Measuring **Compressive Strength**

Avoid **common mistakes** while measuring the compressive strength of concrete.

By Mitch Rector

Editor's Note: *This article is intended to serve as a reference guide for entry-level production employees.*

Manufacturing a quality precast concrete product is a lot like grilling a good steak. One major consideration is how long you wait. The longer you wait, the longer the steak takes up valuable space on the grill, and if you wait too long you'll overcook the meat. However, if you remove it too early, it may not have a good sear or be undercooked.

Just like you can use a poke test to determine how far along a steak is during cooking, you can use a test to determine the strength of your concrete. But instead of a light touch with your finger, a specialized piece of equipment is used to apply several thousand pounds of force.

At least four compressive strength specimens must be cast for each **150 cubic yards** of concrete of each mix or once every week, whichever occurs first.

– NPCA Quality Control Manual for Precast Plants, section 5.3.5.4

DIFFERENT DAY STRENGTHS

Concrete's strength comes from a chemical reaction between cement and water. This creates a paste, binding the aggregates together. As time progresses, more cement can react, causing the concrete to become stronger. The strength of the concrete is not just important for design, but also for production. In wet-cast production, the earlier concrete reaches a minimum stripping strength, the sooner it can be removed from a form and the form can be used for the next product. So how are stripping and design strengths determined?


Compression tests provide a precaster an easy method to track concrete trends that may occur due to material changes or environmental conditions, so they can make needed adjustments.

THE COMPRESSIVE TESTING PROCESS

A concrete compressive strength test machine works by progressively applying force on a specimen. Because strength is defined as the maximum load carried divided by the average cross-section area, the most logical way to determine the strength of a specimen is to load it until it fails. However, this would be impractical to perform for all precast concrete products. Instead, small concrete cylinders are cast and used. Cylinders are commonly 4 by 8 inches or 6 by 12 inches in size. These specimens are easy to cast and require little storage space, especially when produced in large amounts. It is important to cast the cylinders using the same concrete mix so cylinder strengths can be compared.

According to the National Precast Concrete Association Quality Control Manual for Precast Concrete Plants, section 5.3.5.4, at least four compressive strength specimens must be cast for each 150 cubic yards of concrete of each mix or once every week, whichever occurs first. Two specimens are tested at or before seven days after casting. The average of the two specimens helps keep quality consistent. The same process is repeated with two other specimens at or before 28 days after casting.

It is important to fully test the specimens until failure.

NPCA file photo

"A lot of people don't take them through until failure," said Alan Pritchard, quality manager at Smith-Midland Corp. "You can't know the concrete strength unless you take the cylinders through until failure."

These specimens let you model the design compressive strength of your concrete. Additionally, section 4.6.1 states that one-day compressive tests must be performed at least quarterly for each mix design. This adds up to a lot of time, energy and materials. It is important to cast and test cylinders correctly so that the data you receive is accurate.

COMMON MISTAKES

Mistakes can slow down production and more importantly reduce the quality of concrete. There are three common mistakes to avoid when performing a compression test: inappropriate cylinder treatment, misalignment and improper loading rates.

Everything from shape to storage to moisture content will affect the strength of a specimen. While the sizes of a cylinder can vary, it is important to aim for a 2-to-1 length-to-diameter ratio. If the produced cylinder has a length-to-diameter ratio of 1.75 or less, appropriate correction factors will need to be applied. If the length-to-diameter ratio is greater than 2, it can be trimmed down.

"A lot of groups don't really look at that or treat cylinders with two diameters that are out of the normal tolerance," Pritchard said. "They don't recognize that that's a large difference in your cross-sectional area."

Moisture is another common problem when handling or storing cylinders. Due to the chemistry of cement, a dry specimen can show a higher strength than a damp one. This could cause major problems if of the two 7-day specimens tested, one is wet and the other is dry.

"Pretty often they are pulled out and not kept moist-cured up until the time to break them," Pritchard said. "According to ASTM, the ones that require moist curing should be broken while still damp."

Another common problem can arise from how the specimen fits into the testing machine.

"The ones that are probably showing the largest impact on the breaks to me would be alignment in the machine, proper seating of the bearing surfaces and making sure the cylinder is centered," Pritchard said.

A specimen that is misaligned or off-center can develop a point load, which will cause side fractures at the top or the bottom.

Section 7 of ASTM C39 states, "Place the plain (lower) bearing block, with its hardened face up, on the table or platen of the testing machine directly under the spherically seated (upper) bearing block." Then the upper and lower bearing faces are wiped clean before the specimen is placed on the lower bearing block. When unbonded caps are used, the caps should be centered on the cylinder. The specimen is then aligned with the center of thrust through the spherically seated block.

Finally, it is important to use a proper rate of loading when testing a specimen. A low rate of loading will cause the test to take a long time. Additionally, a low rate of loading will cause the specimen to undergo creep, generating lower strength results. Conversely, high loading rates will affect the material properties of concrete by temporarily increasing the compressive strength. This means that the strength of the specimen will not accurately reflect the properties of the mix. What is a proper loading rate, then?

ASTM C39 states that the rate of loading must be applied continuously and without shock or sudden increases. An acceptable load rate is 28-to-42 psi. A higher loading rate is allowed in the first half of the loading phase, but it must be applied in a careful and controlled manner to avoid shock loading. As the suspected failure load approaches, it is important to not adjust the loading rate. It's important to be mindful that the rate a specimen is loaded is a significant part of performing an accurate compression test. Once the test is complete, caution must still be taken.

"The one biggest issue I've had in the past would be transposition and documentation and not getting everything recorded properly," Pritchard said. "They might transpose a number or record it on the wrong sheet."

This small part can cause the biggest problems, so always ensure that you are recording the right numbers in the right place.

BE ALERT

All it takes is a split-second distraction to cause a steak to head into well-done territory, and all it takes is a quick moment of carelessness to render a day's work invalid. Being alert of every step in the testing process is an important part of creating a quality piece of concrete. **PI**

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