 **Bridge Design**

**Design and evaluate a bridge using a computer**

**Objective**

The objective of this project is for the student to gain experience in bridge design, to discover and report on how various geometric concepts affect performance from both a stability and load bearing perspective, and to learn to work effectively in teams.

**Introduction**

We learned how different types of bridges work, now it is time for you to be an engineer and design and build a bridge. But it’s not just about making the bridge work, you also have to make it efficient (or lowest cost). Try to make a bridge in this computer program and see if you can most efficiently use the materials you have available – just like a real engineer!

Bridges are structures that spans a divide such as a waterway, roadway, railway, or other crossing. They are designed to carry traffic (cars, rail, pedestrians) safely from one side to the other. Bridges need both strength and stiffness. The materials in the bridge need to be strong enough to carry the loads. Members can fail due to compression (crushing or buckling) or tension (pulling apart). Most members are stronger in tension than compression because of the lack of buckling in tension. Members are connected at joints which must be designed to carry the member forces from one member to another. Joints are usually designed to be stronger than the members they are connecting. For stiffness, the bridge needs to be able to carry the loads without deflections too much. Stiffness is primarily related to the shape of the members (the I shape is the most efficient) and the overall bridge (top and bottom chords further apart are more stiff). Overall stability is also important. The bridge should not have a collapse mechanism (you don’t want to be able to fold the bridge). The type of collapse can occur in the plane of the bridge (sidesway) or in multiple planes (torsional). Most truss bridges have several stiffening members (diagonals) to enhance stability.

**Scenario**

As a civil engineer working for the state department of transportation you are responsible for designing a truss bridge to carry a two-lane highway across a river valley. Your objectives are:

1) Ensure the bridge can carry its own weight (including the weight of the reinforced concrete deck) plus the weight of a standard truck

2) To keep the cost of the project as low as possible.

**Exercise**

1. Listen/watch the presentation on how bridges work.
2. Form a team of 3 students and install the West Point Bridge Design software <https://bridgedesigner.org/> . Watch the tutorial on its use <https://bridgedesigner.org/tutorial/> When you open the software start a new design with the design project setup wizard. If you can’t access the buttons on the design project setup wizard change your display resolution to 1920x1840 and the zoom to 100%. You may change the elevation of the bridge (but this will affect cost) or choose from different truss designs.
3. Develop a design that is capable of spanning 44 meters and carrying the load (self-weight plus truck). Evaluate at least 3 different designs for the bridge. You may need to change member sizes and/or locations to get the design to work. Record the cost for each design.

**Optional - Report**

Write a report to present your findings and design, focusing on your truss design, cost, and strength. Try to follow the GRADS method when formatting your report: **G**iven, **R**equired, **A**ssumed, **D**iagram, **S**olution. Documenting each of these will allow you to be very clear with your ‘supervisor’ and your ‘client’ about your understanding of the problem, the design goals, assumptions you made along the way, and the path to your design (solution).

The page length of this report is 4 pages, single spaced (1” margins), 12 pt font, including at most 1 page of figures.

Grading Rubric

20% - Load Analysis – Determine if the truss is strong enough for vehicular traffic

1) Identify at least two assumptions made in this load analysis that were necessary to complete the analysis. (Why is there only one truck if it is a two lane bridge?, Are there other potential loads to a truss bridge? How do you know the weights of the materials?...etc.)

2) Discuss how assumed parameters might differ from the actual occupant parameters.

3) How might a bad assumption impact the safety of the bridge?

20% - Truss Design - Evaluate the 3 different designs of the trusses and evaluate which is better at carrying the loads at the lowest costs.

1) Is there a truss shape that seems to work better (Warren, Pratt, etc..)

2) Is there a truss member size that works better? What happens to cost/strength when you change a size?

3) Which design was the most efficient?

20% - Cost Analysis – Evaluate the costs for each of your bridges.

1) What were the most influential parameters affecting the cost of the truss? Discuss.

2) Which design had the lowest cost?

3) Brainstorm some ideas of what to do to help lower the cost of the truss.

20% - Evaluate (and consider redesign) of your truss based on the following criteria:

1. Weight (related to foundation design)
2. number of joints (related to amount of labor)
3. aesthetics (how it looks)

10% - Other truss design issues that have not been addressed

10% - Writing organization (following GRADS method), clarity and grammar