CONCRETE SASK

TECH TIP #9

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LOW CONCRETE CYLINDER COMPRESSIVE STRENGTH

WHAT is low concrete cylinder compressive strength?

Strength test results of concrete cylinders are used as the basis of acceptance of ready mixed concrete when a strength requirement is specified. Cylinders are molded from a sample of fresh concrete, cured in standard conditions and tested at an age indicated in the specification, usually at 28 days.

For strength tests to be reliable, procedures used for making, curing and testing cylinders must be conducted in accordance with applicable CSA Standards (CSA A23.1/A23.2). The average strength of a set of 2-100mm x 200mm cylinders (or 150mm x 300mm depending on aggregate size limitations), made from the same concrete sample, at the same age, constitutes one test result. Cylinders are also tested at 7 days to get an early indication of potential strength, but these test results are not to be used to determine the acceptability of the concrete.

Cylinders used for acceptance of concrete should not be confused with field cured cylinders. Tests of field cured cylinders are used to evaluate whether the in-place concrete has been properly cured and protected, to estimate the early age strength in the structure for stripping of forms, post tensioning and/or to continue construction activity.

Clause 4.4.2.3.1.1 of CSA A23.1-24 states that:

"The strength level of concrete shall be considered satisfactory if for a given strength-class the following two criteria are met for concrete produced from a single mix design:

a) each individual strength test equals or exceeds the acceptable test result (ATR), where
ATR = specified strength − 3.5 MPa when the specified compressive strength is 35 MPa or less; or

b) where ATR = 0.90 × specified strength when the specified compressive strength is above 35 MPa; and

c) the moving average of three consecutive strength tests in the same concrete equals or exceeds the specified strength.

These requirements shall not apply to field-cured specimens."

CSA A23.1 recognizes that when concrete mixtures are proportioned to meet the requirements of the standard, strength tests results can fail to meet acceptance criteria about 10% of the time due to normal variability. This level of risk might not be appropriate to every project. Refer to ACI 214R for more information on risk management.

If the strength test results fail either condition (a) or (b), steps must be taken to increase the strength of the concrete. If the results fail condition (b), an investigation should be made to ensure structural adequacy of that portion of the structure.

WHY are compressive tests low?

The major reasons for low compressive strength tests are:

- Improper cylinder handling, curing and testing - this is typically the reason in most cases.
- The addition of excessive water to the concrete mixture at the jobsite due to delays in placement or requests for a higher slump to facilitate placement and finishing.
- High air content in the concrete (and test specimens); and
- Errors in production and unanticipated factors during delivery.

When low compressive strength test results are reported:

- Collect all test reports and analyze the results before taking action. Labs should not provide reports of only failing tests.
- Look at the pattern and numbers of reported strength results.
- Considering the sequence of results—is there a violation on compliance with the strength acceptance criteria discussed above.
- The strength range of two or three cylinders prepared from the same sample should rarely exceed 8.0% or 9.5% of the strength average, respectively.
- Do the results indicate that the cylinders are being loaded to complete failure.
- Do the test reports provide any causal reasons?
- Review the dates and times of batching, sampling, pick up from jobsite and delivery to the lab.
- Review concrete and ambient temperatures, number of days cylinders were left in the field, procedures used for initial curing in the field, duration of transportation, and subsequent curing in the lab.
- Review the slump, air content, and density, if measured.
- Review for any reported cylinder defects; and
- Review batch records to ensure compliance with mix design requirements.

It is important that procedures are conducted in accordance with CSA standards. Almost all deficiencies in handling and testing cylinders will result in a lower measured strength. All violations add up to cause significant reductions in measured strength.

The more significant factors are improperly finished surfaces, initial curing over (25°C); high air content; frozen cylinders; extra days in the field; damage during transportation; delay in stripping molds and curing at the lab; improper capping and/or grinding and insufficient care in breaking cylinders.

Ensuring that all field testing and laboratory personnel are certified to either CCIL (CSA) or ACI standards. Construction workers untrained in concrete testing must not make and handle cylinders. CSA requires that all laboratories to conform to CAN CSA A283 standards and personnel qualifications.

HOW to reduce low strength tests?

- Ensure that samples of concrete at the jobsite are obtained in accordance with CSA A23.2-1C.
- Ensure that the cylinders are made and cured in accordance with the standard curing requirements in CSA A23.2-3C.
- Ensure that cylinders are handled with care at the jobsite and during transportation in accordance with CSA A23.1-3C.
- Ensure the cylinders are tested in the laboratory in accordance with CSA A23.2-9C.

References:

1. CAN CSA A23.1-24/A23.2-24.
2. In-Place Concrete Strength Evaluation-A Recommended Practice. NRMCA Publication 133, NRMCA, Alexandria, VA., www.nrmca.org.
3. Effect of Curing Condition on Compressive Strength of Concrete Test Specimens, NRMCA Publication 53, NRMCA Alexandria, VA.
4. Review of Variables that Influence Measured Concrete Compressive Strength, David N. Richardson, NRMCA Publication 179, NRMCA, Alexandria, VA.
5. Low Strength Tests? Maybe Not!, E.O. Goeb, Concrete Products, December 1992.
6. Why Low Cylinder Tests in Hot Weather? E.O. Goeb, Concrete Construction, Jan. 1986.
7. CIP 9 - Low Concrete Cylinder Strength, National Ready Mix Concrete Association.