

Concrete Property Test

Strength Development 2-1: Water-Cementitious Materials Ratio (Microwave)

Purpose – Why Do This Test?

The water-cementitious materials (w/cm) ratio has a significant effect on the strength and permeability of a pavement. Acceptance strength tests on hardened concrete are normally performed at least seven days after placement of the concrete. The microwave method can be used to obtain w/cm ratio results within hours, instead of waiting days for strength results. Monitoring the test results may provide an early flag of potentially low-strength concrete, allowing the contractor to adjust operations sooner than conventional strength testing might indicate.

Concrete strength varies inversely with the amount of water in the mixture. In simplest terms, for a given cementitious content, less water leads to higher strength. Other factors, such as consolidation, curing, aggregate quality, air content, and aggregate shape, affect strength as well. For a given mixture with a constant amount of cement, the w/cm ratio has the greatest impact on strength.

Principle – What is the Theory?

The total water in a concrete mixture comes from the following sources:

- Moisture absorbed in the aggregate.
- Free water on the aggregate.
- Water added in the batching process.

The mass of water removed from a fresh mixture by drying in a microwave can be used to calculate the w/cm ratio of the mixture.

Test Procedure – How is the Test Run?

The test is described in AASHTO T 318. A sample of fresh concrete from the project is weighed and then dried in a microwave oven. It is then reweighed to determine the mass of water that was contained in the mixture. The water absorbed in the aggregate is subtracted from the total, and the remainder is used to calculate the w/cm ratio using the batched cementitious materials content.

Test Apparatus (figure 1)

- Microwave oven for drying the concrete sample.
- Glass pan and fiberglass cloth (a container for the concrete sample).
- Scale to obtain the mass of the sample.
- Porcelain pestle for grinding the sample as it is dried.

Test Method – Refer to AASHTO T 318 for Comprehensive Guidance

1. Weigh the glass pan and fiberglass cloth (tare).
2. Place the concrete sample in the glass pan on top of the fiberglass cloth.
3. Weigh the glass pan, fiberglass cloth, and concrete sample.
4. Heat the concrete sample in the microwave oven for five minutes.
5. Remove the sample from the microwave, weigh, and break up the sample using the pestle.
6. Reheat the sample for five minutes.

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Figure 1. Microwave water content test equipment

7. Repeat the weighing, breaking, and heating cycle at two-minute intervals until the sample loses less than 1 g of mass between reheating cycles.
8. Record the mass of the wet concrete sample, the mass of the dry concrete sample, and the difference between the two masses (mass of total water content).

It should be noted that the value of W_i will not provide the true w/cm ratio because the microwave test drives out all of the water in the concrete, including the water that is absorbed in the aggregate. As such, the value of W_i will be greater than the true w/cm ratio of the mixture. By compensating for the measured absorption of the aggregate, the result from this test can be used to monitor variability in the concrete from batch to batch.

Test results should be plotted on control charts.

Output – How Do I Interpret the Results?

The total water content of the concrete sample can be expressed as a percentage:

Total water content % (W_i) = (wet sample mass – dry sample mass) / wet sample mass

This W_i can be monitored and used as a relative indicator of potential variability in pavement strength.

Construction Issues – What Should I Look For?

When variations in W_i are noted, aggregate moisture contents and plant operations should be reviewed to ensure that materials are being batched in the proper proportions.

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