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METHOD FOR DETERMINING CEMENTITIOUS MATERIALS CONTENT OR WATER/CEMENTITIOUS MATERIAL RATIO FOR CONCRETE PAVEMENTS

A. SCOPE

This test method describes the procedure for determining cementitious materials content or water to cementitious material ratio for pavement concrete for a specific cementitious material, admixture, and aggregate materials combination to comply with a design criterion.

B. REFERENCES

AASHTO T 97 - Flexural Strength of Concrete (Using Simple Beam with Third Point Loading)
ASTM C39/C39M - Compressive Strength of Cylindrical Concrete Specimens
ASTM C138/C138M - Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
ASTM C143/C143M - Slump of Hydraulic Cement Concrete
ASTM C173/C173M - Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C192/C192M - Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231/C231M - Air Content of Freshly Mixed Concrete by the Pressure Method
California Test 202 - Sieve Analysis of Fine and Coarse Aggregates
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
Caltrans Standard Specifications - Section 40 Concrete Pavement and Section 90 Concrete

C. APPARATUS

1. A power-driven concrete mixer capable of thoroughly mixing batches of prescribed size.
2. Concrete beam molds with nominal dimensions of 6 in. × 6 in. × 20 in.
3. A testing machine and fixture conforming to AASHTO T 97.
4. Tamping rod: a round, straight steel rod with a diameter $\frac{5}{8}$ in. \pm $\frac{1}{16}$ 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.
5. Vibrators may be internal or external. Internal vibrators shall have a frequency of vibration of at least 7000 vibrations per min or greater while in use. The outside diameter or side dimension of the vibrating element shall be at least $\frac{3}{4}$ in. and not greater than 1 $\frac{1}{2}$ in. The combined length of the shaft and vibrating element shall exceed the maximum depth of the section being vibrated by at least 3 in. External vibrators may be of two types: table or plank. The frequency for external vibrators

shall not be less than 3600 vibrations per min, and preferably higher. For both table and plank vibrators, provision shall be made for clamping the mold securely to the apparatus.

6. A hardwood strike-off tool with approximate dimensions of $\frac{3}{4}$ in. \times $1\frac{1}{2}$ in. \times 12 in., scoops, trowels, and sponges.

D. SAMPLING

1. Determine that the aggregate materials for this test conform to the applicable specifications. Aggregate, cementitious materials, and chemical admixtures sampled for testing shall be of the same character, quality, and source as that proposed for the pavement. The combination of materials shall be those proposed for the work.
2. Obtain a representative sample of the aggregate, cementitious materials, and chemical admixtures that will yield sufficient quantities for the proposed batch sizes.

E. PREPARATION OF MATERIALS

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

1. California Test 206.
2. California Test 207.
3. California Test 202.
4. Before mixing the concrete, bring all materials to a temperature in the range of 68 to 86°F.
5. Cementitious materials – Store them in a dry place, in moisture-proof containers. Each cementitious material shall be thoroughly mixed to ensure uniformity during testing.
6. Aggregates – Air dry the aggregate, and then separate the material by sieving on the following individual sieve sizes: $1\frac{1}{2}$ in., 1 in., $\frac{3}{4}$ in., $\frac{1}{2}$ in., No. 4, No. 8, No. 16, No. 30, No. 50. Fine aggregate need not be separated provided it is maintained in a damp condition, with no visible free draining water.

Before incorporating into the concrete, prepare the aggregate to ensure a uniform condition of moisture. Prior to weighing the aggregate for use, moisture condition the aggregate by one of the following procedures:

- a. The aggregate shall be brought to and maintained in a saturated condition, with surface moisture in sufficiently small amounts to preclude loss by draining, at least 24 hr prior to use. When this method is used, the moisture content of the aggregate must be determined to permit calculation of proper quantities of the damp aggregate. The quantity of surface moisture present must be counted as part of the required amount of mixing water.

- b. Aggregates, fine or coarse, shall be brought to and maintained in a saturated surface-dry condition until weighed for use. Care must be taken to prevent drying during weighing and use.
7. Admixtures – Powdered admixtures that are entirely or largely insoluble, that do not contain hygroscopic salts, and are less than 10 % of the mass of the cementitious materials shall be mixed with a portion of the cementitious material before introduction of the batch to the mixer. Essentially, insoluble materials that are used in amounts exceeding 10 % by mass of cement, such as pozzolans, shall be handled and added to the batch in the same manner as cement. Powdered admixtures, which are largely insoluble but contain hygroscopic salts, shall be mixed with the sand. Water soluble admixtures shall be added to the mixer in solution in a portion of the mixing water. The quantity of such solution used must be included in the calculation of the water content of the concrete. Liquid admixtures shall not be intermixed prior to their addition to the concrete.

NOTE: The time, sequence, and method of adding some admixtures to a batch of concrete can have important effects on concrete properties such as time of set and air content. The method selected must remain unchanged from batch to batch.

F. TRIAL MIXTURES

Trial Mixtures for paving concrete shall be made using at least three different water to cementitious materials ratios or cementitious materials contents that will produce a range of strengths encompassing the specified strength.

1. Trial mixtures shall be designed to produce a slump of 1 in. to 1½ in., and for air entrained concrete, within ± 0.5 % of the maximum allowable air content. Mix the concrete in accordance with ASTM C192/C192M.
2. For each water to cementitious materials ratio or cementitious materials content, fabricate at least three beams (6 in. × 6 in. × 20 in.) for each test age.
3. Calculations – Calculate density, cement content, water to cementitious material ratio, and modulus of rupture at each age. Plot a curve showing the relationship between water to cementitious materials ratio (or cementitious materials content) and flexural strength at each age.
4. The maximum water to cementitious materials ratio or minimum cementitious materials content for paving concrete shall be such as to meet or exceed that specified or desired at the age of interest. The selected cementitious content shall be such that the water to cementitious material ratio does not exceed 0.55, except in freeze-thaw areas, where it shall not exceed 0.51.

Tabulate test results as shown by the example in Figure 1.

G. PROCEDURE

1. Mixing Concrete – Mix concrete in a suitable mixer in batches of such size as to leave about 10 % excess after molding test specimens. Hand mixing shall not be permitted. Prior to starting rotation of the mixer, add the coarse aggregate and

about 60 to 80 % of the mixing water. Start the mixer, and then add the fine aggregate, air entraining agent, powdered admixtures, cement, liquid admixtures, and water while the mixer is running. The batch water may be added incrementally during mixing to adjust to the desired slump. Mix the concrete after all ingredients are in the mixer for 3 min, followed by 3 min rest, followed by 2 min of final mixing. Cover the open end or top of the mixer to prevent evaporation during the rest period. Take precautions (such as “buttering” the mixer) to compensate for mortar retained by the mixer so that the discharged batch, as used, will be correctly proportioned.

2. Testing Fresh Concrete:
 - a. Slump or penetration – Measure the slump or penetration of the concrete immediately after mixing in accordance with ASTM C143/C143M or California Test 533, respectively.
 - b. Air content – Determine the air content in accordance with either ASTM C231/C231M or ASTM C173/C173M.

NOTE: ASTM C231/C231M shall not be used with aggregates of high porosity. Discard the concrete used in the determination of air content.
 - c. Density and yield – Determine the density and yield of each batch of concrete in accordance with ASTM C138/C138M.
 - d. Temperature – Determine the temperature of each batch of concrete in accordance with ASTM C1064/C1064M.
3. Fabricating and Curing Test Specimens – Fabricate and cure test specimens in accordance with ASTM C192/C192M.
4. Testing Beams – Test the flexural beams for modulus of rupture in accordance with AASHTO T 97.

H. REPORTING RESULTS

The test report shall include, at a minimum, the following:

1. Record complete test results, including aggregate properties, slump, air content, unit weight, and flexural strength for each specimen.
2. A graph of age versus flexural strength.
3. A graph showing the selection and criterion for water/cementitious material ratio.
4. Name of tester and date test performed.

I. HEALTH AND SAFETY

Freshly mixed concrete is an alkaline material and can cause dryness of the skin, dermatitis, or chemical burns. Wear rubber gloves for protection.

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.

Users of this method do so at their own risk.

**End of Text
(California Test 559 contains 7 pages)**

Cementitious material content, lb/yd ³	Slump, in	Air, %	W/C	7-day modulus of rupture, psi (Average of 3)	14-day modulus of rupture, psi (Average of 3)	28-day modulus of rupture, psi (Average of 3)	42-day modulus of rupture, psi (Average of 3)
500	1.50	3.4	0.52	270	410	570	605
550	1.00	2.6	0.46	355	484	629	660
600	1.25	2.7	0.43	445	531	666	701

FIGURE 1. Tabulation of Data for Mixes with Increasing Cementitious Material Content

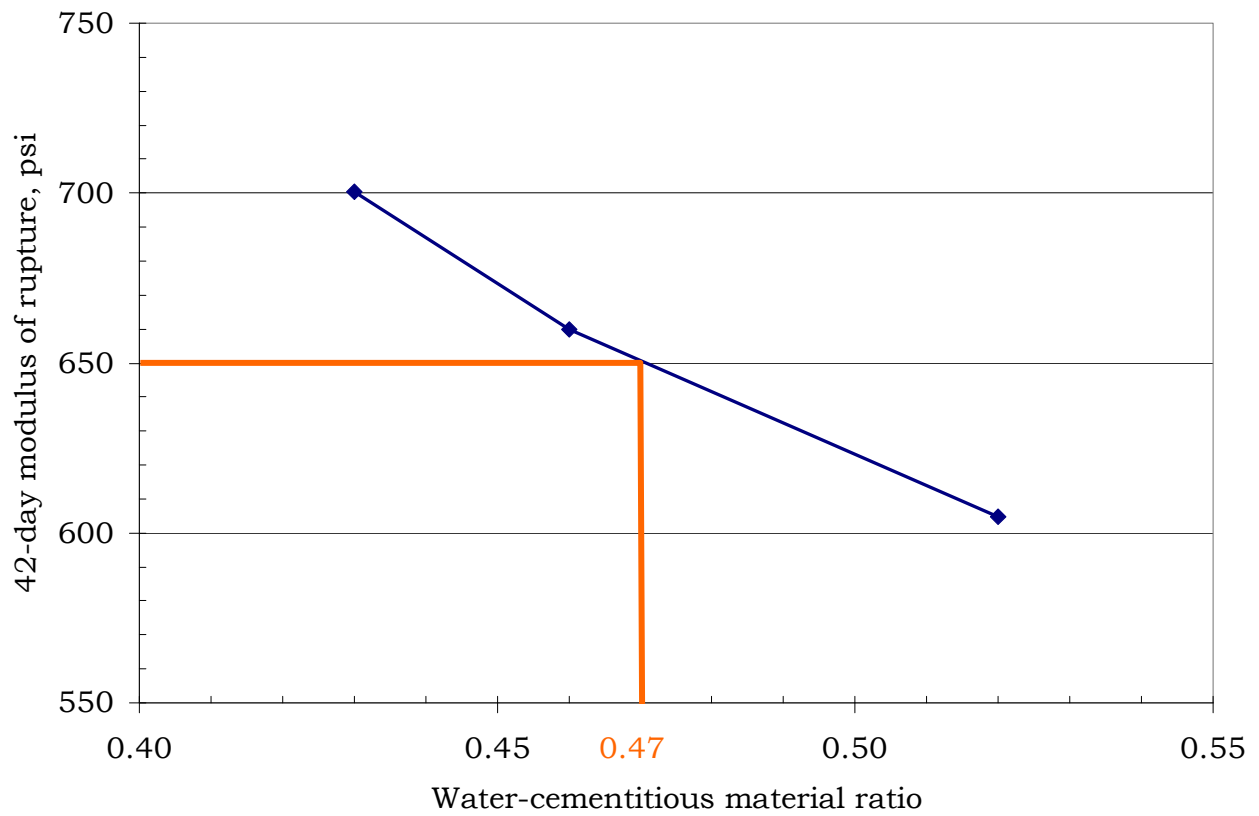


FIGURE 2. Water/Cementitious Material Ratio vs. Flexural Strength