

Prevention of Plastic Shrinkage Cracks in Fresh Concrete

Aamir Munir, MSCS and Luke M. Snell, Director CCRU
Southern Illinois University Edwardsville
Edwardsville, Illinois

Planning and preparation for all weather conditions are keys to successful construction. The formation of Plastic Shrinkage Cracks is one of the problems one can face at the time of placement. The program presented in this paper computes the Rate of Evaporation for concrete according to Nomographs in the American Concrete Institute Guide to Curing Concrete (ACI 308R-01). The air temperature, humidity, concrete temperature, and wind velocity are variables which must be known by the user to determine if adequate condition to stop cracks is being achieved.

Key Words: Plastic Shrinkage Cracks, Computer Program, Air Temperature, Concrete Temperature, Wind Velocity, Humidity

Weather conditions at the time of placement may have a major impact on the formation of plastic shrinkage cracks. Plastic shrinkage cracks are caused by the rapid evaporation of surface moisture for the fresh concrete and are increased by high air temperature, high concrete temperature, low humidity and high wind speed. The reason for plastic shrinkage cracks is that water evaporates faster than it can reach the top surface resulting in tensile stresses on cracks on the top surface.



Figure 1: Photo Courtesy of Portland Cement Association

The equation that relates these variables is shown below:

$$E = [T_c^{2.5} - (R * T_a^{2.5})] [1 + 0.4 V] * 10^{-6}$$

Where:

E = Evaporation rate, lb/ft²/hr

T_c = Concrete Temperature, °F

T_a = Air Temperature, °F

R = (Relative Humidity %) / 100

V = Wind Velocity, mph

Several publications have a nomograph that provides a graphical solution to the above equation. This nomograph is shown in Figure-2.

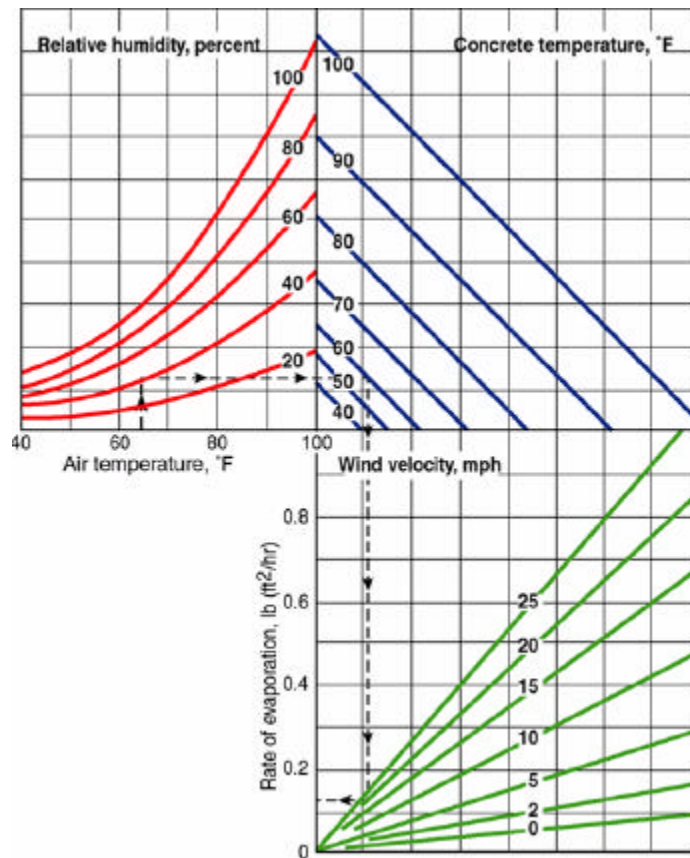


Figure-2: Nomographs in the American Concrete Institute Guide

For past experiences, it has been shown that if the Rate of Evaporation is greater than 0.2 lb/sq. ft/hr then cracking is expected. Precautions against plastic shrinkage are mandatory. If the Rate of Evaporation is less than or equal to 0.2 lb/sq. ft/hr and greater than or equal to 0.1 lb/sq. ft/hr then some shrinkage cracking may occur. If the Rate of Evaporation is less than 0.1 lb/sq. ft/hr then plastic shrinkage cracking is not likely to occur.

From our experience, neither the formula nor the nomograph is used for planning purpose. Typically, these are only used by consultants to explain why the plastic shrinkage cracks occurred and to help access liability. For this reason, a computer program was developed so that the onsite variables (air temperature, concrete temperature, humidity, wind velocity) can be easily assessed and the result used to plan a successful concrete placement with out plastic shrinkage cracks.

In our construction class, this program allows the students to quickly evaluate several site variables and determine which will cause future problems with plastic shrinkage cracks. The student can then adjust these variables and determine if these proposed changes will eliminate the plastic shrinkage cracking. The student is also given the option of letting the

computer determine how much change is required in a site variable so that the plastic shrinkage cracks are likely eliminated.

Several ready mixed concrete companies have used this program to warn their customers that plastic shrinkage crack can be expected during their concrete placement. This will hopefully encourage the contractors to use some precautions and modify concrete construction procedures so that a successful placement with out plastic shrinkage can be accomplished.

The user enters the site variables (air temperature, humidity, concrete temperature, and wind velocity). Once these are submitted, the computer determines if plastic shrinkage cracking is expected. If cracking is expected, the output screen becomes red indicating some variables are needed to change for required results. If the output screen becomes yellow then it means some shrinkage cracking can occur. If cracking is not likely to happen, the output screen becomes green.

Below is an example of the input and the output screen. Note: that in this example cracking is expected and the output screen is in red.

Evaluating Concrete Curing Conditions

Developed By : Luke Snell And Aamir Munir

Cracking is expected Precautions against plastic shrinkage are mandatory
The Rate Of Evaporation is 0.33 lb/Sq. ft/h and is controlled by the following four values.

Air Temperature	: 60 °F
Concrete Temperature	: 70 °F
Humidity	: 20 %
Wind Velocity	: 21 mph

Please Enter the Correct Values :

1. Air Temperature in °F : 60 (Temp Range 40 to 99 °F)
2. Humidity in %age : 20 (Humidity Range 0 to 99 %)
3. Concrete Temperature in °F : 70 (Temp Range 40 to 99 °F)
4. Wind Velocity in MPH : 21 (Wind Velocity 1 to 25 MPH)

Submit Redo Help

Wind Velocity Computer Change

- Air Temperature
- Humidity
- Concrete Temperature
- Wind Velocity

Figure-3: Input and output screen

The users have several options. They can redo this program with different variables or allow the computer to find the value that will eliminate the likelihood of plastic shrinkage cracks. In our example, the wind velocity was selected to be changed. The computer

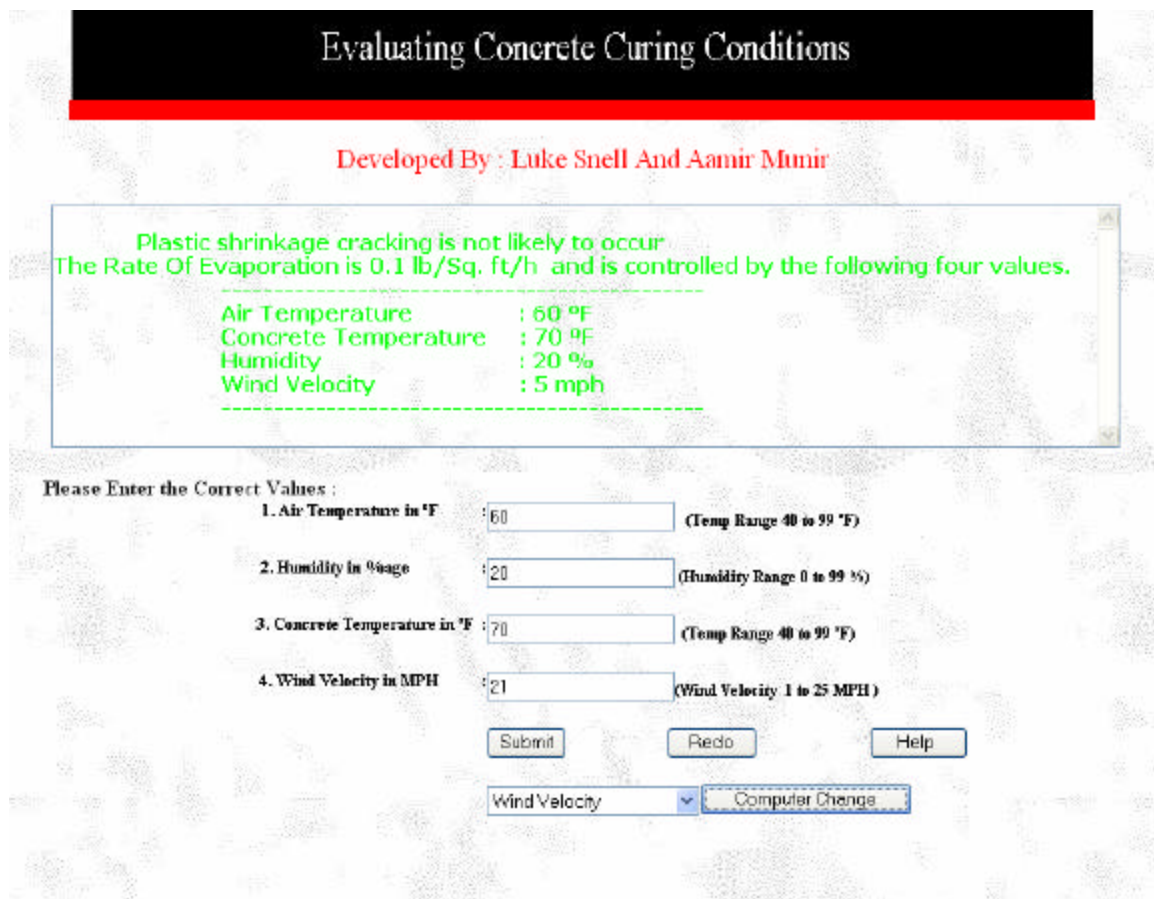


Figure-4: Input and output screen

shows that wind velocity must be changed to 5 mph as shown in Figure-4.

Note: that this output screen is green, thus another indicator that the user now has favorable site conditions for the concrete placement.

This program is available on www.siu.edu/CCRU/research.htm/curing .

References

“Rate Of Evaporation” Page 1-5, [WWW document]

URL: http://www.in.gov/dot/div/testing/manuals/superstructure/chapter_01.pdf

“Design Control of Concrete Mixtures;” Portland Cement Association (PCA); Skokie, 2002. Page 236

“Guide to Curing Concrete (ACI 308R-01)”, American Concrete Institution, Farmington Hill, 2001