STRUCTURAL ENGINEERING

OVERVIEW

Participants work as part of a team on site with supplied materials to build a model of a structure that is destructively tested to determine design efficiency.

A box girder beam, which is a rectangular prism, is the designated structure for 2013 and 2014.

PURPOSE

Working as a team, within time and material constraints, participants will construct a box girder beam that reflects knowledge of engineering design and construction concepts.

ELIGIBILITY

Participants are limited to one (1) team of two (2) members per chapter, one (1) entry per team.

TIME LIMITS

A. All work must be completed and checked in during the two (2) hours and thirty (30) minutes allowed for design and construction.

B. The time begins when the length of the structure is given.

C. Participants with time conflicts must present a written explanation to the event coordinator of the conflict at least one (1) hour before the construction time printed in the conference program. Work must start during the time scheduled for the event.

ATTIRE and SAFETY EYEWEAR

Business Casual dress as described in Competitive Events Attire is the minimum requirement.

Students are required to wear safety-approved eyewear during the fabrication and structure check-in phase of this event. Prescription eyewear will need to have side shields to be considered safety eyewear. Should a team member remove the eyewear, s/he will be

☑ Structural Engineering assignments change every two years and can be bridges, towers, beams, trusses, etc. A box girder beam is the designated structure for 2013 and 2014.

reminded once to replace it. If there is a second infraction, the team will be asked to leave the competition. Sunglasses are not suitable eyewear.

PROCEDURE FOR FABRICATION

A. Participants report to the event area at the time and place stated in the conference program.

B. Students are required to provide and wear safety glasses for this event.

C. Teams are required to provide their own tool box, with identification (school name and address), which must include the following:

1. two cutting devices; the team will check in and use one (1) or two (2) of the following cutting devices from the list below:
   a. a modeling knife or x-acto knife
   b. a miter box and saw
   c. a blade and anvil cutter
   d. scissors
   e. another approved cutting device - none may be electric
2. one (1) ounce of “super glue”
   Note: cyanoacrylate (CA) glue comes in a variety of thicknesses. A team may elect to use one half (½)-ounce of thin CA and one half (½)-ounce of filler CA, for a total of one (1) ounce of adhesive. The glue must be in the original bottle with a manufacturer’s label, which is clearly marked with the capacity. One half (½) ounce in a one (1) ounce bottle will be considered one (1) ounce.
3. a single two (2)-ounce bottle of accelerator [pressurized, aerosol applicators are not allowed; a pump or drip applicator of two (2) ounces or less is acceptable]
4. straight pins as needed
5. simple clamps such as clothespins, binder’s clips or twisty ties
6. a cutting surface that fits in the approved space and prevents modeling knives from marring the table top
7. a single 12" ruler or measuring scale
8. emery boards of various grits or sand paper or sanding blocks
9. safety glasses for team members
10. marking device (e.g., pen, pencil, etc.)
11. Linesman pliers
12. One (1) roll of masking tape

D. Teams will pick up the following supplied materials:

1. Consumable supplies; these are the materials supplied to make the structure. Only materials supplied by the

☑ Participants should practice, practice, practice with CA adhesive! It adheres quickly and does not pull free if incorrectly placed.

coordinator may be used to fabricate the structure. The basswood may be withheld until the drawing is complete.
   a. Twenty (20) feet of $^3/_{32}$" x $^3/_{32}$" basswood
   b. Two sheets of 8½" x 11" copier paper
2. Planning and fabrication supplies. The following materials may **not** be part of the structure submitted for testing:
   a. 11" x 17" paper with ¼" grids for sketching the structure
   b. Pin board, as provided
   c. A sheet of wax paper
   d. Structure label

E. Students are seated in teams of two (2) by a monitor.

F. The construction procedure is explained.

G. The box girder beam is a rectangular prism.
   1. A random drawing of twelve, fourteen or sixteen inches (12", 14", 16") determines the length.
   2. The continuous width will be two inches (2").

H. The length of the structure is recorded, the ending time (which allows 2½ hours for construction) is set, and then both are announced.

I. During the construction, the teams must comply with the following regulations.
   1. The copy paper skin will be applied to the exterior of the box beam girder.
      a. It may not be sandwiched between two (2) basswood members.
      b. The ends of the beams will be left open for inspection of the internal bracing and fabrication.
      c. The skin will be attached with glue, but coating of the skin will be penalized. Any glue spot larger than the size of an American quarter will be considered a rules infraction.
      d. The joints of the copy paper skin will not include an overlap greater than one quarter of an inch (¼"). There will no greater than five (5) overlap joints in the structure.
   2. The beam must rest on the top of the abutments and may not touch the face of the abutments.
   3. No part of the beam may extend below the plane of abutment.
   4. The center of the beam must provide clear passage for the one half inch (½") test rod.
   5. Lamination is defined as:
      a. Two (2) pieces of basswood glued together surface to surface with the grain running parallel.

b. The cross section of laminated beam at any point in the continuous lamination will be a rectangle of 3/32" by 3/16".

6. Laminated members may not be jointed to other laminated members except at 90 degree angles

J. Remaining materials are distributed to each team when the sketch is completed.

K. Participants may leave early, but they must complete check-out as directed.

L. All work stops at the coordinator's signal.

M. Teams return all supplied items as directed.

N. The team must label the structure with the team registration number.

O. Structures are allowed to dry in a secure area until time for testing.

P. Structures are checked for rules violations, and violations are recorded on evaluation forms.

Q. Structures are weighed before testing.

R. Testing is completed by evaluators and is open to all conference participants.

S. Structures are destructively tested to determine failure weight. The coordinator and CRC manager will select the testing device and its use.

T. The efficiency rating of each structure is calculated and ranking is determined.

U. Teams failing to comply with coordinator or monitors' directions receive a penalty of 20% of the team's score.

V. Videotaping of the testing of a participant's structure is permitted by the participant or his/her representative.

☑ Read the General Rules and Regulations in the front of this guide for information that applies to all of TSA's competitive events.

PROCEDURE FOR EVALUATION

A. The structure is weighed before testing, and the weight is recorded on the evaluation form.

B. The test block will be placed on top of the beam. The test block will be two and one quarter inches (2¼") in width and six inches (6") less than the drawn length. The judges will need test blocks that are six inches (6"), eight inches (8") and ten inches (10") long by three quarters of an inch (¾") thick. Each block will have a one half inch (½") hole in the center.

C. An increasing load is applied to the structure via the test block until the structure fails.

D. The failure weight is recorded on the evaluation form. Failure weight is the greatest weight recorded during testing before failure of the structure.

E. The efficiency is determined by the failure weight x 454, divided by the weight of the structure in grams.

F. The efficiency is rounded off to three (3) decimal places and recorded on the evaluation form.

G. The highest numeric efficiency is the winner. In case of an efficiency tie, the greatest weight held by the tied entries will be declared the winner.

H. Failure to comply: If a structure fails to comply with any regulation, a penalty reduction of 20% of the greatest weight held in the contest is subtracted from the team's failure weight.

I. Structures are not to be tested if:
   1. there are two (2) or more rules violations determined before testing
   2. the structure cannot be placed on the tester
   3. the testing hook cannot be placed in the center of the structure
   4. straight pins are left in the structure
   5. there is a failure to wear safety eyewear

STEM INTEGRATION

This event aligns with the STEM educational standards noted below. Please refer to the STEM Integration section of this guide for more information.

Science, Technology, Engineering, Mathematics

PRIMARY LEADERSHIP SKILLS

Leadership skills promoted in this event:

- EVALUATION — Students will work to eliminate the failure of their entry. Suggested leadership lessons: *Evaluation Imagination* and *Evaluation Methods*
- PROBLEM SOLVING — Students will work under time and material constraints to build their entry. Suggested leadership lessons: *Effective Brainstorming* and *Finding The Right Way*
- TEAMWORK — Students will prepare in advance to work together effectively on site. Suggested leadership lessons: *Teams* and *Stepping Stones*

Additional leadership skills promoted in this event: creative thinking, critical thinking

TSA AND CAREERS

This competition connects to one or more of the career areas featured in the TSA AND CAREERS section of this guide. Use *The 16 Career Clusters* chart and the *TSA Competitions and The 16 Career Clusters* grid as resources for information about careers.

CAREERS RELATED TO THIS EVENT

Architect
Civil engineer
Engineering technician
Mathematician
Structural iron and steel worker

STRUCTURAL ENGINEERING EVENT COORDINATOR INSTRUCTIONS

PERSONNEL

A. Event coordinator

B. Construction monitors, a minimum of one (1) per twenty (20) teams

C. A timekeeper

D. Evaluators to qualify structures after construction, two (2) or more

E. Destructive test evaluators, preferably five (5)
   1. One (1) to position the structure on the testing device
   2. One (1) to weigh the structure and record structure weight
   3. One (1) to record failure weight
   4. One (1) to bring the structure to the testing location
   5. One (1) to remove and store the structure following testing

MATERIALS

The event coordinator will supply the basswood, note cards, copy paper, pin boards, wax paper, 11" x 17" graph paper with ¼" grid and structure label. No substitutions or alternate supplies are permitted. The event coordinator will address any special needs before the beginning of check-in.

A. Coordinator's box, containing:
   1. Event guidelines, one (1) copy for the coordinator and for each evaluator
   2. Official rating forms
   3. List of entries, with finalist report
   4. List of evaluators/assistants
   5. Results envelope

B. A sheet of poster board and marker to post the length of the beam and end time

C. Construction tools per team, to be used and returned after construction:
   1. Pin board as supplied, but generally a one-foot by two-foot (1' x 2') piece of fiber or foam board
   2. Grid paper ¼" x ¼" grid on 11" x 17" paper for the sketch of the structure

3. Wax paper to cover the pin board

D. Supplies per team to be used to make the structure:

1. twenty feet (20') of $^3/_{32}$" x $^3/_{32}$" basswood
2. two (2) pieces of copier paper

E. The testing equipment, selected by the event coordinator, provides a downward pull and records the peak force in pounds.

F. Evaluation and recording equipment:

1. Gram scale
2. Tape measure or 2' rule
3. Evaluation gauges
4. Calculator or computer to perform calculations
5. Evaluation forms as provided by the event coordinator, one (1) per entry
6. One (1) American quarter dollar coin

G. Site requirements:

1. Construction session:
   a. Tables and chairs suitable for cutting and gluing
   b. A work area that is at least 2' x 3' for each team (suggested space is two teams per 6' x 2' or 8' x 2' table)
   c. One (1) chair per registered participant
   d. Tables for equipment check-out and check-in
   e. Tables and chairs for evaluators
   f. Area securable for drying of entries and storage of supplies
2. Testing session:
   a. Tables for storage of structures
   b. Table for weighing
   c. Table for testing
   d. Table for recording
   e. Tables for storage of failed structures
   f. Chairs for spectators
   g. Barricade to separate testing area from spectators

RESPONSIBILITIES

A. Upon arrival at the conference, report to the CRC room and check the contents of the coordinator’s box. Review the event guidelines and check to see that enough evaluators/assistants have been scheduled.

B. Inspect the area(s) in which the event is being held for appropriate set-up, including room size, chairs, tables, outlets, etc. Notify the event manager of any potential problems.

C. One (1) hour before the event is scheduled to begin, meet with your evaluators/assistants to review time limits, procedures, and regulations. If questions arise that cannot be answered, speak to the event manager before the event begins.

D. Set up check-in.

E. Set up materials and supplies check-out.

F. Plan the finished structure check-in, designate an area for structure storage, plan the materials check-in, and plan the participant check-out.

G. Administer construction session procedure with participants.

1. The construction session is not a spectator event. No one other than participants will be allowed in the construction site.
2. Check-in may begin before the time printed in the conference program and continues until all teams that have arrived on time have been checked in and seated. Even if all teams are in place, the event does not start before the posted time.
3. Both members of the team need to be present during check-in.
4. No team begins late unless its members have complied with this statement from Time Limits: Participants with time conflicts must present a written explanation to the event coordinator of the conflict at least one (1) hour before the construction time printed in the conference schedule. Work must start during the time scheduled for the event.
5. The recorder checks the registration number and records it on the entry list.
6. Monitors check out supplies and materials.
7. Monitors assign team construction locations.
8. When all teams are seated and the scheduled event time has arrived, the event coordinator will select the length of the structure by random draw and announce dimension details. Post the length on the poster board.
9. The construction time of two (2) hours and thirty (30) minutes begins when the dimensions are announced. Post the completion time.
10. Monitors confirm that the sketch is completed before each team begins construction.
11. No additional supplies are provided during the event.
12. Monitors call “time” to end the construction session two (2) hours and thirty (30) minutes after the dimensions are announced. Teams that fail to comply are penalized 20% of the total earned points.

H. Participant check-out:

1. Participants must leave the assigned area clean.

2. Participants check in excess supplies as directed by the monitors.
3. Participants place the structure in the storage area with the evaluation form and sketch as directed by monitors. The structure must be marked with the team number on the provided tag to insure proper evaluation and recording of results.
4. Participants leave the construction site.
5. The structures are secured by the monitors and allowed to dry for a minimum of twelve (12) hours from the end of the construction session.

I. Evaluation

1. With the help of the evaluators, check structures for compliance to specific regulations.
2. Structures that are in compliance are tested without penalty.
3. Noncompliance is noted on the evaluation form and the penalty is assessed.
4. If a structure has two (2) noncompliance marks, it is not tested.
5. Immediately following the testing session, participants and advisors must be present to break structures that did not qualify for testing.
6. For participants who violate the rules, the decision either to deduct 20% of the total possible points or to disqualify the entry must be discussed and verified with the evaluators, event coordinator, and a CRC manager; all must initial either of these actions on the rating form.

J. Testing session procedure

1. The testing session is a spectator event. The structure storage area and evaluation area are not open to spectators.
2. The testing device is set up and calibrated one (1) hour before the time to begin testing.
3. Monitors bring the structures to the testing area.
4. Each structure is weighed on a gram scale and the structure's weight is recorded on the evaluation form. The load plate weight is recorded and subtracted to determine the material weight.
5. The structure is destructively tested using a breaker block.
6. The failure weight is recorded on the rating form.
7. The structure is removed from the testing area by a monitor and stored with the drawing.
8. The efficiency is figured and recorded on the evaluation form.
9. Structures are not returned to participants after testing.

K. Complete and submit the finalist report, which includes a ranking of the ten (10) finalists, and all related forms in the results envelope to the CRC room.

Participant/Team ID# ________________________________

STRUCTURAL ENGINEERING

2013 & 2014 OFFICIAL RATING FORM — HIGH SCHOOL

Place an x in the noncompliant or compliant box, as appropriate for each regulation

Qualification Regulations

REGULATIONS	NONCOMPLIANT		COMPLIANT	
Team of two	Only one team member is present.		Both team members are present.	
Attire	Attire does not meet requirements.		Attire is appropriate.	
Safety eyewear	Warnings about eyewear were issued.		No warnings about eyewear were issued.	
Tools and fabrication supplies	Inappropriate tools or supplies are brought to the event.		Appropriate tools and supplies are brought to the event.	

Construction Regulations

REGULATIONS	NONCOMPLIANT		COMPLIANT	
Time limits	The beam is not completed during the specified time.		The beam is completed within the specified time.	
Beam identification	The identification sticker is not attached.		The identification sticker is attached.	
Sketch	A sketch is not submitted.		A sketch is submitted.	
Length of beam	The length of the beam is .125 inch greater or less than the announced construction length.		The length of the beam is within the .125 inch tolerance of the announced construction length.	
Width of beam	The width of the beam is .125 inch more or less than the two-inch (2") stated construction width.		The width of the beam is within the .125 inch tolerance of the stated two inch (2") construction width.	
Height of beam	The height of the beam is .125 inch more or less than the two-inch (2") stated construction height.		The height of the beam is within the .125 inch tolerance of the stated two inch (2") construction height.	
Copy paper skin	The end is closed; joints where overlapping are wider than .25 inch; glue is greater than the size of a USA quarter. There are six or more overlap joints on the structure.		Paper skin applications are correct. There are five or less overlap joints on the structure.	
Total the number of regulations that are not in compliance. A deduction of 20% of the failure weight will be given for one noncompliant regulation. If more than two regulations are marked noncompliant, then the structure will not be tested.			Total the number of regulations that are in compliance. A total of nine or more qualifies the structure for testing without deductions.	

Any of the regulations below marked noncompliant will automatically eliminate the structure from final testing or consideration.

	Noncompliant		Compliant	
Plane of abutment (horizontal)	Part of the beam assembly rests below the horizontal plane of abutment.		No part of the beam assembly rests below the horizontal plane of abutment.	
Placement on abutment	The beam is not long enough for placement for testing.		The beam length is appropriate for testing.	
Internal clearance	Placement of the testing rod through the center of the beam is blocked.		The testing rod passes freely through the center of the beam.	
Construction pins	Pins are still in place when the structure is submitted.		All pins have been removed from the structure.	
Laminations	Laminations contain more than two pieces or members face to face in the same direction.		Laminations are correct with no more than two pieces or members glued face to face running in the same direction.	
	TOTAL		TOTAL	

STRUCTURAL ENGINEERING (continued)	
Structure approved for final testing	
Record the mass (weight) of the completed structure prior to testing.	
Record the testing failure weight in pounds.	
Record a deduction of 20% of the greatest failure weight held in the competition if only one regulation is noncompliant.	
Determine the efficiency (shown to three decimal places) by multiplying the failure weight by 454 and then dividing by the mass weight (in grams) of the finished structure.	

TOTAL POINTS	

Comments:

I certify these results to be true and accurate to the best of my knowledge.

Evaluator

Printed name: ____ Signature: ____