Summary of current and completed RAP research at UNH

Jo Sias Daniel

RAP ETG Meeting

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UNIVERSITY of NEW HAMPSHIRE

Completed Projects

- Dynamic Modulus and volumetric changes with increasing RAP contents
  - 2005 TRB paper
  - Funded by RMRC
  - Lab study

Ongoing Projects

- NHDOT: Properties of mixtures containing RAP
  - Follow on to RMRC project
  - |E*|, volumetrics, plant-field-lab comparisons
  - Finishing this summer
- NETC: Effective PG grade of RAP mixtures
  - |E*|, Hirsch model to estimate effective PG grade of binder in RAP mixtures
  - Finishing spring 08

Ongoing Projects

- RMRC: RAP and the MEPDG
  - How to deal with RAP mixtures at various design levels
  - 2006 TRB paper
  - Finishing this fall
- RMRC: Stripping potential of RAP mixtures
  - Accelerated lab loading using MMLS3
  - Finishing this summer

Completed RMRC Project

- Determine effect on asphalt concrete from substitution of RAP for virgin aggregate and binder
- Achieve through evaluation of changes in volumetric and mechanistic properties of mixtures as RAP percentages are increased

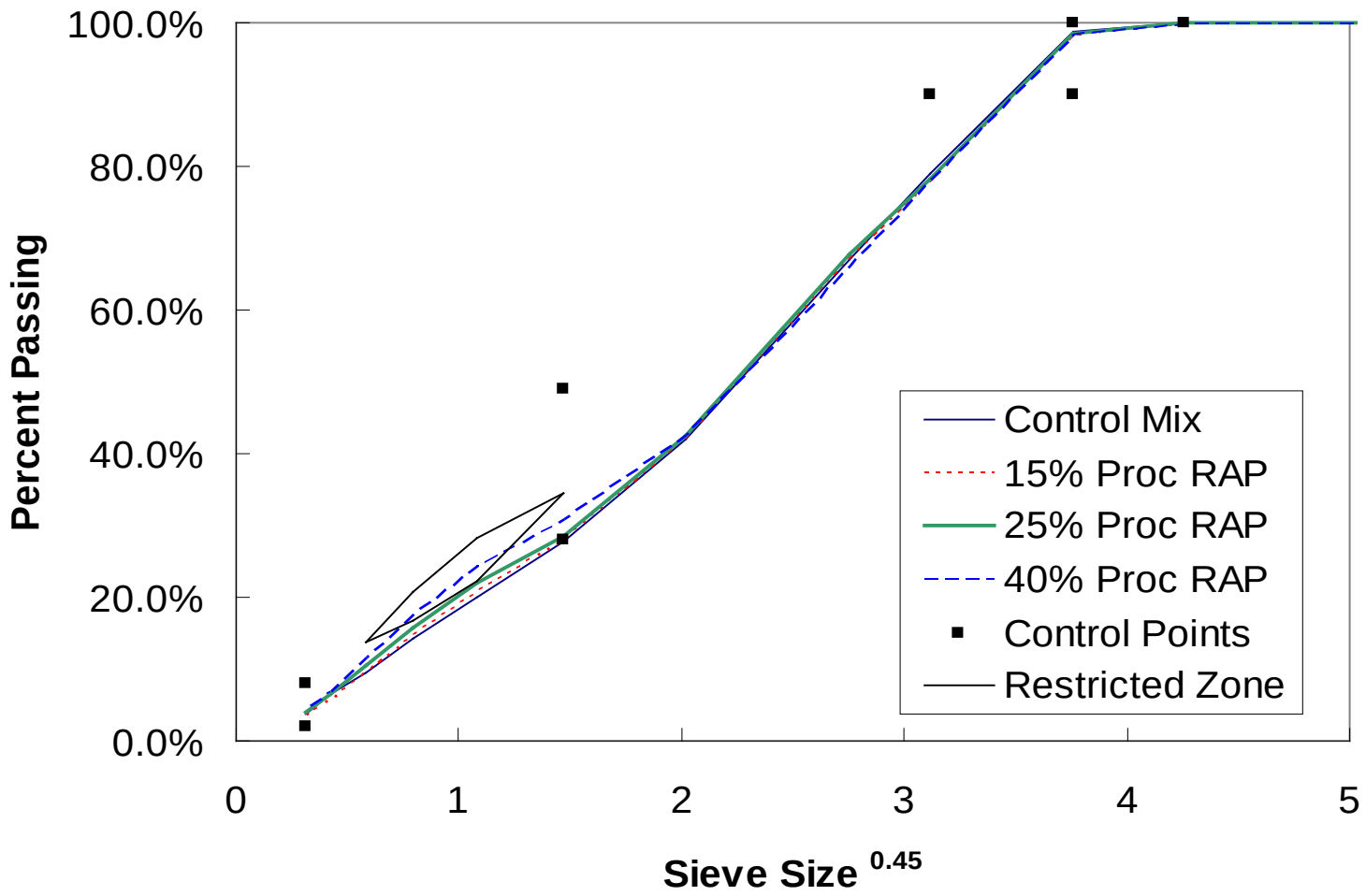
Test Specimens

- Mixes tested at following conditions:
  - 0% RAP (Control)
  - 15% RAP
  - 25% RAP
  - 40% RAP
- Two RAP sources
  - Processed RAP: 3.6% ac PG 94-14
  - Grindings: 4.9% ac PG 82-22

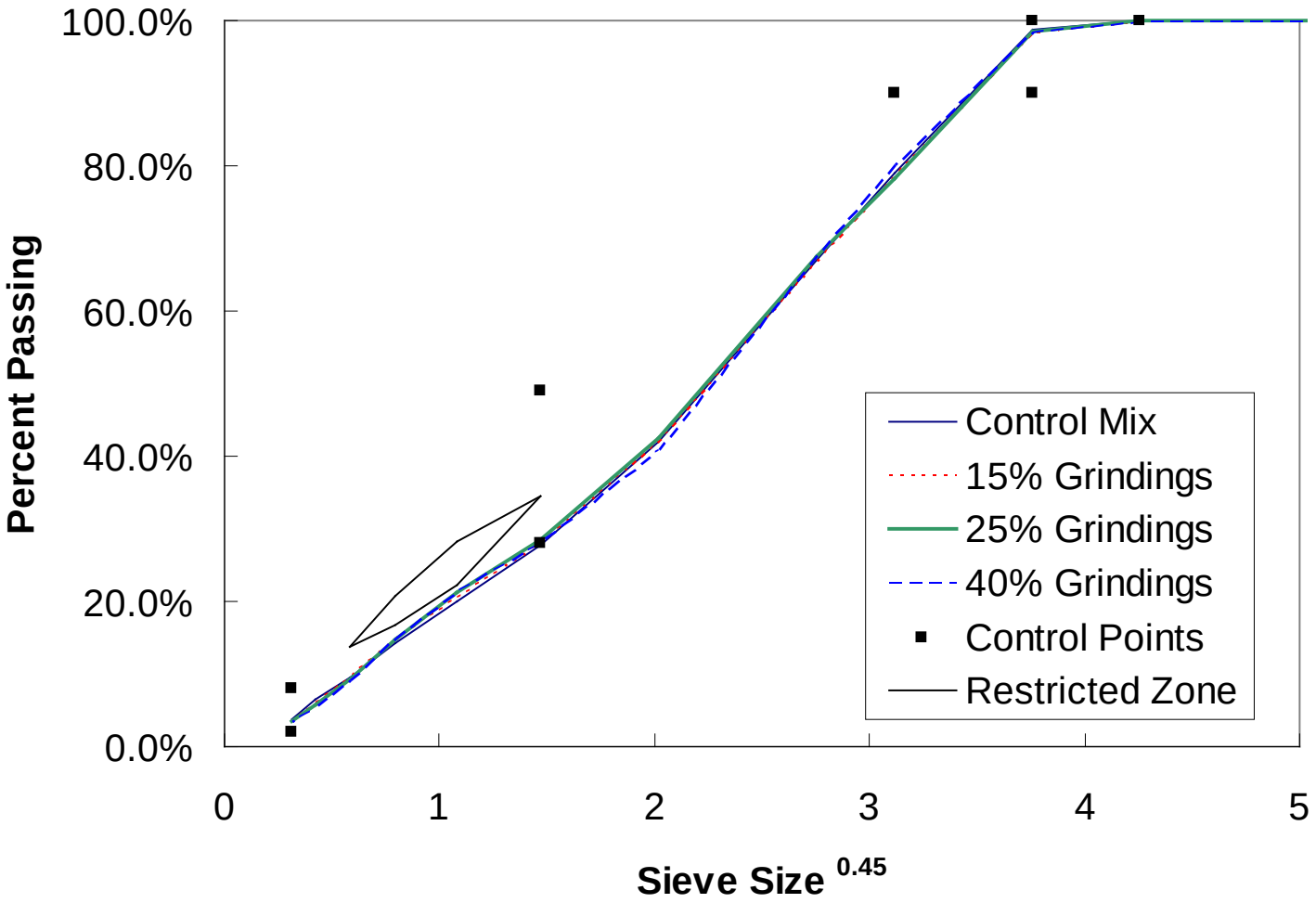
Mix Design

- Existing NHDOT 19 mm 15% RAP mix design
- Target same gradation while keeping relative proportions of virgin blast rock and natural sand the same

Processed RAP Gradations



Grindings RAP Gradations



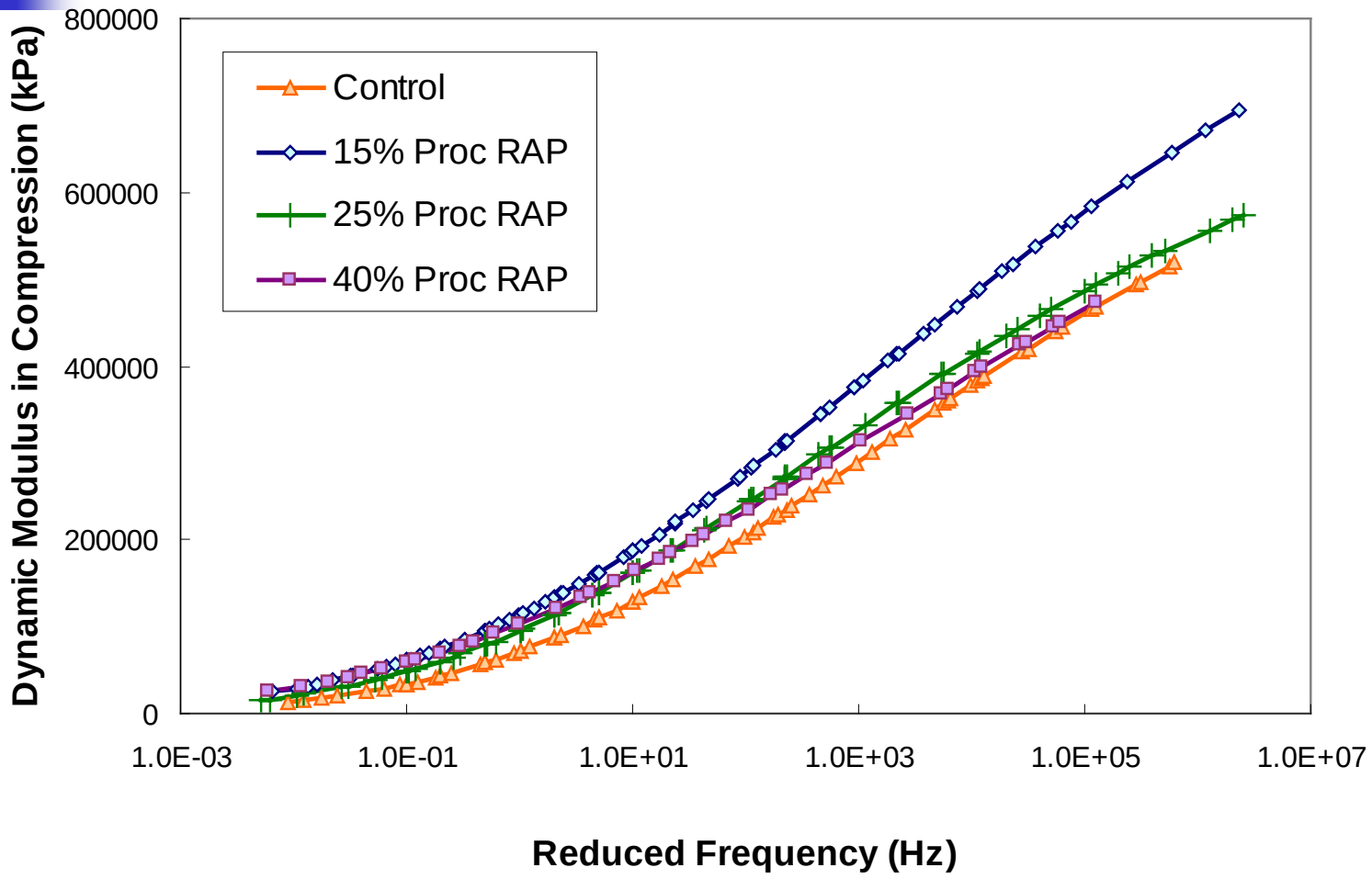
Material Property Tests

- Complex Modulus
  - Tension
  - Compression
- Creep Compliance in Compression
- Static Creep in Compression (flow time)

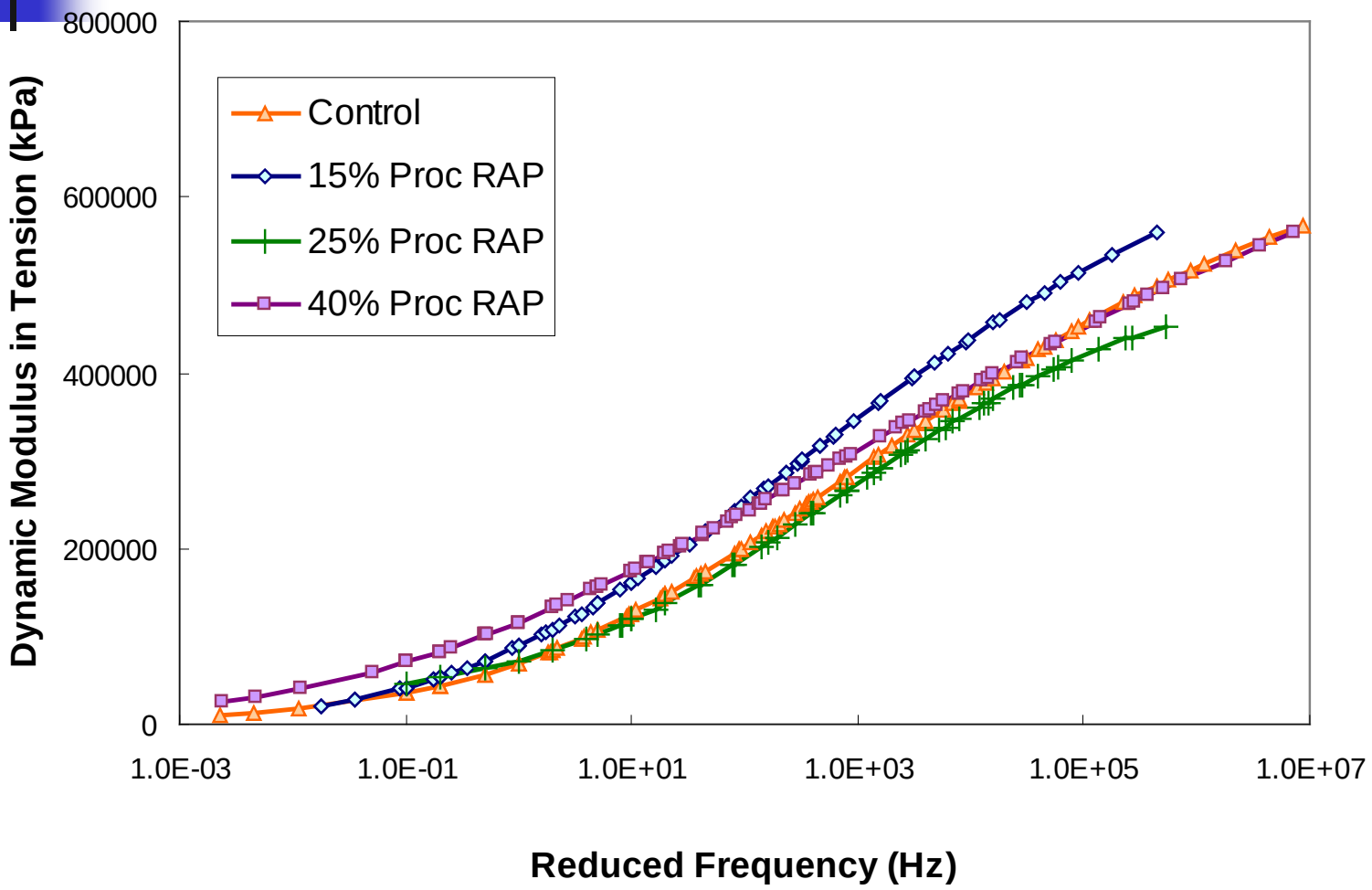
Mixture Volumetrics

		Processed			Grindings		
	Control	15% RAP	25% RAP	40% RAP	15% RAP	25% RAP	40% RAP
% ac	4.8	5.1	5.4	4.9	4.9	5.2	5.2
VMA	13.1	13.3	16.3	15.2	13.8	14.3	14.7
VFA	69.4	69.9	75.4	73.6	71.8	71.0	73.0

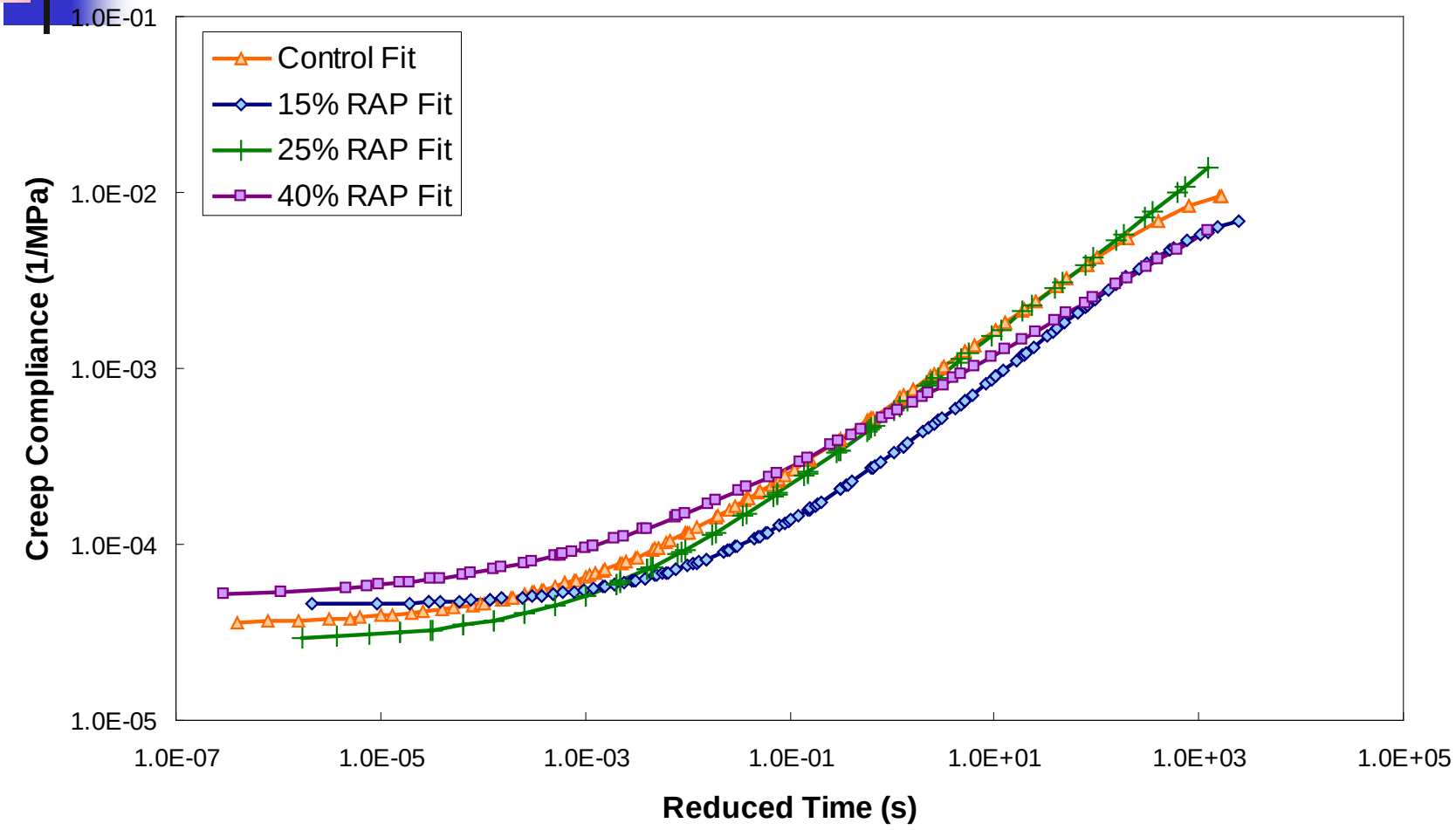
Processed RAP Dynamic Modulus (Compression)



Processed RAP Dynamic Modulus (Tension)



Processed RAP Creep Compliance (Compression)



Processed RAP Static Creep (Flow Time)

Mixture	Creep Flow Time (s)
Control	553
15% RAP	1445
25% RAP	350
40% RAP	3050

Differences

- Higher asphalt content for 25% RAP
- Finer gradation for 25% and 40% RAP
- Angularity of RAP aggregate –not significant
- Higher VMA and VFA for 25% and 40% RAP

Working Hypothesis

- Combination of higher asphalt content and finer gradation could have caused softer response in 25% and 40% mixtures
- Incomplete blending causes effective gradation to be coarser, increasing VMA and decreasing stiffness

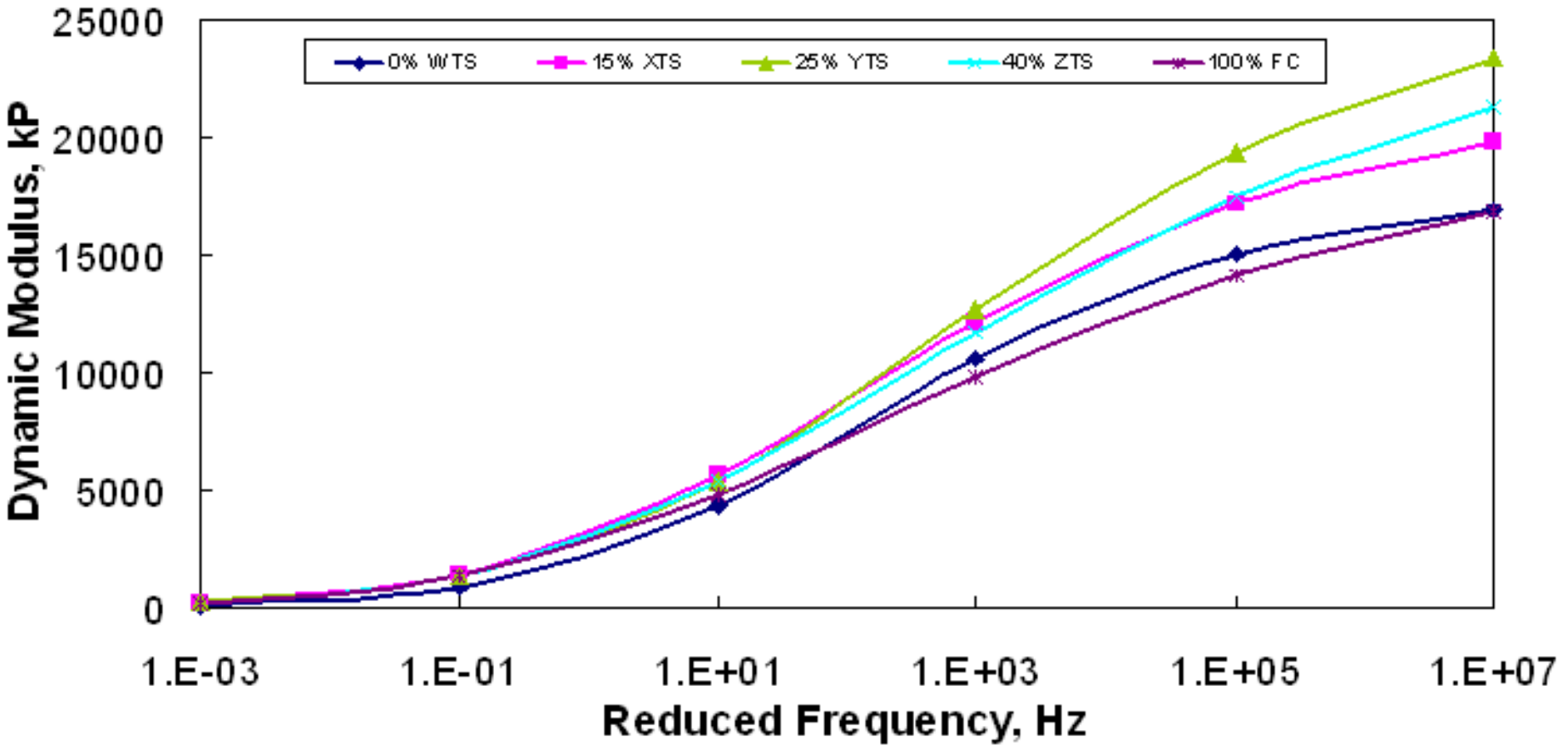
Current NHDOT Project

- Testing using millings from known location
- Target same gradation
- Field cores prior to milling (100% RAP condition)
- Volumetrics, Dynamic Modulus, Strength Testing
- Comparison of field vs lab compaction

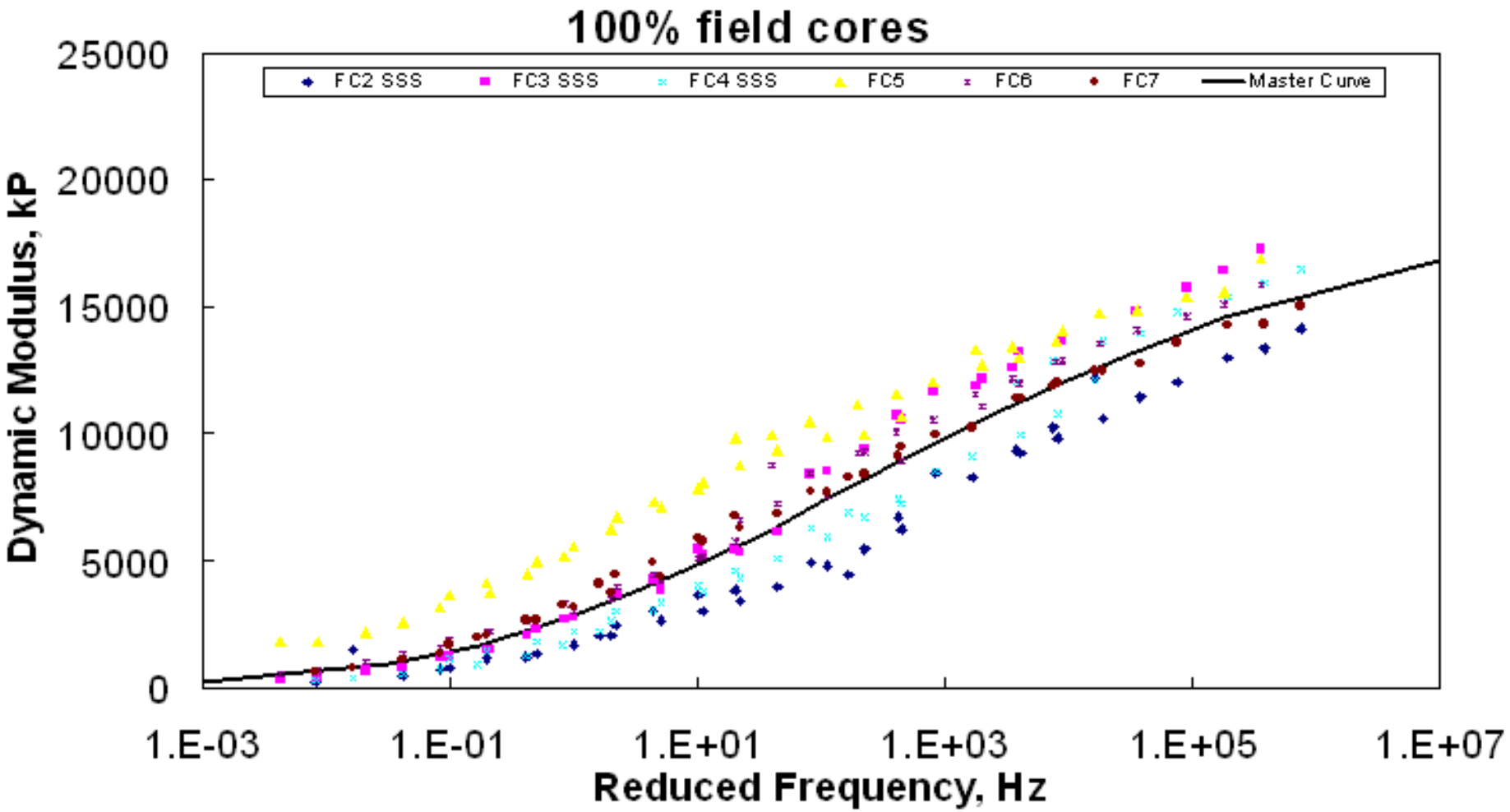
Mix Design Summary

	0%	15%	25%	40%	Specifications
Asphalt Content, %	5.9	5.7	5.9	5.7	
Dust Proportion, %	0.757	0.766	0.712	0.719	0.6 - 1.2
%Gmm @ Nini = 6	0.896	0.901	0.876	0.898	
VMA, %	15.7	15.6	16.1	16.3	Min 14.0
Air Voids, %	4.0	4.0	3.7	4.0	4
VFA, %	74.4	74.5	77.1	75.4	70 - 80

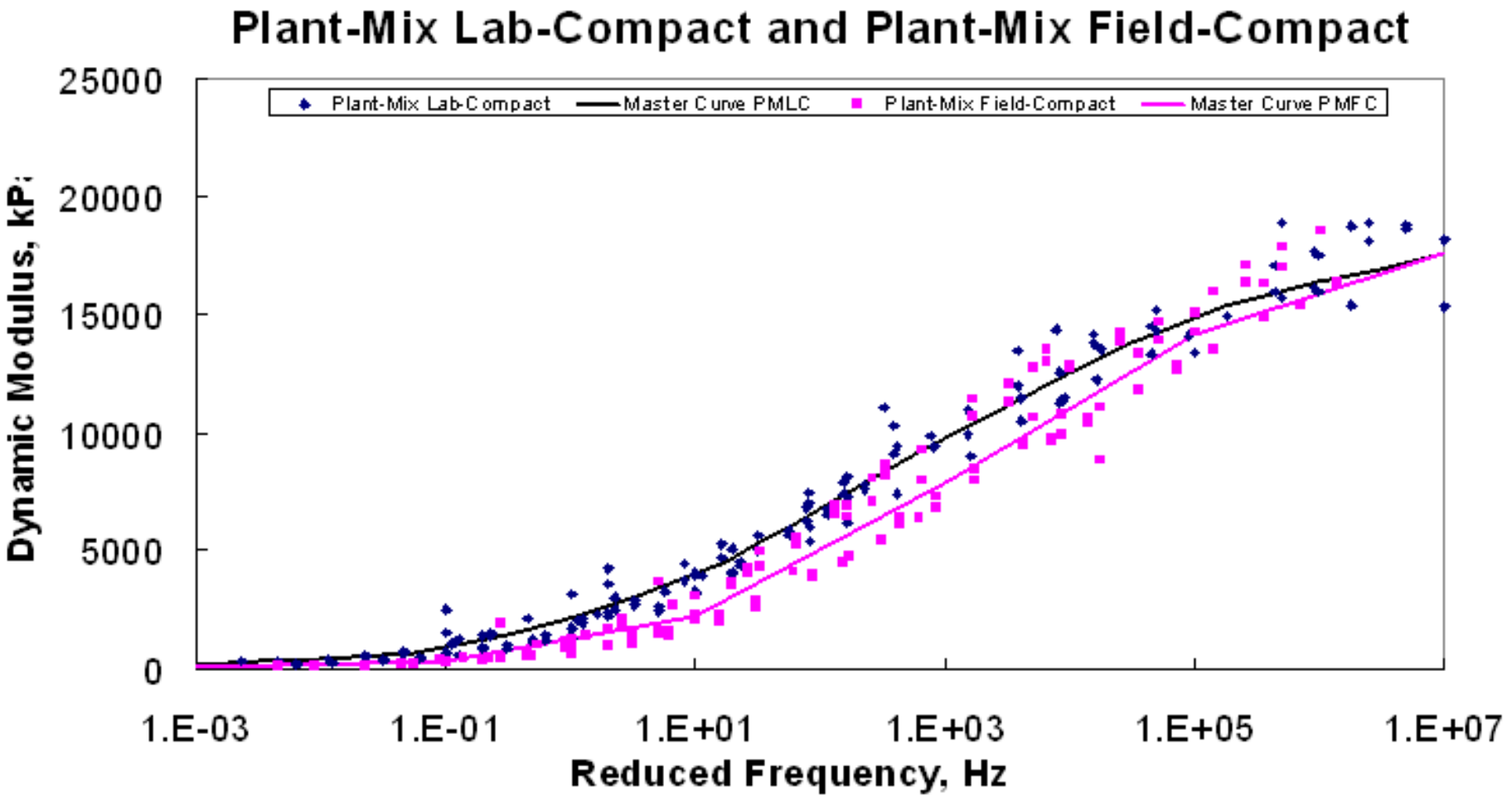
Dynamic Modulus



Field Cores


100% field cores
FC2 SSS
FC3 SSS
FC4 SSS
FC5
FC6
FC7
Master Curve
Dynamic Modulus, kP
25000
20000
15000
10000
5000
0
1.E-03
1.E-01
1.E+01
1.E+03
1.E+05
1.E+07
Reduced Frequency, Hz

Lab vs Field compaction



Current NETC project

	Control	15% RAP	25% RAP	40% RAP
% ac	6.0	5.7	5.3	5.1
VMA	17.4	17.2	17.0	18.0
VFA	77.0	74.0	76.9	70.0

Other Projects

- Stripping evaluation using MMLS3
  - 2 mixes, test wet & dry
- RAP & MEPDG
  - Level 1 using |E*| vs Level 2 & 3
- “Black Rock” gradation study
  - Virgin aggregates –different gradations
  - Look at volumetrics