Design Challenge: Bridge Engineering

Problem Situation

A bridge is a structure that spans a valley, body of water, roadway, railroad tracks, or any other obstruction to continuous travel. Bridges are designed to withstand dead loads and live loads. A dead load is a load that does not change, such as the weight of the structure itself. It includes the deck, sidewalks, parapets, railings, and the steel or concrete load-carrying members. These loads account for a significant and considerable percentage (often the majority) of the stress in the load-carrying member. Live loads change; the changes can be due to increased or decreased traffic and pedestrian loading. Other important loads are a function of wind, snow, impact, earthquake, and temperature variation. When designing a bridge, strength and safety of the structure are the primary considerations, but cost is very important as well.

Your Challenge

You are asked to design a bridge model that spans a distance of two feet. You will investigate how to make the model strong enough to support the test load. Before you determine which type of bridge to build, you will investigate four types of bridges: a beam bridge, an arch

bridge, a suspension bridge, and a truss bridge.

No matter which type of bridge you decide to model, the height of the deck of the bridge above the ground will be set at eight inches. Your bridge must support a load of at least 20 pounds, concentrated at mid-span. The bridge that exceeds the minimum load by the greatest amount for the least cost will be the best design.

Safety Considerations

1. Only use tools and machines after you have had proper instruction.
2. Wear eye protection when using tools, materials, machines, paints, and finishes.
3. Use caution when loading the bridge deck to the failure point, as components may split and break away.

Materials Needed

1. Brass fasteners
2. Building bricks to use as embankments
3. Craft sticks (basswood strips, 1/8 inch × 2 inches × 24 inches)
4. Centimeter sticks (1 cm × 1 cm × 40 cm)
5. Large weights (1/2 pound each)
6. Metal nuts
7. Modeling clay
8. Paper clips
9. Popsicle sticks
10. Small weights (100g to 2 kg)
11. String
12. Tape
13. 30 × 30-inch oak tag sheet
14. White glue
15. Wooden dowels

Clarify the Design Specifications and Constraints

The bridge will be rated according to a figure of merit (F_m), which is defined as F_m = weight/cost. Therefore, the best bridge will support the most weight at the least cost. The weight will be applied at mid-span and will be 20 pounds at minimum. Your bridge must be constructed only with materials specified by your instructor. The bridge must be at least 4½ inches wide so

that a four-inch brick can be placed on the bridge deck as the test load.

Research and Investigate

To complete the design challenge, you need to first gather information to help you build a knowledge base.

1. In your guide, complete the Knowledge and Skill Builder I: Bridge Design Considerations.
2. In your guide, complete the Knowledge and Skill Builder II: Types of Bridges.
3. In your guide, complete the Knowledge and Skill Builder III: Beam Bridge Design.
4. In your guide, complete the Knowledge and Skill Builder IV: Arch Bridge Design.
5. In your guide, complete the Knowledge and Skill Builder V: Suspension Bridge Design.
6. In your guide, complete the Knowledge and Skill Builder VI: Truss Bridge Design.

Generate Alternative Designs

Your group is to choose the type of bridge you want to design and model. Once you determine the type of bridge (beam, arch, suspension, or truss), describe two possible approaches to building that bridge. The approaches may use different materials, different methods of strengthening the bridge, and different systems to support the structure.

Choose and Justify the Optimal Solution

What decisions did you reach about choosing the model? Why did your group settle on this approach? What trade-offs did you make in coming to this conclusion?

Display your Prototypes

Construct a functional model of your bridge. Include drawings and sketches that helped you during the construction of the model.

Test and Evaluate

Explain how you will test the bridge under load. Explain how you calculated the figure of merit.

Redesign the Solution

What did you learn through the design and testing of your bridge that would inform a redesign of the model? What additional trade-offs would you have to make?

Communicate Your Achievements

Describe the plan you will use to present your solution to your class. (Include a media-based presentation.) Demonstrate how you tested your model and what you learned about how the bridge design distributed the load.