

**DEPARTMENT OF TRANSPORTATION**  
**DIVISION OF ENGINEERING SERVICES**  
Transportation Laboratory  
5900 Folsom Blvd.  
Sacramento, California 95819-4612



## **METHOD OF TEST FOR PREPARATION OF HMA FOR TEST SPECIMENS**

### **A. SCOPE**

This test method describes the procedure for determining the preparation of laboratory-mixed and field-mixed hot mix asphalt (HMA) specimens containing aggregate up to 1 in. maximum size. It also describes a procedure for the compaction of HMA by means of a California kneading compactor that imparts a kneading action. The procedure applies to laboratory-mixed and field-mixed HMA containing aggregate up to 1 in. maximum size.

The procedures are presented in two parts:

- Part 1. Preparation of laboratory-mixed and field-mixed HMA samples
- Part 2. Compaction of HMA using the California kneading compactor

Appendices are included as follows:

- Appendix A – Preparation of HMA test specimens containing up to 15 % reclaimed asphalt pavement (RAP)
- Appendix B – Preparation of HMA test specimens containing asphalt binder with liquid anti-strip
- Appendix C – Preparation of HMA test specimens containing damp aggregate treated with dry lime
- Appendix D – Preparation of HMA test specimens containing aggregate treated with lime slurry

More complete descriptions of the procedures needed to prepare HMA samples for mix design and the determination of a job-mix formula (JMF) can be found in the Asphalt Institute MS-2 “Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types”, Superpave Series No. 2 (SP-2) “Superpave Mix Design”, California Test 367 and 368.

### **PART 1. PREPARATION OF LABORATORY-MIXED AND FIELD-MIXED HMA SAMPLES**

#### **1A. REFERENCES**

- California Test 101 – Operation and Calibration of the Mechanical Compactor
- California Test 104 – Operation and Calibration of the Electronically Controlled Compactor
- California Test 105 – Calculations Pertaining to Gradings and Specific Gravities
- California Test 125 – Sampling Highway Materials and Products Used in the Roadway Structural Sections
- 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 367 – Optimum Binder Content (OBC) for HMA Types A, B, and C and Rubberized HMA (Type G)
- California Test 368 – Optimum Bitumen Content (OBC) for Open Graded Friction Course
- AASHTO T 201 – Kinematic Viscosity of Asphalts (Bitumens)

- AASHTO T 245 – Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
- AASHTO T 316 – Viscosity Determination of Asphalt Binder Using Rotational Viscometer
- ASTM D 3549 – Thickness or Height of Compacted Bituminous Paving Mixture Specimens

**1B. APPARATUS**

1. Ovens:
  - a. Oven(s) with free circulation of air for heating aggregates, asphalt binder, mixing bowl, other equipment to within 5°F of the required mixing temperature.
  - b. An oven with free circulation of air capable of maintaining a temperature of 140°F ± 5°F and 295°F ± 5°F for curing HMA.
  - c. Oven(s) with free circulation of air for heating field-mixed HMA samples to within 5°F of the required temperature.
2. Balance: a balance or scale accurate to 0.1 g and having a minimum capacity of 5 kg.
3. Sample Splitters:
  - a. Riffle-type splitter having individual chutes approximately 50 % larger than the maximum size aggregate in the HMA.
  - b. Optional rotating pan type splitter for all HMA.
4. Metal Pans: pans having a surface area of 75 to 100 in.<sup>2</sup>, approximately 1 in. deep.
5. Thermometers: thermometers having metal stems with a minimum range of 100 to 400°F, accurate to 1°F.
6. Sample Mixing Apparatus: suitable equipment for mixing the aggregate and asphalt binder.
  - a. Suitable equipment for hand mixing consists of a sand bath on the surface of a hot plate to minimize localized overheating.
  - b. Suitable equipment for mechanical mixing consists of any type of mechanical mixer that can be maintained at the required mixing temperature. Mixing equipment must produce a well-coated, homogeneous mixture of the required amount and from which essentially all of the batch can be recovered.

**1C. PREPARATION OF LABORATORY-MIXED HMA SPECIMENS**

1. Aggregate
  - a. Sample aggregate under California Test 125.

- b. For mix design and other purposes as required, perform a sieve analysis on individual coarse aggregate samples and a washed sieve analysis on individual fine aggregate samples in accordance with California Test 202. Discard fine aggregate samples after the washed sieve analysis.
- c. If there is a difference in specific gravity of 0.2 or more between the coarse and fine parts of different aggregate blends, compute the blend of aggregate required to produce a combined gradation that conforms to specified requirements modified in accordance with California Test 105.
- d. Separate each of the combined aggregate samples on the coarse and fine aggregate sieves in accordance with California Test 202. Use the sieves and pan appropriate for the gradations required for the mix specified.

NOTE: Use aggregates as received. Do not wash aggregates to be used for preparing HMA for specimens. In the case of coated aggregate, separate by hand if the aggregates are coated to prevent removal of these coatings.

For a combined aggregate sample, split out no more than 10 kg at a time before separating. For individual bin or stockpile samples, combine no more than 10 kg at a time at the proposed proportions before separating.

- e. Batch the aggregate. The cumulative weight for the required batch is derived by simple computation. An example of this computation for an aggregate batch weight of 1200 g follows:

Sieve Size	Percent Passing	Individual Weight	Cumulative Weight
1 in.	100	0.0	0.0
¾ in.	89	132.0	132.0
½ in.	78	132.0	264.0
⅜ in.	73	60.0	324.0
No. 4	67	72.0	396.0
No. 8	51	192.0	588.0
Pan	0	612.0	1200.0

Passing	Retained	1200 g Batch Weight
1 in.	¾ in.	(100 - 89) X 12 = 132.0
¾ in.	½ in.	(100 - 78) X 12 = 264.0
½ in.	⅜ in.	(100 - 73) X 12 = 324.0
⅜ in.	No. 4	(100 - 67) X 12 = 396.0
No. 4	No. 8	(100 - 51) X 12 = 588.0
No. 8	Pan	(100 - 0) X 12 = 1200.0

## 2. Asphalt Binder

- a. Obtain samples of the asphalt binder that will be used on the project.
- b. For hot mix design (per California Test 367), prepare at least 1 sample for each combination of aggregate and binder content. Use at least 4 binder contents in 0.50 % increments for the development of the proposed JMF and the determination of OBC. Approximate binder content (ABC), ABC - 0.50 %, ABC + 0.50 %, ABC + 1.00 % is most commonly used.

Once the OBC has been determined, prepare 3 samples separately at the proposed JMF and test for compliance.

- c. Report binder content as a percentage by weight of total mix. An example of computing binder content as a percentage by weight of total mix and asphalt binder batch weights follows:

The total weight of hot mix is expressed as:

$$W_{\text{Mix}} = W_{\text{Asph}} + W_{\text{Agg}} \quad [1]$$

Where:  $W_{\text{Mix}}$  = Weight of hot mix, in grams (g)  
 $W_{\text{Asph}}$  = Weight of asphalt binder, in grams (g)  
 $W_{\text{Agg}}$  = Weight of aggregate, in grams (g)

The percentage of asphalt binder is:

$$P_{\text{Asph}} = \left( \frac{W_{\text{Asph}}}{W_{\text{Mix}}} \right) \times 100 \quad [2]$$

Where:  $P_{\text{Asph}}$  = Binder percentage (binder content) by weight of total mix

By rearranging equations [1] and [2], the weight of asphalt binder required for a batch can be determined as follows:

$$W_{\text{Asph}} = \frac{W_{\text{Agg}} \times P_{\text{Asph}}}{1 - P_{\text{Asph}}} \quad [3]$$

Example: Determine the asphalt binder batch weight at a binder content of 5 % (by weight of total mix) with an aggregate batch weight of 1200 g.

Step 1 – Use Equation [3]:

$$W_{\text{Asph}} = \frac{1200 \times 0.05}{1 - 0.05} = 63.2$$

Step 2 – Using equation [1], the total weight of hot mix is:

$$W_{\text{Asph}} + W_{\text{Agg}} = 1200 + 63.2 = 1263.2\text{g}$$

Check: To check the binder percentage by weight of total mix, substitute the values obtained in Steps 1 and 2 into equation (2):

$$P_{\text{Asph}} = \frac{63.2}{1263.2} \times 100 = 5.0\%$$

3. Mixing and Curing

- a. Heat the aggregate to the mixing temperature. The mixing temperatures for various asphalt binder types are:

Asphalt Binder	Mixing Temperature <sup>a, b</sup>
Neat, unmodified (PG__ - __)	The range of temperature where the unaged asphalt binder has a kinematic viscosity of $170 \pm 20$ centistokes measured in accordance with AASHTO T 316
Polymer Modified (PG__ - __PM)	Use manufacturer's recommended range.
PG__ - __TR	Use manufacturer's recommended range
Asphalt Rubber Binder	300 to 325°F

Mixing temperatures for OGFC are specified in California Test 368.

- b. Heat the asphalt binder to closely approximate the aggregate temperature, and in no instance exceed 375°F. Do not hold asphalt binder at mixing temperature for more than 2 hr before using. Do not reheat asphalt binder more than 2 times.
- c. Place the mixing bowl in the oven or on the sand bath and heat to a temperature not exceeding 50°F above the mixing temperature and not exceeding 375°F. Charge the mixing bowl with heated aggregates and dry mix thoroughly. Form a crater in the dry blended aggregate. Remove the asphalt binder from the oven and stir thoroughly until uniform. Pour the required amount of asphalt binder into the mixture in accordance with the calculated batch weights. At this point the temperature of the aggregate and asphalt binder must be within the limits of the mixing temperature (Section 1C.3.a).

NOTE: Before laboratory mixing, prepare 1 mixture at the lowest binder content to butter the mixing bowl. Discard this batch.

- d. Mix the aggregate and asphalt binder, preferably with a mechanical mixer or by hand with a trowel or spoon as quickly and thoroughly as possible to yield a mixture where all particles are coated. The length of mixing time varies with the type of material, but 2 to 3 min is generally sufficient.
- e. When mixing is completed, transfer the mixture to a metal pan. Cure at a temperature of  $140^{\circ}\text{F} \pm 5^{\circ}\text{F}$  in an oven for 15 to 18 hrs.

An alternate procedure, when the combined aggregate absorption is less than 2.0 % determined in accordance with California Test 206 and 207 is to cure the mixture at a temperature of  $295^{\circ}\text{F} \pm 5^{\circ}\text{F}$  in an oven for 2 to 3 hrs.

NOTE: When transferring the mixture to a suitable pan, the mixing bowl must be scraped to within  $\pm 0.1$  % of the initial total batch weight.

- f. The mixture is then ready for testing.

**1D. PREPARATION OF FIELD-MIXED HMA (LOOSE MIX) SPECIMENS**

Field-mixed HMA can be heated for workability a maximum of 2 times to temperatures listed below. Do not heat HMA more than 3 hrs.

<b>Asphalt Binder</b>	<b>HMA Temperature (Maximum)</b>	<b>OGFC Temperature (Maximum)</b>
Neat, unmodified (PG__ - __)	275°F	200°F
Polymer Modified (PG__ - __PM)	300°F	200°F
PG__ - __TR	300°F	-----
Asphalt Rubber Binder	300°F	250°F

**1E. REPORTING**

The following information should be included when reporting the test results:

- Mix type
- Asphalt binder type and content
- Individual and composite aggregate gradation
- Aggregate gradation plot on the FHWA 0.45<sup>th</sup> power chart
- Additives (if used): Type, percentage and method of incorporation
- Mixing temperature
- Curing time and temperature

**PART 2. – COMPACTION OF HMA USING THE CALIFORNIA KNEADING COMPACTOR**

**2A. REFERENCES**

- California Test 101 – Operation and Calibration of the Mechanical Compactor  
 California Test 104 – Operation and Calibration of the Electronically Controlled Compactor  
 AASHTO T 245 – Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus  
 ASTM D 3549 – Thickness or Height of Compacted Bituminous Paving Mixture Specimens

**2B. APPARATUS**

1. California Kneading Compactor: use a compactor designed to consolidate the material by a series of individual or roving “kneading action” impressions made by a compactor foot. The compactor must be capable of exerting a force of 500 psi under the compactor foot and must be operated and calibrated in accordance with California Test 101 or California Test 104.
2. Compactor Foot: a ram having a face shaped as a sector of a 4 in. diameter circle as shown in California Test 101 and 104 and having an area of approximately 3.2 in<sup>2</sup>.

The temperature of the compactor foot must be maintained at the compaction temperature by means of a variable transformer controlling the heater.

3. Mold Holder: a mold holder placed into position on the California kneading compactor and used to center the 4 in. mold and hold it securely in position during compaction.
4. Molds: molds of 4 in.  $\pm$  0.005 in. inside diameter and 5 in.  $\pm$  0.10 in. height with steel walls that are at least 0.30 in. thick at room temperature (77°F  $\pm$  9°F). Molds must be hardened to at least a Rockwell hardness of C48. The initial inside finish of the molds must have a root mean square (rms) of 1.60  $\mu$ m or smoother in accordance with ANSI B 46.1.
5. Solid Rubber Specimen: a specimen of approximately 4 in. diameter by 2½ in. height designed to fit in the mold for warming-up the California kneading compactor.  
  
NOTE: A handful of rags stuffed into the mold is a suitable alternative.
6. Paper Disks: heavy paper disks of approximately 4 in. diameter designed to fit in the mold.
7. Metal Disks: metal disks of approximately 4 in. diameter designed to fit in the mold.  
  
NOTE: The base plate used in AASHTO T 245 is a suitable disk.
8. Metal Feeder Trough: a feeder trough 4 in. wide and 16 in. long with a paddle that is shaped to fit the trough.
9. Rod: a round, straight steel rod with a diameter of ¾ in.  $\pm$  ¼ in. and length of at least 16 in. One or both ends of the tamping rod must be rounded to a hemispherical tip of the same diameter as the rod.
10. Mechanical Spader (optional): designed to prevent segregation of coarse and fine material or the formation of rock pockets in the test specimen by introducing the mixture into the compaction mold from an endless belt; at the same time imparting a spading action with four mechanically operated bullet-nosed steel rods that are ½ in. diameter and 23 in. long.
11. Shim: a ¼ in. thick steel shim approximately ¾ in. wide and 2½ in. long.
12. Steel Followers: two steel followers with a flat surface 3.985 in.  $\pm$  0.005 in. in diameter; one 5.5 in.  $\pm$  0.25 in. in height, the other 1.575 in.  $\pm$  0.25 in. in height.
13. Compression Testing Machine: a compression testing machine having a minimum capacity of 50,000 lb and capable of maintaining the specified loading rate.
14. Specimen Extractor: a steel device in the form of a disk with a diameter not less than 3.95 in. and ½ in. thick for extracting the compacted specimen from the mold.
15. Ovens:
  - a. Oven(s) with free circulation of air for heating equipment to the required temperature.

- b. An oven with free circulation of air capable of maintaining a temperature of  $235^{\circ}\text{F} \pm 5^{\circ}\text{F}$  and  $305^{\circ}\text{F} \pm 5^{\circ}\text{F}$  for heating HMA samples prior to compaction.
  - c. An oven with free circulation of air capable of maintaining a temperature of  $140^{\circ}\text{F} \pm 5^{\circ}\text{F}$  for HMA samples after compaction.
16. Balance: a balance or scale having a minimum capacity of 5 kg, accurate to 0.1 g.

**2C. COMPACTION OF HMA**

1. Prepare laboratory-mixed and field-mixed HMA in accordance with California Test 304, Part 1.

NOTE: Normally, 1200 g of dry aggregate is sufficient for the stabilometer specimen. However, if the specific gravity of the aggregate is 2.80 or higher, 1300 g may be required. Three samples are required for the stabilometer test.

2. Warm-up the California kneading compactor by running it through at least 1 complete cycle (20 tamping blows at 250 psi followed by 150 tamping blows at 500 psi) using the solid rubber specimen.
3. Use one of the following specified temperatures when compacting the HMA:

Asphalt Binder	Compaction Temperature
Neat, unmodified (PG__ - __) Polymer Modified (PG__ - __PM)	$235^{\circ}\text{F} \pm 5^{\circ}\text{F}$
PG__ - __TR	$235^{\circ}\text{F} \pm 5^{\circ}\text{F}$
Asphalt Rubber Binder	$305^{\circ}\text{F} \pm 5^{\circ}\text{F}$

4. Place appropriate quantity of HMA in a metal pan and heat to the compaction temperature in an oven for 2 to 3 hr.
5. Preheat the compactor foot, mold holder (one time only), molds, feeder trough and rod to the compaction temperature.
6. Place the mold in position in the mold holder and insert a 4 in. diameter paper disk into the mold on top of the mold holder base.
7. Place a steel shim under the edge of the mold adjacent to the portion of the mold holder that extends up into the mold. Tighten the tightening screw on the mold holder.

NOTE: The maximum time allowed to perform Steps 7 through 9, from removal of the mixture from the oven to starting the compactor, is 1 min. This is necessary to prevent cooling of the sample.

8. Thoroughly mix and disperse the heated mixture in the heated feeder trough. Spread the mixture on the trough to ensure uniformity when transferring to the mold. Use the paddle to push half of the mixture into the mold. Rod this portion of the mixture 20 times in the center of the mass and 20 times around



the edge with the heated rod. Push the remainder of the mixture into the mold and repeat the rodding procedure, just penetrating the first lift.

9. Place the mold holder containing the mixture and the mold into position in the California kneading compactor.
10. Start the compactor and adjust the air pressure to a point where 250 psi will be exerted by the compactor foot.
11. Apply approximately 25 tamping blows at 250 psi to accomplish a semi compacted condition of the mixture so it will not be unduly disturbed when the 500 psi load is applied. The exact number of blows to accomplish the semi compaction is determined by observation and may vary between 20 and 50 depending upon the type of HMA.
12. After semi-compaction has been accomplished, remove the shim and release the mold-tightening screw sufficiently to allow approximately 1/8 in. side movement of the mold during the compaction stroke. Increase the compactor foot pressure to 500 psi and apply 150 tamping blows to complete the compaction.
13. After compaction in the California kneading compactor, place the mold and the specimen upright (tamp side up) on a metal disc and place the assembly in an oven at 140°F ± 5°F for the following range of time prior to applying the static leveling off load:

Asphalt Binder and Compaction Temperature	Time in Oven
Neat, unmodified (PG__ - __) Polymer Modified (PG__ - __PM) PG__ - __TR	1 ½ to 3 hr
Asphalt Rubber Binder	2 to 3 hr

14. Place a 4 in. diameter paper disk on the compacted specimen and apply the 12,600 lb leveling-off load in a compression testing machine. Use a testing machine head or platen speed of 0.25 in /min. Apply the load by the double plunger method in which a free-fitting metal plunger is placed on the top and bottom of the specimen.  
  
NOTE: If the testing machine has a spherically seated type of upper head, use the proper shims to lock it in such a manner that the contact face is fixed firmly in a horizontal plane.
15. Return specimens for stabilometer tests (compacted and contained in the mold) to the 140°F ± 5°F oven for 15 min to 2 hr to retain temperature for testing in accordance with California Test 366.  
  
NOTE: Stabilometer test specimens are used to obtain bulk specific gravity in accordance with California Test 308 unless there is a dispute about the bulk specific gravity result. Then, briquettes must be made for use to determine bulk specific gravity without stability testing first.
16. Cool specimens not compacted for stabilometer and bulk specific gravity testing to room temperature (77°F ± 9°F) before removing specimens from the mold by means of a specimen extractor. Measure the height of the compacted specimen in

accordance to ASTM D 3549 to the nearest 0.01 in. and record the measurement. The compacted specimens are then ready for testing.

17. Laboratory-mixed and field-mixed samples must be 2.5 in. ± 0.05 in. in height. Specimens compacted for mix design must be 2.5 in. ± 0.10 in. in height.

NOTE: To determine the required amount of HMA, it is generally desirable to prepare a trial specimen. For mix designs, the trial specimen should be prepared prior to preparing all the batches. If the trial specimen height falls outside the limits, the amount of HMA used for the specimen may be adjusted as follows:

$$\text{Adjusted HMA Weight} = \frac{2.5 \times \text{Weight of HMA}}{\text{Specimen height obtained}}$$

## 2D. REPORTING

The following information should be included when reporting the test results;

- Mix type
- Binder type and content
- Compaction temperature
- Curing time and curing temperature
- Specimen height

## B. 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](http://www.dot.ca.gov/hq/esc/ctms/pdf/lab_safety_manual.pdf)

**End of Text**  
**(California Test 304 contains 17 pages)**

## APPENDIX A

### METHOD OF PREPARATION OF HMA TEST SPECIMENS CONTAINING UP TO 15 % RAP

#### A. SCOPE

This appendix includes modifications that must be made to California Test 304 when preparing test specimens of HMA containing up to 15 % RAP.

#### B. REFERENCED DOCUMENTS

- California Test 201 – Soil and Aggregate Sample Preparation
- California Test 226 – Determination of Moisture Content by Oven Drying
- California Test 309 – Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
- California Test 382 – Determination of Asphalt Content of Bituminous Mixtures by the Ignition Method
- ASTM D 2172 – Quantitative Extraction of Bitumen from Bituminous Paving Mixtures

#### C. PREPARATION OF LABORATORY-MIXED HMA SPECIMENS

Prior to preparing specimens of HMA that contain up to 15 % RAP, the following procedures must be followed:

1. Sample RAP in accordance with California Test 125.

NOTE: Sample a minimum of 3 separate representative samples of RAP and split each sample into 2 equal parts.

2. Prepare each RAP sample separately for evaluation under California Test 201.

Split or quarter each RAP sample into representative portions for ASTM D 2172, California Test 309 and California Test 382 testing.

HMA Aggregate Size	Size of Sample		
	ASTM D 2172 <sup>a</sup>	CT 309 <sup>b</sup>	CT 382 <sup>c</sup>
	Minimum Weight of Sample, g		
2 in.	--	6000	--
1½ in.	4000	4000	4000
1 in.	3000	2500	3000
¾ in.	2000	2000	2000
½ in.	1500	1500	1500
⅜ in.	1000	1000	1200
No. 4	500	500	1200

- a. ASTM D 2172 is used to determine the asphalt binder content in RAP and RAP gradation for calculating batch weights.
- b. California Test 309 is used to calculate the effective specific gravity of the RAP aggregate.
- c. California Test 382 is compared with ASTM D 2172 to determine a RAP gradation correlation factor.

3. Determine the binder content of each RAP sample in accordance with ASTM D 2172, Method B or Method E (3 minimum). Calculate and report the individual and average binder content. Perform a sieve analysis on each sample of recovered aggregate in accordance with California Test 202, Appendix A (3 minimum). Calculate and report the individual and average gradation.
4. Determine the RAP percentage that will be used in the mix design.
5. Determine the combined gradation of the HMA mixture based on the proposed proportions of RAP and virgin aggregate to be used.
6. Calculate batch weights for each ingredient in the mixture using the information from ASTM D 2172 and the attached "Worksheet for Computing Laboratory Batch Weights for HMA Mixtures Containing RAP" (Figure A1).  
  
NOTE: Other batch worksheets may be used as long as the same information is provided.
7. Oven-dry RAP to a constant weight in accordance with California Test 226, except that the temperature must not exceed 100°F.
8. Add moisture-free RAP on top of aggregate in the amount needed for a batch and proceed with specimen preparation (Section 1C.3.).

**D. PREPARATION OF FIELD-MIXED HMA (LOOSE MIX) SPECIMENS**

There are no modifications.

Worksheet for Computing Laboratory Batch Weights for HMA Mixtures Containing RAP

Date: \_\_\_\_\_ Prepared By: \_\_\_\_\_ EXAMPLE for CT 304

Mix Type:	10
% RAP in HMA (15% Max)	5.7
Asphalt Content of RAP 1	0.5
% Hydrated Lime for Coarse Aggregate 2	0.8
% Hydrated Lime for Fine Aggregate 1	1.0

1 - yellow cell denotes a required input.

2 By weight of total mix. Use average from ASTM D 2172.

3 This percentage is based on the weight of total aggregate plus hydrated lime  
4 This percentage is based on the weight of total aggregate including RAP aggregates; however, RAP aggregates are not treated with hydrated lime.

Table 1: Batch Weights for Virgin Aggregate, RAP, New Asphalt Binder, and Hydrated Lime

Parameter / Sample Number	1	2	3	4	5	6
Desired Total Asphalt Content of Mix, % by wt. of mix	4.3	4.8	5.3	5.9	6.3	6.3
Desired Hot Mix Sample Weight, g	1200	1200	1200	1200	1200	1200
Weight of Total Aggregate, g	1148	1142	1138	1130	1124	1124
New Asphalt, % by wt. of mix	4.3	4.8	5.3	5.9	6.3	6.3
Weight of New Asphalt to be Added, g	51.6	57.6	62.6	69.6	74.6	74.6
RAP, % by wt. of aggregate	0.0	0.0	0.0	0.0	0.0	0.0
Weight of RAP to be Added, g	0	0	0	0	0	0
Weight of Asphalt from RAP, g	0	0	0	0	0	0
New Aggregate, %	100	100	100	100	100	100
Weight of Virgin Aggregate + Hy. Lime, g	1148	1142	1138	1130	1124	1124
Weight of Hydrated Lime for Coarse Aggregate, g	0	0	0	0	0	0
Weight of Hydrated Lime for Fine Aggregate, g	0	0	0	0	0	0
Weight of Virgin Aggregate, g	1148	1142	1138	1130	1124	1124
Check	1200	1200	1200	1200	1200	1200

Table 2: Combined Gradation Summary

AGGREGATE:	RAP	3/4"	1/2"	3/8"	Rock Dust	Natural Sand	Crushed Sand	Hydrated Lime	Blend *
% of Blend	10.0	5.0	25.0	25.0	20.0	10.0	0.0	1.0	100.0
% of Blend w/o RAP or Lime	0.0	5.8	31.1	28.9	22.2	11.1	0.0	1.1	100.0
Sieve Size	% Passing	% of Blend	% of Blend	% of Blend	% of Blend	% of Blend	% of Blend	% of Blend	% of Blend
1 1/2"	100.0	10.0	28.0	100.0	24.0	100.0	0.0	100.0	100.0
1"	100.0	10.0	24.0	100.0	20.0	100.0	0.0	100.0	100.0
3/4"	100.0	10.0	24.0	100.0	20.0	100.0	0.0	100.0	100.0
1/2"	100.0	10.0	24.0	100.0	20.0	100.0	0.0	100.0	100.0
No. 4	100.0	10.0	24.0	100.0	20.0	100.0	0.0	100.0	100.0
No. 8	85.0	6.8	21.1	84.7	17.7	80.8	0.0	100.0	100.0
No. 16	57.0	3.5	13.3	56.1	11.2	52.8	0.0	100.0	100.0
No. 25	39.0	2.5	9.3	38.5	7.7	35.3	0.0	100.0	100.0
No. 30	25.0	1.6	6.2	25.0	5.0	22.2	0.0	100.0	100.0
No. 100	15.0	1.0	3.5	15.0	3.0	14.3	0.0	100.0	100.0
No. 200	10.0	0.5	2.0	10.0	2.0	9.3	0.0	100.0	100.0
* Munt = 100%									

Table 3: Batch Weights Needed for Each Individual Sieve

Sample Fraction	1		2		3		4		5	
	RAP	Virgin	RAP	Virgin	RAP	Virgin	RAP	Virgin	RAP	Virgin
1 1/2" - 1"	0	0	0	0	0	0	0	0	0	0
1" - 3/4"	0	0	0	0	0	0	0	0	0	0
3/4" - 1/2"	0	0	0	0	0	0	0	0	0	0
1/2" - 3/8"	0	0	0	0	0	0	0	0	0	0
3/8" - No. 4	13	0	13	0	0	0	0	0	0	0
No. 4 - No. 8	13	0	26	0	0	0	0	0	0	0
No. 8 - Pan	50	0	76	0	0	0	0	0	0	0
Lime	0	1204	1300	0	0	0	0	0	0	0
Asphalt	0	1204	2402	0	0	0	0	0	0	0

This Microsoft Excel Spreadsheet is available at:  
[http://www.dot.ca.gov/hq/esc/Translab/ofpm/documents/LP\\_9worksheet.xls](http://www.dot.ca.gov/hq/esc/Translab/ofpm/documents/LP_9worksheet.xls)  
 or click [here](#) to access the Excel Spreadsheet

FIGURE A1: Example worksheet for Computing Laboratory Batch Weights for HMA Containing RAP

## APPENDIX B

### METHOD OF PREPARATION OF HMA TEST SPECIMENS CONTAINING ASPHALT BINDER TREATED WITH LIQUID ANTISTRIP

#### A. SCOPE

This appendix includes modifications that must be made to California Test 304 when preparing test specimens of HMA containing asphalt binder treated with liquid anti-strip.

#### B. PREPARATION OF LABORATORY-MIXED HMA SPECIMENS

1. Heat the asphalt binder to be used in the HMA to the appropriate temperature (Section 1C.3.a.).
2. Weigh out a sufficient quantity of asphalt binder into a tared metal container and determine the weight to the nearest 0.1 g.
3. Under a fume hood, slowly stir the required amount of room-temperature ( $77^{\circ}\text{F} \pm 9^{\circ}\text{F}$ ) liquid anti-strip into the required weight of heated asphalt binder.

NOTE: If the liquid anti-strip is too viscous at room temperature, it may be warmed to  $100^{\circ}\text{F}$  and stirred prior to adding it to the asphalt binder.

4. Use a stirring rod and blend the liquid anti-strip and asphalt binder together for a minimum of 2 min.
5. Maintain the treated asphalt binder at the temperature specified until it is used.

NOTE: Discard the treated asphalt binder if not used the same day it is prepared or if allowed to cool so it requires reheating.

6. Proceed with specimen preparation.

#### C. PREPARATION OF FIELD-MIXED HMA (LOOSE MIX)

There are no modifications.

## APPENDIX C

### METHOD OF PREPARATION OF HMA TEST SPECIMENS CONTAINING DAMP AGGREGATE TREATED WITH DRY LIME

#### A. SCOPE

This appendix includes modifications that must be made to California Test 304 when preparing HMA test specimens containing damp aggregate treated with dry hydrated lime.

#### B. REFERENCED DOCUMENTS

California Test 226 – Determination of Moisture Content by Oven Drying

#### C. PREPARATION OF LABORATORY-MIXED HMA SPECIMENS

1. Aggregate Treated with Lime Without Marination
  - a. Before adding lime, place the combined dry aggregate batch in a mixing bowl and add 2 % water by dry weight of aggregate.  
  
Mix the aggregate with water for 1 to 2 min, then add the required proportion of hydrated lime and continue mixing for 2 to 3 additional minutes.  
  
NOTE: Add more moisture, if necessary, to assure complete coating of aggregate particles in lime.
  - b. After mixing, oven-dry the lime-treated aggregate to constant weight in accordance with California Test 226, except that the temperature must be the specified mixing temperature (Section 1C.3.a.).  
  
NOTE: If fine particles or lime residue stick to the pan after drying, use a short-bristle brush to remove the material and recombine it with the rest of the lime-treated aggregate.  
  
Cool to room temperature ( $77^{\circ}\text{F} \pm 9^{\circ}\text{F}$ ).
  - c. Proceed with specimen preparation.
2. Aggregate Treated with Lime and Marinated
  - a. Batch coarse and fine aggregate fractions separately.
  - b. Oven-dry the coarse and fine aggregate fractions in accordance with California Test 226 and then cool to room temperature ( $77^{\circ}\text{F} \pm 9^{\circ}\text{F}$ ).
  - c. Add 1 % water by dry weight of coarse aggregate to the coarse fraction and 2 % water by dry weight of fine aggregate to the fine fraction.
  - d. Mix each coarse and fine fraction with water for 1 to 2 min, then add the required proportion of hydrated lime to each coarse and fine fraction and continue mixing for 2 to 3 additional minutes.

NOTE: Add more moisture to the coarse and fine fraction, if necessary, to achieve complete coating of aggregate particles in lime.

- e. Marinate the coarse and fine fractions separately in plastic containers for 24 to 96 hr.
- f. Combine the marinated aggregate fractions and mix the composite blend thoroughly with a trowel or spoon. Break up any clumps.
- g. Transfer the lime-treated marinated aggregate to a pan and oven-dry to a constant weight under California Test 226, except that the temperature must be the specified mixing temperature. (Section 1C.3.a.)

NOTE: If fine particles or lime residue stick to the pan after drying, use a short-bristle brush to remove the material and recombine it with the rest of the lime-treated marinated aggregate.

- h. Proceed with specimen preparation.

**D. PREPARATION OF FIELD-MIXED HMA (LOOSE MIX)**

There are no modifications.



## APPENDIX D

### METHOD OF PREPARATION OF HMA TEST SPECIMENS CONTAINING AGGREGATE TREATED WITH LIME SLURRY

#### A. SCOPE

This appendix contains modifications that must be made to California Test 304 when preparing HMA test specimens containing aggregate treated with hydrated lime slurry.

#### B. PREPARATION OF LABORATORY-MIXED HMA SPECIMENS

1. Batch coarse and fine aggregate fractions separately.
2. Oven-dry coarse and fine aggregate fractions in accordance with California Test 226 and allow them to cool to room temperature ( $77^{\circ}\text{F} \pm 9^{\circ}\text{F}$ ).
3. Add 1 % water by dry weight of aggregate to the respective coarse and fine fractions and place the fractions in separate plastic containers to retain moisture while preparing lime slurry.
4. Determine the weight of lime required (by dry weight of aggregate) to provide the required lime content of each coarse and fine aggregate fraction. Mix 1 part lime to 2 parts water. Break up any clumps in the lime slurry.
5. Add the required amount of lime slurry to the coarse and fine fraction, separately. In a mixing bowl, use a trowel or spoon to thoroughly mix the slurry with the moisture conditioned coarse aggregate. Stir for a minimum of 3 min.
6. Marinate the coarse and fine fractions separately in air-tight plastic containers for 24 to 96 hrs.
7. Combine the marinated aggregate fractions and mix the composite blend thoroughly with a trowel or spoon. Break up any clumps.
8. Transfer the lime-treated, marinated aggregate to a pan and oven-dry to a constant weight in accordance with California Test 226, except that the temperature must be the specified mixing temperature. (Section 1C.3.a.)

NOTE: If fine particles or lime residue stick to the pan after drying, use a short-bristle brush to remove the material and recombine it with the rest of the lime-treated marinated aggregate.

9. Proceed with specimen preparation.

#### C. PREPARATION OF FIELD-MIXED HMA (LOOSE MIX) SPECIMENS

There are no modifications.