EPD STADIUM® User Guide

For the 2012 ACI Egg Protection Device – Optional Durability Category
**Introduction**

STADIUM® is a concrete durability analysis tool developed to meet the needs of concrete infrastructure owners looking to measure the long-term durability of their new and existing works. STADIUM® is a software model which simulates the physical and chemical changes in concrete as it reacts with its environment, taking into account concrete variables such as chemical composition, permeability, ion diffusion coefficients, moisture transport coefficients, tortuosity, and many other factors, as well as exposure conditions such as ambient humidity, temperature, and chemical aggression.

STADIUM® analysis normally requires an extensive laboratory analysis of the concrete being used in order to provide accurate values for the concrete parameters which have an influence on concrete durability. As mentioned in the rules, for the purposes of this competition, the only lab testing which will be necessary will be ASTM C 642 – Standard Test Method for Density, Absorption, and Voids in Hardened Concrete. All other necessary parameters will be provided in the *EPD STADIUM® Transport Properties Grid* as a function of the properties of your cement paste. Note that these values are taken from extrapolations of the STADIUM® database, and are therefore only approximations and estimates and would not be used in typical modeling situations.

**Getting started**

The version of STADIUM® you will be using is a web-based commercial build of the STADIUM® model. It requires the installation of a user interface and logging in via a username and password, which will be provided to you by the organizers of the Egg Protection Device and/or SIMCO Technologies. Note that for this competition, your username and password will only be valid on a single computer – once STADIUM® has been installed and you have logged in, you will not be able to log in to your STADIUM® account from another computer. The STADIUM® user interface can be installed on any English-language Windows platform.

As your build of the STADIUM® user interface produces reports through printing, it is recommended that this computer be connected to a printer or have a print-to-PDF application.

This guide will feature screenshots from the STADIUM® user interface with red rectangles around where you should click to advance through the interface for the needs of the project. Feel free to explore the model outside these guidelines.

Teams are encouraged to test several mixes before casting their Egg Protection Device in order to select the optimal durability mix. When doing so, run multiple simulations and submit results for the mix that was ultimately used in the Egg Protection Device.

**PLEASE NOTE:** Computation is provided by a SIMCO central server bank. As such, computations could take from several hours to several days to complete, depending on the server load. Please keep this in mind as related to the competition due dates when deciding to model your EPD durability.
Step 1: New project

Once you have installed and logged in to STADIUM®, this screen should appear. On the right hand side are a series of tutorials on using STADIUM®, should you be interested in learning more closely how this model works. You will be asked to name your new project, and you will begin the Project Wizard.

Step 2: Metric Units

1. Select “SI Metric” for the units. Because the output will be in the units of the chosen type, International SI Units are required for ease of judging and comparison.
2. Click “Next”
Step 3: Exposure and location

1. Select the “Marine” module from the modules tab at the top of the screen
2. Select the region of Florida
3. Select the city of Miami
4. Click “Next”

Step 4: Element design

1. Click “Cope Wall” on the structural elements checklist
2. Enter the total vertical thickness of the top section of your Egg Protection Device at the thinnest part. The thinnest section is measured from the top face of your EPD, perpendicular to the horizontal. See the below diagram as a reference.
3. Enter 30 years for scenario duration
4. Click “Next”
Step 5: Reinforcement/Material/Exposure

1. Click “Reinforcement / Material / Exposure”
Step 6: Top rebar position

1. As the competition will only consider chloride threshold at the topmost layer of rebar, slide the number of rebar positions bar to “1”.
2. Enter the minimum depth of cover from the outside face of the Egg Protection Device to the first layer of rebar in your EPD. Note that this is for the outermost rebar at the top surface of the Egg Protection Device. The top surface is being modeled as the face that will be exposed to the tides. Refer to the Reference Diagram on the previous page.
3. Click “OK”
Step 7: Concrete mix

1. Select “0.35 w/b Type I” from the list of concrete mixtures. Note that this only serves as the basic template from which you will make the modifications that represent your own mix – even if this is nowhere near your actual concrete mix, we will change all the parameters of the mix so that they represent your actual concrete.

2. Enter your water/binder (w/b) ratio, composed of the total weight of free water in the mix, divided by the total weight of cementitious binders.

3. Enter your cement type and proportion within your concrete.

4. Enter your supplementary cementitious materials (SCM) if any, such as fly ash or silica fume, along with their proportions and specific gravities within your concrete mix.

5. Enter your proportion of fine aggregates.

6. Enter your proportion of coarse aggregates.

7. Enter your proportion of air.

8. Select the “Transport Properties” tab.

Note that the proportion units are in kilograms per cubic meter for every composite except air, which is a percentage. The specific gravity of your SCM will need to be entered, as well as the specific gravity of your aggregates, if they are different from those included.
Step 8: Transport properties

1. Enter permeability as you determined by ASTM C 642 in your lab.

The following values should all be taken from the *EPD STADIUM® Transport Properties Grid*:

2. Enter the OH⁻ diffusion coefficient.
3. Enter the saturation at 50% relative humidity.
4. Enter the permeability.
5. Slide the hydration parameter bar to your hydration parameter.
6. Enter the hydration (alpha) parameter.

Note that if your mix properties are not precisely listed in the separate *EPD STADIUM® Transport Properties Grid*, you should interpolate from existing values. The methods for this interpolation are left up to individual teams and should be reported in your documentation of the solution.

7. Click “OK”
Step 9: Exposure conditions

1. Select “Seawater – Tidal Zone” under Exposure Type at the top right
2. Select “OK”

For fun, teams may explore the “Advanced” options as they wish, as determining proper exposure conditions is vital to any durability simulation. But modeling for the competition should be performed with the default “Seawater – Tidal Zone” as it represents a fairly accurate estimate of likely exposure conditions in Miami.
**Step 10: Launching the simulation**

1. Review your simulation parameters. This is an important step – a simulation can take several hours to several days, and a misplaced decimal point can have dramatic effects on your simulation results. Double-click on a field to change it.
2. When you are ready, click “Compute the Simulation”

**Step 11: Compute**

1. Click “Compute”. 

STADIUM® User Guide, Fall 2012 ACI Egg Protection Device
This will queue your simulation on SIMCO’s STADIUM® servers, until your simulation reaches the front of the queue. Once at the front of the queue, your simulation will be launched into the STADIUM® model. Depending on the load on the STADIUM® servers, this process can take a few hours to a few days. Running multiple simulations at the same time may slow down your server processing and delay your results.

**Step 12: Viewing results**

1. Once your simulation is complete, click “View Results” from the left-hand toolbox.
2. Click “View Results”

When simulation is complete, the server will send an email to your registered email address, depending on how you set up your account. Otherwise you will have to log in periodically to check if results are available. Viewing the simulation results will download your simulation results from the STADIUM® server, which may take a few minutes.
Step 13: Graphing results

1. Select the “Content vs. Time” tab
2. Check the box for the topmost rebar in your rebar list (there should only be one)
3. Check the “Total Chloride” box

This will show a graph of the concentration of chloride ions at the depth of the topmost layer of rebar, where corrosion is likely to cause degradation of the concrete structure. By clicking on the “Corrosion” tab on the left side in the Toolbox next to the Chart Options, and selecting a base rebar type, this can give teams an idea for how long before the chloride ion concentration causes corrosion on their rebar, leading to cracking and other degradation. ACI recommends chloride content less than 0.15% by weight of cement in freeze-thaw susceptible areas or where wet service is possible, although the actual amount of chloride ion content causing corrosion has been shown to be higher. Note that this is not the only possible cause of degradation nor is it the only cause tracked by STADIUM®. However, for the purposes of this competition, chloride penetration will be the only aspect considered.

4. Add this curve to your report by clicking the icon on the bottom left, below the curves report list.
5. Click the “print report” button on the far left side of the screen.
Step 14: Printing report

1. Select “Print First Page”, “Print All Simulations, Material Data and Exposure Conditions” and “Print Graphical Results”
2. Click “Print”

This will lead to your printing options, where you can either use a print-to-PDF application or print and scan your report. This is the report that must be submitted as part of the official documentation for the durability prize category.

Any questions regarding this guide should be sent to fmorisset@simcotechnologies.com and copied to Michelle Totin with ACI at Michelle.Totin@concrete.org. Good luck to all participants!