

ACI 318-14: And now for something COMPLETELY different

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If you are involved in the concrete industry in the U.S. you have probably already heard that ACI 318, “Building Code Requirements for Structural Concrete”, has been completely rewritten and reorganized. Gone are the sections defining concrete strength overdesign, which are now relegated to ACI 301, “Specifications for Structural Concrete”. What has changed in ACI 318, 301 and the related document ASTM C94 and how does it affect the concrete producer?

ACI 318-14, “Building Code Requirements for Structural Concrete”

The rewrite of ACI 318 provides an ideal opportunity to discuss what the Code is and what it isn't. This document is primarily oriented toward the structural design engineer. It is not meant for the concrete producer or contractor. It provides the minimum design requirements for life safety. It also provides a means of determining the acceptability of concrete.

Not all concrete is governed by ACI 318. Local codes must incorporate ACI 318, and most do. Residential concrete has its own code, ACI 332. There are separate codes for Environmental Structures and for other types of structures. However, most trace their way back to ACI 318.

All of the discussion below is addressed to the design engineer and should be copied to the contract documents when appropriate.

f'c - specified strength: As in the previous revision of ACI 318-11, f'c, the specified strength, is equal to the maximum of the following:

- The requirement from the minimum strength table, Table 19.2.1.1, which is basically 2500 or 3000 psi
- Durability requirements, which are found in the Exposure Class Table 19.3.2.1
- The structural design requirement

There is one change that is extremely important to engineers and concrete producers alike. The new document states, “The value of f'c shall be specified in construction documents...” This means there should be no more mismatches between strength and durability requirements, such as “3000 psi with a maximum 0.40 w/c”. The construction documents must state the design strength which will include any criteria from the Exposure Classes presented in Table 19.3.2.1. If the Engineer wants to specify a maximum 0.40 w/c due to an F3 (severe) freeze-thaw exposure, the design strength must be at least 5000 psi. (FYI, in the 2011 version of ACI 318 the value was 4500 psi, but this is the only major change in the tables.)

Exposure Class W: The only other change to exposure classes is that the old Class P, “Requiring Low Permeability”, is now Class W, “Exposed to Water”. Exposure Class W is for concrete exposed to water, but not freezing and thawing, sulfates or chlorides.

How much overdesign is necessary? The new Building Code does not contain the statistical overdesign requirements for concrete strength from the old Code. Instead it states that the overdesign requirements shall meet or exceed those in ACI 301, Article 4.2.3. The new Code goes on to state when ACI 301 is used to determine overdesign that the tests used to document strength “shall not exceed 24 months”. This is different from ACI 301-10, Para 4.2.3.1, which requires that the tests must cover a period of at least 60 days and no more than 1 year. The Code specifically attempts to override the age requirements of ACI 301, but if the project specification states, “Where there is a conflict between two documents the more restrictive will govern.”, it is unclear whether that 2 year override will hold up.

Concrete producers must receive concrete tests! ACI 318, Para 26.12.1.1 (e) states, “All reports of acceptance tests shall be provided to the licensed design professional, contractor, concrete producer [emphasis added], and, if requested, to the owner and the building official.” This is nothing new, but the commentary does include a statement of the importance of the concrete producer receiving the test results. In my opinion, based upon my years of legal training (not) and non-existent law degree, any project where the test results are not reported to the concrete producer are at risk of being declared “not in compliance” with the Building Code simply due to the fact that the concrete producer hasn’t received them, but that is another soapbox for another time.

Did the concrete meet strength? As stated in previous versions of the Building Code, concrete tests are still acceptable as long as a single test is no less than 500 psi below specified strength for specified strengths at or below 5000 psi, and no less than 10% below specified strength for specified strengths above 5000 psi. Also, the moving average of 3 consecutive tests must meet or exceed the specified strength. This requirement is now in Section 26.12.3.1.

ACI 301-10, “Specifications for Structural Concrete”

Who does ACI 301 affect? ACI 301 includes Specifier instructions to the Contractor. To include ACI 301 as part of his Contract Documents, all a Specifier must do is reference ACI 301 in the Documents and all pertinent requirements from ACI 301 automatically apply to the Contractor. The project need not be governed by ACI 318 for ACI 301 to be used.

Concrete producers might get the tests. Section 1.6 of ACI 301 needs a bit of clarification. First, it states that the Owner may hire a testing lab to do inspection and testing. If so, section 1.6.3.1.c states, “The Owner’s testing agency will report test and inspection results of the Work to Owner, Architect/Engineer, Contractor, and concrete supplier within 7 days after tests and inspections are performed.”

Section 1.6 also describes that the Contractor will retain a testing lab to do tests if required to do so by the Contract Documents. However, there is no specific requirement in ACI 301 that the Contractor’s lab report test results to the Concrete Producer. However, there are statements in several ASTM documents that state any test for acceptance of the concrete must be reported to the Concrete Producer.

Exposure Classes: ACI 301 also contains references to Exposure Classes, but the changes to the Classes discussed in the section on ACI 318 have not been incorporated into ACI 301 yet.

Statistical Overdesign: The techniques for determining overdesign are the same as the traditional statistical techniques that I reported on in my blog at <http://www.commandalkonconnect.com/2014/10/27/concrete-mix-design-art-science-statistical-overdesign-aci-part-1/>. The biggest concern with using ACI 301 to determine overdesign is the 301 requirements that the tests used for determining statistics must span at least 60 days and no more than 1 year. However, as described above, the 1 year limit can be overridden by ACI 318.

ASTM C94, “Standard Specification for Ready-Mixed Concrete”

ASTM C94 also contains overdesign requirements for concrete strength. The statistical overdesign requirements of ASTM C94 appear to be the same as those of ACI 301, but there are some slight differences to be considered.

Use and applicability: ASTM C94 is an agreement between a Purchaser (normally a Contractor) and a Manufacturer (also called the Concrete Producer). It can be specified and enforced totally separately from ACI 301 and 318. The overdesign requirements for C94 appear in a non-mandatory Appendix X1. It does not include limitations on the age of the test results used for the statistical calculations. It does, however, include two things ACI 301 doesn't have: 1) A tabular summary of overdesign requirements (for those who can't or won't determine the values from an equation) and 2) An indication of standard deviation values that might be considered questionable. Given that most projects using statistical overdesign methods will be governed by ACI 318 and/or 301, this Appendix is mostly superfluous.

Test reporting: Para. 6.1 of ASTM C94 contains the following statement, “The purchaser shall ensure that the manufacturer is provided copies of all reports of tests performed on concrete samples taken to determine compliance with specification requirements.” The only problem with this statement is that sometimes the purchaser does not hire the testing lab and does not control the distribution of tests. In that case it is the responsibility of the purchaser to specify to the organization that hires him that the tests must be provided to the manufacturer.

In summary, even though ACI 318 looks like it has been totally changed, the reality is that for the concrete producer's QC department it is still “business as usual”. The two biggest changes are directed to the design engineer and they are: 1) Make certain the specified strength is consistent with durability requirements and 2) Make certain that the concrete producer gets a copy of the concrete test results. Yes, both of these requirements have been in previous versions of the document but they are emphasized a bit more in the current document. It is now up to the engineers to respond accordingly.