

Delaware Bridge Design Competition
7th and 8th Grade Guidelines – Truss Bridge



Refer to the Bridge Design Competition Website for Important Dates

1. **Objective:** The objective of the Delaware Bridge Design Competition is to design and build a model **Truss Bridge** using balsa wood that will be tested for a strength-to-weight ratio. Student teams from across the state of Delaware will compete against one another, with grade levels ranging from 7th to 12th. Teams will be sorted into one of three brackets, based on their education level:
 - 7th & 8th
 - 9th & 10th
 - 11th & 12th

Students will compete against other teams from the same education bracket. Interested teams should fill out the application form provided on the DelDOT Bridge Design Competition website and submit it prior to the deadline. Prior to the in-person competition, teams are required to submit a proposal. The proposal will explain their design process and experiences leading up to the competition. On the day of the competition, teams will present a ten (10) minute PowerPoint presentation and structurally test their bridges against teams within their grade bracket throughout the state to determine the winning bridge. A Challenge Entry Kit will be provided to each team to begin their project. Only materials included in the kit supplied can be used in the construction of the bridge. The material kit will be delivered to each competing school by a DelDOT Bridge Design representative. The competition objectives are for students to:

- a) Design a **Balsa Wood Bridge** with an efficient strength-to-weight ratio to support the desired load. See Section 3 for details related to strength-to-weight ratio.
- b) Effectively communicate their analysis and design processes through a proposal. See Section 6 for proposal specifications.
- c) Give an oral presentation on the final design and answer questions from a panel of judges.
- d) Develop details representing their designed and built bridge. The recommended modeling and design software for the competition is Autodesk Fusion 360. Similar programs are acceptable as long as requirements outlined in Section 7 are fulfilled.

Each bridge design will be checked for consistency according to the specifications. The bridges will be weighed, and strength tested during the competition to calculate a strength-to-weight ratio. A weighted combination of the score for the proposal, presentation, and bridge testing will be used to determine a winner in each grade group. Rubrics for grading and weighted scoring information are included below. It is important to note, while this competition is a bridge building competition, there are multiple scoring components, outside of just bridge performance, that play into producing a winning product. A well-performing structure is only part of the scoring, and emphasis should be placed on each section of the competition.

2. **Eligibility:** Students eligible range from 7th – 12th grade and attend a school located in Delaware. The Delaware Bridge Design Competition is designed for teams of three (3) students to participate. While schools should strive to create teams of three (3) students, the Delaware Bridge Design Competition is an inclusive event and will accommodate teams of two (2) or four (4) as well. Teams of one (1) or larger than four (4) students will **not** be accepted.
3. **The Challenge:** An engineer’s job is to not only design a safe bridge to carry required loads, but also to make sure that it is cost effective (minimize materials needed to hold the desired load). To simulate this process, teams will use the following strength-to-weight ratio calculation to develop a bridge that carries a high load capacity relative to the bridge weight. Carrying a huge load may not be advantageous from a scoring standpoint if the bridge is excessively heavy. Strength-to-weight ratio is determined by dividing the maximum load carried by the weight of bridge.

Example: Assume a team constructs a bridge with the following characteristics

- Maximum load = 120 pounds (lb.)
- Unit conversion: 1 pound = 454 grams (g)
 $(120\text{lb.} \times 454\text{g/lb.}) = 54,480\text{g}$
- Bridge weight = 20g
- Strength-to-weight ratio = $45,480\text{g} / 20\text{g} = 2274:1$

4. **Materials:** Provided in kit
 - a) Balsa Wood
 - b) Ruler
 - c) Long Pins
 - d) Drafting Paper
 - e) S-Hook
 - f) U-Bolt Bracket
 - g) Wax Paper
 - h) Super Glue
 - i) Painter’s Bucket
 - j) Measuring Cup
 - k) Timber Cutter
 - l) X-Acto Knife
5. **Bridge Specifications:** Students will design and build a model bridge based on the following specifications.
 - a) The materials provided in the kit are the **ONLY** materials to be used when building the bridge structure.

- b) The instrument used for testing will be the Pitsco Structures Testing instrument as seen in Figure 1 below.

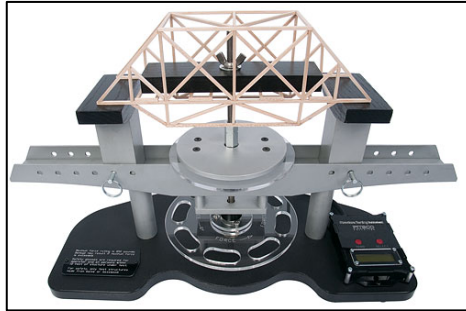


Figure 1. Pitsco Tester
(Not representative of the bridge type)

- c) Lamination shall be permitted one layer thick, in either direction, as shown in the picture below. Lamination is gluing two members along their length. See Figures 2 & 3 for more details.

Acceptable:

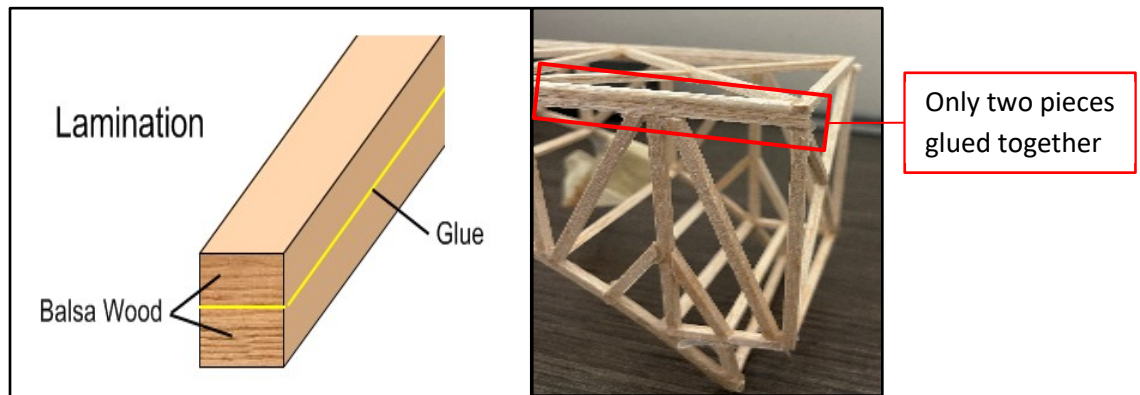


Figure 2. Acceptable Lamination

Not Acceptable:

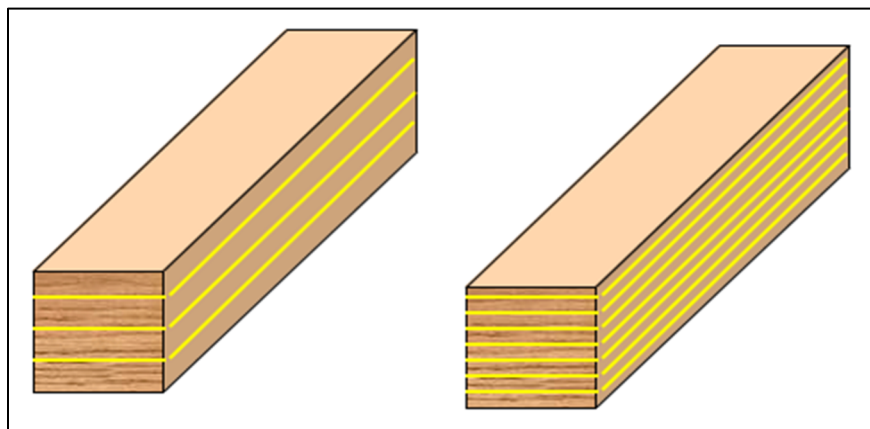


Figure 3. Unacceptable Lamination

- d) Connections can be butt joints, miter joints, or notched joints. Lap splices are permitted, but no greater than 1/4 of an inch thick. Each piece of balsa wood is 1/8 of an inch thick; so, this means no more than 2 pieces of balsa wood may be used to create a lap splice. See Figures 4 & 5 below and Section 5(k) for more details.

Acceptable:

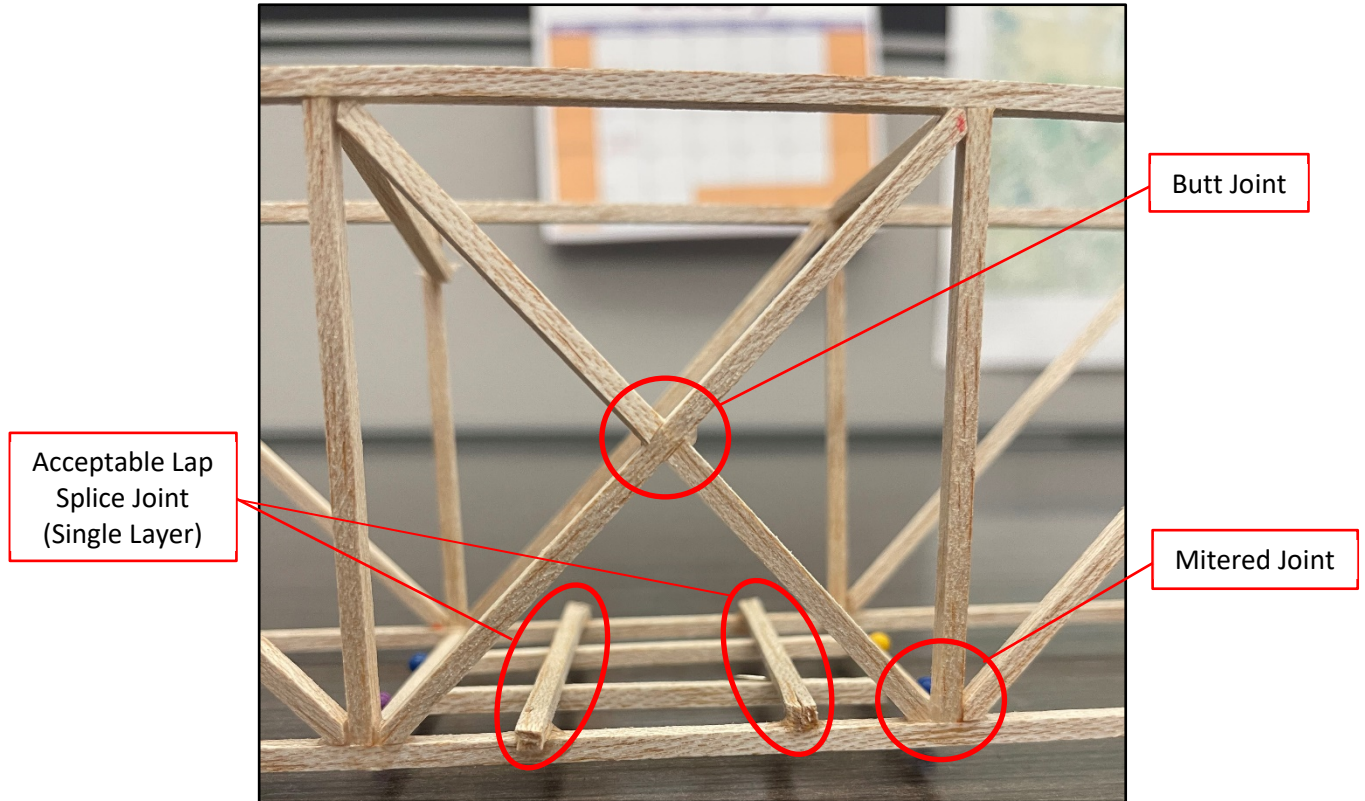
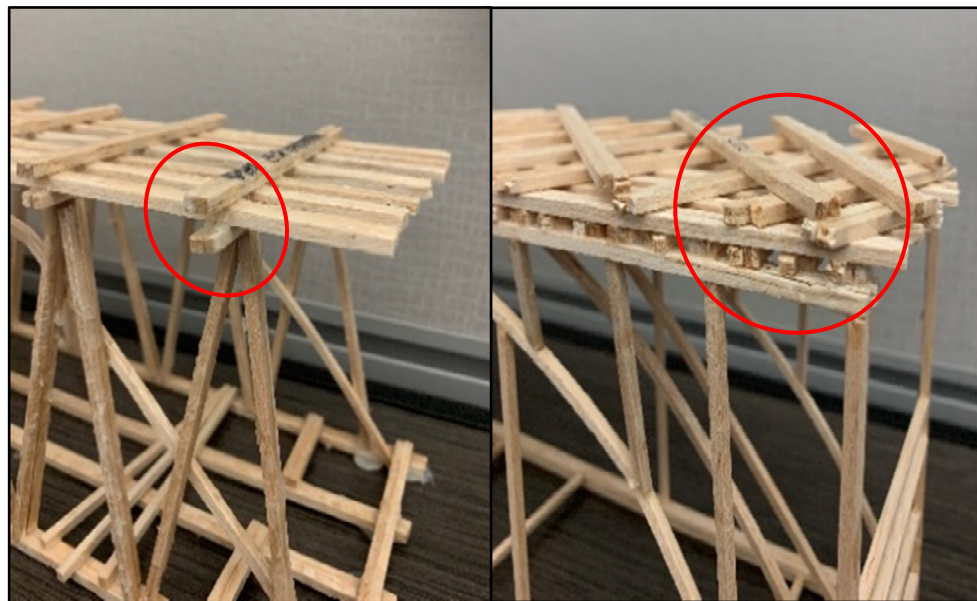


Figure 4. Acceptable Joints

Not Acceptable:



- e) End to end, the length of the entire bridge must be 14 inches, refer to Figure 6.

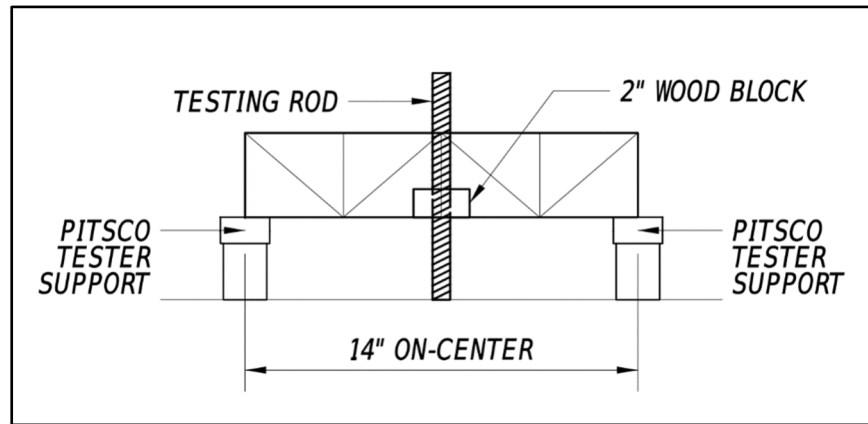


Figure 6. Tester Configuration Detail

- f) Maximum width of the bridge shall be no more than 4.5 inches to fit on Pitsco Tester, refer to Figure 7.

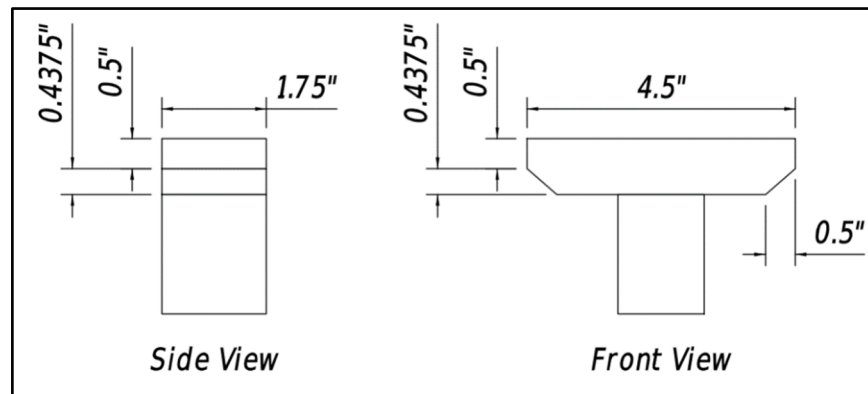


Figure 7. Support Detail

- g) The area where the bridge will be loaded (center of the bridge) must have at least a $\frac{3}{4}$ -inch hole to allow a $\frac{5}{8}$ -inch testing rod to pass through. The rod must also be able to pass through full height of the structure to insert the rod into the tester. This is required to attach the rod to a 2-inch x 2-inch x 1-inch block of wood used for strength testing by the Pitsco Tester. An example configuration can be seen in Figure 6. The block of wood must be able to pass through the loading surface of the bridge (a bridge deck of any kind is not allowed), refer to Figure 8. No more than 2 longitudinal members will be permitted in the top of the bridge structure, refer to figures 9 & 10 for more detail. Please note, diagrams do not represent the required design and shall only be used for reference.

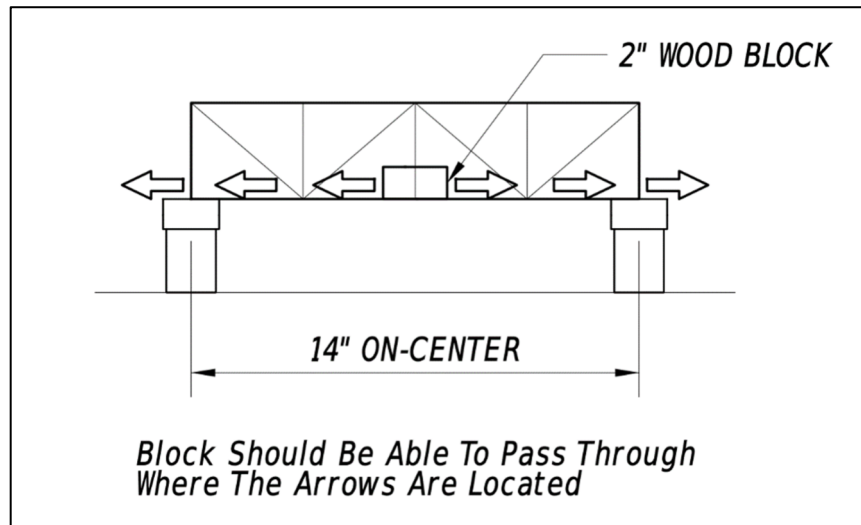


Figure 8. Block Requirement

Acceptable:

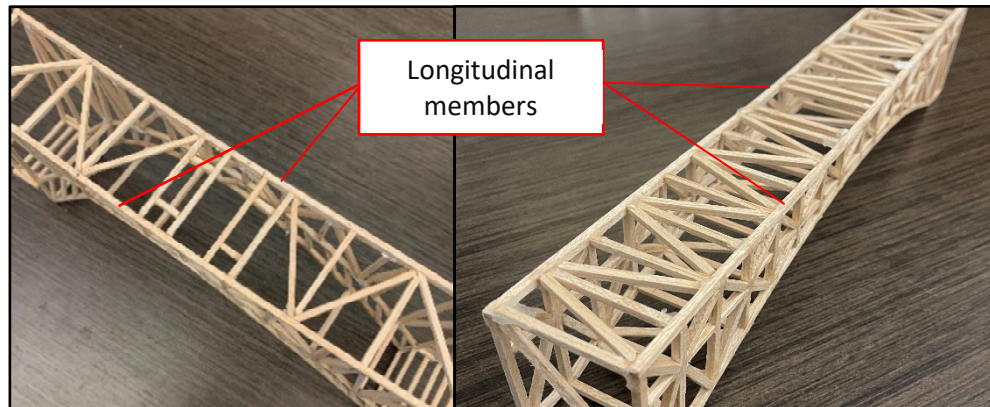


Figure 9. Acceptable Cross Framing

Not Acceptable:

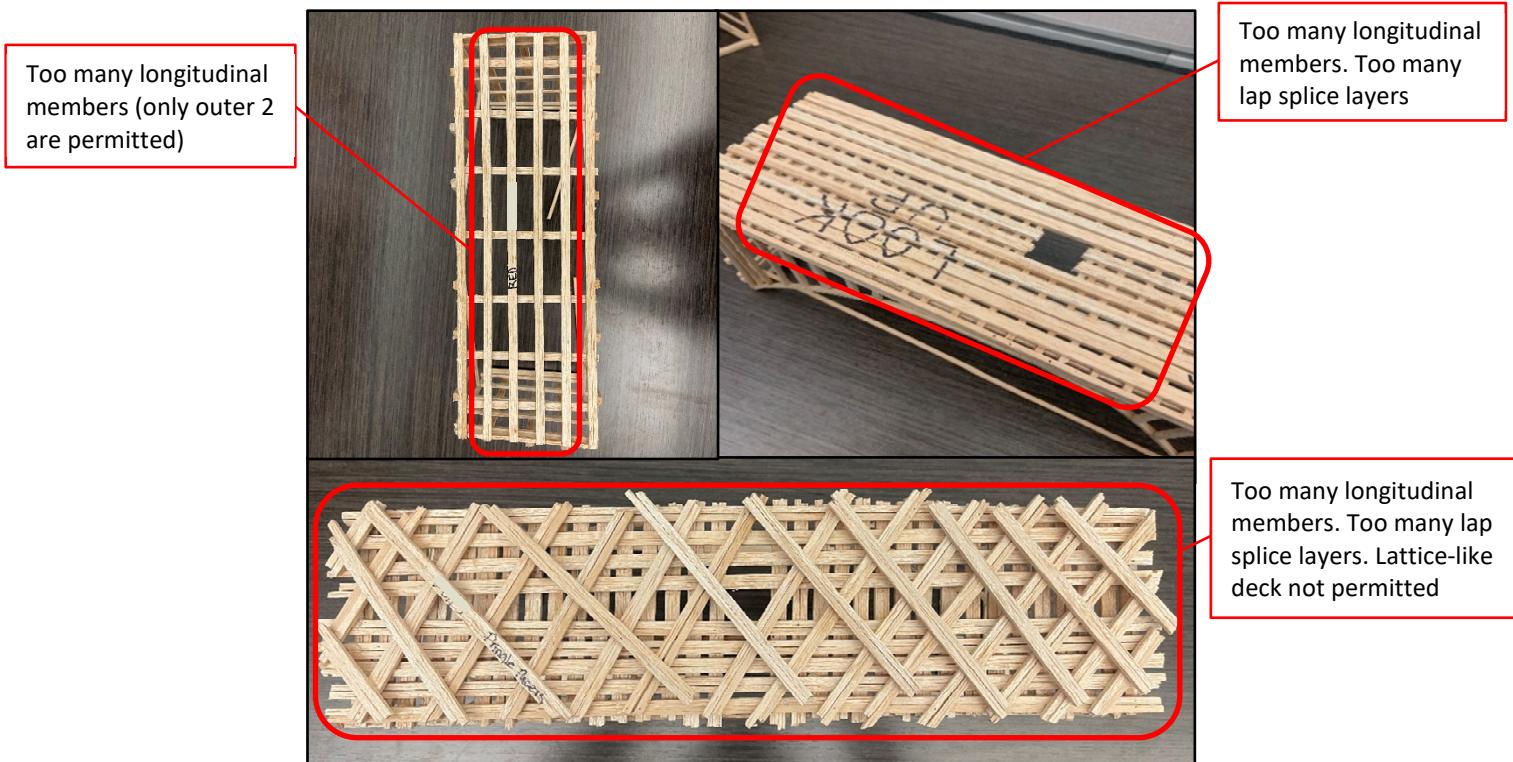


Figure 10. Unacceptable Cross Framing/Deck System

- h) Tester supports will be placed at 14 inches on center. Support dimensions are shown above in Figure 6.
- i) In real world applications, bridges should not be permitted to deflect more than a tolerated amount, even if the structure itself does not fail. This concept will be applied to each team's model bridge. The tolerated deflection during testing for each model bridge is the limit of the Pitsco Tester. If the maximum deflection is reached before bridge failure the resulting load will be measured and used to calculate the strength-to-weight ratio.
- j) The following will result in a bridge receiving a strength-to-weight ratio of zero (0). PLEASE NOTE, if you have questions or concerns of violating any of these please contact us.
 - I. Modification to the structural properties of the balsa wood (soaking wood pieces to allow for bending does not count as modifying the structural properties of the balsa wood).
 - II. Using any material (including glue) other than provided.
 - III. Laminations greater than two (2) layers in any direction (see photos above).
 - IV. Structures having a deck (see photos above). The bridge is designed to function as a truss bridge. If the deck is carrying a majority of the load without distributing it to the rest of the members, it will be disqualified.
 - V. Creating a lap splice greater than $\frac{1}{4}$ " thick (see photos above). Stacking more than 2 members on top of one another will violate this criteria.
 - VI. Deviation from the specifications outlined above.

BRIDGE PERFORMANCE (45% of the total score) – Achievement of performance goals and stability of construction. Bridges will be weighed and then tested on the Pitsco Tester. Results will be used to calculate a strength-to-weight ratio. Any bridge not meeting the specifications will result in a disqualification in the performance section and a score of zero (0) points. **Please securely label your bridge with your team’s name. For judging purposes, we may not be able to award points for the performance if we cannot identify your team’s bridge.** Bridge performance will be given a maximum of 100 points:

Scores on the strength-to-weight ratio will be based on the following equation:

$(\text{Ratio}_i / \text{Ratio}_{\text{Highest}}) * (100 \text{ points})$

- Ratio_i = The strength-to-weight ratio of the team being judged
- $\text{Ratio}_{\text{Highest}}$ = The highest strength-to-weight ratio recorded amongst all teams

Example:

Team 1 – Strength-to-Weight Ratio = 3000; $(3000 / 3000) * (100) = 100$ Points

Team 2 – Strength-to-Weight Ratio = 2000; $(2000 / 3000) * (100) = 66.67$ Points

Team 3 – Strength-to-Weight Ratio = 1000; $(1000 / 3000) * (100) = 33.33$ Points

6. **Proposal Specifications:** The information below gives a more in-depth explanation of the **Proposal Scoring** sheet provided below. The **Proposal Scoring** sheet is what the judges will use when reviewing and determining eligible points for the competition. Please note, the criteria as outlined below are **minimums** and credit will be assigned based on merit.

- a) **Proposal Format:** The written proposal should be typed, double-spaced using size 12 Times New Roman font on 8.5 x 11 paper with all pages numbered, and 1 inch margins all around. Sections **must** be in order of the outline below. Additional points are given for the following: style and presentation (sheet border, headers and/or footers, section titles, etc.), mechanics (spelling, grammar, formatting, etc.), and visuals (colors, clarity of provided graphics, photos, charts, etc.).
 - I. **Title Page** – Include name of competition, type of bridge, team name, team logo (each team must have a unique logo), name of the school or organization, names of students, name of teacher or advisor.
 - II. **Table of Contents**
 - III. **Summary of Proposal** – Clearly and concisely stated. (At least one (1) page, no more than two (2) pages).
 - IV. **Introduction to Team** – Indicate the team’s name, team members as well as the background of each member (At least one (1) paragraph per member).
 - V. **Body** – The main part of the report.
 - i. Sections in order and labeled.
 - ii. Explanation of the scientific principles associated with the design process and bridge engineering. This section is a researched based discussion of your investigation into bridge engineering and how it applies to the competition. This could include a discussion of the importance of material properties, physics of loads/load paths, structural behavior

- based on geometry etc. (At least three (3) paragraphs/principles included)
- iii. Describe the design and engineering challenges you encountered. This section is an application-based discussion of how your findings above apply to your physical bridge. It also includes an outline of the design decisions you made and why. This is **NOT** related to construction or building challenges. This could include which members are laminated and why you decide to laminate them, where and why you included cross braces, how you decided to support the testing block, etc. (At least three (3) paragraphs/challenges included)
 - iv. Include at least five (5) screenshots of modeling software used. Screenshots can be of details in development, final details, model etc.
 - v. Include graphs, charts, and/or calculations representing bridge design, testing, and supporting work. This section could include strength-to-weight ratios from your testing, comparison of preliminary structures and selected final design, comparison of data/loading in modeling software to performance of actual structure built etc. (At least two (2) charts, graphs, and/or calculations)
 - vi. Include at least five (5) pictures. Pictures will include at least one of each of the following: team working during bridge design, team working during construction, fully constructed bridge. Screenshots of software **DO NOT** count as pictures.
 - vii. Explain how you tested your design, and the improvements this led you to make. To develop a competitive bridge, it is recommended to run tests in the West Point Bridge Designer, a modeling program, and also build prototypes, or test structures. Once built, you should load them to failure and see where/how they failed and how to improve your design. This should be an iterative process between software and construction until you develop your final structure. This section is an explanation of how you tested your structure and how you determined which changes to make. (At least three (3) paragraphs discussing at least three (3) testing methods and/or improvements)
 - viii. Describe the construction challenges that you encountered in building your bridge and how you solved these problems. This section is a discussion of the challenges and limitations you encountered in building your bridge(s). This could include timing limitations, material difficulties, bracing members, etc. (At least three (3) challenges included)
- VI. **Conclusions** – Include recommendations about construction and design changes you would consider for future bridges. Summarize the overall success of the project through design and construction. Discuss what the team learned throughout the project.

- VII. **Acknowledgments** – List the names of the adults who assisted you in the project with a brief description of what they did. Include a certification, signed by all student team members and adults assisting, stating that:

“We hereby certify that the majority of the ideas, design, and work was originated and performed by the students, with limited assistance by adults, as described above.”

- VIII. **Bibliography** – List all references used, using MLA formatting. Consideration should be given to any research collected on scientific and engineering principles, bridge building guidance, software tutorials, etc.

IX. **Appendices**

- i. **Daily Journal and Schedule:** Include progress reports of day-to-day work on project, including date, performance, and comments from each team member. Journals should be kept for the duration of the project including notes any time the team meets, or work is completed. Show on a timeline, or similar method, how you scheduled your project. Include brief records of meetings, telling how you managed the schedule. The schedule should be used to outline the overall progression of your participation in the competition up to the submission of the proposal.

- b) **Timeliness:** Proposals received after the deadline will not be accepted.

PROPOSAL (35% of the total score) – Proposal reports will be evaluated on the information outlined above and on the **Proposal Scoring** sheet. Reports should be well thought out and provide substantial information on the design process. See included **Proposal Scoring** rubric for scoring assessment. This is a helpful guide to follow while formulating the proposal. Please note, the criteria as outlined are **minimums** and credit will be assigned based on merit.

Each team is required to submit an electronic copy of their proposal to Nicholas Dean, Project Engineer for the Delaware Department of Transportation. Paper copies may be submitted if needed, please contact Nicholas well in advance of the deadline to coordinate delivery. All entries become the property of the Delaware Department of Transportation and will not be returned. Bridges will **NOT** be submitted prior to the competition. Bridges will be brought to the competition by the team the day of the competition.

7. **Oral Presentation:** Teams attending the DelDOT Bridge Design Competition will present to a panel of judges comprised of various engineers. Each team is expected to make a PowerPoint presentation and be able to answer questions from the panel of judges about their proposal, and constructed bridge. Supporting materials may be presented to the judges.

ORAL PRESENTATION (20% of the total score) – Teams will have a total of fifteen (15) minutes for a presentation to the panel, including a question-and-answer period. The team should prepare an eight (8) – ten (10) minute PowerPoint presentation. A deduction will be assessed if under eight (8) minutes or over ten (10) minutes. A five (5) minute questionnaire session will follow the presentation, where judges will ask questions pertaining to each team’s project. Please note if a

team is under the allotted presentation time, more time will be given to the judge panel for questions as they are NOT held to a five (5) minute limit, if more time remains in the fifteen (15) minutes. The presentation should include an introduction to the team as well as an overview of key elements from your proposal. To develop a competitive proposal, it is recommended to discuss items including engineering principles, design challenges, discussion of iterations between software and trial bridges, testing procedures and results, etc. See included **Oral PowerPoint Presentation Scoring** rubric for scoring assessment. This is a helpful guide to follow while formulating the presentation. Please note, the criteria as outlined are **minimums** and credit will be assigned based on merit.

PREPARING FOR COMPETITION

Form a team of interested students or friends. Discuss the challenges and design specifications. Recommend limiting team sizes to only three (3) students to develop a competitive package and to share the effort. Please note teams of two (2) to four (4) are permitted to enter. Each team must have at least one teacher or other adult to help and advise, though a single adult may be advisor to more than one team. Teams are eligible for mentorship from an industry professional. These **DO NOT** replace an advisor but will help lend more engineering and competition specific guidance.

Study the rules. The individual challenge documents and the grading criteria give important information, which must be followed if your team is to achieve the best results. Failure to adhere to the rules and specifications will result in decreased scores and could lead to penalties, or even disqualification. If any of the information is not clear, please contact for additional help.

Plan the timing of the project. Ensure that everyone in the team knows the important dates for submission of the written proposal and date of the competition. Also ensure everyone recognizes that this means that all major development work should be finished before these dates and participation is essential in the team doing well.

Keep journals and records of meetings carefully. It helps to share tasks and give members of the team responsibility for different sections of the final report with reviews being completed by another team member.

Notes to Adults: It is extremely important that **the work on all phases of the project is to be done by the students.** Adult assistance is to be limited to:

- Mentoring
- Basic guidance of the students
- Teaching engineering, mathematical and scientific principles applicable to the project
- Guiding students in research
- Assisting in the production of the report
- Overseeing the manufacturing stages of the project

Guidance should be in the form of asking questions, (leading questions if necessary) to promote creative thinking by the students to identify the scientific and engineering principles involved. **Encourage students to consult credible web sites and other resources** to help with the project. **Encourage students to test and improve their designs.** A good way to begin is for each student to design and/or construct a rough prototype. Test it and make improvements.

Proposal Scoring
Delaware Bridge Design Competition

Proposal Format

- | | | |
|---|------------|-----------------------|
| <input type="checkbox"/> Typed | (1 point) | |
| <input type="checkbox"/> Double Spaced | (1 point) | |
| <input type="checkbox"/> 12 Point Font (Times New Roman) | (1 point) | |
| <input type="checkbox"/> All pages on 8.5 x 11 paper | (1 point) | |
| <input type="checkbox"/> Information is in the proper order | (1 point) | |
| <input type="checkbox"/> All pages are numbered | (1 point) | |
| <input type="checkbox"/> Presentation (formatting and styling) | (3 points) | |
| <input type="checkbox"/> Mechanics (spelling, grammar, etc.) | (3 points) | |
| <input type="checkbox"/> Visuals (clarity and use of visual aids) | (3 points) | Score_____/ 15 points |

Proposal Presentation

- | | | |
|--|-------------|-----------------------|
| <input type="checkbox"/> Title page | (1 point) | |
| <input type="checkbox"/> Table of Contents | (1 point) | |
| <input type="checkbox"/> Summary (1-2 pages) | (5 points) | |
| <input type="checkbox"/> Introduction | (1 points) | |
| <input type="checkbox"/> Body | | |
| <input type="checkbox"/> Sections identified | (1 points) | |
| <input type="checkbox"/> Scientific principles of the design | (10 points) | |
| <input type="checkbox"/> Design and engineering challenges | (10 points) | |
| <input type="checkbox"/> Modeling/CAD software screenshots | (5 points) | |
| <input type="checkbox"/> Graphs and Calculations | (5 points) | |
| <input type="checkbox"/> Photographs | (5 points) | |
| <input type="checkbox"/> Testing and improvements | (5 points) | |
| <input type="checkbox"/> Solving construction challenges | (5 points) | |
| <input type="checkbox"/> Conclusion | | |
| <input type="checkbox"/> Recommendations | (2 points) | |
| <input type="checkbox"/> Success of the project | (2 points) | |
| <input type="checkbox"/> Lessons learned | (2 points) | |
| <input type="checkbox"/> Acknowledgements | | |
| <input type="checkbox"/> Adults involved | (1 points) | |
| <input type="checkbox"/> Description of what the adults did | (1 points) | |
| <input type="checkbox"/> Certification and signatures | (2 points) | |
| <input type="checkbox"/> Bibliography | (1 points) | |
| <input type="checkbox"/> Appendices | | |
| <input type="checkbox"/> Daily Journals and scheduling
(must be legible, typed recommend) | (20 points) | Score_____/ 85 points |

TOTAL SCORE: __/100 Points

Oral PowerPoint Presentation Scoring

Teams will present to a panel of judges comprised of engineers from DelDOT and consultants. Each team is expected to make a PowerPoint presentation and be able to answer questions from the panel of judges at the conclusion of their presentation. Each presentation should be a minimum of eight (8) and a maximum of ten (10) minutes with an additional five (5) minutes allotted for question at the end. A deduction will be assessed for presentations not meeting the 8-10 minute requirement. A rubric scoring rubric has been provided for the presentation as a guide to assist in preparation.

Scoring:

Each category will be judged on a scale from 0 to 20 points.

CATEGORY	20	15	10	5	0	Sub-Score
Content	Covers topic in-depth with details and examples. Subject knowledge is excellent	Includes essential knowledge about the topic. Subject knowledge appears to be good.	Includes essential information about the topic but there are 1-2 factual errors	Content is minimal or there are several factual errors	Did not fulfill requirements	_____/20
Mechanics	No misspellings or grammatical errors	Three or fewer misspellings and/or mechanical errors	Four misspellings and/or grammatical errors	More than 4 errors in spelling or grammar	Did not fulfill requirements	_____/20
Organization	Content is well organized with related material grouped together	Content is logically organized for the most part	Overall organization is flawed	There was little clear or logical organizational structure	Did not fulfill requirements	_____/20
Presentation	Interesting, well-rehearsed with smooth delivery that holds audience attention	Relatively interesting, rehearsed with a fairly smooth delivery that usually holds audience attention	Delivery not smooth, but able to hold audience attention most of the time	Delivery not smooth and audience attention lost	Did not fulfill requirements	_____/20
Attractiveness	Makes excellent use of font, color, graphics, effects, etc. to enhance the presentation	Makes good use of font, color, graphics, effects, etc. to enhance to presentation	Makes use of font, color, graphics, effects, etc. but occasionally these detract from the presentation content	Use of font, color, graphics, effects etc. but these often distract from the presentation content	Did not fulfill requirements	_____/20
Total Sub-Score						_____/100
Over 10 Minutes: (-2 pts per minute)						_____
TOTAL SCORE						_____

Delaware Bridge Design Competition Suggestions and Helpful Hints

1. Students should be prepared for questions at the end of the presentation. These questions may be concentrated in the following topics. However, note that the judges are free to ask any question about any topic. Therefore, each team should be prepared.
 - a) Choice of design
 - b) Safety considerations in balsa and real-world bridge building
 - c) Impacts and importance of bridges
 - d) Lessons learned by participating in competition
 - e) Civil engineering careers related to bridges
2. Stay organized and keep track of time limits.
3. If you have a question, don't be afraid to ask. Please contact:
 - a) Nicholas Dean at Nicholas.Dean@delaware.gov
 - b) Please CC the following individuals:
 - Marie Burns at Marie.Burns@delaware.gov
 - Paul Huhn at Paul.Huhn@delaware.gov
 - Marc "Gus" Toussaint at Marc.Toussaint@delaware.gov
 - Sean Weaver at Sean.Weaver@delaware.gov
4. Contact your mentors. They will answer many of your questions.
5. Check out other bridges in your area or around the world.
6. Make sure to research topics and concepts.