RELIABLE CONCRETE ACCEPTANCE TESTING FOR IMPROVED SUSTAINABILITY AND PERFORMANCE

NRMCA Position Statement

NRMCA
NATIONAL READY MIXED CONCRETE ASSOCIATION

AMERICAN SOCIETY OF CONCRETE CONTRACTORS
Enhancing the Capabilities of Those Who Build with Concrete.

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ACI CODE-318[1] and ACI SPEC-301[2] establish standards for acceptance testing of concrete. They state that test specimens for acceptance testing for specified strength shall be standard-cured in accordance with ASTM C31/C31M[3]. Test results obtained from standard-cured cylinders are used as the basis for determining if concrete delivered to the project complies with the contract documents. Standard curing of test specimens consists of initial curing at the project site, transportation to the laboratory, and final curing at the testing laboratory. Requirements are established for each phase in ASTM C31/C31M. The initial curing portion at the project site involves storing the specimens for a period of up to 48 hours in an environment that controls moisture loss at a temperature in the range of 60 to 80°F. For concrete mixtures with a specified strength of 6000 psi or greater, the initial curing temperature shall be between 68 and 78°F.

Most deviations from requirements in the standards result in lower measured compressive strength. Lack of adherence to initial curing requirements of ASTM C31/C31M is very common[4] and has been found to result in a 20% reduction of the potential 28-day compressive strength, on average. Supporting data from past studies is summarized in the Table below.

Initial Curing Conditions	Strength loss at 28 days Relative to Standard Curing, %
3 days at 100°F and 25% Relative humidity (lab)[5,6]	22
24 hours at 71°F to 107°F (outdoors in sunlight New Mexico)[7]	15
48 hours at 72°F to 89°F (outdoors in covered 5-gal bucket Maryland)[8]	22
48 hours at 20°F to 34°F (outdoors in covered 5-gal bucket Maryland)[8]	22
22 hours at 80°F in air (lab)[9]	16
24 hours at 67°F to 93°F (outdoors in sunlight Colorado)[10]	28
24 to 48 hours at 90°F immersed in water (lab)[11]	Up to 20

After the non-standard initial curing, cylinders were subject to standard curing in a moist room till the test age of 28 days.

To avoid low-strength test results, and to compensate for the strength reduction due to potential non-standard initial curing, concrete producers typically increase the average strength of their mixtures to greater than that required by ACI SPEC-301. This is accomplished most commonly by increasing the quantity of cement. Even if this increase in strength is half the reduction in strength, i.e. 10%, it still results in increased cost, increased potential for cracking due to temperature and shrinkage, and reduced durability. It also increases the embodied carbon content of concrete (typically reported as Global Warming Potential or GWP), by 10% or more[12].

Complying with standards for the initial curing of test specimens will minimize these problems. Strength test results that do not comply with the acceptance criteria trigger an investigation. This often requires concrete cores to be taken from the structure and tested in accordance with ASTM C42/C42M[13]—these efforts are expensive, can delay a project, and can result in contentious relationships among project stakeholders. Adherence to the standards for acceptance testing of concrete will limit the occurrence of low-strength test results to genuine situations where there could be a problem with the mixture. This minimizes additional costs for evaluation and delays in a project schedule.

The responsibilities of different stakeholders to obtain reliable test results are addressed in various codes and standards. ACI CODE-318 requires the testing agency to comply with ASTM C1077[14] and the acceptance test specimens to be standard-cured in accordance with ASTM C31/C31M. ACI SPEC-301 requires the contractor to provide a secure location, sources of water and electrical power, and access to the project site for the testing agency to facilitate the initial curing of test specimens. Field tests of concrete are required to be conducted by technicians with current ACI Field Testing Technician Grade I certification[15]. This certification includes knowledge of ASTM C31/C31M. ACI SPEC-311.6[16] requires the testing agency to verify that the initial curing of specimens is performed in

accordance with ASTM C31/C31M and to report the curing method and maximum and minimum temperatures during the initial curing period. ACI PRC-132.1[17] states that the designer should address responsibility for initial curing in the contract documents and verify that it conforms to the referenced standards. The testing agency should include the cost of initial curing in the bid for testing services. The AIA MasterSpec[18] is consistent with the above requirements. Checklists[19,20] list the details related to acceptance testing that should be addressed before the concrete placement begins. The Concrete Testing Adherence Collaboration (CTAC) program can help provide oversight for compliance with the requirements in the standards[4]. In most instances, initial curing by immersing test specimens in water is very effective.

To avoid unnecessary low-strength investigations and detrimental impact on concrete performance, and sustainability the owner or their representative (designer or contractor) should select a proficient testing agency and establish a contract to provide reliable testing services in compliance with the acceptance testing requirements of ACI CODE-318. The contract for quality assurance testing should assign the responsible entity who provides systems used to store test specimens that will comply with initial curing temperature and moisture retention requirements; and require the test report to include information on the curing method and maximum and minimum temperatures recorded during the initial curing period. In some projects, the contractor may provide the initial curing facility. The requirements in standards should be enforced on projects and nonconformance should invalidate the results and have financial consequences to the responsible entities.

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