In-Depth Analysis of the Arrigoni Bridge: an Exemplary Model of a Through Arch Truss and Suspension Combination

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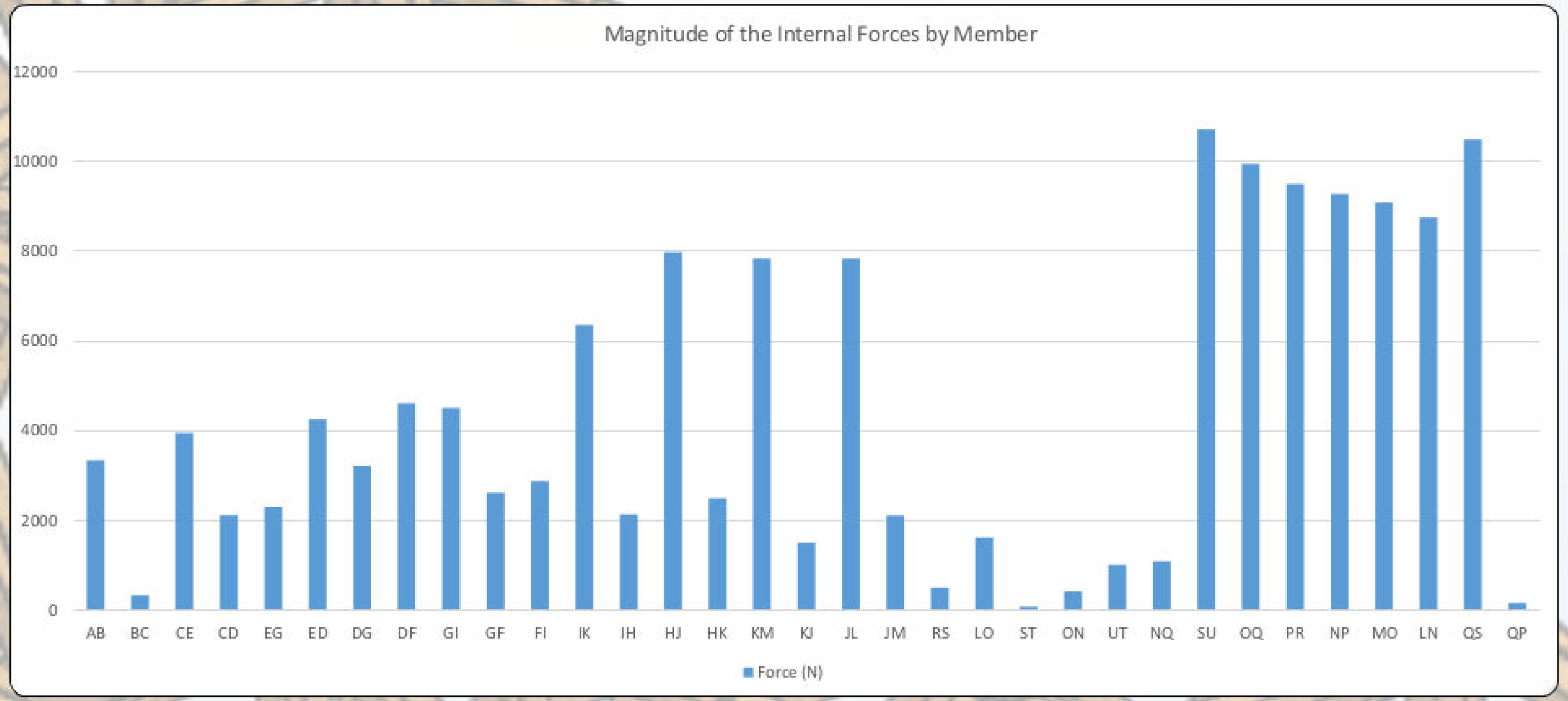

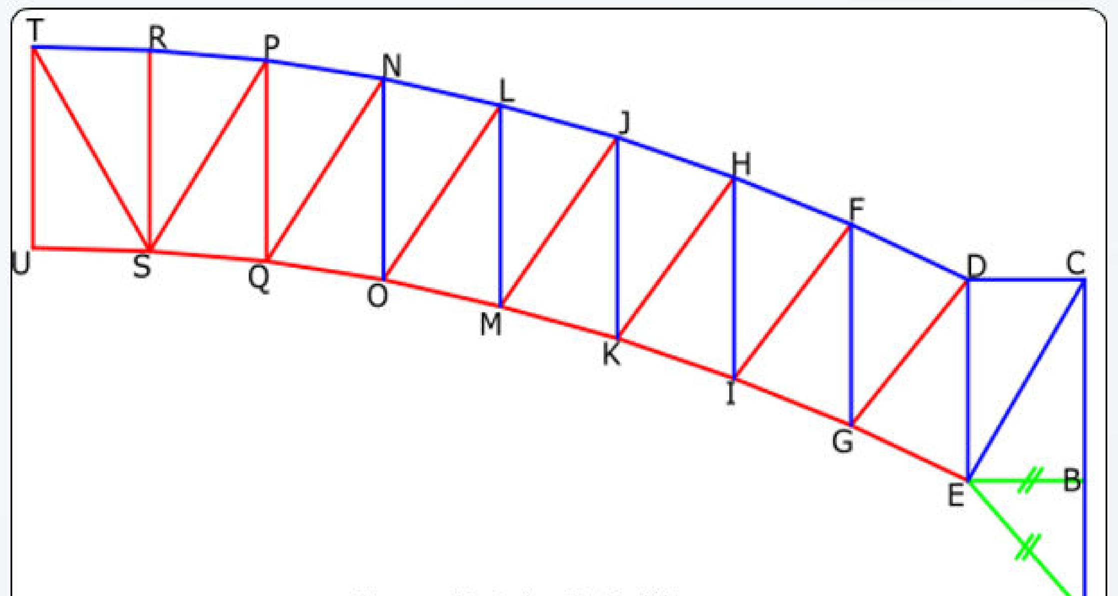

Figure 5: Joint Labelling
Compression (Blue) and Tension (Red) Visualization

ABSTRACT

Bridges have been an integral part of human transportation networks for thousands of years. The Arrigoni Bridge in Middlesex County, Connecticut, is a great example of the ingenuity of engineering design; the structural combination of through-arch trusses and vertical, helical wire suspender components are an ingenious and iconic application of multiple design approaches. The purpose of this project was to create a replica of the Arrigoni Bridge, which allowed the creators to visualize the different components and forces interacting with and within the bridge. A scale model of the bridge was constructed; a truss manifold and high gauge suspension wires composed the basis of the model. A theoretical analysis of the internal forces of the bridge among its individual components was completed with respect to the model. The model was subjected to high and particular forces to verify the results of the analysis; especially, the estimated point of failure inferred from the highest strain. The extrapolated information is then compared with the actual bridge verifying the validity of the concepts used, and the representativeness of the scale model to larger, non-arbitrary structures.

ASSUMPTIONS

To make calculations feasible:
- Members are perfectly joined at the end by fixed, smooth, frictionless pins
- All forces are applied at the joints
- Structural members are all slender
- All members are ideal two force members
- The bridge is of a single homogenous material
- Assembly was perfect and the model is ideal
- All suspension elements were equivalently and evenly tensioned
- The base of the bridge comes to a single unfixed point, labelled A
- The load is applied completely vertically (in “y”)
- There were no “z” forces

BACKGROUND RESEARCH

Blueprints of the Arrigoni bridge were requested from the Connecticut Department of Transportation but were never delivered. Thus, the team had to rely on public information that was reachable such as, for instance, information of the bridge found on governmental websites found on the Internet. A Google search query returned as a result an analysis paper that contained the dimensions of the bridge and vital information that can be used to provide better assessment for the design model and the analysis to be carried on.

PROCEDURE

A 3D model of the bridge was designed using SolidWorks. The 3D model was then imported into a 2D scalable vector graphic print which was used to feed the laser cutting system with specific dimensions and design needed to assemble the bridge. Using the tools available at The Innovation Lab the bridge was assembled.

After various iterative models were built in succession, a final working model was achieved. As a final procedure of the design analytics, the bridge was subjected to a continuous variable load using the hydralic press.

MATERIALS

*Plywood Sheets
*Suspension Cables System
 -Washers
 -Crimps
 -Nuts
 -Eye Nuts
 -Wire
 -Nail/Screws
*Wood Glue (Elmer's)

ENGINEERING GOALS

- Learn how to efficiently and reliably build a truss.
- Learn how to appropriately suspend objects in equilibrium.
- Be able to calculate and measure the amount of tension and compression each structural member is subjected to.
- Subject the model to load testing to determine failure point.
- Compare experimental results with analytical results.

CONCLUSION AND DISCUSSION

The goal of this project was to determine member forces for the truss of the Arrigoni Bridge. A mathematical model using method of joints was utilized to simplify the analysis procedure. A scaled model was designed, via SolidWorks. The model of the bridge was built using a laser cutting system and wood glue. It was coerced under precise pressure, via a hydraulic press, until the bridge gave way. During this testing, the maximum force for the bridge was determined and the force and force variability were discussed. In the analysis, it was apparent that the base of the bridge came to a single joint. The member forces of the truss were adequately measured using method of joints to model where the maximum member force was located. This coincided with where the model gave out.