Concrete in Practice

What, why & how?

NRMCA

CIP 41 - Acceptance Testing of Concrete

WHAT is Acceptance Testing

Acceptance testing involves measuring the properties of representative samples of concrete supplied to a project. This includes tests on fresh concrete for slump, air content, density (unit weight), temperature; and tests on hardened concrete for strength or other durability properties as required in Contract documents or project specifications. Standardized procedures should be used for obtaining samples and performing the tests.

Tests on hardened concrete, typically compressive strength, are performed to determine whether the concrete as delivered has the potential of developing the properties assumed in design and specified by the designer. These test results are not intended to quantify 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 is Acceptance Testing Done

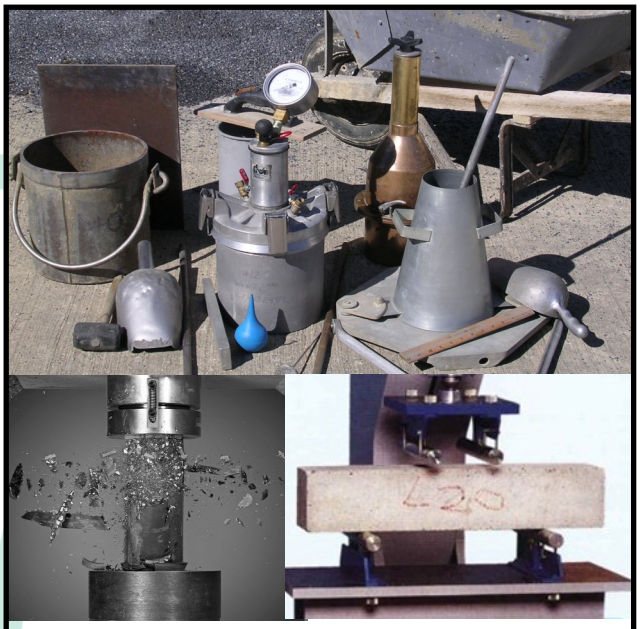
Acceptance testing is performed to quantitatively verify that concrete supplied complies with the requirements of the purchaser, or as defined in a project specification. The requirements should identify the standard test methods and the acceptance criteria that govern. In most cases these are invoked by reference to industry standards, such as ACI 301, ACI 318, and ASTM C94.

Contractors are legally bound to facilitate inspection and acceptance testing by the Code adopted by local jurisdictions. Typically this would be the International Building Code that references ACI 318 for concrete.

It is important that acceptance testing is done properly to produce reliable results. Incorrect results from improper testing will have significant implications to the project schedule, cost to project participants, and may impact the safety of the structure and its occupants.

How Should Acceptance Testing be Done

Acceptance testing must be performed by technicians maintaining current certification through a program that includes a written exam and performance evaluation of the applicable test methods. Certification programs are offered by the American Concrete Institute (ACI) and other organizations for tests conducted in the field and laboratory. Laboratories should conform to the requirements of ASTM C1077. This involves an audit of their quality system by an independent evaluation organization and their participation in proficiency sample testing programs to evaluate their testing proficiency. Laboratories are required to correct deficiencies in their quality systems and procedures as identified by these audits. Laboratory inspections and proficiency sample programs of the Cement and Concrete Reference Laboratory (CCRL), or equivalent, are established standards. These programs are the basis for laboratories to obtain accreditation that is a requirement in many areas.



Testing equipment; cylinder and beam tests

Acceptance tests of concrete must be performed in accordance with the standards referenced in the specification. Deviation from standard procedures can invalidate test results.

The details of acceptance testing, responsibilities, and contingencies should be addressed in a pre-construction meeting. At a minimum these should include proper sampling, authority to reject loads, facilities and controls for standard curing specimens at the jobsite, site access, transportation of test specimens to the laboratory, and subsequent laboratory testing. See CIP 32.

Sampling: Samples of concrete for acceptance tests should be obtained in accordance with ASTM C172. For concrete delivered in concrete truck mixers, the sample should be obtained as it is discharged from the chute. Two or more portions of concrete from the middle portion of the load are combined to create a composite sample representative of the load. If the specification requires samples to be obtained at the point of placement in the structure, the sampling process should be established because no standard defines the procedure. Additional tests on samples obtained at the end of the chute are recommended. Concrete should be discharged

without modifying the placement process and portions of the discharged concrete transferred to the sample container to create a composite sample. ASTM C94 describes obtaining a preliminary sample after 0.25 yd^3 (0.20 m^3) has been discharged. This sample is used to check the slump and air content and make appropriate adjustments to the load, if necessary. Strength specimens should not be prepared from this preliminary sample.

Slump and Air Content: When the slump and air content measured on the preliminary sample are lower than specified ASTM C94 permits adjustments to the load with water or admixtures followed by adequate mixing. If slump and air contents are higher than specified, check tests on a separate sample should be made. Retests on a separate sample should be performed if tests on the sample obtained in accordance with C172 fail the requirements of the specification before a decision is made to reject the load.

Slump is measured in accordance with ASTM C143. Slump flow of self-consolidating concrete is measured in accordance with ASTM C1611. Tolerances for slump and slump flow as ordered or specified are addressed in ASTM C94 and summarized in the table below.

Specified Slump	Tolerance
Specified as "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)
Slump Flow (for self-consolidating concrete)	
≤ 22 in. (550 mm)	±1½ in. (40 mm)
> 22 in. (550 mm)	±2½ in. (65 mm)

Air content of concrete is measured in accordance with the pressure method, ASTM C231; or by the volumetric method, ASTM C173 for lightweight concrete. 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 C94 requires the density (unit weight) of the concrete be measured in accordance with ASTM C138. This can be done by weighing the pressure meter base when filled and before measuring air content. Measured density can identify problems with the mixture as delivered and provides useful information when evaluating reasons for low strength test results. Density is used to determine yield; ASTM C94 requires density to be measured on separate samples from three different loads of concrete to estimate the yield of a mixture. See CIP 8. Density should be measured for lightweight concrete to verify that the specified equilibrium density will be achieved (See CIP 36). It should also be measured when heavyweight concrete is ordered.

Temperature: The temperature of concrete is measured in accordance with ASTM C1064. Temperature is measured to determine conformance to temperature limits in a specification and should be recorded when strength test specimens are prepared. It is permitted to measure temperature of concrete placed in the structure. If a sample is not obtained.

Strength Tests: ASTM C31 describes the procedures for making and curing cylinders and beams in the field for compressive and flexural strength tests, respectively. For acceptance of concrete, strength test specimens should be standard-cured according to ASTM C31. After casting, test specimens at the jobsite should be maintained in a moist condition in a temperature range of 60 to 80°F (16 to 27° C). If the specified strength exceeds 5000 psi (35 MPa), specimens should be stored in a temperature range of 68 to 78°F (20 to 26°C). A record of the temperature conditions during initial curing of the specimens in the field should be maintained, typically with a max/min thermometer or a device that continuously records temperature. Failure to comply with the standard curing requirements will result in low strength test results. Field-cured specimens are used to estimate the strength of concrete in the structure and is not an acceptance test for the quality of the concrete supplied. Specimens should be transported to the laboratory within 48 hours after casting and protected with adequate cushioning. The testing agency should have access to the site to pick up test specimens, especially on weekends. Transportation time should not exceed 4 hours. At the laboratory specimens should be stripped, logged, and placed in moist curing as defined in ASTM C31 as soon as they are received. The compressive strength should be measured in accordance with ASTM C39. See CIP 9 and 34 for more details. See CIP 16 for flexural strength tests.

Specifications typically require the contractor to provide adequate facilities, like space and power, for curing test specimens at the jobsite. The testing agency is responsible to cure test specimens in accordance with ASTM C31. Concrete is sensitive to temperature and moisture at early ages. Deviations from standard procedures for initial curing at the jobsite will result in low strength results and can be a basis to reject results of these acceptance tests. See CIP 9.

Test reports of all acceptance tests should include the reporting requirements of the standards. Reports should be distributed to the owner or his representative, contractor, and concrete producer in a timely manner. This is very important for monitoring quality on the project and to take corrective action if necessary. A complete record of acceptance tests also serves as necessary documentation for submittals for concrete for future projects.

References

1. International Building Code, International Code Council, www.iccsafe.org.
2. ACI 301 and 318, American Concrete Institute, Farmington Hills, MI, www.concrete.org.
3. ASTM C31, C39, C94, C138, C143, C172, C173, C231, C1064, C1077, C 1611, Annual Book of ASTM Standards, Volume 4.02, ASTM International, West Conshohocken, PA, www.astm.org.
4. CIP 8, 9, 32, 34, 36 - Concrete in Practice Series, NRMCA, Alexandria, VA, www.nrmca.org.

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