STRUCTURAL DESIGN AND ENGINEERING

OVERVIEW

Participants work as a team to build a designated structure. Teams apply the principles of structural design and engineering through research, design, construction, destructive testing, and assessment to determine the design efficiency of the structure.

Details about the structure and information related to it will be posted on the TSA website under Competitions/ Themes and Problems. The onsite semifinalist problem will be a variation of the pre-conference problem posted on the TSA website.

ELIGIBILITY

One (1) team of two (2) members per chapter is allowed to participate, one (1) entry per team.

SAFETY EYEWEAR

1. Participants are required to wear safety-approved eyewear during the onsite phase of this event.
2. Prescription eyewear will need to have side shields to be considered safety eyewear.
3. Should a team member remove the eyewear and fail to replace it, s/he will be reminded once.
4. If there is a second infraction, the team will be asked to leave the competition.
5. Sunglasses are not suitable.

TIME LIMITS

PRELIMINARY ROUND

Pre-built structures must be started and completed during the current school year.

SEMIFINAL ROUND

1. Onsite structures must be started, completed, and checked in during the three (3) hours allowed for design and construction.
2. 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 schedule. Work must begin during the time scheduled for the event.
3. During the construction time, each team will participate in a LEAP interview that will last a maximum of five (5) minutes.

LEAP

A team LEAP Report is required for this event and must be submitted at event check-in (see LEAP Program).

ATTIRE

TSA competition attire is required for this event.

PRELIMINARY ROUND

PRE-BUILT STRUCTURE REGULATIONS

A. The structure and documentation portfolio must be submitted at the designated time and place noted in the conference program.

B. Documentation materials (comprising “a portfolio”) are required and should be secured in a clear front report cover. The report cover must include the following single-sided, 8½" x 11" pages, in this order:

   1. LEAP Report
   2. Title page with the event title, the conference city and state, and the year; one (1) page
   3. Table of contents; one (1) page
   4. All work must be completed by the team members only, and then verified by the team’s chapter advisor using the *Team Verification* form, found on the TSA website under Competitions/Themes and Problems; one (1) page.
   5. Students must complete and provide a copy of the *Analysis and Assessment* form, found on the TSA website under Competition Themes and Problems, for their submitted structural design; one (1) page.

C. Teams must provide a full-size, three (3)-view (front, top, and right end) drawing (hand or computer-generated) of their structure.

ONSITE DESTRUCTIVE TESTING OF PRE-BUILT STRUCTURES PROCEDURE

A. Open viewing of the onsite destructive testing of pre-built structures is allowed.

B. All structures will be assessed (using the evaluation rubric) prior to the onsite 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 onsite problem, which will feature the construction and destructive testing of a structure similar to the pre-conference structure.

SEMIFINAL ROUND

SEMIFINALIST ONSITE CONSTRUCTION AND DESTRUCTIVE TESTING PROCEDURE

A. Twenty (20) semifinalist teams, of two (2) members each, 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.

1. The tool box must include identification (school name, address, and advisor cell phone number).
2. It must not exceed twenty (20) inches (508 mm) length x ten (10) inches (254 mm) width x ten (10) inches (254 mm) height
3. The box must contain all items needed to fabricate the solution. The following is a suggested list (note that some items are required):
   a. Cutting devices; NONE may be electric
   b. Adhesives
   c. Aerosol and electric applicators are not allowed
   d. A bottle of Uncure or Debonder is recommended
   e. Temporary fastening devices
      i. Straight pins
      ii. Clamps
      iii. Tape
   f. A cutting surface that prevents table-top marring (required)
   g. Rulers, straightedges, and/or measuring scales
   h. Abrasives sheets, sponges, boards
   i. Marking devices (pens, pencils, etc.) and sharpener
   j. Sheet of wax paper, as large as is needed for the competition (required)
   k. Pliers, wrenches, nut drivers, as needed
   l. Safety glasses and side shields, (required)
   m. Jigs and fixtures to assist with assembly and construction

D. Teams will be issued a packet of construction materials to use for fabrication of the designated structure. These materials will be withheld until the team's design drawing is complete.

1. Planning and fabrication supplies (these materials may not be part of the structure submitted for testing):
   a. Drawing paper with ¼" or ⅛" 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 process 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 identification number, using the label provided.

M. During the construction time, each team will participate in a LEAP interview that will last a maximum of five (5) minutes.

N. Structures are allowed to dry in a secure area until destructive testing time.

O. Structures are checked for rules violations and weighed before testing.

P. Destructive testing is completed by judges and is open for spectator viewing.

Q. 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.

R. Teams that fail to comply with the coordinator or monitor directions, after one (1) warning, will be issued a penalty of 20% of the team's total score.

S. Videotaping of the destructive testing of a structure is permitted, but only by a participant or representative of a respective team.

T. The LEAP Report

1. Teams document the leadership skills the team developed and demonstrated while working on this event, and on a non-competitive event leadership experience.
2. Teams will respond to questions about the content of the LEAP Report.
3. Specific LEAP Report regulations can be found in the LEAP Program section of this guide and on the TSA website.

PROCEDURE FOR EVALUATION OF STRUCTURES

A. All structures are weighed before testing and the weight is recorded on the scoring rubric.

B. A designated structural testing device will be used for testing each structure.

C. A specific testing block or attachment may be necessary, depending on the nature of the onsite problem. Any special or unusual configurations for the attachment will be posted with the design problem on the TSA website.

D. An increasing load is applied to the structure via the test block or attachment until the structure fails.

E. The failure weight is recorded on the evaluation rubric. (The failure weight is the greatest weight recorded during testing before the failure of the structure.)

F. The efficiency is determined by the failure weight x 4.54, divided by the weight of the structure in grams.

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

H. Each team's assessment form is reviewed.

I. The highest numeric efficiency determines the winner. In case of an efficiency tie, the greatest weight held by the tied entries will determine the winner.

J. Failure to comply: If a structure fails to comply with any regulation, a penalty reduction of 20% 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.)

STEM INTEGRATION

This event aligns with the STEM educational standards of Science, Technology, Engineering, and Mathematics.

CAREERS RELATED TO THIS EVENT

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

Participant/Team ID# _____

STRUCTURAL DESIGN AND ENGINEERING

2019 & 2020 OFFICIAL RATING FORM

HIGH SCHOOL

Judges: Using minimal (1-4 points), adequate (5-8 points), or exemplary (9-10 points) performance levels as a guideline in the rating form, 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.

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 next to the item 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 and identified.
- ☐ The Team Verification form is complete and present.
- ☐ The Analysis and Assessment form is complete and present.
- ☐ Drawings are present.
- ☐ Completed LEAP Report is present.
- ☐ There are no unapproved laminations present.
- ☐ ENTRY NOT EVALUATED

PRE-BUILT STRUCTURE (Construction)

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

Regulation	Noncompliant		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.	
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.	
Placement on abutment	The structure cannot be appropriately placed on the abutment.		The structure can be appropriately placed on the abutment.	
Internal clearance	The testing apparatus and rod cannot be placed and passed through the center of the structure to allow for testing.		The testing apparatus and rod pass freely through the center of the structure to allow for testing.	
Other Construction Regulation				
Other Construction Regulation				
			DISQUALIFIED	
			PRE-BUILT STRUCTURE APPROVED FOR TESTING	

PRE-BUILT STRUCTURE (Construction) – continued	
Record the mass (weight) of the structure (in grams) prior to testing.	
Record the failure weight in pounds.	
Record the maximum failure rate for all tested structures.	
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.	

Rules violations (a deduction of 20% of the total possible points for the above sections) must be initialed by the judge, coordinator, and manager of the event. Record the deduction in the space to the right. Indicate the rule violated: _____	

PRE-BUILT STRUCTURE TOTAL POINTS	

Go/No Go Specifications

- ☐ There are no unapproved laminations present.
- ☐ ENTRY NOT EVALUATED

ONSITE STRUCTURE (Qualification)

For the Onsite STRUCTURE: Indicate N for noncompliant or C for compliant, in the Qualification and Construction sections below. In the Qualification section, one noncompliant mark will result in disqualification. In the Construction section, one noncompliant mark will result in a 20% deduction; two noncompliant marks will result in disqualification.

Regulation	Noncompliant		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.	
Placement on abutment	The structure cannot be appropriately placed on the abutment.		The structure can be appropriately placed on the abutment.	
Internal clearance	The testing apparatus and rod cannot be placed and passed through the center of the structure to allow for testing.		The testing apparatus and rod pass freely through the center of the structure to allow for testing.	
Construction pins	Pins are still in place when the structure is submitted.		All pins have been removed from the structure.	
Other Construction Regulation				
Other Construction Regulation				
	TOTAL		**TOTAL**	

ONSITE STRUCTURE (Construction)				
Regulation	**Noncompliant**		**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.	
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.	
			DISQUALIFIED	
			Onsite structure approved for testing	
			Record the mass (weight) of the structure (in grams) prior to testing.	
			Record the failure weight in pounds.	
			Record the maximum failure rate for all tested structures.	
			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.	

ONSITE STRUCTURE TOTAL POINTS	

SEMIFINAL LEAP INTERVIEW (20 points)				Record scores in the column spaces below.
CRITERIA	Minimal performance	Adequate performance	Exemplary performance	
	1-4 points	5-8 points	9-10 points	
LEAP Report/ Interview (X2)	The team's efforts are not clearly communicated, lack detail, and/ or are unconvincing; few, if any, attempts are made to identify and/or incorporate the SLC Practices and Behaviors.	The team's efforts are adequately communicated, include some detail, are clear, and/or are generally convincing; identification and/or incorporation of the SLC Practices and Behaviors is adequate.	The team's efforts are clearly communicated, fully-detailed, and convincing; identification and/or incorporation of the SLC Practices and Behaviors is excellent.	
			SEMIFINAL LEAP INTERVIEW SUBTOTAL (20 points)	

Rules violations (a deduction of 20% of the total possible points for the above sections) must be initialed by the judge, 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 any subtotals and subtract rules violation points, as necessary. **TOTAL**	

Comments:

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

JUDGE

Printed name: _____ Signature: _____

STRUCTURAL DESIGN AND ENGINEERING EVENT COORDINATOR INSTRUCTIONS

PERSONNEL

A. Event coordinator
B. Construction monitor, one (1) per twenty teams
C. A timekeeper
D. Judges:
    1. to evaluate pre-built structures, two (2) or more, as necessary
    2. to qualify structures after onsite construction, two (2) or more
    3. 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

MATERIALS

A. Coordinator's packet, containing:
    1. Event guidelines, one (1) copy each for the coordinator and judges
    2. TSA Event Coordinator Report
    3. List of judges/assistants
    4. Pre-populated flash drives for judges
    5. Results envelope
    6. Envelope for LEAP Reports
    7. LEAP Interview Judging Protocol

B. Semifinalist team packets provided by TSA containing construction materials and instructions
    1. Construction tools per team, to be used and returned to the event coordinator or helpers after constructions:
        a. Pin board as supplied, but generally a one-foot by two-foot (1' x 2') piece of fiber or foam board
        b. Grid paper with ¼" x ¼" or ⅛" x ⅛" grid on 17" x 22" paper for structure sketch (to remain with the completed structure when turned in)
        c. Wax paper to cover the pin board (to remain with the completed structure when turned in)
        d. Label for structure
    2. Balsa strips and sheets, as specified in the problem statement (on the national TSA website)
    3. Card stock, as specified in the problem statement (on the national TSA website)
    4. Instructions

C. Testing equipment, provided by TSA
D. Evaluation and recording equipment
    1. Gram scale (3-decimal place calculation)
    2. Tape measure or 2' rule
    3. Evaluation gauges

E. The testing equipment, selected by the event coordinator, provides a downward pull or force, and records the peak force in pounds.
F. 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' table)
        c. One (1) chair per participant
        d. Tables for equipment check-out and check-in
        e. Tables and chairs for judges
        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

RESPONSIBILITIES

PRE-CONFERENCE

1. Prepare the structure problem statement (including any necessary related information such as materials to be used for pre-built structures) for posting on the TSA website.
2. Prepare the onsite structure problem statement.

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. At least 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.

EVENT CHECK-IN

1. Set up check-in for testing of pre-built structures.
2. Check in the pre-built entries, the portfolios and the LEAP Reports at the time stated in the conference program.
3. Anyone reporting who is not on the entry list may check in only after official notification is received from the CRC.
4. Late entries are considered on a case-by-case basis and only when the delay is caused by events beyond participant control.

PRELIMINARY ROUND/PRE-BUILT STRUCTURES

1. Coordinate and manage the onsite testing of pre-built structures, the recording of results, and the determination of the twenty (20) semifinalist teams.
2. Decisions about rules violations must be discussed and verified with the judges, event coordinator, and CRC manager to determine either:
   a. To deduct 20% of the total possible points or
   b. To disqualify the entry
   c. The event coordinator, judges, and CRC manager must all initial either of these actions on the rating form.
3. Review and submit semifinalist results to the CRC for posting.
4. Assemble semifinalist packets of construction materials and directions for the twenty (20) onsite semifinalist teams.

SEMIFINAL ROUND/ONSITE 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 (2.5) 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 onsite 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.

11. Immediately following the completion of the semifinalist structures, each semifinalist team will participate in a LEAP interview that will last a maximum of five (5) minutes.
12. 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 will 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.

EVALUATION

1. Check 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 onsite 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 construction regulations are found to be non-compliant 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.
    f. Laminations contain more than two (2) pieces or members that are face to face in the same grain direction.
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 evaluators, the destructive testing of all structures that were not officially tested due to non-compliance.
5. Decisions about rules violations must be discussed and verified with the judges, event coordinator, and CRC manager to determine either:
    a. To deduct 20% of the total possible points or
    b. To disqualify the entry
    c. The event coordinator, judges, and CRC manager must all initial either of these actions on the rating form.
6. Review and submit the finalist results and all other items/forms in the results envelope to the CRC room.
7. Semifinalist teams may pick up their structures at a time designated by the event coordinator.