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Abstract

The purpose of this project was to explore the feasibility of incorporating a Phase Change Material (PCM) into Hot Mix Asphalt (HMA) as a method for reducing damage caused by thermal stresses. The HMA and PCM mix is expected to improve safety by reducing debris and damage. Since utilizing PCM in HMA has never been tested, Phase 1 was designed to investigate the evaporation and absorption properties of PCM-6. Phase 2 evaluated the feasibility of integrating HMA with PCM-6 by using Light Weight Aggregate (LWA). Samples with different PCM concentrations were produced (1.25%, 2.5%, Control) and tested in the Guarded Longitudinal Calorimeter (GLC). Both PCM concentrations reduced the rate of cooling, the maximum cold temperature, and the time required to thaw the sample. Phase 3 attempted to refine the mix design for a 1.25% PCM concentration in order to evaluate the volumetric properties of the mix and comply with the Superpave specification.

Goals and Objectives

Goals

- Incorporate PCM into HMA through LWA absorption
- Investigate the thermal benefits of utilizing PCM in HMA
- Investigate material limitations of using LWA to incorporate PCM

Objectives

- Improve the method of incorporating PCM into HMA
- Investigate the changes in thermal properties as a result of PCM incorporation



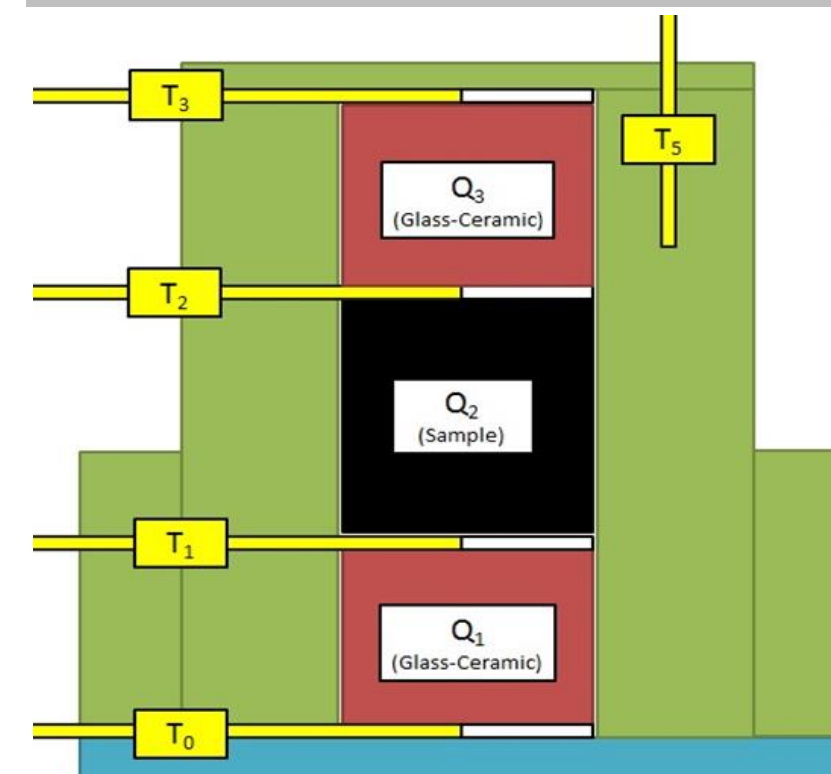
Project Outline

Phase	Test	Amount/Size
Phase 1 - Absorption and Evaporation Tests		
1	PCM-6 Heating	20 mL
	Absorption/Evaporation	-
Phase 2 - Feasibility of a HMA/PCM Mix		
2	GLC Testing	2"x2"x2"
	Control	
	1.25% PCM-6	
Phase 3 - Improved Mix Design		
3a	GLC Testing	2"x2"x2"
	Control	
3b	Theoretical Maximum Density	2"x2"x2"
	1.25% PCM-6	
3c	Bulk Specific Gravity	2"x2"x2"
	Control	

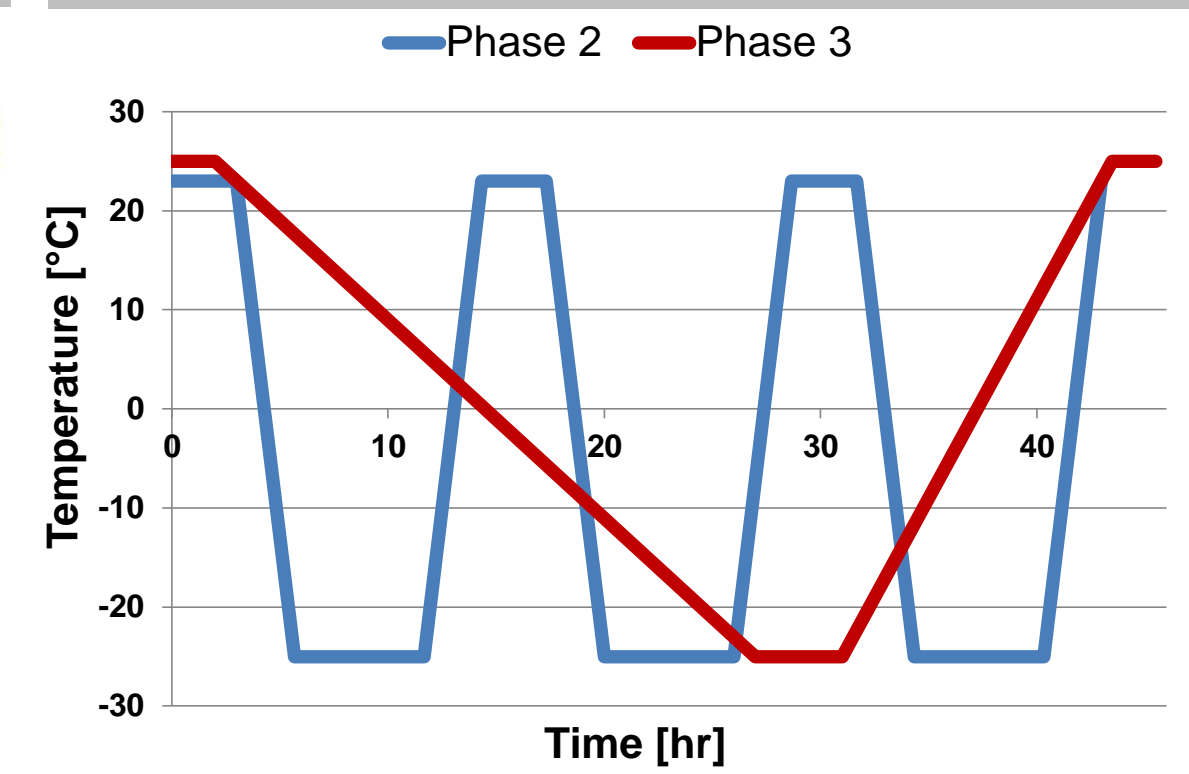
Feasibility of an HMA/PCM Mix

- Produced sample batches with the following mass concentrations of PCM-6: 0% (control), 1.25%, 2.5%, 5.5%, and 10.5%
- Maximum feasible content of PCM-6 was 2.5%
- Reasonable content of PCM-6 was 1.25%, which corresponded to 10% LWA
- Samples subjected to thermal testing in the Guarded Longitudinal Calorimeter (GLC)

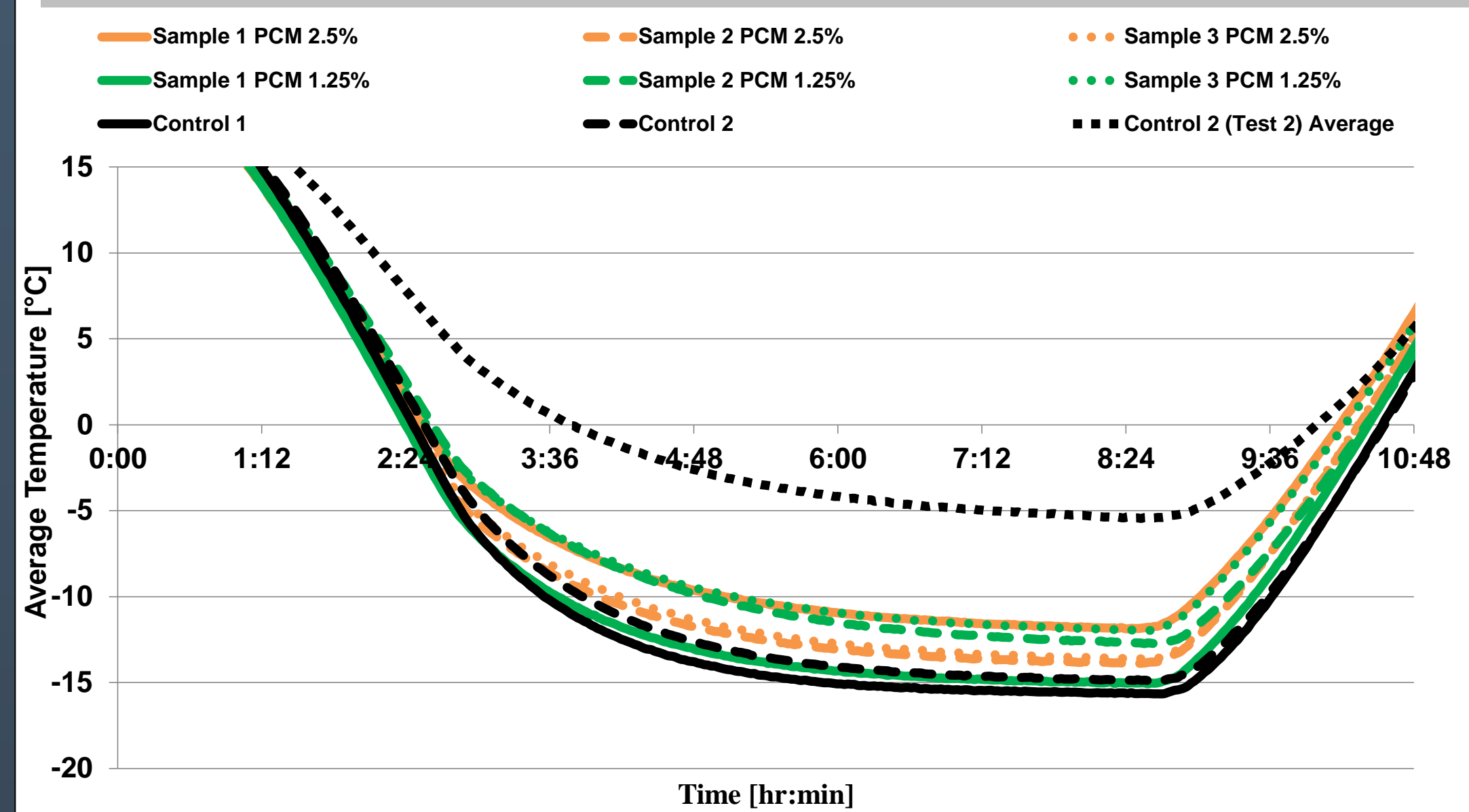
Guarded Longitudinal Calorimeter



Freezing/Thawing Profiles



Phase 2 GLC Results



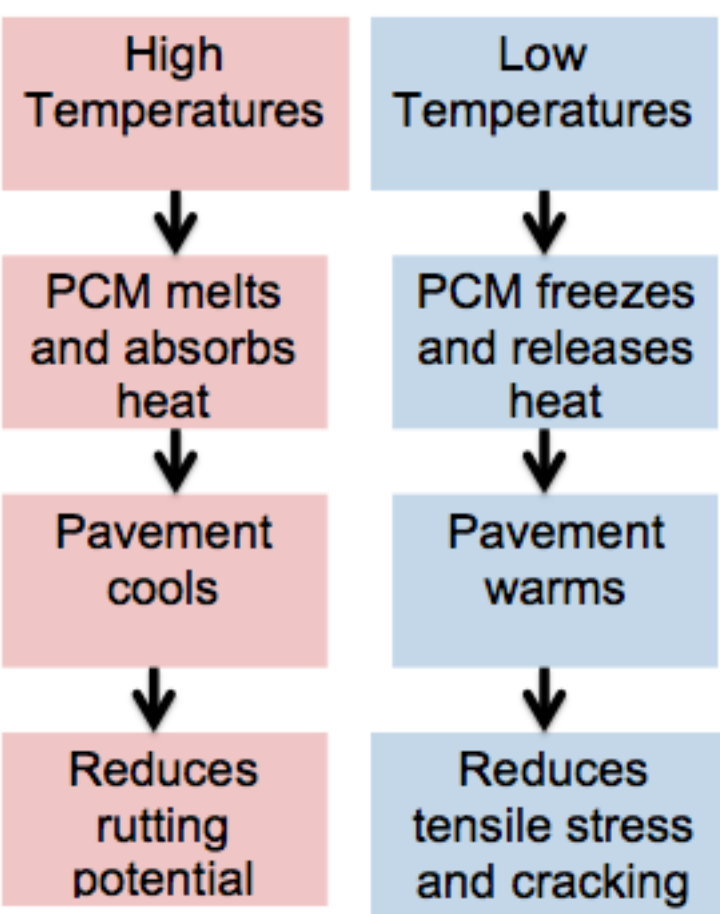
- PCM may reduce the rate of cooling, the maximum cold temperature, and the time required to thaw the sample

Background

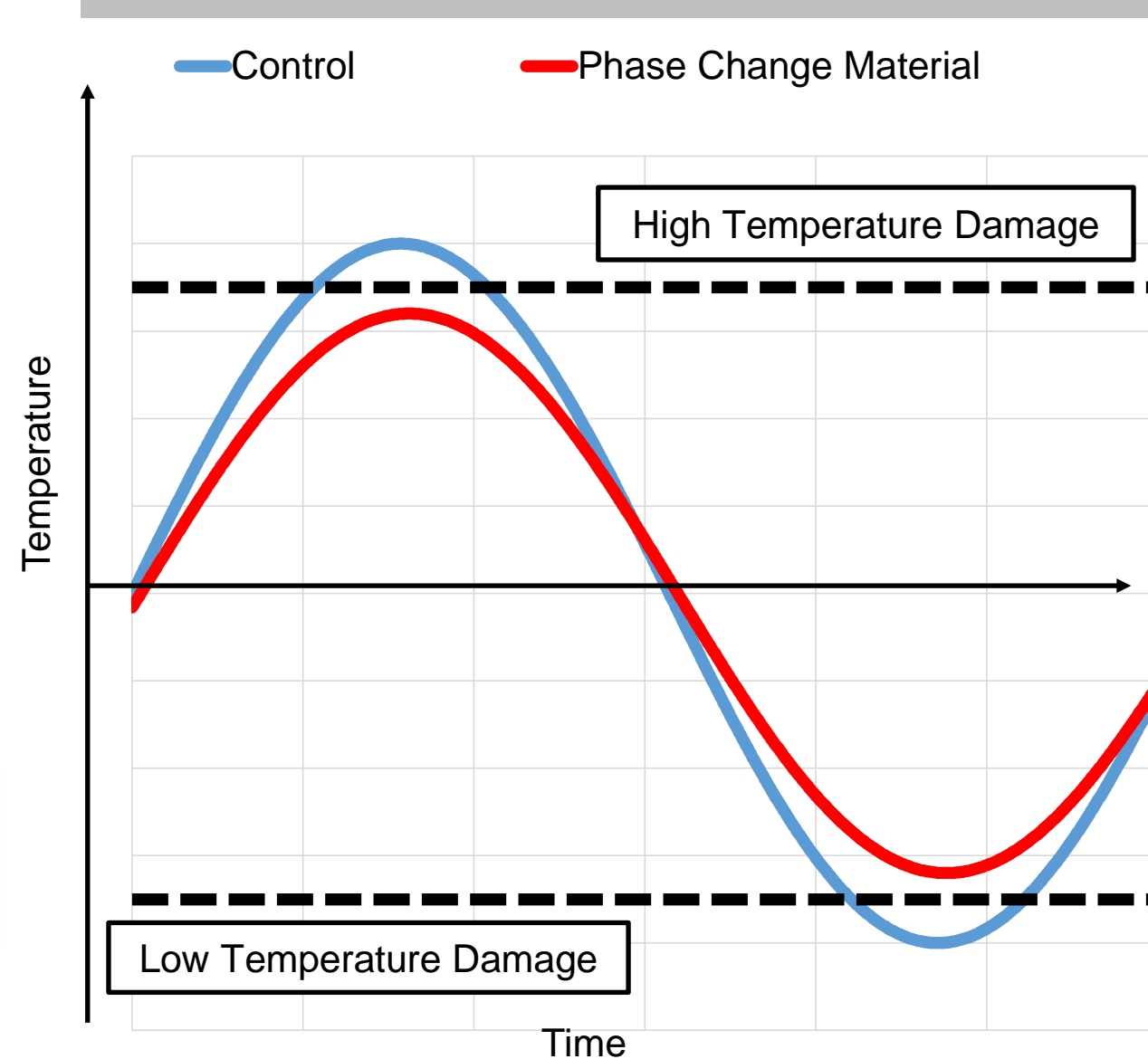
Phase Change Materials (PCMs)

- Regulate temperature
- Store or release energy during phase change
- PCM-6 (paraffin blend) undergoes a phase change at 6 °C

Application of PCMs in Hot Mix Asphalt



Theoretical Results



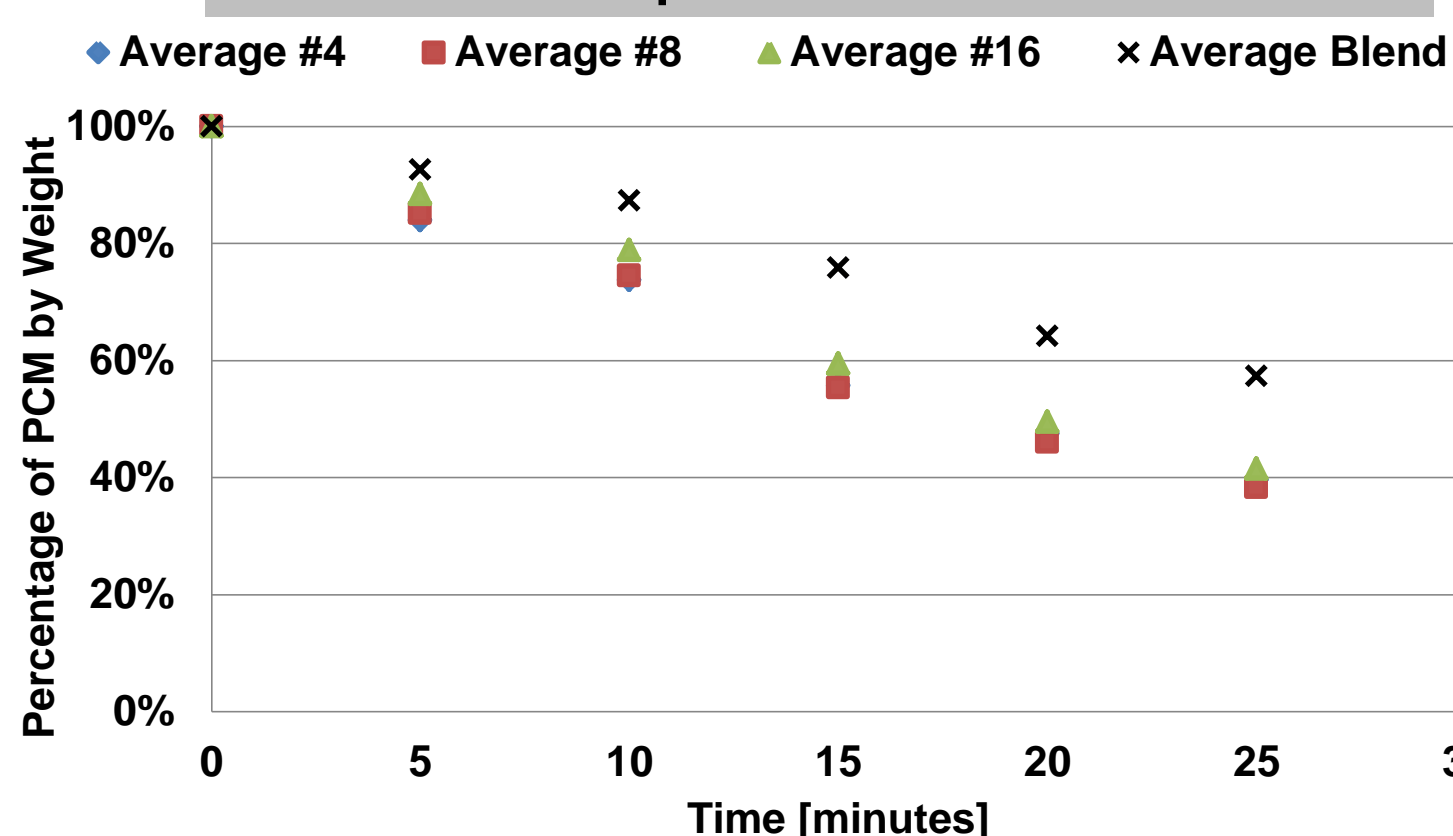
Absorption and Evaporation Tests

- PCM-6 did not combust, but evaporated quickly from LWA
- Exposed briefly (<5 minutes) to hot temperatures during HMA mixing

Absorption Results

Sieve Size	Average Absorption	Standard Deviation
#4	10.1%	0.509
#8	13.3%	0.532
#16	18.1%	0.632
Blend	11.9%	0.279

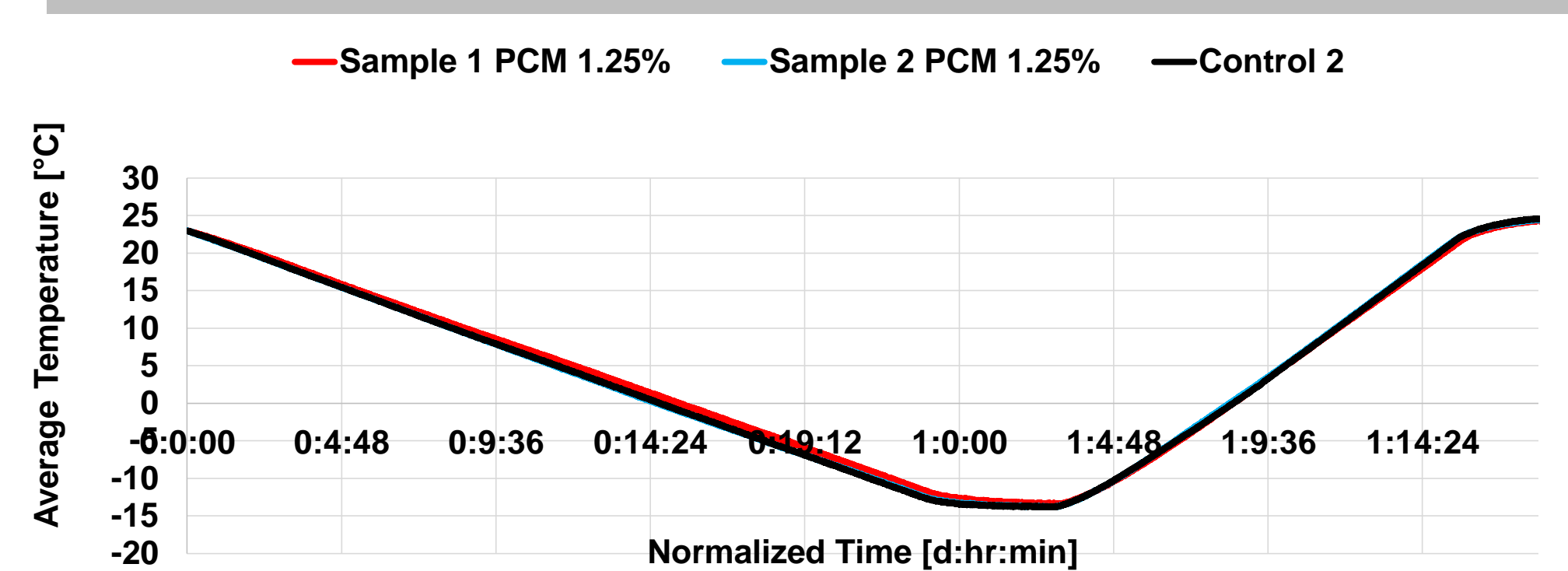
Evaporation Results



Improved Mix Design

- Utilized aggregate gradation and calculated binder content to conform to the Superpave specification
- Produced and tested a control and a 1.25% PCM-6 batch for Bulk Specific Gravity (BSG) and Voids in the Total Mix (VTM), with target value for the VTM of 4%

Phase 3 GLC Results



- Sample 1 PCM 1.25% reduced the maximum low temperature and the rate of cooling
- Sample 2 PCM 1.25% and Control 2 produced approximately the same profile
- Further testing is required to establish conclusions

Future Work

- Find a less invasive way to incorporate PCM-6 into the HMA
- Determine the effect of PCM-6 on the strength properties of the HMA
- Conduct thermal tests on samples exposed to outdoor conditions (water saturation)
- Construct and test samples with different types of PCM
- Determine the accuracy of the GLC

Acknowledgements

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