REVISION 1 – SEPTEMBER 20, 2023

Updates are shown in red

3D Printing Competition: Bridging the Future

2024 Rules and Requirements

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1. Welcome

The American Society of Civil Engineers (ASCE) supports and encourages a fully inclusive culture that celebrates individual uniqueness, engenders a sense of belonging, and promotes equitable opportunity for all people to participate in the 3D Printing Competition. (See ASCE Policy statement 417 - Justice, equity, diversity, and inclusion.) Participation should be inclusive, open, and fair to all interested and eligible students. Welcome!

2. About the Competition

Three-dimensional printing (3DP) is an emerging construction technology. 3DP operates by adding sequential layers of material to create a three-dimensional object, which saves labor cost, minimizes material waste, and optimizes building time. While 3DP has been used to create prototypes and small-scale models of the built environment for some time, the technology has advanced to the construction of houses and bridges.

Figure 1: First 3D-printed home in the United States, 2021, Williamsburg, VA (Alquist 3D)

The goal of the 3D Bridge Printing Competition is to promote the application of 3D printing technology in the field of civil engineering. For students, the goal is to design an aesthetically-pleasing, strong, and stiff bridge that will take the least amount of assembly time and meets the geometric requirements.

Figure 2: The world's first 3D printed footbridge, 2021, Amsterdam, the Netherlands (Ana Fernandez/SOPA Images/LightRocket via Getty)

Students must pay attention not only to the design, but also the details of the print, which play a significant role in the shape, tolerances, and strength of the bridge. Students will demonstrate teamwork, organization, analytical skills, and creativity throughout the process of the competition.

The 3D Printing Competition has its origin at the New Jersey Institute of Technology's inter-collegiate competition in November 2021. ASCE gratefully acknowledges NJIT's efforts in creating the competition and working to expand its reach among civil engineering students.

3. Participation and Eligibility

a. Team Member Requirements
Team members must be undergraduate students, enrolled during all or part of the current competition academic year, members of an ASCE Student Chapter in good standing, registered participants of the student symposium, and Society Student Members of ASCE. (Society student membership is free; be sure to join.)

Graduate students are encouraged to serve as advisors.

b. Team Requirements
It is an expectation that teams will reflect diversity, foster an inclusive culture, and treat everyone with dignity and respect.

Only one team per ASCE Student Chapter may compete in the competition. A student chapter may compete in only one ASCE Student Symposium. Each team must designate one captain. Conference assignments and student symposium hosts are listed here.

ASCE Student Chapters hosting symposia may invite Official Guest teams, which are teams from Region 10 colleges or universities that have an official ASCE Student Chapter that is not yet assigned to any Student Conference. Official Guest teams may compete in only one student symposium per year and are eligible to place and receive awards at the student symposium competition (if they meet the other requirements, including eligibility requirements). ASCE Student Services shall be notified by the ASCE Student Symposium host school of an Official Guest team prior to the start of the student symposium via email to student@asce.org.

An ASCE Student Chapter team wanting to enter a competition that is NOT being hosted at their assigned student symposium, may request to compete at another ASCE Student Symposium as a guest team. If the student symposium host grants permission, the guest team may compete. The guest team will be scored but shall not win awards at the student symposium competition.

c. Student Chapter Eligibility
Eligibility criteria for the Student Symposium Competition are shown in Appendix A.

d. Intent and Eligibility Acknowledgement Form
Teams shall submit an Intent and Eligibility Acknowledgement Form (see Appendix B), no later than 5:00 p.m. Eastern on November 3, 2023. By completing this form, a student chapter states their intent to have a team participate in the competition at their assigned student symposium as well as acknowledges the eligibility requirements for student symposium competition participation. The form must be

signed by the Team Captain, ASCE Student Chapter Faculty Advisor, ASCE Student Chapter President, and Competition Team Faculty Advisor (if different than ASCE Student Chapter Faculty Advisor).

The team captain shall upload the Intent and Eligibility Acknowledgement Form to ASCE's Cerberus files transfer protocol (ftp) server. Refer to Appendix C for upload directions.

4. Ethics and Required Conduct

This competition is to be conducted with the highest regard for ethical responsibility per ASCE's Code of Ethics. All members of ASCE, regardless of their membership grade or job description, commit to all of the ethical responsibilities in this Code. All ASCE members should make themselves familiar with ASCE's Code of Ethics.

All participants shall act professionally and respectfully at all times. Failure to act appropriately may result in sanctions, disqualifications, and loss of invitations to future symposia competitions or Society-wide competitions. The inappropriate use of language, alcohol, or materials, uncooperativeness, and general unprofessional or unethical behavior will not be tolerated.

5. Safety

Safety is the highest priority and risk of personal injury will not be tolerated. Judges and student symposium hosts, including the Safety Officers, are empowered to stop or prohibit an activity which is deemed to be hazardous, or to postpone an activity until the hazard is rectified.

Participants acknowledge that there are risks to be considered when creating and testing 3D printed structures. Bridges should be printed in a well-ventilated area, and care should be taken to avoid injury when working with a 3D printer. Connections that are 3D printed are prone to some error, and participants are encouraged to print tests of connections to account for tolerancing issues. If any parts need to be filed or cut, participants need to ensure proper caution and use hand and eye protection. In the testing of bridges, participants must be cognizant of PLA's brittle nature. Bridges can fail suddenly and even explosively. Only participants actively involved with the testing of bridges should be near the loading apparatus and should wear eye protection as well as work gloves if handling the bridge or the loading apparatus during testing. Participants should consistently use the safety features included in the loading apparatus (e.g., plexiglass shield).

All participants are responsible for complying with all campus/venue protocols and procedures, including those deemed necessary for public health purposes.

Given continually changing environments, virtual competition provisions may be provided and may be activated in coordination with ASCE.

If there is a thunderstorm, all outdoor activities shall cease and may not resume until at least 30 minutes have passed since the last observed occurrence of thunder or lightning.

6. Bridge Dimensions

The bridge must span an open length of 24 inches (610 mm). The total bridge length can be no longer than 28 inches (711 mm) for a 2-inch (51 mm) bearing support on each side, no taller than 8 inches (203 mm), and no wider than 6 inches (152 mm). The bridge structure can extend no more than 2.5 inches (64 mm) below the piers and no more than 8 inches (203 mm) above the piers. The structure must not touch the lateral face of the bridge pier in order that its support depends entirely on vertical (not longitudinal) loading through the bridge pier. The cross section through the bridge must have an area greater than 3 inches by 3 inches (76 mm x 76 mm) through its entire length to allow a test vehicle of those dimensions to pass easily through without obstructions. This volume must not be interrupted by structural elements. The clear volume should be 1.5 inches (38 mm) above the piers and should be underlain by a deck for a vehicle to pass over (see Figure 3 and Figure 4). The load will be applied to the bridge through a 3 inch by 3 inch (76 mm x 76mm) plate threaded on to a ¼-inch (6 mm)-diameter threaded steel rod that will be attached to the nut and washer from the bottom side. Therefore, there must be at least a $^{3}/_{8}$-inch (9 mm) clearance at the center of the bridge from the bottom side to allow for the attachment of the ¼-inch (6mm) rod.

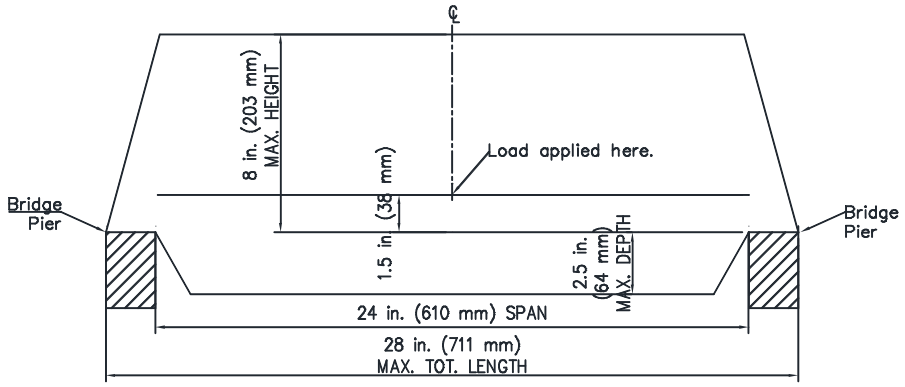


Figure 3: Elevation View of Bridge

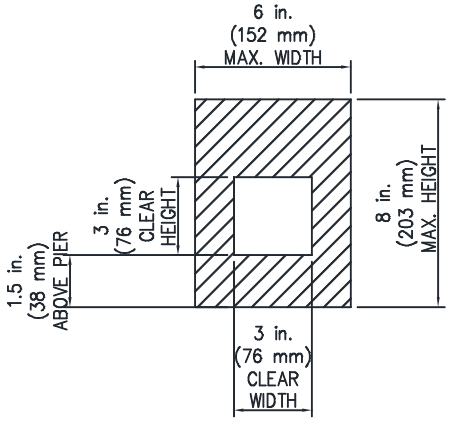


Figure 4: Section View of Bridge

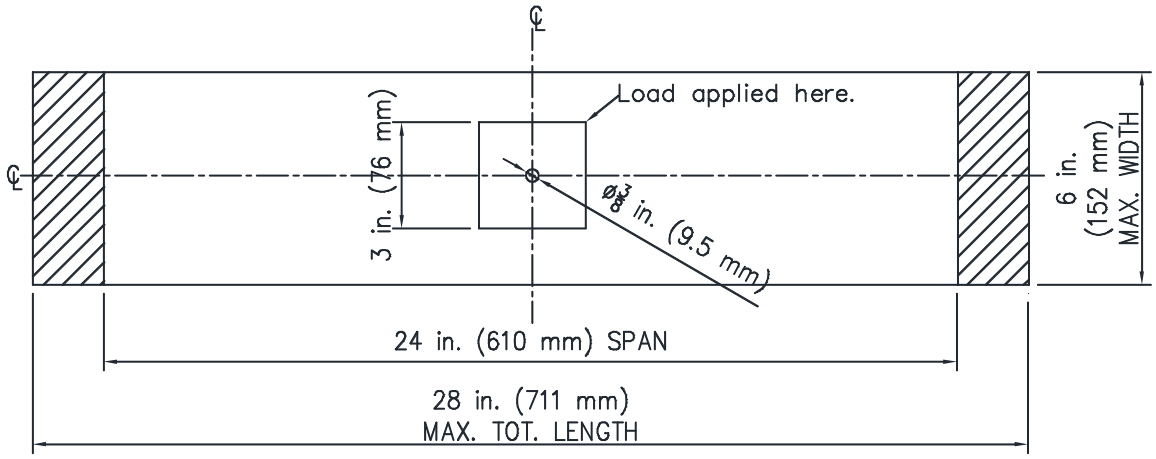


Figure 5: Plan view of bridge

7. Bridge Parts

a. All parts must be printed with 100% Plain PLA (Polylactic acid). No other material fill material is allowed.
b. The maximum allowed bridge weight is 17.6 ounces (500 grams).
c. The design must include at least one circular arc.
d. All parts together must fit into a box 8.7 in. (220 mm) wide, 8.7 in. (220 mm) long, and 6.5 in. (165 mm) high.
e. Only mechanical connections (No adhesive allowed).
f. No unextruded filament may be used in the bridge.
g. There is no limit on testing of parts and bridges before competition.

8. Tips

- Make sure that all parts you design can fit within the bed of the 3D printer you are using.
- 3D printed sockets tend to be slightly smaller than designed, so be sure to adjust your designs to accommodate shrinkage as the filament cools during printing. Test printing small samples of the connections will help you calibrate connection fits with your printer/filament.
- Check the fits of all components before the day of the competition as much as possible.
- Ensure the length and width of your bridge match the specifications so that your bridge qualifies and can be tested.
- It is important to engage the entire superstructure in supporting the load—not just the bridge deck or the point at which the load is applied, so make sure the area where the load is applied is well-connected to the superstructure.
- Because there is a maximum load (about 100 lb), you want only as much material as will support that load and little more to avoid being penalized for having a heavy bridge.

9. Scoring

There are five weighted metrics which will be added in aggregate to determine the teams' overall scores. The metrics and their weighted contribution are shown below in Table 1. In addition to receiving a single score which will be the basis for winning 1st, 2nd, and 3rd place overall, the top two teams in each category will be separately recognized for their superior performance in that category.

Adherence to the rules is crucial to ensuring a fair competition. Teams will be subject to deductions determined by the judges for deviations from the rules as they relate to each category. Information on each category is detailed in the following sections.

Qualitative categories (Creativity and Presentation) will be determined by a simple ranking system, and quantitative categories (Load, Stiffness, and Assembly Time) will be based on a proportional ranking system. The last-place team in a given category will receive 1 point, and the first-place team will receive the full points (e.g., 50 points for highest vertical load). The remaining teams will be allocated points based on linear interpolation. For example, if four teams compete and have vertical loads of 260, 160, 140, and 100 lb., the first team will receive 50 points, the second team will receive 19.4 points, the third team will receive 13.25 points, and, and the fourth team will receive 1 point.

Table 1: Overall Category Score Weighting

Vertical ~~Load~~ Strength	Vertical Stiffness	Assembly Time	Creativity	Presentation
50	20	10	10	10

a. Vertical ~~Load~~ Strength

i. The load will be applied vertically at center span~~, with maximum points awarded to the bridge supporting the largest load at failure~~up until a maximum of about 100 lb.
ii. The performance will be calculated by normalizing the load supported by the weight of the bridge.
iii. Maximum points will be awarded to the bridge with the highest load-to-weight ratio.
~~iv. If multiple bridges do not fail at the maximum testing load, deflection at center span will again be measured. The team with the least deflection at this load will be awarded 10 additional points, and those with greater deflections will be awarded points based on linear interpolation.~~

b. Vertical Stiffness

i. Stiffness will be judged at the same load for all bridges (25 lb.) by measuring the change in vertical deflection at center span.
ii. The performance will be calculated by normalizing the stiffness (25 lb. force divided by deflection) by the weight of the bridge.
iii. The bridge with the highest stiffness-to-weight ratio will receive the maximum points for this category.

c. Assembly Time

i. Each team shall have one or more competitors work together to assemble the bridge.
ii. The time is multiplied by the number of members working on assembly.
iii. Teams taking 15 minutes (not multiplied by number of people) or longer to assemble will receive the minimum score in this category.

d. Creativity

i. The aesthetic theme for this competition is the future. Designs should reflect some aspect of forward-thinking design. Inspiration can be drawn from the ASCE Future World Vision website.
ii. Include information about the design inspiration in the presentation.
iii. Judges will rank bridges based on their correspondence to an inspiration the team chooses as well as the innovation in the design and the quality of the print.
iv. A circular arc must be incorporated in some way into the design of the bridge.

e. Presentation (Poster Board)

i. Each team will present in five minutes or less a poster board (24 inches x 36 inches) outlining:
   1. Team composition
   2. Design inspiration for bridge
   3. 3D images of bridge
   4. Print details

ii. Judges will rank presentations based on:
   1. Readability of poster
   2. Aesthetics of poster
   3. Adherence to the 5-minute time limit
   4. Presentation mechanics (projection, pace, facing judges, etc.)

f. Structural Calculation Accuracy

i. Teams will be required to predict the ultimate load based on structural calculations.

ii. The two teams whose ultimate failure load is closest to their calculations will be honored with separate prizes (this is not included in the overall score).

10. Requests for Information (RFIs)

Requests for information (RFIs) regarding the 2023 competition should be sent to student@asce.org with the subject line "**2024 3D Printing Competition RFI**". Clarifications will be posted at the ASCE 3D Printing Competition Collaborate Site approximately one week after being received starting September 29, 2023 until February 16, 2024. The cutoff date for submitting an RFI is Wednesday, February 7, 2024 at 11:59 p.m. Eastern. Those received after this date will not be acknowledged or addressed. **Teams are strongly encouraged to submit RFIs to avoid misinterpretation of the rules. All RFIs will be made public**. All teams are responsible for all information provided in the Rules and Regulations and RFI responses posted to the Collaborate site.

11. Timeline

- Release of 3D Bridge Competition Rules and Regulations – 9/7/23
- Intent and Eligibility Acknowledgement Form - due by 11/3/23 at 5:00 p.m. Eastern
- Last day to submit an RFI – 2/7/24~~3~~
- Symposium dates vary – early March through end of April 2024
- Awards for 2024 ASCE 3D Printing Competition – Student symposium awards ceremony

12. Awards

a. Recognition awards will be awarded for categories (1st and 2nd):
    i. Largest Load,
    ii. Fastest Assembly Time,
    iii. Stiffest Bridge,
    iv. Best Aesthetics,
    v. Best Presentation, and
    vi. Best Estimate of Ultimate Load
b. The team that earns the highest overall score will be awarded the best overall award.
c. The teams that earn the second and third highest overall scores will be awarded second and third place.

13. Judging

The student symposium host shall recruit judges. The judging panel, consisting of a minimum of three judges, shall be composed of industry professionals or educators familiar with bridge design, structural testing, and/or 3D printing.

Judges should be well versed in the rules and RFIs posted on the Collaborate site. The Head Judge is required to attend the Head Judge Webinar hosted by ASCE in February 2024.
Scoring data shall be recorded for each team that competes. Official judging forms shall be used and will be provided by the competition rules committee prior to the symposia. The information from the judges' data sheets is entered into an official scoring spreadsheet which tabulates the official results of the competition. A summary report will be provided to each symposium host for their records and distribution.

At the end of the student symposium competition, the head judge shall promptly upload the completed official scoring spreadsheet for a student symposium competition to ASCE's Cerberus ftp server. ASCE will provide the head judge a secure submission link for ASCE's Cerberus ftp server in February 2024.

Appendix A - Eligibility for Student Symposium Competition

Invitations to Student Symposia Competitions are a privilege, not a right. Failure to act professionally can result in letters of reprimand, mandatory behavior management plans, and loss of invitations to further competition for individual institutions and/or entire conferences.

Student Chapter Eligibility for Student Symposium Competition

The following qualifications are required of all ASCE Student Chapters to compete at the Student Symposia Competitions:

An ASCE Student Chapter must:

1. Be in good standing with ASCE:

a. Have paid their annual dues, as received by ASCE, **no later than the start of their Student Symposium.**

b. Have submitted their student chapter's full Annual Report or EZ Annual Reporting Form **no later than February 1, 11:59 p.m. Eastern Standard Time (EST).**

Questions regarding eligibility should be directed to student@asce.org.

Appendix B – Intent and Eligibility Acknowledgement Form

2024 ASCE 3D Printing Competition
Statement of Intent and Acknowledgement of Eligibility Requirements for Student Symposium Competition Participation

Teams shall submit an Intent and Eligibility Acknowledgement Form, **no later than 5:00 p.m. Eastern on November 3, 2023.** By completing this form, a student chapter states their intent to have a team participate in the competition at their assigned student symposium as well as acknowledges the eligibility requirements for student symposium competition participation. The form must be signed by the Team Captain, ASCE Student Chapter Faculty Advisor, ASCE Student Chapter President, and Competition Team Faculty Advisor (if different than ASCE Student Chapter Faculty Advisor).

The team captain shall upload the Intent and Eligibility Acknowledgement Form to ASCE's Cerberus ftp server. The main folder contains a sub-folder for each Student Symposium. (Note: This is a pilot competition. Please verify that your student symposium host is conducting this competition prior to completing this form and if not, consider the guest team option.) This is a Read/Write link (no delete). Refer to Appendix C – How to Navigate Folders and Upload Intent and Eligibility Acknowledgement Form for directions**.**

File names shall be in the form of "School Name – 3D Printing Intent and Eligibility Acknowledgement Form Year" (example: NJIT – 3D Printing Intent and Eligibility Acknowledgement Form 2024).

Click this hyperlink to submit the Intent and Eligibility Acknowledgement Form:

https://upload.asce.org/public/folder/Mf9AZtHUA0S1MvwqjPomlQ/ASCE%203D%20Printing%20Competition

Late and/or incomplete submission of this form may be subject to deduction.

_____
School/University Name

_____
ASCE Student Chapter Name

_____
Assigned Student Symposium Name

Statement of Intent

It is the intent of our student chapter to have a team participate in the 2024 ASCE 3D Printing Competition at our assigned Student Symposium.

Acknowledgement of Eligibility Requirements for Student Symposium Competition Participation

ASCE 3D Printing Team Captain (TC) and ASCE Student Chapter Faculty Advisor (FA), please initial next to each statement below to indicate your acknowledgement and understanding of that item. If you have questions about any statement, please contact us at student@asce.org.

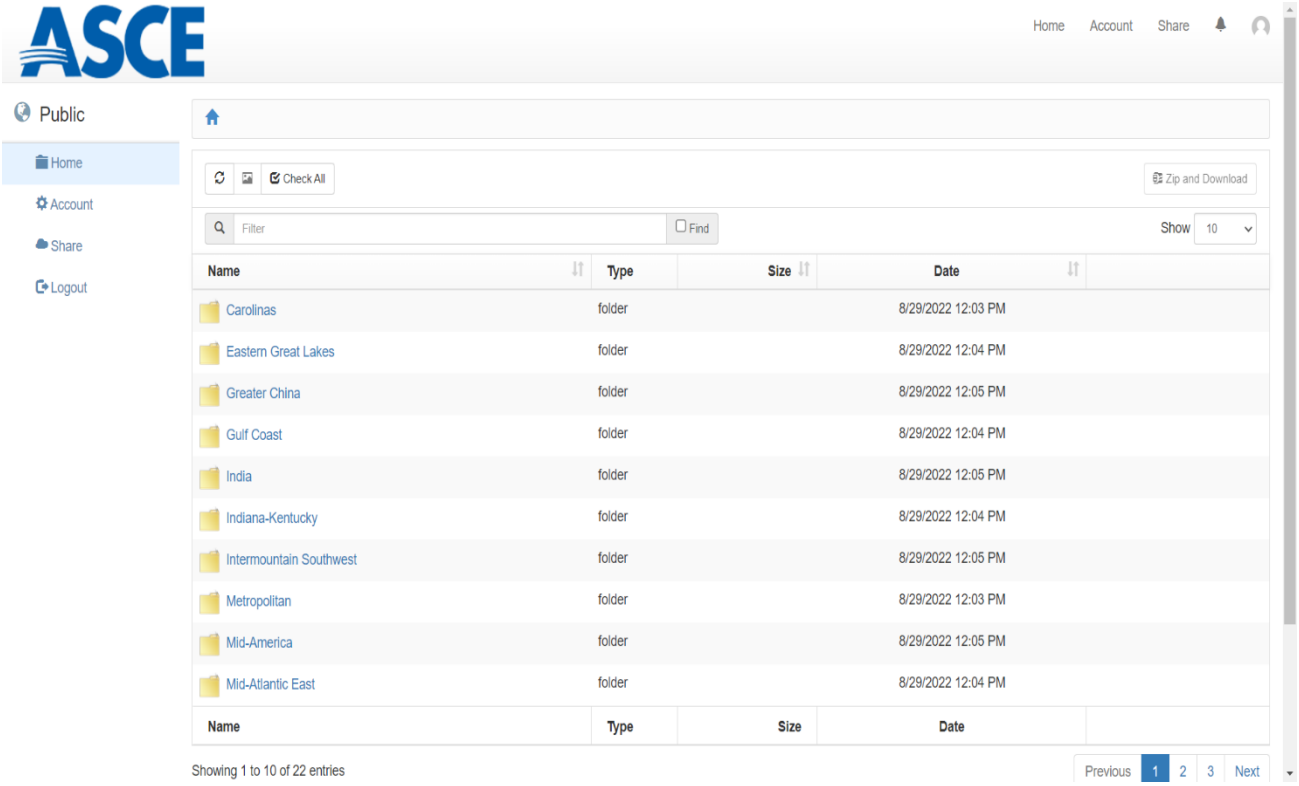
	TC	FA
1. We have read the 2024 ASCE 3D Printing Competition Rules and understand the following:		
a. The team member requirements per Section 3.a of the Rules.		
b. The team requirements per Section 3.b of the Rules.		
c. The student chapter eligibility requirements to participate in the ASCE Student Symposium Competition per Appendix A of the Rules, specifically: **An ASCE Student Chapter must:** **1.** Be in good standing with ASCE: **a.** Have paid their annual dues, as received by ASCE, **no later than the start of their Student Symposium.** (Please note that some educational institutions managing student chapter finances may require long lead times to generate and send payments. ASCE strongly recommends that these requests are generated by December before you leave for winter break.) **b.** Have submitted their student chapter's full Annual Report or EZ Annual Reporting Form **no later than February 1, 11:59 p.m. EST.**		
2. Submitting a student chapter annual report is typically the responsibility of the student chapter officers. As team captain and faculty advisor, ASCE suggests that you connect with your student chapter officers as early as possible to discuss the annual report and deadline.		

I have read and understand the student symposium competition information stated above, including eligibility requirements for student symposium competition participation.

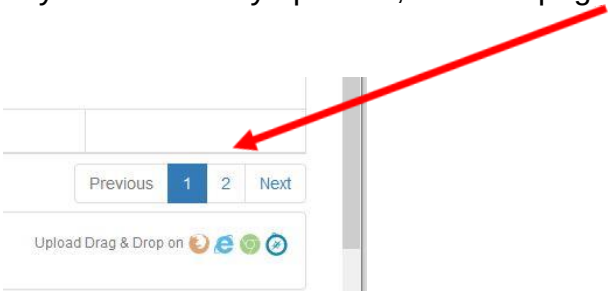
Team Captain	ASCE Student Chapter Faculty Advisor
Date	Date
Email Address	Email Address
Signature	Signature
ASCE Student Chapter President	ASCE 3D Printing Competition Faculty Advisor (if different than ASCE Student Chapter Faculty Advisor)
Date	Date
Email Address	Email Address
Signature	Signature

Appendix C – How to Navigate Folders and Upload Intent and Eligibility Acknowledgement Forms

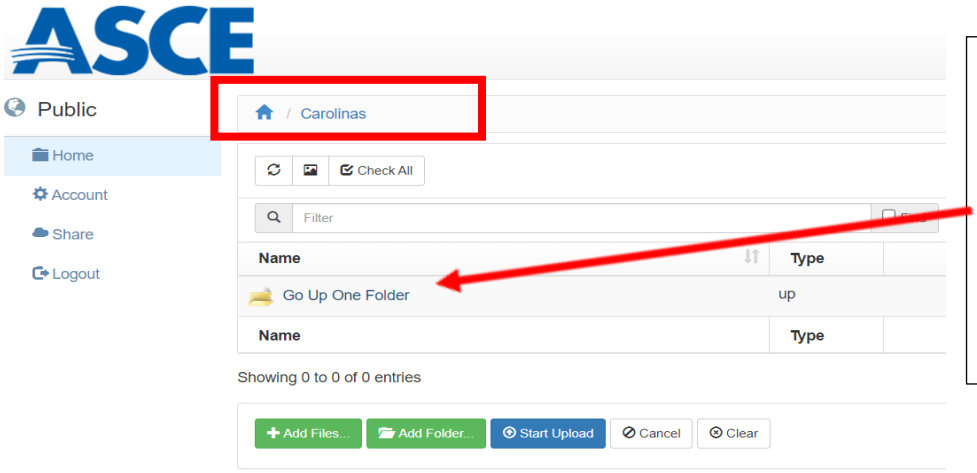
When you first arrive at the upload site, you will see folders labeled for each Student Symposium:



Locate your Student Symposium and click the folder to open it. If you don't see the name of your Student Symposium, click the page navigation to move to the second page:

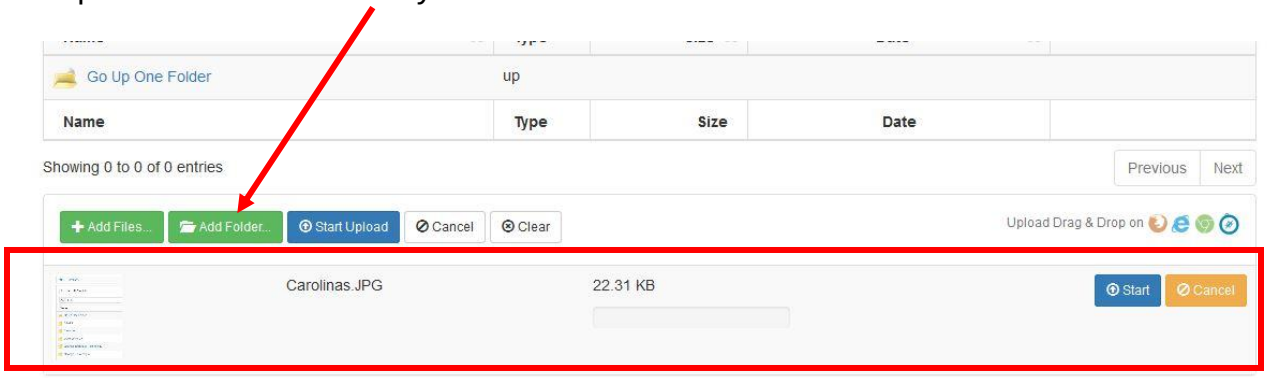


When you have opened the folder for your Student Symposium, double-check that you are in the correct location before you begin uploading your files (In this case, **The Carolinas** Student Symposium):



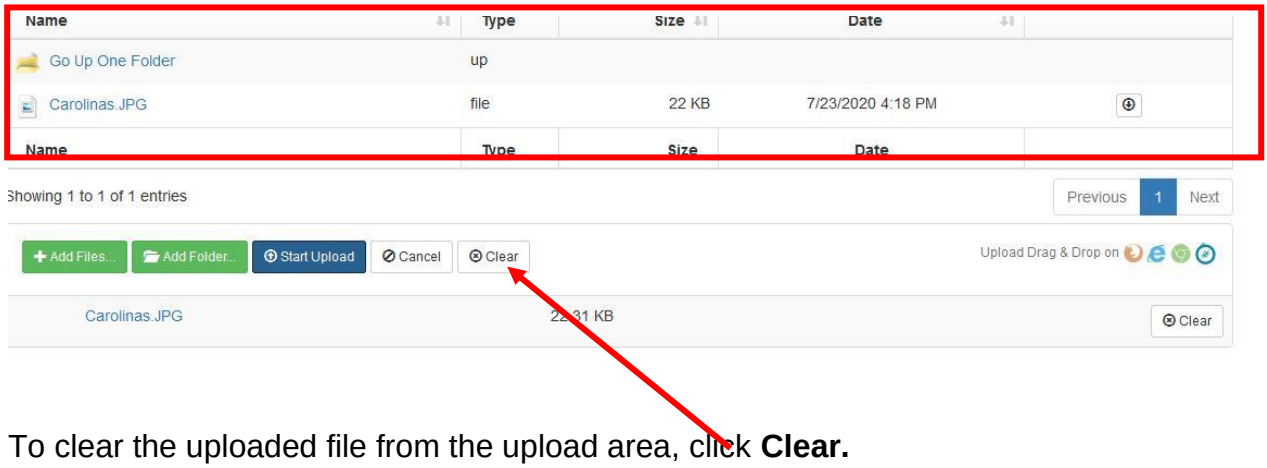
If you accidentally open the wrong folder, you can "back up" by clicking the **Go Up One Folder** folder and navigate correctly.

When you have confirmed that you have navigated correctly to the proper folder, you can either click the **+Add Files** button and then browse to find the files to upload, or drag and drop files to the area directly below the **+Add Files** button.



The selected (or dragged and dropped) files will appear in the upload area. To upload the file into the folder, click **Start Upload.**

When the file has been successfully uploaded, the name of the file will appear under the **Go Up One Folder** folder



To clear the uploaded file from the upload area, click **Clear.**

Need help?
If you uploaded a file to the wrong folder, or want to replace an uploaded file with a corrected version, **s**end an email to jupmeyer@asce.org and ask that the incorrect file be deleted. Include both the location (folder path) and **exact name** of the file you want deleted. (Files cannot be moved – you will have to upload the file again to the correct folder after it has been deleted).

Reminder
Please ensure you have uploaded to the correct folder for your symposium and school. Submissions outside of your own symposium folder will be considered non-responsive and will not be considered.