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METHOD OF TEST FOR EVALUATION OF AGGREGATE FOR LEAN CONCRETE BASE (LCB)

A. SCOPE

This test method describes the procedure for (1) evaluating the strength producing properties of aggregate for use in lean concrete base (LCB), and (2) determining the amount of portland cement needed in LCB to achieve the compressive strength design criteria with a given source of aggregate.

B. REFERENCES

ASTM C 143/C 143M - Slump of Hydraulic-Cement Concrete
ASTM C 192/C 192M - Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 617/C 617M - Capping Cylindrical Concrete Specimens
California Test 201 - Soil and Aggregate Sample Preparation
California Test 206 - Specific Gravity and Absorption of Coarse Aggregate
California Test 208 - Apparent Specific Gravity of Fine Aggregates
California Test 504 - Determining Air Content of Freshly Mixed Concrete by the Pressure Method
California Test 518 - Unit Weight of Fresh Concrete
California Test 521 - Compressive Strength of Molded Concrete Cylinders
California Test 543 - Determining Air Content of Freshly Mixed Concrete by the Volumetric Method

C. MATERIALS

1. Aggregate shall be representative of that to be used on the job.
2. Cement for the tests shall be the same brand as to be used in the proposed work, if available.

If not available, cement conforming to the Caltrans Standard Specifications for Type II Modified may be used.

D. EQUIPMENT

1. Cylinder Molds: 6 in. dia × 6 in. high
2. Unit Weight Measure
3. Slump Cone
4. Air Meter
5. Tamping Rod: A round, straight steel rod with a diameter of $\frac{5}{8}$ 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.

6. Concrete Mixer: A power-driven revolving drum tilting mixer, revolving pan, or revolving paddle mixer capable of thoroughly mixing batches of the prescribed sizes at the required slump.

E. PROCEDURE

1. Design the lean concrete base at 255, 285 and 315 lb of cement per cubic yard. The size of the batch shall be at least 0.4 cu. ft. or a minimum of 50 % the capacity of the mixer, whichever is larger.
2. Prior to batching the test mixes, combine and thoroughly mix all materials of each primary size as submitted from the job. Quarter or split into design batch quantities using accepted procedures outlined in California Test 201 (Section J).
3. Prepare three separate batches for each mix design.

NOTE: The intent is to have 3 batches mixed with cement content below the specified minimum, 3 above the specified maximum, and 3 in-between the specified limits. If the distribution of the actual cement contents calculated (Section G below) does not meet this distribution, make additional batches until there are at least 3 in each cement content category. Do not discard any data except as described in Section H below.

4. Mix each batch according to established laboratory procedure (ASTM C 192/C 192M).

Prior to starting rotation of the mixer, add the aggregate, some of the mixing water, and the solution of admixture. Admixtures shall be dispersed in about one-half of the mixing water before addition. Start the mixer, then add the cement and remaining water with the mixer running. If it is impractical to add the cement and water while the mixer is running, these components may be added to the stopped mixer after permitting it to turn a few revolutions following charging with aggregate and some of the water. Mix the concrete, after all ingredients are in the mixer, for 3 min followed by 3 min rest, followed by 2 min final mixing. Cover the open end or top of the mixer to prevent evaporation during the rest period. Take precautions to compensate for mortar retained by the mixer so that the discharged batch, as used, will be correctly proportioned. To eliminate segregation, deposit machine-mixed concrete in a clean, damp mixing pan and remix by shovel or trowel until it appears to be uniform.

It is difficult to recover all of the mortar from mixers. To compensate for this difficulty, the following procedure may be used to ensure the correct final proportions in the batch.

Just prior to mixing the test batch, the mixer is “buttered” by mixing a batch proportioned to simulate closely the test batch. The mortar adhering to the mixer after discharging is intended to compensate for loss of mortar from the test batch.

5. Adjust the water content to obtain a slump of $2\frac{1}{2}$ in. \pm $\frac{1}{2}$ in. (ASTM C 143/C 143M).
6. Adjust the amount of air-entraining admixture to result in an air content of $3\frac{1}{2}\%$ \pm $1\frac{1}{2}\%$ in accordance with California Test 504 or California Test 543, the latter to be used with slag or other highly porous aggregates.

7. Determine Unit Weight of the fresh concrete in accordance with California Test 518.
8. Fabricate a minimum of three cylinders for 7-day tests. Additional cylinders may be fabricated for special tests from the remaining mixture if desired.
 - a. Filling and compacting with a tamping rod:
 - (1) Place the measure on a level, firm surface.
 - (2) Using a scoop, fill the measure in 2 layers of equal depth. Move the scoop around the perimeter of the measure opening to ensure an even distribution of the material with minimal segregation. Fill the topmost layer to overflowing. Level the surface of each layer with the fingers prior to tamping.
 - b. Rod each layer 25 times with the rounded end of the tamping rod, distributing the strokes evenly over the surface of the layer.
 - c. While rodding the first layer, penetrate nearly full depth into the layer, but avoid striking the bottom of the base.
 - d. While rodding the second layer, penetrate approximately 1 in. into the layer below with each stroke.
 - e. After each layer is rodded, tap the sides of the measure with a hand or stake or jig the measure (this will be determined by container or process) using such force so as to close any voids left by the tamping rod and to release any large bubbles of air that may have been trapped.
 - f. Level the surface of the compacted aggregate with the fingers or a straightedge in such a way that any slight projections of the larger pieces of coarse aggregate approximately balance the larger voids in the surface below the top of the measure.
9. After the top layer has been rodded and the sides of the mold patted, strike off the surface of the concrete even with the top edge of the mold. Wipe the sides of the mold free of excess concrete and place lid on the can to prevent evaporation.

F. HANDLING OF SPECIMENS

1. Store specimens in a vibration free environment at $73^{\circ}\text{F} \pm 3^{\circ}\text{F}$ for approximately 24 hr.
2. On the day after fabrication ($24 \text{ hr} \pm 4 \text{ hr}$), remove lids and place specimens in a moist room or cabinet or in saturated limewater. DO NOT ATTEMPT TO REMOVE MOLDS PRIOR TO OR DURING THE MOIST CURE PERIOD.
3. At the age of 7 days after fabrication, remove the specimens from moist curing, strip from molds, cap in accordance with ASTM C617/C617M and test in compression in accordance with California Test 521. Use care in handling the specimens.

G. CALCULATIONS

1. The volume of LCB, S, per batch is calculated as follows:

$$S = \frac{(W_a + W_f + W_c + W_w)}{W}$$

Where:

S = Volume of concrete per batch in cubic feet.

W_a = Total weight of cement in the batch in pounds.

W_f = Total weight of fine aggregate, including moisture as batched, in pounds.

W_c = Total weight of coarse aggregate, including moisture as batched, in pounds.

W_w = Total weight of water added during mixing per batch, in pounds

W = Unit weight of the fresh LCB as determined under E.7. above, in pounds per cubic foot

2. Cement Content:

The cement content, "CC", in pounds per cubic yard of LCB produced is calculated as follows:

$$CC = \left(\frac{N}{S}\right) * 27$$

Where:

CC = The cement content in pounds per cubic yard

N = The weight of cement in the batch, in pounds

S = Volume of LCB produced per batch in cubic feet as determined in G.1. above

3. Compressive Strength:

Calculate the compressive strength as the average of the three LCB cylinders tested. Round off test results to two significant figures. Do not make any compressive strength corrections for LCB specimen lengths.

H. EVALUATING THE AGGREGATE FOR SPECIFICATION COMPLIANCE

1. Record all LCB test results as shown in Table 1.
2. Prepare a graph using the data as illustrated in Figure 1. Plot individual compressive strengths (ordinate) versus portland cement content (abscissa).
3. Calculate a least square best fit line by linear regression, using all available data points.
4. Plot the regression line on the graph.

5. Examine the graph for any outlying data points that obviously do not fit the trend. Eliminate outliers from the data and recalculate the regression line.
6. Plot the specification requirement for strength vs. cement content (aggregate qualification point).
7. If the point established in H.6. is on or below the line established in H.4. or H.5., the aggregate complies with the specification. If it is above the line, the aggregate does not meet the specification.

NOTE: Use the graph format shown in Figure 1.

**I. DETERMINING RECOMMENDED MINIMUM CEMENT CONTENT
(For aggregate complying with specification requirements)**

1. Determine the point where the design strength intersects the strength curve.
2. Read the cement content on the abscissa.
3. Increase this cement content to the next higher multiple of 10 pounds. This is the recommended minimum cement content for LCB to be reported.
4. Alternatively, insert the design compressive strength into the regression equation calculated in Part H above to determine the corresponding portland cement content and round up as in I.3. above.

J. REPORTING OF RESULTS

The test report shall include:

1. A statement as to aggregate compliance to specifications.
2. Recommended minimum cement content for LCB.
3. Summary of all test data and mix design information.
4. Copy of graph used to determine the cement content.

K. PRECAUTIONS

Portland cement, when mixed with water, makes an alkaline solution. Contact with the skin can cause drying and cracking. Take care to prevent skin contact by wearing impervious gloves. If skin contact occurs, wash promptly with soap and water.

Mixing and fabricating concrete specimens often involves lifting and stooping. Use proper lifting practices to prevent injury.

L. HEALTH AND SAFETY

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

Users of this method do so at their own risk.

**End of Text
(California Test 548 contains 7 pages)**

Aggregate Source	Dist. Co. Rte	Date
	Contract	

RESULTS OF TESTS ON LEAN CONCRETE BASE

ALL VALUES ARE AVERAGE RESULTS OF _____ ROUNDS OF TESTS

Mix No.	Unit Weight lb/ft ³ (fresh)	Slump in.	% Air Content	Cement Content lb/yd ³	Compressive Strength 7d
260A	142	2.50	1.5	260.70	608
260B	147	2.75	3.1	259.70	775
260C	149	2.50	2.5	260.10	1138
285A	146	3.15	2.9	285.70	585
285B	147	2.50	2.0	286.20	783
285C	149	2.75	2.7	285.60	910
310A	143	3.00	3.2	309.90	589
310B	146	2.75	3.0	310.50	679
310C	143	2.50	3.1	309.40	1109

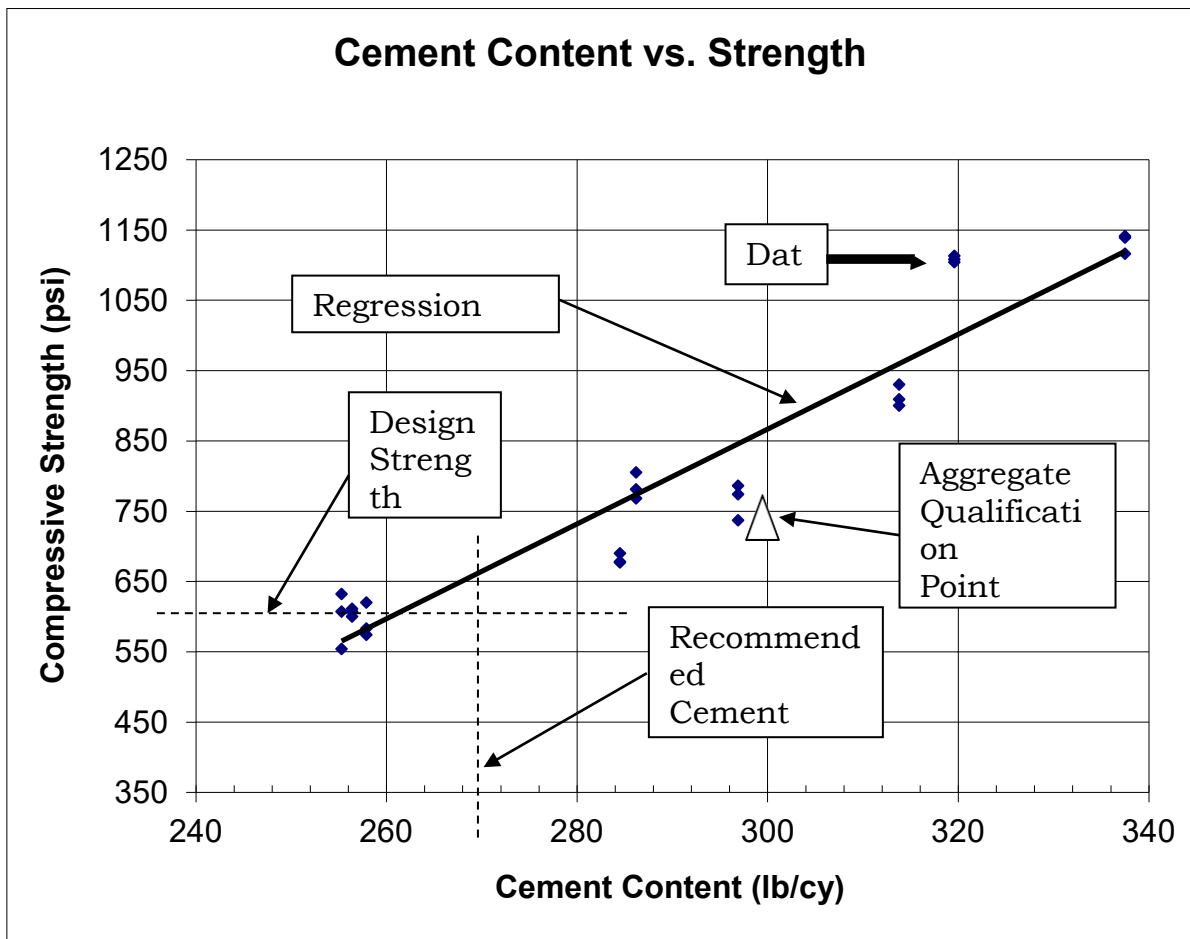


FIGURE 1. Graph For Evaluating Aggregate And Determining Minimum Cement Content