Method of Test for
AIR CONTENT OF FRESHLY MIXED CONCRETE
METHOD B – PRESSURE METHOD

DOTD Designation: TR 202 (Method B)

I. Scope

A. This method of test covers the determination of the air content of freshly mixed concrete for all ranges of slump but not for nonplastic concrete such as is commonly used in the manufacture of pipe and concrete masonry units. This is the only method allowed for concrete containing aggregates greater than 1.5 inch. This method shall only be used for concrete containing aggregates with absorption less than 4.0%. If aggregate absorption is 4.0% or greater, use TR 202 (Method A). This method is not applicable to concrete made with lightweight aggregates or air-cooled blast furnace slag.

B. Reference Documents
   1. DOTD TR 201 – Weight Per Cubic Foot, Yield, and Air Content (Gravimetric) of Concrete
   2. DOTD S301 – Sampling Fresh Concrete
   3. DOTD TR 640 – Calibration of Measures Used to Determine Unit Weights
   4. ASTM C192 – Standard Practice for Making and Curing Concrete Test Specimens for the Laboratory
   5. ASTM C231 – Air Content of Freshly Mixed Concrete by the Pressure Method

Note 1: *ASTM C231 may be used in lieu of this method.*

II. Apparatus

A. Air Meter **–** Consisting of a measuring bowl and cover assembly conforming to the requirements shown below. The operating principle of this meter consists of equalizing a known volume of air at a known pressure in a sealed air chamber with the unknown volume of the air in the concrete sample. The dial on the pressure gauge shall be calibrated in terms of percent air for the observed pressure at which equalization takes place. (Figure 1)
   1. Measuring Bowl – A flanged or otherwise constructed cylindrical bowl, made of hard metal not readily attacked by cement paste, having a diameter equal to 0.75 to 1.25 times the height and a capacity of at least 0.20 ft^3.
   2. Cover Assembly – Shall be made of hard metal or other hard material not readily attacked by cement paste. It shall have smoothly machined interior surfaces contoured to provide an air space above the level of the top of the measuring bowl. It shall be flanged or otherwise constructed such that the cover and the measuring bowl can be fitted together into a pressure-tight assembly. The cover shall be fitted with a gauge for obtaining a direct reading of air content. The graduations for a suitable range in air content shall be within 0.1%. The cover shall be fitted with an air bleeder valve for venting of the air chamber, a main air valve, and petcocks for bleeding off water as required. Suitable means of clamping the cover to the bowl shall be provided to make a pressure-tight seal without entrapping air at the joint between the flanges of the cover and bowl. A suitable hand pump shall be provided with the cover, either as an

attachment or as an accessory.

Figure 1

B. Calibration Vessel – A measure having an internal volume equal to an even (whole) percentage of the volume of the measuring bowl corresponding to the approximate percent of air in the concrete to be tested; or, if smaller, it shall be possible to check calibration of the meter indicator at the approximate percent of air in the concrete to be tested by repeated filling of the measure.
C. Syringe – A small rubber bulb syringe.
D. Calibration Tubes – Auxiliary calibration tubes of approximate diameters provided either as an integral part of the cover assembly or separately, shall be constructed to assist in adding and removing water from the container during the aggregate correction factor determination.
E. Tamping Rod – Shall be a round, smooth straight 5/8 ± 1/16 inch diameter rod at least 16 inches long with both ends rounded to a hemispherical tip of the same diameter. The rod shall be made of steel, high-density polyethylene, or other plastic of equal or greater abrasion resistance.
F. Mallet – With a rubber or rawhide head, weighing 1.25 ± 0.50 pounds for use with measures of 0.5 ft^3 or smaller, and a mallet weighing approximately 2.25 ± 0.50 pounds for use with measures larger than 0.5 ft^3.
G. Strike-Off Bar – A flat, straight steel bar at least 1/8 x ¾ x 12 inch or a flat, straight high-

density polyethylene bar, or other plastic of equal or greater abrasion resistance, at least ¼ x ¾ x 12 inches.

H. Strike-Off Plate – A flat, rectangular metal plate at least ¼ inch thick or a glass or acrylic plate at least ½ inch thick with a length and width at least 2 inches greater than the diameter of the measure with which it is to be used. The edges of the plate shall be straight and smooth within a tolerance of 1/16 inch.
I. Vibrator with Power Source – As prescribed in ASTM C192 (when required).
J. Container – Having a ½ or 1 gallon (2 or 4 L) capacity as required shall be provided to fill the assembled air meter with water from the top of the concrete to overflow at the petcock.
K. Scoop – A small metal scoop.
L. Scale – Of sufficient capacity to determine the weights of fine and coarse aggregates required for the determination of the aggregate correction factor in Step IV (P).
M. Paper Towel, Towel or Sponge
N. Personal Protective Equipment – Rubber boots, gloves, eye and ear protection, etc.
O. Applicable Documentation
    1. Batch Certification for Portland Cement Concrete (DOTD 03-22-4028)
    2. Structural Concrete Tests (DOTD 03-22-0740, Figure 2)
    3. Portland Cement Concrete Report (DOTD 03-22-4035)
    4. Approved computer generated forms or spreadsheets.

III. Health Precautions

A. Protect against potential injury by avoiding skin contact with fresh concrete by wearing appropriate protective clothing and eyewear.
B. If the freshly mixed concrete should contact skin or eyes, immediately flush with water for a minimum of 5 minutes. If symptoms continue, consult a physician immediately.
C. Observe all precautions as specified by the manufacturer before handling fresh concrete.

IV. Calibration

Note 2: *Rough handling will affect the calibration of the pressure-type apparatus for the determination of air content. Should the accuracy of the air meter be questioned, it should be returned to the Materials and Testing Section for a calibration check.*

A. Calibration Vessel – Determine the weight of water, ω, required to fill the calibration vessel in accordance with DOTR TR 640 Steps III (A) to III (C).
B. Measuring Bowl – Determine the weight of water, W, required to fill the measuring bowl, in accordance with DOTD TR 640 Steps III (A) to III (C).
C. Effective Volume of the Calibration Vessel – The constant R, represents the effective volume of the calibration vessel expressed as a percentage of the volume of the measuring bowl:

$$R\ (\%) = 100 \times (\omega / W)$$

where,
ω = weight of water required to fill calibration vessel
W = weight of water required to fill measuring bowl

D. Initial Pressure Line Calibration – Follow the manufacturer's recommendations for obtaining the initial pressure line.
E. Calibration Test to Check the Air Content Graduations on the Pressure Gauge – Fill the measuring bowl with water. Screw the short piece of tubing or pipe furnished with the apparatus into the threaded petcock hole on the underside of the cover assembly. Assemble the apparatus. Close the air valve between the air chamber and the measuring bowl and open the two petcocks on holes through the cover assembly. Add water through the petcock on the cover assembly having the extension below until all air is expelled from the second petcock.
F. Pump air into the air chamber until the pressure reaches the indicated initial pressure line.
G. Allow a few seconds for the compressed air to cool to normal temperature. Stabilize the gauge hand at the initial pressure line by pumping or bleeding off air as necessary tapping the gauge lightly. Close the petcock opposite the tube or pipe extension on the underside of the cover.
H. Remove water from the assembly to the calibrating vessel controlling the flow.

Note 3: *Depending on the particular meter design, by opening the petcock provided with the tube or pipe extension and opening the air valve between the air chamber and the measuring bowl, or by opening the air valve and using the petcock to control flow.*

I. Perform the calibration at an air content which is within the normal range of use.

Note 4: *If the calibration vessel has a capacity within the normal range of use, remove exactly that amount of water.*

J. With some meters, the calibrating vessel is quite small and it will be necessary to remove several times that volume to obtain air content within the normal range of use. In this instance, carefully collect the water in an auxiliary container and determine the amount removed by weighing to the nearest 0.1%. Calculate the correct air content, R.
K. Release the air from the apparatus at the petcock not used for filling the calibration vessel.

Note 5: *If the apparatus employs an auxiliary tube for filling the calibration container, open the petcock to which the tube is connected to drain the tube back into the measuring bowl.*

Note 6: *At this point, the measuring bowl contains the percentage of air determined by the calibration test of the calibrating vessel.*

L. Pump air into the air chamber until the pressure reaches the initial pressure line marked on the pressure gauge, close both petcocks in the cover assembly, and then open the valve between the air chamber and the measuring bowl.

Note 7: *Refer to manufacturer's directives to determine and verify the initial pressure line.*

M. If two or more determinations show the same variation from the correct air content, reset

the dial hand to the correct air content and repeat the test until the gauge reading corresponds to the calibrated air content within 0.1%.

N. If the dial hand was reset to obtain the correct air content, recheck the initial pressure mark.

Note 8: *If difficulty is encountered in obtaining consistent readings, check for leaks, for the presence of water inside the air chamber, or the pressure of air bubbles clinging to the inside surfaces of the meter from the use of cool aerated water. In this latter instance, use de-aerated water which can be obtained by cooling hot water to room temperature.*

O. If a new initial pressure reading is required, repeat the calibration to check the accuracy of the graduation on the pressure gauge described earlier in step IV (D).

P. Determine the aggregate correction factor, G, on a combined sample of fine and coarse aggregated as follows:
   1. Mix representative samples of fine aggregate of weight, F_s, and coarse aggregate, C_s, and place in the measuring bowl.
   2. Fill the bowl 1/3 full of water.
   3. Add the mixed aggregate a small amount at a time until all of the aggregate is covered with water.
   4. Add each scoopful in a manner that will entrap as little air as possible and remove accumulations of foam promptly.
   5. Tap the sides of the bowl and lightly rod the upper inch of the aggregate about 10 times and stir after each addition of aggregate to eliminate entrapped air.
   6. When all aggregate has been placed in the bowl and allowed to soak for at least 5 minutes, strike off all foam and excess water.
   7. Thoroughly clean the flanges of both the bowl and conical cover so that when the cover is clamped in place, a pressure-tight seal will be obtained.
   8. Attach the cover assembly to the measuring bowl.
   9. With both petcocks open, pump air into the air chamber until the predetermined initial pressure line is reached.
   10. Close both petcocks and open the main air valve between the air chamber and measuring bowl.
   11. Read the air content scale and record as the aggregate correction factor, G.
   12. See Steps VII (A) for calculations for determination of F_s and C_s.

Note 9: *Ensure all petcocks and bleeder valves are closed to prevent water from entering pump chamber.*

Note 10: *The aggregate correction factor must be determined for each Portland cement concrete mix design, at the beginning of each project, or whenever there is a change in the aggregate properties.*

V. Sample

Obtain a representative sample of the concrete to be tested in accordance with DOTD S 301 of the Materials Sampling Manual and meet the minimum sample quantity of 0.50 ft^3.

VI. Procedure

A. Place concrete in the measuring bowl in three layers of approximately equal volume. Consolidate each layer of concrete by 25 strokes of the tamping rod evenly distributed over the cross section.
B. After each layer is rodded, strike the sides of the measure 10 to 15 times with the mallet to close any voids left by the tamping rod and to release any large bubbles of air that may have been trapped.
C. Rod the bottom layer throughout its depth, taking care not to allow the rod to forcibly strike the bottom of the measure. In rodding the second and final layers, use only enough force to cause the rod to penetrate the surface of the previous layer about 1 inch. When adding the final layer of concrete, be careful not to overfill the measure.
D. After consolidating the concrete, strike off the excess concrete with the strike-off bar until the surface is flush with the top of the bowl. Wipe the flange of the bowl clean.
E. Assemble the apparatus, close the main air valve between the air chamber and the measuring bowl and open both petcocks.
F. Using a syringe, inject water through one petcock until water emerges from the opposite petcock.
G. Place a finger over one petcock and tilt slightly to expel air bubbles from this opposite petcock. Return to original position and readjust water.

Note 11: *If water level changes, there is a leak.*

H. Close the air bleeder valve on the air chamber and pump air into the air chamber until the gauge hand is on the initial pressure line. Allow a few seconds for the compressed air to cool to normal temperature.
I. Stabilize the gauge hand at the initial pressure line by pumping or bleeding-off air as necessary, tapping the gauge lightly.
J. Close both petcocks and open the main air valve between the air chamber and the measuring bowl. Tap the sides of the measuring bowl sharply to relieve local restraints. Lightly tap the pressure gauge to stabilize the gauge and read the percentage of air, A_1, on the dial of the pressure gauge.
K. Make sure the main air valve is closed and release the pressure by opening both petcocks before removing the cover.
L. Determine the air content, A, in accordance with Step VII (B).

VII. Calculations

A. Determination of Aggregate Correction Factor
   1. Calculate the weights of fine and coarse aggregate present in the volume, S, of the sample of fresh concrete whose air content is to be determined, as follows:

$$F_s = \frac{S}{B} \text{ x } F_b$$

$$C_s = \frac{S}{B} \text{ x } C_b$$

where:
F_s = Weight of Fine Aggregate in Concrete Sample Under Test, lbs
S = Volume of Concrete Sample (Same as Volume of Measuring Bowl of Apparatus), ft^3
B = Volume of Concrete Produced Per Batch (Note 10), ft^3
F_b = Total Weight of Fine Aggregate in Batch, lbs
C_s = Weight of Coarse Aggregate in Concrete Sample Under Test, lbs
C_b = Total Weight of Coarse Aggregate in Batch, lbs

Note 12: *The volume of the concrete produced per batch can be determined in accordance with DOTD TR 201 Part V (D).*

example:
S = 0.25 ft^3
B = 217.8 ft^3
F_b = 10,848 lbs
C_b = 13,627 lbs

$$F_s = \frac{0.25\ ft^3}{217.8\ ft^3}\ x\ 10{,}848\ lbs = 12.45\ lbs$$

$$C_s = \frac{0.25\ ft^3}{217.8\ ft^3}\ x\ 13{,}627\ lbs = 15.64\ lbs$$

B. Calculate the air content, A, of the concrete to the nearest 0.1% by using the following formula:

$$A = A_1 - G$$

where:
A = Air Content, Percentage by Volume of Concrete
A_1 = Apparent Air Content of the Sample, Percentage by Volume of Concrete
G = Aggregate Correction Factor, Percentage by Volume of Concrete (See Step IV (P))

example:
A_1 = 7.2%
G = 0.2%

$$A = 7.2\% - 0.2\% = 7.0\%$$

VIII. Report

Report air content to the nearest 0.1%.

IX. Normal Test Reporting Time

The normal test reporting time is 15 minutes.