

# ACI Egg Protection Device Competition

## Objectives

Design and build the highest-impact-load resistant plain or reinforced concrete Egg Protection Device (EPD). Learn and report on concrete's sustainable benefits related to durability, impact resistance and other real-life aspects which an EPD simulates. Two prize categories will be awarded – one for overall performance and one for efficiency of design. Note that only one team is allowed entry per school.

## Prizes

First, Second, and Third place entries in each prize category will each be awarded a certificate of recognition, will be recognized in *Concrete International* magazine if space allows, and will be recognized on ACI's website. In addition, the First Place team will receive a \$750 award, the Second Place team will receive \$500, and the Third Place team will receive \$250. Awards and overall results are not announced until the end of the Student Lunch on Monday of Convention.

## Rules

### 1. Eligibility

- a. Each team must have a supervising faculty advisor who will see that the student team complies with the rules of the competition. The faculty member is permitted to advise more than one team.
- b. Each team must consist of students in high school, technical school, trade school, or undergraduate students of a college or university at the time of casting the EPD. Undergraduate students on cooperative or internship work assignment are also eligible to compete. Although there are no restrictions on the geographical location of the school, all members of a given team must be from the same school.
- c. A team may consist of up to eight students.
- d. A student may not be a member of more than one team.
- e. At least one individual (faculty advisor or student team member) must be designated to represent each team and be present during the testing of the specimen at the time and location specified for this competition. Participation by additional team members is both permitted and encouraged.
- f. Each school will be permitted to enter no more than one team.

### 2. Material

- a. The binder shall be cementitious material consisting of any combination of the following: portland cement meeting ASTM C 150; blended cement meeting ASTM C 595 or C 1157; slag cement meeting ASTM C 989; fly ash meeting ASTM C 618; and silica fume meeting ASTM C 1240.

- b. Chemical admixtures, meeting ASTM C 494 or 1017, are allowed. Epoxies and other polymers, glue, and similar binders shall not be used. The concrete must be cured to the stage that it is a solid (i.e., no fresh concrete).
- c. All reinforcement, longitudinal and stirrups (transverse reinforcing), shall not be greater than **1.6 mm (0.06 in)** diameter (approx. 16 gauge), and must be metal. No more than 11 stirrups may be used in the EPD. Bundling of reinforcement for stirrup construction is not permitted. Longitudinal reinforcement shall be limited to 8 bars/wires in a cross section. No wire meshes, soldering, or welding of cages is permitted. (For fabrication of cages, small gauge tie wire or glue is permitted). Fibers of any type are not permitted to be used. Reinforcing shall not be visible at the surface of the EPD as this would indicate insufficient concrete cover and ultimately a structure that is not durable. Visible reinforcing may result in disqualification.
  - 1. For the determination of longitudinal versus shear (stirrups) reinforcement, an imaginary plane will be used and may pass anywhere along the structure, cutting parallel or perpendicular to the horizontal (see Figure 1).
  - 2. In the supports of the structure, any reinforcing that passes through a vertical plane at an angle greater than 30 degrees will be considered shear reinforcing and count against the total number of stirrups.
  - 3. In the main horizontal member, any reinforcing that passes through a horizontal plane at an angle greater than 30 degrees will be considered shear reinforcing and count against the total number of stirrups.
- d. No flat plate type embedments or coverings are allowed (i.e., metal or plastic sheets, etc.)
- e. Any type of aggregate may be used, except metal

### **3. Curing and Age of Specimens**

- a. Curing shall be at atmospheric pressure. The curing temperatures shall not exceed the boiling point of water. Use of a standard moist curing room is permitted.
- b. EPDs and Cylindrical Specimens shall not be older than 8 weeks during the day of competition.
- c. Each EPD and Cylindrical Specimen shall be marked in marker with a 5 digit identification that matches the 5 digit code provided in the team registration and the EPD report.

### **4. Specimen and Testing Configuration**

- a. EPDs must fit into the slot in a base plate **400 mm (15.75 in) ± 5 mm (0.2 in)** long by **200 mm (7.87 in) ± 5 mm (0.2 in)** wide (as shown in the diagram).
- b. EPD must provide clear passage of a rectangular template measuring **210 mm (8.27 in)** high by **275 mm (10.83 in)** wide; the top surface of the EPD may not be higher at any point than **250 mm (9.84 in)** above bottom of the base (to fit into loading frame).

- c. EPD footings are allowed only at the ends of the base plate slot. The maximum size of the footing is **50 mm (1.97 in)** long by **200 mm (7.87 in)** wide. The footings shall be made of concrete only, but reinforcement in compliance with Section 2(b) may be used. Between the footings, the EPD must remain clear of the base plate of the loading frame during testing.
- d. There must be at least a **50 mm (1.97 in)** diameter flat area on top of the EPD, centered **25 mm (0.98 in)** to **both sides** of the centerline (where the load will impact), which must be made out of solid concrete (Reinforcement in compliance with Section 2(c) may be used in this area if unexposed). This will result in a **100 mm (3.94 in)** long area at the center of the EPD where the load will impact (as shown in the diagram).
- e. Loading of the device will not take place along the center line, but **25 mm (0.98 in)** to either direction of the centerline. This direction will be determined on the day of competition, randomly, by the judges.
- f. The maximum mass of the EPD shall be **3.000 kg (6.61 lbs)**.
- g. Modification of entries shall not be permitted once they are submitted for competition.
- h. Two standard 10cm diameter, 20cm length (4"x8") specimens must be cast from the concrete batch used in the EPD and brought to the competition for verification of mix design and testing of Bulk Resistivity

## 5. Qualification and Testing Procedures

- a. *Qualification Test*  
The competition procedures consist of three steps, all handled by a group of judges appointed by the Chair of ACI S 801 and/or the lead judge of the competition. First, the report (as described in Section 8) will be evaluated. Second, every EPD entry is individually weighed and checked for size and clearances and compliance with the requirements of Sections 1 to 4 (above) will be checked. Only after the first two qualification steps have been completed will each qualifying EPD be taken to the final step of the destructive test. Refer to Section 1 for final qualification and prize eligibility.
- b. *Resistivity Test*  
Two 10cm x 20cm (4"x8") specimens of the concrete used to cast the EPD will be presented at competition check-in for testing for Bulk Resistivity. Specimens will be submerged by judges for a minimum of 3 hours and tested in general accordance with ASTM C1876-19 (with the exception of the soak time) using a Giatec RCON device and will result in an average resistivity value in units kΩ.cm
- c. *Impact Test*  
During this phase, each EPD will be subjected to an impact load of 8.39 kg (18.5 lb) falling, one time, from each of the following increasing heights of **0.5 m (1.64 ft)**, **1.0 m (3.28 ft)**, **1.5 m (4.92 ft)**, **2.0 m (6.56 ft)**, **2.5 m (8.20 ft)**, and up to five times from the maximum height of **3.0 m (9.84 ft)**. The winning EPD is

determined based on the maximum energy (load x height) prior to failure (as defined below) and larger number of impact repetitions at **3.0 m (9.84 ft)** height (for EPDs reaching this load stage). In the event of a tie (for the EPDs that survive the 5 impact load repetitions at **3.0 m (9.84 ft)** height and do not fail), the winning EPDs will be determined based on the minimum mass determined at the beginning of the competition.

d. *Failure Criteria*

Cracking of the egg constitutes failure of the EPD. Cracking of the egg can be due to structural damage of the EPD or spalling of concrete. **Note:** If due to vibration, the egg is not damaged by the EPD, but instead jumps out of the eggcup, a new egg will be used and the loading will continue. The EPD must be stable and must not fall under its own weight during the test. Stability checks will be performed after every impact load. Unstable EPDs will be disqualified.

## 6. Judging

- a. The judges will be appointed by the Chair of Committee S 801 and/or the lead judge of the competition.
- b. The judges will determine whether or not the rules have been followed.
- c. The decision of the judges will be final, and appeals will not be considered.
- d. Advance registration is required. All teams must **register** through the competition website by **30 September 2020 at 11:59 p.m.** eastern time and indicates your intent to enter an EPD in the competition. **Final submission** of required information, including a pdf copy of the EPD report detailed in section 7, must be completed through the ACI competition website by 11:59 p.m. Eastern Time on **7 October 2020**. The actual EPD and two cylindrical specimens must be submitted on the day of the competition at the check-in time provided to the team by ACI. On-site team check-in times will be provided within a week of the competition and may be as early as 7:30am on the day of the competition, though other check-in times may be selected as necessary by the competition committee. See the ACI competition website for registration forms and additional information. Failure to meet the above deadlines due to technical problems or for any reason may result in the inability to participate in the competition or point penalties at the discretion of the judges.
- e. Final competition results will be calculated based on the following formulae:  
Overall Final Score = 0.80 (Impact Ranking) + 0.15 (Resistivity Ranking) + 0.20 (Report)  
Efficiency Final Score = [(# longitudinal)<sup>2</sup> \* (# shear) \* (mass)] / [(Resistivity)<sup>2</sup> \* (Impact Height)]
- f. In the instance of a tied overall final score, the team with the higher number of impacts will receive the higher rank. In the unlikely event the teams are still tied, the team with the lower number of stirrups will receive the higher rank.  
In the instance of a tied efficiency final score, the team with the higher resistivity will receive the higher rank.

## 7. EPD Report and Submission Details

The EPD and cylindrical specimens shall be submitted in person at the team's provided time for on-site check-in. Final registration through the ACI competition website must be completed by 11:59 p.m. on 7 October 2020. An EPD report is required as part of that submission, along with other items listed there. **Failure to provide the following documentation will disqualify a team from participating.**

The structure of the EPD report shall be the following, and will have a maximum of 8 pages:

1. Cover page with Team name, team members and advisor, and 5 digit team identification Code, matching the one used to label the EPD specimen and two 10cm x 20cm (4"x8") specimens
2. Photographs and/or descriptions of the following:
  - a. Batching and placing procedures (max. 1 page)
  - b. Reinforcing cage construction and layout including a photo of the completed cage (max. 2 pages). The judges should be able to review the reinforcing steel layout in the documentation provided, match with the reinforcing steel within the EPD structure once it is broken, and verify compliance with the reinforcing per 2.c. Failure to provide suitable photographs of the reinforcing cage for determination of reinforcing steel quantity will result in penalties to the team and possible disqualification.
  - c. Casting of the specimen and curing procedures (max. 1 page)
3. Describe and list the mixture design, the manufacturing process of the EPD, selection of the reinforcing and its layout, and the curing processes, including the cast date or anticipated cast date of the EPD (max. 3 pages).

### Summary of submission deadlines:

Team Registration: by 11:59 p.m. 30 September 2020

EPD Report and Supporting Materials: by 11:59 p.m. 7 October 2020

EPD and Cylindrical Specimen onsite submission: At the designated check-in time at the Student Competition on 25 October 2020 or as otherwise directed

## 8. Compliance with ACI-EPD Competition Rules:

ACI reserves the right to perform detailed examination and check entries for compliance with the competition rules. Due to the complexity of this task, the examination may be done after the competition. If the examination shows that a team did not follow the rules, the team, their advisor and all his/her teams will be disqualified. S801 committee will further document recommendations to sanction the team and its advisor and/or the school/university's participation in future competitions. Failure to supply the required submittals or failure to meet the established deadlines may result in penalties, up to and including disqualification.

## 9. Contact Information

<https://www.concrete.org/students/studentcompetitions.aspx>

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