D.C.-area testing labs compare compressive strength test-result differences

Annual program allows lab self-evaluation

Many producers get the impression that, while not nearly as risky as buying a lottery ticket, testing labs often hold their company's future in a plastic mold.

Five years ago, when Teck Chua tried to resolve test result differences, he didn't get the respect his Virginia Concrete lab deserved. As a registered professional engineer in charge of QC/QA for Florida Rock Industries, which owns Washington, D.C.-area ready-mix producer Virginia Concrete, Chua needed a way to validate the quality of his own facility's lab results to the engineering community. Since Beltway-area municipal building departments have adopted BOCA #1705, producers and building owners have had to rely on the quality of third-party engineering labs to inspect and test all aspects of the construction process.

The absence of a municipal testing program created a void in the customary cycle of checks and balances. "When I presented our lab-test results to engineers, I was constantly asked how our results compared to local engineering labs," says Chua.

Frustrated by a lack of an interlaboratory precision standard in ASTM, Chua proposed that the Ready Mixed Concrete Producers Technical Committee initiate a program to generate the precision standard. Members of RMC-PTC, an ad hoc committee of local producers' technical personnel, felt that participation of local commercial laboratories would be vital to the program's success.

Concrete Engineering Inc.

Another truckload of concrete departs from Virginia Concrete's plant for a jobsite in the Washington, D.C., area. With the documentation from its involvement in a round-robin lab testing program, the producer demonstrates that its test breaks are as accurate as area engineering laboratories'.

The committee contacted Tom Cohn, executive director of the Washington Area Council of Engineering Laboratories. After a series of discussions, producer and testing lab representatives agreed to cosponsor a round-robin compressive strength testing program according to the procedures established by ASTM C 802, "Standard Practice for Conducting an Interlaboratory Test Programs to Determine the Precision of Test Methods for Construction Materials." Thirty to 40 testing facilities now participate annually.

Participants recognized the significance of the round robin-testing results and realized that there was a need for a qualified referee. "At the time, we were fortunate that Colin Lobo, the National Ready Mixed Concrete Association's vice president of engineering, wanted to gather data on the subject," says Cohn.

How the program works

The program evaluates variability in test results attributable to differences in laboratory curing, capping and cylinder testing methods. On the starting date for testing, drivers from Virginia Concrete deliver two 4-cubic-yard loads of central-mixed concrete representing two strength levels to Chua's lab at the Edsall Road plant in Springfield, Va. After discarding the first two wheelbarrows from each truckload, volunteers use the rest of the batch to cast enough test cylinders for each participating lab.

To satisfy the test's requirements, employees make as many as 180 cylinders. To avoid rodding, technicians keep slump below 3 inches so one volunteer can consolidate the cylinders with a pencil vibrator.

Florida Rock technicians then cover the test cylinders with plastic and store them for the first 24 hours at 70° F. Technicians from participating labs pick up assigned test cylinders, transport them to their facilities and finally test them at a 28-day age on the assigned date. Lab technicians follow their normal company procedures in curing, capping and breaking the test cylinders. Results are reported to the NRMCA coordinator.

Results

"Program results provide lab managers a baseline for quality," says Cohn. By comparing their individual results against the group's precision, managers can adjust their lab procedures.

Lobo says the round-robin test results are useful when engineers have questions about the quality of testing. First, questioners should review the range in strength of the two cylinders from the same sample. Based on the C-39 precision statement, differences should rarely exceed 500 psi for concrete up to 5000 psi.

The summary of the 1998 test results for the low- and medium-strength tests results are shown in the table on page 13. In accordance with ASTM C 802, the data coordinator next examines the difference between each lab's two breaks. ASTM C 39, "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens Guidelines" states that the single operator precision of tests of individual cylinders from the same sample of concrete is 2.37% (acceptable range of 2 cylinders = 6.6%) for cylinders made in a laboratory environment. The within-test precision factor from the 1998 data was 2.1% for the low-strength batch and 2.4% for the medium-strength batch, comparable to the values in the C 39 precision statement.

The next comparison level comes from the calculation of the multilab standard deviation, an estimate of the variability of a large group of individual test results (average of two cylinders) from different laboratories. In the 1998 testing program, the multilab standard deviations were reasonably similar at 4.5% of the overall average for the low-strength batch and 4.8% of the overall average for the medium-strength batch.

In ASTM terminology, the multilab "d2s" are precision estimates determined from the multilab standard deviation and are defined as the acceptable difference between test results obtained from two labs. This acceptable difference between two individual test results would be exceeded only one time in 20 (5%) under normal and correct operation of the test method. Based on the program's multilab precision factor, the test results from two labs testing concrete cylinders prepared from the same concrete sample should not differ by more than about 12% to 13% of the average.

What is excluded in this variation are initial 24-hour curing procedures; therefore, unacceptable differences in test results may sometimes be caused by deviations from standard procedures in sample preparation and initial curing, which can invalidate test results.

D.C.-area labs' round-robin strength test results, 1991-98

Year	Batch	Average strength	Number of cylinders	Number of labs	Within-test S.D., psi	Within-test C.V., %*	Multilab S.D., psi	Multilab C.V., % *
1991	1	4982	3	20	90.3	1.8	184.7	3.7
	2	7080	3	20	171.6	2.4	243.1	3.4
1993	1	3807	2	30	90.2	2.4	202.9	5.3
	2	7335	2	28	172.4	2.4	330.9	4.5
1994	1	4584	2	25	94.8	2.1	261.7	5.7
	2	7824	2	23	173.9	2.2	271.8	3.5
1995	1	3344	2	28	86.2	2.6	177.7	5.3
	2	7170	2	27	124.7	1.7	272.2	3.8
1996	1	4863	2	36	134.0	2.8	199.9	4.1
	2	8323	2	34	170.4	2.0	433.6	5.2
1997	1	3899	2	38	89.8	2.3	194.3	5.0
	2	8082	2	36	247.6	3.1	387.2	4.8
	3	11,740	2	14	304.4	2.6	608.8	5.2
1998	1	4175	2	28	85.6	2.1	188.0	4.5
	2	7255	2	29	177.0	2.4	349.0	4.8

* precision factor

A comparison of compressive strength in a round-robin testing program cosponsored by the Washington Area Council of Engineering Laboratories and the Ready Mixed Concrete Producers Technical Committee shows that test variability has been consistent.

Test-precision estimates are also particularly important when compressive-test results are used for acceptance and payment decisions, since precision is a major factor affecting the required overdesign needed to avoid penalties.

Chua says the program has helped. He now finds it easier to explain strength-test differences. "With the round-robin results, I can explain to engineers that a 200-psi break difference is acceptable because it falls within one standard deviation of precision error," says Chua.

But as successful as the program has been, Chua thinks there's still work to be done. He points out that there's always one lab result that falls outside two standard deviations. "If the culprit is a commercial lab, I hope it doesn't test my concrete," says Chua. ■

— Rick Yelton

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