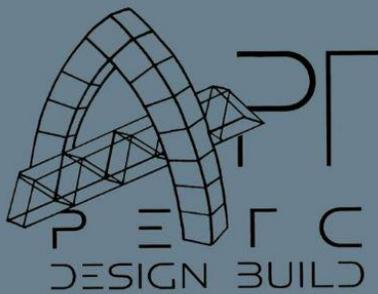


ASSOCIATION FOR PRESERVATION TECHNOLOGY

Masonry Arch: 8th Annual Student Design-Build Competition

- ✓ Exposure to Historic Masonry
- ✓ Hands-on Application
- ✓ Real Project Experience
- ✓ Industry Networking

- 👥 Teams of up to 6 Students
- ✈️ Finals in Seattle, WA



PHASE 1

March 10, 2023

- Notice of Participation
 - Historic Arch Selection
- 📍 Home Campus



PHASE 2

June 12, 2023

- Home Campus Masonry Arch Build and Load Testing
- Report (Background Research, Structural Analysis, Conservation Plan)

📍 Home Campus



PHASE 3

October 9 - October 14, 2023

- Poster and Presentation
- Conference Dry-Stack Arch Build
- Preservation Problems

📍 Seattle, WA

2023 Competition Specifications to be released February 13, 2023. More information and link to our mailing list here!

✉️ aptpetc@gmail.com

🌐 <https://linktr.ee/APTPETC>



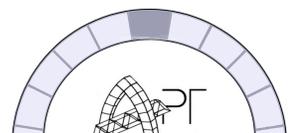
In This Package

This package provides information about this year’s Student Design-Build Competition hosted by APT’s Preservation Engineering Technical Committee. In this document you will find background information, an overview of the competition phases, as well as the specifications and competition requirements. **Take a look to see if you and your team are inspired to enter!**

Quick Dates Guide

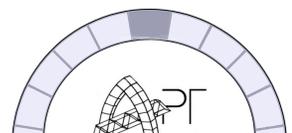
The following schedule is preliminary and may be subject to change. PETC will notify teams should dates or deadlines change.

DATE	ITEM	DEADLINE/INFO
February 2023	Competition Information Announced	Info
Mid- February	Specifications Package Released	Info
March 10, 2023	Teams submit Phase 1: Notice of Participation and Arch Selection	DEADLINE
March 17, 2023	PETC notifies teams that will move from Phase 1 to Phase 2	Info
April 13, 2023	Phase 2 Teams submit Funding Plan (Sponsorship)	DEADLINE
June 2, 2023	Team requests for PETC to clarify any questions regarding Phase 2	Last Day
June 12, 2023	Teams submit Phase 2: Report, Design-Build, and Videos	DEADLINE
June 30, 2023	PETC notifies the teams that are invited to the Phase 3 Finals	Info
October 1, 2023	Requests for clarification of Phase 3	Last Day
October 9 – 15, 2023	Phase 3 Competition	Finalists Compete at APT Conference in Seattle, Washington

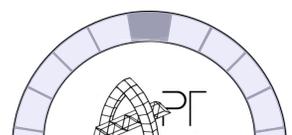


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Our History:

APT PETC's Student Design-Build Competition began in 2016 with the Timber Bridge at the San Antonio conference, and two schools, Texas A&M University and Carleton University, competed in the finals. In 2017, teams at the Ottawa conference competed in the first Masonry Arch competition.

From there, the competition has alternated between the Timber Bridge (Buffalo 2018, Edmonton 2020, and Detroit 2022) and the Masonry Arch (Ottawa 2017, Miami 2019, and DC 2021).

This year, the competition returns to the Masonry Arch. PETC looks forward to your submissions!

2023 The Masonry Arch

APT Preservation Engineering Technical Committee Student Design-Build Competition

1 Introduction

Conservation of masonry structures is a multi-billion-dollar industry in North America, with an ever-growing demand for qualified and capable designers and trades people. Structural arches have been used in construction for centuries to span openings while adding significant heritage value to a masonry structure.

This year, the Association for Preservation Technology (APT) Preservation Engineering Technical Committee (PETC) Student Design-Build Competition will focus on masonry design and conservation by highlighting the intricacies of masonry arch construction and the technologies used for their preservation.

Team will be tasked to research, design, and build a masonry arch to understand their design and preservation principles which allow these structures to withstand the test of time.

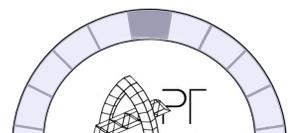
1.1 Competition Objectives

The key objectives of this competition include:

1. Expose students to the fundamentals of researching and analyzing a historic masonry arch.
2. Expose students to the materials common in masonry construction and preservation by providing a hands-on experience.
3. Introduce students to preservation engineering fundamentals, using a real structure as a case study.
4. Promote "out of the box" learning and problem solving.
5. Promote interaction between students and APT members through mentoring during the on-campus work and networking during conference finals.
6. Expose students to real project experience elements by understanding logistics, stakeholders' interactions, project budgeting, and constructability constraints.

1.2 Desired Learning Outcomes

1. Understand the value of multi-disciplinary teams
2. Learn to manage a team
3. Build networks to engage external professionals
4. Understand the basics of traditional masonry design and construction
5. Transfer design to physical construction
6. Design and execute a laboratory testing procedure
7. Learn from conference presentations and other 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 2023 APT Conference, and will include team presentations of research, an on-site build competition, and answering preservation challenges in front of the APT community live (in-person or virtually) at the conference. *Refer to the Technical Specifications and Appendices for details.*

- Phase 1
 - Notice of Participation
 - Masonry Structure (Arch) Selection and Reporting
- Phase 2 – On-Campus Report, Design-Build, and Videos
 - Home-campus Masonry Arch Build and Videos
 - Report covering Historic Research and Design Review, Structural Analysis, and Conservation Plan
- Phase 3 – Finals
 - Present and Display Posters at APT Conference
 - Conference “Dry Stack” Arch Build
 - Answer Preservation Problems

1.4 Conference Schedule

APT’s Annual Conference is scheduled to be held in Seattle, Washington from **October 9 – 15**. Phase 3 of the Student Design-Build Competition will occur during the conference, and PETC will communicate the specific dates and schedule in mid-2023 once the full conference agenda is established. The Phase 3 Finals activities will generally include:

- Presentation of Poster and Phase 2 on-campus build videos to the conference audience
- Teams attend student workshops, with presentations by industry professionals
- Preservation Problems are assigned and worked on by teams during the conference to provide further learning and networking opportunities
- Team dinner and/or other social events
- Teams attend conference paper sessions
- Teams build and test their dry stack masonry arch structures during the conference
- Announcement of winners at the APT Annual Awards Ceremony

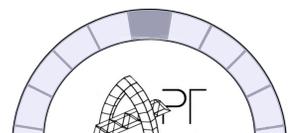
Note that APT PETC is assuming that the conference will be held in-person and is planning accordingly. Accommodations for a virtual competition will be arranged if circumstances dictate.

2 Introduction

2.1 Team Members

Teams are to be formed from post-secondary students from a single university (undergraduate or graduate program), college, or trade school. Teams are recommended to include engineering, architectural, and conservation/preservation students. Teams are to have a minimum of 4 people and a maximum of 6 people. Each team must name a Team Captain to liaise with PETC. An institution can have more than one team enter the competition.

If a team member must drop out of the competition after the Phase 1 team roster is submitted, the team is to notify PETC with a student substitution, if desired.



2.2 Faculty Advisors

Each team must have at least one Faculty Advisor, with more as desired. Their role is to advise students on technical and design issues, and to support and monitor the on-campus arch construction. Faculty Advisors also serve as a formal link to the institution for educational, construction, and/or safety matters.

2.3 Mentors

During Phase 2, PETC will assign teams to an APT-provided mentor who is typically a preservation practitioner in a related field. Out of respect for the mentors' time, PETC provides the following direction regarding team interactions with mentors:

- Teams will be student driven, and mentors will serve as sounding boards for ideas.
- Teams are expected to touch base with their mentor every week or two for discussion.
- Teams will be responsible for scheduling meetings and to be prepared for meetings with their mentors.

Each student team is encouraged to interact with their team mentor and other professionals throughout the competition. The goal of these interactions should be, in part, to provide opportunities for the students to gain constructive feedback on their methodology and craft at critical steps throughout the competition. The teams are encouraged to self-assess their practice area strengths; determine where additional professional mentoring and guidance could be best served.

2.4 Contacts

The Team Captains should contact the PETC Competition Committee via email for any questions or support. Answers will be issued to all Team Captains, to ensure all teams receive the same information.

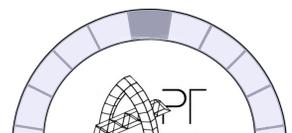
- Team contact for PETC competition communications: aptpetc@gmail.com

2.5 Media

The PETC Student Design-Build Competition has no restrictions on talking to the media, and teams are encouraged to promote their work. PETC asks that articles, photographs, quotes, etc. are professional and in good taste. PETC asks to be sent a copy of any published (written or digital) articles in which the competition is discussed.

Be sure to include **#APTPETC** on social media posts.

The PETC Conference Committee will provide updates to APT members and the greater preservation community about the competition and teams. Please share photos and updates of the Phase 2 process throughout your team's work for inclusion in APT's social media platforms, APT's email Communique, and in PETC's e-blasts!



Technical Specifications

3 Phase 1 – Notice of Participation and Arch Selection

There will be two submissions for this first phase: The Notice of Participation memo and the Arch selection narrative.

3.1 Notice of Participation

Each team is to provide a written Notice of Participation which shall be a 1-page submission with the following information:

- Name of the 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 number, Team Captain's surname, etc.) so as to distinguish them from other teams within the same institution.
- Name, email, and phone number of each team member
- Year and program of study of each team member
- Identification of Team Captain
- Name, email, and phone number of the team's Faculty Advisor(s)
- Desire to compete in Phase 3 **at the conference**

3.1.1 Arch Selection

Teams are to select an in-situ (real world) unreinforced masonry arch structure that the team can access for the required field inspection work. The arch may be an interior or exterior element of the existing structure. The selection of this arch is the keystone of the team's Phase 1 research on historic construction practices and will serve as the base model for the Phase 2 arch analysis, design, and build.

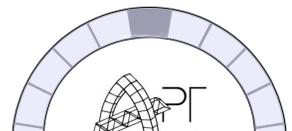
The Masonry Arch Selection submission is a 1-2-page report (double-spaced). The report is to include the following:

- Name and location of the selected structure
- Date of construction (approximate if not possible to find the exact date)
- General information on the arch's history and construction, including its historical significance or designations
- Original materials used in its construction
- References for the literature used to understand the history and construction of the structure
- References for the historic codes that will be used to analyze the structure
- Three to five images of the arch and surrounding structure (Note: The images are not included in the page length.)

If a team is unable to locate a masonry arch that meets the given criteria outlined above, a non-local arch may be selected, or the team can contact the PETC Competition Committee for alternatives.

Teams are to notify the PETC Competition Committee if they have not received notification on receipt of Phase 1 documents by the committee **within one week** of their submission to ensure transmittal of the information to PETC was successful.

Once the team submissions are received, the PETC Competition Committee will provide feedback and/or approval of each team's submission. Teams should prepare to respond promptly to any feedback provided by



the Competition Committee's questions during the review period. PETC will notify the teams that will move to Phase 2.

4 Phase 2 – On-Campus Report, Design-Build, and Videos

Phase 2 consists of two components, (1) a report on the team's arch selected in Phase 1; and (2); a design-build of scale masonry arch at their home campus.

4.1 Report

The Phase 2 report assesses the arch selected in Phase 1 and consists of the four components described:

- Background research and Historic Significance
- Structural analysis
- Preservation (conservation) plan
- Appendices

See Appendix A for specific report format requirements and Appendix C for Scoring Criteria

4.1.1 Historic Research and Design Review

In the first part of the report, teams will build upon the information presented in their Phase 1 Arch Selection narrative and prepare a more detailed report including:

- Date of construction and architect (if known)
- The significance of the selected structure, including its architectural, cultural/technological significance. Historic literature and reference materials should be used as a guide.
- The materials used in construction, identification of the original material source and their composition, etc.
- Identify and describe the structural type of the arch
- Archival or current photos/drawings.

4.1.2 Structural Analysis

The second part of the report demonstrates an understanding of the structural behavior of the selected arch. Teams will assess the structural arch by utilizing methods and principles likely used in its original design and construction. The items within the following clauses are to be included in the report:

4.1.2.1 Define Relevant Loads and Assumptions

Teams are to identify the relevant loads or conditions used in the evaluation, as well as any load combinations (if applicable). Discussion may include:

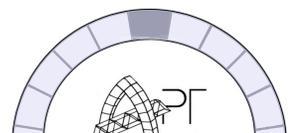
- What loads have been selected and why?
- Were any loads intentionally not evaluated?
- Is any specialized load evaluation required?

Teams are also to describe any assumptions made in their analysis regarding material properties, boundary conditions, limitations etc.

4.1.2.2 Evaluate Performance

Teams will evaluate the arch's performance and possible failure mechanisms. Teams shall undertake their evaluation using any **two** of the following approaches:

- Empirical Design (Classical Approaches)
- Nineteenth Century Analytical Models (Graphic Statics or Similar)



- Contemporary Structural Engineering Analytical Software

Teams must justify why at least one of the selected approaches would provide a safe analysis and comment on any limitations of the selected analysis method.

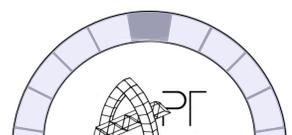
The findings from the structural evaluation of the arch shall be discussed and may include the following discussion points:

- *What is the ultimate load capacity of the arch? Is the arch able to resist the applied loads?*
- *What are the general failure mechanisms of arches?*
- *What are the visible signs that an arch has become over-stressed? Are there any signs that your team's selected "real world" arch is over-stressed?*
- *What structural interventions would you recommend to address any structural deficiencies? Are there any interventions visible on the arch which correspond to your analysis?*
- Comment on how some of your assumptions may impact the capacity or failure mechanisms of your arch.
- Other noteworthy observations from your analysis.

4.1.3 Preservation (Conservation) Plan

The final part of the report is to provide a preservation (conservation) plan for the masonry structure over the next 25+ years.

The built environment is subject to external forces that often wreak havoc on the condition, materials, and structural integrity of historic structures. As preservationists, it is our responsibility to assess the condition and provide guidelines for owners on how to best conserve and maintain their assets.



Building pathology refers to the study of decay, deterioration, and defects of a building material or assembly. Deterioration can be caused by natural forces such as water and wind erosion, poor maintenance, or an inherent vice in the building design. Understanding this science is important for maintaining a structure's health and prolonging its service life. This involves identifying the root causes of decay and prescribing appropriate treatments or repairs.

Teams are to conduct a visual survey and identify three pathological conditions with their arch and/or surrounding masonry. For each condition include the following:

- Name of the pathological condition
- Location on the building/structure
- Cause of the pathological condition
- A judgment on the severity of the pathological condition: Is it in good, fair, or poor condition? Is it urgent to fix, or can be fixed in the short or long-term?
- Proposed repair, treatment, or monitoring program for the condition
- One photo demonstrating the condition

Pathological conditions may fall under the umbrella of structural issues, moisture issues, materiality, aesthetics, and issues related to maintenance. The three pathological conditions must impact the masonry directly (e.g. cracked stone, displacement) or indirectly (e.g. poor water-shedding). Pathological conditions which only impact non-masonry elements such as windows, doors, etc. are not allowed.

4.1.4 Report Appendix

The report appendix does not count toward the report's word count or illustration limits, and shall include the following:

- Supplementary calculations from arch analysis (refer to Section 4.1.2)
- Mortar mix specifications including constituent ingredients (type and manufacturer), mix ratios, and mixing procedure (Section 4.2.1.2)
- Demonstration of dimensional compliance of the arch design-build (Section 4.2.2.1 and Figure 2)
- Construction and Safety Protocol (Section 4.2.5)
- Photos and a description of the monitoring set-up for loading
- Table of the measured movements/deflections at each load increment (Section 4.2.6)

4.2 Structural Arch Design-Build

Teams are to design an original structural masonry arch out of any masonry material in accordance with competition specifications. Teams will build and load-test their arch at their home campus. Videos must be submitted for both the build and the load testing.

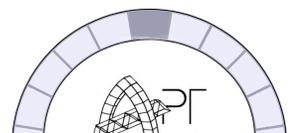
4.2.1 Material Requirements

4.2.1.1 Masonry Units

- Teams can select any type of masonry unit, including, but not limited to, brick, stone, and terracotta.
- Masonry units are to be joined with plane flat surfaces. No interlocking of masonry units beyond standard keying is allowed. No mortise and tenon, tongue and groove, and/or dowel type engagements are allowed.

4.2.1.2 Mortar

- Teams are to develop the mortar mix based upon research of historic masonry practice. Pre-bagged or pre-mixed mortar is not permitted.



- Mortar should be appropriate for historic structures. Mortar should have no, or a practically minimal, Portland cement content. Teams using Portland cement should provide their rationale. No mortar admixtures or bonding agents are permitted.
- Mortar mix is to be recorded and documented in the report.
- Mortar cure time and procedures shall be considered as part of the mortar mix design. Record curing procedures and cure time in the report appendix.

4.2.1.3 False Work

- Teams may use any material(s) to construct the arch false work.

4.2.2 Assembly Requirements

4.2.2.1 Overall Arch Requirements

Refer to Figure 1 for assembly requirements. Deductions from score will be made for violations.

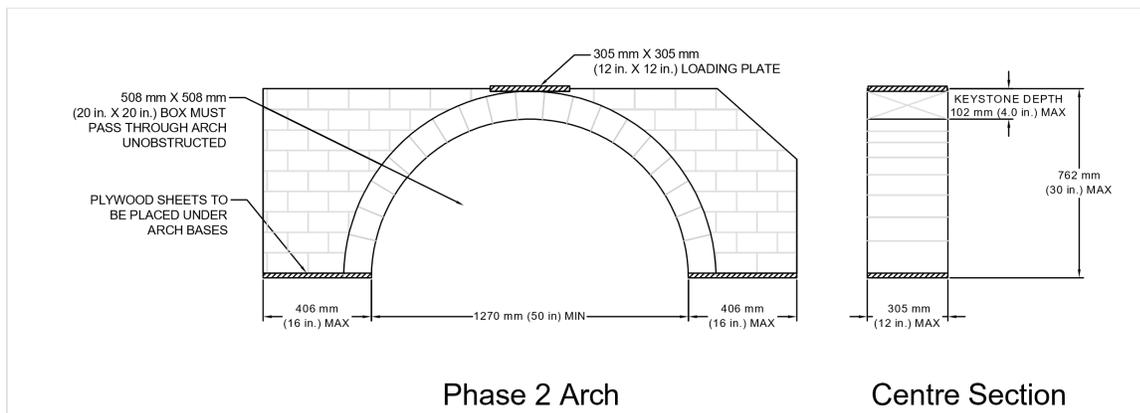


Figure 1: Sketch of the Phase 2 Arch dimensional requirements and test set-up. Diagram illustrates the dimensional and testing requirements; individual team arches do not need to look identical to the arch shown.

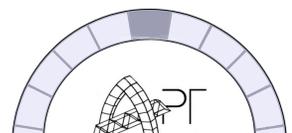
4.2.2.2 Base Locations

The base of either side of the arch must fit inside two squares that are 16 inches by 16 inches (406 mm x 406 mm), with a minimum 50 inches (1270 mm) of clear space between the squares. The squares cannot be closer together or further apart.

Each base is to be built atop two separate plywood sheets, with no mechanical attachment between the two sheets or the ground during testing. The plywood should be exterior grade, A-Grade or B-Grade.

4.2.2.3 Build Surface

The arch is to be built on a flat, smooth, and level surface, preferably an interior concrete floor slab or exterior concrete paving slab. No obstructions (shear engagement) that restrain outward movement on the build surfaces are allowed. Encountering any obstructions in the surroundings during testing will be considered as an arch failure.



4.2.3 Construction

4.2.3.1 Protocol

Teams are to document the protocol they use for arch construction and assembly, including safety protocols approved by the Faculty Advisor. This protocol is to be provided in the report appendix and showcased in a video recording of the build (see Appendix C for video requirements).

4.2.3.2 Safety and Stability

Teams are to ensure all work is done safely following protocols approved by their Faculty Advisor. The following shall apply:

- All team members must wear proper Personal Protective Equipment (PPE), including steel toe boots, gloves, hard hats, and safety glasses.
- No work can be done by any team member without supervision by another team member.
- All team members must follow Workplace Hazardous Materials Information System (WHMIS) or Occupational Safety and Health Administration (OSHA) guidelines for safety and receive any supplemental lab or safety training required by their institution.

The stability of the arch during construction must be monitored to ensure no risk is posed to people or surrounding equipment.

4.2.4 Testing Requirements

4.2.4.1 Overview

Teams are to have loading protocols established in writing, and all members are to be familiar with required procedures. Teams are to record a video beginning with a review of all safety measures taken before loading. While recording, teams are to load the arch to failure or the greatest load that can be safely applied, whichever is reached first. See Appendix C for Video Requirements.

Phase 2 evaluation and judging will consider situations when an arch cannot reach failure safely after a team takes reasonable measures to find safe testing approaches.

4.2.5 Safety and Supervision

At any point a team member, Team Captain, or Faculty Advisor can halt the testing if any aspect of the testing is unsafe.

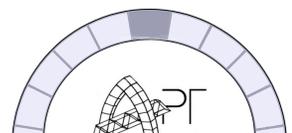
4.2.5.1 Individual Responsibilities

All team members are to be aware of the safety risks and abide by the safety plans approved by their Faculty Advisor. Plans should include emergency contingency plans. Personal protective equipment (PPE), inclusive of eye protection, steel toe boots, hard hats and gloves shall be worn during the build. Points will be deducted for missing PPE.

4.2.5.2 Team Captain

The Team Captain will act as a visual observer during the arch testing, watching all aspects of the loading procedures and intervening in the case of unsafe execution.

If a safety concern is reported and the testing is halted, the Team Captain can either direct how the safety concern is to be addressed or refer to the Faculty Advisor.



4.2.5.3 Faculty Advisor

The Faculty Advisor is to be present during testing of the arch. In the case of an unsafe condition that has not been identified by team members or team captain, the Faculty Advisor can call a halt to the testing. If the testing is halted by the Faculty Advisor, the testing shall record the load at that point as the failure load. This intervention is intended to ensure team safety.

4.2.6 Loading the Arch

4.2.6.1 Load Procedure

Testing is to be performed by loading a 12-inch x 12-inch x 3/4-inch-thick (305 mm x 305 mm x 19 mm) plywood square placed on the top of the arch, centered.

Teams can select their own loading plans and types of weights. Based on accessibility to load testing equipment, PETC understands that multiple loading approaches may be employed. All approaches will be evaluated equally.

4.2.6.2 Load Monitoring and Measurements

Teams are to monitor the following movements during loading:

- Load increments applied to the arch, and total load placed on the arch at each increment. The load amount should be recorded on a card, whiteboard, or tablet that is clearly visible in the video.
- Lateral movements at the top of the arch
- Outward movements of each arch footing
- Vertical deflection at the top of the arch
- Loads applied to the arch

Teams can take measurements manually or digitally. The details of the procedure and measurements are to be documented clearly in the report appendix, with measurements reported to the nearest 1/16th of an inch (1.6 millimeter).

4.2.6.3 Failure Load

The failure load is to be identified as the last recorded load at which the arch sustained the load for 10 seconds with no visible movement occurring. In the case that the arch failed while load was increasing/being placed on the arch, the failure load is to be identified as the load on the arch 15 seconds prior to failure.

4.2.7 Compliance

Teams are to provide photographic and written evidence of compliance with the mortar, dimensional, and measurement requirements in the appendix to the Phase 2 Report.

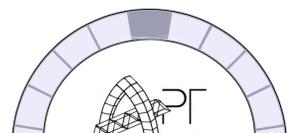




Figure 2: Example of a photo to be included in the report appendix to demonstrate dimensional compliance for the arch height.

4.2.8 Videos

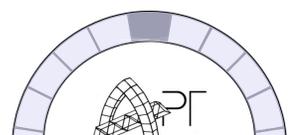
The purpose of recording the arch build and loading with videos is to demonstrate and document the working procedure, construction approach and testing procedure, and to provide a visual for the Judges and conference attendees in Phase 3.

The video shall include:

- A time-lapse of the arch construction
- A feature showing the mortar mixing procedure
- Load testing of the arch including the load amount being applied

The suggested length of each video is about 4 - 7 minutes, and students are encouraged to time-lapse the repetitive and/or irrelevant portions of the work (particularly the build). Videos longer than about 7 minutes will be edited by PETC for brevity.

One video file is required to show the arch construction, and one separate video file is required to show the testing. Refer to Appendix C for video requirements.



5 Phase 3 – Finals

As many as five teams will be selected to take part in the competition finals as part of the APT’s Annual Conference. The finals provide the teams with an opportunity to meet and network with the Competition Judges, PETC members, and other conference attendees. The finals are also an opportunity for teams to demonstrate their presentation, communication, and teamwork skills.

5.1 Posters

The Phase 3 competition finalists are to prepare a poster for presentation during the APT conference. The poster will act as a “guided tour” through the team’s project and should be a condensed version of the Phase 2 report. The poster should follow the general guidelines given in Appendix B.

5.2 Presentations

The team will give a presentation of their Phase 2 project to a panel of judges at the conference. Presentation requirements include:

- **Maximum length** - 10 minutes
- **Format** - PowerPoint (or similar) presentation slides with verbal presentation by student team members. Each student is to introduce themselves and speak for at least 1 minute.
- **Content** – The presentation should summarize information from the Phase 2 report (historic research and structural analysis) and the design-build and testing process.
- **Questions** - After each presentation, the team will have approximately 10 minutes for a live Q&A session with the judges and conference attendees.
- **Judging Criteria** - The presentations will be judged on both content and quality/professionalism. All team members are encouraged to participate in the presentation and the Q&A session, and this will factor into scoring.

5.3 Dry Stack Arch Design-Build

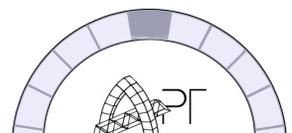
Each team will participate in a dry stack arch design-build, which will occur under timed conditions at the conference, with viewing open to conference attendees.

Teams are to ensure all requirements and intent of the specifications are met. The Phase 3 arch may be inspired by their Phase 2 work, but does not need to be a replica. Scoring criteria and penalties for violations can be found in Appendix D.3.

5.3.1 Masonry Units

The masonry units can be made from **any** material, so long as the material and the units meet the following requirements:

1. Units must be of ‘regular’ shape commonly seen in masonry construction, with a maximum of six-sides and no convex shapes (L-shapes, T-shapes, U-shapes). Units are to be joined with plane flat surfaces. No mortise and tenon, tongue and groove, and/or dowel type engagements are allowed.
2. No mortar, adhesive, magnetic, or mechanical attachments of units are allowed. Rubber or rubber-like materials will be deemed adhesive. A unit will be deemed adhesive if a piece of paper can hold to the underside of a unit.
3. The surface of the units should be less rough to the touch than 80 grit sandpaper. Competition judges will be the evaluators if questions arise.
4. All units must be solid and safe for use in a hotel/conference environment.
5. Units cannot be made of a material that could easily shatter into pieces from improper handling, such as glass.



6. All units must be clean and leave no mess at the competition site.
7. The arch system must be composed of no fewer than 31 units. The largest unit must be no more than 3 times the size of the smallest.
8. The maximum density for the material used in the arch is 125 lb/ft³ (2000 kg/m³).

5.3.2 Material Weight and Volume Restrictions

The competition finals are designed to provide some practical allowances for teams traveling various distances. Therefore, restrictions have been placed on material allowed:

The maximum weight of the arch is 200 lb (92 kg).

1. The maximum weight of the arch is 200 lb (92 kg).
2. All units to be used in the arch must fit inside 4 cases (boxes/containers/suitcases) that would each be accepted as a checked-bag item. That is, maximum dimensions of 62 inches (1580 mm) (length + width + height) and maximum weight of 50 lb (23 kg). These 4 cases may contain materials for falsework and tools for use during erection, so long as the size and weight limits are met.
3. An additional 2 cases containing only falsework and tools to be used during the erection of the arch and that would each be accepted as airline check-in items are allowed; that is, maximum dimensions of 62 inches (1580) mm (length + width + height) and maximum weight of 50 lb (23 kg).

Before construction, each of the cases used by the teams will be weighed and recorded. Except for PPE and materials provided by APT, nothing to be used for construction can be outside the cases. The weight of the arch material will be included in the final judging score.

5.3.3 Assembly Requirements

5.3.3.1 Overall Arch Requirements

The Phase 3 dry stack arch is to meet the requirements illustrated in Figure 3:

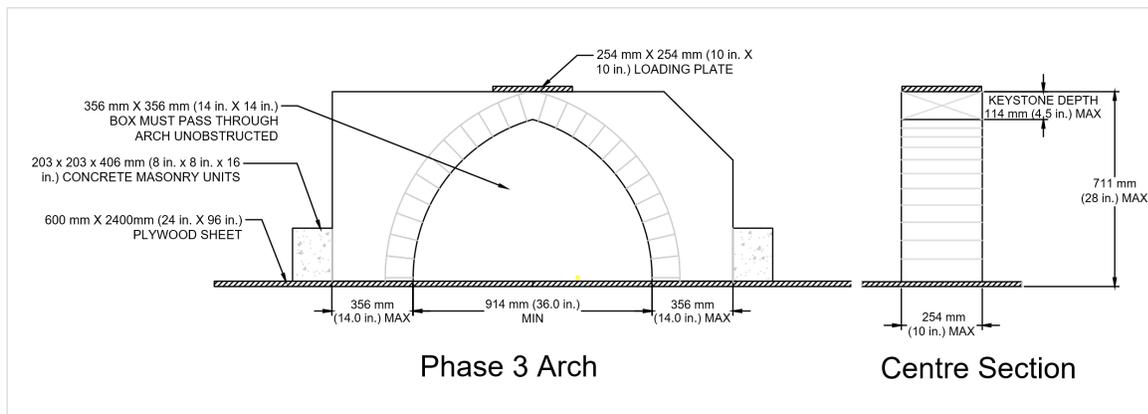
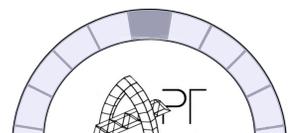


Figure 3: Sketch of the Phase 3 arch dimensional requirements and test set-up. Diagram is representative of dimensional and testing requirements; individual team arches do not need to look identical to the arch shown.

5.3.3.2 Testing

Teams are to clearly mark off the construction area surrounding their arch. Protective blankets for the build area will be provided by APT.



A 24-inch x 48-inch (610mm X 1219 mm) sheet of plywood will be placed on the protective blankets. This is the surface on which the arch will be built

Each team will have two 8-inch x 8-inch x 16 inch (203 x 203 x 406 mm) concrete masonry units provided to them by the competition. These concrete blocks are to be placed on the plywood sheets against the arch side. The arch cannot be under the blocks or on top of the blocks.

5.3.4 Construction and Testing of the Dry Stack Arch

5.3.4.1 Construction

All conference construction work will be carried out under the supervision of PETC.

1. Prior to construction, all materials should be inside their respective suitcases, with the construction area marked out and blankets down.
2. All team members to be involved with the arch construction and loading are to wear gloves, safety glasses, and steel toed boots.
3. Construction will begin upon the organizer's announcement. All builds will be timed.
4. Teams are responsible to ensure the safe erection of the arch.
5. All masonry units are to be put in place one at a time, as is done in conventional practice. No placing of units in groups or tilt-up construction will be allowed.
6. If competition organizers or judges feel that a team's construction practices are unsafe, they will request that the team halt construction. Teams will be allowed appeal to the judging panel for any requested stop; however, the time will continue during this process. If the appeal finds that safety had been adequately considered, then teams may continue the built. If the construction is deemed unsafe, the team must disassemble and reassemble or receive last place in the conference build.
7. When all units have been placed, the timer stops.

5.3.4.2 Testing

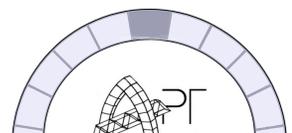
1. Prior to loading, judges will ask each team to discuss the expected failure mode of their arch.
2. Testing will be performed by loading the arches with pre-defined masses up to a maximum of 220 lb [100 kg].
3. Loading will be done by individuals wearing the required personal protective equipment.
4. No lateral loads will be applied.
5. Deflections will not be measured or judged.
6. All testing will be done under the direction of PETC and the Judges.
7. The arch will be deemed to have failed if more than one unit has fallen, or, the arch collapses within 30 seconds of loading.

The arches will be left in place for viewing by the conference attendees immediately after loading; however, teams are responsible for clean-up and removal of their arches by the required date/time defined by PETC or the APT Conference Committee.

5.4 Preservation Problems

Teams will select a pair of preservation problems during the conference (two total questions). The selection of problem pairs will be done as follows:

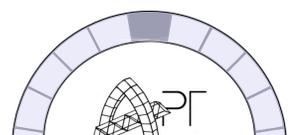
1. The PETC Competition Committee will show all problem pairs to all teams.
2. Teams will select their problems in order, based upon their ranking from Phase 2.



Teams are encouraged to engage conference attendees to discuss information to develop solutions for their selected preservation problems.

Teams will have until judging starts to develop their solutions. Each team will give an oral presentation of their solutions to the preservation problems. All team members must participate. Presentations are to be 15 minutes, with an additional 15 minutes allowed for questions. Visual solutions (sketches, etc.) to show during the Presentation Problem presentation are encouraged.

Once the presentations are concluded, the judges will deliberate, tally up their judging cards, and provide some constructive feedback to the teams.



Appendix A Report Format

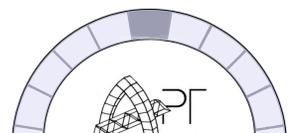
The report should clearly identify the following:

- Project Title
- Name of institution, individual team members, Faculty Advisor(s), and mentors
- References (educational references, literature, etc.)

The report should be formatted as per below:

- Word count: approximately 4000
- Page size: Letter (8-1/2 inches x 11 inches), Portrait orientation
- Font sizes:
 - Title/Headings: Calibri, size 14
 - Subheadings: Calibri, size 11
 - Body: Calibri, size 11
- Alignment: Left aligned
- Standard Margins and Headings
- Six to ten labeled 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, 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.



Appendix B Poster Content

The poster should clearly identify the following:

- Project Title
- Name and insignia of institution
- Names of team members
- Acknowledgements: Names of Faculty Advisor(s), APT mentors, 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 arch that was studied and analysed in Phase 2, including clear identification of the following:

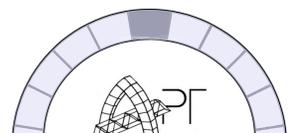
- Name of structure
- Location of the structure
- Material makeup (masonry type, mortar type, etc.)
- Date of construction and construction methods

Most of the poster should present the Phase 2 structural analysis findings. Provide 4-10 photos, sketches, figures, or charts to convey findings. Provide a brief statement of the Preservation Plan from the report.

B.1 Poster Format

- Poster Size: 36 inches (91.4 cm) high x 48 inches (121.9 cm) wide, Landscape orientation
 - Printing, transportation, and set-up of the poster is the responsibility of the team. Teams are to supply poster board for mounting their posters on an easel or table provided by APT.
- Font: Readable font with sizes below:
 - Title/Headings: size 130 (minimum)
 - Subheadings: size 54 (minimum)
 - Body: 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. Indicate citation at end of each caption (if not produced by the team). Images should be referenced within the narration 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 institutions have examples of research poster presentation templates and tips are available online.

Poster Tip: Keep presented information simple. This poster will be read by judges and conference attendees who will want to know only the most important aspects of the project. The viewers should be able to review the poster within 5 minutes.



Appendix C Video Requirements

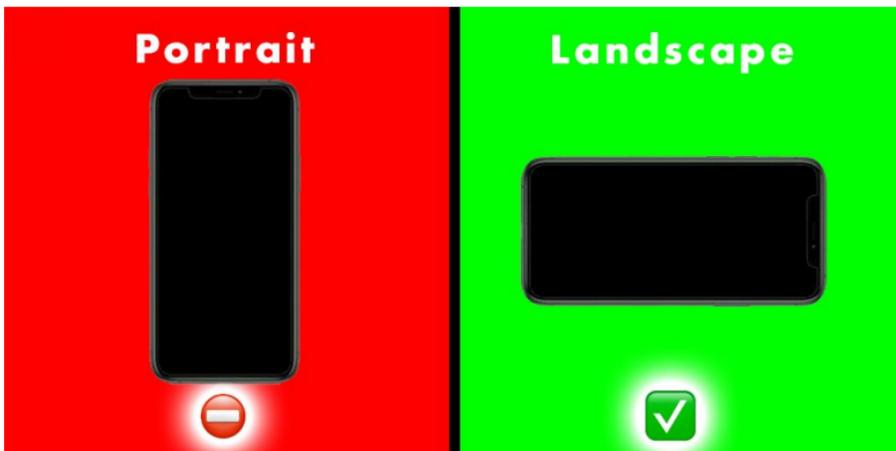
Each team is to submit two videos that record their Phase 2 on-campus build and testing:

- **Video 1:** captures your team building the arch and verifies compliance to the Phase 2 specifications. This video documents the team's working procedures, materials (including mortar mixing), construction approach, sequence of laying the masonry units and building up the arch, and the dimensions and unique features of the team's arch.
- **Video 2:** captures the safety procedures, loading sequence, displacements/deflections at each loading sequence, and, if relevant, the failure of the team's arch. This video is to have a timer placed within the view of the camera. Narration or captions may be used for clarity.

The videos provide visuals for the Competition Judges and conference attendees. The Phase 2 videos by the Finalist Teams that move to Phase 3 will be uploaded to the online conference platform.

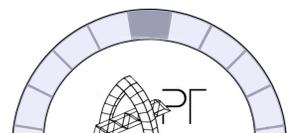
Video Requirements:

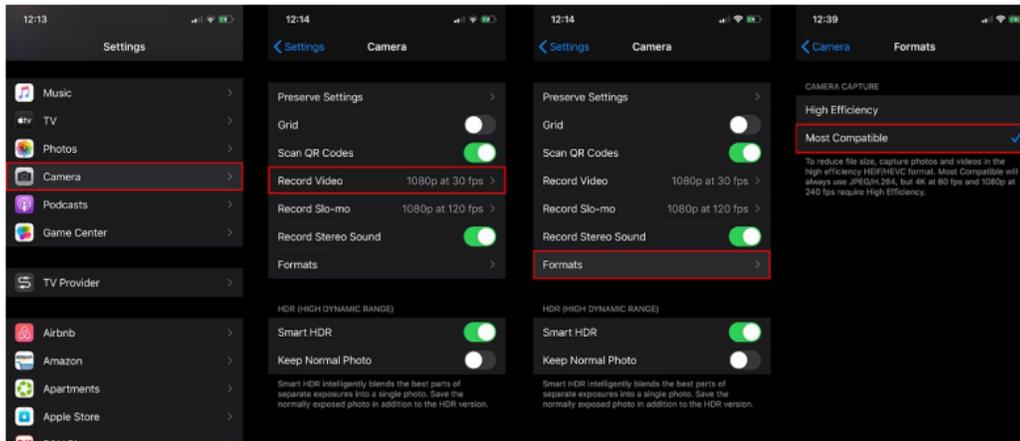
- Record videos in in .MOV or .MP4 file type
- Record videos using landscape orientation



Portrait vs. Landscape orientation

- Android phone/tablets: Adjust camera settings to 1080p resolution.
- iPhone/iPad users:
 1. Select "Camera" settings
 2. Select "Record Video" settings and select "1080p at 30fps"
 3. Select "Formats"
 4. Select "Most Compatible"



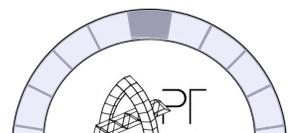


Step 2 Step 3 Step 4 Step 5

iPhone Camera Settings Navigation

- If the team needs to record the Arch Build using more than one MOV/MP4 file, then each file must be named using the following naming convention:
“Institution Name_Build_File #”, with the # being sequentially ordered files 1, 2, 3, etc.
- If the team needs to record the Arch Load Test using more than one MOV/MP4 file, then each file must be named using the following naming convention:
- *“Institution Name_Load_File #”*, with the # being sequentially ordered files 1, 2, 3, etc.

PETC will provide a link to a shared folder on Google Drive to upload your files. The link will be provided prior to the Phase 2 submission deadline.



Appendix D Judging Criteria

Submissions will be reviewed by the PETC Competition Committee and the Competition Judges. The Committee and Judges will act in good faith to conduct objective and fair evaluations to the greatest extent possible. Final scoring will be at the Judges' discretion. Numeric score or weighting may be changed by PETC; if so, PETC will notify all teams in writing in advance of the relevant Phase submission deadline.

Teams must pass Phase 1 to proceed to Phase 2. Teams will be notified via email of their Phase 1 acceptance. Phase 2 submissions are evaluated to determine the finalist teams for Phase 3. Phase 2 ranking also determines the order of Preservation Problem selection during Phase 3.

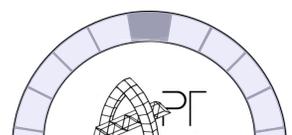
During the APT Conference, a group of selected professionals from different sectors of the design and construction industry will form the Judges' panel. The Judges will evaluate the Phase 3 posters, Preservation Problems, and the conference build.

D.1 Phase 1 Scoring

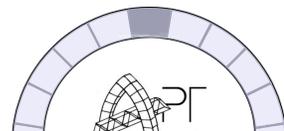
Deliverable	Criteria	Score
Notice of Participation	Submission includes all required team and team member information	Pass/Fail
Masonry Arch Selection	Submission narrative document includes all required information, including references and images	Pass/Fail

D.2 Phase 2 Scoring

Deliverable	Criteria	Total Possible Score
Report	Historic Research and Design Review <ul style="list-style-type: none">- All required information in Section 4.1.1 is included- Points credited for quality of report content- Points credited for quality of report format	10

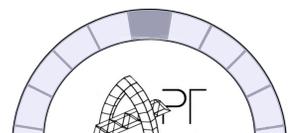


Deliverable	Criteria	Total Possible Score
	Structural Analysis <ul style="list-style-type: none"> - Relevant loads and assumptions documented as discussed in Section 4.1.2.1 - Loads, load cases, and assumptions are documented - Two analysis methods implemented, each analysis method is clearly described, and each analysis method provides required calculations and/or graphics - Discussion of structural analysis findings as mentioned in Section 4.1.2.2 - Supplemental calculations and additional analysis are presented in Appendix 	25
	Preservation Plan <ul style="list-style-type: none"> - Discussion is complete regarding materials, deterioration, and proposed repair 	15
<i>Design-Build</i>	Design <ul style="list-style-type: none"> - Design approach - Aesthetics of the completed arch 	20
	Construction <ul style="list-style-type: none"> - All materials are documented - All dimensions meet specifications - All required information from Section 4.1.4 included in Appendix 	20
	Loading <ul style="list-style-type: none"> - All loading procedures meet specifications - All load increments and deflections/displacements are documented 	5
	<i>Protocol Deductions</i> <ul style="list-style-type: none"> - Deduct points for safety/PPE violations - Deduct points for use of non-masonry materials (except for falsework) - Deduct points for use of admixtures, bonding agents, etc. - Deduct points for dimensional violations - Deduct points for loading violations 	n/a
	Build and Load Videos	5
TOTAL POSSIBLE SCORE		100



D.3 Phase 3 Scoring

Deliverable	Criteria	Total Points Possible
Poster	<ul style="list-style-type: none"> - Digital and/or paper formats conform to the specification. - All required content is provided on the poster. - Posters are legible and readable. - Content is engaging and describes the team’s project and unique features. 	10
Presentation	<ul style="list-style-type: none"> - Each team member presents a portion of their Phase 2 research, arch construction, and arch loading. - Points will be credited for clarity, relevance, interest, and staying within the time limit. - Points will be deducted for going over the time limit. 	20
Dry Stack Arch Build and Loading	Speed of Build: <ul style="list-style-type: none"> - Quickest build: 10/10 - Second quickest build: 8/10 - Third quickest build: 6/10 - Fourth quickest build: 4/10 - Fifth quickest build: 2/10 - Any team that has safety issues: 0/5 	10
	Strength: <ul style="list-style-type: none"> - Reached and sustained load of 220 lb (100 kg) 15/15 - Reached and sustained load of 200 lb (90 kg) 13/15 - Reached and sustained load of 175 lb (80 kg) 11/15 - Reached and sustained load of 155 lb (70 kg) 9/15 - Reached and sustained load of 130 lb (60 kg) 7/15 - Reached and sustained load of 110 lb (50 kg) 5/15 - Reached and sustained load of 55 lb (25 kg) 3/15 - Sustains self-weight 2/15 - Does not sustain self-weight or incomplete 0/15 	15
	Weight of materials used (arch + falsework + tools + cases): <ul style="list-style-type: none"> - Lightest total weight 10/10 - 2nd lightest weight 8/10 - 3rd lightest weight 6/10 - 4th lightest weight 4/10 - 5th lightest weight 2/10 - Exceed maximum allowed weight: 0/10 	15



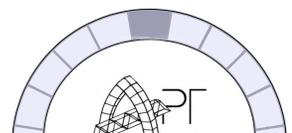
Deliverable	Criteria	Total Points Possible
	Penalties: <ul style="list-style-type: none"> - Safety/PPE violations (-5 points) - Dimensional violations under Section 5.3.1, 5.3.2 or 5.3.3 (-3 points for each type of violation) - Material violation in Section 5.3.1 or 5.3.2 (-5 points) - Judges may administer additional penalties for safety and compliance violations at their discretion 	
Preservation Problems	- Points will be awarded for correct responses and thoroughness of responses. Credit will also be given for connecting a response to a real-world situation, such as elements researched or observed from their selected building/arch.	30
PHASE 3 TOTAL		100

FINAL SCORE FOR PHASE 3 FINALISTS
Final Score = (Phase 2 Score + Phase 3 Judges Score) / 2

D.4 Final Scoring

The final score for Phase 3 finalists is calculated as follows:

$$Final\ Score = \frac{1}{3}(Phase\ 2\ Score) + \frac{2}{3}(Phase\ 3\ Score)$$



Appendix E Financial

PETC will pay the APT conference registration fee (non-ticketed events) for up to 6 students, and up to 3 hotel rooms, for each team selected to attend the Phase 3 Finals. Details will be provided to Finalist teams. All other expenses (travel, extended stay, additional lodging, food, competition materials, etc.) are the responsibility of the teams. The PETC will not financially support any Faculty Advisors or mentors.

Each team is to 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 to ask for support, and while doing so, make connections that may be of future value. The PETC Competition Committee can provide a general list of potential sponsors to 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.).

Each team is to develop their own financial plans, including all anticipated costs and anticipated funds raised, to be included in the Phase 2 submission if the team intends to vie for travel to the APT Conference. The Competition Committee will use these plans to help teams that may be short of travel funds.

Teams should make their own travel arrangements and are responsible for travel visa application and costs if required. APT may be able to support or sponsor a visa; please contact the PETC Competition Committee if this is needed.

