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Effect of Conditioning Time and Temperature on the Volumetrics and Stability of Dry Process Crumb Rubber Modified Warm Asphalt Mixtures

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Outline

- Overview on Study
- Laboratory Compactor Selection
- Materials and Test Matrix
- Volumetrics
- Marshall Stability and Flow
- Conclusion
- Future Work

Warm Mix Asphalt (WMA)

Reduce the mixture viscosity for better coating of aggregates increase the workability of the loose mixtures provide better compaction at lower temperatures

Types

- chemical additives/surfactants
- foaming methods
- non-foaming additives

Experience

Perform equivalent or better than HMA mixtures

Crumb Rubber Modified Asphalt Mixtures

Types

- Dry Process (DryCR)
- Wet Process (WetCR)
- Terminal Blend (TBCR)

Experience

CR modified mixtures perform equal or better than traditional mixtures.

Dry Process

CR is added as a replacement of fine aggregate up to 5% by total weight of the mixture.

Advantages:

(i) Good skid resistance and de-icing properties.
(ii) Less expensive
(iii) More crumb rubber is utilized

Disadvantages:

(i) Anti-oxidants are not completely mixed with binder

Wet Process

CR is added to liquid asphalt at temperatures around 325-400^{o}F. About 15% by weight of the binder is utilized (1-1.5% by total weight of the mix)

Advantages:

(i) Superior performance compared to many polymer modified asphalt pavements

Disadvantages:

(i) Possible segregation of CR grains if not mixed properly.

Terminally Blend

CR is added to liquid asphalt at temperatures around 375-400^{o}F. About 10 % by weight of the binder is utilized The main difference is in the additive used to keep the CR particles suspended in the mixture.

Advantages:

(i) superior performance compared to many polymer modified asphalt pavements
(ii) No segregation of CR particles
(iii) Can be hauled for long distances.

Disadvantages:

(i) More costly than the other processes
(ii) Less crumb rubber is utilized

WMA + Dry CR ?

- Environmentally friendly
- Natural resources
- Energy
- Economy

Focuses of the Study

- Conditioning time
- Mixing temperature
- Conditioning time

Conditioning Time

If the conditioning time is not taken into account to increase this interaction, it causes lower resistance to moisture, reduced adhesion between the aggregates and binder medium, and reduction in the stiffness of the pavement.

Materials and Test Matrix

•Marshall mix design procedure is followed to understand the effect of CT and MT.

Aggregate gradation

•Open graded aggregate gradation:

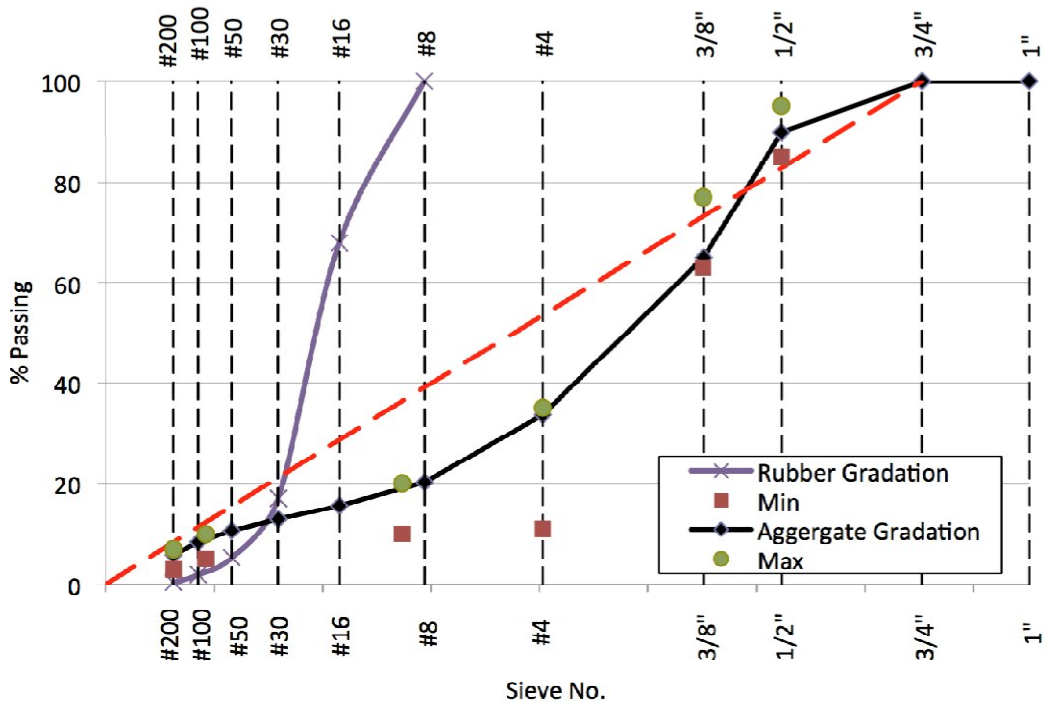
66.4% of coarse aggregates

27.8% of fine aggregates

5.8% of filler

CR Gradation

The CR granulates are used 2% by weight of the mix within the suggested limits.



WMA Additive

A chemical based WMA additive (Sasobit) used

1.5% and 3% by weight of the binder.

Binder Selection

•Pen 50/70

Traditional HMA according to AI:

• Mixing temperature (MT) : 150 ° C

• Compaction temperature (CT): 140 ° C

CR modified HMA according :

• Both MT and CT increased by 10 ° C to provide interactions between the CR particles and the binder.

Test Matrix

Mix Type	WMA additive (% by weight binder)	Conditioning Time (min.)	MT (° C)	CT (° C)
HMA	0%	0, 45,90, 120	160	150
WMA 1	1.5%	0, 45,90, 120	160	150
WMA 2	3%	0, 45,90, 120	160	150
WMA 3	3%	0, 45,90, 120	145	135

-Six replicates for each combination

-Overall 96 samples

Sample Prepration

For HMA samples:

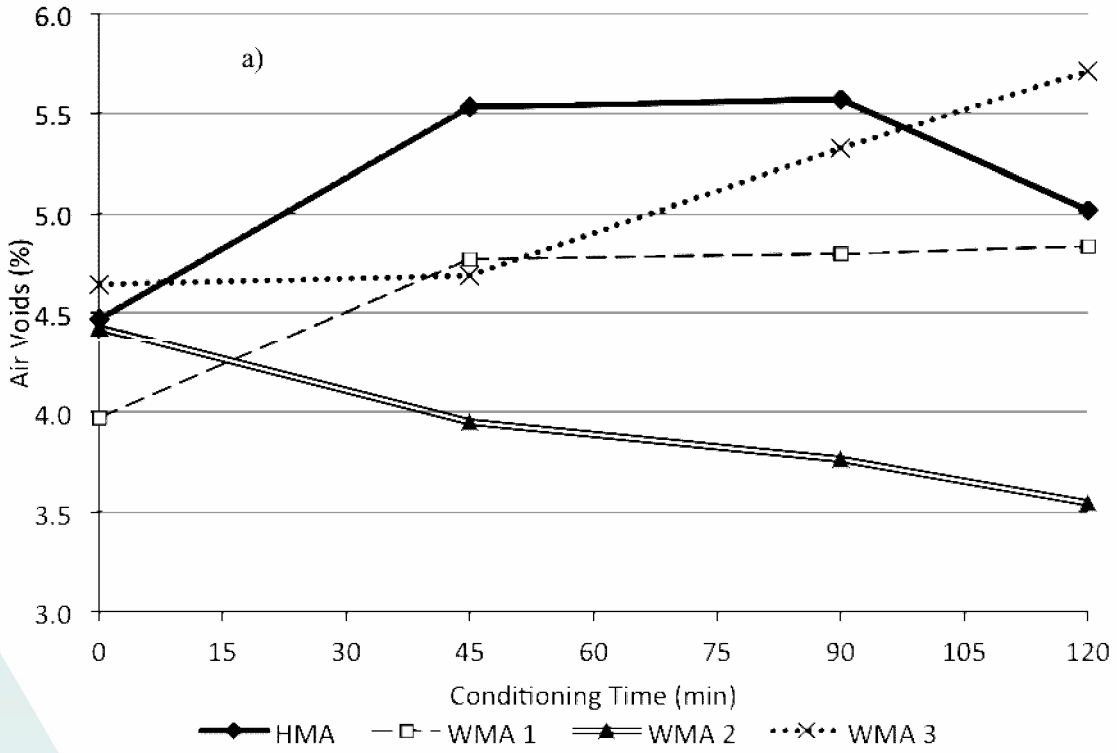
- CR particles and pre-heated aggregates in pre-heated mixing bowl, hand-mixed with a spatula for 30sec
- The binder is poured into crater
- The bowl is mixed in heater equipped mechanical mixer.
- The mixtures are brought the desired temperature by mixing with a spatula
- The samples are compacted in molds preheated to CT

Sample Preperation

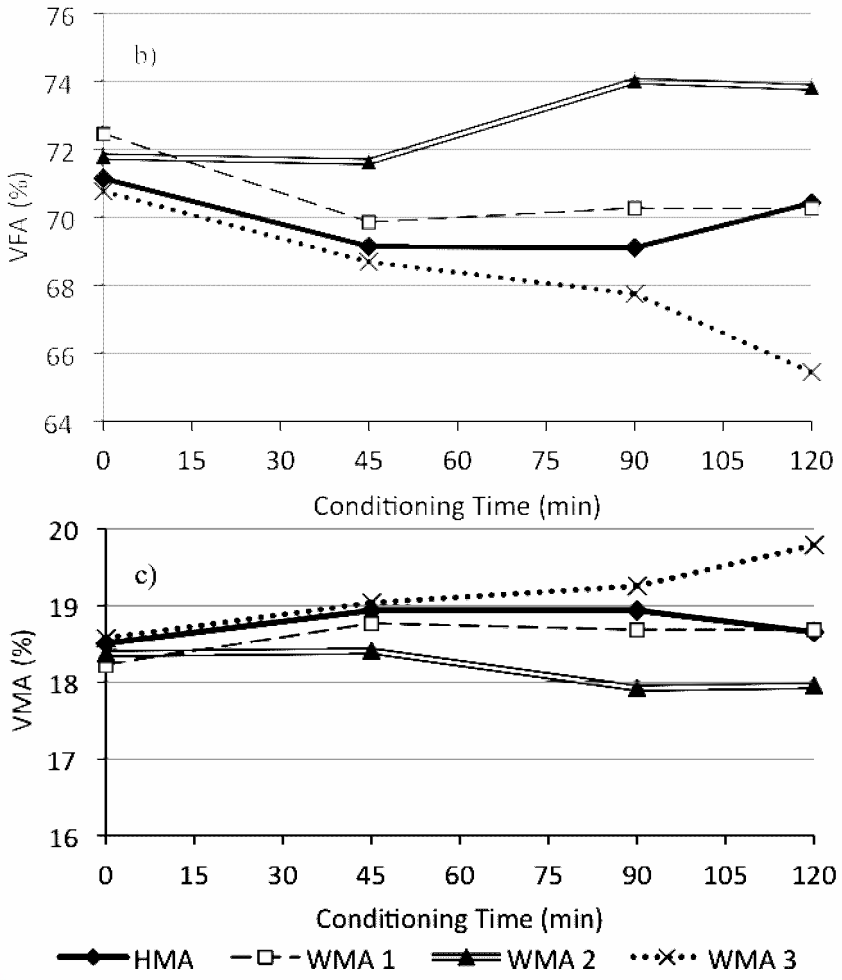
For WMA samples:

- Before the mixing of CR particles with the aggregate
- Preheated aggregates are mixed with Sasobit with a spatula for 15sec
- The CR particles are added and mixing with spatula for 30sec
- The following steps are kept same as HMA samples

Results


a)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
Air Voids (%)
0
15
30
45
60
75
90
105
120
Conditioning Time (min)
HMA
WMA 1
WMA 2
WMA 3

Results


b)
VFA (%)
76
74
72
70
68
66
64
0
15
30
45
60
75
90
105
120
Conditioning Time (min)
c)
VMA (%)
20
19
18
17
16
0
15
30
45
60
75
90
105
120
Conditioning Time (min)
HMA
WMA 1
WMA 2
WMA 3

Conclusion

•WMA additives improve the compactibility and indirectly the performance of DryCR mixtures

•A decrease in AV and an increase in stability are observed, except WMA 3 prepared at lower temperatures

•Increase in WMA additive dosage has a positive impact on the compactibility of DryCR modified mixtures

•Increase in the conditioning time increases the interaction between the CR granulates and the binding medium, except WMA 3 mix which is prepared at lower temperatures and it negatively affects the CR granulates and binder medium

Conclusion

•Lower production temperatures can be accepted only if the conditioning time is limited

•Maximum conditioning time needs to be limited to 90 minutes.

•MT/CT can be lowered for DryCR modified WMA mixes

• Although this study gives broad information on the DryCR modified WMA mixes, it is crucial to further analyze the mechanical performance of dry process.

Thank you for your attention…

Questions