Method of

PROPORTIONING AND MIXING PORTLAND CEMENT CONCRETE FOR ADMIXTURE TESTING

DOTD Designation: TR 224-86

Scope

1. This method describes the procedure for proportioning and mixing component materials for portland cement concrete in the laboratory using accurate control of materials for admixture source approval. This method applies to each series of concrete mixes which consists of a control mix (mix containing no admixture) and test mix (mix containing the admixture under evaluation).

Apparatus

2. (a) **Concrete Mixer** - A power driven revolving drum, capable of thoroughly mixing a sufficient quantity of concrete in one batch to accommodate the number of test specimens required plus approximately 10 percent excess volume.

(b) **Metal Pan** - A watertight, heavy gage metal pan having a flat bottom and sufficient capacity to receive the entire batch during discharge of the mixer.

(c) **Scale** - A scale accurate to within 0.3% of the load at any point within the range of use.

(d) **Sieves** - Metal or hardwood framed 1 1/2 in., 3/4 in., 1/2 in., and No. 4 sieves conforming with AASHTO Designation: M 92. The capacity of each sieve shall be such that separation of coarse aggregate in accordance with paragraph 4(c) can be conveniently accommodated for each series of tests.

(e) **Small Tools and Items** - Tools and items such as shovels, scoops, weighing containers for component materials, rubber gloves and trowels.

(f) **Burlap**

Materials

3. (a) **Cement** - The Cement used in each series of mixes shall be Type 1 portland cement from a single source listed on the Department's Qualified Products List.

(b) **Aggregates** - The fine and coarse aggregate shall be from a single source listed on the Department's Qualified Products List. Aggregates shall conform to the requirements set forth in the standard specifications for concrete sand and Grade A coarse aggregate.

(c) **Potable Water**

(d) **Admixture**

Preparation of Materials

4. (a) The temperature of the laboratory and component materials shall be maintained between 70 and 76 °F prior to and during mixing.

(b) Store a sufficient quantity of cement for each series of mixes in moisture proof containers.

(c) In order to preclude segregation of the coarse aggregate, separate the coarse aggregate into the following individual sizes prior to batching concrete:

	Sieve Size	
Size No.	Passing	Retained
1	1 1/2 in.	3/4 in.
2	3/4 in.	1/2 in.
3	1/2 in.	No. 4

(d) The moisture content of the coarse and fine aggregates shall be uniformly distributed throughout the sample.

(e) Determine moisture contents of the fine and coarse aggregates in accordance with DOTD Designation: TR 106.

Proportions of Material

5. (a) Proportions of material may be calculated in accordance with American Concrete Institute Standard 211.1 "Recommended Practice for Selecting Proportions for Normal Weight Concrete" or other methods. The following shall be adhered to when proportioning concrete mixes:

(1) The quantity of concrete for each mix shall be such that the number of test specimens required for the admixture under test is accommodated with an excess of approximately 10 percent by volume.

(2) The composition of each control mix and test mix shall conform to Tables 1 and 2 of this procedure, respectively.

(3) The proportions of fine and coarse aggregate shall result in a workable mix conforming to the slump requirements of Tables 1 and 2. The proportions of fine aggregate to coarse aggregate based on the absolute volume of the total aggregate is generally in the range of 38 to 40 percent for the control mix.

(4) The individual size fractions of coarse aggregate as shown in paragraph 4(c) under "Preparation of Materials" shall be combined in the following proportions to result in the total saturated surface-dry weight of coarse aggregate for the control mix and test mix:

Size No.	Percent by Weight
1	25
2	45
3	30

(5) Both the free moisture, determined by DOTD Designation: TR 106 contributed by the aggregate, and the amount of the water in the liquid admixture must be included in the total mixing water.

(6) Any deviation in air or water content from the control mix shall be compensated for in the test mix by adjusting the absolute volume of the fine aggregate.

(7) The absolute volume of the coarse aggregate in the test mix shall remain the same as that of the control mix.

(8) Final batch weights shall be calculated to the nearest 0.1 pound.

(b) The following are sample computations for a control mix and a test mix containing an air entraining admixture using the absolute volume method of proportioning materials. The dosage of admixtures to be evaluated is assumed to be 2.5 ounces/cwt and the solids content of the admixture is 6.5%. It is also assumed that local aggregate and cement combinations result in approximately 2% entrapped air and the total air content desired in the test mix is 5%. The specific gravities of the gravel and sand are found in the Department's Qualified Products List for Aggregates (QPL No. 2) and for the purpose of these computations are found to be 2.53 for the gravel and 2.62 for the sand. Also, from QPL No. 2, the corresponding absorption factors are 2.2% and 0.5%, respectively. The moisture contents of the gravel and sand were found to be 2% and 6%, respectively. The desired batch size is 3 cubic feet.

(1) Control Mix: The following information is taken from Table 1 for an air entraining admixture evaluation:

Cement Content = 6 bags/yd^3 or 564 lb/yd^3
Max. Water Content = 6 gal/bag or 36 gal/yd^3

Step 1. Calculate the absolute volumes of all ingredients per cubic yard (27 ft^3).

(a) Calculate the absolute volumes of cement, water, and entrapped air:

$$CAV = \frac{C}{SG \times 62.4}$$

where:

CAV = Absolute Volume of Cement, ft^3
C = Weight of Cement, lb
SG = Specific Gravity of Cement

Cement = 564/(3.15 x 62.4) = 2.86 ft^3

$$WAV = \frac{WC}{7.48}$$

where:

WAV = Absolute Volume of Water, ft^3
WC = Maximum Water Content, gal

Water = 36/7.48 = 4.81 ft^3

$$EA = A/100 \times 27$$

where:

EA = Absolute Volume of Entrapped Air, ft^3
A = Entrapped Air Content, %

Entrapped Air = 2/100 x 27 = 0.54 ft^3

(b) Calculate the absolute volumes of aggregate using a fine to coarse aggregate ratio of 40 percent:

Total Aggregate = 27 - (2.86 + 4.81 + 0.54)
= 18.79 ft^3
Fine Aggregate = 0.4 x 18.79 = 7.51 ft^3
Coarse Aggregate = 18.79 - 7.51 = 11.28 ft^3

Step 2. Calculate the batch weights (pounds) per cubic yard of concrete. The DOTD Materials Section maintains a list of approved aggregate sources (QPL 2) with corresponding saturated surface-dry specific gravities and absorption factors:

(a) Cement = 564 lb

(b) W = WAV x 62.4

where:

W = Batch Weight of Water, lb
WAV = Absolute Volume of Water, ft^3

Water = 4.81 x 62.4 = 300 lb

(c) FA = FAV x SSG x 62.4

where:

FA = Batch Weight of Fine Aggregate, lb
FAV = Absolute Volume of Fine Aggregate, calculated in Step 1(b), ft^3
SSG = Saturated Surface Dry Specific Gravity of Fine Aggregate

Fine Aggregate = 7.51 x 2.62 x 62.4 = 1228 lb

(d) CA = CAV x SSG x 62.4

where:

CA = Batch Weight of Coarse Aggregate, lb
CAV = Absolute Volume of Coarse Aggregate calculated in Step 1(b), ft^3
SSG = Saturated Surface-Dry Specific Gravity of Coarse Aggregate

Coarse Aggregate = 11.28 x 2.53 x 62.4 = 1781 lb

Step 3. Adjust batch weights per cubic yard of concrete to compensate for free moisture in the aggregate:

$$\text{Coarse Aggregate} = 1781 \times \frac{(100 + \%\,\text{Moisture} - \%\,\text{Absorption})}{100}$$

$$= 1781 \times \frac{(100 + 2.0 - 2.2)}{100}$$

= 1777 lb

$$\text{Fine Aggregate} = 1228 \times \frac{(100 + 6.0 - 0.5)}{100}$$

= 1296 lb

Water = 300 + (1781-1777) + (1228-1296)

= 236 lb

Step 4. Reduce corrected batch weights for one cubic yard to the desired batch size for the control mix. Desired batch size, 3 cubic feet.

Cement = 564 lb x 3/27 = 62.666 lb = 62.7 lb
Water = 236 lb x 3/27 = 26.222 lb = 26.2 lb
Coarse Aggregate = 1777 lb x 3/27 = 197.444 lb
Fine Aggregate = 1296 lb x 3/27 = 143.999 lb = 144.0 lb

Step 5. Calculate the quantities of the individual size fractions of coarse aggregate based on the percentages in paragraph 5(a)(4).

Size 1 = 197.444 x 0.25 = 49.361 lb = 49.4 lb

Size 2 = 197.444 x 0.45 = 88.849 lb = 88.8 lb

Size 3 = 197.444 x 0.30 = 59.233 lb = 59.2 lb

Total = 197.443 lb

Step 6. The batch proportions for the first trial control mix are as follows:

Cement = 62.7 lb
Water = 26.2 lb
Coarse Aggregate Size 1 = 49.4 lb
Size 2 = 88.8 lb
Size 3 = 59.2 lb
Fine Aggregate = 144.0 lb

(2) Test Mix: The following information is taken from Table 2 for testing air entraining admixtures:

Cement Content = 6 bags/yd^3 or 594 lb/yd^3
Water Content = 90% of Control Mix

Step 1. Calculate the absolute volumes (ft^3) of all ingredients per cubic yard.

(a) Calculate the absolute volumes of cement, water, and air:

Cement = 2.86 ft^3 (same as control mix)

$$\text{Water} = \frac{0.9 \times 36 \text{ gal}}{7.48} = 4.33 \text{ ft}^3$$

Air = 27 x 0.05 = 1.35 ft^3

(b) Calculate the absolute volumes of aggregate:

Total Aggregate = 27 - (2.86 + 4.33 + 1.35) = 18.46 ft^3
Coarse Aggregate = 11.28 ft^3 (same as control mix)
Fine Aggregate = 18.46 - 11.28 = 7.18 ft^3

Step 2. Calculate the batch weights per cubic yard of concrete:

Cement = 564 lb (same as control mix)
Water = 4.33 x 62.4 = 270 lb
Coarse Aggregate = 1781 lb (same as control mix)
Fine Aggregate = 7.18 x 2.62 x 62.4 = 1174 lb

Step 3. Adjust batch weights for one cubic yard to compensate for free moisture in the aggregate:

Coarse Aggregate = 1777 lb (same as control mix)
Fine Aggregate = 1174 x 1.055 = 1239 lb
Water = 270 + (1781-1777) + (1174-1239) = 209 lb

Step 4. Reduce batch weights to desired batch size for the test mix:

Cement = 564 x 3/27 = 62.666 lb = 62.7 lb
Water = 209 x 3/27 = 23.222 lb = 23.2 lb
Coarse Aggregate = 1777 x 3/27 = 197.444 lb
Fine Aggregate = 1239 x 3/27 = 137.666 lb = 137.7 lb

Step 5. Calculate the required amount of admixture for the batch:

$$\text{DOS} = \text{DR} \times \frac{\text{RC}}{100} \times 29.6$$

where:

DOS = Admixture Dosage, ml
DR = Admixture Dosage rate, oz/cwt
RC = Reduced Batch Weight of Cement, lb

$$\text{Admixture} = 2.5 \times \frac{62.7}{100} \times 29.6 \text{ ml/oz} = 46.4 \text{ ml}$$

Step 6. Adjust the water content to compensate for the amount of water in the admixture:

$$\text{WA} = \frac{(\text{DR} \times \text{RC}/100) \times (1 - \text{S}/100)}{128}$$

where:

WA = Water Adjustment, gal.
S = Solids Content, %

Water Adjustment = [(2.5 x 62.7/100) x (1 - 6.5/100)] ÷ 128
= 0.011 gallons which is negligible.

Step 7. The batch proportions for the first trial test mix are as follows:

Cement = 62.7 lb
Water = 23.2 lb
Coarse Aggregate Size 1 = 49.4 lb (same as control)
Size 2 = 88.8 lb (same as control)
Size 3 = 59.2 lb (same as control)
Fine Aggregate = 137.7 lb
Admixture = 46.4 ml

(c) Adjustments to the proportions for the control mix and test mix must be made within the criteria shown in paragraph 5(a) if tests on the plastic concrete do not result in conformance with Tables 1 and 2.

Mixing Procedure

6. (a) Add the entire amount of coarse aggregate, fine aggregate, and approximately 2/3 of the total water to the mixer and allow these components to mix for one minute. If an air entraining admixture is to be added to the mix, the admixture shall be added directly to the fine aggregate.

(b) Stop the mixer and allow the water to absorb into the aggregate for two minutes.

(c) Start the mixer and add the total amount of cement and approximately 1/3 of the remaining amount of water and mix for four minutes. If a water reducing or set accelerating admixture is to be added to the mix, the admixture shall be in solution with this addition of water.

(d) Add the remaining water during the four minute mixing period until the desired consistency is obtained.

(e) Discharge the concrete into a watertight metal pan and remix by shovel to assure a uniform concrete mix.

NOTE: The above mixing procedure is suitable for drum type mixers. Variations in times and water quantities are acceptable provided a uniform mix is obtained. The mixing sequence, however, should not be varied. Prior to mixing the control mix, the concrete mixer shall be buttered by mixing a smaller batch proportioned to simulate the control mix.

PROPORTION TABLES
for
ADMIXTURE SOURCE APPROVAL

TABLE 1 Control Concrete Mixes

	Air-Entraining	Water Reducing	Water Reducing and Retarding	Water Reducing High Range	Accelerating
Cement Content bags/yd^3	6.0±0.05	6.0±0.05	6.0±0.05	7.0±0.05	7.0±0.05
Water Content, max., gal/bag	6.0	6.0	6.0	5.5	6.0
Air Content, max. %	3.0	3.0	3.0	3.0	3.0
Slump, in.	3±1/2	3±1/2	3±1/2	3±1/2	3±1/2

TABLE 2 Concrete Mixes Containing Admixture

	Air-Entraining	Water Reducing	Water Reducing and Retarding	Water Reducing High Range	Accelerating
Cement Content bags/yd^3	6.0±0.05	6.0±0.05	6.0±0.05	7.0±0.05	7.0±0.05
Water Content, max., % of Control	90	95	95	88	--
Air Content, %	5.0±1.0	3.0 max.	3.0 max.	3.0 max.	3.0 max.
Slump, in.	3±1/2	3±1/2	3±1/2	100% of Control to 8 max.	3±1/2