

Can Testing Laboratories Have True Companions?

Q. *We work in a rural area with only two ready mixed concrete producers within 30 minutes of most of our jobsites. Concrete testing agencies are directly engaged by the owner, so we have no control over the choice of testing laboratories that monitor our work. However, our local producers often provide their own test personnel to perform concurrent (companion) testing, and they occasionally challenge the test results (for slump, air content, or compressive strength) provided by the owner's testing agency. Table 1 shows test results for one of our projects. How do we know this testing is being conducted properly, and what is an acceptable variance between results from two laboratories performing parallel testing on the same load of concrete?*

A. ACI 301-20, Section 1.7.3,¹ specifies the duties and responsibilities of the owner's testing agency, including:

- Samples are to be obtained in accordance with ASTM C172/C172M² from a full load after all adjustments are made;
- Slump and air content are to be measured in accordance with ASTM C143/C143M³ and ASTM C231/C231M,⁴ respectively; and
- Cylinders produced for strength testing are to be made and cured in accordance with ASTM C31/C31M.⁵

Tests of air content and slump can be made on preliminary samples and adjustments can be made and communicated to the batch plant for subsequent loads. In accordance with ASTM C94/C94M, Section 17.6,⁶ if the slump or air content fall outside specified limits, a check test should be made on a separate sample before a decision is made to reject the load.

When preparing cylinders for testing, they must be cured in the field in accordance with ASTM C31/C31M. Per Section 10.1.2, specimens should be initially stored for up to 48 hours at a 60 to 80°F (16 to 27°C) temperature range for concrete mixtures with a specified strength less than 40 MPa (6000 psi) and 68 to 78°F (20 to 26°C) for mixtures with specified strength of 40 MPa or greater. The initial curing should be documented using a minimum/maximum thermometer or by a

continuous temperature recording device. The cylinders are to be transported to the laboratory within 48 hours (2 days) and subject to curing in a moist room or immersed in lime water and maintained within a temperature of 73.5 ± 3.5°F (23 ± 2°C).

While ACI 301 is silent on the topic, it is acceptable for companion testing to be conducted by quality control personnel representing the concrete producer (alternatively, a third party can capture video of the testing conducted by the owner's testing agency).

The acceptable differences in test results between the two testing agencies are based on interlaboratory studies and stated in precision statements in relevant ASTM standards:

- ASTM C143/C143M, Section 9.1.4, indicates that the acceptable difference of measured slump between two tests on the same sample is 0.82 in. for 1.2 in. (20 mm for 30 mm) slump, 1.10 in. for 3.4 in. (28 mm for 85 mm) slump, and 1.50 in. for 6.5 in. (38 mm for 160 mm) slump;
- ASTM C231/C231M, Section 11.2.2.2, indicates that the acceptable difference between results of two tests on the same sample varies depending on the air content but it's around 0.49 to 1.30% for an average air content between 3 and 8%; and
- ASTM C39/C39M, Section 11.1.3, indicates that test results made from the same sample are not expected to differ by more than 14% of their average, where a test result is the average measured strength of two or three test specimens.

These acceptable differences can be used to compare test results obtained by two testing agencies, ideally performed on the same sample (wheelbarrow), or, less ideally, on different samples from the same load of concrete.

As you noted in your question, Table 1 provides data obtained by two testing agencies. The difference in companion slump test results is no more than 3/4 in. for 4 to 5 in. (19 mm for 102 to 127 mm) slump, which is less than the limit of an acceptable difference stated in ASTM C143/C143M. The maximum difference in air content is 0.3%, which is also less than the acceptable difference stated in ASTM C231/C231M. Finally, differences in compressive strength test results measured by the two testing agencies do not exceed 14% of their average (shown in parentheses) stated in ASTM C39/C39M.

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Table 1:
Comparisons of test results provided by the owner's and producer's testing agencies

Date	Testing agency	Slump, in.	Air content, %	28-day compressive strength, psi
10/27/21	Owner	1.00	4.50	5730
	Producer	1-1/2	4.50	6240
	Difference	0.50	0.00	510 (838) [*]
2/8/22	Owner	4-1/2	4.70	5100
	Producer	5.00	4.80	5230
	Difference	0.50	0.10	130 (723) [*]
2/8/22	Owner	4-1/4	4.75	5540
	Producer	4-1/2	4.60	5640
	Difference	0.25	0.15	100 (783) [*]
2/9/22	Owner	4-1/4	7.20	4310
	Producer	4-1/2	7.50	4280
	Difference	0.25	0.30	30 (601) [*]
2/25/22	Owner	5-3/4	4.80	3590
	Producer	5-3/4	5.00	3730
	Difference	0.00	0.20	140 (512) [*]
3/1/22	Owner	4-1/4	5.20	4060
	Producer	5.00	5.50	4530
	Difference	0.75	0.30	470 (601) [*]

^{*}The value in parentheses is 14% of the average of two test results stated in ASTM C39/C39M as the maximum (not-to-be-exceeded) allowable difference between two laboratories

Note: 1 in. = 25 mm; 10 psi = 0.07 MPa

Based on these test results, the differences between the testing agencies are within the precision stated in the applicable ASTM test methods. In most cases, the compressive strength from the concrete supplier's testing agency is marginally higher than those of the owner's testing agency, suggesting that there may be a systemic bias, but there is no basis to indicate that these results are statistically different. We also can't say if the results of one testing agency are better or worse than another.

Further guidance regarding third-party concrete testing and troubleshooting typical testing issues that arise during construction projects, as well as sample concrete strength calculations to help ensure quality of concrete testing, are provided in NRMCA TIP 16,⁷ part of the NRMCA's Technology in Practice (TIP) series.

References

1. ACI Committee 301, "Specifications for Concrete Construction (ACI 301-20)," American Concrete Institute, Farmington Hills, MI, 2020, 69 pp.
2. ASTM C172/C172M-17, "Standard Practice for Sampling Freshly

Mixed Concrete," ASTM International, West Conshohocken, PA, 2017, 3 pp.

3. ASTM C143/C143M-20, "Standard Test Method for Slump of Hydraulic-Cement Concrete," ASTM International, West Conshohocken, PA, 2020, 4 pp.

4. ASTM C231/C231M-17a, "Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method," ASTM International, West Conshohocken, PA, 2017, 10 pp.

5. ASTM C31/C31M-21a, "Standard Practice for Making and Curing Concrete Test Specimens in the Field," ASTM International, West Conshohocken, PA, 2021, 7 pp.

6. ASTM C94/C94M-21b, "Standard Specification for Ready-Mixed Concrete," ASTM International, West Conshohocken, PA, 2021, 15 pp.

7. "TIP 16 - Evaluating Strength Test Results," National Ready Mixed Concrete Association, Alexandria, VA, 8 pp.

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