PCI Engineering Student Design Competition

Applications due by March 15, 2010 • Results due by June 15, 2010

PROGRAM
The PCI Student Education Committee is inviting entries from students to participate in the Engineering Student Design Competition for the 2009-10 academic year. Each student team must work with a PCI Producer Member to build a Precast concrete beam which is 15 ft. long. The beams will be tested and prizes awarded for best performance in the stated areas. **Students must discuss both the structural design and the mix design for the beam.**

ELIGIBILITY
Any student enrolled in an Associate, Baccalaureate or Graduate Degree Program in any of the following areas is eligible:
- Civil Engineering (including all subdisciplines) or Technology
- Construction Engineering or Technology, Construction Management
- Architecture, Architectural Engineering or Technology
- Building Sciences or Technology

Students enrolled any time during the contest period are eligible.

STUDENT TEAMS
A student team of 3-4 members is optimal, but teams of any size may participate. Only one entry per team is permitted. Graduate and undergraduate students and/or students from different degree programs within a university/college may be on the same team.
PRODUCER MEMBER PARTICIPATION

Each team must work with a PCI Producer Member. A Producer Member may work with more than one team and may work with teams from different schools. There is no limit to the number of teams a given Producer Member may support. Producers who are members of PCI chapters, partners, affiliates or allied organizations meet this requirement.

A Producer Member is expected to provide: advice and expertise to aid the student teams, all materials, beam fabrication and beam transportation to the testing facility (or provide for testing at the plant). The actual design must be done by the students, but the faculty advisor and the producer member are encouraged assist in this phase. Students are expected to participate in the fabrication of beam to the extent deemed safe and practical by the Producer Member. If a team cannot find a Producer Member who will work with them or if there is no Producer Member within a reasonable driving distance, a team may obtain a waiver of this requirement from the Chair of the Student Education Committee or the PCI Staff Representative to the Student Education Committee.

FACULTY ADVISOR

Each team must have a faculty advisor. A single advisor may work with multiple teams. The advisor provides advice and assistance to the student teams. Advisors are expected to provide for and supervise testing of the beam.

GENERAL RULES

All entries must be accompanied by a report containing all the following elements in the order listed. Entries submitted with an insufficient report may be disqualified by the judges.

1) A cover page with the name of the school, the team members, the sponsoring producer member, the faculty advisor and the regional marketing director, as applicable. If a school submits more than one entry, the teams shall be numbered.

2) A completed summary form.

3) Certification that the calculations were performed before testing the beam. The calculations may be certified by the producer member, a regional director or a neutral third party.

4) A drawing of the cross section(s) and elevation of the beam with all reinforcement shown.

5) Provide a one page narrative about the concrete mix used, including proportions, measured unit weight, slump, air content and 28 day compressive and tensile strengths. A discussion of the reasoning for choosing the mix, any modifications to the mix and a discussion of how the chosen mix performed with respect to the student’s design requirements is required.

6) A one page discussion of the structural design. In addition, the design calculations along with a prediction of the cracking load, maximum applied load and a prediction of the deflection due to applied load at peak applied load shall be provided.

7) A narrative of not more than 8 pages (including any pictures) describing the beam fabrication and the testing of the beam. This must include the load/deflection graph showing peak load, maximum deflection and cracking load (from the bend over point).

8) A statement by the team members explaining what they learned from the contest.

9) A DVD of the test showing at least the highlights of the test and the failure. This is for verification purposes. The video shall contain a visible scale showing the beam deflection.
Mail application form to:

**Before February 1, 2010:**
Alex Morales • PCI Big Beam Contest
209 W. Jackson Blvd., Suite 500 • Chicago, IL 60606

**After February 1, 2010:**
Alex Morales • PCI Big Beam Contest
200 W Adams St., Ste 2100 • Chicago, IL 60606

Application forms are due by March 15, 2010.
**DEFINITIONS, SPECIFICATIONS, AND INTERPRETATIONS FOR THE BIG BEAM CONTEST**

For the standards listed below, contestants may use either the listed English unit standard or the equivalent metric standard.

<table>
<thead>
<tr>
<th>Category</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aggregates</strong></td>
<td>Shall meet ASTM C33 or ASTM C330 (Lightweight Aggregates)</td>
</tr>
<tr>
<td><strong>Chemical Admixtures</strong></td>
<td>Shall meet ASTM specifications D98, C494, C260, or C1017.</td>
</tr>
<tr>
<td><strong>Compressive Strength of Concrete</strong></td>
<td>Shall be determined according to ASTM C39.</td>
</tr>
<tr>
<td><strong>Concrete</strong></td>
<td>Concrete is a mixture of Portland cement, water, and aggregate. Mineral and chemical admixtures may be included. The material must have both coarse and fine aggregate. Fiber-reinforced concrete is permitted.</td>
</tr>
<tr>
<td><strong>Concrete Beam</strong></td>
<td>A concrete beam resists load through flexure and the primary load-resisting system is made of concrete and reinforcing steel. Composite systems, trusses, and arches do not qualify under this definition.</td>
</tr>
<tr>
<td><strong>Enclosed Reinforcement</strong></td>
<td>The reinforcement must be completely enclosed within the concrete with adequate cover as stated by ACI 318.</td>
</tr>
<tr>
<td><strong>Mineral Admixtures</strong></td>
<td>Shall meet indicated ASTM specifications and be silica fume (C1240), class C or F fly ash (C618), class N metakaolin (C618), or Grade 100 or 120 ground granulated blast-furnace slag (C989).</td>
</tr>
<tr>
<td><strong>Portland Cement</strong></td>
<td>Conforms to ASTM C150.</td>
</tr>
<tr>
<td><strong>Proprietary Materials</strong></td>
<td>Any material whose contents are not available to the public. These materials are banned, as the judges cannot verify compliance with the rules.</td>
</tr>
<tr>
<td><strong>Reinforcing Steel</strong></td>
<td>All reinforcing steel must meet one of the following ASTM specifications: A615, A616, A617, A706, A775, A934, A185, A497, A184, A884, A416, A886, A910, A722, or A1035. Structural steel plates or shapes are not allowed as primary or confining reinforcement. Fiber-reinforced plastics are not allowed.</td>
</tr>
<tr>
<td><strong>Steel Plates</strong></td>
<td>Steel plates are permitted as bearing plates or as anchorage plates for mild or prestressing steel.</td>
</tr>
<tr>
<td><strong>Tensile Strength of Concrete</strong></td>
<td>Determined using either ASTM C78 or C496.</td>
</tr>
</tbody>
</table>

International entries may use the equivalent specifications from their countries.
Date

Student Team (school name)  Team Number  Date of Casting

Basic information

1. Age of beam at testing (days)  _______

2. Compressive cylinder tests*
   Number tested: _______________________________
   Size of cylinders: _______________________________
   Average: ______________________________ psi

3. Unit weight of concrete (pcf)  _______
   Slump (in.):  _______
   Air content (%):  _______
   Tensile strength (psi):  _______
   Circle one:
   Split cylinder  MOR beam

4. Pretest Calculations
   a. Applied point load at midspan to cause cracking (kip)  _______
   b. Maximum applied point load at midspan (kip)  _______
   c. Maximum anticipated deflection due to applied load only (in.)

Pretest calculations MUST be completed before testing.

*International entries may substitute the appropriate compressive strength test for their country.

TEST SUMMARY FORMS ARE DUE BY JUNE 15, 2010.

Judging Criteria

Teams MUST fill in these values.

a. Actual maximum applied load (kip)  _______

b. Measured cracking load (kip)*  _______

c. Cost (dollars)  _______

d. Weight (lb)  _______

e. Largest measured deflection (in.)  _______

f. Most accurate calculations  _______
   (a) Absolute value of (maximum applied load – calculated applied load) / calculated applied load
   _______
   (b) Absolute value of (maximum measured deflection – calculated deflection) / calculated deflection
   _______
   (c) Absolute value of (measured cracking load – calculated cracking load) / calculated cracking load
   _______

Total of three absolute values  (a + b + c) = _______

‡Measured cracking load is found from the “bend-over” point in the load/deflection curve. Provide load/deflection curve in report.
CERTIFICATION

As a representative of (name of Producer Member or sponsoring organization)

Sponsoring (name of school and team number)

I certify that:
• The big beam submitted by this team was fabricated and tested within the contest period.
• The calculations of predicted cracking load, maximum load, and deflection were done prior to testing of the beam.
• The students were chiefly responsible for the design.
• The students participated in the fabrication to the extent that was prudent and safe.
• The submitted test results are, to the best of my knowledge, correct, and the video submitted is of the actual test.

Certified by:

Signature

Name (please print)

Date

After February 1, 2010, mail application and test result forms to:
PCI
Attn: Alex Morales, Big Beam Contest
200 W Adams St., Ste 2100
Chicago, IL 60606

TEST SUMMARY FORMS ARE DUE BY JUNE 15, 2010.
### BIG BEAM DIMENSIONS AND DESIGN

1) The beam must no longer than 15 feet and must be tested as a simply supported span of 14 feet, center to center of bearing. The beam may have any shape cross section, but the top must be flat, horizontal along the entire span and at least 8 inches wide.

2) The beam shall be designed for dead load plus an applied service (UNFACTORED) live load of 20 kips (i.e., in equations 9-1 through 9-7 in ACI 318-08 LL = 20 kips). This translates to a factored load of 32 k. The beam must not crack under service live load.

3) The beam shall be loaded by a single point load at the midspan of the beam.

4) Bearing pads and/or bearing plates, not exceeding 6” in length (along the span) may be used at supports and/or under the load.

5) Load and midspan deflection shall be measured.

6) The entry must resist load primarily through flexure. Trusses, arches and other non-flexural members are prohibited.

7) The beam must be made primarily of concrete — cement, coarse aggregates, fine aggregates and water. Pozzolans, fibers, lightweight aggregates and admixtures are permitted.

8) The beam must be reinforced with steel bar and/or strand. **Reinforcing shall be pretensioned and/or post-tensioned.** Embedded or partially embedded steel sections are not allowed. Reinforcement must be completely embedded in the beam with proper clearance.

9) All materials must be commercially available. No experimental materials. Steel plates may be used as bearing plates and/or as anchorage plates for post-tensioning steel only. Steel plate may not be used as any type of reinforcement or for confinement.

10) All entries must meet the provisions of ACI-318-08 or the **PCI Design Handbook** for a precast beam, interior exposure. International entries must meet the equivalent of these documents for their country.

11) Entries which, in the opinion of the judges, are obviously impractical or an attempt to circumvent the rules may be disqualified.

12) If an entry fails to meet some aspect of the rules, the judges may, at their option:
   a. Disqualify the entry entirely
   b. Allow the entry to stand, but award “0” points in the categories where the violation occurred

### JUDGING CRITERIA

The Big Beam Competition will consist of a zone competition and a national competition. Each entry will be judged in relationship to the other entries in the zone. The winner of each zone will then move on to the national competition. In the national competition, the zone winners will be re-judged against each other to determine the national champion. International entries will be considered as a zone.

The judging categories shall be:

1) Design accuracy. The beam should hold at least the FACTORED live load of 32 kips and should not hold more than 39 kips. The beam shall not crack under the service load of 20 k. Beams meeting this criteria receive 20 points.
   a. Beams which do NOT hold 32 kips shall be penalized 2 points for each kip, or part of a kip, below 32.
   b. Beams which hold more than 39 kips shall be penalized 1 point for each kip, or part of a kip, above 39.
   c. Beams which crack before 20 kips receive a 5 point penalty.

2) Lowest cost.

3) Lowest weight.

4) Largest measured deflection before failure.

5) Most accurate prediction of applied load, cracking load and deflection at maximum load.

6) Report quality. Reports MUST contain a discussion of the concrete mix design and the beam structural design.

7) Practicality, innovation and conformance with code.

For judging categories 2–5, the entries in each zone will be ranked from best to worst in that category. The best entry receives 10 points in that category; the 2nd best receives 9 points and so on. If there are more than 10 entries in a zone, places 11 and below receive 0 points.

In category 6, the judges will award 0-5 points for the quality of the report.

In category 7, the judges will award 0-5 points for practicality, innovation, compliance with the applicable code and demonstration of good engineering judgment.

In case of a tie in a category, the tied teams will be awarded the points for the tied places and a subsequent number of places eliminated (e.g. if two teams tie for 2nd, each will be awarded 2nd place points; 3rd place is eliminated, 4th place is awarded).

Prizes shall be awarded based on total points. In the event of a tie in total score, the individual scores in each category, in the order listed above, shall be used to break the tie. If the tie is not broken by this method, the prizes for the tied positions shall be combined and split equally.
MATERIAL COSTS AND BEAM WEIGHT

The following unit cost shall be used to determine the beam cost. Concrete cost is based on actual strength, not design strength.

<table>
<thead>
<tr>
<th>Material</th>
<th>Cost</th>
<th>Notes/Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>$100/yd³</td>
<td>Using gross section geometry.</td>
</tr>
<tr>
<td>High-Strength Concrete</td>
<td>$120/yd³</td>
<td>Defined as $f'_c \geq 10$ ksi.</td>
</tr>
<tr>
<td>Fiber-Reinforced Concrete</td>
<td>$110/yd³</td>
<td>Add $10/cu yd to the concrete cost.</td>
</tr>
<tr>
<td>Lightweight Concrete</td>
<td></td>
<td>Use estimated lengths used in the beam.</td>
</tr>
<tr>
<td>3/8 in. diameter</td>
<td>$0.17/ft</td>
<td></td>
</tr>
<tr>
<td>1/2 in. diameter</td>
<td>$0.30/ft</td>
<td></td>
</tr>
<tr>
<td>1/2 in. special</td>
<td>$0.32/ft</td>
<td></td>
</tr>
<tr>
<td>0.6 in. diameter</td>
<td>$0.42/ft</td>
<td></td>
</tr>
<tr>
<td>0.7 in. diameter</td>
<td>$0.55/ft</td>
<td></td>
</tr>
<tr>
<td>Steel:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A615/A706</td>
<td>$0.45/lb</td>
<td></td>
</tr>
<tr>
<td>Welded wire (deformed or smooth; for shear)</td>
<td>$0.50/lb</td>
<td></td>
</tr>
<tr>
<td>A1035</td>
<td>$0.70/lb</td>
<td></td>
</tr>
<tr>
<td>Plate steel</td>
<td>$.055/lb</td>
<td></td>
</tr>
</tbody>
</table>

There is no need to include cost of forming, steel fabrication, concrete fabrication, curing, inserts, etc. Concrete cost is based upon actual strength. The beam weight shall be estimated by using the measured unit weight of the concrete or by actually weighing the beam. If the beam weight is estimated, it is estimated based on the gross concrete cross section only, ignoring reinforcing, bearing plates, etc.

REPORT COMPETITION

The judges shall select a beam report for the “Best Report”. The criteria shall be that report which best demonstrates student learning, application of sound engineering judgment and excellence in presentation. The judges may elect not to award a prize if there are no suitable entries or to award multiple prizes if there is more than one worthy report.

BEST VIDEO

A prize will be awarded for best video presentation of the test results.

PRIZES:

SIKA AWARDS PROGRAM SPONSORSHIP

SIKA Corporation is providing prize money. Prizes will be awarded to the first through fourth places in each of the 6 Zones and an international zone. The Zone winners will compete for the national title. There will be a prize for the best report and best video.

*International entries will be considered as the seventh zone.

DISCLAIMER:

This contest is sponsored by the Precast/Prestressed Concrete Institute (PCI). The PCI Student Education Committee shall be the final judge of the contest and all decisions/interpretations made by that Committee and/or the panel of judges shall be final. Entries received by PCI by 6/15/2010 will be accepted; entries received after this date but before the contest is judged may be accepted at the discretion of the judges and PCI.

All entries become property of PCI and will not be returned. PCI reserves the right to publish any entry, in whole or in part, without compensation. By entering, contestants agree to allow their photographs to be used in PCI literature without compensation.

PCI reserves the right to disqualify an entry if any part of it does not meet these rules. PCI and/or the judges may revise submitted calculations or quantities to correct errors or inconsistencies as an alternative to disqualification. If there are not enough acceptable entries, not all prizes will be awarded. PCI reserves the right to award additional prizes.