Properties of Asphalt Mixtures Containing Recycled Asphalt Pavement

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Recycled Asphalt Pavement (RAP)

- Ground up old pavements
- Added as component in new asphalt mixtures
- Contains aged asphalt binder
  - Stiffer than virgin binder
  - Blends with virgin binder to some extent
- Changes properties of new mixture

Purpose of Research

- 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

Using RAP in New Mixtures

- Replacement for some of virgin aggregate and binder
  - Gradation and % binder in RAP must be considered
- “Black rock” condition when RAP is used at low percentages
- Blending of binder is more influential to properties at higher RAP percentages

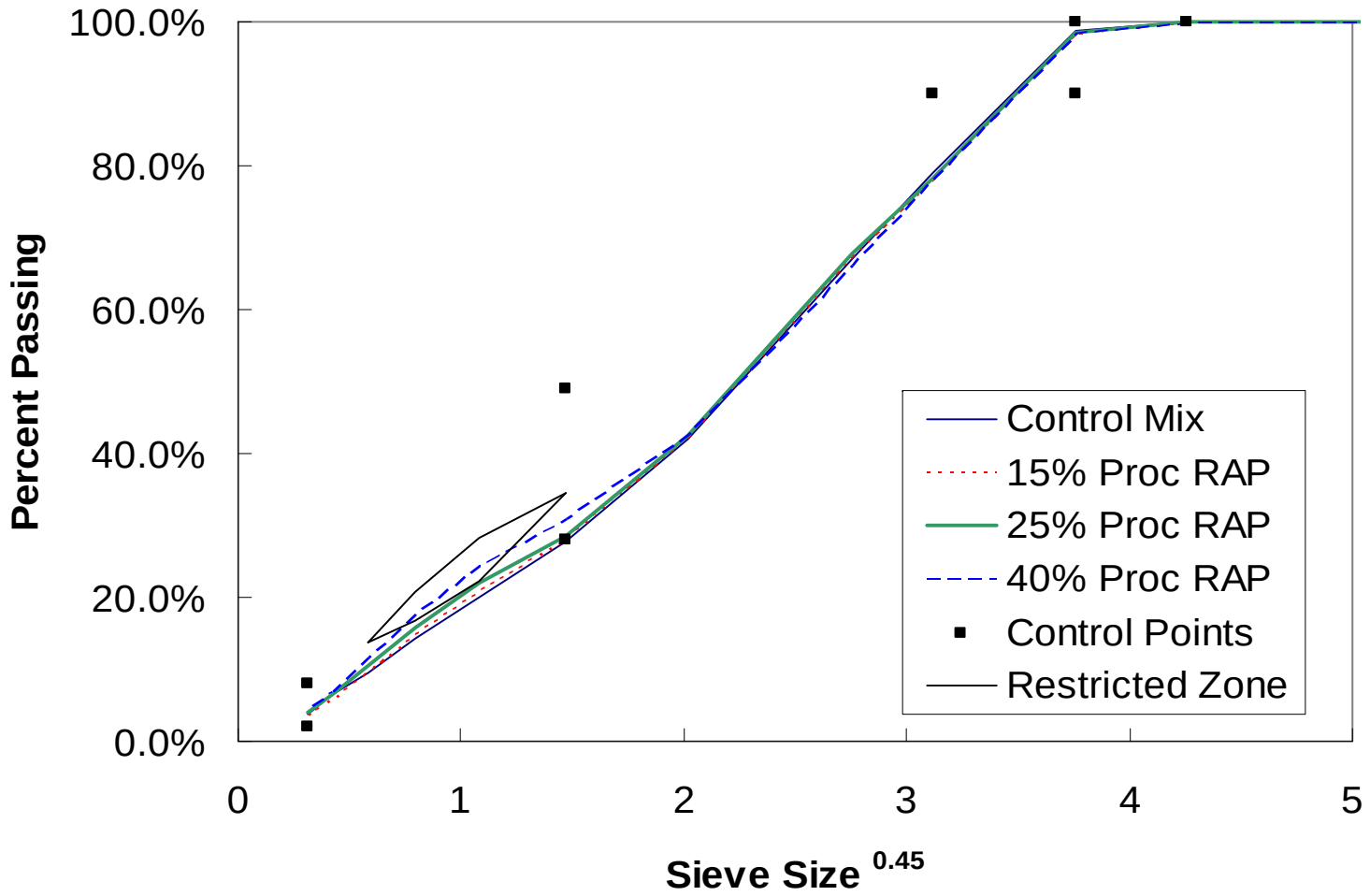
Test Specimens

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

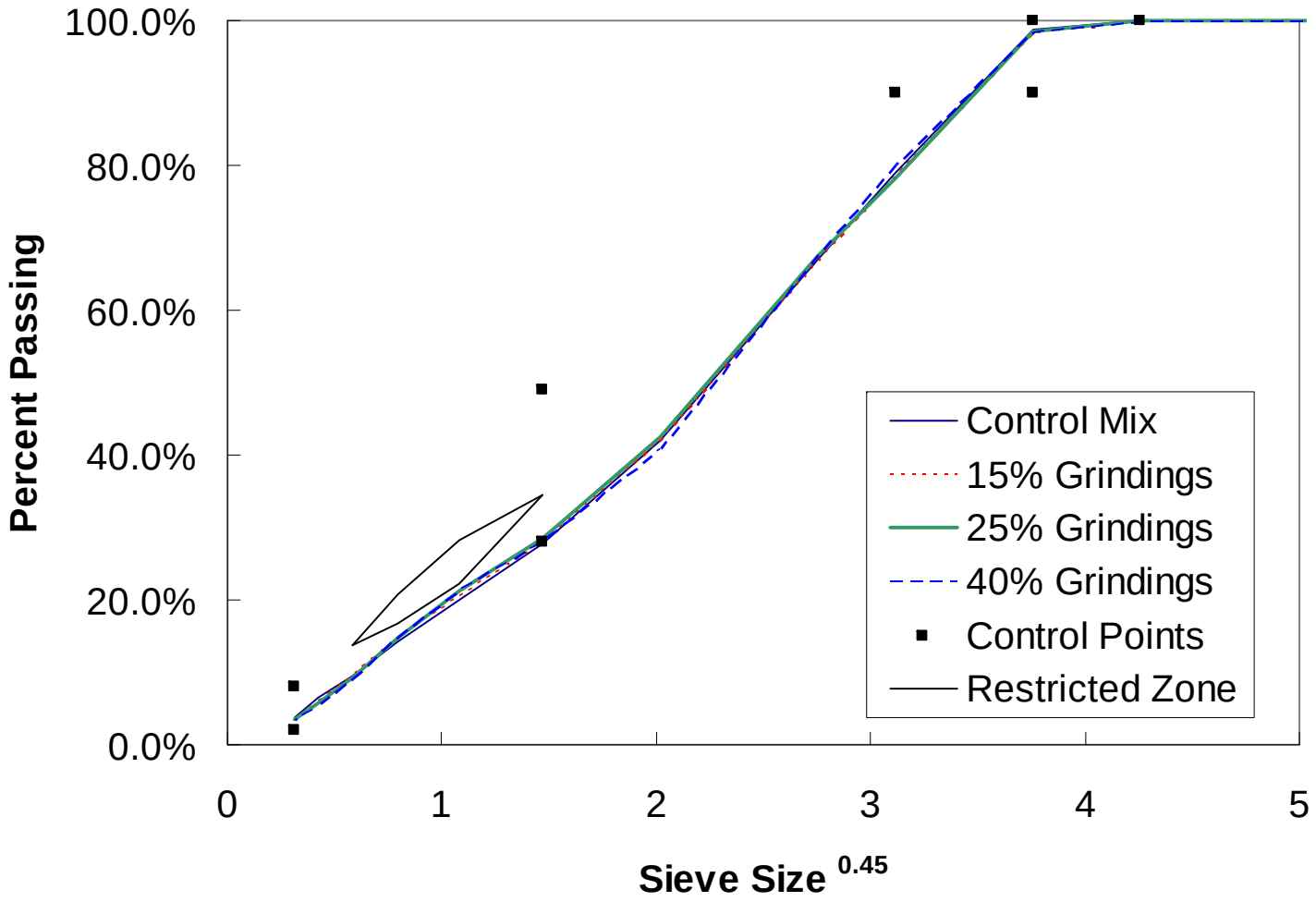
Mix Design

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

Processed RAP Gradations



Grindings RAP Gradations



RAP Binder Properties

- Processed RAP: PG 94-14
- RAP Grindings: PG 82-22
- High temp. grades much higher than PG 58-28 virgin binder
  - Based on research by Daniel & Kim, expect RAP mixtures to be stiffer

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

Mixture Volumetrics

- Asphalt content for 25% processed RAP higher than others
- VMA for 25% and 40% RAP mixtures higher than that for the control and 15% RAP mixtures

Specimen Fabrication

- Mixing
- Compaction
  4% air voids

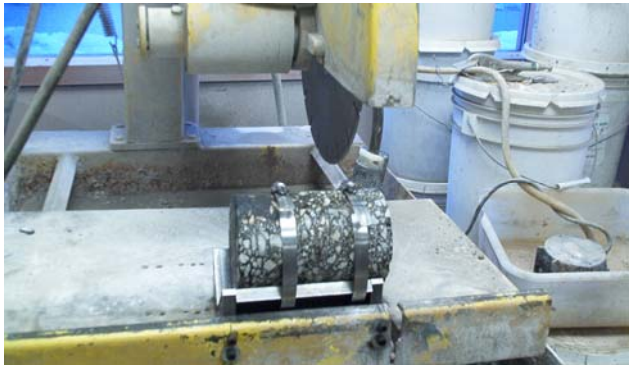
COMPACTION MOLD

SUPERPAVE GYRATORY COMPACTOR

Specimen Fabrication

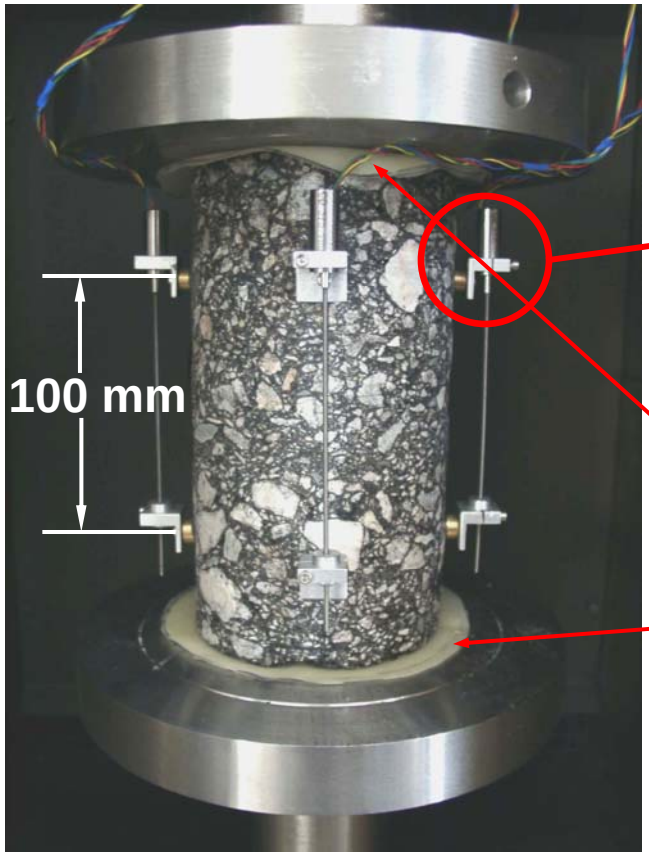
- Coring

- Cutting

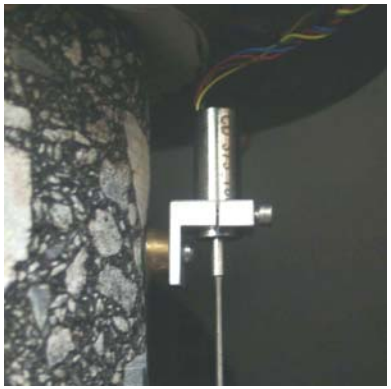


Test Setup Overview

Test Specimen (Compression)



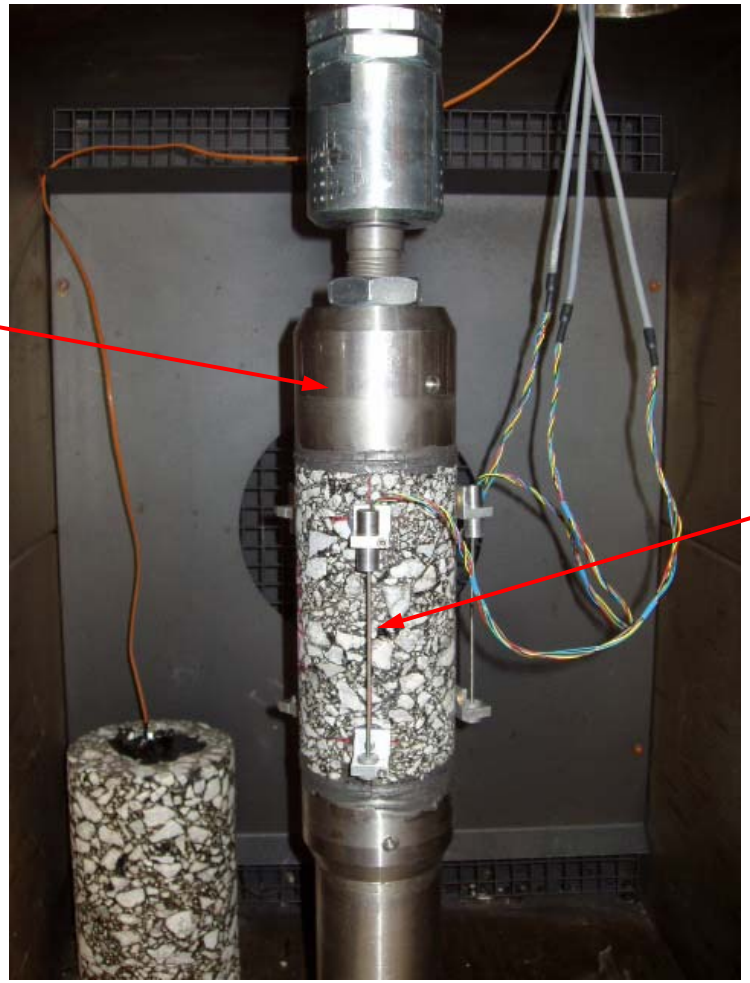
LVDTs MOUNTED ON SPECIMEN



FRICTIONLESS MEMBRANES

Test Specimen (Tension)

SPECIMEN GLUED TO END PLATES

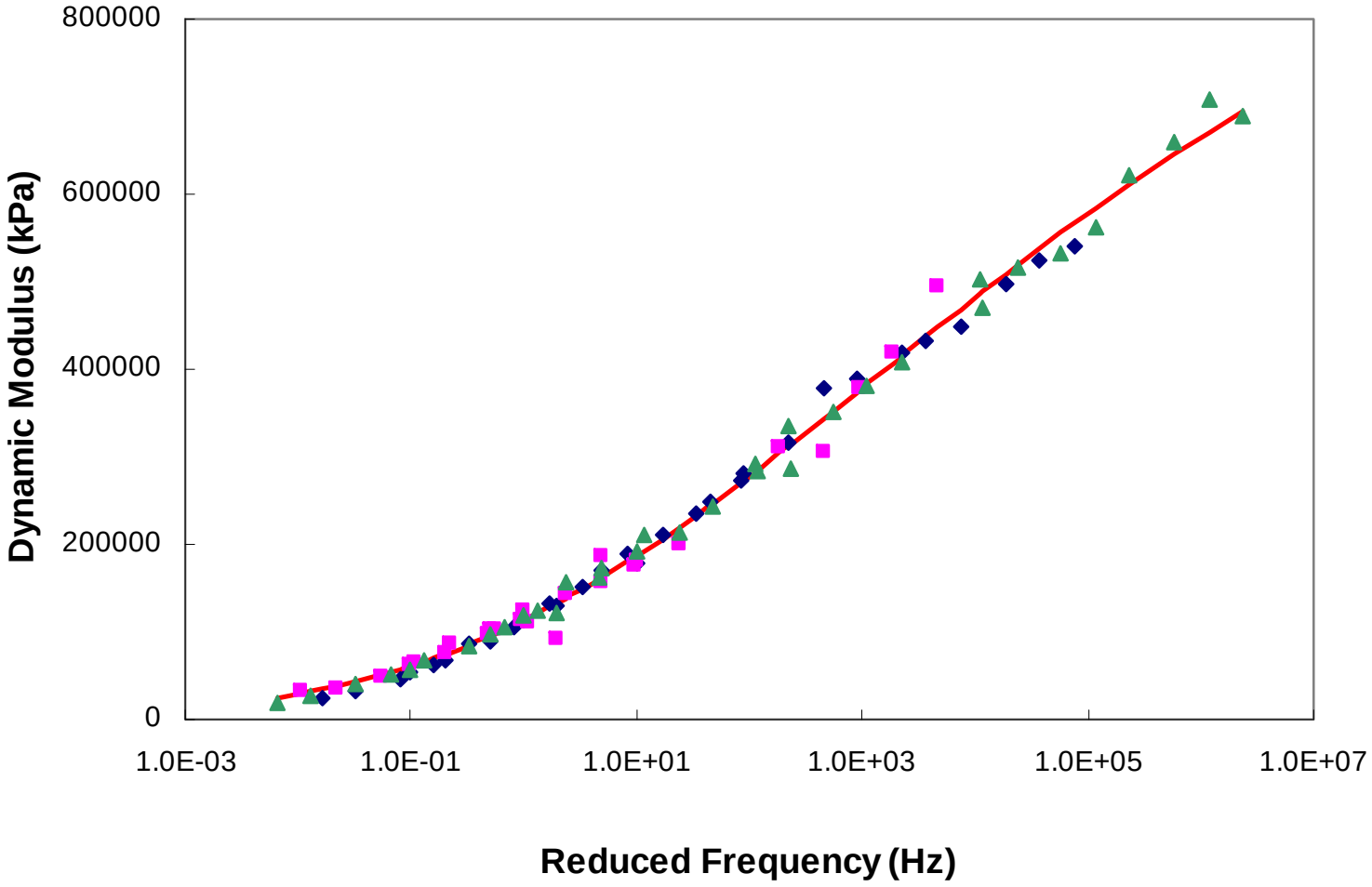


LVDTs MOUNTED ON SPECIMEN

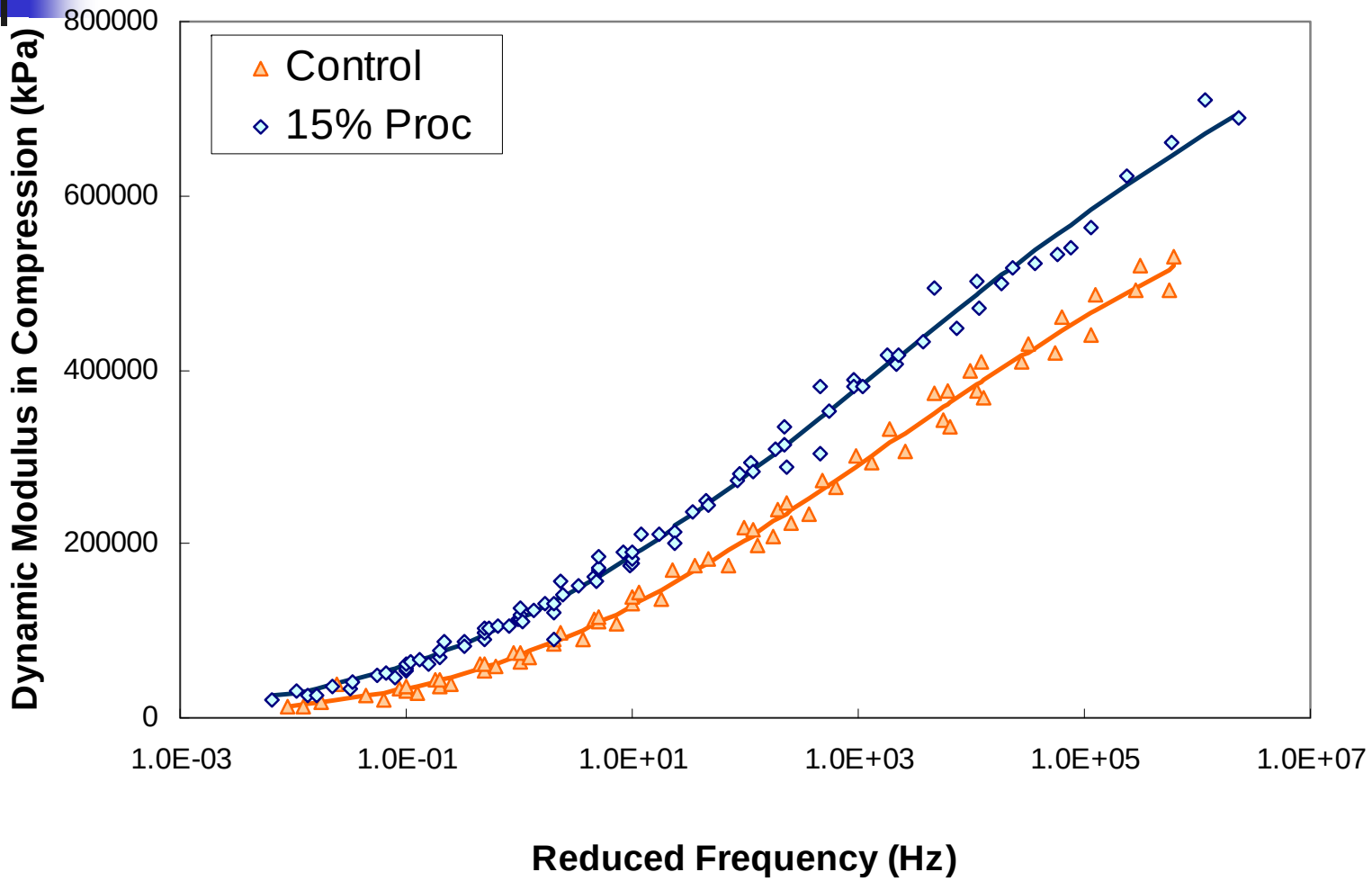
Material Property Tests

- Complex (Dynamic) Modulus
  - Tension
  - Compression
- Creep Compliance in Compression
- Static Creep in Compression (flow time)
- Why These Tests?
  - Mechanistic-Empirical Design Guide
  - Simple Performance Test

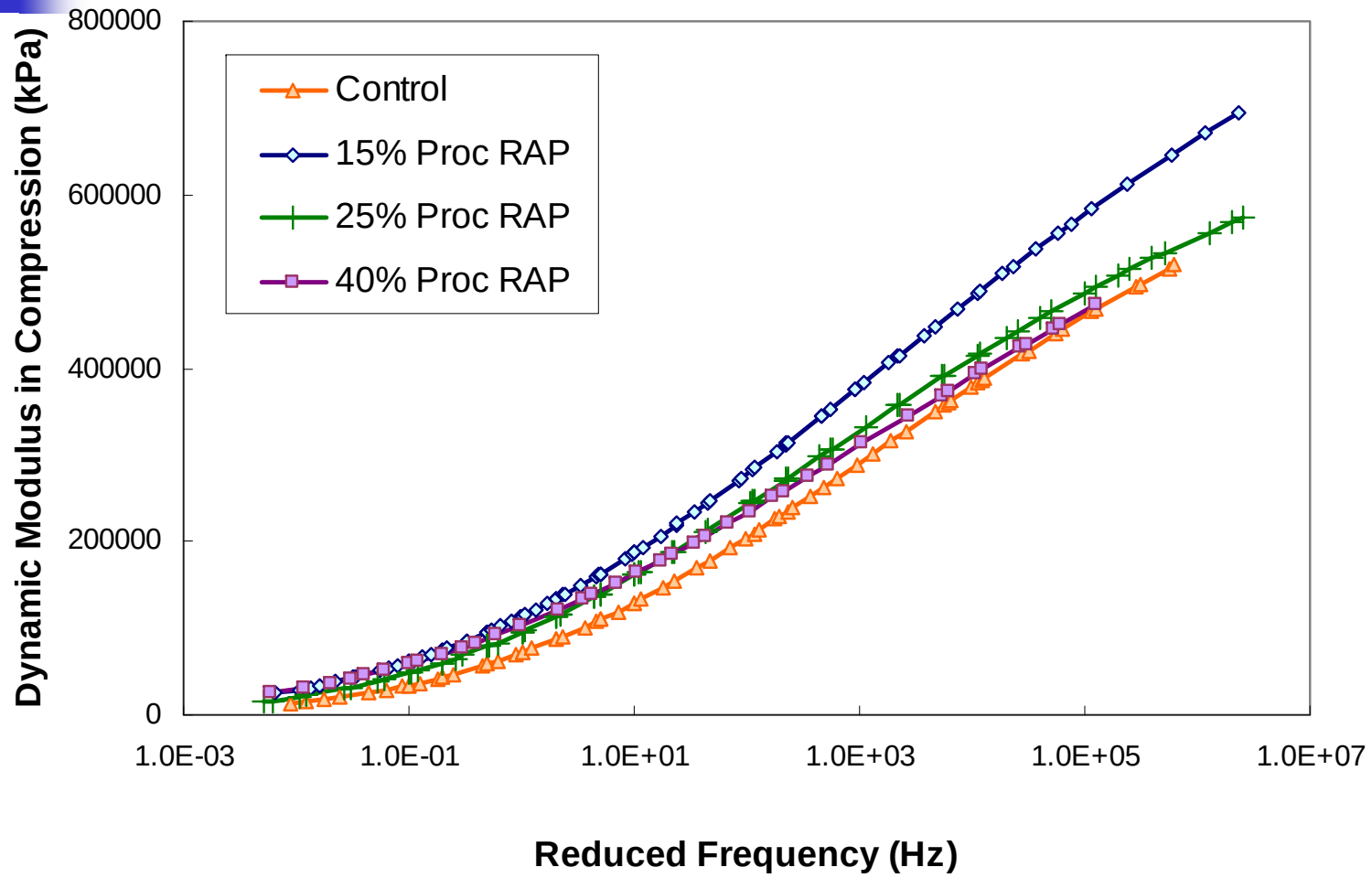
15% Processed RAP



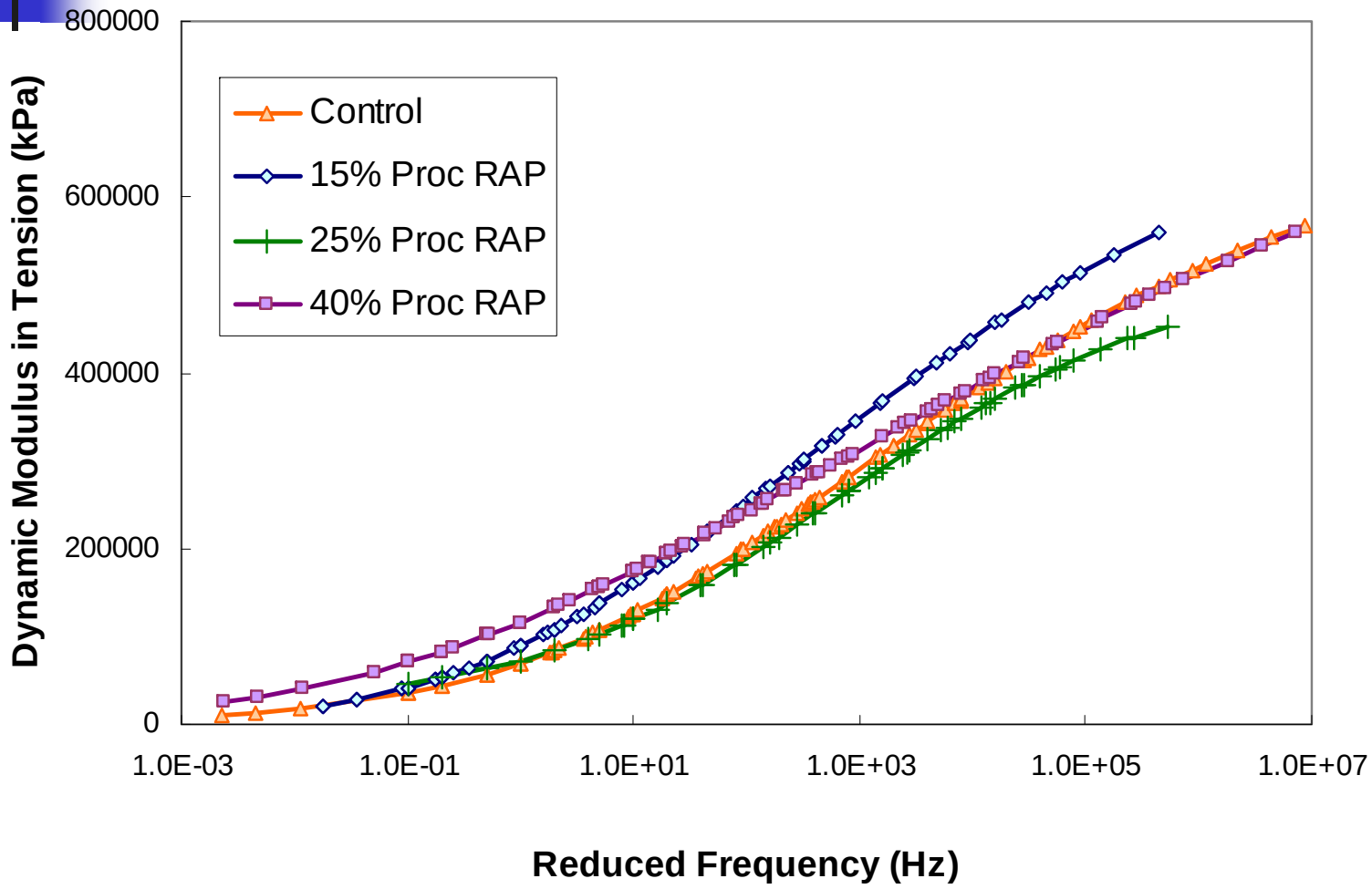
Dynamic Modulus (Compression)



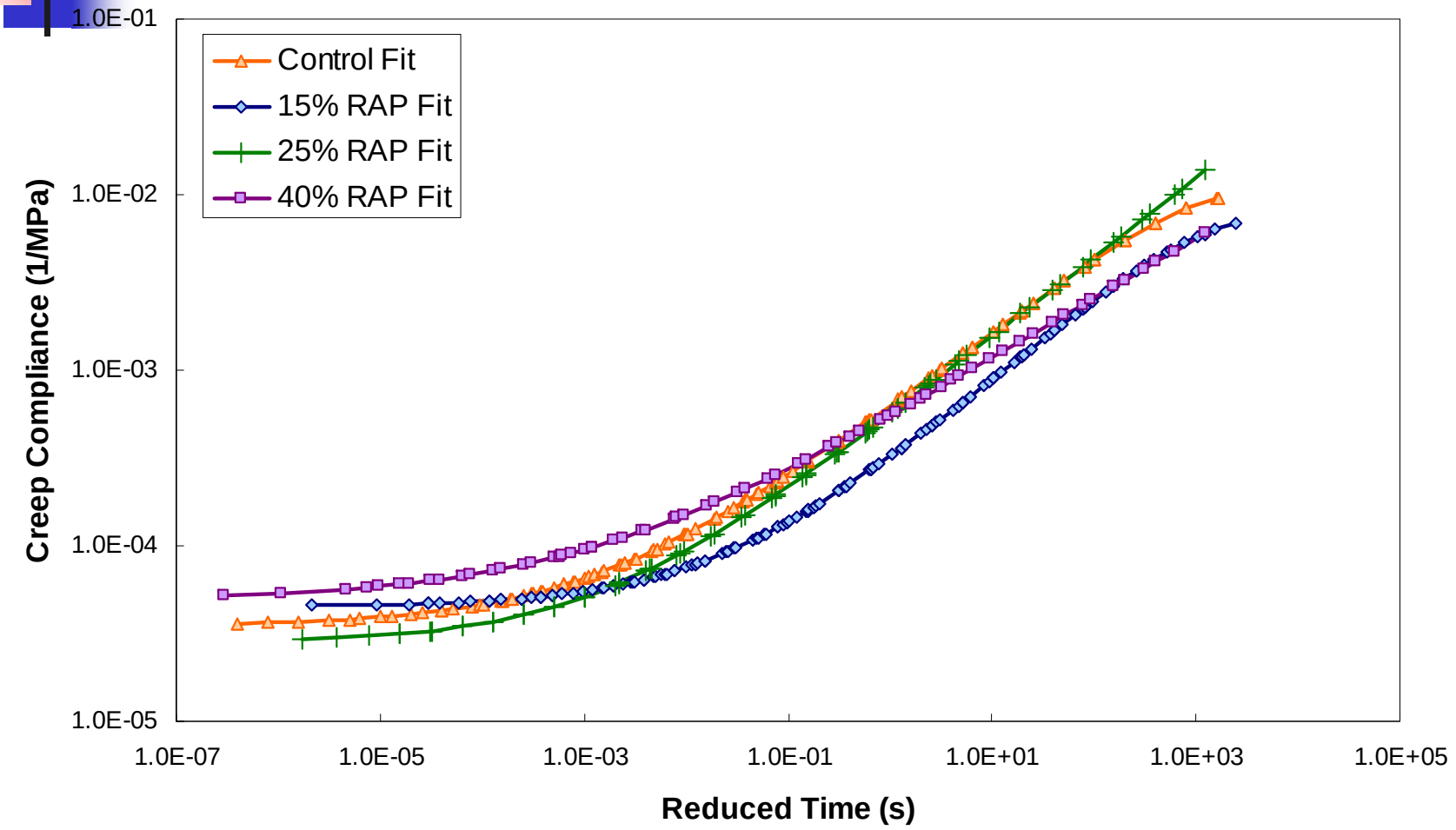
Dynamic Modulus (Compression)



Dynamic Modulus (Tension)



Creep Compliance (Compression)



Static Creep (Flow Time)

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

Why don’t we see expected trends?

- Higher asphalt content for 25% RAP
  - Higher asphalt contents will tend to decrease the stiffness. This may partially explain the decreased stiffness measured on the 25% RAP mixture, but does not explain the behavior of the 40% RAP mixture
- Finer gradation for 25% and 40% RAP
  - Finer gradations are typically less stiff.

Why don’t we see expected trends?

- Angularity of RAP aggregate may be different
  - If the angularity of the RAP aggregate is significantly different than the virgin aggregate, it could have an effect on strength at higher RAP percentages. The RAP aggregate angularity was measured and was not significantly different than the virgin aggregate. Also, if angularity was a significant effect, a difference would be expected between the tension and compression measurements (angularity will have minimal effect in tension).

Why don’t we see expected trends?

- Higher VMA and VFA for 25% and 40% RAP
  - Mixtures with higher VMA and VFA will have lower stiffness. The higher % RAP mixtures likely have the higher VMA and VFA because less of the RAP binder is blending with the virgin binder and the RAP is therefore acting more like a black rock. The more the RAP acts like a black rock, the coarser the effective gradation becomes, which increases the VMA. The expected increase in stiffness from the additional RAP binder is offset by the decrease in stiffness due to the higher VMA.

NHDOT Partnership

- Selection of materials and RAP percentages
  - DOT now has dynamic modulus and creep compliance information on mixtures that have been used in the field. This will be useful in future mechanistic-empirical design and analysis
- Further understanding of complexity of RAP mixtures
  - Recognize the need for more research at state, regional, and national levels
- Interaction between DOT personnel and students
  - No formal presentations were done, but the undergraduate student was in regular contact with DOT throughout project

Impact

- Undergraduate research experience
- Furthered relationship between PI and NHDOT
- New NHDOT research project with RAP materials started in summer 2005
- Results from this project presented at:
  - 2004 New England State Materials Engineers Association
  - 2005 Transportation Research Board
  - 2005 Petersen Asphalt Research Conference
- Project results part of a paper to be published in the Transportation Research Record

Future Work

- Complex modulus testing on grindings mixtures (ongoing)
- Testing of other RAP sources, virgin binders (DOT project)
- M-E design guide (RMRC project)
- “effective” PG grade of RAP mixtures (NETC project)