CE2200 – Statics

Fall 2024

Final Project:

____/100pts

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Problem Statement – DO NOT COPY THIS, WRITE YOUR OWN INTRODUCTION

On June 29, 1956, President Dwight D. Eisenhower signed the Federal-Aid Highway Act of 1956. Originally, the bill authorized the use of $25 billion handled in a Highway Trust Fund, in which federal money as well as state money was used to build the Interstate Highway System. The highways build cut through many neighborhoods and decimated many under-represented minoritized (URM) communities. Currently, there is a push to re-tie these neighborhoods by capping the interstate.

In this project, you will design and build a prototype of a steel bridge that re-connects severed communities above Jefferson Street here in Nashville. The learning outcomes of this effort are the following:

- Researching the impact of the highway act on URM groups.
- Applying structural analysis to a real-world problem by designing a steel truss.
- Building the truss prototype in the lab using real-world techniques of welding/bolting and testing the bridge for the loads designed for.
- Analyzing potential failure mechanisms of the truss
- Comparing the analytical calculations with the test results
- Reaching out to the affected communities with a letter explaining the need for capping the interstate and your proposed solution to build the bridge.

At the end of this project, I would like you to reflect on the lessons learned, and how this can help you be a better engineer in the future.

Step 1: Federal Highway Act research (10 pts)

In this step, you need to research the following:

- The original goal of building the federal highway system
- The way it was enacted by the states
- The effect on URM groups when it was built
- The long-term effect still lingering on URM communities
- The current solutions presented in 3 different cities to cap the interstate.

You should aim for 500-750 words. Make sure you cite all your external sources using the References tab above (you may pick a style you are comfortable using) and use reliable sources. The bibliography for this section will be included in the bibliography of the whole project at the end of the report.

You may not copy/paste text generated by any AI tool. You may use AI tools for brainstorming, grammar verification, etc. Make sure your whole project is homogeneous with respect to the writing.

Step 2: Preliminary Truss Design (35 pts)

In this step, you will design a simple truss for the maximum load it can carry. You may use a truss calculation tool online to verify your work. A is a pin connection, and E is a roller.

For this first iteration, set P = 350 lb.

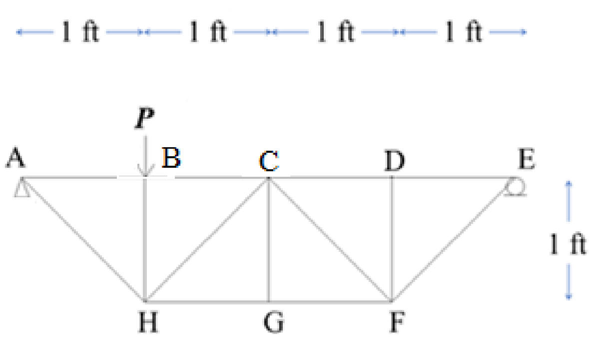

Figure 1: Truss

(1) Use the method of joints to calculate all your internal forces for the load combination in **Error! Reference source not found.**. ***Show all your work***.

(2) Verify your answers using the method of sections at by cutting at 2 different locations within your truss. ***Show all your work***.

(3) Use an online truss calculator to verify the results from (1) (You may use STAAD or similar, or the Johns Hopkins Truss Calculator: https://ei.jhu.edu/truss-simulator/)

Step 3: Building the truss prototype (10 pts)

In this part, you will explain how you built your truss. Make sure to include many pictures, explanations, and any challenges you may encounter.

In this section, you will also include the testing process and results.

-------------------------------------PART 1 ENDED HERE-------------------------------

Step 4: Calculating for failure (10pts)

In this step, you will verify whether your truss members will fail under buckling or yielding. The manufacturer mixed up the labels on the members, and we *think* the members are made from structural A-36 steel alloy.

The equation that governs yielding is: $\sigma_{\square} < \sigma_y$ where

$$\sigma_{\square} = \frac{N}{A} \qquad (1)$$

The equation that governs buckling is: $C < N_{cr}$ where

$$N_{cr} = \frac{\pi^2 EI}{(kL)^2} \qquad (2)$$

N: Normal force on the members, can be in tension or compression, calculated by user

σ: Normal stress on the members, calculated using equations above

σ_y: Yield stress of the material, found in material properties

A: Cross-sectional area of the members, calculated by user

C: Compression load on the members, calculated by user

N_{cr}: Maximum compressive load a member can withstand, calculated using formula above

E: Young's modulus of a member, found in material properties

I: Smaller moment of inertia of a member about its centroidal axes, calculated by user

k: effective length factor, use k=1 because all members have pins on both ends

L: member length, given in problem statement.

(1) What is the maximum load P that you can apply on your truss at node B before a member fails in buckling (compression)?

(2) What is the maximum load P that you can apply on your truss at node B before a member fails in yielding (tension)?

(3) What is the controlling load P that you can apply on your truss at node B before any member fails (compression and tension)?

Step 5: Comparing calculations with lab results (10pts)

In this step, you will show whether your analytical calculations matched the test results. You will list all the provisions you had to do for your truss to match your design (connections, dimensions, etc.). Thinking of the load you designed for and the load used in testing, your discussion should answer these questions:

- Did any of your truss members yield in testing?

- Did any of your truss members buckle in testing?
- Did your calculations predict the failure modes?
- What do you think was different between your model and your built truss that might explain the discrepancies that might have happened?

Step 6: Designing the Community Bridge (10pts)

The bridge is supposed to hold one landscaping area, one community building and one playground. The scaled resultant load from each is 400lb, 250lb and 170lb respectively. You are tasked to apply these loads at different joints on the top of your truss and find the controlling load combination. One combination is shown in **Error! Reference source not found.** below:

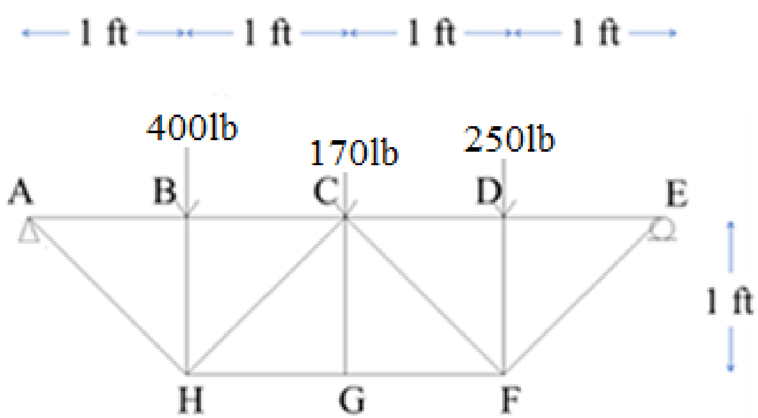

Figure 2: Example of a load combination

(1) For each load combination you use, draw the FBD and list the internal forces of all members in a table (you may use your truss calculator for this).

(2) Verify whether any member fails in buckling or yielding.

(3) Which combination would you recommend the community uses? Which one would you recommend the community avoids?

Step 6: Conclusion and letter to the community (10pts)

For this final step, you will gather the lessons learned from this project, and will write the community letter. Your letter should include:

- A brief history explanation for the need to cap the interstate
- The benefits of capping the interstate
- The plan you have for developing the cap
- A brief explanation of the impact the construction will have on the community, as well as the future impact of the project
- A brief explanation of your design.

Keep in mind that this letter is geared towards an audience that might not fully grasp engineering terms but can also be read by engineering members of the community.

At the end of your report, write a conclusion that explains briefly what you did in your report, what your conclusions are, and which recommendation you made for the community.

Quality and clarity of report: (5pts)

Make sure you include the following:

i. Have an introduction/conclusion to your report.
ii. Follow the format of this document: Assign the correct style for your sections.
iii. Make sure your figures are neat and clear, and your font easily readable.
iv. Caption your tables/figures/equations using the automated captioning from Word.
v. Cross-reference your tables/figures/equations when you mention them in the text.
vi. Add an automated table of content, a table of figures, a table of tables, and a bibliography if needed. Please note that anything you don't produce yourself (including figures from the project description) need to be cited.