Concrete in Practice

What, why & how?

NRMCA®

CIP 41 - Acceptance Testing of Concrete

WHAT is Acceptance of Concrete?

Acceptance testing is the process of testing representative samples of concrete furnished to a project. Acceptance testing includes tests on plastic concrete for slump, air content, density (unit weight), temperature, and tests on hardened concrete for strength and other durability properties as required in Contract documents or project specifications.

Acceptance testing on hardened concrete is conducted in accordance with standardized procedures to determine whether the concrete as delivered has the potential of developing the desired properties intended by the design professional. These test results are not intended to imply the actual properties of concrete in the structure. There are several variables during construction that will impact in-place concrete properties that are beyond the control of the concrete supplier.

WHY Conduct Acceptance Testing?

Acceptance testing is conducted to quantitatively verify that concrete conforms to the requirements of the purchaser. The requirements of the purchaser, relative to the tests and acceptance criteria, are generally stated in writing in project specifications or are invoked by reference to industry standards, such as ACI 301, ACI 318 and ASTM C 94.

Contractors are legally bound to facilitate or to conduct acceptance testing by local jurisdictions which adopt model codes such as such as the International Building Code. These model codes in turn refer to the ACI 318 Building Code.

It is important for those involved in testing to realize that the results of acceptance testing have significant implications on the project schedule, cost to project participants, and may impact the safety of the structure and its inhabitants.

HOW Should Acceptance Testing Be Conducted?

Acceptance testing must be conducted by certified technicians who have demonstrated a written and practical knowledge of performing tests in accordance with the pertinent standards. Certification programs are offered by the American Concrete Institute (ACI) and other organizations for test conducted in the field and laboratory. Laboratories performing acceptance tests should conform to the requirements of ASTM C 1077. Laboratories should be proficient in testing concrete, should have been through quality system audit by an independent evaluation organization and participate in reference sample testing programs to evaluate their testing proficiency and correct processes if necessary. Laboratory inspections and reference sample programs of the Cement and Concrete Reference Laboratory (CCRL), or equivalent, are established standards.

Typical Equipment for Acceptance Tests

All acceptance testing of concrete must be conducted in accordance with established standards referenced in Contract documents. Any deviation from standard procedures is adequate reason for invalidating test results so obtained.

It is important that the process of conducting acceptance testing and the responsibilities of all involved parties for proper sampling, specimen storage, handling, transportation to the laboratory, jobsite sample disposition and subsequent laboratory testing are clearly defined prior to the start of a project. In medium to large projects a pre-construction conference is strongly recommended to establish processes, contingencies and responsibilities (CIP 32).

Sampling: Samples of concrete from concrete delivery vehicles for acceptance tests should be obtained in accordance with ASTM C 172. The sample should be obtained at the end of the truck chute. Two or more portions of concrete as discharged from the middle portion of the load are composited to obtain a sample that is representative of the load. When the specification requires additional tests to be conducted at the point of placement in the structure after concrete has been moved through some conveying means (such as a pump, bucket or conveyor) sampling procedures

should be conducted such that the means of conveyance is not temporarily shut off or relocated to ease sampling as this can temporarily change the properties measured. ASTM C 94 permits a preliminary sample to be obtained after 0.25 yd^3 (0.20 m^3) has been discharged to measure slump and air content and make appropriate adjustments to the load at the jobsite. The preliminary sample should not be used to make specimens for acceptance tests of hardened concrete.

Slump and Air Content: When the slump and air content measured on the preliminary sample are lower than specified jobsite adjustments with water or admixtures followed by adequate mixing are permitted. If slump and air contents are higher then a retest is made immediately and if the retest fails then the concrete is considered to have failed the requirements of the specification.

Slump of concrete is measured in accordance with ASTM C 143. The tolerance on slump varies by slump level as ordered or specified. The slump tolerances of ASTM C 94 are summarized in the table below. There is no established tolerance for the slump flow of self consolidating concrete, that is measured in accordance with ASTM C 1611.

Specified Slump	Tolerance
Specified as a Maximum Slump	
<3 in. (75 mm)	+0 to -1½ in. (40 mm)
>3 in. (75 mm)	+0 to -2½ in. (65 mm)
Specified as Nominal Slump	
<2 in. (50 mm)	±½ in. (15 mm)
2 - 4 in. (50 - 100 mm)	±1 in. (25 mm)
>4 in. (50 mm)	±1½ in. (40 mm)

The air content of concrete is measured in accordance with the pressure method, ASTM C 231 or by the volumetric method, ASTM C 173 for lightweight concrete or for aggregates with high absorptions. For air-entrained concrete, the tolerance on air content as ordered or specified is ±1.5%.

Density and Yield: When samples are obtained for strength tests ASTM C 94 requires measuring the density (unit weight) of the concrete in accordance with ASTM C 138. This can be done by determining the weight of the air meter container after the sample has been prepared. The minimum container size based on the nominal maximum size of the aggregate in the concrete mixture should be followed. Density measurements can also be correlated with air content measurements and can be an indicator of the water content in the mixture. When determining yield, ASTM C 94 requires that the density should be determined on separate samples from three different loads of concrete and compliance with volume of concrete ordered be done on that basis (CIP 8).

Temperature: The temperature of concrete is measured in accordance with ASTM C 1064. Temperature is measured to determine conformance to temperature limits in a specification and is a required test when strength test specimens are prepared. It is permitted to measure the temperature of concrete in place when it is not measured in conjunction with strength tests.

Hardened Concrete Tests: ASTM C 31 describes the procedures for preparing cylinders and beams for compressive and flexural strength tests, respectively. It describes the procedures for storing specimens at the jobsite and transporting specimens to the laboratory. ASTM C 31 requires the test specimens to be maintained in a moist condition in a temperature range of 60 to 80°F (16 – 27°C) in the field. For high strength concrete with a specified strength greater than 5000 psi (35 MPa), the storage temperature limits are tighter at 68 to 78°F (20 – 26°C). A record of the temperature conditions during field storage of the specimens should be maintained. A curing box with max/min temperature recording device is generally required to verify conformance to these requirements. The same procedures should be adhered to for test specimens prepared for other tests. Test specimens should not be stored at the jobsite for longer than 48 hours. Specimens should be protected with adequate cushioning when transported to the laboratory. Transportation time should not exceed 4 hours. Specimens delivered to the laboratory should be stripped of molds, logged and placed in moist curing as defined in ASTM C 31 as soon as possible and no later than about 6 hours. More details can be found in CIPs 9 and 34.

While most specifications delegate the contractor with the responsibility for providing adequate facilities for storage of specimens at the jobsite, it is also incumbent on the testing technicians and the individual certifying test results to ensure that standard procedures are followed. Concrete is very sensitive to temperature and moisture at early ages and any deviation from standard procedures is a basis for rejecting results of these acceptance tests as it increases the likelihood of failing test results of acceptable concrete. This has implications to the project cost and schedule. A significant number of low strength results can be attributed to cylinders being subjected to non standardized initial curing at the job site (CIP 9).

Test reports with data on all tests conducted, as well as other reporting requirements addressed in the standards, should be distributed to the owner or his representative, contractor and concrete producer in a timely manner. This is very important to the ongoing project quality and serves as documentation for the ability of the concrete producer to furnish quality concrete for future projects.

References

1. International Building Code 2006, International Code Council, Inc. Falls Church, Virginia, www.iccsafe.org.
2. ACI 301 and 318, American Concrete Institute, Farmington Hills, Michigan, www.concrete.org.
3. ASTM C 31, C 94, C 138, C 143, C 172, C 173, C 231, C1064, C 1077, C 1611, *Annual Book of ASTM Standards*, Volume 4.02, ASTM International, West Conshohocken, Pennsylvania.
4. CIP 8, 9, 32, 34, *Concrete in Practice Series*, NRMCA, Silver Spring, Maryland, www.nrmca.org.
5. Technical Bulletins #1, #2, #3, Virginia Ready-Mix Concrete Association, Charlottesville, Virginia.

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