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DIVISION OF ENGINEERING SERVICES
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METHOD OF TEST FOR CEMENT CONTENT FOR PORTLAND CEMENT CONCRETE PAVEMENTS

A. SCOPE

This test method describes the procedure for determining the cement needed in pavement concrete with a given source of aggregate to comply with the design criteria.

B. REFERENCES

AASHTO T 97 - Flexural Strength of Concrete (Using Simple Beam With Third-Point Loading)
ASTM C 39/C 39M - Compressive Strength of Cylindrical Concrete Specimens
ASTM C 143/C 143M - Slump of Hydraulic Cement Concrete
ASTM C 173/C 173M - Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C 192/C 192M - Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 231/C 231M - Air Content of Freshly Mixed Concrete by the Pressure Method
Caltrans Standard Specifications - Sections 40 and 90
California Test 206 - Specific Gravity and Absorption of Coarse Aggregate
California Test 207 - Specific Gravity and Absorption of Fine Aggregate
California Test 518 - Unit Weight of Fresh Concrete

C. APPARATUS

1. A power driven concrete mixer capable of thoroughly mixing batches of the prescribed size.

2. Concrete beam molds with nominal dimensions of 6 in. × 6 in. × 20 in.

3. Concrete cylinder molds with nominal dimensions of 6 in. dia × 12 in. length.

4. A testing machine and fixture in accordance with AASHTO T 97.

5. A testing machine in accordance with ASTM C 39/C 39M.

6. Tamping rod: a round, straight steel rod with a diameter of $\frac{5}{8}$ in. ± $\frac{1}{16}$ in. and length of at least 4 in. greater than the depth of the measure in which rodding is to be performed, but not more than 24 in. One or both ends of the tamping rod must be rounded to a hemispherical tip of the same diameter as the rod.

7. A hardwood strike-off tool with approximate dimensions of ¾ in. × 1½ in. × 12 in.

8. Scoops, trowels and sponges.

D. SAMPLING

1. Before sampling aggregate materials for this test, perform all other routine aggregate tests to assure that the aggregate passes the applicable specifications.

Aggregate sampled for testing should be of essentially the same character and quality as that proposed for the pavement.

2. Obtain a representative sample of the aggregate that will yield the following minimum quantities:

Size	Weight
1½ in. × 1 in.	500 lb
1 in. × ¾ in.	300 lb
¾ in. × ⅜ in.	500 lb
⅜ in. × No. 4	150 lb
Passing No. 4	1000 lb

NOTE: Obtaining a sample of coarse aggregate of representative gradation is not of prime importance since the material is separated into individual size fractions and recombined for the test concrete.

E. LABORATORY PREPARATION

1. Perform the following tests on representative portions of the coarse and fine aggregate:

   a. California Test 206

   b. California Test 207

2. Air dry the remainder of the aggregate and then separate this material by sieving on the following individual sieve sizes: 1½ in., 1 in., ¾ in., ⅜ in., No. 4, No. 8, No. 16, No. 30, and No. 50. The passing No. 4 portion need not be separated if the required grading can be achieved.

3. The cement used in the testing program shall conform to the Caltrans Standard Specifications for Type II Modified, and shall be composed of a blend of equal parts produced by the following five mills:

   a. Lehigh Southwest Cement (Permanente)
   Cupertino, California

   b. Lehigh Southwest Cement
   Redding, California

   c. CEMEX
   Victorville, California

   d. TXI Riverside Cement
   Oro Grande, California

   e. CalPortland Cement Co.
   Mojave, California

F. MIX DESIGN

1. Design the test concrete mixes at cement contents of 5, 5½, and 6 sacks per cubic yard. Except when concrete is used in freeze-thaw areas, then design the test concrete mixes at cement contents of 6 and 6½ sacks per cubic yard.

2. The concrete test slump shall be 2½ in. ± ½ in.

   NOTE: The 2½ in. slump is considered to simulate specification concrete in the field at point of delivery.

3. Use a Vinsol resin type air-entraining admixture in all mixes to impart 3½ % ± ½ % total air, except that the total air content must be 5½ % ± ½ % for concrete used in freeze-thaw areas. Where the total air content in this test method differs from the total air content in the current Caltrans Standard Specifications, then the total air content specified in the latter shall prevail.

4. Use a combined grading for the test concrete within the following limits:

Sieve Size	% Passing
1½ in.	100
1 in.	72-78
¾ in.	59-65
⅜ in.	44-50
No. 4	35-41
No. 8	25-35
No. 16	18-28
No. 30	12-20
No. 50	5-9
No. 100	1-3
No. 200	0-2

G. TESTING PROGRAM

1. Prepare three batches of concrete for each mix design, each on a separate day. Make each batch large enough to produce two 6 in. × 6 in. × 20 in. beams, and two 6 in. dia. × 12 in. cylinders, leaving an excess of about 10 % of the total size of the batch after molding the specimens. Make the 5 sack batch (or the 6 sack batch in freeze-thaw areas) large enough to produce one 4 in. × 5 in. × 18 in. shrinkage bar per batch in addition to the above beams and cylinders.

2. Mix the concrete in accordance with ASTM C 192/C 192M.

3. Measure the slump in accordance with ASTM C 143/C 143M to the nearest ¼ in. Determine the density per California Test 518. Measure the air content in accordance with ASTM C 231/C 231M or ASTM C 173/C 173M.

   NOTE: If air content is measured by ASTM C 173/C 173M, the batch size must be increased by the volume used in the test.

4. Fabricate test specimens in accordance with ASTM C 192/C 192M.

5. Protect the specimens from loss of moisture by the use of wet blankets for beams and shrinkage bars, and by the use of lids on cylinder cans, for a period of

24 hr ± 4 hr. At that time, remove the specimens from the molds and place them in a moist curing room.

6. Remove the beams and cylinders from the curing room at an age of 14 d and perform the appropriate tests. Test the flexural beams for modulus of rupture in accordance with AASHTO T 97.

7. Cure the shrinkage bars in the moist room for 7 d and then place them in a drying room (50 % ± 4 % RH, 73.4°F ± 3°F) for 28 d. Make length and mass measurements at ages of 1, 7, 14, 21, and 35 d.

8. Record complete test results, including averages of all test information, on a laboratory work card.

H. CRITERIA FOR RECOMMENDING CEMENT CONTENT

1. Assuming a coefficient of variation, V, of 15 %, and a willingness to accept a probability that four out of five, or 80 % of the test results will be 550 psi or greater, the average 28 d modulus of rupture would have to be 630 psi using third-point loading. Since it is desirable and practical to reduce the time required for the laboratory test as much as possible, a 14 d strength will be used. Again, assuming a 15 % increase in concrete strength in the period from 14 to 28 d, the average 14 d strength, as determined in the laboratory, should be 550 psi. Therefore, the recommended cement content is that cement content (½ sack increments) which will produce an average 14 d laboratory modulus of rupture of at least 550 psi.

2. The recommended cement content shall be such that the water-cement ratio will not exceed 52 lb per sack, except in freeze-thaw areas, where it will not exceed 48 lb per sack, as determined in the testing program.

I. REPORTING RESULTS

1. Include in the test report tabulation as shown by the example below:

Cement Content (Sks/CY)	Slump, in. (Avg. of 3)	% Air (Avg. of 3)	W/C (lb/Sk) (Avg. of 3)	14 day Compr. Str., (psi) (Avg. of 6)	14 day Mod. of Rupture, (psi) (Avg. of 6)
5	2 ½	3.4	52.4	2720	490
5 ½	2 ¾	3.2	50.1	3230	560
6	2 ½	3.2	48.6	3490	600

2. Also include in the test report a statement as follows:

"Based on the data obtained from California Test 536, the minimum recommended cement content for paving concrete using the aggregate indicated above is ___sacks per cubic yard. If other sources of aggregate are used or intermingled, additional testing will be required."

J. SAFETY AND HEALTH

It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Prior to handling, testing or disposing of any materials, testers must be knowledgeable about safe laboratory practices, hazards and exposure, chemical procurement and storage, and personal protective apparel and equipment.

Caltrans Laboratory Safety Manual is available at:

http://www.dot.ca.gov/hq/esc/ctms/pdf/lab_safety_manual.pdf

End of Text
(California Test 536 contains 5 Pages)