NRMCA

What, Why & How?

Low Concrete Cylinder Strength

CONCRETE IN PRACTICE | CIP 9

WHAT Constitutes Low Cylinder Strength?

Cylinders are molded from a sample of fresh concrete. Procedures must be in accordance with ASTM standards.[1] The average strength of the set of 2 or 3 cylinders, broken at 28 days, constitutes one "test." Additional cylinders are often made for 7-day tests or to be field cured to check early strength for form stripping.

Under ACI Standards,[2] concrete is acceptable if no one "test" is lower than specified by more than 500 psi and the average of three consecutive "tests" equals at least the specified strength. If an average of three "tests" in a row dips below the specified strength, steps must be taken to increase the strength of the concrete. If a "test" falls more than 500 psi below the specified strength, there may be more serious problems. An investigation would be made to ensure structural adequacy; and, again, steps taken to increase the strength level.

WHY Are Compressive Tests Low?

Two major reasons are: (a) improper handling and testing—found to contribute in the majority of low strength investigations, and (b) reduced concrete quality due to an error in production, or the addition of too much water to the concrete on the job due to delays in placement or requests for wet concrete. High air content, for example, can be a cause of low strength.

Collect all test reports and analyze results before taking action. Look at the pattern of strength results. Does the sequence actually violate the specification? Do the test reports give any clue to the cause? Look at the slump, air content, concrete and ambient temperatures, number of days cylinders were left in the field, and any reported cylinder defects.

If the deficiency justifies investigation, first verify testing accuracy and then compare the structural requirements with the measured strength.[3] If testing is deficient or if strength is greater than that actually needed, there is little point in investigating the in-place strength. However, if procedures conform to the standards and the specified strength is required for the member in question, further investigation of the in-place concrete may be required. (See CIP-10 on "Strength of In-Place Concrete.")

Have ASTM testing procedures been followed? Minor discrepancies in curing cylinders in mild weather will probably not affect strength much, but if major violations are discovered, large reductions in strength can occur.[4] Almost all deficiencies in handling and testing cylinders will lower strength. A number of violations may combine to cause significant reductions, such as: extra days in the field; curing over 80°F; frozen cylinders; impact during transportation; delay in curing at the lab; improper caps; and insufficient care in breaking cylinders.

4000 psi Specified Strength

Test No.	Individual Cyl. No. 1	Individual Cyl. No. 2	"Test" Average	Average of 3 Consecutive
Acceptable Example				
1	4110	4260	4185	——
2	3840	4080	3960	——
3	4420	4450	4435	4193
4	3670	3820	3745	4047
5	4620	4570	4595	4258
Low Strength Example				
1	3620	3550	3585	——
2	3970	4060	4015	——
3	4080	4000	4040	3880*
4	4860	4700	4780	4278
5	3390	3110	3250†	4023

*Average of 3 consecutive low.
†One "test" more than 500 psi low.

The laboratory should be held responsible for deficiencies in its procedures. Use of qualified lab personnel is essential; untrained construction workers must not make and handle cylinders. All labs should meet ASTM C 1077 criteria for laboratories testing concrete and concrete aggregates and be CCRL inspected.[5] Personnel testing concrete should be qualified by the ACI certification program or equivalent.

WHY Are Compressive Tests Low?

It is essential that testing personnel be trained in the proper application of the ASTM Standards for strength tests of field-made, laboratory-cured cylinders:

a. Sample concrete falling from chute in two increments, in the middle part of the load, after some has been discharged.

b. Transport sample to the location of curing for the first day.

c. Remix the sample to ensure homogeneity.

d. Use molds conforming to standards.

e. Rod concrete in three layers and tap sides of the mold to close rod holes.

f. Finish tops smooth and level to allow thin caps.

g. If necessary, move cylinders immediately after molding; support the bottom.

h. Cure cylinders in the field at 60°F to 80°F.

i. Protect from loss of moisture.

j. Transport day-old cylinders to the laboratory; handle gently or cure in accordance with C 31 at the job.

k. Demold and promptly place in moist curing at 73 ±3°F.

l. Maintain water on cylinder surfaces at all times.

m. Caps on cylinders must be flat and less than $^{3}/_{16}$ inch thick.

n. Use minimum 5000 psi capping material.

o. Wait at least 2 hours for sulfur caps to harden.

p. Use calibrated testing machine.

q. Measure cylinder diameter and check cap planeness.

r. Center cylinder and use proper loading rate.

s. Observe break pattern (vertical cracks through the cap indicate improper load distribution).

Test reports must be promptly distributed to the concrete producer, as well as the contractor and engineer. This is essential to the timely solution of problems.

References

1. ASTM Standards C 31, C 39, C 172, C 470, C 617, and C1077. American Society for Testing and Materials, West Conshohocken, PA.
2. "Building Code Requirements for Reinforced Concrete." ACI 318, American Concrete Institute, Farmington Hills, MI.
3. "In-Place Concrete Strength Evaluation—A Recommended Practice." NRMCA Publication No. 133.
4. "Effect of Curing Condition on Compressive Strength of Concrete Test Specimens." NRMCA Publication No. 53.
5. Cement and Concrete Research Laboratory (CCRL), National Institute of Standards and Technology, Gaithersburg, MD.

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