

Technology in Practice

What, Why & How?



TIP 23 - Establishing Required Average for Specified Properties

This TIP outlines the process of establishing required average values of any specified property for concrete mixtures to ensure compliance with acceptance criteria.

WHAT is a Required Average Property?

For some properties, tests are performed on concrete as delivered to verify conformance to acceptance criteria stated in the specification. For these properties the required average values are calculated and these become the target levels to be used when proportioning concrete mixtures. Most commonly this is for hardened concrete properties but these concepts apply for acceptance of fresh concrete characteristics as well.

This TIP outlines the process of establishing required average values for properties other than compressive strength. These can include flexural strength (ASTM C78 or C293), modulus of elasticity (ASTM C469), the penetrability of chlorides or the rapid chloride permeability (RCP) test (ASTM C1202), the resistivity of concrete (ASTM C1876 or AASHTO TP 119 for bulk resistivity; or AASHTO T 358 for surface resistivity), and measurement of water content to estimate w/cm (AASHTO T 318).

For concrete properties that will not be tested on concrete as delivered, a required average value of the property does not need to be established. The specified value is the target level that has to be used when proportioning mixtures and documented as a prequalification test result of the proposed mixture in the submittal to the specifier. The target property value should exceed a lower-bound specified limit, stated as a minimum (S_{min}), or be less than an upper-bound specified limit, stated as a maximum (S_{max}). The specified properties can include tests for durability, like alkali-silica reactivity, sulfate resistance, abrasion resistance, freeze-thaw durability, resistance to scaling, and measures of transport properties or permeability; or for other properties such as drying shrinkage, or modulus of elasticity. Some of these test methods are not conducive to testing on concrete as delivered to projects.

WHY is the Required Average Value used for Mixture Proportioning?

If tests are required to be performed on concrete as delivered, the producer should recognize the risk associated with this testing and ensure that the concrete is adequately *overdesigned* to avoid not conforming to stated acceptance criteria. This involves establishing a required average value of the property more restrictive than the specified value. The acceptance criteria should be statistically based and the assumption in this TIP is that test results from different loads of concrete will follow a statistically normal distribution.

The required average value for the property will depend on the specified value, the acceptance criteria, and the estimated variability of test results, quantified as the standard deviation (SD) or the coefficient of variation (V). The components of the variability of test results include that associated with materials, production and delivery, and testing. For some test methods, the component of testing variability, related to the precision of the test method and the proficiency of the laboratory, can be large.

Producers are familiar with the concepts used for compressive strength, where the *required average strength* is greater than the specified strength. Concrete mixtures are designed to achieve an average strength equal to or greater than the required average strength that is appropriately higher than the specified strength such that the probability that test results will fail the acceptance criteria is 1% or less.

Consider the example of modulus of elasticity (MOE). For most projects, MOE for design is estimated from the