Compressive Strength of Cores and Specification Compliance

Q. *Last winter, we placed concrete grade beams for an industrial building. A technician from the owner's testing agency took test cylinders but left them unprotected in the cold weather for a week. At 28 days, the average cylinder compressive strength was 2750 psi. Because this was far below the specified f_c' of 6000 psi, the engineer required three cores to be taken to evaluate the in-place concrete strength. The individual core compressive strengths were 4940, 4970, and 5370 psi, resulting in an average strength of 5090 psi (84.8% of f_c'). The engineer rejected the concrete on the basis that the ACI 318-19 Code[1] requires the average core strength to equal 85% of the specified strength. In this case, 0.85 f_c' = 5100 psi, so isn't the average core strength of 5090 psi close enough?*

A. ACI 318-19, Section 26.12.6.1(e), states: "Concrete in an area represented by core tests shall be considered structurally adequate if (1) and (2) are satisfied:

(1) The average of three cores is equal to at least 85 percent of f_c'.

(2) No single core is less than 75 percent of f_c'."

Section 26.12.6.1(f) of the Code also states that: "Additional testing of cores extracted from locations represented by erratic core strength results shall be permitted."

NRMCA Publication No. 185, "Understanding Concrete Core Testing,"[2] provides a methodology to evaluate erratic core results using ASTM E178, "Standard Practice for Dealing with Outlying Observations." Based on this analysis, the 4940, 4970, and 5370 psi core tests are not erratic core test results. Thus, the reported core test results should be used in the analysis.

ASTM C39/C39M, "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens," requires the calculated compressive strength to be reported to the nearest 10 psi. For a 5000 psi strength level, the 10 psi represents 0.2%. However, the required rounding could result in a higher or a lower value.

The ACI Technical Committee Manual (ACI TCM-20)[3] provides guidance on decimal point and implied tolerances in Section 11.6.7: "If tolerances are not stated explicitly, then tolerances are implied by the way the limit is written. For example, if a temperature is specified as 23°C, by the rules of rounding, any temperature between 22.5°C and 23.5°C will round to 23°C and satisfy this requirement. However, if the temperature is specified as 23.0°C, then the permitted range is from 22.95°C to 23.05°C. If a numerical limit is given as a whole number, the implied tolerance is ±0.5, if a limit is given to the nearest 0.1 the implied tolerance is ±0.05, and so forth. These principles need to be considered when using decimal points in numerical limits."

Based on ACI TCM-20, and the way the Code expresses the specified value as 85%, any value above 84.5% should be considered to be within specification compliance.

Lastly, ASTM E29, "Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications," is intended to be used in determining compliance with specifications. The rounding method described in this standard would also indicate that an average core test result of 84.8% would satisfy the Code-required 85%.

References

1. ACI Committee 318, "Building Code Requirements for Structural Concrete (ACI 318-19) and Commentary (ACI 318R-19)," American Concrete Institute, Farmington Hills, MI, 2019, 623 pp.

2. Suprenant, B.A., "Understanding Concrete Core Testing," NRMCA Publication No. 185, National Ready Mixed Concrete Association, Alexandria, VA, 19 pp.

3. ACI Technical Activities Committee, "Technical Committee Manual (ACI TCM-20)," American Concrete Institute, Farmington Hills, MI, 2020, 72 pp.

Note: Additional information on the ASTM standards discussed in this article can be found at **www.astm.org**.

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