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Research Update: High RAP

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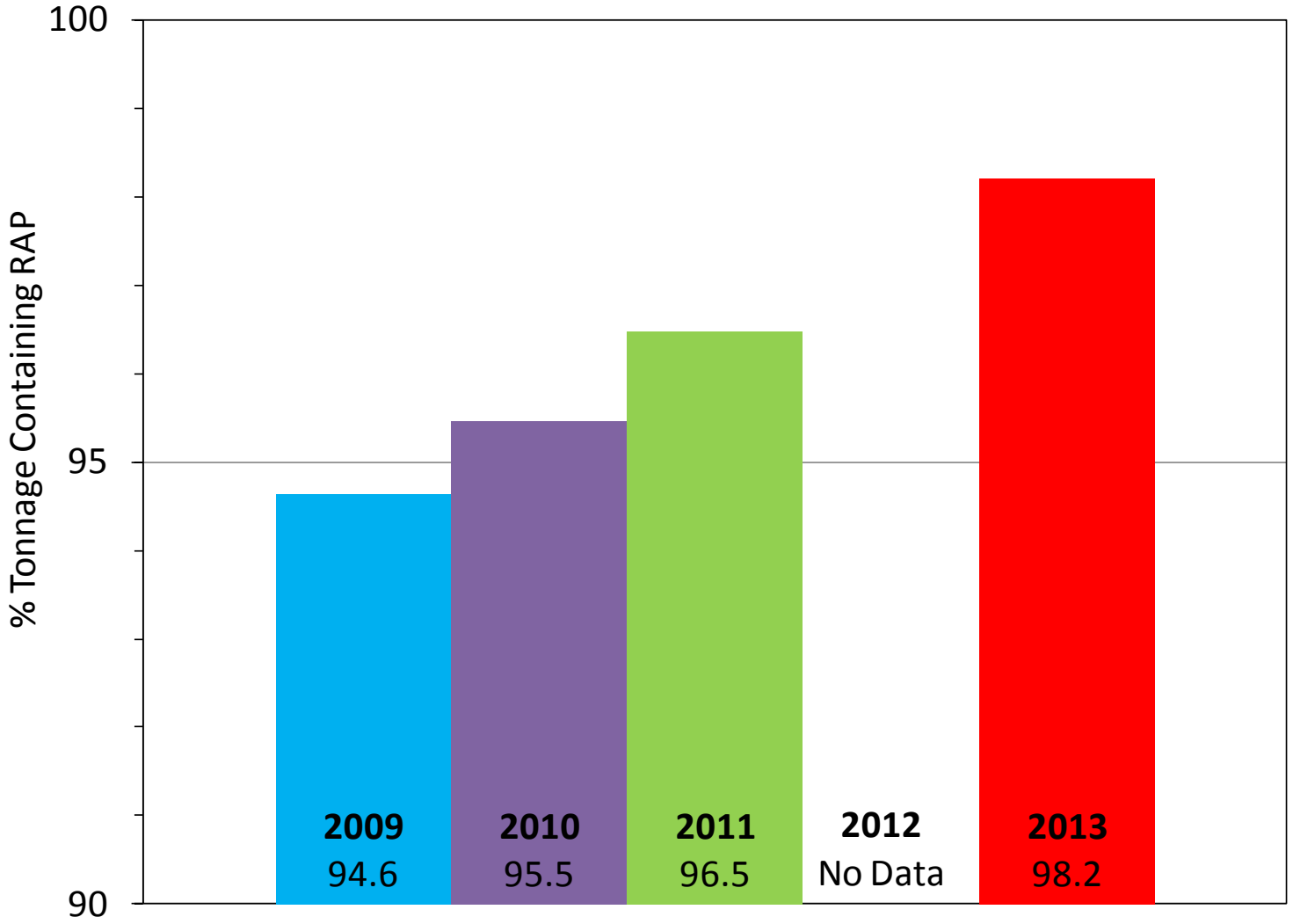
% VDOT Tonnage Containing RAP



Questions About RAP Use

- How does RAP content influence binder grade and mixture performance?
- Are RAP binders activated in mixtures?
- What binders should we use with various RAP contents for best performance?
- How much RAP can we use in a mixture?

Focus Areas

- In 2008, VDOT allowed up to 30% RAP in surface mixes
  - How well have these mixtures performed?
- Recent interest in higher RAP contents – up to 45% RAP
  - Can we design/produce/pave these mixtures?
  - How well will they perform?

Analysis: 20-30% RAP Mixtures

- Anecdotally, early mixtures appeared “dry”
  - RAP does not contribute as much binder as assumed
  - Recent spec changes have addressed this
- Need quantitative answer for performance
  - Visual surveys indicate trial sections performed similarly to controls
  - Performance test results under review

How Much RAP?

- Fredericksburg District, 6/2013
  - 20% (PG 70-22)
  - 30%, **40%, 45%** (PG 64-22)
- City of Hampton, 8/2013
  - 30%, **40%** (PG 64-22)
- Fredericksburg District, 7/2014
  - **40%** (PG 58-28)
- Lynchburg District, 8/2014
  - 0% (PG 70-22)
  - 30%, **40%, 45%** (PG 64-22)

Can High RAP Contents Work?

- Sometimes!
  - Depends on the RAP material, contractor, plant, project, etc.
- Issues
  - Can be difficult to produce
    - Plant setup and RAP handling capacity
  - Meeting current volumetric acceptance criteria
    - Controlling / measuring RAP properties
    - Addressing VMA, VFA, voids, and %AC
- Lab performance testing is interesting
- Proof will be in long-term performance

Addressing Challenges

30% RAP

45% RAP

Addressing Challenges

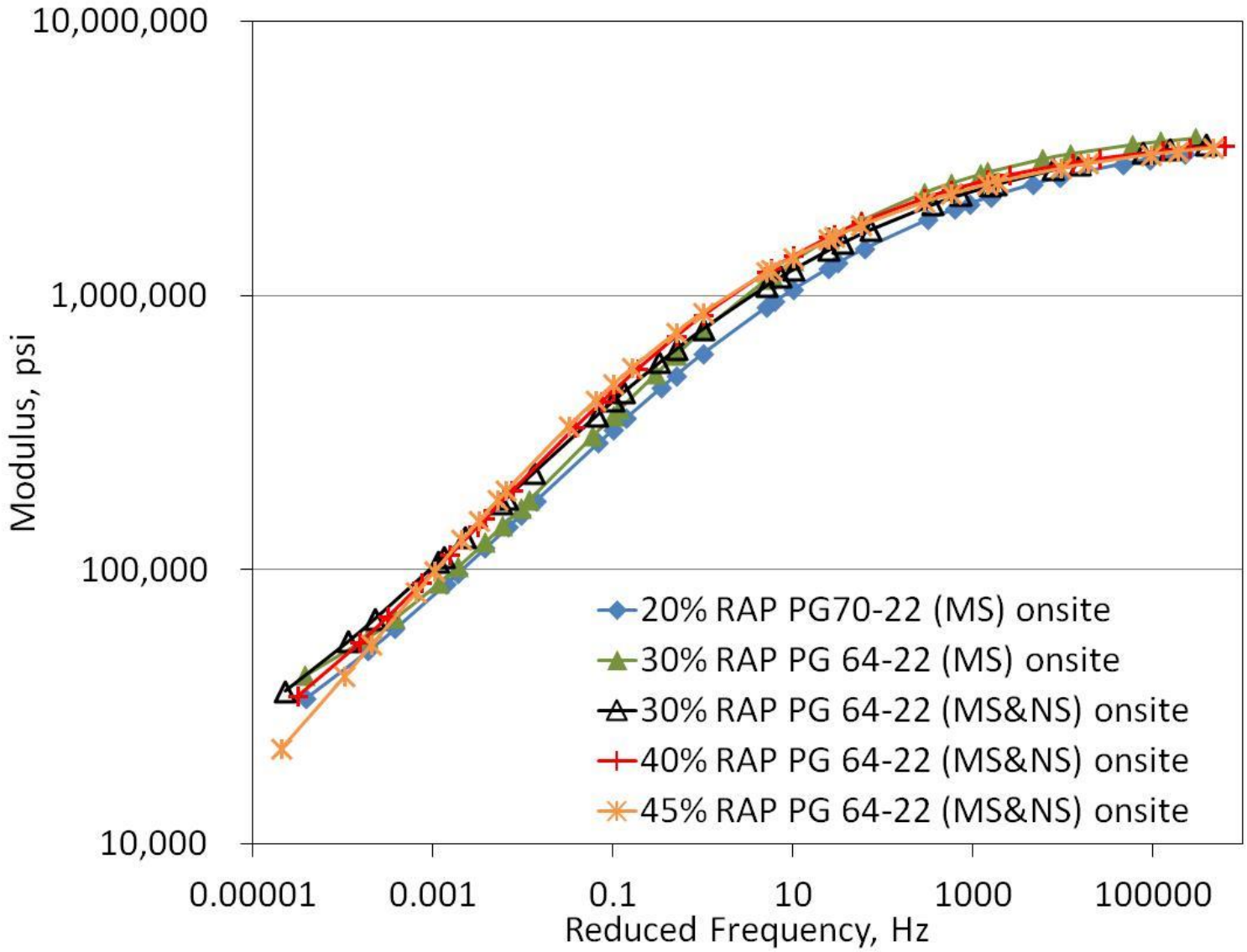
Extracted RAP Binder

Sampling Date		6/12	6/13	6/14	6/17	6/18	6/19	6/25
High Failure Temp.	G*/sin delta	86.1	85.3	89.3	87.6	88.5	89.0	88.5
Intermediate Failure Temp.	G* sin delta	29.8	28.6	33.6	30.5	32.0	32.9	32.0
Low Failure Temp.	Stiffness	-9.5	-9.7	-7.5	-9.9	-8.3	-7.8	-8.6
	m-value	-6.7	-6.4	-1.5	-6.7	-7.0	-6.6	-5.6
Performance Grade		**82-16**	**82-16**	**82-10**	**82-16**	**82-16**	**82-16**	**82-10**

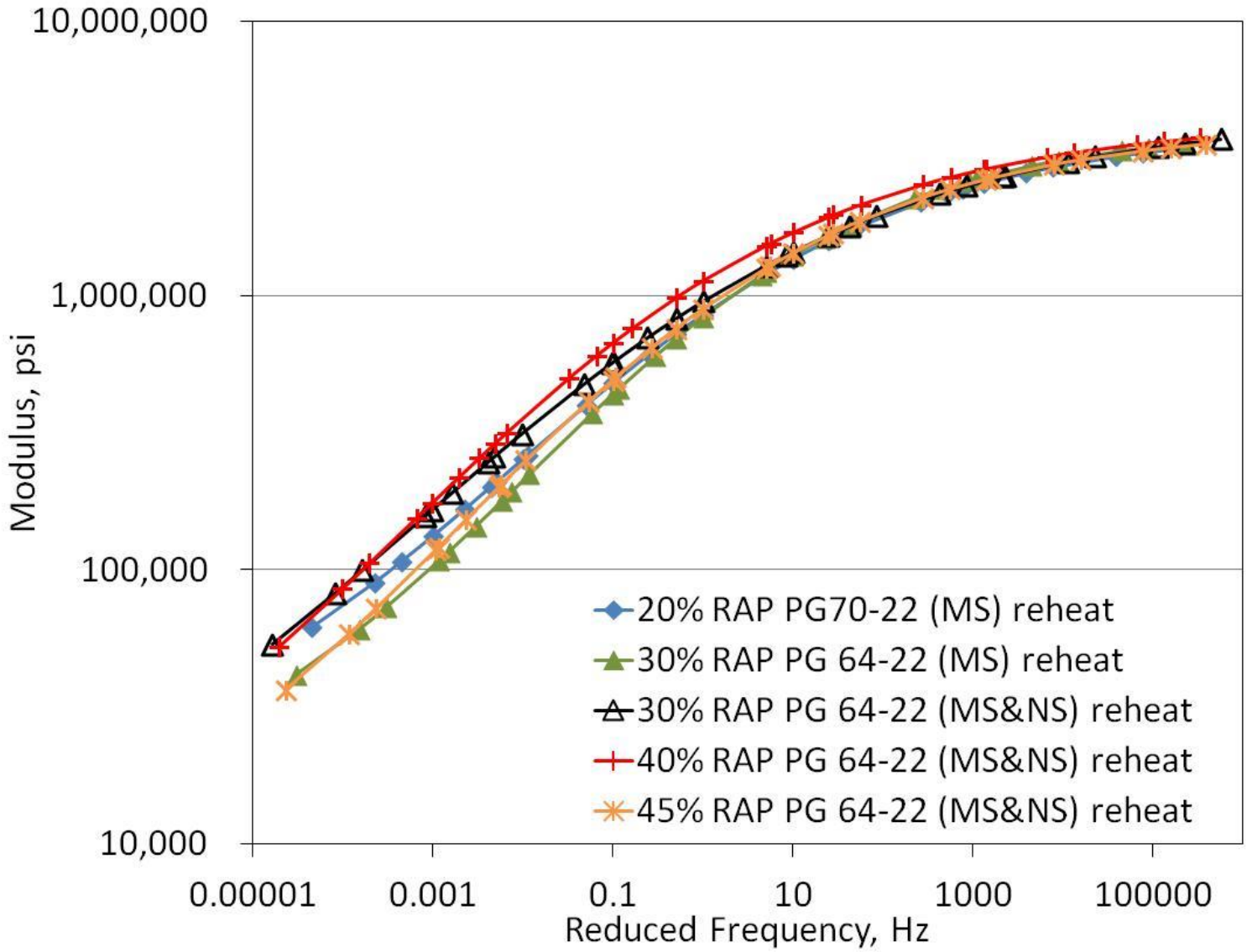
Rt. 3 King George County, June 2013

- SM-12.5 mix designs
  - 20% RAP, PG 70-22, manufactured sand
  - 30% RAP, PG 64-22, manufactured sand
  - 30% RAP, PG 64-22, manf. & natural sand
  - 45% RAP, PG 64-22, manf. & natural sand
- 5th mixture – adjustment to 45% design
  - 40% RAP, PG 64-22, manf. & natural sand

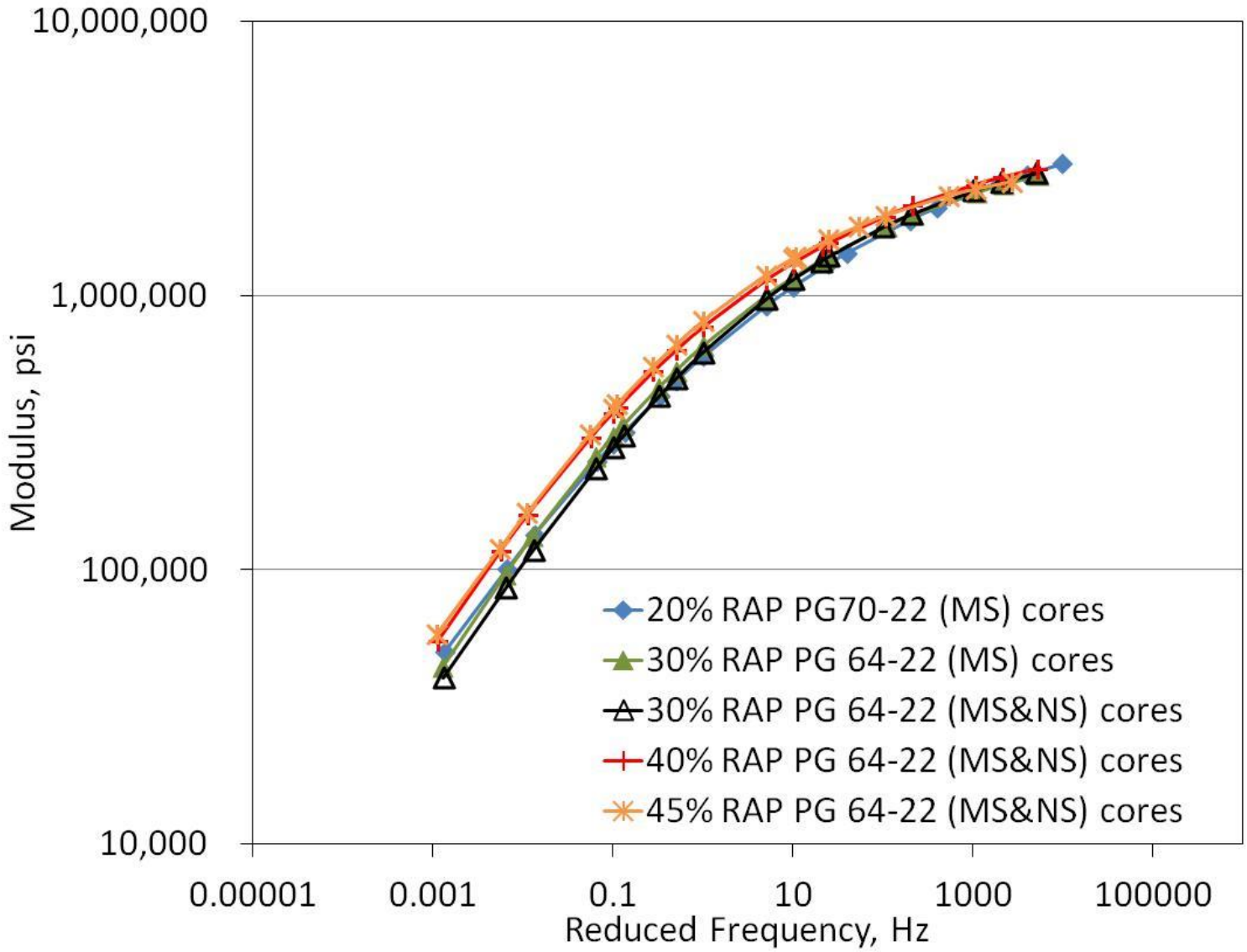
Dynamic Modulus - onsite



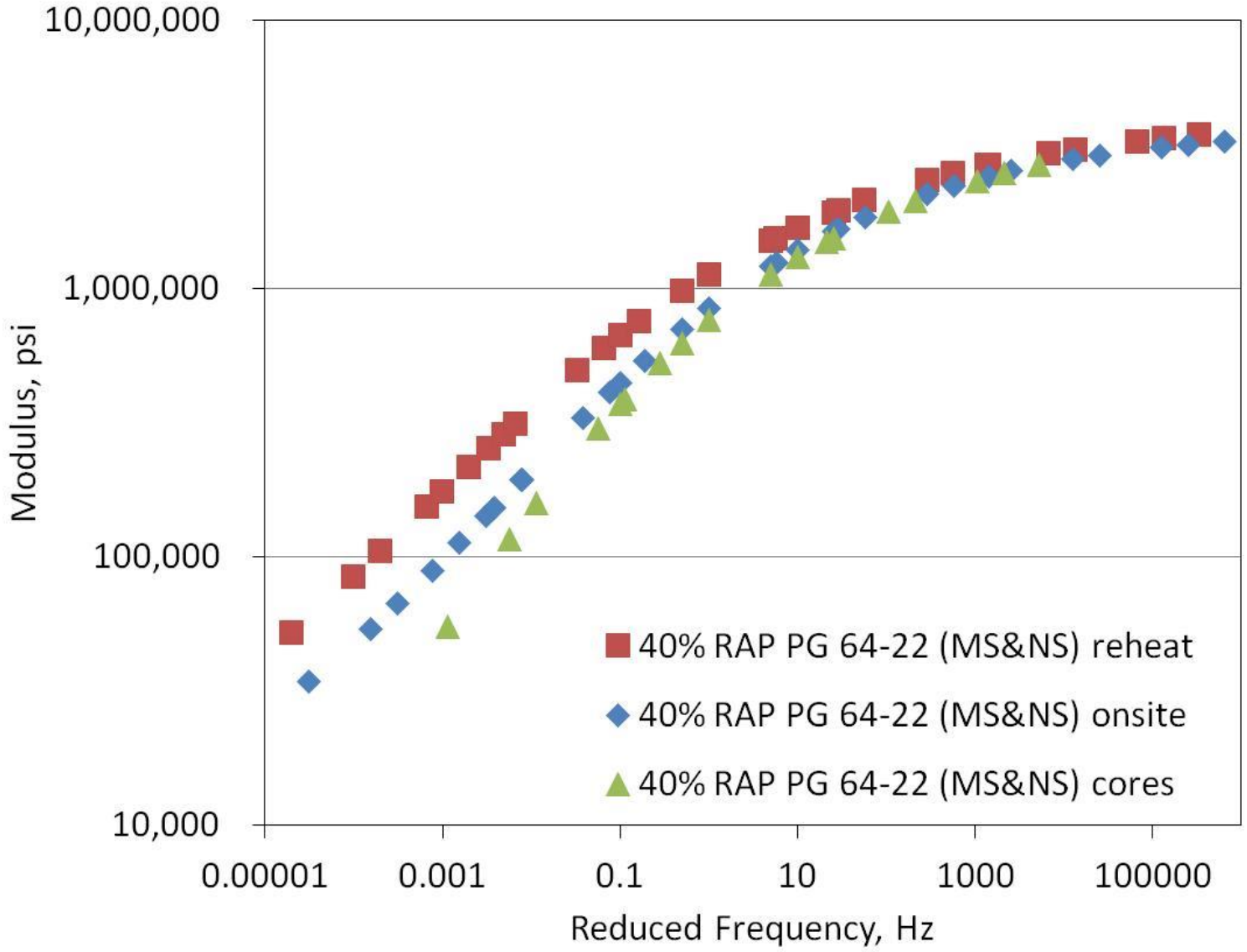
Dynamic Modulus - reheat



Dynamic Modulus - cores



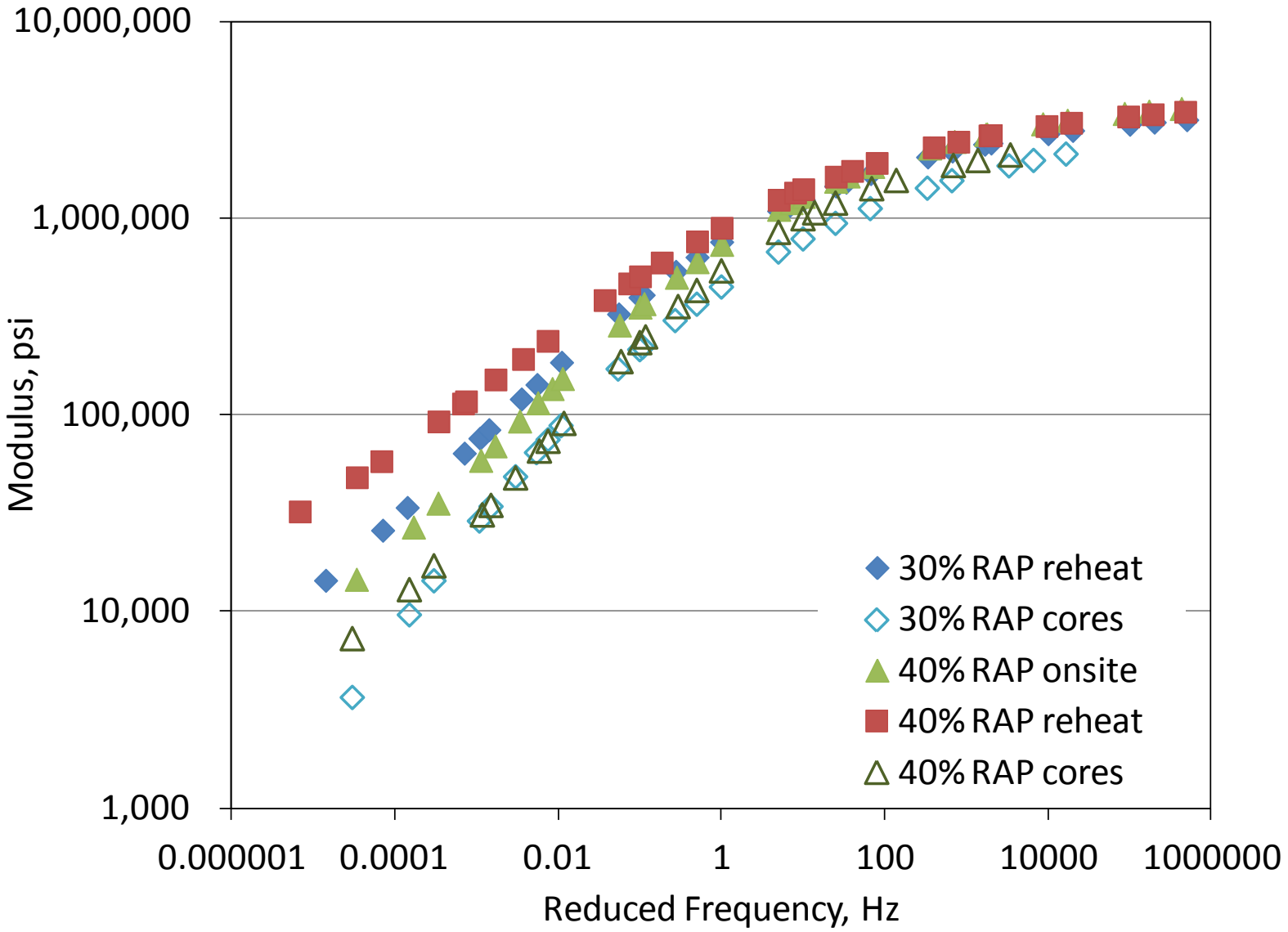
Dynamic Modulus – 40% RAP



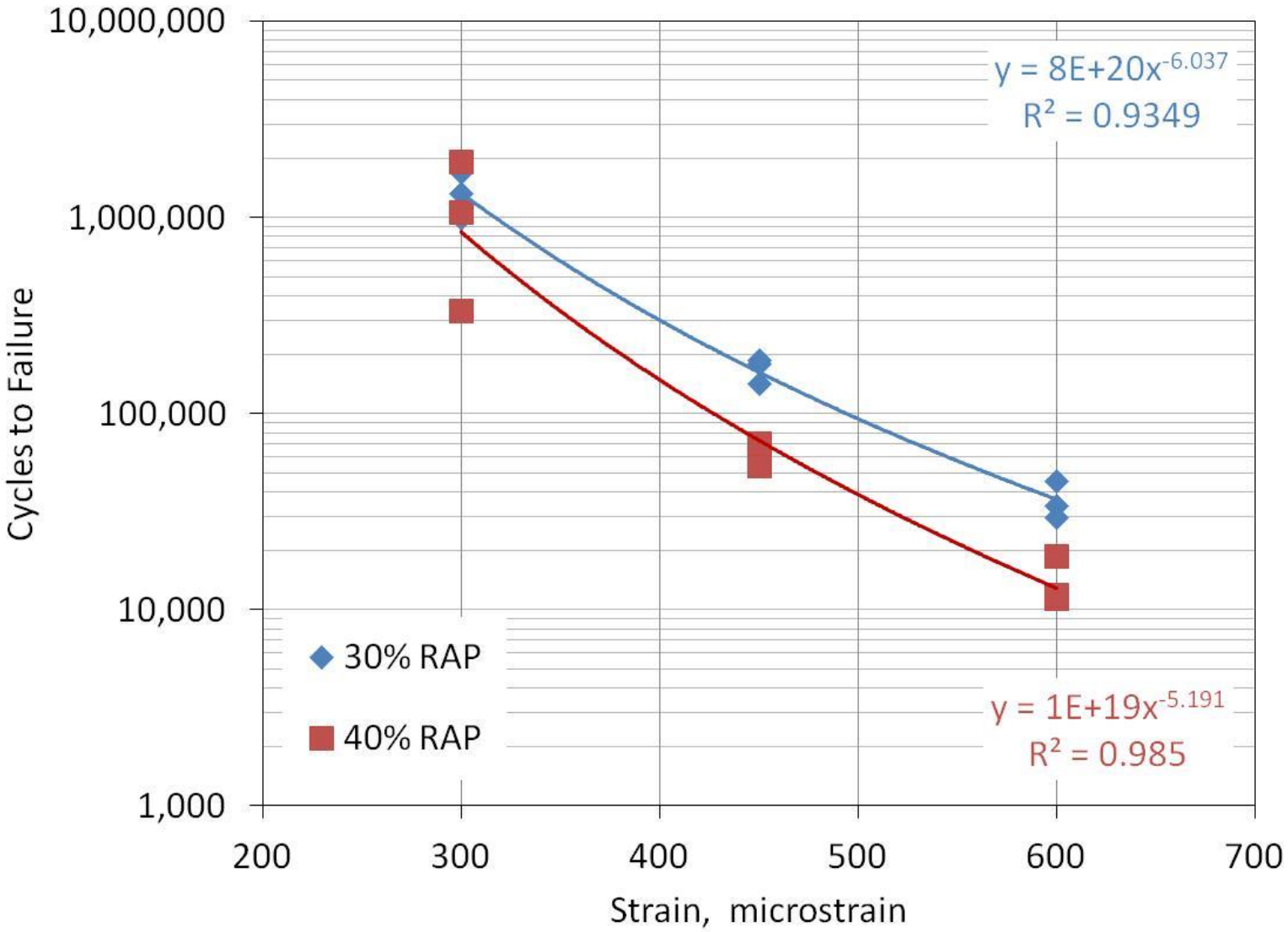
City of Hampton, August 2013

- 2 SM-9.5 mixtures
  - 30% RAP, PG 64-22
  - 40% RAP, PG 64-22
- Testing
  - 40% RAP specimens made on site
  - 30% and 40% RAP reheated specimens
  - Cores

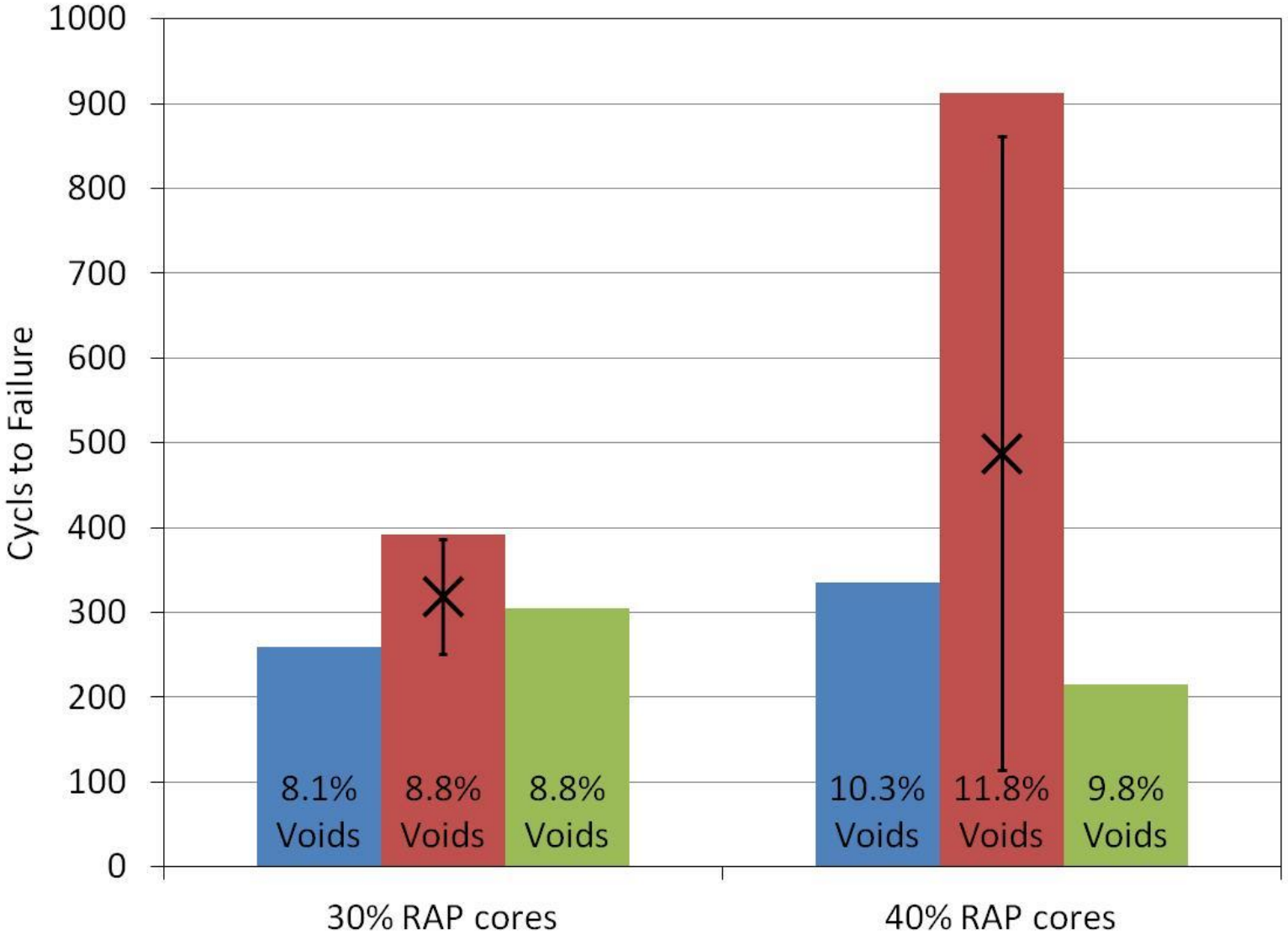
Dynamic Modulus



Fatigue Curves



Overlay Test - Cracking



Continued Testing

- Mix Testing
  - Cracking - Texas Overlay Test
  - Rutting – APA Rut Tester
  - Fatigue – Beam Fatigue
- Cores
  - Permeability
  - Dynamic modulus
  - Extraction and recovery
  - Binder grading
- Performance predictions with AASHTO Pavement ME
- Performance monitoring of pavements

Moving Forward

- Additional trial experiences
  - Need variety of contractors/projects
- Continued performance testing and in-service performance evaluation
- Investigation of mix design process and mix acceptance criteria

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Thank You!

Acknowledgements

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