1. Abstract

This project presents a finite element analysis (FEA) of a regular hexagon structure using Static Structural and Transient Structural simulation techniques. The material properties were derived from the student roll number (ME-1867), resulting in a Young's Modulus of 67,000 MPa and a Poisson's Ratio of 0.28.

The static analysis utilized a load of 2,011 N (calculated from the date of birth), while the transient simulation applied a time-dependent load of 280.5 N (based on the USD to PKR exchange rate). One face of the hexagon was fixed, and a remote force was applied at one-third off the face. The analysis compares the deformation and stress results between the static equilibrium and the time-dependent transient response.

2. Introduction

Finite Element Analysis (FEA) is a numerical method used to predict how a part behaves under physical conditions. In this project, a regular hexagon geometry was analyzed under two distinct conditions:

1. Static Structural: Assumes the load is applied slowly, ignoring inertial and damping effects.
2. Transient Structural: Analyzes the dynamic response of the structure over a defined time period (time-dependent), considering inertia and damping.

The goal is to observe how the hexagon deforms when a remote force is applied at a specific offset location on the fixed face.

3. Problem Statement

The objective is to analyze a regular hexagon structure under custom-defined constraints based on personal data.

3.1 Material Properties (Derived from Roll No.1902)

Young's Modulus (E):

$$E = (\text{Last two digits}) \times 10^3 = 67 \times 1{,}000 = 67{,}000 \text{ MPa}$$

- Poisson's Ratio:

$$\nu = 0.28$$

3.2 Loading Conditions

- **Static Load : Calculated from Date of Birth (06-Jan-2004).**

$$F_{Static} = 6 + 1 + 2004 = 2{,}011 \text{ N}$$

- **Transient Load: Based on the USD to PKR exchange rate.**

$$F_{Transient} = 281.5 \text{ N}$$

3.3 Boundary Conditions

- Support: One face is fully Fixed.
- Load Application: Remote Force applied at 1/3rd distance of the fixed face.
- Time Step (Transient): 0.2 seconds**.**

4. Geometry Modeling

The geometry consists of a regular hexagon extruded to a specified thickness. The model was generated using the Design Modeler/Space Claim interface within Ansys.

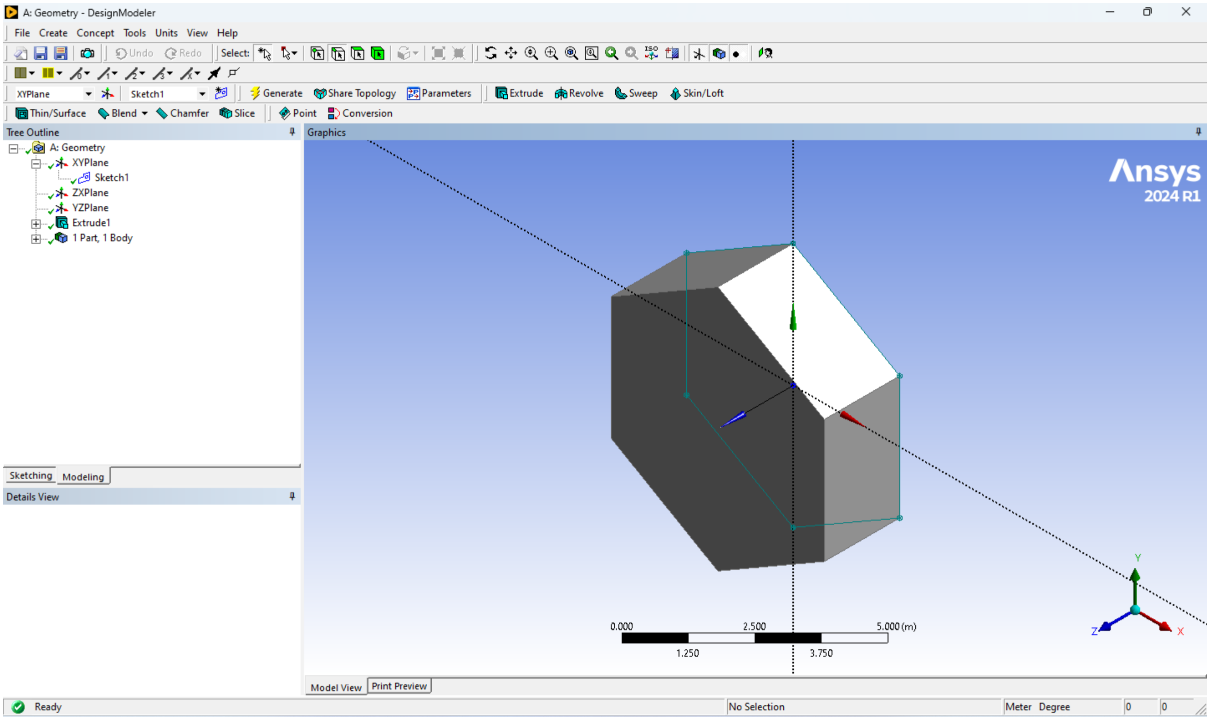
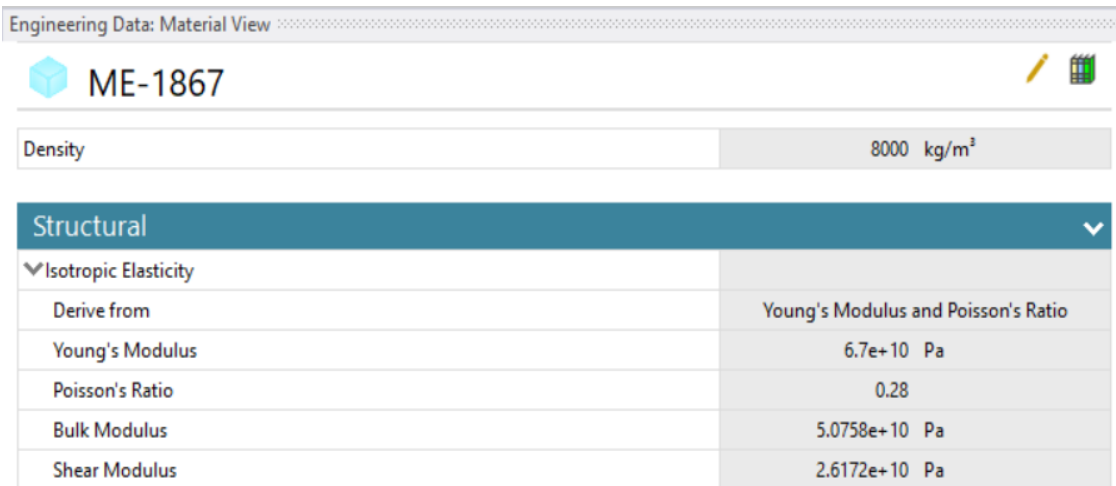


Figure 1: 3D Geometry of the extruded hexagon model.

5. Material Properties

A custom material named "ME-1867" was defined in Engineering Data with the calculated stiffness values**.**


Engineering Data: Material View

ME-1867

Density	8000 kg/m³
Structural	
Isotropic Elasticity	
Derive from	Young's Modulus and Poisson's Ratio
Young's Modulus	6.7e+10 Pa
Poisson's Ratio	0.28
Bulk Modulus	5.0758e+10 Pa
Shear Modulus	2.6172e+10 Pa

Figure 2: Engineering Data showing Young's Modulus of 67,000 MPa.

6. Boundary Conditions

To simulate the physical bending and shear, specific constraints were applied:

1. Fixed Support: Applied to one side face of the hexagon.
2. Remote Force: Applied to the same face but offset to 1/3rd of the length. This creates a moment arm, inducing rotation/bending in addition to the linear force.

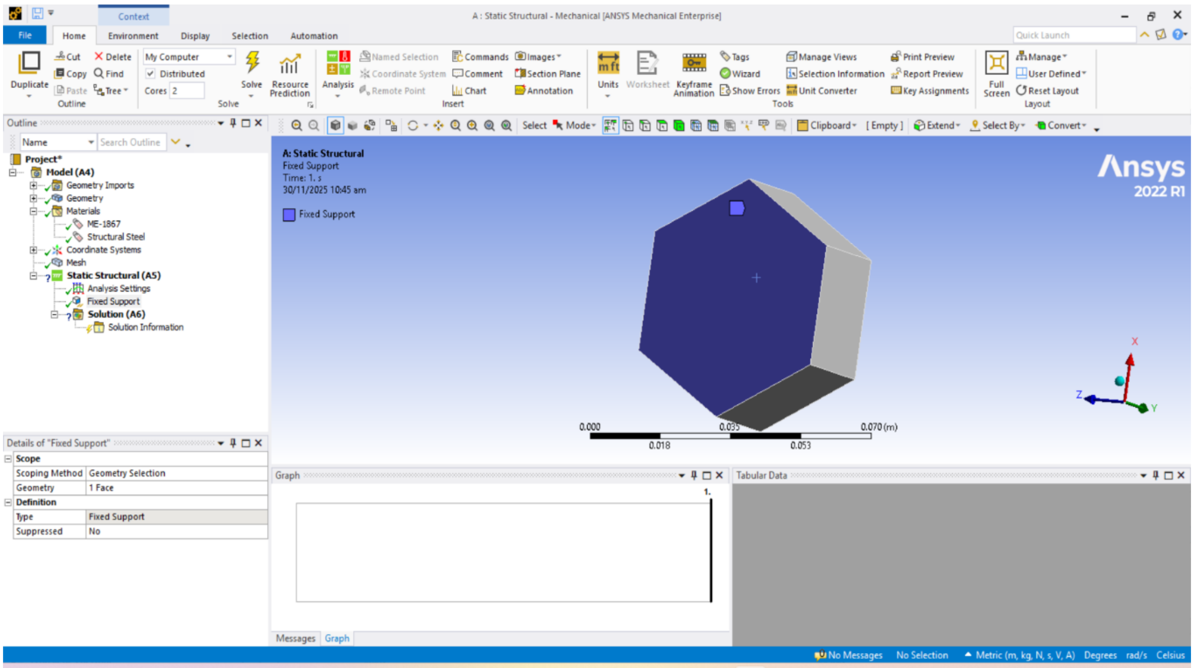


Figure 3: Fixed Support applied to the face.

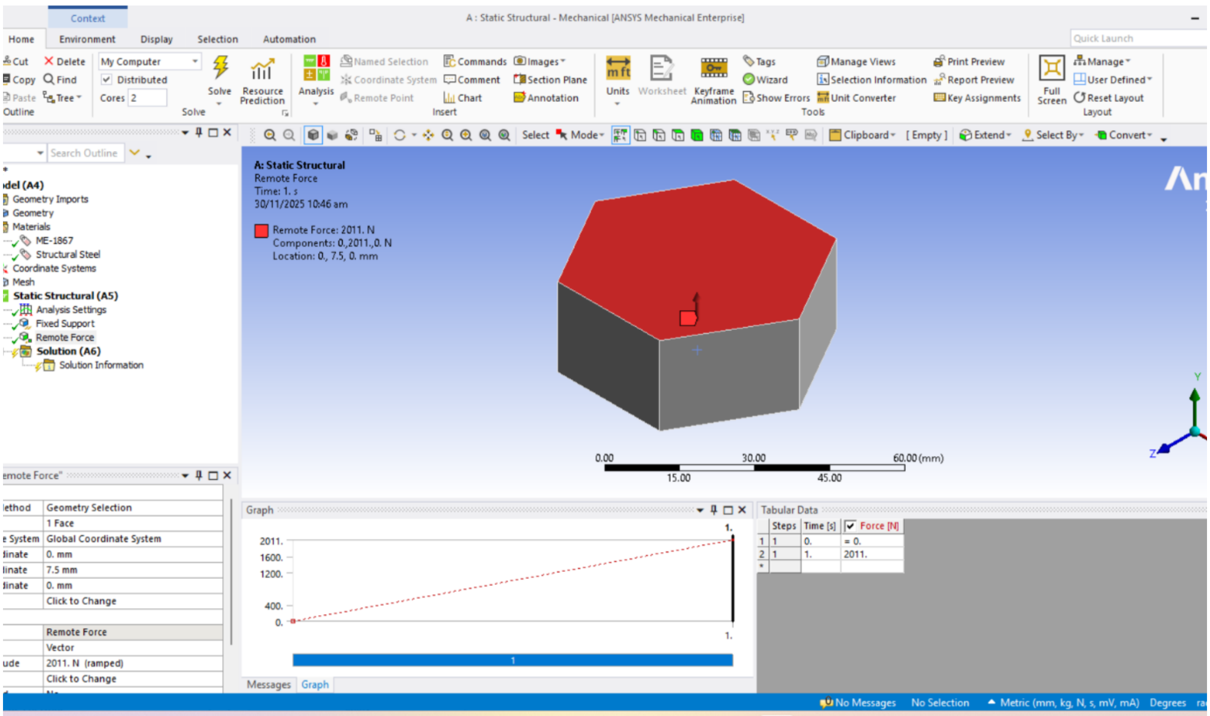


Figure 4: Remote Force applied at 1/3rd offset location.

7. Meshing & Convergence

A mesh convergence study was conducted to ensure the accuracy of the results. The mesh was refined in three iterations to observe the stability of the Equivalent Stress.

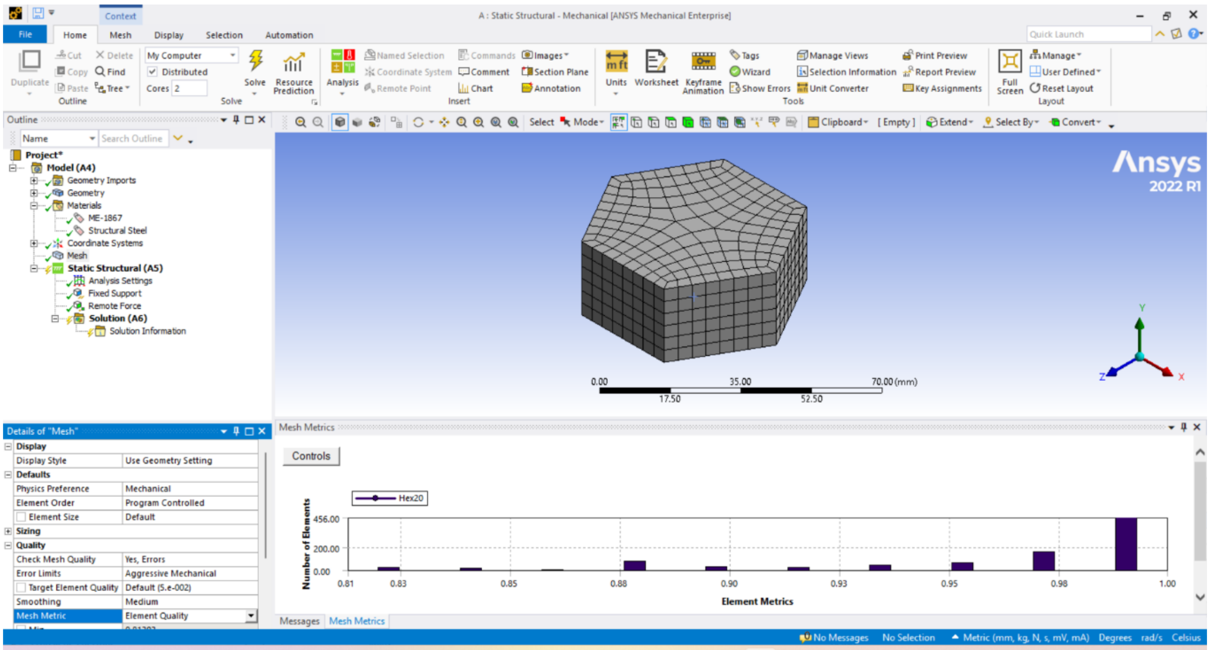


Figure 5: Meshed model of the hexagon with element Quality**.**

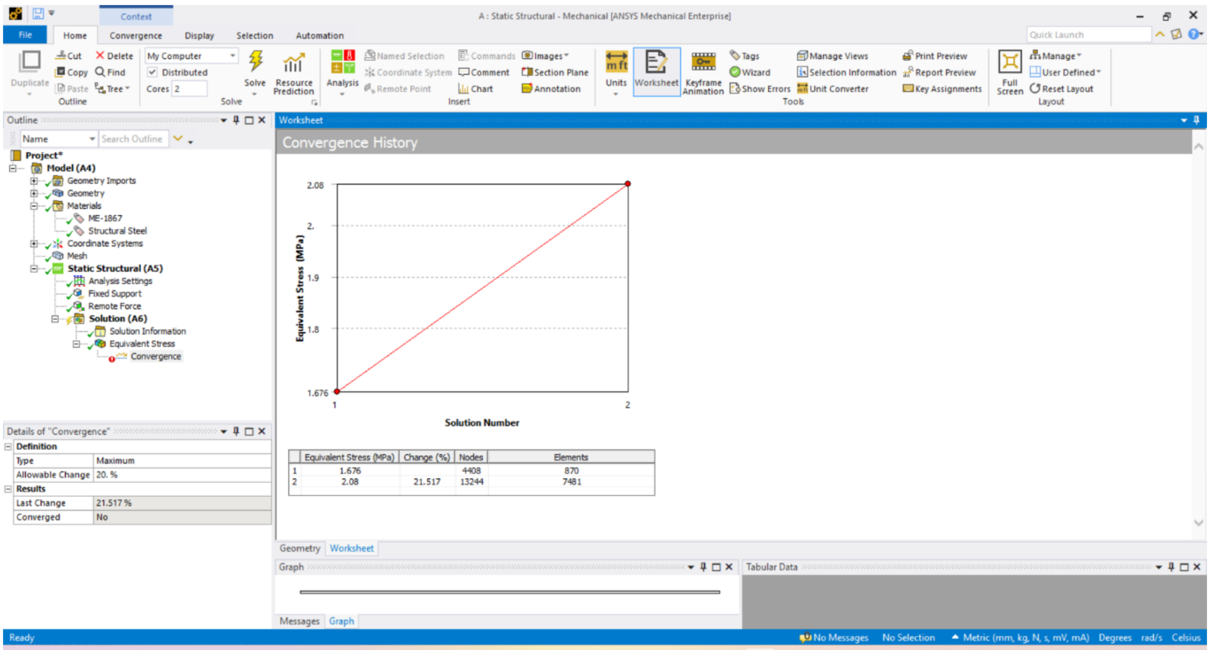


Figure 6: Mesh Convergence Graph (Solution Number vs. Stress).

8. Static Structural Simulation

In the static analysis, the load of **2,011 N** was applied. The solver calculated the final equilibrium state.

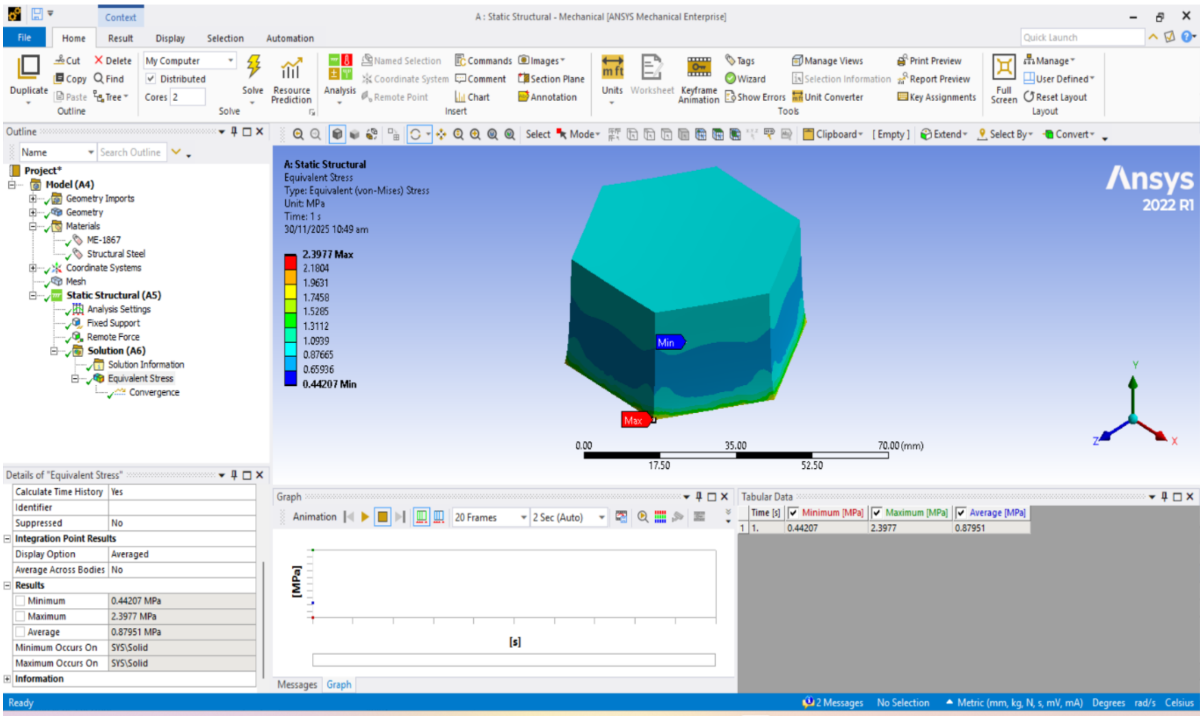


Figure 8: Equivalent (von-Mises) Stress (Static).

Results

The static results show the maximum deflection occurring at the tip of the hexagon opposite the fixed face.

9. Transient Structural Simulation

The Transient Structural analysis was performed to determine the time-dependent response. Unlike Explicit Dynamics (used for high-speed impact), Transient Structural is used here for a standard dynamic load over a duration of 1.2 second.

Simulation Settings:

- **Load: 281.5 N (USD Rate).**
- **Step End Time: 1.2 s.**
- **Time Step: 0.2**

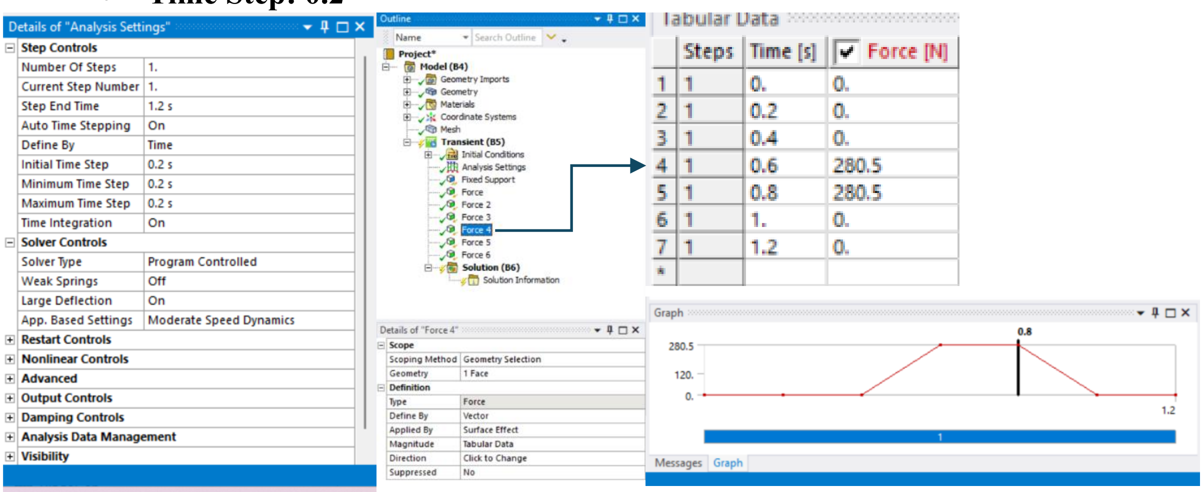


Figure 9: Transient setup showing time steps of 0.2s and tabular data of force 4 with graph.

Boundary Conditions (Transient)

For dynamic behavior, the boundary conditions are demonestrated blow.

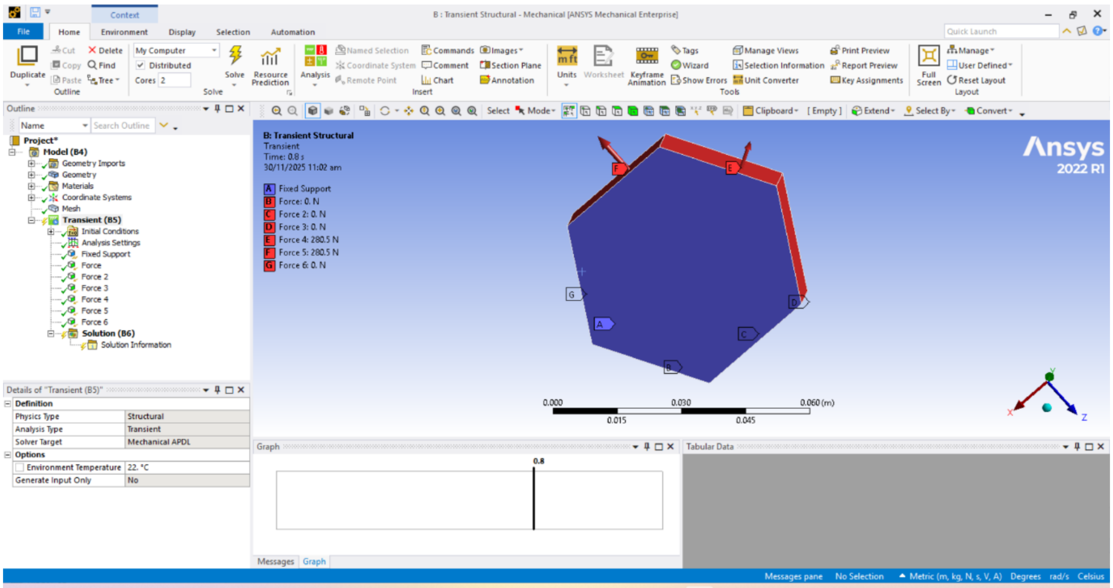
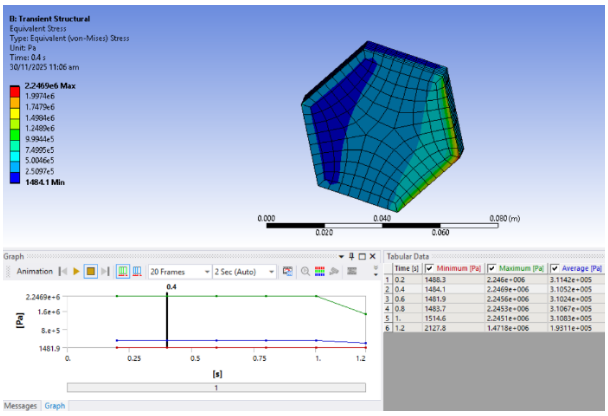
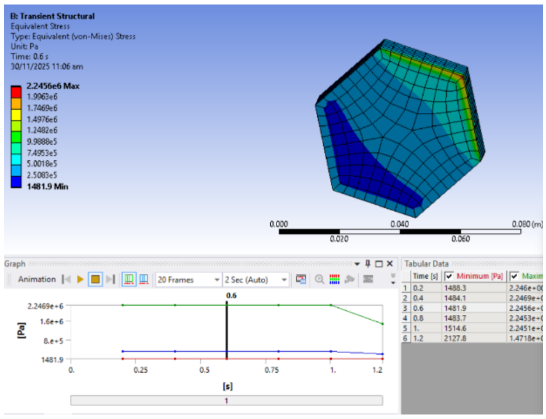


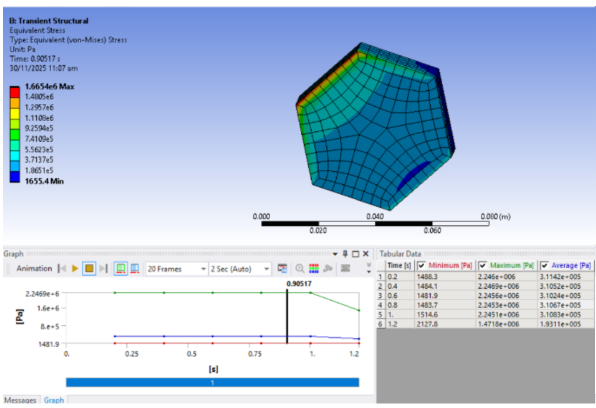
Figure 10: Figure 10: Fixed Support(face A) and Forces (B,C,D,E,F,G) applied in the Transient environment.



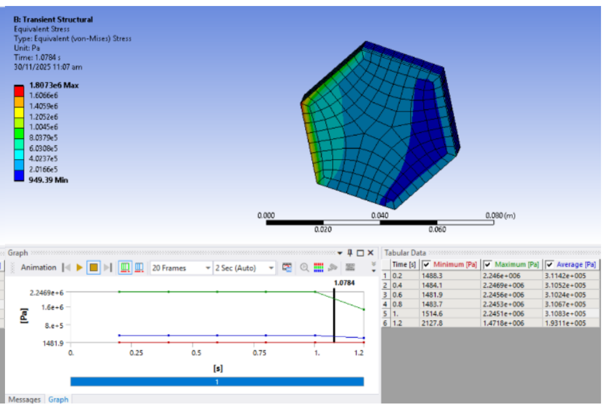
t = 0.4



t =0.6



t = 0.90517



t = 1.0784

10. Comparison & Conclusion

Parameter	Static Structural	Transient Structural
Load Magnitude	2,011 N	280.5 N
Time Dependency	None (Equilibrium)	Time-Dependent (0.2s steps)
Deformation Trend	Higher (due to higher load)	Lower (due to lower load)

Table 1: Comparison of Results

Conclusion

The project successfully demonstrated the application of FEA on a hexagon model using personal data for boundary conditions. The **Static Structural** analysis provided the maximum stress limits under a heavy load (Date of Birth derived), while the **Transient Structural** simulation visualized the system's behavior under a lighter, time-stepped load (USD Rate derived). The use of a **Remote Force at 1/3rd distance** introduced realistic moment effects on the fixed face.