**Cost-Efficient Bridges**

*Student Packet*

**Part 1: Identify the Problem**

 The Elm Street bridge over Grand River in Lansing, Michigan is in need of repair because it is structurally deficient and in need of immediate corrective action. At this time, the state of Michigan does not have a plan for a budget that will allow bridges in the state to be repaired. For example, the Elm Street bridge will cost $3 million dollars to repair, but there is only $8 million dollars currently available to do bridge repairs across the entire state. As a result, we need to figure out a way to construct the safest and strongest bridge possible without spending too much money.

***Your Task***

As civil and structural engineers, you and your partner will **design and build a prototype** for the Elm Street Bridge that is **cost-efficient and can safely maintain a load**. The goal of your prototype is to have the **largest mass to cost ratio**. It is suggested that you and your partner split this task into two roles, and, at the same time, support each other in the entire process:

* The Construction Company CEO/Accountant will make sure that the prototype gets built, and will keep track of spending.
* The Structural Engineer/Architect will make sure the bridge is safe, and will select the materials to be used.

***Design Constraints***

* The prototype may only be built from **provided materials**.
* The prototype must be **freestanding** (i.e. not taped to the surface of an object).
* The prototype must include a **deck.**
* The prototype’s **substructure** must be a minimum of **5 centimeters in height**.
* The prototype must be **between 15 and 20 centimeters (cm) in length**.
* The prototype must be **wide enough to hold a Dixie cup**.
* A "car" must be able to drive under your prototype

**Part 2: Research**

On your own, research civil/structural engineering and bridge design using the resources provided (Posted on the class website: brunnerscience.weebly.com). As you research, keep in mind the restrictions and your overall goal (cost effective and safe).

*Civil and Structural Engineering Videos* [*1*](https://www.youtube.com/watch?v=oqpp8L4J4ek)*,* [*2,*](https://www.youtube.com/watch?v=od_MpNUzeCE) *and* [*3*](https://www.youtube.com/watch?v=t8nvuASMdhU)

1. What problems do civil/structural engineers solve? Provide specific examples from the videos.

*What Makes Bridges So Strong* [*Video*](https://www.youtube.com/watch?v=oVOnRPefcno&list=PLik7wSqQrVWdwkspuVWAnG9kN_c5QAA2g&index=3)

1. What are some different types of bridges?
2. What shape is really strong and sturdy for building?
3. What is the part of the bridge that you actually travel on called?

[*Bridges*](http://www.asceville.org/cw_bridges_explore.html) *Website* (Notice that in each arrow there is a *next* button. Use this often.)

1. Describe the relationship between tension and compression. (Engineering Challenges: A Balancing Act Between Forces Tab)
2. What materials can be used to build bridges? (Engineering Challenges: Building Materials Tab)
3. Is it true that only structural engineers work on bridges? Why or why not? (Engineering Challenges: Bridge Engineering Tab)
4. What factors must be considered when designing a bridge? (Engineering Challenges: Questions to Ponder Tab)
5. Complete the table (Types of Bridges Tab)

|  |  |  |
| --- | --- | --- |
| **Type of Bridge** | **Pros (Good)** | **Cons (Not So Good)** |
| *example:* Beam Bridge | simple; fewer materials  | cannot be longer than 250 ft. |
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[*Bridge Challenge*](http://www.pbs.org/wgbh/buildingbig/bridge/challenge/) (if time allows)

*Directions: Try to build a bridge for each scenario. In the space below, record any tips or recommendations that you learn as you complete this part.*

**Part 3: Imagine Possible Solutions**

*Directions: Imagine two different bridge designs that you believe could solve our Elm Street bridge problem. Draw your ideas in the boxes below, and explain why you believe this will be the best design.*

|  |  |
| --- | --- |
| Idea 1: | Idea 2: |
| Reasoning: | Reasoning: |

**Part 4: Choose a Solution**

With your partner, design your final prototype on graph paper provided. Use the design checklist to evaluate your design. **Label each part of the design with the potential materials you will use.** Materials available are listed in the order form section. Glue your design on the next page.

**Design Checklist**

|  |  |  |
| --- | --- | --- |
| * Top view of design
 | * Side view of design
 | * Substructure included
 |
| * Deck included
 | * Labeled with materials to be used
 | * Labels for measurements (once its built)
	+ Total length
	+ Total width
	+ Total height
 |
| * Neat
 | * Takes up the majority of the graph paper
 | * Design is glued to this page
 |

**Order Form**

Use your design to complete the order form below.

|  |
| --- |
| ***Prototype Supplies Order Form*** |
| **Item** | **Quantity** | **Price** |
| Thin beam (toothpick or skewer) -- 2 toothpicks for $1 or $5 for skewer |  |  |
| Wide beam (straw) -- $2 each |  |  |
| Extra wide beam (popsicle stick)-- $3 each  |  |  |
| Liquid Nails Adhesive (tape) -- $1 for 10 cm |  |  |
| Cable (thin wire) -- $20 for 10 cm |  |  |
| Rod (paper Clip) -- $5 per clip |  |  |
| Filler metal (hot glue) -- $40 per stick |  |  |
| Welding machine rental fee (hot glue gun) -- $50 for unlimited use |  |  |
| **Grand Total** |  |

**Prototype Design Pasted Here**

**Part 5: Create and Test Prototype**

When you have completed your design and order form, bring them to the lead contractor for approval. Once you have obtained the contractor’s stamp of approval, you will receive the materials you have ordered and may begin building.

Stamp

**Part 6: Improve**

After preliminary testing, feel free to modify your design/structure to help improve its cost and/or the amount of weight it can hold. Write about any improvement you made below:

**Communication**

**Final Testing**

On the line below, write the greatest mass the prototype was able to sustain prior to breaking. Remember your unit of measure.

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_**

**Efficiency Ratio**

The state of Michigan is looking for the most cost-efficient bridges to replace those that are structurally unsound. To determine whether your design might support the city in creating structurally sound and safe bridges, determine the mass to cost ratio of your prototype. Then, simplify your ratio.

\_\_\_\_\_\_\_\_\_\_:\_\_\_\_\_\_\_\_ (actual)

\_\_\_\_\_\_\_\_\_\_:\_\_\_\_\_\_\_\_ (simplified)

**Group Comparison**

As instructed by the lead contractor, complete the data table below.

|  |  |  |  |
| --- | --- | --- | --- |
| *Names* | *Total Price ($)* | *Mass (g)* | *Ratio* |
|  |  |  |  |
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**Recommendations**

Based on the data obtained in the group comparison section, which prototype would you recommend to the Governor Whitmer, and why? Reminder: The state of Michigan is looking for the most cost-efficient bridge to safely support a large load. **Support your recommendation with data.**

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**Group Work Reflection**

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| --- | --- | --- | --- |
| Group Work Term | Rating Myself | Rating My Table Group | Rating My Class |
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**What I Have Learned**

1. Was there a time in this project when you struggled? What did you do to move forward?
2. Was there a time in this project when you felt disappointed? What steps did you take to correct the problems you faced?
3. Look at the Group Work ratings. Was there a time when the class scored poorly? How do you think we could have taken responsibility to change that?