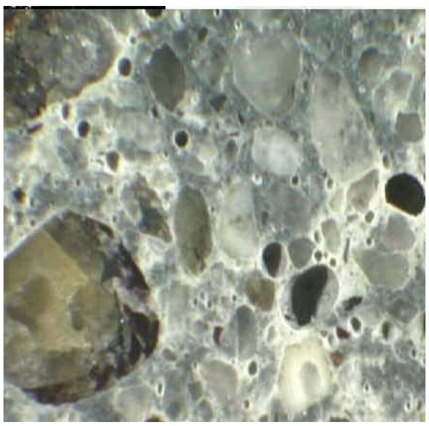
Purpose
The **AVA** (Air Void Analyzer) is used to measure the air-void parameters of samples of fresh air-entrained concrete.

Background
The durability of concrete subjected to wetting and cycles of freezing and thawing can be enhanced by deliberately introducing many, small and closely spaced air bubbles (voids) in the cement paste. During freezing, the ice formed in the capillary pores of the paste will expand into adjacent air voids without damaging the paste, provided the air-void spacing and the size distribution of the air voids are within certain limits. To characterize the air voids, the spacing factor (the maximum distance from any point in the cement paste to an air-void boundary) and the specific surface (the ratio of the surface area of the air voids to their volume) are used. In general, a good quality, frost resistant concrete requires a spacing factor < 0.20 mm and a specific surface greater than 25 mm^{-1}.

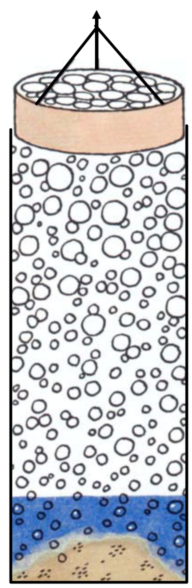


The spacing factor and the specific surface of the air-void system are determined typically according to ASTM C 457 "Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete." This method requires a sample cored from the hardened concrete on-site and prepared properly in the laboratory as illustrated in the photo to the left. The spacing factor and the specific surface are then measured manually by the linear traverse method using a microscope, or by an automated image analyses system as illustrated on page 16. Determination of the air-void structure in this manner cannot produce timely information during construction, which would be needed to make adjustments to the concrete mixture if the measured parameters are not within specified limits.

Timely information is important, as practice has shown that the air-void structure created by air entraining agents can easily change during construction, e.g., due to the type and dosage of normal or high-range water-reducing admixtures, by changes in sources of cementitious materials, by pressure influences in concrete pumps, by high hydrostatic pressure, or by over-vibration.

With the **AVA**, the air-void structure is measured while the concrete is still fresh, thereby providing timely information of the spacing factor and the specific surface of the air-void system in the cement paste of the concrete. The time of testing is 25 minutes or less.

Principle
The air bubbles entrained in a mortar sample, which is removed from fresh concrete, are transferred to a blue **AVA** release liquid as the mortar is stirred. Provided the release liquid has the proper viscosity and hydrophilic character, the bubbles released from the mortar retain their original size and neither coalesce nor disintegrate into smaller bubbles.



Above the blue **AVA** release liquid there is a column of water through which the air bubbles rise. According to Stoke´s Law, larger bubbles will rise faster than smaller bubbles.

The air bubbles rising through the water column are collected under an inverted and submerged pan attached to a sensitive balance. As air bubbles accumulate in the top of the pan, the apparent mass of the pan decreases as water is displaced by air. The apparent mass of the pan is recorded over time.

On the basis of the recorded change in apparent mass of the pan, an algorithm calculates the size distribution of the collected air bubbles. From the size distribution, the spacing factor and the specific surface are calculated. The algorithm ensures the parameters are the same as obtained from ASTM C 457 linear traverse measurements.

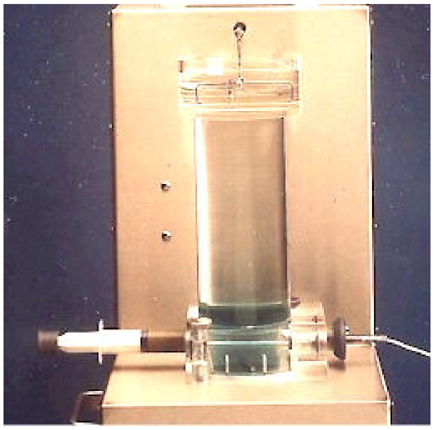
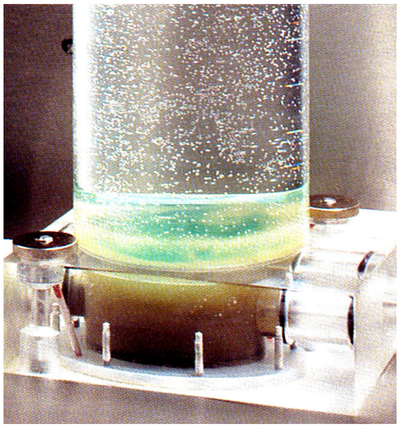
Correlation and Variability

The results from the **AVA** have been correlated to ASTM C 457 determinations. Among the published reports are:

- Brite Euram Project No: BE-3376-89, Task 2, "Quantitative and Qualitative Determination of the Air Void structure in Fresh Concrete," Dansk Beton Teknik A/S, Hellerup, Denmark, Feb. 1994
- FHWA-SA-96-062, "Air Void Analyzer Evaluation," Federal Highway Administration, Washington DC, USA, 1995
- Price, B., "Measuring Air Voids in Fresh Concrete," CONCRETE, July/August 1996
- Wojakowski, J., "Air in Portland Cement Concrete Pavements," Kansas Department of Transportation, USA, 2002
- Crawford, G.L., Wathne, L.G., and Mullarky, J.I.: "A 'Fresh' Perspective on Measuring Air in Concrete," Federal Highway Administration, Washington DC, 2003 Bridge Conference, USA

The general conclusion is that the **AVA** results in air-void parameters that are within ± 10 % of those obtained by ASTM C 457. The repeatability coefficients of variation for the **AVA** spacing factor and the specific surface determinations are normally 8 to 10 %.

Testing Example

- A sample of the mortar fraction of the air-entrained concrete is taken by vibrating a wire cage into the plastic concrete (left above). The mortar enters the cage, which excludes particles larger than 6 mm. A syringe is used to collect a 20 cm^3 mortar test specimen from within the cage.
- The specimen is injected into the riser column (center above). The riser column has the blue **AVA** release liquid at the bottom and water above it. The mortar and the liquid are stirred gently by a magnetic stirrer for 30 seconds, and the air voids are released (right above).
- The bubbles rise through the liquids at rates that depend on their size, providing a separation in time when different sizes arrive at the top of the column.
- The bubbles are collected under a submerged pan attached to a balance. A computer connected to the balance records the change in mass of the pan as a function of time.
- In the early stages of the measurement, the size distribution of the air bubbles collecting under the pan range from a few mm to a few micrometers. For each succeeding period, the size of the bubbles that collect under the pan decrease.
- The measurement continues for 25 minutes unless there is no mass change recorded for 2 consecutive minutes, in which case the measurement is stopped.
- The **AVA** software processes the balance readings and calculates the air-void parameters including the spacing factor and the specific surface as indicated on the following page.
- In addition, the software produces a graph of the bubble size distribution and a histogram of the different bubble sizes, also illustrated on the following pages.

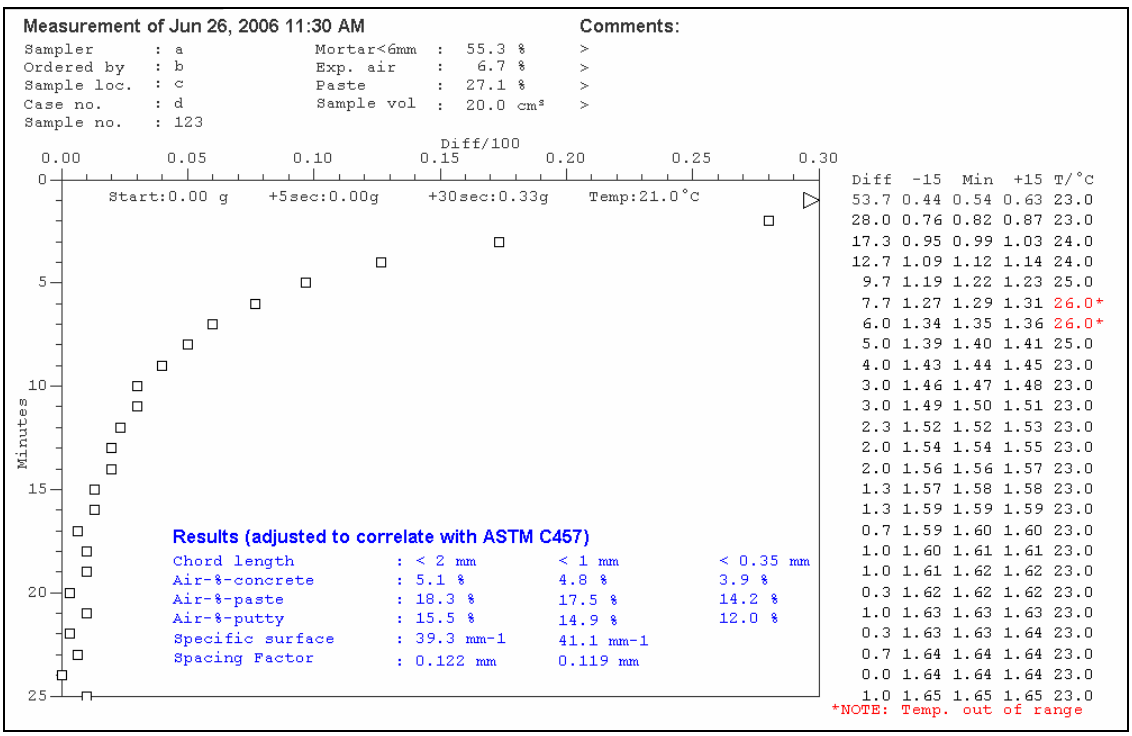
AVA-3000 System Features

Recently developed, the AVA-3000 features:

- Latest microprocessor technology with components minimized in size and number
- Only one USB cord connecting the laptop computer and the base unit
- Incorporates a mini balance that can withstand rough treatment during transport and/or testing
- Elimination of the influence of external vibrations on the test results, including the introduction of a wind shield positioned on top of the riser column
- Improved stirrer operation with constant rotational speed independent of the load applied on the stirrer
- Incorporates a 35-L temperature bath tank for automated de-aerating and tempering of the water and the AVA release liquid for testing. The bath tank may also function as ballast for stabilizing the base unit
- In addition to the calculation of the spacing factor and the specific surface for chord length <2 mm, the AVA-3000 calculates the air-void parameters for chord length <1 mm, as required by the latest ASTM C 457-06 standard

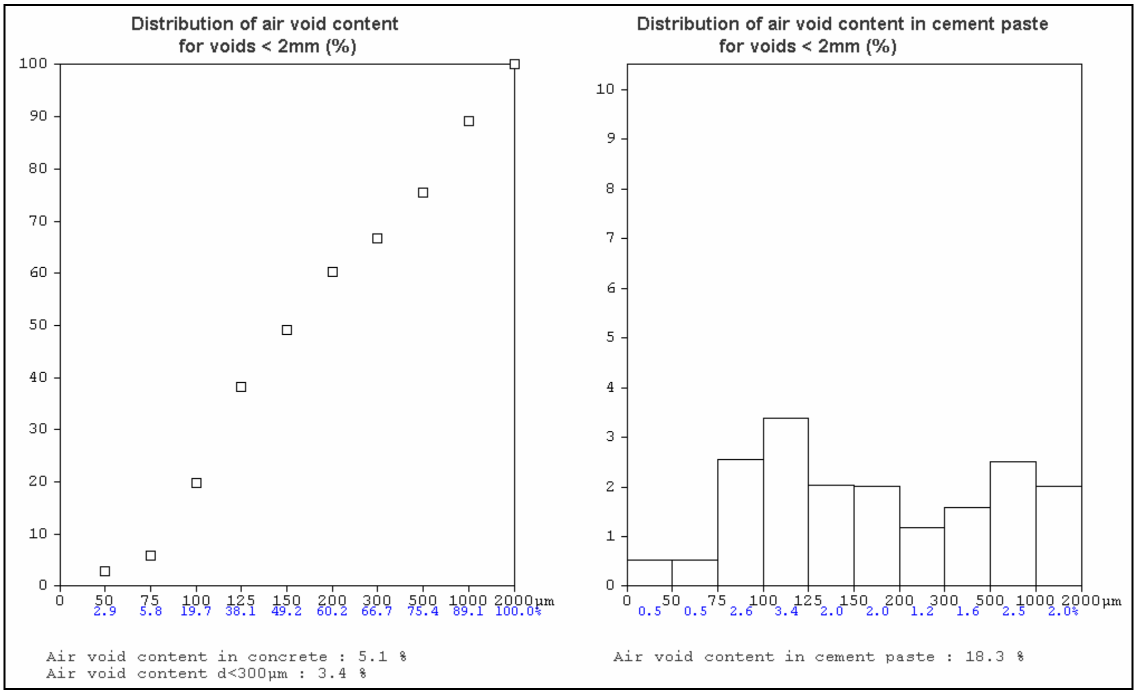
Example of AVA-3000 printout, documenting:

- The change in mass of the buoyancy pan (x-axis) as a function of time (y-axis),
- The results of the analyses, including the spacing factor and the specific surface, and
- Comments



Example of AVA-3000 printout, documenting:

- The size distribution of air voids < 2 mm (left), and
- A histogram of air void sizes < 2 mm (right).



The AVA-3000 System

AVA-3000 *System composed of base unit, riser column, temperature bath and laptop computer*

AVA-3000 *accessories as described below*

AVA-3000 System Ordering Numbers

Item	Order #
Base unit	AVA-3010
Riser column	AVA-3020
Piston	AVA-3030
Buoyancy pan	AVA-3040
Vibrating cage	AVA-3050
Vibrating collector	AVA-3060
Electric drill	AVA-3070
Funnel for insertion of **AVA** release liquid into riser column	AVA-3080
Sampling syringes, 5 pcs	AVA-3090

Item	Order #
Bottle for heating **AVA** release liquid	AVA-3120
Brush	AVA-3130
Plexiglas plate with hole for sampling	AVA-3140
Laptop computer	AVA-3150
Cord, PC to base unit	AVA-3180
AVA-3000 software diskette	AVA-3220
AVA-3000 manual	AVA-3230
AVA release liquid, 5 L	AVA-2240

The **AVA**-2260 verification kit for checking the balance is offered separately as well as a 1-day training course by an AVA specialist.

The **AVA**-2240 release liquid comes in 5-L containers with controlled batch number and certificate that it has the proper viscosity and hydrophilic characteristics.

Each test requires 200 mL of liquid.

GERMANN INSTRUMENTS A/S
Emdrupvej 102, DK-2400 Copenhagen, Denmark
Phone: +45 39 67 71 17, Fax +45 39 67 31 67
E-mail: germann-eu@germann.org Web site: www.germann.org

GERMANN INSTRUMENTS, Inc.
8845 Forest View Road, Evanston, Illinois 60203, USA
Phone: (847) 329-9999, Fax: (847) 329-8888
E-mail: germann@germann.org Web Site: www.germann.org

Test smart - Build right