Chloride Specifications in Concrete Construction

What's Kosher for Code Changes

or

Moving the Yardstick in 318

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ACI 318 Code and Changes

- The current version is 2014. It was a major re-organization from the 2011 Code
- The next version will be 2019—and after that 2024.
- Changes to the code go though 318 subcommittee ballot prior to 318 ballot.
- For Materials and Durability, this is 318-A
- Change proposed from a “feeder committee” such as C201, must first be approved by that committee.

Current ACI 318 Code Requirements for C2 Chloride Exposure

- Table 19.3.1.1 Exposure Classes

Corrosion protection of reinforcement (C)	C0	Concrete dry or protected from moisture
	C1	Concrete exposed to moisture but not to an external source of chlorides
	C2	Concrete exposed to moisture and an external source of chlorides from deicing chemicals, salt, brackish water, seawater, or spray from these sources

Current ACI 318 Code Requirements for C2 Chloride Exposure

Table 19.3.2.1—Requirements for concrete by exposure class

Exposure class	Maximum w/cm[1]	Minimum f_c', psi	Additional requirements			Limits on cementitious materials
			Air content			
			Maximum water-soluble chloride ion (Cl^-) content in concrete, percent by weight of cement[7]			
			Nonprestressed concrete	Prestressed concrete	Additional provisions	
C0	N/A	2500	1.00	0.06	None	
C1	N/A	2500	0.30	0.06		
C2	0.40	5000	0.15	0.06	Concrete cover[8]	

Specifying Strength and Limiting w/cm in 318

- These are indirect ways of trying to limit ingress of chlorides
- Porosity and continuity of pore system ware related to w/cm
- Measuring w/cm in the truck and in hardened concrete is difficult but strength is related to w/cm, so 5,000 psi (35 MPa) strength is an indirect indicator of 0.40 w/cm.
- However, with SCMs and blended cements, this relationship becomes unclear.
  - E.g. a silica fume mix could have high strength at a higher w/cm than expected for a Portland cement concrete.

Traditional Durability Requirements have used indirect measures

- ACI 318-14
- currently *f*c' and w/cm
  are used instead of permeability limits
- But blended cements, SCMs and admixtures change this relationship

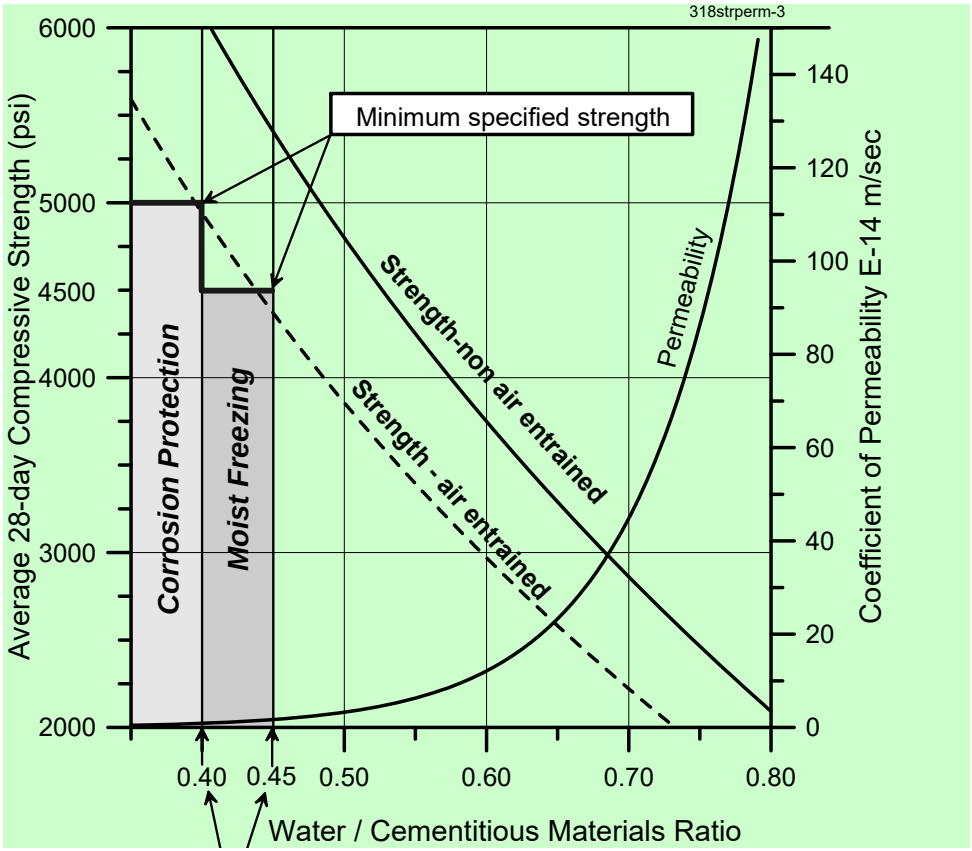

Figure from Ken Hover

Excerpt from paper by C. Bognacki of the Port Authority of New York & New Jersey

Historical data on Port Authority projects show instances of concrete with compressive strengths greater than 6000 psi (41 MPa) that failed to meet the RCPT requirements of less than 1000 coulombs. This demonstrates that strength and *w/cm* requirements alone are insufficient for producing low-permeability concrete, particularly when the water content of the concrete is never verified.

Test Methods Referenced in ACI Standards

ACI has long-standing relationship with ASTM regarding test methods

4.1.2.3 *Test methods*

Test methods prescribe means of testing for compliance of materials or construction methods that are proposed for or used in projects. They are written to the testing agency and may be incorporated by reference in material specifications, construction specifications, or Contract Documents. They are subject to the process rules as described for material specifications in 4.1.2.2.

Test methods are only to be developed when an ASTM standard test method has not been developed. The committee is to follow the document outline and format shown in the *Form and Style of ASTM Standards* (www.astm.org) for preparing a test method, but otherwise use ACI style. After publication, ACI staff sends the test method to the ASTM staff manager responsible for the committee that addresses that area of technology. ACI test methods must be withdrawn if ASTM subsequently develops a test method for the subject.

Allowing for an index of resistance to chloride penetration

- **All test methods referenced in the 318 Code are ASTM standards.**

  i.e. consensus standards

ASTM has several chloride resistance test methods including C1202 and C1543, C1556 and C1760.

- C1556 is a bulk diffusion test that takes several months to complete and would only be applicable for prequalification on large projects.
- C1543 takes even longer to complete than C1556 and ingress is not just by diffusion.
- C1202 is a rapid index test measuring electric conductivity over a 6h period.

  C1202 is widely used and specified.
- C1760 is a rapid electric conductivity test that only takes 5 minutes, but it is not widely used or specified.

Bulk Resistivity Tests

- There is a move to change from ASTM C1202 to a simpler, faster bulk resistivity test, but the ASTM test is still under ballot.
- AASHTO has a new bulk resistivity test, but AASHTO tests are not referenced in the 318 code since not developed by consensus.
- The draft ASTM test has an annex that explains how to convert resistivity values to Formation Factors (FF). Use of FF eliminates the interference caused by different electric conductivity of pore fluids caused by different cementitious-admixture combinations.
- Since this test is not ready, we would have to wait until the 2024 Code to introduce it.

The Options for the 2019 Code from a 318A Perspective

1. Ballot inclusion of an ASTM C1202 coulomb limit in the 2019 Code as an option in lieu of the 0.40 w/cm limit for C2 exposure (along with commentary)

   or

2. Do nothing and wait for the Bulk Resistivity test and a formation factor limit, for the 2024 Code

Option 1 requires: C201 to pass this first, and forward to 318A for ballot, then on to 318 ballot. Given the time line, all the ballots would have to pass the first time.-----place your bets now.