Texas Aggregates and Concrete Association

Position Statement #7

The Misconception of W/CMT Ratio Design

How to Spend Owners Money with No Return on Investment

From a historical perspective, most engineers are taught that the use of a water to cement ratio (w/cmt) can be a design tool that is an implicit indicator of concrete performance. Unfortunately, the practical reality of using w/cmt for design is much less successful, is no guarantee of any actual performance, and in fact quite costly.

The w/cmt ratio is a simple mathematical relationship between the weight of water to the weight of cementitious material in a concrete mix design, not a measure of performance. The cementitious material includes the cement and any pozzolanic materials that are used as a replacement or in addition to the cement.

A specification that makes use of a w/cmt will state a maximum w/cmt not to exceed within the mix design. The idea is that by limiting the w/cmt, some performance characteristic such as compressive strength, shrinkage, or creep can be controlled. But since it is only a mathematical relationship between the weights of materials, it is only through assumption that a specification can hope to achieve certain levels of performance.

As an example, a standard commercial concrete specification may include the following requirements:

- f_c' = 3000 psi at 28 days
- Maximum w/cmt = 0.45
- Minimum cement content = 5.0 sacks (470 lbs.)
- Maximum Slump = 4 in.
- Maximum 1.5 in. aggregate

Based on the max w/cmt of 0.45, and the 470 lb minimum cementitious content, the maximum water content for the design can only be 212 lbs (0.45 x 470 lb = 212 lb). However, the question becomes, is 212 lb of water enough to generate a 4.0 in max slump? According to ACI 211 Chp. 6, Table 6.3.3 the water content for a 1.5 in aggregate, with a 3 to 4 in slump is 300 lb of water.

Assuming that a standard ASTM C494 Type A water reducer is used (8% water reduction) the required water content becomes 276 lb (300 lb x 92% = 276 lb).

If the specified design only allows 212 lb and ACI states we need 276 lb, there is a 64 lb difference in necessary water content. A standard rule of thumb used in the field is that 1 gal/yd^3 of water will increase the slump by 1.0 in. In this case the 64 lbs is about 7 ½ gallons of water, thereby reducing the slump by about 7.5 inches. Essentially it makes the slump of the concrete 0 inches, if we followed the specified w/cm and used the minimum cementitious content.

Since this is not a practical concrete, then the question becomes, what choices are left to make it a concrete that can be produced, delivered, placed, and finished? If we use the water content of 276 lb, and keep the max w/cmt in place, the new cementitious content becomes 613 lb (276 lb ÷ 0.45 = 613.) The original 470 lbs has now been increased by 1.5 sk/yd^3 to satisfy the w/cmt requirement.

So, in an effort to satisfy a w/cmt ratio that had no real basis in the performance of the structure, to meet the design requirements and practical delivery and placement issues, the following consequences result:

- The cost per yard will increase accordingly with a 1.5 sk/yd^3 increase.
- The concrete will be prone to higher shrinkage and creep with the higher paste content.
- The higher paste content will accelerate hydration and heat generation during warm and hot weather conditions, decrease finishing time, and intensify the potential for plastic shrinkage cracking.
- There is no guarantee of durability and more paste is subject to deterioration and chemical attack.

The attempt to use w/cmt to create durable and cost effective concrete can actually result in just the opposite. A more sensible approach is for the specifications to explicitly detail the performance characteristics, rather than assume they can be accomplished with a mathematical ratio.

Texas Aggregates and Concrete Association
900 Congress Ave., Suite 200
Austin, TX 78701 Phone: 512-451-5100 FAX: 512-451-4162
www.tx-taca.org