Technology in Practice

What, Why & How?

TIP 17 - Drying Shrinkage of Concrete

This TIP discusses the mechanisms of volume change and factors that impact shrinkage of concrete. It provides guidance on developing concrete mixtures for shrinkage specifications and the test method for shrinkage.

WHAT is Drying Shrinkage of Concrete?

When concrete dries, the moisture loss from its fine pores results in shrinkage. The shrinkage of the hydrated cement paste is rather large, but the shrinkage of concrete is considerably reduced because aggregates take up 65—75 percent of its volume. When shrinkage of concrete is restrained by the subgrade, foundation, or another part of the structure internal tensile stresses develop. Concrete is weak in tension and when the tensile stresses exceed its tensile strength, concrete will crack. Another consequence of shrinkage is curling or warping of concrete slabs. This occurs due to differential drying between the top surface that is exposed and the bottom surface that is in contact with the wet subgrade. In slabs contraction joints are provided so that concrete can crack due to shrinkage at predetermined locations. Reducing spacing of contraction joint reduces the amount of curling. For other types of structural members, shrinkage should be considered when designing the structure with appropriate detailing of reinforcement to minimize cracking. Typically, drying shrinkage related cracking is evident within days to several weeks after construction.

Plastic, autogenous, and carbonation shrinkage are other forms of volume change that occur in concrete. Plastic shrinkage occurs when the top surface of a slab dries before concrete sets. If the rate of surface drying exceeds the rate of bleeding the potential for plastic shrinkage cracking exists. Autogenous shrinkage is related to cement hydration and can occur without any external loss of water. It is the combined effect of reduction of volume of the hydrated system compared to the volume of the original water and cement (referred to as chemical shrinkage) and self-dessication as water is consumed by hydration. Autogenous shrinkage is a significant component of volume change when the w/cm of concrete mixtures is less than about 0.40. Thereby, autogenous shrinkage may be a large component of shrinkage in high-strength concrete. Most of the autogenous shrinkage of concrete occurs during the first 24 hours. Because length change measurements are not made during the period the specimens are in the mold in ASTM C157, the autogenous component of total shrinkage will not be measured. The magnitude of autogenous shrinkage is small for most concrete mixtures. Exposed hardened concrete reacts with atmospheric carbon dioxide, which results in carbonation shrinkage of concrete. Carbonation depths are very low for well-cured low permeability concrete.

WHERE is Drying Shrinkage Specified?

Drying shrinkage requirements are becoming more common in specifications for concrete. The typical specification clause:

- Length Change measured in accordance with ASTM C157: 500 microstrain (0.05%) at 28 days of drying.

The specified limit of length change can be 400 microstrain (0.04%) or lower. Requirements for water storage (curing) and air storage durations are often modified from those stated in ASTM C157. Specifications typically require 7 days of water storage (curing) followed by 21 or 28 days of air storage (drying).

Drying shrinkage limits are typically specified when shrinkage or associated cracking can impair intended functionality or reduce service life. Shrinkage requirements are often specified for floor slabs, bridge members, structural members that require dimensional stability, and for environmental engineering structures. In floor