VCHS Bridge Design-Build Project 4.1

Principles of Engineering

Parts of a simple bridge

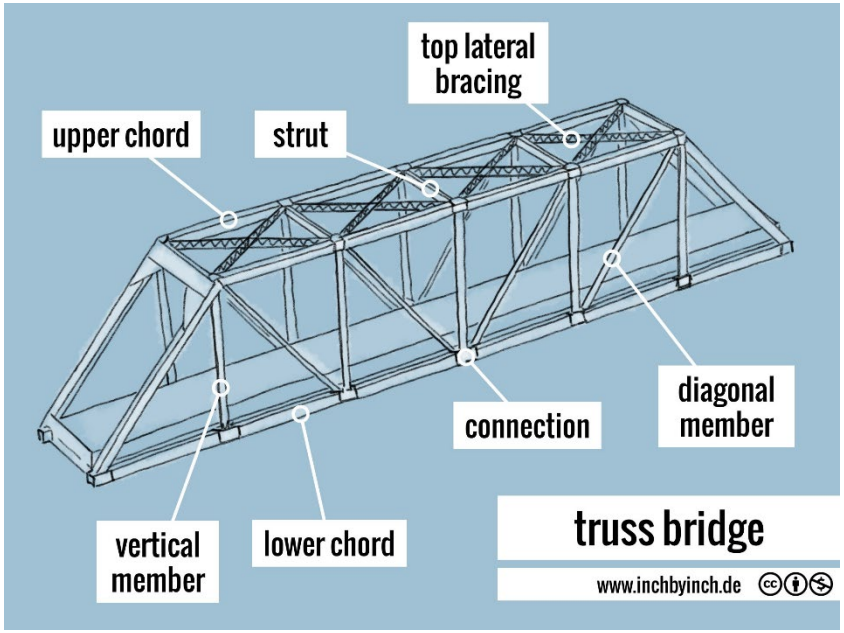
Truss – Framework made by connecting triangles and other forms that share load and stress forces across its entire structure.

Vertical member – Part of framework that connects the lower chord to the upper chord

Strut – bracing beam that runs perpendicular to the direction of the bridge

Chord – bracing beam that runs parallel to the direction of the bridge

Diagonal Member – sometimes called triangulating members, these are support beams that run at angles between struts and chords.



Objectives

- Design and build a bridge that meets the design constraints and maximizes performance in three criteria:
  1. Supports the largest applied load before failure
  2. Most efficient in ratio of Maximum Load supported to total bridge weight
  3. Most attractive structure
- Student Teams will demonstrate:
  - Engineering skills with critical thinking
  - Problem solving with Creativity
  - Appreciation of civil engineering
  - Application of the Engineering Design Process

Illustrious History

- One of the traditional competitions in the civil engineering community is the Popsicle Stick Bridge Contest. Students build bridges using only popsicle sticks and glue as building materials. Bridges are loaded until the bridge collapses.

Why Popsicle Sticks?

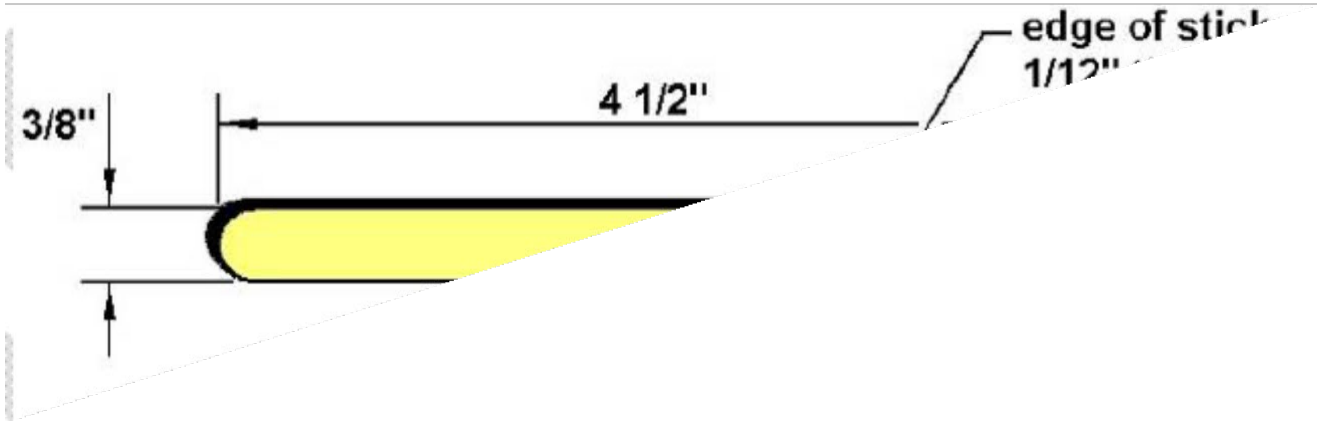
- Popsicle sticks are imperfect. Some may be bent, warped, or knotty; while others may be brittle, thin, or cracked. Visual inspection will weed out grossly deformed sticks, but students must deal with the slight imperfections present in all sticks. This is true in the real world where perfect materials are not available and careful thought must be given to the reliability of the construction materials. Engineers must attempt to quantify and account for deficiencies in both initial and post-construction material properties. Popsicle sticks are limited to a standard size that falls short of the overall bridge dimensions. In order to span a distance of 20 inches, several sticks must somehow be connected together in a straight line. This reflects real design problems where materials are finite in dimension and must be assembled in some manner to meet the engineer's needs.
- By being limited to only two allowable materials -wood popsicle sticks and wood glue -students will need to use creativity, ingenuity, and resourcefulness in order to maximize the strengths and minimize the inherent shortcomings of each material.

Design Constraints

- Materials
  - Wood popsicle sticks and coffee stir sticks
  - Gorilla Wood Glue Only
- Design Requirements
  - Teams must demonstrate design prior to build
  - The bridge must interface with the SA1000 test rig including the .38 inch diameter hole for loading rod.
  - Roadway must allow vehicle clearance shown from side to side:
  - Road surface must be flat as shown:
  - Loading will be from 2” x 2” plate on deck.
  - 3/8” hole at bridge center required

  to load the plate.
  - Bridge truss no lower than 2” below bank.

Introduce the Material



- Wood – The Official Popsicle Stick
  (measure one yourself)
- Glue
- Tools
- Xacto knife
- Scale
- Binder Clips

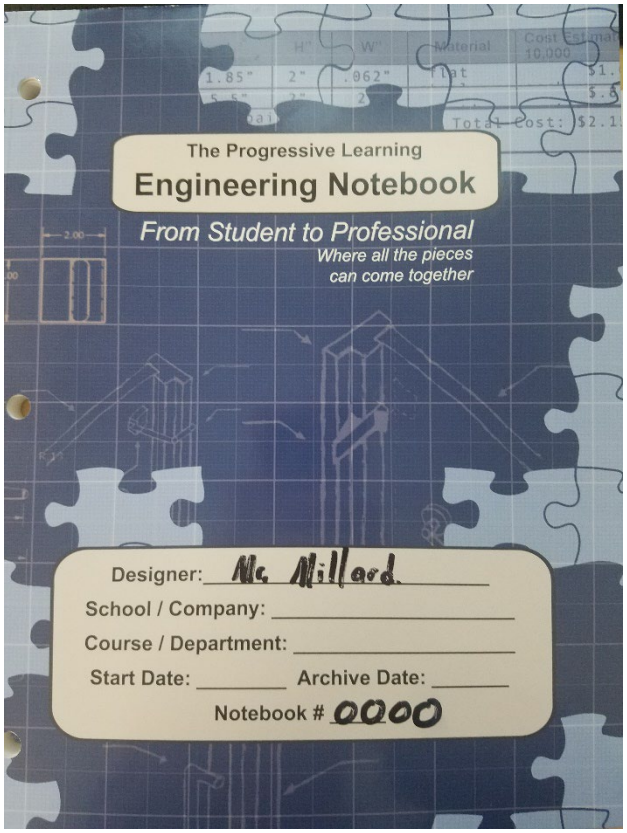
Grading

- ***Strength (30%)*** *Awarded to the students whose bridge is able to support the most load to weight ratio prior to failure. The bridges will be graded on a scale from the highest weight to the lowest.*
- **Workmanship & Artistry** ***(25%)*** Awarded to the students whose bridge appears to the judges to be the most professional looking and shows a high level of craftsmanship and beauty.
- **Presentation** ***(5%)*** Awarded to the students that presents their bridge in the most creative and professional manner. Includes a bridge name and sign posted on the bridge and an oral Power Point presentation.
- **Technical Report & Drawings** ***(40%)*** Technical report (including journal) describing the design and construction phases of their bridge. All Engineering Design Process steps need to be easily identified.

Process Requirements

- Engineering notebook
  - Problem Statement
  - Reason for decision (e.g. Fabrication Complexity, Load efficiency, Amount of sticks required)
  - Every step and calculations must be documented
  - Take pictures of the steps and include them as part of the documentation
  - Include sketches and software program results
  - The steps must be in a chorological manner following the rules of engineering notebooks
    - Dated
    - Signed
    - Legible

Rules of the Engineering Journal



<u>Each day's journal entry should include</u>

1. Clearly defined problem or task for the day.
2. Generate concepts to solve the problem (and delegate tasks if this is a research or blueprint day)
3. A blueprint of your design and an explanation of your proposed solution
4. Record of each team member's contribution that day.
5. Brief reflection of the progress made today and conclusion clearly stating if the day's problem was solved/addressed.
6. Each day students should all initial the bottom of the page.

Grade C Engineering Notebook

1) Incredibly vague task/problem.

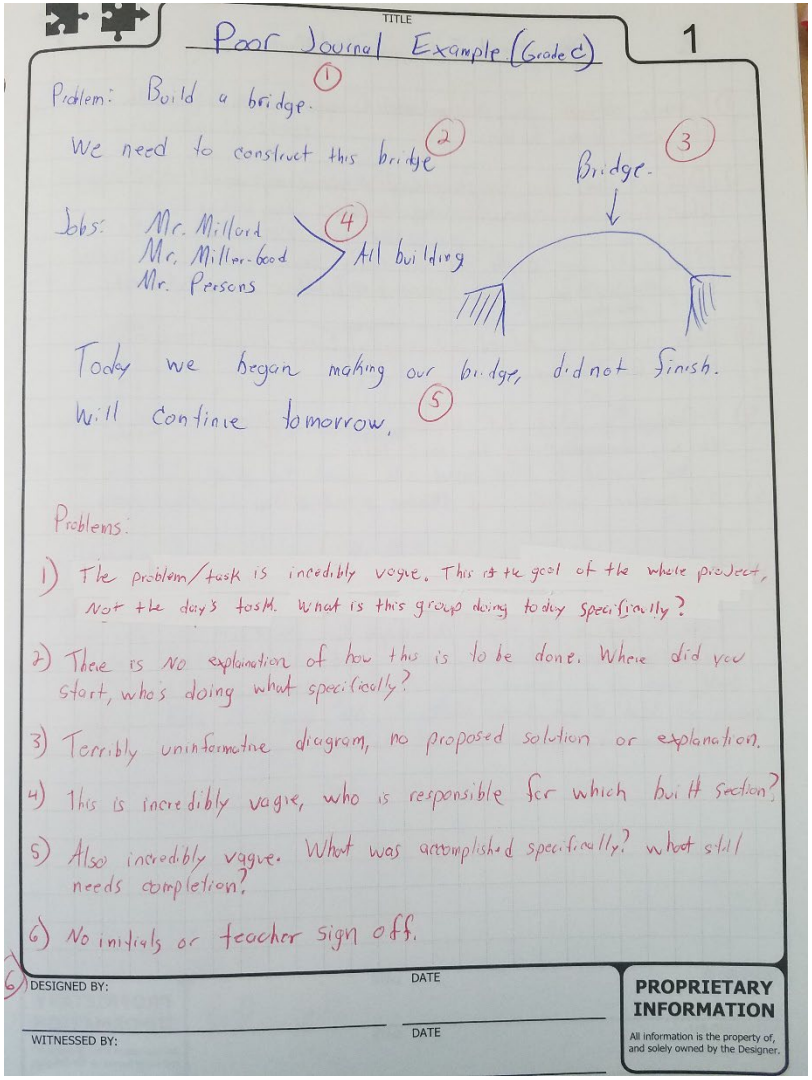
2) No explanation of how to accomplish task/solve problem

3) Uninformative diagram. No proposed solution.

4) All vague jobs. Who builds what? What else are you doing?

5) What specifically was accomplished? What needs finishing?

6) No initials



Grade B Engineering Notebook

1) Clearly obtainable goal/problem with a specific task related to the goal of building the bridge

2) Brainstormed ideas and shows experimental concepts.

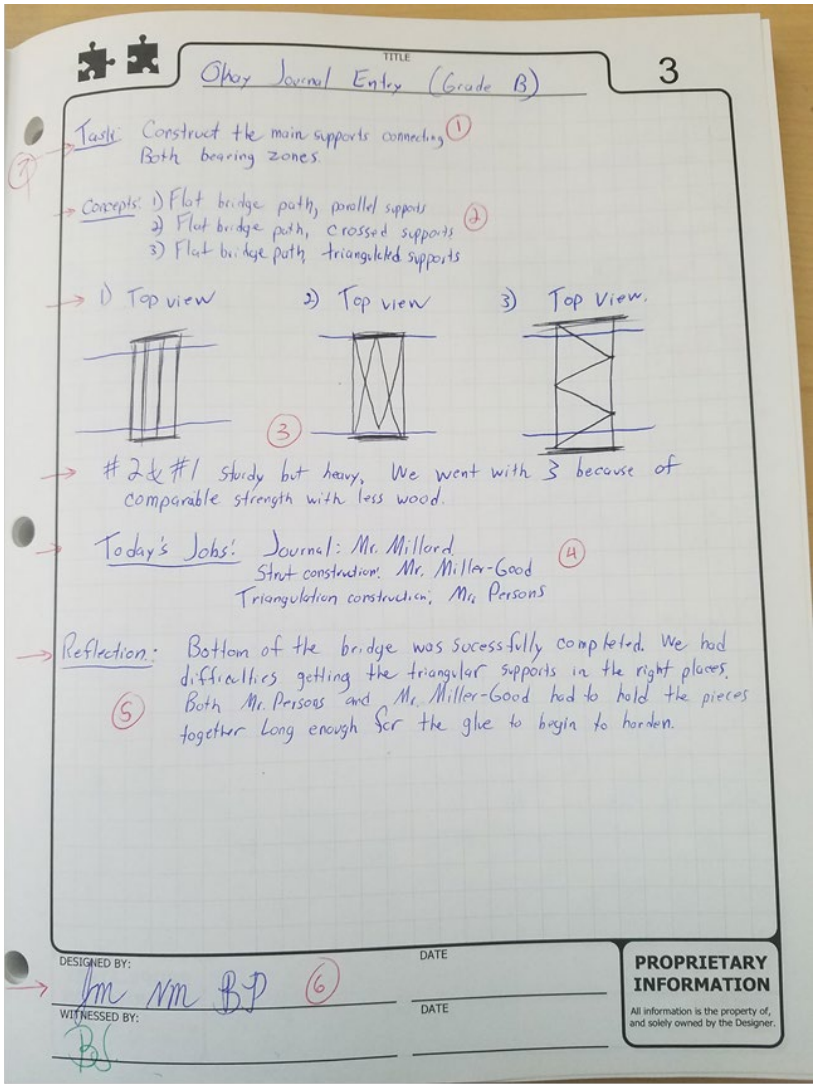
3) Drawings are crude but present and understandable. Different designs are prototyped and decision is well reasoned.

4) Daily jobs are clearly defined and unique. Each person contributes equally for the day.

5) Reflection is short but properly reflects on a problem they encountered in the day.

6) All members and teacher initialed.

7) General organization is neat and clearly understandable. Journal entry is not squished together in any way.



Grade A Engineering Notebook

1) Task is clear and it's importance in the larger construction is evident.

2) Researched concepts utilizing technology

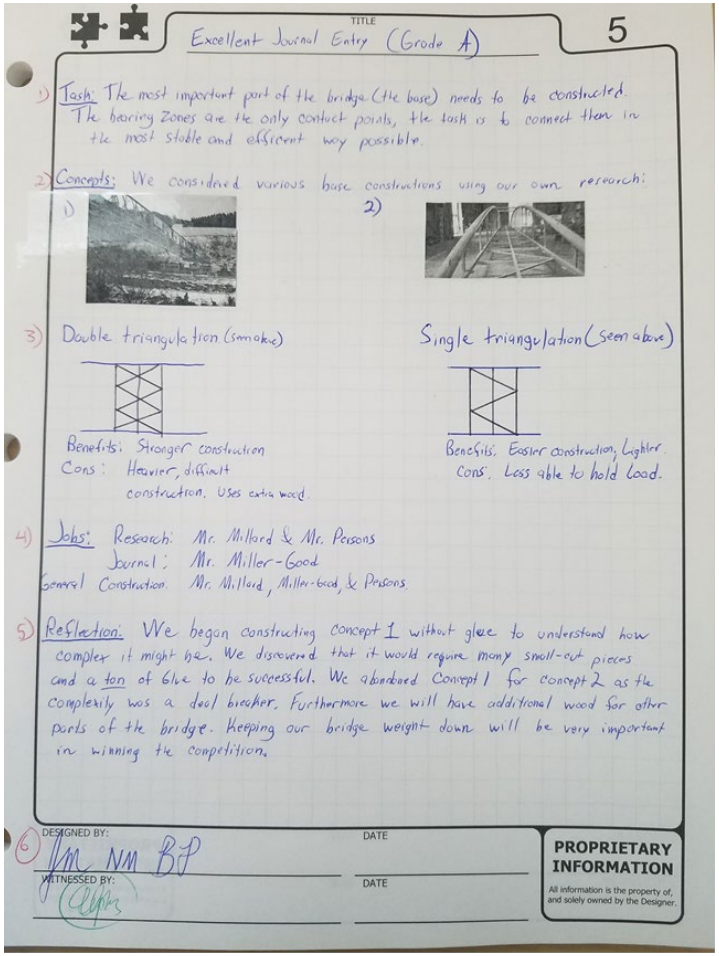
3) Carefully drawn illustrations are accompanied by thought process of selection.

4) Daily jobs/responsibilities are shown. All members fully participated and all responsibility was shared.

5) Reflection is lucid with insight into decision making process. Daily reflection includes information about how this work affects the whole project.

6) All members and teacher initialed.

7) Entire entry is neat and tidy with little to no mess or cross-outs/whiteout. Writing is legible and not clumped together in one single paragraph.


TITLE
Excellent Journal Entry (Grade A)
5

1) Task: The most important part of the bridge (the base) needs to be constructed. The bearing zones are the only contact points, the task is to connect them in the most stable and efficient way possible.

2) Concepts: We considered various base constructions using our own research:

1)

2)

3) Double triangulation (same as 1)

Benefits: Stronger construction
Cons: Heavier, difficult construction. Uses extra wood.

Single triangulation (seen above)

Benefits: Easier construction, lighter.
Cons: Less able to hold load.

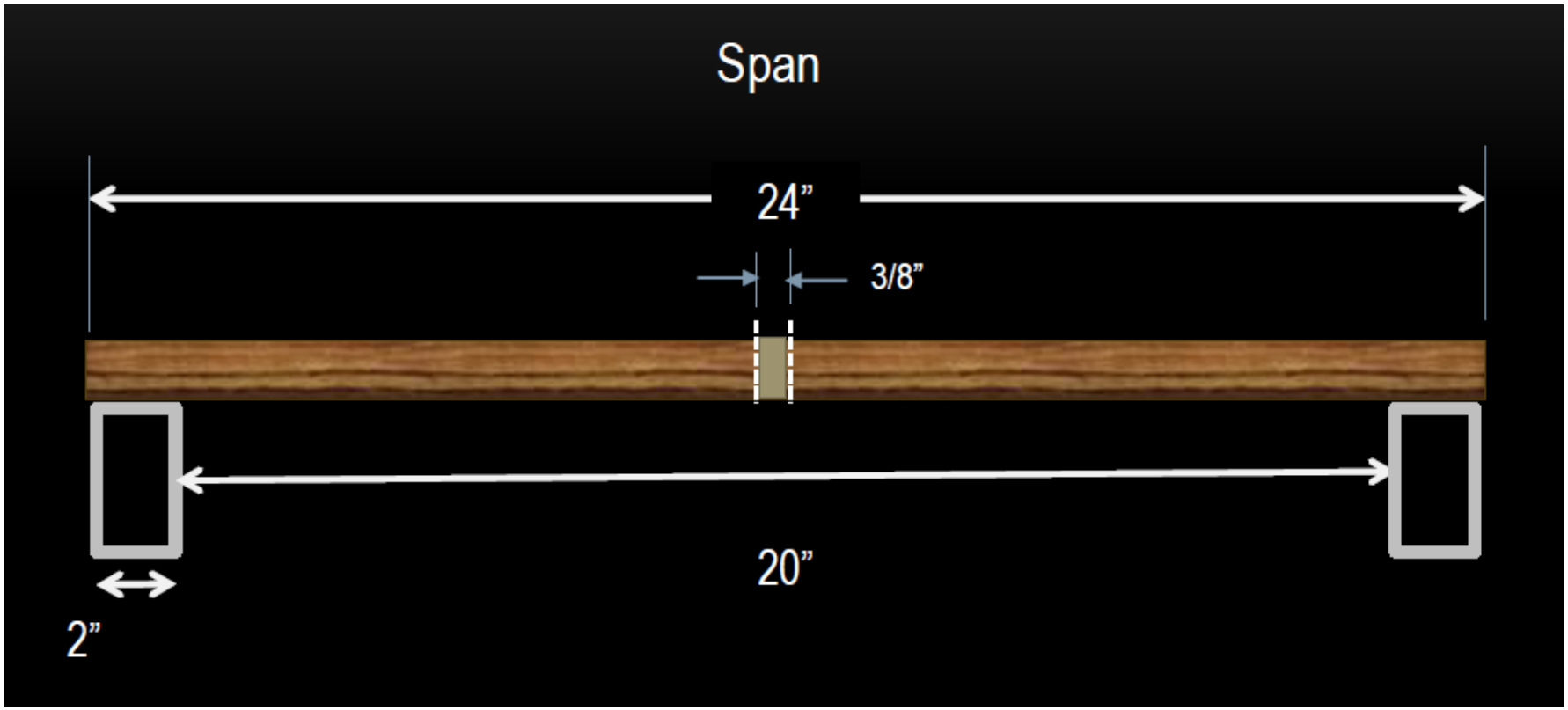
4) Jobs: Research: Mr. Millard & Mr. Persons
Journal: Mr. Miller-Good
General Construction: Mr. Millard, Miller-Good, & Persons

5) Reflection: We began constructing concept 1 without glue to understand how complex it might be. We discovered that it would require many small-cut pieces and a ton of glue to be successful. We abandoned Concept 1 for concept 2 as the complexity was a deal breaker. Furthermore we will have additional wood for other parts of the bridge. Keeping our bridge weight down will be very important in winning the competition.

6) DESIGNED BY: NM BP DATE
WITNESSED BY: DATE

PROPRIETARY INFORMATION
All information is the property of, and solely owned by the Designer.

SA1000 Interface



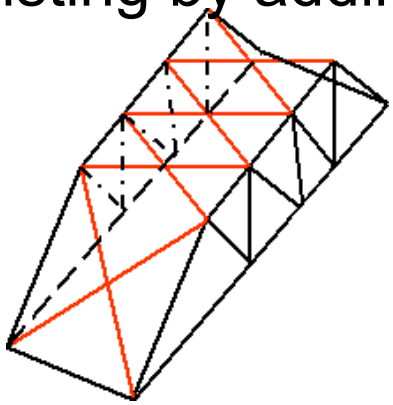
- **Be sure to measure width and height available in test rig.**

Alternative Bridge Designs

- Arch
- Overhead Truss
- Pratt Truss
- Howe Truss
- Warren Truss
- K Truss
- Design your own

Design Hints

- Focus thought around loading and reaction points and their forces.
- Use scale drawings (and consider full scale at key areas).
- Remember cross bracing. This is a three dimensional system.
  - Keep bridge from twisting by adding lateral bracing



- Use the whole Engineering Design Process.

Research Ideas

- Joist or Planks
- Truss joints
  - Double/Triple/Quadruple
- Test popsicle stick to failure under multiple load configurations.

- Sources on Bridge Projects available on internet.

Construction Ideas

- **Not all popsicle sticks are equal**
  - Deformed popsicle sticks won't be as strong as straight ones
  - Low quality popsicles could result in a weak bridge
  - Examine the popsicle sticks
  - Twisted popsicle sticks are a big problem because they don't glue flat to each other.
  - Bad Characteristics:
    - Knots
    - Twisted
    - Bent
    - Bad grain structure

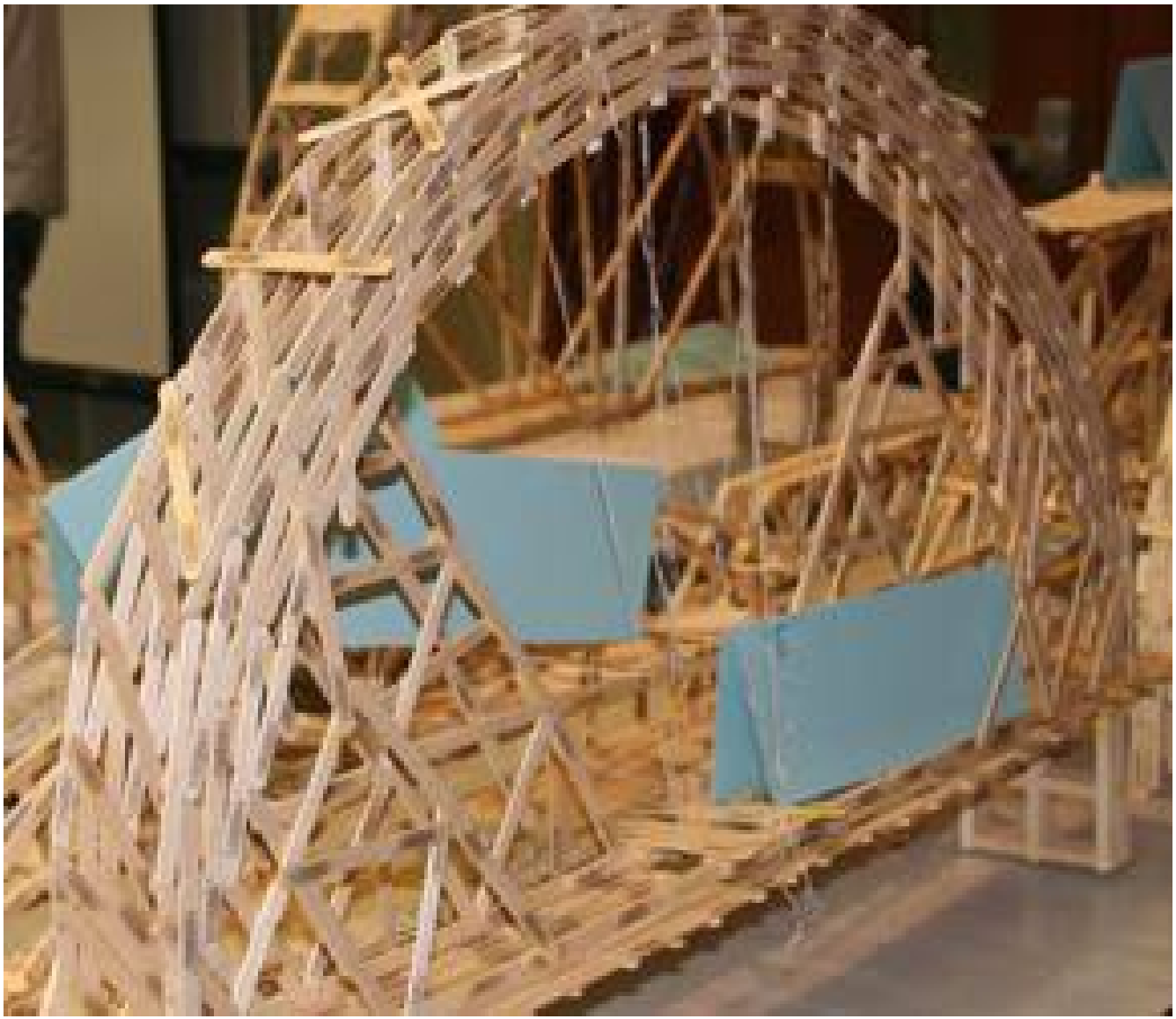
Testing the Wood Quality

- Sorting the popsicle sticks
  - Split the “good” pile into two new piles
    - Examine the grain structure of each popsicle stick, and make sure that each one is perfectly straight.
    - The extra time taken ensures utilizing the best of the best popsicle sticks in key areas.
  - Grain Structure
    - The grain to be parallel to the stick, and not on a diagonal. This is especially important for popsicle sticks that will be in tension

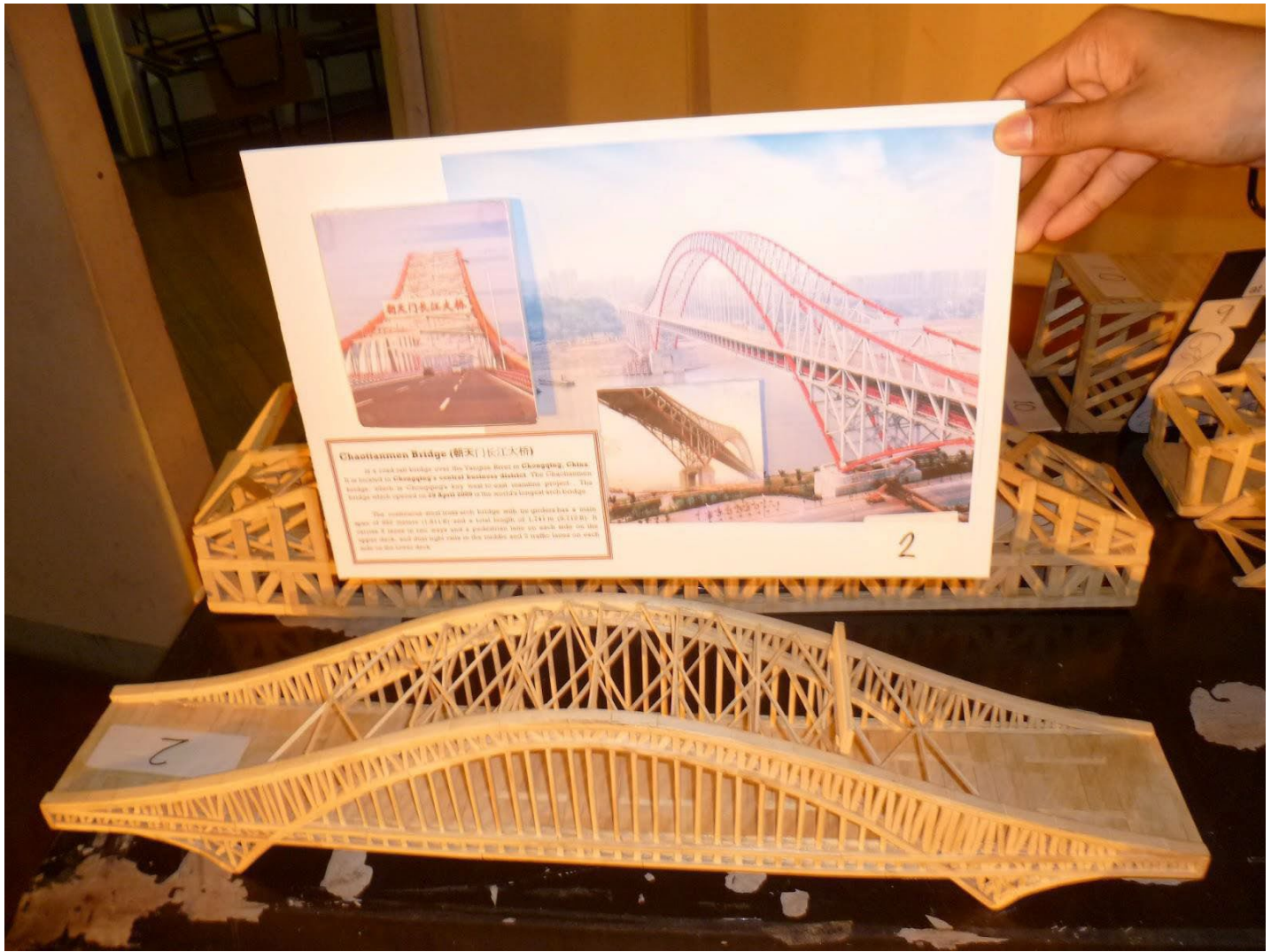
Examples

Beauty

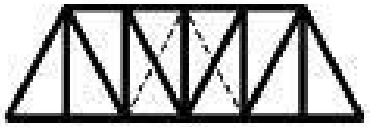
The Beast



Above and Beyond



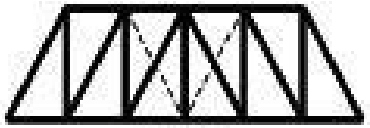
Dream it, Build it, Break it



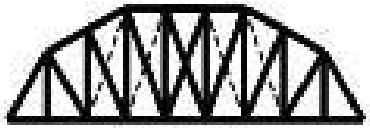
Pratt

Parker

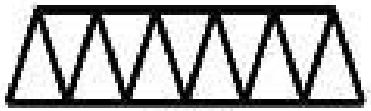
K-Truss



Howe

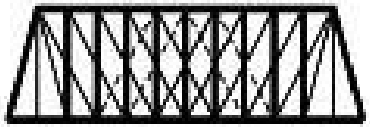


Camelback

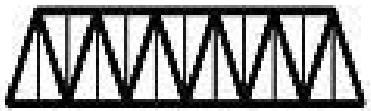


Warren

Fink

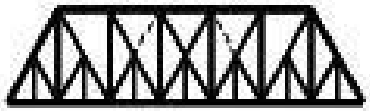


Double Intersection Pratt

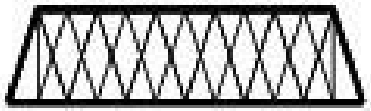


Warren (with Verticals)

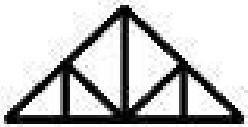
Bowstring



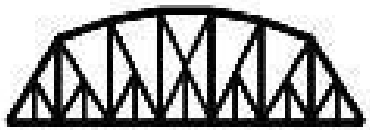
Baltimore



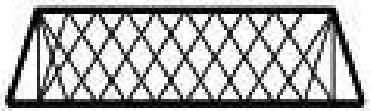
Double Intersection Warren



Waddell "A" Truss



Pennsylvania



Lattice