# Compressive Deformation of Honeycomb Structure: A Discrete Simulation Approach

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# Background

1. Low weight-to-strength ratio
2. High energy absorption capacity
3. Cost-effective and crashworthy

**Applications**

- Shock absorbers in **airplanes** and **high-speed trains**
- Absorbs energy during crashes via **plastic strain energy**

**Impact Effectiveness**

- Superior performance in **out-of-plane impact**
- Effective energy absorption through **compressive strokes**

- Outstanding mechanical properties with reduced material usage
- Widely adopted in numerous promising applications in the fields of:
    - Architecture
    - Aerospace
    - Medical implant
    - 3d printing

# Project overview

## Goal:

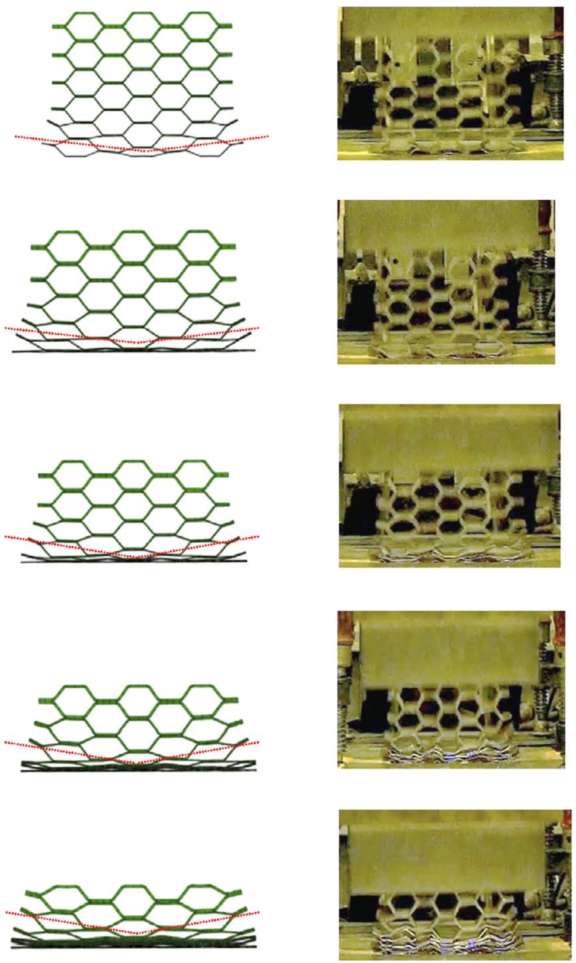
- Simulate the **compressive deformation** of honeycomb structures using a discrete simulation approach.
- Analyze the mechanical behavior of honeycomb structures under **various applied loads**.

## Method:

- Based on **2D** discrete elastic beam model.
- Implicit solution using Newton-Raphson scheme.

## Assumption:

- Uniform density (and other mechanical properties) throughout the structure.
- Negligible viscous damping from air.
- External forces are applied **gradually** to simulate compression.

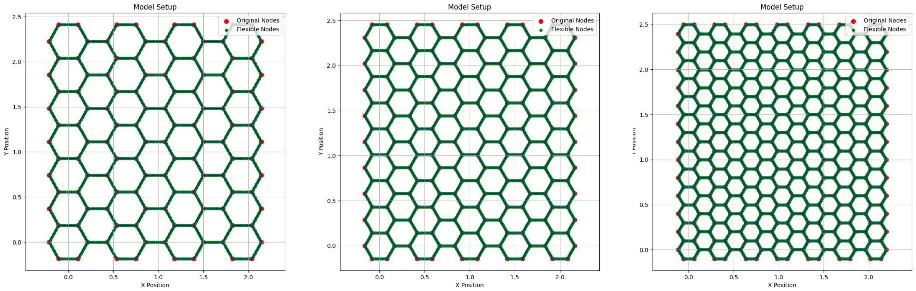


Compression test on honeycomb structure (Galehdari et al.)

# Model setup

## Helper functions:

- generate_hexagonal_nodes(rows, cols, edge_length)
- generate_rods(sorted_nodes, rows, cols)
- generate_flexible_nodes(rods, structure_nodes, nv_rod)




- calculate_curvature(connections, nodes): store the initial curvature for each main node in the honeycomb structure.

## Simulation parameters:

- Time Step: dt = $1 \times 10^{-3}$ seconds
- Total Time: 2 seconds

## Material properties:

- Density: 7000 $kg/m^3$ (typical for metals)
- Total mass: 20 kg
- Young's modulus (E): 300 GPa

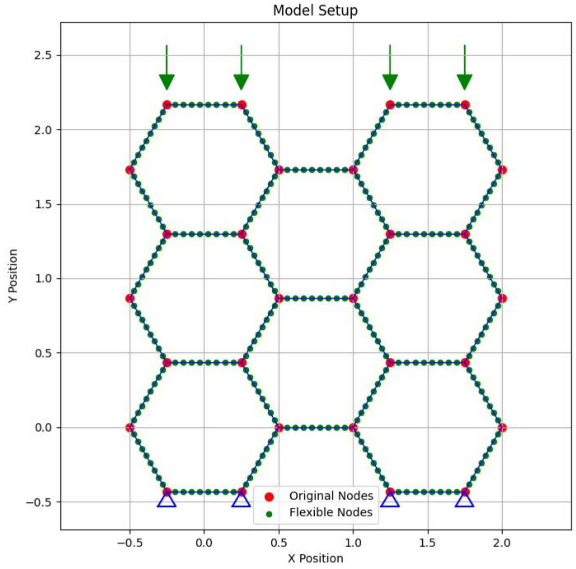
## Boundary Conditions:

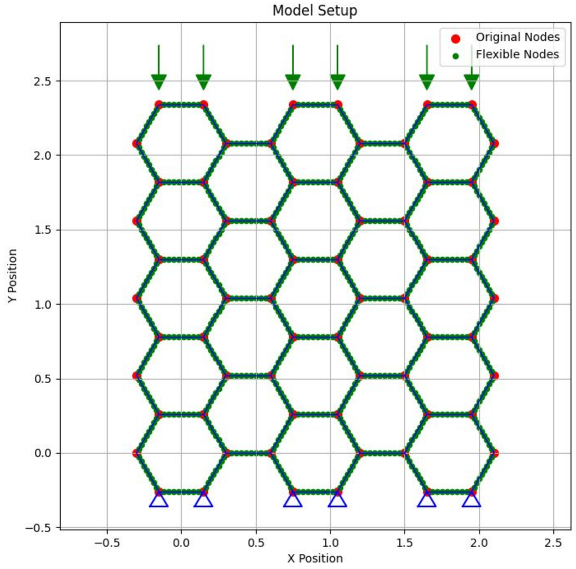
- Bottom nodes are pined

## Loading:

- Total maximum load: -20 kN (downward)
- Load is distributed evenly across top nodes
- Force increases linearly with time (starts from 0 and reaches the maximum in the end)

# Model setup


Model Setup
Original Nodes
Flexible Nodes
X Position
Y Position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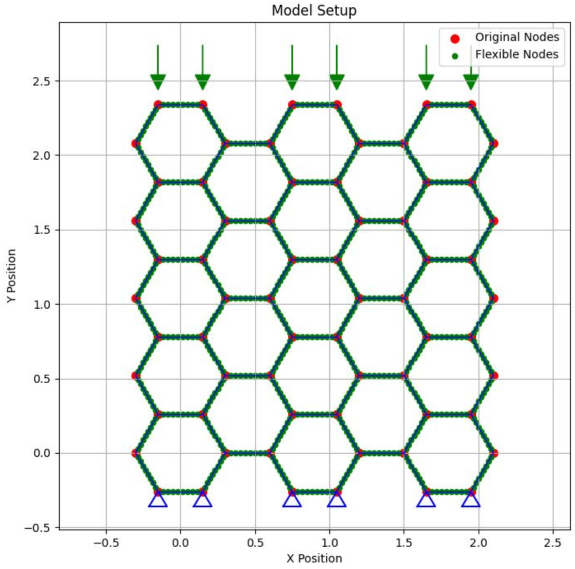
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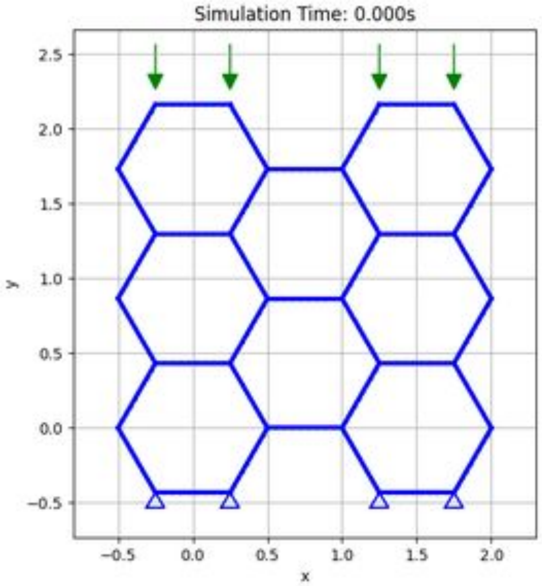
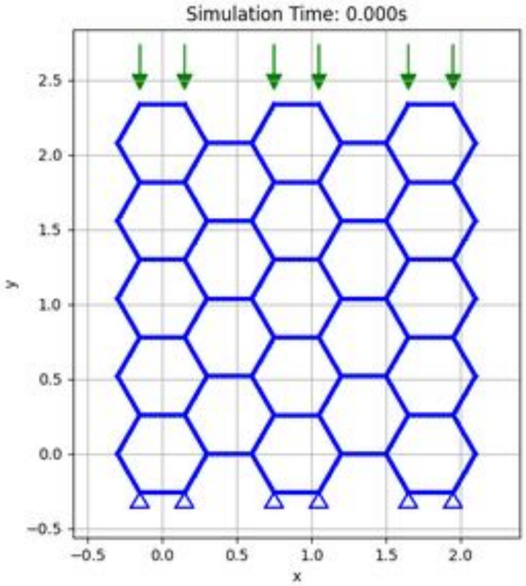
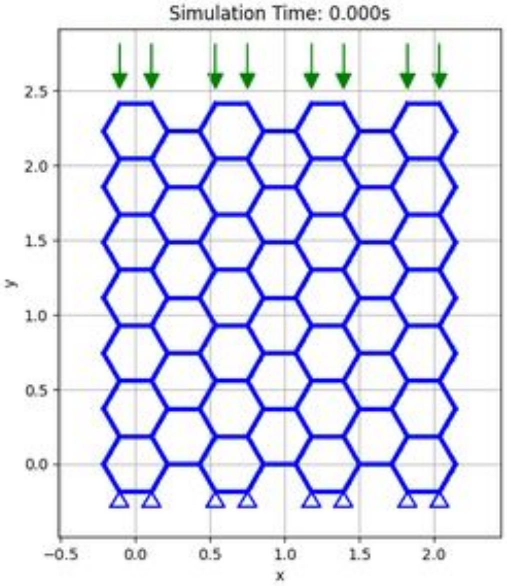
# Simulation results



# Simulation results

We also played with some different loadings...

# Final analysis

1. Final compressed ratio vs. Cell counts (for a given total weight, it seems that more cells means more strength)
2. We only tested a limited number of models, not enough to get a strong conclusion
3. Future work could involve improving code efficiency(it’s taking really long to run one larger than 7*7)

# Reference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