



February 2, 2022

**MEMORANDUM: Concrete Maturity: Requirements and Guidance**

***Background:***

The department offers several ways to determine opening strength for concrete. One of the methods that can be used is maturity. Maturity is the concept of measuring the concrete's temperature and the time it takes to reach that temperature. This time-temperature relationship can then be used to estimate the concrete's strength when cylinders or beams are broken at certain times. This method provides a non-destructive means of estimating the in-situ concrete's strength and determine if the concrete has gained enough strength to open it to service or removing formwork and falsework.

***Requirements for Calibrating Maturity Curves:***

CMM 870.4.8.1 and CMM 870.4.8.2 outlines the requirements for calibrating maturity curves for WisDOT contracts. A maturity curve must be developed for each mix design that will use this method to determine opening strength. The procedure for developing and calibrating the maturity curve requires the calibration samples being made in the field instead of being made in the lab. The cylinders used to develop the curve are casted on the first day of the concrete pour on the project. After the cylinders have been casted, they need to be cured in similar conditions to the concrete in the field. This means placing these cylinders in with the concrete that was placed so the cylinders can cure under the same environmental conditions. It has been shown that calibrating maturity curves using this method matches with how the concrete is curing in the field. Standard Specification 502.3.10.1.3.3 requires the maturity curve to have data points that exceed 120 percent or greater than the required opening strength. What this means is the curve only needs to be developed for the duration it takes the concrete strength to exceed 120 percent of the required opening strength specified in the contract. Once the data points reach or exceed the 120 percent threshold and meets the other remaining requirements found in ASTM C1074, the maturity curve can be used to estimate the opening strength on the project. Submit the newly established maturity curve to WisDOT project staff for review and approval prior to use.

***Requirements for Verifying Concrete Maturity:***

Standard Specification 502.3.10.1.3.3 outlines the verification of the maturity curve and when a new one must be developed. A set of verification cylinders must be made each work week to validate the curve. These verification cylinders must be field cured alongside the concrete element that was casted. This curing process is not dissimilar to how the calibration cylinders were cured during development of the curve. The verification cylinders that are broken must break within +/- 10% of the curve. If the verification cylinders vary greater than +/- 10%, the maturity curve must be redone. Similarly, a new maturity curve must be developed if the concrete mixture design changes. Any changes to the mix design may affect how the concrete reacts which may impact the time-temperature relationship. Development of the new curve will have to follow the same procedures as the previous curve.

***Guidance on Concrete Maturity:***

Concrete maturity is a good way to estimate the in-situ concrete strength. However, there are items to consider when using maturity. One of those items is the placement of the maturity sensor(s) within the concrete element. CMM 870.4.8.3 states to install sensors in locations that are critical in terms of exposure conditions and structural requirements. One such critical area are the edges of the concrete element. Concrete at the edges will cure slower than concrete in the center of the element. It is good practice to place sensors 2" – 4" from the edge of the element. Another item to consider with maturity are seasonal changes. A maturity curve developed during colder weather will not be valid during warmer weather. The hydration (reaction) of cement can be impacted by temperature and humidity changes which has a direct impact on the maturity curve. A new maturity curve will be needed to reflect with the change of seasons. In addition to seasonal changes, the maturity sensors should not be turned on until they have been embedded in the mass of concrete or the verification cylinders. Premature activation of these sensors can impact the maturity calculation and provide inaccurate data. The next item to consider is to have multiple maturity sensors placed in the concrete. Though 502.3.10.1.3.3 specifies the minimum number of sensors to be placed in the concrete, it is good practice to place an extra sensor just in case of sensor failure. This extra sensor should be placed in a different critical location. Additionally, having more sensors will help build a better temperature profile of the concrete element to ensure different parts of the element are curing at the same rate. The last item to consider is to cast a separate set of opening strength cylinders. Doing this can help supplement the maturity curve if there are sensor failures or if the verification cylinders exceed the +/- 10% threshold.