State of Nevada
Department of Transportation
Materials and Testing Division

# METHOD OF TEST FOR UNIT WEIGHT, VOLUME AND CEMENT FACTOR OF CONCRETE

## SCOPE

This test method, which is a modification of ASTM Designation C138, describes the procedure for determining the unit weight in pounds per cubic foot (kilograms per cubic metre) of freshly mixed concrete and furnishes formulas for calculating the volume of concrete per batch and the actual cement factor.

## A. APPARATUS

1. Scales. Capacity of 105 lbs. (47.66 kg), sensitivity to 0.1 lb. (45.4 grams).

2. Measure. A cylindrical, watertight steel measure having a nominal capacity of 1/2 cu. ft. (14 $dm^3$), provided with handles. It shall have an inside diameter of 10 in. (254.0 mm) and an inside height of 11 in. (279.4 mm). It shall be constructed of No. 10 to No. 12 U.S. gauge steel and shall be reinforced around the top with a steel band of the same gauge, 1-1/2 in. in width. The top rim shall be machined to a plane surface.

3. Tamping rod. A round, straight, steel rod, 5/8 in. (15.88 mm) in diameter approximately 24 in. (609.6 mm) long, having one end rounded to a hemispherical tip, the diameter of which is 5/8 in. (15.88 mm).

4. Internal vibrators. Internal vibrators may have rigid or flexible shafts, preferably powered by electric motors. The frequency of vibration shall be 7000 vibrations per minute or greater while in use. The outside diameter or the side dimensions of the vibrating element shall be at least 0.75 in. (19 mm) and not greater than 1.50 in. (38 mm). The length of the shaft shall be at least 24 in. (600 mm).

5. Glass cover plate approximately 12 in. (304.8 mm) square, 1/4 in. (6.35 mm) thick and wire reinforced.

6. Platform with hinged, collapsible wings on three sides, made of plywood. Level bubbles are attached to the platform at one corner.

## B. CALIBRATION OF MEASURE

The actual volume of the measure shall be determined accurately by determining the weight and volume of water at 60° to 70° F. (15.6° to 21.1° C.) required to fill it. A calibration factor, F, shall be calculated for the measure by dividing 62.336 (998.59 $dg/m^3$) by the weight of water required to fill it. The calibration factor, F, is given for new measures as they are shipped. The value of the factor shall be verified at the start of each job and also at any time there is reason to suspect a change. See Paragraph 5, Section E. Calibrate the measure by filling it

with water having a temperature between 60° and 70° F. (15.6 to 21.1° C.) as measured with a thermometer. Place the glass plate firmly in contact with the rim of the measure and add water if necessary to eliminate bubbles under the glass. Wipe surplus water from the outside of the measure and glass plate. Weigh to the nearest 0.05 lb. (22.7 grams) with the glass plate in place. Subtract the tare weight of the empty, dry measure and glass plate and compute the calibration factor, F, as described above.

C. TEST PROCEDURE

1. Sampling fresh concrete.

   a. Whenever possible take freshly mixed concrete from the mass as it is deposited in the work. When this is not possible, as for example, when concrete is deposited in narrow forms, take the sample from the transporting buggy, or, in the case of ready-mixed concrete, by repeatedly passing a receptacle through the discharge stream of the mixer or agitator. Do not, however, take a sample from the beginning or end portions of the discharged batch unless it is desired to check the uniformity of mixing.

   b. Transport samples obtained by any of the above methods in watertight containers to the place where the test is to be performed.

2. Filling the measure and consolidating.

   a. Base the selection of the method of consolidation on the slump, unless the method is stated in the specifications under which the work is being performed. The methods of consolidation are rodding and internal vibration. Rod concrete with a slump greater than 3 in. (75 mm). Rod or vibrate concrete with a slump of 1 to 3 in. (25 to 75 mm). Vibrate concretes with a slump less than 1.

   b. Rodding - Place the concrete in the measure in three layers of approximately equal volume. Rod each layer with 25 strokes of the tamping rod. Rod the bottom layer throughout its depth but the rod shall not forcibly strike the bottom of the measure. Distribute the strokes uniformly over the cross section of the measure and for the top two layers, penetrate about 1 in. (25 mm) into the underlying layer. After each layer is rodded, tap the sides of the measure smartly 10 to 15 times with the appropriate mallet to close any voids left by the tamping rod and to release any larger bubbles of air that may have been trapped. Add the final layer so as to avoid overfilling.

   c. Internal Vibration - Fill and vibrate the measure in two approximately equal layers. Place all of the concrete for each layer in the measure before starting vibration of that layer. Insert the vibrator at three different points for each layer. In compacting the bottom layer, do not allow the vibrator to rest on or touch the bottom or sides of the measure. In compacting the

final layer, the vibrator shall penetrate into the underlying layer approximately 1 in. (25 mm). Take care that the vibrator is withdrawn in such a manner that no air pockets are left in the specimen. The duration of vibration required will depend upon the workability of the concrete and the effectiveness of the vibrator. Continue vibration only long enough to achieve proper consolidation of the concrete. Observe a constant duration of vibration for the particular kind of concrete, vibrator, and measure involved. Usually, sufficient vibration has been applied as soon as the surface of the concrete becomes relatively smooth. Overvibration may cause segregation and loss of appreciable quantities of intentionally entrained air.

3. Strike-off, cleaning and weighing

a. After the last layer has been properly consolidated, use the tamping rod held horizontally to strike off the top surface to its approximately correct elevation. Work the rod back and forth across the top with a sawing motion until a reasonably plane surface is obtained with all particles of coarse aggregate well buried. Clean the rim of the measure for a distance of about 6 in. Place one side of the glass plate firmly in position on the cleaned portion of the rim. Advance the plate with a sawing motion across the measure using sufficient pressure to maintain tight contact with the rim. There should always be a slight surplus of mortar ahead of the plate. If particles of coarse aggregate appear in front of the advancing edge of the plate use your hand to shove them down into the concrete. Using a cloth or damp sponge, clean off all concrete or other material adhering to the outside of the measure and glass plate. Adjust the plywood platform to a level condition with the wings set in position to eliminate the effect of wind. Place the scales on the platform and adjust the counter-weight on the scale beam so that the pointer indicates zero. Weigh the filled measure with the glass plate in place to the nearest 0.05 lb. (22.7 grams) and record the weight.

b. Slide the glass plate off the measure using a sawing motion. Examine the surface for evidence of incomplete filling of the measure. A slight depression of the surface near one edge of the measure and shallow voids up to 3/4 in. (19.05 mm) in diameter with a depth no greater than 1/16 in. (1.549 mm) may be disregarded. Deeper voids are indications that the measure was incompletely filled. In case of uncertainty, add a small amount of concrete and repeat the operations of screeding with the rod and working the glass plate into position. Weigh again. If the new weight agrees with 0.1 lb. (45.4 grams) with the first weight, the original weight may be taken as correct.

3. CALCULATIONS

1. Unit weight, W, in pounds per cubic foot (kilograms per metre$^3$).

The net weight of the concrete sample is equal to the gross weight of the measure, concrete, and cover plate minus the weight of the measure and cover plate. Calculate the unit weight of the concrete in pounds per cubic foot (kg/m$^3$) by multiplying the net weight of the concrete in the container by the calibration factor, F, determined for the measure used. Express the unit weight to the nearest 0.1 lb. (45.4 grams).

W = Unit weight in pounds per cubic foot (kg/m$^3$) = Net weight of concrete x calibration factor, F.

2. The volume of concrete, S, per batch is calculated as follows:

$$S = \frac{Wa + W_1 + Wc + Ww}{W}$$

Where:

S = Volume of concrete per batch in cubic feet (cubic metre).

Wa = Total weight of cement in the batch in pounds (kilograms).

$W_1$ = Total weight of fine aggregate, including moisture as batched, in pounds (kilograms).

Wc = Total weight of coarse aggregate, including moisture as batched, in pounds (kilograms).

Ww = Total weight of water added during mixing per batch, in pounds (kilograms).

W = Unit weight of the fresh concrete as determined under (1) above, in pounds per cubic foot (kilograms per metre$^3$).

3. Cement Factor

The cement factor, CF, in sacks per cubic yard of concrete produced is calculated as follows:

$$CF = \frac{27N}{S}$$

Where CF is the cement factor in sacks per cubic yard:

N = number of sacks of cement in the batch.

S = volume of concrete produced per batch in cubic feet (cubic metre) as determined in (2) above.

E. PRECAUTIONS

1. Use proper lifting methods when lifting the measure full of concrete.

2. Always use the standard rod. Do not substitute.

3. Keep scale level when weighing.

4. The plywood windshield is helpful when weighing on a windy day. Watch for scale movements caused by wind and take the necessary steps to eliminate these effects.

5. Be sure to clean off all material adhering to outside of measure and glass cover plate before weighing. Clean measure well, particularly around handles and inside corners, to avoid build-up of any hardened concrete on the measure, thereby changing its tare weight and volume. Check tare weight before each test.

F. NOTES

1. Do not confuse the calibration factor, F, that applies to the measure with the cement factor, CF, which is a value computed from the composition and unit weight relationship of the concrete.

2. ASTM Designation C138 requires that a measure having a volume of 1 cu. ft. (28 $dm^3$) be used in testing concrete having a maximum size of aggregate in excess of 2 in. (50.8 mm). However, under this method (Nev. T435) the 1/2 cu. ft. (14 $dm^3$) measure shall be used for concrete containing 2-1/2 in. (63 mm) maximum size of aggregate. When testing for unit weight of such concrete, two tests shall be made from the same batch. The average of the two tests shall be reported as a single determination.

G. TEST REPORT

The test report shall include the slump of the batch of concrete tested, the air content by the pressure method if determined, the calculated unit weight, W, of the concrete in pounds per cubic foot, the calculated size of the batch, S, and the calculated cement factor, CF, together with suitable identification as to date and hour and the station number or portion of the structure in which the concrete was placed.

REFERENCE

ASTM Designation C138