



STRUCTURAL ENGINEERING

OVERVIEW

Teams apply the principles of structural design and engineering through basic research, design, construction, and destructive testing to determine the design efficiency of a structure. Details about the structure and information related to it will be posted on the TSA website (www.tsaweb.org) under Competitions/Themes and Problems. The on-site semifinalist problem will be a variation of the pre-conference problem posted on the TSA website.

ELIGIBILITY

One (1) team of two (2) individuals per chapter may participate, one (1) entry per team.

SAFETY EYEWARE

Participants are required to wear safety-approved eyewear during the on-site phase of this event. Prescription eyewear will need to have side shields to be considered safety eyewear. Should a team member remove the eyewear and fail to replace it, s/he will be reminded once. If there is a second infraction, the team will be disqualified. Sunglasses are not suitable.

TIME LIMITS

- A. Pre-built structures must be started and completed during the current school year.
- B. On-site structures (semifinalist teams only) must be started, completed, and checked in during the three (3) hours allowed for design and construction.
- C. Semifinalist participants with time conflicts must present a written explanation of the conflict to the event coordinator at least one (1) hour before the construction time noted in the conference program. Work must begin during the time scheduled for the event.

ATTIRE

TSA competition attire is required.

PRE-BUILT STRUCTURE REGULATIONS

- A. All work must be completed by the team members only, and verified by the team's chapter advisor using the Team Verification form.
- B. Teams must provide a full-size, three (3)-view (front, top, and right end) drawing (hand or computer-generated) of their structure.
- C. The structure and any related required materials (including the Analysis and Assessment form) must be submitted at the designated time and place noted in the conference program.
- D. The structure will undergo destructive testing.
- E. Teams will submit a LEAP Response at event check-in.

PROCEDURE FOR ON-SITE DESTRUCTIVE TESTING OF PRE-BUILT STRUCTURES

- A. Open viewing of the destructive testing of pre-built structures is allowed.
- B. All structures will be assessed prior to the destructive testing.
- C. Destructive testing will be completed using structural testing equipment, as designated by TSA



- D. When the destructive testing is completed, a list of twenty (20) semifinalist teams will be posted.
- E. The twenty (20) semifinalist teams will take part in the on-site problem, which will feature the construction and destructive testing of a designated structure to determine the ten (10) finalist teams.

REGULATIONS AND PROCEDURE FOR SEMIFINALIST ON-SITE CONSTRUCTION AND DESTRUCTIVE TESTING

- A. Twenty (20) semifinalist teams report to the event area at the time and place stated in the conference program.
- B. Participants must provide and wear safety glasses for this portion of the event.
- C. Participants are required to provide their own tool box (with identification [school name, address, and advisor cell phone number]), which should not exceed twenty (20) inches (508 mm) length x ten (10) inches (254 mm) width x ten (10) inches (254 mm) height. The box must contain all items needed to fabricate the solution. The following is a suggested list:
 - 1. Cutting devices; NONE may be electric
 - 2. Adhesives
 - a. aerosol and electric applicators are not allowed
 - b. a bottle of Uncure or Debonder is recommended
 - 3. Temporary fastening devices
 - a. straight pins
 - b. clamps
 - c. tape
 - 4. A cutting surface that prevents table-top marring (required)
 - 5. Rulers, straightedges, and/or measuring scales
 - 6. Abrasives sheets, sponges, boards
 - 7. Marking devices (pens, pencils, etc.) and sharpener
 - 8. Sheet of wax paper, as large as is needed for the competition (required)
 - 9. Pliers, wrenches, nut drivers, as needed
 - 10. Safety glasses and side shields, as required
- D. Planning and fabrication supplies will be provided first. Teams will be issued a packet of construction materials (necessary balsa wood) to use for fabrication of the on-site designed structure once the team's drawing of the on-site solution is complete.
 - 1. Planning and fabrication supplies (these materials may not be part of the structure submitted for testing):
 - a. 11" x 17" paper with 1/4" grids for sketching the structure
 - b. pin board
 - c. a sheet of wax paper
 - d. structure label
- E. Teams will be seated by a monitor.
- F. The design problem will be explained and a list of directions for the construction problem will be provided.
- G. Teams will be allowed thirty (30) minutes to review the problem and create a sketch/drawing of their solution.
- H. During the building of the team's structure, construction regulations must be observed.
- I. Participants may leave early, but they must complete check-out as directed.
- J. All work stops at the coordinator's signal.
- K. Teams return all supplied items as directed, and clean and clear their work stations.
- L. Teams must identify their structure with only their team ID number, using the label provided.
- M. Structures are allowed to dry in a secure area until destructive testing time.



- N. Structures are checked for rules violations and weighed before testing.
- O. Destructive testing is completed by evaluators and is open for spectator viewing.
- P. When all testing is completed, the greatest failure weight of all tested structures is recorded on the rating form, the efficiency rating of individual structures is calculated, and ranking is determined.
- Q. Teams that fail to comply with coordinator or monitor directions, after one (1) warning, will be issued a penalty of 20% of the team's total score.
- R. Videotaping of the destructive testing of a structure is permitted, but only by a participant or representative of a respective team.
- S. The LEAP Response:
 - 1. Teams document the leadership skills the team has developed and demonstrated while working on this event, and on a non-competitive event leadership experience.
 - 2. Find the specific LEAP Response regulations in the LEAP Program section of this guide, and on the [TSA website](#).

EVALUATION

Evaluation is based on the compliance and design efficiency of a pre-built structure and an on-site structure (semifinalists only), both of which are destructively tested, and the content and quality of the LEAP Response (semifinalists only).

Please see the official rating form for more information.

STEM INTEGRATION

This event has connections to the STEM areas of Science, Technology, Engineering, and Mathematics.

TSA AND CAREERS

This competition has connections to one or more of the careers below:

- Architect
- Civil engineer
- Engineering technician
- Mathematician
- Structural engineer
- Structural iron and steel work technician



STRUCTURAL ENGINEERING EVENT COORDINATOR INSTRUCTIONS

PERSONNEL

- A. Event coordinator
- B. Judges
 - 1. Preliminary round to evaluate pre-built structures, two (2) or more
 - 2. Semifinal round, to qualify structures after construction, two (2) or more
 - 3. Semifinal round, destructive test judges, two (2) or more
 - a. One (1) to weigh the structure, record structure weight, and record failure weight
 - b. One (1) to bring the structure to the testing location, position the structure on the testing device, operate the tester, and then remove and store the structure following testing
- C. Construction monitor, one (1) per twenty teams
- D. Timekeeper, one (1)

MATERIALS

- A. Coordinator's packet, containing:
 - 1. Event guidelines, one (1) copy for the coordinator and each judge
 - 2. TSA Event Coordinator Report
 - 3. List of judges/assistants
 - 4. Stick on labels for identifying entries
 - 5. Results envelope with coordinator forms
- B. Testing equipment, provided by TSA
- C. Sample structures for the both testing sessions that can be used to demonstrate the testing procedure and that the testing equipment is working properly.
- D. Evaluation and recording equipment
 - 1. Gram scale (3-decimal place calculation)
 - 2. Tape measure or 2' rule
 - 3. Evaluation gauges (rulers)
- E. Site requirements
 - 1. Construction session
 - a. tables and chairs suitable for cutting and gluing
 - b. work area, at least 2' x 3' for each team (suggested space is two (2) teams per 6' x 2' or 8' x 2' area)
 - c. one (1) chair per participant
 - d. tables for equipment check-out and check-in
 - e. tables and chairs for evaluators
 - f. secured area 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
3. Semifinalist team packets provided by TSA containing construction materials and instructions.
- a. Construction tools per team, to be used and returned to the event coordinator or helpers after construction:
 - i. Pin board as supplied, but generally a one-foot by two-foot (1' x 2') piece of fiber or foam board
 - ii. Grid paper, 1/4" x 1/4" grid on 11" x 17" paper for structure sketch (to remain with the completed structure when turned in)
 - iii. Wax paper to cover the pin board (to remain with the completed structure when turned in)
 - iv. label for structure
 - b. Construction materials - Balsa as needed for each team
 - c. Instructions

RESPONSIBILITIES

- A. Prepare the structure problem statement (including any necessary related information) for posting on the TSA website.
- B. Upon arrival at the conference
 1. Attend the mandatory coordinator's meeting at the designated time and location.
 2. Report to the CRC room and obtain the coordinator's packet; check the contents.
 3. Review the event guidelines and check to see that enough judges/assistants have been scheduled.
 4. Check to see that all event equipment and materials have been secured.
 5. One (1) hour before the event is scheduled to begin, meet with judges/assistants to review time limits, procedures, and regulations. If questions arise that cannot be answered, speak to the event manager before the event begins.
- C. Preliminary round
 1. Set up check-in for testing of pre-built structures.
 2. Coordinate and manage the on-site testing of pre-built structures, the recording and tabulation of results, and the determination of the twenty (20) semifinalist teams.
 3. Submit semifinalist results to the CRC for posting.
 4. Assemble semifinalist packets of construction materials and directions for the twenty (20) on-site semifinalist teams.

On-site construction

1. This portion of the event is not open to spectators. No individuals other than participants and event personnel will be allowed in the construction area.
2. Check-in will begin at the time noted in the conference program and will continue until all teams arriving on time have been checked in and seated. The event will begin at the posted time.
3. Both members of a team must be present during check-in.
4. No team is allowed to begin late unless its members have complied with the following: Participants with time conflicts must present a written explanation of the conflict to the event coordinator at least one (1) hour before



the construction time noted in the conference program. Work must begin during the time frame scheduled for the event.

5. Assign team construction locations.
 6. When all teams are seated, distribute instructions and review these, as well as any details for the assigned structure.
 7. Teams will be allowed a maximum of three (3) hours to complete their structure. Thirty (30) minutes of this time is allotted for completing the design drawing, and two and one-half (2 ½) hours, is allotted for actual construction.
 8. When a team notifies a monitor that the required sketch is complete, and the monitor confirms this, the team will receive a materials packet and may begin the on-site construction phase of the event.
 9. No additional supplies are provided during the event.
 10. Call time at the end of the allotted three (3) hour time-frame. All teams must stop working at this point.
- D. Establish the procedure for check-in and recording of finished structures, designate an area for storage, and allow for the return of construction materials.

Team check-out

1. Teams must leave their work space clean. Failure to do so will result in a 20% penalty deduction.
 2. Teams check in excess supplies as directed by the monitors.
 3. Teams place their structures in the storage area with the sketch as directed by the monitor. The structure must be identified with the team number only (using the label provided in the materials packet).
 4. Once check-in is complete, all participants leave the competition area.
 5. The structures are secured by the monitor and allowed to dry for a minimum of twelve (12) hours.
- E. Evaluation
1. Check (with assistance from judges) all structures for regulations compliance. Structures that are in compliance will be tested without penalty.
 - a. Weigh all structures before testing and record the weight on the evaluation rubric.
 - b. Use the testing device, designated by TSA, to test each structure. (A specific testing block or attachment for the structure may be necessary for the on-site problem.)
 - c. Apply an increasing load to the structure, via the test block or attachment, until the structure fails.
 - d. Record the greatest failure weight on the rubric. This weight is the greatest weight recorded (of all the tested structures) during testing before failure of the structure.
 - e. Determine each structure's efficiency by the greatest failure weight x 4.54, divided by the weight of the structure in grams; round off the efficiency to three (3) decimal places and record it on the rubric.
 - f. The highest numeric efficiency determines the winner. In the case of an efficiency tie, the greatest weight held by the tied entries will determine the winner.
 2. Structures will not be tested if:
 - a. Two (2) or more non-compliance construction regulation violations are determined before testing.
 - b. The structure cannot be placed on the tester.
 - c. The testing attachment cannot be properly placed within or on the structure.
 - d. Straight pins are left in the structure.
 - e. There is a failure to wear safety eyewear and/or to follow safe practices.
 - f. Laminations fail to comply with the guidelines as specified in the current year's annual event challenge.
 - g. Failure to use each of the materials specified in the current year's annual event challenge.
 3. Structures with one (1) construction regulation non-compliance mark will be tested, but a 20% penalty will be noted on the rating form. (The penalty, a 20% reduction of the greatest weight held in the competition, is subtracted from the team's failure weight. This penalty factor will not be determined until all structures have been tested).



4. Manage, with assistance from judges, the destructive testing of all structures that were not officially tested due to non-compliance.
 5. For participants who violate the rules, the decision either to 1) deduct twenty percent (20%) of the total possible points or 2) disqualify the entry, must be discussed and verified with the evaluators, event coordinator, and CRC manager, who all must initial either of these actions on the rating form.
- F. Submit the finalist results and all other related forms in the results envelope to the CRC room.
- G. Semifinalist teams may pick up their structures at a time determined by the event coordinator.



Team ID# _____

MIDDLE SCHOOL STRUCTURAL ENGINEERING ANALYSIS AND ASSESSMENT

PRE-BUILT STRUCTURE

For TEAMS:

How many structures were designed, built, and tested prior to competition?	_____
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Record the weight of the structure designated for competition:	_____
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Predict the ultimate load-carrying capacity of the structure:	_____
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Predict where or how the structure will fail:	_____
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What are the four major types of forces that act on a structure under stress?	1. _____
	2. _____
	3. _____
	4. _____

What is the static load of a structure?	_____
_____	_____
_____	_____

What part of a testing device should be considered live load?	_____
_____	_____
_____	_____

What effect would a shorter length test block have during stress testing?	_____
_____	_____
_____	_____

For JUDGES:

Record the weight of the structure after check-in and prior to testing:	_____
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Record the actual load-carrying capacity of the structure:	_____
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Team ID# _____

STRUCTURAL ENGINEERING

2018 & 2019 OFFICIAL RATING FORM

MIDDLE SCHOOL

GO/NO GO SPECIFICATIONS

Before judging the entry, ensure that the items below are present; indicate presence with a check mark in the box. If an item is missing, leave the box blank and place a check mark in the box labeled ENTRY NOT EVALUATED. If a check mark is placed in the ENTRY NOT EVALUATED box, the entry is not to be judged.

- Team of two is present.
- The structure is present, identified, and in its storage box.
- The Team Portfolio is present and includes:
 - The Team Verification form completed
 - The Analysis and Assessment form completed
 - Full Size Three (3) View Orthographic (Front, Top, and Right Side) Drawing
- Completed LEAP Response is present.
- ENTRY NOT EVALUATED

Indicate N for non-compliant or C for compliant, for each regulation in the Construction section. One non-compliant mark will result in a 20% deduction; two non-compliant marks will result in disqualification. * Serves as two non-compliant marks.

PRE-BUILT STRUCTURE (CONSTRUCTION)

QUALIFICATION	NON-COMPLIANT	COMPLIANT	
Length of structure	The length of the structure is greater or less than the designated tolerance of the assigned construction length.	The length of the structure is within the designated tolerance of the assigned construction length.	
Outside width of structure	The outside width of the structure is greater or less than the designated tolerance of the assigned construction width.	The outside width of the structure is within the designated tolerance of the assigned construction width.	
Outside height of structure	The height of the structure is greater or less than the designated tolerance of the assigned construction height.	The height of the structure is within the designated tolerance of the assigned construction height.	
Inside structure width	The inside structure width is greater or less than the designated tolerance of the assigned construction inside width.	The inside structure width is within the designated tolerance of the assigned inside structure width.	
Structure side and platform thickness	The structure side and platform thickness is greater or less than the designated tolerance of the assigned thickness.	The structure side and platform thickness is within the designated tolerance of the assigned construction side and platform thickness.	
Construction materials	The construction materials (sizes of balsa) are not used in the correct horizontal or vertical configurations as set in the assigned problem.	The construction materials (sizes of balsa) are used in the correct horizontal or vertical configurations as set in the assigned problem.	
Substructure *	A substructure is present.	No substructure is present	
Laminations	Laminations do not follow the allowable variations as illustrated on the annual event challenge.	Laminations are correct and follow the allowable variations as illustrated on the annual event challenge.	
Coating of materials *	Coating of the construction materials with glue is present.	No coating of the construction materials with glue is present.	
Testing rod and block clearance *	The testing block and rod cannot be placed and passed through the center of the structure to allow for testing.	The testing block and rod pass freely through the center of the structure to allow for testing.	
DISQUALIFIED			

PRE-BUILT STRUCTURE APPROVED FOR TESTING.			
Record the mass (weight) of the structure (in grams) prior to testing to the nearest tenth of a gram.			
Record the failure weight in pounds to the nearest tenth of a pound.			
If only one construction regulation is noncompliant, record a deduction of 20% of the maximum failure weight.			
Adjusted failure weight			
Determine the efficiency (shown to three decimal places) by multiplying the failure weight (or adjusted failure weight, as applicable) by 4.54 and then dividing by the mass (weight) of the structure.			
PRE-BUILT STRUCTURE TOTAL POINTS			
ON-SITE STRUCTURE (QUALIFICATION)			
For the ON-SITE STRUCTURE: Indicate N for non-compliant or C for compliant, in the Qualification and Construction sections below. In the Qualification section, one non-compliant mark will result in disqualification. In the Construction section, one non-compliant mark will result in a 20% deduction; two non-compliant marks will result in disqualification. * Serves as two non-compliant marks.			
REGULATION	NON-COMPLIANT		COMPLIANT
Team of two	Only one team member is present.		Both team members are present
Safety eyewear	Warnings about eyewear are issued.		No warnings about eyewear are issued.
Structure identification	The identification sticker is not attached.		The identification sticker is attached.
Tools and fabrication supplies	Inappropriate tools or supplies are brought to the event.		Appropriate tools and supplies are brought to the event.
ON-SITE STRUCTURE (CONSTRUCTION)			
CONSTRUCTION	NON-COMPLIANT		COMPLIANT
Drawing	The required drawing is not submitted.		The required drawing is submitted.
Length of structure	The length of the structure is greater or less than the designated tolerance of the assigned construction length.		The length of the structure is within the designated tolerance of the assigned construction length.
Width of structure	The width of the structure is greater or less than the designated tolerance of the assigned construction width.		The width of the structure is within the designated tolerance of the assigned construction width.
Height of structure	The height of the structure is greater or less than the designated tolerance of the assigned construction height.		The height of the structure is within the designated tolerance of the assigned construction height.
Inside structure width	The inside structure width is greater or less than the designated tolerance of the assigned construction inside width.		The inside structure width is within the designated tolerance of the assigned inside structure width.
Structure side and platform thickness	The structure side and platform thickness is greater or less than the designated tolerance of the assigned thickness.		The structure side and platform thickness is within the designated tolerance of the assigned construction side and platform thickness.
Laminations	Laminations do not follow the allowable variations as illustrated on the annual event challenge.		Laminations are correct and follow the allowable variations as illustrated on the annual event challenge.
Construction materials	The construction materials (sizes of balsa) are not used in the correct horizontal or vertical configurations as set in the assigned problem.		The construction materials (sizes of balsa) are used in the correct horizontal or vertical configurations as set in the assigned problem.
Substructure *	A substructure is present.		No substructure is present.
Coating of materials *	Coating of the construction materials with glue is present.		No coating of the construction materials with glue is present.



Testing rod and block clearance *	The testing block and rod cannot be placed and passed through the center of the structure to allow for testing.		The testing block and rod pass freely through the center of the structure to allow for testing.	
Structure identification	The identification sticker is not attached.		The identification sticker is attached.	
DISQUALIFIED				
On-site structure approved for testing				
Record the mass (weight) of the structure (in grams) prior to testing to the nearest tenth of a gram.				
Record the failure weight in pounds to the nearest tenth of a pound.				
If only one construction regulation is noncompliant, record a deduction of 20% of the maximum failure weight.				
Adjusted failure weight				
Determine the efficiency (shown to three decimal places) by multiplying the failure weight (or adjusted failure weight, as applicable) by 4.54 and then dividing by the mass (weight) of the structure.				
ON-SITE STRUCTURE TOTAL POINTS				

CRITERION PERFORMANCE LEVELS

CRITERIA	Minimal performance 1-4 points	Adequate performance 5-8 points	Exemplary performance 9-10 points	
Evaluators: Using minimal (1-4 points), adequate (5-8 points), or exemplary (9-10 points) performance levels as a guideline, record the scores earned for the event criteria in the column spaces to the right. The X1 or X2 notation in the criteria column is a multiplier factor for determining the points earned. (Example: an "adequate" score of 7 for an X1 criterion = 7 points; an "adequate" score of 7 for an X2 criterion = 14 points.) A score of zero (0) is acceptable if the minimal performance for any criterion is not met.				

SEMIFINAL LEAP RESPONSE SUBTOTAL (10 points)

LEAP Response (X1)	The team's efforts are not clearly communicated, lack detail, and are unconvincing; few, if any, attempts are made to identify and incorporate the SLC Practices.	The team's efforts are adequately communicated, include some detail, are clear, and are generally convincing; identification and incorporation of the SLC Practices are satisfactory.	The team's efforts are clearly communicated, fully-detailed, and convincing; identification and incorporation of the SLC Practices are excellent.	
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SEMIFINAL LEAP RESPONSE SUBTOTAL (10 points)

Rules violations (a deduction of 20% of the total possible points for the semifinalist section) must be initialed by the evaluator, coordinator and manager of the event. Record the deduction in the space to the right.

Indicate the rule violated: _____

SEMIFINAL SUBTOTAL

(To arrive at the TOTAL score, add the PRE-BUILT STRUCTURE TOTAL POINTS and the SEMIFINAL SUBTOTAL.) **TOTAL**

Comments:

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

Evaluator
 Printed name: _____ Signature: _____