WHAT is the Required Average Strength, $f_{cr}$?

ACI 318, Building Code Requirements for Structural Concrete, and ACI 301, Specifications for Structural Concrete, contain specific requirements and procedures for establishing mixture proportions to meet the strength requirements of concrete structural members. These strength requirements for concrete mixtures use statistically based concepts to ensure that the concrete furnished will meet the strength acceptance criteria. The project specifications indicate a specified strength, $f'_c$, which the designer uses to design the structural members. The required average strength, $f_{cr}$ of the concrete mixture will 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

There is considerable expense and delay on project schedules when strength tests fail the acceptance criteria 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 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 their material cost.

HOW is the Required Average Strength Established?

There are two distinct alternatives to establish the required average strength for a class of concrete:

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

For the purpose of strength, a similar class would be when the specified strengths are within 1000 psi. Currently the test record should have been obtained within the past 12 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 of record, to revise the required average strength of the class of concrete in accordance with Alternative 2.