"Evaluation of Plant-Produced High-Percentage RAP Mixtures in the Northeast"
Transportation Pooled Fund Project TPF-5(230)

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The following sections summarize the work that has been completed to date.

Phase I Mixture Summary

Tables 1 shows a summary of all the production details for mixtures produced during Phase I, All research team groups use the same Gmm, VMA, and VFA values in their calculations.

Table1. Phase I production details summary

Phase I mixes info																						
ID	Production Plant	Plant Type	PG grad	% ac	NMAS (mm)	% RAP	% ac of RAP	% ac Rep.	Final Gradation of the mix									Dis. Tem	Com. Tem.	Gmm	VMA	VFA
									12.5	9.5	#4	#8	#16	#30	#50	#100	#200					
NYb40	Callanan NY	Drum	58-28	5.2	12.5	40	4.9	37.69	98.1	89.3	53.7	32	18	12.5	8.5	5.1	3.2	330	275	2.540	12.70	88.36
NYb30	Callanan NY	Drum	58-28	5.2	12.5	30	4.93	28.44	97.5	91.2	59.5	33.3	21	14.7	9.7	5.8	5.3	305	275	2.539	13.70	81.12
NYd40	Callanan NY	Drum	64-22	5.2	12.5	40	4.9	37.69	97.6	88.7	53	30.9	19	14.3	10.1	6.1	4.3	330	290	2.546	12.53	87.90
NYd30	Callanan NY	Drum	64-22	5.2	12.5	30	4.93	28.44	95	85.8	54.4	30.2	23	16.5	11.6	7.8	6	305	290	2.543	12.96	85.08
NYd20	Callanan NY	Drum	64-22	5.2	12.5	20	4.95	19.04	99.1	90.8	59	30.9	19	11.8	8.3	6.7	3.8	320	290	2.528	14.09	79.86
NYd00	Callanan NY	Drum	64-22	5.2	12.5	0	--	0.00	99.8	90.8	68.3	42.3	27	18.9	13.2	5.2	3.8	310	290	2.530	12.64	89.32
VTa40	Pike VT	Batch	52-34	6.6	9.5	40	5.41	32.64	100	97.9	76.8	48.8	29	18.4	11.8	7.5	4.6	300	295	2.472	18.00	77.78
VTa30	Pike VT	Batch	52-34	6.6	9.5	30	5.41	24.74	100	98.6	75	48.1	30	18.7	11.7	7.4	4.5	320	320	2.466	17.72	82.51
VTa20	Pike VT	Batch	52-34	6.8	9.5	20	5.41	16.01	100	98.4	79.2	51.1	31	19.1	11.8	7.4	4.6	324	324	2.458	18.75	81.86
VTa00	Pike VT	Batch	52-34	6.7	9.5	0	--	0.00	100	98.8	78.8	51.1	31	19.3	10.7	6.1	3.8	340	340	2.465	20.23	76.28
VTe40	Pike VT	Batch	64-28	6.6	9.5	40	5.41	33.04	100	98.5	75.1	46.6	27	15.7	9	4.8	4.5	295	295	2.473	18.24	76.43
VTe30	Pike VT	Batch	64-28	6.6	9.5	30	5.41	24.55	100	97.8	77.5	48.9	29	17.8	11	7	4.3	322	310	2.464	19.10	75.91
VTe20	Pike VT	Batch	64-28	6.7	9.5	20	5.41	16.13	100	98.7	81.3	53.5	32	19.9	11.9	7.1	4.3	300	300	2.467	18.69	79.67
VTe00	Pike VT	Batch	64-28	6.5	9.5	0	--	0.00	100	99.6	76.9	48.8	30	18	9.9	5.5	3.3	330	300	2.482	20.33	71.48
NHe40	Pike NH	Drum	64-28	5.7	12.5	40	4.79	33.61	98.7	86.4	55.5	41.2	33	24.8	15	6.1	2.65	335	315	2.435	14.50	82.10
NHe30	Pike NH	Drum	64-28	5.7	12.5	30	4.79	25.21	98.7	86.5	56.2	41.9	34	25.8	16	6.9	3.62	335	315	2.434	14.40	81.30
NHe20	Pike NH	Drum	64-28	5.7	12.5	20	4.79	16.81	98.7	86.5	57.5	42.4	33	25.5	15.8	7	3.6	315	310	2.430	14.50	79.90
NHe00	Pike NH	Drum	64-28	5.7	12.5	0	--	0.00	98.6	85.8	58.3	42.5	32	24.7	15.5	7.2	3.58	330	300	2.419	14.90	74.80

Work Completed This Quarter:

A. Binder Testing

Extraction and recovery of binder from all of the Phase I mixtures has been completed by Pike Industries, Inc. The extracted and recovered asphalt binders have been sent to Rutgers University and University of Massachusetts for testing.

B. Mixture Testing

The IDT specimens have been fabricated and conditioning for T-283 testing has begun at UNH.

Dynamic modulus was measured in accordance with AASHTO TP79 on specimens compacted at the Quality Control Lab during production, as well as on specimens compacted from collected loose mix. Test specimens were fabricated to 7±1% air voids using the TPF-5 (230) reheating test procedure. After the dynamic modulus was measured, dynamic modulus master curves were constructed in accordance to AASHTO PP61.

The master $|E^*|$ curves for the four NH mixtures are shown in Figure 1. The trend in the test results is what would be expected – mixture modulus increases as RAP content increases. However, the data generated for the 0 and 20% RAP mixtures were closer than anticipated. Further evaluation of the production data, shown as a table inset in Figure 1, indicate that the 0% RAP mixture was stored in the silo for 6 hours, more than 4 times longer than the 20% RAP mixture.

Figure 2 shows the comparison between the plant compacted and reheated, laboratory compacted specimens for the 0% NH RAP mixture. The results indicate that the laboratory reheating procedure caused little to no change in the dynamic modulus master curve for the 0% RAP mixtures. This contradicts the findings reported last quarter for the NY Callanan mixtures. Although testing has only been completed for one of the reheated and compacted mixtures, the lack of change in the modulus may be explained by the longer storage time at elevated temperature in the silos creating a stiffened material that is less sensitive to reheating.

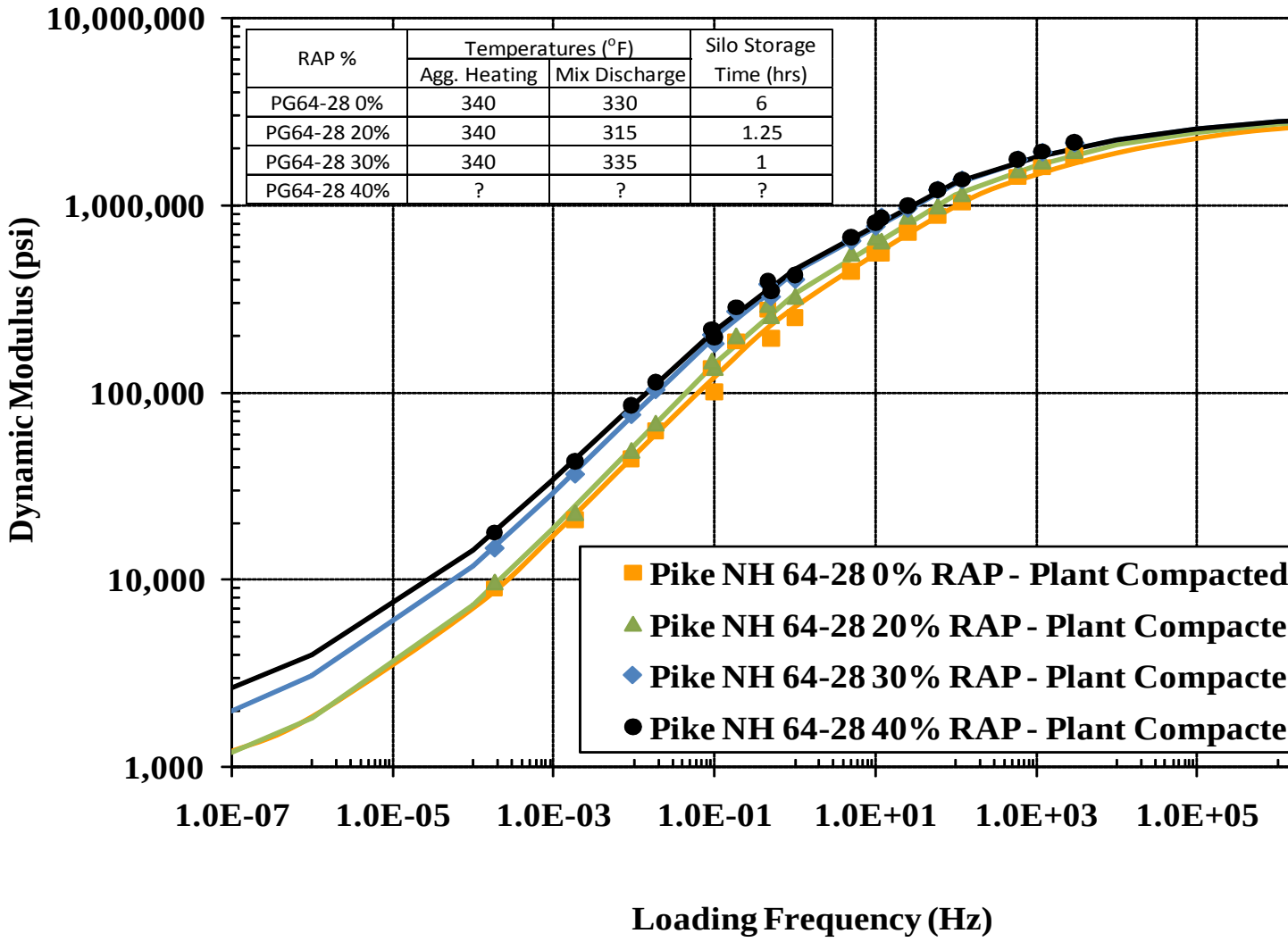

Figure 1 – Master $|E^*|$ Curves for Pike NH RAP Mixtures – Plant Compacted

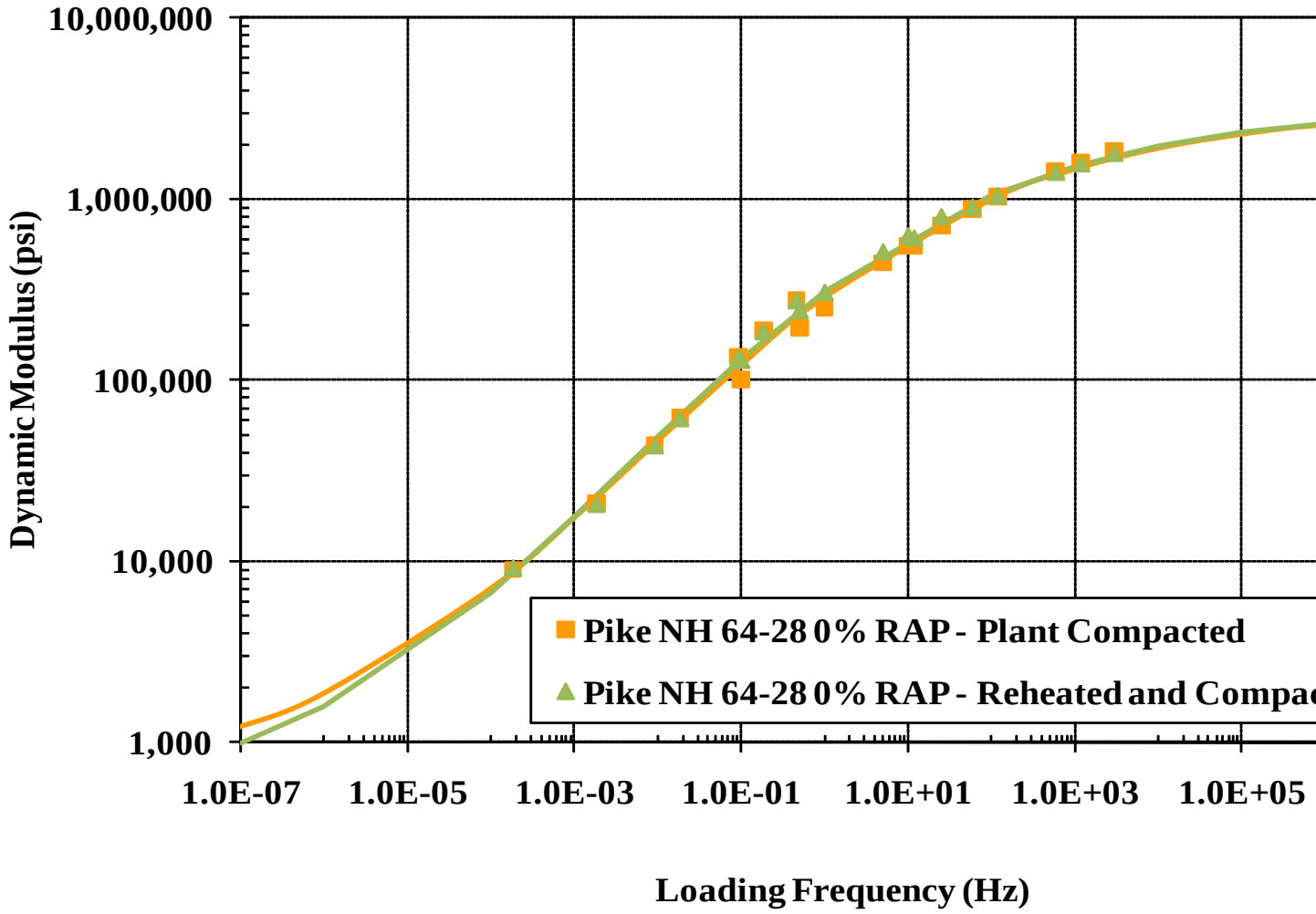

Figure 2 – Master $|E^*|$ Curves for Pike NH 0% RAP – Plant Compacted and Reheated Mixtures

Two replicates of the moisture sensitivity test using the Hamburg Wheel Tracking Device (HWTD) were conducted on all the Pike Industries - Portsmouth, NH 30% and 40% RAP mixtures and the Pike Industries Williston, VT PG64-28 mixtures (Control, 20%, 30% and 40% RAP) and 52-34 mixtures (20% and 30% RAP only). Specimens were fabricated to 7±1% air voids using the TPF-5(230) reheating test procedure. The water temperature for the HWTD tests was 50ºC (122ºF) as outlined in AASHTO T324. The results for the HWTD tests are shown in Tables 2 and3.

The NH mixtures (drum plant) tested thus far all pass the HWTD criteria. The 9.5 mm VT mixtures (batch plant) all reach the stripping inflection point (SIP) in 3,000 cycles or less. The average response indicates that the higher RAP content increases the number of cycles to the SIP. Also, the mixtures with the PG 64-28 binder appear to have better performance than the comparison mixtures with PG 52-34 binder.

Table 2. HWTD Results for Plant Produced Mixtures Pike Industries – Portsmouth, NH

Mixture NMAS	Binder	RAP Content	Lab Identifier	Air Voids, %	HWTD Cycles to SIP
12.5mm	PG64-28	30% RAP	Nhe30LM01	7.26	20,000 (PASS)

			Nhe30LM02	6.77	20,000 (PASS)
12.5mm	PG64-28	40% RAP	Nhe40LM01	6.26	20,000 (PASS)
			Nhe40LM02	6.00	20,000 (PASS)

SIP = Stripping Inflection Point

Table 3. HWTD Results for Plant Produced Mixtures Pike Industries – Williston, VT

Mixture NMAS	Binder	RAP Content	Lab Identifier	Air Voids, %	HWTD Cycles to SIP
9.5mm	PG64-28	0% RAP (Virgin Mix)	VTe00LM01	7.87	1,200
			VTe00LM02	7.96	1,500
9.5mm	PG64-28	20% RAP	VTe20LM01	7.04	1,900
			VTe20LM02	6.74	2,300
9.5mm	PG64-28	30% RAP	VTe30LM01	6.69	2,300
			VTe30LM02	6.54	3,000
9.5mm	PG64-28	40% RAP	VTe40LM01	7.70	2,800
			VTe40LM02	6.41	3,000
9.5mm	PG52-34	20% RAP	VTa20LM01	7.46	1,400
			VTa20LM02	6.80	1,800
9.5mm	PG52-34	30% RAP	VTa30LM01	7.06	1,700
			VTa30LM02	7.18	2,400

SIP=StrippingInflectionPoint

C. Database

The database for storing mixture data and testing results has been developed. The database is currently being populated with available test results, and will be uploaded to the internet soon.

Work Planned for Next Quarter:

A. Binder Testing

PG-grading, G* master curves, critical cracking temperature, Asphalt Binder Cracking Device (ABCD), and softening point testing on tank supplied and the extracted and recovered asphalt binders from the Phase I mixtures will be completed.

B. Mixture Testing

The Instronservo-hydraulic testing machine at UNH will be ready soon and low temperature creep and strength and T-283 moisture sensitivity testing of Phase I mixtures will begin.

The dynamic modulus testing on the remaining Phase I mixtures will be completed.

The VECD fatigue (Push-Pull) testing willbegin once the AMPT fatigue testing software is finalized based on NC State continuum damage fatigue protocol.

Moisture sensitivity test using the HWTDwill be completed for the Phase I mixtures.

C. AMPT Procedure Finalization

The research team at NCSU recognized the need for some additional calibration testing on the AMPT equipment to ensure the proper use of this equipment and to ensure that the findings from this study can be universally adopted by others. The primary focus is to finalize an efficient testing procedure that ensures test samples are properly conditioned. It is anticipated that this study will be completed in the next fewweeks and testing will commence on the primary study mixtures.

D. Phase II Planning

The research team will be developing a plan for Phase II mixtures that will be sought during the 2011 construction season. It is anticipated that a conference call with the technical committee will be held once a draft plan has been put together by the research team.