High School STRUCTURAL DESIGN AND ENGINEERING
2017 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 **Bridge Crane** structures and develop a design for a bridge crane that meets the specifications in this problem statement. (You may wish to refer to the latter portion of this problem statement before you continue, as there are drawings and resources provided that will help you better understand the nature of the project.)

Consider the following:

1. Aesthetics
2. Height requirements
3. Width requirements
4. Maximum allowable span between vertical supports
5. Dead load of a span
6. Live load of a span
7. Minimalist design and engineering concepts
8. Materials
9. Off-site pre-built or pre-fabricated components
10. Utilities

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.

Balsa wood is the designated construction material; participants may choose their own glue type. The test block will rest on the top of the carrier surface.

SIZE CONSTRAINTS

Truss girder structures - 2
Length 16"
Width 1 ¾"
Height 2 ½"

Carrier structure - 1
Length 4"
Width 6 ¼"
Height 3 ¼"

MATERIALS

Truss girder structure
1/8" x 1/8" Balsa wood strips
1/8" x ¼" Balsa wood strips

Carrier structure
1/32" Balsa wood sheets
1/8" x ¼" Balsa wood strips

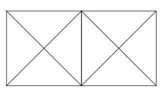
DESIGN CONSTRAINTS

1. Teams should design and construct a pair of truss girder structures, applying the principles of engineering while using the least amount of materials. The design should serve as a modular component for a bridge crane.
2. The design will also include a carrier or gantry sleeve that will allow the pair of truss girders to move freely inside of the gantry sleeve.
3. The truss girders must be permanently attached at each end.
4. At check-in, teams must present a full size orthographic, three-view drawing (all views on one side of an appropriate sized sheet) that show each structural member of their design.
5. Exact amounts of designated materials are not being specified
6. Contestants should remember that the use of too many materials will be a negative factor when calculating the efficiency of the structure after testing.

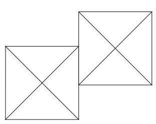
CONSTRUCTION CONSTRAINTS

1. Substructures are not allowed.
2. *Lamination* is the combining of two or more pieces of like materials with the grain running in the same direction.
3. **Examples of laminations not allowed.**

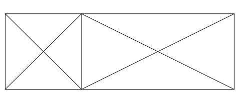
   1/8" x 1/8" to 1/8"x 1/8" = 1/8" x ¼"

   1/8" x 1/8" to 1/8" x 1/8" = new shape

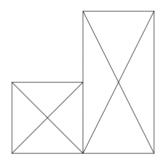
   

   1/8" x 1/8" to 1/8" x ¼" to create a 1/8" x 3/8"

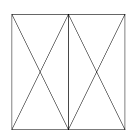
   

   Examples of laminations that are allowed.

   1/8" x1/8" to 1//8" x ¼" to create an L or rabbet shaped piece of material

   <u>Laminating 1/8" x ¼" material to create the top beam (1/4" x 1/4") of the truss girders is allowed as pictured in the illustration drawing</u>. (top beam only)

4. 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.
5. The 1/32" balsa wood sheets are to be used for the construction of the carrier/gantry sleeve structure
6. No hot glue may be used, and the use of glue for coating structural components is not allowed.
7. The 16" length must be maintained for the two crane truss girder structures.
8. The dimensions noted for crane truss girder structures and the carrier/gantry sleeve are fixed in terms of maximum widths and heights.
9. To fully clarify constraint item #8, the truss girder structures and the carrier/gantry sleeve may be designed and built at a smaller width and height than noted, but the 16" length (crane truss girder structures) and the 4" length (carrier gantry sleeve) must be maintained, as well as the 1" diameter hole through the center of the top and bottom of the carrier/gantry sleeve to allow for the placement of the testing device rod.
10. A 1/16" tolerance will be applied to all stated maximum measurements.

TESTING

1. A TSA designated structural testing instrument will be used for stress testing of structures.
2. Testing block: 3" width x 4 3/4" length x ¾" height
3. Failure of a structure occurs when the testing instrument records structural failure.

REQUIREMENTS FOR CHECK-IN

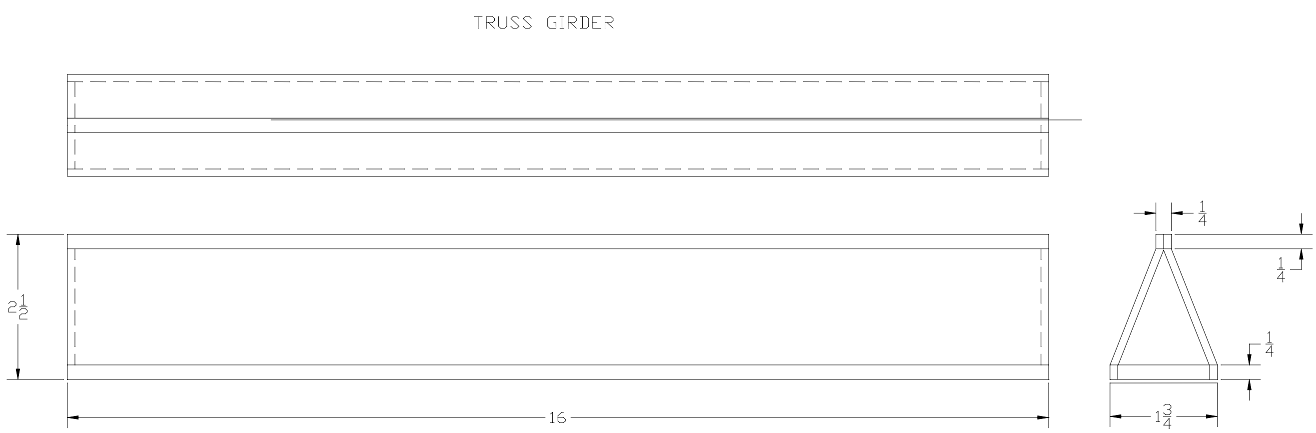
1. Completed model structure
2. Three-view drawing
3. Verification form
4. Assessment form

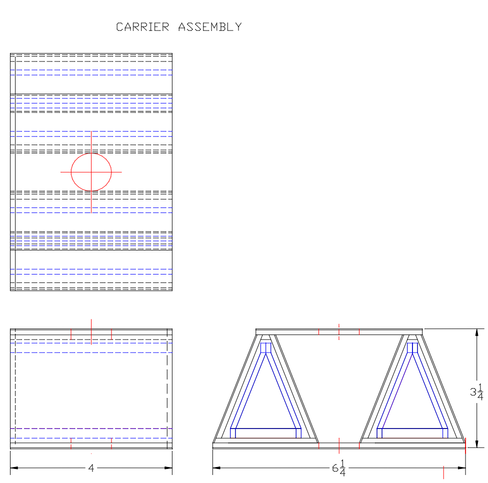
ILLUSTRATIONS/PHOTOS

The illustrations and photos that follow provide basic information and examples for the Bridge Crane structures. ***Although the illustration shows a triangular shape for the two truss beams, teams may choose to use a different shape for these truss beams, which would require a change in the shape of the carrier assembly.***

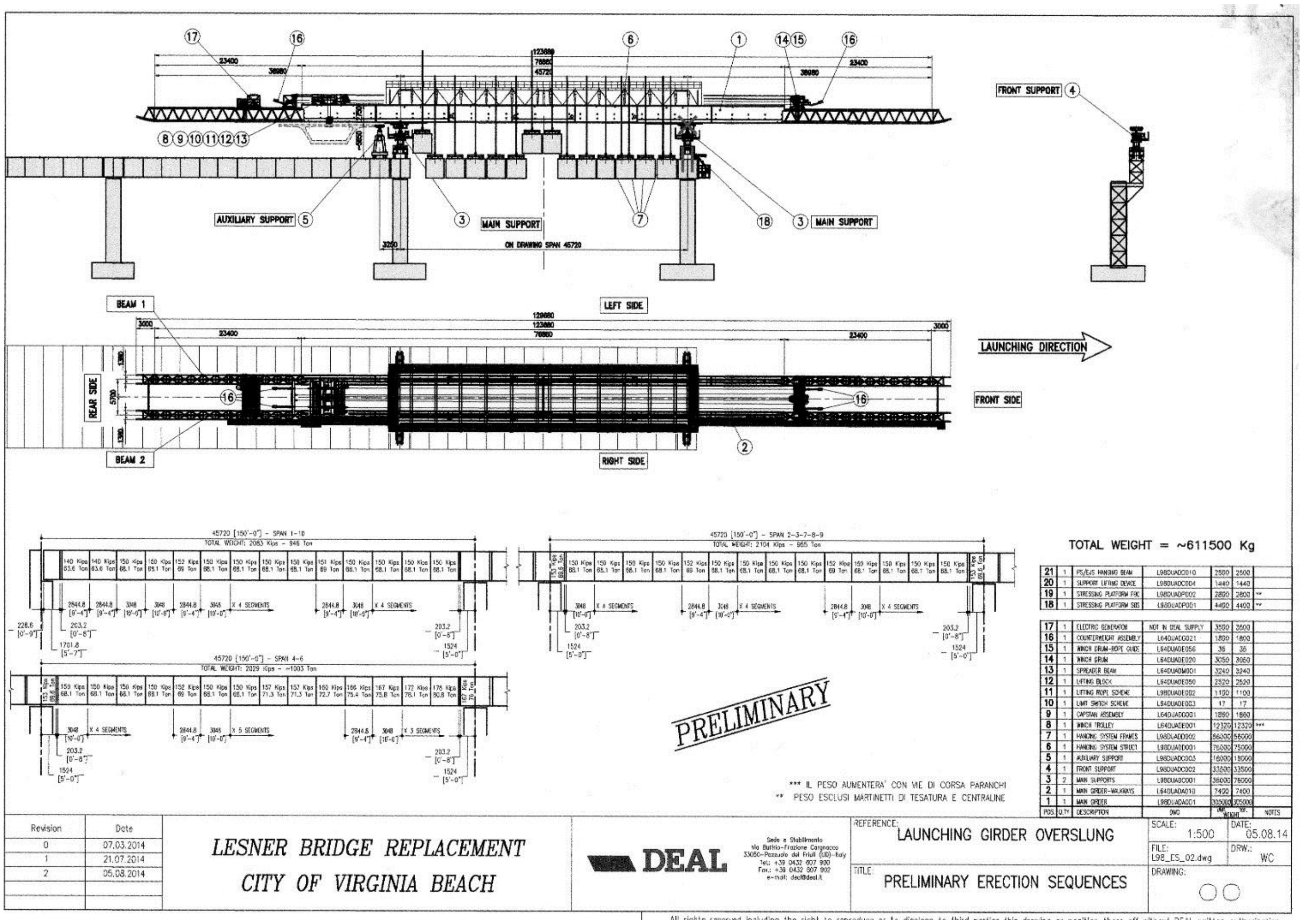
Basic configuration

The drawings below provide the measurements and basic configurations for the three (3) elements of the structure that each team must design and build. As noted, two (2) truss girders are required and one (1) carrier assembly. The truss girder drawing does not provide placement of truss members, and the drawing for the carrier assembly only shows a portion of the truss girders (blue lines) as they pass through the carrier assembly.





The drawing that follows illustrates the placement and configuration of the bridge crane structure as it is being used in the construction of the segmental concrete Lesner Bridge replacement.



This URL (http://www.workzonecam.com/projects/rshcs/rshcs/workzonecam) links to the construction cam that is being used to record and document the Lesner Bridge project (the bridge crosses the Lynnhaven Inlet in Virginia Beach, VA). Logging into this site will allow you to view the actual use of a bridge crane in real time. You can also view a time-lapse movie of the construction process.

This URL (http://www.vbgov.com/government/departments/public-works/roadways/Pages/lesner-bridge-7-14.aspx) will allow you to visit the Lesner Bridge Replacement Project page found on the City of Virginia Beach webpage. Under the *Additional Information* heading on the right side of the page, you will find access to a construction sequence animation and various staging steps for the construction, completion, and maintenance of the bridge structure.

This URL (http://www.posttensioning.org/Uploads/Conference/2012%20Convention/Segmental%20Bridge%20Constructin%20Techniques.pdf) will take you to a presentation on Segmental Bridge Construction Techniques given by Bob Seward at the 2012 PTI Convention, held on May 7, 2012 in Nashville, TN. The presentation is a good resource for understanding the engineering concepts and practices used in this type of bridge construction.