FINITE ELEMENT ANALYSIS
Final Lab Project

Analysis of a Hexagonal Solid Using Finite Element Method

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1. STATIC STRUCTURAL SIMULATION

1.1 Objective

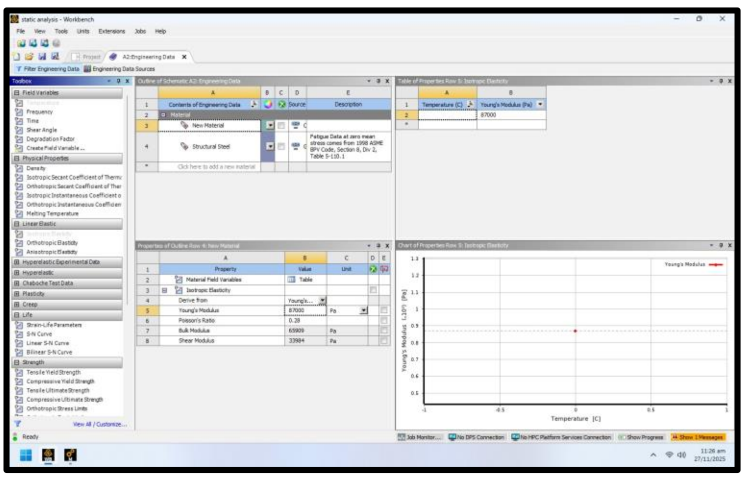
The objective of this static structural analysis is to investigate the stress distribution and structural response of a hexagonal beam subjected to an external static load using the Finite Element Method (FEM). The analysis aims to identify critical stress regions and verify whether the structure behaves as expected under cantilever loading conditions.

1.2 Static Structural Analysis Setup

A Static Structural analysis system was created in the simulation environment to evaluate the mechanical behavior of a hexagonal beam under steady loading. This type of analysis assumes that inertial and damping effects are negligible, making it suitable for evaluating stress and deformation under constant loads.

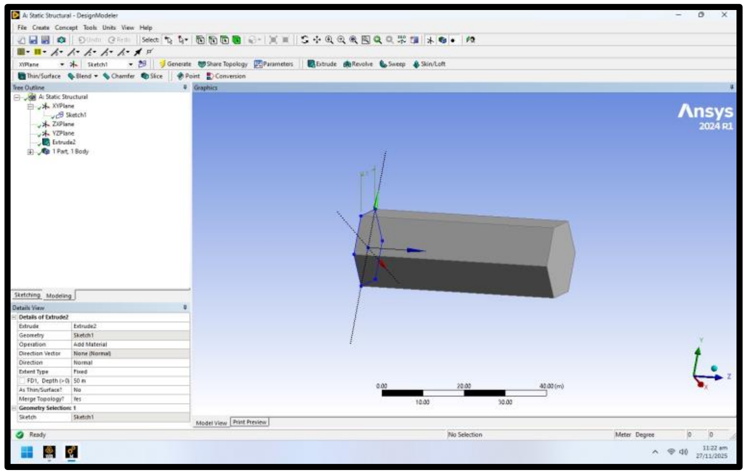
1.3 Material Definition (Engineering Data)

A new custom material was defined within the Engineering Data module. The material behavior was specified using a Linear Elastic and Isotropic Elasticity model. Mechanical properties such as Young's modulus and Poisson's ratio were entered to accurately describe the elastic response of the material within the operating stress range.



1.4 Geometry Creation (DesignModeler)

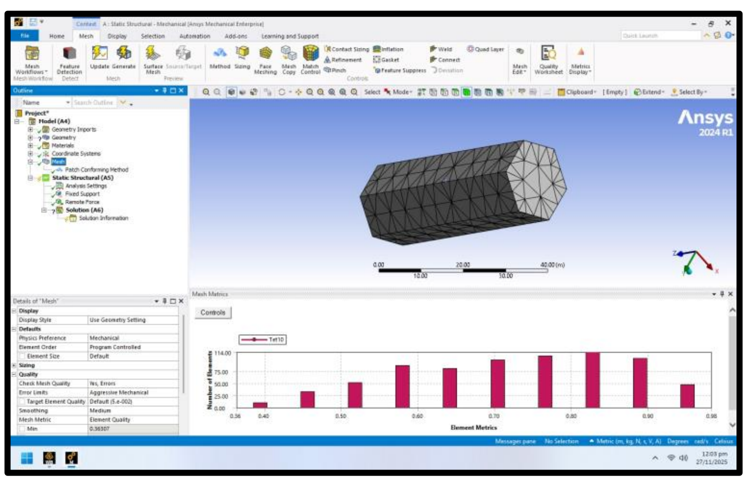
The geometric model of the beam was created in DesignModeler. The XY-plane was selected as the sketching plane, and a regular hexagonal cross-section was drawn using appropriate dimensions. The two-dimensional sketch was then extruded to a length of 50 m to generate a three-dimensional hexagonal beam.



1.5 Model Setup in Mechanical: Material Assignment and Meshing

After completing the geometry, the model was imported into the Mechanical environment. The previously defined custom material was assigned to the solid body. A tetrahedral mesh was generated to discretize the geometry into finite elements.

Tetrahedral elements were selected due to their ability to accurately mesh complex polygonal geometries such as a hexagonal cross-section. These elements automatically fill three-dimensional volumes and provide reliable accuracy for general structural analysis. Mesh quality checks were performed to ensure acceptable skewness, aspect ratio, and element shape.



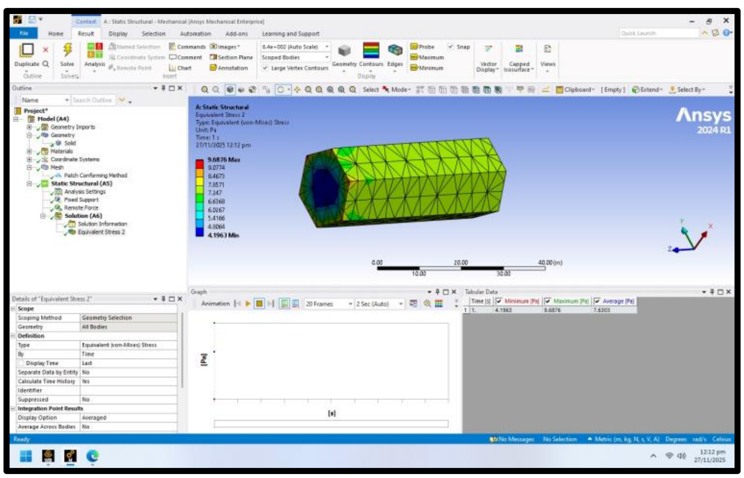
1.6 Boundary Conditions and Loading

To simulate cantilever conditions, one end of the hexagonal beam was constrained using a Fixed Support, restricting all translational and rotational degrees of freedom. A Remote Force of 2018 N was applied at a point located one-third of the beam length from the fixed end, approximately 16.66 m along the beam axis.

The use of a remote force allows the load to be applied at a specific spatial location without requiring physical geometry at that point, ensuring accurate representation of the applied loading condition.

1.7 Stress Evaluation (Equivalent Stress)

A von Mises equivalent stress result was inserted to evaluate the combined stress state within the hexagonal beam. This criterion is commonly used for ductile materials to assess the likelihood of yielding under complex loading conditions.



1.8 Summary of Static Results

The stress distribution obtained from the static analysis exhibited behavior typical of a cantilever beam. Maximum stress values were observed near the fixed support, where bending moments are highest. Stress magnitude gradually decreased toward the free end of the beam. The stress pattern across the hexagonal cross-section reflected the geometry and applied load direction.

2. TRANSIENT (IMPLICIT) STRUCTURAL SIMULATION

2.1 Objective

The objective of the transient structural analysis is to study the time-dependent stress and deformation response of a hexagonal beam subjected to sequentially applied forces. This analysis captures the effect of varying loads over time, which cannot be evaluated using static analysis alone.

2.2 Transient Structural Analysis Setup

A Transient Structural analysis system was initiated to evaluate the dynamic response of the beam under time-varying loading conditions. The implicit solver formulation was used to ensure numerical stability during the simulation.

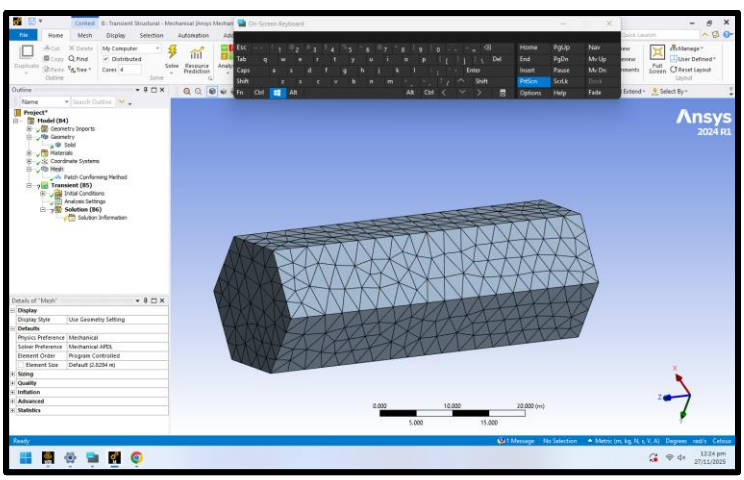
2.3 Geometry Definition

The same hexagonal beam geometry used in the static structural analysis was employed in the transient analysis to ensure consistent comparison of results.

2.4 Meshing in Mechanical

Material assignment and meshing were performed in the Mechanical environment. A tetrahedral mesh was generated to accurately capture stress concentrations at the edges and corners of the hexagonal geometry.

Mesh quality metrics such as skewness, Jacobian, and aspect ratio were checked to ensure that the mesh met acceptable numerical standards.



2.5 Time Step Definition

Within the analysis settings, the time step size was defined as 0.2 seconds. This time increment allowed the solver to capture the sequential application of forces while maintaining computational efficiency.

2.6 Boundary Conditions and Force Application

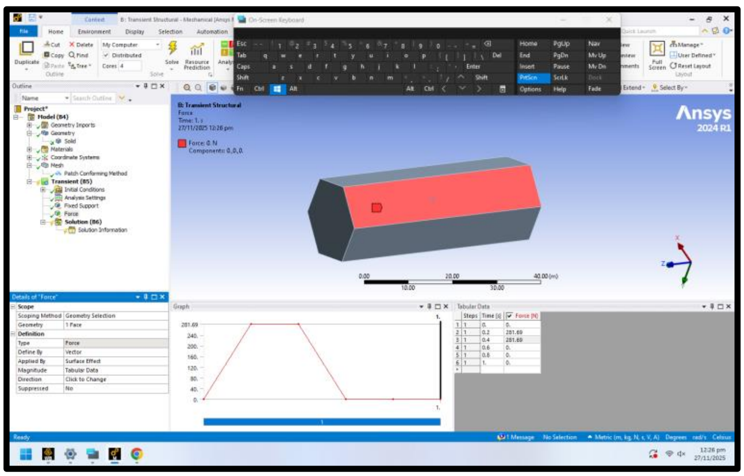
One end of the beam was constrained using a Fixed Support, similar to the static analysis. A force of 281.69 N was applied to each face of the hexagonal cross-section using time-dependent tabular data.

2.7 Time-Dependent Force Definition

Each face of the hexagon was subjected to the same force magnitude, but at staggered time intervals to simulate sequential loading. The loading schedule was defined as follows:

• Face 1: 0.2 – 0.4 s
• Face 2: 0.4 – 0.6 s
• Face 3: 0.6 – 0.8 s
• Face 4: 0.8 – 1.0 s

Outside the specified intervals, the applied force was set to 0 N. This loading strategy produced a progressive or rotating load effect around the hexagonal beam.

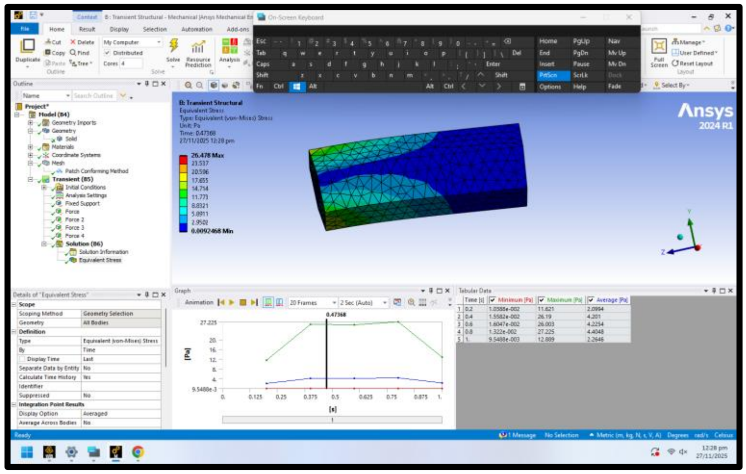


2.8 Result Evaluation: Stress and Deformation

The primary output quantities examined in the transient analysis included equivalent (von Mises) stress and total deformation. These results provided insight into how the structure responded to time-varying loads.

2.9 Summary of Transient Results

The transient analysis results showed that peak stresses occurred on individual faces during their respective loading intervals. Stress concentrations remained highest near the fixed support due to combined bending and shear effects. Total deformation increased incrementally as each face was loaded, demonstrating the expected time-dependent structural response.



3. CONCLUSION

The finite element analysis of the hexagonal beam successfully demonstrated both static and transient structural behavior. The results were consistent with theoretical expectations for a cantilever beam and confirmed the accuracy of the numerical model. Mesh convergence verification further ensured solution reliability, highlighting the effectiveness of FEM for analyzing complex polygonal geometries under static and time-dependent loading conditions.