# The AE-55 Indicator for Air in Concrete

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● THE AE-55 AIR INDICATOR, or Chace air meter, is a pocket-sized device intended for use in the field to estimate the air content of plastic concrete. This apparatus, developed by L. M. Chace, a consulting engineer of North Bridgton, Me., has been purchased by a number of state highway departments and other organizations for experimental use. The interest stems from its low cost, rapidity of operation, and convenience to the engineer in the field.

Tests were made in the Bureau of Public Roads laboratory to obtain information on the accuracy and dependability of the apparatus. The air content of a large number of concrete mixes prepared in the laboratory was determined using this indicator, the results being compared with those obtained by the gravimetric and the pressure methods (AASHO T 121 and T 152, respectively).

The AE-55 air indicator (Fig. 1) consists of two parts. One part is a small cylinder of Pyrex glass about 1 in. in diameter and 3 in. long, which tapers at one end to a stem or tube about $\frac{1}{4}$ in. in diameter and 3 in. in length. This is similar to the filtration crucible holders shown in catalogs of laboratory apparatus. The other part is a rubber stopper with a brass cup mounted on the smaller end. The stopper fits the larger end of the glass cylinder. The brass cup is 3/4 in. in diameter and $\frac{1}{2}$ in. in depth, and has a volume of approximately 3.7 ml. When the stopper and cup are inserted into the cylinder, the volume of the latter is about 27 ml. Eleven equally-spaced graduations are etched on the stem of the cylinder, each pair indicating a volume of about 0.08 ml.

When the concrete tested contains 15 cu ft of mortar per cu yd, each graduation on the stem of the indicator represents 1 percent of air in the concrete. If the concrete contains a different amount of mortar, the correction factors given in Table 1 are applied.

In determining the air content of concrete with the indicator, the following procedure was used: The brass cup was filled with mortar from the concrete, excluding particles of sand larger than about 0.1 in. The mortar was compacted by rodding with a thin, stiff wire (the wire in a No. 1 Gem paper clip is suitable) and then struck off flush with the top of the cup. The sides of the cup and stopper were cleaned of mortar. The stem end of the cylinder was closed by holding the thumb over the end, and the cylinder was filled with denatured alcohol (used instead of water to prevent foaming of the liquid when mortar was added) to the mark on the cylinder.

The stopper and cup were then inserted into the cylinder. The indicator was inverted, the thumb removed, and the stopper pressed firmly into the cylinder. The level of the alcohol was brought to the upper graduation on the stem of the cylinder by addition of alcohol or by slight movement of the stopper. When alcohol was added, a small syringe or dropper was used. Care was taken to remove all air bubbles from the cylinder and to keep the stopper seated firmly enough to prevent leaking of the alcohol.

Figure 1. The AE-55 air indicator.

The thumb was replaced over the open end of the stem and the indicator turned gently from a vertical to a horizontal position while the body of the cylinder was tapped with the palm of the hand. Care was taken not to disturb the setting of the stopper. This procedure was continued until all of the mortar had been dispersed into the alcohol and no more air bubbles appeared. The indicator was then held in a vertical position and the new level of the alcohol read to the nearest half gradation on the graduated stem. The stopper was then removed and the indicator washed clean with water. Less than 3 min was required to make the test.

This method of determining the air is a volumetric method and is similar in principle to that described in ASTM Method C 173, "Air Content of Freshly Mixed Concrete by the Volumetric Method." In the ASTM method the air in the fresh concrete is measured by displacing it with a liquid and then determining the volume of liquid used. This method is not in common use except where the concrete contains slag or other porous aggregates.

TABLE 1

CONVERSION FACTORS FOR AE-55 AIR INDICATOR USED TO CORRECT INDICATED AIR CONTENT WHEN THE CONCRETE CONTAINS OTHER THAN 15 CUBIC FEET OF MORTAR[1]

| Mortar per Cu Yd of Concrete, Cu Ft | Conversion Factor[2] | Mortar per Cu Yd of Concrete, Cu Ft | Conversion Factor[2] |
|---|---|---|---|
| 10.1 | 0.67 | 15.5 | 1.04 |
| 10.5 | 0.70 | 16.0 | 1.07 |
| 11.0 | 0.73 | 16.5 | 1.10 |
| 11.5 | 0.76 | 17.0 | 1.13 |
| 12.0 | 0.80 | 17.5 | 1.16 |
| 12.5 | 0.83 | 18.0 | 1.20 |
| 13.0 | 0.86 | 18.5 | 1.23 |
| 13.5 | 0.90 | 19.0 | 1.26 |
| 14.0 | 0.93 | 19.5 | 1.30 |
| 14.5 | 0.96 | 20.0 | 1.33 |
| 15.0 | 1.00 | | |

1/Factors furnished by manufacturer of apparatus.
2/Multiply reading on stem of indicator by conversion factor to obtain correct air content.

Two other methods for the determination of air in plastic concrete are in general use. In ASTM Method C 231 (AASHO Method T 152), the air is determined by measuring the reduction in volume of the concrete when held in a closed container and subjected to a definite pressure. This method is used extensively and is considered the most reliable. In ASTM Method C 138 (AASHO Method T 121), the air is determined by calculation from the unit weight of the concrete and the batch weights and specific gravities of the materials used. This method is used where a pressure air

meter is not available. Where specific gravities and weights are correct and a representative sample is obtained, this method should give an accurate measure of the air content.

To determine the suitability of the AE-55 indicator, tests of 84 different concrete mixes were made using this indicator and the pressure and gravimetric methods. The concrete mixes were prepared using different cements and aggregates, and different amounts of air-entraining admixtures to give air contents varying from 1 to 9 percent as determined by the pressure method. Each value reported for the AE-55 indicator is an average of two tests, usually made by two operators who generally found results agreeing within $\frac{1}{2}$ percent of air. Each value determined by the pressure or gravimetric methods is for a single test. A comparison between the results obtained for each mix by the pressure method and the AE-55 indicator is shown in Figure 2. A similar comparison between the results obtained by the AE-55 indicator and the gravimetric method is shown in Figure 3.

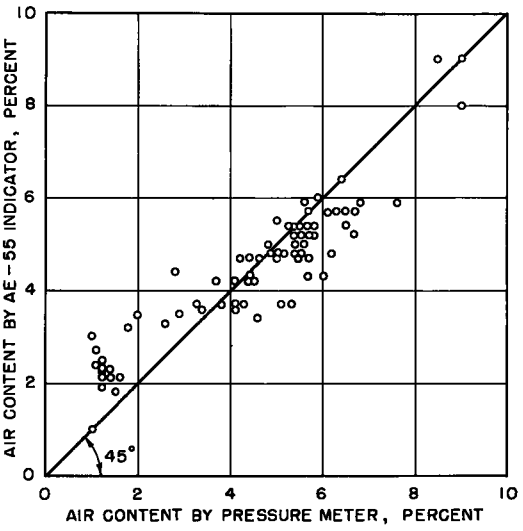


Figure 2. Air content of concrete as determined by AE-55 indicator and standard pressure meter.

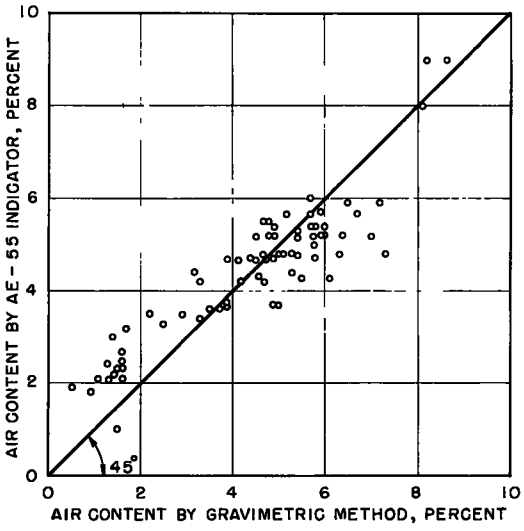


Figure 3. Air content of concrete as determined by AE-55 indicator and gravimetric method.

Average values for several different ranges in air content are given in Table 2, together with the difference between the average values for the pressure meter and that for the AE-55 indicator. These show good concordance of the average air contents determined by the pressure and gravimetric methods for all values except those above 7 percent. However, the pressure air meter read only to 8 percent, and higher values shown for this meter were estimated. This shows that either method may be used, with general assurance that the values obtained accurately indicate the amount of air in the concrete.

The results obtained with the AE-55 indicator did not show as good concordance with those obtained by the pressure meter. For values of air less than 3.0 percent as determined by the pressure meter, the AE-55 indicator gave results averaging about 1.0 percentage point too high. For air

TABLE 2

AVERAGE VALUES FOR DIFFERENT RANGES IN AIR CONTENT OF CONCRETE

| Air Content by Pressure Meter, % | No. Samples Tested | Average Air Content, % | | | |
|---|---|---|---|---|---|
| | | Pressure Meter | Gravimetric Method | AE-55 Indicator | Difference Col. 3 minus Col. 5 |
| 1.0 - 1.9 | 14 | 1.28 | 1.36 | 2.26 | -0.98 |
| 2.0 - 2.9 | 4 | 2.58 | 2.70 | 3.68 | -1.10 |
| 3.0 - 3.9 | 4 | 3.55 | 3.65 | 3.80 | -0.25 |
| 4.0 - 4.9 | 14 | 4.41 | 4.55 | 4.24 | 0.17 |
| 5.0 - 5.9 | 33 | 5.45 | 5.36 | 5.12 | 0.33 |
| 6.0 - 6.9 | 10 | 6.42 | 6.24 | 5.38 | 1.04 |
| 7.0 - 7.9 | 1 | 7.6 | 6.5 | 5.9 | 1.7 |
| 8.0 - 8.9[1] | 4 | 8.75[1] | 8.28[1] | 8.75[1] | 0.0 |

[1] Estimated air only, meter can only be read to 8.0 percent.

contents of more than 6.0 percent the AE-55 indicator gave values averaging more than 1.0 percentage point too low. These values indicate that it might be feasible to prepare a correction curve (Fig. 4) for the AE-55 indicator readings, indicating the amount by which the reading for the AE-55 indicator should be corrected to bring the value to agree with that for the pressure meter. In Figure 4 the circles indicate the results for each mix, whereas the crosses are the average values given in Table 2.

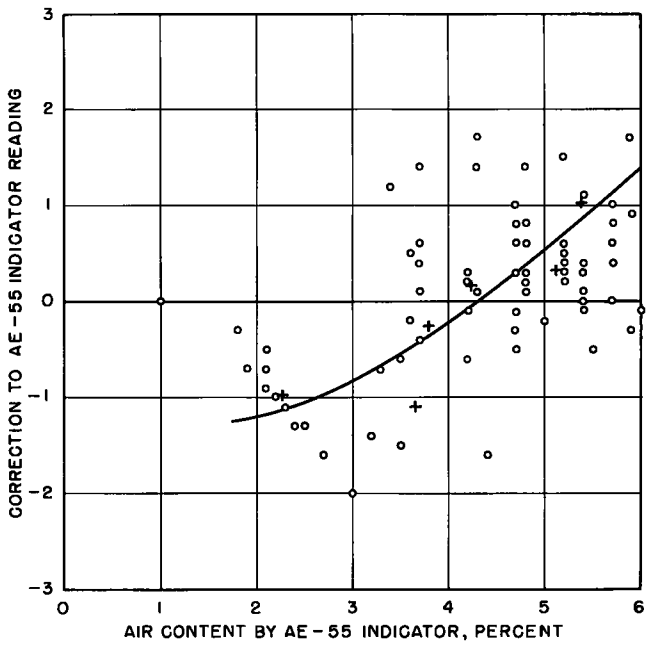


Figure 4. Correction for AE-55 indicator reading to agree with air content by pressure meter.

A limited number of tests were made in the field to determine the accuracy and usability of this apparatus on a paving job. Tests were made on concrete containing 4 percent air as determined by a pressure air meter. The values obtained with the AE-55 indicator were between 3.5 and 4.5 percent, with no correction for the mortar content. The corrected values would be from 3.2 to 4.1 percent. If these values were further corrected by use of Figure 4, the values obtained would be 3.9 to 4.3 percent, agreeing closely with the pressure air meter determination. The determinations were made by four different engineers, three of whom had not seen the apparatus before. The device was very favorably

received because of its size and the rapidity with which the test could be made in the field.

SUMMARY

The AE-55 indicator is found to be an apparatus of considerable merit for use in the determination of the approximate air content of concrete in the field, providing the amount of mortar in the concrete is known. The test can be completed in less than 3 min and the apparatus can be carried in a pocket. Attention is called, however, to the small amount of mortar used in a test. To insure the most reliable result, at least three tests should be made for each determination of air content.

The AE-55 indicator method is considered not suitable as a replacement of the pressure or gravimetric methods for the air content of concrete, but is useful as a supplementary test. It appears to be of most value for use in determining the uniformity of the air content from batch to batch of concrete when no change in the materials or proportions occurs. It also may be used as a rapid check to determine whether the air content is probably within the specification limits. In no case, however, should the AE-55 indicator method be considered suitable for replacing any of the standard methods previously mentioned.

## Discussion

BRYANT MATHER, Waterways Experiment Station, Corps of Engineers, Jackson, Miss.—This report shows remarkable similarity to the findings at the Waterways Experiment Station laboratory from a somewhat similar study. In this case an AE-55 indicator was used to test 158 mortar samples from 107 batches of 3/4-in. aggregate concrete, from which samples were also tested for air content by the pressure method. From 104 batches only one mortar sample was tested; from 4, a series of from 11 to 15 mortar samples were tested. The results are summarized in Figure 5.

The difference in indicated air content by the two methods is summarized in the following:

| Air Content by Pressure Method, % | No. of Mortar Samples Tested | Deviation of Air Content Indicated for Mortar from that Indicated for Concrete | |
|---|---|---|---|
| | | Average | Range |
| 1.8 - 3.0 | 16 | +1.4 | +0.7 to +2.1 |
| 3.1 - 4.0 | 26 | +0.8 | -0.1 to +1.4 |
| 4.1 - 5.0 | 33 | +0.4 | -1.6 to +1.4 |
| 5.1 - 6.0 | 57 | +0.3 | -0.5 to +1.4 |
| 6.1 - 7.0 | 11 | +0.2 | -0.7 to +1.0 |
| 7.1 - 8.0 | - | - | - - |
| 8.1 - 9.0 | 15 | +0.3 | -0.2 to +1.3 |

The repeated mortar tests on the four batches gave the results tabulated on the following page.

Statistical analyses indicated that results obtained with the AE-55 meter would agree with those obtained by the pressure method within $\pm 0.6$ percent air two-thirds of the time for concrete with 3 percent or less of air and within $\pm 0.5$ percent air for concrete with 5 percent air or more,

| Batch | Air Content by Pressure Method, % | No. of Mortar Samples Tested | Average Air Content by Mortar Test, % | Average Deviation of Air Content for Mortar Test from Pressure Test, % |
|---|---|---|---|---|
| 1 | 3.1 | 11 | 3.7 | +0.6 |
| 2 | 3.6 | 15 | 4.4 | +0.8 |
| 3 | 4.1 | 14 | 5.1 | +1.0 |
| 4 | 8.2 | 15 | 8.5 | +0.4 |

provided correction factors such as shown in Figure 4 were established for the meter being used.

The results of these tests are given more fully in Waterways Experiment Station Miscellaneous Paper No. 6-189 (Nov. 1956), "A Limited Investigation of the Chace Air Meter," by C. H. Willetts and T. B. Kennedy. The tests were made under the direct supervision of W. O. Tynes and R. A. Bendinelli.

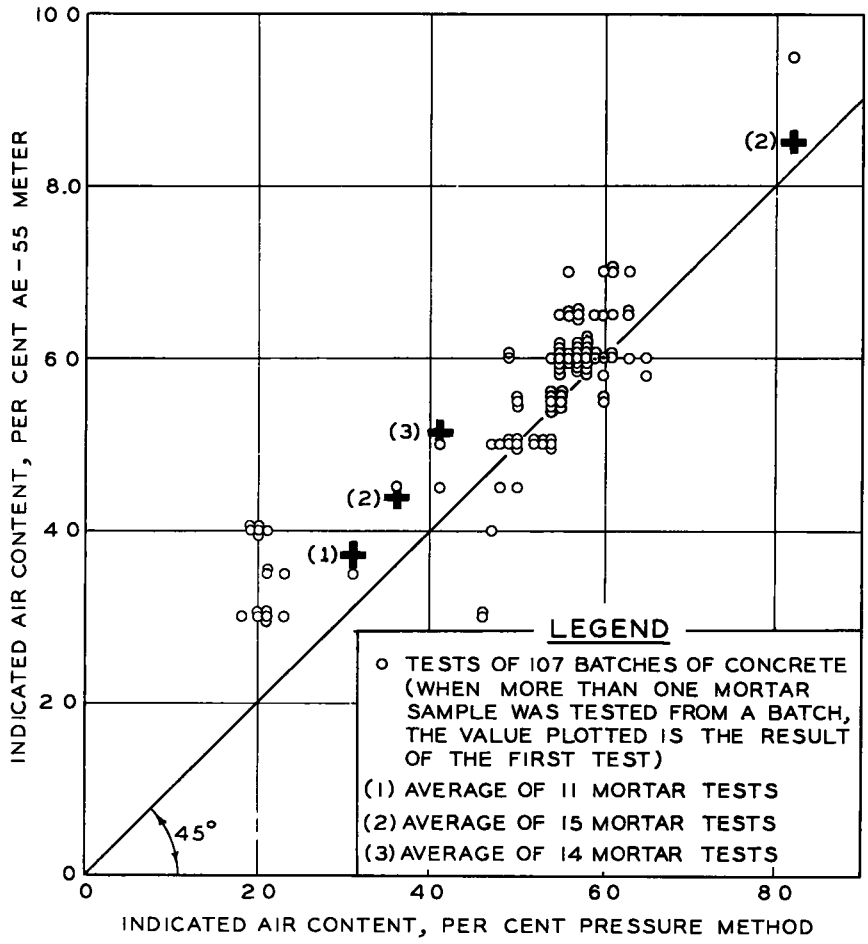


Figure 5. Air content of concrete as indicated by AE-55 meter and pressure method.