Analysis of Internal Forces and Deflections in Roof Trusses using the Finite Element Method

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Abstract—This project implements a computational framework for analyzing internal forces and deflections in 2D roof truss systems using Finite Element Method (FEM) through MATLAB programming and ANSYS Mechanical validation. The study focuses on a double-link truss configuration with 19 beam elements and 11 nodes, analyzing Euler-Bernoulli beam formulations.

I. INTRODUCTION

Structural analysis of roof trusses is a critical aspect of civil and mechanical engineering, essential for ensuring the safety, efficiency, and longevity of buildings and infrastructure. Traditional methods of truss analysis often rely on simplifying assumptions that may not capture the full complexity of structural behavior, especially under varied loading conditions. The Finite Element Method (FEM) has emerged as a powerful tool to address these limitations, offering a more comprehensive and accurate approach to structural analysis.

This project focuses on the application of FEM to analyze 2D roof trusses, specifically targeting the modeling of internal forces and deflections using beam elements. By leveraging computational methods, we aim to gain deeper insights into the structural behavior of trusses, which are fundamental components in many architectural and engineering designs.

II. OBJECTIVES

- Formulate element stiffness matrices for 2D beam elements considering Euler-Bernoulli beam theory.
- Implement the Direct Stiffness Method to:
  - Assemble global stiffness matrix from elemental contributions
  - Apply boundary conditions and solve for nodal displacements
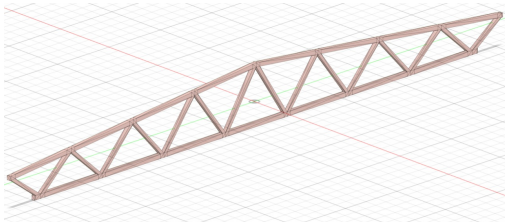

Fig. 1. Schematic of the truss

- Calculate internal force distributions through post-processing
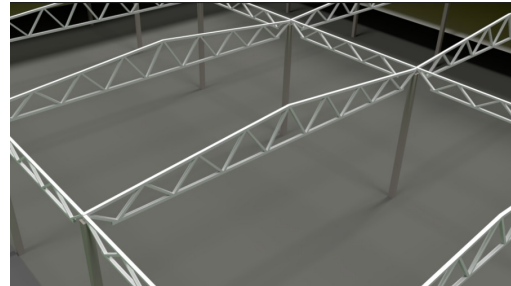- Validation of results using ANSYS Mechanical

Fig. 2. Schematic of the truss

III. METHODOLOGY

- **Literature Review**
  - Comprehensive study of FEM principles and beam theories
  - Critical review of truss analysis methodologies
  - Survey of existing implementations in structural mechanics
- **Model Development**
  - MATLAB script development for:
    * Formulation of 2D beam element stiffness matrices for Euler-Bernoulli beam theory
    * Implementation of Direct Stiffness Method framework
- **Analysis Implementation**
  - Application to 2D roof truss configurations
  - Computation of:
    * Nodal displacements
    * Element forces (axial, shear, bending)
    * Stress distributions
- **Validation & Comparison**
  - Cross-validation with **ANSYS** simulations
- **Result Interpretation**
  - Structural behavior analysis under various loads
  - Critical assessment of modeling approaches
  - Practical recommendations for truss design