cross-section type can be any convex polygon including conventional shapes – I, L etc.
  - Exact Value of stress at a specified point for above.

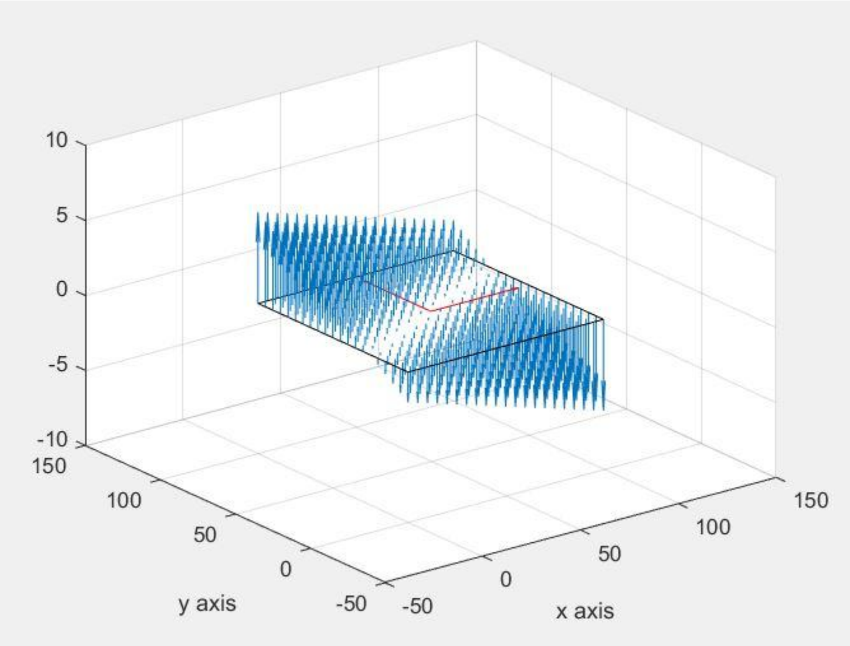
- Drawbacks & Bottlenecks (What cannot be accomplished with the visualization module within the stated objective?)
  - Code is not applicable for curved shapes – elliptic etc.
  - GUI is multi-paged. May intrude comparison between cases .
  - The 3D plot used within the code effectively visualizes stress distributions within a limited range of dimensions. This happens due to finite discretization performed for plotting stress distribution. For dimensions with higher magnitudes, points get overcrowded making it harder to visualize stress vectors

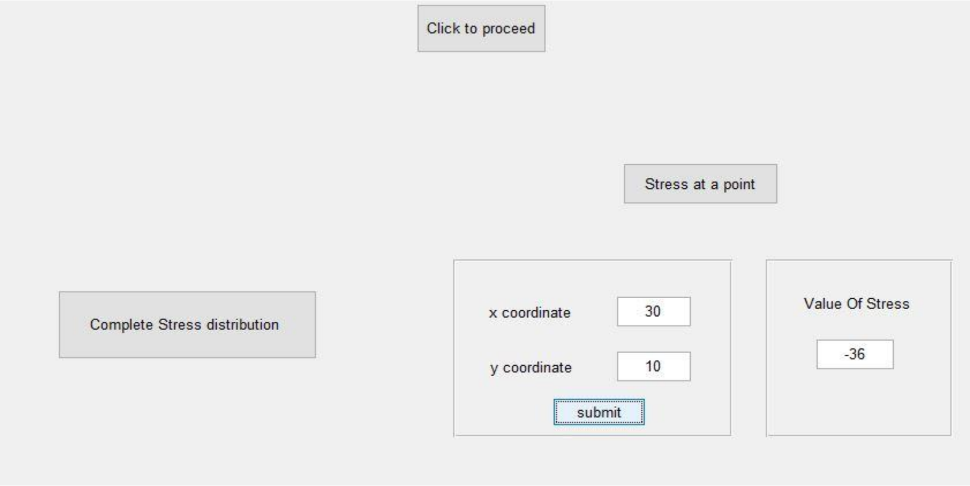
- Self-rating on a score of 5 : 4.2

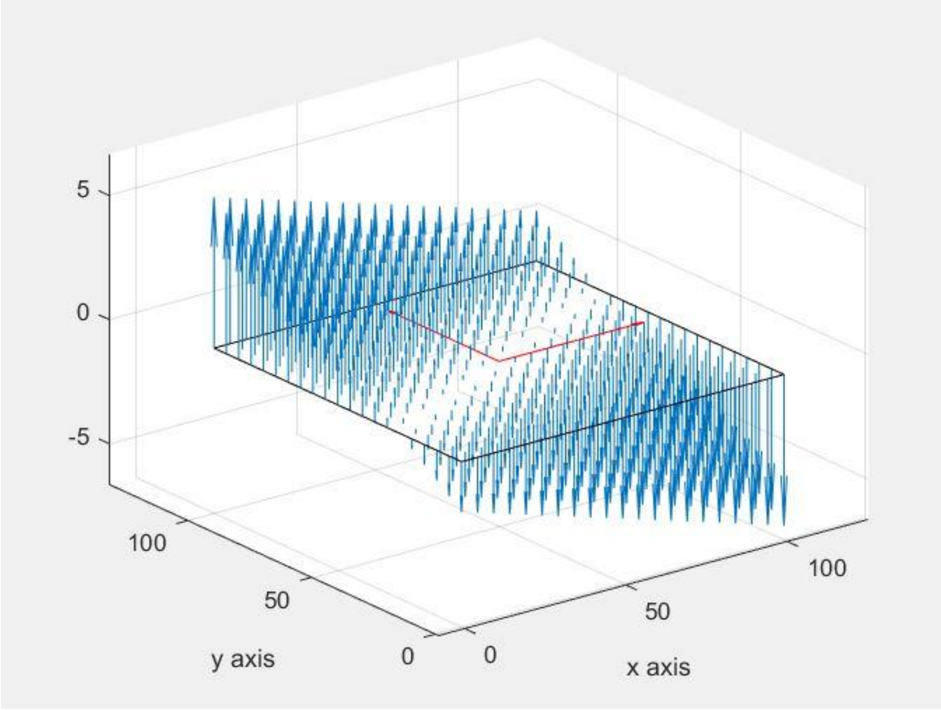
Validation

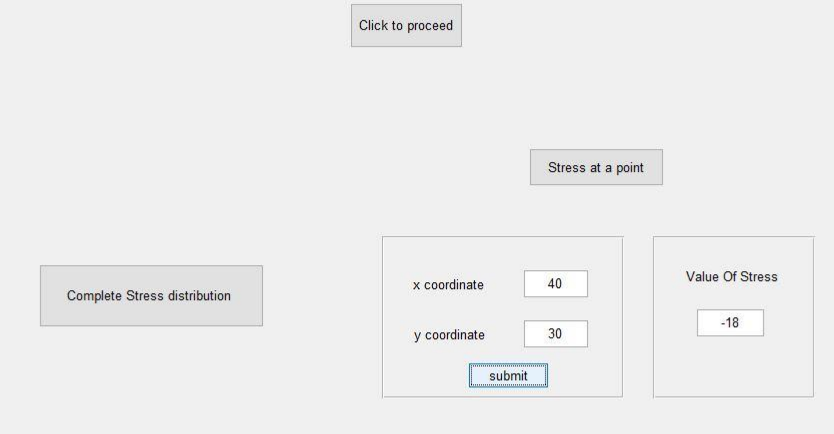
- Objective: The objective of this part is to test as many varied cases as possible to make the software robust and rectify the errors that may exist.

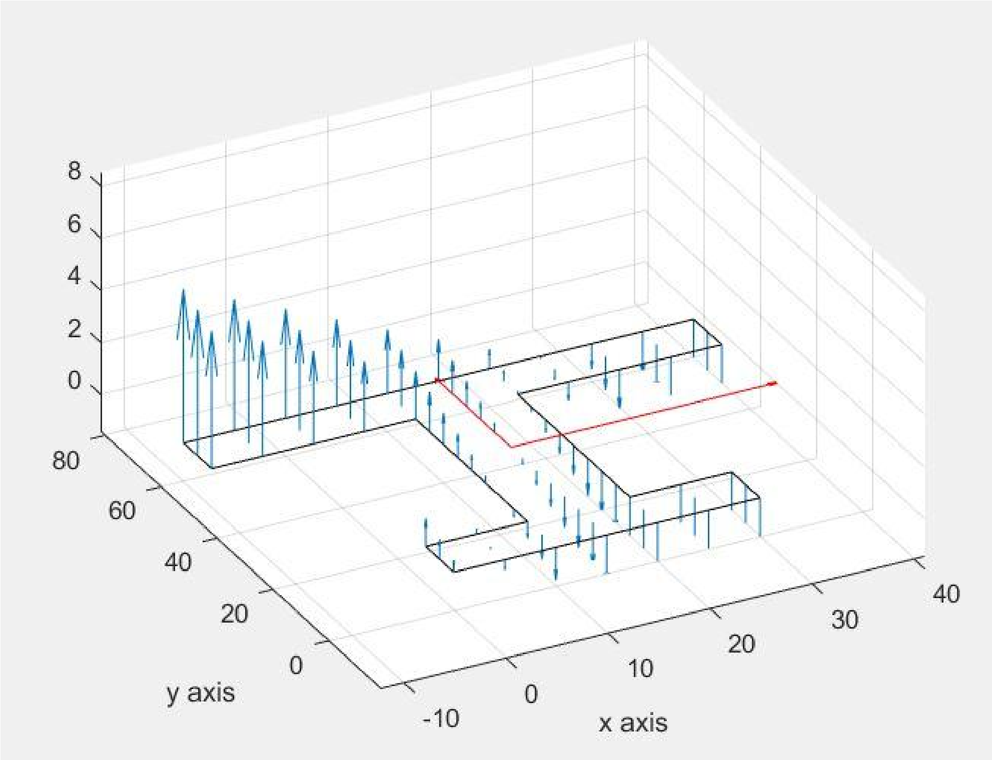
- Test cases chosen and why only these specific test cases? All the basic geometries have been taken into consideration and the stresses for various point on these geometries have been tested. Calculations for symmetric and unsymmetric sections have been done.


10
5
0
-5
-10
150
100
50
0
-50
y axis
-50
0
50
100
150
x axis

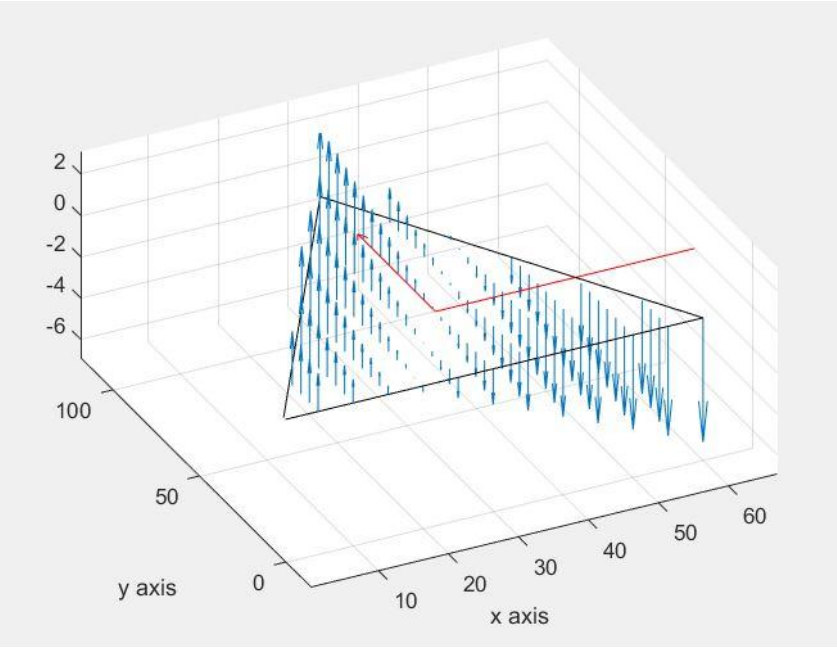

Click to proceed
Stress at a point
Complete Stress distribution
x coordinate
30
y coordinate
10
submit
Value Of Stress
-36

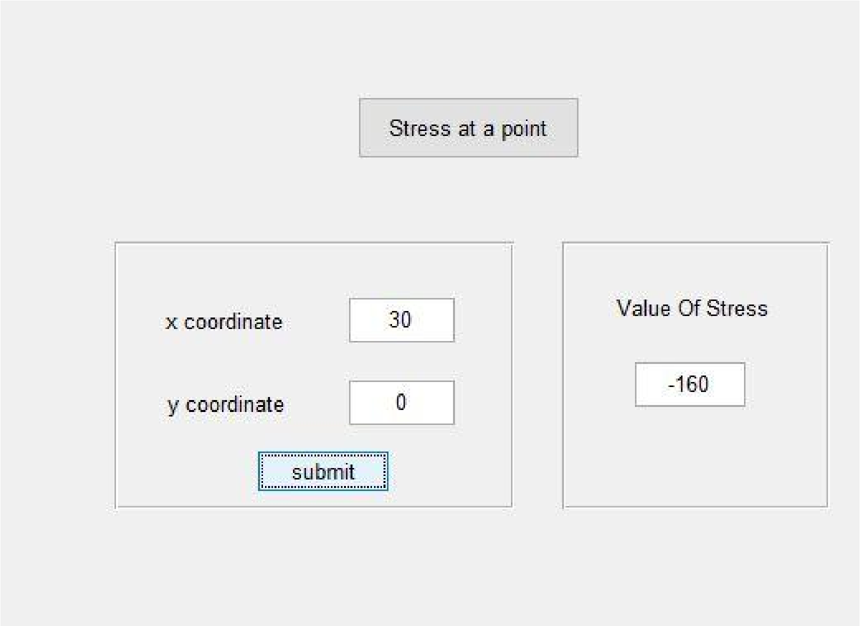

5
0
-5
100
50
0
y axis
0
50
100
x axis


Click to proceed
Stress at a point
Complete Stress distribution
x coordinate
40
y coordinate
30
submit
Value Of Stress
-18


8
6
4
2
0
80
60
40
20
0
y axis
-10
0
10
20
30
40
x axis


Click to proceed
Stress at a point
Complete Stress distribution
x coordinate
20
y coordinate
0
submit
Value Of Stress
-267.0313


2
0
-2
-4
-6
100
50
0
y axis
10
20
30
40
50
60
x axis


Stress at a point
x coordinate
30
y coordinate
0
submit
Value Of Stress
-160

- Analytical Solutions and test methodology followed along with Documentation

  The validation part has been well documented providing
  - The geometry and moment inputs
  - Diagram of the cross section
  - Table comparing obtained and calculated values for various point

- What are the cases the code has not been tested for and documented?
  - L section
  - Circle and semicircle
  - Arbitory
  - Shear stress

- Self-rating on a score of 5 : 3.8

Documentation

- Objective: The aim of this part of the project was to come up with an elaborate but easy to comprehend documents that details all the subtleties of the project and the topic.
- Flow of Document:
    - Introduction
    - Why this Project
    - Theory
    - Working of the Software
    - User Manual
    - Validation and test cases
    - References

- Theoretical Review: The theoretical topics covered in this document are:
    - Neutral Axis
    - Moment of Inertias
    - Pure Bending
    - Derivation of Flexural formula for various cases
    - Application of Flexural formula
- User Manual and Validation Documentation
  A step by step guide to the software has been presented in the documentation. The user manual also includes pictorial representation of each step.
  The validation part has been well documented providing
    - The geometry and moment inputs
    - Diagram of the cross section
    - Table comparing obtained and calculated values for various points
- Self-rating on a score of 5 : 4

Thank You!

Team:

Meet Gandhi	15110049
Darshan Patel	15110083
Rajat Ranjan	15110098
Saksham Singal	15110112