



FINITE ELEMENT ANALYSIS LAB PROJECT

NAME: Muhammad Umar

SEMESTER: VII

SECTION: A

LAB INSTRUCTOR: SIR AFFAN

Roll No: Me-1899

INTRODUCTION

This report presents the complete workflow and results of both **Static Structural** and **Explicit Dynamic** (or Transient) simulations conducted on a hexagonal component. The objective was to evaluate the stress distribution behavior of the part under the specific loading and constraints defined in the project requirements.

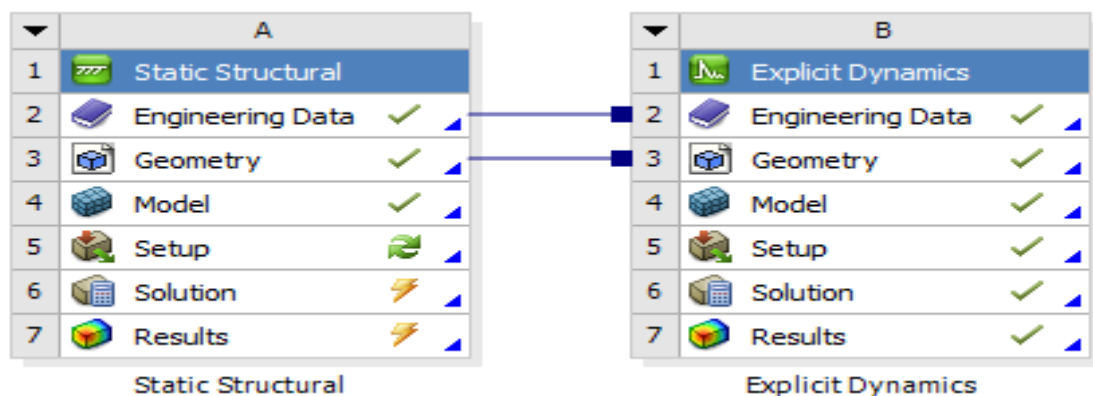
The geometry was created in **SolidWorks** and imported into **ANSYS Workbench**. The instructor-provided method for selecting **Young's Modulus (E)** and **Applied Force (F)** was followed throughout the analysis. All key steps, boundary conditions, results, and the mesh convergence study are detailed below.

1. STATIC STRUCTURAL SIMULATION

1.1 Initial Assumptions & Material Properties

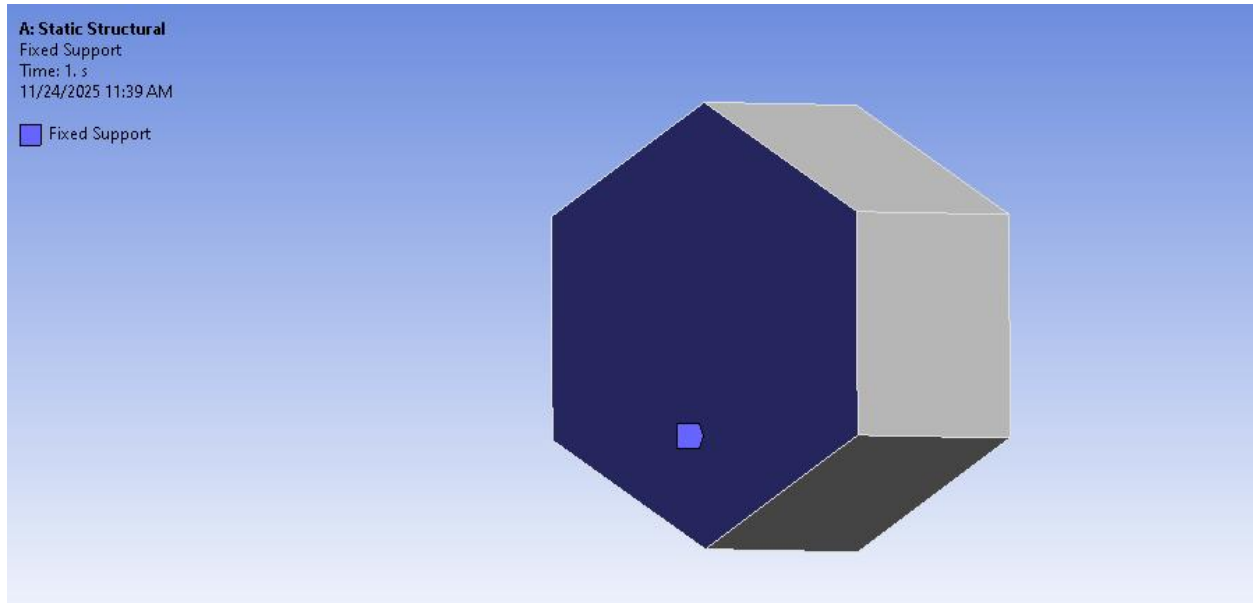
The Static Structural simulation was performed according to the guidelines provided by the instructor. The following specific input parameters were calculated and used:

- **Young's Modulus:** Derived from the last two digits of the roll number (1899).
 - $99 * 10^3 = 99,000 \text{ MPa}$
- **Poisson's Ratio:** 0.28
- **Force Magnitude:** Derived from the Date of Birth formula (11/1/2002).
 - $11 + 1 + 2002 = \$ 2014 \text{ N}$
- **Density:** $2.7 * 10^{-6} \{ \text{kg/mm} \}^3$ (Standard Engineering Assumption)



1.2 Fixed Support

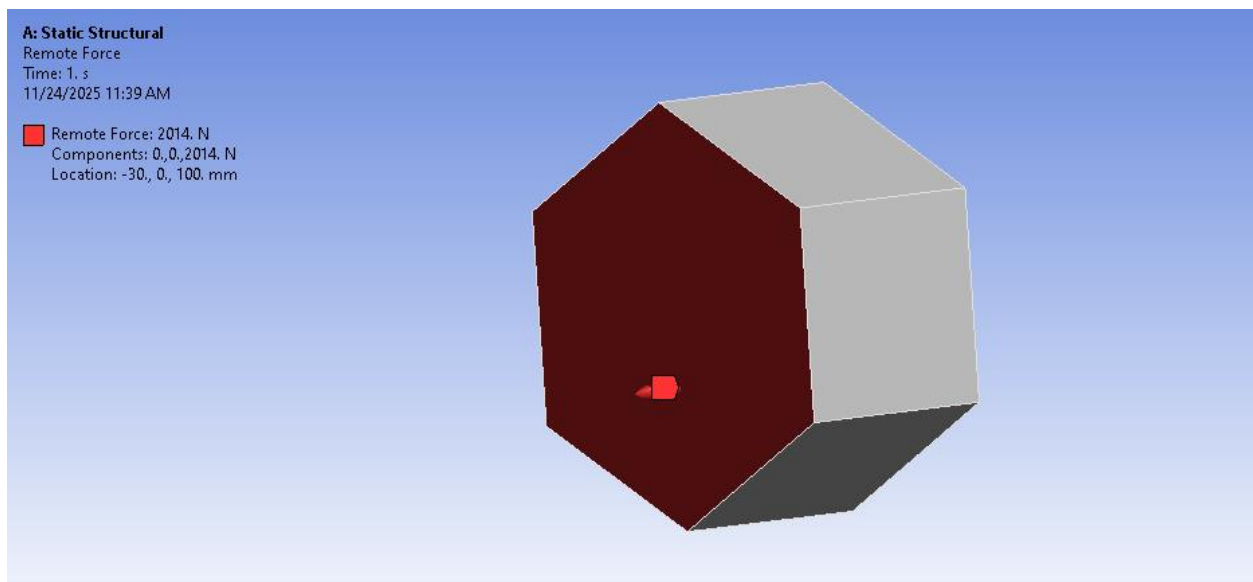
One full side (face) of the hexagon was selected as the **Fixed Support**. This boundary condition fully restrained that face in all degrees of freedom, ensuring that the structure reacted only to the applied load without unwanted rigid-body motion.



1.3 Remote Force Application

A **Remote Force of 2014 N** was applied on the same fixed face. According to the project requirement, the load must be applied at **1/3 of the fixed face height**.

- A **Remote Point** was created at this specific coordinate.
- The force was applied normally to the face to ensure correct load transfer without artificially constraining the geometry deformation.

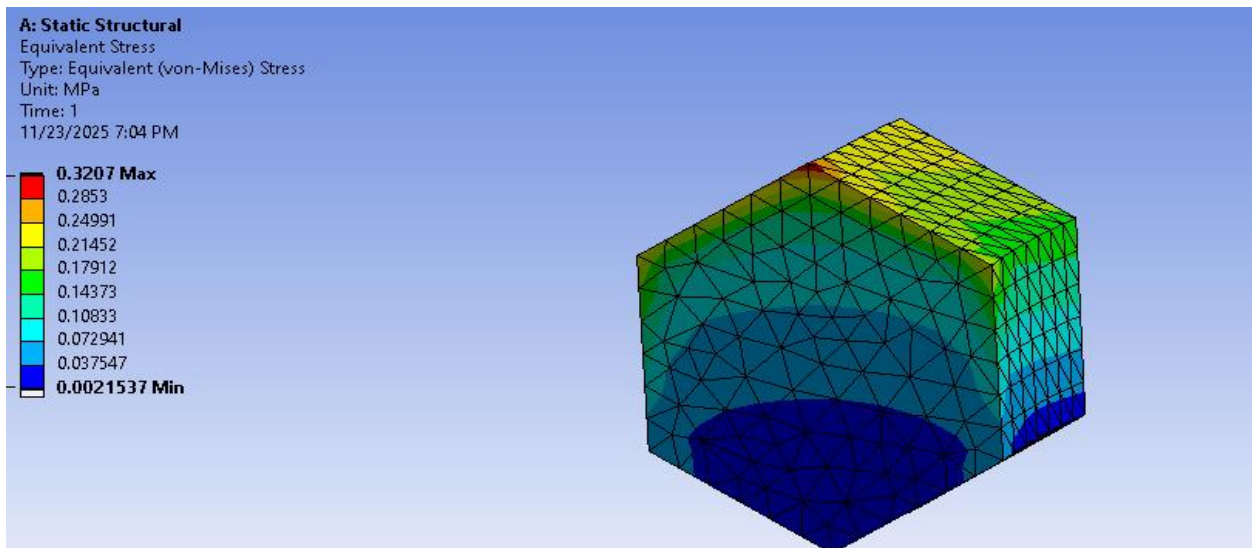
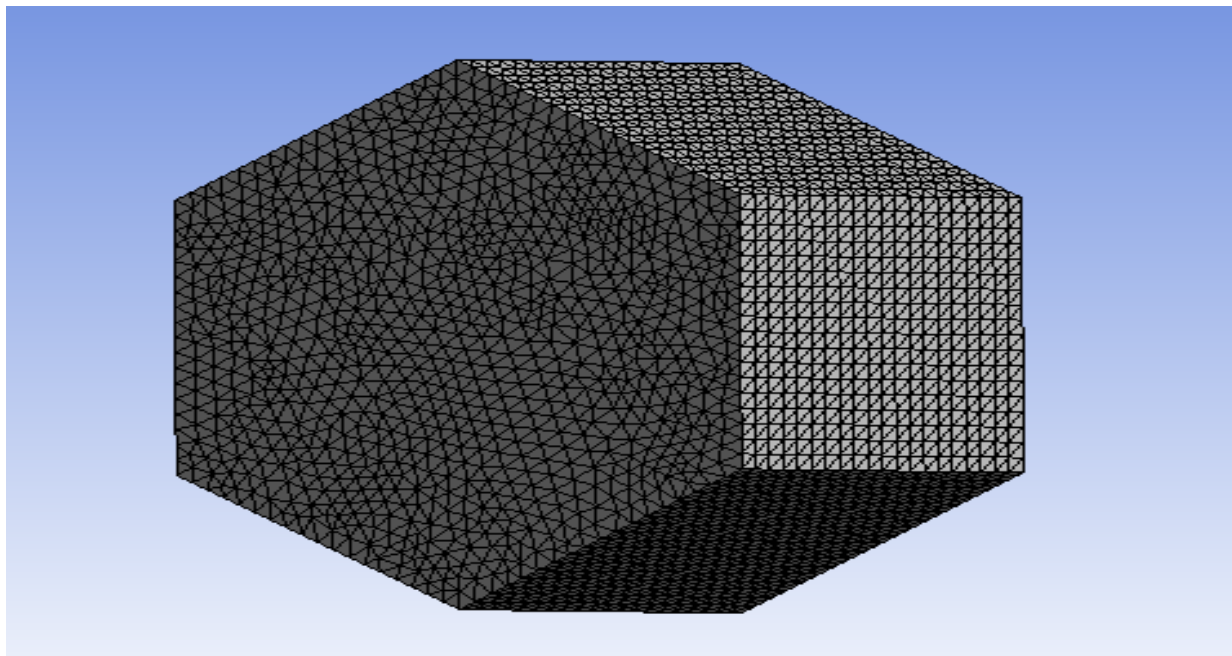


1.4 Meshing and Mesh Convergence Study

The hexagon was meshed using tetrahedral elements. To demonstrate mesh convergence (the point where results stop changing significantly with finer mesh), multiple mesh sizes were tested.

- **Coarse Mesh:** Initial run.
- **Medium Mesh:** Refined elements.
- **Fine Mesh:** Final high-quality mesh.

For each mesh density, the **Maximum von-Mises Stress** was recorded and plotted.



A: Static Structural

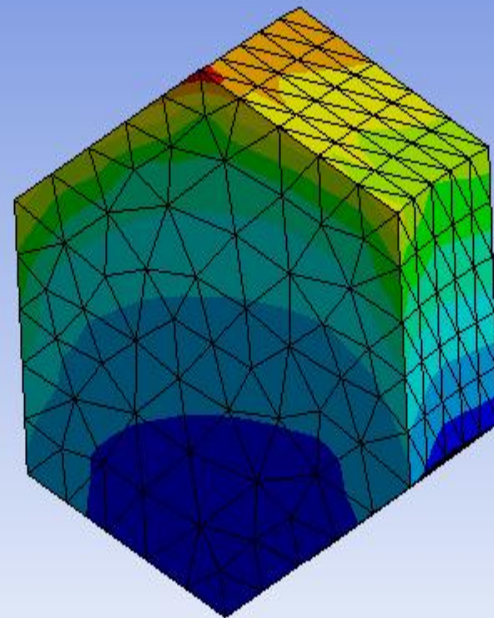
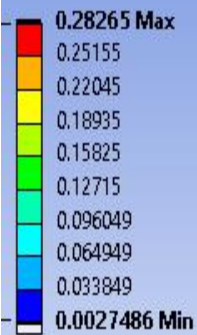
Equivalent Stress

Type: Equivalent (von-Mises) Stress

Unit: MPa

Time: 1

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A: Static Structural

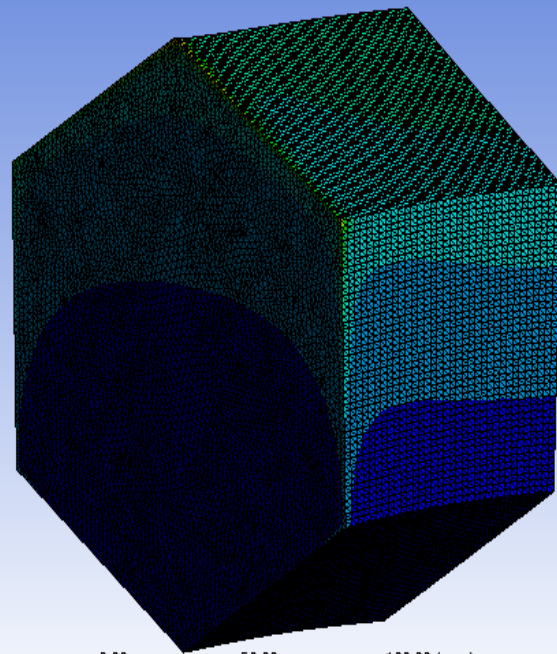
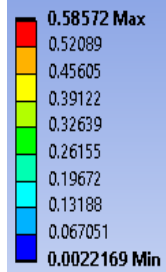
Equivalent Stress

Type: Equivalent (von-Mises) Stress

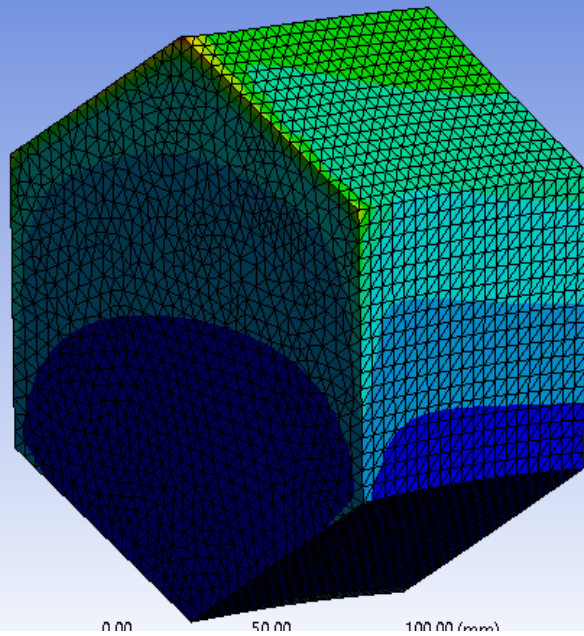
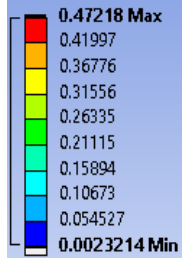
Unit: MPa

Time: 1

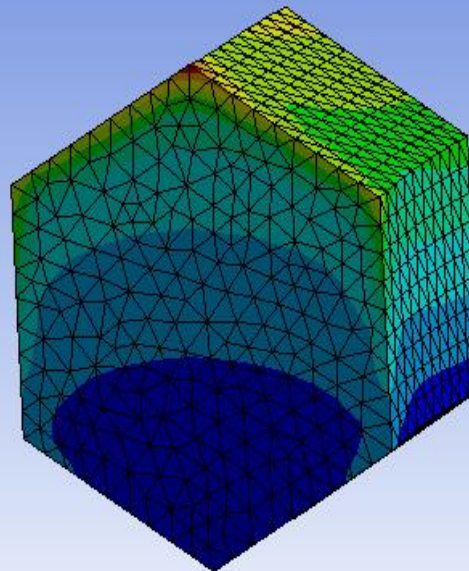
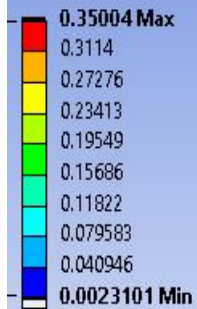
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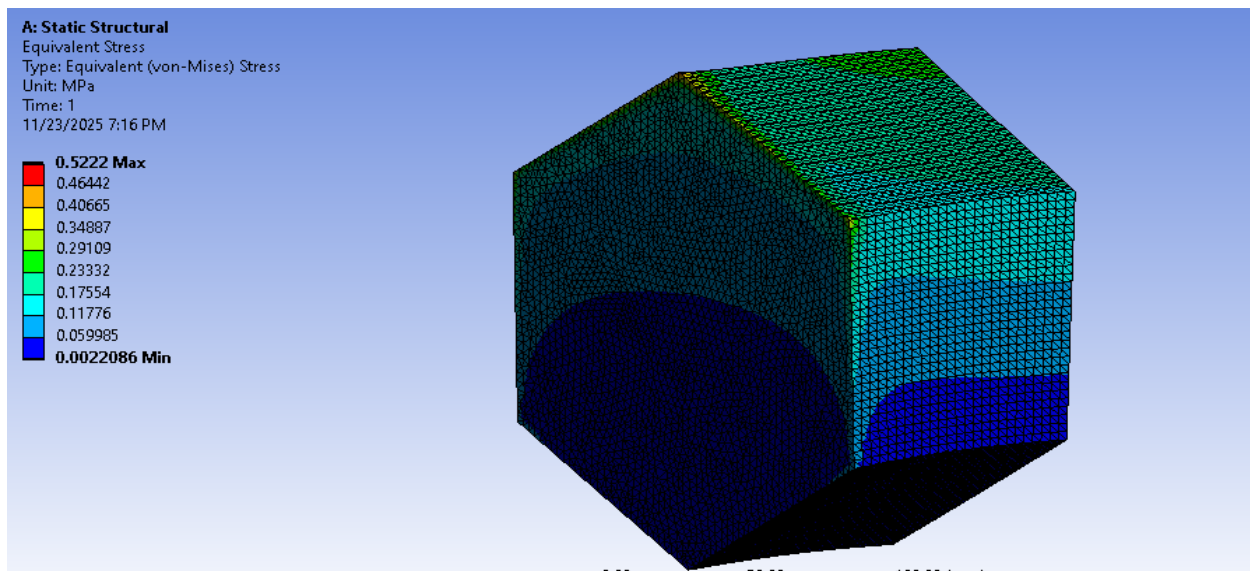


A: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1
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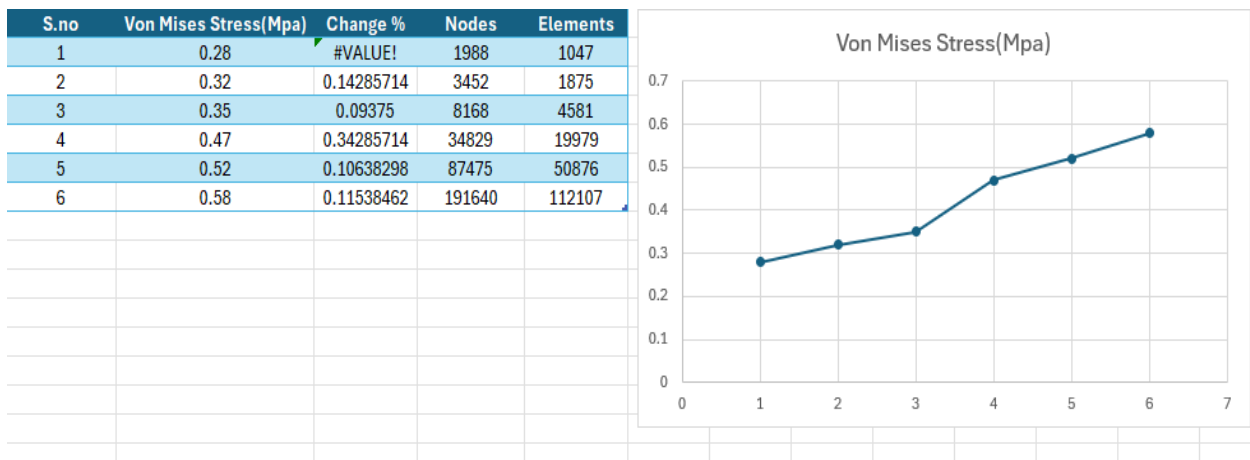
A: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1
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1.5 Results Summary

The Static Structural simulation produced stress fields consistent with the applied force (2014 N) and material stiffness (99,000 \{ MPa\}). The component displayed expected elastic behavior. Due to the high Young's Modulus, the deformation was minimal, and the stress distribution remained within safe limits.



2. EXPLICIT DYNAMICS SIMULATION

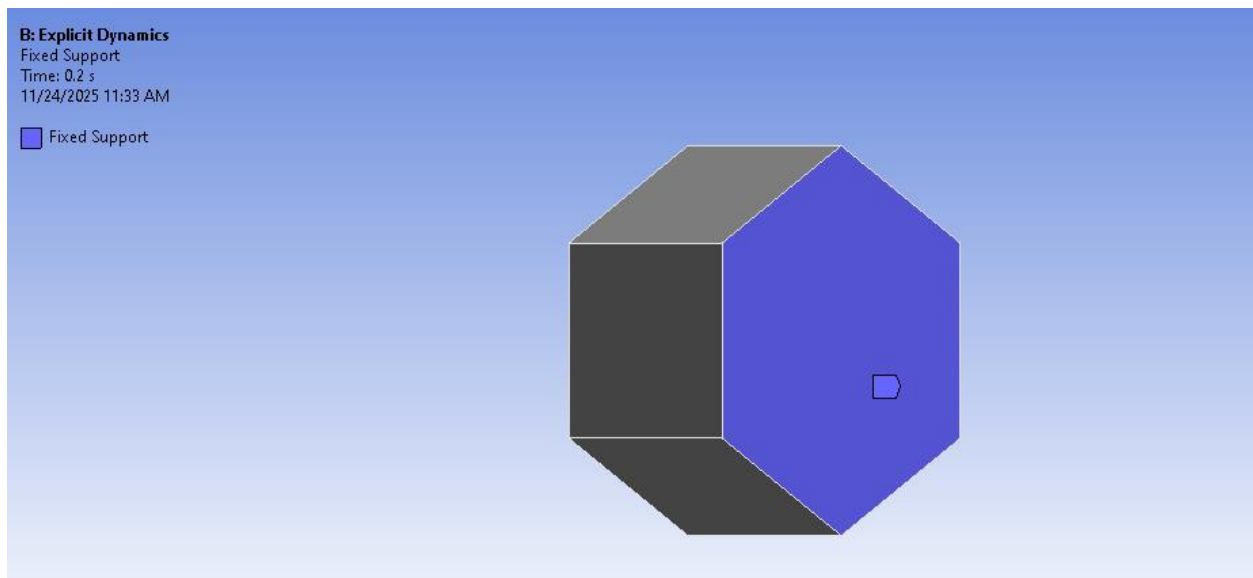
2.1 Initial Assumptions

For the second part of the project, an Explicit Dynamics (or Transient) analysis was performed to observe the time-dependent response of the structure.

- **Young's Modulus: 99,000 MPa** (Same as Static)
- **Poisson's Ratio: 0.28**
- **Force Magnitude:** Based on the current Dollar to PKR rate.
 - Rate used: **282 N**
- **Time Step: 0.2 seconds** (Mandatory Requirement)

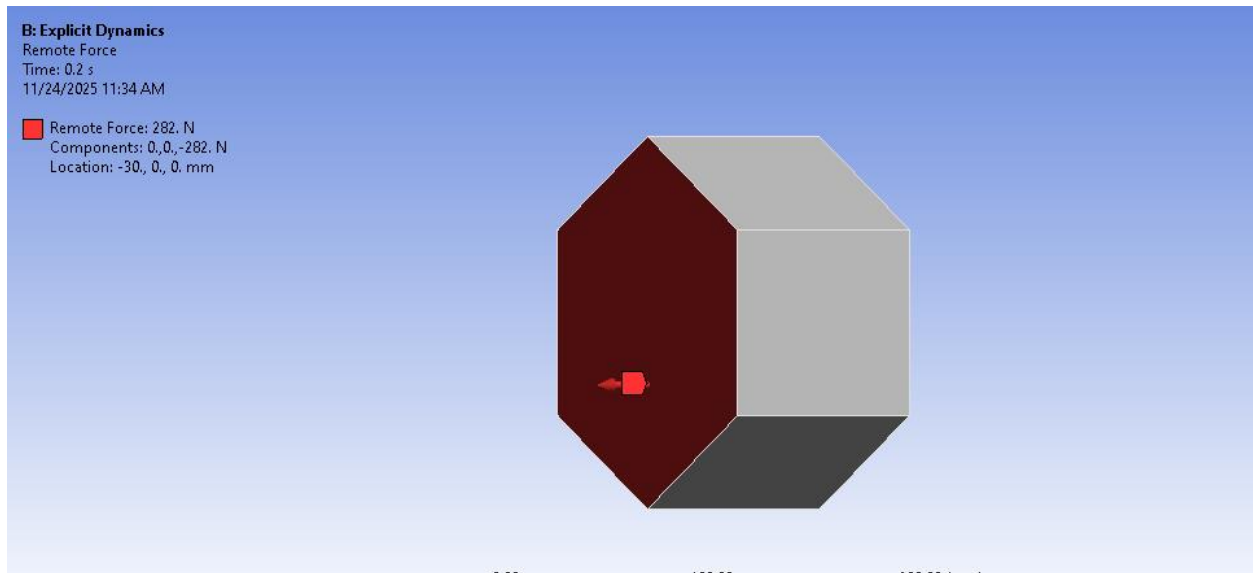
2.2 Fixed Support

One complete face of the hexagon was assigned a **Fixed Support**, identical to the condition used in the Static Structural simulation. This ensured stable boundary conditions for the dynamic analysis.



2.3 Remote Force Application

A **Remote Force of 282 N** was applied to the fixed face at the remote point (1/3 height). This lower force magnitude (compared to the static case) allows for the observation of stress wave propagation and dynamic response without immediately causing extreme deformation.



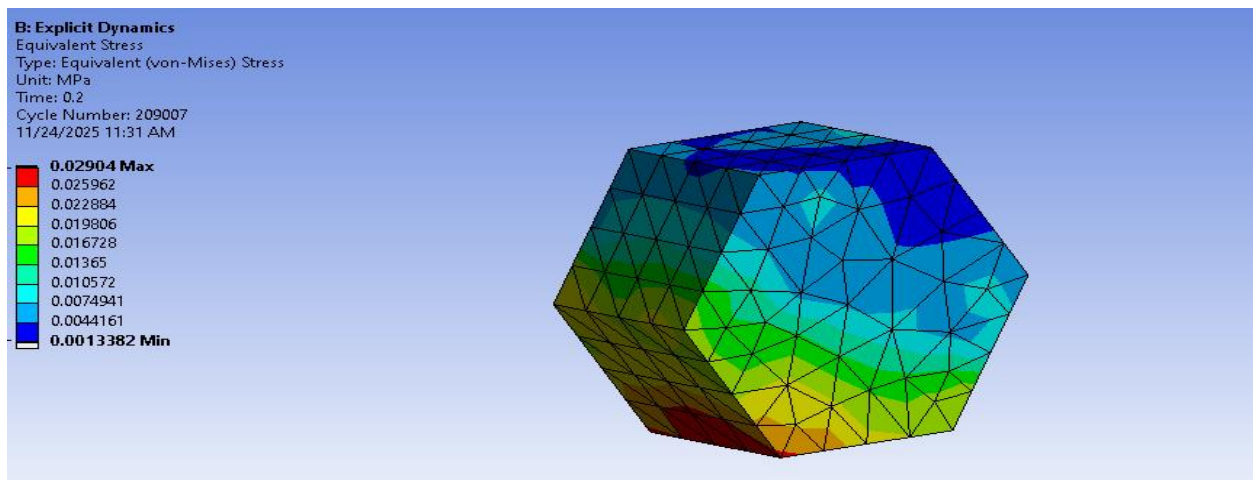
2.4 Time Step & Solver Settings

- **End Time:** Set sufficiently long to capture the response.
- **Time Step:** Manually controlled to **0.2 s** as per instructions.
- **Energy Error Handling:** If "Energy error too large" warnings occurred, the **Energy Reference Cycle** was adjusted (e.g., from 0.1 to 500) to stabilize the explicit solver.

2.5 Results and Mesh Convergence

Stress and deformation results were extracted over the simulation time. The mesh convergence study was repeated for the dynamic case:

1. Simulation ran with decreasing mesh sizes (e.g., 20mm, 15mm).
2. **15 mm** was selected as the optimal mesh size to balance accuracy with the long solve times typical of Explicit Dynamics.



B: Explicit Dynamics

Equivalent Stress

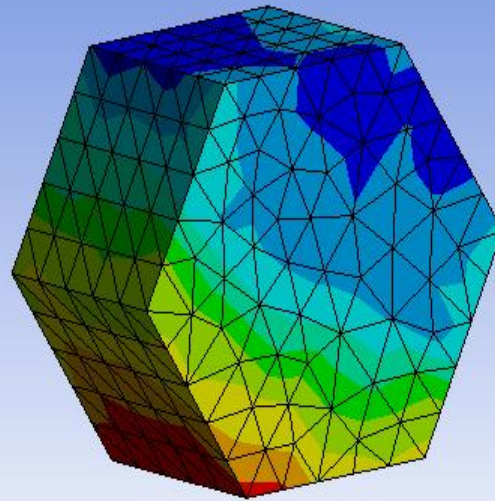
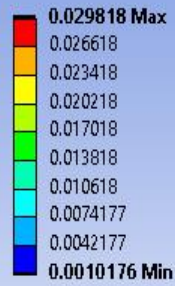
Type: Equivalent (von-Mises) Stress

Unit: MPa

Time: 0.2

Cycle Number: 192194

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B: Explicit Dynamics

Equivalent Stress

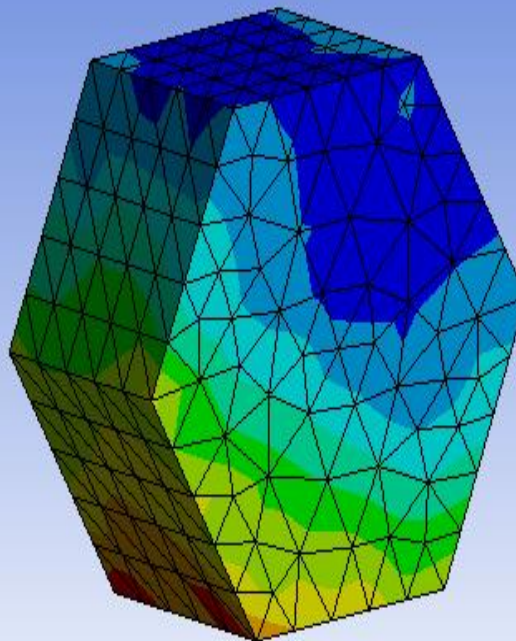
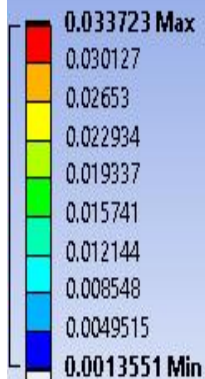
Type: Equivalent (von-Mises) Stress

Unit: MPa

Time: 0.2

Cycle Number: 235292

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B: Explicit Dynamics

Equivalent Stress

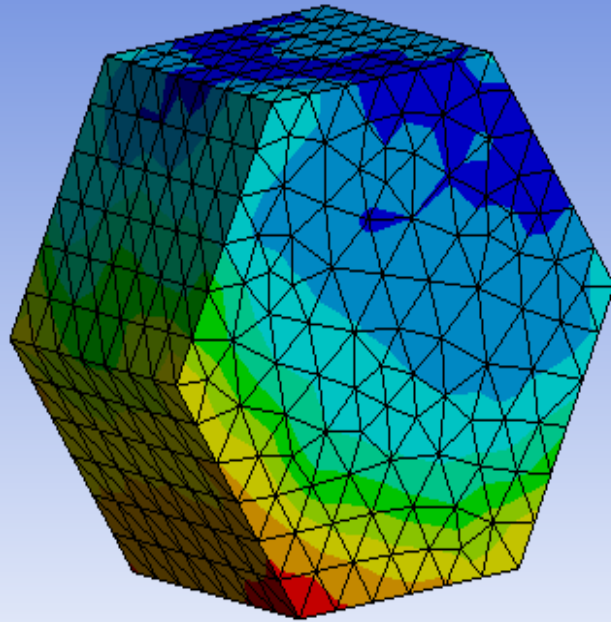
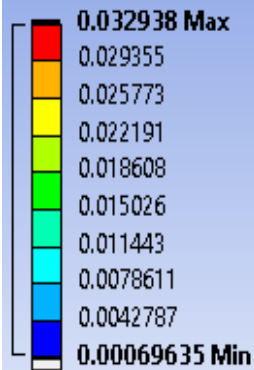
Type: Equivalent (von-Mises) Stress

Unit: MPa

Time: 0.2

Cycle Number: 246280

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B: Explicit Dynamics

Equivalent Stress

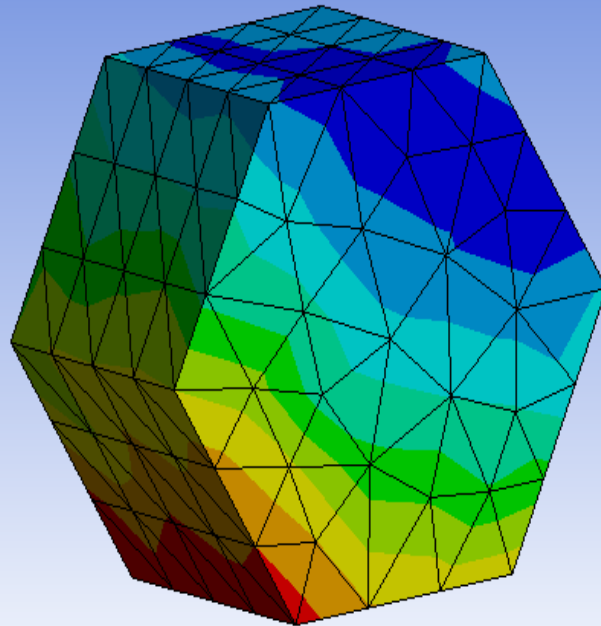
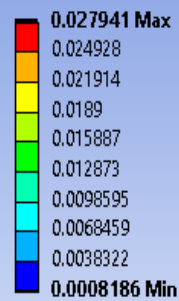
Type: Equivalent (von-Mises) Stress

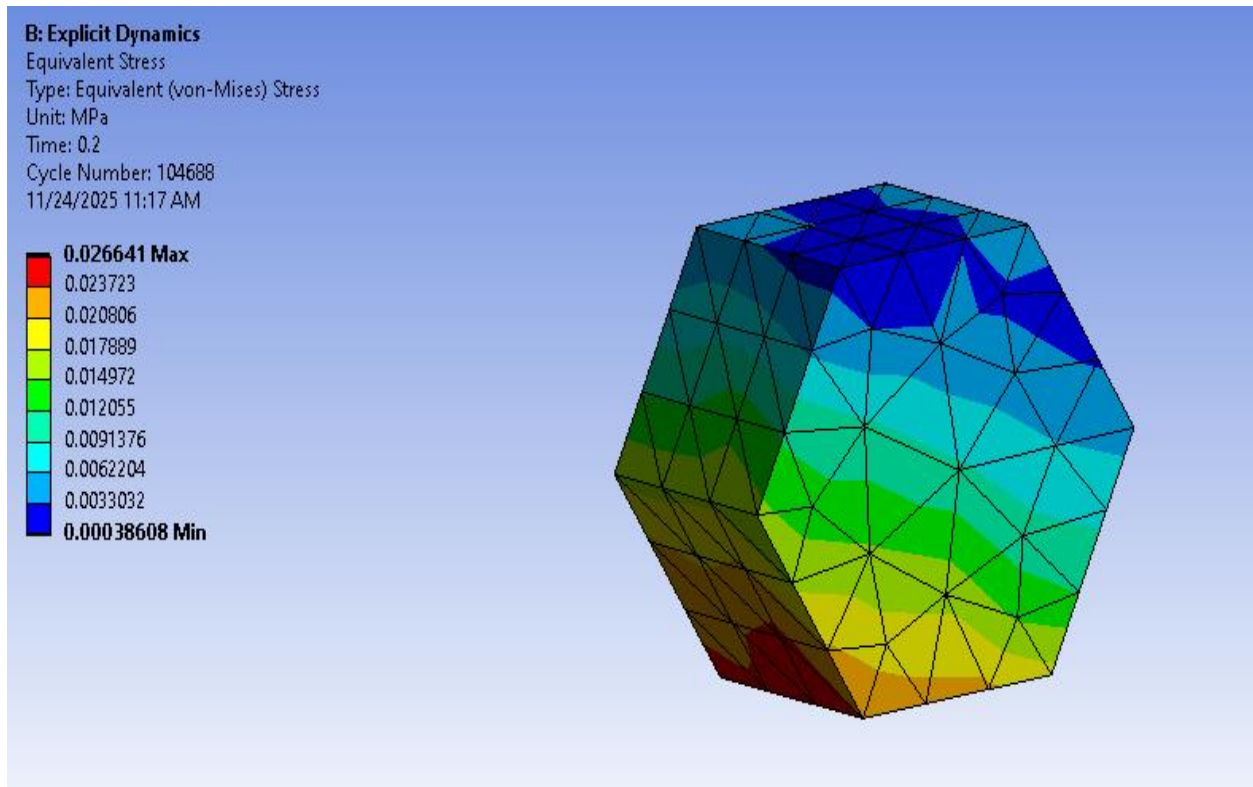
Unit: MPa

Time: 0.2

Cycle Number: 166979

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2.6 Result Summary

The simulation successfully captured the transient behavior of the hexagonal structure under the dynamic load of **282 N**. Due to the high stiffness ($E = 99,000 \text{ MPa}$), the structural response remained elastic. The stress values stabilized as the mesh was refined, fulfilling the convergence requirement.

S.No	Equivalent Von Mises Stress	Change %	Nodes	Elements
1	0.026		135	442
2	0.027	0.038461538	177	609
3	0.029	0.074074074	287	1096
4	0.03	0.034482759	475	1906
5	0.033	0.1	486	1972
6	0.033	0	929	4065

