

## Project Background

Restoring and improving urban infrastructure is the grand challenge we chose to model our demo after. This grand challenge focuses on the infrastructure challenges facing the world. Ranging from infrastructure in developing countries to handling the difficulties of a city of 10 million plus or simply repairing and replacing the old, urban infrastructure presents many issues and will continue to do so for the foreseeable future. The United States is in particularly rough shape with regards to our current infrastructure. A majority of the US infrastructure was built in the past century and some bridges and buildings are 100 years in age. Decades of limited funding for maintenance and repairs has left many structures in critical condition. As of right now the American Society of Civil Engineers has rated the US at a D+ in overall level of infrastructure. The current problem is not lack of technology or resources but rather a lack of funds to complete the projects necessary. ASCE currently estimates a total invest of 3.6 trillion dollars would be necessary by 2020 to raise the US rating from a D+ to a B (which can be seen in the Appendix) [1]. With such a large amount of funding needed, increased emphasis will have to be placed on project cost.

## Overview

Each team has been asked to provide a sample design of a new communications tower to be built in Terre Haute. Each team will use the provided budget sheet prior to designing to keep track of the overall cost of their tower. The goal is to not only build the strongest tower, but the most cost effective as well. Each tower must meet the requirements listed following handout.

## Time Allotment

Introduction and Explanation of Rules	10 minutes
Brainstorming	5 minutes
Buying Materials and Build Time	15 minutes
Judging/Testing and Questions	5-10 minutes
Total Time:	30-40 minutes

## Materials

Prices obtained from local walmart [2]

Material	Amount	Cost
Marshmallows	2 bags mini-mallows 2 bags jumbo-mallows	\$12.00
Gummy Candy	40 oz bag	\$4.00
Spaghetti Noodles	4 lb box	\$4.00
Styrofoam Block	1 Board	\$5.00
	Total:	\$25.00

# Build your own Communications Tower Handout

## Overview

Your team has been asked to provide a sample design of a new communications tower to be built in Terre Haute. Your team will use the provided budget sheet prior to designing to keep track of the overall cost of your tower. Your goal is to not only build the strongest tower, but the most cost effective as well. Each tower must meet the requirements listed below:

## Rules:

- Tower has to be at least two (2) feet tall
- Tower must be free standing
- Tower must be able to withstand testing
- Teams may not exceed \$300 budget
- Tower may not exceed limits of base
- Teams must keep track of their own finances

## Budget Spreadsheet:

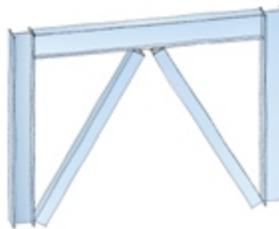
Material	Unit Cost	Amount	Cost
Spaghetti Noodle	1 noodle - \$5		
Large Marshmallow	1 marshmallow - \$15		
Gummy Bear	1 bear - \$10		
Small Marshmallow	1 marshmallow - \$10		

## Tower Design Options:

Cross Bracing



Chevron Bracing



Diagonal Bracing



More design options can be found at: <http://responsivebydesign.com/12/brace-yourself-for-the-2006-ibc/>

# Instructions

## Pre-Activity Preparation

Before the activity, build an example tower using whichever materials you choose. Be sure to use the three different types of braces. The cross bracing, chevron bracing and diagonal bracing, which are shown in the class handout for the students. This is to give another visual reference for the students.

Cut the styrofoam board into the appropriate 6" X 6" squares. These styrofoam squares will be given to the groups as a base to build their towers on. These bases are reusable.

## Introduction - (5 minutes)

### 1. Go Over Design Process and Requirements

Explain to the students that they will be building a model building as part of a grand challenge of urban infrastructure. Give the students reasons why urban infrastructure is important to the United States and the world, by explaining to them that there is an inadequate amount of room for people and the designing of smarter more efficient buildings would help reduce problems. Explain the rules for the model which are provided in the handout (Page 2).

### 2. Material Experimentation and Cost Explanation

Show the students what materials they will be able to choose from. Explain that each material costs a different price. Give the students the budget sheet, in order to plan out their design with the amount of money that they will be given. Explain to students that is important to design a building so that it is structurally sound and that the cheapest building may not be the best and vice versa.

### 3. Display Model as Example

Present the students with the model which you have prepared for the activity as an example. Be sure to highlight the different types of bracings you used to provide a visual for the students to reference during their design and build process. This will help provide an actual example to the description in the handout (Page 2).

## Team Forming and Brainstorming - (5 minutes)

### 4. Divide Students into teams of 2-4

Either divide up your students into groups of 2-4 students, or let them divide themselves into groups of 2-4 students. Choose either option, you know your students best. Once the students are split up into teams provide each team with a copy of the budget sheet provided.

#### 5. Design on graph paper

Give the teams 5-10 minutes to consider what has been presented to them and begin to draw out how they want to build their tower. During this time the instructor should be checking in on the teams and making sure their designs are feasible and reminding them of the cost efficiency aspect and the building constraints. The students should also use the material cost spreadsheet at this time to calculate a total cost of their tower.

### **Buying Materials and Build Time - (15 minutes)**

#### 6. Material Purchasing

Allow students to calculate their costs using the budget sheet. The prices of materials are given in the handout. More materials may also be purchased during construction time, if students require more material. The total cost should be within the budget, specified at the beginning of the class.

#### 7. Construction Time

Teams can begin construction as soon as they are finished purchasing all materials. Give the teams 10-15 minutes to construct their towers. All towers should reach a minimum height requirement of two (2) feet and cannot be any wider than the base provided to be considered for testing. Towers must also include at least one (1) of the types of tower bracing shown in the model tower provided. The instructor should continue to check in on each team during this time. If teams need to purchase more materials, they can do so, and must make sure to keep track of this on their material cost spreadsheet. If teams complete the height requirement before time runs out, encourage them to continue building and increase the height or stability of their tower.

### **Testing and Conclusion - (5-10 minutes)**

#### 8. Testing of Towers

After construction of the towers are complete, each team will then bring their tower up to the front of the class for testing. Before testing begins, ask each group to briefly explain what design they choose, and why. Testing will be conducted using a small desk fan with at least three (3) settings. Start with the lowest setting, and increase until the tower fails. Tower failure will be defined by collapse of any part of the tower. If any tower(s) pass all three settings, place a single piece of paper on the side of the tower the fan is blowing against. This gives the wind a larger surface to act on, leading to a higher likelihood for failure. Increase the fan through all three settings until failure occurs.

## 9. Design Improvements

After the towers have been tested, have a quick discussion about which designs worked best and which were not as good. If any towers survive the testing phase, discuss what features made that tower(s) the most structurally sound. Refer back to the opening discussion when necessary to point out good building strategies. Have each group discuss together and come up with a short list (three to four items) of improvements they could have made.

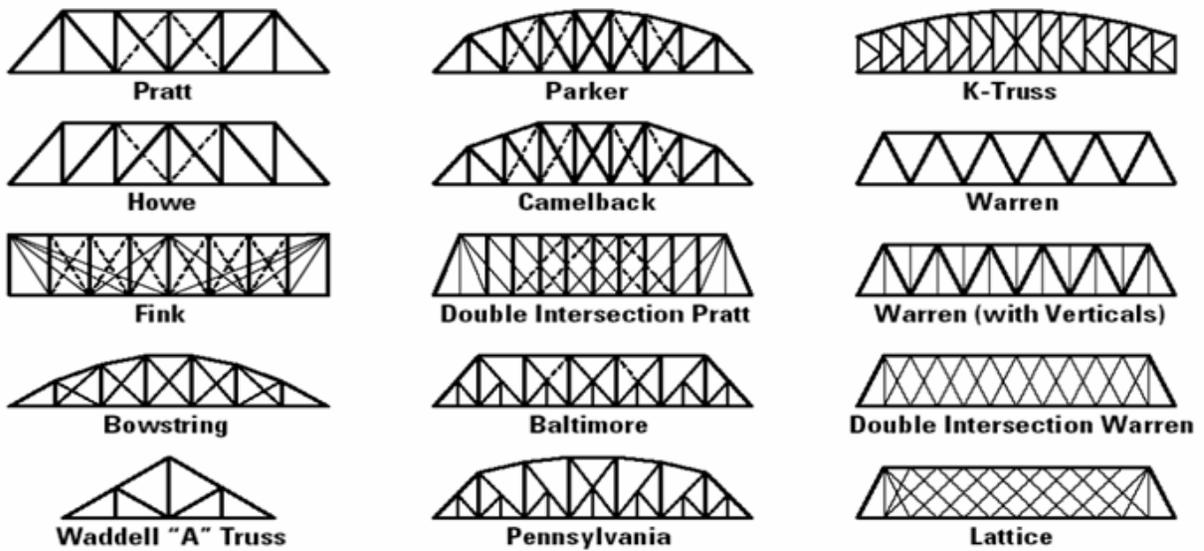
## 10. Clean Up

At the end of the learning activity have the kids throw away all the used building materials. Make sure to keep the styrofoam bases and all build material that was not used. Close the marshmallows and gummy bears to keep from going stale. Put everything away and have it for another time.

# Appendix



[1]



[3]



[4]

## References

[1] ASCE. (2014, January 15). America's Infrastructure GPA. [Infrastructurereportcard.com](http://www.infrastructurereportcard.com) [Online]. Available: <http://www.infrastructurereportcard.org/a/#p/grade-sheet/gpa>

[2] Walmart. (2014, January 15). [Online]. Available: <http://www.walmart.com/>

[3] sayedmujtaba. (n.d.). sayedmujtaba. Retrieved February 6, 2014, from <http://sayedmujtaba.wordpress.com/>

[4] Brace Yourself for the 2006 IBC – BJG. (n.d.). BJG RSS. Retrieved February 6, 2014, from <http://responsivebydesign.com/12/brace-yourself-for-the-2006-ibc/>

## References For Further Information

The following page is a list of references that helped us create the tower construction learning activity as well as gives further background information about the project.

1. This link leads to the most recent report card of the United States infrastructure as conducted by the American Society of Civil Engineers. This can be highly beneficial to instructors and students to be exposed to the ratings of our own country in a format that they are very familiar with.

<http://www.infrastructurereportcard.org/a/#p/grade-sheet/gpa>

2. The following link leads to the Grand Challenges video, which was the basis of the after-school learning activities. Our learning activity specifically deals with the Rehabilitation of Infrastructure.

<http://www.engineeringchallenges.org/cms/challenges.aspx>

3. The following are Indiana State Learning Standards that our learning activity addresses:

**SCI.5.4.2 2010**

Investigate the purpose of prototypes and models when designing a solution to a problem and how limitations in cost and design features might affect their construction.

**MA.5.5.7 2000**

Add and subtract with money in decimal notation.

**MA.5.2.1 2000**

Solve problems involving multiplication and division of any whole numbers.

**MA.4.7.1 2000**

Analyze problems by identifying relationships, telling relevant from irrelevant information, sequencing and prioritizing information, and observing patterns.

4. This link provides brief descriptions of different types of bracing used in the learning activity.

<http://responsivebydesign.com/12/brace-yourself-for-the-2006-ibc/>

5. This link has similar design projects similar to our learning activity.

<http://deceptivelyeducational.blogspot.com/2013/04/shapes-letters-towers-building-with.html>