Model Truss Bridge Design

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Abstract

Bridges are one of the most important and costly engineering projects, involving extensive design considerations that try to minimize expenses while insuring the bridge will not fail. Different models of bridges were constructed in order to perform experiments that determined which beams were in compression and how much force was experienced in the beam's when a static load was applied. Computer simulations were also performed to determine the loads on the different beams. The simulation and calculated results were compared to ensure accuracy of the final results. It was determined that a Howe bridge offers the lowest maximum compression on any beam when compared to the Pratt bridge. The cost did not increase because the diagonal members only switched positions and no extra material was needed.

Introduction

Bridges have been one of the most important parts of travel dating back to the primitive days. In order to cross rivers and valleys, bridges were needed. The first-century Romans greatly advanced these ancient ideas, with architectural masterpieces that are still standing today. In 2016 the average person crosses more than one bridge every day just on their way to work. Bridges are one of the most important parts of the transportation infrastructure, but also one of the costliest. As in most engineering projects, bridges need to be the safest they can be while still being cost effective. This is why bridge design is of the utmost importance. Truss bridges are extremely effective because they have a high strength to weight ratio. In this experiment we have tested which type of truss bridge is the strongest, yet uses the least amount of material. Two of the most used truss bridges are of the Pratt and Howe design.

Objectives

The first objective was to create a Pratt bridge model (Figure 1) that spans at least 65 cm. A 1 kg weight was placed in three different positions on the bride to simulate a car driving over it. Then force sensors were used to measure the internal forces in each truss member for all three positions. ANSYS, which is a computer simulation, created a finite element analysis of the bridge that we compared to the data obtained by using the force sensors. The last objective was to redesign the bridge to minimize the maximum compression, while keeping the cost of the bridge as low as possible. For this objective a Howe Bridge (Figure 2) was created and compared its results to the Pratt Bridge.

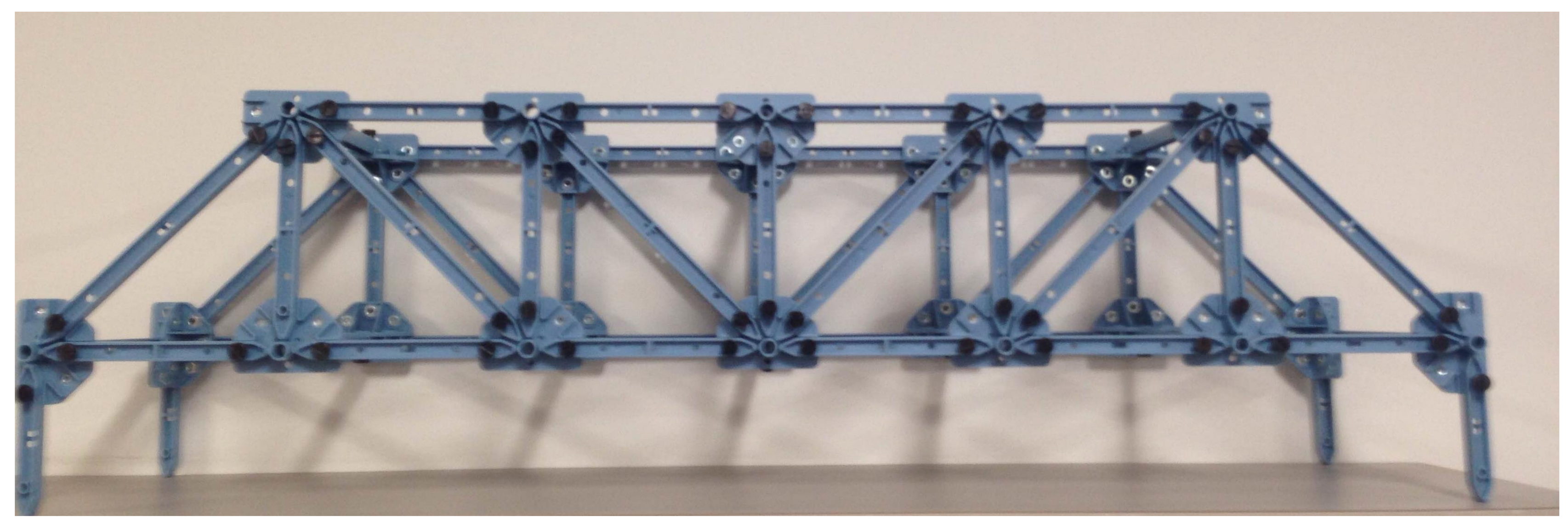

Fig. 1 Pratt bridge model

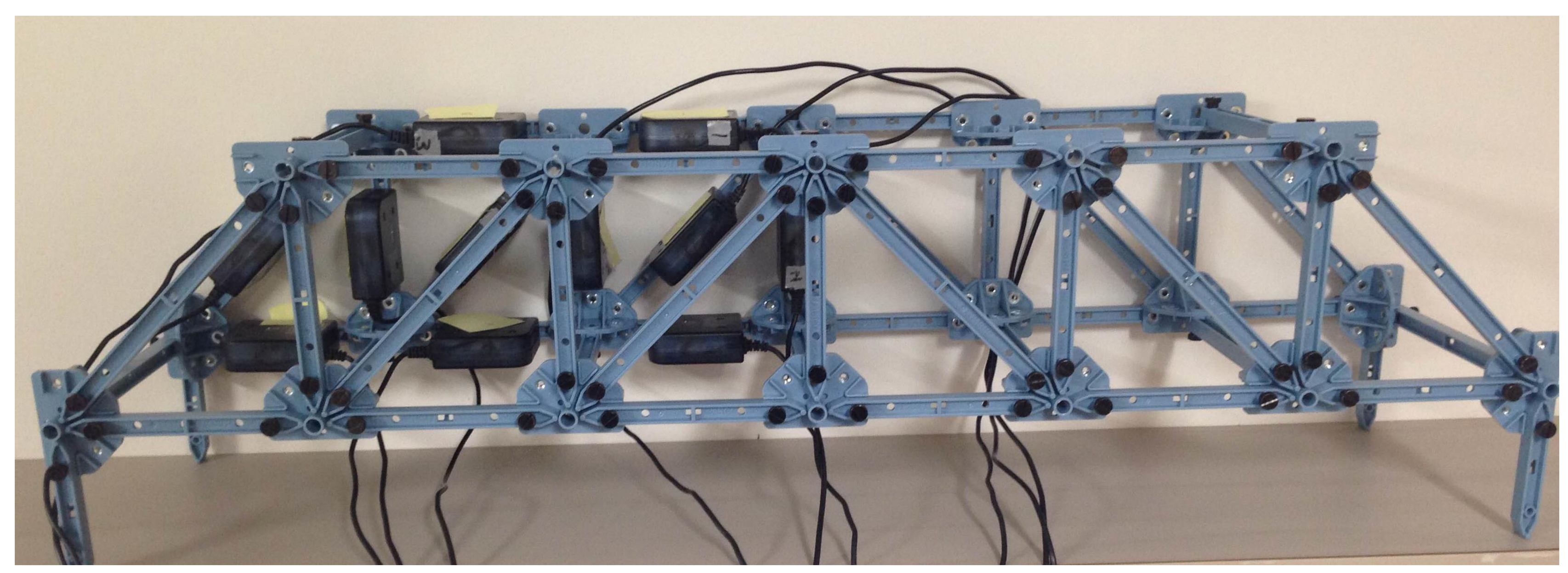

Fig. 2 Howe bridge model

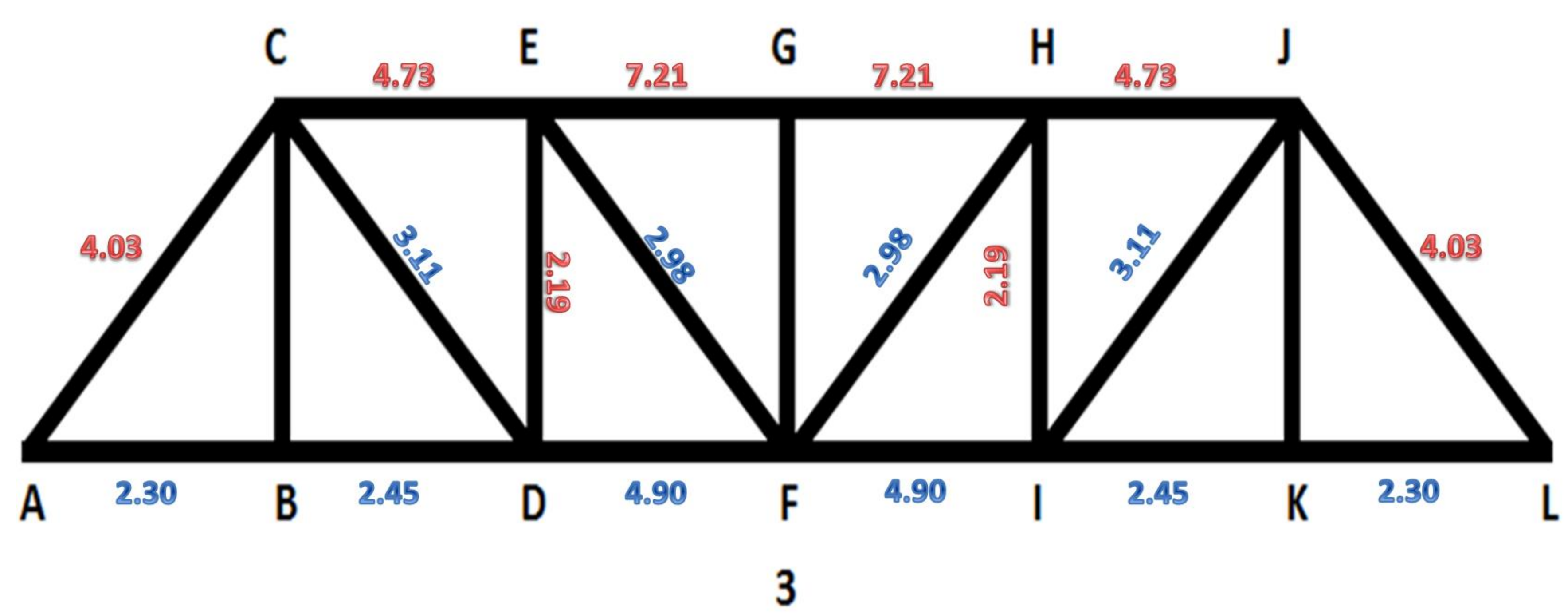

Fig. 3 Forces in Pratt bridge with load in position 3

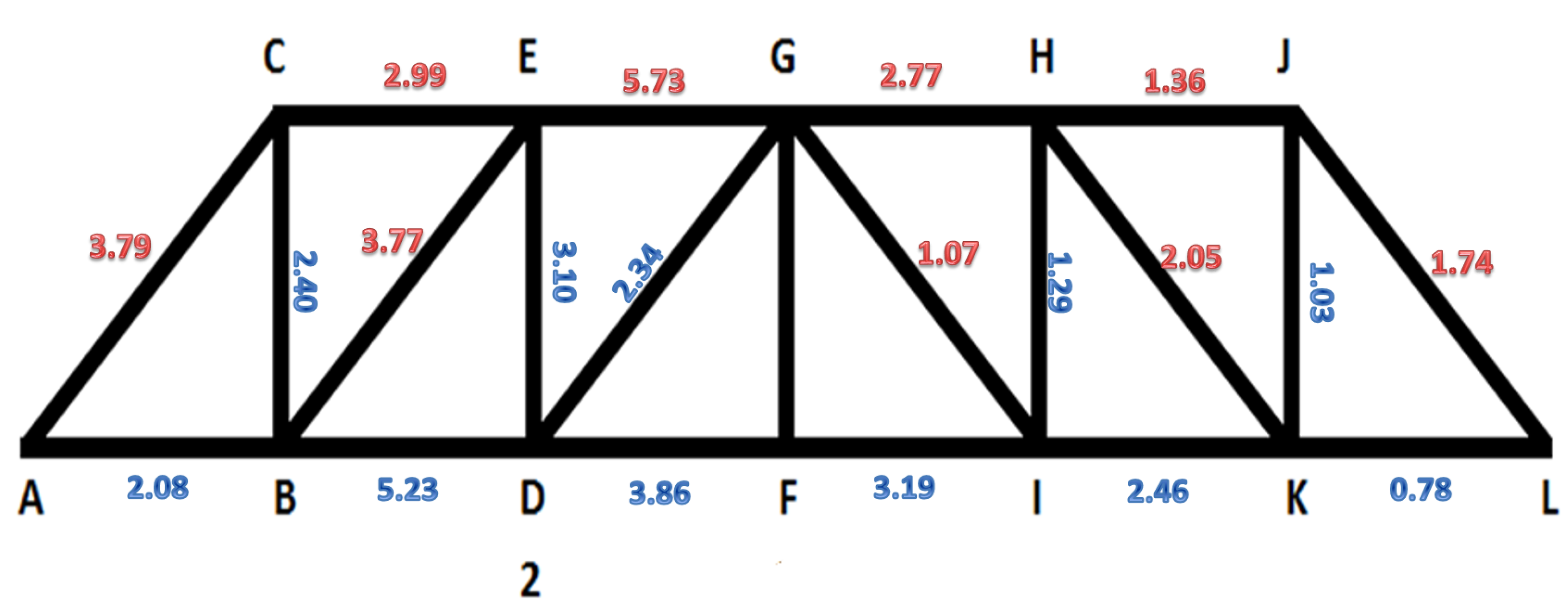

Fig. 4 Forces in Howe bridge with load in position 2

Instrumentation

- 100N load cells
- amplifier (PASCO item PS-2199)
- a truss bridge building set (PASCO item ME-6991)
- PASCO PASPORT USB link (item PS-2100A)
- a desktop computer with DataStudio software installed

Data Acquisition and Analysis

As the objective of this experiment was to determine the effect of bridge construction on maximum compression force in truss members, two different bridge structures were compared. In order to do so, Pratt and Howe type bridges were built, and the internal forces in truss members were measured under varying load conditions.

For this experiment, the PASCO bridge set was used to construct a Pratt bridge that spanned a gap of at least 65 cm. Three positions were chosen where the 1 kg weight was hung while force measurements were taken. After construction of the bridge, critical measurements such as bridge span, bridge height, and length of the diagonal members were taken to enable the calculation of theoretical/expected values for internal forces.

Results and Conclusions

Through our experiment it was found that the bridge design that minimized the maximum compression force was the Howe Bridge. Both bridges spanned 78.5 cm. For the Pratt Bridge the maximum compression force was 7.21 N on member EG when the weight was in the third position, as shown in Figure 3. For the Howe Bridge the maximum compression force was 5.73 N on member EG when the weight was in the second position, as shown in Figure 4. The Howe bridge design created a 1.48 N drop in the maximum compression force on a member. Because both bridges used the exact same amount of material the Howe Bridge would not cost any more to make. The only difference between the two bridges was that the diagonal members changed direction.

References

- PASCO, PASPORT Load Cell Amplifier Manual 012-10400B
- PASCO Load Cell Manual 012-10638B