2020 SPECIFICATIONS
The Timber Bridge - Revision 1

APT Preservation Engineering
Student Design-Build Competition

Over the past 200 years of North American history, timber bridges have been used as quick, cost effective, and practical solutions to provide river crossings. While varying greatly in their design, many of these bridges remain in use. In order to understand how they work and how they can be preserved, an understanding of how they were originally built is critical.
What you will find in this package:

This is intended to get you thinking about the competition. In this document you will find background information, an overview of the different phases of the competition, and the specifications and competition requirements.

Take a look and see if you and your team are inspired to enter!

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2020

The Timber Bridge

APT Preservation Engineering
Student Design-Build Competition

1 Introduction

The 2020 Association for Preservation Technology (APT) Preservation Engineering Technical Committee (PETC) Student Design Build Competition will focus on historic timber bridges.

For this competition, teams will design and analyze a timber bridge similar to one that would have been constructed between 1840 and 1890. A scaled model of the bridge will be constructed and load tested at the national APT Conference in Edmonton. Evaluation criteria will include stability, strength, and serviceability.

The 1840s marked a turning point for timber bridge development. Until this time, most timber bridges, including those of Wernwag, Burr, Town, and Long, were built almost totally from wood. Iron components, when used, were limited to small fasteners or other hardware that could be forged by blacksmiths. Starting in the 1830s, rapid railroad expansion provided great motivation for bridge development, and cast iron bridges were introduced. Although wood continued to be used as a primary bridge material, iron became a structural component for timber bridges, and the so-called combination bridges were born. Until 1840, the development of timber bridges was empirical. The concepts of earlier designs were often used as a basis for developing newer bridge types.

Although pioneer builders may have considered the use of mathematical rules when determining structural elements for their bridges, no substantiating records of this exist.

2016 – San Antonio
The foundation year of the APT Preservation Engineering Student Design Build Competition took place in 2016 with the Timber Bridge. Two schools competed in the finals. This successful test year provided the foundation from which further competitions have grown.

2017 - Ottawa
The second year of the competition featured the Masonry Arch.

2018 - Buffalo
The Timber Bridge. Five schools competed in the finals in Buffalo.

2019 - Miami
The Masonry Arch.

2020 - Edmonton
The 2020 competition in Edmonton will feature the third iteration of the Timber Bridge.
After the Long trusses, no significant timber bridge developments occurred until William Howe of Massachusetts patented his bridge in 1840. Howe's patent was also the first to include a complete stress analysis of the design by mathematical practices then in use. In 1844, shortly after the Howe truss became popular, Thomas W. Pratt and Caleb Pratt patented their truss design.

In the last decade of the 19th century, steel took the place of iron and timber as the predominant bridge material. Although timber continued to be used for bridges, its use began to decline as alternate materials were introduced and selected for durability and economic factors. Until about 1890, timber lattice bridges could be built with lumber for one-half the cost of iron bridges. Twenty years later (1910), steel bridges could be built as economically as those of wood.

The competition looks to challenge students from a range of backgrounds in friendly competition while providing the best “take-away” experience possible.

1.1 Competition Objectives
The key objectives of this competition are as follows:

Objective 1. Get students thinking outside the box and dealing with unique challenges.
Objective 2. Promote interaction between students and APT members though mentoring before and networking during the 2020 APT Conference.
Objective 3. Expose students to the fundamentals of analyzing an historic timber bridge.
Objective 4. Expose students to the materials common in timber preservation, providing hands on experience.

1.2 Desired Learning Outcomes
Several learning outcomes underline what the student teams should take away from this competition:

Learning Outcome 1. Value of multi-disciplinary teams
Learning Outcome 2. Management of a team with competing and varied tasks
Learning Outcome 3. Creation of internal support networks
Learning Outcome 4. Engagement of external professional community for support
Learning Outcome 5. An understanding of the basics of design and construction with wood and associated fastening systems
Learning Outcome 6. An understanding of historic timber and bridge design, including construction techniques and preservation issues associated with the materials
Learning Outcome 7. The ability to transfer paper design to real physical structure
Learning Outcome 8. An opportunity to partake in APT Conference paper sessions and other conference activities.

1.3 Competition Framework
The competition is structured with three main phases. In Phases 1 & 2, teams will work at their home campuses on identification, analysis, and design-build components. Phase 3 will culminate with the finals at the 2020 APT Conference in Edmonton, Alberta, including an on-site build, test, and associated preservation challenge. The finals will be structured to maximize exposure to the APT community, engaging the students with the conference attendees as much as possible, including physical building and testing of the bridges.
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2 Competition Overview

2.1 Phase 1 – Bridge Selection

Teams are to select a timber bridge design similar to those designed between 1840 and 1890 and submit their proposed bridge for review by the APT PETC competition task force in conjunction with their Notice of Participation. The selected bridge design can be a review of an existing bridge found locally, one found through historic research, or an original design developed by the team. The design is to use historic construction methods that would have been used between 1840 and 1890. There will be two submissions for this first phase: The Notice of Participation memo and the Bridge Selection and Structural Description narrative.

The Notice of Participation shall be a single sheet submission which will provide the following information:

- **Name of Institution wishing to Participate in the Competition**
  
  **Note:** If multiple teams from a single institution are submitting proposals, please provide an individual identifier (for example, specific campus location, name of arch, Team Captain’s Surname, etc.) so as to distinguish them from other teams within the same institution. Team names that give no reference to the project will not be accepted as identifiers.

- **Name and contact information (emails and phone numbers) of each team member**

- **Identification of Team Captain (All correspondence with APT-PETC will be through the team captain)**

- **Identification and contact information (email and phone number) of Faculty Advisor (See Section 4.3 for additional information on Faculty Advisor.)**

The Bridge Selection and Structural Description is to be a narrative report with a minimum length of 50 words and a maximum length of 1 page (double-spaced). It is to include the following:

- A structural description of the bridge, including the time period from which the bridge design is based
- What codes or historic literature will be used to guide the bridge design
- What loading will be assumed for the bridge design
- What building materials will be used for the bridge design (for this Phase, list materials to be used in a theoretical full scale construction of the bridge, not materials for use building the scale model at the competition)

Teams are to notify the APT-PETC Task Force by **February 7, 2020**, if anything is unclear in the information provided to prepare their Phase 1 documents.

**FINAL DATE FOR PHASE 1 TEAM SUBMISSIONS: FEBRUARY 17, 2020**

Teams are to notify the APT-PETC Task Force if they have not received notification on receipt of Phase 1 documents by the committee **within one week** of submission to ensure transmittal of information was successful.
Once submitted, the PETC Competition Task Force will provide feedback and/or approval of the submitted bridge prior to proceeding to the next steps. Feedback and approval will be given as needed within the weeks following Phase 1 submission. Teams should prepare to respond promptly to Task Force questions that may arise at that time in order revise and resend Phase 1 documents (if need be) in a timely fashion. Notice to proceed to Phase 2 will be given to each team as soon as possible, but no later than February 28, 2020.

2.2 Phase 2 – In-House Research & Design

2.2.1 Part 1: Design and Analysis of an Historic Bridge
Teams are to assess the durability of their selected bridge by designing and analyzing it in a similar fashion to timber bridges designed between 1840 and 1890. Design and analysis are to be presented in report form; full details and requirements are outlined in the Specification section.

2.2.2 Part 2: Development of Structural Documentation
Teams are to prepare documentation of their bridge design in the form of standard professional structural drawings. Full details and requirements are outlined in the Specification section.

Phase 2 Submission:
- Report
- Drawings

FINAL DATE FOR PHASE 2 TEAM SUBMISSIONS: APRIL 17, 2020
FINALISTS TO BE NOTIFIED THE WEEK OF MAY 11, 2020

2.3 Phase 3 – Finals
Up to five teams will be selected to take part in the finals, which will be held in Edmonton, Alberta on October 3-7, 2020, as part of the APT national conference.

Teams are to build a scaled model of their timber bridge design at the APT conference, which will be tested for stability, strength, and serviceability (full details and requirements are outlined in the Specification section). Teams will present their design formally to a panel of competition judges and informally to conference attendees throughout the conference.

Teams will also be given preservation problems to solve and advised to engage with experts attending the conference. This is to promote engagement with conference attendees. These solutions will also be presented formally to the competition judges.

Team performance will be evaluated and the competition winner will be announced at the conference.

Phase 3 Submission:
- Poster & Presentation
- Design Build Scale Model (which will be load tested at competition)
- Preservation Problems
2.4 Schedule

2.4.1 Pre-Conference Schedule
- December 9, 2019: Release of 2020 APT Competition Specifications
- February 17, 2020: Phase 1 Team Submissions Due
- April 17, 2020: Phase 2 Team Submissions Due
- Week of May 11, 2020: Team Finalists Announced

2.4.2 Conference Schedule
The APT Conference will be held in Edmonton, Alberta, on October 3-7, 2020. Exact schedule of competition will be determined in the months preceding the conference. General schedule will be similar to the following and will align with the conference structure:

Day 1 – Arrival and Student Workshop *
- Teams to arrive
- Judges to assign preservation criteria and questions to teams
- Teams to attend a field-trip and/or workshop
- Teams to present their poster to general APT Conference audience

Day 2 – Attend Conference *
- Teams to attend Conference paper sessions
- Continued work with teams and mentors to address preservation problems
- Posters to be on display
- Team Dinner

Day 3 – Build Day and Judging *
- Teams to build their structures in a public forum. Teams to be available to answer questions during the build time
- Load testing and judging of builds
- Teams to present their bridges and answer preservation problems for judging
- Announcement of winners

Day 4 – Departure

* Actual schedule subject to change. Updated scheduling information will be provided to competition finalists in 2020 once the conference agenda is established.
III Team Requirements

3.1 General
Teams are to be made up of Engineering and/or Architectural students at the Undergraduate or Graduate Level, college or trade school students with conservation-minded curriculum, or other post-secondary students willing to tackle engineering style problems. Teams are to be made up of a minimum of 4 and a maximum of 6 people. More than one team may represent the same University or Institution.

Each team is to nominate a team captain who will be the main contact with the APT PETC competition task force. Names and contact emails are to be provided with the team’s Notice of Application (Phase 1 Submission).

3.2 Financial
The Preservation Engineering Technical Committee (PETC) of APT will pay all conference registration fees for up to 6 students for the teams selected to attend the Competition Finals. Each student will receive all benefits not identified as ‘ticketed events’. The PETC will also pay for (2) hotel rooms for the (3) nights of the competition for each team, as well as one group dinner event. All other expenses (travel, extended stay, additional lodging, food, competition materials, etc.) is the responsibility of the teams. The PETC will not be able to financially support any faculty advisors or mentors.

Each team raise money for their expenses. One of the values in a competition of this nature is that it allows and encourages students to reach out to companies asking for support, and while doing so, make connections that may be of future value. The PETC can provide a general list of potential sponsors that we can share with the teams upon request to assist in finding potential sources of sponsorship, especially pertaining to the masonry industry for this year’s competition. Teams are encouraged to define their own ways in which to acknowledge the support they received (sponsored t-shirts, posters, etc.).

We would like each team to develop their own financial plans, including all anticipated costs and anticipated funds raised. The competition task force will use these plans to help teams that may have a shortage of fundraising. Financial plans are to be sent to the Task Force no later than June 1, 2020.

Teams should make their own travel arrangements. If this requires a Visa Application or other assistance, please contact the Task Force as soon as possible.

APT will take care of the hotel arrangements (2 rooms for 3 nights) and conference registration as noted above. In order to do this, the Task Force will need a final list of team members, including names, phone numbers, email addresses, home addresses, and hotel room groupings (who will be sharing each room). This information is to be sent to the Task Force no later than July 1, 2020. Later changes to names will be possible until August 15, 2020.
4 APT Process & Support

4.1 Contacts
The PETC competition task force may be contacted for questions or support. The task force will advise when required, ensuring that all teams receive the same information.

All teams are encouraged to stay in touch with and update the competition task force on progress moving forward.

Contact Information:

• Email: APTpetc@gmail.com

4.2 Mentors
Each team will be assigned an APT-provided industry mentor after completion of Phase 1. These individuals have agreed to volunteer their time to support a team. A great deal of thanks is owed to those who step forward.

Out of respect for their time, the following clarifications are provided:

• Teams will be student-driven; mentors will serve as sounding boards for ideas.
• Teams will likely need to touch base every week or two for discussion.
• Teams will be responsible to schedule meetings and to be prepared for meetings.

Teams are welcome to identify their own mentor, and should notify organizers of who is serving this role.

4.3 Faculty Advisors
Each team should have one or more faculty advisors. Similar to mentors, faculty advisors are volunteering their time and energy towards the competition. They will likely be more available than mentors, and they serve as a formal link to the University. Their main role is to advise students.

4.4 Media
The APT Preservation Engineering Student Design Build Competition has no restrictions on talking to the media, and teams are encouraged to do so. Teams are to send the PETC competition task force a copy of any articles including student papers in which the competition is discussed.

The competition task force will provide updates to APT and the greater preservation community on the competition teams, so teams are encouraged to send photos and updates to be posted on the website and APT news.
5 Specifications

5.1 Phase 1 – Bridge Selection
Please find all information pertaining to Phase 1 in Section 2.1 of this packet.

5.2 Phase 2 – In-House Research and Design
Once the PETC competition task force approves of the team’s proposed bridge, teams are to design, analyze and assess the durability of their timber bridge. Findings will be presented in report format and the design will be presented in drawings format, both of which are outlined below.

5.2.1 Part 1 – Historic Research and Design Review (15% of Phase 2 score)
The report should introduce timber as an historic building material, its history and significance, and the team’s intended design. Teams are to research typical historic construction methods and materials to be used in their bridge design and demonstrate how the materials and techniques they choose are an accurate representation of a bridge built between 1840 and 1890. The team should introduce the general concepts of their design and identify the various materials used, the original source of these materials, composition, connections, and assembly. Description is to be provided on the architectural, cultural and/or technological significance of historic timber bridges, as well as the thought process behind the team’s selection. Historic literature and reference materials may be used as a guide.

5.2.2 Part 2 – Structural Analysis (40% of Phase 2 score)
Teams are to undertake a structural analysis of their historic timber bridge design. The second part of the report should demonstrate an understanding of how the designed bridge behaves. This section should identify the structural principles used in the bridge’s construction, analyzing and explaining its behavior. Calculations shall be provided.

5.2.2.1 Define Relevant Codes and Loads
Teams will be required to describe relevant criteria that would have influenced the design of the bridge, such as historic codes used at the time of construction (as already defined in Phase 1), and assess the structural design of the bridge by identifying the principles used in its construction. Any appropriate material may be selected as reference. Example materials include the 1863 American Timber Bridges Book by James Mosse.

Teams are to identify the relevant loads and load combinations to be used in their evaluation. What loads have been selected and why, and which loads or load combinations have intentionally not been evaluated. Identify any unique aspects of the design process.

5.2.2.2 Evaluate Performance
Teams are to evaluate the performance and anticipate failure mechanisms of their structure. This may include evaluating the structure using rules of thumb, empirical design, historic analytics and contemporary analytical software.

Teams must justify why at least one of the selected approaches would provide a safe analysis. Comparison of multiple types of analysis results (example: contemporary vs. empirical) is recommended to showcase the reliability of the calculated results. The ultimate load carrying capacity
of the bridge and a snapshot of the analysis undertaken are to be provided. Provide explanation on how the design compares to the design standards used today.

5.2.3 Part 3 - Evaluate Durability (20% of Phase 2 score)
The built environment is subject to conditions that can wreak havoc on the condition, material makeup and structural integrity of historic structures. As preservationists, it is our responsibility to assess the condition of these structures and provide guidelines to owners on how to best conserve and maintain their properties for years to come.

The final part of the report is to provide a preservation plan for the maintenance of the structure over the next 30 years. The preservation plan should outline the materials of the structure and identify common decay mechanisms and other external forces that may lead to material deterioration or structural instability. The team is to select three key components of the structure that may require structural intervention due to these mechanisms/forces and provide a brief scope of work as to how these components may be restored. Teams are to develop a long-term treatment program, to be implemented at regular intervals as determined by the team that could be used by an owner to prevent the structure from reaching advanced states of deterioration or structural instability.

5.2.4 Part 4 – Construction Documents (25% of Phase 2 score)
Teams are to develop construction level documentation of their bridge design in the form of full-size drawings that would be typical of professional project deliverables. Mentors and other committee members can provide examples of such level of documentation upon request.

Drawings are to consist of the following:

- (1) Plan View
- (2) Elevation Views: (1) Transverse and (1) Longitudinal
- (2) Section Cuts: (1) Transverse and (1) Longitudinal
- (2) Detail Connections, to be chosen by the team
- Additional detailing, such as isometric views or other visuals that can be added to the drawings to better identify structural design and detailing intent, is encouraged

Each view is to be labeled clearly and provide the following (including but not limited to):

- Grid system, including grid dimensions
- Overall layout
- General dimensions (length and width of structure)
- Intermittent dimensions as would be needed to clearly identify lengths of individual members and components
- Elevations, heights, etc.
- Identification of materials
- Identification of elemental sizes
- Identification of detailing components (size, dimensioning, material, etc.)

5.2.5 Deliverable Requirements
The deliverable requirements for Phase 2 are a report and construction-level documentation in the form of drawings as outlined below.
5.2.5.1 Report Format
The report should clearly identify the following:

- Project Title
- Name of college/institution, individual team members, mentors and advisors
- References (educational references, literature, etc.)

The report should be formatted as per below:

- Maximum word count: 2000
- Page size: Letter (8-1/2” x 11”, Portrait Orientation)
- Font: Other fonts may be used at the equivalent size to the recommended font below:
  - Title/Headings: Calibri, size 14
  - Subheadings: Calibri, size 11
  - Body: Calibri, size 11
- Alignment: Left aligned
- Standard Margins and Headings
- Six to sixteen illustrations (including tables)
  - Each illustration must have its own number (Fig. 1, Fig. 2, not Fig. 1a, 1b) and its own caption. Please indicate illustration reference at end of each caption (if not produced by the team). Images should be referenced within the body of the report.
- For endnotes, bibliography, and other matters of style, authors should follow the Chicago Manual of Style.
  - Endnotes, if applicable, must be numbered consecutively throughout the text in superscript, and then placed at the end of the paper.
  - A bibliography is not necessary if all important sources are given in the endnotes.

Submit one electronic .pdf file of the paper with all embedded photos, figures and attachments. PDF file must be less than 5 MB in final size.

5.2.5.2 Construction Documents Format
The drawings should be produced via a computer-aided design and drawing (CADD) software, such as AutoCAD or Revit, or may be hand drafted, and formatted as per below:

- Page size: 24”x 36”, Landscape Orientation
- Consistent Title block with the following information:
  - Project Title
  - Name of college/institution, individual team members, mentors and advisors
  - Views (elevation, plan, etc.) shown on individual sheets
  - Scale
  - Sheet number
- Scale:
  - Plan: ¼” = 1’-0” minimum
  - Elevations: ¼” = 1’-0” minimum
  - Section Cuts: 3/4” = 1’-0” minimum
  - Details: ½” = 1’-0” minimum
Submit electronic files (.pdf) by E-mail in a separate mail from the report. The .pdf file must be less than 5 MB in size.

5.3 Phase 3 – Finals

5.3.1 Part 1 - Poster Presentation (20% of Phase 3 score)

The competition finalists are to prepare a poster for presentation during the conference proceedings. The poster will act as a “guided tour” through the team’s project and should be a condensed version of the previously submitted report. It should follow the general guidelines below:

5.3.1.1 Poster Content

The poster should clearly identify the following:

- Project Title
- Name and insignia of college/institution
- Names of team members
- Acknowledgements: Names of advisors, collaborators, donors, etc. who aided in the work (including funding, materials and other resources)
- References (educational references, literature, etc.)

The purpose of the poster is to provide a brief introduction to the bridge, including clear identification of the following:

- Overall bridge design
- Material makeup
- Historic “date of construction” and construction methods

The poster should present the structural analysis findings as set forth in section 5.2.2. Provide 4-10 photos, sketches, figures or charts to convey findings.

Provide a brief statement about the anticipated preservation plan to ensure the structure can remain functional for the near future.

5.3.1.2 Poster Format

The Poster should be presented in the following format:

- Poster Size: 36” (91.44cm) high x 48” (121.92cm) wide (Landscape orientation)
  - Printing, transportation and set-up of the poster is the responsibility of the team.
  - Teams are to ensure their poster is stiff enough to be supported by an easel (to be provided by the competition task force).
- Font: Other fonts may be used at the equivalent size to the recommended font below:
  - Title/Headings: Calibri, size 130 (minimum)
  - Subheadings: Calibri, size 54 (minimum)
  - Body: Calibri, size 32 (minimum)
- Four to ten illustrations (including tables):
  - Each illustration must have its own number (Fig. 1, Fig. 2, not Fig. 1a, 1b) and its own caption. Please indicate illustration reference at end of each caption (if not produced by the team). Images should be referenced within the narrative of the poster.
- Illustrations should be a minimum of 100 dpi and imported at the same size they will be on the poster (or smaller). Ideal resolution for poster presentations is 150 dpi (smaller resolution will create pixilated images while larger resolutions create large file sizes).
- Illustration size is at the discretion of the team but should be large enough to be read/interpreted clearly.

Many colleges/institutions have examples of research poster presentation templates and tips available online.

*Poster Tip:* Keep presented information simple. Judges and conference attendees who will want to know the most important aspects of the project only will read this poster. Onlookers should be able to review the poster within 5 minutes.

### 5.3.2 Part 2 – Historic Timber Bridge Design-Build (35% of Phase 3 score)

Each competing team is to build an approximately 1:10 scale model of a bridge designed upon the Phase 2 bridge concept and which meets the Phase 3 model size section of these specifications. Teams selected for the finals will erect their models at the APT conference, where the models will be tested for stability, strength, and serviceability using APT standardized lateral and vertical loads. Practicing professionals will judge the models by multiple criteria including durability, constructability, usability, stiffness, construction speed, efficiency, economy, attractiveness and restoration planning.

The timber bridge design-build will occur under timed conditions at the conference with viewing open to the public.

- Teams are responsible for understanding the full requirements of the build.
- Teams are responsible for ensuring all requirements are met.
- Requirements are not presented in chronological order.
- Teams are to meet the intent of the specifications.

If anything is not clear, it is the responsibility of the teams to request clarification at least 21 days prior to the start of the Conference. The competition committee will provide final responses at least 10 days prior to the start of the Conference.

### 5.3.3 Part 3 - Preservation Problems (45% of Phase 3 score)

At the Conference a set of preservation problems will be assigned to each team, and full details provided. Teams are encouraged to engage with conference attendees and will present their solutions to the panel of judges. Alongside the presentation of the preservation problems the judges are allowed to ask any questions related to the competition, the preservation problems, or the earlier submissions.

### 5.4 Clarifications

Each team will be allowed to submit three separate sets of questions for clarification during each Phase of the competition. Clarification inquiries will be responded to within 10 business days. Questions and responses will be provided to all teams. Any questions within 21 days of the final deadline for a Phase will not be answered.
6 Phase 3 Part 2 Design Build Specifications

6.1 Measurement
Conformance with the specifications in this section will be checked with the bridge in its as-built condition after termination of timed construction, and before the bridge is load-tested. The bridge shall not be modified or distorted from its as-built condition to conform to these specifications. Dimensions specified below will be checked without applied load.

6.2 General Requirements
The following specifications must be met:

- The maximum work area for each team is to be 12 ft. by 10 ft. This work area includes poster display. All materials and tools during assembly, including the bridge, must fit within this area.
- No assembly outside the work area is allowed.
- Teams shall construct and load the bridge safely using the site, equipment, and floor surfaces provided by the conference organizers. Bridges and participants shall accommodate local conditions, including but not limited to:
  - No use of power tools
  - No connections to floors
  - No damage to location
  - Respect for the public on site.

6.3 Dimensions
The following specifications must be met:

- The maximum footprint of the scaled bridge is to be 8'-0" long by 3'-0" wide.
- The minimum clear span between piers shall be 5'-0".
- The minimum bridge length shall be 5'-6" to ensure a minimum of 3" of bearing on each pier.
- The bridge shall have a decking surface that is continuous over the full length of the bridge that is at least 1'-6" wide. Note that the surface must be continuous, but the decking material shall not be a single continuous piece (see Section 6.4.2 for member dimensions).
- The bridge shall have a minimum 1'-0" high clear space from the top of the deck surface to any bridge truss or bracing members through which a theoretical user of the bridge could pass.
- The top of the bridge assembly shall not extend more than 2'-0" above the top of the piers.
- The bridge shall provide access for safely placing load anywhere on the deck (i.e. the bridge should not be covered and the layout of the truss and bracing members should allow for weights of the shape and size defined in Section 7.3 to be placed onto the bridge deck from the top of the bridge).
- The underside of the bridge shall not extend below the line of the top surface of the piers.
- Decking shall not distort the bridge from its as-built condition.
- The bridge shall not be anchored or tied to the floor or piers.
- Parts of the bridge shall not extend beyond the vertical plane defined by the ends of the piers.

Refer to the diagrams below for a visual representation of the dimensional requirements.
PLYWOOD SHEET PLACED OVER PROTECTIVE BLANKET. BLANKET AND PLYWOOD TO BE PROVIDED BY APT PETC.

END PIERS TO BE PROVIDED BY APT PETC. PIERS WILL BE CONSTRUCTED OF THREE (3) UNGROUTED 12" CMU BLOCKS (ACTUAL DIMENSIONS: 11-3/4" W X 15-3/4" L X 7-1/2" H) WITH A PLYWOOD TOP. WOOD BLOCKING WILL BE SCREWED TO UNDERSIDE OF PLYWOOD TOP TO PREVENT TOP FROM SLIDING ON CMU BLOCKS. PIERS WILL NOT BE ANCHORED TO PLYWOOD SHEET BASE IN ANY WAY. TEAM WILL CHOOSE SPECIFIC PIERS LOCATION; HOWEVER, PIERS SHALL NOT BE PLACED TO EXTEND OVER EDGES OF PLYWOOD SHEET AND MUST BE PLACED WITH MINIMUM 5'-0" CLEAR SPACE BETWEEN (THIS MEANS THERE IS ONLY 2-3/8" OF LATERAL ADJUSTABILITY AT EACH PIER). BRIDGE WILL REST ON TOP OF PIERS, BUT MUST NOT BE FASTENED TO PIER IN ANY WAY.

MAXIMUM BRIDGE MEMBER SIZE: 1-1/2" X 1-1/2" X 2'-0" (ACTUAL SIZE)

NOTE: MAXIMUM MEMBER SIZE ALSO APPLIES TO MATERIAL USED FOR BRIDGE DECK (I.E. A SINGLE CONTINUOUS DECK SURFACE SUCH AS PLYWOOD IS NOT ALLOWED)

ASSUME TYPICAL 50 LBS. STEEL SCAFFOLD COUNTERWEIGHTS (12"X 14"X 1-1/6" THICK) PLACED ONE-BY-ONE IN TWO STACKS AT CENTER SPAN FOR LOAD TESTING. WEIGHTS WILL BE PLACED FROM THE TOP OF THE BRIDGE (THROUGH THE BRIDGE MEMBERS), NOT FROM THE ENDS.

BOTTOM SURFACE OF BRIDGE SHALL NOT EXTEND BELOW THE TOP OF THE PIERS PRIOR TO LOADING

NOTE: MAXIMUM MEMBER SIZE ALSO APPLIES TO MATERIAL USED FOR BRIDGE DECK (I.E. A SINGLE CONTINUOUS DECK SURFACE SUCH AS PLYWOOD IS NOT ALLOWED)

END PIERS TO BE PROVIDED BY APT PETC (SEE PLAN VIEW FOR ADDITIONAL INFORMATION)

PLYWOOD SHEET PLACED OVER PROTECTIVE BLANKET. BLANKET AND PLYWOOD TO BE PROVIDED BY APT PETC.
6.3.1 Violations
A weight penalty will be assessed for each specification in this sub-section that is violated per team. If there are multiple violations of the same specification, the penalty will be based on the largest violation.

The penalty will be an addition to the weight of the bridge determined as follows:
- 50 pounds for each dimensional violation of 1/4” or less;
- 250 pounds for each violation greater than 1/4” but not exceeding 1”;
- 750 pounds for each violation greater than 1” but not exceeding 2”; and
- If a violation exceeds 2”, the team will receive last place for the weight portion of the build.

All connections and members shall be visible in the completed bridge so that compliance can be verified with specifications. A penalty of 100 pounds will be added to the weight of the bridge for every part that cannot be inspected.

6.4 Components
6.4.1 Bridge
- Bridge must be assembled on site during the allotted 4-hour time period. No pre-assembly of individual components is allowed prior to the start of the build.
- No cutting, drilling, or use of power tools will be allowed on site.
- The bridge for Phase 3 is to be built at approximately 1/10 scale. A full size bridge based upon the scale model should be made of feasible dimensions. For example, if the full scale bridge would be required to have a 50’ long, 4’ by 4’ foot beam this would be considered unrealistic.
- The bridge for Phase 3 should be based upon the Phase 2 bridge, but can be a unique design to meet requirements.

6.4.2 Members
- A member is a rigid component. Members with moving and flexible parts are prohibited. Exception: Deformations caused by mechanical strain (e.g., bending, stretching) during construction and load testing are not violations.
- Members are to be pre-cut for on-site assembly. No pre-assembly of individual components is allowed prior to the start of the build.
• Maximum member size is 1-1/2" x 1-1/2" x 2'-6" (actual size).
• The bridge decking shall also comply with the maximum member size noted above (i.e. a single continuous deck surface such as a sheet of plywood is not allowed).

6.4.3 Volume and Weight of Material Restrictions
The competition finals are designed to provide some practical allowances for teams travelling various distances. Therefore, restrictions have been placed on the volume of material allowed.

• The total weight of the bridge materials (excluding tools, support structure, and cases) shall not exceed 50 lbs.
• All members to be used in the construction of the bridge must fit inside 3 cases (boxes/containers/suitcases) that would each be accepted as U.S. air travel checked luggage requirements. That is, maximum length of 5’ and maximum weight of 50 lbs. These 3 cases may contain tools for use during erection so long as the size and weight limits are met.
• An additional 2 cases containing only support structure, safety equipment and tools to be used during the erection of the bridge are allowed as long as the cases would each be accepted as U.S. air travel checked luggage requirements. That is, maximum length of 5’ and maximum weight of 50 lbs.
• The timed build will start with all materials, tools etc., inside closed suitcases, and all connections fully disassembled.

6.4.4 Violations
Any violations of the component specifications will result in penalties as follows: teams will receive last place for the speed portion of the build.

6.5 Materials
6.5.1 Composition
The bridge is required to be 90% timber by weight. Other materials, including modern day substitutions for materials that would have been readily available at the time of construction (i.e. steel for wrought iron), are allowed in combination with timber so long as they meet other competition requirements.

6.5.2 Alternatives
If any material used in the model bridge was not available for construction purposes between 1840 and 1890, the team is to provide justification for design decisions in using the alternative material. If questions arise during judging, it is the responsibility of the team to defend material use. For example, obtaining wrought iron may not be practical so materials similar to it (e.g. carbon steel) may be used instead; the teams will be expected to justify this decision. Similarly, use of any modern connections is to be justified. Substitutions with dissimilar modern materials chosen solely to reduce the overall weight of the structure (e.g. epoxies or fiber reinforced plastics) should be avoided.

6.5.3 Weighing Procedure
The procedure for weighing bridge materials shall be as follows:
• Teams shall place all bridge materials (including members, connections, and decking) inside one or more cases (as described in Section 6.4.3). Cases shall have straps or handles that will allow them to be weighed using a hanging (aka fish) scale. Total weight will be recorded.
• Team will remove any non-timber materials from case(s) and they will be re-weighed and recorded.
• Team will remove all remaining materials from case(s) and weight of case(s) alone will be recorded.
• Recorded weights will be used to verify that bridge materials meet the 90% timber by weight requirement in Section 6.5.1. Weights of case(s) will not count toward weight totals, nor will weights of tools, PPE, or temporary support or construction supplies.

6.5.4 Violations
A violation of the material specifications will result in penalties as follows: a 2-point deduction for each 5 percent increment below 90 percent for the weight of the wood shall be included in the weight scoring section of the competition. At their discretion, judges may also impose additional point deductions for dissimilar alternate materials that are used with the sole intention of reducing the overall weight of the structure.

6.6 Assembly Requirements for Conference Site Competition
6.6.1 Overall Timber Bridge Requirements
The final bridge is to meet the requirements outlined in Section 6 Structural Specifications.

6.6.2 Setup for Conference Site Testing
Teams are to clearly mark off the construction area surrounding the bridge.

Teams are to layout under the build location protective blankets and plywood sheet provided by the competition. Before construction, the building materials will be removed from each of the cases to be used by the teams will be weighed and recorded. With the exception of PPE and materials provided by the competition Task Force, nothing to be used for construction can be outside the cases. The weight of the bridge materials, exclusive of tools, support materials, and cases, is to be included in the final judging score.

6.7 Construction of the Conference Timber Bridge
All on-site construction work will be carried out under the supervision of the organizers.

• Prior to construction, all materials should be inside their respective cases, with the construction area marked out and blankets and plywood down.
• All personnel to be involved with the bridge construction and loading are to have proper PPE, which includes but is not limited to gloves, safety glasses, and steel-toed boots.
• Construction to begin upon the organizers clear announcement and all builds will be timed.
• Teams are responsible to ensure the safe erection of the bridge.
• If competition organizers or judges feel that a team’s construction practices are unsafe, they may request that the team halt construction. Teams will be allowed to appeal to the judging panel for any requested stop, however the time will continue during this process. If the appeal feels that safety had been adequately considered, then teams may continue the build. If the construction is deemed unsafe, the team must disassemble and reassemble or receive last place in the conference build.
7 Load Test Instructions

7.1 Damage
A bridge with damage that would reduce its strength or stability will not be approved for load testing and is not eligible for awards in any category. Repair and modifications are not permitted after timed construction except under special allowance by the judging team.

7.2 Safety Precautions
It is the responsibility of judges, host personnel, and competitors to effectively employ all safety precautions. Competitors should follow the same precautions when proof testing bridges in preparation for competition.

- General Precautions
  - An activity shall be halted if any judge considers it to be hazardous. If competitors cannot load their bridge safely, loading will cease, and the bridge will not be eligible for awards in any category.
  - Competitors who are not participating in loading, faculty, advisers, and other spectators shall observe from a safe area designated by the judges and conference organizers.
  - While participating in load testing, competitors shall wear appropriate personal protection equipment (PPE).
  - Damaged bridges shall not be tested.

- Lateral Load Test Precautions
  - No more than three competitors shall participate in lateral load tests.
  - Bridges that sway in excess of 2” during lateral load testing shall not be loaded vertically.

- Vertical Load Test Precautions
  - Bridges may collapse suddenly without warning, and a failure may involve only one side so that the load tips sideways. The intent of the provisions of this section is to prevent personal injury if a bridge collapses.
    - The number of people near the bridge shall be minimized during vertical load tests. No more than three competitors shall participate in the vertical load test.
    - Safety supports shall be provided by the organizers, and shall be of adequate strength, height, and number to arrest falling load if a bridge collapses.
    - Safety supports shall be in place under the decking units before load is placed on the bridge.
    - The number and location of safety supports under a decking unit shall be sufficient to arrest the load even if only one side or one end of the bridge collapses. Therefore, safety supports are needed under the sides and ends of the decking units, not just in the middle. Safety supports should be directly under decking units rather than under bridge trusses or cross braces, if possible.
No one shall reach, crawl, or step under a bridge while any portion of vertical load is in place. If safety supports must be adjusted during loading, the load shall first be removed without disturbing the bridge, adjustments made, and the load replaced as it was before being removed.

- Bridges that inhibit safely placing vertical load shall not be tested.
- Judges shall observe sway carefully during vertical load testing. If sway exceeds 1”, loading shall cease and load shall be removed carefully.
  - Judges shall observe vertical deflections carefully. If deflection at any target exceeds 3”, loading shall cease and load shall be removed carefully.
  - Judges shall observe the behavior of the bridge. Loading shall cease and the load shall be removed carefully if, in the opinion of a judge, collapse is imminent.
- Organizers will apply the lateral loads.

### 7.3 Preparation

The team captain shall observe the load tests and may handle load. A captain who does not handle load does not count toward the three-person limit.

- The temporary pier, if used during construction, is not allowed during load tests.
- The judge designates the “A” side of the bridge by a random process. The “B” side is opposite the “A” side. “Left” and “right” ends are determined by facing the “A” side from the outside of the bridge.
- Teams shall accept imperfect field conditions such as bent decking, sloping floors, and unfavorable floor surfaces.
- At the discretion of the judges, a penalty may be imposed for a bridge that incorporates parts having the primary function of interfering with placement of targets, decking, load, or measuring devices. If the bridge cannot be loaded safely, or sway or deflection cannot be measured in accordance with the provisions of this section, the bridge shall not be load tested and is not eligible for awards in any category.
- “Sway” is translation in any horizontal direction. Typically, sway is determined by using a plumb bob attached to the bridge at a specified target. A sway requirement is failed if any part of the bridge causes the displacement of the plumb bob at floor level to exceed the specified limit, even if the plumb bob is not attached to that part.
- For design purposes, assume typical 50 lbs. steel scaffold counterweights (12”x14-1/4”x1-1/8” thick) or round gym weights will be used for loading. Weight increments may be modified slightly at the time of the competition based on available weights at the conference location.

### 7.4 Lateral Load Test

- Refer to the diagrams below for a visual representation of the lateral load test procedure.
- Lateral load test is conducted by placing 100 pounds of weight on the decking near the “B” side of the bridge at the center. This load is intended to restrain the bearing surfaces of the bridge from lifting off the piers when lateral load is applied. No additional uplift restraint will be used, even if bearing surfaces lift.
- Bearing surfaces are prevented from sliding by lateral restraint applied (i.e. students hold bridge). This lateral restraint shall not restrain rotation or uplift. The restraint is applied on the “A” side of the bridge as close to the piers as possible. The lateral load test is failed if the
bridge is restrained in other than the lateral direction, or if the restraint is not applied close to the piers, or if the restraint is not effective.

- A sway target is established for measurement on the “A” side of the bridge, at centre span.
- A 35-pound lateral pull force is to be applied and the maximum sway is to be measured. The pulling force is located on the “A” side of the bridge as close as possible to the decking and not more than 2” from the sway target. To pass the lateral load test, the sway must not exceed 1”.
- If the bridge does not pass the lateral load test, it is not approved for further testing and is not eligible for awards in this category. Do not conduct any other load test. Check the appropriate box on the judges’ scoring form.
- If the bridge passes the lateral load test, proceed with the vertical load test.
7.5 Vertical Load Test

“Deflection” is translation in a vertical direction.

- Refer to the diagrams in Section 6.3 for a visual representation of the approximate placement of load during the vertical load test.
- If deemed necessary by the organizers and judges, safety supports are placed under the decking so that no portion of the load will drop more than approximately 6” if the bridge collapses.
- Judges to determine locations for loads, measured from centre span, to be used on all bridges. For design purposes, it should be assumed that the entire load will be placed approximately within the center two feet of the span.
- Three vertical deflection targets are located as close as possible to the decking.
  - Position measuring devices on the three vertical deflection targets.
- The scoring spreadsheet computes aggregate deflection as the sum of the three deflection measurements, rounded to the nearest 1/8”.
- Load the bridge and measure the deflections, using the following procedure:
  - Initialize the sway measurement device (i.e. plumb bob).
  - Initialize the three vertical deflection-measuring devices or record the initial readings.
  - Competitors place 50 pounds of load at the first location, and then place 50 pounds of additional load at the second location, and so on. Load is laterally centered on the decking and is placed as uniformly as possible at all times during loading. Load is distributed and aligned identically for every bridge. Load shall be placed at a steady pace, without hesitation.
  - Loads to be placed so that they do not contribute to the bridge stiffness (i.e. stacks of weights shall not touch).
  - As the load is being placed, observe the deflection and sway targets. Stop loading if any of the following occurs:
    - Sway exceeds 1”
    - Deflection at any deflection target exceeds 3” downward
    - Decking or any part of the bridge, other than the intended bearing surfaces, comes to bear on a safety support or the floor
    - A decking unit or some of the load falls off the bridge
    - All 500 pounds of available load are used
    - The bridge collapses or a dangerous collapse is imminent, in the opinion of any judge

7.6 Results

If loading is stopped for any of the situations, the bridge is not approved for further load testing. Remove the load and do not continue load testing.

If the bridge passes, record the final deflection and sway readings at each recording location. If the bridge remains elastic when unloaded or residual deflection measures less than ½”, teams will receive 1 bonus point in the stiffness category.
8 Host Equipment
Equipment provided by APT is indicated below in this section. All other equipment for the bridge is to be provided by each team as part of their design and construction. Each team will be responsible for the procurement of their materials.

8.1 Setup
APT will provide the following:

- Protective blankets for each team’s work area
- One 4 x 8 foot plywood sheet for each team’s work area
- Two end piers: each constructed of three (3) un-grouted 12” concrete masonry units (CMU blocks, actual dimensions 11-5/8” w x 15-5/8” l x 7-5/8” h) with a plywood top. Wood blocking will be screwed to underside of plywood top to prevent top from sliding on CMU blocks. Piers will not be anchored to plywood sheet base in any way.
- Easel for poster display

8.2 Safety Supports
Safety supports may be used during load tests and are intended to limit the consequences of a bridge collapsing (necessity to be determined by APT PETC). Safety supports shall be of sufficient height, strength, number, and extent so that none of the load will fall more than approximately 6” if the bridge collapses. Wood pallets or other similar elements may be used.

8.3 Load
A total load of 500 pounds will be supplied in pieces of uniform size and weight that can be handled safely. For design purposes, assume typical 50 lbs. steel scaffold counterweights (12”x1-4-1/4”x1-1/8” thick) will be used for loading. When in place, the load should not provide significant stiffness in the longitudinal direction of the bridge – arching action should be avoided.

8.4 Measurement Devices
APT will provide the following:

- Measurement devices (to check bridge dimensions, deflection, and sway)
- Deflection and sway targets
- Scales (to weigh bridge components and for lateral load testing)
9 Evaluation of Phase 3 Part 2 Build and Testing

The build and testing will be evaluated as follows:

- Speed of build to be graded upon order at which teams complete construction and will be ranked as follows:
  - First team completed: 10/10
  - Second team completed: 9/10
  - Third team completed: 8/10
  - Fourth team completed: 6/10
  - Fifth team completed: 5/10
  - Any team which did not meet suitcase limits but managed build: 3/10
  - Any team which could not complete build due to safety or lack of materials: 0/10

- Strength of bridge to be graded upon highest load achieved:
  - Reached and sustained 500 lb. load: 10/10
  - Reached and sustained over 450lb load: 9/10
  - Reached and sustained over 400lb load: 8/10
  - Reached and sustained over 350lb load: 7/10
  - Reached and sustained over 300lb load: 6/10
  - Reached and sustained over 250 lb. load: 5/10
  - Reached and sustained over 200 lb. load: 4/10
  - Sustained self weight: 3/10
  - Does not sustain self weight or incomplete: 0/10
  - If the bridge collapses during unloading of vertical or lateral testing 0/10
  - Masses may not be in units that will exactly meet loads. Bridge must meet or exceed (based upon mass) a given limit to gain a given grade. All bridges will be loaded with the same masses.

- Weight of materials used (actual bridge) to be graded upon the order of which the teams were relative to one another, The bridge with the least total weight will win in the lightness category. Total weight is the weight of the bridge (measured by organizers) plus weight penalties prescribed above and ranked as follows:
  - Team with the lightest total weight: 10/10
  - Team with the second lightest weight: 9/10
  - Team with the third lightest weight: 8/10
  - Team with the forth lightest weight: 6/10
  - Team with the fifth lightest weight: 5/10
  - Any team which did not meet suitcase limits but managed build: 3/10

- The bridge with the lowest aggregate deflection at the highest load sustained will win in the stiffness category. Aggregate deflection is determined from measurements as prescribed in previous sections and to be graded upon the teams relative to one another, and ranked as follows:
  - Team with the lowest deflection: 10/10
  - Team with the second lowest deflection: 9/10
  - Team with the third "": 8/10
Team with the forth “” : 6/10
Team with the fifth “” : 5/10
Teams exceeding the maximum deflection: 0/10

9.1.1 Phase 3 – Presentation and Preservation Problems
Teams will select a pair of preservation problems at the conference. The PETC competition committee will develop these problems. The selection of problem pairs will be done as follows:

- The PETC competition committee will show all problem pairs (individual problems cannot be separated) to all teams.
- Teams will select their problem based upon their ranking from Phase 2 of the competition.

Teams are encouraged to engage conference attendees to find more information to develop solutions for their selected preservation problems and should cite specific references including individuals. Visual solutions (sketches, etc.) are encouraged. If so desired, last year’s preservation problems are available upon request.

Teams will have until the judging period to find solutions. As a final part of the competition, each team will give a presentation where they will present their structure, the loading test findings, and their solutions to the preservation problems. Presentations are to be 15 minutes (including both the presentation of their bridge and the responses to the preservation problems), and an additional 10 minutes will be allotted for judges’ questions and team responses. Professionalism during the presentation and question period will be taken into consideration.

Once presentations are concluded, the judges will deliberate, tally up their judging cards, and provide some constructive feedback to the teams before announcing the winners.
10 Judging Criteria

Competition judging is as follows:

Phase 1 must be passed to proceed to Phase 2; however, the grade will not be retained for final (Phase 3) judging. The review of Phase 1 will be completed by the PETC competition committee members. Teams will be notified via email on their Phase 1 acceptance.

Phase 2 submissions are evaluated to determine finalist teams for Phase 3 and to determine ranking for preservation problem selection. The evaluation of Phase 2 submissions will be completed by the PETC competition committee. Teams will be notified via email on their standings after Phase 2 and their acceptance into the final round (Phase 3).

During the APT Conference, a group of selected professionals from different sectors of the design and construction industry will form a judges’ panel. These judges will be responsible for evaluating the Phase 2 deliverables previously reviewed by the competition committee members, as well as the evaluation of the Phase 3 performance-based events.

Judges will grade Phase 2 submissions, as follows:

- Historic Research and Design Review /15
- Structural Analysis /40
- Durability /20
- Construction Documents /25

Phase 2 Judges Score = (a + b + c + d)/25

The grading for Phase 3 will have three components: poster, team presentations and preservation problems, and their on-site builds.

Judges will grade the following:

- Poster /20
- Build and Test /35
- Presentation and Defense /45

Phase 3 Judges Score = (a + b + c)/50

Final evaluation:

Final Grade = Phase 2 Judge Score + Phase 3 Judge Score