Technology in Practice

What, Why & How?

TIP 2 - Establishing the Required Average Strength, f'_{cr}, of Concrete Mixtures

This TIP outlines the process of establishing strength of concrete mixtures as per ACI 318 and ACI 301

WHAT is the Required Average Strength, f'_{cr}?

ACI 318, *Building Code Requirements for Structural Concrete*, and ACI 301, *Specifications for Structural Concrete*, have specific requirements for judging the acceptability of strength test results. ACI 301 addresses procedures for establishing the target strength when proportioning concrete mixtures to meet these strength acceptance criteria using statistically-based concepts. Project specifications indicate a specified strength, f'_c, which the designer uses to design structural members, or based on durability requirements. The required average strength, f'_{cr}, is the target strength when proportioning a concrete mixture that should be higher than the specified strength, f'_c, to ensure that the concrete furnished on the project has a low probability of failing the strength acceptance criteria.

WHY Should the Concrete Mixture be Designed to Achieve the Required Average Strength?

Concrete strength acceptance criteria used by ACI indicate that the strength tests measured during the course of a project should meet both the following criteria:

- the average of 3 consecutive strength test results should equal or exceed the specified strength, f'_c; and
- each individual strength test result should not be less than (f'_c – 500) psi; or (0.90f'_c) if f'_c exceeds 5000 psi

A strength test result is the average of at least two 6 × 12-in. or three 4 × 8-in. cylinders at the age designated in the specification. There is considerable expense and delay on project schedules when strength tests fail the acceptance criteria associated with the subsequent evaluations. These problems can be avoided by ensuring that the proposed mixtures are designed to a strength level that will have a low likelihood of failing these acceptance criteria. Producers who design their mixtures to the criteria discussed below ensure that the mixtures are optimized for the required performance and thereby save on material cost of a concrete mixture.

HOW is the Required Average Strength Established?

There are two alternatives to establish the required average strength for a concrete mixture:

1. When the concrete producer does not have a recent strength test record for the type of mixture
2. When the concrete producer has a strength test record for the same type of mixture from a recent project.

For the purpose of strength, a similar type of concrete would be when the specified strengths are within 1000 psi. The strength test record should not be older than 24 months.

Alternative 1 – When the producer does not have an acceptable test record for the specified strength, the required average strength is established in accordance with the Table 1. This is a conservative alternative that usually requires the producer to develop a concrete mixture at a higher required average strength (f'_{cr}) than Alternative 2.

During the course of a project, when a minimum of 15 strength test results are available to calculate a standard deviation, the producer is permitted, with the approval of the engineer, to revise the required average strength and to modify the concrete mixture in accordance with Alternative 2.