

BULLETIN #7: CONCRETE SPECIFICATIONS – WHY WATER CEMENT RATIOS: WHY NOT?

The water-cement ratio (more correctly water-cementitious ratio) is a criterion for concrete that is very important and governs many of its desirable properties to include porosity, permeability, freezing/thawing resistance, and strength, just to name a few. So it's not unexpected that specifications may call for a limit on the maximum water-cementitious ratio (w/cm). But when is a maximum w/cm really required?

In accordance with ACI 318-14 Building Code Requirements for Structural Concrete, the requirement for a maximum limit on w/cm is based upon the anticipated in-service exposure conditions of the concrete element where durability is a concern. The exposure conditions or categories that require a maximum limit on w/cm are:

- Category F (freezing and thawing exposure),
- Category S (sulfate exposure),
- Category W (exposed to water where low permeability is required), and
- Category C (corrosion protection from external chlorides)

The corresponding maximum w/cm requirement will be dependent on the degree of severity within each exposure category. Specific requirements can be found in ACI 318-14, Table 19.3.2.1. Also, there is a corresponding minimum compressive strength requirement for each respective exposure category.

If w/cm is so important then why not specify a maximum limit on w/cm for all concrete? The answer is simple; specifying a maximum w/cm when it is not needed comes with unintended consequences. Concrete used in interior applications, such as floor slabs and columns, will not be exposed to adverse environmental conditions and durability is not a concern. The property that interior concrete must meet is compressive strength, sufficient to satisfy structural loads and/or provide adequate abrasion resistance. Also, interior concrete should be non-air entrained; in fact maximum limits on air content are often imposed on hard-troweled floor slabs. Non-air entrained concrete will typically require about 1 to 3 gallons more water per cubic yard compared to air entrained concrete although it will have about 500 psi to 1000 psi higher strength at equal cementitious contents than air entrained concrete. Due to the higher water content for non-air entrained concrete an unnecessarily high cementitious content may have to be derived to meet a maximum w/cm limit. These higher cement contents and ensuing strength levels may be well in excess of that needed to meet structural and/or abrasion resistance requirements. Not only does this needlessly increase the cost of the concrete it can lead to problems with increased drying shrinkage and increased curling potential. A w/cm commensurate with that needed to achieve the desired compressive strength is all that is needed for non-air entrained concrete.

A maximum limit on w/cm only applies to concrete that will be subjected to one or more of the in-service exposure conditions noted above where durability is a concern. When the concrete will not have an adverse exposure condition in-service there is no reason or requirement for a maximum limit on w/cm.