SELF DESIGNED EXPERIMENT

ME 218 - S2 **Solid Mechanics Lab** **Group 7**

Experiment documentation

Aim of the experiment:

This experiment aims to rigorously examine the fundamental principles governing truss structures and material behaviour by conducting experiments on 2D truss systems.

Objective:

The primary objectives are to verify truss theory, assess the applicability of Hooke's Law, investigate the existence of zero force members, and compare the structural strength and deformation characteristics of various truss designs.

Theory-

A **truss** is a structure that consists of a collection of structural elements connected at pin joints or nodes. In theory, the pin joints provide no rotational resistance and behave as hinges. The benefit of a truss is that the members are predominantly axially loaded. This means they are either in compression, tension or have no force, so-called zero-force members. This makes trusses a particularly efficient structural form.This leads to the second assumption; the members within a truss are subject to axial loads only, tension, compression or no force. Provided all external loads are applied at joints, then no bending will be induced within any of the members. The two common methods of analysis of trusses are the method of joint and the method of section. Using them axial forces in different members can be found.Zero force members are component members of a truss where there is no compression or tension on the member. These members provide stability to the entire truss in general, even if they are not actively going through any tension or compression.

Hooke's law states that the strain of the material is proportional to the applied stress within the elastic limit of that material. The law helps in predicting the behaviour of certain materials when they undergo stress.

The basic concept of **Digital Image Correlation** is to compare two images of a component before and after deformation. Displacements and strains are determined by correlating the position of pixel subsets or blocks in the original and deformed image, normally based upon contrast.
The main advantage of the technique is suited to any kind of image as long as the deformation causes a contrast change in the digital pixels of the image before and after deformation.

The technique begins with a picture before loading(reference image) and then a series of pictures are taken during the deformation process and then these images are compared to detect displacements by searching a matched point from one image to another. Since it is not possible to find matched point using single pixel, we take area of multiple pixel points called as subset.
A cross correlation criterion quantifies the similarity of a particular region in the deformed image to that of the subset by searching the peak position of distribution. Once correlation coefficient extremum is detected, the position of deformed subset is determined.

Solution of the constructed truss:

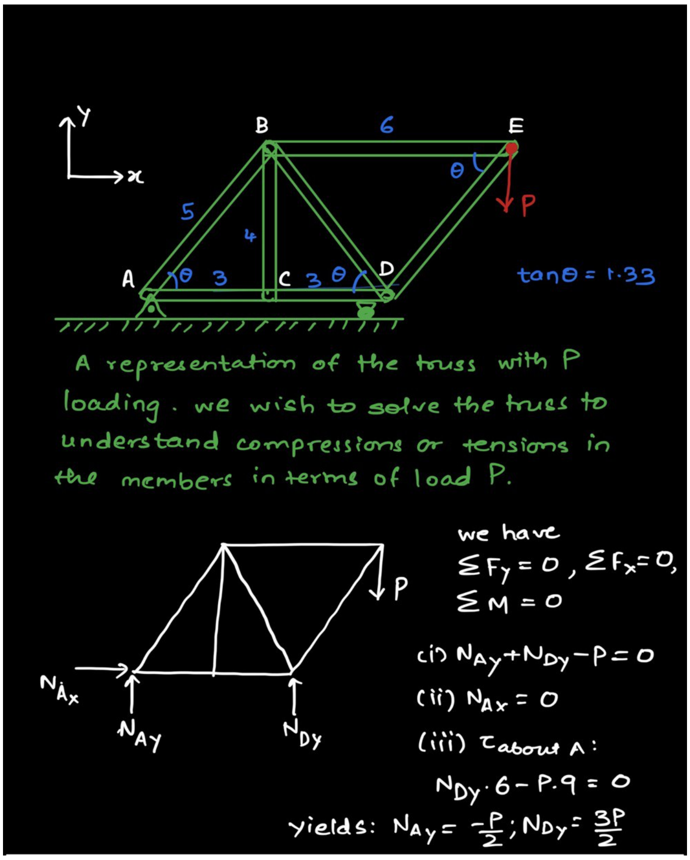


Figure 1

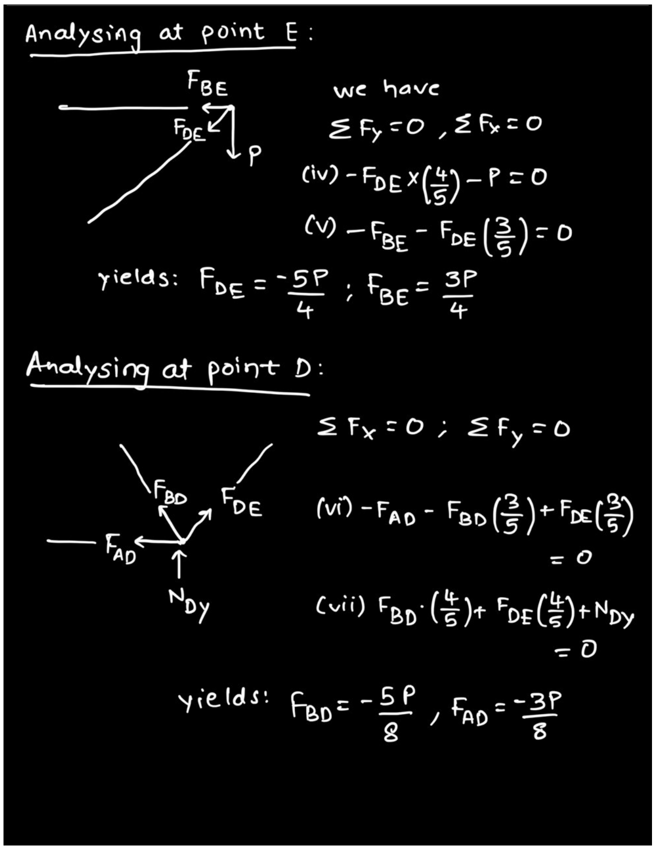
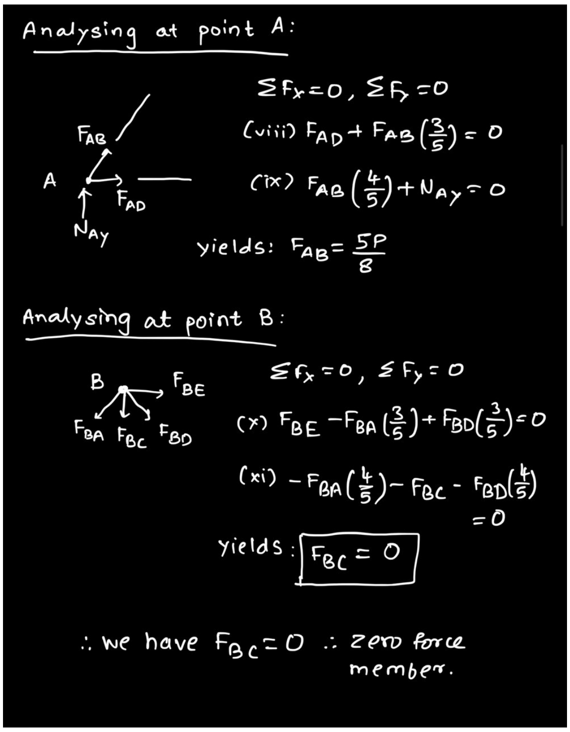


Figure 2



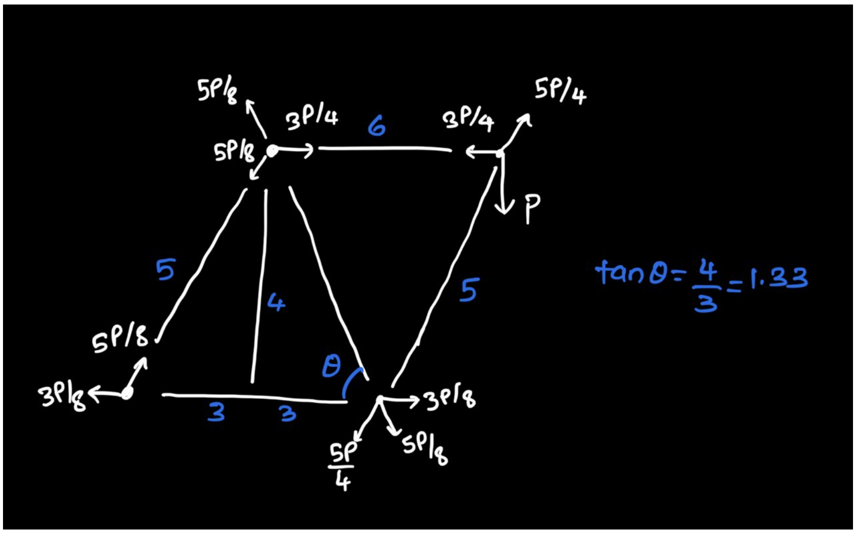


Figure 4 - Final Truss Forces

Figure 3

Thus, we've identified the zero force member. Since force = 0 at F_BC, we conclude strain = 0 by Hooke's law.

Procedure:

1. Preparation of truss :-

A CAD Model was prepared on Solidworks using the required geometry choosing ABS as the material.

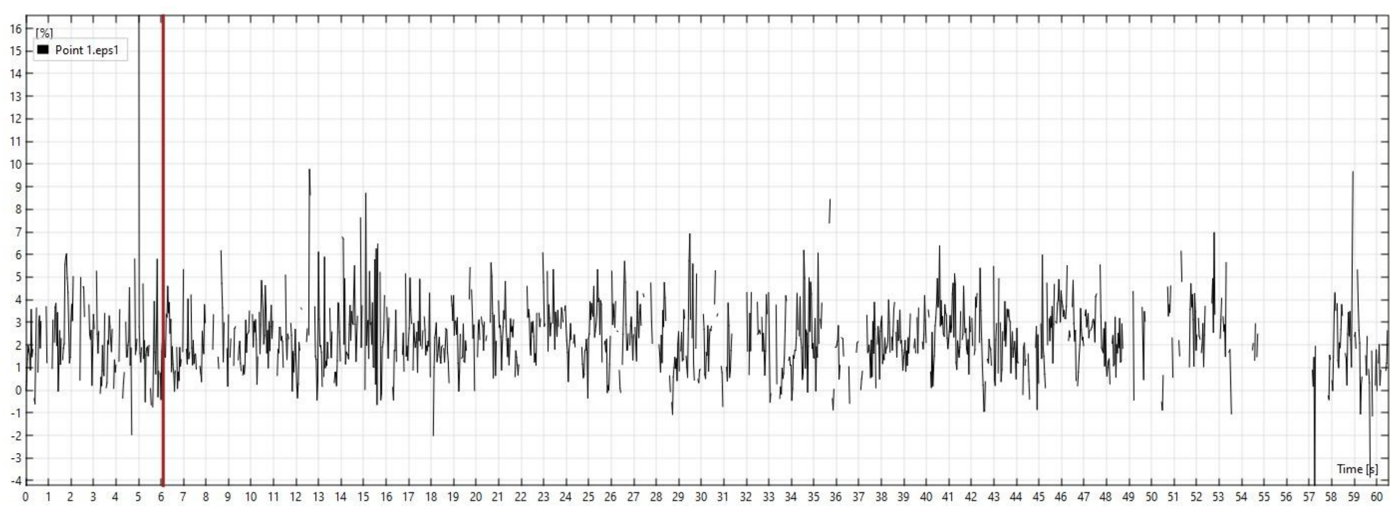
The ABS beams were 3D printed following dimensions then assembled using nuts and bolts to allow free rotation across joints. After that the castor wheel was attached to one end with the help of an L shaped joint to ensure simply supported conditions.

The Aluminum plate was cut into 6 members of following dimensions using a wire EDM machine and then assembled using nuts and bolts to allow free rotation across joints and hence Aluminium truss was made.

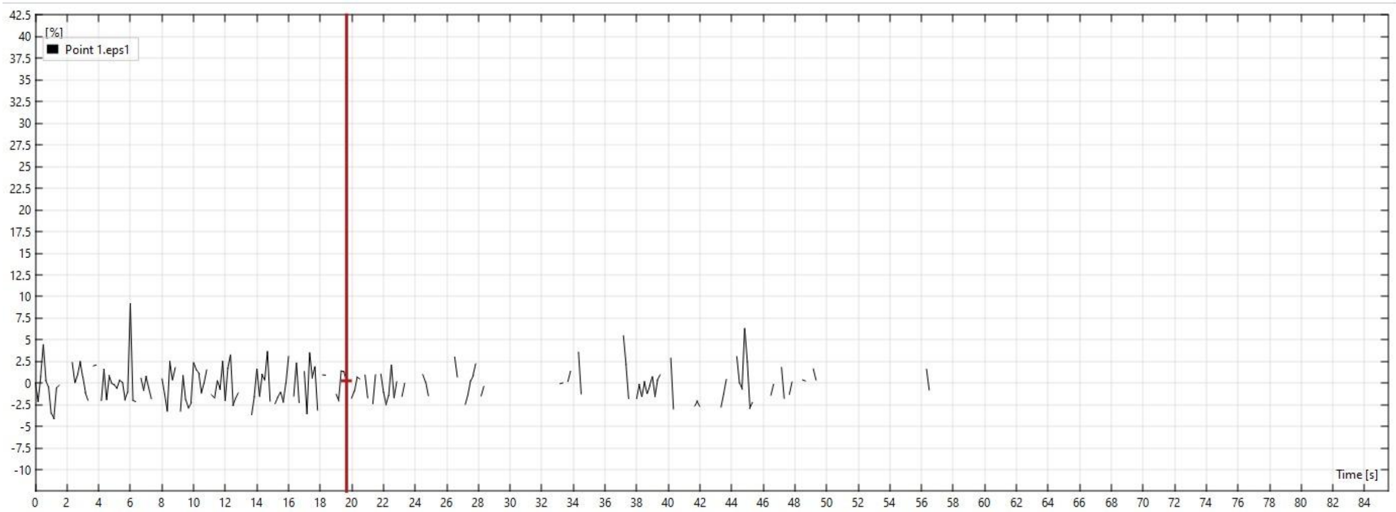
2. DIC :-
A speckle pattern was sprayed on the 3D-printed ABS Truss using white paint. The phone was kept fixed using a tripod stand. Setting up the aperture range such that we obtained the lowest possible f-number to allow maximum entry of light, a non-deformed image was clicked. The truss was then subjected to loads varying from 2 to 7 kgs and the deformed images were clicked. The images were uploaded into Gom correlate software to get displacement in pixels. Using a simple linear calibration, the displacement was calculated x/y mm/pixels.

Observations:

Strain observed in member under compression as found by GUM software:



Strain observed in zero force member as found by GUM software:



Calculations:

Applied Load, max(P) = 3 * 9.8 = 29.4N
Cross Sectional area of Truss (A) = 6 mm * 4mm = 0.024 cm^2
Stress in DE = 5/4 * (P / A) = 1531250 Pa
Assuming Young's Modulus of ABS ~ 2GPa
Strain in DE = 7.65 * 10^-4
Elongation = 7.65 * 10^-4 * 0.1 = 76.5 microns

Conclusion:

1) There was some strain observed in zero force member due to DIC which averaged to 0 hence it can be concluded that the values were noise due to various factors and there was no actual strain.
2) Substantial strain was calculated by the graph for the member that actually experienced some force hence we can conclude that other members of the truss experience some strain and that was detected by the DIC software. However we cannot calculate the exact value of this strain, due to excessive noise and inaccurate readings.

Causes of Errors:

1. Truss might be shaking while loading weights, which changes the strains obtained that are already in milliunits.
2. The mobile phone's resolution is not as high as required to record the strains for a given load.
3. Supports might not be frictionless and they can vibrate while loading because the loading is not quasi static, and the truss is facing sudden jerks.
4. The speckle pattern is not visible clearly and the software is not able to correlate with the frames supplied.

5. The graph is discontinuous because we used every 5th frame for processing to reduce the processing time

References :

1. https://www.youtube.com/watch?v=aBmb0-fKA84
2. https://www.youtube.com/watch?v=0a1r5knZM6o
3. https://www.sciencedirect.com/science/article/pii/S1369702110702352