Maturity Curves

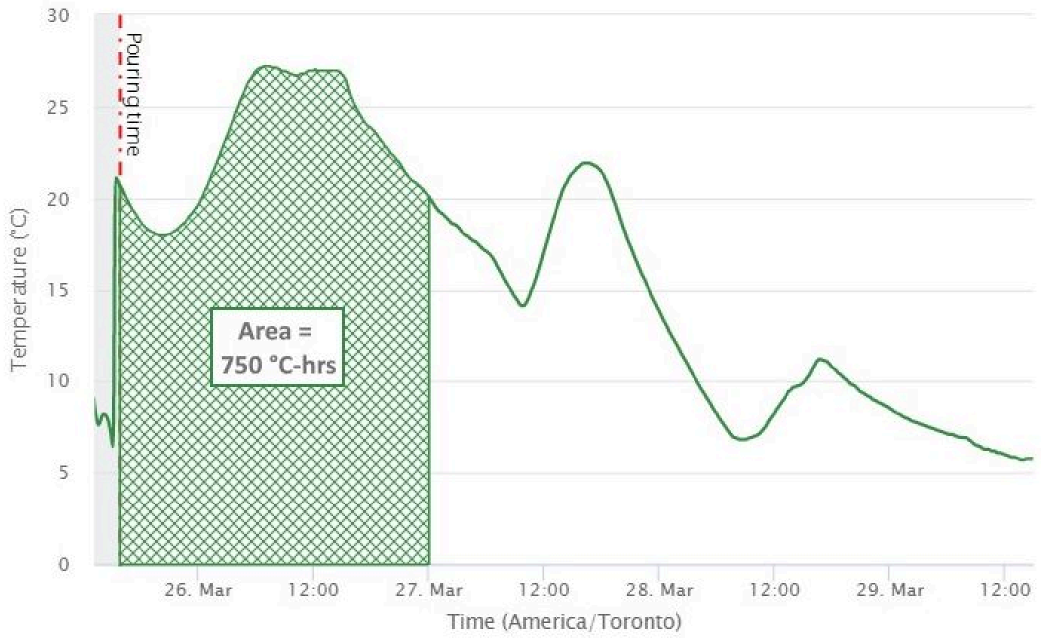
Technical Bulletin #31 - July 2024

What is a Maturity Curve?

Concrete develops strength when given time, temperature, and appropriate moisture. If we consider properly cured concrete as having a consistent moisture, the "maturity" of concrete can be expressed as a function of time and temperature. A maturity curve is a method used to estimate the in-place concrete strength without doing destructive testing. It can be very useful on large or repetitive pours and save time and expense of cylinder or beam molding, transportation and breaking.

How do you develop a maturity curve and how do they work?

Maturity curves are developed by developing a maturity relationship of a given mix design and then applying strength data at known maturities to develop a maturity-strength relationship. That's a lot to take in, so let's unpack the process. First, a trial batch is performed of the desired mix design and sixteen cylinders or beams (depending on if one is testing for compressive or flexural strength) are molded. The internal temperature of one of the cylinders is monitored every 30 minutes for the first 48 hours and then once an hour thereafter. This is done by placing a thermocouple wire in the concrete and connecting it to a maturity meter which records the temperature readings. This data can be shown in a graph, and the area under the line and above a "datum" temperature when concrete theoretically will not gain strength (often set at -10°C) is the amount of "maturity" the concrete has gained.



This area under the temperature line can then be shown as a function of maturity vs time, also called a TTF (Time-temperature function).

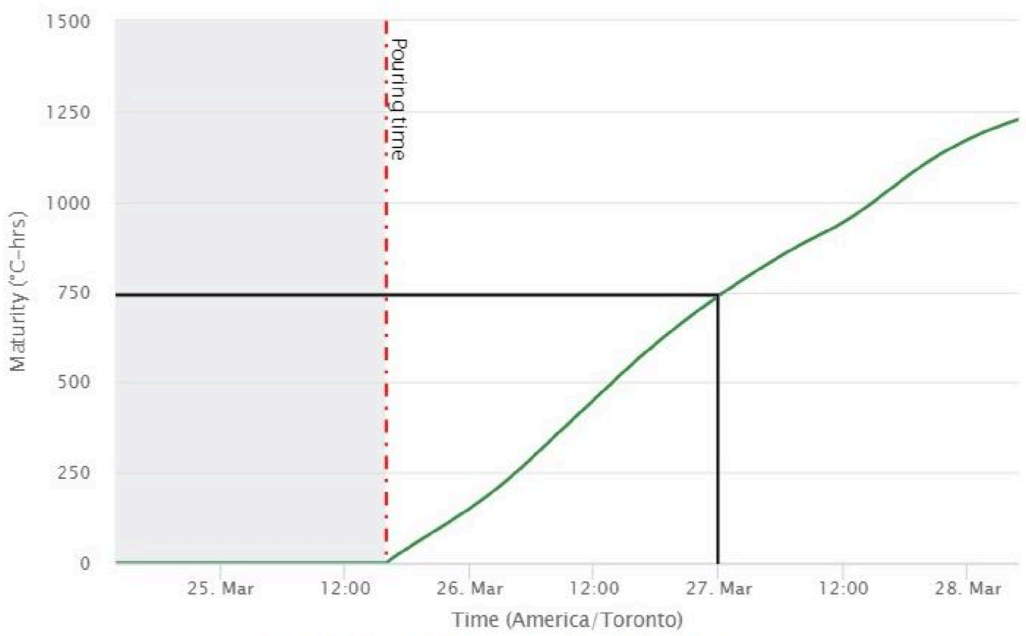
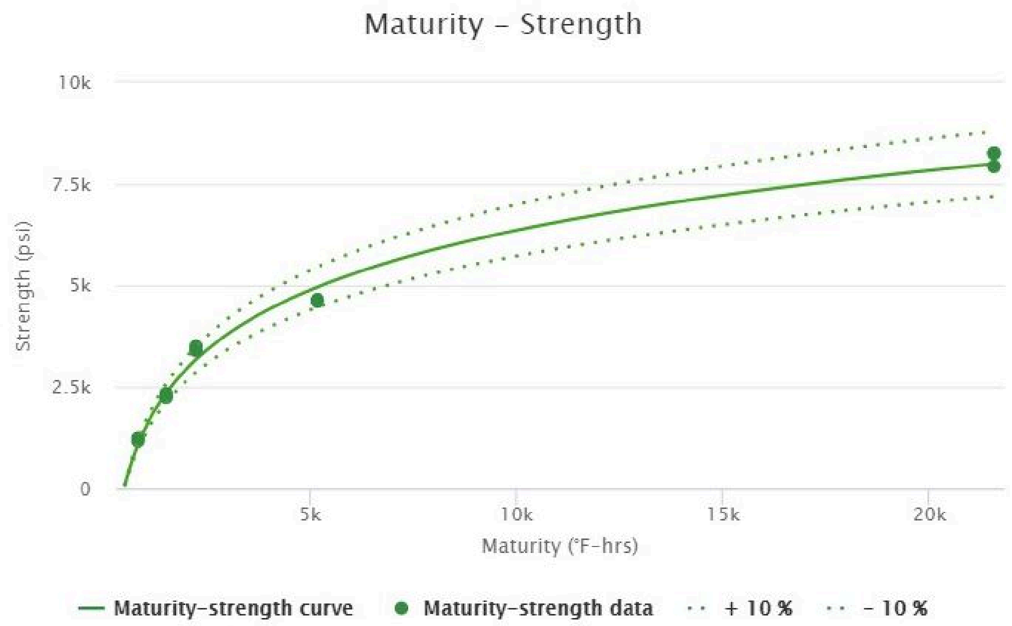


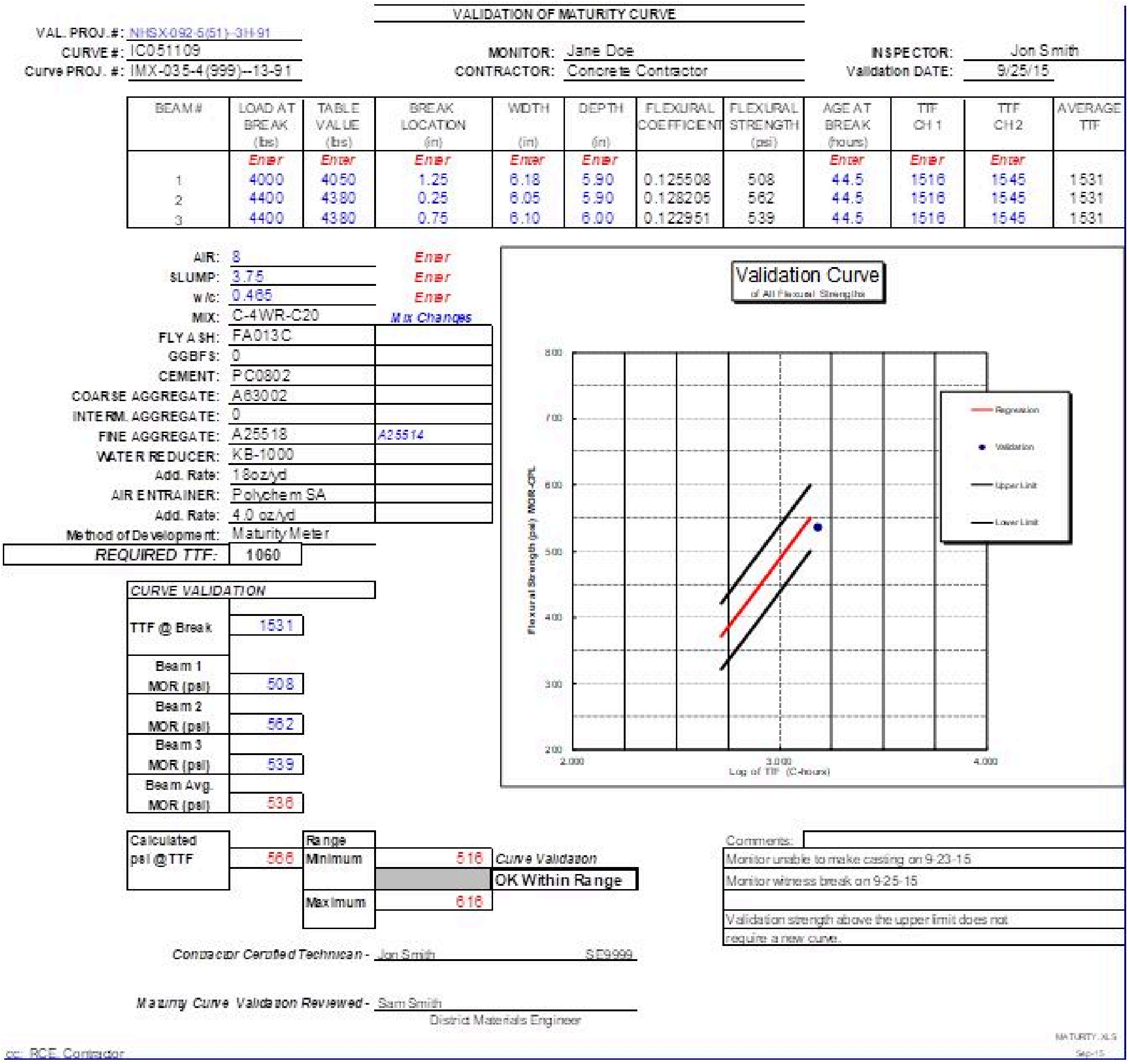
Figure 2: Time-Maturity Curve – Area Under a Curve Example

Finally, one can break the cylinders or beams at different ages and apply the strength to the TTF curve to develop a maturity-strength relationship. It's important to know that the curve is only relevant to that exact mix design, with those exact materials, in similar weather conditions. Therefore, curves need to be validated or sometimes re-created when there is a mix design change, material source change, or periodically as the seasons change. The Iowa DOT, for example, requires a curve validation every 90 days.



In the field..

Once a curve is established, it can be used in the field to theorize strength of in-place concrete. This is done by inserting or placing a thermocouple wire in a couple locations in a pour and taking a reading of the concrete temperature with a fluke meter immediately after it is placed. Then, concrete temperature readings are taken at different times and applied to the TTF curve. The maturity curve will inform what level of maturity is needed to achieve theoretical opening strength.



VALIDATION OF MATURITY CURVE

VAL. PROJ.#: NHSX-092-5(51)--3H-91
CURVE #: IC051109
Curve PROJ. #: IMX-035-4(999)--13-91
MONITOR: Jane Doe
CONTRACTOR: Concrete Contractor
INSPECTOR: Jon Smith
Validation DATE: 9/25/15

BEAM #	LOAD AT BREAK (lbs)	TABLE VALUE (lbs)	BREAK LOCATION (in)	WIDTH (in)	DEPTH (in)	FLEXURAL COEFFICIENT	FLEXURAL STRENGTH (psi)	AGE AT BREAK (hours)	TTF CH 1	TTF CH 2	AVERAGE TTF
	Enter	Enter	Enter	Enter	Enter			Enter	Enter	Enter	
1	4000	4050	1.25	6.18	5.90	0.125508	508	44.5	1516	1545	1531
2	4400	4380	0.25	6.05	5.90	0.128205	562	44.5	1516	1545	1531
3	4400	4380	0.75	6.10	6.00	0.122951	539	44.5	1516	1545	1531

AIR: 8 — Enter
SLUMP: 3.75 — Enter
w/c: 0.465 — Enter
MIX: C-4WR-C20 — Mix Changes
FLY ASH: FA013C
GGBFS: 0
CEMENT: PC0802
COARSE AGGREGATE: A63002
INTERM. AGGREGATE: 0
FINE AGGREGATE: A25518 — A25514
WATER REDUCER: KB-1000
Add. Rate: 18oz/yd
AIR ENTRAINER: Polychem SA
Add. Rate: 4.0 oz/yd
Method of Development: Maturity Meter
REQUIRED TTF: 1060

CURVE VALIDATION

TTF @ Break	1531
Beam 1 MOR (psi)	508
Beam 2 MOR (psi)	562
Beam 3 MOR (psi)	539
Beam Avg. MOR (psi)	536

Calculated psi @TTF	566	Range Minimum	516	Curve Validation
				OK Within Range
		Maximum	616	

Comments:
Monitor unable to make casting on 9-23-15
Monitor witness break on 9-25-15
Validation strength above the upper limit does not require a new curve.

Contractor Certified Technician - Jon Smith SE9999

Maturity Curve Validation Reviewed - Sam Smith
District Materials Engineer

cc: RCE, Contractor

MATURITY.XLS
Sep-15

Sounds great, but when should maturity curves be used?

Maturity curves are wonderful for large concrete placements where the same mix design will be used repetitively and opening as soon as possible is desirable. The maturity method also allieviates some of the risk of traditional strength testing such as improper specimen casting, improper curing of specimens, or improper handling. However, it is important to know that the maturity method is a *theoretical* measurement. If there are large swings in concrete temperature in between when measurements are made of the in-place concrete, that maturity or lack thereof will not be factored in the calculation. If concrete structures, for example, need to have a minimum strength before a load is applied, it's probably a good idea to take cylinders in lieu of or in addition to a maturity curve. Additionally, small pours or jobs with a variety of mix designs are probably not ideal for the use of the maturity method due to the time and expense of creating curves and monitoring temperatures of many pours. In those instances, it's probably just easier to make cylinders or beams in the field.

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Hahn Ready Mix

3636 West River Drive , 52802, Davenport