One of the most frustrating setbacks that occurs on jobsites is low concrete breaks. It seems like they always happen at the worst time, when your schedule is already delayed and you are trying to move your project along as fast as possible. When testing your concrete for early-age strength, if the lab comes back to you with a psi/MPa that is lower than what is expected from your mix, you have very limited options moving forward, all of which require more time and money.

The Official Definition of a Low Concrete Cylinder Break

Under ACI and CSA Standards, a break is considered to be of low compressive strength when an individual strength test (average of two cylinders) is more than 500 psi (3.5 MPa) below the required expected strength. Or, if the averages of all three consecutive sets of tests does not equal or exceed expected strength of the mix design. These nationally accepted specifications do account for normal and expected variability of concrete strength tests. However, if your samples exceed these specified values, more investigation into the cause is required.

The 6 Causes of Low Concrete Breaks

1. Concrete Mix Design

The concrete mix does not gain strength in the time that had been specified, making compressive strength testing lower than expected. This may happen if the wrong mix has been sent to you or if during transportation additional water is added to a mix. This technique may be done so that while the concrete is making its way to the jobsite, it is easier to pump out and does not clog the mixer. As a result, the water to cement ratio is affected, reducing the overall strength of the mix.

2. Sample Production

When casting your concrete cylinders, the testing specimen are not properly prepared and rodded. If this process is not done according to ASTM standards you may end up with voids or aggregate segregation in your samples. As a result, your concrete cylinder will have a lower measured strength when compressed.

3. Curing Conditions

The ambient conditions of your field-cured specimen do not reflect those of your in-situ structure. When curing concrete cylinders in the field, the samples must remain in the same conditions as your in-situ element. If this is not done, the strength value when the cylinder is broken will not represent the strength value of your structure. This leads to a miscalculation of the strength value of your in-situ concrete, affecting the quality of your structure.

> **Read more about the importance of initial curing conditions Here**

4. Improper Handling

The concrete samples are not handled or transported properly. When this is done before early age testing takes place, the specimen are more vulnerable and susceptible to micro-cracking. Therefore, when the samples are broken, these voids created by the micro-cracking affect the strength value tested, resulting in a low cylinder break that does not represent the strength of the in-situ concrete.

5. Cylinder Preparation

After the concrete specimen have been curing for a specific number of days [3, 7, 14 days], they are prepped by the lab for breaking. This involves either grinding the ends of the cylinder so that they are parallel or capping them. Grinding the ends of a break is done to ensure continuity in contact while load is applied. Capping cylinders, according to ASTM C617, is utilized when grinding is not possible. If the concrete cylinder is not prepared with care and attention before breaking, the cylinder will not break properly when load is applied and the strength value that results will therefore show up as a low break.

6. Calculation Errors

Before a lab can break the concrete cylinders, the break test machine much be properly calibrated. Not only is regular calibration needed to ensure the machine is working properly, but some machines need to be calibrated according to the engineer's specification. This information is essential to ensure that when the strength value is given, it represents the in-situ element.

Your Next Steps When Concrete Cylinder Breaks Are Low

When you get a call from the lab and find out that your cylinders are breaking low, it's never good news. The most common solution is to wait and let your concrete continue curing, then test strength again on your next break day (i.e. day 7 or 14). This is done to see whether the issue is a result of the samples, rather than the entire structure. If your concrete is still under performing after that second break, then you have a real problem.

You now have to detect where inaccuracies have happened. This often leads to expensive delays and unexpected costs. It is recommended that you look at the slump, air content, ambient temperatures, number of days cylinders were left in the field, and any reported cylinder defects. First, to see if the deficiencies justify investigation, verify the testing accuracy, and then compare the structural requirements with the measured strength.

If all the previous procedures have conformed to the standards, compare the data from the break tests with another testing technique, such as coring, as outlined in ASTM C42. Although this is rather an expensive route to go, it allows for further investigation into the differences between your field-cured cylinders and the in-situ element. As a last resort, load tests may be required to check the capacity of structural elements, as outlined in ACI 318. In rare cases where a structural element fails the load test, corrective measures need to be taken. This may involve adding supporting beams to the structure or tearing up the part of the element with low strength and starting over.

Bottom Line, Low Concrete Breaks Happen Because of Human Error

As you've probably noticed, the main causes of low breaks are the result of mistakes made because of human-error. These issues happen, not only at the beginning stages of pouring when specimen are first made, but also during curing, transportation, and even after samples have already made it to the lab. Since cylinders need to be created as soon as pouring takes place, mistakes are often made onsite because workers are in a rush. Lack of experience also plays a big role. It's no secret that there is a shortage of skilled labor. As the workforce matures, new technicians and field personnel managing the process are less experienced with ASTM standards. In the lab, human errors are further exacerbated as technicians are often rushed by managers trying to meet project deadlines. There are few ways you can prevent these mistakes from happening. One of which is to hire more experienced workers, but this is not always within your control, or your budget.

How to Easily Eliminate Low Concrete Breaks on Your Next Project

Another option, one that is becoming increasingly more popular, is to ditch field-cured cylinders for early age testing altogether and switch to wireless maturity sensors to monitor strength and maturity. These sensors are embedded in your in-situ concrete element and secured on the rebar. Strength is monitored constantly in real-time and sent to your mobile device via an app. This means that you can check the performance of your mix at any time. Standard-cured cylinders are still made and tested on day 28 for acceptance purposes. However, all other points of data you would normally receive from the lab with break tests on days 3, 7, 14, etc. are instead sent to you in real-time. Plus, since all your strength data is calculated within the app, it saves a lot of time spent on labor that would normally be used making, transporting, and testing the cylinders. This story from Bottorff Construction Inc. featured below shows just how compelling this new technique is.

Learn How Bottorff Eliminated Low Concrete Breaks and Accelerated Project Timelines

Wanting to avoid any further delays or discrepancies with their cylinders, the team contacted Geiger Ready-Mix, who introduced them to wireless maturity sensors. During the construction of a 276-unit, super energy-efficient multi-family apartment in Kansas City, Bottorff Construction Inc. faced a lot of challenges, such as;

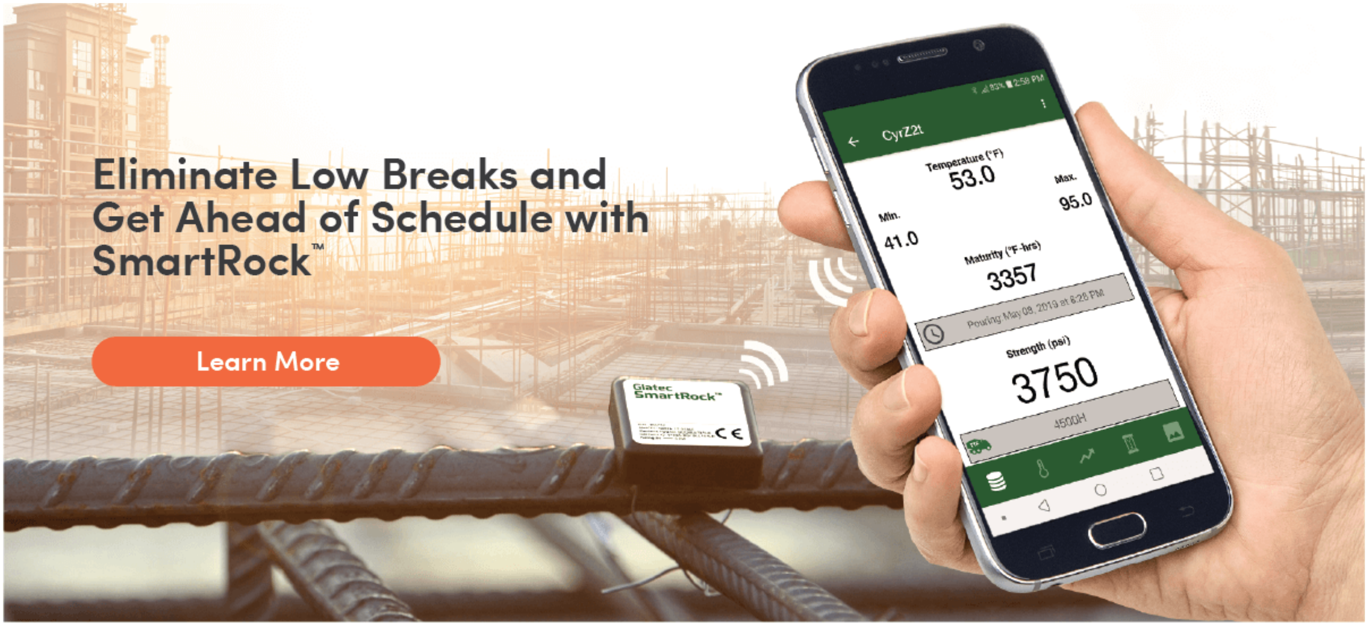
- Construction completely stopping onsite due to extreme cold weather,
- An inspection agency reporting that traditional break tests were low,

- The team almost having to "rip and replace" completed concrete work at a tremendous cost.

"The conditions made it extremely difficult, if not unrealistic, for field-cured cylinders to capture the accurate in-place strength results required. With a tight schedule to maintain, the time-consuming process of cylinder break tests was not meeting our needs, nor the building owner."

– William Pettit, Project Manager, Bottorff Construction Inc.

> **Read the full Bottorff Case Study Here**



Sources:
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Concrete Construction
NRMCA