

Concrete Property Test

Air Entrainment 3-4: Air Content (Hardened Concrete)

Purpose – Why Do This Test?

Another method of determining the quality of an air-void system in concrete is microscopical analysis of hardened concrete. This method provides information on the total air content, as well as the spacing factor and other parameters.

Principle – What is the Theory?

The air-void structure of concrete can be measured and characterized by examining a section of a core with a microscope. The linear traverse method consists of measuring the air voids as a polished concrete sample travels under a microscope in regularly spaced lines. The length of travel across air voids is compared to the length of travel across paste and aggregate, and the data are used to calculate the air content, spacing factor, and specific surface of the air voids in the concrete sample.

Test Procedure – How is the Test Run?

The manual method is described in ASTM C 457. A core from the slab is sectioned and polished. The apparatus is used to move a core sample under a microscope (or vice versa) in straight lines. The total length traversed and the length traversed across air voids are recorded.

Alternate automated methods use computer hardware and software to analyze an image of a polished concrete sample. These image analysis methods produce similar results for entrained air properties of concrete.

Test Apparatus (figure 1)

- Saw for cutting a section of a core.
- Polishing tools for grinding, lapping, and preparing the core section.
- Hardware and software for measuring air voids in the core section.

Generic Automated Test Method – Refer to ASTM C 457 for Comprehensive Guidance or Manufacturer's Recommendations for Specific Image Analysis Techniques

1. Obtain a core from the pavement.
2. Cut a section of the core.
3. Grind, lap, and polish the core section until it is smooth and flat.
4. Cover the polished face of the core section with black ink from a stamp pad.
5. Heat the core to 54°C (130°F) and coat the ink-covered core section with a zinc paste.
6. Allow the core section to cool, and scrape the zinc paste off the surface. The melted zinc paste will remain in the

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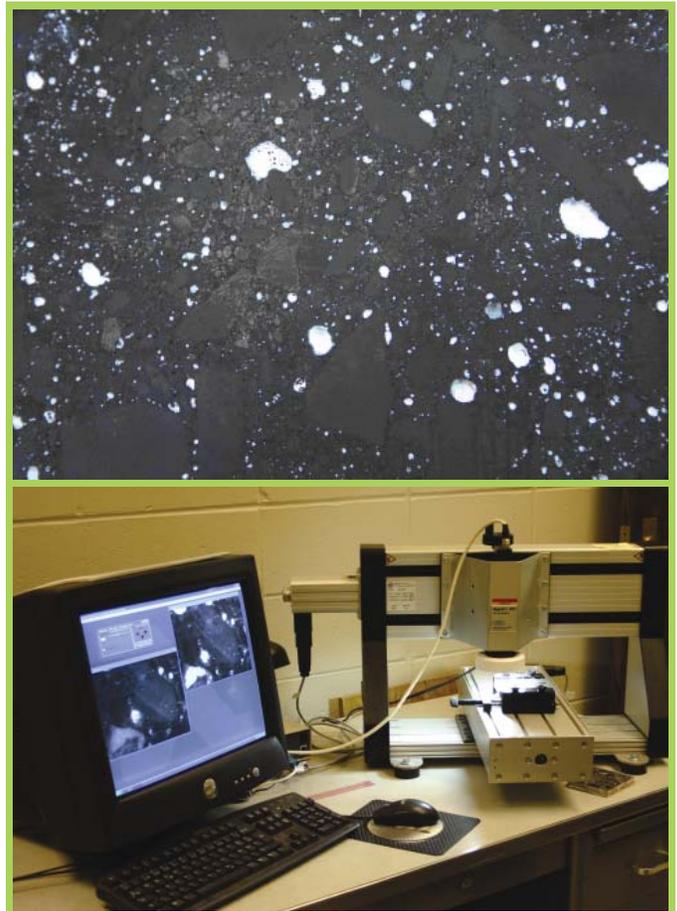


Figure 1. Close-up of a concrete core section prepared for testing and rapid-air test equipment

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air voids of the surface, providing a white contrast to the black ink surface of the core section.

7. Mount the prepared core section in the image analysis apparatus.
8. Start the image analysis apparatus.
9. The image analysis hardware and software automatically traverse the section and record the data.

Output – How Do I Interpret the Results?

The software produces a tabular report showing air content, spacing factor, and specific surface area of the air voids (table 1). A digital image of the core section can also be viewed or printed.

The air content is expressed as a percent of volume of the concrete sample.

Spacing factor is the average distance from any point to the nearest air void, or the maximum length measured from the cement paste to the edge of an air void.

Specific surface area is the surface area of the air voids divided by the air voids' volume.

Construction Issues – What Should I Look For?

Spacing factors should be less than 0.2 mm (0.008 in.).

Air-void spacing can be impacted by many factors, ranging from cement and admixture chemistry to mixing time to aggregate grading.

Table 1. Example Hardened Air Test Results

Air-void parameter	Chords < 0.0197 inch	Chords < 0.0394 inch	All chords
Number of voids	2683	2752	2770
Percent of total number of voids	96.9	99.4	100
Length of air traversed (in.)	11.01	12.85	14.00
Percent of total length of air traversed	78.7	91.8	100
Air content (%)	11.59	13.52	14.73
Average chord length (in.)	0.0041	0.0047	0.0051
Paste to air ratio	2.07	1.77	1.63
Specific surface (in ⁻¹)	974.8	856.8	791.6
Void frequency (in ⁻¹)	28.24	28.97	29.16
Spacing factor (in.)	0.0021	0.0021	0.0021

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