Concrete Property Test

Strength Development 2-4: Flexural Strength and Compressive Strength (Three and Seven Day)

National Concrete Pavement Technology Center
www.cptechcenter.org

Purpose – Why Do This Test?

Concrete strength is critical because it reflects concrete's ability to carry intended loads. Flexural and compressive strength testing are currently the standard methods of evaluating and assessing pay factors for pavement concrete. The tests are required for calibrating maturity-based monitoring systems.

Principle – What is the Theory?

A measured force is applied to concrete samples of consistent cross-sectional area (beams and cylinders) until the samples fail. The force required to break the sample is used to calculate the strength based on the cross-sectional area of the sample.

Test Procedure – How is the Test Run?

Samples of fresh concrete from the project are cast in cylinder and/or beam molds. These test specimens are cured in laboratory conditions until they are broken in accordance with ASTM C 39 (compression) or ASTM C 78 (flexure). A consistent and continuously increasing force is applied to the test specimens by a hydraulic testing machine. The maximum force required to break the sample and the actual dimensions of each sample are recorded.

Test Apparatus

- Cylinder and beam molds for casting strength specimens (6-in. diameter x 12-in. height or 4-in. diameter x 8-in. height for cylinders and 6-in. width x 6-in. height x 24-in. length for beams).
- Curing tanks to provide consistent curing conditions for the specimens.
- Hydraulic testing frame for applying the force (figure 1).
- Cutoff saw, neoprene cap, and miscellaneous tools for preparing the specimens.

Test Method

1. Sample and cast cylinder and beam specimens in accordance with standard procedures.
2. Cover and protect specimens from evaporation and damage for 24 hours.
3. Remove specimens from the molds and transfer to the curing tanks.
4. Cure the specimens in a controlled environment until they are broken.
5. Remove the specimens from the curing tanks.
6. Place the specimens in the hydraulic testing frame and apply a force until the specimen breaks.
7. Record the maximum force applied and the dimensions of the specimen.

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Figure 1. Hydraulic compression tester

FOR MORE INFORMATION
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Output – How Do I Interpret the Results?

Strength results are reported in a tabular format in units of pounds per square inch (lb/in^2). Other data in the report should include specimen identification, specimen dimensions, span length (beams), and maximum force applied.

Formulas for concrete strength calculations are as follows:

Flexural strength = ([force x span] / [width x depth^2])

Compressive strength = force / (π x radius^2)

Construction Issues – What Should I Look For?

Laboratory-cured strength tests are a representation of the concrete mixture's strength properties. The strength of the pavement will differ from laboratory-molded and laboratory-cured specimens due to differences in consolidation and differences in the curing environment. Core specimens taken from the slab can be used to verify pavement strengths.

Conditions that may prevent the strength tests from being representative of the actual concrete strength include the following:

- The load rate does not conform to standard procedures; faster load leads to higher strength test results.
- Beam specimens are allowed to dry before testing, resulting in lower strength test results.
- Specimen dimensions are not uniform, or equipment surfaces are not straight and flat, resulting in lower strength test results.
- Specimens are not adequately consolidated, resulting in lower strength test results.
- Quality control and acceptance specimens should be cured in a lab environment (70ºF to 76ºF), which leads to a difference between the temperature history of the specimens and the pavement. Thus, the strength of the specimens is not equivalent to the strength of the pavement.

The strength of the concrete pavement structure is influenced by the following factors:

- Water-cementitious materials ratio.
- Air content.
- Consolidation.
- Curing conditions.
- Aggregate grading, quality, and shape.

Concrete strength has long been an acceptance criterion for concrete pavements. From a long-term performance standpoint, characteristics other than strength have a significant impact on pavement durability. Adequate strength is a good indicator of concrete quality, but it does not guarantee performance. Focusing on strength alone may ignore important properties, such as air entrainment, permeability, and workability.

APRIL 2008

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This test summary is one of a set of summaries originally published in chapter 7 of the *Testing Guide for Implementing Concrete Paving Quality Control Procedures* (Fick, G., Iowa State University, Ames, Iowa, 2008). The testing guide is a product of a 17-state, Federal Highway Administration pooled-fund project, Material and Construction Optimization for Prevention of Premature Pavement Distress in PCC Pavements, TPF-5(066). The project was managed by the National Concrete Pavement Technology Center at Iowa State University.