FIELD CONCRETE TECHNICIAN STUDY GUIDE

CONCRETE SAMPLING AND TESTING PROCEDURES

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GSP 17

Sampling Procedure for Freshly Mixed Structural Concrete

The process of testing fresh concrete in the field begins with the procedures for obtaining and preparing the sample of concrete to be tested. GSP 17 gives the standardized procedures for obtaining a representative sample of a batch of concrete, from mixing and/or agitating equipment.

All too often, it is has been the bad habit of the technicians to obtain the sample of concrete as quickly as possible upon its arrival at the jobsite, resulting in sampling the first portion of the batch discharge. This practice is in violation of the specification under which concrete is being supplied and it may result in a non-representative sample of concrete. When you consider that the specifications may only require strength tests to be made every 50 cubic yards (38 cubic meters) or every 100 cubic yards (76 cubic meters), the need for a truly representative sample becomes readily apparent. The minimum 1 cubic foot (0.03 cubic meters) sample of concrete, from which the compressive strength test specimens will be made, represents only 0.13 to 0.025 per cent of the total amount of concrete placed.

To assure accuracy in testing of fresh concrete, every precaution should be taken to obtain a sample of concrete which is truly representative of the entire batch and then to protect that sample from the damaging effects of evaporation and contamination.

A. General Description

Use this procedure to sample freshly mixed structural concrete.

Take samples of freshly mixed structural concrete from two sources:

- Mixers and Agitators
- Concrete buckets

NOTE: Ensure that all samples accurately represent the concrete to be placed.

NOTE: Take the sample, complete the tests, and mold the specimens within 15 minutes.

1. Sampling from Mixers and Agitators
   a. Inspect the mixing unit.
      1) Ensure that the rate of discharge of the batch is regulated by the drum's rate of revolution and not by the size of the discharge opening.
   b. Take samples from agitators and mixers in two ways:
      1) Pass a container through the entire discharge stream, or
      2) Divert the stream completely so that it discharges into a container.
2. Sampling from Concrete Buckets
   a. Move the concrete bucket into a position above a sheet of plywood or some other suitable surface or container.
   b. Discharge the amount required for the sample.
3. Samples for Strength Tests
   a. Take fresh concrete samples for this test at the same time.
      1) Take the samples after at least 10 percent of the batch has been discharged and before the last 10 percent of the batch is discharged.
      2) Ensure that the sample contains at least 1 ft^3 ($0.028m^3$).
   c. Remix the samples with a shovel to ensure uniformity.
   d. Identify each strength test specimen on Form 319.
      1) Report results of tests performed in the field on both Form 319 and Form 525.
4. Samples for Air Content, Slump, and Temperature Tests
   a. You may take samples "early"—before any concrete is placed—for these tests.
      1) Take the entire sample from the batch at one time before more than 2 ft^3 ($0.057\ m^3$) of concrete has been discharged.
      2) Ensure that samples are at least 0.5 ft^3 ($0.014\ m^3$).
   b. Remix the samples with a shovel to ensure uniformity.
   c. Report results from the air content and slump tests on Form 319.
   d. Report results from the temperature test on Form 525.

PERFORMANCE CHECKLIST

GSP-17 Sampling Procedures for Freshly Mixed Structural Concrete

Transit Mixers and Agitators:

1. Obtain sample after 10 percent of batch has been discharged and before the last 10 percent is discharged by diverting the entire discharge stream into a suitable container.

2. Early samples may be obtained for determining compliance with air content and slump specifications.

3. Sample shall consist of not less than 1 cubic foot (0.03 cubic meters) when it is to be used for strength tests.

4. Remix sample prior to conducting tests to insure uniformity.

5. Care should be taken to insure that all samples are representative of the concrete being placed.

Concrete Buckets:

Samples can be obtained by moving the bucket in position above a sheet of plywood or other suitable container and discharging amount required for sample.

GDT 122

Temperature of Freshly Mixed Portland Cement Concrete

Concrete temperature is one of the most important factors influencing the quality, time of set and strength of the concrete. Without control of the concrete temperature, predicting the concrete's performance is very difficult if not impossible.

A concrete with a high initial temperature will probably have higher than normal early strength and a lower than normal later strength. The ultimate overall quality of the concrete will also probably be lowered. Conversely, concrete placed and cured at low temperatures will develop strength at a lower rate, but ultimately will have higher strength and be of higher quality. The temperature of concrete is used to indicate the type of curing and protection that will be needed, as well as the length of time the curing and protection should be maintained. By controlling the concrete temperature within acceptable limits, immediate and future problems may be avoided. Concrete temperature affects the performance of chemical admixtures, air entraining admixtures and other additives and admixtures.

GDT 122

A. Scope

For a complete list of GDTs, see the Table of Contents.

Use this test method to determine the temperature of freshly mixed Portland cement concrete.

B. Apparatus

The apparatus consists of the following:

Temperature Measuring Device: Use a device that can measure the temperature of the freshly mixed concrete to ± 1 °F (± 0.5 °C) throughout the entire temperature range likely to be encountered in the fresh concrete.

You may use ASTM liquid-in-glass thermometers having a range from 0 ° to 120 °F (–18 ° to 49 °C) that conform to the requirements for ASTM thermometer No. 36 as prescribed in specification E-1. Other thermometers of the required accuracy, including the metal immersion type, are acceptable (WT-04-2).

C. Sample Size and Preparation

Sample the freshly mixed concrete according to GSP 17 in a large enough quantity to provide a minimum of 3 in (75 mm) of concrete cover around sensor in all directions.

D. Procedures

1. Place thermometer in sample with a minimum of 3 in (75 mm) cover around the sensor.
2. Gently press concrete around the thermometer.
3. Read temperature after a minimum of 2 minutes or when temperature readings stabilize.
4. Complete temperature measurement within 5 minutes after obtaining the sample.

E. Calculations

No calculations are necessary for this test.

F. Report

Record the temperature to the nearest degree on Form 525.

PERFORMANCE CHECKLIST

GDT-122 Temperature of Freshly Mixed Portland Cement Concrete

1. Use ASTM approved thermometer accurate to ± 1 °F (± 0.5 °C) and with a temperature range from 0 to 120 °F (-18 to 49 °C).

2. Obtain sample of concrete large enough to provide a minimum of 3 inches (75 mm) of concrete cover around sensor in all directions.

3. Place thermometer in sample with a minimum of 3 inches cover around sensor.

4. Gently press concrete around thermometer.

5. Read temperature after a minimum of 2 minutes or when temperature reading stabilizes.

6. Complete measuring the temperature within 5 minutes after obtaining sample.

7. Record temperature to nearest degree on DOT Form 525.

GDT 27

Slump of Portland Cement Concrete

The purpose of the slump test is to determine the consistency of the concrete. This is a measure of the relative fluidity or mobility of the concrete mixture. Slump does not measure the water content or workability of the concrete. It is true that an increase or decrease in the water content will cause a corresponding increase or decrease in the slump of the concrete, provided that all of the other materials and conditions are constant. However, many factors can cause the slump of the concrete to change without any change in the water content.

Also, the water content may increase or decrease without any apparent change in the slump of the concrete. Factors such as a change in the aggregate properties or grading, mix proportions, air content, concrete temperature, or the use of special admixtures can influence the slump of the concrete, or conversely can result in a change in the water content requirement for maintaining a given slump. For example, an over-sanded mix may require more mixing water than the original design mix proportions call for, but the slump may remain the same. Therefore, you cannot assume that the water-cement ratio (w/c) is being maintained by simply because the slump is within the specification limits.

A. Scope

For a complete list of GDTs, see the Table of Contents.

Use this test method of test both in the laboratory and in the field for determining consistency of concrete.

NOTE: Do not use this test for nonplastic and noncohesive concrete, nor when there is a considerable amount of coarse aggregate over 2 in (51 mm) sized in the concrete.

B. Apparatus

The apparatus consists of the following:

1. Mold (see Figure 27-1): Form the test specimen in a mold made of metal not thinner than No.16 (1.66 mm) gage and not readily corroded by the cement paste. The mold's form should have a lateral surface of the frustum of a cone with the base 8 in (203 mm) diameter, the top 4 in (102 mm) diameter, and the height 12 in (305 mm).

   Ensure the base and the top are open and parallel to each other and at right angles to the axis of the cone. The mold must have foot pieces and handles (WC-4).
2. Tamping Rod: Use a round, straight steel rod, 5/8 in (16 mm) diameter, approximately 24 in (600 mm) long with 1 end rounded to a hemispherical tip that is 5/8 in (16 mm) diameter (WR-7).
3. Trowel: Use a standard brick mason's type (WT-07).
4. Measuring Device: Use a ruler or other measure at least 12 in (305 mm) long, graduated in inches (millimeters).

C. Sample Size and Preparation

Obtain the sample of freshly mixed concrete according to GSP 17.

D. Procedures

NOTE: Complete the entire test without interruption, from filling the mold through removing the mold, within 2-l/2 minutes.

5. Dampen the mold and place it on a flat, moist, nonabsorbent surface.
6. From the sample of concrete obtained as described in Sample Size and Preparation, fill the mold immediately in three layers, each approximately 1/3 the volume of the mold.
7. In placing each trowel-full of concrete, move the trowel around the top edge of the mold as the concrete slides from it. This will ensure symmetrical distribution of concrete within the mold.
8. Rod each layer 25 strokes with the tamping rod.
   e. Distribute the strokes in a uniform manner over the cross section of the mold.
   f. Ensure each stroke penetrates the underlying layer.
   g. Rod the bottom layer throughout its depth.
9. After rodding the top layer, strike off the surface of the concrete with a trowel so that the mold is exactly filled.
10. Remove the mold immediately from the concrete by raising it carefully in a vertical direction. Steadily lift the mold with no lateral or torsional motion.
11. Immediately measure the slump. Measure the height difference between the top of the mold and the displaced original center of the top surface of the specimen.

    If part of the specimen has fallen away or sheared from the mass, disregard the test. Start a new test on another portion of the sample.
12. Measure the Slump
    h. Record the consistency (slump) as inches (millimeters) of subsidence of the specimen during the test:

       Slump = 12 in (305 mm) – (the inches (millimeters) of height after subsidence)
    i. After measuring the slump, gently tap the side of the concrete frustum with the tamping rod. The concrete's reaction to the tapping is a valuable indication of the cohesiveness, workability, and placeability of the mix.
       1) A well-proportioned, workable mix will gradually slump to lower elevations and retain its original identity.
       2) A poor mix will crumble, segregate, and fall apart.

E. Calculations

No calculations are required for this test.

F. Report

Report the slump on Form 319 and Form 525.

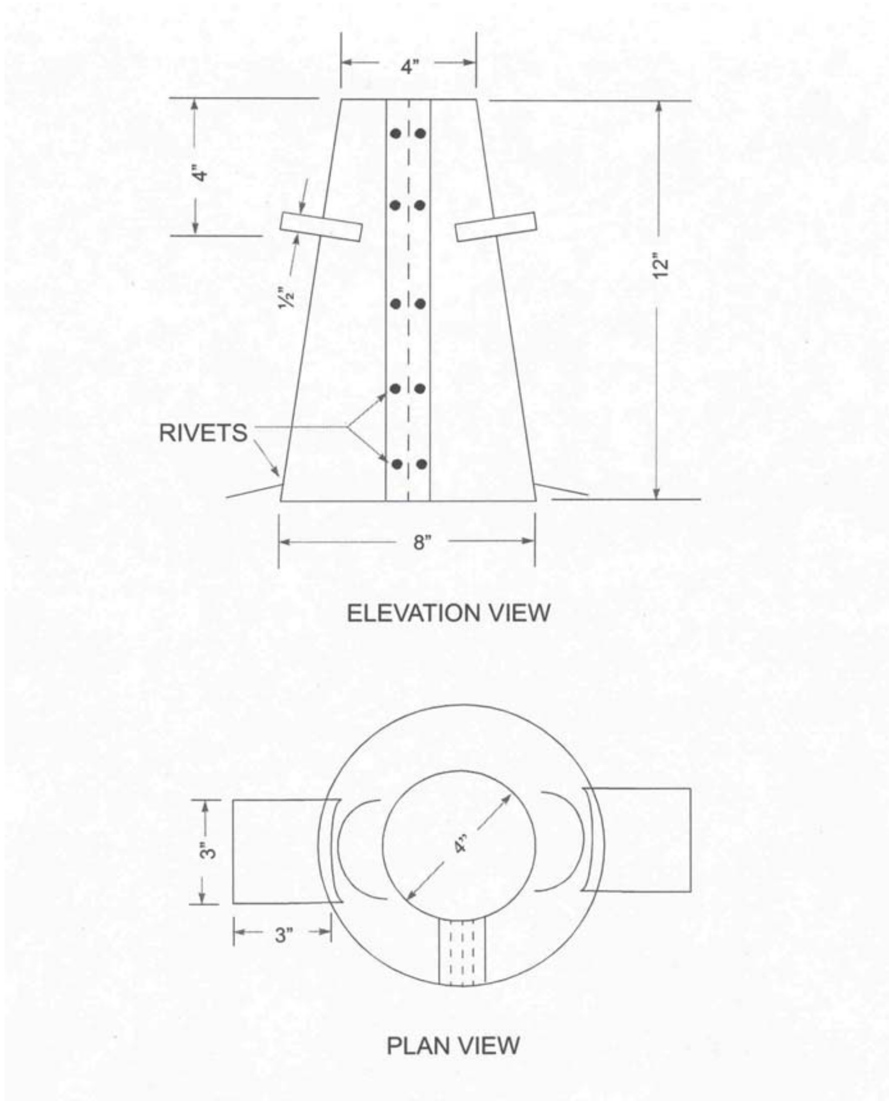


Figure 27-1

PERFORMANCE CHECKLIST

GDT-27 Slump of Portland Cement Concrete

1. Dampen the interior face of the cone and place on flat, moist, rigid horizontal surface.

2. Fill cone in three equal layers by volume approximately 2-5/8 inches and 6-1/8 inches measured from the base while holding cone firmly against the floor or base plate.

3. Rod each layer with rounded end of rod 25 times while holding cone firmly against the floor or base plate. Rod the first layer uniformly distributing strokes throughout its depth. After the first layer, the rod should penetrate the previous layer slightly. On the third layer, keep the concrete mounded above top of the cone at all times.

4. Strike off the last layer with a screeding motion of the tamping rod or a suitable float while holding cone firmly against the floor or base plate.

5. Remove concrete from area surrounding base of cone while holding mold firmly against the floor or base plate.

6. Raise cone vertically with no lateral or twisting motion, in 5 ± 2 seconds.

7. Measure the difference in height of the cone and the displaced original center.

8. Complete the entire test within 2-1/2 minutes.

9. Record the slump to the nearest 1/4 in. (5 mm) on DOT Form 525 and/or DOT Form 319.

GDT 26

Air Content of Freshly Mixed Concrete by Pressure Method

This test method can be used to determine the air content of normal and heavy weight concretes. However, it cannot be used with highly porous aggregates, such as found in lightweight concrete. This test method will determine the amount of both the entrained and entrapped air voids in the concrete. The pressure method is based on Boyle’s law, which relates pressure to volume.

Air entrainment is necessary in concrete that will be exposed to cycles of freezing and thawing, and deicing chemicals. The microscopic entrained air voids provide a source of internal pressure relief within the concrete to accommodate the pressures that develop as ice crystals form in the pore and capillaries of the concrete. Without the proper air content in the mortar faction of the concrete, normal concrete that is exposed to cycles of freezing and thawing will scale and/or spall, resulting in a durability failure of the concrete.

However, we must be careful not to have too much entrained air in the concrete. As the air content increases, say by 5 percent, there will be a corresponding reduction in the strength of the concrete. Typically, this strength reduction will be on the order of 3 to 5 percent for each one percent of air content above the design value. For example, a concrete proportioned for 5 percent air will be approximately 15 to 25 percent lower in strength if the air content rises to 10 percent.

A. Scope

For a complete list of GDTs, see the Table of Contents.

Use this test method to determine the air content of freshly mixed concrete.

NOTE: This method will not work for concrete containing lightweight or highly porous aggregates. For this type of concrete, use GDT 32, "Test for Air Content of Freshly Mixed Concrete by the Volumetric Method," to perform the air tests.

This method includes instructions for using two types of air meters:

- Pressure Air Meter
- Press-Ur-Meter

B. Apparatus

1. Pressure Air Meter

   The apparatus consists of the following:

   a. Complete Air Meter: The complete meter is listed as Warehouse Stock WE-4. The meter includes the following pieces:

      1) Material Container
      2) Lid Assembly
      3) Tamping Rod (WR-7)
      4) Strike-off Bar (WS-13-1)
      5) Carrying Case

   b. Field Check of Pressure Air Meter (Test For Accuracy)

      Figure 26-1, below, shows the basic equipment used in determining air content. Some of the steps below make reference to the numbers shown on the figure.

NOTE: Quickly check meter calibration with an approved calibration canister.

1) Figure 26-1.

   Place the meter in a level position.

2) Determine volume of material container by filling it with water (use weight or volumetric method: 1 g of water = 1 ml). The volume of the container will normally be approximately 1.87 gal (7100 ml).
3) With the material container filled with water, place the lid (5) on the container and close the four toggle clamps (6).
4) Close the main air valve (4) on top of the lid.
5) Close the bleeder valve (10).
6) Gently pump air into the receiver until the gauge hand (12) is near the red line.
   a. Make sure the hand passes the initial starting point (the stationary pointer).
   b. Do not worry about whether the hand is on one side or the other of the red line.
7) Tap the gauge (13) gently with one hand. At the same time, crack the bleeder valve (10) until gauge hand (12) rests exactly on the initial starting point.
8) Quickly close the bleeder valve (10).
9) Close both petcocks (8 and 9).
10) Open the main air valve (4) and record reading when gauge hand (12) comes to rest. This initial reading will probably be greater than one percent.
11) Close the main air valve (4) and open center petcock (8) slowly to release air pressure and ensure no water loss.
12) Open petcock (9) and remove a volume of water equal to 1 to 2 percent of the volume of the material container.
13) Tip container and pour off water from the petcock (9) into a receptacle for weighing or volumetric measurement.

14) Repeat steps 5 through 11. The reading on the gauge should be 1 to 2 percent plus the reading obtained in step 10 (initial reading).

15) Repeat steps 7 and 8, then steps 5 through 11, in that order, until you have removed at least 8 percent of the water volume in the material container.

16) If the meter deviates from the theoretical reading by more than 0.2 percent at any point, return the meter to the District Office for inspection. The theoretical reading is the initial reading plus the percentage of water removed from the material container.

c. Maintenance of Apparatus

1) Always close main air valve before releasing pressure from either the material container or the air receiver. If this valve is not closed, it will draw water into air receiver and ruin future measurements.

a. If water is drawn into air receiver, open the bleeder valve in end of the receiver and top lid so that the water runs out the bleeder valve.

b. Pump the handle several times to blow out the last traces of water.

2) The gauge hand should not exceed 1/2 in (13 mm) beyond the red line limit.

3) Release pressure on the meter before opening toggle clamps.

d. Care of the Pressure Air Meter

1.) To ensure trouble free operation, keep the meter clean and dry after each test.

Clean meter by flushing it with a pressurized stream of water or by washing in water with a brush.

NOTE: Do not submerge the gauge in water.

2) Remove sand or grit from the underside of the material container lip and toggle clamps before assembling.

3) When meter is not in use, leave bleeder valve and both petcocks open.

4) Apply a light, protective, lubricating film of paraffin wax to the underside of the material container lip every 15 to 20 tests.

5) When not using the meter, store it in its carrying case. Do not store with the lid clamped to the material container.

NOTE: After prolonged use, the surface of the meter may look dull. Do not repolish. This may damage the meter.

2. Press-Ur-Meter

The apparatus consists of the following:

a. Material Container

b. Lid Assembly

c. Tamping Rod (WR-7)

d. Strike-off Bar (WS-31-1)

e. Threaded Straight Tubing

f. Threaded Curved Tubing

g. Calibrating Vessel (.1 gal (379 ml))

h. Syringe

i. Mallet (WM-01)

j. Carrying Case

k. Calibration Of Press-Ur-Meter (Test For Accuracy):

1) Open the air bleeder valve in the end of the air receiver.

If gauge hand does not stop in the hand-free position, send the meter to the District Office for mechanical check. If the gauge hand does rest in the hand-free position, continue with the calibration.

2) Place the material container on a level surface.

3) Fill the container full of water.

4) Screw the short piece of straight tubing into the threaded petcock hole on the underside of the lid.

5) Clamp lid on the material container with the tube extending down into the water.

6) With both petcocks open, add water with a syringe through the petcock having the pipe extension below, until all air is forced out opposite petcock.

7) Tap the meter gently until no air bubbles come out through opposite petcock. Leave both petcocks open.

8) Add air pressure to slightly past the predetermined initial pressure line.

9) Wait a few seconds for compressed air to cool to normal temperature.

10) Stabilize the gauge hand at the proper initial pressure line by gently tapping gauge with one hand. At the same time, crack the bleeder valve until gauge hand rests exactly on the predetermined initial pressure line.

11) Quickly close bleeder valve. Pump and bleed off as needed.

12) Close both petcocks and immediately press down the thumb lever to release the air into the material container.

13) Wait a few seconds until the hand stabilizes.

14) If all air was eliminated and the initial pressure was correctly selected, the gauge should read 0 percent.

a. If two or more tests show a consistent variation from 0 percent in the result, change initial pressure line to compensate for the variation.

b. Use the new initial pressure line for subsequent tests.

15) Screw curved tubes into the outer end of the petcock.

16) Press the thumb lever and control flow with petcock lever until you fill the 5 percent calibrating vessel (.1 gal (379 ml)) level full of water from the material container.

17) Release the air at the free petcock.

18) Open the other petcock and let the water in the curved pipe run back into the material container. There is now 5 percent air in the material container.

19) With petcocks open, pump air pressure in the exact manner outlined in steps k.8 through k.11.

20) Close petcocks and immediately press the thumb lever.

21) Wait a few seconds for exhaust air to warm to normal temperature and for the needle to stabilize.

22) The dial should now read 5 percent.

If two or more consistent tests show that the gauge reads incorrectly at 5 percent air in excess of 0.20 percent, remove gauge glass and reset the dial hand to 5 percent by turning the recalibrating screw located just below and to the right of the center dial.

23) When gauge hand reads correctly at 5 percent, withdraw more water to check the results at 10 percent, 15 percent, 20 percent, etc.

24) Check increments of 1 percent by removing .02 gal (76 ml) of water per 1 percent from the material container.

l. Care of the Press-Ur-Meter

Apparatus, 1.d, Care of the Pressure Air Meter.

C. Sample Size and Preparation

1. Place concrete to be tested in the material container in three equal layers.
2. Rod each layer 25 times, as directed in making compressive test cylinder specimens.
3. Tap the outside of the material container after rodding each layer of concrete.
4. Remove excess concrete by sliding the strike-off bar across the top flange with a sawing motion until container is just full.
5. Wipe the lip of the container clean of all sand and mortar.

D. Procedures

1. Pressure Air Meter

Figure 26-1 shows the basic equipment used in determining air content. Some of the steps below include a number reference in parentheses to the numbers shown on the figure.

a. Close the red-colored main air valve on top of the air receiver.

b. Open both petcocks (8 and 9) on top of lid.

c. Place lid (5) on the material container and close the four toggle clamps (6).

d. Pour water into the funnel (7) until water comes out the petcock (8) in the center of the lid.

e. Jar the meter gently until no air bubbles come out through the center petcock.

f. Close both petcocks (8 and 9).

g. Close the main air valve (4) and bleeder valve (10) in the end of the air receiver.

h. Gently pump air into the receiver until gauge hand (12) gets close to the red line.

1) Make sure the hand passes the initial starting point.

2) Do not worry about whether the hand is on one side or the other of the red line.

i. Tap the gauge (13) gently with one hand. At the same time, crack the bleeder valve (10) until gauge hand (12) rests exactly on the initial starting point.

j. Quickly close bleeder valve (10).

k. Open the main air valve (4) between the air receiver and the material container.

l. Jar the container slightly after releasing the pressure to allow particles to rearrange.

m. Tap the gauge (13) gently until the hand (12) comes to rest. Record the reading as the percent of air entrained.

n. Immediately close the main air valve (4).

o. When the aggregate has large voids, and you want to subtract their volume from the measured air content:

1) Place the amount of each size of aggregate used in the test in the material container.

2) Fill the container with water.

3) Complete the regular determination for air content. This reading is the aggregate correction factor.

2. Press-Ur-Meter

a. Place a representative sample of the concrete obtained according to GSP 17, "Sampling Freshly Mixed Structural Concrete," in the material container in three equal layers.

b. Rod each layer of concrete with 25 strokes of the tamping rod, evenly distributed over the cross section.

c. When rodding the first layer, do not strike the bottom of the container.

d. Tap the sides of the bowl sharply with the mallet after rodding each layer. Do this until the cavities left by rodding are leveled out and no large bubbles of air appear on the surface of the rodded layer.

e. In rodding the second and final layers, use only enough force to cause the rod to penetrate the surface of the previous layer.

f. Slightly overfill the bowl with the third layer. After rodding and tapping, remove the excess concrete by sliding the strike-off bar across the top flange with a sawing motion until the material container is just level full.

g. Wipe top lip of container clean of all sand and mortar.

h. Open both petcocks on top of lid.

i. Place lid on material container and close the four toggle clamps.

j. Using the rubber syringe to inject water through one petcock until all air is expelled through the opposite petcock.

k. Jar the meter gently until no air bubbles come out through petcock.

l. Leave the petcocks open.

m. With the built-in pump, pump air into the receiver until gauge band has slightly passed the predetermined initial pressure line.

n. Wait a few seconds for the compressed air to cool to normal temperature.

o. Tap the gauge gently with one hand. At the same time, crack bleeder valve in the air receiver until gauge hand rests exactly on the predetermined initial pressure line.

p. Quickly close bleeder valve.

q. Close both petcocks and press down on thumb lever to release the air into the base.

r. Hold thumb lever down for a few seconds and slightly jar the container when pressure is on to allow particles to rearrange.

s. Tap gauge gently until the hand comes to rest. This reading is percent of air entrained.

t. Open the petcocks to release the pressure.

u. Remove the lid.

v. When the aggregate has large voids, and you want to subtract their volume from the measured air content:

1) Place the amount of each size of aggregate used in the test in the material container.

2) Fill the container 1/3 full with water.

3) Add the mixed aggregate, a small amount at a time, until all of the aggregate is inundated.

4) Tap the sides of the material container and lightly rod the upper 1 in (25 mm) of the aggregate about 10 times.

5) Stir after each addition of fine aggregate to eliminate entrapped air.

6) When all of the aggregate has been inundated for at least 5 minutes, strike off all foam and excess water.
7) Thoroughly clean top lip on container.
8) Complete the regular determination for air content. This reading is the aggregate correction factor.

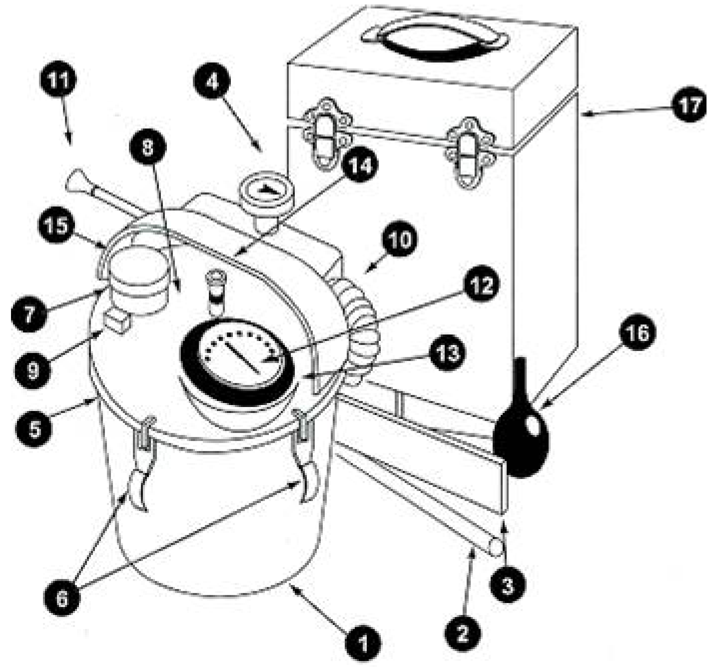


Figure 26-1

E. Calculations

No calculations are required for this test.

F. Report

Report the aggregate correction factor and percent of air entrained on Form 319 and Form 525.

PERFORMANCE CHECKLIST

GDT-26 Air Content of Freshly Mixed Concrete by Pressure Method

1. Dampen the interior of measuring bowl and lid.

2. Fill measuring bowl in three equal layers, rodding each layer 25 times, uniformly distributing strokes to a depth of approximately 1 in. (25 mm) into the previous layer, except the bottom layer is rodded throughout its depth. Tap the sides 10 to 15 times after rodding each layer.

3. Strike off excess concrete and clean lid contact surface. Dampen the rubber seal on the lid and clamp to bowl.

4. Open both the funnel cock and petcock.

5. Close main air valve between air chamber and measuring bowl.

6. Pour water into funnel cock until all air is expelled. Jar or tap meter gently during this step.

7. Pump pressure up until the needle goes slightly past the start point on the gauge.

8. Using bleeder valve, bleed pressure off until needle reaches start point.

9. Close both the funnel cock and petcock.

10. Open main air valve and lightly tap the gauge.

11. Read air content on the gauge.

12. Close main air valve and release pressure by opening the petcock.

GDT 35

Making and Curing Compression Test Specimens in the Field

Most concrete is bought and sold on the basis of strength test cylinders. Therefore, cylinders are very important in the world of concrete construction.

Concrete strength test cylinders must be made according to GDT 35 for two reasons: 1) so that the results are reliable, and 2) so that the test can be reproduced by someone else with the same concrete, following the same procedure and getting (nearly) the same results.

Most of GDT 35 is about molding and curing concrete cylinders. Cylinders must be molded – that is, filled and compacted – according to standard procedures. Then they must be cured under proper temperature and moisture conditions. If these procedures are not followed, the strength test results are meaningless.

Even small variations from the standard procedure can cause significant difference in strength. For example, cylinders cured at 90 to 100 °F (32.2 to 37.8 °C) will have much lower strengths than cylinders cured at the temperature of 60 to 80 °F (15.5 to 26.7 °C).

GDT 35

A. Scope

For a complete list of GDTs, see the Table of Contents.

Use this test method to make and cure compression and flexure test specimens of concrete sampled from concrete being used in construction.

B. Apparatus

The apparatus consists of the following:

13. Cylindrical Mold: Use a cylindrical mold made of non-absorbent material that is substantial enough to hold its form during the molding of test specimens.

    Molds must not vary from the standard diameter by more than 1/16 in (1.18 mm) or from the standard length by more than 1/4 in (6 mm). Oil reusable molds before use. Single-use molds (WM-10) need not be oiled. All molds must be watertight when assembled for use.

    You can use molds made from the following materials:

    - Cold-drawn, seamless steel tubing; or steel pipe machined on the inside (cut the tubular sections to the proper length, split along the element, and fit it with circumferential metal bands and bolts to close.)
    - Iron or steel castings
    - Standard plastic or cardboard molds manufactured for concrete specimens

NOTE: Do not use molds of formed sheet metal.

14. Base Plates: Use steel plates that do not allow leakage for all reusable molds.
15. Scoop: Use a standard scoop (WS-03).
16. Trowel: Use a standard brick mason's type (WT-07).
17. Tamping Rod: Use a 5/8 in (16 mm) round metal rod, approximately 24 in (600 mm) long with one end rounded to a hemispherical tip with a 5/8 in (16 mm) diameter (WR-7).
18. Beam Mold: Use molds for flexure test specimens that are rigid, non-absorptive, watertight, and at least 20 in (500 mm) long.
19. Vibrator (Flexural Test): Use an internal vibrator that has a rigid shaft or flexible shaft powered by electric motor. The frequency of vibration must be 7,000 revolutions per minute or greater. The outside diameter of the vibrating element must be at least 0.75 in (19 mm) and at most 1.5 in (37.5 mm). The shaft must be at least 24 in (600 mm) long.

C. Sample Size and Preparation

Obtain the sample of freshly mixed concrete according to GSP 17, or the method for sampling and testing Portland cement concrete pavement (see Sampling Requirements for Section 430), whichever is applicable.

D. Procedures

20. Compression Test Specimens

    j. Use cylindrical compression test specimens with a length equal to twice the diameter. Use standard cylindrical specimens that are 6 in (150 mm) in diameter by 12 in (300 mm) long.

    k. Mold specimens promptly on a level, rigid, horizontal surface, free from vibration and other disturbances. Try to mold the specimens close to where they will be stored during the first 24 hours.

    l. If you cannot mold the specimens where they will be stored, move them to storage immediately after striking off the excess concrete.

NOTE: To move cardboard molds, use a trowel under the mold to prevent specimen distortion.

m. Avoid jarring, striking, tilting, or scarring the surface of the specimens when moving them to a safe place.

n. Form the test specimens by placing the concrete in the mold in three layers of approximately equal volume.

o. While adding concrete to the mold, move each scoop full around the top edge of the mold to ensure a symmetrical distribution of the concrete within the mold.

p. Distribute the concrete further with a circular motion of the tamping rod.

q. Rod each layer with 25 strokes of the tamping rod. Distribute the strokes uniformly over the cross-section of the mold.

   Rod the bottom layer throughout its depth. Make sure the rod penetrates the subsequent layers and the underlying layer.

r. Tap the size of the mold to close voids left by the tamping rod.

s. After rodding the top layer, strike off the excess concrete to the level of the mold with a trowel.

t. Immediately after molding, cover the specimens with three plies of wet burlap, plastic bags, or glass or metal plates to prevent evaporation.

u. If using the standard plastic mold, cover with the standard sealing lid to prevent evaporation.

v. After molding, store the specimens between 60 ° and 80 °F (16 ° to 27 °C) for the first 24 hours and remove from casting site within 3 days.

   1) With the standard plastic molds, set the curing temperature at 70 ° to 76 °F (21 ° to 24 °C).

   2) Use heating elements in curing tanks from November through April to maintain the proper temperature.

w. After 24 hours, remove the test specimens from the molds.

NOTE: If using standard plastic molds, do not remove the specimen from the mold.

   For test specimens used to determine when a structure shall be put into service, protect them from the elements with the same materials you protect the structures they represent.

x. Store the test specimens in a curing tank or other temperature controlled facility until you ship them to the laboratory for testing.

y. For the 28-day test, send the specimens to the Laboratory so they arrive not more than seven days prior to the testing time. Carefully prevent damage to specimens in transit to the Laboratory.

z. For other test periods, keep the specimens in the field for at least 3/4 of the test period.

21. Flexure Test Specimens

aa. The cross-section of the flexure test specimen is 6 x 6 in (150 x 150 mm). The length is at least 20 in (500 mm).

bb. Overfill the mold with one lift of concrete with a scoop or shovel. Symmetrically distribute the concrete within the mold to minimize segregation.

cc. Consolidate the concrete with internal vibration for the time required to achieve proper consolidation, based on the type of concrete.

NOTE: Too much vibration may cause segregation.

   1) Observe a standard duration for the particular kind of concrete, vibrator, and specimen involved. The time required will depend on the workability of the concrete and the effectiveness of the vibrator.

   2) Be sure to withdraw the vibrator so that no air pockets are left in the specimen.

   3) Vibration is sufficient when the surface of the concrete appears relatively smooth.

dd. Insert the vibrator at three intervals along the longitudinal centerline of the specimen. Do not strike the bottom or sides of the mold.

   1) Insert the vibrator first at the center of the specimen, and then at the quarter points.

   2) After vibrating the concrete, spade the specimen along the sides and ends with a trowel or other suitable tool.

   3) Tap the sides of the mold to close the voids.

ee. For test specimens made to check the adequacy of the laboratory design for strength of the concrete:

   1) Cover the specimen immediately after molding with a double layer of wet burlap.

   2) Keep the specimen wet until you remove it from the mold or cover it with an impervious curing blanket.

   3) During the first 24 hours, cover with three plies of wet burlap, plastic bags, or glass or metal plates to prevent evaporation.

   4) After the 24-hour period, remove the specimens from the molds.

   5) Store the specimens until the time of test in a curing tank at 70 ° to 76 °F (21° to 24 °C).

ff. For test specimens used to determine when a structure or pavement slab may be put into service:

   1) Cure for 24 hours as nearly as practicable in the same manner as the concrete in the structure or pavement slab.

2) After 24 hours, take the specimens in the molds to a location preferably near a field laboratory.
3) Remove the specimens from the molds.
4) Store the specimens on the ground as molded, with the top surfaces up.
5) Bank the sides and ends of the specimen with damp earth or sand, leaving the top surfaces exposed to the specified curing treatment.
6) Keep the earth or sand damp with water.
7) At the end of the curing period, leave the specimens in-place with the top surfaces exposed to the weather in the same manner as the structure.
8) In lieu of storing the specimens with the top surfaces exposed, cure the specimens in a moist curing tank at a temperature of 70 ° to 76 ° F (21° to 24 °C).
9) Test the specimens in the moist condition resulting from the specified curing treatment.

E. Calculations

No calculations are required.

F. Report

Include all pertinent information about the concrete on the form sent with the cylinders for testing at the laboratory. include:

22. Date and time the samples were first made
23. Site name
24. Where at the site the samples were taken
25. Cement Contractor (and corresponding Qualified Products List number)
26. Number of samples
27. Your (the Inspector's) name and signature

PERFORMANCE CHECKLIST

GDT-35 Making and Curing Compression Test Specimens in the Field

1. Dampen equipment.
2. Fill cylinder mold in three equal layers.
3. Fill mold in three equal layers, rodding each layer 25 times, uniformly distributing strokes to a depth of approximately 1 in. (25 mm) into the previous layer, except the bottom layer is rodded throughout its depth.
4. Tap the sides 10 to 15 times after rodding each layer to close voids left by the rod.
5. Strike off surface of concrete with trowel or float.
6. Cap cylinder and identify.
7. Protect cylinders from freezing temperatures for first 24 hours.
8. After 24 hours, move cylinders to curing tank or other suitable curing facility with temperature maintained between 70 and 76 °F (21.1 and 24.4 °C).

APPENDICIES

GDT 28

Weight Per Cubic Foot, Yield and Air Content (Gravimetric) of Concrete

The unit weight and yield can be sufficiently accurate to determine the quantity of concrete produced per batch. The test also can give indications of air content provided the specific gravities of the ingredients are known.

A. Scope

For a complete list of GDTs, see the Table of Contents.

Use this test method to determine the weight per cubic foot (meter) of freshly mixed concrete and to calculate:

- The yield
- The actual cement factor
- The air content of the concrete

Yield is defined as the volume of concrete produced from a mixture of known quantities of the component materials.

Use this method of calculating air content when equipment is not available for making the air test in GDT 26, or when making field determinations of yield-per-batch.

B. Apparatus

The apparatus consists of the following:

28. Scale: Use a scale of at least 150 lbs (70 kg) capacity and sensitive to 0.1 lb (0.045 kg).
29. Tamping Rod: Use a round, straight metal rod, 5/8 in (16 mm) diameter and approximately 24 in (600 mm) long, with one end rounded to a hemispherical tip with a 5/8 in (16 mm) diameter (WR-7).
30. Measure: Use a cylindrical metal measure, preferably with handles. The measure must be watertight, preferably machined to accurate dimensions on the inside. It must be reinforced around the top with No. 10 to No. 12 (2.77 to 3.51 mm) U.S. gauge steel and 1-l/2 in (38 mm) wide.

    Depending upon the maximum nominal size of the coarse aggregate in the concrete, the measures required must have capacities of 1/2 or 1 ft^3 (0.0141 or 0.0283 m^3) and shall conform to the requirements prescribed in the following table (WM-02):

Dimensional Requirements for Cylindrical Measures —English				
Capacity (ft^3)	**Inside Dia., inches**	**Inside Height, inches**	**Thickness, U.S. Gauge**	**Max. Nominal Size of Coarse Aggregate**
1/2	10.00	11.00	No. 10 to No. 12	Up to 2" inclusive
1	14.00	11.23	No. 10 to No. 12	Over 2"

Dimensional Requirements for Cylindrical Measures—metric				
Capacity (m^3)	**Inside Dia., mm**	**Inside Height, mm**	**Thickness of Metal, mm**	**Max. Nominal Size of Coarse Aggregate**
0.0141	254	279	2.77 to 3.51	Up to 51 mm inclusive
0.0283	356	285	2.77 to 3.51	Over 51 mm

31. Calibration of the Measure

    gg. Accurately calibrate the measure by determining the weight of water at 62 °F (16.7 °C) required to fill it.

NOTE: Ensure the measure is properly full by using a glass cover plate.

    hh. Obtain the factor for any measure by dividing the unit weight of water at 62 °F (16.7 °C) (62.4 lbs/ft^3 [1000 kg/m^3]) by the weight required to fill the measure (in pounds [kilograms] of water at 62 °F [16.7 °C]).

C. Sample Size and Preparation

Obtain the sample of freshly mixed concrete according to GSP 17 or ASTM C172, whichever is applicable.

D. Procedures

32. Fill the measure to capacity in three layers.
33. Rod each layer evenly over the cross section of the measure as follows:
    - ii. While rodding the first layer, make sure the rod does not forcibly strike the bottom of the measure.
    - jj. In rodding the second and final layers, use only enough force to cause the rod to penetrate the surface of the previous layer.
    - kk. When using the 1/2 ft^3 (0.0141 m^3) measure, rod each layer with 25 strokes. When using the 1 ft^3 (0.0283 m^3) measure, rod each layer with 50 strokes.
    - ll. Tap the exterior surface of the measure 10 to 15 times after rodding each layer, or until large bubbles of air appear on the surface of the rodded layer.
34. After consolidating the concrete, strike off the top surface and finish it smoothly with a flat cover plate. Be sure to leave the measure exactly full.
35. Clean all excess concrete from the exterior.
36. Weigh the filled measure to the nearest 0.1 lbs (0.045 kg).

E. Calculations

1. Weight per Cubic Foot (meter)
   The net weight of the concrete shall be calculated by subtracting the weight of the measure from the gross weight. The weight per cubic foot (meter) shall be calculated by multiplying the new weight by the factor for the measure used, determined as described in Section B, "Apparatus".

2. Yield
   The yield of concrete produced per batch shall be calculated as follows:

$$Y = \frac{Wcem + Wf + Wc + Ww}{W}$$

Where:

Y = yield of concrete produced per batch, in cubic feet (meters)
W_{cem} = total weight of cementitious material (cement, fly ash or slag) in batch, in pounds (kilograms)
W_f = total weight of fine aggregate in batch in condition used, in pounds (kilograms)
W_c = total weight of coarse aggregate in batch in condition used, in pounds (kilograms)
W_w = total weight of mixing water added to batch, in pounds (kilograms), and
W = weight of concrete, in pounds per cubic foot (kilograms per cubic meter)

3. Cement Content
   The "actual" cement content shall be calculated as follows:

$$C = \frac{27\,Cw}{Y} \quad \text{or} \quad C = Cw \div Y \text{ (SI units)}$$

Where:

C = actual cement content, in pounds per cubic yard (kilograms per cubic meter)
C_w = weight of cement in the batch, in pounds (kilograms)
Y = yield of concrete produced per batch, in cubic feet (meter)

4. Air Content
   The air content shall be calculated as follows:

$$A = \frac{T - W}{T} \times 100$$

or by the formula:

$$A = \frac{Y - V}{Y} \times 100$$

Where:

A = air content (percentage of voids) in the concrete
T = theoretical weight of the concrete, in pounds per cubic foot (kilograms per cubic meter), computed on air-free basis*

W = weight of concrete, in pounds per cubic foot (kilograms per cubic meter)
Y = yield of concrete produced per batch, in cubic feet (meters), and
V = Total absolute volume of the component ingredients in the batch in cubic feet (meters)

*NOTE: The theoretical weight per cubic foot (meter) is customarily a laboratory determination, the value for which is assumed to remain constant for all batches made, using identical component ingredients and proportions. It is calculated from the formula:

$$T = \frac{W1}{V}$$

Where:

T = theoretical weight of the concrete, in pounds per cubic foot (kilograms per cubic meter), computed on an air-free basis
W_1 = total weight of the component ingredients in the batch, in pounds (kilograms), and
V = total absolute volume of the component ingredients in the batch, in cubic feet (meters)

NOTE:

The absolute volume of each ingredient in cubic feet is equal to the quotient of the mass of that ingredient divided by the product of its specific gravity times 62.4. The absolute volume of each ingredient in cubic meters is equal to the mass of the ingredient in kilograms divided by 1000 times its specific gravity.

For the aggregate components, the bulks specific gravity and weight should be based on the saturated surface-dry condition. For cement, use a value of 3.15.

F. Report

Report the weight per cubic foot (meter), the yield, and the air content of the concrete on Form 319 and Form 525.

GDT 32

Air Content of Freshly Mixed Concrete by Volumetric Method (Highly Porous, Cellular or Lightweight Aggregate)

This test method can be used to determine the air content of concrete containing any type of aggregate including lightweight or porous materials. The volumetric method requires the removal of air from a known volume of concrete by agitating the concrete in an excess of water.

A. Scope

For a complete list of GDTs, see the Table of Contents.

Use this test method to determine the air content of freshly mixed concrete containing highly porous, cellular, or lightweight aggregate.

B. Apparatus

The apparatus consists of the following:

1. Air Meter: Use an air meter consisting of a bowl and a top section (see Figure 32-1) conforming to the following requirements:
   a. Bowl: The bowl must be machined metal, thick and rigid enough to withstand normal field use, and be material not readily corroded by cement paste.

      The bowl must have a diameter equal to 1 to 1.25 times the height and be constructed with a flange at or near the top surface. Use bowls of not less than 0.20 ft^3 (0.0056 m^3) for general use with structural or pavement concrete containing aggregate with maximum size of 2 in (50 mm) or less.

NOTE: You may use a bowl of not less than 0.075 ft^3 (0.002 m^3) capacity for routine work, but check the results against those obtained with the 0.20 ft^3 (0.0056 m^3) bowl if the results are questionable.

   b. Top Section: The top section must of the same machined metal as the bowl.

      The top section must have a capacity similar to the bowl. It must be equipped with a flexible gasket and hooks or lugs to attach to the flange on the bowl to make a watertight connection.

      The top section must have a glass-lined or transparent plastic neck, graduated in increments not greater than 0.5 percent, from 0 at the top to 9 percent or more of the volume of the bowl. The upper end of the neck must be threaded and equipped with a screw cap having a gasket to make a watertight fit.
2. Funnel: Use a metal funnel with a spout that can be inserted through the neck of the top section and long enough to extend to just above the bottom of the top section. The discharge end of the spout must be able to add water to the container without disturbing the concrete.
3. Tamping Rod: Use a round, straight, steel rod, 5/8 in (16 mm) diameter and approximately 24 in (600 mm) long, with one end rounded to a hemispherical tip with a 5/8 in (16 mm) diameter (WR-7).
4. Strike-Off Bar: Use a steel bar approximately 1/4 (6 mm) x 1 (25 mm) x 24 in (600 mm) long (WS-13-1).
5. Measuring Cup: Use a metal cup having a capacity equal to 1.0 percent of the volume of the air meter bowl.
6. Syringe: Use a small rubber bulb syringe with a capacity at least that of the measuring cup.
7. Pouring Vessel: Use a metal or glass container of approximately 1 qt (1 L) capacity.
8. Trowel: Use a blunt-nosed brick mason's trowel (WT-7).
9. Scoop: Use a small metal scoop (WS-03).
10. Calibration of Apparatus
    a. Determine the volume of the air meter bowl, in cubic feet (meters), by weighing the amount of water at 70 °F (21 °C) required to fill it.
    b. Divide this weight by 62.40 lb/ft^3 (1000 kg/m^3), the unit weight of water at 70 °F (21 °C).
    c. Cover the bowl with a glass plate. The plate will help remove excess water and ensure that the container remains full.
    d. Determine the accuracy of the graduations on the neck of the air meter's top section.

       Fill the assembled measuring bowl and top section with water to the level of the mark for any air content.
    e. Add more 70 °F (21 °C) water equal to 1.0 percent of the volume of the bowl to the water already in the neck. The height of the water column must increase by an amount equivalent to 1.0 percent of air.
    f. Check the volume of the measuring cup by adding one cupful of water to the assembled apparatus in the manner described in Apparatus steps 10.d and 10.e. The addition must increase the height of the water column equivalent to 1.0 percent of indicated air.

C. Sample Size and Preparation

Obtain the sample of freshly mixed concrete according to GSP-17.

D. Procedures

1. Use the scoop and trowel to fill the bowl with freshly mixed concrete in three layers of equal depth.
2. Rod each layer 25 times with the tamping rod.
3. Tap the sides of the bowl 10 to 15 times after each rodding, as outlined in Section D of GDT 28.
4. After placing the third layer of concrete, strike off the excess concrete with the strike-off bar until the surface is flush with the top of the bowl.
5. Wipe the flange of the bowl clean.
6. Clamp the top section into position on the bowl, insert the funnel, and add at least 1 pint (473 ml) of water followed by the selected amount (NOTE 1) of alcohol. Record the amount of alcohol added. Continue adding water until it appears in the neck of the top section. Remove the funnel and adjust the water level, using the rubber syringe, until the bottom of the meniscus is level with the zero mark. Attach and tighten the screw cap.
7. Invert and agitate the unit until the concrete settles free from the base; and then, with the neck elevated, roll and rock the unit until the air appears to have been removed from the concrete. Set the apparatus upright, jar it lightly, and allow it to stand until the air rises to the top. Repeat the operation until no further drop in the water column is observed.
8. Make a direct reading of the liquid in the neck, reading to the bottom of the meniscus, and estimating to the nearest 0.1 percent.

NOTE 1: The amount of isopropyl alcohol necessary to obtain a stable reading and a minimum of foam at the top of the water column will depend on concrete air content, the amount and type of air-entraining admixture, the cement content and perhaps other factors. Many concretes made with less than 500 lb/yd^3 (296 kg/m^3) of cement and air contents less than 4% may require less than 0.5 pint (237 ml) of alcohol. Generally, the amount of alcohol necessary can be established for given mixture proportions and should not change greatly during the course of a job.

E. Calculations

The final meter reading tends to be slightly higher than the actual air content of the sample when 2.5 pints (1.18 L) or more of alcohol is used.

1. When less than 2.5 pints (1.18 L) of alcohol is used, the final meter reading is the air content of the sample of concrete tested.

2. When 2.5 pints (1.18 L) or more alcohol is used, subtract the correction from Table 1 from the final meter reading to obtain the air content of the concrete sample tested.

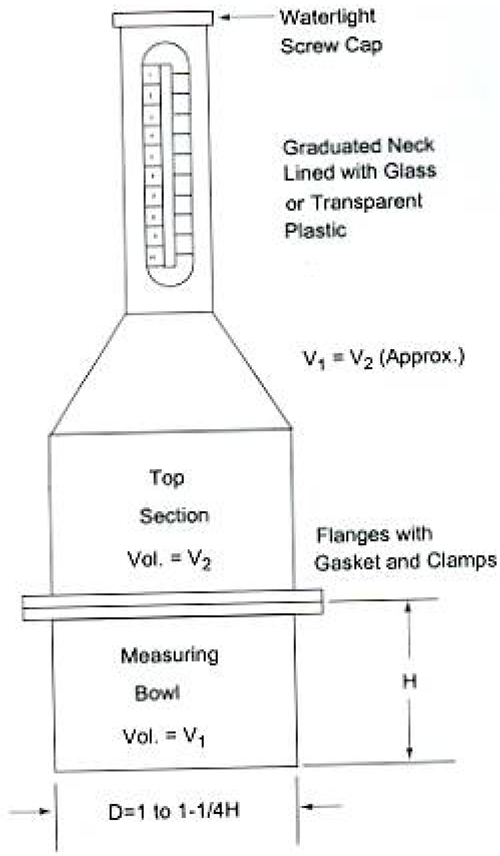
Table 1 – Correction for the Effect of Alcohol on Air Meter Reading

70% Isopropyl Alcohol Used		Correction (Subtract)
Pints	Ounces (ml)	
0.5	8 (237)	0.0
1.0	16 (473)	0.0
1.5	24 (710)	0.0
2.0	32 (946)	0.0
3.0	48 (1420)	0.3
4.0	64 (1893)	0.6
5.0	80 (2366)	0.9

NOTE: Read the calibrated marks on the glass directly in percent.

F. Report

Report the final air content of the concrete on Form 319 and Form 525.



Apparatus for Measuring Air Content of Fresh Concrete by Volumetric Method

Figure 32-1