WACEL CONCRETE PRACTICAL

This guide has been drafted to aid technicians in preparing to take the WACEL Concrete Practical Examination. Each test included in the practical examination is covered in this guide. This guide is not intended to replace the need for a technician to obtain copies of the current ASTM Standard Test Methods and be familiar with them. Hard copies of this guide may last longer than the time a Standard remains valid (current). The ASTM Standards may change from year to year, so stating this one more time is not overstating the intent, technicians should obtain copies of the current ASTM Standard Test Methods and become familiar with them. Even if a Standard changes, the information contained in this guide may provide valuable insight into some of the steps required to properly perform the tests.

The practical examination verifies that a technician is capable of performing the tests in accordance with the applicable ASTM Standards. Just knowing the steps and being able to verbalize them is not sufficient. A technician will be required to actually perform each test, in full, in front of an examination proctor. One other point to keep in mind is that a technician must also be capable of reading the instruments that they are using. One example of a problem that is commonly encountered is the volumetric air meter. A number of technicians have difficulty reading the meter. It is highly recommended that technicians have experience performing these tests and are familiar with the equipment (and how to read it) before scheduling to take the practical examination.

The procedures outlined are just that - procedures. Health and safety precautions are not included. Technicians are responsible for following any safety precautions required by their employer.

Technicians must be scheduled to take the practical examination. The examinations are held at the Virginia Concrete Plant in Springfield, VA. Generally, the examinations are given on the second and third Tuesday of each month during the evening. Examination times are assigned when scheduling. Assigned times can be 5:00, 6:00, 7:00, and if enough technicians - 8:00, with a maximum of 3 technicians for each time slot.

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ASTM C172 – Sampling

1) We will start the 'Sampling' section by discussing equipment. Lets also assume that you are starting a day at the office and told that you will be covering a concrete job. You will be performing nearly every (fresh) concrete test imaginable throughout the day. What equipment should you pack into your vehicle to take with you or ensure that the equipment is already in the field for your use?

wheelbarrow
bucket(s)
scoop
pressure air meter
volumetric air meter
- with measuring cup and funnel

slump cone
cylinder molds & caps
calibrated concrete thermometer
flat, rigid, non-absorbent base for slump
strike-off bar
strike-off plate
rod(s)
tape measure
scale / balance
70% isopropyl alcohol
syringe
sponge / brush / rags
rubber mallet

2) **All** equipment should be moistened before coming into contact with concrete. The **only** exception to this is cylinder molds. Cylinder molds should not be moistened before introducing concrete into the mold.

3) When obtaining a sample of concrete, first of all the concrete ticket should be checked to ensure that the concrete is an approved mix and checked for batch-to-placement time. You should also check the job specifications to determine if you should be sampling at the point of discharge or the point of placement. Only sample after all job-site water has been added to the concrete.

4) Obtain a *representative* sample of concrete. This means that your sample should come from at least two different areas of the truck. Avoid sampling the first 10% and the final 10% of the truck. The sample size should be determined by the number and type of tests that you are required to perform. If you are only making cylinders, the minimum acceptable sample size is 1 ft^3. The elapsed time shall not exceed 15 minutes between obtaining the first and final portion of the representative sample. In order to make your representative sample into a *composite* sample, mix the different portions well before testing.

ASTM C31 – Cylinders

Selecting the Proper Equipment

Both 4" x 8" and 6" x 12" cylinders are approved for use by C31. Know what size cylinders that you need to be using for the project that you are assigned to. 4" x 8" cylinders require a 3/8" diameter tamping rod that is 12" long. 6" x 12" cylinders require a 5/8" diameter tamping rod that is 24" long. One other point to keep in mind is that concrete with a slump < 1" must be consolidated using a vibrator. The requirements for consolidating concrete using a vibrator can be found in C31. The WACEL Concrete Practical Examination will not use concrete with a slump < 1". Also, the WACEL Concrete Practical Examination will use 6" x 12" cylinders, so the procedure outlined below has been written with this in mind. Any difference in procedures for 4" x 12" cylinders will be included as notes.

Detailed step-by-step procedure:

1) Record any necessary information on the outside of the cylinder mold. Do not moisten the mold.

2) The mold will be filled with concrete in 3 equal layers by volume. Since the shape of the mold is a cylinder, volume and height will be the same. The mold should be placed on a flat, level, rigid surface that is free of vibration and other disturbances.

   Note: 4" x 8" cylinders are filled in 2 equal layers by volume.

3) Place the first layer of concrete into the mold. This should result in approximately 4" of concrete in the mold after rodding and consolidation. Rod the concrete 25 times and tap the sides of the mold 10 – 15 times, using either a rubber mallet or your open palm. Take care when rodding the first layer not to forcibly strike the bottom of the mold. Place the second layer into the mold. This should result in approximately 8" of concrete in the mold after rodding and consolidating. Rod the concrete 25 times, penetrating the previous layer approximately 1" and tap the sides of the mold 10 – 15 times. Place the third layer into the mold. The third layer should overflow the top of the mold. Rod the concrete 25 times, penetrating the previous layer approximately 1" and tap the sides of the mold 10 – 15 times. At this point, there should be an excess of concrete in the mold.

4) Strike off the excess concrete using the tamping rod. If necessary, a float or trowel may be used to finish the top surface.

5) Place a cap on the cylinder and carefully transport the cylinder to the initial curing site (preferably a curing box). Cylinders should be allowed to sit, undisturbed, at a temperature range from 60° to 80°F for a period up to 48 hours. For high strength concrete (specified strength of 6,000 psi or greater), the initial curing temperature should be between 68° and 78°F.

   Note: A max-min thermometer should be used to monitor the temperature adjacent to the cylinders. If a curing box is not used, the initial curing temperatures should still be adhered to and the specimens should be shielded from direct sunlight.

ASTM C1064 – Temperature

Detailed step-by-step procedure:

1) Select a concrete thermometer. The concrete thermometer must be capable of measuring the temperature of concrete to the nearest 1°F throughout a range of 30° to 120°F.

2) If the concrete thermometer includes a plastic protective sheath, remove the thermometer from the sheath. Moisten the thermometer and position the thermometer in the concrete so that there is a minimum of 3 inches of concrete around the stem of the thermometer. Also, the tip of the thermometer should not be touching the bottom of the concrete container.

3) Push concrete around the stem of the thermometer to close the void left by placement.

4) Allow the thermometer to stay in the concrete for at least two minutes, or until the temperature stabilizes, then record the temperature to the nearest 1°F. Read the temperature on the thermometer while the thermometer is in the concrete.

ASTM C143 – Slump

Detailed step-by-step procedure:

1) Moisten the cone and the non-absorbent base. The base should be flat and level. The test should also be performed in an area that is free of vibration.

2) Hold the cone firmly against the base. This can be accomplished in two different ways. First, if you are using the "slump kit", secure the cone to the base using the "dog ears" on the base. The "slump kit" is not available for use at the concrete practical given by WACEL. For WACEL, you need to stand on the foot piece "flanges" at the bottom of the cone. Once you start filling the cone, you cannot step off of the foot pieces, so it is important that you are near your concrete sample and have all necessary equipment near you.

3) Fill the slump cone in 3 equal layers by **volume**. Unlike a cylinder, the volume of a cone changes as you go from the bottom up. A note is provided in C143 which gives proper heights for each layer. The first layer should be 2 5/8", the second layer should be 6 1/8" (total height), and the third layer should fill the cone to more than level full. One good point to keep in mind is that the slump cone is approximately the same volume as a 6" x 12" cylinder. This means that the same amount of concrete that is required for a layer of a 6" x 12" cylinder should be same amount of concrete required for each layer of the slump cone.

4) Using a scoop, place the first layer of concrete into the cone. Following the shape of the cone, rod the first layer 25 times, taking care to go through the entire layer but not forcibly strike the bottom. Place the second layer of concrete into the cone. Rod the second layer 25 times. This rodding procedure should go through the entire layer and *just penetrate* the previous layer (you should be rodding through approximately 3 ¼" of concrete). Place the third layer into the cone to overflowing. Rod the third layer 25 times, just penetrating the previous layer (you should be rodding through approximately 6" of concrete). After rodding the third layer 25 times, there should be an excess of concrete above the top of the cone. If, as you are rodding the third layer, you notice that the concrete level falls below the top of the cone - pause your rodding, add more concrete to the cone, and continue rodding from the point you paused, up to a total of 25 rods. If, after rodding 25 times, there is a deficient amount of concrete in the cone, add the required amount of concrete to fill the cone, but **do not** rod the concrete any more.

   Note: A few "do nots": 1 – Do not tap the top of the cone with the scoop to get excess concrete out of the scoop. 2 – Do not tap the sides of the slump cone after rodding each layer. 3 – Do not step off of the cone after beginning to fill it.

5) Strike off the excess concrete from the top of the cone using the rod. Use the rod in a screeding and rolling motion.

6) Slump is a measure of the consistency of the concrete. Consistency is defined as the relative mobility or ability to flow. This means that any excess concrete on the base – around the bottom of the cone, must be removed, otherwise it will act as a dam and impede the flow of the concrete.

   Note: From the time you started filling the cone until now, you have not stepped off of the cone.

7) Some technicians find it useful to mark the original center with a coin. This can be useful but is not required. Transfer pressure from one foot to a handle on the same side (obviously using your hand to do so). Then transfer pressure from the other foot to the handle on that side. With your hands, keep downward pressure on the handles until you are ready to lift the cone.

8) Without turning or twisting, lift the cone a distance of 12 inches in 5 ± 2 seconds in a steady, continuous motion. When performing this, you should attempt to raise the bottom of the cone to a height of 12 inches in 5 seconds, giving you a two second window on either side (faster or slower).

9) Invert the cone and set it beside the slumped concrete. Place the rod on the top of the cone (actually the bottom of the cone) and measure from the bottom of the rod to the ***displaced original center*** of the top surface of the specimen. Record this measurement to the nearest ¼ inch. The total elapsed time, from start to finish, to perform the slump test should not exceed 2 ½ minutes.

ASTM C173 – Volumetric Air Meter (Roll-A-Meter)

The two main procedures for determining the air content of freshly mixed concrete are the pressure method (C231) and the volumetric method (C173). Most technicians are familiar with the pressure method, but rarely see the test performed by the volumetric method. When looking at the theory behind what is going on with the test, it is somewhat ironic that technicians have difficulty understanding the volumetric method and have no problem with the pressure method. The theory of the volumetric test method is much more easily understood than that of the pressure method.

The general theory behind the volumetric method lies with two key components to the volumetric air meter, the bowl and the "top". The volume (capacity) of the bowl must be calibrated. The "top" of the meter must then be verified to read accurately. The graduations in the neck of the meter generally start with a zero line at the top and go down to 9 percent at the bottom, graduated in 0.25% increments. These percentages shown in the neck represent a percent of the volume of the bowl.

A brief overview of the test is as follows. Concrete is placed into a bowl and struck off flush. A "top" is clamped onto the bowl and then a combination of water and alcohol is added through the top. The water is added to bring the level up into the neck of the meter - up to a starting point, or "ZERO". At this point, a lid is placed on the meter and the meter is agitated to break loose all of the concrete out of the bowl and to allow a thorough mixing of the water/alcohol solution with the concrete. What happens during this step is that the air entrained in the concrete (very miniscule air voids, not detectable by the naked eye) is replaced with water. The volume that these air voids occupy is being replaced with water and the resulting decrease from the starting point (zero) is the volume of the air that was entrained in the concrete.

Detailed step-by-step procedure:

1) Moisten the bowl and fill with concrete in two equal layers. Each layer should be rodded 25 times and the sides of the bowl should be tapped with a rubber mallet 10-15 times after rodding. Care should be taken while rodding the first layer not to forcibly strike the bottom.

2) Strike off the excess concrete using a strike off bar. Thoroughly clean the rim of the bowl taking extra care to ensure that the area where the rubber gasket of the top makes contact with the bowl is free of any concrete or sandy material.

3) Attach the "top" to the bowl, securing with a clamp(s).

4) Place the funnel into the meter. The funnel is used so that the concrete in the bowl is not disturbed by the addition of the water and alcohol. If the funnel was not used, the process of pouring water into the meter would add additional consolidation to the concrete and also eliminate some of the air entrained in the concrete.

5) Add approximately 1 pint (16 oz or 2 cups) of water to the meter through the funnel.

6) Add a minimum of ½ pint of isopropyl alcohol (70%) to the meter through the funnel. WACEL recommends starting with ½ pint. The alcohol is mainly used to control the amount of foam generated during the agitation period. Also, the water must be added before the alcohol to limit the contact of concentrated alcohol with the concrete.

7) Continue to add water to the meter, using the funnel, until the water level is readable in the neck of the meter. This will generally require an additional 3 to 5 pints of water. When the water level is readable in the neck of the meter, remove the funnel and adjust the water level to zero. It is recommended to bring the water level up toward the top of the neck rather than just into the bottom of the neck because after removing the funnel, the water level must be adjusted using the syringe. One other point on this topic is with the water level itself. Because of surface tension and atmospheric pressure, the water level is not going to be a flat, straight level. The surface of the water is actually a meniscus and the bottom of this meniscus must be adjusted to zero.

8) Place the lid onto the meter. Then invert and agitate the meter for at least 45 seconds. During this process, the meter should be completely inverted and shaken, then brought back to completely upright. Do not invert the meter for more than 5 seconds at a time to prevent aggregate from lodging in the neck, but it is recommended to agitate the meter (inverted) for at least 3 seconds at a time. There is no specified time for the meter to remain in the upright position, just long enough to allow the aggregate to fall down out of the neck. The aggregate can be felt and heard coming out of the neck.

9) Set the meter down on a solid surface. Tilt the meter to a 45° angle and roll for 1 minute. This 1 minute rolling period should be broken into thirds. With one hand 'cradling' the neck of the meter and one hand on the bowl, vigorously roll the meter between ¼ to ½ of a turn for 20 seconds (1/3 of a minute). After 20 seconds, stop rolling and spin the meter 1/3 of a turn. Continue rolling between ¼ to ½ of a turn for 20 seconds. After this 20 seconds (total time of 40 seconds), stop and spin the meter the final 1/3 of a turn and continue rolling between ¼ and ½ of a turn for 20 seconds. At this point, the meter has been rolled for a total time of 1 minute.

10) Set the meter upright and remove the lid. Allow the meter (water level) to stabilize for at least 2 minutes and a maximum of 6 minutes. If it takes more than 6 minutes for the water level to stabilize (chances are good that the meter is leaking), stop the test and restart with a fresh sample – this time increasing the amount of alcohol used.

11) Check the amount of foam. If there is more than 2% foam sitting on top of the water level, the foam is excessive and the test should be stopped. Restart the test with a new sample – increasing the amount of alcohol used. If the foam is less than 2%, record the water level (to the nearest 0.25%) as the initial reading.

12) The initial reading must be confirmed by a second reading. In order to obtain the second reading, replace the lid and re-roll the meter identically to the procedure outlined in Step 9. After rolling, set the meter upright and remove the lid. Again, allow the meter (water level) to stabilize for at least 2 minutes and a maximum of 6 minutes. Record the water level as the 2nd reading.

13) If the 2nd reading is within 0.25% of the initial reading, record the 2nd reading as the final answer (air content of the concrete) to the nearest 0.25%. If the 2nd reading is not within 0.25% of the initial reading, disregard the initial reading. Replace the lid and perform the rolling procedure as outlined in Step 9. After rolling, set the meter upright and remove the lid. Again, allow the meter (water level) to stabilize for at least 2 minutes and a maximum of 6 minutes. Record the water level as the 3rd reading.

14) If the 3rd reading is within 0.25% of the 2nd reading, record the 3rd reading as the final answer (air content of the concrete) to the nearest 0.25%. If the 3rd reading is not within 0.25% of the 2nd reading, the test should be stopped. Restart the test with a new sample – increasing the amount of alcohol used. Basically, you are looking to confirm a reading within 0.25% and you are only allowed to take 3 readings.

ASTM C138 – Density (Unit Weight) of Concrete

Detailed step-by-step procedure:

1) There is one critical piece of information that must be known about the unit weight bowl (or measure) that is to be used before a technician even takes the bowl into the field to perform the test. It is the CALIBRATED VOLUME of the bowl. This calibrated volume is usually determined in the laboratory and should be calibrated to the nearest 0.001 ft^3.

2) In regards to bowl sizes (capacities), C138 contains a table with several different types of concrete and different *minimum* bowl size requirements. For WACEL purposes, the minimum bowl sizes that a technician needs to be familiar with are 0.2 ft^3 and 0.5 ft^3. When testing the unit weight of lightweight concrete, a 0.5 ft^3 bowl must always be used. With normal weight concrete, the minimum bowl size is dependent on the maximum size of coarse aggregate in the concrete. For concrete with aggregate up to 1 inch, a bowl with a minimum capacity of 0.2 ft^3 is required. For concrete with aggregate up to 2 inches, a bowl with a minimum capacity of 0.5 ft^3 is required.

3) Determine the empty weight of the bowl. When weighing the empty bowl, the bowl should be moistened **both** inside and outside. The reasoning behind moistening the outside of the bowl is because at the end of the test, before determining the full weight, the bowl will be wiped down to clean off excess concrete. The outside of the bowl will be damp when determining the full weight.

4) Fill the bowl with concrete in 3 equal layers by volume. Rod each layer with 25 strokes of the tamping rod and tap the sides of the bowl 10-15 times with the rubber mallet after rodding each layer. Take care when rodding the first layer to rod through the entire layer but not to forcibly strike the bottom of the bowl. Generally, most technicians perform this test using an air-pressure meter bowl. Most air-pressure meter bowls have a volume of approximately 0.25 ft^3 and are approximately 8.5 inches in depth. For ease of discussion, just look at the depth as being 9 inches. This means that each layer should be approximately 3 inches in depth. When rodding, each layer should be penetrated entirely through the layer and approximately 1 inch into the previous layer (obviously, with the exception of the first layer). This means that for each layer that is rodded (after the first layer), the rod should have about 4-4.5 inches of concrete on it in order to be rodding the proper depth. Also, after rodding and tapping the sides of the third layer, the bowl will be full and have, ideally, 1/8 inch of excess concrete.

5) Strike off the excess concrete. This 'strike off' process requires the use of a strike off plate. The plate should be moistened before making contact with the concrete. Using the plate **flat**, cover approximately 2/3 of the top surface of the bowl (the 2/3 nearest to you, leaving the exposed 1/3 of the bowl away from you) and press

it firmly down onto the rim of the bowl. Using a *sawing motion*, draw the plate toward yourself, until the far end of the plate comes completely off of the near side of the bowl. Take the plate and replace it (flat) in the exact same position that it started in, covering the same 2/3 of the bowl that was just struck off. Using a *sawing motion*, push the plate away from yourself until the near end of the plate comes completely off of the far side of the bowl. DO NOT stop this second pass once the plate has removed all of the excess concrete and just pick the plate straight up. There is, essentially, a vacuum created under the plate and picking the plate up will pull concrete out of the bowl that should remain in the bowl.

6) Using a rag/sponge/hand/brush (preferably a sponge), clean all excess concrete off of the outside of the bowl. The outside of the bowl should be in the exact same condition as it was when you determined the empty weight of the bowl.

7) Determine the full weight of the bowl.

8) Calculate the unit weight (density) of the concrete. The terms unit weight and density mean the same thing, the preferred term is actually density. Density is mass per unit volume (D = M/V). The net mass of the concrete is the weight of the bowl full of concrete minus the empty weight of the bowl (this will be in pounds). Divide the net weight of concrete by the calibrated volume of the bowl (which is in ft^3) and you will get the density of the concrete in pounds per cubic feet (pcf).

ASTM C231 – Air Content By the Pressure Method

Detailed step-by-step procedure:

1) Moisten the bowl. Fill the bowl with concrete in 3 equal layers by volume. Rod each layer with 25 strokes of the tamping rod and tap the sides of the bowl 10-15 times with the rubber mallet after rodding each layer. Take care when rodding the first layer to rod through the entire layer but not to forcibly strike the bottom of the bowl. Most air-pressure meter bowls are approximately 8.5 inches in depth. For ease of discussion, just look at the depth as being 9 inches. This means that each layer should be approximately 3 inches in depth. When rodding, each layer should be penetrated entirely through the layer and approximately 1 inch into the previous layer (obviously, with the exception of the first layer). This means that for each layer that is rodded (after the first layer), the rod should have about 4-4.5 inches of concrete on it in order to be rodding the proper depth. Also, after rodding and tapping the sides of the third layer, the bowl will be full and have, ideally, 1/8 inch of excess concrete.

   Note: The procedure for filling up a pressure meter bowl is identical to the procedure for filling up a unit weight bowl.

2) Strike off the excess concrete. Either a strike-off bar or a strike-off plate can be used to strike off the excess concrete. If using a strike-off plate, use the same strike off procedure outlined in C138. If using a strike-off bar, there is no specified procedure – just start at one edge of the bowl and strike off all of the excess concrete using the bar in a sawing motion.

3) Using a rag/sponge/hand/brush (preferably a sponge), clean all excess concrete off of the rim of the bowl. It is important that all excess concrete and sand be cleaned off of the rim of the bowl, otherwise the apparatus will leak when tested.

4) Moisten the bottom side of the lid, taking care to ensure that the rubber gasket is in satisfactory condition and moistened. Also check to make sure that the petcocks are open, ensure that there is no pressure in the air chamber, and check the initial pressure of the meter. Place the lid onto the bowl and secure the lid to the bowl. Most air-pressure meters have 4 latches. Clamp two opposing latches simultaneously and then clamp the other two simultaneously.

5) Using the syringe, add water into the meter through one of the petcocks. Do not place the tip of the syringe into the petcock – leave the tip approximately ½ inch outside of the petcock. Do not forcefully introduce the water, but also do not introduce the water at a dripping pace – find a happy medium. There is no need to switch between the two petcocks, only add water into the meter through one of the petcocks until water emerges from the other petcock. At this point, there may still be some air bubbles left in the meter and C231 says to gently jar the meter to

expel any remaining air. The best practice to accomplish this step is to gently tilt the meter in the direction of the petcock that you were placing water into. Much like how a carpenter's 'bubble level' works, any air will move to the high point, so an air bubble will move toward the petcock opposite of where you were introducing the water. Replace the meter back to a level position and add a little more water into the same petcock that you had previously, until water emerges from the other petcock. Any air that was left in the meter should now be evacuated.

6) Leaving the petcocks **OPEN**, pump the air chamber up the calibrated initial pressure. When the pressure gets near the initial pressure, use shorter strokes of the plunger and continually tap the backside of the gauge to settle the needle. If you overshoot the IP, use the **BLEEDER VALVE** to release pressure. Once the initial pressure is set, close the petcocks.

7) Using the main air valve, release the pressure from the air chamber into the bowl. While holding the main air valve open, hit the side of the bowl with the rubber mallet. These steps do **not** need to be performed simultaneously, in fact, it is not recommended to perform them simultaneously – open the main air valve and then strike the side of the bowl. Continue to hold the main air valve open for another second or two. Release the main air valve and lightly tap the gauge to settle the needle. Record the air content to the nearest 0.1%.

8) An aggregate correction factor, if available, will be given by the concrete supplier. If given, an aggregate correction factor must be subtracted from the air content read on the gauge.