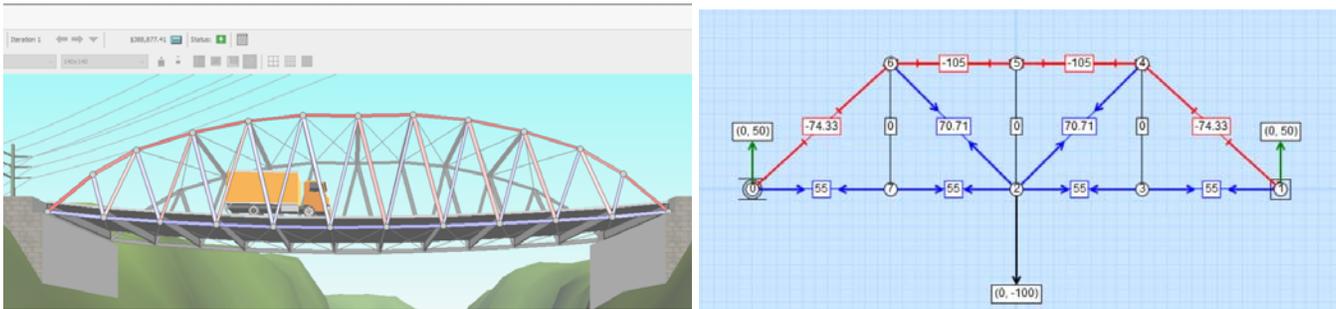


CE DESIGN PROJECT

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 outlined below. Students will then do an in-class presentation (for either option).

(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.

1.1 BRIDGE DESIGNER 2016 OPTION

Students will use the Bridge Designer 2016 software to design a bridge that supports a load (225 kN truck 2 lanes) at **MINIMUM COST**. The software must be installed on your computer (Windows or Mac). This is the preferred method as the software is quite nice, providing many design options. Note the software is getting old and sometimes there can be issues (usually related to resolution). We can usually work with screen resolution but some have issues installing and running the software at all. If so, you may have to use the Hopkins option.

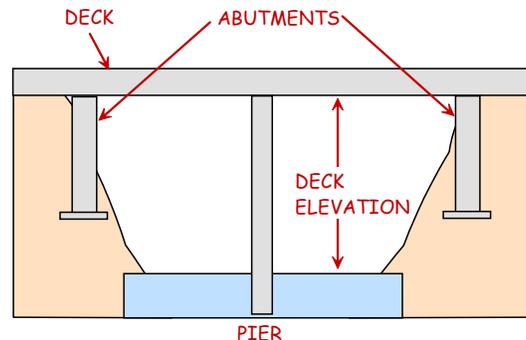
STEPS

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.
6. BACK UP those screen shots (USB flash drive, external hard drive, 2nd computer, cloud storage, etc.)

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...

SOFTWARE ISSUES

Sometimes the buttons on the CONTEST SCREEN do not appear at the bottom of the screen (at start of a design) and so you get stuck there. If so, 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

Sometimes you have resolution issues for the entire program (not just the contest screen). If so try these steps. First close the software.

1. Go to the software properties (right-click icon > open file location).

An explorer window opens (you may have to do this again (right-click > open file location).
An explorer window opens that holds the software's *.exe file.
This file may be "bdv16j243.exe" and it should be of the type "application")
Now right-click the *.exe file.

2. The properties window should now open.
3. Click the "compatibility" tab
4. Click "For all users"
5. Check "[x] Run program in compatibility mode for:"
Select "Windows 7"
6. Click on "Change High DPI Settings"
7. Check [x] Override high DPI scaling behavior. Scaling performed by"
Select "System (enhanced)". Click OK
8. Click Apply. Click OK. Click OK.
9. Run the software. You may get a window warning you about screen resolution. Click "Yes".

1.2 HOPKINS + EXCEL OPTION

GOALS

The goal is to design a bridge with a **MAXIMUM "SCORE"** (which is computed in an Excel file). The Hopkins software is web-based so there's no software to install. In Hopkins you design the truss - locating the joints and members. Then you load the bridge in the middle with 100 (units don't matter). The software then tells you the forces that develop in the members (it does not tell you the bridge strength). After that you export some of the Hopkins data to an Excel spreadsheet that I provide. This spreadsheet takes the Hopkins data (forces, member length, etc.) and computes a strength for the bridge assuming you are making a small model bridge made of basswood. The SCORE is the strength divided by the bridge weight. Again your goal is to MAXIMIZE this score.

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 presentation)

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 needed 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 presentation.
17. Screenshot the bridge design & spreadsheet of those 3 designs (backup your files!)

2 - PRESENTATION & SLIDES

Each student will do a CLASS presentation - showing the 3 selected designs.

Students must be prepared for the presentation at the START of class.

Students who do not do a presentation may upload a PDF file to Canvas showing the 3 design (partial credit).

PRESENTATION

1. Be present on the day of presentation ON TIME (at the start of class).
2. Bring the USB flash drive with PDF file on it (do not use Powerpoint).
Note - there are deductions if you are not prepared with your file on a flash drive
3. Present 3 designs (early, middle, and BEST (cheapest or if using Hopkins highest score))
4. Each design should be on a separate page (or slide). Each design should show a screenshot showing your design and it should have a HEADING in large letters indicating cost (or score) (eg, DESIGN 1 - \$250K). Round the cost to the nearest \$1k. Ensure the heading is above the screenshot and on the same page.

Try not to stress out about the presentations. They should be short ~5-7 minutes. Just show your designs and explain what you did and what you think helped reduce costs.

MISSED PRESENTATIONS - if you miss the presentation, you must then upload a pdf file to Canvas ON TIME for partial credit. Do NOT upload any file if you presented in class.

The PDF file must be a 3-page, multi-page single pdf file. Each page showing one design as discussed above. IE - the slides you would have shown in the presentation.

3 - GRADING

The presentation is ESSENTIAL as it is your proof that you did the project.

Maximum points are per below

100 points - full credit if you present in class

90 points - no in-class presentation, but pdf file uploaded to Canvas on time

Deductions

- not meeting the requirements listed above

- 2% - not being ready to present on presentation day (having a pdf file on USB drive)

SUPER IMPORTANT - if you don't present in class AND you don't upload a pdf file ON TIME, then you get a ZERO for the project!

4 - 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.

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

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

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