DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION
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California Test 312
1978

DESIGN AND TESTING OF CLASSES "A" AND "B" CEMENT TREATED BASES

A. SCOPE

The procedure for determining the proper cement and moisture contents to be combined with available aggregates in the preparation of cement treated bases is described in this test method. Procedures for determining compressive strengths of test specimens and for determining relative compaction of cement treated bases are also described.

This test method is divided into the following parts:

I. Preparing Laboratory Processed Materials.
II. Field Sampling and Preparation Procedures.
III. Fabricating and Curing Test Specimens.
IV. Determining Optimum Moisture, Cement Content and Test Maximum Density.
V. Determining Compressive Strength.
VI. Calculating Percent Relative Compaction.

PART I. PREPARING LABORATORY PROCESSED MATERIALS

A. SCOPE

The preparation of aggregates and the batching and mixing of materials for fabricating compressive strength test specimens is described in this part.

B. APPARATUS

1. Scales, 5,000 gram capacity, accurate to 1 gram.
2. Water spray metering device with turntable.
3. Mixing pan and trowel or spoon.

C. PREPARING LABORATORY PROCESSED MATERIALS

1. Aggregate samples submitted for cement treatment tests are divided into three categories:

a. Processed. Materials which will not be subjected to any further processing prior to mixing with cement, such as bin samples, windrow samples and some stockpile samples.
b. Unprocessed. Materials which will require additional processing to attain a satisfactory grading such as pit samples, quarry samples and some stockpile samples which require scalping, crushing, blending, etc.
c. In-place. Materials which are part of an existing road which will be scarified, pulverized and mixed with cement.

2. Initial preparation of all samples is to be done in accordance with California Test 201, except that in-place materials containing lumps of bituminous mix should have the lumps reduced in size to pass a one-inch sieve and no sieve analysis is required.

3. Determine the moisture content of representative samples of coarse and fine aggregates according to the procedures described in California Test 226.

4. Determine the desired grading for the sample.

a. The grading as determined on a sample prior to any adjustment such as scalping, wasting or crushing, is known as the "as received" grading. Before a material can be tested, it is often necessary to adjust the grading either to meet specifications or to eliminate material too large to test. This adjusted grading is referred to as the "as used" grading. See California Test 105 for methods of adjusting grading. In cases where 100 percent of the material as received passes the 1 inch sieve and no adjustments are necessary, the "as received" and the "as used" gradings will be the same.
b. Using the sieve analysis of the sample or samples to be tested, design the mix to conform to the specified grading limits by blending or adjusting as necessary. Designing to a smooth grading curve approximately in the middle of a specified range is desirable but not always essential. General practice is to produce the best possible grading within the specification limits with the material on hand, but any adjustment should be such that it can be duplicated under actual field conditions.
c. In cases where an aggregate size larger than 1 inch maximum is specified, waste (scalp) the aggregate retained on the 1 inch sieve.

5. Estimate the required amount of material necessary to fabricate a 4 inch diameter x 4 inch high test specimen.

a. Most well graded aggregates have dry densities within the range of 130 to 145 pounds per cubic foot. Density of the aggregate can be estimated fairly close with some experience.
b. To convert the estimated density to total

weight, in grams, of aggregate and cement required for a 4 inch x 4 inch test specimen, the following formula may be used: $W_g = 13.2\ W_f$

W_g = Dry weight in grams of 4 inch x 4 inch compacted test specimen.

W_f = Dry density in pounds per cubic foot of compacted test specimen.

13.2 = Constant used to convert pounds per cubic foot to weight in grams for a 4 inch diameter by 4 inch high specimen.

Example:

Assume a density of 130 pounds per cubic foot for a trial specimen. Substituting in the above formula,

$W_g = 13.2 \times 130 = 1716$ g.

This weight includes the weight of cement as well as the weight of the aggregate. The following formula is used to calculate the weight of the aggregate only.

$$W_a = [W_g / (100 + C)] \times 100$$

Where:

W_a = Dry weight of aggregate.

W_g = Dry weight of aggregate + cement.

C = Percent of cement in the mix.

Using a total dry weight of 1716 g. and a cement content of 5 percent, substitute in above formula.

$W_a = [1716/(100 + 5)] \times 100$

$= 1634$ g. of aggregate.

Subtracting the aggregate weight from the total dry weight gives the weight of cement.

$1716 - 1634 = 82$ g. of cement.

c. In order to simplify the procedure for calculating the amount of aggregate and cement to be used in fabricating one 4 inch x 4 inch test specimen, Table 1 is provided. This table gives dry weights of materials in grams required to produce one 4 inch x 4 inch test specimen with cement contents varying from 2 percent to 8 percent by weight, and densities varying from 107 to 150 pounds per cubic foot. If quantities of material are needed to make specimens with a density lower than 107 or higher than 150 pounds per cubic foot the above formula must be used. All the specimens shall have a measured height after compaction of 4.000 ± 0.200 inches.

To obtain weight of aggregate, subtract weight of cement from total weight of cement and aggregate.

Example:

Assume a dry density of 130 lb. per cu. ft. and a cement content of 5 percent. From Table 1,

Weight per cu. ft.	*Grams of cement and aggregate*	*Grams of Cement*
130	1,716	82

Weight of aggregate = 1,716 − 82 = 1,634 g.

6. Convert the desired grading of the material to percent of the sample in each increment size.

Sieve Size	*Percent Passing*	*Increment Size*	*Percent of Sample*
1"	100	1" × ¾"	4
¾"	96	¾" × ½"	6
½"	90	½" × ⅜"	10
⅜"	80	⅜" × No. 4	20
No. 4	60	Pass No. 4	60

7. Calculate the required dry weights of each increment size on the basis of the total weight estimated in Section C-5.

Increment Size	*Percent of Sample*		*Total Dry Wt. in Grams*		*Wt. of each Increment Size in Grams*
1" × ¾"	4 × .01	×	1634	=	65
¾" × ½"	6 × .01	×	1634	=	98
½" × ⅜"	10 × .01	×	1634	=	163
⅜" × No. 4	20 × .01	×	1634	=	327
Pass No. 4	60 × .01	×	1634	=	981
Total	100				1634

8. Adjust the batch weights to compensate for the moisture in the material and record the cumulative weights.

Increment Size	*Wt. of Each Increment Size in Grams*	*% Moisture*	*Adjusted Wt. in Grams*	*Cumulative Batch Wt. in Grams*
1" × ¾"	65	.8	66	66
¾" × ½"	98	.8	99	165
½" × ⅜"	163	.8	164	329
⅜" × No. 4	327	.8	330	659
Pass No. 4	981	1.2	993	1652

9. Separate the passing No. 4 material into representative portions of the approximate quantity needed for each specimen. Weigh out the exact amount of passing No. 4 material according to the batch weights calculated in Section C-8.

10. Recombine the coarse and fine aggregates according to the batch weights calculated in Section C-8.

TABLE 1
TABLE OF WEIGHTS FOR USE IN FABRICATING 4-IN. DIAM. × 4-IN. HIGH TEST SPECIMENS OF VARIOUS WEIGHTS PER CU. FT.

Pounds per cubic foot	Total grams cement + agg.	Grams cement						
		2 per-cent	3 per-cent	4 per-cent	5 per-cent	6 per-cent	7 per-cent	8 per-cent
107	1,412	28	41	54	67	80	92	105
108	1,426	28	42	55	68	81	93	106
109	1,439	28	42	55	69	82	94	107
110	1,452	29	42	56	69	82	95	108
111	1,465	29	43	56	70	83	96	109
112	1,478	29	43	57	70	84	97	109
113	1,492	29	44	57	71	85	98	110
114	1,505	30	44	58	72	85	99	111
115	1,518	30	44	58	72	86	99	112
116	1,531	30	45	59	73	87	100	113
117	1,544	30	45	59	74	87	101	114
118	1,558	31	45	60	74	88	102	115
119	1,571	31	46	60	75	89	103	116
120	1,584	31	46	61	75	90	104	117
121	1,597	31	47	61	76	90	105	118
122	1,610	32	47	62	77	91	105	119
123	1,623	32	47	62	77	92	106	120
124	1,637	32	48	63	78	93	107	121
125	1,650	32	48	64	79	93	108	122
126	1,663	33	49	64	79	94	109	123
127	1,676	33	49	65	80	95	110	124
128	1,690	33	49	65	81	96	111	125
129	1,703	33	50	66	81	96	111	126
130	1,716	34	50	66	82	97	112	127
131	1,729	34	50	67	82	98	113	128
132	1,742	34	51	67	83	99	114	129
133	1,756	35	51	68	84	99	115	130
134	1,769	35	52	68	84	100	116	131
135	1,782	35	52	69	85	101	117	132
136	1,795	35	52	69	86	102	118	133
137	1,808	36	53	70	86	102	118	134
138	1,822	36	53	70	87	103	119	135
139	1,835	36	53	71	87	104	120	136
140	1,848	36	54	71	88	105	121	137
141	1,861	37	54	72	89	105	122	138
142	1,874	37	55	72	89	106	123	139
143	1,888	37	55	73	90	107	124	140
144	1,901	37	55	73	91	108	124	141
145	1,914	38	56	74	91	108	125	142
146	1,927	38	56	74	92	109	126	143
147	1,940	38	57	75	92	110	127	144
148	1,954	38	57	75	93	111	128	145
149	1,967	39	57	76	94	111	129	146
150	1,980	39	58	76	94	112	130	147

11. Mix the individual test specimens in the following manner:

a. Mix together the proper proportion of aggregates and cement prior to adding water. After the dry ingredients are thoroughly mixed, add the required amount of water and continue mixing until all of the aggregates are coated. The required amount of water to be added to the aggregates and cement is determined by the procedures outlined in Part IV.

b. Any mechanical mixer which will produce a homogeneous mix may be used, or the materials may be mixed with a trowel or spoon in a mixing pan.

c. After mixing, place the aggregate-cement-water mixture in a can and cover with a tight fitting lid for a period of one hour ± 15 minutes before compacting the individual test specimens.

12. Figure 1 shows a sample form for calculating batch weights and for recording fabrication data.

PART II. FIELD SAMPLING AND PREPARATION PROCEDURES

A. SCOPE

The methods for sampling and preparing cement treated base mixtures for fabrication of test specimens are described in this part.

B. APPARATUS

1. Shovel.
2. Closed container.
3. Sieve, U.S. Standard 1 inch size.
4. Scales, 5000 gram capacity, accurate to 1 gram.

C. SAMPLING AND PREPARATION OF CEMENT TREATED BASE MIXTURE

1. Obtain a representative sample of the cement treated base mixture from the street immediately before the first pass of the roller. Obtain at least enough material to fabricate two compressive strength specimens and a moisture sample. Record the location of the sample site and the time the water, cement and aggregate were mixed.

2. Place the material in a closed container for transportation to the point of fabrication. The test specimens must be fabricated one hour ± 15 minutes after water is mixed with the cement and aggregate. When initial rolling is started more than one hour after mixing, sample the cement treated base mixture immediately before the first pass of the roller and fabricate the test specimens as soon as possible.

3. When the aggregate contains particles larger than one inch, screen the sample through a one inch sieve and discard all aggregate retained on the one inch sieve. Only the minus one inch material is used for making test specimens.

4. Obtain representative portions of material needed for a moisture determination and for fabricating two test specimens. See Part I for a description of how to estimate the weight of material needed for test specimens.

5. Carefully adjust the amount of material to obtain the weight required for each test specimen.

6. Determine the moisture content of the material according to the procedures described in California Test 226.

7. If the moisture content of the sample is not within the proper range, it should be adjusted according to the procedures described in Part IV.

8. Fabricate two test specimens according to the procedures described in Part III.

Increment Size	Percent of Sample	Total Dry Wt. gms.	Weight of Increment Size in gms.	Percent Moisture	Adjusted Weight gms.	Cumulative Batch Wt. gms.
1" x 3/4"	4 x .01	x 1634 =	65	0.8	66	66
3/4" x 1/2"	6 x .01	x 1634 =	98	0.8	99	165
1/2" x 3/8"	10 x .01	x 1634 =	163	0.8	164	329
3/8" x No.4	20 x .01	x 1634 =	327	0.8	330	659
Pass No.4	60 x .01	x 1634 =	981	1.2	993	1652

	Test Specimen	1-A							
a.	Dry Wt. Agg.	1634							
b.	Cement	3 % 49	%		%		%		
c.	Agg. & Cement (a+b)	1683							
d.	Initial Moisture	18 XXXXX		XXXXX		XXXXX		XXXXX	
e.	Added Moisture	133 XXXXX		XXXXX		XXXXX		XXXXX	
f.	Total Moisture (d+e)	9 % 151	%		%		%		
g.	Batch Wet. Wt. (c+f)	1834							
h.	Adjusted Wet Wt.	1831							
i.	Liner	81							
j.	Gross Wt. Before Comp. (h+i)	1912							
k.	Gross Wt. After Comp.	1905							
l.	Exuded Water (j-k)	7							
m.	Gage Reading	.501							
n.	Height (m+3.5)	4.001							
p.	Dry Density, pcf	127.2							
q.	Days Cured	7							
r.	Total Compressive Load	8210							
s.	Compressive Strength, psi	655							

$$\text{Dry Density} = \frac{30.3 \times \text{Adjusted Wet Wt.}}{(100 + \%\ \text{Moisture})\ \text{Height}}$$

$$\text{Compressive Strength, psi} = \frac{\text{Total Compressive Load}}{12.57}$$

or

Total Compressive Load x .08

FIGURE 1

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION

TRANSPORTATION LABORATORY

REPORT OF TESTS ON
CEMENT TREATED BASE
CONTROL SAMPLES

District 05 County Mon Route 101 P.M. 38.8/43.5

Contract Number 025234 Date 10-7-68

Material Type Cl. B CTB Sampled By D.L. Durr

Sampling Data	Test Specimen		1-A			
	Time Mixed		0830			
	Station		19+50			
	Location		35' Lt. ℄			
	Specified % Cement		3			
Moisture	a. Wet Weight		1375			
	b. Dry Weight		1290			
	c. Tare		350			
	d. Net Dry Wt.	(b-c)	940			
	e. Water	(a-b)	85			
	f. % Moisture		9.0			
Specimen Data	g. Wet Weight		1834			
	h. Adjusted Wet Wt.		1831			
	i. Liner		81			
	j. Gross Wt. before Comp.	(h+i)	1912			
	k. Gross Wt. after Comp.		1905			
	l. Exuded Water	(j-k)	7			
	m. Gage Reading		.501			
	n. Height	(m+3.5)	4.001			
	p. Density, PCF, dry ☒ wet ☐		127.2			

$$\text{Density (dry)} = \frac{30.3 \times \text{Adjusted Wet Wt.}}{(100+\%\ \text{Moisture})\ \text{Height}}$$

$$\text{Density (wet)} = \frac{0.303 \times \text{Adjusted Wet Wt.}}{\text{Height}}$$

$$\%\ \text{Moisture} = \frac{\text{Wet Wt.} - \text{Dry Wt.}}{\text{Net Dry Wt.}} \times 100$$

FIGURE 2

PART III. FABRICATING AND CURING TEST SPECIMENS

A. SCOPE

The procedures for fabricating and curing test specimens are described in this part. The procedures and equipment for use in a field construction laboratory and in a central laboratory are included.

B. APPARATUS

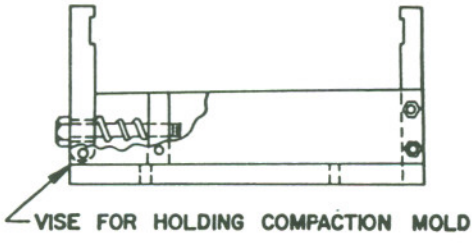
1. Compaction mold.
   a. Split compaction mold and accessories shown in Figure 3.

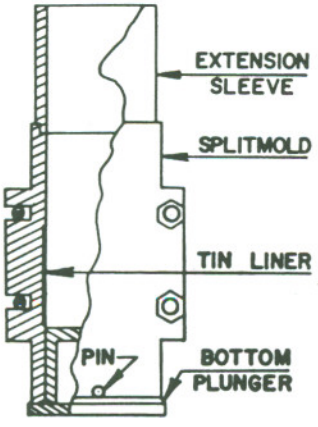
   or

   b. Solid wall compaction mold and accessories shown in Figure 4.
2. Compression testing machine.
   a. Frame and hydraulic jack shown in Figure 5 for field testing.

   or

   b. Any suitable testing machine for laboratory use.
3. Sample extractor shown in Figure 6 for use with solid wall mold.
4. Measuring gage and accessories shown in Figure 7.
5. Bullet nosed rod, ⅜ inch diameter.





SPLIT COMPACTION MOLD
FIGURE 3

6. Hand tamper, one inch diameter weighing 6 ± 0.05 pounds.
7. Scales, 5000 gram capacity, accurate to 1 gram.
8. Four inch x four inch tin liners and caps.
9. Masking or adhesive tape.
10. Shipping cartons.

C. ASSEMBLY OF THE COMPACTION MOLD

1. Split Compaction Mold.
   a. Position a tin liner inside the split compaction mold as shown in Figure 3 and firmly tighten the lock bolts.
   b. Insert the bottom plunger and fasten in place with the pin. The bottom plunger must be positioned so that the rim of the mold does not come in contact with the plunger before compaction is completed. Several holes are provided in the bottom plunger so that its position can be adjusted according to the type of material being tested. Use the lowest hole when testing granular material which does not compress appreciably. Use one of the upper holes when testing fine grained materials which will compress.
   c. Place the extension sleeve on top of the assembled mold. The split mold is now ready for fabricating the testing specimen.
2. Solid Wall Compaction Mold.
   a. Position a tin liner inside, and at the lower end, of the long expansion liner as shown in Figure 4.
   b. Insert the long expansion liner into the top of the compaction mold so that the ends of the expansion liner and the mold are flush and the tin liner is positioned toward the center of the mold.
   c. Insert the short expansion liner from the opposite end of the mold until butted against the tin liner and long expansion liner.
   d. Insert the bottom plunger into the short expansion liner.
   e. Insert a U-shaped spacer between the bottom of the mold and the bottom plunger. A set of these spacers should be available with thicknesses of 1/16 inch, ⅛ inch and 3/16 inch, so that the proper spacing can be used to prevent the rim of the mold from coming in contact with the bottom plunger before compaction is completed. Use the thin spacer when compacting granular materials which do not compress appreciably and the thicker spacers when compacting fine grained materials which will compress.
   f. Place the extension sleeve on top of the assembled mold. The solid wall mold is now ready for fabricating the test specimen.

D. FABRICATING TEST SPECIMENS

1. Prepare the material for fabricating test specimens according to the instructions in Part I for laboratory prepared samples and according to the instructions in Part II for construction control samples.

2. At the end of the one hour ± 15 minute loose curing period, place the prepared samples in the compaction mold in accordance with the following instructions. Care must be taken to avoid losing material during fabrication of the test specimen.

a. Pour approximately one-half of the material into the mold.
b. Rod the material 30 times with the ⅜ inch bullet nosed rod to prevent the formation of rock pockets at the bottom or sides of the specimen.
c. Tamp the first layer of material with 50 blows of the six pound tamper. Tamping is accomplished by allowing the tamper to drop free from a height of six inches above the surface of the material being tamped. Guide the tamper over the entire surface of the specimen to obtain uniform density.
d. Pour the remaining portion of the sample into the mold.
e. Rod the material 30 times with the ⅜ inch bullet nosed rod. When rodding the second layer, the rod should penetrate slightly into the underlying layer with each stroke. This will prevent the formation of a compaction plane between the two layers.
f. Tamp the second layer with 100 blows of the tamper falling free from a height of six inches.
g. Smooth off and level the top of specimen by additional light tamping with the hand tamper. The intent is to make a smooth surface on an even plane at right angles to the axis of the mold.

3. Remove the extension sleeve from the mold.

4. Calculate the adjusted wet weight of the specimen which is used for calculating the density of the specimen. Even under laboratory conditions there is some unavoidable loss of material during fabrication.

a. When using the solid wall mold, weigh the mold, liner and specimen after tamping, then subtract the weight of the mold and liner. This is the adjusted wet weight of the specimen.
b. When using the split mold, estimate the adjusted weight. The split mold is usually too heavy to weigh on available scales. The weight loss is considered to be a constant value for an experienced operator and should not exceed two or three grams. Subtract the estimated weight loss from the batch wet weight to obtain the adjusted wet weight.

5. Seat the upper plunger on top of the specimen and place the mold assembly in the testing machine.

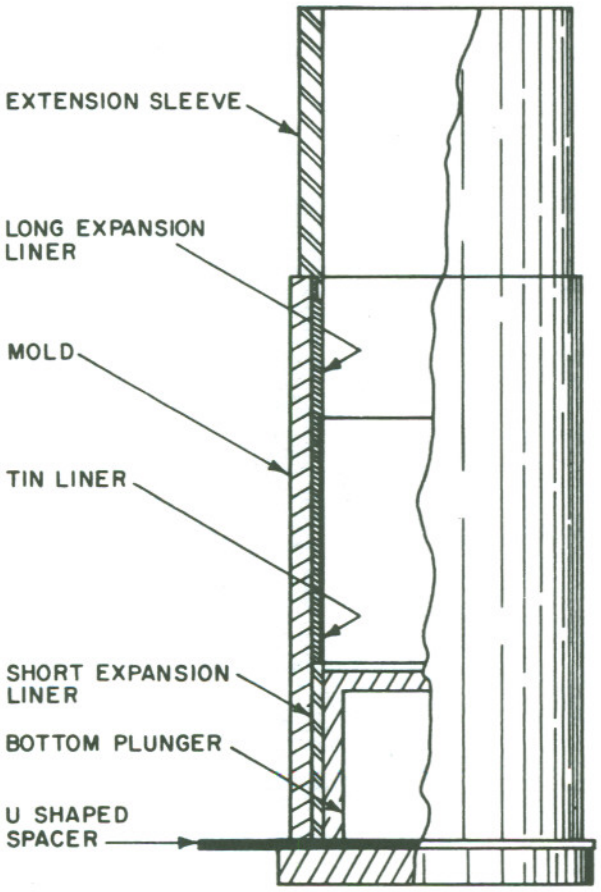
6. Remove the pin or spacer from the mold so the bottom plunger is free to move. This provides a double plunger action and results in a more uniformly compacted specimen.

7. Uniformly apply a 15,000 pound load in one minute. Hold the 15,000 pound load for one minute and gradually release it.

8. Remove the specimen in its tin liner from the mold. When the solid wall mold is used the sample extractor shown in Figure 6 can be used.

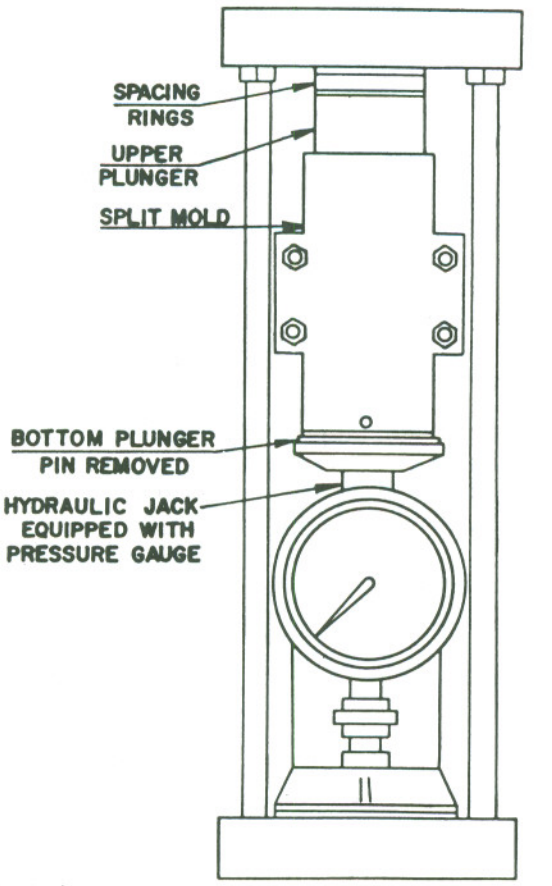
9. Weigh the specimen and tin liner to the nearest gram.

10. Measure the height of the specimen to the nearest 0.001 inch. The specimen must be 4.000 ± 0.200 inches high. If it is not, discard the specimen and make a new one.



SOLID WALL COMPACTION MOLD

FIGURE 4



COMPRESSION MACHINE

FIGURE 5

a. Using the gage shown in Figure 7 take three or more readings (more than three readings should be taken when the surface of the specimen is rough) between the center and edge of the specimen. The height is reported as the average of these readings.
b. The average height of the specimen may be determined by using the tripedal block. Set the block on top of the specimen and one reading will determine the average height.
c. The accuracy of the measuring gage should be frequently checked with the calibration bar furnished with the gage. Using the calibration bar, set the gage to read 0.500 inches. When measuring a specimen, the gage reading is added to 3.500 inches to determine the actual height of the specimen.

11. Place caps on each end of the specimen and seal with tape.
12. Mark each specimen for identification purposes.
13. Cure the specimens for seven days at room temperature. Perform compressive strength tests on the seventh day according to the procedures described in Part V.
14. Cure specimens fabricated in the field for construction control purposes in the field laboratory for two days before shipping to the District Laboratory for testing. They must arrive in the District Laboratory by the sixth day after fabrication. Cardboard shipping cartons that hold four test specimens are available.

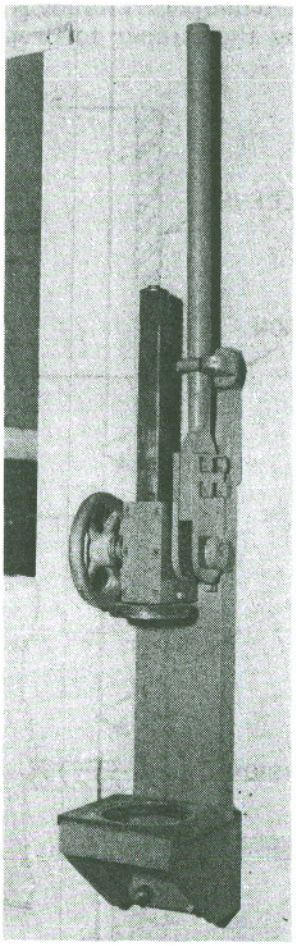


FIGURE 6

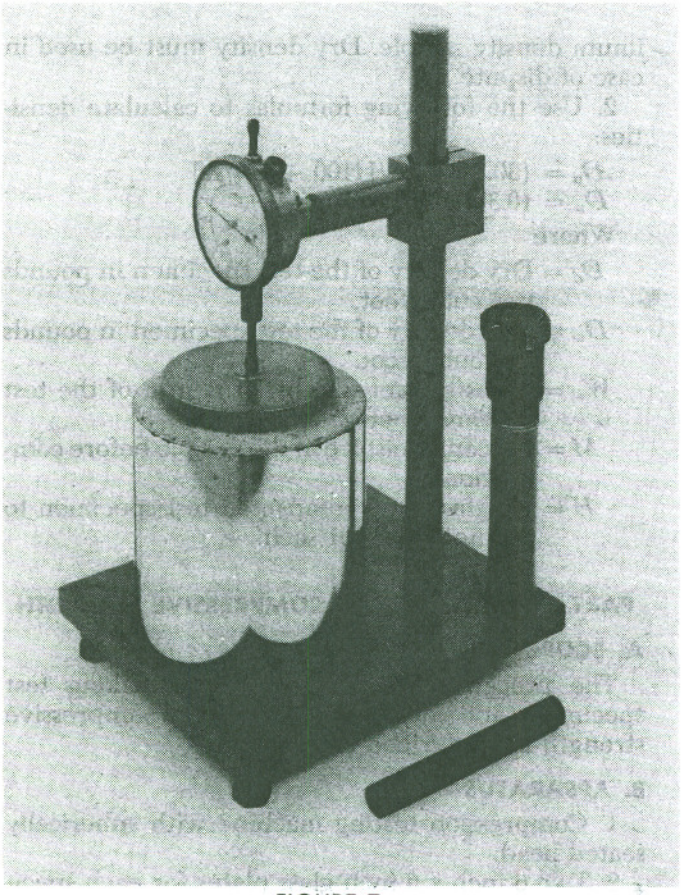


FIGURE 7

PART IV. DETERMINING OPTIMUM MOISTURE, CEMENT CONTENT AND TEST MAXIMUM DENSITY

A. SCOPE

The procedures for determining optimum moisture content and recommended cement content for preliminary design samples and for determining optimum moisture content and test maximum density for construction control samples are described in this part.

B. PRELIMINARY DESIGN SAMPLES

1. Optimum moisture content.

a. Optimum moisture is the moisture content required to attain the best compaction results in the field. This moisture content can be estimated in the laboratory by the amount of water exuded from the material during fabrication of the test specimen. A sample from which one to six grams of water are exuded is considered to be at optimum moisture.

b. Prepare material for one or more test specimens in accordance with Part I. Use the same aggregate grading and cement content for each specimen.

c. Add water to the first specimen in small increments until visual inspection and hand squeezing of the mixture indicate sufficient water has been added to provide a cohesive mixture.

d. Compact the specimen in accordance with Part III.

e. Determine the grams of water exuded by subtracting the gross weight of the compacted specimen from the adjusted gross weight before compaction.

f. Determine the height of the specimen as described in Part III.

g. Calculate any adjustments in sample weight and/or moisture content necessary to obtain the required 4.000 ± 0.200 inch high specimen and one to six grams of exuded water.

h. Continue to fabricate new specimens until one is obtained that has both the proper height and moisture content. With experience, no more than two or three trials should be necessary.

i. Cure the final specimen and test for compressive strength. The compressive strength of this specimen can be used in selecting the recommended cement content.

j. The amount of water added to the CTB mixture in the field is sometimes higher than the laboratory determined optimum moisture content. This allows for the evaporation that inevitably takes place during construction operations.

2. Recommended cement content.

a. The recommended cement content is the amount of cement required to insure that field fabricated control specimens will attain desired compressive strengths. Because of variables inherent in the construction process, the ultimate in-situ strength of CTB generally averages approximately 70% of the 7-day laboratory strength. Compensation for this difference is provided in the following procedure.

b. Fabricate three test specimens containing 5% cement and the optimum moisture determined in Section B-1 above.

c. Test each of the three test specimens for unconfined compressive strength, according to Part V of this test and average the results.

d. If the average strength meets the minimum requirement for the aggregate, calculate the recommended cement content (%) using the formula:

$$C = (1100/Sa) \times 5$$

where:

C = Recommended cement content (%)
Sa = Averager strength (psi) with 5% cement

e. If an in-situ strength other than 750 psi is specified, use a factor equal to the specified in-situ strength × 1.5 in place of 1100 in the above formula.

C. FIELD CONTROL SAMPLES

1. Test Maximum Density.

a. The test maximum density is the average density, in pounds per cubic foot, of two test specimens fabricated from material which has been sampled and tested in accordance with Parts II and III and the instructions below.

b. The material used for test maximum density must have a moisture content which will result in the exudation of between one and 25 grams of water from each specimen during the fabrication process.

1. If no water is exuded from a specimen it must be discarded and sufficient water added to the remainder of the sample so that one to 25 grams of water will be exuded from each of the two specimens. When water is added to the material, a new moisture sample must be taken and this moisture content used in calculating the dry density.

2. If more than 25 grams of water is exuded from a specimen the sample is spread in a thin layer in an open pan and allowed to air dry, with occassional stirring, to the proper moisture content. No artificial heat should be used to dry the sample. The test specimens must still be fabricated within the one hour ± 15 minute time limit. If it is not possible to adequately air dry the sample, the entire sample must be discarded and a new one obtained from drier material.

c. Determine the grams of water exuded by subtracting the gross weight of the compacted specimen from the adjusted gross weight before compaction.

d. All specimens used for determining test maximum density must be fabricated within one hour ± 15 minutes after water is mixed with the cement and aggregate as previously specified in this test method. When initial rolling is started more than one hour after mixing, sample the cement treated base mixture before the first pass of the roller (as described in Part II) and fabricate the test specimens as soon as possible.

e. Specimens used for determining test maximum density are cured and tested for compressive strength to meet the frequency of sampling required in the construction manual.

D. CALCULATING DENSITIES OF TEST SPECIMENS

1. Dry density is always used for preliminary design samples. Wet density may be used for calculating relative compaction of field control samples only when the moisture content of the in-place density sample does not vary more than one percentage point from the moisture content of the test maximum density sample. Dry density must be used in case of dispute.

2. Use the following formulas to calculate densities:

$$D_d = (30.3 \times W_w)/[(100 + M)H]$$

$$D_w = (0.303 \times W_w)/H$$

Where

D_d = Dry density of the test specimen in pounds per cubic foot.

D_w = Wet density of the test specimen in pounds per cubic foot.

W_w = Adjusted wet weight, in grams, of the test specimen before compaction.

M = Percent moisture in the sample before compaction.

H = Height of the compacted test specimen to the nearest 0.001 inch.

PART V. DETERMINING COMPRESSIVE STRENGTH

A. SCOPE

The procedure for capping and breaking test specimens and for determining their compressive strength are described in this part.

B. APPARATUS

1. Compression testing machine with spherically seated head.
2. Two 6 inch x 6 inch glass plates for each specimen.
3. Mixing bowl and spoon.
4. Plaster of paris.
5. Water tank for immersing test specimens.

C. PREPARATION OF SPECIMENS

1. On the morning of the seventh day of the curing period, remove the lids and tin liner from each specimen. Transfer the identifying marks to the side of each specimen with a felt tip pen, grease pencil or other suitable marking device.

2. Immerse the specimens in water for six ± one hours to complete the seven day curing period.

3. Remove the specimens from the water bath and cap both ends of each specimen with plaster of paris as follows:

a. Lay out two glass plates for each specimen. Lubricate one surface of each glass plate with kerosene or lubricating oil to prevent the plaster of paris from sticking to the glass plate.

b. Mix enough plaster of paris with water to form a thick paste for capping both ends of each specimen.

c. Place a spoonful of paste on top of each specimen and immediately force one of the plates down on the paste to form a full cap on top of each specimen.

d. Place a spoonful of paste on each of the other glass plates and force each specimen down on

the paste to form a full cap on the bottom of each specimen.

e. Adjust the specimens while the plaster is still soft so that the top and bottom plates are parallel and as nearly as possible at right angles to the vertical axis of the test specimen. A small level may be used to facilitate this operation.

f. Allow the plaster caps to harden for 30 to 40 minutes and then remove the glass plates by tapping the edges lightly with a piece of soft wood. If the glass plates are difficult to remove, apply warm water to the plates and continue tapping lightly.

D. TESTING OF SPECIMENS

1. The specimen may be tested for compressive strength as soon as the glass plates are removed. Center the specimen directly in line with the spherically seated head of the testing machine. Apply the load at the rate of 12,000 ± 2,000 pounds per minute. Apply the load continuously and without shock.

2. Increase the load until the specimen fails. Initial fracturing may begin to occur at approximately 90 percent of the maximum load, but loading should continue until the maximum load is attained.

E. REPORTING OF RESULTS

1. Report the test results on Form T.L.-342.

2. Report the test results as compressive strength in pounds per square inch, which equals the total compression load divided by the end area of the test specimen.

For the standard four inch diameter test specimen, the end area is 12.57 square inches.

An optional method for calculating compressive strength is to multiply the total compression load by 0.080.

PART VI. CALCULATING PERCENT RELATIVE COMPACTION

A. SCOPE

The procedures for calculating percent relative compaction are described in this part.

B. TEST RECORD FORM

1. When in-place densities are determined with the sand volume apparatus (California Test 216), use Form T.L.-297 for recording test data and for reporting percent relative compaction.

2. When in-place densities are determined by the use of nuclear gages (California Test 231), use Form T.L.-2124 for recording test data and for reporting percent relative compaction.

C. CALCULATING PERCENT RELATIVE COMPACTION

1. Use the following formula for calculating percent relative compaction:

Percent relative compaction = [(In-place density/ Test maximum density)] × 100

2. Percent relative compaction may be calculated using in-place dry density and test maximum dry density or in-place wet density and test maximum wet density. Wet densities may be used only when the moisture content of the in-place density sample does not vary more than one percentage point from the moisture content of the test maximum density sample. In case of dispute, use dry densities for calculating percent relative compaction.

3. Test maximum density is determined by the procedures outlined in Part IV of this test method.

4. In-place density may be determined by the use of nuclear gages as described in California Test 231 or with the sand volume apparatus described in California Test 216.

5. When using the sand volume apparatus, perform the in-place density test within 5 feet of the test maximum density sample site. Instructions for taking the test maximum density sample are given in Part II of this test method. When using nuclear gages to determine in-place density the test maximum density sample site should be in the approximate center of the test area.

6. There may be times when it is necessary to perform additional in-place density tests at locations where test maximum density samples were not taken. In these cases use the average of the three nearest test maximum densities that are representative of the material under consideration to calculate percent relative compaction.

REFERENCES

California Tests 201, 216, 226, 231 and 105

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