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METHOD OF TEST FOR OPTIMUM BINDER CONTENT (OBC) FOR HMA TYPE A, B, C, AND RHMA-G

A. SCOPE

This test method describes the procedure to determine the optimum binder content (OBC) by total weight of mix at design air voids for hot mix asphalt (HMA) Type A, B, C and rubberized hot mix asphalt gap-graded (RHMA-G) specimens compacted using the California Kneading Compactor.

This test method also contains the following appendices:

Appendix A	Definitions and Equations for Volumetric Relationships
Appendix B	Determining Optimum Binder Content for HMA Containing up to 15 % Reclaimed Asphalt Pavement
Appendix C	Calculations for Converting Between By Dry Weight of Aggregate and By Total Weight of Mix
Appendix D	Sample Mix Design and Job-Mix Formula Report

B. REFERENCES

CT 106	Definitions of Terms Relating to Specific Gravity
CT 202	Sieve Analysis of Coarse and Fine Aggregate
CT 206	Specific Gravity and Absorption of Coarse Aggregate
CT 207	Specific Gravity and Absorption of Fine Aggregate
CT 208	Apparent Specific Gravity of Fine Aggregate
CT 304	Preparation of Hot Mix Asphalt for Test Specimens
CT 308	Specific Gravity of Compacted HMA Specimens
CT 309	Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt

C. DETERMINING OPTIMUM BINDER CONTENT

SPECIAL NOTE: Prior to the issuance of this California Test 367 (dated November 2010) binder content, etc. were calculated based on dry weight of aggregate. Beginning with the issuance of this test method, binder content, etc. are calculated based on total weight of mixture. Appendix C contains examples of converting from by dry weight of aggregate to by total weight of mix and from total weight of mix to by dry weight of aggregate.

To determine OBC fabricate HMA briquettes with various binder contents, test the briquettes for stability and air voids content, evaluate their volumetric properties (Appendix A), and choose the binder content that will provide a mix that meets the specifications. An approximate binder content (ABC) is selected to start the process.

ABC selection may be made based on prior experience with the proposed aggregate or use the ABC values in Table 1:

TABLE 1

Recommended ABC for Hot Mix Asphalt Aggregate Size

HMA Aggregate Size	Recommended ABC by Total Weight of Mix [1, 2]
1 1/2 in	4.00%
1.0 in	4.50%
3/4 in	5.00%
1/2 in	5.50%
3/8 in	6.00%
No. 4	6.50%

[1] For all RHMA-G mixes use 7.50 % by total weight of mix
[2] All binder contents are for mixes without reclaimed asphalt pavement (RAP). See Appendix B for mixes that include RAP.

1. Select 4 trial binder contents: ABC — 0.50%, ABC, ABC + 0.50%, and ABC + 1.00%.

NOTE: 0.50% interval is recommended, smaller intervals may be used for sensitive mixes.

2. Fabricate 1 briquette at each trial binder content in accordance with California Test 304. Determine the stability value of each briquette in accordance with California Test 366 and the bulk specific gravity (G_{mb}) of each briquette in accordance with California Test 308, Method A.
3. Determine the theoretical maximum specific gravity (G_{mm}) and unit weight of the HMA in accordance with California Test 309. Use the G_{mm} result for each trial binder content to calculate the corresponding effective specific gravity (G_{se}) of the aggregate. Because G_{se} is considered constant, use the G_{se} results at the 4 trial binder contents to determine the average G_{se}, and use this average as the G_{se} value in subsequent calculations.
4. Determine the air voids content at each trial binder content.
   Trial binder contents should result in air voids contents that encompass the specified design air voids. If the trial binder contents do not encompass the specified design air voids, select additional trial binder contents to encompass design air voids. Repeat Steps 1 through 4 at additional trial binder contents. Do not extrapolate to determine binder content at design air voids content.
5. Calculate other volumetric parameters (Appendix A and Appendix C).
6. Plot the following:
   - binder vs. air voids content
   - binder content vs. stability
   - binder content vs. voids in mineral aggregate, VMA
   - binder content vs. voids filled with asphalt, VFA
   - binder content vs. bulk specific gravity, G_{mb}
   - binder content vs. max theoretical maximum density (unit weight)
   - binder content vs. dust proportion, DP
7. Select the OBC at the specified design air voids content meeting the stability, VMA, VFA, and DP requirements.
8. Fabricate and test 3 briquettes at the selected OBC to verify compliance with the project specifications.
   If the volumetric properties do not meet the specification requirements, the mix design process must be repeated until the specification requirements are met.

D. REPORTING OF RESULTS

Report the HMA mix design and job-mix formula (JMF) information on Form CEM-3512.

For JMF Verification report the information on Form CEM-3513.

For JMF Renewal report the information on Form CEM-3514.

Forms are available at:

https://dot.ca.gov/programs/construction/forms

E. 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.

Refer to the Safety Manual for your laboratory.

Caltrans Laboratory Safety Manual is available at:

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

End of Text
(California Test 367 contains 35 pages)

APPENDIX A

DEFINITIONS AND EQUATIONS FOR VOLUMETRIC RELATIONSHIPS

A. SCOPE

This appendix describes the definition and equations necessary to compute the volumetric relationships of an HMA mixture.

B. VOLUMETRIC PROPERTIES OF HMA

Mix design is a volumetric process, but weights are much easier to measure and control in the laboratory than volumes. Calculations are based on weight-volume relationships of compacted mixture specimens.

Figure 1 depicts the volumetric relationships:

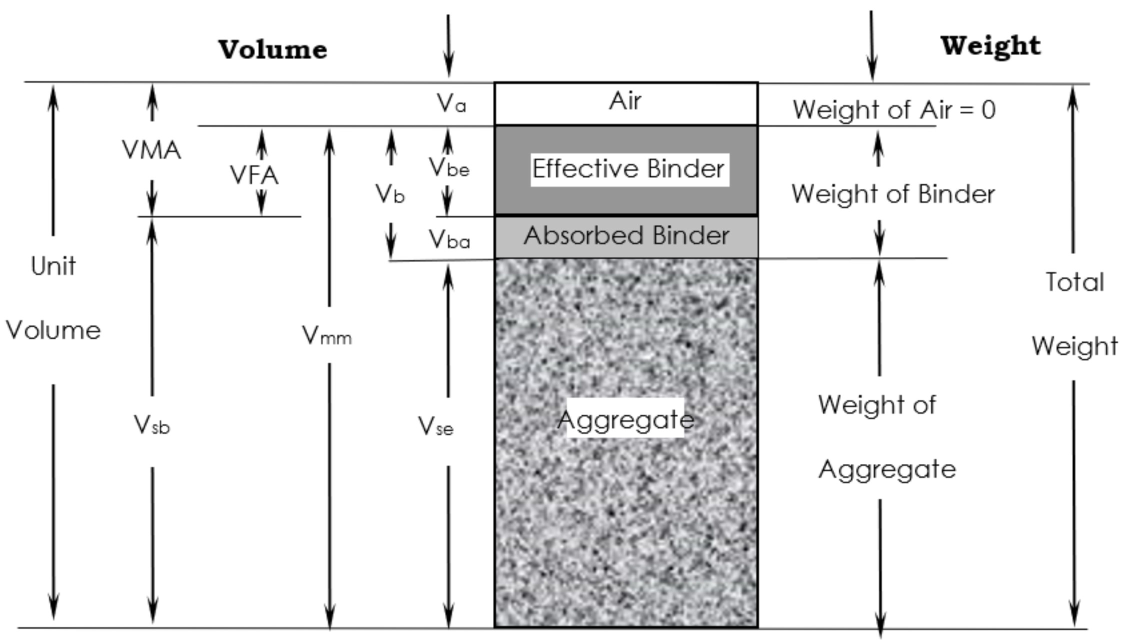

FIGURE 1. Weight-Volume Relationships in Compacted HMA

Where:
- V_a = Volume of air voids, percent
- V_b = Total volume of asphalt binder, percent
- V_{ba} = Volume of absorbed asphalt binder, percent
- VFA = Volume of voids filled with asphalt binder, percent
- VMA = Volume of voids in mineral aggregate, percent
- V_{mb} = Bulk volume of compacted mix
- V_{mm} = Voidless volume of paving mix
- V_{sb} = Bulk volume of mineral aggregate (for bulk specific gravity)

V_{se} = Effective volume of mineral aggregate (for effective specific gravity)

The differences between bulk, apparent, and effective specific gravities are that they are based on different volumes. The volume for bulk specific gravity (dry) is the largest and includes the volume of the aggregate and of surface and interior voids (permeable and impermeable). The volume for effective specific gravity excludes the voids that are filled with asphalt binder. Apparent specific gravity considers only the impermeable volume (smallest).

The volumetric calculations herein can be used in conjunction with any method of HMA volumetric mix design, including Hveem and Superpave among others.

Notation

A widely used, consistent system of notation has been developed by The Asphalt Institute and established as a national standard. This system is used in this document and here are the keys to understanding it.

"P" stands for the percentage of any component by total weight of mix and subscripts identify which component:

- "b" stands for binder,
- "m" stands for mix, and
- "s" stands for stone, i.e. aggregate.

"G" stands for specific gravity and two subscripts are used as identifiers:

The first subscript identifies the material:

- "b" stands for binder,
- "m" stands for mix, and
- "s" stands for stone, i.e. aggregate

The second subscript identifies which type specific gravity is being used:

- "a" stands for apparent,
- "b" stands for bulk,
- "e" stands for effective, and
- "m" stands for theoretical maximum specific gravity

Examples: G_{sb} = Bulk specific gravity of the aggregate
G_{mb} = Bulk specific gravity of the mixture
G_{mm} = Theoretical maximum specific gravity of the mixture

C. EQUATIONS AND FEINITIONS FOR VOLUMENTRIC CALCULATIONS

SPECIAL NOTE: Prior to the issuance of this California Test 367 (dated October 2010) binder content, etc. were calculated based on dry weight of aggregate. Beginning with the issuance of this test method, binder content, etc. are calculated based on total weight of mixture.

Appendix C contains examples of converting from by dry weight of aggregate to by total weight of mix and from by total weight of mix to by dry weight of aggregate.

1. **Theoretical Maximum Specific Gravity**

The theoretical maximum specific gravity (G_{mm}) is determined on HMA samples that include admixture (if it will be used in the mix) in accordance with California Test 309. Theoretical maximum specific gravity is determined for the 4 trial binder contents (ABC — 0.50%, ABC, ABC + 0.50%, and ABC + 1.00%).

Theoretical maximum specific gravity can be calculated for other binder contents (Equation A3) using the effective specific gravity of the aggregate-admixture blend (G_{se}).

Theoretical maximum density (unit weight) is $G_{mm} \times 62.245$ lb/ft^3 (the density of water at 77°F).

2. **Effective Specific Gravity of Aggregate-Admixture Blend, G_{se}**

Effective specific gravity of the aggregate-admixture blend (G_{se}) is considered constant regardless of binder content. Gse is calculated as follows:

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}}$$

(A1)

Where:
G_{se} = Effective specific gravity of the aggregate-admixture blend, to the nearest 0.001
P_b = Binder content at which the theoretical maximum specific gravity test was performed, as percent by total weight of mix to the nearest 0.01
G_{mm} = Theoretical maximum specific gravity of the HMA at binder content (Pb), to the nearest 0.001

G_b = Specific gravity of the asphalt binder, to the nearest 0.001

During the mix design, calculate G_{se} for each of the 4 trial binder contents and average. Use this average as the G_{se} value in subsequent calculations.

3. **Bulk Specific Gravity of Aggregate-Admixture Blend, G_{sb}**

Bulk specific gravity of aggregate-admixture blend (G_{sb}) is considered constant regardless of binder content. G_{sb} is calculated as follows:

$$G_{sb} = \frac{P_1 + P_2 + \cdots P_n}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \cdots \frac{P_n}{G_n}}$$

(A2)

Where: G_{sb} = Bulk specific gravity of the aggregate-admixture blend, to the nearest 0.001
P_1, P_2, P_n = Individual percentages of aggregate, including fine aggregate, coarse aggregate and supplemental fines (if used), by total weight of mix to the nearest 0.1. (Total = 100.0%)
G_1, G_2, G_n = Individual bulk specific gravities of aggregate components, including fine aggregate, coarse aggregate and supplemental fines (if used), to the nearest 0.001

During the mix design, calculate G_{sb} for each of the 4 trial binder contents and average. Use this average as the G_{sb} value in subsequent calculations.

4. **Theoretical Maximum Specific Gravity for Different Binder Contents, G_{mm}**

NOTE: This equation for G_{mm} may be used only for determining G_{mm} of additional mixtures when it requires more than 4 trial asphalt binders to develop air voids contents that encompass the specified design air voids. For all other circumstances, determine G_{mm} in accordance with California Test 309.

Theoretical maximum specific gravity of the HMA at binder content (Pb) by WTM is simply solving the G_{se} equation for G_{mm} instead, as follows:

$$G_{mm} = \frac{100}{\frac{P_s}{G_{se}} - \frac{P_b}{G_b}}$$

(A3)

Where: G_{mm} = Theoretical maximum specific gravity of the HMA at binder content (P_b), to the nearest 0.001
P_s = Aggregate content, as percent by total weight of mix to the nearest 0.1 (except P_{200} – to the nearest 0.01) (P_s = 100 – P_b)
P_b = Trial binder content, as percent by total weight of mix to the nearest 0.01
G_{se} = Effective specific gravity of the aggregate-admixture blend, to the nearest 0.001
G_b = Specific gravity of the asphalt binder, to the nearest 0.001

5. **Percent Absorbed Asphalt Binder, P_{ba}**

Percent absorbed asphalt binder (P_{ba}) is calculated as follows:

$$P_{ba} = 100\frac{G_{se} - G_{sb}}{G_{sb}(G_{se})}G_b$$

(A4)

Where: P_{ba} = Absorbed asphalt binder, as percent by dry weight of aggregate to the nearest 0.01
G_{se} = Effective specific gravity of the aggregate-admixture blend, to the nearest 0.001
G_{sb} = Bulk specific gravity of the aggregate-admixture blend, to the nearest 0.001
G_b = Specific gravity of the asphalt binder, to the nearest 0.001

6. **Effective Binder Content of the Mixture, P_{be}**

Effective binder content of the mixture (P_{be}) is calculated as follows:

$$P_{be} = P_b - \left(\frac{P_{ba}}{100}\right)P_s$$

(A5)

Where: P_{be} = Effective binder content of the mixture (free asphalt binder not absorbed), as percent by total weight of mix to the nearest 0.01

P_b = Binder content, as percent by total weight of mix to the nearest 0.01
P_{ba} = Absorbed asphalt binder, as percent by total weight of mix to the nearest 0.01
P_s = Aggregate content, as percent by total weight of mix to the nearest 0.1 (except P_{200} – to the nearest 0.01) (P_s = 100 – P_b)

7. **Percent Effective Asphalt Binder Volume, V_{be}**

Percent effective asphalt binder volume of the mixture (V_{be}) is calculated as follows:

$$V_{be} = \frac{P_{be} \times G_{mb}}{G_b}$$

(A6)

Where: V_{be} = Effective asphalt binder volume, as percent of bulk volume to the nearest 0.1
P_{be} = Effective asphalt binder content of the mixture (free asphalt binder not absorbed), as percent by total weight of mix to the nearest 0.01
G_{mb} = Bulk specific gravity of compacted mixture, to the nearest 0.001
G_b = Specific gravity of the asphalt binder, to the nearest 0.001

8. **Percent Voids in Mineral Aggregate (VMA) in Compacted Mixture, VMA**

Voids in Mineral Aggregate (VMA) is the void space between the aggregate particles in a compacted paving mixture that includes the air voids and the effective binder content, expressed as a percentage of the total mixture volume. Where mixture composition is determined as percent by total weight of mix, the following equation applies:

$$\text{VMA} = 100 - \frac{G_{mb} P_s}{G_{sb}}$$

(A7)

Where: VMA = Voids in the mineral aggregate, as percent of bulk volume to the nearest 0.1

G_{sb} = Bulk specific gravity of the aggregate-admixture blend, to the nearest 0.001
G_{mb} = Bulk specific gravity of compacted mixture, to the nearest 0.001
P_s = Aggregate content, as percent by total weight of mix to the nearest 0.1 (except P_{200} – to the nearest 0.01) (P_s = 100 – P_b)

9. **Percent Air Voids in Compacted Mixture, V_a**

Air voids are the spaces between coated aggregate particles that are not filled with asphalt binder. The calculated G_{mm} values for the respective binder contents are used to determine the corresponding air voids contents of the compacted specimens at each binder content level as follows.

$$V_a = 100 - \left(\frac{G_{mm} - G_{mb}}{G_{mm}}\right)$$

(A8)

Where: V_a = Volume of effective air voids in the compacted mixture, as percent of total volume to the nearest 0.1
G_{mm} = Theoretical maximum specific gravity of the HMA at binder content (P_b), to the nearest 0.001
G_{mb} = Bulk specific gravity of compacted mixture, to the nearest 0.001

10. **Percent Voids Filled with Asphalt in Compacted Mixture, VFA**

VFA is the percentage of the VMA (void space between the aggregate particles) that is filled with asphalt binder. VFA is calculated as follows:

$$\text{VFA} = \frac{100(VMA - V_a)}{VMA}$$

(A9)

Where: VFA = Voids filled with asphalt binder, percent of VMA to the nearest 0.1
VMA = Voids in the mineral aggregate, as percent of bulk volume to the nearest 0.1
V_a = Volume of effective air voids in the compacted mixture, as percent of total volume to the nearest 0.1

11. **Dust Proportion in the Compacted Mixture, DP**

Dust proportion (DP) is the ratio of weight of dust (percentage passing #200 sieve) to the effective binder content in the mixture. DP is calculated as follows:

$$\mathrm{DP} = \frac{P_{200}}{P_{be}}$$

(A10)

Where: DP = Ratio of percentage passing #200 sieve to the effective binder content, by total weight of mix to the nearest 0.01

P_{200} = Percentage passing #200 sieve by dry weight of aggregate, to the nearest 0.01

P_{be} = Effective binder content, as percent by total weight of mix to the nearest 0.01

APPENDIX B

DETERMINING OPTIMUM BINDER CONTENT (OBC) FOR HMA CONTAINING UP TO 15% RECLAIMED ASPHALT PAVEMENT (RAP)

A. SCOPE

This appendix describes the modifications that must be made to the method for determining OBC described in California Test 367 and to the basic volumetric calculations in Appendix A when preparing HMA containing up to 15 % RAP by dry weight of aggregate.

B. REFERENCES

ASTM D 2172	Quantitative Extraction of Bitumen from Bituminous Paving Mixtures

C. HMA MIX CONTAINING RAP PREPARATION AND DETERMINATION OF THE PROPERTIES

Sample and prepare the RAP and HMA mix containing RAP as follows:

1. Prepare virgin aggregate and RAP blend in accordance with California Test 304.
2. Select the ABC and the other 3 trial binder contents to be used with the selected aggregate gradation, based on experience with the subject materials and/or the values recommended in Table 1 of California Test 367.
3. Determine the amount of virgin asphalt binder (by total weight of mix) to add for each trial by subtracting the asphalt binder in the proposed portion of RAP from the total asphalt binder of each trial.
4. Mix, compact, and test briquettes at the selected trial binder contents and perform volumetric calculations as specified in Section D.
5. Select an OBC that provides an HMA mixture that conforms to specifications.

D. VOLUMETRIC CALCULATIONS USING RAP

The binder content, gradation, and theoretical maximum specific gravity of the RAP are used to calculate the volumetric properties by total weight of the RAP and of the HMA containing the RAP. This section presents the modifications to the volumetric calculations to account for the RAP using example data shown in Table B-1.

TABLE B-1

Example Mix Design Containing RAP (Design Air Voids Content = 4.0 %)

Component	Bulk Specific Gravity	By Dry Weight of Aggregate (Percent)	By Total Weight of Mix (Percent)
Proposed total asphalt binder, P_b	G_b = 1.020 [1]	5.82	5.50
Asphalt binder in RAP, P_{br} (From ASTM D 2172)	G_{br} = 1.020 [2]	5.70	5.39
Virgin asphalt binder to be added	G_b = 1.020 [2]	5.25 [3]	4.99
RAP, P_r	Calculate G_{ser}	10.0	9.5
Virgin coarse aggregate, P_1 (retained No. 4 sieve)	G_1 = 2.720	49.8	47.1
Virgin fine aggregate, P_2 (passing No. 4 sieve)	G_2 = 2.700	39.2	37.0
Supplemental fines, P_3 [4]	G_3 = 2.380	1.0	0.9
Compacted mixture	G_{mb} = 2.440	California Test 308A	
Loose mixture	G_{mm} = 2.542	California Test 309	

1 Value should be available from asphalt supplier
2 Assumed values which may be used if no test results are available
3 Calculated: 5.82% - (5.70% x 10%) = 5.25%
4 May include lime, baghouse fines, or other mineral filler

TABLE B-2

Example Aggregate Blend

	RAP		**Virgin Aggregate**		**Supplemental Fine**		**Blend**
Percent of Blend	**10.0**		**89.0**		**1.0**		**100.0**
Sieve Size	**Percent**		**Percent**		**Percent**		**Percent Passing**
	Passing	**Used**	**Passing**	**Used**	**Passing**	**Used**	
1"	100.0	10.0	100.0	89.0	100.0	1.0	100.0
3/4"	100.0	10.0	100.0	89.0	100.0	1.0	100.0
1/2"	100.0	10.0	97.5	86.8	100.0	1.0	97.8
3/8"	100.0	10.0	72.7	64.7	100.0	1.0	75.7
#4	83.0	8.3	44.0	39.2	100.0	1.0	48.5
#8	66.0	6.6	32.3	28.7	100.0	1.0	36.3
#16	52.0	5.2	23.7	21.1	100.0	1.0	27.3
#30	39.0	3.9	17.1	15.2	100.0	1.0	20.1
#50	26.0	2.6	10.3	9.2	100.0	1.0	12.8
#100	16.0	1.6	5.4	4.8	100.0	1.0	7.4
#200	10.00	1.00	3.30	2.90	90.00	0.90	4.80

The following calculations illustrate the procedures to determine the percentages of RAP (Pr), virgin binder content (Pbv), virgin coarse aggregate (P1), virgin fine aggregate (P2), and, supplemental fines (P3) by total weight of mix:

$$P_r = P_s \times P_{sr} = (100\% - 5.50\%) \times 10\% = 94.50\% \times 10\% = 9.5\%$$

(B1)

$$P_{bv} = P_b - P_{br} = 5.50\% - (5.39\% \times 9.5\%) = 4.99\%$$

(B2)

Where: P_r = RAP, as percent by total weight of mix to the nearest 0.1
P_s = Aggregate content, as percent by total weight of mix to the nearest 0.1 (except P_{200} – to the nearest 0.01) (P_s = 100 – P_b)
P_{sr} = RAP in gradation blend chart, as percent by total weight of mix to the nearest 0.1
P_b = Total binder content, as percent by total weight of mix to the nearest 0.01 ($P_b = P_{br} + P_{bv}$)
P_{br} = Binder content of RAP, as percent by total weight of mix to the nearest 0.01
P_{bv} = Virgin binder content, as percent by total weight of mix to the nearest 0.01

NOTE: When developing an aggregate blend including both RAP and virgin aggregates, current industry practices considers asphalt binder in the RAP as part of the aggregate in the calculation as illustrated in Table B-2.

$$P_1 = P_s \times P_{sv} \times \%\ retained\ on\ \#4 = 94.50\% \times 85.0\% \times 56.0\% = 45.0\%$$

(B3)

$$P_2 = P_s \times P_{sv} \times \%\ passing\ \#4 = 94.50\% \times 85.0\% \times 44.0\% = 35.3\%$$

(B4)

$$P_3 = P_s \times P_{ss} = 94.5\% \times 1.0\% = 0.9\%$$

(B5)

Where: P_s = Total aggregate, as percent by total weight of mix to the nearest 0.1

P_{sv} = Virgin aggregate in gradation blend chart, as percent by total weight of mix to the nearest 0.1
P_{ss} = Supplemental fines in gradation blend chart, as percent by total weight of mix to the nearest 0.1
P_1 = Virgin coarse aggregate, as percent by total weight of mix to the nearest 0.1
P_2 = Virgin fine aggregate, as percent by total weight of mix to the nearest 0.1
P_3 = Supplemental fines, as percent by total weight of mix to the nearest 0.1

1. **Effective Specific Gravity of RAP Aggregate, G_{ser}**

One of the primary differences in the volumetric calculations when RAP is used is that the effective specific gravity is used to approximate the bulk specific gravity (G_{sb}) of the RAP aggregate. Use the binder content of the RAP determined in accordance with ASTM D 2172 and the theoretical maximum specific gravity of the RAP determined in accordance with California Test 309 to calculate the effective specific gravity of the RAP aggregate.

NOTE: Test 3 samples in accordance with California Test 309 and use the average of the results as G_{mmr} in the following calculations.

Given: G_{mm} = 2.542 (average of 4 California Test 309 results for trial binder contents)
G_{mmr} = 2.533 (average of 3 California Test 309 results)
G_b and G_{br} = 1.020

$$_{ser} = \frac{100 - P_{br}}{\frac{100}{G_{mmr}} - \frac{P_{br}}{G_{br}}} = \frac{100 - 5.39}{\frac{100}{2.533} - \frac{5.39}{1.020}} = 2.767$$

(B6)

Where: G_{ser} = Effective specific gravity of the RAP aggregate, to the nearest 0.001
G_{mmr} = Theoretical maximum specific gravity of the RAP mix at binder content P_{br}, by total weight of mix to the nearest 0.001
P_{br} = RAP binder content at which the theoretical maximum specific gravity test was performed, as percent by total weight of mix to the nearest 0.01

G_{br} = Specific gravity of the RAP asphalt binder, to the nearest 0.001

2. **Bulk Specific Gravity of the Virgin Aggregate and RAP Blend, G_{sb}**

To calculate the bulk specific gravity of the blend of virgin aggregate and RAP, treat the RAP as another aggregate. Use the percentage of RAP and the G_{ser} for the RAP for the bulk specific gravity of the RAP aggregate as follows:

$$ {}_{sb} = \frac{P_1 + P_2 + \cdots + P_r}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \cdots + \frac{P_r}{G_{ser}}} = \frac{47.1 + 37.0 + 0.9 + 9.5}{\frac{47.1}{2.720} + \frac{37.0}{2.700} + \frac{0.9}{2.380} + \frac{9.5}{2.767}} = 2.712 $$

(B7)

Where: G_{sb} = Bulk specific gravity of the blend of virgin aggregate and RAP, to the nearest 0.001
P_1 = Virgin coarse aggregate, as percent by total weight of mix to the nearest 0.1
P_2 = Virgin fine aggregate, as percent by total weight of mix to the nearest 0.1
P_3 = Hydrated lime, as percent by total weight of mix to the nearest 0.1
P_r = RAP, as percent by total weight of mix to the nearest 0.1
G_1 = Bulk specific gravity of the virgin coarse aggregate, to the nearest 0.001
G_2 = Bulk specific gravity of the virgin fine aggregate, to the nearest 0.001
G_3 = Bulk specific gravity of the hydrated lime, to the nearest 0.001
G_{ser} = Effective specific gravity of the RAP aggregate, to the nearest 0.001

The rest of the volumetric calculations are based on the properties of the HMA mix including the RAP and are the same as presented in Section D of this test method.

3. **Theoretical Maximum Specific Gravity of HMA and RAP Mix, G_{mm}**

Perform California Test 309 on the trial HMA mixture(s) of blended virgin aggregate and RAP. G_{mm} must be determined at each of the trial binder contents (ABC — 0.50%, ABC, ABC + 0.50%, and ABC + 1.00%). Once the average effective specific gravity of the blend (G_{se}) is determined for the 4 trial binder contents, all other G_{mm} can be calculated using:

$$ {}_{mm} = \frac{100}{\frac{P_s}{G_{se}} + \frac{P_b}{G_b}} $$

(B8)

Where: G_{mm} = Theoretical maximum specific gravity of the HMA at binder content Pb, to the nearest 0.001

P_s = Aggregate content, as percent by total weight of mix to the nearest 0.1 (except P_{200} – to the nearest 0.01) (Ps = 100 – P_b)

P_b = Trial binder content, as percent by total weight of mix to the nearest 0.01

G_{se} = Effective specific gravity (average) of the aggregate-admixture blend, to the nearest 0.001

G_b = Specific gravity of the asphalt binder, to the nearest 0.001

4. **Effective Specific Gravity of Virgin Aggregate and RAP Blend, G_{se}**

The effective specific gravity of the virgin aggregate and RAP blend (G_{se}) is calculated from the G_{mm} determined for the HMA and RAP blend at binder content P_b using:

$$ {}_{se} = \frac{100\% - P_b}{\frac{100\%}{G_{mm}} - \frac{P_b}{G_b}} = \frac{100\% - 5.50\%}{\frac{100\%}{2.542} - \frac{5.50\%}{1.020}} = 2.784 $$

(B9)

Where: G_{se} = Effective specific gravity of the virgin aggregate and RAP blend to the nearest 0.001

G_{mm} = Theoretical maximum specific gravity of the HMA and RAP mix at binder content Pb, by total weight of mix to the nearest 0.001

NOTE: Perform California Test 309 at the 4 trial binder contents (ABC — 0.50 %, ABC, ABC + 0.50 %, and ABC + 1.00 %), calculate G_{se} for each trial binder content; and use the average of the G_{se} values in the calculations.

P_b = Binder content, as percent by total weight of mix to the nearest 0.01

NOTE: Binder content at which California Test 309 was performed which includes both the virgin and RAP asphalt binder (Pb at ABR = 5.50 % for this example)
G_b = Specific gravity of the asphalt binder, to the nearest 0.001

5. **Absorbed Asphalt Binder, P_{ba}**

The percent absorbed asphalt binder is calculated using the G_{sb} value for the blend of virgin aggregate and RAP, and the corresponding G_{se} value (or average thereof) calculated using:

$$\mathrm{P}_{ba} = 100\% \left(\frac{G_{se} - G_{sb}}{G_{se}(G_{sb})}\right) G_b = 100\% \left(\frac{2.784 - 2.712}{2.784(2.712)}\right) 1.020 = 0.97\%$$

(B10)

Where: P_{ba} = Absorbed asphalt binder, as percent by total weight of the HMA mix to the nearest 0.01
G_{se} = Effective specific gravity of the virgin aggregate and RAP blend, to the nearest 0.001
G_{sb} = Bulk specific gravity of the virgin aggregate and RAP blend, to the nearest 0.001
G_b = Specific gravity of the asphalt binder, to the nearest 0.001

6. **Effective Binder Content of the HMA with RAP Mix, P_{be}**

$$\mathrm{P}_{be} = P_b - (P_{ba} \times P_s) = 5.50\% - (0.97\% \times 94.50\%) = 4.58\%$$

(B11)

Where: P_{be} = Effective binder content of the mixture, as percent by total weight of mix to the nearest 0.01 (free asphalt binder not absorbed)
P_b = Binder content, as percent by total weight of mix to the nearest 0.01
P_{ba} = Absorbed asphalt binder, as percent by total weight of mix to the nearest 0.01
P_s = Aggregate content, as percent by total weight of mix to the nearest 0.01 (100.00 % - P_b = 94.50 %)

7. **Effective Asphalt Binder Volume of the HMA with RAP Mix, V_{be}**

$$V_{be} = \frac{P_{be}(G_{mb})}{G_b} = \frac{4.58\%(2.440)}{1.020} = 10.96\%$$

(B12)

Where: V_{be} = Effective asphalt binder volume, as percent of bulk volume to the nearest 0.01
P_{be} = Effective binder content of the HMA mix (free asphalt binder not absorbed), as percent by total weight of mix to the nearest 0.01
G_{mb} = Bulk specific gravity of compacted mixture, to the nearest 0.001
G_b = Specific gravity of the asphalt binder to the nearest 0.001

8. **Voids in the Mineral Aggregate in Compacted HMA with RAP Mix, VMA**

$$V_{be} = \frac{P_{be}(G_{mb})}{G_b} = \frac{4.58\%(2.440)}{1.020} = 10.96\%$$

(B13)

Where: V_{be} = Effective asphalt binder volume, as percent of bulk volume to the nearest 0.01
P_{be} = Effective binder content of the HMA mix (free asphalt binder not absorbed), as percent by total weight of mix to the nearest 0.01
G_{mb} = Bulk specific gravity of compacted mixture, to the nearest 0.001
G_b = Specific gravity of the asphalt binder to the nearest 0.001

9. **Percent Air Voids (V_a) in Compacted HMA with RAP Mix, V_a**

$$V_a = 100\%\left(\frac{G_{mm} - G_{mb}}{G_{mm}}\right) = 100\%\left(\frac{2.542 - 2.440}{2.542}\right) = 4.0\%$$

(B14)

Where: V_a = Volume of effective air voids in the compacted mixture, percent of total volume to the nearest 0.1
G_{mm} = Theoretical maximum specific gravity of the HMA mix at binder content (P_b), by total weight of mix to the nearest 0.001

G_{mb} = Bulk specific gravity of compacted mixture, to the nearest 0.001

10. **Voids Filled with Asphalt in Compacted HMA with RAP Mix, VFA**

$$\text{VFA} = \frac{100\%(VMA - V_a)}{VMA} = \frac{100\%(15.0\% - 4.0\%)}{15.0\%} = 73\%$$

(B15)

Where: VFA = Voids filled with asphalt binder, as percent of VMA to the nearest 0.1
VMA = Voids in the mineral aggregate, as percent of bulk volume to the nearest 0.1
V_a = Bulk specific gravity of compacted mixture, to the nearest 0.001

11. **Dust Proportion in the HMA with RAP Mix, DP**

$$\text{DP} = \frac{P_{200}}{P_{be}} = \frac{4.80\%}{4.58\%} = 1.05$$

(B16)

Where: DP = Dust Proportion, to the nearest 0.01
P_{200} = Aggregate passing the No. 200 sieve, as percent by total weight of mix to the nearest 0.0 (P_{200} = 4.80 % for this example)
P_{be} = Effective binder content of the HMA mix (free asphalt binder not absorbed), as percent by total weight of mix to the nearest 0.01

APPENDIX C

CALCULATIONS FOR CONVERTING BETWEEN BY DRY WEIGHT OF AGGREGATE AND BY TOTAL WEIGHT OF MIX

A. SCOPE

The volumetric calculations in this test method (California Test 367) are primarily based on proportions of the asphalt binder and aggregate components by total weight of the HMA mixture (by total weight of mix) rather than proportions by dry weight of aggregate.

This Appendix C provides examples of converting from by dry weight of aggregate to by total weight of mix and from by total weight of mix to by dry weight of aggregate.

1. **Converting From Proportioning By Dry Weight of Aggregate to By Total Weight of Mix**

Example 1: Convert binder content and coarse and fine aggregate fractions from percentages by dry weight of aggregate to percentages by total weight of mix using the data in Table C-1. This example uses weights of the mix components, because 100 g is the total weight of aggregate, the percentages by dry weight of aggregate may be substituted for weights.

Assume: Total weight of the combined aggregates is 100.0 g.

TABLE C-1

Converting from by Dry Weight of Aggregate to by Total Weight of Mix

Material	(Given) By Dry Weight of Aggregate (Percent)	(Computed) By Total Weight of Mix (Percent)
Asphalt Binder [1]	5.15	4.90
Coarse Aggregate (Retained on No. 4 sieve)	56.9	54.1
Fine Aggregate (Passing No. 4 sieve) [2]	43.1	41.0
Supplemental Fines [2]	0	0

1 Calculate and report to the nearest 0.01%

2 May include lime, bag house fines, or other mineral filler

Compute total weight of mix by dry weight of aggregate:

$$Total\ weight\ of\ mix = Total\ aggregate\ weight\ +\ Asphalt\ binder\ weight$$

$$= 100.0g + (0.0515 \times 100g)$$

$$= 100.0g + 5.15g$$

$$= 105.15g$$

Compute binder content by total weight of mix:

$$\%\ asphalt = \frac{5.15}{105.15} \times 100\%$$

$$= 4.90\%$$

Compute percent of coarse aggregate by total weight of mix:

$$\%\ coarse\ aggregate$$

$$= \frac{coarse\ aggregate\ weight\ (by\ dry\ weight\ of\ aggregate)}{total\ weight\ of\ mix} \times 100\%$$

$$= \frac{0.569 \times 100g}{105.15g} \times 100\%$$

$$= 54.1\%$$

Compute percent of fine aggregate by total weight of mix:

$$\%\ fine\ aggregate$$

$$= \frac{fine\ aggregate\ weight\ (by\ dry\ weight\ of\ aggregate)}{total\ weight\ of\ mix} \times 100\%$$

$$= \frac{43.1g}{105.15g} \times 100\%$$

$$= 41.0\%$$

Check:

$$100\%\ of\ total\ weight\ of\ mix$$

$$= 4.90\%\ (binder) + 54.1\%\ (coarse) + 41.0\%(fine)$$

$$= 100\%$$

Example 2: Convert binder content and coarse and fine aggregate fractions from percentages by total weight of mix to percentages by dry weight of aggregate using the data in Table C-2. This example uses weights of the mix components, but their percentages by dry weight of aggregate may be substituted for weights.

Assume: Total weight of the combined aggregates is 100.0 g.

TABLE C-2

Converting from by Dry Weight of Aggregate to by Total weight of mix

Material	**(Computed) By Total Weight of Mix (Percent)**	**(Given) By Dry Weight of Aggregate (Percent)**
Asphalt Binder [1]	4.90	5.15
Coarse Aggregate (Retained on No. 4 sieve)	54.1	54.1
Fine Aggregate (Passing No. 4 sieve)	41.0	41.0
Supplemental Fines [2]	0	0

1 Calculate and report to the nearest 0.01%
2 May include lime, bag house fines, or other mineral filler

<u>Compute total weight of aggregate:</u>

$$total\ weight\ of\ aggregate = (0.541 \times 100.0g) + (0.410 \times 100.0g) + (0 \times 100g)$$

$$= 54.1g + 41.0g + 0g$$

$$= 95.1g$$

Or

$$100.0g - 4.90g = 95.1g$$

<u>Compute total weight of mix:</u>

$$total\ weight\ of\ mix = total\ aggregate\ weight + asphalt\ binder\ weight$$

$$= 95.1g + (0.0490 \times 100.0g)$$

$$= 95.1g + 4.90g$$

$$= 100.0g$$

<u>Computer binder content by dry weight of aggregate:</u>

$$binder\ content = \frac{asphalt\ binder\ weight\ (by\ DWA)}{dry\ aggregate\ weight} \times 100\%$$

$$= \frac{0.0490 \times 100g}{95.1g} \times 100\%$$

$$= 4.90\%$$

<u>Computer percent coarse aggregate by dry weight of aggregate:</u>

$$\%\ coarse\ aggregate$$
$$= \frac{coarse\ aggregate\ weight\ (by\ total\ weight\ of\ mix)}{total\ weight\ of\ aggregate} \times 100\%$$

$$= \frac{0.541 \times 100g}{95.1g} \times 100\%$$

$$= 56.9\%$$

<u>Compute percent fine aggregate by total weight of mix:</u>

$$\%\ fine\ aggregate = \frac{fine\ aggregate\ weight\ (by\ taol\ weight\ of\ mix)}{total\ weight\ of\ aggregate} \times 100\%$$

$$= \frac{0.410g \times 100g}{95.1g} \times 100\%$$

$$= 43.1\%$$

<u>Check:</u>

$$100\%\ of\ aggregate = 56.9\%\ (coarse) + 43.1\%\ (fine)$$

$$= 100\%$$

APPENDIX D

SAMPLE MIX DESIGN AND JOB-MIX FORMULA REPORT

A. SCOPE

This Appendix provides a sample mix design and job-mix formula (JMF) report that would be developed for the HMA mix. Mix design and job-mix formula (JMF) information is summarized on Form CEM-3512.

The mix design volumetric relationships are solved using the data given in Table D-1.

TABLE D-1

Converting from by Dry Weight of Aggregate to by Total Weight of Mix

Material	By Dry Weight of Aggregate (Percent)	By Total Weight of Mix (Percent)	Specific Gravity
Asphalt Binder[1]	5.26 [1]	5.00 [1]	G_b = 1.025
Coarse Aggregate (Retained on No. 4 sieve)	39.5	37.5	G_1 = 2.754
Fine Aggregate (Passing No. 4 sieve)	60.5	57.5	G_2 = 2.665
Supplemental Fines [2]	0	0	G_3 =2.455
HMA Briquette	Bulk Specific Gravity, G_{mb} = 2.384		
Loose HMA	Theoretical maximum specific gravity, G_{mm} = 2.563		

1 Calculate and report to the nearest 0.01%
2 May include lime, bag house fines, or other mineral filler
Note: Passing No. 200 sieve (P_{200}) = 5.1%

1. **Theoretical Maximum Specific Gravity**

The theoretical maximum specific gravity is determined in accordance with California Test 309 for all 4 trial binder contents, and for this example is given as:

G_{mb} = 2.384
G_{mm} = 2.563

2. **Effective Specific Gravity of Aggregate-Admixture Blend (G_{se})**

$$G_{\mathrm{se}} = \frac{100 - P_b}{\frac{100}{G_{\mathrm{mm}}} - \frac{P_b}{G_b}} = \frac{100 - 5.00}{\frac{100}{2.563} - \frac{5.00}{1.025}} = 2.783$$

3. **Bulk Specific Gravity of Aggregate-Admixture Blend (G_{sb})**

$$G_{sb} = \frac{P_1 + P_2 \ldots\ldots + P_n}{\frac{P_1}{G_1} + \frac{P_2}{G_2} \ldots\ldots + \frac{P_n}{G_n}} = \frac{37.5 + 57.5}{\frac{37.5}{2.754} + \frac{57.5}{2.665}} = 2.702$$

4. **Theoretical Maximum Specific Gravity for Different Binder Contents**

$$G_{mm} = \frac{100}{\frac{P_s}{G_{se}} + \frac{P_b}{G_b}} = \frac{100}{\frac{95.0}{2.783} + \frac{5.0}{1.025}} = 2.563$$

5. **Percent Absorbed Asphalt Binder**

$$P_{\mathrm{ba}} = 100 \frac{G_{\mathrm{se}} - G_{\mathrm{sb}}}{G_{\mathrm{sb}}(G_{\mathrm{se}})} G_b = 100 \times \left(\frac{2.783 - 2.703}{2.703 \times 2.783}\right) \times 1.025 = 1.09$$

6. **Effective Binder Content of the Mixture**

$$P_{be} = P_b - \left(\frac{P_{ba}}{100}\right) P_s = 5.00 - \left(\frac{1.09}{100}\right) \times 95.0 = 3.97$$

7. **Percent Effective Asphalt Binder Volume**

$$V_{be} = \frac{P_{be} \times G_{mb}}{G_b} = \frac{3.97 \times 2.384}{1.025} = 9.2$$

8. **Calculating Percent Voids in Mineral Aggregate (VMA) in Compacted Mixture**

$$VMA = 100 - \frac{G_{mb} P_s}{G_{sb}} = 100 - \frac{2.384 \times 95.0}{2.703} = 16.2$$

9. **Calculating Percent Air Voids (Air Voids Content, V_a) in Compacted Mixture**

$$V_a = 100\left(\frac{G_{mm-}G_{mb}}{G_{mm}}\right) = 100\left(\frac{2.563 - 2.384}{2.563}\right) = 7.0$$

10. **Calculating Percent Voids Filled with Asphalt (VFA) in Compacted Mixture**

$$\text{VFA} = \frac{100(\text{VMA} - V_a)}{\text{VMA}} = \frac{100(16.2 - 7.0)}{16.2} = 56.9$$

11. **Calculating Dust Proportion (DP) in the Compacted Mixture**

$$\text{DP} = \frac{P_{200}}{P_{\text{be}}} = \frac{5.1}{3.97} = 1.28$$

Figure D-1 that follows is an example of the documentation for this mix design.

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION
CONTRACTOR HOT MIX ASPHALT DESIGN DATA
CEM-3512

Hot Mix Asphalt (HMA) Producer Name, Address and Phone:	HMA Type:	Date:
EXAMPLE for CT 367	½-inch HMA Type A	
	Producer Mix Identification Number:	
Name and address of qualified laboratory preparing the mix design:		

Aggregate Gradation

Bin	1	2	3	4	5	Reclaimed Asphalt Pavement		Lime	Combined Gradation (JMF TV)
Material Size	¾"	½"	⅜"	Dust	Manuf. Sand	N/A	N/A	N/A	—
Bin %	0	15	25	44	16	(JMF TV)		- -	100%
Sieve Size	% Passing								
2"	- -	- -	- -	- -	- -	- -	- -	- -	- -
1½"	- -	- -	- -	- -	- -	- -	- -	- -	- -
1"	100	100	100	100	100	- -	- -	- -	100
¾"	94	100	100	100	100	- -	- -	- -	100
½"	20	81	100	100	100	- -	- -	- -	97
⅜"	2	12	92	100	100	- -	- -	- -	85
No. 4	1	1	14	94	97	- -	- -	- -	61
No. 8	1	1	1	64	87	- -	- -	- -	43
No. 16	1	1	1	44	71	- -	- -	- -	31
No. 30	1	1	1	31	46	- -	- -	- -	21
No. 50	1	1	1	21	19	- -	- -	- -	13
No. 100	1	1	1	15	6	- -	- -	- -	8
No. 200	0.5	0.4	0.4	10.7	1.7	- -	- -	- -	5.1

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION
CONTRACTOR HOT MIX ASPHALT DESIGN DATA
CEM-3512

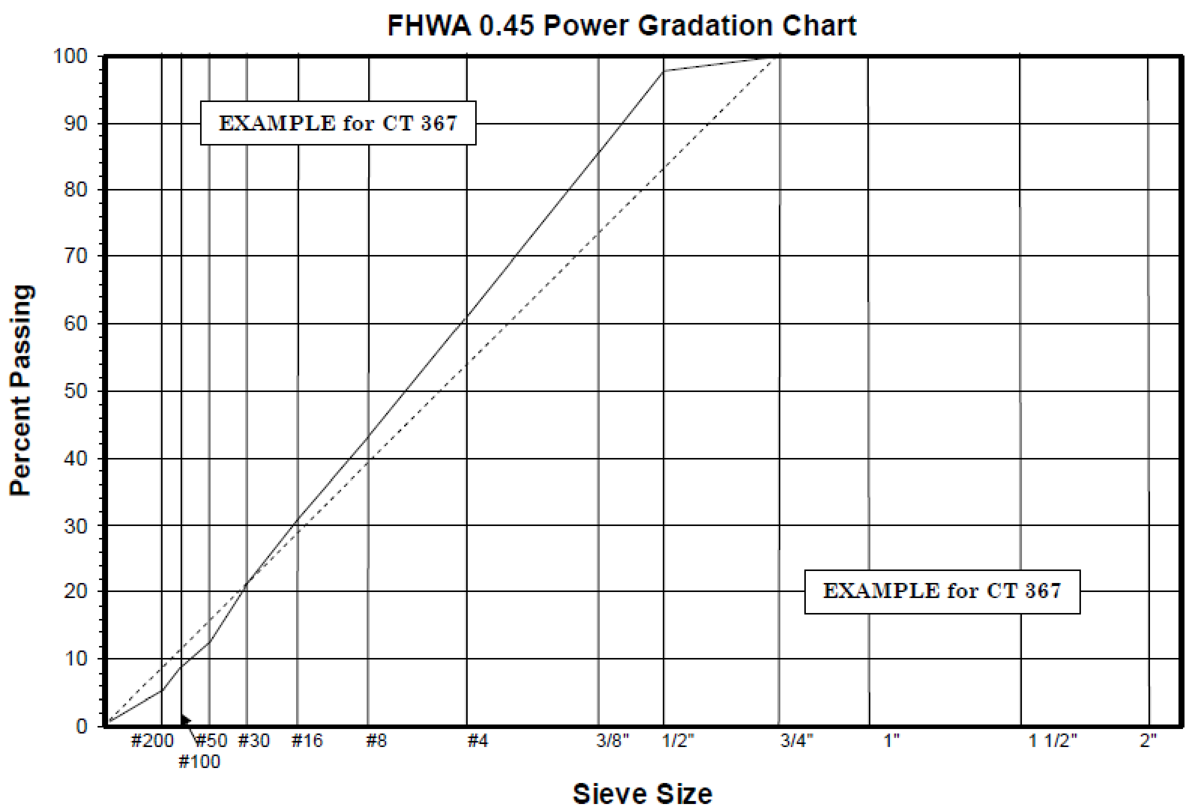

FIGURE D-1. Example of Mix Design and Documentation

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

CONTRACTOR HOT MIX ASPHALT DESIGN DATA

CEM-3512

HMA Type: ½-inch HMA Type A	Producer: EXAMPLE for CT 367	Producer Mix ID No.:	Date:
Approximate Bitumen Ratio (ABR) from CT 367 Table 1 –	5.50		

Hot Mix Asphalt Design Data

Quality Characteristic	Test Method	ABR - 0.5%	ABR
Asphalt binder content (%)	CT 367	5.00	5.50
Briquette height (inches)	CT 304	2.52	2.50
Briquette bulk specific gravity, G_{mb}	CT 308 (Method A)	2.384	2.422
Maximum specific gravity	CT 309	2.563	2.543
Air voids content, V_a (%)	CT 367	7.0	4.8
Voids in mineral aggregate, VMA (%)	CT 367	16.1	15.2
Effective specific gravity of RAP aggregate	CT 367	N/A	N/A
Voids filled with asphalt, VFA (%)	CT 367	56.6	68.7
Dust proportion, DP	CT 367	1.02	0.905
Effective specific gravity of aggregate mix, G_{se}	CT 367	2.783	2.783
Stabilometer value	CT 366	46	47
Modified stabilometer value	CT 366	N/A	N/A

Quality Characteristic	Test Method	ABR + 0.5%	ABR + 1.0%
Asphalt binder content (%)	CT 367	6.00	6.50
Briquette height (inches)	CT 304	2.49	2.48
Briquette bulk specific gravity, G_{mb}	CT 308 (Method A)	2.437	2.444
Maximum specific gravity	CT 309	2.529	2.508
Air voids content, V_a (%)	CT 367	3.6	2.6
Voids in mineral aggregate, VMA (%)	CT 367	15.1	15.3
Effective specific gravity of RAP aggregate	CT 367	N/A	N/A
Voids filled with asphalt, VFA (%)	CT 367	75.9	83.4
Dust proportion, DP	CT 367	0.828	0.746
Effective specific gravity of aggregate mix, G_{se}	CT 367	2.790	2.788
Stabilometer value	CT 366	42	36
Modified stabilometer value	CT 366	N/A	N/A

FIGURE D-1 (continued). Example of Mix Design and Documentation

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION
CONTRACTOR HOT MIX ASPHALT DESIGN DATA
CEM-3512

HMA Type: ½-inch HMA Type A	Producer: EXAMPLE for CT 367	Producer Mix ID No.:	Date:

Aggregate Quality [1]					
Quality Characteristic/Property	Test Method	Test Result			
Crushed particles, coarse aggregate (Retained on No. 4 sieve) One fractured face (%)	CT 205	96			
Crushed particles, coarse aggregate (Retained on No. 4 sieve) Two fractured faces (%)	CT 205	88			
Crushed particles, fine aggregate (Passing No. 4 sieve and retained on No. 8 sieve) One fractured face (%)	CT 205	93			
Los Angeles Rattler, Loss at 100 Rev. (%)	CT 211	6			
Los Angeles Rattler, Loss at 500 Rev. (%)	CT 211	19			
Sand equivalent	CT 217	67	70	68	Average 68
Fine aggregate angularity (%)	CT 234	52			
Flat and elongated particles (% by mass at 3:1)	CT 235	N/A			
Flat and elongated particles (% by mass at 5:1)	CT 235	2			
Plasticity Index	CT 204	NP			
Sodium sulfate soundness	CT 214	N/A			
Cleanness Value, C_v	CT 227	N/A			
Fine aggregate Durability Index, D_f	CT 229	N/A			
Coarse aggregate Durability Index., D_C	CT 229	N/A			
Bulk specific gravity (oven dry) of coarse aggregate, G_C	CT 206	2.754			
Absorption of coarse aggregate	CT 206	0.7 %			
Bulk specific gravity (SSD) of fine aggregate	CT 207	2.711			
Bulk specific gravity (oven dry) of fine aggregate, G_f	CT 207	2.665			
Apparent specific gravity of supplemental fines, G_{sf}	CT 208	2.455			
Absorption of fine aggregate	CT 207	1.7 %			
Bulk specific gravity of the aggregate blend, G_{sb}	CT 367	2.699			

Note:
[1] Aggregate must comply with the quality specifications before it is treated with lime.

FIGURE D-1 (continued). Example of Mix Design and Documentation

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION
CONTRACTOR HOT MIX ASPHALT DESIGN DATA
CEM-3512

HMA Type: ½-inch HMA Type A	Producer: EXAMPLE for CT 367		Producer Mix ID No.:		Date:
Hot Mix Asphalt Design Data at Job Mix Formula [1]					
Quality Characteristic	**Test Method**	**Test Result**			
Asphalt binder content (%) (JMF TV)	CT 367	5.80			
Briquette bulk specific gravity, G_{mb}	CT 308 (Method A)	2.426	2.430	2.431	*Average* *2.429*
Maximum specific gravity	CT 309	2.538			
Air voids content, V_a (%)	CT 367	4.4	4.3	4.2	*Average* *4.3*
Voids in mineral aggregate, VMA (%)	CT 367	15.5	15.3	15.2	*Average* *15.3*
Effective specific gravity of RAP aggregate	CT 367	N/A			
Voids filled with asphalt, VFA (%)	CT 367	71.4	72.2	72.4	*Average* *72.0*
Dust proportion, DP	CT 367	1.09			
Effective specific gravity of aggregate	CT 367	2.792			
Stabilometer value	CT 366	44	41	43	*Average* *43*
Modified stabilometer value	CT 366				*Average* *N/A*
Surface abrasion (%)	CT 360				*Average* *N/A*
Tensile strength ratio (TSR) untreated [2]	CT 371	N/A			
Tensile strength ratio (TSR) treated [2]	CT 371	N/A			

[1] For mix design, prepare 3 briquettes separately at the proposed JMF and test for compliance. Report the average of 3 tests. Prepare new briquettes and test if the range of stability for the 3 briquettes is more than 12 points.
[2] Attach Figure 1 from CT 371.

EXAMPLE for CT 367

FIGURE D-1 (continued). Example of Mix Design and Documentation

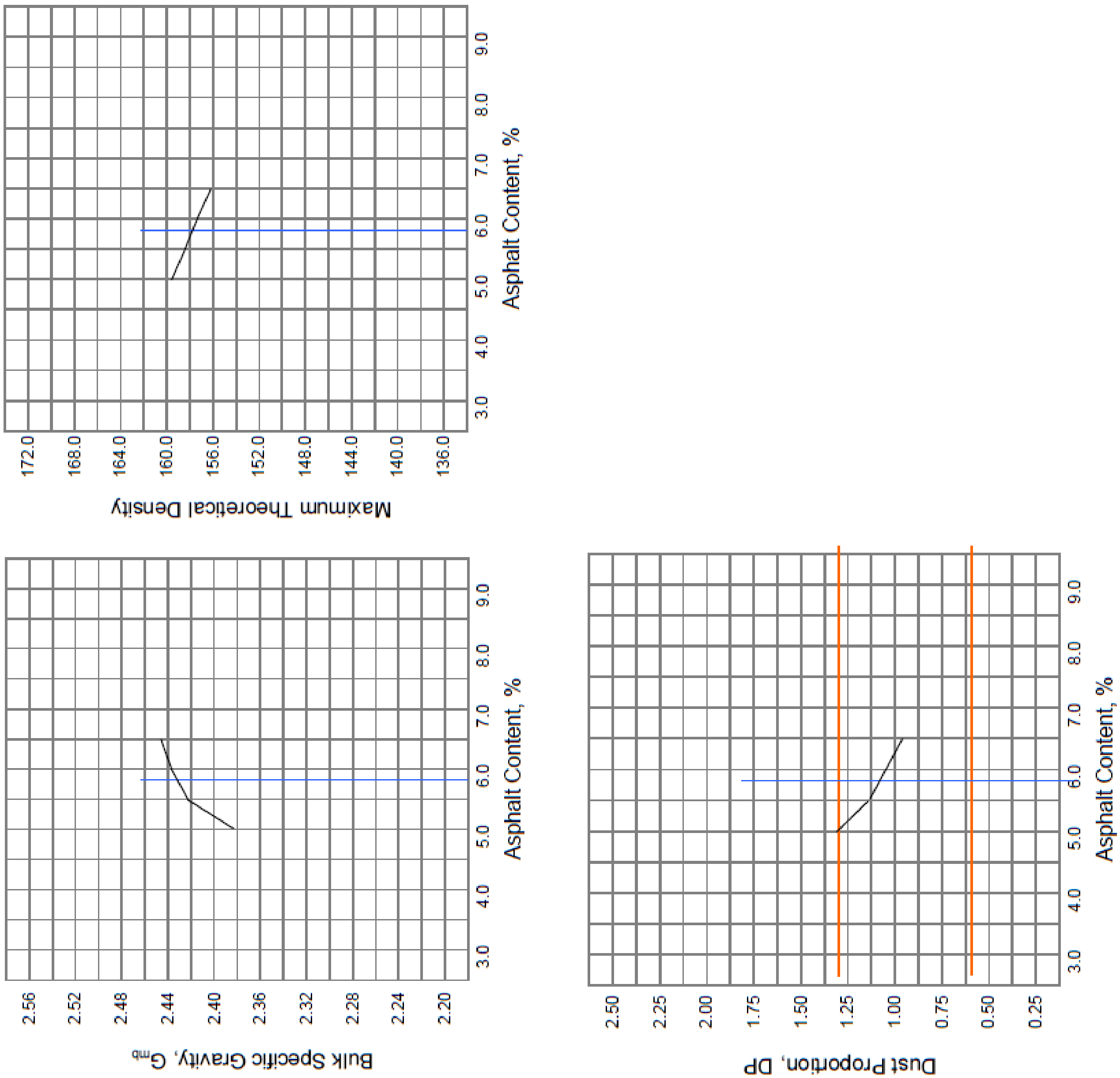

FIGURE D-1 (continued). Example of Mix Design and Documentation

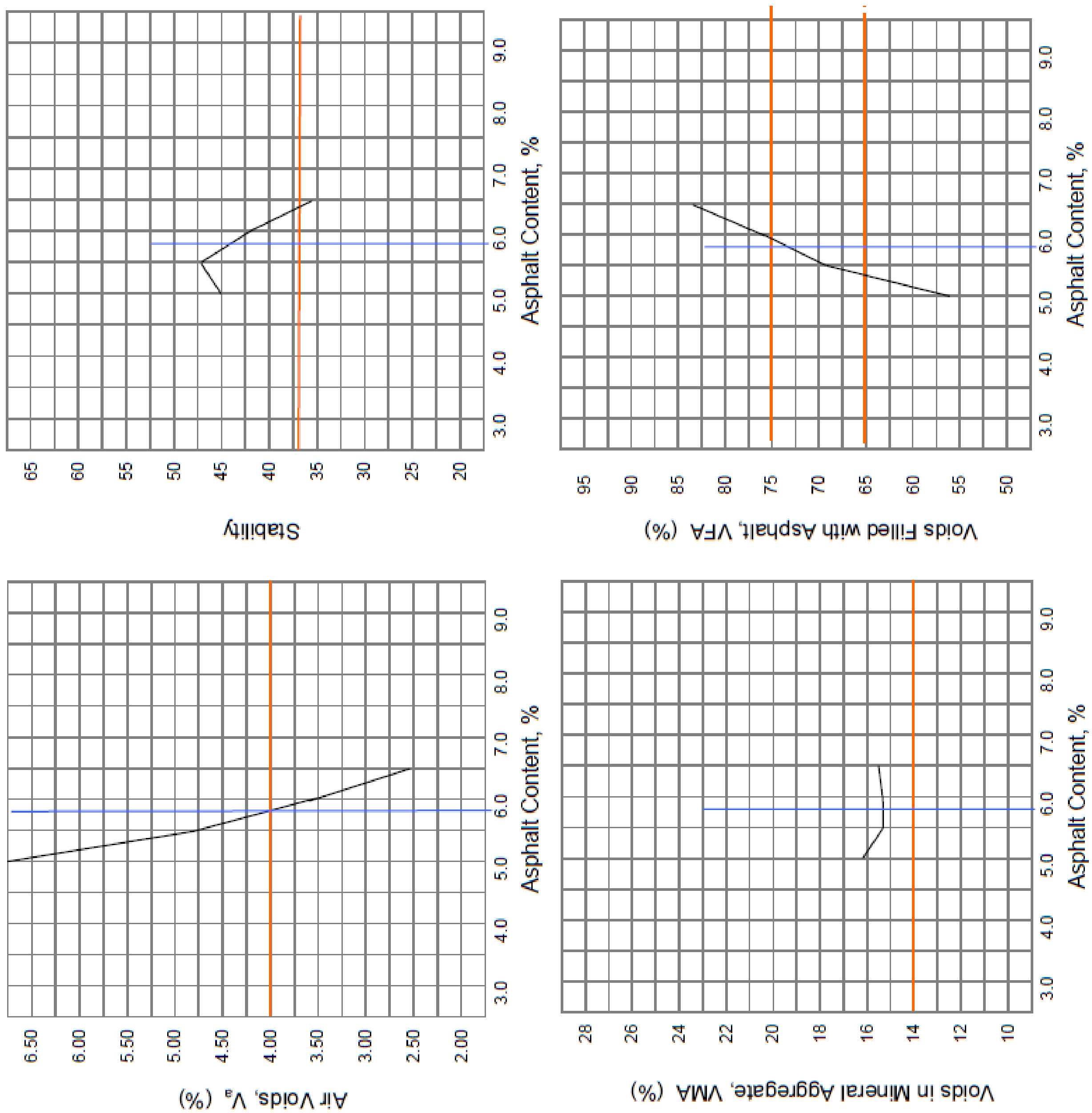

FIGURE D-1 (continued). Example of Mix Design and Documentation