Concrete Property Test

Permeability 4-2: Permeable Voids (Boil Test)

National Concrete Pavement Technology Center
www.cptechcenter.org

Purpose – Why Do This Test?

Permeability of the concrete in a portland cement concrete pavement is a major factor for long-term durability. Pavements with low permeability resist penetration of moisture into the concrete matrix, leading to improved freeze-thaw resistance and improved resistance to damage from ASR. Compared to other test methods for permeability, the boil test is simple to perform and does not require any specialized equipment. Although limited, studies by the Kansas Department of Transportation show a strong correlation between boil test results and the rapid chloride penetration test method (ASTM C 1202).

Principle – What is the Theory?

Permeability is defined as the ease with which fluids can penetrate concrete (*12*). Permeability can be lowered by reducing the number of connected pores within the paste system of a mixture. This can be accomplished through a lower w/cm, improved curing, and the use of SCMs. The boil test measures the volume of permeable pore space in a concrete mixture.

Test Procedure – How is the Test Run?

ASTM C 642, the *Standard Test Method for Density, Absorption, and Voids in Hardened Concrete*, estimates the volume of permeable pore space in a hardened concrete specimen by determining the hardened concrete's density in different states (oven dry, saturated, saturated-boiled).

Test Apparatus (figure 1)

- Scale accurate to 0.025% of the mass of the specimen.
- Container for immersing the samples.
- Wire for suspending the sample in water.
- Hot plate.

Test Method – Refer to ASTM C 642 for Comprehensive Guidance

1. Section cores or cylinders in accordance with the specimen volume required by C 642.
2. Determine the mass of the concrete samples.
3. Oven dry the samples and determine their mass.
4. Saturate the samples and determine their mass.
5. Boil the samples for 5 hours.
6. Remove the samples from the boiling container and cool the samples for at least 14 hours.
7. Dry the surface of the samples and determine their mass after immersion and boiling.
8. Suspend the sample in water by a wire and determine the apparent mass of the sample in water after immersion and boiling.
9. Calculate the volume of permeable pore space.

Figure 1. Boil test equipment

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Output – How Do I Interpret the Results?

For portland cement concrete pavements, a volume of permeable pores less than or equal to 12% is desirable for long-term durability. The worksheet below summarizes example test results for tests performed on a 4-in. lab molded cylinder.

Construction Issues – What Should I Look For?

Permeability of a pavement, or its resistance to the infiltration of harmful fluids, can be adversely affected by segregation of the mixture during paving operations. Both inadequate consolidation and over-vibration can leave a concrete pavement vulnerable.

The following mixture design issues can influence permeability:

- Lower water-cementitious materials ratio will lead to a reduction in permeable voids.
- Use of fly ash; ground, granulated blast-furnace slag; and silica fume will generally reduce permeable voids.

The following paving process inputs influence permeability:

- Improved consolidation will reduce permeable pores.
- Premature final finishing when excessive bleed water is present will increase surface permeability.
- Proper curing will reduce permeable pores.

Table 1. Example Permeable Voids Lab Worksheet

	Description of test activity	Test data (average of 9 specimens) (g)
	Determine the mass of each 2-in. cylinder section	952.2
	Place the specimens in a 210ºF to 230ºF oven for 24 hours	n/a
	Remove the specimens from the oven and allow them to cool in dry air to a temperature of 68ºF to 77ºF	n/a
	Determine the mass of each 2-in. cylinder section	926.8
	Place the specimens in a 210ºF to 230ºF oven for 24 hours	n/a
	Remove the specimens from the oven and allow them to cool in dry air to a temperature of 68ºF to 77ºF	n/a
A	Determine the mass of each 2-in. cylinder section (A-mass of oven dried sample in air)	924.7
	Place the specimens in a 70ºF water bath for 48 hours	n/a
	Determine the mass of each 2-in. cylinder section	958.7
	Place the specimens in a 70ºF water bath for 24 hours	n/a
	Remove the specimens from the water bath, towel off surface moisture, and determine the mass of each specimen	963.8
	Place the specimens in a 70ºF water bath for 24 hours	n/a
B	Remove the specimens from the water bath, towel off surface moisture, and determine the mass of each specimen; if the change in mass from the previous determination is less than 0.5%, record this mass as B (B-mass of surface dry sample in air after immersion)	964.4
	Boil the specimens for 5 hours	n/a
	Remove the specimens from the boiling vessel and allow to cool for at least 14 hours until they are between 68ºF and 77ºF	n/a
C	Towel off surface moisture and determine the mass of each specimen (C-mass of surface dry sample in air after immersion and boiling)	966.8
D	Suspend the specimen by a wire and determine the apparent mass in water (D-apparent mass of sample in water after immersion and boiling)	546.6
	Bulk density, dry (Mg/m^3)	2.20
	Apparent density (Mg/m^3)	2.45
	Volume of permeable pore space (voids)	10.0%

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