ECOCONCRETE STUDENT COMPETITION 2025

SUBCOMMITTEE ACI S-801 - Student Activities
SUBCOMMITTEE ACI 130-G - Education

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1 OBJECTIVES AND PRIZES

1.1 Objectives

In order to contribute to and educate the future generation of civil engineers on the sustainable development of concrete, this student competition aims to promote the idea of environmental performance in concrete mix designs. Teams thus have the mission to develop an innovative concrete mixture, which will have the lowest possible environmental impacts while maintaining or improving the durability performance. To achieve this goal, teams are encouraged to seek out and use local resources of eco-friendly materials such as supplementary cementitious materials (SCMs).

After designing their concrete mixture, teams are asked to perform a simplified life-cycle assessment (LCA) and present their results in a written report and a recorded presentation. The format of this report is inspired by an environmental product declaration document, which is favored by the industry to communicate the environmental footprint of products.

In addition to the report, teams shall prepare the simulation results of their mixtures using the Life 365™ software. This open-source tool has been extensively used by concrete designers and engineers to predict the durability performance of concrete against chloride attacks. In this competition, teams will also have to present a recorded video of their concrete mix designs to the judges, with an emphasis on the environmental aspect considered in their decision.

1.2 Prizes

The durability performance improvement, quality of the report and recorded presentation as well as answering judges' questions during an online interview, and environmental score from the simplified life-cycle assessment will be the parameters in determining the winners. First, second and third-place entries will each be awarded a certificate of recognition and will be recognized on the ACI website as well as in *Concrete International* magazine if space allows. 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. Winners will be announced online following competition.

Note: Teams are highly encouraged to read the following Concrete International publication to learn from the challenges and students' outcomes related to the previous versions of the EcoConcrete competition:

The Eco Concrete Competition: Lessons learned by (and from) students

2 RULES

2.1 Eligibility

a. Each team must consist of students in high school, technical school, trade school, or undergraduate students at a college or university at the time of the competition. Undergraduate students on cooperative or internship work assignments are also eligible to participate. All members of the team must be from the same school.

b. Each team can get help from one graduate student to participate in designing the mixtures and running the simplified life-cycle assessment (LCA), though the student shall be mentioned in the report.

c. A team is limited to six individuals and a school may register only one team.

d. Each team must have a supervising faculty advisor who will oversee the compliance of the student mix designs, calculations, and report with the rules of the competition.

e. Since this competition involves an online interview, it is required that the team members join the preset time schedule for answering judges' questions.

f. Registration dates are listed at the end of these rules. Teams will receive confirmation of registration from ACI and must be sure to submit all required paperwork and information by the deadlines noted.

2.2 Materials

All materials and mix design(s) used for the competition have to be clearly described in the written report and the recorded video (see Section 2.3). Material requirements indicated below should be closely followed, as teams failing to do so will be penalized, possibly with disqualification from the competition.

a. Portland cement Type I or II satisfying ASTM C150 or hydraulic cement GU type complying with ASTM C1157 must be considered. Commercial blended cement is not allowed.

b. Supplementary cementitious materials (SCM), such as fly ash, silica fume, and/or slag cement, can be incorporated into the concrete mixtures but as separate products from the portland cement.

c. Virgin Aggregates shall be considered in the BCS and ACS mixtures.

2.3 Concrete mix designs

Mix design requirements indicated below shall be closely followed for both mixtures, as teams failing to do so will be penalized, possibly with disqualification from the competition.

- Water-to-binder ratio

i. The water-to-binder ratio (by mass) is fixed to **0.40**. The binder shall include all types of portland or hydraulic cement specified in section 2.2.a and SCMs, as identified in section 2.2, that are used in the mix.

- Aggregate proportioning
  i. The aggregate(s) shall constitute **a minimum of 75%** of the total mass of concrete mixtures (therefore, the total mass proportion of paste in concrete is 25% or less). This percentage shall be calculated based on a comparison of the total mass of all aggregates in surface saturated dry (SSD) condition, to the total mass of the concrete (based on yielded proportions). The contribution of coarse aggregates (aggregates with a minimum size of 5 mm) mass must be more than 30% of the mass of the total aggregate.

2.4 Simplified Life Cycle Assessment

Each team must prepare a simplified LCA using the EcoConcrete Calculation Tool V2.01, following the specifications listed below. This simplified LCA calculates the environmental impacts of mixtures. For each process, five environmental impact categories, namely global warming, carcinogenic, ozone depletion, ecotoxicity, and fossil fuel depletion, are computed. The average reduction in the value of these five categories is considered to form the Single Score Ratio. More information on this approach is provided in the "EcoConcrete calculation tool instruction" document provided on the competition website.

a. Goal and Scope

The objective of this competition is to design a concrete mix using alternative materials with low environmental impacts while improving durability performance.

b. Functional unit

The functional unit is the production of one cubic meter of concrete mixture complying with the rules mentioned in sections 2.2 and 2.3.

c. System boundaries

The system boundaries analyzed, in compliance with the ready-mix concrete supply chain, including the extraction of the raw materials to the production of one cubic meter of ready-mix concrete (See Figure 1). Each team shall comply with their Simplified LCA scope with the following system boundaries for a **cradle-to-gate analysis**.

i. Extraction of raw materials and transportation to the plant.
ii. Materials processing at the plant.
iii. Transportation of the processed and raw materials from the plant or site to the batching plant (your school location).

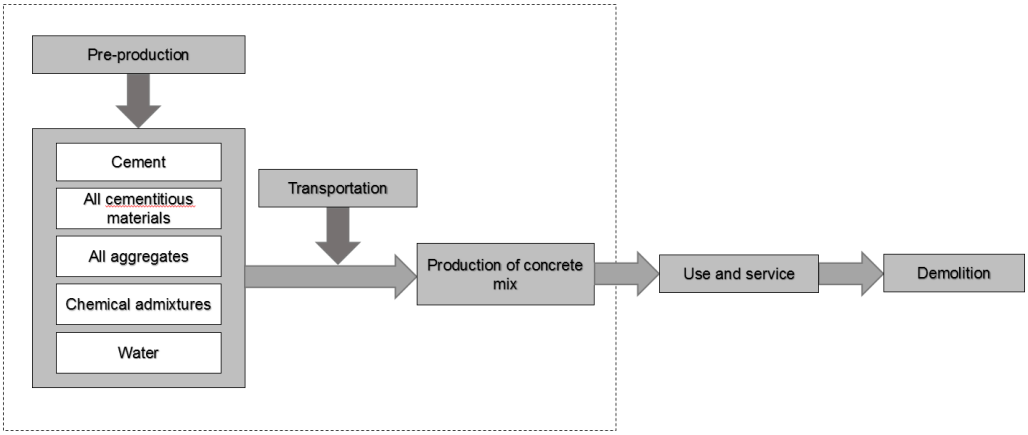

Figure 1: Schematic representation of system boundaries

The following shall not be included in the simplified LCA:

iv. Production of concrete at batching plant (your school location).
v. Manufacturing and maintenance.
vi. Demolition and end-of-life.

d. Inventory (To be completed in the EcoConcrete Calculation Tool V2.01)
   i. Each team shall consider the electrical and/or thermal energy required for producing (transform) each material used as a concrete mixture ingredient. The appropriate energy mix of the region must be selected in the EcoConcrete Calculation Tool V2.01 to represent their local production emissions.
   ii. Transport of each material shall be considered. Teams are responsible for collecting the transportation distance data for portland cement and aggregates. The batching plant shall be the location of your school lab.
   iii. The following table shall be considered and used to make assumptions about the transportation distances of SCM. All teams shall calculate the environmental impacts of transportation for SCM using the values stated in Table 1.

Table 1. Transportation modes and distances for different types of SCMs allowed in the EcoConcrete Competition

SCM Type	Transportation mode and distance		
	Road (km)	Rail (km)	Waterway (km)
Slag	20	0	250
Fly ash	100	200	0
Silica Fume	50	200	0

Each team shall provide a travel map demonstrating the transportation path of Portland cement and aggregates. Each transportation impact should be listed in the calculation table provided in the EcoConcrete Calculation Tool V2.01.

Each team must design two concrete mixtures using the corresponding worksheets in the EcoConcrete Calculation Tool V2.01: (1) Base-Case Scenario (BCS) and (2) an Alternative-Case Scenario (ACS). Both scenarios must respect the criteria presented in sections 2.2 and 2.3.

2.4.1 Designing Base-Case Scenario and Alternative-Case Scenario

a. Designing the Base-Case Scenario (BCS) concrete mixtures
    i. BCS cementitious binder must be designed with 100% portland or hydraulic cement specified in section 2.2.a.

b. Designing the Alternative-Case Scenario (ACS) concrete mixtures
    i. A **maximum of 40%** of the mass of the binder materials can be replaced by non-portland cement material (e.g., SCMs).
    ii. ACS must be designed with the same total volume of cementitious materials (binder) as the BCS mixture (in kg/m³).
    iii. ACS must be designed with the same volume of the total fine and coarse aggregates as the BCS mixture (for example, if 80% of the BCS mixture volume consists of aggregates, the same 80% volume shall be incorporated for the ACS mixture considering the difference in the density of the aggregates used in the ACS and BCS).

IMPORTANT NOTE: All the inputs in the tool, such as materials, transportation distances, and the processing energy, must be based on the real case and shall be explicitly presented in the report and recorded presentation. In addition, all the identical materials in ACS and BCS (e.g., portland cement and virgin aggregates) shall be supplied from the same source or plant.

After computing the environmental single score (SS) of each scenario (by the EcoConcrete Calculation Tool V2.01), the SS ratio is calculated, as presented in Equation 1, to highlight the relative environmental improvements from the base case to the alternative mix. A **minimum 15% improvement in the environmental impact score** is required for this competition.

$$SS_{Ratio} = \left(1 - \frac{SS_{ACS}}{SS_{BCS}}\right) \times 100 \geq 15\% \quad (1)$$

Where: SS_{ACS} = Single score of Alternative-Case Scenario
SS_{BCA} = Single score of Base-Case Scenario
SS_{Ratio} = Single score ratio

Such scenarios will allow comparing the relative environmental improvement of each team and avoiding geographical distortion.

2.4.2 Calculating environmental impacts with the EcoConcrete Calculation Tool V2.01

The EcoConcrete Calculation Tool V2.01 provides a simple way for students to calculate and compare the environmental impacts of the ACS and BCS concrete mixtures. The instructions for using this tool are provided in the "EcoConcrete calculation tool instruction" document provided on the competition website.

2.5 Service life prediction in Life-365™

Students shall simulate the service life of the ACS and BCS mixtures for the marine environment located in the state of Florida, where the chloride attack is the dominant determining factor for the durability of concrete structures. The durability of BCS and ACS mixtures against rebar corrosion shall be simulated using the Life-365™ software v2.2.3. This software has been widely used in the concrete industry can be great training for students to learn how the concrete mix design parameters can affect the chloride penetration rate in concrete. The software is available and ready to use after registering in the platform from the following link:

https://app.life-365.org/Teams are encouraged to read the manual before (https://life-365.org/wp-content/uploads/2024/11/Life-365_v2.2.3_Users_Manual.pdf) and after registering online to access to the tool. Nevertheless, the rules regarding the software default inputs for the exposure conditions and materials properties are provided in this section. For a consistent exposure condition, parameters other than the mix designs are set consistently among the participant teams. It is highly recommended to choose the SI system in the Default Setting and Parameter Tab for the software input units right after registering to the platform to accurately enter the specified inputs.

Teams shall model their ACS and BCS mixtures, save the output file (JSON file), and submit the file along with other requested documents (calculation tool including the mix designs and calculated environment impacts, report, and recorded presentation).

The instruction for the simulation in Life-365™ software starts with creating a new project from the navigation menu. After creating the project, a new window with several tabs will appear on the screen.

i. Under the first tab, "Project" (See Figure 2):
- In the "Identify Project" section, the "Title" cell shall be filled with the team's name and in the "Analyst" cell, teams shall provide all the team members' names and last names. Filling other cells such as the date and description is not mandatory.
- Under the "Select Structure Type and Dimensions" section, the type of structure shall be set as "slabs and walls (1-D)" from the dropdown menu; The "Thickness", "Reinf. depth", and "Area" cells shall be entered as 200 mm, 50 mm, and 5 m^2, respectively. Therefore, the total volume of concrete shown in that section is 1 m^3. The "Chloride concentration units" shall be set as "% wt. conc".
- Under the "Define Economic Parameters", the "Base year" and "Analysis period" values shall be set to 2023 and 100, respectively.
- Under the "Define Alternatives (up to 6)" section, by double-clicking on the cells, the name of mixtures shall be set to "BCS" and "ACS".

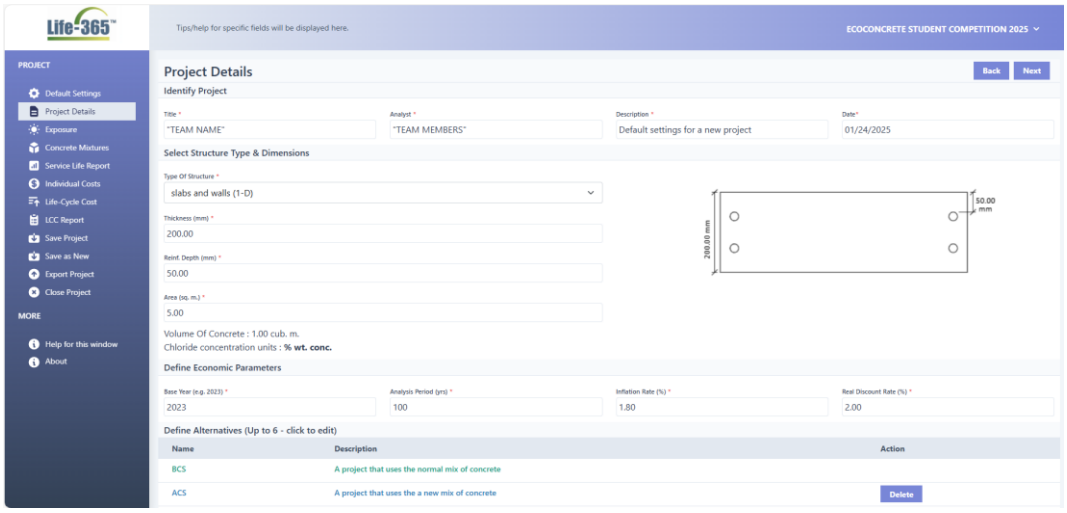

Figure 2: Overview of the "Project" tab in Life Life-365™ online tool

ii. After verifying the inputs with teammates, students will define the inputs in the second tab "Exposure" (See Figure 3):

- Under the "Select Method for Setting External Concentration and Temperature Profile" section, the "Use defaults" shall be set, and the "Location", "Sub-location" and "Exposure" shall be set to "Florida", "TAMPA", and "Marine spray zone", respectively. No other inputs shall be changed in this Tab.

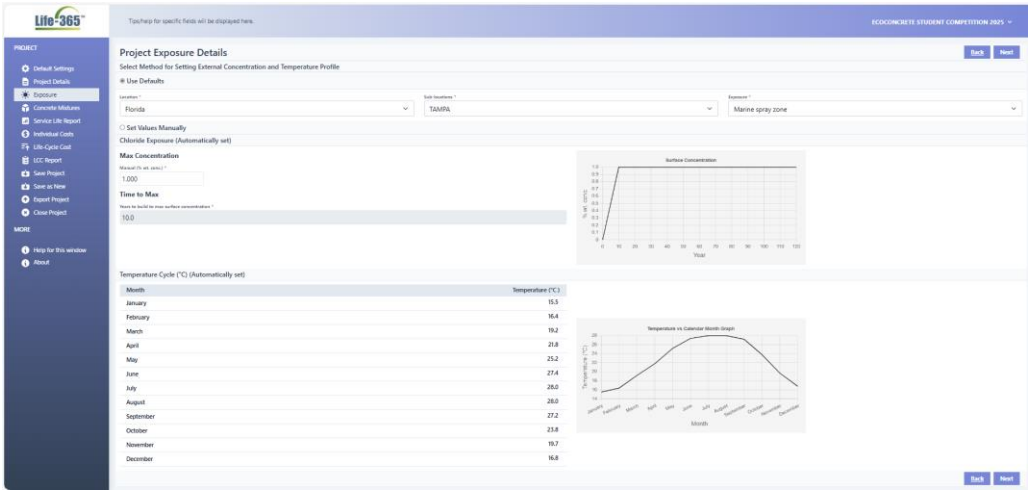

Figure 3: Overview of the "Exposure" tab in Life Life-365™ online tool

iii. After verifying the inputs with teammates, students will define the inputs in the third tab "Concrete Mixtures":

- Under the “Define Concrete Mixtures” section, no inputs shall be changed unless specified below.
- By clicking on “BCS”, the first mixture constituents shall be defined:
    - w/cm = 0.40
    - Class F fly ash, Slag, Silica fume = 0
    - Under the “Rebar” section, the “Rebar steel type” shall be selected as “Black Steel” from the dropdown menu and the “Rebar % vol. concrete” shall be entered as 3%. The “inhibitor” and “Barriers” shall be chosen as “<none>”.
- After finishing the “BCS” specifications, teams will enter the specifications of “ACS” under the “Define Concrete Mixtures” section:
    - w/cm = 0.40
    - Class F fly ash, Slag, and Silica fume, as designed by the team (please make sure the content of SCMs satisfies the requirement specified under Section 2.3)
    - Under the “Rebar” section, the “Rebar steel type” shall be selected as “Black Steel” from the dropdown menu and the “Rebar % vol. concrete” shall be entered as 3%. The “inhibitor” and “Barriers” shall be chosen as “<none>”.

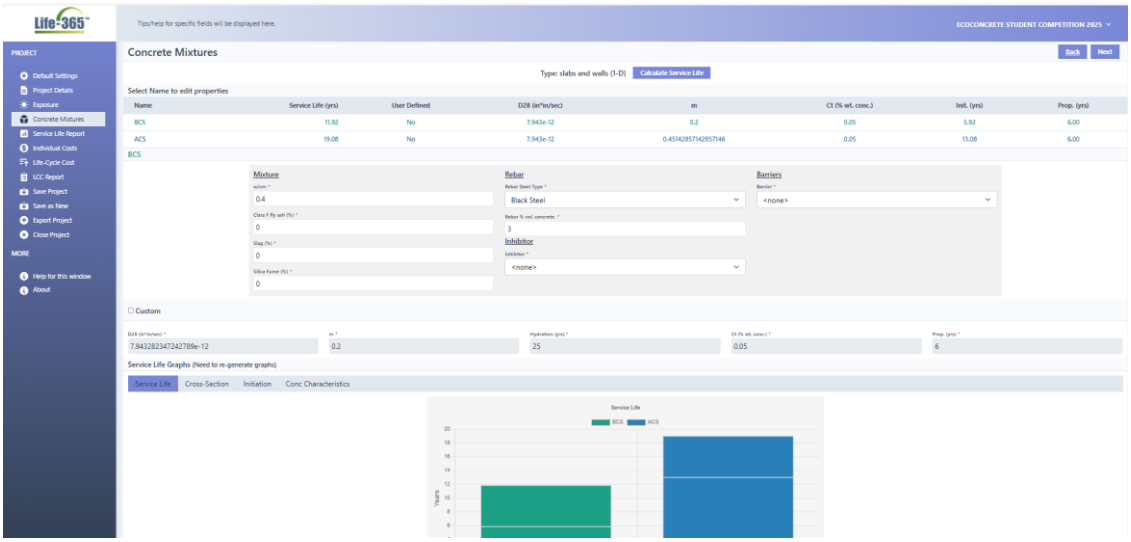

Figure 4: Overview of the “Concrete Mixtures” tab in Life-365™ online tool

No other inputs are required for the service life simulation. After clicking on the “Calculate service life” button at the top of the window, the bar charts will appear showing the initiation and propagation years for the BCS and ACS mixtures. The relative service of life of ACS/BCS shall be calculated according to the simulation results and shall be reported in the written report summary and presentation. After finishing the service life modeling, the JSON file (by clicking “Save Project” first and then “Export Project”) shall be saved and included in the document submission.

a. Scoring

Teams will be ranked on the relative improvement in the service life of their mixtures, showing how much increase in the service life was obtained using the ACS compared to the BCS mixtures. The durability performance score is obtained by the division of ACS/BCS "propagation service lives" (values corresponding to the top of the grey bar charts shown in Figure 4). Teams with the largest improvement in service life will obtain the first rank and a score of 100. Other teams will be awarded scores of an evenly graduated decrease according to the total number of teams.

2.6 Written Report

Teams shall submit a written report meeting the requirements listed below for the judges to review and score. An electronic version of the report shall be submitted as described below in standard PDF format. The electronic report due date is indicated in Section 6 below. Teams failing to submit the electronic version of the report shall receive a zero score in the written report section of the Final Score equation provided in Section 3.

Judges will score each report using the indicated scoring percentages (based on a total of 100%). Each report shall contain the following (see the scoring sheet for more details):

a. Include a cover page containing the following: **– 5%**
   i. School name and department
   ii. Team members and faculty advisor name
   iii. 4-Character Team ID
b. Abstract **– 5%**
   In 300 words or less, the teams must provide the following information:
   i. Description of the goal.
   ii. Overview of constraints of the competition.
   iii. Overview of materials and mixture proportions of the final mixture.
   iv. A brief description of the environmental and durability results.
c. Introduction **– 5% (maximum one page)**
   i. The environmental aspect of concrete and its implications in sustainable development.
   ii. The importance of material and mix design in the environmental impacts of concrete and durability of concrete.

d. Materials selection **– 20%**
   i. Provide the concrete mixtures designed for the BCS and the ACS using the saturated surface dried (SSD) densities (kg/m³). The mixtures presented in the written report shall correspond with those proposed in the EcoConcrete Calculation Tool V2.01 submitted by each team and the binders tested in the service life simulation software.
   ii. Identify each material category: cementitious materials, aggregates used in the mixture, and their origin (main-product, co-products, waste, recycled materials, etc.). A discussion about why they are selected as sustainable materials is highly recommended.

iii. Provide general information about each material used in the BCS and ACS concrete mixture if possible, including, but not limited to, the location, where each material is manufactured.
iv. Discuss the five environmental impact categories for every single material and the whole mixture (BCS and ACS).

e. Concrete mix design optimization **– 15%**
   i. Discuss the selected concrete mix design and how parameters are optimized in order to achieve the objectives defined in the introduction. Explaining the mechanisms behind the durability improvement for different types of SCMs is highly encouraged.
   ii. Provide data about the performance results of the optimization process.

f. Provide a maximum of three pages on a discussion of the simplified LCA. **– 20%**
   The discussion shall include:
   i. Clear definitions of the system boundaries in the simplified LCA and how such boundaries affect the results of an LCA (simplified or not).
   ii. Presenting the environmental impact results of BCS and ACS obtained from the Official Eco-Concrete Spreadsheet. A discussion on the importance of this aspect regardless of the durability performance in the mixture design process is highly encouraged.
   iii. Summary of major factors affecting the outcomes of the simplified LCA of the mixtures. For example, how do components such as portland cement, SCM, water content, and aggregates affect positively and/or negatively the environmental burdens in distinct damage categories? A thorough discussion around all the five life cycle impact categories will result in a full score consideration for this section.

g. Provide instructions of no more than one page on how the ACS mixtures can be scaled up and how it affects the constructability. **– 15%**
   i. Clear description of the use of proposed mixtures for different end-use applications (for example pavements, buildings, precast elements, etc.)
   ii. Qualitative implication of the proposed ACS mixture on the constructability of the construction projects (for example, impact on the project cost – e.g., potential delay on the construction due to strength gain rate, permeability, finishability, etc.) compared to the BCS case.

h. Conclusions **– 5% (maximum one page)**
   The key findings and lessons or insights of the mixtures must be explained.

i. References**– 5%**
   All external references are cited using standard reference format (e.g., MLA, APA, etc.).

j. Formatting– **5%**
   The text must be written in the format of single spacing. 12 pt. font size. Times New Roman. (This applies to captions and fonts in figures and tables, as well.) The margins must be set to 1 inch all around. All the figures must be labeled with a number and title. In addition, all the pages must be numbered except the cover sheet.

Considering all the described sections in the report, the whole document shall not be longer than **20 pages**. Submit a PDF file of the report prior to the deadline. All reports shall be scored between zero and 100%, with 100% being the best.

2.7 Recorded video

Teams must make a recorded video prepared in the English language. The recording must meet the requirements listed below for the judges to review and score.

Submission consisting of a YouTube video URL, no longer than 7 minutes, meeting the requirements specified below, shall be submitted through the competition webpage prior to 11:59 p.m. Eastern Daylight Time (UTC-4.0) on 10 April 2025. The YouTube video settings must be public, and the "Made for Kids" option must be turned off. The YouTube video should be uploaded in the following format:

a. Title: TEAM NAME - ECOCONCRETE
b. Description: Include the Team Name, University Name, and a brief description of the solution presented in the video.

As directed on the competition webpage, Letter of Verification, Official Information Form, remaining team members, and PowerPoint slide of the team are also required to complete the team's submission. Details of these required items will be included on the student registration website. It is suggested to avoid waiting to the last minute for submission to avoid delays with obtaining all parts of the required documentation. Failure to provide the required documentation will disqualify a team from participating. Late entries will be penalized, up to and including possible disqualification from the competition.

Content should be understood by an English-speaking audience. Ethical and professional responsibility stated elsewhere in these rules must be followed.

a. Slides content: **– 50%**
   i. Each presentation shall document the decision-making process and materials chosen for the mixture design used, and the simplified Life Cycle Assessment (LCA). **– *10%***
   ii. Each presentation shall explain briefly the decision-making process. **– *10%***
   iii. Each presentation needs to fully identify the mixture used for Base-Case Scenario (BCS) and Alternative-Case Scenario (ACS) in the simplified LCA. **– *15%***
   iv. Each presentation shall present the major factors affecting the outcome of the Simplified LCA. **– 10%**
   v. Each presentation shall present the importance of the simplified LCA in the decision-making process regardless of the durability performance. ***10%***
   vi. Each presentation is designed to convey information, but consideration should be given to doing this in a creative way.

b. Questions and answers: **– 50%**
   i. The top 20 teams that received the best total scores of environmental performance, service life improvement, report writing, and video content, will be invited for a short interview to answer the questions of jury members.

c. Scoring

   Judges will score each video appearance and presentation using the indicated scoring percentages (based on a total of 100%). All the presentations shall be scored between zero and 100%, with 100% being the best.

Only the top 20 teams will be invited for the interview with the judges at least one week prior to the competition.

3 FINAL SCORING

The final score will be calculated based on the following formula, inputting judges' scores for the written report and presentation, and the team ranking for strength and resistivity:

$$Final\ score = 0.20\ WR + 0.30\ PP + 0.25\ R_{\rho} + 0.25\ R_{SS}$$

Where: WR is the overall score for the written report;
PP is the overall score for the video presentation and Q/A interview;
Rρ is the score according to the team ranking for durability performance;
R_{SS} is the score according to the team ranking for Single Score Ratio (SS_{Ratio}) from the simplified LCA.

Teams will be ranked based on the highest final score, and the highest (closest to 100) will be the winner. In the case of a tie, the winner shall be the team with the best service life simulation score. A detailed table of scoring is presented in the appendix.

A team can be disqualified if the mix design does not respect the design rules as listed below;

- A maximum of 40% of the binder may be non-portland cement material;
- Aggregates mass shall constitute at least 75% of the total mass of concrete mixture;
- The water-to-binder mass ratio is w/b = 0.40.

4 JUDGING

a. The judges will be appointed by ACI Committee 130G and the chair of S-801 as necessary. Judges may be different for each testing category.

b. The judges will make the final determination on compliance with the rules and penalties for rules violations. Disqualified entries shall not be included in the scoring or considered for awards. All penalties will be explained fully to the teams.

c. The decision of the judges will be final, and appeals will not be considered. Suggestions for improvement may be submitted to the ACI Subcommittee 130G.

5 REGISTRATION AND MATERIAL SUBMISSION

a. Advance registration is required. Teams shall register through the competition webpage on the ACI website by 11:59 p.m. Eastern Daylight Time on **10 March 2025**. It indicates the team's intent to enter the competition. Registration will be confirmed via email. This registration is the first of two required steps to participate in the competition.

b. The electronic report, presentation slides, video link, and JSON output file from Life 365™ as described above, shall be submitted no later than 11:59 p.m. Eastern Daylight Time on **10 April 2025** through the official registration process link on the ACI website. The Excel format of the EcoConcrete Calculation Tool V2.01 completed shall also be attached. The receipt of the report will be confirmed. Failure to receive confirmation indicates incomplete submission.

c. Top 20 teams based on the best-aggregated scores of service life, LCA, written report, and video recording will be invited for an interview with the judges.

6 COMPLIANCE WITH ACI ECOCONCRETE COMPETITION RULES

ACI reserves the right to perform a detailed examination and check all 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 of his/her teams will be disqualified. ACI Subcommittee S-801 will further document recommendations to disallow the team, their advisor, and/or school/university from participation in future competitions.

7. Contact Information

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