

PCI Prestress Mini-Beam Gulf Coast Competition Rules

Overview

The Prestressed Mini-Beam Competition focuses on constructing precast, prestressed concrete beams, a method characterized by primary reinforcement using seven wire-wrapped steel cables pre-tensioned before concrete casting, thereby achieving prestressing. In this competition, participants substitute traditional steel cables with tensioned bass guitar strings. Each team is tasked with designing and fabricating beam cross-sections adhering to specific dimensions and volumes, followed by casting the concrete beams.

Each constructed beam undergoes testing the day after casting to determine its ultimate load capacity. Testing employs a simply supported center-point loading method to assess structural performance under load. Teams are evaluated not only on the strength of their beams but also on the accuracy of their design calculations. Evaluation criteria include calculating the percentage difference between the ultimate load achieved during testing and the load predicted through design calculations. This method ensures a comprehensive assessment of structural integrity and design accuracy in the competition.

Objective

Teams will use bass guitar strings as the prestressing force within a concrete beam. Each team will have control over the beam's ultimate shape (cross-section), but defining factors such as length, width, height of the formwork, and the amount of mortar material (.28 cf) that will be provided dictate the final product.

Teams are not limited by the number of students allowed to join the building team. However, only three (3) students are allowed to participate when loading the beam onto the testing apparatus. Each team should designate a team captain. Each school may have one team, and only one beam per school will be evaluated. (It is recommended that, at a minimum, three (3) students from each school participate in Day One activities (design and casting) to ensure completion of the beam within the allotted timeframe.)

Procedures

Teams will arrive at the designated competition location to calculate, design, build, and cast their mini-beam onsite at the competition. **Testing and scoring must be conducted within 24 hours of casting.** A compressive strength of the mortar mix of 200 psi will be used for initial

calculations. Two concrete test cylinders of the mortar mix will be cast and tested to determine the mix's compressive strength (psi) prior to the beam testing. The average compressive strength of the tested cylinders will be given to the teams at the start of the next day and used in their final calculations of estimated load capacity. The finalized calculations and schematic of the beam cross-section will need to be submitted to the judging team before any beams are tested.

Supplies Required

Teams are required to bring the following items for the competition:

- One standard tarp – at least 8' x 6' (optional)
- Paper, pen/pencils, calculators, Bass guitar tuning app (such as DaTuner in Google Play)
- Safety glasses and personal protective equipment (PPE)
- Teams are allowed to bring their own tools, but not materials to aid in building the form or beam

The Competition Committee (head judge, assistant judges, and helpers) will provide the following material:

- Wood casting form (inside dimensions: L=32", W=12", H=6")
- 4 packs of bass guitar strings – (each pack contains one each of the following diameters: 0.100", 0.080", 0.065", 0.045")
- 1 aluminum L bracket (12"x1"x1")
- 2 sheets (24"x24"x1") polystyrene foam – to create beam cross-sections
- 16 machine screws – for tuning/tensioning strings
- ½" x 3/16" x 12" aluminum bar
- Drywall screws – 1.25"
- Mortar mix – beam max volume to be 0.28 cf
- 5-gallon buckets – for mixing the mortar
- 2 mortar test cylinder molds
- Form release agent
- Duct Tape, Drills & bits, pliers, 3/8 "ratchet sets, mallets, hack saws, caulk, margin trowel, adjustable wrench, tape measures, wire cutters, nitrile gloves, utility knives, mallets
- Calculation and cross-section forms

Construction

The construction of beams, including casting, must be completed on the first day by 3:00 pm local time. Unless otherwise noted, beam construction will start at 8:00 am local time.

Only materials provided by the competition may be used for beam construction. Teams must use the guitar bass strings to act as the prestressing strands in the beam. The beams must conform to

the maximum depth, width, and length (32”) of the formwork provided. Depth & width can be smaller, but length cannot be shorter than the inside length of the form. Students may use various tools (measuring devices, guitar tuner app, etc.) at their discretion to aid in constructing the beam. The beam shall not be disturbed, touched, or handled after 3:00 PM local time. No additional materials will be given to the teams other than what was initially provided.

Constraints

1. The teams must only use the materials provided at the competition.
2. Beams must maintain the length of the formwork provided. Beams shorter than the provided formwork will be disqualified.
3. Other dimensional constraints:
 - a. Width – no greater than 12”
 - b. Height – no greater than 6”
 - c. Beam volume cannot exceed the .28 cf of mortar mix provided.
4. All casting, finishing, handling, etc. must be completed by 3:00 PM local time
5. Beam shall stand freely, without added support, on a flat surface
6. Beams shall be required to maintain a minimum of 1” bearing on each end during testing
7. The beam’s loading surface or top of the beam shall be constructed flat so it can be loaded uniformly during testing (flat top surface required)
8. The Competition Committee will dictate the water/cement ratio, which will be the same for all teams. Typically, this will be 72 oz. of water for the .28 cf of mortar mix. Teams will mix their own mortar. Note: concrete mix design knowledge is not required as the mortar mix is already an engineered material.

Loading

The beams shall be loaded at the center or midspan until forces are no longer increased. The judges will measure the beams and mark a centerline on the top of each beam prior to testing. The judges will visually determine when the ultimate load has been achieved or failure has occurred. One of the judges shall apply the loading force manually and consistently.

Report Requirements

Each team will submit their report to the judges right before beam testing. It is anticipated that the report will be written neatly by hand on the calculation and cross-section forms provided. The report must include:

1. Drawing of beam cross-section with dimensions and locations and sizes of each string used and total cross-sectional area (square feet - sf)

2. Calculation of total cubic feet (cf) volume of the beam (assuming length to be 32"). Total cubic feet should not exceed 0.28 cf.
3. Calculation of predicted ultimate loading in pounds based on a simply-supported center point loading and using mortar compressive strength (psi) from testing cylinder average.

Judging

Teams will be ranked in order of lowest overall score. Each team will be ranked in descending order for each of the 2 test categories (actual/ultimate load (in lbs.) at failure, and percentage difference between the predicted vs. actual ultimate load), and the combined two rankings are the final score. **The team with the lowest score at the end of the competition wins.** The tiebreaker shall be determined by the smaller percentage difference between the predicted vs. actual ultimate loading, with the predicted not higher than the actual ultimate load value.

FYI:

- Teams will need to be very cognizant of how to form beam cross-sections because wooden form and foam boards must be removed without damaging the beam.
- The teams will identify the location and orientation of the strings in their beam cross-section. They will use this information to drill holes in the wooden form at each end and thread the strings. Each string will be tightened to an appropriate tension using the provided machine screws (see diagram below). Each string has a diameter and a designed frequency - hertz (Hz) so when the string is plucked it gives the tone of the musical note if tightened appropriately. The students may achieve this by using a bass string tuning app on their phones (such as DaTuner) and measuring that the designated Hertz or note has been achieved by plucking the string.
- Tension for 34" Normal Bass Guitar strings.

E1 - .102 dia.	40.359 lbs.	41.203 Hz
A1 - .079 dia.	43.04 lbs.	54.99 Hz
D2 - .065 dia.	52.962 lbs.	73.416 Hz
G2 - .045 dia.	46.54 lbs.	97.99 Hz
- The actual string tension is unknown until it is in the form, tensioned, and tested; thus, the manufacturer's recommended string tensions above are given.
- Per the competition rules, each team is responsible for the quantity and location of strings. No additional strings will be given.
- Teams can use the following website to help determine the forces of each string:
www.stringtensioncalculator.com.
- Bearing at testing should be 1" in from each end. See the illustration below.
- Three judges will be involved with testing. One reads and records the gauge, one operates the testing machine, and one observes and determines failure.

- Testing shall be done with simply supported, center-point loading.

