FLH ADDENDUM TO AASHTO T 308 – Standard Method of Test for

Correction Factors for Hot Mix Asphalt (HMA) Containing Recycled Asphalt Pavement (RAP) by the Ignition Method

U.S. Department of Transportation
Federal Highway Administration

FLH Designation: Addendum T 308

A1. ASPHALT BINDER AND AGGREGATE

A1.1. Asphalt binder content results may be affected by the type of virgin aggregate and RAP material in the mixture and the ignition furnace. Therefore, asphalt binder and aggregate correction factors must be established by testing a set of correction factor specimens for the job mix formula (JMF) containing RAP. Correction factor(s) must be determined before any acceptance testing is completed and repeated each time a change in the mix design occurs. Any changes greater than 5 percent in stockpiled aggregate proportions shall require new correction factors.

A1.1.1. *Asphalt binder correction factor*—Certain virgin aggregate types or RAP materials may result in unusually high correction factors (greater than 1.0 percent). Such mixes should be corrected and tested at a lower temperature as described A.2.11.1. Each ignition furnace will have its own unique asphalt binder correction factor determined in the location where testing will be performed.

A1.1.2. *Aggregate gradation correction factor*—Due to potential virgin and RAP aggregate breakdown during the ignition process, an aggregate gradation correction factor will be determined for each ignition furnace in the location where testing will be performed.

A2. CORRECTION FACTOR PROCEDURE

A2.1. Obtain samples of virgin aggregate and RAP in accordance with T 2.

A2.2. Obtain samples of asphalt binder in accordance with T 40.
Note 1—Include other additives that may be required by the JMF.

Note 2 – If lime is included as a component of the mixture and it has not been previously added to the virgin aggregates, add the appropriate amount of lime per the mix design proportion. Add the lime to the virgin aggregates by making a lime slurry (lime and water mixture) and thoroughly mixing with the virgin aggregates prior to the oven-dry process.

A2.3. Oven-dry the virgin aggregate at a temperature of 230°F (110°C) and RAP at a temperature of 140°F (60°C) to a constant mass.

A2.4. Prepare an initial, or "butter mix" at the design asphalt binder content. Mix and discard the butter mix prior to preparing any of the correction specimens to ensure accurate asphalt binder content.

A2.5. Prepare two correction specimens at the JMF design asphalt binder content and virgin aggregate and RAP gradations. Virgin aggregate and RAP used for correction specimens shall be sampled from the stockpiles designated for use in production.

A2.6. Prepare a "blank" (virgin aggregate only) specimen at the JMF gradation. Determine the virgin aggregate gradation in accordance with T 30 on the "blank" specimen. Provide an additional gradation analysis on a representative sample of burned RAP aggregate.

A2.7. Mathematically compute the "calculated blank" gradation for the virgin aggregate and the burned RAP aggregate by combining the individual gradation analyses at the specified batch percentages for each material as determined in the JMF. Adjust the percentages of virgin aggregate and RAP aggregate accordingly to account for binder present in the RAP specimen.

A2.8. Place the freshly mixed specimens directly into the specimen basket assembly. If specimens are allowed to cool prior to placement in the specimen basket assembly, the specimens must be dried to constant mass at a temperature of 110 ± 5°C (230±9°F). Do not preheat the specimen basket assembly.

A2.9. Test the specimens in accordance with Method A or Method B of the procedure.

A2.10. Once both of the correction specimens have been burned, determine the asphalt binder content for each specimen by calculation or from the printed oven tickets, if available.

A2.11. If the difference between the asphalt binder contents of the two specimens exceeds 0.15 percent, repeat Section A2.3 through A2.7 with two more specimens and, from the four results, discard the high and low result. Determine the correction factor from the two original or remaining results, as appropriate. Calculate the difference between the actual and measured asphalt binder contents for each specimen. The asphalt binder correction factor, C_f, is the average of the differences expressed as percentage by mass of the HMA.

A2.11.1. If the asphalt binder correction factor exceeds 1.0 percent, the test temperature should be lowered to 483 ± 5°C (900 ± 8°F) for convection type furnace. If there is no improvement in the correction factor, it is permissible to use the higher temperature.
Note 2—The temperature for determining the asphalt binder content of HMA specimens by this procedure shall be the same temperature determined for the correction specimens.

A2.11.2. For the direct IR irradiation-type furnaces, the DEFAULT burn profile should be used for most materials. The operator may select burn-profile OPTION 1 or OPTION 2 to optimize the burn cycle. Option 1 is designed for aggregate that require a large aggregate correction factor (greater than 1 percent)—typically very soft aggregate (such as dolomite). Option 2 is designed for samples that may not burn completely using the DEFAULT burn profile. The burn profile for testing HMA samples shall be the same burn profile selected for correction samples.

A2.12. Perform a gradation analysis on the residual aggregate in accordance with T 30, if required. The results will be utilized in developing an aggregate gradation correction factor and should be calculated and reported to the nearest 0.1 percent.

A2.12.1. From the gradation results, subtract the percent passing for each sieve from the percent passing each sieve on the "calculated" blank gradation results from Section A2.7.

A2.12.2. Determine the average difference for the two values. If the difference for any single sieve exceeds the allowable difference for that sieve as listed in Table A1, then aggregate gradation correction factors (equal to the resultant average differences) for all sieves shall be applied to all acceptance gradation test results determined by T 30, prior to final rounding and reporting. If the 0.075-mm (No. 200) sieve is the only sieve outside the limits in Table A1, apply the aggregate correction factor to only the 0.075-mm (No. 200) sieve.

Table A1—Permitted Sieving Difference

Sieve	Allowable Difference
Sizes larger than or equal to 2.36 mm (No. 8)	±5.0 percent
Sizes larger than 0.075 mm (No. 200) and smaller than 2.36 mm (No. 8)	±3.0 percent
Sizes 0.075 mm (No. 200) and smaller	±0.5 percent

EXAMPLE:

CALCULATION OF CORRECTION FACTORS FOR HOT MIX ASPHALT (HMA) CONTAINING RECYCLED ASPHALT PAVEMENT (RAP)

Note: Example calculations follow data entries of FHWA Form 1648

1. ASPHALT BINDER CORRECTION FACTOR:

Determine quantity of virgin asphalt binder required to achieve target asphalt content by mass of mix.

Mix Design Parameters:

-Target binder content by mass of mix, % = 6.20%

-Binder content of RAP by mass of mix, % = 5.15%

-Mix Composition, by mass of mix, %:

Virgin Aggregate Blend = 80.0%

RAP Blend = 20.0%

-Total Sample Mass (Virgin Aggregate + RAP), g = 2001.2 g

Dry virgin aggregate mass = 1601.0 g

Mass of RAP = 400.2 g

1.1. Determine the amount of aggregate and binder present in the RAP portion:

$$Binder_{RAP} = Mass_{RAP} \times AC\%_{RAP}$$

$$Aggregate_{RAP} = Mass_{RAP} - Binder_{RAP}$$

1.1.1. Binder mass from RAP = 400.2 g x 5.15%

Binder mass from RAP = **20.6 g** **FHWA Form 1648 (F)**

1.1.2. Aggregate mass from RAP = 400.2 g – 20.6 g

Aggregate mass from RAP = **379.6 g** **FHWA Form 1648 (E)**

1.2. Determine the total amount of aggregate present between the virgin aggregate and the RAP combined:

$$Aggregate_{TOTAL} = Mass_{TOTAL} - Binder_{RAP}$$

1.2.1. Total aggregate in sample = 2001.2 g – 20.6 g

Total aggregate in sample = **1980.6 g**

1.3. Determine the total weight of binder required to achieve the target binder content by mass of mix:

$$Binder_{TOTAL} = \left[\left(\frac{100}{100 - AC\%_{TARGET}}\right) \times Aggregate_{TOTAL}\right] - Aggregate_{TOTAL}$$

1.3.1. Total binder = $\left[\left(\frac{100}{100-6.20}\right) \times 1980.6\right] - 1980.6$

Total binder = 2111.5 g – 1980.6 g = **130.9 g** **FHWA Form 1648 (I)**

1.4. Determine the amount of virgin binder required for the mix:

$$Binder_{VIRGIN} = Binder_{TOTAL} - Binder_{RAP}$$

1.4.1. Virgin binder = 130.9 g – 20.6 g

Virgin binder = **110.3 g** **FHWA Form 1648 (H)**

*Follow procedures indicated on FHWA Form 1648 for Hot Mix Asphalt Containing RAP to determine the asphalt binder correction factor for the proposed mix.

2. AGGREGATE GRADATION CORRECTION FACTOR:

Determine the calculated "blank" gradation for the virgin aggregate and RAP blend using the individual gradations.

Mix Design Parameters:

-RAP Asphalt Binder Content, % = 5.15%

-Mix Composition, by mass of mix, %:

Virgin Aggregate Blend = 80.0%

RAP Blend = 20.0%

-Individual Gradations:

Sieve Size	Virgin Aggregate Gradation	Burned RAP Aggregate Gradation
1" - 25.0mm	100.0	100.0
3/4" - 19.0mm	100.0	100.0
1/2" - 12.5mm	87.3	100.0
3/8" - 9.5mm	68.5	78.7
#4 - 4.75mm	51.1	65.6
#8 - 2.36mm	37.5	55.9
#30 - 600μm	32.3	43.2
#40 - 425μm	16.7	25.1
#50 - 300μm	13.4	19.4
#200 - 75μm	6.5	9.8

2.1. Determine the mix composition by mass of aggregate, %.

NOTE 1—The percentages of virgin aggregate and RAP aggregate must be adjusted to account for the binder in the RAP specimen.

$$Aggregate_{RAP,}\% = Mass_{RAP,}\% - \left(Mass_{RAP,}\% \times Binder_{RAP,}\%\right)$$

$$Aggregate_{VIRGIN,}\% = 100 - Aggregate_{RAP,}\%$$

2.1.1. $Aggregate_{RAP}$, % = 20.0 - (20.0 x 0.0515)

$Aggregate_{RAP}$, % = **19.0%**

2.1.2. $Aggregate_{VIRGIN}$, % = 100.0 - 19.0

$Aggregate_{VIRGIN}$, % = **81.0%**

2.2. Determine the calculated "blank" gradation using the adjusted percentages of Virgin Aggregate and RAP aggregate and the individual gradations for each specimen.

$$Calculated\ "blank"_{SIEVE} =$$

$$\left(Aggregate_{VIRGIN,}\% \times \%Passing_{VIRGIN\ SIEVE}\right) + \left(Aggregate_{RAP} \times \%Passing_{RAP\ SIEVE}\right)$$

2.2.1. Calculated "blank" for the 3/8" (9.5 mm) sieve = (81.0% x 68.5) + (19.0% x 78.7)

2.2.2. Calculated "blank" for the 3/8" (9.5 mm) sieve = **70.4%**

2.2.3. Repeat the calculation for each sieve to determine the calculated "blank" gradation.

3.0. Example using FHWA Form 1648.

Print Form Reset Form

U.S. Department of Transportation
Federal Highway Administration
Federal Lands Highway

WORKSHEET FOR IGNITION FURNACE BINDER CORRECTION FACTOR AND AGGREGATE GRADATION CORRECTION FACTOR FOR MIXES INCLUDING RAP

Project: Example Project Date:

Sample No.: Tested by: Test Temp, (°C) 538

Target binder content, % by mass of Mix: 6.20 Binder content, RAP, % by mass of RAP: 5.15

Ignition Furnace Manufacturer: Thermoline Serial #: 12345 Location of Furnace

	Trial No. 1		Trial No. 2
(A) Initial "buttered" bowl mass, g	2674.9		2675.0
(B) Final bowl mass[1], g	2674.9		2675.0
(C) Bowl mass difference, (B – A), g	0.0		0.0
(D) Mass of RAP, g	400.2		400.2
(E) Mass of RAP Aggregate, g (D – D*(RAP/100))	379.6		379.6
(F) Mass of RAP Binder, g (D*(RAP/100))	20.6		20.6
(G) Dry Virgin Aggregate mass, g	1601.0		1601.0
(H) Virgin Binder mass[2]	110.3		110.3
(I) Total Binder mass, (F+H), g	130.9		130.9
(J) Corrected binder mass, (I – C), g	130.9		130.9
(K) Actual binder content by mixture mass, (J / (D + G + H)) * 100, %	6.20		6.20
(L) Sample basket assembly mass, g	3249.7		3249.7
(M) Sample basket assembly & mix mass[3], g	5361.2		5361.2
(N) Mix mass[4], (M - L), g	2111.5		2111.5
(O) Ignition furnace binder content by mass of mix, %	6.34		6.46
(P) Correction factor, (O - K), %	P1 0.14	P2	0.26
(Q) Average correction factor[5], ((P1 + P2) / 2), %	Average	0.20	
(R) Difference in correction factor[6], |P1 – P2|, %	Difference	0.12	

[1] Scrape the bowl until the final mass is within ± 0.5 grams of the initial "buttered" mass.
[2] For guidance on determining required virgin asphalt content see the FLH Addendum to AASHTO T 308: Correction Factors for Hot Mix Asphalt (HMA) Containing Recycled Asphalt Pavement (RAP) Example 1.4.
[3] After placing the basket assembly and mix into the ignition furnace verify that the displayed mass and the mass recorded in (M) agree within ± 5 grams.
[4] Be certain to enter (N), the mix mass into the ignition furnace control panel prior to initiating the burn cycle.
[5] If the correction factor exceeds 1.0%, lower the test temperature to 482 °C and repeat the test. Use the correction factor at 482 °C even if it exceeds 1.0%.
[6] If the difference is greater than ± 0.15 percent, run two more samples and discard the high and low test results.

Remarks:

Form FHWA 1648 (Rev 01-11 draft)

Page 1 of 2

Print Form Reset Form

U.S. Department of Transportation
Federal Highway Administration
Federal Lands Highway

WORKSHEET FOR IGNITION FURNACE BINDER CORRECTION FACTOR AND AGGREGATE GRADATION CORRECTION FACTOR FOR MIXES INCLUDING RAP

Project: Example Project Date: _____

Sample No.: _____ Tested by: _____ Test Temp, (°C) 538

Target binder content, % by mass of Mix: 6.20 Binder content, RAP, % by mass of RAP: 5.15

Ignition Furnace Manufacturer: Thermoline Serial #: 12345 Location of Furnace _____

Mix Composition, % mass of Mix: **Virgin Agg:** 80 **RAP:** 20

Mix Composition, % mass of Agg.: **Virgin Agg:** 81.0 **RAP Agg:** 19.0

☑ English ☐ Metric

Aggregate Gradation Correction Factor (AASHTO T 30, Sieve Analysis, % Passing)

Sieve Size	Trial #1	Trial #2	Virgin Agg. Gradation "blank"	Burnd RAP Agg. Gradation "blank"	Calculated "blank"	Trial #1 Difference	Trial #2 Difference	Average Difference	Allowable Difference
1 inch	100.0	100.0	100.0	100.0	100.0	0.0	0.0	0.0	±5.0
3/4 inch	100.0	100.0	100.0	100.0	100.0	0.0	0.0	0.0	±5.0
1/2 inch	86.5	89.5	87.3	100.0	89.7	3.2	0.2	1.7	±5.0
3/8 inch	69.3	72.1	68.5	78.7	70.4	1.1	-1.7	-0.3	±5.0
No. 4	52.1	55.6	51.1	65.6	53.9	1.8	-1.7	0.1	±5.0
No. 8	38.5	42.3	37.5	55.9	41.0	2.5	-1.3	0.6	±5.0
No. 30	32.7	37.0	32.3	43.2	34.4	1.7	-2.6	-0.5	±3.0
No. 40	16.1	17.9	16.7	25.1	18.3	2.2	0.4	1.3	±3.0
No. 50	12.6	13.4	13.4	19.4	14.5	1.9	1.1	1.5	±3.0
No. 200	6.8	7.4	6.5	9.8	7.1	0.3	-0.3	0.0	±0.5

Remarks:

Form FHWA 1648 (Rev 01-11 draft)