



Control of Cement Content in Concrete

The Standard Specifications (SS)¹ require that the cement content of concrete mixtures be verified in accordance with procedures described in California Test 518. As stated in the SS², "...For testing purposes, supplementary cementitious materials (SCM) are considered to be cement. ..." Although California Test 518 is titled *Method of Test for Unit Weight of Fresh Concrete*, it also gives instructions for determining the volume of concrete(s) per batch, and determining the cement content (CC_A) in pounds per cubic yard of concrete produced.

Form DS-OS C68, *Worksheet for California Test 518, Unit Weight of Fresh Concrete*, was originally developed by Materials Engineering and Testing Services (METS) and modified by Structure Construction (SC) (Form SC-3702) to facilitate the calculations process to determine that the cement content complies with specification requirements. (Attachments No. 1 and No. 2 are examples of completed Form SC-3702 (formerly form DS-OS C68).)

Unit Weight Testing

For concrete mixes, the goal is to obtain the required cement content in each cubic yard of concrete. If it were practical to accurately weigh all the ingredients required to produce one cubic yard of concrete, mix them thoroughly, and place them in an accurate cubic yard measure, then determining the proper amount of cement would be easy. If the batch which contained the specified amount of cement overflowed the cubic yard measure, it would actually not contain enough cement per cubic yard. If the batch did not fill the cubic yard measure, it would actually contain more cement than required per cubic yard. In the event that the mix contained too much or too little cement per cubic yard, adjustments would have to be made to produce nearly an exact cubic yard containing the specified amount of cement per cubic yard. Since it is not practical to check the cement content by making use of a cubic yard measure, the unit-weight test is used to provide the necessary data needed to make adjustments to the mix design and to make corresponding adjustments to the load weight.

In effect, these two procedures are the same, except that in the unit-weight test, a small sample, that is practical to handle, is used, and the volume produced per load is calculated by simple proportion. The unit-weight test is limited to the determination of the unit-weight of fresh concrete in pounds per cubic foot, but does include equations that may be used for calculating the volume of concrete per load and the actual cement content of the concrete produced.

In reviewing the calculations, only two factors are needed to calculate the volume of the load. The calculation for volume of load is as shown below:

¹ 2010 SS, Section 90-1.01, *General*.

² 2010 SS, Section 90-1.01D(2), *Cementitious Material Content*.

W = Unit weight in pounds per cubic foot (the net weight of concrete in the calibrated bucket times the calibration factor)

W_t = Total scale weight in pounds per load of all the ingredients in the load of concrete.

S = Volume of concrete produced in cubic feet per load.

Then $S = W_t/W$

By simple proportion the total weight in pounds-per-load of concrete, divided by its unit weight in pounds-per-cubic-foot, equals the quantity in the load in cubic feet. The important thing to remember is that you must have the actual weights of the water, cement and aggregates going into the load.

It is important to note that the unit-weight test does not check batching accuracy. The Field Engineer must first be assured that scales at the batch plant are accurate by the State Bureau of Weights and Measures inspection and seal. Batching accuracy can then be checked by observing the batching operation and by requiring the Contractor to determine the gross and tare weights on the mixer truck. The gross minus tare weight method should only be used as a rough check of batching accuracy, not as the value to be used in the calculations of batch volume³.

To determine the cement content of the concrete being produced, the actual weight of cement included at the batch plant will need to be known. The weight of cement should be verified by observation of the scale weights as the batch is being produced. The calculation for cement content is shown below:

*CC = Cement content in pounds per cubic yard.

W_a = Number of pounds of cement in the load (verified by observation or recording equipment record).

S = Volume of concrete produced per load in cubic feet (determined from unit weight as described above).

Then by proportion: $CC/27 = W_a/S$ or $CC = 27W_a/S$

*Note: CC = the actual weight of all cementitious materials.

The cement content in pounds per cubic yard is to 27 cubic feet per cubic yard, as the number of pounds in the load is to the number of cubic feet in the load. The number of pounds of cementitious material in the load, must be the actual amount of cement, as determined by plant scales. Weighing is the only way to know exactly how much cement is in the load.

³ 2010 Standard Specifications (SS) Section 90-1.02F(3)

When the unit-weight test is to be performed, the actual batching of the load to be checked should be observed and scale weights recorded for use in determination of load volume. The mixer drum should also be checked prior to batching to be sure that a significant quantity of water is not left in the drum and unaccounted for in batch weights. *If you have not verified by observation or been assured by automatic recording batching equipment records that the intended amounts of cementitious material, water and aggregate were actually batched into the mixer, then the subject test and subsequent calculations cannot be used to determine the cement content.*

BCM 90-2.0
ATTACHMENT NO. 1
09/30/14
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STATE OF CALIFORNIA . DEPARTMENT OF TRANSPORTATION							
WORKSHEET FOR CALIFORNIA TEST 518				JOB STAMP			
FORM SC-3702 (Formerly DS-OS C68) (REV. 09/30/14)							
TEST NO.		TEST BY	Example #2 for BCM 100-2.0		DATE		
MIX NO.		POUR NO.			LOAD CY	7	
DELIVERY SLIP NO.					PENETRATION (KELLY BALL)		
F = CALIBRATION FACTOR FOR MEASURE*						2.006	
1. GROSS WT. OF MEASURE, CONCRETE AND COVERPLATE.						95.54	lb
2. WT. OF MEASURE AND COVER PLATE						24.25	lb
3. NET WT. OF CONCRETE SAMPLE (line 1 minus line 2)						71.29	lb
W = UNIT WT. OF CONCRETE SAMPLE (line 3 times F)						143.0	lb/ft ³
W_a = TOTAL WT. OF CEMENTITIOUS MATERIAL PER LOAD, AS BATCHED.						5593	lb
W₁₁ = TOTAL WT. OF FINE AGGREGATE #1 PER LOAD, INCL MOISTURE, AS BATCHED.						9394	lb
W₁₂ = TOTAL WT. OF FINE AGG. #2 PER LOAD, INCL MOISTURE, AS BATCHED.							lb
W_{c1} = TOTAL WT. OF COARSE AGG. #1 PER LOAD, INCL MOISTURE. AS BATCHED.						10024	lb
W_{c2} = TOTAL WT. OF COARSE AGG. #2 PER LOAD, INCL MOISTURE, AS BATCHED.							lb
W_{w1} = TOTAL WT. OF WATER PER LOAD AS ADDED AT PLANT. (8.33 LBS PER GAL)						2015.3	lb
W_{w2} = TOTAL WT. OF WATER PER LOAD AS ADDED AT JOB SITE. (8.33 LBS PER GAL)							lb
S =	VOLUME OF CONCRETE PER LOAD IN CUBIC FT.						
	W						
						27026.3/143=	
=	W _a + W ₁₁ + W ₁₂ + W _{c1} + W _{c2} + W _{w1} + W _{w2}				=	188.98	ft
	W						
CY = VOLUME OF CONCRETE PER LOAD IN CUBIC YARD = S/27 =						7.00	yd
CC** = CEMENTITIOUS MATERIAL CONTENT IN LB PER CUBIC YARD OF CONCRETE							
PRODUCED = W_a /cy =						799.06	Lb/Yd
FILE CATEGORY 37							
NOTES:							
* Refer to <i>California Test 18, Step D, Calibration of Measure</i> , for calculating the <i>Calibration Factor</i> .							
**CC = the actual weight of all cementitious material (cement and supplementary cementitious material).							