ACCELERATED BRIDGE CONSTRUCTION
UNIVERSITY TRANSPORTATION CENTER

Activity: Balsa Wood Bridge (ABC-style)

Introduction

Bridges come in many different shapes and sizes, and can be made out of an assortment of materials. A sample of some of the different types of bridges is shown below. The type of bridge and material used is

Arch

Garabit Viaduct
By Gustave Eiffel

Suspension / Cable Stayed

Brooklyn Bridge
By John Roebling

Girder

Walnut Lane Memorial Bridge
By Gustave Magnel

Truss

Francis Scott Key Bridge
J.E. Greiner Co., Inc.

Suspension

George Washington Bridge
By Othmar Amman

Cable Stayed

Puente del Alamillo
By Santiago Calatrava

dependent on many different factors: location, span length, type of traffic, etc. While types and materials may differ, bridges always have the same purpose: to transport people or things over an obstacle from one location to another.

A typical bridge project will occur over several years, affecting traffic in some way during the duration of construction. Accelerate Bridge Construction (ABC) is a design and construction practice that focuses on

Prefabrication

Lateral Slides

SPMTs

shortening the time of construction to a few months to even as short as a few days. Some of the methods of ABC are:

1. *Prefabrication*: where portions of the bridge are constructed offsite and then assembled onsite (like Legos); bridge designs can best utilize prefabrication if they use repeatable parts
2. *Lateral Slides*: where the full bridge is constructed next to the existing bridge and then slid into place at one time
3. *Using SPMTs*: where full bridge segments are constructed offsite and then driven into place using large truck-like machines called self-propelled modular transporters (SPMTs)

The purpose of this activity will be to explore different types of bridges and use Accelerated Bridge Construction to speed up the construction of the bridge.

Basic Activity: Balsa Wood Bridge Project with Accelerated Bridge Construction Techniques

This activity can be done in a number of ways. The necessary materials will be very dependent on the span length requirements.

Materials Needed

- Balsa wood (1/16th inch thick rods, 3-inch wide sheets) (ordered from **Tower Hobbies**, but can purchase at any craft store)

1/16” rod x 36” long balsa	50 per team	$16.79 / 60 rods
1/16”-thick x 3” balsa sheet	3 per team	$12.99 / 16 sheets

  Note: use two 3” wide sheets next to each other to make the bridge deck

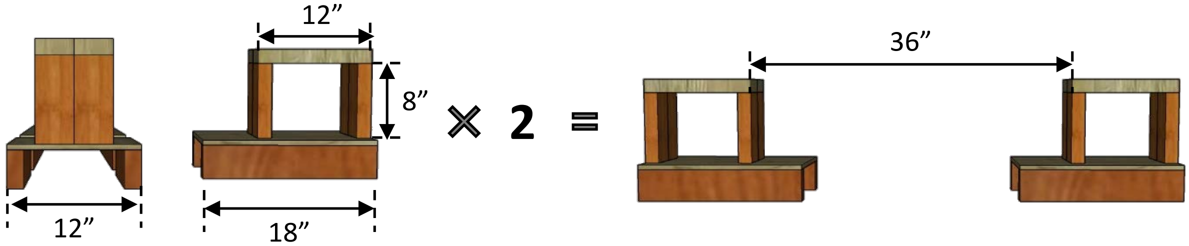
- Hot glue guns (2 per team recommended)
- Hot glue refill pack

5/16” diameter x 4” long	16 per team	$11.66 / 100 rods

- Wax paper
- Poster board (large enough that students can draw their bridge to scale)
- Rulers (2 per team recommended)
- Scissors (2 per team recommended)
- Weights and/or Toy Car to Load Bridge
- Materials for creating the base (wood or textbooks)

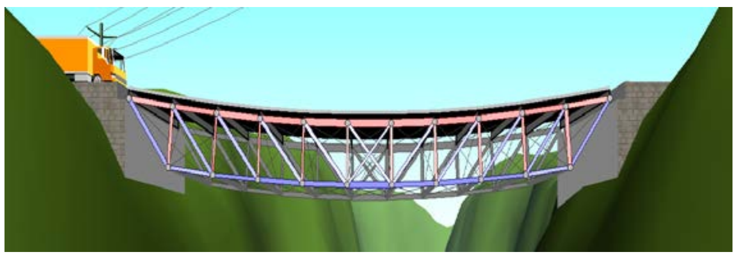
Procedure

1. Build a base for bridge testing (do prior to activity with students)
   a. Option 1: construct base out of wood (the base dimensions provided below can be made out of 2”x4”s and ½” thick plywood)



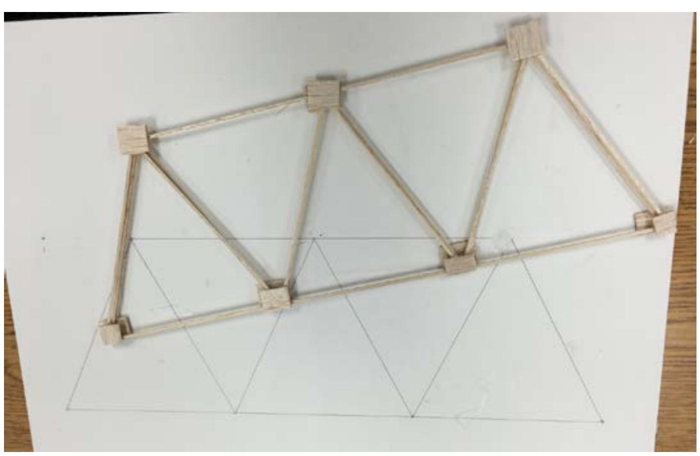
   b. Option 2: stack several thick text books on top of each other to make each support

2. Divide students into teams and give them problem statement (a developed problem statement is included)
3. *Exploration of Bridge Shapes*: Allow students the opportunity to work with Bridge Designer software to explore different bridge shapes and develop design concept
   a. Bridge Designer Software (free) - https://bridgecontest.org/resources/download/



Note: Bridge Designer offers a free national competition to create low cost bridges for different spans. This could be a fun activity for your students.

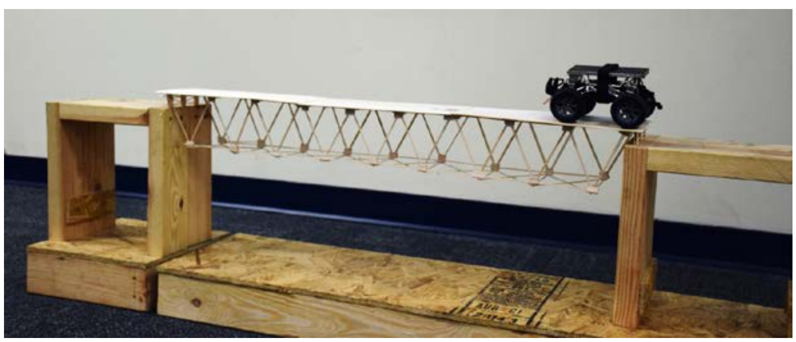
4. *Design Bridge*: Students should use software to decide on a design. They should draw their final design to determine the total amount of materials required. The students can sketch their design to scale on poster board; this will also aid in assembly.



5. *Request for Materials*: You can have the students request for all of their materials (specifically balsa wood) up front to add an additional challenge. The students can learn about project planning through this step.

6. *Build Bridge Components*: Students will now build their bridge as they designed it. The bridge should be constructed and left in sections until final construction day. Constructing the bridge in sections offsite is prefabrication. What are some of the challenges of prefabrication?
   Note: Making small squares out of the balsa wood sheets for the joints (see picture above) can make connections easier. These plate connections are called "gusset plates" in real bridges.
7. *Construct Full Bridge*: Teams will now assemble all of their prefabricated sections into one bridge. Teams should have 10 minutes to construct their full bridge.

8. *Test Bridge*: Bridge can be tested using anything with weight, toy cars, or anything else you can come up with. Testing the bridges to failure will be the most entertaining; offering a prize for the team who can hold the most weight will encourage participation.



Possibilities Modifications

1. ***Use Thicker (1/8") Balsa Wood***: Using 1/16" thick balsa is difficult and tedious. If you want to speed up the activity you can use thicker balsa wood (1/8" thick). Remember that if you use thicker balsa wood, you will need more weight to fail the bridge.
2. ***Use Shorter Span***: Using a shorter span will also speed up the activity. Using a span of 12" will make the activity go faster. Remember that if you use a shorter span you will need more weight to fail the bridge.
3. ***Use Alternate Materials***: Other materials can be used to make the bridge (e.g. popsicle sticks, cardboard, paper clips, etc.). If you use an alternate material, create a test bridge so you can play with span lengths and loads required for failure.

4. ***Changing Loading Apparatus***: Think about how you will apply the load on the bridge beforehand. Using a toy car is fun, but adding static loads is simpler.
5. ***Add Natural Disaster Components***: You could try and apply wind loading using a leaf blower. Also, balsa wood is sensitive to moisture, so you could spray different parts of your bridge to cause damage (similar to durability concerns on real bridges)

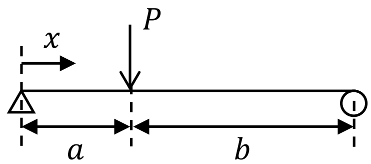
Points to Emphasize

There are several things that can be highlighted in this activity:

- *Accelerated Bridge Construction*: ABC is the technology of the future. The students should learn how to prefabricate pieces and see the value of repeatable parts; both of these should be strongly considered in the initial design. The students will then further be able to see how ABC works during the 10 minute full bridge assembly. The connection details need to be well thought out.
- *Truss Element Force Types and Magnitudes*: The force type and magnitudes can be clearly seen in the Bridge Designer Software. Students can see how their design will perform and modify their construction based on the design. Places where there are compressive forces or larger tensile forces should have multiple balsa wood rods.

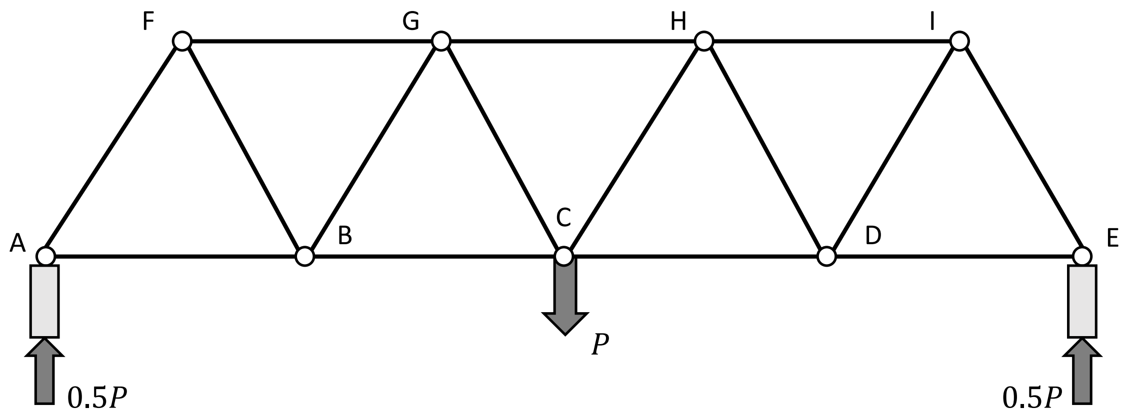
Math Applications

1. Calculating truss forces
   a. Find the forces in each of supports

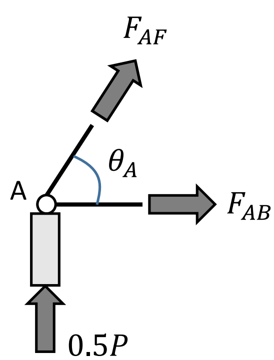


$$\Delta_x = \frac{Pax}{6LEI}\left(L^2 - a^2 - x^2\right)$$

   b. Can calculate the force in each of the elements



The forces can be calculated at each joint using trigonometry and algebra. The forces can be found at Joint A as shown below.



$$\sum F_x = 0$$

$$F_{AB} + F_{AF}\cos\theta_A = 0$$

$$\sum F_y = 0$$

$$0.5P + F_{AF}\sin\theta_A = 0$$

This can be repeated for all the joints in the truss.