PCI Engineering Student Design Competition

Applications due by March 15, 2008
Results due by June 15, 2008
Program
The PCI Student Education Committee is inviting entries from students to participate in the Engineering Student Design Competition for the 2007–08 academic year. Each student team must work with a PCI Producer Member to build a precast concrete beam, no more than 18 feet long. The beams will be tested and prizes awarded for best performance in the stated areas. Again this year there is an optional Innovative Division, where students are given the freedom to experiment with beam design and an optional mix design competition.

Contest Period
The contest begins September 15, 2007, and ends June 15, 2008. All beams should be fabricated and tested within this time frame. 

Applications are due by March 15, 2008, and results due by June 15, 2008 at PCI headquarters.

Eligibility
Any student enrolled in a 2-year degree program, a 4- or 5 year bachelor’s or a graduate degree program in any of the following areas is eligible:

• Civil Engineering (including all sub-disciplines) or Technology
• Construction Engineering or Technology
• Architecture, Architectural Engineering, or Technology
• Building Sciences or Technology

Students who are enrolled when the contest begins but graduate during the contest period are still 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 or 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 colleges/universities. There is no limit to the number of teams a given Producer Member may support.

A Producer Member is expected to furnish materials, transportation, advice, and expertise to aid the student teams. The actual design must be done by the students, but the faculty advisor and the Producer Member are encouraged to assist in this phase. Students are expected to participate in the fabrication of the beam, but the Producer Member shall determine the extent of student participation in the fabrication process to avoid safety or liability issues. PCI staff and PCI Regional Directors can help student teams locate a Producer Member to work with. If a team cannot find a Producer Member to work with 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 this committee.

Faculty Advisor
Each team must have a faculty advisor. A single advisor may work with multiple teams.

General Rules
All entries must be accompanied by a Test Summary Form containing all elements listed. Entries submitted with an insufficient report may be disqualified by the judges.

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

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

3) The design calculations.

4) A prediction of the cracking load, maximum applied load, and a prediction of the deflection due to applied load at peak applied load. There must be a certification that these predictions were made before the test (see Item 8).

5) A narrative of not more than seven pages (including any pictures) describing the beam fabrication and the testing of the beam.

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

7) A completed Test Summary Form.

8) 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.

If the students do their own mix design, this is submitted as a separate report (see Mix Design Competition).
Application Form

Date

Student Team Members

Faculty Advisor

University/College Department

Address City/State/Zip

Telephone Fax

Email Web

PCI Producer Member

Contact Person

Address City/State/Zip

Telephone Fax

Email Web

PCI Regional Director (if applicable)

Note: Please see the Big Beam brochure for additional information and official rules for this competition.

Mail application form to:

Paul Johal
PCI Big Beam Contest
209 W. Jackson Boulevard, Suite 500
Chicago, IL 60606

Application forms are due by March 15, 2008.
**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>Beam</strong></td>
<td>A beam is a member that resists load primarily through flexure. Members that carry load primarily through discrete axial members (arches or trusses) are not allowed under the rules of this contest.</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 using 6 in. x 12 in. or 4 in. x 8 in. cylinders according to ASTM C39. 4 in. x 8 in. cylinders are allowed if the testing equipment has a limited capacity.</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. Previous judges have indicated that they interpret the word “concrete” to mean the material must have both coarse and fine aggregate. Material with only fine aggregate is mortar or grout and cement-only material is also grout. The interpretation of the judges has been that grout and mortar are not concrete and do not meet the rules or intent of the contest.</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 C 150.</td>
</tr>
<tr>
<td><strong>Proprietary Materials</strong></td>
<td>Any material where the 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 bars, wires and strands must meet one of the following ASTM specifications: A615, A616, A617, A706, A775, A934, A185, A497, A184, A884, A416, A886, A910, and A722. The reinforcing steel must be completely enclosed within the concrete with adequate cover as stated by ACI 318.</td>
</tr>
<tr>
<td><strong>Special Cements</strong></td>
<td>Any non-portland cement (e.g. epoxies, latex modified, magnesium phosphate cements). Bagged grouts are considered special cements unless portland cement is the main cementing material and all other ingredients meet the rules of the contest.</td>
</tr>
<tr>
<td><strong>Steel Plates</strong></td>
<td>Steel plates are permitted as bearing plates, for mild or prestressing steel anchorage, or for concrete confining. Structural steel shapes are not allowed.</td>
</tr>
<tr>
<td><strong>Tensile Strength of Concrete</strong></td>
<td>Determined using either ASTM C78 or C496.</td>
</tr>
</tbody>
</table>
Test Summary Form

Date

Student Team (school name)  Team Number  Date of Casting

1. Basic information*

2. Weight of beam (kip) ________

3. Age of beam at testing (days) ________

4. Compressive cylinder tests
   (1) ________________________________________________________
   (2) ________________________________________________________
   (3) ________________________________________________________
   Avg. _____________________________________ psi

Cylinders must be 6 x 12 in. or 4 x 8 in. and be tested at 28 days.

5. Costs
   Concrete  $ _________________________________
   Prestressing strand  $ _________________________________
   Reinforcement  $ _________________________________
   Total Cost:  $ _________________________________

6. Pretest Calculations
   a. Applied point load at midspan to cause cracking (kip) ____________
   b. Maximum applied point load at midspan (kip) ____________
   c. Calculated deflection at predicted maximum load due to applied load only (in.) ________

7. Actual largest applied load at any time (kip)__________

8. Actual deflection at maximum load due to applied load only (in.)

9. Applied load at cracking – from bend over point on the load/deflection curve (kip) ________

Judging Criteria

Formula: Use numbers from left.
a. Actual maximum applied load (kip) ____________
   b. Total cost (dollars) ____________
   c. Deflection at maximum load (#8) (in.) ____________
   d. Weight (kip) ____________
   e. Average concrete compressive strength (#4) (psi) ____________

Most accurate calculations

(a) Absolute value of (maximum applied load – calculated applied load) / calculated applied load
   $\text{Abs} \frac{|#7 - #6a|}{#6a} = ____________$

(b) Absolute value of (maximum measured deflection – calculated deflection) / calculated deflection
   $\text{Abs} \frac{|#8 - #6c|}{#6c} = ____________$

(c) Absolute value of (measured cracking load – calculated cracking load) / calculated cracking load
   $\text{Abs} \frac{|#9 - #6a|}{#6a} = ____________$

Total of three Absolute Values (a + b + c) = ____________

*1 kip = 1000 lb
Test Summary
Forms are due by June 15, 2008.

Producer Member or Regional Director Certification

As a representative of (name of Producer Member or PCI Regional Director)

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 design was completed by the students.
- 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 tape submitted is a tape of the actual test.

Certified by:

________________________________________
Signature

________________________________________
Name (please print)

________________________________________
Date

Mail application and test result forms to:
PCI
Attn: Paul Johal, Big Beam Contest
209 W. Jackson Boulevard, Suite 500
Chicago, IL 60606
**Judging Criteria**

The 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 judged against one another to determine the national champion.

The Innovative Division will be a national competition only.

The judging categories shall be:

1) **Design accuracy.** The beam should hold at least the factored live load of 32 kip and should not hold more than 38 kip. Beams meeting this criterion receive 20 points.
   a. Beams that do not hold 32 kip shall be penalized 2 points for each kip below 32.
   b. Beams that hold more than 38 kip shall be penalized 1 point for each kip above 38.

2) **Lowest cost.**

3) **Lowest weight.**

4) **Largest measured deflection before failure.**

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

6) **Report quality.**

7) **Practicality/innovation.**

For judging categories 2 through 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 second-best receives 9 points, and so on. If there are more than 10 entries in a zone, places 11 and below will 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, compliance with the code, and demonstration of good engineering judgment. In the Open Division, the judges will award points for the innovative qualities of the entry and the ability to justify any deviations from codes/standard practices.

In the event 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. For example, if two teams tie for second place, each will be awarded half of the total second- and third-place points, and third place will be eliminated.

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.

<table>
<thead>
<tr>
<th>Material</th>
<th>Cost</th>
<th>Notes/Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>$100/cu yd</td>
<td>Using gross section geometry without allowance for the volume occupied by the reinforcement.</td>
</tr>
<tr>
<td>High Strength Concrete</td>
<td>$120/cu yd</td>
<td>Defined as over 10 ksi.</td>
</tr>
<tr>
<td>Fiber-Reinforced Concrete</td>
<td>$110/cu yd</td>
<td></td>
</tr>
<tr>
<td>Experimental Concrete</td>
<td>$175/cu yd</td>
<td>Open Division only.</td>
</tr>
<tr>
<td>Prestressing Strand:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/8 in. diameter</td>
<td>$0.17/ft</td>
<td>Use estimated lengths used in the beam.</td>
</tr>
<tr>
<td>1/2 in. diameter</td>
<td>$0.30/ft</td>
<td></td>
</tr>
<tr>
<td>0.6 in. diameter</td>
<td>$0.42/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>Use estimated lengths used in the beam and nominal unit weights in this calculation as provided in the PCI Design Handbook, Sixth Edition.</td>
</tr>
<tr>
<td>Welded wire (deformed or smooth)</td>
<td>$0.50/lb</td>
<td></td>
</tr>
<tr>
<td>All other steel</td>
<td>$0.50/lb</td>
<td></td>
</tr>
<tr>
<td>Non-Steel Reinforcement</td>
<td>$0.50/ft</td>
<td>Innovative Division only.</td>
</tr>
<tr>
<td>(longitudinal or shear)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There is no need to include cost of forming, steel fabrication, concrete fabrication, curing, inserts, etc. The beam weight shall be estimated by assuming concrete weighs 150 lb/ft³, 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.

Mix Design Competition

Student teams that create their own mix design for the Big Beam may participate in the optional Mix Design Competition. To participate, the student team must submit a separate report on the mix design for the concrete used in the Big Beam. Students shall start with a base mix, which may be either an existing mix or a mix designed by the students. Students must then improve the mix to improve the fresh concrete properties and/or the hardened concrete properties and/or the economics. Students must clearly demonstrate an understanding of how their changes to mix design resulted in an improvement in the concrete properties. This is not a highest strength competition. The judges shall choose the report that best demonstrates an understanding of concrete material principles and sound engineering judgment. 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.

Students are encouraged to contact the contest sponsor, Sika Corporation, for assistance with the Mix Design Competition.

Report Competition

The judges shall select as “Best Report” the report that 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.

Prizes: Sika Awards Program Sponsorship

Up to $25,000 will be awarded in prize money to individual Zone Winners* and Overall Winners from seven zones, and to the winners in the Innovative Division and Mix Design Competition.

*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.

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 reproduced in PCI printed and electronic materials without compensation.

PCI reserves the right to disqualify any entry. PCI and/or the judges may revise submitted calculations or quantities to correct errors or inconsistencies as an alternative to disqualification. If an entry does not comply with the rules in one or more of the judging categories, the judges may, at their option, give 0 points for the categories where there is non-compliance but award points for categories where the entry complies with the rules. If there are not enough acceptable entries, not all prizes will be awarded. PCI reserves the right to award additional prizes.

Sponsored by

PCI and Sika