

CITY OF COLUMBUS, OHIO

**SUPPLEMENT 1098
PROCEDURE FOR ESTIMATING CONCRETE STRENGTH
BY THE MATURITY METHOD**

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1098.01 Scope. The Maturity Method is a non-destructive procedure using the in-place internal concrete temperature over a period of time to estimate the in-place concrete strength. The Maturity Method determines when contraction joints may be sawed; forms or falsework may be removed; concrete has achieved adequate strength to accept construction loads; or concrete may be opened to traffic.

Do not use the Maturity Method for determining concrete strength for payment or to decrease specification curing times.

1098.02 Acceptable Applications for using the Maturity Method.

A. The Maturity Method may be used for any Item 499 concrete specified in:

- Item 255 Full Depth Pavement Removal and Rigid Replacement
- Item 256 Bonded Patching of Portland Cement Concrete Pavement
- Item 305 Portland Cement Concrete Base
- Item 451 Reinforced Portland Cement Concrete Pavement
- Item 452 Non-Reinforced Portland Cement Concrete Pavement
- Item 511 Structural Concrete
- Item 526 Approach Slabs

1098.03 Procedure for Developing a Maturity Curve.

Develop the maturity curve according to ASTM C 1074 using the temperature-time factor maturity function. Use a value of 0° C for T^o (datum temperature) unless a more accurate value is determined in according to ASTM C 1074, Annex A1.

When the concrete specification requires tensile or compressive strength, use 6" x 12" (150 mm x 300 mm) cylinders to develop the maturity curve for compressive strength.

- A. Make all specimens from the same batch of concrete. The batch size should be at least 3 cubic yards (2.3 cubic meters) and use the same materials, mix design and mixing technique that will be used for concrete on the project. Mix at the maximum w/c ratio and plus or minus 0.5 % of the maximum air content.
- B. Determine the plastic properties of the batch by performing slump, air content, unit weight and concrete temperature before making the strength specimens.
- C. Make a minimum of seventeen (17) specimens according to ASTM C 192. Embed maturity sensors in the center of two (2) of the specimens. For standard-set concrete, test at ages of 1, 3, 7, 14, and 28 days. For high early strength, moderate-set, and fast-set concrete, test when strengths are approximately equal to 30, 60, 75, 85 and 100% of the design strength. Additional specimens can be made and tested at other ages to help define the maturity curve. Do not test the specimens with the embedded sensors.
- D. Ensure that personnel making cylinders and beams and performing slump, air content, unit weight and concrete temperature are ACI certified as Concrete Field Testing Technicians, Grade I. Ensure that personnel testing cylinders for compressive strength and beams for flexural strength are ACI certified as Concrete Strength Testing Technicians. Provide documentation of the ACI certification with the submittal under 1098.04.
- E. Use digital data-loggers that connect to a commercially available maturity instrument that automatically computes and displays the concrete maturity.

1098.04 Acceptance of a Maturity Curve by the Department.

Submit a hardcopy of the maturity curve; mix design and material sources; plastic concrete test results; concrete strength test results; maturity curve data with calculations and method used for monitoring maturity in the laboratory to the Engineer and concurrently to the Laboratory. The City will have thirty (30) days to evaluate the results for acceptance.

1098.05 Using Concrete Maturity in the Field.

Use of maturity to estimate concrete strength is acceptable for City applications listed in 1098.02 if the concrete uses the same aggregates, cementitious and admixture materials; mix design; and mixing technique as the concrete tested to develop the maturity curve. Do not exceed the w/c ratio used to develop the curve.

- A. Use the same type digital data-loggers and commercial maturity instrument as used in 1098.03 to monitor field placed concrete. Use the same value for *T_o* (datum temperature) that was used to develop the maturity curve.
- B. For Items 255 or 256 – Install at least two (2) sensors for each work day. Install the first sensor where maturity gain is expected to be the slowest.

- Maturity gain is typically slowest in the thinnest section of pavement or volumetrically smallest patch or repair. If all sections, patches or repairs have the same dimensions and no concrete is expected to gain maturity slower than another, install the first sensor randomly in concrete from any load except the last load. Install the other sensor in concrete from the last load mixed and placed that day.
- C. For Items 305, 451, or 452 – Install at least one (1) sensor for every 3,750 yd² (3135 m²) or fraction thereof placed each day. Install the sensor in the last load of concrete mixed and placed in the 3,750 yd² (3135 m²), or fraction thereof. Each day, install at least one (1) additional sensor in any concrete placed within the last four (4) hours of the last load and where the maturity gain is expected to be the slowest.
 - D. Maturity gain typically is expected to be the slowest in the thinnest section of pavement. If all sections of pavement have the same dimensions and no section is expected to gain maturity slower, place the additional sensor in the section of pavement constructed from the second to last load of concrete mixed and placed that day. Install sensors half way down in the pavement thickness.
 - E. For substructure Item 511 – Install sensors to monitor the maturity of each substructure element (i.e. each abutment, pier, footing, wingwall, column, pier cap, intermediate diaphragm between pre-stressed I-beams, cast in place pile, or backwall). If a substructure element is placed in phases, install sensors to monitor the maturity of each phase. If a substructure element placement or any phase of a substructure element placement exceeds 200 yd³ (153 m³), install additional sensors to monitor the maturity of each 200 yd³ (153 m³) placed, or fraction thereof. Install sensors as follows:
 - 1. If a substructure element placement, phase of a substructure element placement, or 200 yd³ (153 m³) substructure increment placement has uniform dimensions throughout with no changes in the least dimension, install one (1) sensor in the last load of concrete placed in the substructure element, phase, or increment. If the least dimension of the placement changes, install one (1) sensor in the least dimension and one (1) sensor in the last load of concrete placed for that substructure element, phase, or increment. If the last load placed corresponds with the least dimension, only one (1) sensor installation in the least dimension is required.
 - F. For superstructure Item 511, and Item 526 – Install sensors to monitor maturity every 200 yd³ (153 m³), or fraction thereof, of concrete placed per day. In the last 200 yd³ (153 m³) or fraction thereof section placed for the day, install the sensor in the last load of concrete placed. If the total amount of concrete placed for the day is 200 yd³ (153 m³) or less, place one sensor in the first 1/3 of the concrete placed for the day and a second sensor in the last load of concrete placed.
 - G. Locations for installing sensors should be selected where the concrete is expected to gain maturity the slowest. Do not place sensors in the center of a placement where the

concrete will be the hottest. Typical sensor placement should be 1 foot (300 mm) from an edge or corner and 6 inches (150 mm) from the surface.

- H. If the least dimension of a concrete element is less than 6 inches (150 mm), the desired cover for the sensor of 3 inches cannot be maintained. Ambient conditions may affect the sensor with thinner covers causing the maturity readings from that sensor to be more variable. When sections thinner than 6 inches (150 mm) are used additional sensors may be required by the engineer to check that the thin sections have uniform maturity readings.

So that the Engineer can independently monitor the concrete maturity, provide one (1) set of the same maturity monitoring equipment being used on the project and show the Engineer how to operate the equipment. The monitoring equipment will be returned at the completion of the project.

Maintain a separate log for each sensor which includes a unique ID; location; date and time of installation; date and time that the sensor began monitoring maturity; dates and times of all readings taken from the sensor; the corresponding temperature, maturity, and concrete age at each reading; and the date when readings were discontinued. Notify the Engineer immediately if there are problems or discrepancies with readings or damaged or improperly operating sensors. Document the date and time this determination was made, what the problem is, and the steps taken to correct it on the log. Have the log available for the Engineer at all times and provide an updated copy of the log to the Engineer weekly.

1098.06 Verification of the Maturity Curve.

Perform a maturity curve verification weekly. If four (4) consecutive weekly maturity curve verifications confirm the original maturity curve, reduce the frequency to one verification every two (2) weeks.

If maturity curve verification testing does not verify a maturity curve, immediately notify the Engineer and discontinue using maturity for estimating strength. Investigate why the maturity curve was not verified and provide the Engineer with a written report detailing why the curve was not verified and what actions will be taken to ensure the maturity is correct and verifiable in the future. If a curve cannot be verified, it indicates changes or alterations in the mix design, batching procedures, material proportions, or properties in the materials being used, or that the maturity curve being used was not developed correctly.

If the Engineer accepts the report and solution, maturity can be used again on the project with maturity curve verification frequency as directed by the Engineer, but no less than once a week. If future maturity curve verifications determine that the curve is verified, the Engineer may decrease the frequency of verification.

Maturity curve verification consists of the following:

- A. Sample concrete from a load or batch being used on the project. If the maturity curve is based on tensile or compressive strength, make five (5) 6" x 12" (150 mm x 300 mm) cylinders for test specimens. Sample in accordance with ASTM C 172. Make and cure test specimens in accordance with ASTM C 31. Ensure personnel sampling and making specimens in the field are ACI certified as Concrete Field Testing Technicians, Grade I.
- B. Place a sensor in the center of one of the test specimens and monitor the maturity.
- C. Test the specimens in pairs and average the results to determine strength. Test the first pair of specimens when maturity readings show the specimens have achieved strength between 50% and 70% of the design strength. Test the remaining pair when maturity readings show the specimens have achieved strength between 85% and 100% of the design strength. Test compressive strength cylinders in accordance with ASTM C 39. Test tensile strength cylinders in accordance with ASTM C 496. Do not test the specimen with the embedded sensor. Ensure personnel testing cylinders for tensile and compressive strength are ACI certified as Concrete Strength Testing Technicians.
- D. Compare the actual strength determined by destructive testing with the estimated strength determined by maturity to see if the curve is verified or not. If the actual strength is greater than the strength estimated by maturity or less than 10% below the strength estimated by maturity, the curve is verified. If the actual strength is more than 10% below the strength estimated by maturity, the curve is not verified.

1098.07 Maturity Curve Life.

A maturity curve is valid for two (2) years from the date of first approval by the City as long as the curve continues to be verified according to 1098.06. A maturity curve may be renewed twice for one (1) year increments.

To renew a maturity curve, submit a written request to the City before the maturity curve's expiration date. Submit the request and verification data conforming to 1098.06 to the Laboratory.

Designer Note:

This supplement is not intended as a stand alone specification. It is a description of the Department's methods for use of maturity testing. The Designer is responsible for either developing a plan note or using already developed proposal notes when the maturity method of determining concrete strength is going to be used.

If there are questions on this supplement's use or application, contact the Laboratory.