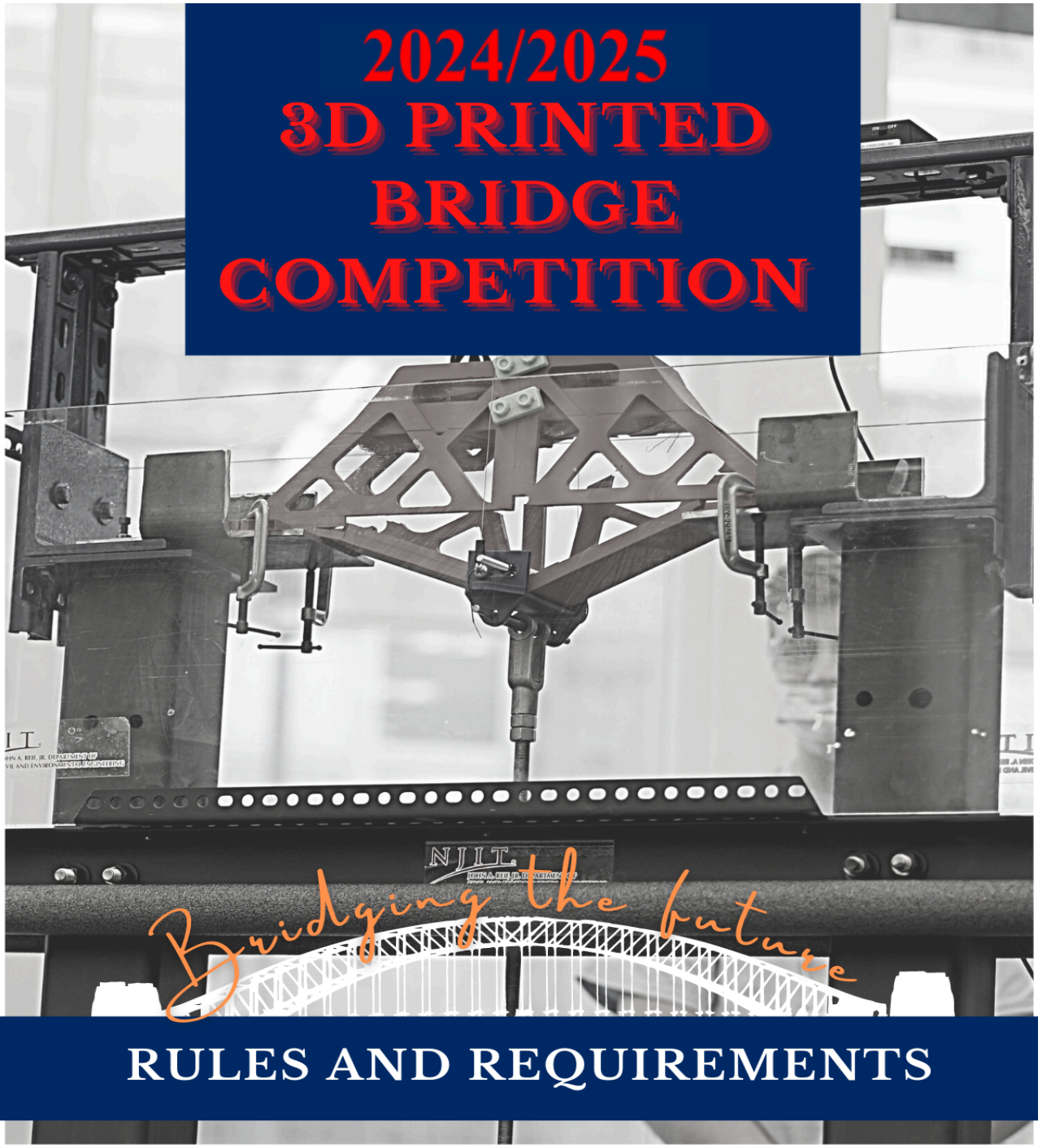
2024/2025
3D PRINTED BRIDGE COMPETITION



RULES AND REQUIREMENTS

PRIZES IN THE FORM OF
3D PRINTERS PER DIVISION!

1ST Valued at $1,000
2ND Valued at $500
PLUS The winning teams from each division will be interviewed for regional or national article publication.

**All participants will receive a certificate of participation*

DATE OF COMPETITION - TBD | NEWARK, NEW JERSEY

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1. 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.

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.

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 capacity 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.

2. Participation and Eligibility

a. Team Requirements

For each institution, only one team of 3 to 5 members and one advisor may participate.

b. Registration

Please fill out the initial registration form to indicate your interest in participating as soon as possible. On December 13, 2024, the team information packet to officially register your team is due along with the $150 registration fee. For questions, please contact Maria Botei at davidgood3dbridge-group@njit.edu or call 973-596-2447.

3. Ethics and Required Conduct

This competition is to be conducted with the highest regard for ethical responsibility per 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 competitions. The inappropriate use of language, alcohol, or materials, uncooperativeness, and general unprofessional or unethical behavior will not be tolerated.

4. Safety

Safety is the highest priority and risk of personal injury will not be tolerated. Judges and 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 consider 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 tolerance issues. If any parts need to be filed or cut, participants need to ensure proper caution and use hand and eye protection. When testing 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 within 10 feet of 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 with 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.

5. Bridge Dimensions

The bridge must span a clear span of 20 inches (559 mm). The total bridge length must be less than or equal to 24 inches (610 mm) providing up to a 2-inch (51 mm) wide bearing surface on each abutment. Bridge shall be less than or equal to 8 inches (203 mm) from the extreme bottom surface to the extreme top surface, and less than or equal to 6 inches (152 mm) in width. The bridge superstructure must be less than or equal to 3.5 inches (89 mm) below and less than or equal to 6 inches (152 mm) above the pier bearing surface. The structure must not touch the pier on any surface other than the top bearing surface of the pier and have a 24^{o} relief angle from the superstructure to the pier. See Appendix A - Figure 1.

The cross section through the bridge must have a continuous open width greater than 3.5 inches and a continuous open height greater than 3.5 inches (89 mm x 89 mm) through the entire length of the superstructure to allow a test square of those dimensions to pass easily through without obstructions. See Appendix A - Figure 2.

The 3.5-inch clear width should be underlain by a continuous bridge deck for a vehicle driving surface. The deck must be 3D printed and can be made of multiple pieces but must provide a smooth continuous surface after construction. The deck must be absent of any voids or obstructions. The deck is considered as part of the bridge when determining the weight of the bridge. The deck, at a minimum, must span the clear span of 20 inches. See Appendix A - Figure 1

6. Bridge Parts

The following rules and deductions are applicable for the bridge parts.

a. All parts must be printed with 100% Plain PLA (Polylactic acid). No other fill material is allowed.
    i. Deduction: Disqualification
b. The maximum allowed bridge weight is 35.27 ounces (1,000 grams).
    i. Deduction: 15% deduction of the measured vertical load for every 2 ounces (50 grams) increment over 35.27 ounces (1,000 grams).
c. The design must include at least one complete circle feature with a minimum radius of 2-inches (5.08 cm). The loading saddle bolt on the load frame shall not pass through this circle feature.
    i. Deduction: 10% increase in measured weight

d. All parts together must fit in an 8.7 in. (220 mm) wide, 8.7 in. (220 mm) long, and 6.5 in. (165 mm) high box.
    i. Deduction: 10% increase in the measured deflection for each part that does not fit in the box.
e. Only mechanical connections are allowed. No adhesives are allowed.
    i. Deduction: Disqualification
f. No unextruded filament may be used in the bridge.
    i. Deduction: Disqualification

7. Bridge Loading

Bridges will be placed on the load platforms (bridge piers) and centered. Figure A, to the right, shows the load frame, including the platforms that will serve as the bridge piers. The loading saddle (aluminum piece in the middle of image to right) is hung over the center span of the bridge by a 5/8" bolt (see Figure B), and weights in 22 lb (10 kg) increments will be successively placed on the platform attached to the load saddle by a clevis rod. Only weights in 10kg denominations will be added. The total weight on the load frame when the bridge fails will be the record Vertical Load. Deflection will be measured by string potentiometers following each applied load, with a measurement at a load corresponding to 50 lb used to determine bridge stiffness. Loads will be applied until a maximum weight of 309 lb (140 kgs).

Figure B: Bridge loaded to failure

8. Tips

The following tips are provided for a successful bridge.

a. Pre-competition testing of parts and bridge is permitted to optimize bridge. Make sure that all parts you design can fit within the bed of the 3D printer you are using.
b. 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 the connections will help you calibrate connection fit with your printer/filament.
c. Check the fits of all components before the day of the competition.
d. 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.
e. Because there is a maximum load of 309 lbs., a team only wants as much material as required to support the maximum load. Building a bridge capable of carrying more than 309 lbs. is of no benefit.
f. Make sure that all parts you design can fit within the bed of the 3D printer you are using.
g. Ensure the length and width of your bridge match the specifications so that your bridge qualifies and can be tested.
h. Be sure to reinforce the area where the 5/8” bolt will rest on the centerline of the bridge deck during loading.

9. Scoring

Five weighted metrics will be added in aggregate to determine a team's overall score. The metrics and their weighted contribution are shown below in Table 1. In addition to overall 1st, 2nd, and 3rd place awards, the top two teams in each metric will be separately recognized for their superior performance in each metric.

Table 1: Overall Point Value Per Metric

Load/Weight Efficiency	Stiffness Efficiency	Construction Time	Presentation	Design
30	30	15	15	10

Adherence to the rules is crucial to ensuring fair competition. Teams will be subject to deductions determined by the judges for deviations from the rules as they relate to each metric. The Head Judge has final say over deductions.

Information on each metric is detailed in the following sections.

Presentation and Design scores will be determined by a direct scoring system based on the judgment of the judges. Team scores will be assigned as a percentage of a maximum metrics system. The first-place team will receive the full points (e.g., maximum 10 points for Design). The remaining teams will be allocated points based on a ratio of their Design score divided by the largest Design score. e.g., if four teams compete and have Design scores of 95, 85, 80, and 70 the high score will receive 10 points, the second team will receive 8.9 points [10 x (85/95)], the third team will receive 8.4 points [10 x (80/95)], and the fourth team will receive 7.8 points [10 x (70/95)]. The presentation score will be calculated similarly.

Load/Weight efficiency, Stiffness efficiency, and Construction Time will be based on the ratios defined below. Team scores will be assigned as a percentage of a maximum metrics system. The high score will receive the full points (e.g., maximum 30 points for Load/Weight efficiency). The remaining teams will be allocated points based on a ratio of their Load/Weight efficiency divided by the largest Load/Weight efficiency. e.g., if four teams compete and have Load/Weight efficiencies of 22, 17, 12, and 9, the first team will receive 30 points, the second team will receive 23.2 points [30 x (17/22)], the third team will receive 16.4 points [30 x 12/22)], and, and the fourth team will receive 12.3 points [30 x (9/22)]. The Stiffness efficiency and Construction Time scores will be calculated similarly.

a. Load/Weight Efficiency

i. Loading will be applied vertically at center span up to a maximum load of 308 lbs.
ii. The Load/Weight Efficiency will be calculated by dividing the load supported by the weight of the bridge e.g., Load/Weight.

iii. Maximum points will be awarded to the bridge with the highest Load/Weight efficiency.
iv. Other bridges will be awarded points based on the ratio of their efficiency to the maximum Load/Weight efficiency.

b. Stiffness Efficiency

i. Deflection will be measured at the center of the clear span on the bottom surface of the bridge. All bridges will be measured on both sides of the bridge. Deflection will be measured when the bridge is supporting a 50 lb. load. The bridge must carry 50 lbs.
i. The Stiffness Efficiency will be calculated by dividing the 50 lbs. load by the deflection in mm divided by the weight of the bridge. e.g., Load/Deflections/Weight.
ii. Maximum points will be awarded to the bridge with the highest stiffness efficiency.
iii. Other bridges will be awarded points based on the ratio of their efficiency to the maximum efficiency.

c. Construction Time

i. A team may have multiple constructors working together to construct the bridge.
ii. The construction time will be multiplied by the number of constructors to calculate the total construction time.
iii. A construction time limit of 15 minutes will be imposed. A team exceeding 15 minutes will receive a score of 22 minutes.
iv. Maximum points will be awarded to the team with the shortest total construction time.
v. Other teams will be awarded points based on the ratio of their total construction time to the shortest total construction time.
vi. If a team has finished constructing their bridge, but needs to go back to make corrections to any errors made in the construction process, they will be given a period to do so. The time allowed to make corrections cannot exceed 5 minutes. The total time spent to make corrections will be multiplied by 1.5 and added to the initial construction time to determine a team's total construction time
vii. After a team has finished constructing their bridge and made any corrections if necessary, no other changes can be made and the bridge must be handed off to the judges until it is loaded.

d. Presentation (Poster Board)

i. Each team will create 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. Each team will give a presentation on their poster board. All team members must participate in the presentation. Judges will rank the presentations based on:
    1. Readability of poster
    2. Aesthetics of poster
    3. Adherence to a 5-minute time limit. Presentations longer than 5 minutes will have 10 percent deducted from the score of each increment of 30 seconds over 5 minutes.
    4. Presentation mechanics (projection, pace, facing judges, flow, etc.).
iii. Maximum points will be awarded to the team with the highest presentation score.
iv. Other teams will be awarded points based on the ratio of their presentation score to the highest presentation score.

e. Design

i. The design theme for this competition is Accelerated Bridge Construction (ABC). Designs should reflect some aspect of the ABC mindset and keep ABC ideologies in mind throughout the design process.
ii. Include information about the design inspiration in the presentation.
iii. Judges will score bridges based on their correspondence to an inspiration the team chooses.
iv. Judges will also score bridges on the innovation in the design/printing techniques, print quality and resolution, and tolerances.
v. A 2-inch (5.08 cm) diameter circle must be incorporated into the design of the bridge.
vi. Maximum points will be awarded to the team with the highest Design score.
vii. Other teams will be awarded points based on the ratio of their Design score to the highest Design score.

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 (absolute value) to their predicted load will receive the Engineer of the Day award for 1st and 2nd places. (This award is not included in the overall score).

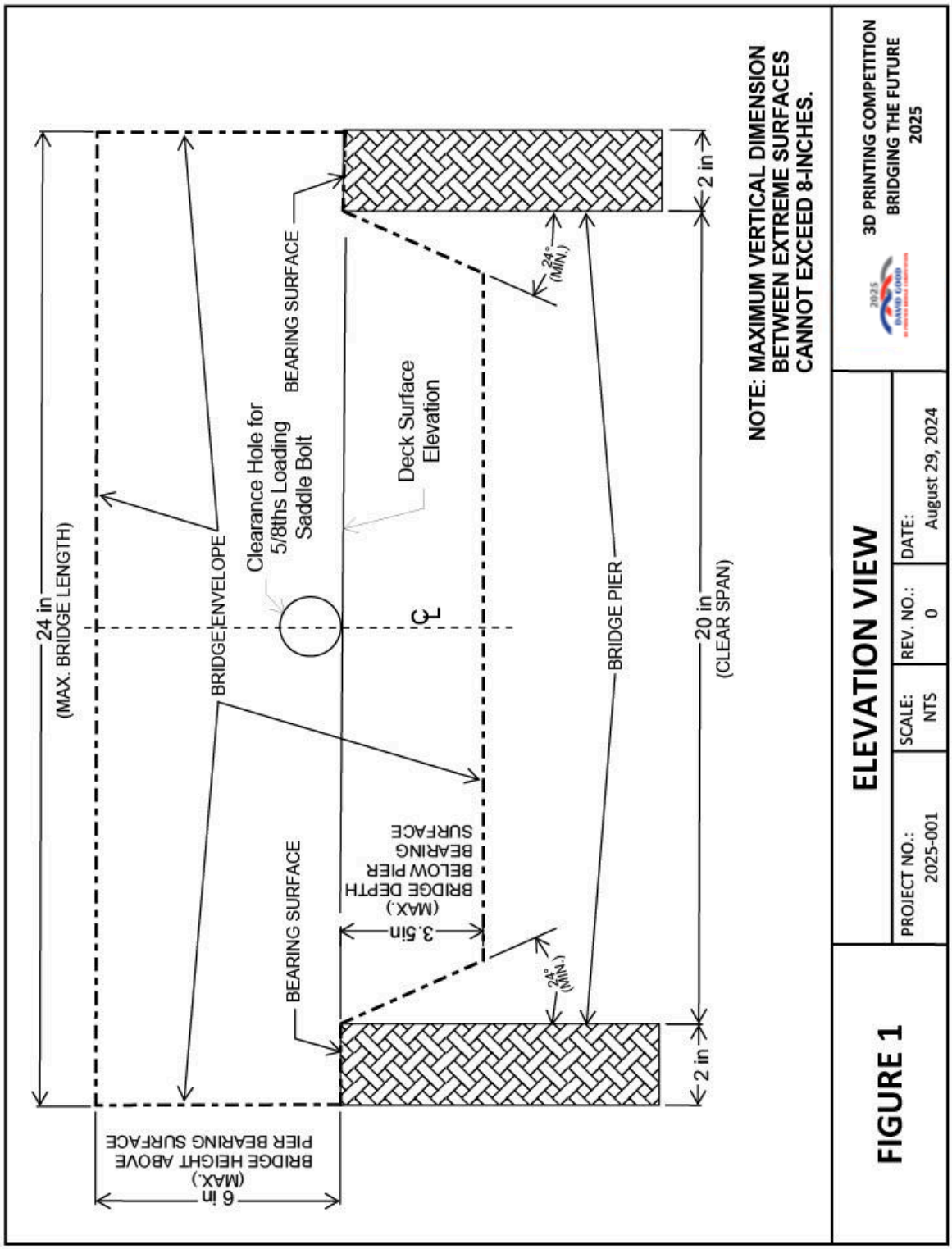
10. Key Dates

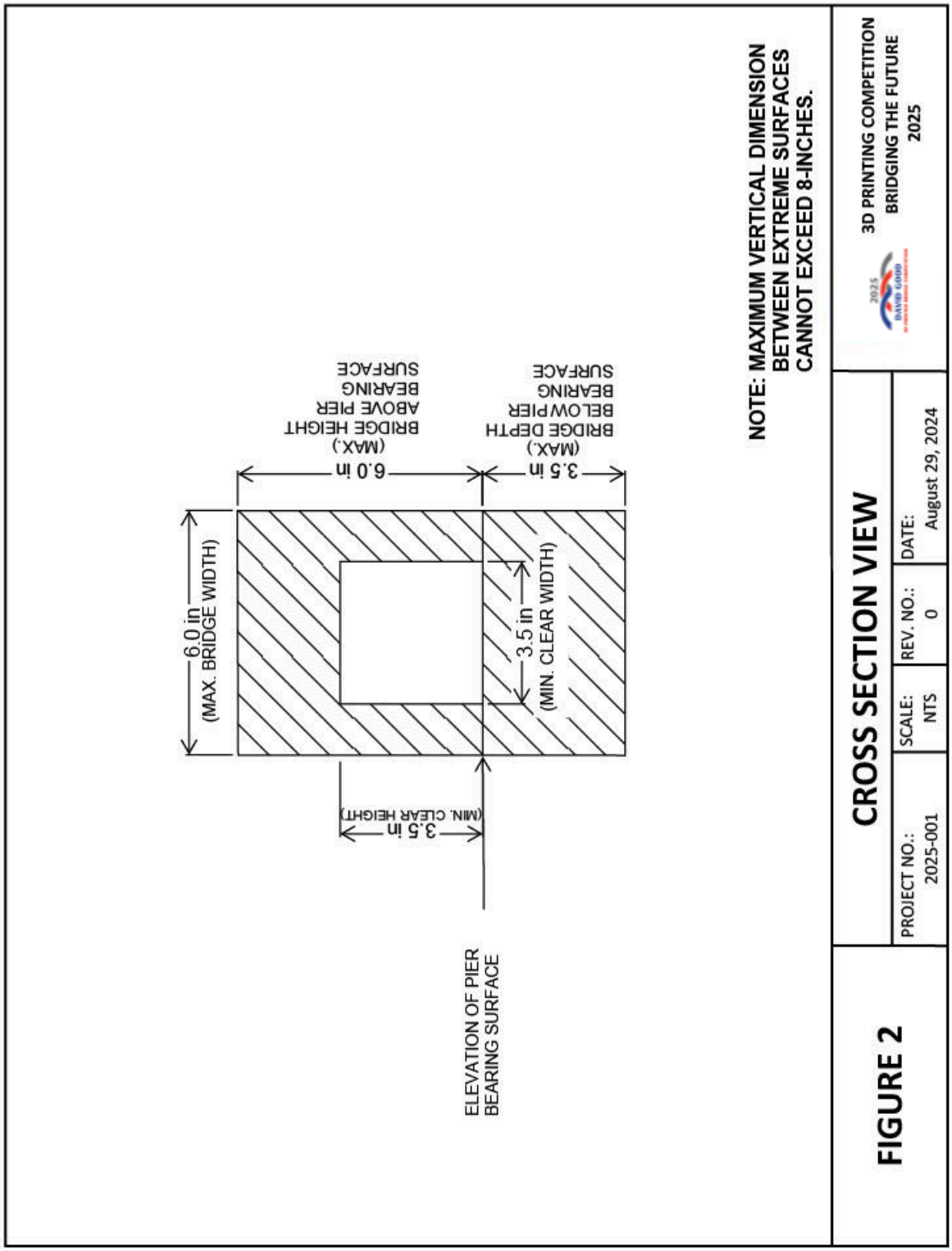
a. Town Hall/Interest Meeting (virtual) - Friday, November 15, 2024 at 12 p.m.
b. Town Hall/Interest Meeting (virtual) - Friday, December 13, 2024 at 12 p.m.
c. Deadline for Proposals - Friday, January 24, 2025 to davidgood3Dbridge-group@njit.edu
d. **Competition Date - Friday, March 21, 2025 | 8:00 AM - 3:00 PM | NJIT Campus Center**

11. Awards

a. Awards for 1st, 2nd and 3rd places will be awarded for the highest overall scores.
b. Awards for 1st and 2nd place will be awarded for the following metrics:
    i. Largest Load,
    ii. Stiffest Bridge,
    iii. Fastest Construction Time,
    iv. Best Presentation,
    v. Best Design, and
    vi. Most Accurate Ultimate Load Calculation

Appendix A - Figures and Drawings




NOTE: MAXIMUM VERTICAL DIMENSION
BETWEEN EXTREME SURFACES
CANNOT EXCEED 8-INCHES.
3D PRINTING COMPETITION
BRIDGING THE FUTURE
2025
CROSS SECTION VIEW
PROJECT NO.: 2025-001
SCALE: NTS
REV. NO.: 0
DATE: August 29, 2024
FIGURE 2
BRIDGE DEPTH BELOW PIER BEARING SURFACE (MAX.)
3.5 in
BRIDGE HEIGHT ABOVE PIER BEARING SURFACE (MAX.)
6.0 in
6.0 in (MAX. BRIDGE WIDTH)
3.5 in (MIN. CLEAR WIDTH)
3.5 in (MIN. CLEAR HEIGHT)
ELEVATION OF PIER BEARING SURFACE

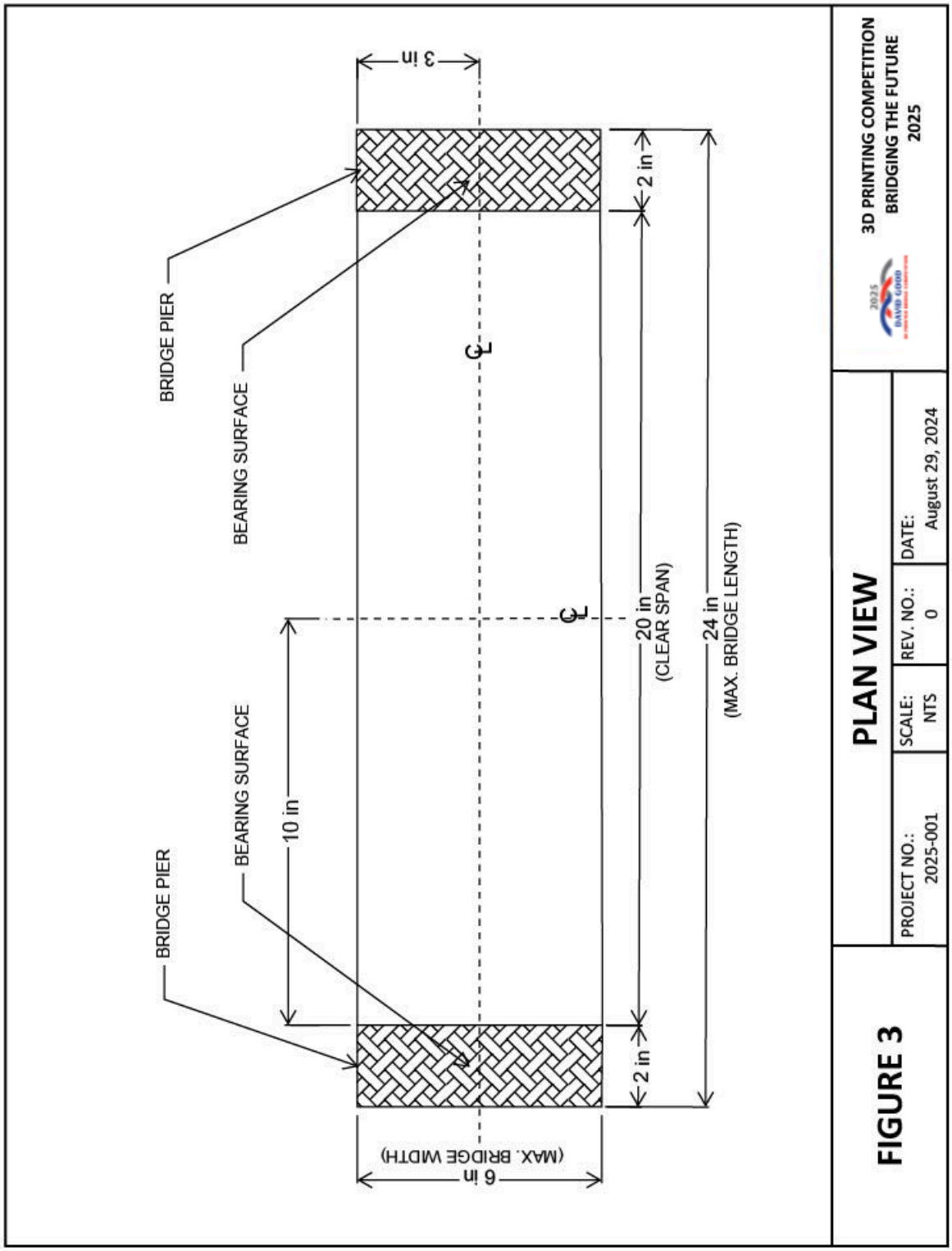

3 in
BRIDGE PIER
BEARING SURFACE
2 in
20 in
(CLEAR SPAN)
24 in
(MAX. BRIDGE LENGTH)
BEARING SURFACE
10 in
BRIDGE PIER
2 in
6 in
(MAX. BRIDGE WIDTH)
3D PRINTING COMPETITION
BRIDGING THE FUTURE
2025
PLAN VIEW
PROJECT NO.: 2025-001
SCALE: NTS
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FIGURE 3