Discussion of the following Blending Chart Examples;

The following blending charts and accompanying calculations follow examples in Chapter 11 of MS-2 Asphalt Mix Design Methods (7th Edition) by the Asphalt Institute, and are dependent on the following variables:

a.) JMF binder content (tot wt. of the mix)
b.) RAP binder content (tot wt. of rap)
c.) Percent RAP (belt feed %'g)= Wt of (RAP AGG + RAP Binder)/(RAP AGG +RAP Binder + Virg Agg)x100%
d.) The Projects Specified PG Binder Grade
e.) The contractor proposed grade of the virgin binder
f.) Critical Temperatures of the virgin binder and binder extracted from RAP

The upper portion of the spreadsheet calculates the "RAP Agg in Agg Blend", and the "RAP Pavement Binder Ratio (RPBR)" based on JMF info (i.e. variables a.), b.) and c.) above.

The lower portion calculates the maximum RAP Agg in the Agg Blend and the maximum RPBR as a function of the projects specified binder and the true grades of the virgin and binder extracted from RAP (i.e. variables d.), e.) and f.) above.

Two primary checks are performed:

"Proposed RPBR" **must be <** "the lowest maximum RPBR from the four blending charts"

and " **must be <** either 0.40 or 0.25 (dependent on

"%RAP Agg in the Agg Blend" **must be <** "maximum RAP Agg in the Agg Blend"

and **must be <** 25%

~~*Strikethrough text*~~ and red text are used to indicate when one or both conditions are not met.

See next sheet for a summary of the example blending charts.

Example 1: An existing JMF using a project specified PG70-10 binder and greater than 15% RAP is examined per CPD 16-__. The JMF must be analyzed to determine if the blended binder (virgin and rap binder) when combined at the percentages defined in the JMF meets the specifications for the projects specified binder. Critical temps (i.e. true grades) of the virgin and RAP binder are determined and entered on the spreadsheet with the JMF info (yellow cells). The virgin and extracted RAP binder grades and the projects specified binder grades are plotted on the blending charts. The max RAP pavement binder ratio (i.e. binder replacement ratio) is determined to be 0.1266 (12.66%) which is less the current design RPBR of 0.28. Therefore this JMF needs to be revised. (See examples #2a, 2b and 2c for options).

Example 2a: Here we determine potential options to revise the JMF in Ex#1 where the RPBR exceeded the maximum determined from the blending charts. In this example, the virgin binder is bumped down a grade from PG 70-10 to PG 64-16. Under the initial assumption that true grading will be used during production, we select NO in cell B2, and enter the true grades for the virgin PG 64-16, leaving the 70-10 grades unmodified (same RAP stockpile). Using the same JMF BC (which may change) indicates that "Max RAP agg in the Agg Blend" is 18.57%. With this value, the %RAP (belt feed %) is lowered from 25% to 19.5% which lowers the RAP Agg in Agg Blend to 18.42% (less than 18.57% max shown to its right).

Example 2b: In this example, we use the same RAP true grades, and the same virgin binder as in example 2a, but under the assumption that we will use the "Certification Program for Suppliers of Asphalt" to establish the critical temps of the virgin binder. Selecting YES in cell B2 automatically populates the virgin binder true grade based on the selected virgin binder grade of PG 64-16. Note the virgin binder true grade cells are no longer "yellow" and are populated with vertical lookup equations from tables elsewhere on the spreadsheet. *Entering a value in these cells overwrites the equations that automatically populate the cells. These equations can be automatically re-populated by clicking the button immediately to the right.* Using the previous examples RAP Binder critical temps, limits the RAP Agg in Agg Blend to 14.35% (less than 15%). In this example, per specifications, the contractor could use 15.2% percent RAP (% belt feed) which corresponds to 14.35% RAP aggregate in the aggregate blend (which is less than 15%). Summarizing this example, as the contractor is choosing to rely on the "Certification Program for Suppliers of Asphalt" to determine the true grades of the virgin binder (rather than weekly testing discussed in example 2a), the blending charts indicate that they cannot use more than 15% RAP aggregate in the aggregate blend.

Example 2c: To allow a higher percentage RAP be used than in the previous examples 2a and 2b, in this example, the virgin binder is dropped two grades from a PG 70-10 to a PG 58-22. "YES" was selected in cell B2 to indicate that the "Certification Program for Suppliers of Asphalt" will be used to control the virgin binder (i.e. weekly true grading of the virgin binder not required). Selecting "YES" replaces the virgin binder true grades with the most conservative values for a PG 58-22. Using these values, the max RPBR pulled from the blending charts is 25.32%, which exceeds 25% maximum covered by the specifications, therefore the 25% maximum controls. The Percent RAP (percentage of belt feed) is lowered until the RAP aggregate in the agg blend is less than 25%. In this example the Percent RAP (percentage of belt feed) is lowered to 26%, given the JMF OBC and RAP BC, equates to a RAP Aggregate in the Aggregate blend amount of 24.67% (less than the 25% max). RPBR values up to 0.40 are allowed by specification in lifts below the upper 0.20' of the layer, but only up to 0.25 in the upper 0.20 of the layer. As the corresponding RPBR is 0.292, this HMA with RAP to be placed below the upper 0.20' of the HMA layer. To use this material in the upper 0.20 of the layer, the RAP (percentage belt feed) has to be reduced from 26% to 22.3% or less to prevent the RPBR from exceeding 0.25.

Example 1: An existing JMF using a project specified PG70-10 binder and greater than 15% RAP is examined per CPD 16-__. The JMF must be analyzed to determine if the blended binder (virgin and rap binder) when combined at the percentages defined in the JMF meets the specifications for the projects specified binder. Critical temps (i.e. true grades) of the virgin and RAP binder are determined and entered on the spreadsheet with the JMF info (yellow cells). The virgin and extracted RAP binder grades and the projects specified binder grades are plotted on the blending charts. The max RAP pavement binder ratio (i.e. binder replacement ratio) is determined to be 0.15 which is less the current design RPBR of 0.28. Therefore this JMF needs to be revised. (See examples #2a, 2b and 2c for options). The resulting 23.7% RAP Agg Blend must also be less than the 12.66% Max RAP Agg Blend.

Caltrans Blending Chart for blending Virgin and RAP Binders (>15% RAP)

NO

<== Is contractor using the COC program for true grading the virgin binder (rather than performing weekly true grade testing)?

Select YES if the contractor plans to use the "Certification Program for Suppliers of Asphalt" as a control check of the virgin binder critical temperatures, rather than performing weekly true grade testing of the virgin binder. Selecting YES, auto populates the Virgin Binder critical temperatures in the "True Grade Test Data table" using the most conservative values that correspond to the chosen virgin binder. These assumed values typically require the proposed virgin binder grade (in cell E36) to be "bumped down" one grade when using RAP Aggregate %g's exceeding 15%. These assumed virgin binder critical temp values must be used during the JMF and also production. If the RAP pile gets augmented, new true grades of the extracted RAP binder must be determined and used from that point forward.

Select NO if the contractor plans to perform true grading to determine the critical temperatures of virgin binder. This true grading must be performed during development of the JMF as well as weekly during production. Under this method, the contractor is required to perform "true grading" of the virgin binder on a weekly basis, then check the "blended binder grade" against specifications tolerances. After entering those weekly virgin binder critical temperature test results and the true grades from the extracted rap, the check of the "blended binder" grade against the specifications in cells J40:J43.

Spreadsheet Revision Date 04/21/16

JMF Information

Gray cells are general info input

Yellow cells are User required values that drive blending charts

Project Name:	Rte 247 Rehab near Mythical Valley		
EA (or Project ID):	08-123454	Contractor:	HMA Builders Inc.
JMF No.	1922-28c-3cxxx	HMA Plant:	Hot Mix w/ RAP Inc.
Co/Rte/PM:	08-SBD-247-PM12.3/45.6	QC Manager:	John Smith
		Resident Engineer:	Jane Doe
HMA Type:	3/4" HMA Type A w/ xx%RAP	QC Lab:	Quality Is Our Business, Inc.

Strikethrough indicates JMF needs to be revised

Binder Source: Bid Item # 55

% JMF OBC (xta)=>	5.80%	*Xta, total asphalt content of HMA from JMF, expressed as a percentage of the tota weight of the mix			
% RAP BC (xra)=>	6.80%	*Xra, asphalt content of RAP expressed as a percentage of the total weight of the RAP			
Percent RAP (percentage of belt feed) =>	25.00%	where RAP% = [(Wt of RAP)/(Wt of Virgin Agg + Wt of RAP)]x100%			
RAP Aggregate in the Aggregate Blend => Specifications limit this to the lesser of 25% or as determined from the lowest maximum RPBR value on the blending charts.	~~23.70%~~	function of the above 3 variables where; RAP Agg% = [(1 /xra)-1)/[((1 /xra)/RAP%)-1) Strikethrough Red font indicates value is too high (exceeds cell I16)		12.66%	<= Minimum of 25% or "Max RAP Agg in Agg Blend as based on Lowest Max RPBR value from blending charts"(Calc'd below in cell H53)
Proposed RAP Pavement Binder Ratio (RPBR)=> Maximum allowed in the upper 0.2 feet of HMA (exclusive of OGFC) is 25% and 40% below.	~~0.280~~	<=A function of JMF OBC, RAP BC and RAP Agg in Agg%, where; RPBR=[((RAP Agg%)/(1-Xra))x(Xra)x(1-Xta))/Xta Red text is a reminder when this value exceeds 0.25, and that specifications limit material placed in the upper 0.2' to 0.25 (or 25%), 0.40 (40%) in areas below 0.2'.			

True Grade Test Data Table

Enter Critical Temperature (True Grading) Test Results for Virgin Binder and Extracted binder from RAP.

AGING	PROPERTY	TEMP RANGE	Virgin Binder(°c)	RAP Binder(°C)
Original	DSR G*/sin(delta), ≥1.00 kPa	High	70	n/a
RTFO	DSR G*/sin(delta), ≥2.20 kPa	High	70	103
PAV	DSR G*sin(delta), ≤ 5,000 kPa	Intermediate	32	44
PAV	BBR Stiffness, "S" ≤ 300MPa	Low	-22	5
PAV	BBR m-value, m ≥ 0.300	Low	-20	7
For Low Temp, enter True Grade values which are 10C lower than the test temperature. The plotted low test temp will be 10C higher than the True Grade.		Lowest "High"	70	103
		Highest "Low"	-20	7
	PG	Actual (True Grade)	PG 70-20	PG 103+7
		Equivalent M320 grade	PG 70-16	

On M320, but not in CT SS Sec 92

Virgin binder cells are yellow indicating contractor selected "NO" above. Contractor plans to perform true grading during JMF and weekly during production to demonstrate blended binder grade within production tolerances. During weekly production, the blended binder is determined and compared against production tolerances in cells immediately below. When selecting YES, checking during production is not required, unless RAP stockpile augmented

Specified Binder Grade / Blended Binder Grade / CHECKS on Production HMA Mixture Binder Grade against contract specs.

Projects Specified Binder Grade =>	PG 70-10	<= The PG Grade selected here populates the horizontal lines on the blending charts.
Proposed Virgin Binder Grade =>	PG 70-10	<= Per specification, when using RAP exceeding 15%, contractor may bump down one grade. See graphic in cell s19 for "likely choices" for bumping down a grade.
"HMA Mixture Binder Grade" at Proposed RPBR =>	PG 79-12	<=For High PG Temp, where "RPBR" crosses High Temp blending line. For Low PG temp, where "RPBR" crosses the highest Low temp blending line.

Determination of HMA Mixture Binder Grades (critical temperatures).
Where the RPBR (black line) crosses the blending line (blue line)

			Critical Temps of blended binder per blending charts (°C)	Production Tolerance Check: Lower Spec Limit Temp	Production Tolerance Check: Upper Spec Limit Temp	Production Tolerance Check: Are Critical Temps of Blended Binder within Production tolerances.
High Temp Blending Line Crosses Proposed RPBR at Tcrit=	79		79	70	77	Out of Spec Limits
Intermed. Temp Blending Line Crosses Proposed RPBR at Tcrit=	35		35	n/a	34	Out of Spec Limits
	Low Test Temp	Low Grade Temp (-10C)	Highest Low Temp			
Low Temp Stiffness (S) Crosses Proposed RPBR at Tcrit=	-4	-14	-12	n/a	-8	OK
Low Temp m-value Crosses Proposed RPBR at Tcrit=	-2	-12				

Calc's for Check on Max Allowable RAP Aggregate in the Aggregate Blend (aka %RAP)

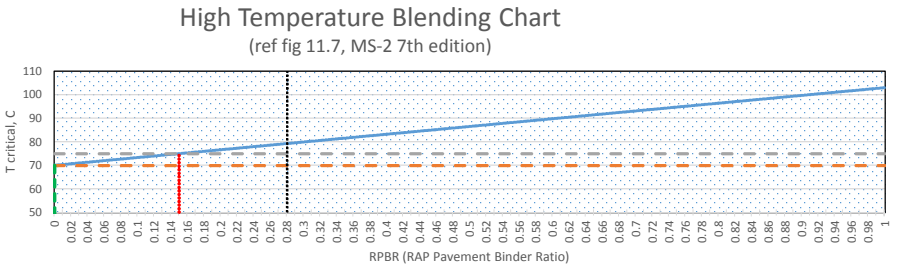
Xta, total asphalt content of HMA from JMF, expressed as a percentage of the total weight of the mix=>	5.80%	<= % JMF OBC (x_{ta})
Xra, asphalt content of RAP expressed as a percentage of the total weight of the RAP=>	6.80%	<= % RAP BC (x_{ra})
Lowest Max RPBR from 4 blending Charts=>	0.15	<= a function of the true grades of virgin and reclaimed rap binder
Max RAP Agg in Agg Blend corresponding to Lowest Max RPBR)	12.66%	a function of the above 3 variables

For questions or comments on this blending chart, contact pete.spector@dot.ca.gov, 916-227-7306

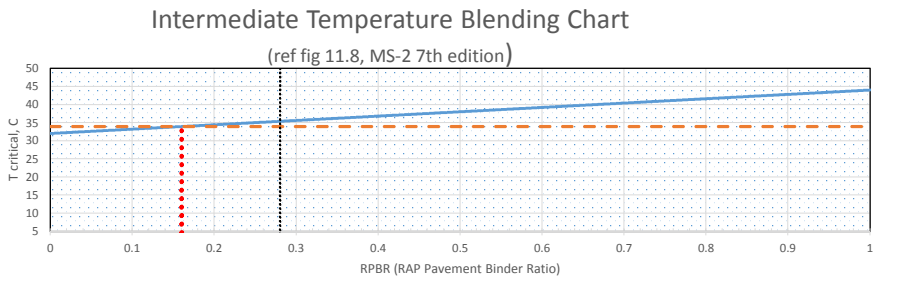
Caltrans Blending Chart Check of JMF's using greater than 15% RAP aggregate in the aggregate blend

EA (or Project ID): 08-123454
JMF No. 1922-28c-3cxxx
Co/Rte/PM: 08-SBD-247-PM12.3/45.6
HMA Type: 3/4" HMA Type A w/ xx%RAP

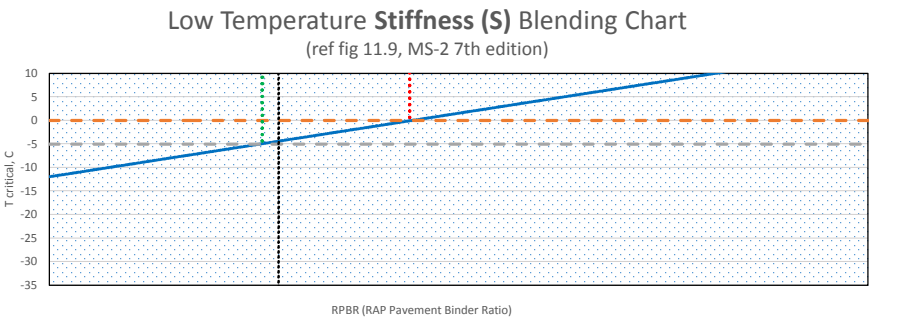
Blending Charts



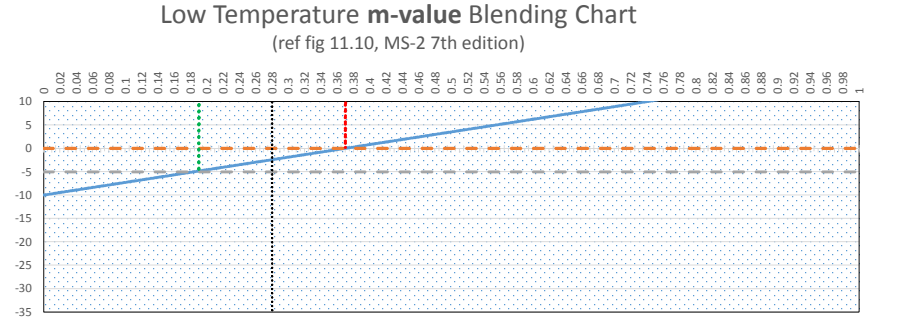
- Blending Line 70C (High temp of virgin binder) to 103C (High Temp of RAP binder)
- 70+5C=75C Upper limit of projects specified binder. During production, the combined binder High temp grade tolerance is 2C higher
- PG 70-XX, Projects Specified Binder Grade
- Min RPBR (=0)
- Max RPBR (=0.15)
- Proposed RPBR (0.28), must be greater than or equal to Min RPBR and less than or equal to Max RPBR on this Chart



- Blending Line 32C (Intermediate Temp of virgin binder) to 44C (Intermediate Temp of RAP binder)
- Intermediate Temp 34 C (this is a max temp for JMF and production, there is no min temp). When %RAP exceeds 15%, subnote d that allows +3C in the Section 92 PG Asphalt Binder table does not apply.
- Max RPBR (=0.16)
- Proposed RPBR (0.28), must be less than or equal to Max RPBR on this chart



- Blending Line -12C to 15C. (BBR-S true grades +10C)
- 0 C, (per the m320 table = specified PG low grade +10C)
- -5 C, (the above temp less 5 C)
- Max RPBR (=0.44)
- Min RPBR (=0.26). For Low Temp only, RPBR may be less (i.e. to the left)
- Proposed RPBR (0.28)



- Blending Line -10C to 17C. (BBR m-value true grades +10 C)
- 0 C, (per the m320 table = specified PG low grade +10C)
- -5 C, (the above temp less 5 C)
- Max RPBR (=0.37)
- Min RPBR (=0.19). For Low Temp only, RPBR may be less (i.e. to the left)
- Proposed RPBR (0.28)

Example 2a: Here we determine potential options to revise the JMF in Ex#1 where the RPBR exceeded the maximum determined from the blending charts. In this example, the virgin binder is bumped down a grade from PG 70-10 to PG 64-16. Under the initial assumption that true grading will be used during production, we select NO in cell B2, and enter the true grades for the virgin PG 64-16, leaving the 70-10 grades unmodified (same RAP stockpile). Using the same JMF BC (which may change) indicates that "Max RAP agg in the Agg Blend" is 18.57%. With this value, the %RAP (belt feed %) is lowered from 25% to 19.5% which lowers the RAP Agg in Agg Blend to 18.42% (less than 18.57%). In the next example 2b, we will assume the same virgin binder, but use the "Certification Program for Suppliers of Asphalt", which assumes the most conservative critical temps for the virgin PG 64-16.

Caltrans Blending Chart for blending Virgin and RAP Binders (>15% RAP)

NO

<== Is contractor using the COC program for true grading the virgin binder (rather than performing weekly true grade testing)?

Select YES if the contractor plans to use the "Certification Program for Suppliers of Asphalt" as a control check of the virgin binder critical temperatures, rather than performing weekly true grade testing of the virgin binder. Selecting YES, auto populates the Virgin Binder critical temperatures in the "True Grade Test Data table" using the most conservative values that correspond to the chosen virgin binder. These assumed values typically require the proposed virgin binder grade (in cell E36) to be "bumped down" one grade when using RAP Aggregate %g's exceeding 15%. These assumed virgin binder critical temp values must be used during the JMF and also production. If the RAP pile gets augmented, new true grades of the extracted RAP binder must be determined and used from that point forward.

Select NO if the contractor plans to perform true grading to determine the critical temperatures of virgin binder. This true grading must be performed during development of the JMF as well as weekly during production. Under this method, the contractor is required to perform "true grading" of the virgin binder on a weekly basis, then check the "blended binder grade" against specifications tolerances. After entering those weekly virgin binder critical temperature test results and the true grades from the extracted rap, the check of the "blended binder" grade against the specifications in cells J40:J43.

Spreadsheet Revision Date 04/21/16

JMF Information | Gray cells are general info input | Yellow cells are User required values that drive blending charts

Project Name:	Rte 247 Rehab near Mythical Valley		
EA (or Project ID):	08-123454	Contractor:	HMA Builders Inc.
JMF No.	1922-28c-3cxxx	HMA Plant:	Hot Mix w/ RAP Inc.
Co/Rte/PM:	08-SBD-247-PM12.3/45.6	QC Manager:	John Smith
		Resident Engineer:	Jane Doe
HMA Type:	3/4" HMA Type A w/ xx%RAP	QC Lab:	Quality Is Our Business, Inc.
Binder Source:		Bid Item #	55

% JMF OBC (xta)=>	5.80%	*Xta, total asphalt content of HMA from JMF, expressed as a percentage of the tota weight of the mix
% RAP BC (xra)=>	6.80%	*Xra, asphalt content of RAP expressed as a percentage of the total weight of the RAP
Percent RAP (percentage of belt feed) =>	19.50%	where RAP% = [(Wt of RAP)/(Wt of Virgin Agg + Wt of RAP)]x100%
RAP Aggregate in the Aggregate Blend => (Specifications limit this to the lesser of 25% or as determined from the lowest maximum RPBR value on the blending charts.)	18.42%	function of the above 3 variables where; RAP Agg% = [(1 /xra)-1)/[((1 /xra)/RAP%)-1) ~~Strikethrough~~ Red font indicates value is too high (exceeds cell I16)
	18.57%	<= Minimum of 25% or "Max RAP Agg in Agg Blend as based on Lowest Max RPBR value from blending charts"(Calc'd below in cell H53)
Proposed RAP Pavement Binder Ratio (RPBR)=> (Maximum allowed in the upper 0.2 feet of HMA (exclusive of OGFC) is 25% and 40% below.)	0.218	<=A function of JMF OBC, RAP BC and RAP Agg in Agg%, where; RPBR=[((RAP Agg%)/(1-Xra))x(Xra)x(1-Xta))]/Xta Red text is a reminder when this value exceeds 0.25, and that specifications limit material placed in the upper 0.2' to 0.25 (or 25%). 0.40 (40%) in areas below 0.2'.

Percent RAP (belt feed %) lowered until resulting RPBR and Max RAP Agg in Agg Blend values are less than maximum allowed

True Grade Test Data Table

Enter Critical Temperature (True Grading) Test Results for Virgin Binder and Extracted binder from RAP.

AGING	PROPERTY	TEMP RANGE	Virgin Binder(°c)	RAP Binder(°C)
Original	DSR G*/sin(delta), ≥1.00 kPa	High	67	n/a
RTFO	DSR G*/sin(delta), ≥2.20 kPa	High	68	103
PAV	DSR G*sin(delta), ≤ 5,000 kPa	Intermediate	28	44
	BBR Stiffness, "S" ≤ 300MPa	Low	-18	5
	BBR m-value, m ≥ 0.300	Low	-23	7
For Low Temp, enter True Grade values which are 10C lower than the test temperature. The plotted low test temp will be 10C higher than the True Grade.		Lowest "High"	67	103
		Highest "Low"	-18	7
	PG	Actual (True Grade)	PG 67-18	PG 103+7
		Equivalent M320 grade	PG 64-16	

On M320 Table and in CT SS Sec 92

Date:

Specified Binder Grade / Blended Binder Grade / CHECKS on Production HMA Mixture Binder Grade against contract specs.

Projects Specified Binder Grade =>	PG 70-10	<= The PG Grade selected here populates the horizontal lines on the blending charts.
Proposed Virgin Binder Grade =>	PG 64-16	<= Per specification, when using RAP exceeding 15%, contractor may bump down one grade. See graphic in cell s19 for "likely choices" for bumping down a grade.
"HMA Mixture Binder Grade" at Proposed RPBR =>	PG 75-13	<=For High PG Temp, where "RPBR" crosses High Temp blending line. For Low PG temp, where "RPBR" crosses the highest Low temp blending line.

Determination of HMA Mixture Binder Grades (critical temperatures). Where the RPBR (black line) crosses the blending line (blue line)			Critical Temps of blended binder per blending charts (°C)	Production Tolerance Check: Lower Spec Limit Temp	Production Tolerance Check: Upper Spec Limit Temp	Production Tolerance Check: Are Critical Temps of Blended Binder within Production tolerances.
High Temp Blending Line Crosses Proposed RPBR at Tcrit=	75		75	70	77	OK
Intermed. Temp Blending Line Crosses Proposed RPBR at Tcrit=	31		31	n/a	34	OK
	Low Test Temp	Low Grade Temp (-10C)	Highest Low Temp			
Low Temp Stiffness (S) Crosses Proposed RPBR at Tcrit=	-3	-13	-13	n/a	-8	OK
Low Temp m-value Crosses Proposed RPBR at Tcrit=	-6	-16				

Calc's for Check on Max Allowable RAP Aggregate in the Aggregate Blend (aka %RAP)

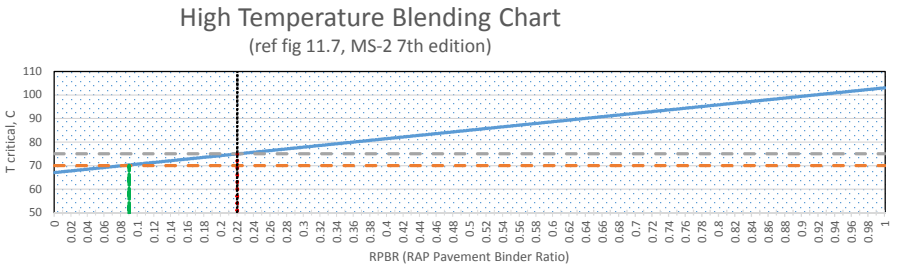
Xta, total asphalt content of HMA from JMF, expressed as a percentage of the total weight of the mix=>	5.80%	<= % JMF OBC (x_{ta})
Xra, asphalt content of RAP expressed as a percentage of the total weight of the RAP=>	6.80%	<= % RAP BC (x_{ra})
Lowest Max RPBR from 4 blending Charts=>	0.22	<= a function of the true grades of virgin and reclaimed rap binder
Max RAP Agg in Agg Blend corresponding to Lowest Max RPBR)	18.57%	a function of the above 3 variables

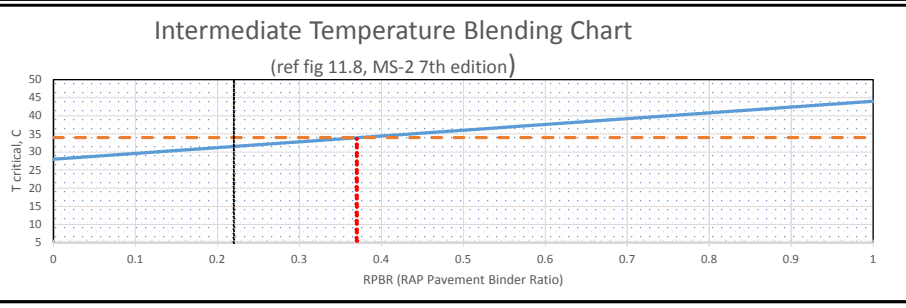
For questions or comments on this blending chart, contact pete.spector@dot.ca.gov, 916-227-7306

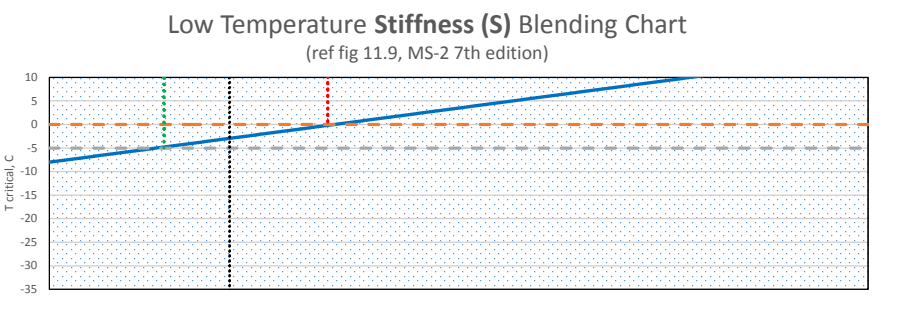
Caltrans Blending Chart Check of JMF's using greater than 15% RAP aggregate in the aggregate blend

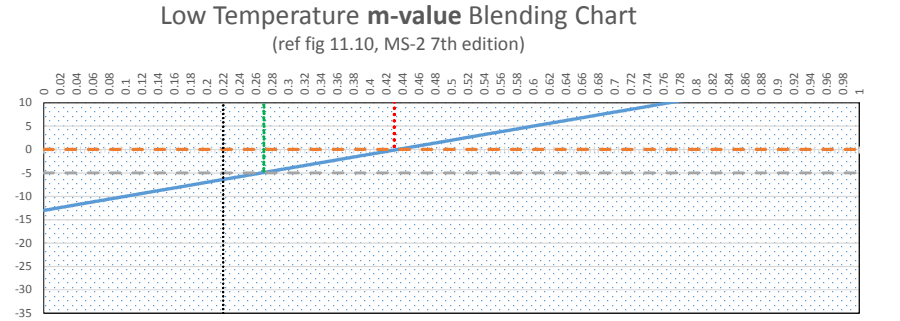
EA (or Project ID): 08-123454
JMF No. 1922-28c-3cxxx
Co/Rte/PM: 08-SBD-247-PM12.3/45.6
HMA Type: 3/4" HMA Type A w/ xx%RAP

Blending Charts









Example #2b. In the previous example, when we chose the option to perform true grading of the binder on a weekly basis, the max RAP % was 19.5%. Here we determine the amount under the assumption that we will use the Certification Program for Suppliers of Asphalt to control the virgin binder. Selecting YES in cell B2 populates the virgin binder grade with the most conservative values (note these cells are not yellow, they are populated automatically based on the "Proposed Virgin Binder Grade"). Using the previous examples RAP Binder critical temps, limits the RAP Agg in Agg Blend to 14.35%, which is less than 15%. In this example, per specications, the contractor could use 15.2% percent RAP (%belt feed), which corresponds to 14.35% RAP aggregate in the aggregate blend (which is less than 15%), therefore not be required to use blending charts.

Caltrans Blending Chart for blending Virgin and RAP Binders (>15% RAP)

YES	<== Is contractor using the COC program for true grading the virgin binder (rather than performing weekly true grade testing)? Select YES if the contractor plans to use the "Certification Program for Suppliers of Asphalt" as a control check of the virgin binder critical temperatures, rather than performing weekly true grade testing of the virgin binder. Selecting YES, auto populates the Virgin Binder critical temperatures in the "True Grade Test Data table" using the most conservative values that correspond to the chosen virgin binder. These assumed values typically require the proposed virgin binder grade (in cell E36) to be "bumped down" one grade when using RAP Aggregate %g's exceeding 15%. These assumed virgin binder critical temp values must be used during the JMF and also production. If the RAP pile gets augmented, new true grades of the extracted RAP binder must be determined and used from that point forward. Select NO if the contractor plans to perform true grading to determine the critical temperatures of virgin binder. This true grading must be performed during development of the JMF as well as weekly during production. Under this method, the contractor is required to perform "true grading" of the virgin binder on a weekly basis, then check the "blended binder grade" against specifications tolerances. After entering those weekly virgin binder critical temperature test results and the true grades from the extracted rap, the check of the "blended binder" grade against the specifications in cells J40:J43.	Spreadsheet Revision Date 04/21/16

JMF Information | Gray cells are general info input | Yellow cells are User required values that drive blending charts

Project Name:	Rte 247 Rehab near Mythical Valley		
EA (or Project ID):	08-123454	Contractor:	HMA Builders Inc.
JMF No.	1922-28c-3cxxx	HMA Plant:	Hot Mix w/ RAP Inc.
Co/Rte/PM:	08-SBD-247-PM12.3/45.6	QC Manager:	John Smith
		Resident Engineer:	Jane Doe
HMA Type:	3/4" HMA Type A w/ xx%RAP	QC Lab:	Quality Is Our Business, Inc.
Binder Source:		Bid Item #	55

% JMF OBC (xta)=>	5.80%	*Xta, total asphalt content of HMA from JMF, expressed as a percentage of the tota weight of the mix
% RAP BC (xra)=>	6.80%	*Xra, asphalt content of RAP expressed as a percentage of the total weight of the RAP
Percent RAP (percentage of belt feed) =>	15.20%	where RAP% = [(Wt of RAP)/(Wt of Virgin Agg + Wt of RAP)]x100%
RAP Aggregate in the Aggregate Blend => (Specifications limit this to the lesser of 25% or as determined from the lowest maximum RPBR value on the blending charts.)	14.31%	function of the above 3 variables where; RAP Agg% = [(1 /xra)-1)/[((1 /xra)/RAP%)-1) Strikethrough Red font indicates value is too high (exceeds cell I16) — 14.35% — <= Minimum of 25% or "Max RAP Agg in Agg Blend as based on Lowest Max RPBR value from blending charts"(Calc'd below in cell H53)
Proposed RAP Pavement Binder Ratio (RPBR)=> Maximum allowed in the upper 0.2 feet of HMA (exclusive of OGFC) is 25% and 40% below.	0.169	<=A function of JMF OBC, RAP BC and RAP Agg in Agg%, where; RPBR=[((RAP Agg%)/(1-Xra))x(Xra)x(1-Xta))/Xta Red text is a reminder when this value exceeds 0.25, and that specifications limit material placed in the upper 0.2' to 0.25 (or 25%), 0.40 (40%) in areas below 0.2'.

True Grade Test Data Table

Enter Critical Temperature (True Grading) Test Results for Virgin Binder and Extracted binder from RAP.

AGING	PROPERTY	TEMP RANGE	Virgin Binder(°c)	RAP Binder(°C)
Original	DSR G*/sin(delta), ≥1.00 kPa	High	69	n/a
RTFO	DSR G*/sin(delta), ≥2.20 kPa	High	69	103
PAV	DSR G*sin(delta), ≤ 5,000 kPa	Intermediate	28	44
PAV	BBR Stiffness, "S" ≤ 300MPa	Low	-16	-5
PAV	BBR m-value, m ≥ 0.300	Low	-16	-7
For Low Temp, enter True Grade values which are 10C lower than the test temperature. The plotted low test temp will be 10C higher than the True Grade.		Lowest "High"	-69	103
		Highest "Low"	-16	-7
	PG	Actual (True Grade)	PG 69-16	PG 103+7
		Equivalent M320 grade	PG 64-16	

On M320 Table and in CT SS Sec 92

Virgin Binder bumped down one grade.

YES above uses the most conservative virgin binder true grades. Because YES was selected, the production tolerance check below is not necessary on a weekly basis. RAP agg binder properties unchanged from previous examples.

Specified Binder Grade / Blended Binder Grade / CHECKS on Production HMA Mixture Binder Gra

Projects Specified Binder Grade =>	PG 70-10	<= The PG Grade selected here populates the horizontal lines on the bl
Proposed Virgin Binder Grade =>	PG 64-16	<= Per specification, when using RAP exceeding 15%, contractor may b
"HMA Mixture Binder Grade" at Proposed RPBR =>	PG 75-12	<=For High PG Temp, where "RPBR" crosses High Temp blending line. For Low PG temp, where "RPBR" crosses the highest Low temp blending line.

Determination of HMA Mixture Binder Grades (critical temperatures). Where the RPBR (black line) crosses the blending line (blue line)			Critical Temps of blended binder per blending charts (°C)	Production Tolerance Check: Lower Spec Limit Temp	Production Tolerance Check: Upper Spec Limit Temp	Production Tolerance Check: Are Critical Temps of Blended Binder within Production tolerances.
High Temp Blending Line Crosses Proposed RPBR at Tcrit=	75		75	70	77	OK
Intermed. Temp Blending Line Crosses Proposed RPBR at Tcrit=	31		31	n/a	34	OK
	Low Test Temp	Low Grade Temp (-10C)	Highest Low Temp			
Low Temp Stiffness (S) Crosses Proposed RPBR at Tcrit=	-2	-12	-12	n/a	-8	OK
Low Temp m-value Crosses Proposed RPBR at Tcrit=	-2	-12				

Calc's for Check on Max Allowable RAP Aggregate in the Aggregate Blend (aka %RAP)

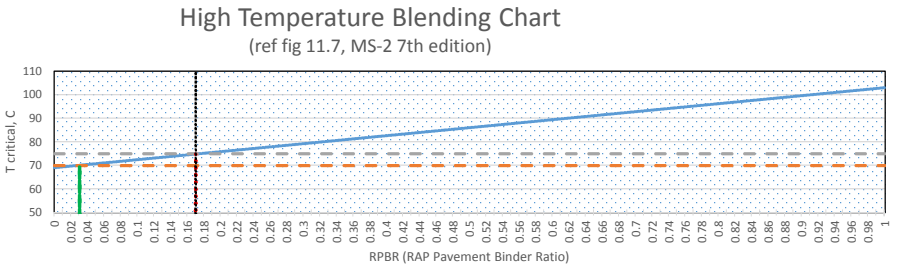
Xta, total asphalt content of HMA from JMF, expressed as a percentage of the total weight of the mix=>	5.80%	<= % JMF OBC (x_{ta})
Xra, asphalt content of RAP expressed as a percentage of the total weight of the RAP=>	6.80%	<= % RAP BC (x_{ra})
Lowest Max RPBR from 4 blending Charts=>	0.17	<= a function of the true grades of virgin and reclaimed rap binder
Max RAP Agg in Agg Blend corresponding to Lowest Max RPBR)	14.35%	a function of the above 3 variables

For questions or comments on this blending chart, contact pete.spector@dot.ca.gov, 916-227-7306

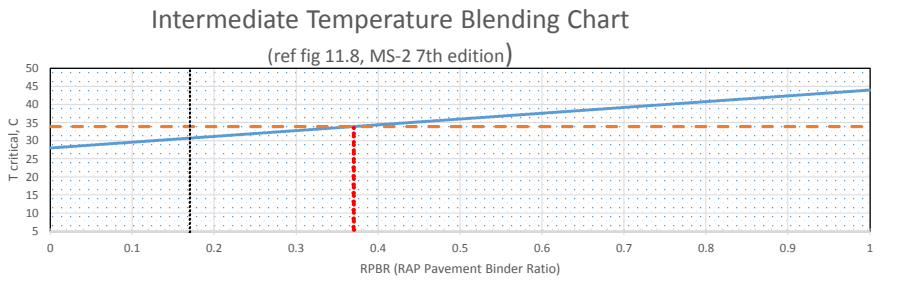
Caltrans Blending Chart Check of JMF's using greater than 15% RAP aggregate in the aggregate blend

EA (or Project ID): 08-123454
JMF No. 1922-28c-3cxxx
Co/Rte/PM: 08-SBD-247-PM12.3/45.6
HMA Type: 3/4" HMA Type A w/ xx%RAP

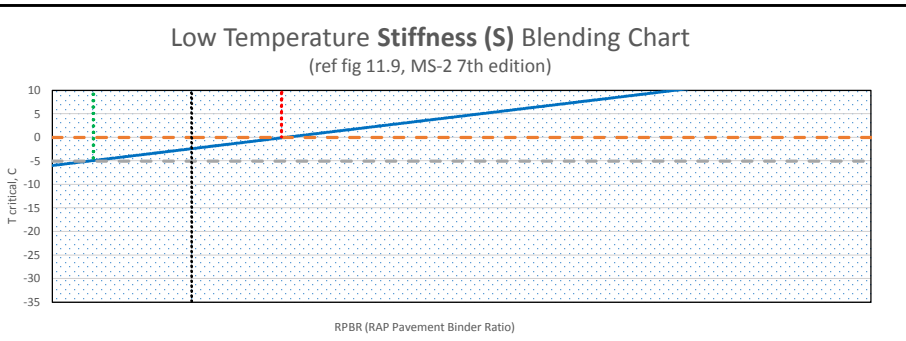
Blending Charts



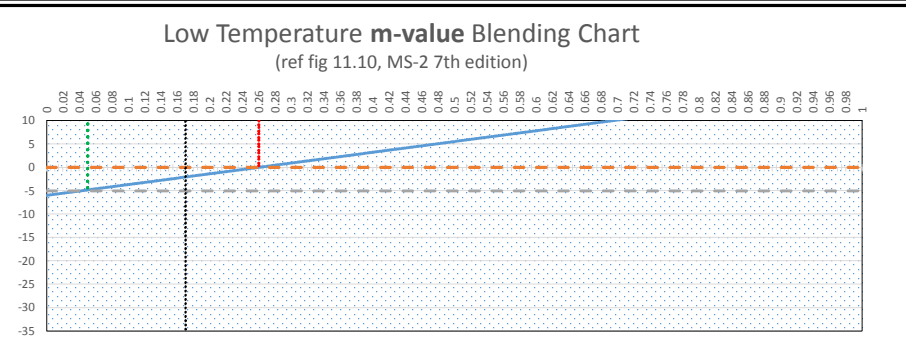
- Blending Line 69C (High temp of virgin binder) to 103C (High Temp of RAP binder)
- 70+5C=75C Upper limit of projects specified binder. During production, the combined binder High temp grade tolerance is 2C higher
- PG 70-XX, Projects Specified Binder Grade
- Min RPBR (=0.03)
- Max RPBR (=0.17)
- Proposed RPBR (0.169), must be greater than or equal to Min RPBR and less than or equal to Max RPBR on this Chart



- Blending Line 28C (Intermediate Temp of virgin binder) to 44C (Intermediate Temp of RAP binder)
- Intermediate Temp 34 C (this is a max temp for JMF and production, there is no min temp). When %RAP exceeds 15%, subnote d that allows +3C in the Section 92 PG Asphalt Binder table does not apply.
- Max RPBR (=0.37)
- Proposed RPBR (0.169), must be less than or equal to Max RPBR on this chart



- Blending Line -6C to 15C. (BBR-S true grades +10C)
- 0 C, (per the m320 table = specified PG low grade +10C)
- -5 C, (the above temp less 5 C)
- Max RPBR (=0.28)
- Min RPBR (=0.05). For Low Temp only, RPBR may be less (i.e. to the left)
- Proposed RPBR (0.169)



- Blending Line -6C to 17C. (BBR m-value true grades +10 C)
- 0 C, (per the m320 table = specified PG low grade +10C)
- -5 C, (the above temp less 5 C)
- Max RPBR (=0.26)
- Min RPBR (=0.05). For Low Temp only, RPBR may be less (i.e. to the left)
- Proposed RPBR (0.169)

Example 2c: To allow a higher percentage RAP be used than in the previous examples, in this example, the virgin binder is dropped two grades from a PG 70-10 to a PG 58-22. "YES" was selected in cell B2 to indicate that the COC program will be used to control the virgin binder. Selecting YES replaces the virgin binder true grades with the most conservative values for PG 58-22. As shown in this example, bumping down two grades allows a RAP belt feed % of up to 26%, resulting in an RPBR of 0.292, which exceeds 0.25 limitation for HMA in the upper 0.2' of layer thickness, but is less than the 0.40 limitation for HMA below the upper 0.2'. The RAP belt feed % has to be lowered to 22.3% to prevent the RPBR from exceeding 25% (not shown in this example).

Caltrans Blending Chart for blending Virgin and RAP Binders (>15% RAP)

YES

<== Is contractor choosing to not true grade the virgin binder?

Select YES if the contractor plans to use the "Certification Program for Suppliers of Asphalt" as a control check of the virgin binder critical temperatures, rather than performing weekly true grade testing of the virgin binder. Selecting YES, auto populates the Virgin Binder critical temperatures in the "True Grade Test Data table" using the most conservative values that correspond to the chosen virgin binder. These assumed values typically require the proposed virgin binder grade (in cell E36) to be "bumped down" one grade when using RAP Aggregate %g's exceeding 15%. These assumed virgin binder critical temp values must be used during the JMF and also production. If the RAP pile gets augmented, new true grades of the extracted RAP binder must be determined and used from that point forward.

Select NO if the contractor plans to perform true grading to determine the critical temperatures of virgin binder. This true grading must be performed during development of the JMF as well as weekly during production. weekly testing of the virgin binder, for both the JMF and use true grades of the proposed virgin binder when determining the "blended binder grade". Under this method, during production the contractor is required to perform "true grading" of the virgin binder on a weekly basis, and check the "blended binder grade" against specifications tolerances. After entering those weekly test results and the true grades from the extracted rap, the check of the "blended binder" grade is this sheet in cells J39:J43 .

Spreadsheet Revision Date 04/21/16

JMF Information | Gray cells are general info input | Yellow cells are User required values that drive blending charts

Project Name: Rte 247 Rehab near Mythical Valley
EA (or Project ID): 08-123454
JMF No. 1922-28c-3cxxx
Co/Rte/PM: 08-SBD-247-PM12.3/45.6
HMA Type: 3/4" HMA Type A w/ xx%RAP
Binder Source:

Contractor: HMA Bui
HMA Plant: Hot Mix
QC Manager: John Sm
Resident Engineer: Jane Doe
QC Lab: Quality Is
Bid Ite

Above 0.25, therefore HMA with this RAP can't be used in upper 0.20' of layer, but OK below upper 0.20' of layer

% JMF OBC (xta)=>	5.80%	*Xta, total asphalt content of HMA from JMF, expressed as a perc weight of the mix
% RAP BC (xra)=>	6.80%	*Xra, asphalt content of RAP expressed as a percentage of the total weight of the RAP
Percent RAP (percentage of belt feed) =>	26.00%	where RAP% = [(Wt of RAP)/(Wt of Virgin Agg + Wt of RAP)]x100%
RAP Aggregate in the Aggregate Blend => Specifications limit this to the lesser of 25% or as determined from the lowest maximum RPBR value on the blending charts.	24.67%	function of the above 3 variables where; RAP Agg% = [(1 /xra)-1)/[((1 /xra)/RAP%)-1) Strikethrough Red font indicates value is too high (exceeds cell I16)
	25.00%	<= Minimum of 25% or "Max RAP Agg in Agg Blend as based on Lowest Max RPBR value from blending charts"(Calc'd below in cell H53)
Proposed RAP Pavement Binder Ratio (RPBR)=> Maximum allowed in the upper 0.2 feet of HMA (exclusive of OGFC) is 25% and 40% below.	0.292	=A function of JMF OBC, RAP BC and RAP Agg in Agg%, where; RPBR=[((RAP Agg%)/(1-Xra))x(Xra)x(1-Xta)]/Xta Red text is a reminder when this value exceeds 0.25, and that specifications limit material placed in the upper 0.2' to 0.25 (or 25%), 0.40 (40%) in areas below 0.2'.

True Grade Test Data Table

Enter Critical Temperature (True Grading) Test Results for Virgin Binder and Extracted binder from RAP.

AGING	PROPERTY	TEMP RANGE	Virgin Binder(°C)	RAP Binder(°C)
Original	DSR G*/sin(delta), ≥1.00 kPa	High	63	n/a
RTFO	DSR G*/sin(delta), ≥2.20 kPa	High	63	103
	DSR G*sin(delta), ≤ 5,000 kPa	Intermediate	22	44
	BBR Stiffness, "S" ≤ 300MPa	Low	-22	5
	BBR m-value, m ≥ 0.300	Low	-22	7
	p, enter True Grade values which are 10C he test temperature. The plotted low test	Lowest "High"	63	103
		Highest "Low"	-22	7
	PG	Actual (True Grade)	PG 63-22	PG 103+7
		Equivalent M320 grade	PG 58-22	

Binder Prop

On M320 Table and in CT SS Sec 92

Though Max RAP Agg in Agg Blend calculated below as 25.32%, specifications limit this to 25%

Bumped down two grades and selected YES above

Specified Binder Grade / Blended Binder Grade / CHECKS on Production HMA Mixture Binder Grade against contract specs.

Projects Specified Binder Grade =>	PG 70-10	<= The PG Grade selected here populates the horizontal lines on the blending charts.
Proposed Virgin Binder Grade =>	PG 58-22	<= Per specification, when using RAP exceeding 15%, contractor may bump down one grade. See graphic in cell J19 for "likely choices" for bumping down a grade.
"HMA Mixture Binder Grade" at Proposed RPBR =>	PG 75-14	<=For High PG Temp, where "RPBR" crosses High Temp blending line. For Low PG temp, where "RPBR" crosses the highest Low temp blending line.

Determination of HMA Mixture Binder Grades (critical temperatures).
Where the RPBR (black line) crosses the blending line (blue line)

			Critical Temps of blended binder per blending charts (°C)	Production Tolerance Check: Lower Spec Limit Temp	Production Tolerance Check: Upper Spec Limit Temp	Production Tolerance Check: Are Critical Temps of Blended Binder within Production tolerances.
High Temp Blending Line Crosses Proposed RPBR at Tcrit=	75		75	70	77	OK
Intermed. Temp Blending Line Crosses Proposed RPBR at Tcrit=	28		28	n/a	34	OK
	Low Test Temp	Low Grade Temp (-10C)	Highest Low Temp			
Low Temp Stiffness (S) Crosses Proposed RPBR at Tcrit=	-4	-14	-14	n/a	-8	OK
Low Temp m-value Crosses Proposed RPBR at Tcrit=	-4	-14				

Calc's for Check on Max Allowable RAP Aggregate in the Aggregate Blend (aka %RAP)

Xta, total asphalt content of HMA from JMF, expressed as a percentage of the total weight of the mix=>	5.80%	<= % JMF OBC (x_{ta})
Xra, asphalt content of RAP expressed as a percentage of the total weight of the RAP=>	6.80%	<= % RAP BC (x_{ra})
Lowest Max RPBR from 4 blending Charts=>	0.30	<= a function of the true grades of virgin and reclaimed rap binder
Max RAP Agg in Agg Blend corresponding to Lowest Max RPBR)	25.32%	a function of the above 3 variables

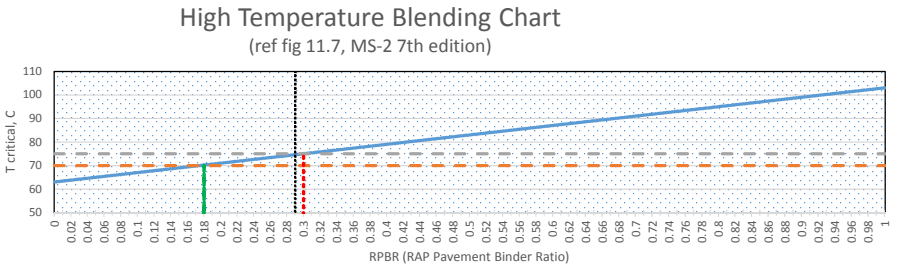
For questions or comments on this blending chart, contact pete.spector@dot.ca.gov, 916-227-7306

Caltrans Blending Chart Check of JMF's using greater than 15% RAP aggregate in the aggregate blend

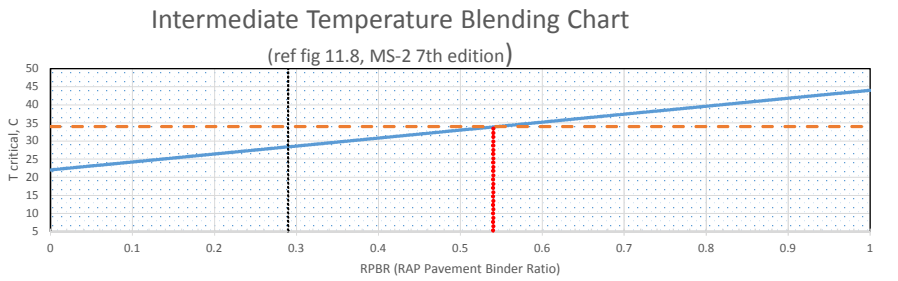
EA (or Project ID): 08-123454
JMF No. 1922-28c-3cxxx
Co/Rte/PM: 08-SBD-247-PM12.3/45.6
HMA Type: 3/4" HMA Type A w/ xx%RAP

Spreadsheet Revision Date 04/21/16

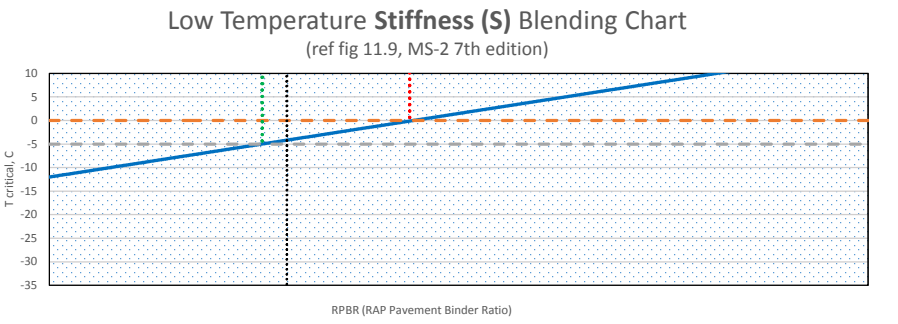
Blending Charts



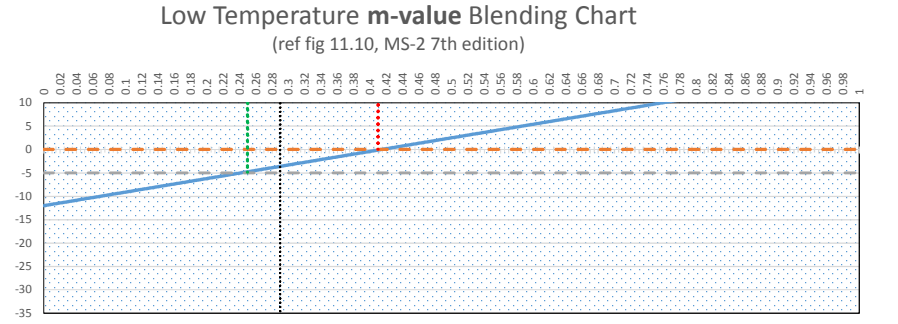
- Blending Line 63C (High temp of virgin binder) to 103C (High Temp of RAP binder)
- 70+5C=75C Upper limit of projects specified binder. During production, the combined binder High temp grade tolerance is 2C higher
- PG 70-XX, Projects Specified Binder Grade
- Min RPBR (=0.18)
- Max RPBR (=0.3)
- Proposed RPBR (0.292), must be greater than or equal to Min RPBR and less than or equal to Max RPBR on this Chart



- Blending Line 22C (Intermediate Temp of virgin binder) to 44C (Intermediate Temp of RAP binder)
- Intermediate Temp 34 C (this is a max temp for JMF and production, there is no min temp). When %RAP exceeds 15%, subnote d that allows +3C in the Section 92 PG Asphalt Binder table does not apply.
- Max RPBR (=0.54)
- Proposed RPBR (0.292), must be less than or equal to Max RPBR on this chart



- Blending Line -12C to 15C. (BBR-S true grades +10C)
- 0 C, (per the m320 table = specified PG low grade +10C)
- -5 C, (the above temp less 5 C)
- Max RPBR (=0.44)
- Min RPBR (=0.26). For Low Temp only, RPBR may be less (i.e. to the left)
- Proposed RPBR (0.292)



- Blending Line -12C to 17C. (BBR m-value true grades +10 C)
- 0 C, (per the m320 table = specified PG low grade +10C)
- -5 C, (the above temp less 5 C)
- Max RPBR (=0.41)
- Min RPBR (=0.25). For Low Temp only, RPBR may be less (i.e. to the left)
- Proposed RPBR (0.292)