All About Concrete Cylinders

Technical Bulletin #37 - January 2025

Why do we make cylinders?

The primary purpose of cylinders is to test the compressive strength of a concrete load or mix design. Many jobsites set minimum limits to compressive strength, often referred to as f'c. Concrete cylinders can be cast on a site, at the plant, or in a lab to ensure the mix design or individual loads meet the specification requirements. There are specific rules, outlined in ASTM C31, on how to cast and cure concrete cylinders.

Casting Cylinders

To cast concrete cylinders, refer to the sampling practices described in ASTM C172. Once you have your sample, perform any other quality control tests, such as air content, slump, or unit weight. These measures are important information to accompany concrete strength reports in case there is any issue with the strength.

Place the molds on a rigid, even, non-vibrating surface and fill 1/3 of the way with concrete. Rod the concrete 25 times to consolidate and then repeat until the cylinder mold is full. Tap the sides with a mallet and then strike off to create a smooth surface. Cap and label the mold.

Standard Curing

Perhaps the most challenging part of the strength testing process is ensuring the proper cure of the cylinders. Remember, curing is defined as giving concrete the proper time, temperature and access to water to hydrate the cement in the mix.

It's important to know that the purpose of standard cured cylinders is to test the *potential* of the concrete. To this end, concrete must be allowed to cure in optimal conditions. First the cylinder molds must be capped immediately after casting. ASTM C31 requires the cylinders be stored at 60°-80° F (68°-78°F for high strength concrete) on site for between 8 and 48 hours after final set. This can be very challenging in both hot or cold temperatures, but is critical to testing accuracy. Many jobsites are beginning to require thermostatically controlled coolers as a means to meet the site curing requirements. Allowing the cylinders to overheat or freeze can cause low breaks and allowing them to be cooler than 60°F may slow the strength gain. If you see cylinders being improperly cured on a site, report it to the testing lab, general contractor or owner.

Not Okay!

Still Not Okay!

Very Much Not Okay!

Temperature controlled concrete curing box

Cylinders must be carefully transported to the lab from the jobsite in padded containers, again thermally protected from freezing. Then they must be stripped out of the mold placed in a lime-water tank or 100% humidity curing room at 73°F until they are ready to be broken. Cylinders can be broken at any age, but 28 days is typical for acceptance testing. 3, 7, and 14 day tests are also common. When the time has come to break the cylinders, they are pulled from the curing environment, capped with a neoprene cap or sulfur compound and then have an ever increasing load applied to the cylinder in a cylinder breaking machine. When the concrete fails, the applied load is registered and converted to a psi number.

Field Curing

Another use for cylinders is to try to understand what is happening with the concrete in place on a jobsite. Field curing is the method to determine when concrete is acceptable to be opened to traffic, post-tensioned, or forms can be stripped. It is **NOT** to be used as acceptance criteria for the concrete itself. In field curing, protection of the concrete is supposed to mimic as near as possible what is happening to the in-place concrete. So, for example, if a concrete slab has blankets over it, the cylinders should be placed next to the slab under the same blankets. If the concrete is baking in the hot sun, so should the cylinders.

Beams

Another way to test the strength of concrete is through casting beams. Beams test the flexural strength of concrete as opposed to the compressive strength tested in cylinders. Flexural strength is actually a more important metric for many types of concrete, such as flatwork or paving, where compressive strength is kind of irrelevant from an engineering standpoint. As there is no reliable method of converting compressive strength to flexural strength, breaking beams are a method of determining the flexural strength. Beams are cast in a similar manner to cylinders, and then can be center-point or third-point loaded to test the flexural strength of the concrete. Third-point loading is also sometimes called the "modulus of rupture" and is an important metric for concrete in many high-rise buildings. Beams can be treated as standard curing or field curing just like cylinders, but field curing is more common, particularly for opening strengths on road paving.

Low Strengths

In the case of a low cylinder break, there are a few things to keep top of mind. First, according to ACI 318, a low break is only to be categorized as having insufficient strength if A) the break is 500psi or more below f'c. or B) the running average of three consecutive breaks is lower than f'c. One might have three breaks for a 4000psi mix at 3750, 4200 and 4100. According to code, this would meet specifications. However, being that close to the line of acceptability would certainly be cause for investigation.

If low strengths are recorded, there are a number of options depending on the concrete member and the project it is on.
1) Wait for 56 days. Often, testing labs will hold a cylinder to test at 56 days should a 28-day break come in low. This may not be a big deal for something like a parking lot, but would probably not be an option on a column in a multi-floor building, where construction must progress.

2)Take a core sample. In order to eliminate the possibility of improper sampling, casting, curing, handling, or breaking of cylinders, a core can often be drilled from the in-place concrete member and broken like a cylinder for strength testing. The readings have to be adjusted for the aspect ratio of the core, and cores are considered acceptable at 85% of f'c because they were not necessarily cured in the optimal environment that would be present in standard curing.
3) Assess the engineering necessity of the specified strength. Sometimes engineers spec strengths just because they are used to doing it and the actual structural load the concrete needs to carry is significantly less than the specified strength.
4) Apply any appropriate remediation techniques. Sometimes there are engineering solutions to reinforce low strength concrete, such as carbon fiber wrapping on a column.
5) Tear out and replace. Often the last resort due to cost and time delays, deficient concrete may need to be removed and replaced if there is no other economical engineering solution to the low strength.

Click here for previous Tech Bulletins

Hahn Ready Mix
3636 West River Drive, Davenport, IA 52802