HIGH SCHOOL STRUCTURAL DESIGN AND ENGINEERING

Below is an informal checklist to assist participants in preparation for competing in this event.

REQUIREMENTS FOR CHECK-IN

- ☐ Completed model structure in box
  (Fabricated according to the design specification)
- ☐ Team Verification form
- ☐ Analysis and Assessment form
- ☐ Three (3) view orthographic drawing of pre-built structure
- ☐ TEAM LEAP Resume

Team ID# ______________________

High School STRUCTURAL DESIGN AND ENGINEERING

Team Verification Form

As the advisor for the team of students representing the school indicated below, I certify that the students have used only the specified list and quantity of materials, as designated by TSA, in the construction of their entry for the Structural Design and Engineering event. I also certify that only the two (2) team members noted have worked on the entry they are submitting for testing and evaluation.

Date: ____________________________________

Team member names (printed, with signatures):

____

____

Advisor's name (printed, with signature):

____

____

Team ID# ________________________

High School STRUCTURAL DESIGN AND ENGINEERING
Analysis and Assessment Form

Complete and submit this form (signed by the chapter advisor) with the Structural Design and Engineering entry, as confirmation that a structure was designed, built, and tested prior to and in preparation for participation in conference competition.

1) Structure weight prior to testing ________________________________

2) Predicted ultimate load carrying capacity: Fu,p Fu,p____________________________

3) Use the equation to calculate the error in prediction for the ultimate load carrying capacity:

$$E = \frac{Fu - Fu,p}{Fu}$$

E________________________________

where

E = Error
Fu,p = Predicted Ultimate Load
Fu = Ultimate load attained in testing

4) Structural efficiency: Ns Ns_______________________________
Use the equation to calculate structural efficiency:

$$Ns = \frac{Fu}{M}$$

where

Fu = Ultimate load (failure weight) attained in testing
M = Dead weight of structure as measured in testing

5) Predicted failure mode: FM

6) Where or how was the structure predicted to fail? ____

7) What are the four major types of forces that act on a structure under stress?
____

8) What is the static load of a structure? ____

9) What part of a testing device should be considered live load? _____________________________________

10) What effect would a shorter length test block have during stress testing?
____

____ ____ ________

Chapter advisor printed name **Chapter advisor signature** **Date**

High School STRUCTURAL DESIGN AND ENGINEERING
2018-2019 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	4. Live and dead loads of a span
2. Height requirements	5. Minimalist design and engineering concepts
3. Width requirements	6. Materials

The submitted structure will be tested using a TSA-designated testing instrument. The center of the structure must maintain a one (1)-inch hole and clearance so that a rod can be passed through the structure for testing.

The structure, along with required documents and drawing must be submitted at check-in in a box with a top that the team has constructed from standard poster board paper. The size of the box is to be 18” long, 10” wide, and 5” deep.

Balsa wood is the designated construction material; participants may choose their own glue type. The test block will rest on the utmost top of the trestle structure. No structure member may be higher than the surface where the test block is placed.

SIZE CONSTRAINTS

The Trestle (1/16” tolerance)
Length 16"
Width 2 ½”
Height 8"

Opening for the Boat
Height Minimum 3”, no maximum
Width Minimum 6”, no maximum

MATERIALS

1/8" x 1/8" Balsa wood strips
1/8" x ¼" Balsa wood strips

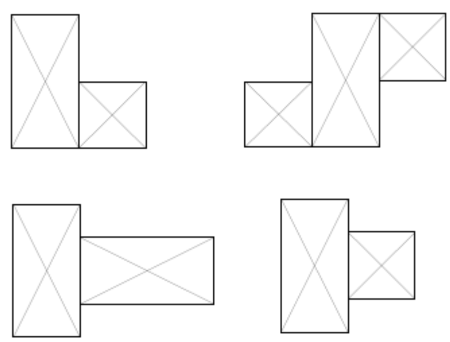
DESIGN CONSTRAINTS

1. Teams must design and construct the trestle structure applying the principles of engineering while using the least amount of materials. The design should emulate and serve as a modular component for a trestle bridge.
2. The utmost top of the trestle should be designed in such a way that railroad ties and rails could be laid once the bridge is erected, and must maintain the length and width given in the size constraints from end to end.
3. At check-in, teams must present a full size orthographic, three-view drawing (all views on one side of an appropriate sized sheet) that shows each structural member of their design.
4. Exact amounts of designated materials are not being specified for the pre-built. The semi-finalists will be given a similar problem, but teams must plan and design their structure to use only the material given to them.
5. Contestants should also 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 of the trestle ends (feet) 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.

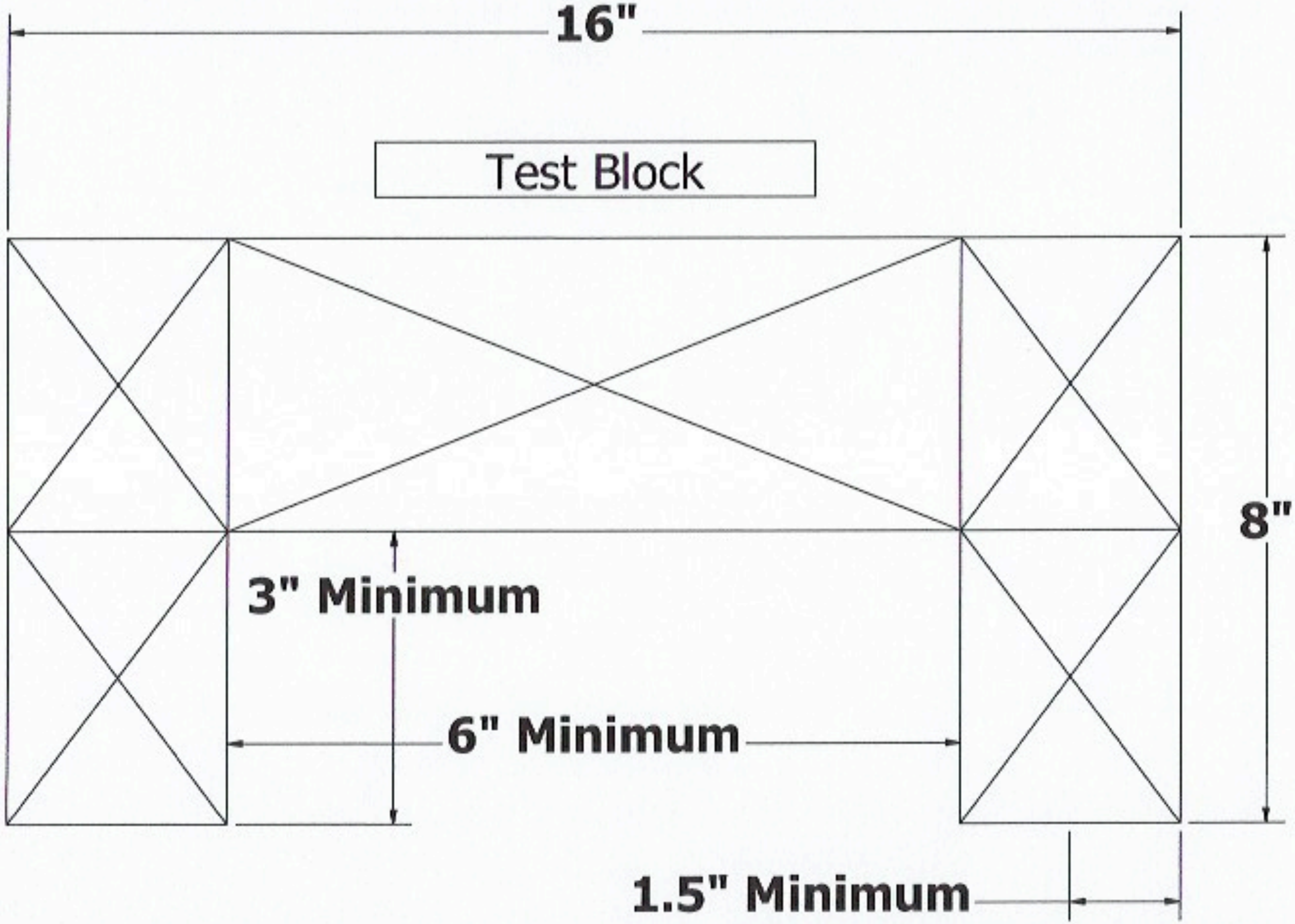
Examples of Laminations that are allowed.
1/8” x ¼” to 1/8” x 1/8” to create an L or rabbet shape
1/8” x 1/8” to 1/8” x ¼” to create two offsets
1/8” x ¼” to 1/8” x ¼” to create a T shape
1/8” x ¼” to 1/8” x 1/8” to create a T shape



3. Lap joints are allowed and involve gluing two pieces of balsa material with the grain pattern normally at right angles; however, any lap joint less than 10° or greater than 170° would circumvent the lamination guidelines and be ruled unacceptable.
4. The opening for the boat may be rectangular, arched, or any shape, but must be large enough at all points to allow a piece 3” high and 6” wide to pass through.

TESTING

1. A TSA designated structural testing instrument will be used for stress testing of structures.
2. Testing block: 2 ½’" width x 6” length x ¾" height.
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”.
5. Each bottom end (foot) of the structure must be a minimum of 1 ½” long
6. Failure of a structure occurs when the testing instrument records structural failure, which is when the tester stops recording a higher force.
7. Structures that sag or bend in testing without indication of structural failure, will have the highest force indicated used as the failure weight.


16"
Test Block
8"
3" Minimum
6" Minimum
1.5" Minimum