STRUCTURAL DESIGN AND ENGINEERING

OVERVIEW

Applying leadership and 21st century skills, team members collaborate 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 will be posted on the TSA website under Competitions/Themes and Problems. The on-site semifinalist problem is a variation of the Pre-conference problem posted on the TSA website.

ELIGIBILITY

One (1) team of two (2) individuals per chapter is allowed to participate.

SAFETY EYEWEAR

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

TIME LIMITS

A. On-site structures must be started, completed, and checked in during the three (3) hours allowed for design and construction.
B. 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.

ATTIRE

TSA competition attire is required for this event.

PROCEDURE

PRE-CONFERENCE

A. Teams review the details about the structure on the TSA website under Competitions/Themes and Problems.
B. Participants conduct research and apply principles of structural design and engineering to their current structure while considering the theme.
C. Pre-built structures must be started and completed during the current school year.
D. All work must be completed by the team members only and verified by the team's chapter advisor using the Team Verification form on the TSA website under Competitions/Themes and Problems.
E. Teams must provide a full-size, three (3)-view (front, top, and right end) drawing (hand or computer-generated) of their structure.

PRELIMINARY ROUND

On-site Destructive Testing of Pre-Built Structures

A. Participants check in the following at the time and place stated in the conference program:
    1. Pre-built structure and any related required materials (including the Analysis and Assessment form on the TSA website under Competitions/Themes and Problems.)
    2. Documentation portfolio materials
B. Participants are required to wear safety approved eyewear (refer to the Safety Eyewear section of this guide).
C. Structures are assessed and undergo destructive testing.
D. Destructive testing of pre-built structures is not open for public viewing.

E. Destructive testing is completed using structural testing equipment, as designated by TSA.

F. When the destructive testing is completed, a list of twenty (20) semifinalist teams are posted.

SEMIFINAL ROUND

On-site Construction

A. The twenty (20) semifinalist teams take part in the on-site problem, which features the construction and destructive testing of a designated structure to determine the ten (10) finalist teams.

B. Twenty (20) semifinalist teams report to the event area at the time and place stated in the conference program.

C. Teams are seated by a monitor.

D. The design problem is explained and a list of directions for the construction problem are provided.

E. Teams have a three (3) hour window when drawing begins and building stops, typically allotted as:

   1. Thirty (30) minutes to review the problem and create a sketch/drawing of their solution.
   2. Two and one-half (2 ½) hours to review the problem and construct a solution.

F. During the building of the team's structure, construction regulations must be observed.

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

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

I. Teams return all supplied items, as directed, and clean and clear their work stations. Failure to do so will result in a 20% penalty deduction.

J. Teams must identify their structure with only their team ID number, using the label provided.

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

Destructive Testing

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

B. Destructive testing is completed by evaluators and is open for spectator viewing.

C. 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.

D. Subjective criteria is scored only after all the destructive testing is completed.

E. The top ten (10) finalist teams are announced at the conference awards ceremony.

REGULATIONS AND REQUIREMENTS

Students will work to develop their leadership and 21st century skills in the process of preparing for and participating in this TSA competitive event. The development and application of those skills must be evident in their submission, demonstration, and/or communication pertaining to the entry.

PRE-CONFERENCE

A. Documentation Portfolio:

   1. Documentation materials (comprising "a portfolio") are required and must be secured in a clear front report cover with the following single-sided, 8½" x 11" pages, in this order:
      a. Title page with the event title, the conference city and state, the year, and the team/chapter ID number; one (1) page
      b. Team Verification Form (See the TSA website under Competitions/Themes and Problems.
      c. Analysis and Assessment Form (See the TSA website under Competitions/Themes and Problems).
      d. Participants must provide a full-size, three (3)-view (front, top, and right end) drawing (hand or computer-generated) of their structure.

PRELIMINARY ROUND

A. Participants must provide and wear safety glasses for this portion of the event.
B. Drawing and pre-built structures must be completed prior to check-in.
C. The testing of pre-built structures is not open to spectators.

SEMIFINAL ROUND

A. Participants must provide and wear safety glasses for this portion of the event.
B. 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 (note that some items are required):
    1. The following is a *suggested* list:
        a. Cutting devices; NONE may be electric
        b. Adhesives
            i. Aerosol and electric applicators are not allowed
            ii. A bottle of Uncure or Debonder is recommended
        c. Temporary fastening devices
            i. Straight pins
            ii. Clamps
            iii. Tape
        d. A cutting surface that prevents table-top marring (required)
        e. Rulers, straightedges, and/or measuring scales
        f. Abrasives sheets, sanding sponges, emery boards
        g. Marking devices (pens, pencils, etc.) and sharpener
        h. Sheet of wax paper, as large as is needed for the competition (required)
        i. Pliers, wrenches, nut drivers, as needed
        j. Safety glasses and side shields, as required
        k. Jigs and fixtures to assist with assembly and construction.
    2. Planning and fabrication supplies are provided by TSA. Teams are issued a packet of construction materials (such as a specific type of wood) to use for fabrication of the on-site designed structure once the team's drawing of the on-site solution is complete.
    3. 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
C. 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.
D. Filming and taking of photographs is prohibited during the viewing of the structure, judging, and testing.
E. Subjective criteria is scored only after all destructive testing is completed.

EVALUATION

A. All structures are weighed before testing and the weight is recorded on the scoring rubric.
B. A designated structural testing device is used for testing each structure.
C. A specific testing block or attachment may be necessary, depending on the nature of the on-site problem. Any special or unusual configurations for the attachment are 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 determines 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.)

Refer to the official rating form for more information.

STEM INTEGRATION

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

LEADERSHIP AND 21ST CENTURY SKILLS DEVELOPMENT

This event provides opportunity for students to build and develop leadership and 21st century skills including but not limited to:

- Communication
- Collaboration/Social Skills
- Initiative
- Problem Solving/Risk Taking
- Critical Thinking
- Perseverance/Grit
- Creativity
- Relationship Building/Teamwork
- Dependability/Integrity
- Flexibility/Adaptability

CAREERS RELATED TO THIS EVENT

This competition has connections to one (1) or more of the careers below:

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

Participant/Team ID# _____

STRUCTURAL DESIGN AND ENGINEERING

2021 & 2022 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
☐ Team Verification form is complete
☐ Analysis and Assessment form is complete
☐ Drawings are 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/ Rule Regulation				
Other Construction/ Rule 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

ON-SITE STRUCTURE (Qualification)

For the On-site 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/ Rule Regulation				
Other Construction/ Rule Regulation				
	TOTAL		**TOTAL**	

ON-SITE 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	
			On-site 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.	

ON-SITE STRUCTURE TOTAL POINTS	

SUBJECTIVE CRITERIA (30 points)				Record scores in the column spaces below.
CRITERIA	Minimal performance	Adequate performance	Exemplary performance	
	1-4 points	5-8 points	9-10 points	
Team Participation (X1)	The majority of the construction is done by one (1) member of the team; the partner may be disengaged.	Both team members generally are engaged in the process, though one (1) member may take on more responsibility than the other.	Both team members are actively involved in the construction; there is shared responsibility between team members.	
Drawing (X1)	The submitted drawing was incomplete, not accurate, of proper quality, or was not to scale; a complete parts list was not included.	The submitted drawing was complete but lacked clarity, accuracy, or was of poor quality; the parts diagram was not complete or was incorrect.	The submitted drawing was complete, accurate, and to scale; the parts list was complete and accurate.	
Portfolio (X1)	Portfolio is unorganized and/or missing three (3) or more components; leadership and/or 21st century skills are not evident.	Portfolio includes most components and is generally organized; leadership and/or 21st century skills are somewhat evident.	All components of the portfolio are included, and content and organization are clearly evident; leadership and/or 21st century skills are clearly evident.	
			SUBJECTIVE CRITERIA SUBTOTAL (30 points)	

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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. 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 for 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 both testing sessions that can be used to demonstrate the testing procedure and to determine 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 entries and storing 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, ¼" x ¼" 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 – check with the event manager for the specific wood type needed for each team
    c. Instructions

RESPONSIBILITIES

PRE-CONFERENCE

A. 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.

AT THE CONFERENCE

A. Attend the mandatory coordinator's meeting at the designated time and location.

B. Report to the CRC room and check the contents of the coordinator's packet.

C. Review the event guidelines and check to see that enough personnel have been scheduled.

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

E. Check to see that all event equipment and materials have been secured.

F. At least one (1) hour before the event is to begin, meet with judges and assistants to review time limits, procedures, regulations, evaluation, and all other details related to the event. If questions arise that cannot be answered, speak to the event manager before the event begins.

EVENT CHECK-IN

A. Check in participants at the time and place stated in the conference program.

B. Participants check in:

1. The pre-built structures
2. The documentation portfolio

C. Anyone reporting who is not on the entry list may check in only after official notification is received from the CRC.

D. 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

A. Coordinate and manage the on-site testing of pre-built structures, the recording of results, and the determination of the twenty (20) semifinalist teams.

B. Decisions about rules violations must be discussed and verified with the judges, event coordinator, and CRC manager to determine either:

1. To deduct 20% of the total possible points or
2. To disqualify the entry

The event coordinator, judges, and CRC manager must initial either of these actions on the rating form.

C. Submit the semifinalist results and all related forms in the results envelope to the CRC room.

D. Assemble semifinalist packets of construction materials and directions for the twenty (20) on-site semifinalist teams.

SEMIFINAL ROUND

Team Check-in for On-site Construction

A. No individuals other than participants and event personnel are allowed in the construction area.

B. Check-in begins at the time stated in the conference program and continues until all teams arriving on time have been checked in and seated. The event begins at the posted time.

C. Both members of a team must be present during check-in.

D. 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 stated in the conference program.

E. Work must begin during the time frame scheduled for the event.

On-site Construction

A. Assign team construction locations.

B. When all teams are seated, distribute and review instructions, as well as any details for the assigned structure.

C. Teams are allowed a maximum of three (3) hours to complete their structure:
   1. Thirty (30) minutes of this time is allotted for completing the design drawing.
   2. Two and one-half (2 ½) hours is allotted for actual construction.

D. When a team notifies a monitor that the required sketch is complete, and the monitor confirms this, the team receives a materials packet and may begin the on-site construction phase of the event.

E. No additional supplies are provided during the event.

F. Call time at the end of the allotted three (3) hour time frame. All teams must stop working at this point.

G. All work stops at the coordinator's signal. Failure to comply with instructions will result in a penalty of 20% to the team's total score.

Team Check-out

A. Establish the procedure for check-in and recording of finished structures.

B. Designate an area for storage, and allow for the return of construction materials.

C. Coordinate the return and removal of all supplied items and ensure that teams clean and clear their work stations. Deduct a 20% penalty for teams that do not comply.

D. Teams check-in excess supplies as directed by the monitors.

E. Ensure that teams identify their structure with only their team ID number, using the label provided.

F. Teams place their structures in the storage area with the sketch as directed by the monitor.

G. Once check-out is complete, all participants leave the competition area. Participants may leave early, but they must complete check-out as directed.

H. The structures are secured by the monitor and allowed to dry for a minimum of twelve (12) hours.

Destructive Testing

A. After the structures have dried, judges report to the event area at the time and place stated in the conference program.

B. Judges test each structure and score the results.

C. Judges score the Subjective Criteria for semifinalists after destructive testing has taken place.

EVALUATION

A. Check all structures for regulations compliance. Structures that are in compliance are tested without penalty.
   1. Weigh all structures before testing and record the weight on the evaluation rubric.
   2. 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.)
   3. Apply an increasing load to the structure, via the test block or attachment, until the structure fails.
   4. 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.
   5. 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.
   6. The highest numeric efficiency determines the winner. In the case of an efficiency tie, the greatest weight held by the tied entries determines the winner.

B. Structures are not be tested if:
   1. A non-compliance construction regulation violation was determined before testing.
   2. The structure cannot be placed on the tester.
   3. The testing attachment cannot be properly placed within or on the structure.
   4. Straight pins are left in the structure.
   5. There is a failure of a participant to wear safety eyewear and/or to follow safe practices.
   6. Laminations fail to comply with the guidelines as specified in the current year's challenge.
   7. Failure to use each of the materials specified in the current year's challenge.

C. Structures with one (1) construction regulation non-compliance mark is 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.)

D. Manage, with assistance from evaluators, the destructive testing of all structures that were not officially tested due to non-compliance.

E. Discuss rule violations (e.g. 20% deduction, disqualification) and have all relevant parties initial the rating form.

F. Judges use the evaluation metrics and determine the placement of ten (10) finalists.

G. Submit the finalist results and all related forms in the results envelope to the CRC room.

H. If necessary, manage the security and removal of materials from the event area.

I. Semifinalist teams may pick up their structures at a time designated by the event coordinator.