FAQ 10.012
Concrete Strength Evaluation During Construction

As the engineer of record (EOR) for a new building project with concrete foundations we performed all the regular construction administration tasks (review of submittals, response to RFIs, etc) but were not copied on the results of concrete compressive strength testing.

Eventually however, we were informed that some “breaks” had come in low, and that the testing agency was planning on doing a 56-day break on a few samples to verify that strength was ok. We asked for a tabulation of the strength test data and reminded the testing agency and the contractor of the code requirements (which were in the specifications also) for acceptance of concrete based on strength. The tabulation we finally received did not include an average of the three 28-day breaks for each sample (these were 4x8 cylinders), did not separate the test record by mix design (two mixes were approved for the foundations), and did not include the three consecutive tests average that would be needed to evaluate the concrete strength test record (ACI 318-14, 26.12.3.1).

We quickly entered the break data into a spreadsheet that performs the needed calculations and found that, although no strength test value (the average of three breaks from one sample) was more than 500 psi below the specified strength, there was a period two months previously, where the three consecutive tests average was below the specified strength for several pours in a row.

It was also clear from the record that the tested 28-day strengths had been decreasing from pour to pour during that period. I should note that the required average strength $f'_c$ used to qualify this mix (see ACI 301, Article 4.2.3) was well above the strengths represented by the tests.

What is the EOR’s responsibility, and who should have raised the red flag on this? Submitted by an Engineer

Response Submitted by Art Dell, PE

I have always been a proponent of the engineer taking a more proactive role in the quality assurance process during construction. That could include being aware of the schedule and the required inspections and tests, making sure you are on the distribution list for reports, and asking what is going on if you are not getting information. The code requirement (which may not be the same as your contract requirement or the contract requirement of the testing agency) in CBC 1704.2.2 is this:

“...The approved agency shall submit reports of special inspections and tests to the building official and to the registered design professional ….Discrepancies shall be brought to the immediate attention of the contractor for correction. If they are not corrected, the discrepancies shall be brought to the attention of the building official and to the registered design professional…”

So, the first duty is the testing agency’s duty to submit reports and to report “discrepancies” to the contractor immediately. You should then have been receiving reports, and many will say that good practice would include making sure you get them.

But the discrepancy needs to be recognized by the testing agency and reported to the contractor. That means the testing agency needs to be aware of the two acceptance criteria (ACI 318-14, 26.12.3.1):

Every arithmetic average of any three consecutive strength tests equals or exceeds $f'_c$.

No strength test falls below $f'_c$ by more than 500 psi (or by more than 0.10 $f'_c$ for higher strength concrete.)

The testing agency in your example did not seem to be fully aware of this and did not even seem to be clear on the difference between a cylinder break (one break) and a strength test (the average of two or three breaks from one sample). However, is it reasonable to put the burden on the testing agency to evaluate the strength test record each time they complete a 28-day strength test, in order to see if there is a “discrepancy”? This is why I always add in the specifications that the contractor must tabulate the strength test data for each mix. After all, the contractor is in control of the work and is responsible for compliance with the construction documents. This means that the test reports need to go to the contractor. Note in the CBC section above that the code does not require this unless a discrepancy is noted.

So, for this to work, the testing agency needs to be permitted by their client to send test reports to the contractor, flagging as a potential discrepancy any strength test (not any “break”) that is below $f'_c$. This should happen almost immediately if possible. Then, the contractor’s quality control function is invoked. They can (should) notify the concrete supplier who may consider taking steps to increase the strength, as suggested by ACI 318-14, 26.12.3.1 (c).

In this case, as this problem could not reasonably be expected to be “corrected” by the contractor you would need to be involved right away if an actual discrepancy is found. You can then think about your force demands and discuss with your client whether to implement any kind of investigation into the low-strength results.

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