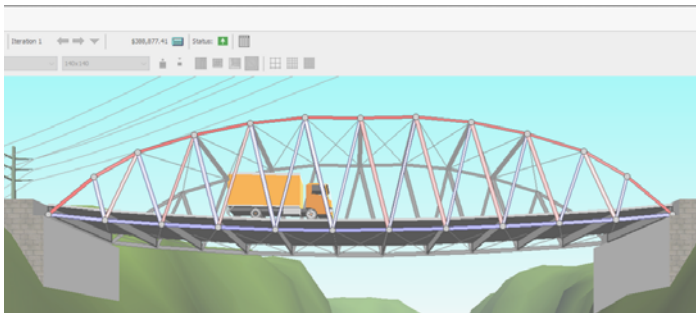
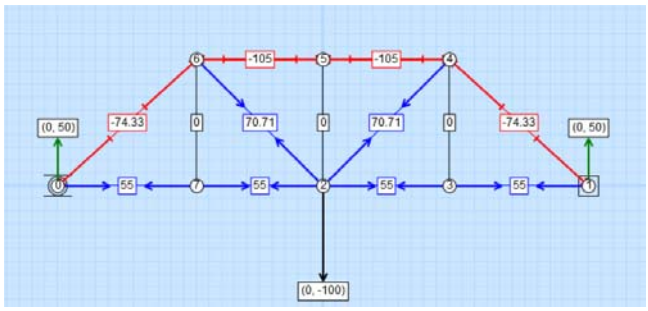
CE DESIGN PROJECT

BRIDGE SIMULATOR

Engr 100A





1 - PROJECT BASICS

This design project is meant to expose students to a civil engineering related project: bridge design. Students will choose ONE of the following options:

(1.) BRIDGE DESIGNER 2016 (BD2016)

This is the **preferred** option and is best for students with a Windows or Mac computer at home since the software must be installed on a computer. Students without a PC or Mac at home may use the Academic Computing Center (ACC) at SAC.

(2.) HOPKINS (+ EXCEL)

This is an alternative for students without Windows or Mac-based computer at home (e.g., they only have a Chrome book). This software is web-based, but students must do an additional step of using a spreadsheet that I provide to perform a secondary analysis.

Students will then write a short report and do an in-class presentation (for either option).

1.1 BRIDGE DESIGNER 2016 OPTION

GOALS

The goal is to design a bridge that supports a load (225 kN truck 2 lanes) at **MINIMUM COST**.

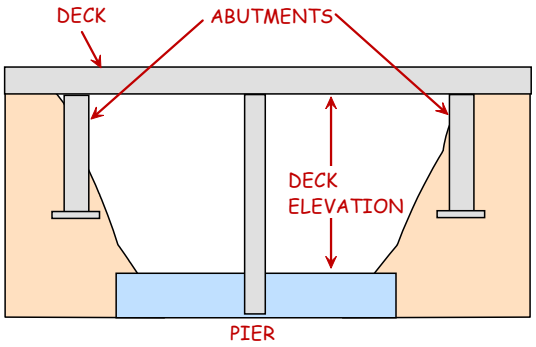
STEPS

1. Download the Bridge Designer 2016 software (bridgedesigner.org). Available for PC or Mac.
2. Watch the video guide (https://www.youtube.com/watch?v=9w9fTC4eh3w)
3. Complete multiple designs (~ 20 designs) - enough to get a sense of how to reduce costs
   Each subsequent design should attempt to improve on the prior one.
4. Select 3 successful designs (early, middle, & best) from the attempts above.

5. Screen shot those 3 designs showing the bridge design and the cost for that iteration.

DESIGN OPTIONS

The various designs are obtained by adjusting the variables below.



- Deck elevation (affects excavation costs)
- Support configuration (standard vs. arch abutments, pier or no pier)
- Deck material and loading (use standard **225 kN truck, 2 lanes**)
- Truss design (location of joints, member connections, use of standard designs (e.g. K truss) or custom
- Member material type (carbon steel, etc.) (note changes can be made to INDIVIDUAL members)
- Member type (solid, hollow)
- Member size (dimensions)
- and more...

CONTEST SCREEN ISSUE

For some folks, when starting a new bridge design, they cannot get past the "contest" screen as there are no buttons at the bottom. Try these steps in Windows (not sure about Mac).

While on the "contest" screen, just hit ENTER or the SPACE BAR.
(do NOT touch or click anything beforehand... if you do, just start a new design again)

OR
1. In Windows search bar, enter "Display settings" (press enter)
2. You are taken to a display tab. Find a setting called "change the size of apps and text on the main display"
3. Change to a smaller size
4. Reset Bridge Designer software

1.2 HOPKINS + EXCEL OPTION

GOALS
The goal is to design a bridge with a **MAXIMUM "SCORE"** (which is computed in an Excel file).

STEPS

1. Go to the Hopkins website and start new design (https://ei.jhu.edu/truss-simulator/).

2. Bottom corner nodes must be placed at x = +2.1 units on the right and x = –2.1 units on the left.
3. This ensures the bridge length of 4.2 units (this results in exactly 1/3 scale of a 14" span).
4. Support these bottom corner nodes with a horizontal roller on one end & a pinned joint on the other.
5. Place a "CENTER" node half way along the bridge's length (@ x = 0, the load will be applied here)
6. Place the remaining nodes and connect with members (truss must be "built up" as discussed in class)
7. It is suggested you make a symmetrical bridge (the left side is a mirror image of the right side)
8. Add a load on the CENTER node of 100 units down.

9. Press SOLVE "Once" to solve the simulation.

   Hopkins will compute 2 important things:
   (1) the internal stresses in each member and whether they are in tension or compression, and
   (2) the length of each member.

   Note - the simulator does NOT compute the strength of the bridge.
   Screen cap the Hopkins result (save the file for the report)

10. Screenshot the table data from Hopkins - the member length and stress data
11. OPEN THE EXCEL SPREADSHEET PROVIDED

    The spreadsheet takes member length and stress data and computes bridge strength. Only the compression members will determine bridge strength, but all member data is need to compute bridge weight, which is part of the SCORE.

    The computation assumes the bridge is made from 1/8 x 1/8" hobby basswood.
    The computation assumes failure will occur due to buckling in compression members

12. Copy Hopkins data into the spreadsheet. Only fill out yellow-shaded cells. Do not alter other cells.
13. Be sure to enter the negative (-) sign for compression member stress values.
14. Excel should provide an overall score (load supported divided by bridge mass, with some scaling)
15. Repeat the steps above multiple times in an attempt to MAXIMIZE SCORE (look for patterns!)

16. Select 3 of those attempts (see above) to include in your report and presentation.
17. Screen shot the bridge design & spreadsheet of those 3 designs.

2 - PRESENTATION

Each student must do a presentation IN CLASS of their designs.
The requirements are below.

1. Be present on the day of presentation.
2. Use POWERPOINT slides (pdf'd is okay) (do not just show your report)
3. Present 3 designs (an early one, a middle one, and your BEST (cheapest) one)
   - above each screenshot indicate in big letters, design number and cost (eg, "DESIGN 1 - 220K")
   - cost must be rounded to nearest 1k. (Eg - report 280k, not $279,872.15)
4. Be prepared - presentation file on USB drive (deductions for not being prepared with USB flash drive)

3 - REPORT

Use the report template posted.

A short (2-3 "pages") report is required and should contain the following

1. Report title
2. Screen shot of your BEST design on front page.
3. Your first and last name
4. Course number, course name, and semester (e.g., Fall 2022)
5. Short paragraph - write a concise summary (5 to 10 sentences) of your project that describe highlights of the design, construction, and performance of your project. What changes seemed to reduce the project cost? What changes affected bridge performance? Describe any patterns you recognized.
6. Screen shots of the 3 selected designs (early, middle, best designs). At the top of each screen shot indicate design number and cost (eg, "DESIGN 1 - 280K")
   - cost must be rounded to nearest 1k. (Eg - report 280k, not $279,872.15)

4 - GRADING

The report and presentation are ESSENTIAL as they are your proof that you did the project.

70 points - uploaded report to Canvas (upload rules followed)
30 points - presentation in class
- those who do not present in class may upload a short video presentation to Canvas for partial credit (upload must be ON TIME or no credit is given)

Deductions
- not meeting the requirements listed above
- Presentation deductions (in general, not meeting requirements specified)
  - (-10) not presenting in class (but uploaded a video presentation to canvas ON TIME)
  - (-30) no presentation in class AND also did not upload video
  - (-5) for not being ready to present on presentation day (Powerpoint file on USB drive)
- Report deductions (in general, not meeting requirements specified)
  - eg - improper report format, not including 3 screenshots of designs,

5 - Appendix

The Excel table takes the member length and stress data and computes bridge strength.
The student uses a load of 100 "units" in the Hopkins simulator so scaling is easier.
The student need only transfer data from compression members.

$$F_{MAX} = \frac{\pi^2 E(s^4/12)}{L^2} = \frac{\pi^2 E s^4}{12L^2}$$

$$\frac{F_1}{F_{MAX}} = \frac{100}{W_{MAX}}$$

F1 = force in member with 100 "unit" load

$$W_{MAX} = \frac{2 \cdot 100 \cdot F_{MAX}}{F_1}$$

Solve for Wmax. x2 because there are 2 trusses on the bridge.

$$W_{MAX} = \frac{2 \cdot 100}{F_1} \cdot \frac{\pi^2 E(s^4/12)}{L^2}$$

$$W_{MAX} = \frac{2 \cdot 100 \cdot \pi^2 E(s^4/12)}{F_1 \cdot L^2}$$

Equation that solves bridge strength