Concrete Tech Tip
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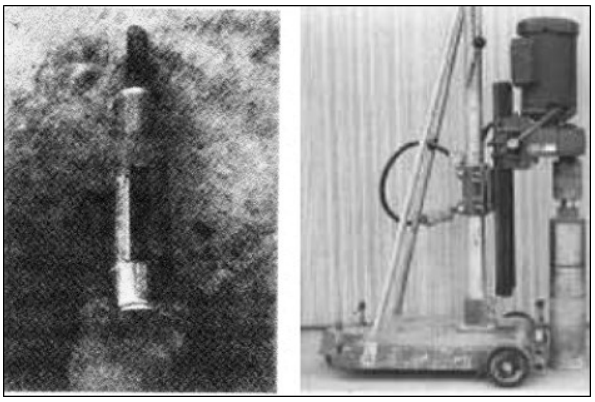
Strength of In-Place Concrete

1. WHAT is the Strength of In-Place Concrete?

Drilled cores test lower than properly made and tested standard molded 100 by 200mm cylinders. This applies to all formed structural concrete. Exceptions may occur for cores from concrete cast against an absorptive subgrade or cores from lean, low strength mass concrete.

Means of measuring or comparing the strength of in-place concrete include: rebound hammer, penetration probe, pullouts, cast-in-place cylinders, tests of drilled cores, and load tests of the structural element.



Rebound Test (A23-2 Annex A.3.2.2)

Core Test (A23.2-14C)

The standard CSA test procedure evaluates the strength potential of the concrete. Cylinders are molded and cured at 15 - 25°C for one day and then moist cured in the laboratory until broken in compression, normally at 7, 28 and 56 days age. Job practices for handling, placing, compaction, and curing of job concrete are relied upon to provide an adequate percentage of that potential strength in the structure. The CSA Building Code recognizes that under current design practices, concrete construction can be considered structurally adequate if three cores average at least 85 percent of specified strength with none below 75 percent.

2. WHY Measure In-Place Strength?

Tests of in-place concrete may be needed when standard cylinder strengths are low; however, do not investigate in-place without first checking to be sure that: the concrete strengths actually failed to meet the specification provisions; low strengths are not attributable to faulty testing practices; and the specified strength is really needed. (See CTT-9 on "Low Concrete Cylinder Strength.") In many cases the concrete can be accepted for the intended use without in-place strength testing.

There are many other situations which may require the investigation of in-place strength, including: shore and form removal, post-tensioning, or early load application; investigation of damage due to freezing, fire, or adverse curing exposure: evaluation of older structures; and when a lower strength concrete is placed in a member by mistake. When cores or other in place tests fail to assure 85 percent of the design strength, additional curing of the structure may provide the necessary strength. This is particularly possible with concretes containing slow strength-gaining cement, fly ash, or slag.

References:
1. *Building Code Requirements for Reinforced Concrete,* ACI 318, American Concrete Institute, Farmington Hills, MI.
2. ACI 228.1R, *In-Place Methods to Estimate Concrete Strength,* ACI, Farmington Hills, MI.
3. ACI 214.4R, *Guide for Obtaining Cores and Interpreting Compressive Strength Results,* ACI, Farmington Hills, MI.
4. ASTM C31, C39, C42, C805, C803, C873, C900, ASTM Book of Standards 04.02, American Society for Testing and Materials, Conshohocken, PA.
5. *Guide to Non-Destructive Testing of Concrete,* G.I. Crawford, Report FHWA-SA-97-105, Sept. 1997, Federal Highway Administration, Washington, D.C.
6. *CIP 9, 39, Concrete in Practice Series,* NRMCA, Silver Spring, MD.
7. TIP 11, Testing Concrete Cores, *Technology in Practice Series,* NRMCA, Silver Spring, MD.
8. *In-Place Concrete Strength Evaluation – A recommended Practice, NRMCA Publication 133, NRMCA, Silver Springs, MD.*
9. *Understanding Concrete Core Testing,* Bruce A. Suprenant, NRMCA Publication 185, NRMCA, Silver Spring, MD.

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3. HOW to Investigate In-Place Strength

If only one set of cylinders is low, often the question can be settled by comparing rebound hammer or probe results on concrete from areas with good cylinder results. Where the possibility of low strength is such that large portions need to be investigated a well-organized study will be needed. Establish a grid and obtain systematic readings including good and questionable areas. Tabulate the hammer or probe readings. If areas appear to be low, drill cores from both low and high areas. If the cores confirm the hammer or probe results, the need for extensive core tests is greatly reduced.

Core Strength, CSA A23.2-14C - If core drilling is necessary, observe these precautions:

(a) Test 3 cores.
(b) Use 100mm minimum diameter and larger cores for over 20mm aggregate.
(c) Try to obtain a length at least 2 times the diameter.
(d) Trim to remove steel if the 1.0 L/D ratio can be maintained.
(e) Trim ends square with an automatic feed diamond saw.
(f) Keep cap thickness under 3mm.
(g) Use high strength capping material.
(h) Check planeness of caps and bearing blocks.
(I) Do not drill cores from the top layers of columns, slabs, walls, or footings. They will be 10 to 20 percent weaker than cores from the mid or lower portions.
(j) Test cores after drying for 7 days if the structure is dry in service; otherwise, soak cores 40 hours prior to testing.

Probe Penetration Resistance, Annex (A) Non Destructive Methods for Testing Concrete A 3.2.3- Probes driven into concrete can be used to study variations in concrete quality; (a) different size probes or a change in driving force may be necessary for large differences in strength or unit weight, (b) accurate measurement of the exposed length of the probe is required, (c) probes should be spaced at least 178mm apart and not be close to the edge of the concrete, (d) probes not firmly embedded in the concrete should be rejected and, (e) develop a strength calibration curve for the materials and conditions under investigation.

Rebound Hammer, Annex (A) Non Destructive Methods for Testing Concrete A 3.2.2 - Observe these precautions:

(a) Wet all surfaces for several hours, or overnight, because drying affects rebound number.
(b) Don't compare readings on concrete cast against different form materials, or concrete of varying moisture content, or readings from different impact directions, or on members of different mass, or results using different hammers.
(c) Don't grind unless the surface is soft, finished, or textured.
(d) Test structural slabs from the bottom.
(e) Don't test frozen concrete.

Advance Planning - When it is known in advance that in-place testing is required, such as for shore and form removal, other methods can be considered such as: cast-in-place, push-out cylinders and pullout strength measuring techniques covered by CSA A23.2-15C..

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