Structural Design and Engineering

2022 DETAILS / PROBLEM STATEMENT

BACKGROUND

Structural engineers design and analyze structures that support or resist loads, such as buildings, large non-building structures, machinery, medical equipment, vehicles, or any item for which structural integrity affects function or safety. Structural engineering work is based on physical laws and practical knowledge about the performance of different materials and geometries.

Structural engineers use of a number of simple structure elements to build complex structural systems. Through structural analysis (a key component in the structural design and engineering process), engineers determine the effects of loads on structures and their components. Applied mechanics and mathematics, and materials science are used in structural analysis to help compute a structure's deformations, internal forces, stresses, support reactions, accelerations, and stability. Analysis results help to verify a structure's fitness for use and, in many cases, can eliminate the need for actual physical tests.

CHALLENGE

Research **Trestle Bridge** structures and develop a design for a railroad trestle bridge that spans a canyon that has a river running through it. The bottom ends (or feet) of the trestle sit on concrete bases that are on the banks of the river and abut the near vertical canyon walls. The trestle must support the weight of the railroad and the ore carrying trains that pass over the canyon. Another company also uses the river to run sightseeing tours on a restored steam paddle boat, so the bottom middle of the trestle must be open to allow the boat to pass through safely.

Consider the following:

1. Aesthetics
2. Measurement requirements
3. Test block size
4. Live load
5. Minimalist design and engineering concepts
6. Materials

The submitted structure will be tested using a TSA-designated testing instrument. Prior to testing, a random draw of 0, 1”, or 2” will determine how far off center of the bridge that the center of the testing block will be placed. Consideration of the placement of cross members and other pieces must be used to allow the metal rod of the tester to be able to pass up through the bridge at any of these locations. The test block will rest on the top of the bridge surface.

The structure, along with the required documentation and drawing, must be submitted at check-in in a designated box with a lid. The team is to construct the entire box and lid from standard poster board. The size of the box is to be 18” long, 10” wide, and 5” deep. Instructions for construction of the box are included on page 4 and 5.

DIMENSIONS

The Trestle (1/16” tolerance)	
Length	16”
Width	2"
Height	8”

Opening for the Boat (no tolerance)		
	Minimum	Maximum
Height	4.5”	None
Width	8”	None

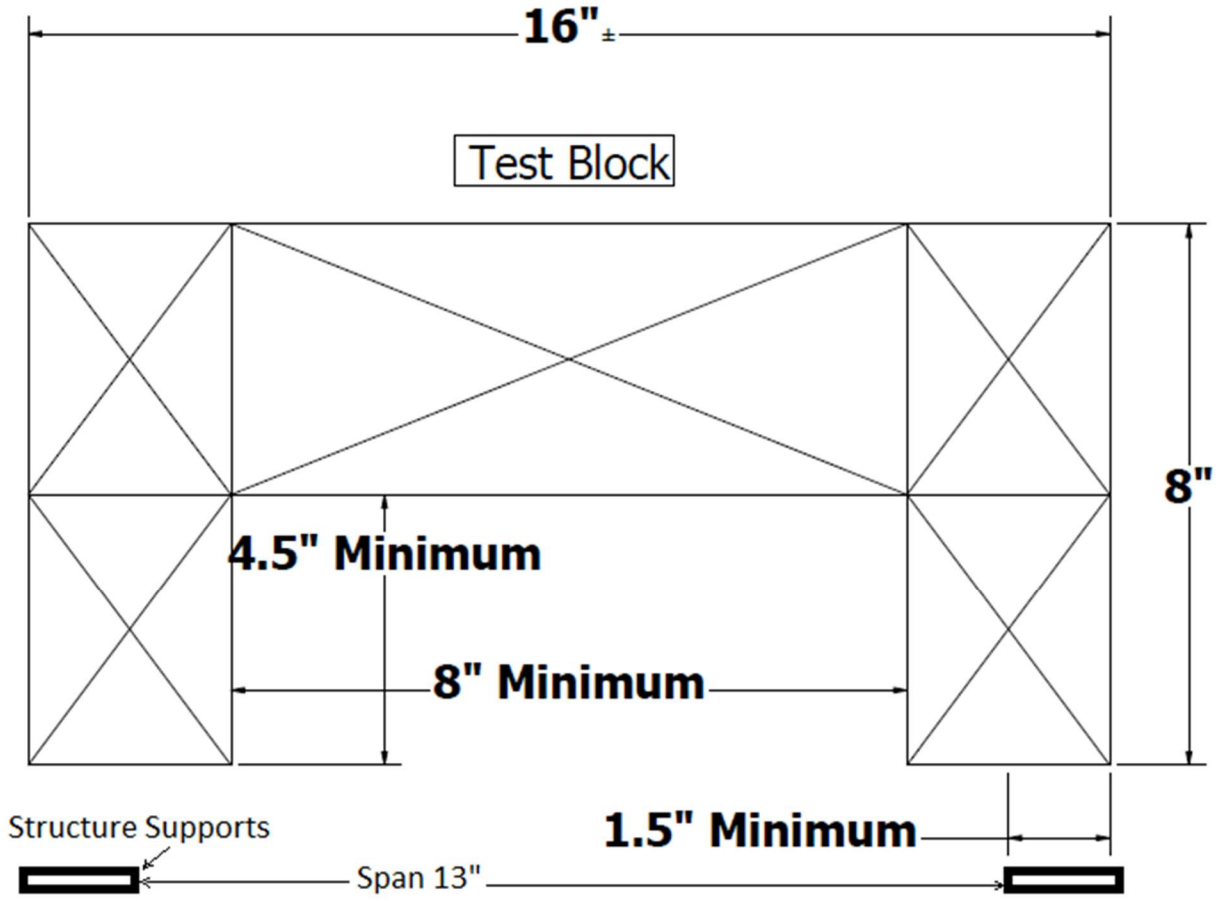


Figure 1

The **span** of the tester will be 13”.

MATERIALS

Basswood strips is the designated construction material. 1/8” x 1/8” and 1/8” x 1/4"

The participants may choose a **glue** type; however, hot-melt glue is not allowed for the pre-built or on-site structures. Keep the time limit in mind when selecting the glue for semifinals.

DESIGN CONSTRAINTS

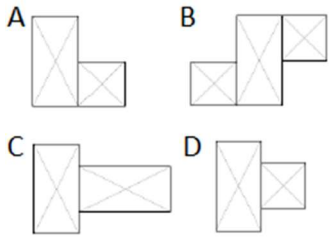
1. Teams must design and construct the trestle structure applying the principles of engineering while using the least materials. The design should emulate and serve and a modular component for a trestle bridge.
2. The top of the trestle must be flat and designed in such a way that the railroad ties and rails could be laid once the bridge is erected. The very top must be flat the entire way from end to end and not have any cross members on it. Cross members may be used even with, or immediately under the very top, as well as anywhere else in the bridge as long as they do not block the testing rod.
3. Exact amounts of designated materials are not being specified for the pre-built. However, a designated amount of material will be used for the semifinalist portion of the event.
4. Each designated material must be utilized in the construction of the structure.
5. Contestants should remember that the use of too many materials will be a negative factor when calculating the efficiency of the structure after testing.

CONSTRUCTION CONSTRAINTS

1. Substructures that extend below the bottom ends (feet) of the trestle are not allowed.
2. *Lamination* is the combining of two or more pieces of like materials (or size) with the grain running in the same direction. Only the examples of allowable laminations shown below are permitted.

Examples of Laminations that are allowed:

A - 1/8” x 1/4” to 1/8” x 1/8” to create an L or rabbet shape
B - 1/8” x 1/8” to 1/8” x 1/4" to create two offsets
C - 1/8” x 1/4" to 1/8” x 1/4" to create a T shape
D - 1/8” x 1/4" to 1/8” x 1/8” to create a T shape



3. Lap joints are allowed and involve gluing two pieces of basswood material with the grain pattern normally at right angles; however, and lap joint less than 10° or greater than 170° would circumvent the lamination guidelines and will be ruled unacceptable.
4. Coating of the wood, other than the joints, with any material is not permitted.
5. The opening for the boat may be rectangular or arched, but must be large enough to allow a piece 4.5” high and 8” wide to pass through.

TESTING

1. A TSA designated structural testing instrument will be used for the stress testing of the structures.
2. Testing block (will rest on the top of the bridge surface): 2” wide and 6” long
3. The structure will be placed on the tester with the bottom ends (feet) of the trestle resting on the tester supports.
4. The span of the tester will be 13”, but based on the random draw, the testing rod can be anywhere from 0 to 2 inches off center (0, 1” or 2”). The judge will solely determine which side of the bridge will face forward when testing.
5. The metal rod of the tester must be able to pass up through the bridge at any of the possible testing locations (0, 1” or 2”).
6. Each bottom end (foot) of the structure must be a minimum of 1 1/2" long (see **Figure 1**).
7. Failure of a structure occurs when the testing instrument records structural failure, which is when the tester stops recording a higher force.
8. Structures that sag or bend in testing without indication of structural failure, will have the highest force indicated used as the failure weight.

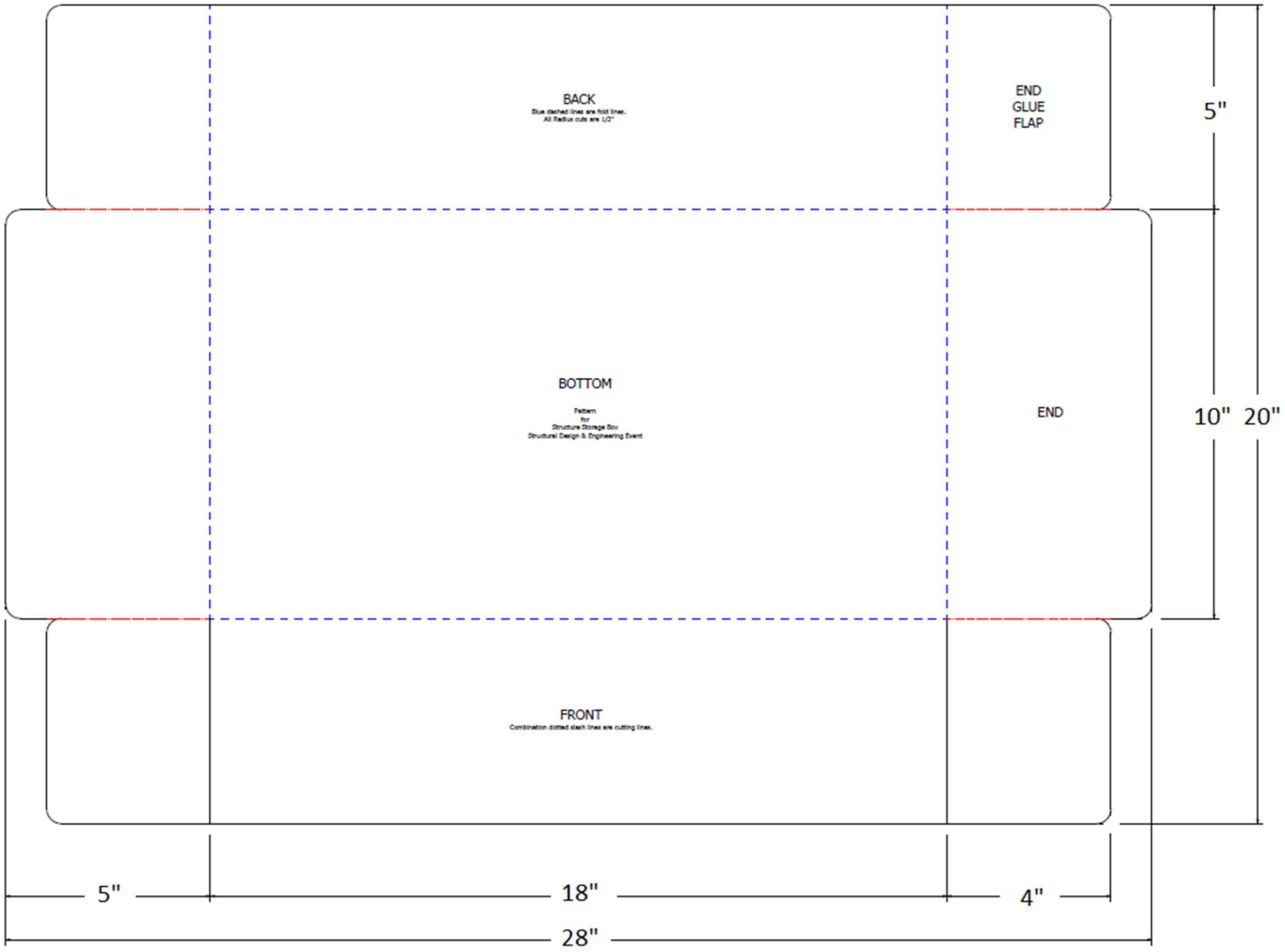
DRAWING

Teams must present a proper mechanically drawn or computer-generated full size orthographic, three (3)-view (front, top, and right end) drawing. The drawing must be on one side of an appropriately sized sheet that shows each structural member of their design. The only identifying information on the drawing is the **team/chapter ID** number. The drawing may be folded as needed and placed in the portfolio.

STORAGE BOX AND LID

The drawing pattern (on the next page) is provided for each team to utilize in the layout and fabrication of a storage box and lid using 22” x 28” standard poster board. The pattern shows the bottom section of the box and must also be used to create the top section. Teams should note that making both the top and bottom sections the same size will result in a rather snug fit. The 10” wide x 18” long bottom size should be decreased slightly (no more than 1/8” each direction) so that the top can be removed and replaced without difficulty.

The blue dashed lines are folds. The red dashed lines are cuts.



REQUIREMENTS FOR CHECK-IN ON-SITE

1. Storage box and lid constructed using standard poster board.
2. Completed trestle bridge.
3. The documentation portfolio, which is placed inside of the storage box, must include the following materials:
   - Team Verification Form
   - Analysis and Assessment Form
   - Full size, three (3)-view (front, top, and right end) drawing of the structure