FEA Lab Project Report

Title: Static and Transient Structural Analysis of a Simple Polygon Structure

Course: Finite Element Analysis Lab

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Roll Number: ME-1878

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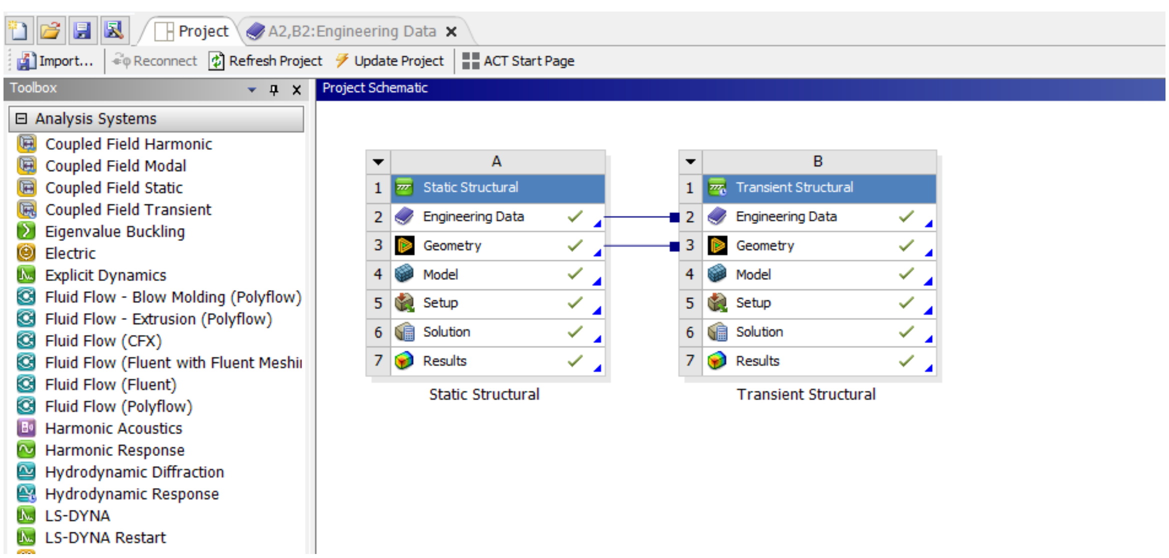
1. Introduction

The objective of this project is to perform Static Structural and Transient Structural (Explicit) simulations on a simple polygonal structure using ANSYS Workbench. All material properties, loading parameters, and boundary conditions were derived from the student's roll number (ME-1878) and date of birth (24 October 2003), as required by the lab instructions.

This report presents the complete workflow including:

- selection and creation of geometry,
- material definition based on assigned properties,
- application of loads and constraints,
- meshing strategy and mesh convergence study,
- static structural analysis and results,
- transient explicit analysis with force-time history mapping,
- deformation and stress responses over time.

The results provide insight into the structural behavior of the selected polygon under both static and time-dependent loading.



2. Problem Definition

2.1 Geometry Selection

Based on the roll number 1878 (even), the assigned shape for analysis was a Pentagon.

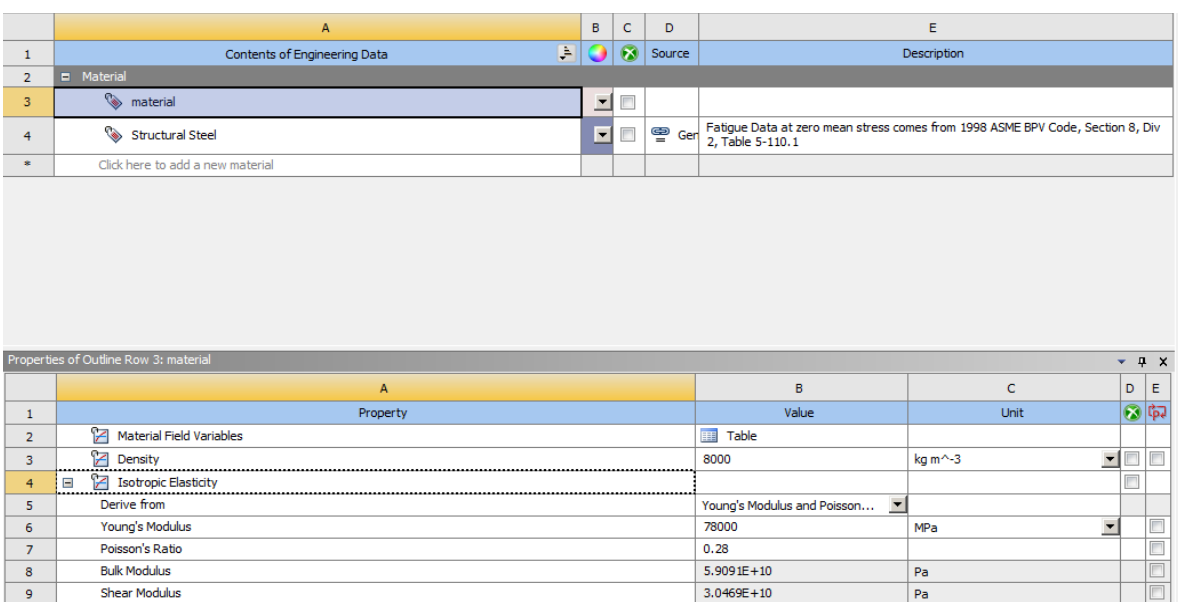
- Selected Shape: Regular Pentagon
- The pentagon was chosen for its geometric symmetry and suitability for investigating load transfer on multi-faced structures.

2.2 Material Properties

Material properties were assigned using the specified formulas:

- Elastic Modulus (E) =78 (last digits of roll no.) ×1,000 MPa=78,000 MPa
- Poisson’s Ratio (v) =0.28

These properties represent a moderately stiff, linearly elastic material suitable for both static and explicit analyses.



	A	B	C	D	E
1	Contents of Engineering Data			Source	Description
2	Material				
3	material				
4	Structural Steel			Ger	Fatigue Data at zero mean stress comes from 1998 ASME BPV Code, Section 8, Div 2, Table 5-110.1
*	Click here to add a new material				

Properties of Outline Row 3: material

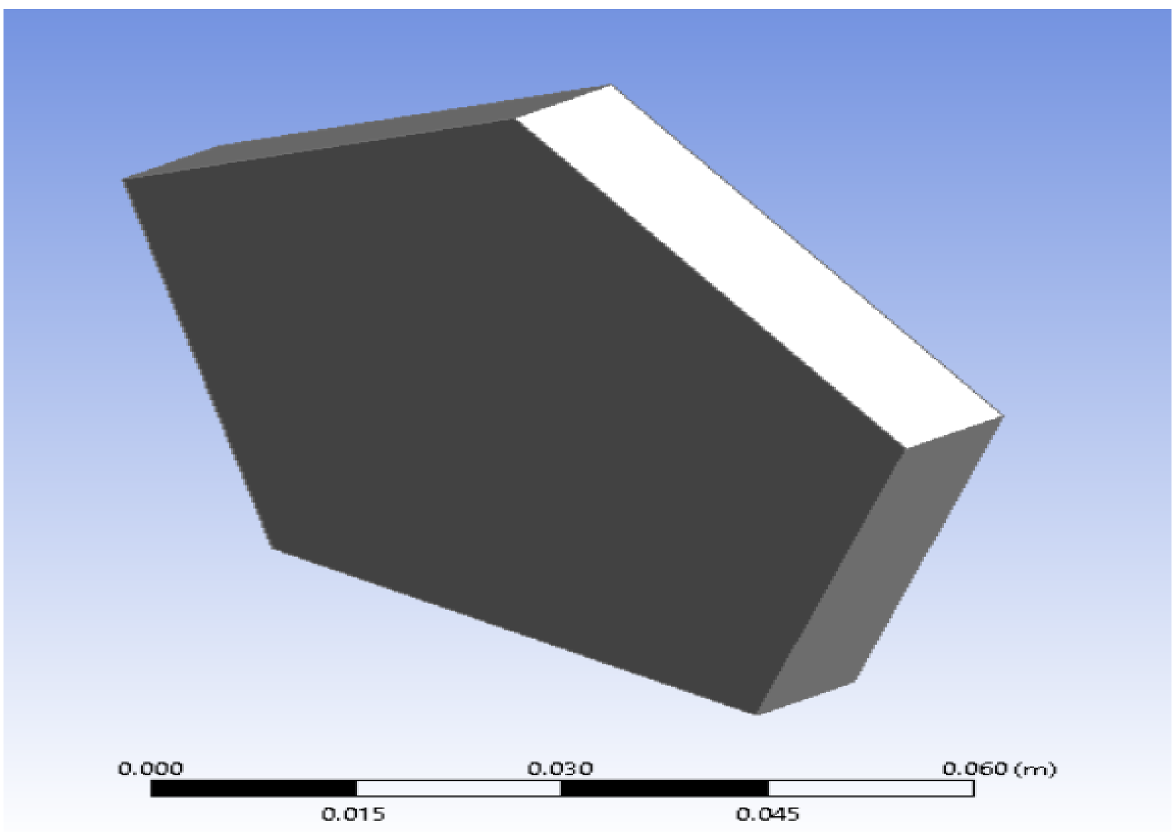
	A	B	C	D	E
1	Property	Value	Unit		
2	Material Field Variables	Table			
3	Density	8000	kg m^-3		
4	Isotropic Elasticity				
5	Derive from	Young's Modulus and Poisson...			
6	Young's Modulus	78000	MPa		
7	Poisson's Ratio	0.28			
8	Bulk Modulus	5.9091E+10	Pa		
9	Shear Modulus	3.0469E+10	Pa		

3. Geometry and Modeling

A regular pentagon was sketched in ANSYS Design Modeler with appropriate edge length and orientation. The model was then extruded to a suitable thickness to form a 3-D solid body.

Key modeling considerations:

- One face was positioned horizontally for easier application of fixed support.
- The vertex distribution ensured symmetric deformation and stress propagation.
- The geometry was checked for topology errors before meshing.

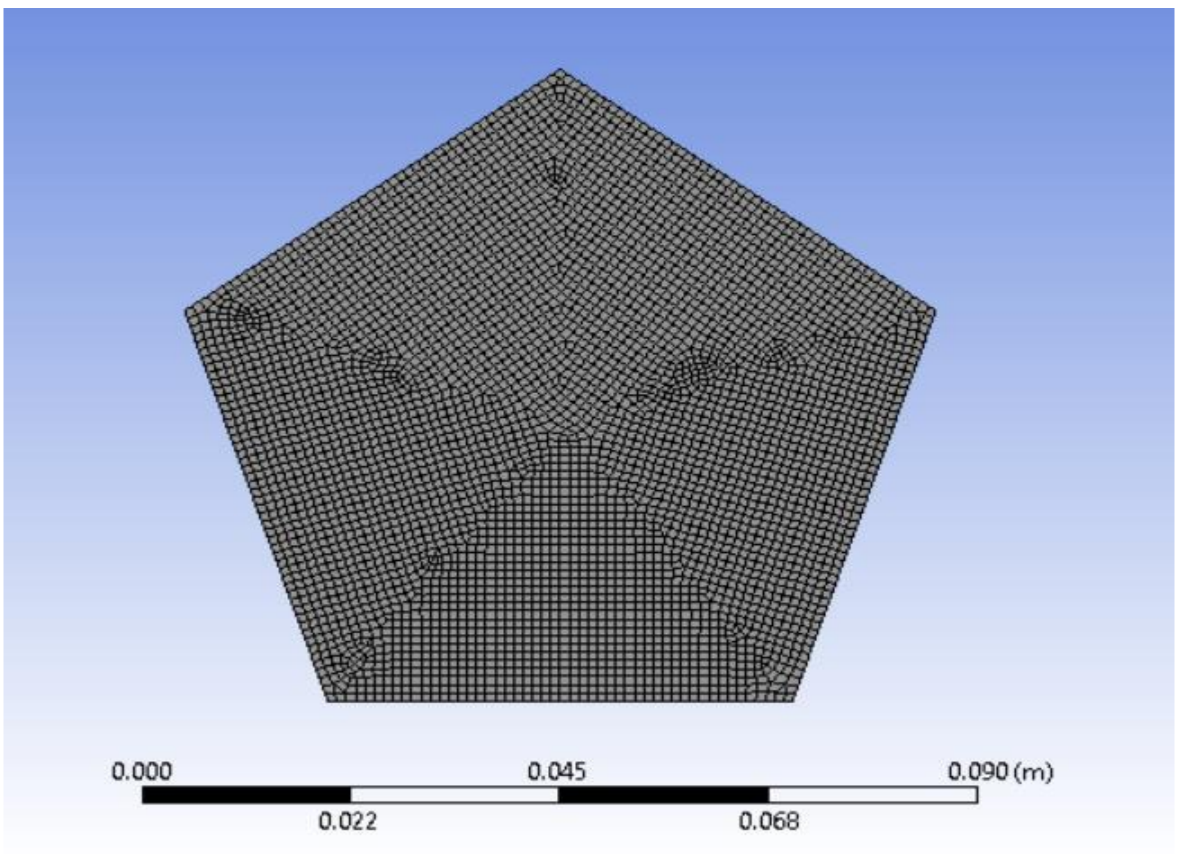


4. Meshing

Meshing is critical for obtaining accurate numerical results.

- **Element Type:** Hexahedral-dominant mesh
- **Element Quality:** Verified to avoid skewness and aspect-ratio issues
- **Mesh Convergence:**
    - Performed only for static analysis
    - Multiple mesh densities (coarse → medium → fine) were used
    - Total deformation and maximum von-Mises stress were compared
    - Once the results stabilized, the mesh was accepted as converged

Note: Transient explicit analysis does not include an automatic mesh convergence tool in ANSYS.



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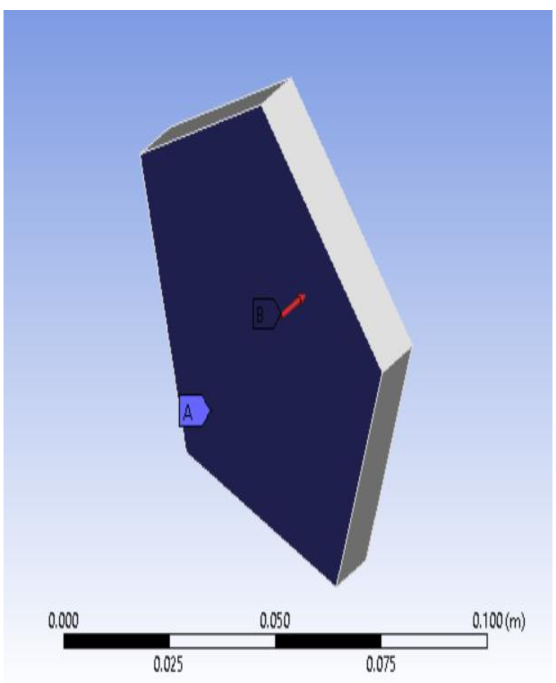
5. Static Structural Simulation

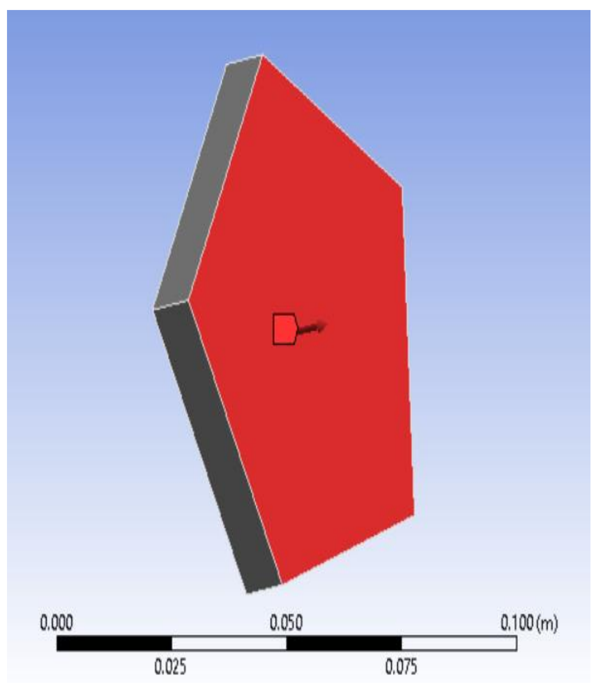
5.1 Boundary Conditions

The following boundary conditions were applied:

- **FixedSupport:**
  One complete face of the pentagon was fully constrained in all degrees of freedom.
- **Remote Force Application:**
  - Force applied at 1/3rd of the length of the fixed face.
  - Magnitude of force calculated from sum of digits of Date of Birth:
    - DOB: 24-11-2003
    - Sum = 24 + 11 + 2003 = 2038 N (static case)

This ensures proper load transfer while maintaining the constraint conditions.

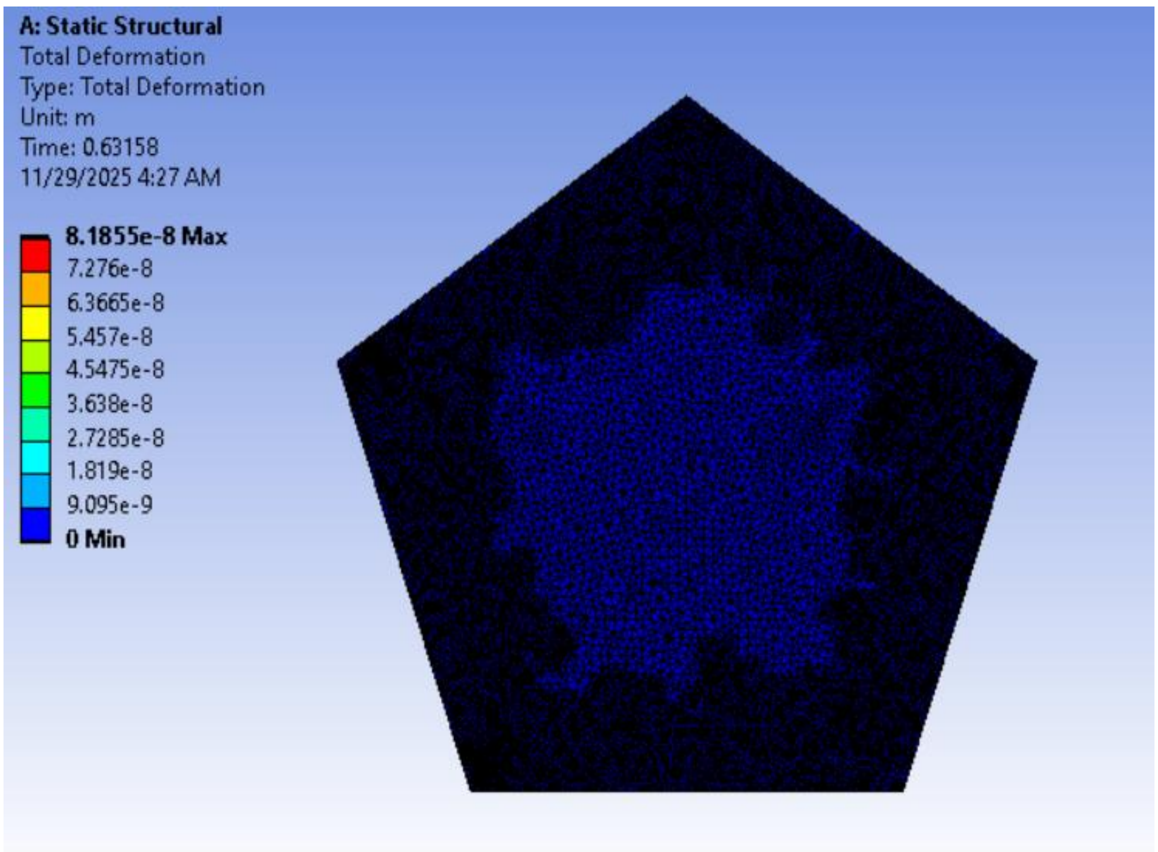




5.2 Results

5.2.1 Total Deformation

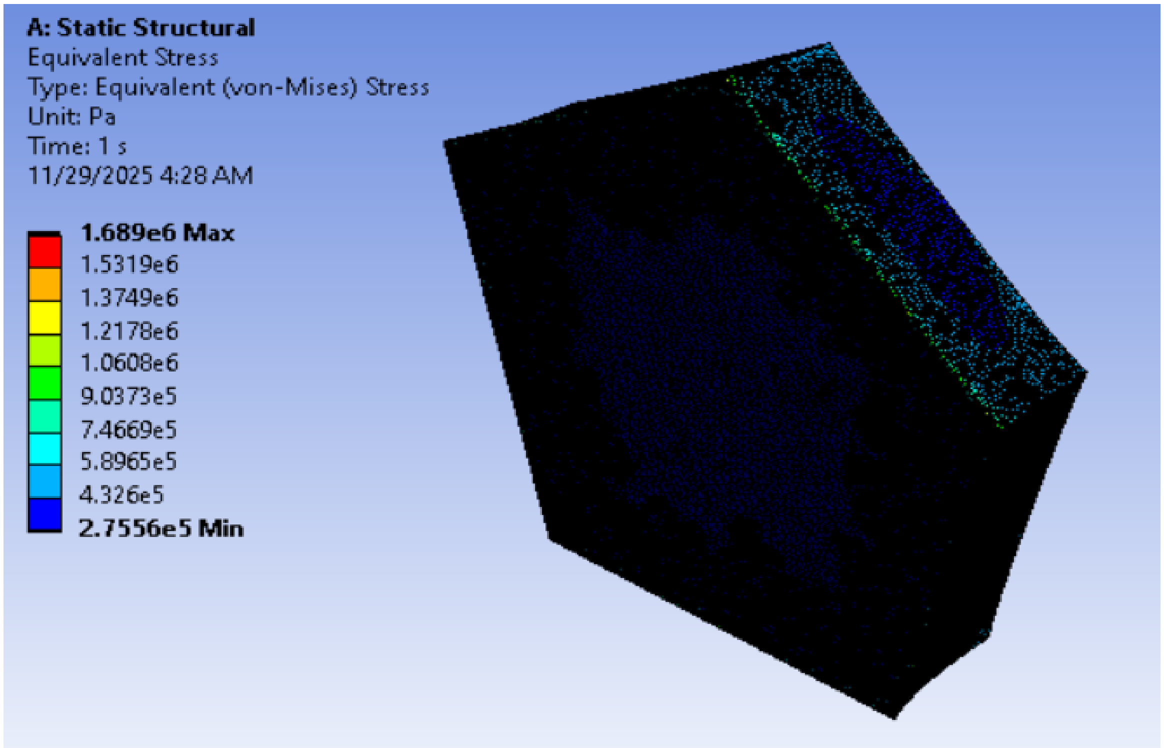
- Maximum deformation occurs at the face opposite the fixed support.
- Deformation distribution was smooth and symmetric due to regular geometry.
- The deformation plot provided a clear visualization of structural flexibility under static load.



5.2.2 Equivalent Stress (von Mises)

- Highest stress concentrated near the fixed face, as expected.
- Stress intensity increased near the load application region.

- von-Mises results confirmed linear elastic behavior without exceeding material limits.

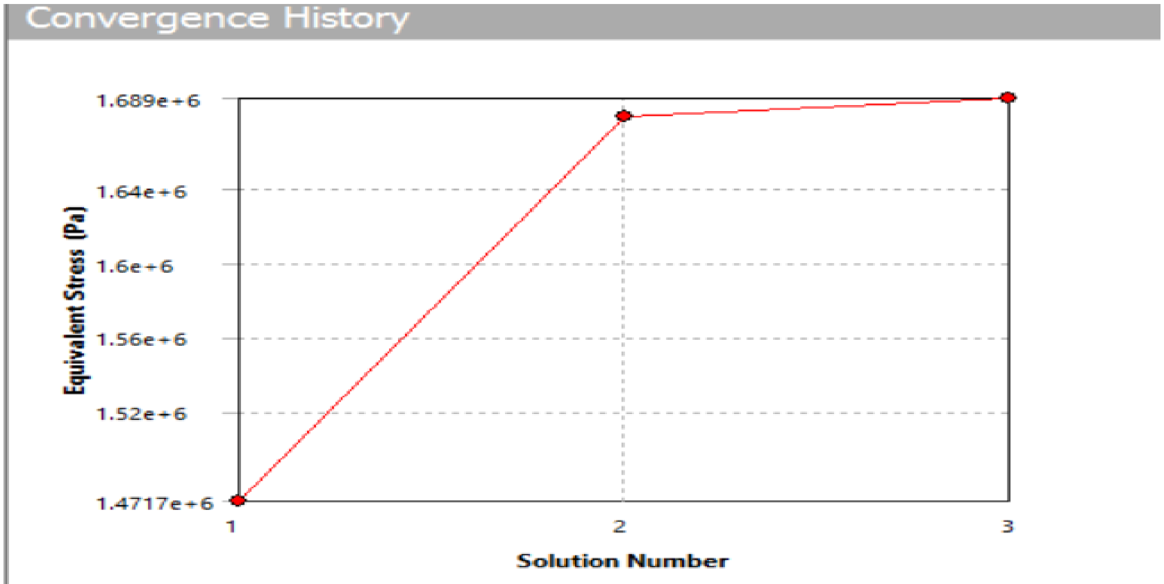


5.2.3 Mesh Convergence (Static)

The mesh convergence study showed:

- Coarse mesh → considerable variation in stress
- Medium mesh → reduced variation
- Fine mesh → stable stress/deformation values

Thus, the fine mesh was used for simulation.



	Equivalent Stress (Pa)	Change (%)	Nodes	Elements
1	1.4717e+006		193158	44030
2	1.6789e+006	13.153	80835	40828
3	1.689e+006	0.59703	415386	253623

6. Transient Structural Simulation

6.1 Loading and Time Setup

For the transient (explicit) structural simulation, the loading configuration was updated according to the applied forces shown in the model.

Boundary Conditions (Transient Analysis)

- Front face fully fixed (complete constraint of translation and rotation).
- Forces applied on the remaining five faces of the pentagon.
- Each face was assigned its own directional force vector according to its orientation, creating a realistic multi-directional loading scenario.

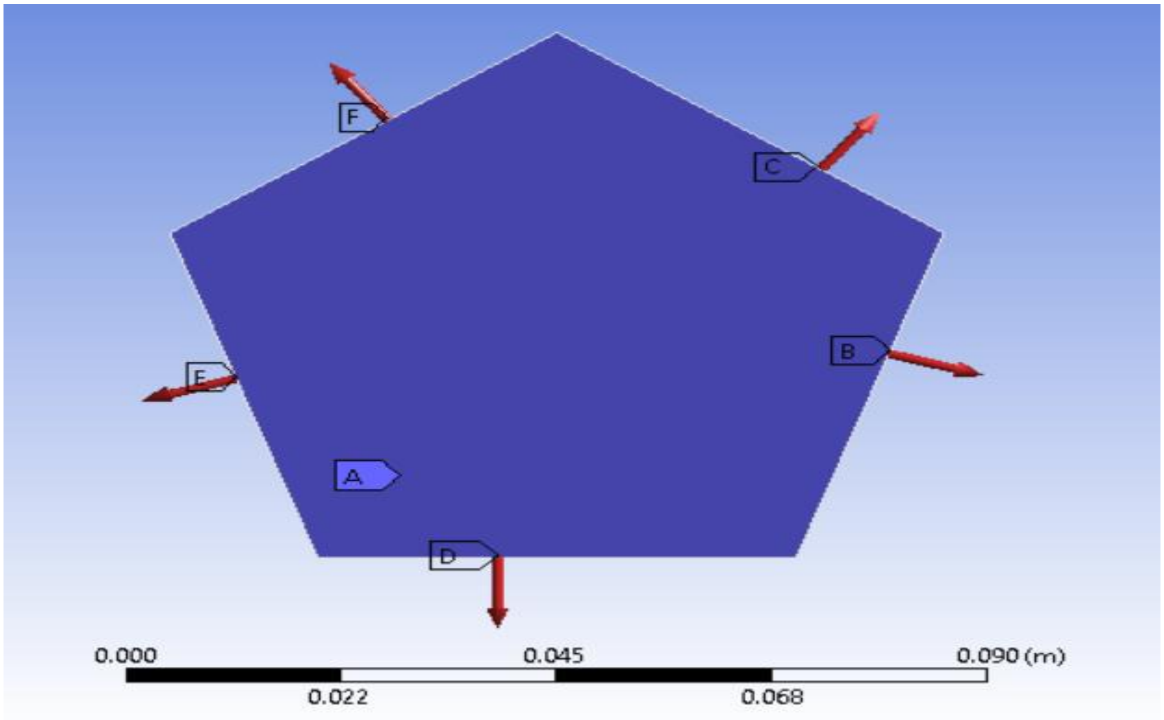
Force Input Details

- Instead of applying a single constant force, each of the five faces received a time-varying force.
- The magnitude of force at each time step was taken from peak USD→PKR (1 USD = 281.5 PKR, applied force=281.5N) exchange-rate values of the selected date.
- These five peak values were mapped across the five load steps (0 to 1 second).

Time Setup

- **Number of steps:** 5
- **Time step size:** 0.2 seconds
- **Total simulation time:** 1.0 second

This loading method allowed the structure to experience *realistic fluctuating and multi-directional forces*, making the simulation closer to a real-world dynamic scenario.



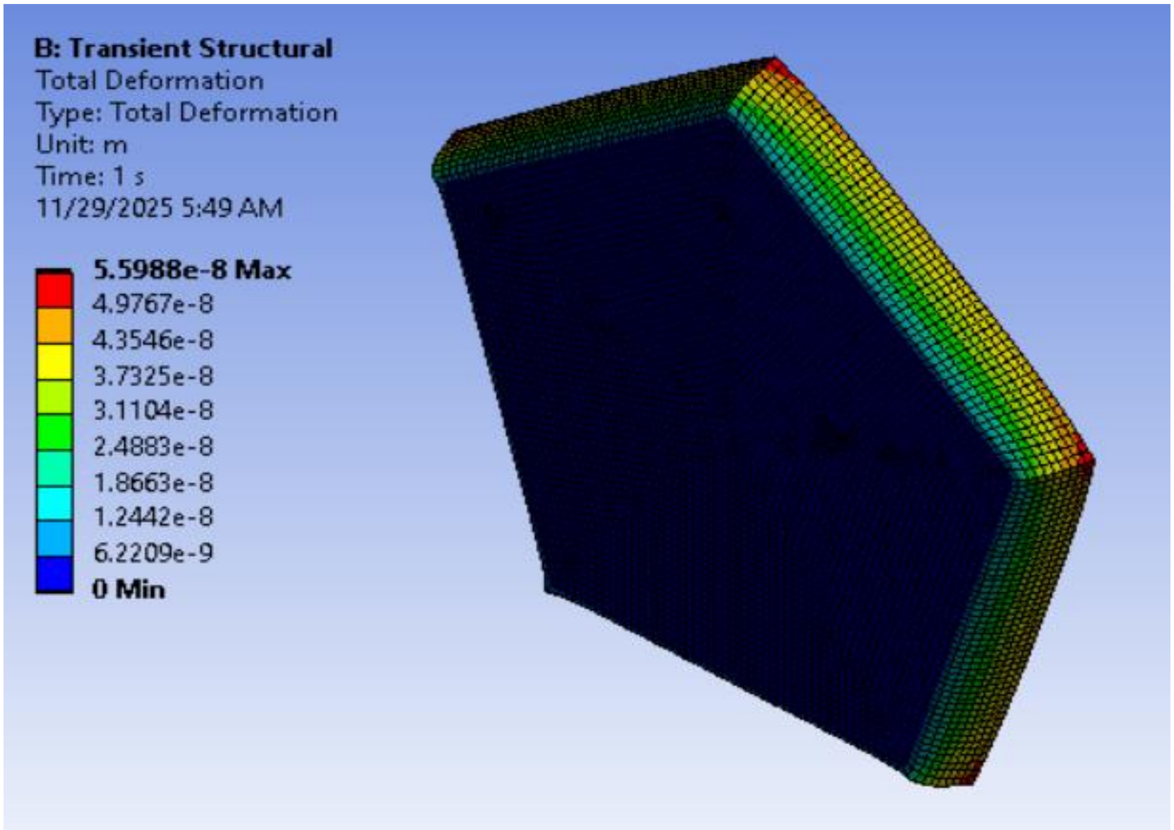
6.2 Results

6.2.1 Deformation vs Time

Because forces were applied on five different faces and each force acted in a different direction:

- Deformation increased and decreased depending on the combined effect of all directional forces.
- At time steps where exchange-rate peak values were higher, the structure showed greater overall displacement**.**
- Maximum deformation shifted between corners/edges depending on which face received the highest force in that specific time step.
- Since the front face was fixed, the largest deformation always occurred at the opposite or upper faces away from the fixed boundary.

- The deformation pattern was *asymmetric* due to uneven load directions on each step.



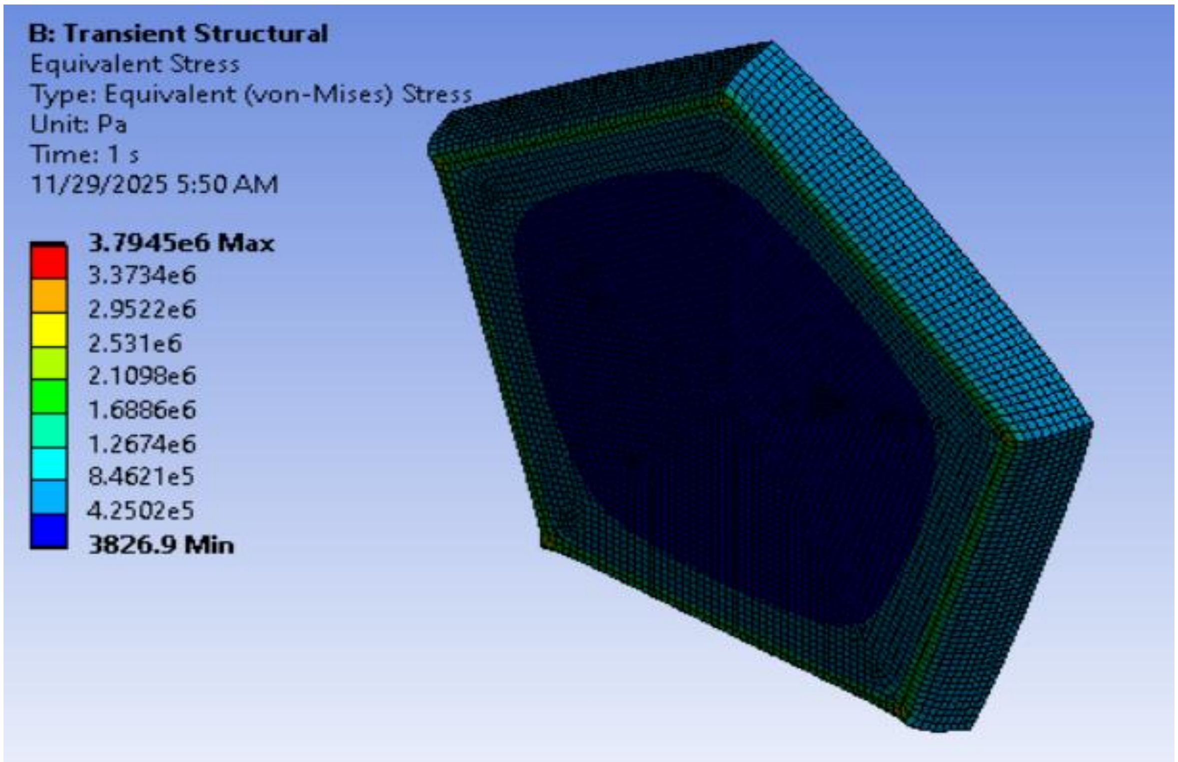
6.2.2 Stress-Time Response

Because the pentagon was loaded on five different sides, the stress pattern varied significantly:

- Peak stresses occurred at the edges connected to the fixed face**,** because forces from different directions created bending + shear effects.
- During the time steps with the highest applied force (based on exchange-rate peaks), the structure experienced maximum von Mises stress.
- Stress was concentrated near:
    - The fixed bottom face (stress anchors)

- The corners adjacent to heavily loaded faces.
- Regions where opposite directional forces created torsional effects

- As the forces fluctuated, the stress field also changed over time, showing both:
  - Transient stress waves, and
  - Localized peak stresses depending on force direction.



Overall, the transient loading produced a dynamic stress distribution quite different from the static case, with constantly shifting high-stress zones.