2018 SPECIFICATIONS
The Timber Bridge

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, a key aspect of understanding how they can be preserved, an understanding of how they were originally built is critical.

2018

The Timber Bridge

APT Preservation Engineering Student Design-Build Competition

1 Introduction

The 2018 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 a timber bridge similar to one that would have been designed between 1840 and 1890. This bridge will be evaluated for its design, and then subjected to a set of preservation problems. Additional evaluate criteria include serviceability, construction cost, construction duration, material cost.

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 1830's, 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.

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

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, Texas A&M University and Carleton University, competed in the finals. This successful test year provided the foundation from which further competitions have grown.

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 2018 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 2018 APT Conference in Buffalo, 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 design a timber bridge 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. Full details and requirements are outlined in the Specification section.

Phase 1 Submission:

- Notice of Participation letter
- Structural Description: one paragraph, 50 words max

FINAL DATE FOR PHASE 1 TEAM SUBMISSIONS: FEBRUARY 2, 2018

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 1, 2018

FINALISTS TO BE NOTIFIED THE WEEK OF MAY 4, 2018

2.3 Phase 3 – Finals

Up to five teams will be selected to take part in the finals, which will be held in Buffalo, New York on September 22-26, 2018, 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

- Wednesday, October 10 – Sunday, October 15, 2017, APT 2017 National Conference: Release of 2018 APT Competition Poster
- Friday, December 1, 2017: Release of 2018 APT Competition Specifications
- Friday, February 2, 2018: Phase 1 Team Submissions Due
- Monday, April 1, 2018: Phase 2 Team Submissions Due
- Week of May 4, 2018: Team Finalists Announced

2.4.2 Conference Schedule

The APT Conference will be held in Buffalo, New York, on September 22-26, 2018. 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 *

- Teams to arrive

Day 2 – Student Workshop *

- Judges to assign preservation criteria and questions to teams
- Teams to attend a field-trip
- Teams to present their poster to general APT Conference audience

Day 3 – 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 4 – 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 preservation problems for judging
- Announcement of winners

Day 5 – Departure

* Actual schedule subject to final conference arrangements are made. Updated scheduling information will be provided to competition finalists as appropriate.

3 Team Requirements

3.1 General

Teams are to be made up of Engineering and/or Architectural students at the Undergraduate or Graduate Level, collage 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 contact person and a team captain (they can be different or the same) 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 of the teams selected to attend the Competition Finals. Each student will receive all conference benefits not identified as 'ticketed events'. The PETC will also have a small reserve fund to be strategically used where required.

Each team should strive to raise money for their expenses outside of the conference registration. One of the values in a competition of this nature is that it allows and encourages students to reach out to companies to help sponsor the participants, and in doing help make connections that may be of future value. The PETC can provide a general list of potential sponsors that can be shared with the teams upon request to assist in finding potential sources of sponsorship. Teams are encouraged to define their own ways in which to acknowledge the support they received (posters, logos on bridge deck, etc.).

Each team is to develop their own financial plans, including all anticipated costs and anticipated funds to be raised. In order to help teams that may have a shortage of fundraising, the competition task force will use these plans to determine if any additional reserve funds can be made available.

Teams should make their own hotel and travel arrangements. The PETC does not cover any faculty, advisor or mentor costs.

4 APT Process & Support

4.1 Contacts

The 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 up to two mentors. 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.

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

Teams are to submit a Notice of Participation letter, identifying the name of the University or Institution, names of team members, faculty advisor, and contact information. Teams are to provide a structural description of the bridge, including the time period their bridge design is to mimic, what codes or historic literature their design is to adhere to, what loading their bridge will be designed for, and what materials they are going to be using for the competition. The competition task force will then provide feedback and/or approval of the submitted structure prior to proceeding to the next phase.

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. 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, 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: 1 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 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 a 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.

The scaled model bridge to be testing at the finals should be based upon the bridge used in ***Phase 2, but*** *adapted to meet size requirement* ***s in Phase 3***

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 Functionality and Safety

The following specifications must be met:

- The bridge shall have a decking surface that is continuous over the full length of the bridge that is at least 16 inches (actual) wide in the scaled design.
- The model bridge shall provide access for safely placing load anywhere on the deck.
- Decking shall not distort the bridge from its as-built condition.
- The bridge shall not be anchored or tied to the floor.
- The maximum footprint of the scaled bridge is to be 8 ft. by 5 ft. wide.
- 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.
- The bridge assembly materials are not all required on site at the start of the construction period; however, 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 Usability

The following specifications must be met:

- The scaled bridge shall not touch the river (clear span) or the ground outside the piers. The scaled river is 5’ wide, thus, a with 5’ min. clear space between piers.
- The top of the scaled bridge assembly shall not extend more than 5’-0” above the ground or river.

- The scaled bridge shall not be wider than 3'-0" at any location along the span.
- Vertical clearance shall be provided under the bridge at all points directly over the river. The clearance shall be at least 3'-0" high, measured from the surface of the river.
- The decking surfaces shall be no more than 5'-0" above the surface of the river or ground at any point for the scaled bridge.
- Parts of the bridge or piers shall not extend beyond the vertical plane defined by the ends of the decking support surfaces at each end of the bridge.
- Decking support surfaces at each end of the bridge shall not extend beyond the vertical plane defined by the pier edge farthest from the river.
- Teams are responsible for providing their own end piers to counterweight anticipated loading scenarios.

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 Materials

6.4.1 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.

6.4.2 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.

6.4.3 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.

6.5 Components

6.5.1 Bridge

- Bridge must be assembled on site during the allotted 4-hour time period.
- No cutting, drilling, or use of power tools will be allowed on site.
- The bridge for Part 2 of Phase 3 is to be built approximately 1/10 scale. A full size bridge based upon the scale model would 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 Part 2 of Phase 3 should be based upon the Phase 2 bridge, but can be a unique design to meet requirements.

6.5.2 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.
- Maximum unscaled member size is 12" x 12" x 5'-0" long lumber.

6.5.3 Volume 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.

- 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 materials for the abutments and 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.

6.5.4 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.

6.6 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 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 material, 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 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.

Bridge must demonstrate adequate lateral testing results to have vertical testing done."

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 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.

7.4 Lateral Load Test

- Lateral load test is conducted by placing 75 pounds of weight on the decking near the "B" side of the bridge at the centre. 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. This lateral restraint shall not restrain rotation or uplift. The restraint is applied 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 ground, or if the restraint is not effective. Bridges must be laterally restrained by their base without the assistance of the team members holding it in place. Note the team members may need to hold the piers in place.
- 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 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.

- 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. Determination of load locations shall be done prior to commencement of the competition but will not be shared with teams until the Head Judge will indicate where the bridge is to be loaded after it is built. For design purposes, it should be assumed that the entire load will be placed within the center 12-inches 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.
  - Uniformly distribute 50 pounds of preload on each of the two locations. The preloads are laterally centered on the decking unit. The preloads are located and aligned identically for every bridge.
  - A decking unit that does not contact the decking support surface at a vertical deflection target will be clamped to the decking support surface at or near that location until the preload has been placed and the vertical deflection measuring devices have been initialized. The clamp will be removed before additional load is placed.
- The scoring spreadsheet computes aggregate deflection as the sum of those three measurements, rounded to the nearest 0.1".
- Load the bridge and measure the deflections, using the following procedure:
  - The preload remains in place.
  - Initialize the sway measurement device.
  - Initialize the three vertical deflection-measuring devices or record the initial readings.
  - Competitors place 10 pounds of additional load at the location furthest from centre span, and then place 10 pounds of additional load at the second location. Load is laterally centered on the decking and is 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
  - 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 readings at each recording location. If the bridge remains elastic when unloaded or residual deflection measures less than ½", teams will receive1 bonus point. If any of those values exceeds 2", penalties will be added to the scoring spreadsheet in the stiffness section as follows: 1 point loss for each ½" increment beyond the 2" deflection.

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 Safety Supports

Safety supports must be used during load tests and are intended to limit the consequences of a bridge collapsing. 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.

8.2 Load

A total load of 500 pounds will be supplied in pieces of uniform size and weight that can be handled safely. When in place, the load should not provide significant stiffness in the longitudinal direction of the bridge – arching action should be avoided.

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
  - Forth 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, lateral or deflection 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 later sections and to be graded upon the teams were 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 – 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 an oral presentation (no digital tools) where they will present their structure, the loading test findings, and their solutions to the preservation problems. Presentations are to be 15 minutes, with an additional 15 minutes allowed for questions and defense.

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 two components: team presentations and their on-site builds.

Teams are to present an understanding of their structures and the problems they have been assigned in a formal presentation to the judges. 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*