Midterm Report of deformation behavior of hexagonal

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***Abstract*—This report presents the development and implementation of a numerical simulation to study the deformation behavior of hexagonal lattice structures under external loads. The dynamic time step method was used to model the mechanical response of the structure. It includes the generation of hexagonal lattice geometry, the definition of mechanical properties, the establishment of motion equations, and the realization of numerical solutions. We hope to learn the mechanical properties and contribute to the design of elastic materials.**

I. INTRODUCTION

Hexagonal lattice structures are widely used in various engineering applications due to their high strength-to-weight ratio and efficient material distribution[1]. Understanding the mechanical behavior of such structures under external loads is critical for designing elastic and lightweight materials, especially in the aerospace, mechanical and civil engineering fields.

In this project, the goal is to study the deformation of hexagonal lattice structures. Due to its unique mechanical properties and excellent energy absorption capacity, hexagonal lattices not only have high strength and ductility, but also exhibit excellent impact resistance in complex dynamic environments[2], providing an ideal model for the design of high-performance elastic materials.

In this study, the deformation behavior of hexagonal lattice structures under applied loads is studied from the perspective of engineering. We simplified the structural model to a hexagonal frame. The deformation characteristics of hexagonal lattice structures under load are studied by computer simulation. By simulating and analyzing the deformation characteristics of hexagonal lattice structures under load conditions, we hope to understand the mechanical properties of hexagonal lattice structures and contribute to the design of advanced elastic materials[3].

II. CURRENT PROGRESS

Figure 1 below is the initial state of the simulation.

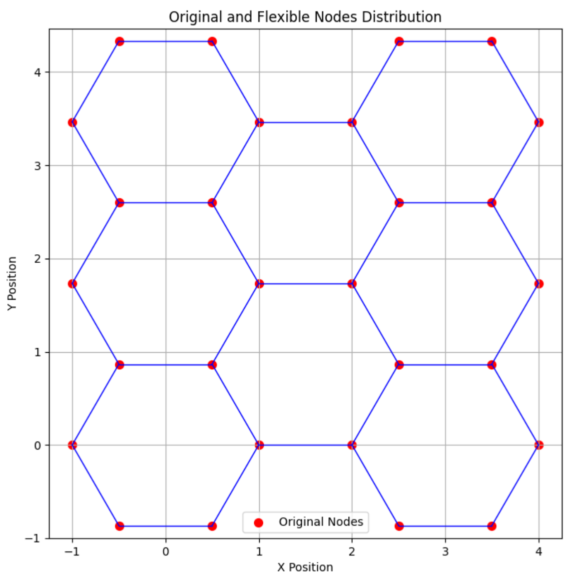

Fig. 1 Initial state of the simulation

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The simulation generates a hexagonal lattice structure composed of rods. All rods have the same physical properties. These rods connect nodes to form the overall structure, while there are also rods that connect the vertices of hexagons to the centers of adjacent units, enhancing the structural network. The length of each rod is 0.5 meters. The structure is subject to gravity and additional downward loads, and nodes at the bottom are fixed to simulate anchoring conditions.

At the same time, we set the boundary condition that the bottom 4 points of the entire model are fixed, and the entire model has a downward load in the upper left corner and the upper right corner.

The state of the simulation(At t=0.02s) is shown below:

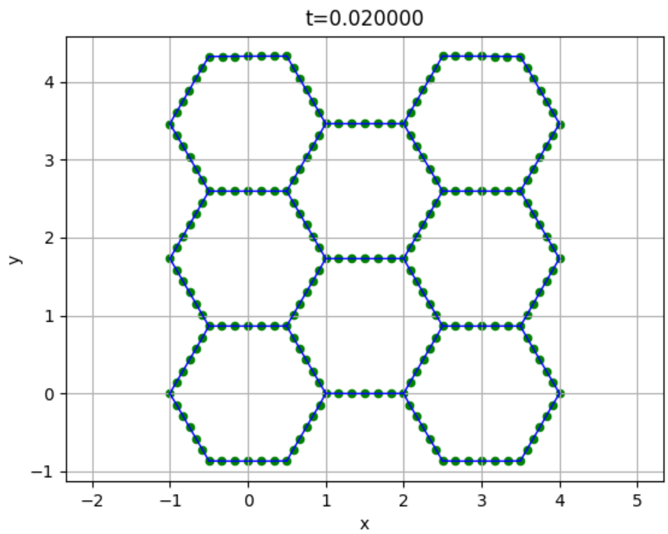

Fig. 2 State of the simulation at t=0.02s

The state of the simulation(At t=0.05s) is shown below:

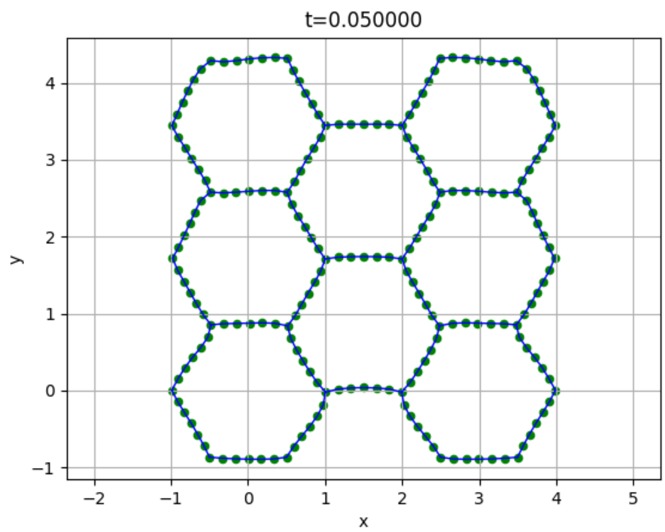

Fig. 3 State of the simulation at t=0.05s

The final state of the simulation is shown below:

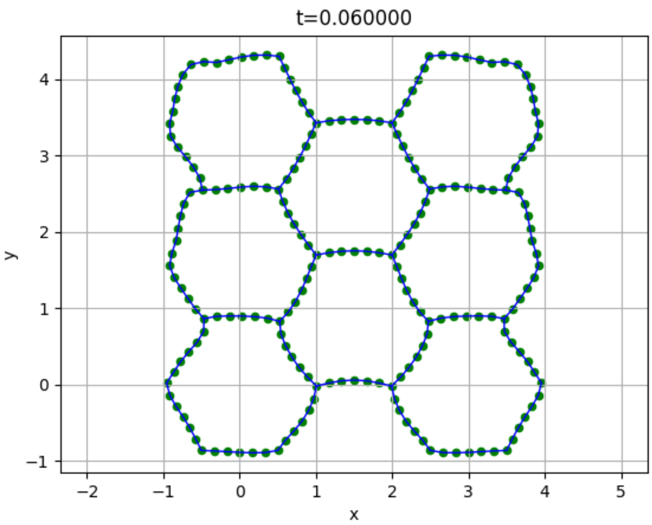

Fig. 4 Final state of the simulation

In this simulation, the time interval is 0.06 seconds and delta_t = 0.005s. The mechanical model of bending and axial deformation is calculated as follows:

Curvature at node k is:

$$K = 2\tan(\frac{\theta_k}{2}) / l_k \tag{1.1}$$

Simple geometry:

$$R_k = \frac{dl}{2\tan(\phi_k / 2)} \tag{1.2}$$

$$\phi_k = \tan^{-1}\frac{(e^{k-1}\times e^k)\cdot \hat{e_z}}{e^{k-1}\cdot e^k} \tag{1.3}$$

For naturally curved beam:

$$E_b = \sum_{k=2}^{N-1} E_{b,k} \tag{1.4}$$

where $E_{b,k} = \frac{1}{2}\frac{EI}{dl}(K_k - K_k^0)^2$, $K_k = 2\tan(\phi_k / 2)$

Total elastic stretching energy:

$$E_s = \sum_{k=1}^{N-1} E_s^k \tag{1.5}$$

Stretching energy per edge:

$$E_s^k = \frac{1}{2}EA\varepsilon^2 dl \tag{1.6}$$

Axial stretch:

$$\varepsilon = 1 - \frac{\sqrt{(x_{k+1}-x_k)^2 + (y_{k+1}-y_k)^2}}{dl} \tag{1.7}$$

We built a larger model of the 6-sided shape composition

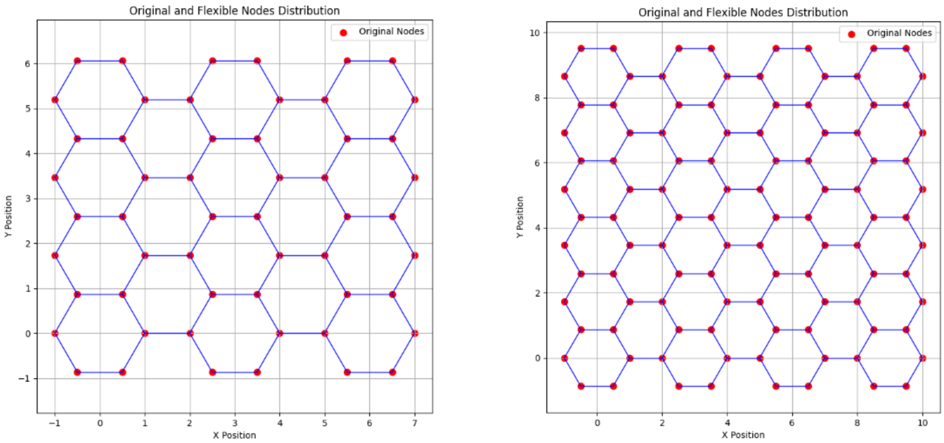

Fig. 5 Larger model

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