FINITE ELEMENT ANSLYSIS 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.

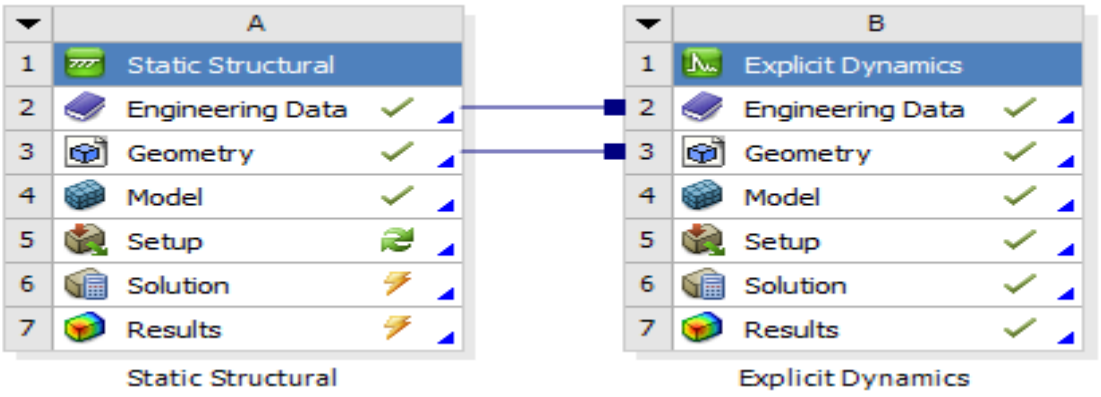
---

1. STATIC STRUCTURAL SIMULATION

1.1 Initial Assumptions & Material Properties

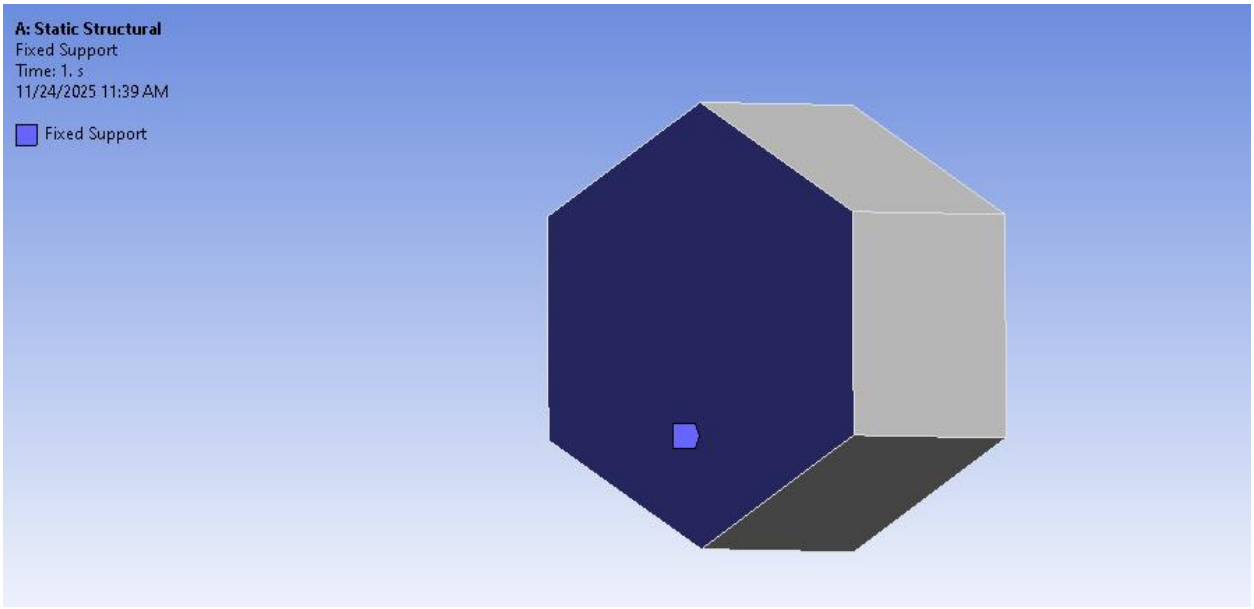
The Static Structural simulation was performed according to the guidelines provided by the instructor. The following specific input parameters were calculated and used:

- **Young's Modulus:** Derived from the last two digits of the roll number (1899).
    - 99 * 10^3 = **99,000 MPa**
- **Poisson's Ratio:** 0.28
- **Force Magnitude:** Derived from the Date of Birth formula (11/1/2007).
    - 11 + 1 + 2007 =$ **2019 N**
- **Density:** 2.7 * 10^{-6}{ kg/mm}^3$ (Standard Engineering Assumption)



1.2 Fixed Support

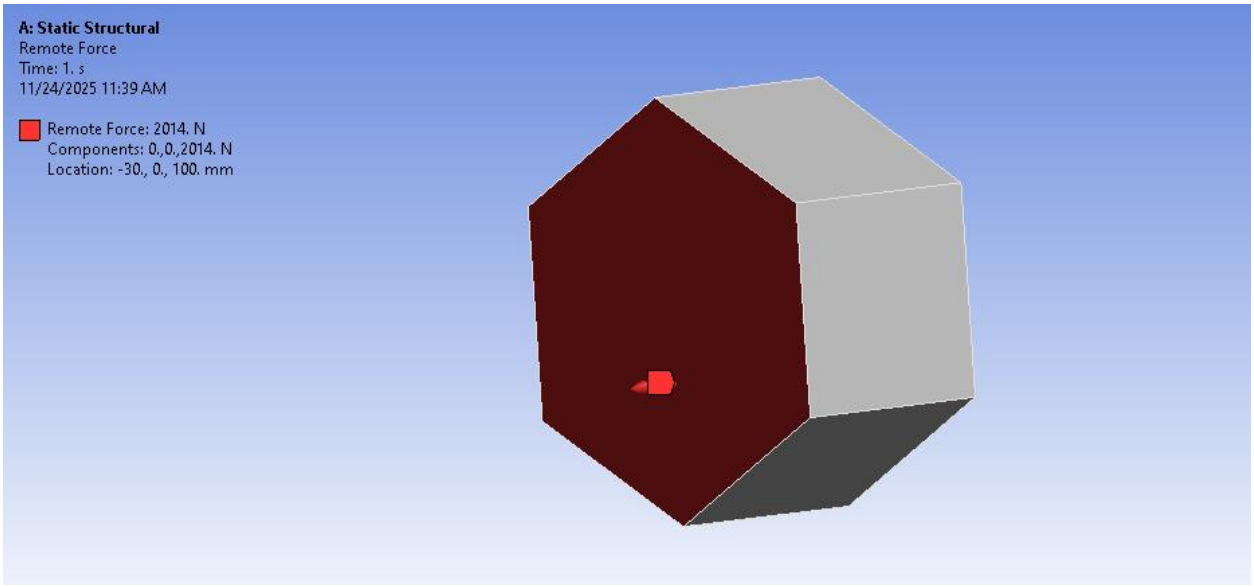
One full side (face) of the hexagon was selected as the **Fixed Support**. This boundary condition fully restrained that face in all degrees of freedom, ensuring that the structure reacted only to the applied load without unwanted rigid-body motion.



1.3 Remote Force Application

A **Remote Force of 2019 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.

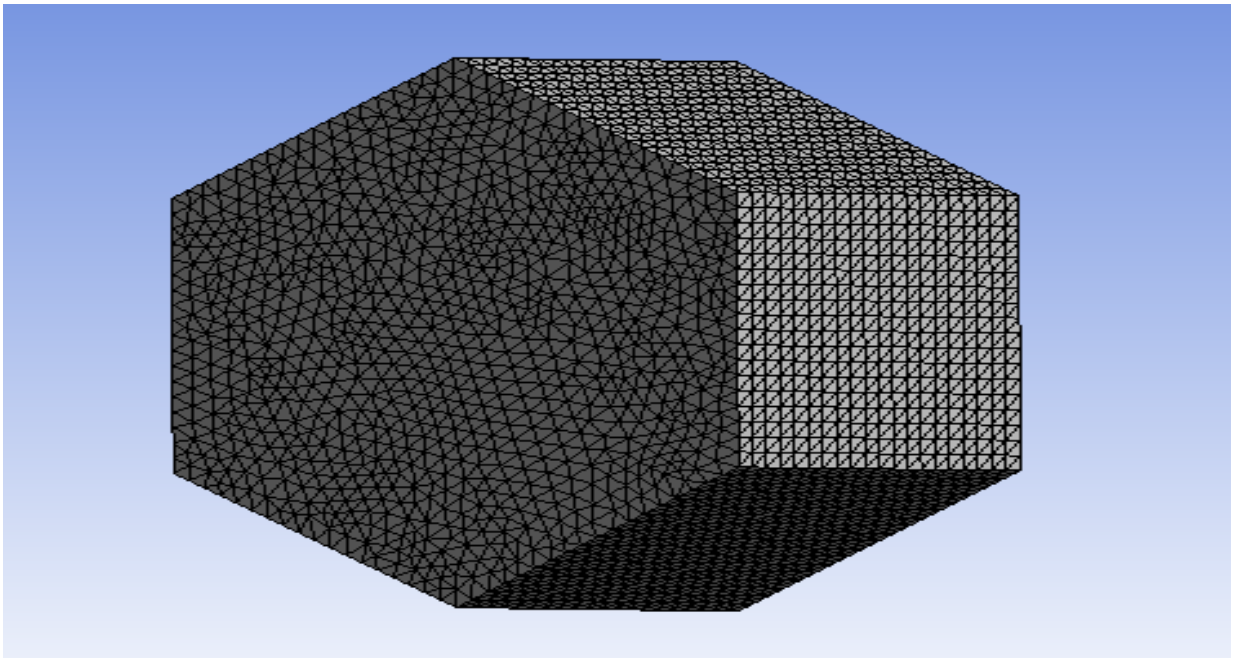


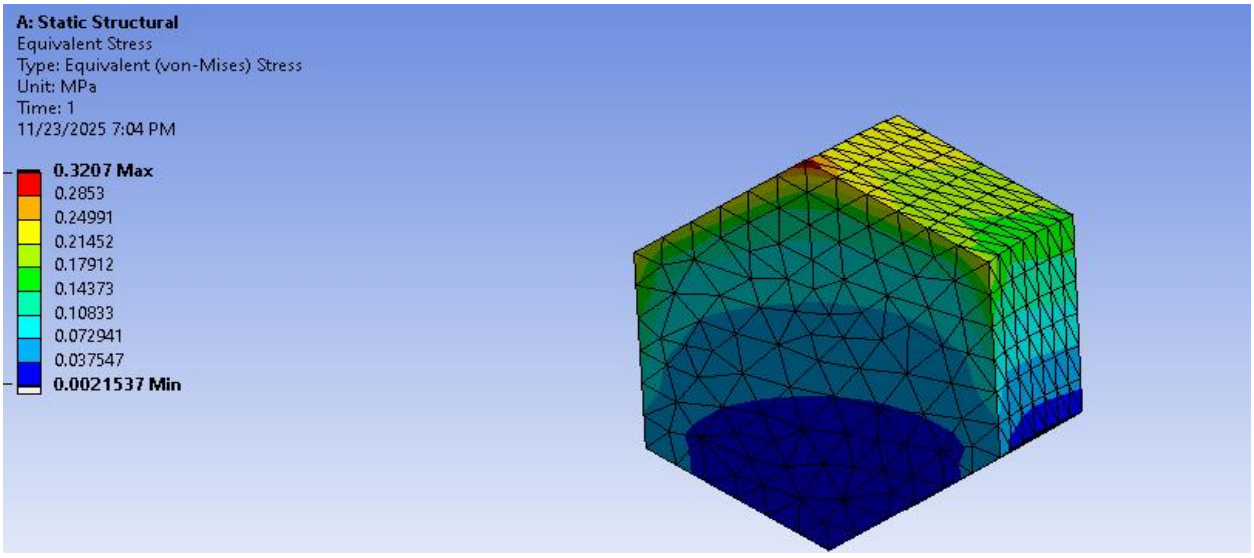
1.4 Meshing and Mesh Convergence Study

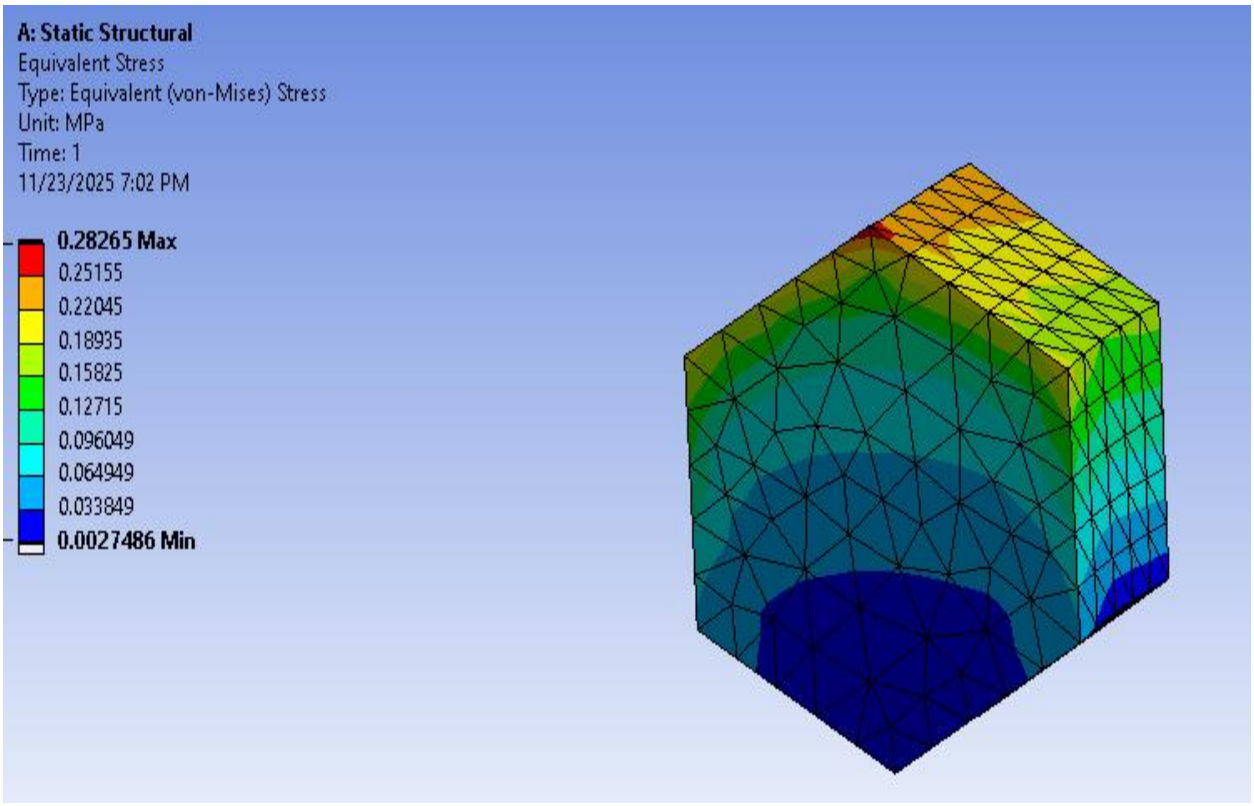
The hexagon was meshed using tetrahedral elements. To demonstrate mesh convergence (the point where results stop changing significantly with finer mesh), multiple mesh sizes were tested.

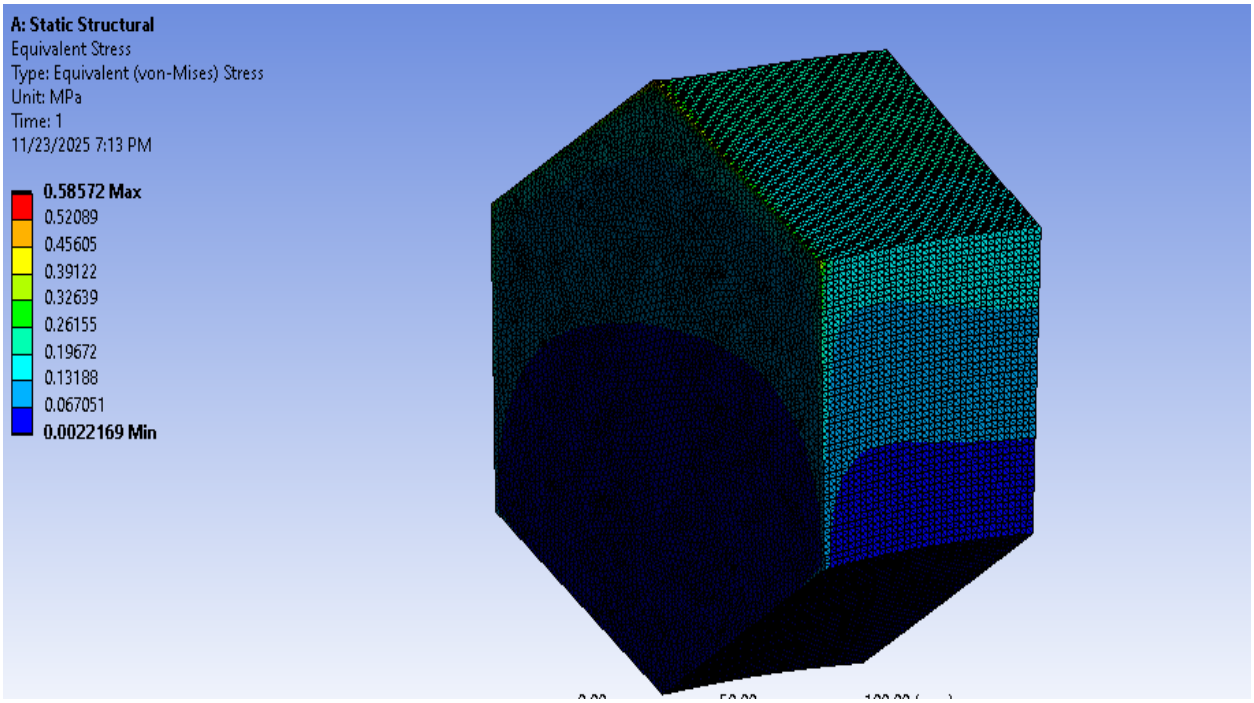
- **Coarse Mesh:** Initial run.
- **Medium Mesh:** Refined elements.
- **Fine Mesh:** Final high-quality mesh.

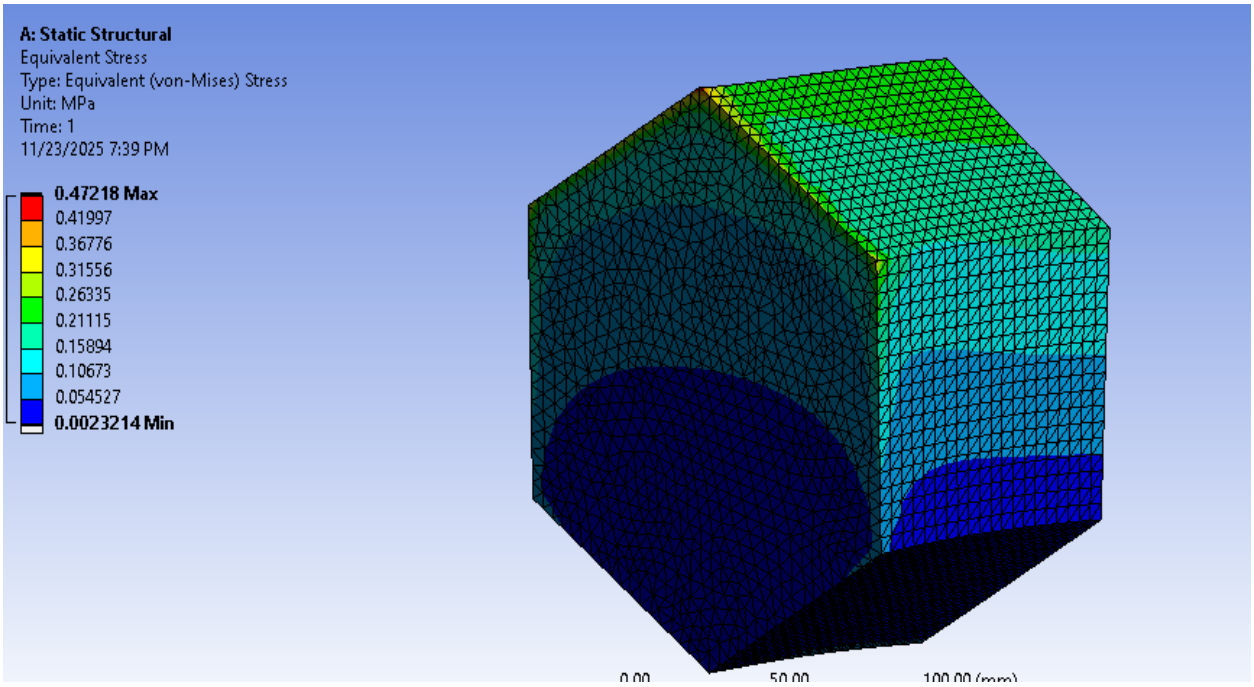
For each mesh density, the **Maximum von-Mises Stress** was recorded and plotted.

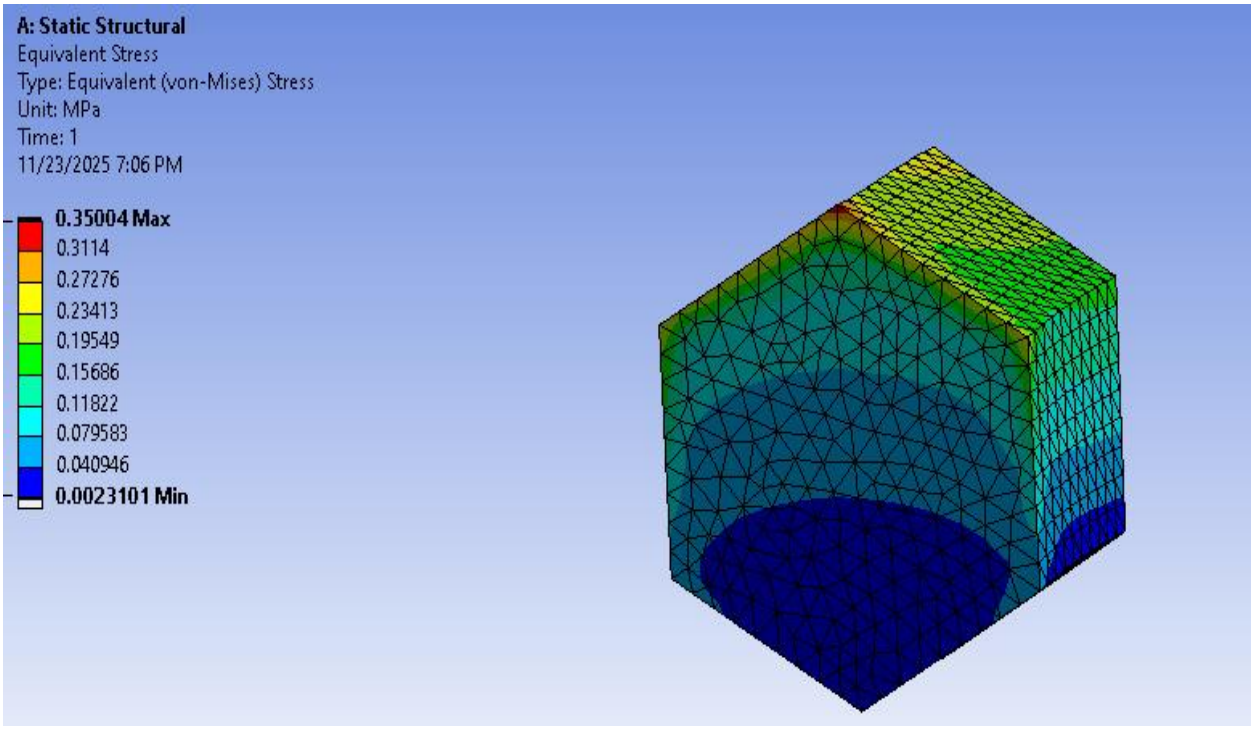


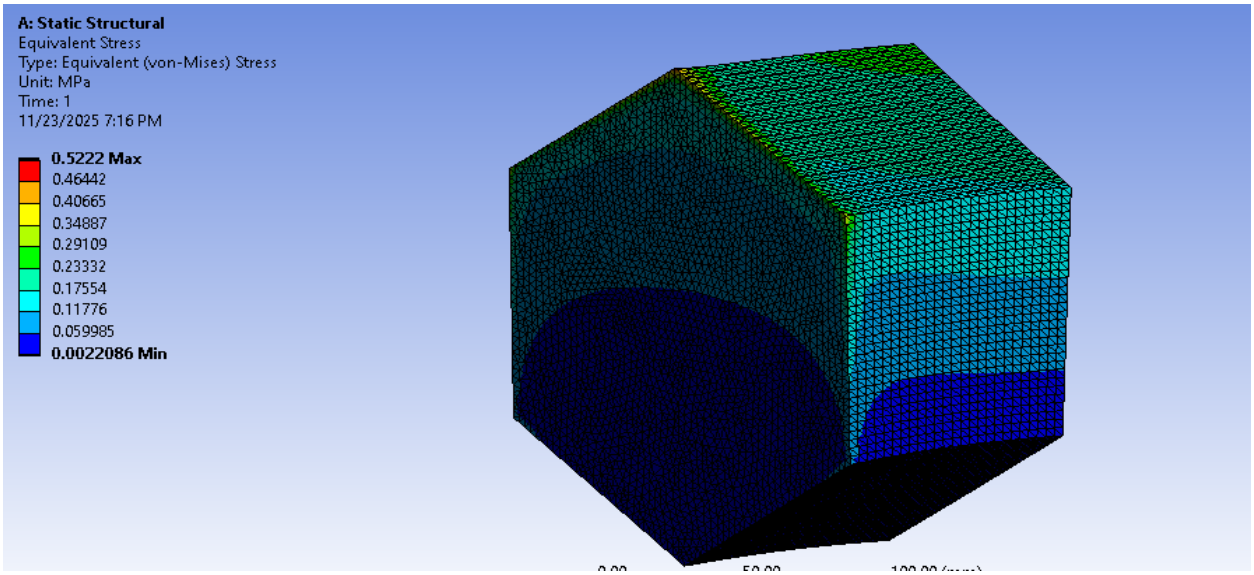



A: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1
11/23/2025 7:02 PM
0.28265 Max
0.25155
0.22045
0.18935
0.15825
0.12715
0.096049
0.064949
0.033849
0.0027486 Min


A: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1
11/23/2025 7:13 PM
0.58572 Max
0.52089
0.45605
0.39122
0.32639
0.26155
0.19672
0.13188
0.067051
0.0022169 Min


A: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1
11/23/2025 7:39 PM
0.47218 Max
0.41997
0.36776
0.31556
0.26335
0.21115
0.15894
0.10673
0.054527
0.0023214 Min
0.00
50.00
100.00 (mm)

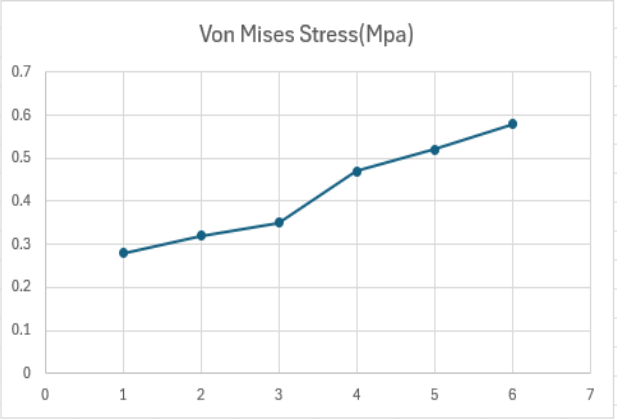

A: Static Structural
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 1
11/23/2025 7:06 PM
0.35004 Max
0.3114
0.27276
0.23413
0.19549
0.15686
0.11822
0.079583
0.040946
0.0023101 Min



1.5 Results Summary

The Static Structural simulation produced stress fields consistent with the applied force (2019 N) and material stiffness ($99,000 \text{ MPa}$). 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.

S.no	Von Mises Stress(Mpa)	Change %	Nodes	Elements
1	0.28	#VALUE!	1988	1047
2	0.32	0.14285714	3452	1875
3	0.35	0.09375	8168	4581
4	0.47	0.34285714	34829	19979
5	0.52	0.10638298	87475	50876
6	0.58	0.11538462	191640	112107



2. EXPLICIT DYNAMICS SIMULATION

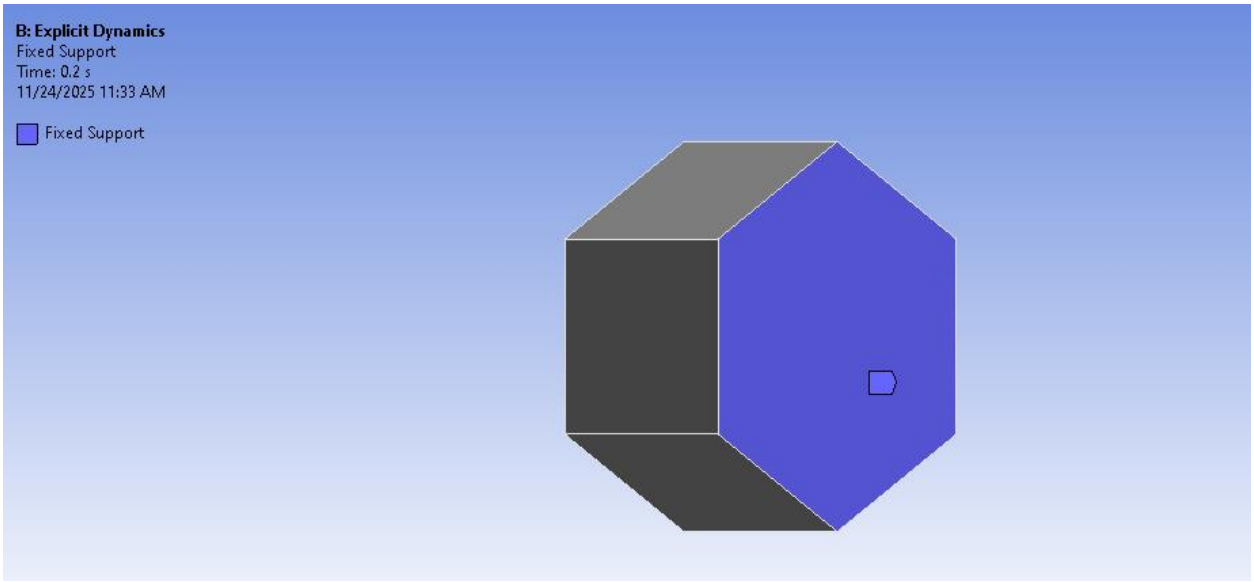
2.1 Initial Assumptions

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: **278 N**
- **Time Step: 0.2 seconds** (Mandatory Requirement)

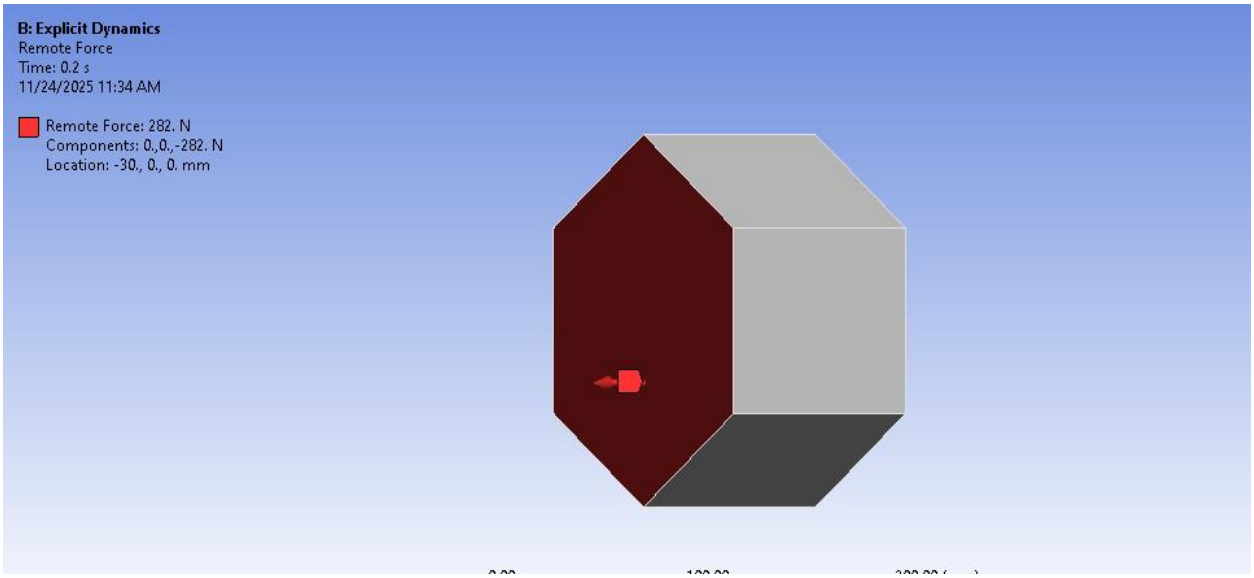
2.2 Fixed Support

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 278 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.



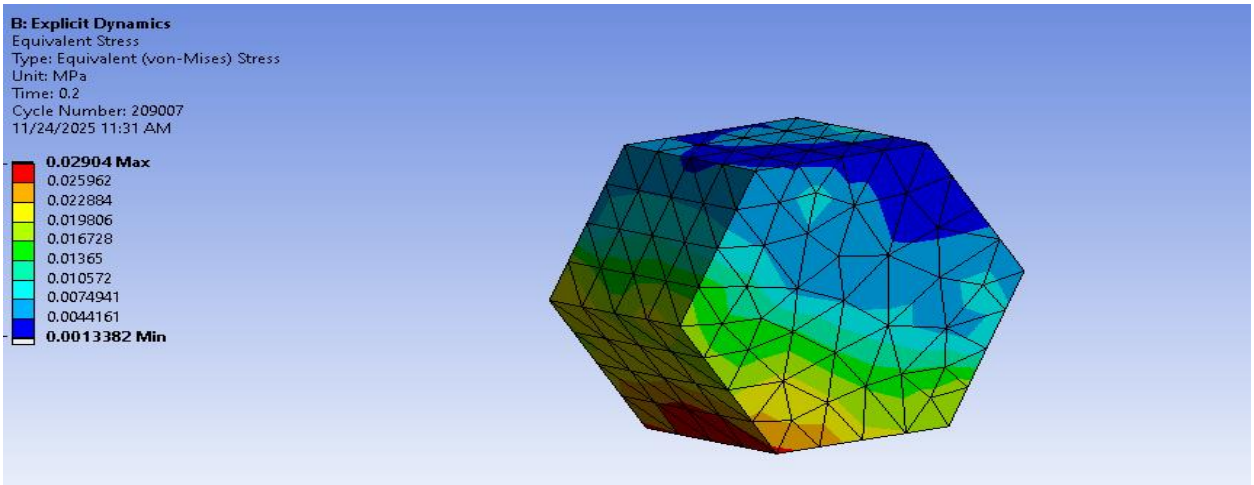
2.4 Time Step & Solver Settings

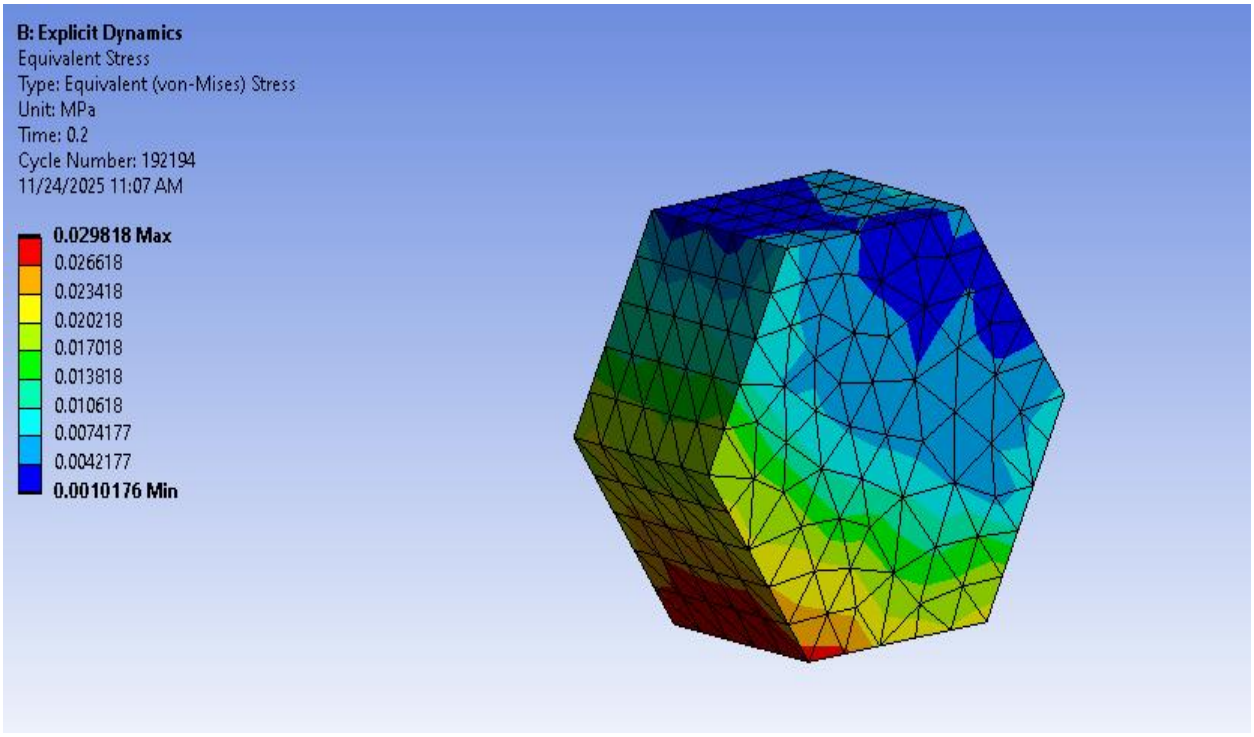
- **End Time:** Set sufficiently long to capture the response.
- **Time Step:** Manually controlled to **0.2 s** as per instructions.
- **Energy Error Handling:** If "Energy error too large" warnings occurred, the **Energy Reference Cycle** was adjusted (e.g., from 0.1 to 500) to stabilize the explicit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

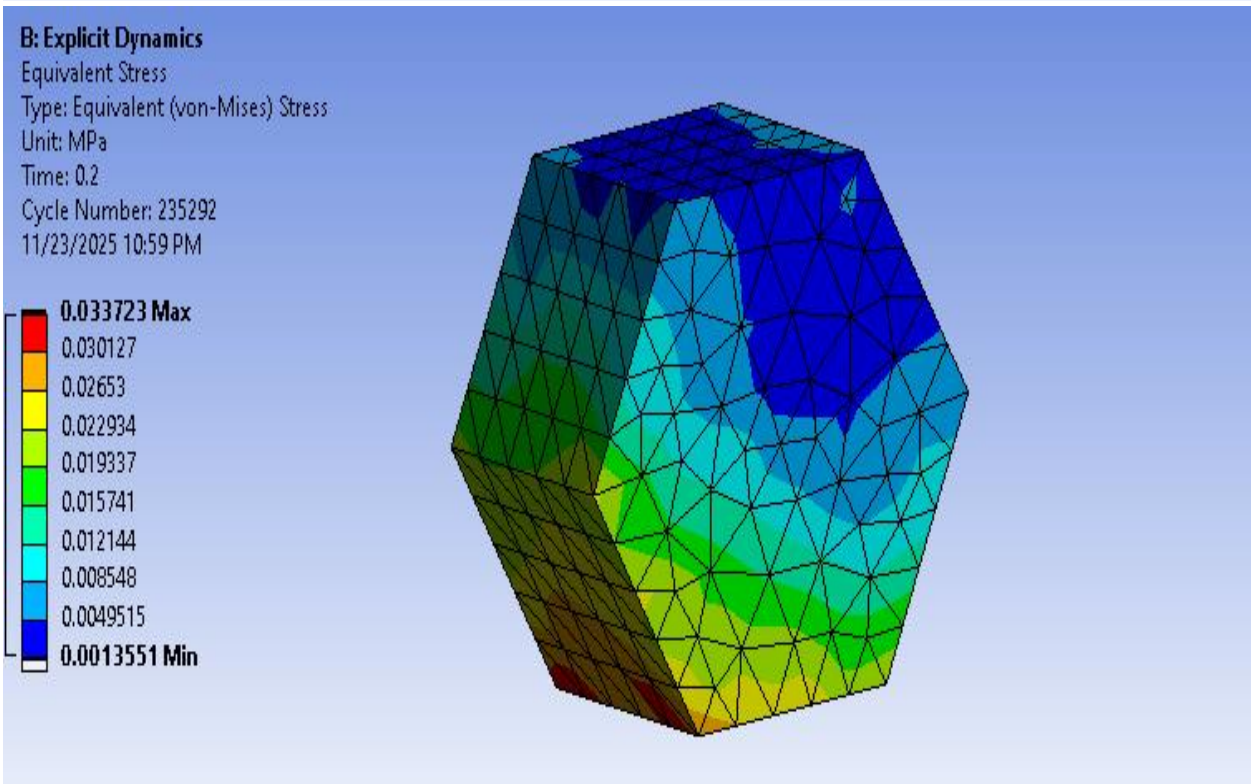
2.5 Results and Mesh Convergence

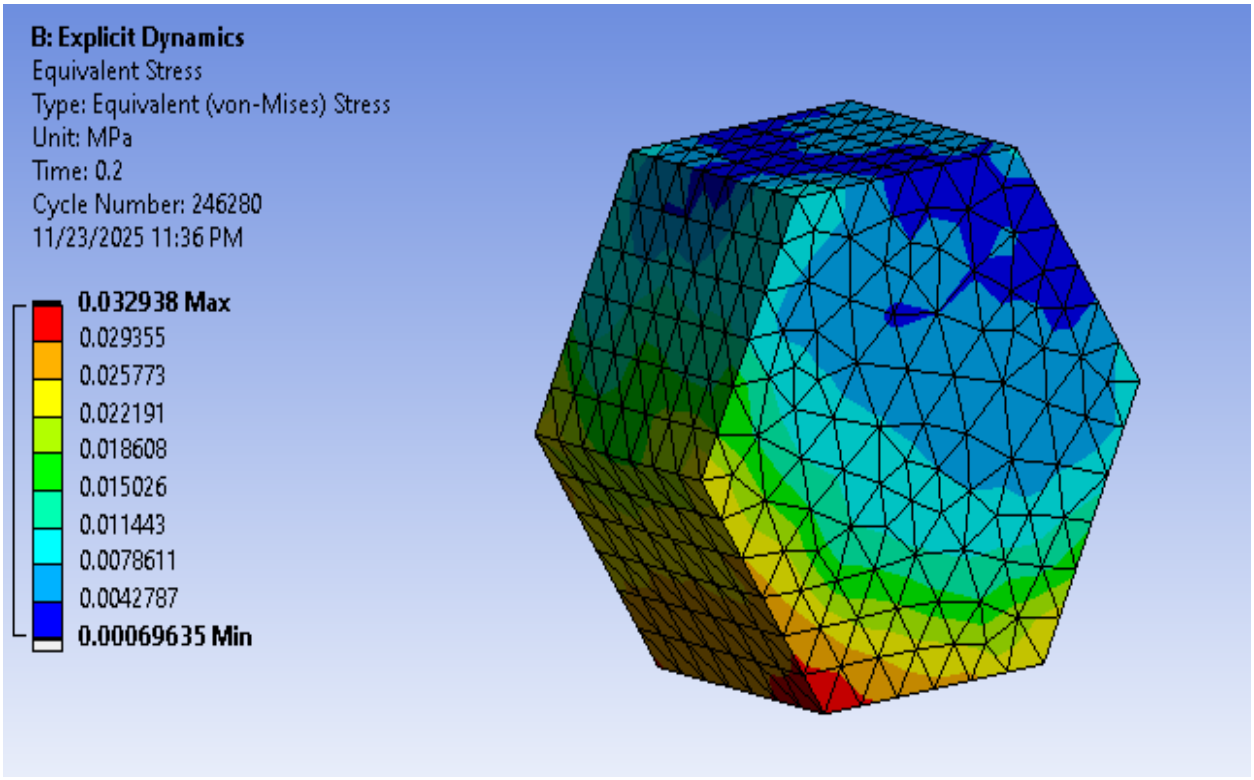
Stress and deformation results were extracted over the simulation time. The mesh convergence study was repeated for the dynamic case:

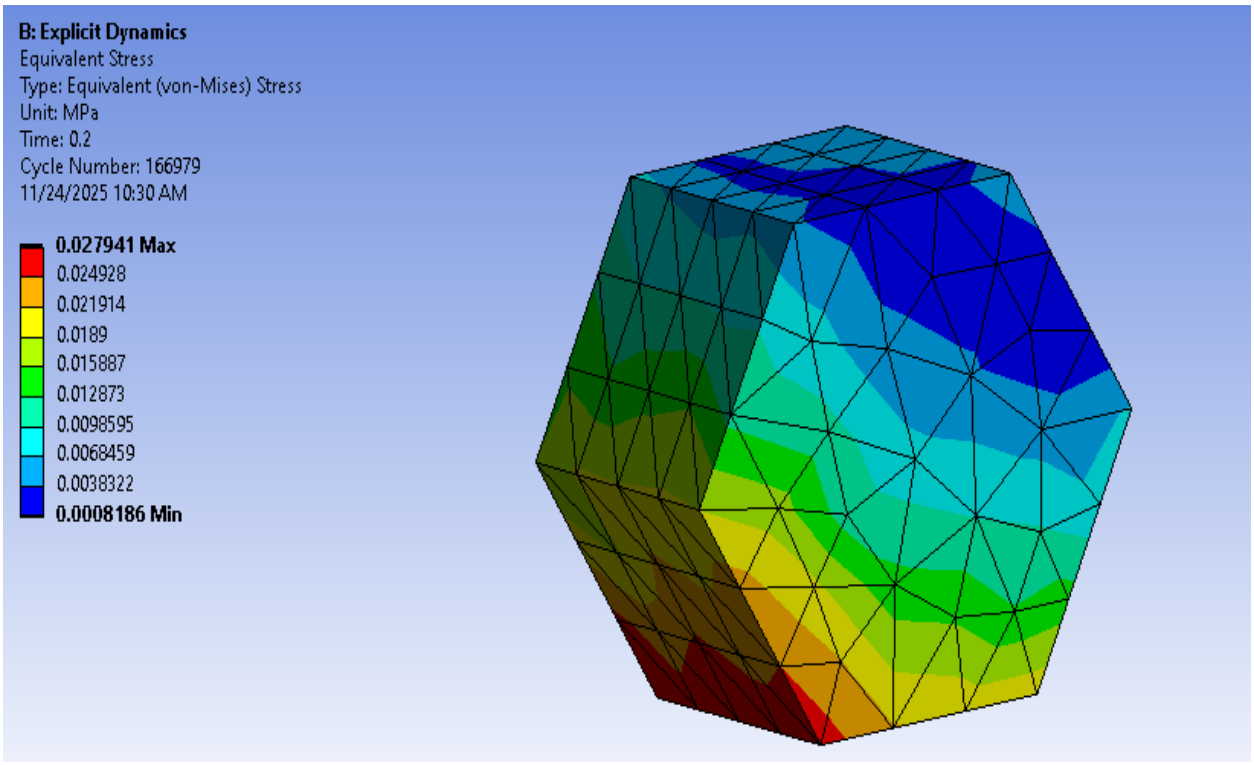
1. Simulation ran with decreasing mesh sizes (e.g., 20mm, 15mm).
2. **15 mm** was selected as the optimal mesh size to balance accuracy with the long solve times typical of Explicit Dynamics.

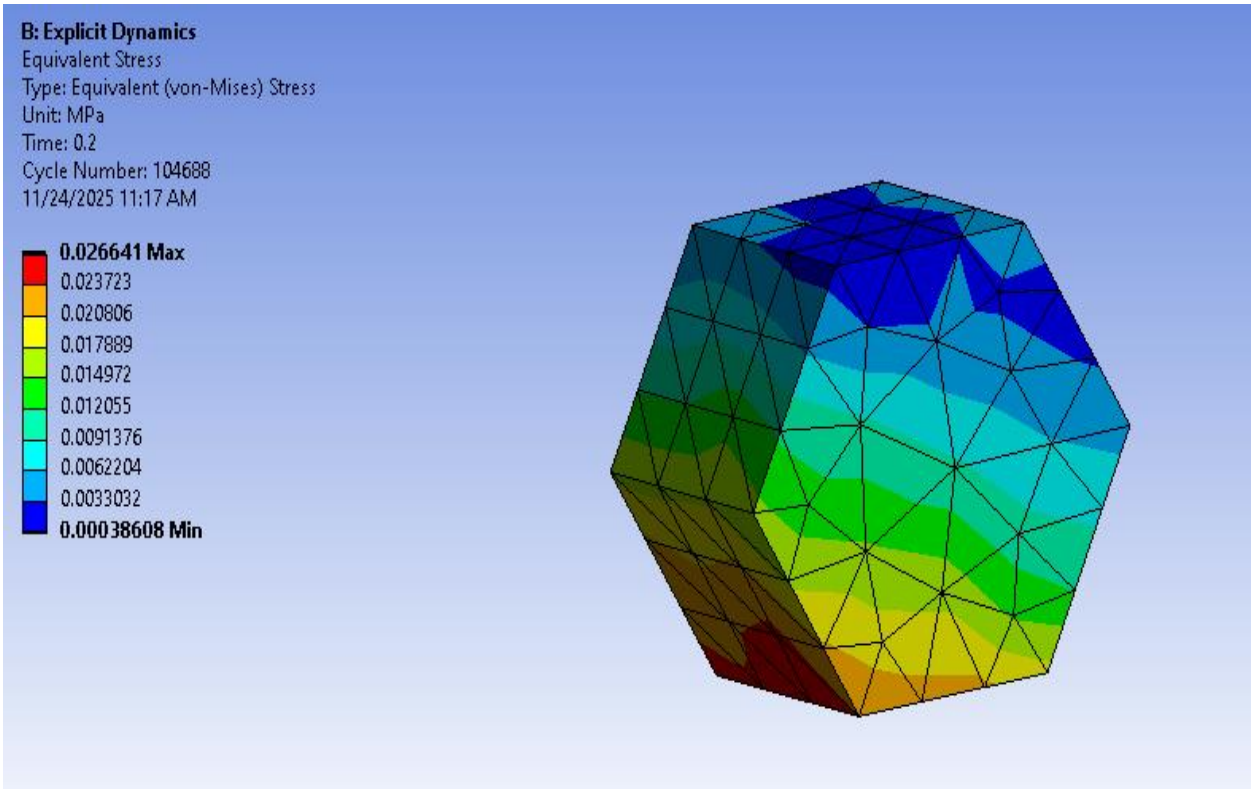



B: Explicit Dynamics
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 0.2
Cycle Number: 192194
11/24/2025 11:07 AM
0.029818 Max
0.026618
0.023418
0.020218
0.017018
0.013818
0.010618
0.0074177
0.0042177
0.0010176 Min


B: Explicit Dynamics
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 0.2
Cycle Number: 235292
11/23/2025 10:59 PM
0.033723 Max
0.030127
0.02653
0.022934
0.019337
0.015741
0.012144
0.008548
0.0049515
0.0013551 Min


B: Explicit Dynamics
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 0.2
Cycle Number: 246280
11/23/2025 11:36 PM
0.032938 Max
0.029355
0.025773
0.022191
0.018608
0.015026
0.011443
0.0078611
0.0042787
0.00069635 Min


B: Explicit Dynamics
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 0.2
Cycle Number: 166979
11/24/2025 10:30 AM
0.027941 Max
0.024928
0.021914
0.0189
0.015887
0.012873
0.0098595
0.0068459
0.0038322
0.0008186 Min



2.6 Result Summary

The simulation successfully captured the transient behavior of the hexagonal structure under the dynamic load of **278 N**. Due to the high stiffness (E = 99,000 \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