Purpose

The **COMA-Meter** (**CO**ncrete **MA**turity-**Meter**) is used to measure the maturity of newly cast concrete at a depth of 80 mm from the surface for the following purposes:

- Estimating the compressive strength at an early age using a pre-established strength-maturity relationship
- Timing of pullout testing with **LOK-TEST** (consult Technical Data Sheet) for early-age strength measurement
- Evaluating the effective in-place curing temperature

Maturity Method

The maturity method is a technique to estimate in-place strength after casting by accounting for the effects of temperature and time on the strength gain of concrete. The use of the method is described in ASTM C1074 "Practice for Estimating Concrete Strength by the Maturity Method." The temperature history of the concrete and a maturity function are used to calculate a maturity index that quantifies the combined effects of time and temperature. The strength of a particular concrete mixture is expressed as a function of its maturity index by means of a **strength-maturity relationship**. If portions of the same concrete are subjected to different conditions, the strength-maturity relationship for that concrete and the temperature histories measured at the different locations in the structures can be used to estimate in-place strengths at those locations.

Various maturity functions have been proposed to convert the measured temperature history to a maturity value. The one that has proven to be most accurate in accounting for the combined effects of time and temperature over wide temperature ranges is based on the Arrhenius equation:

$$t_e = \sum_{0}^{t} e^{\frac{-E}{R}\left(\frac{1}{T}-\frac{1}{T_r}\right)} \Delta t$$

where

Δt = time interval at actual concrete temperature
t_e = the equivalent age at the reference temperature,
E = apparent activation energy, J/mol,
R = universal gas constant, 8.314 J/mol-K,
T = average absolute temperature of the concrete during interval Δt, Kelvin, and
T_r = absolute reference temperature, Kelvin.

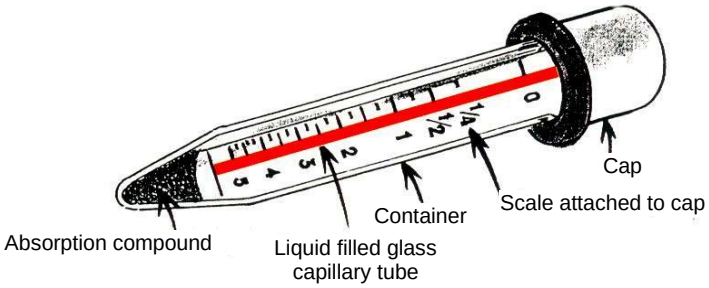
The exponential function is an **age conversion factor** that converts a time interval at the actual concrete temperature to an equivalent time interval, in terms of strength gain, at the reference temperature. The reference temperature is usually taken as the standard-curing temperature for concrete specimens, typically 20 °C (293 K) or 23 °C (296 K).

The activation energy represents the temperature sensitivity of the rate of strength gain during the acceleratory period following final setting and it depends on the cementitious materials in the concrete. For ordinary portland cement it has a value of about 40 kJ/mol, and it is greater for mixtures with slag cement and smaller for mixtures with fly ash **(1, 2).** ASTM C1074 provides strength-testing procedures for estimating the activation energy for a specific cementitious system. Others have used isothermal calorimetry **(2)** and setting time tests to evaluate activation energy **(3)**.

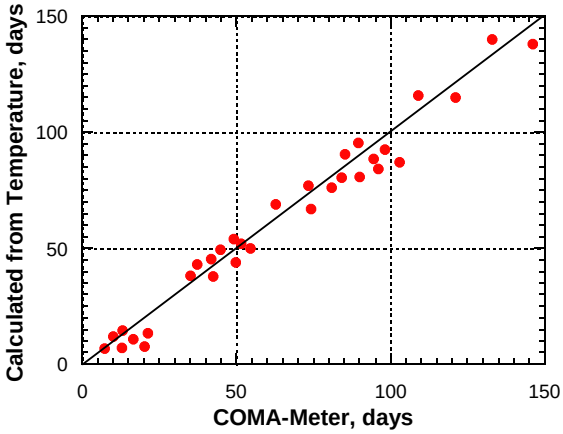
To use the maturity method for estimating in-place strength, it is necessary to develop the **strength-maturity relationship** for the particular concrete mixture. As described in ASTM C1074, this can be done by measuring the strength of specimens of the concrete mixture at different values of maturity. The strength-maturity data can be used for estimating the strength as a function of age at the locations of the **COMA-Meter** probes.

Principle

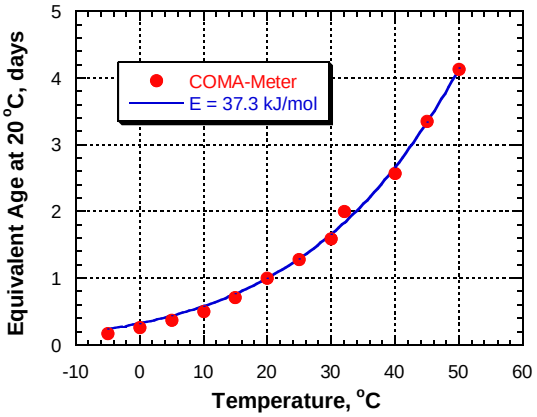
A glass capillary tube contains a special liquid for which the rate of evaporation varies with temperature according to the Arrhenius equation that is used to determine maturity of concrete from its temperature history. The closed capillary is placed on a card with a calibrated scale indicating maturity in equivalent age at 20 ºC. The card is attached to a cap that fits into a transparent glass container. After the concrete is cast, the capillary tube is snapped at the zero mark on the scale, the cap is pushed into the container, and the container is inserted into the fresh concrete.



The temperature within the probe will stabilize quickly with the temperature of the surrounding concrete. The liquid in the capillary tube evaporates at a rate determined by the temperature and time. The level of the liquid, readable on the scale, measures the maturity of the concrete stated in M_{20} units, which is the number of equivalent days of curing at 20 ºC.



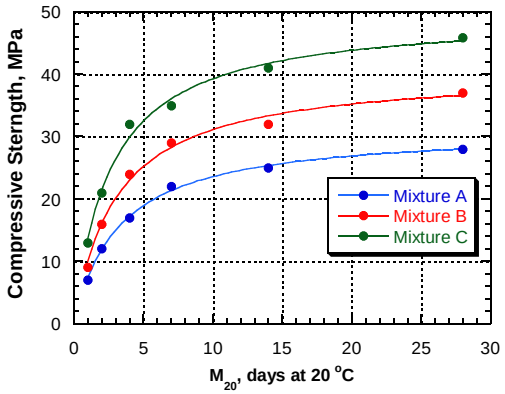
Comparison between **COMA-Meter** *maturity and maturity calculated from temperature readings Source: Möller, G. "Evaluation of COMA-test," Report 8335-1983, CBI, Stockholm, Sweden*



Maturity calculated by Arrhenius equation with activation energy of 37.3 kJ/mol compared with **COMA-Meter** *readings after one actual day at temperatures between -5 ºC and 50 ºC*

Strength-Maturity Relationship

In order to estimate the in-place strength, the **strength-maturity relationship** for the concrete mixture needs to be developed beforehand. The detailed procedure is given in ASTM C1074, but basically a set of standard specimens are made in the laboratory. A COMA-Mater is installed in two specimens. At ages of 1, 3, 7, 14, and 28 days, at least two replicate specimens are tested for strength and the average maturity is recorded. The strength-maturity data are plotted and a best-fit curve is determined and used for estimating the in-place strength. The plot on the right shows examples of strength-maturity curves for three concrete mixtures.

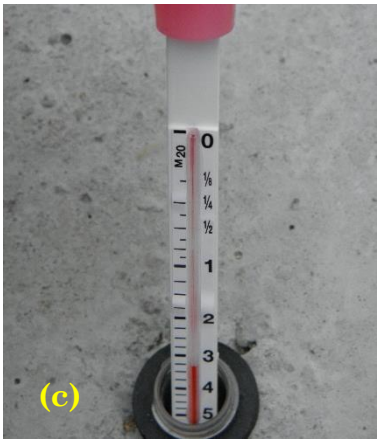


COMA-Meter

Application

The basics steps in using the COMA-Meter are:

a) Break the glass capillary at the 0 mark and introduce the scale card into the container
b) Insert the probe into the fresh concrete
c) At the desired time, pull out the card and read the maturity days (M_{20} at 20°C). Introduce the card again if the expected maturity has not been reached.



COMA-Meter Specifications

- Measuring ranges:
  - **COMA-5** = 0 to 5 M_{20} days
  - **COMA-14** = 0 to 14 M_{20} days
- Precision: ±0.1 M_{20} days
- Accuracy: ±5 % compared with maturity values calculated from direct temperature readings
- Activation energy, E ≈ 40 kJ/mol.

Ordering Numbers:

Item	Order #
COMA-Meter 0 to 5 M_{20} days. Pack of five probes.	COMA-5
COMA-Meter 0 to 14 M_{20} days. Pack of five probes.	COMA-14

COMA-5

COMA-14

References

1. Carino, N.J. and Lew, H.S., "The Maturity Method: From Theory to Application" http://fire.nist.gov/bfrlpubs/build01/PDF/b01006.pdf
2. Schindler, A.K., "Effect of Temperature on Hydration of Cementitious Materials," *ACI Materials Journal*, Vo. 101, No1, Jan-Feb 2004, pp. 72-81.
3. Pinto, R.C.A. and Schindler, A.K., "Unified modeling of setting and strength development," *Cement and Concrete Research*, Vol. 40, 2010, pp. 58-65.