SUPPLEMENTAL MATERIALS FOR VTRC PROJECT 120030, EVALUATION OF RECYCLED PLASTIC MODIFIED ASPHALT MIXTURES: PHASE I

January 17, 2025

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These supplemental materials accompany the following publication:

Project No. 120030, *Evaluation of Recycled Plastic Modified Asphalt Mixtures and Pavements: Phase I – A Case Study in Virginia*, by Habbouche, J.; Lloyd, L.N.; and Martinez, D.

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SUPPLEMENTAL ITEM A. ASPHALT BINDER TESTING AND MASTER CURVES RESULTS

Table A1. Properties of Evaluated Unmodified and Polymer-Modified (RPM and SBS) Asphalt Binders (During Design)

Property		Test Results Binder / Binder Blend ID PG 64S-22	PG 64S-22 + 2% P1	PG 64S-22 + 4% P1	PG 64S-22 + 6% P1	PG 64E-22
Original Viscosity at 135°C, Pa.s		0.475	0.833	1.980	3.362	1.995
Dynamic Shear, 10 rad/s, specification: |G*|/sin δ > 1.0 kPa						
Original |G*|/sin δ, kPa	64°C	1.54	12.83	--	--	--
	70°C	0.73	12.25	5.29	--	1.77
	76°C	--	11.64	3.39	--	0.95
	82°C	--	8.459	1.72	--	--
Original Failure Temperature, °C		**67.4**	**94.2**	**85.4**	--	**75.5**
RTFO Mass Loss, %		-0.016	-0.115	+0.078	--	-0.194
Dynamic Shear, 10 rad/s, specification: |G*|/sin δ > 2.2 kPa						
RTFO |G*|/sin δ, kPa	64°C	3.09	--	--	--	--
	70°C	1.42	3.03	4.98	--	3.96
	76°C	--	1.45	2.34	--	2.09
	82°C	--	--	1.18	--	--
RTFO Failure Temperature, °C		**66.6**	**72.6**	**76.7**	--	**75.5**
Dynamic Shear, 10 rad/s, specification: |G*|.sin δ < 5,000 kPa						
PAV |G*|.sin δ, kPa	19°C	7,147	8,779	--	--	6,455
	22°C	4,859	12,080	--	--	4,684
	25°C	--	--	5,234	--	3,319
	28°C	--	--	3,962	--	--
PAV Failure Temperature, °C		**21.78**	**24.3**	**25.5**	--	**21.3**
Creep Stiffness, 60 sec, specification: Stiffness (S) < 300 MPa and m-value > 0.300						
PAV Stiffness (S), MPa	-6°C	--	80	117	--	--
	-12°C	159	143	205	--	146
	-18°C	288	--	--	--	235
PAV m-value	-6°C	--	0.361	0.308	--	--
	-12°C	0.342	0.288	0.275	--	0.303
	-18°C	0.309	--	--	--	0.207
PAV Stiffness Failure Temperature (T_s), °C		-18.4	-19.6	-16.1	--	-21.1
PAV m-value Failure Temperature (T_m), °C		-19.6	-11.0	-7.5	--	-12.2
PAV Low Failure Temperature, °C		**-28.4**	**-21.0**	**-17.5**	--	**-22.2**
PAV $\Delta T_c = T_S - T_m$, °C		1.2	-8.6	-8.7	--	-8.9
Performance Grade (AASHTO M 320)		**PG 64-28**	**PG 70-16**	**PG 76-16**	--	**PG 70-22**
Multiple Stress and Creep Recovery (MSCR) Test at 64°C						
RTFO J_{nr}, kPa^{-1}	0.1 kPa	2.8650	1.2530	0.3257	--	0.4054
	3.2 kPa	3.0950	1.4010	0.5866	--	0.5077
RTFO Recovery, %	0.1 kPa	3.55	8.93	46.52	--	53.83
	3.2 kPa	1.17	3.28	8.96	--	44.23
Performance Grade (AASHTO M 322)		**PG 64S-28**	**PG 64H-16**	**PG 64E-16**	--	**PG 64E-22**

S = standard traffic; E = extremely heavy traffic; P1 = plastic; -- = data not available or testing was not completed.

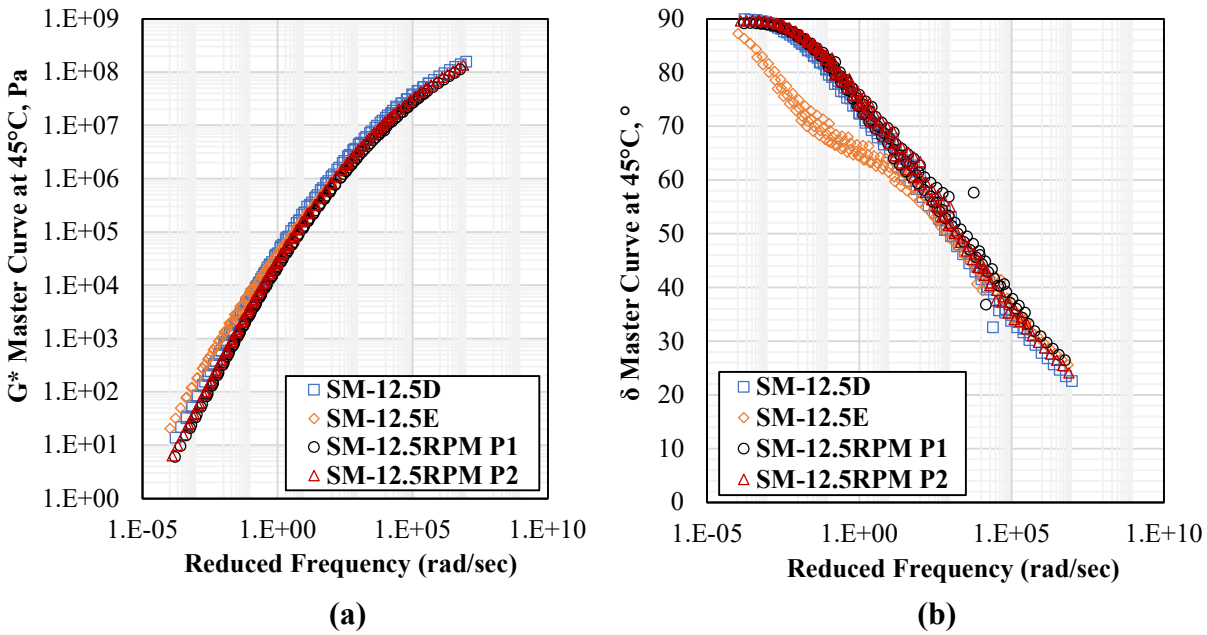

Figure A1. Performance Test Data in Terms of Master Curves at 45°C for All Extracted and Recovered Asphalt Binders at As-Recovered Conditions: (a) Dynamic Shear Modulus (G*); (b) Phase Angle (δ). SM = surface mixture; D = mixture designation; E = extremely heavy traffic; RPM = recycled plastic modified.

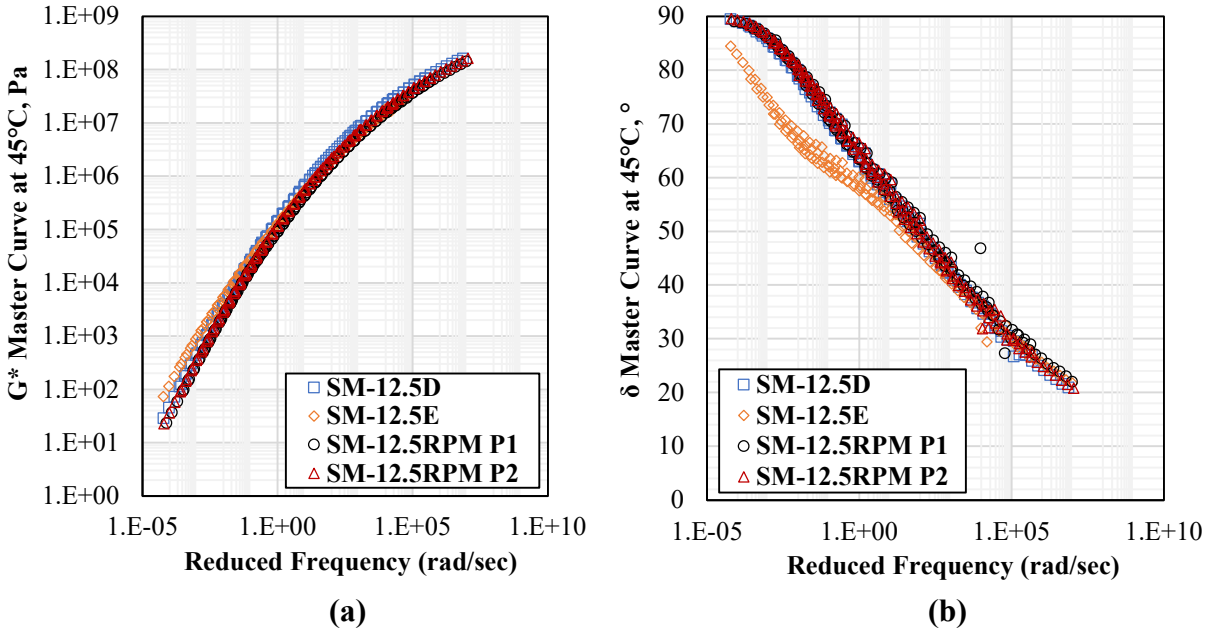

Figure A2. Performance Test Data in Terms of Master Curves at 45°C for All Extracted and Recovered Asphalt Binders at 20-Hour PAV Aging Conditions: (a) Dynamic Shear Modulus (G*); (b) Phase Angle (δ). SM = surface mixture; D = mixture designation; E = extremely heavy traffic; RPM = recycled plastic modified; PAV = pressure aging vessel.

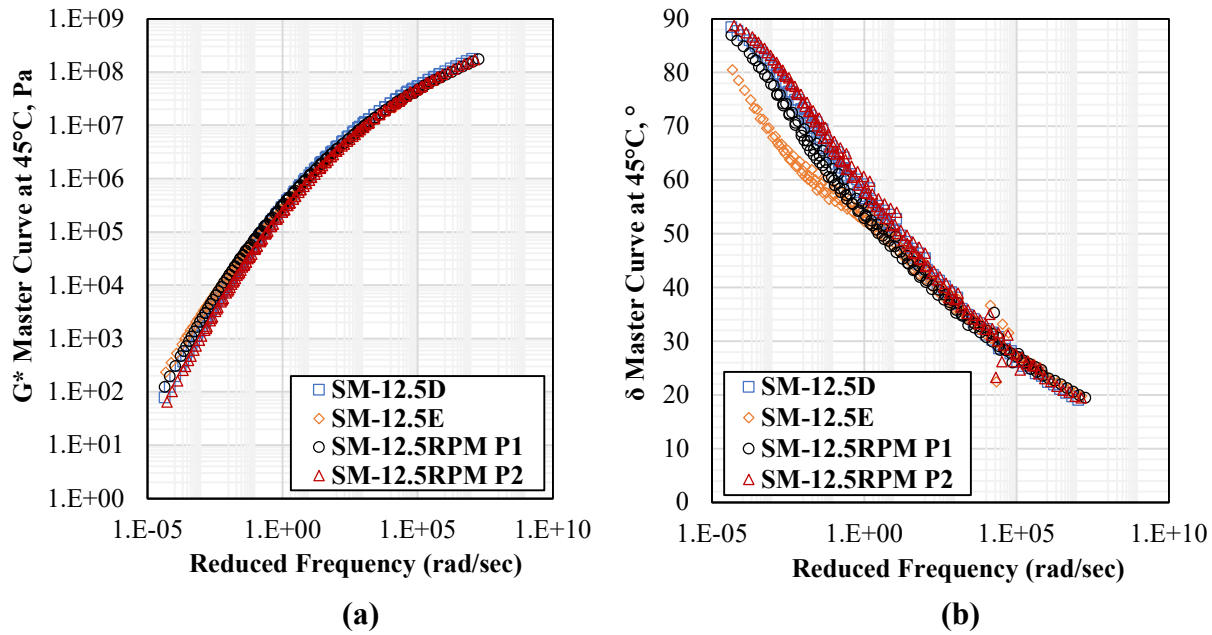

Figure A4. Performance Test Data in Terms of Master Curves at 45°C for All Extracted and Recovered Asphalt Binders at 40-Hour PAV Aging Conditions: (a) Dynamic Shear Modulus (G*); (b) Phase Angle (δ). SM = surface mixture; D = mixture designation; E = extremely heavy traffic; RPM = recycled plastic modified; PAV = pressure aging vessel.

SUPPLEMENTAL ITEM B. ADVANCED PERFORMANCE CHARACTERISTICS: RUTTING—REPEATED TRIAXIAL LOAD TEST

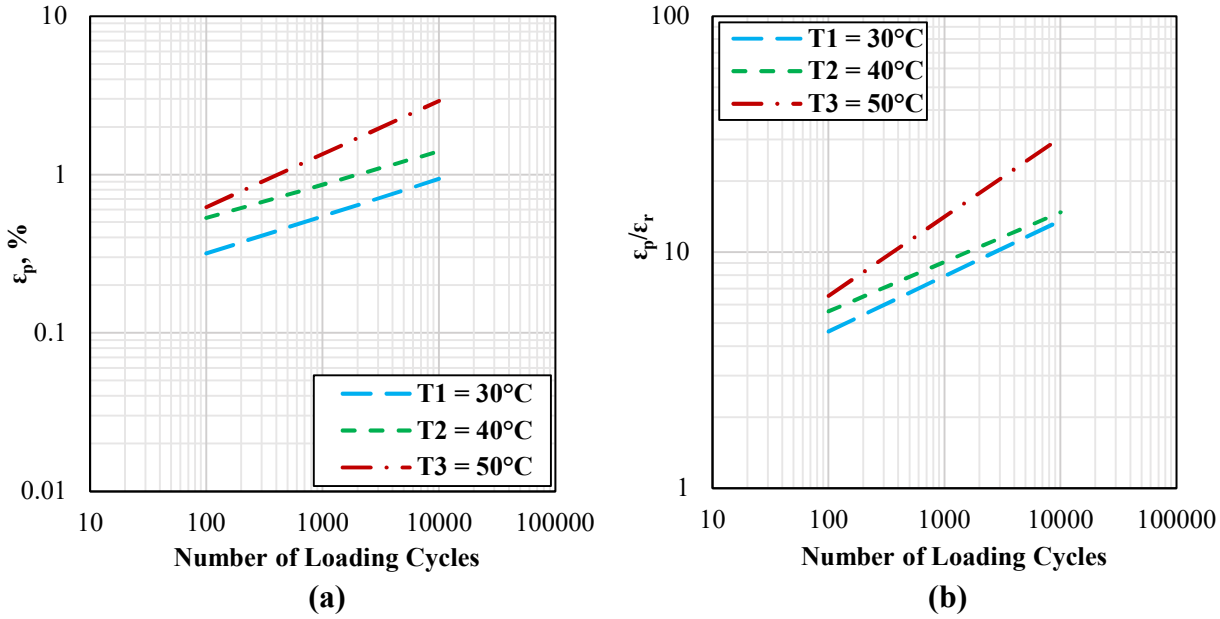

Figure B1. Rutting Performance Characteristics of SM-12.5D at 30, 40, and 50°C: (a) ε_p; (b) $\varepsilon_p/\varepsilon_r$. SM = surface mixture; D = mixture designation; ε_p = permeant axial strain; ε_r = resilient axial strain; T = temperature.

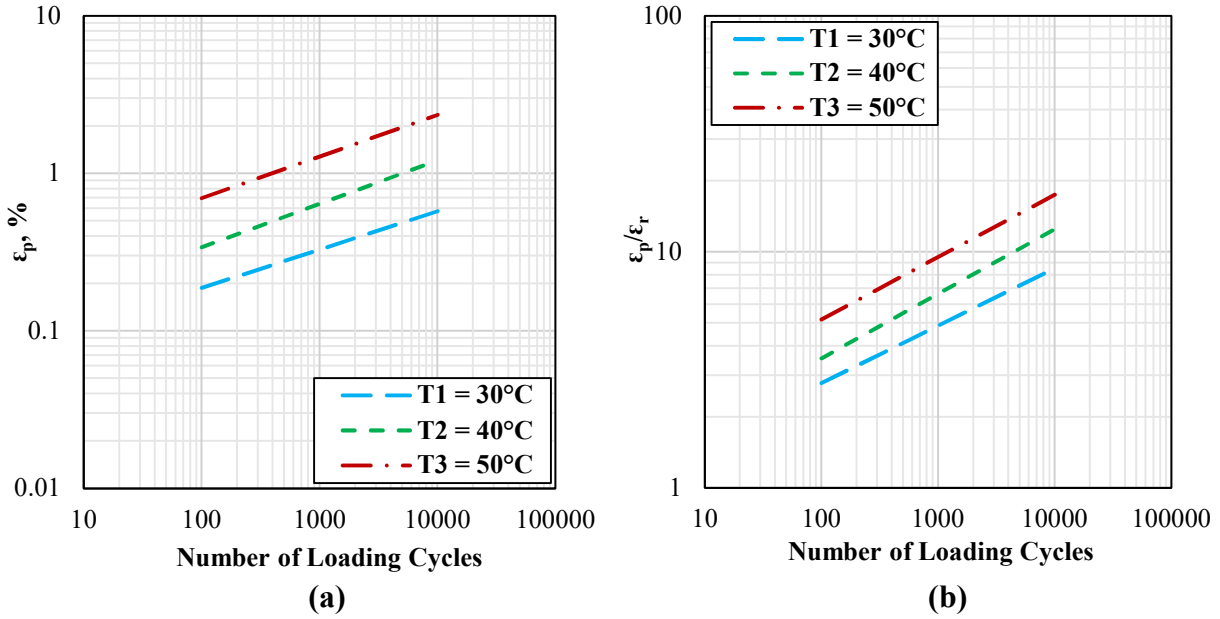

Figure B2. Rutting Performance Characteristics of SM-12.5E at 30, 40, and 50°C: (a) ε_p; (b) $\varepsilon_p/\varepsilon_r$. SM = surface mixture; E = extremely heavy traffic; ε_p = permeant axial strain; ε_r = resilient axial strain; T = temperature.

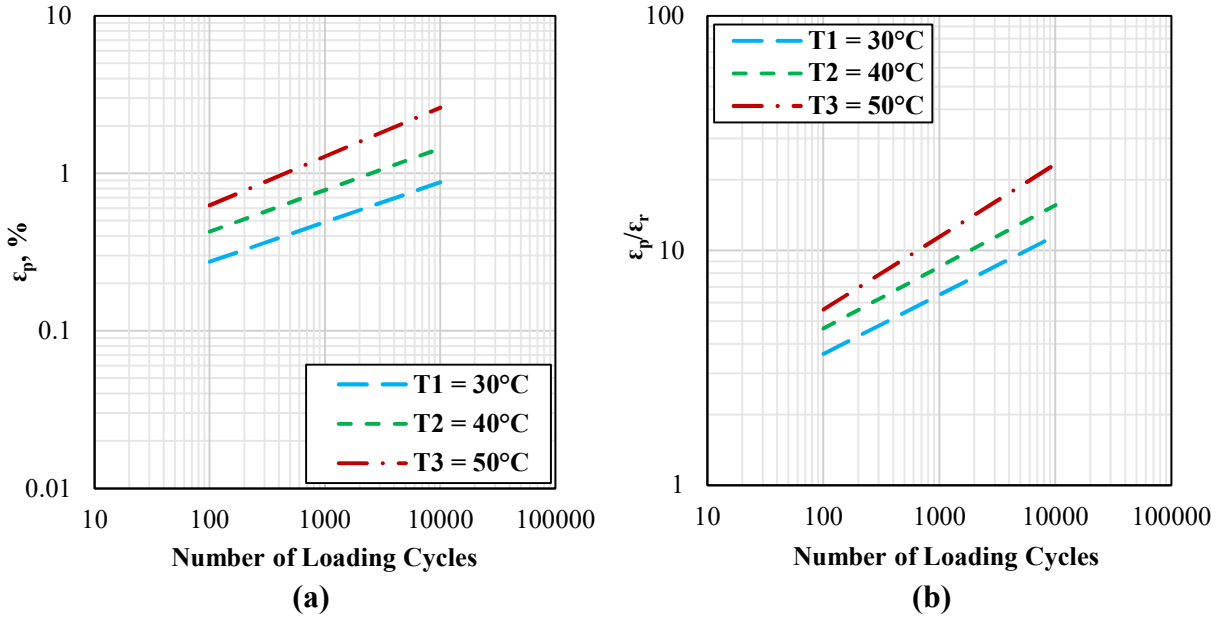

Figure B3. Rutting Performance Characteristics of SM-12.5RPM P1 at 30, 40, and 50°C: (a) ε_p; (b) $\varepsilon_p/\varepsilon_r$. SM = surface mixture; RPM = recycled plastic modified; ε_p = permeant axial strain; ε_r = resilient axial strain; T = temperature.

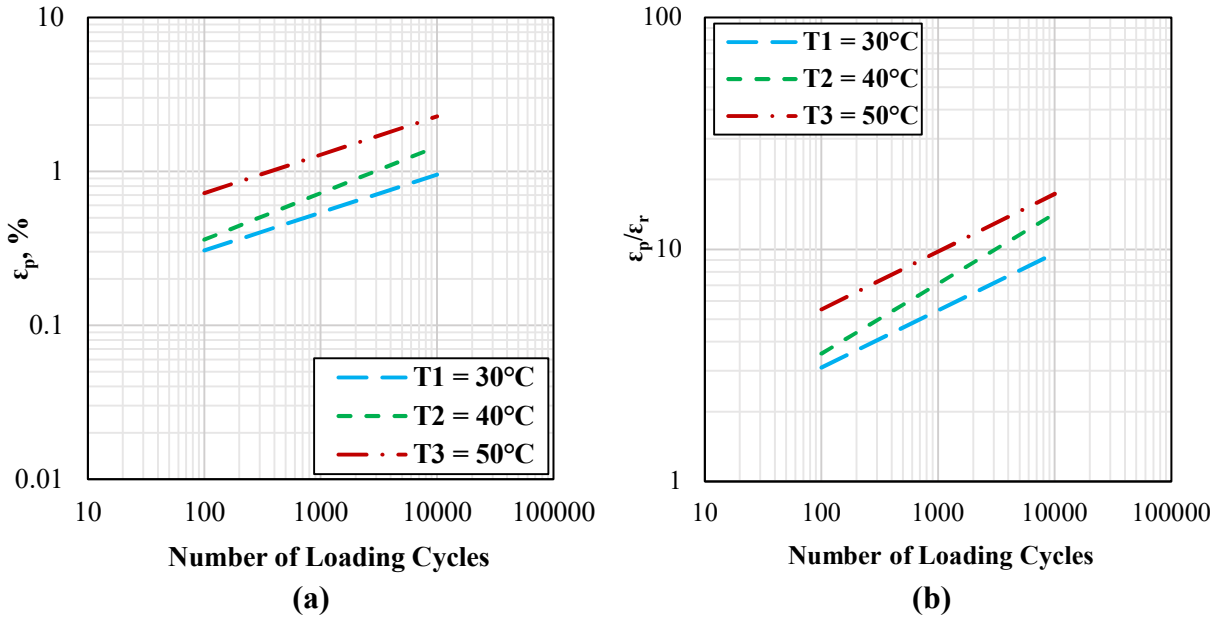

Figure B4. Rutting Performance Characteristics of SM-12.5RPM P2 at 30, 40, and 50°C: (a) ε_p; (b) $\varepsilon_p/\varepsilon_r$. SM = surface mixture; RPM = recycled plastic modified; ε_p = permeant axial strain; ε_r = resilient axial strain; T = temperature.

The RLT test was conducted at three different temperatures: 86, 104, and 122°F (30, 40, and 50°C) for all evaluated D, E, and RPM asphalt mixtures. A rutting laboratory model for each mixture was developed following Equation C.1 based on the approach recommended in the MEPDG. Table B1 summarizes the regression coefficients of the rutting models

$$\frac{\varepsilon_p}{\varepsilon_r} = 10^{k_{r1}} * (T)^{k_{r2}} * (N)^{k_{r3}} \quad \text{[Eq. B1]}$$

where

ε_p = permanent axial strain, inch/inch (or mm/mm)
ε_r = resilient axial strain, inch/inch (or mm/mm)
N = number of loading cycles
T = temperature of the asphalt mixture in °F
k_{r1}, k_{r2}, *and* k_{r3} = experimentally determined coefficients.

Table B1. Summary of MEPDG Rutting Model Coefficients for D, E, and RPM Mixtures

Mixture ID	Rutting Model Coefficients		
	k_{r1}	k_{r2}	k_{r3}
SM-12.5D	-3.399570	1.802240	0.257970
SM-12.5E	-3.951573	1.986852	0.261925
SM-12.5RPM P1	-3.297747	1.694866	0.274627
SM-12.5RPM P2	-3.332932	1.687759	0.265816

MEPDG = mechanistic-empirical pavement design guide; D = mixture designation; E = extremely heavy traffic; RPM = recycled plastic modified; SM = surface mixture.