Design Project #1

Replacement of Vehicle Bridge over Spring Creek

Centre County, PA

Introduction to Engineering Design

EDGSN 100 Section 002

G4

Design Team 4

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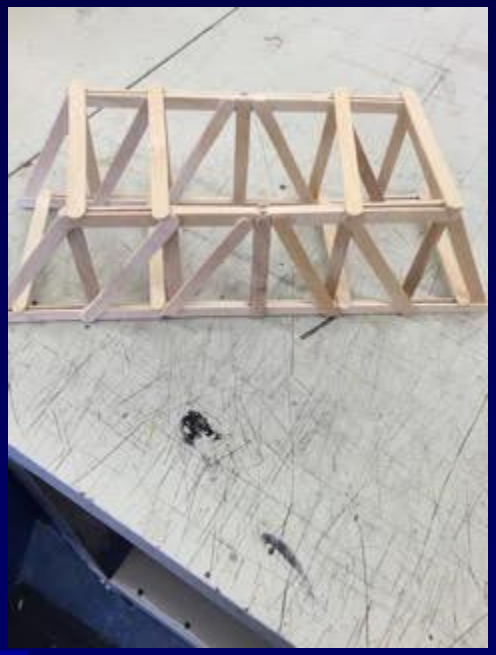


Presented to:

Prof. Berezniak

Fall 2015

PENNSTATE

Statement of Problem

- A vital bridge located in Pennsylvania Department of Transportation (PennDOT) Engineering District 2-0 for vehicle access to the Mount Nittany Medical Center located in State College, PA has been completely destroyed by a recent 100-year flood event. All traffic now must be re-route more than 10 miles around the destroyed bridge. State College's traffic flow, local commerce, as well as residential safety have been influenced.

Objective

- To design a replacement vehicle bridge over Spring Creek as an emergency project.

Design Criteria

- PennDOT established design criteria for the bridge to include (for both Warren through truss bridge and Howe through truss bridge): standard abutments, no piers (one span), deck material shall be medium strength concrete (0.23 meters thick), no cable anchorages and designed for the load of two AASHTO H20-44 trucks (225kN) with one in each traffic lane. The bridge deck elevation shall be set at 20 meters and the deck span shall be exactly 40 meters. Steel member type, steel cross section type, and steel member size can be selected by the design team.

Technical Approach Phase 1: Economic Efficiency

- Economic efficiency can be determined by Engineering Encounters Bridge Design 2015 (EEBD 2015) software based on the requirements, constraints, and performance criteria specified herein. While the bridge can support the dead load (its own weight) and the live load (weight of a standard truck loading), the cost needs to be as low as possible.

Technical Approach Phase 2: Structural Efficiency

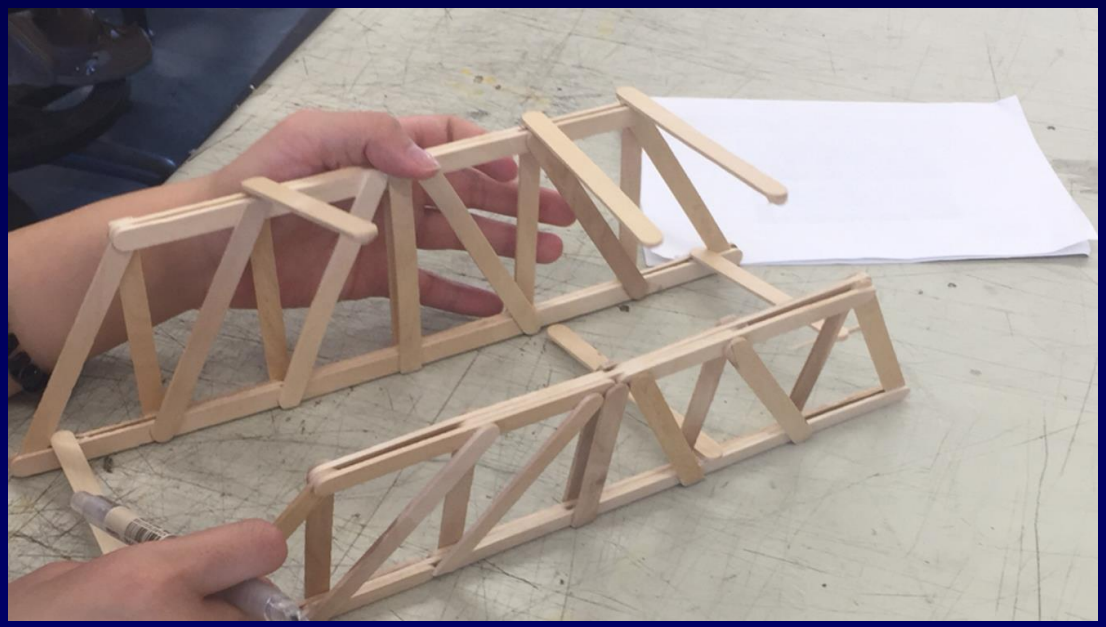
- A prototype bridge shall be designed and built for both Warren through truss bridge and Howe through truss bridge. Each prototype bridge is required to accomplish load test for the catastrophic failure in the lab. Structural efficiency (SE) is calculated by the load of bridge support at failure divided by the weight of the prototype bridge.
- The prototype bridges are constructed using standard (4-1/2 x 3/8 x 1/12 inch) wooden (white birch) Popsicle (craft) sticks, Elmer's white glue, and hot glue (only to attach beams between the two adjacent truss sections). For each bridge, a maximum of 60 Popsicle sticks is allowed to be used.
- All of the prototype bridges are accurately weighed prior to the loading test. The load at failure is measured and recorded in order to be analyzed later. A forensic engineering investigation to determine the cause of bridge failure including why did it fail; where did it fail; and how did it fail is performed by the design team for each bridge. The location of failure is determined by the structural members and joints labeled prior to the load test.

Results Phase 1: Economic Efficiency

- The cost of Howe Truss Bridge is $289,957.55 while the cost of Warren Truss Bridge is $272,664.59; the cost of Howe Truss Bridge is slightly more expensive than the Warren Truss Bridge.

Results Phase 2: Structural Efficiency

- According to the load test in the lab, the load at failure of Howe Truss Bridge is 65.4, and the structural efficiency is 378.0. However, the load at failure of Warren Truss Bridge is 38.2, and the structural efficiency is 228.7. Apparently the structural efficiency of Howe Truss Bridge is much higher than the structural efficiency of Warren Truss Bridge.



Best Solution

Comparing and contrasting the economic efficiency and structural efficiency of Howe Truss Bridge and Warren Truss Bridge, the best solution of the problem is to build a Howe Truss Bridge. The reasons are as follows:

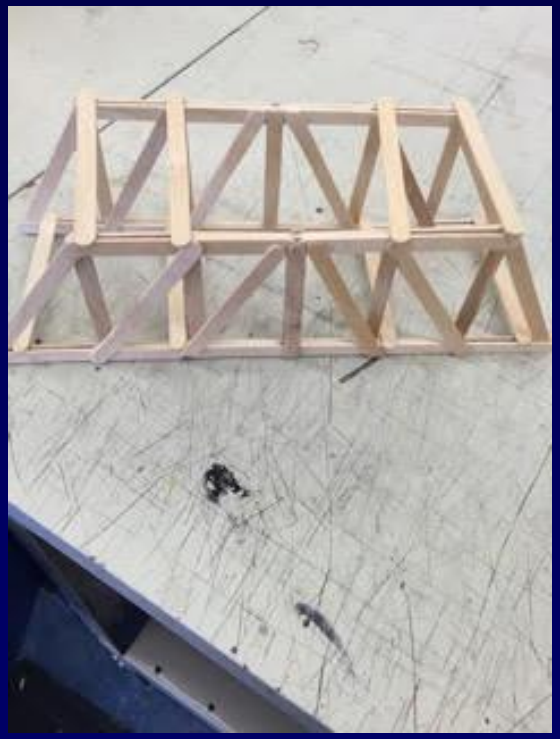
1. Even though the total cost of Warren Truss Bridge is lower than the total cost of Howe Truss Bridge, but the difference of cost is only $17,292.96. Considering other factors such as Structural Efficiency, a slightly higher cost would not be a problem.

2. The Structural Efficiency of Howe Truss Bridge is 378.0, while the mean of Structural Efficiency of all eight teams is 370, which means it is above average. The maximum Howe Structural Efficiency is 570, the minimum is 238, and the range is 332 (Table 7). However, the Structural Efficiency of Warren Truss Bridge is 228.7, while the mean of Structural Efficiency of all eight team is 358, which is 100 less than the average value. The maximum Warren Structural Efficiency is 581, the minimum is 201, and the range is 358 (Table 8).

- Since the difference between economic efficiencies is much smaller than the difference between structural efficiencies, Howe Truss Bridge is the best solution.

Conclusions

- Based on both the economic efficiency factor and structural factor, a Howe Truss Bridge shall be built to replace the bridge destroyed by the recent extreme flood event



Recommendations

- Some suggestions to advance the project include: making the structure to by asymmetric, as a result the bridge would be more stable; strengthen the solid bar and hollow tube on the sides of the bridge which would significantly increase the strength of the bridge