

# Moisture Damage in HMA with Marginal Aggregates

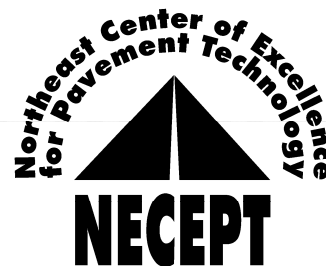
**84<sup>th</sup> Annual NESMEA Conference**

**October 8, 2008**

**Atlantic City, NJ**

**Mansour Solaimanian,  
Penn State University**

**Steve Snyder  
Pennsylvania Department of Transportation**



# Research Personnel

---

- Project Technical Director
  - Steve Snyder (PennDOT District 1-0 Materials Manager)
  
- Research Team
  - Jason Chang (Graduate Student - PSU)
  - Ghassan Chehab (Assistant Professor -PSU)
  - Scott Milander (Lab Manager- PSU)





**Why This Research?**



**Approach & Testing Program**



**Analysis/Discussion**



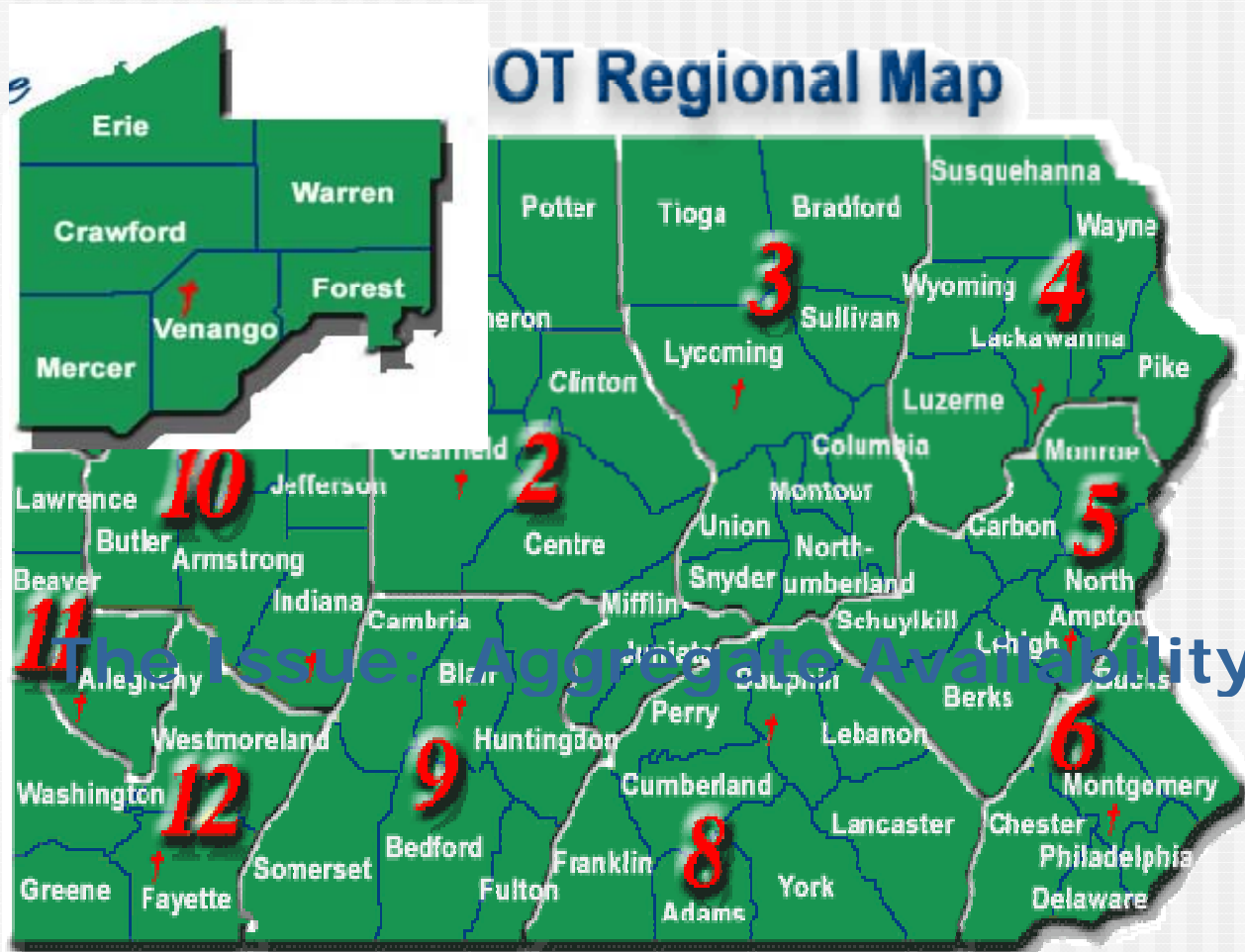
**Future Work**



**Summary**



# Depleting Aggregate Sources



The Issue: Aggregate Availability



# District 1-0 Available Aggregates

---

- Approximately 30 to 35 Sand and Gravel Operations.
- Of that total only 1 source is able to meet the current Bituminous criteria for # 8's, needed 9.5mm mixes.
- That source will be depleted in approximately 5 years.



# Aggregate Selection Criteria

---

- PennDOT Bituminous Type A Course Aggregate Requirements
  - Crush Count
  - LA Abrasion
  - Sodium Sulfate
  - Absorption
  - Gradation
  - Skid Resistance Level



# Coarse Agg. Quality Requirements

	Type A	Type B	Type C
Soundness, Max. %	10	12	20
Abrasion, Max. %	45	45	55
Thin and Elongated Pieces, Max. %	15	20	—
Material Finer Than 75 $\mu\text{m}$ (No. 200) Sieve, Max. %	*	*	10
Crushed Fragments, Min. %	55	55	50
Compact Density (Unit Weight), Min. kg/m <sup>3</sup> (lbs./cu. ft.)	1100 (70)	1100 (70)	1100 (70)
Deleterious Shale, Max. %	2	2	10
Clay Lumps, Max. %	0.25	0.25	3
Friable Particles, Max. % (excluding shale)	1.0	1.0	—
Coal or Coke, Max. %	1	1	5
Glassy Particles, Max. %	4 or 10	4 or 10	—
Iron, Max. %	3	3	3
Absorption, Max. %	3.0	3.5	—
Total of Deleterious Shale, Clay Lumps, Friable Particles, Coal, or Coke Allowed, Max. %	2	2	15



# The Stopper

---

- Type A Sodium Sulfate requirement of 10% or less.
- Type A Absorption requirement of 3% or less.
- Many of District 1-0's sources are between 12% and 20% on the Sodium Sulfate test.
- All other requirements can be met and the materials have an excellent skid value.





# Outsource Aggregates

---

- District producers forced to acquire aggregates from outside the District.
- Materials are brought in by boat, rail, and truck.
- SRL E material hauled a 100 mile distance for District 1-0 SMA projects.
- Result: Increase in the cost of the raw material.



# The Idea

---

- To use District 1-0 local aggregates on lower volume roads.
- To evaluate HMA performance with these aggregates to determine what would be the best course of action if the materials were to be incorporated.
- To implement the best course of action on an actual project and then monitor its performance.



---

**1** Why This Research?

**2** Approach & Testing Program

**3** Analysis/Discussion

**4** Future Work

**5** Summary



# Materials

---

- Five Gravel Aggregate Sources
- One Limestone Aggregate
- For each aggregate
  - Control
  - Liquid Antistripping Agent (LAS)
  - 50/50 Blend on #8 Material (Gravel+Limestone)
  - 1% Lime (No Data Yet)

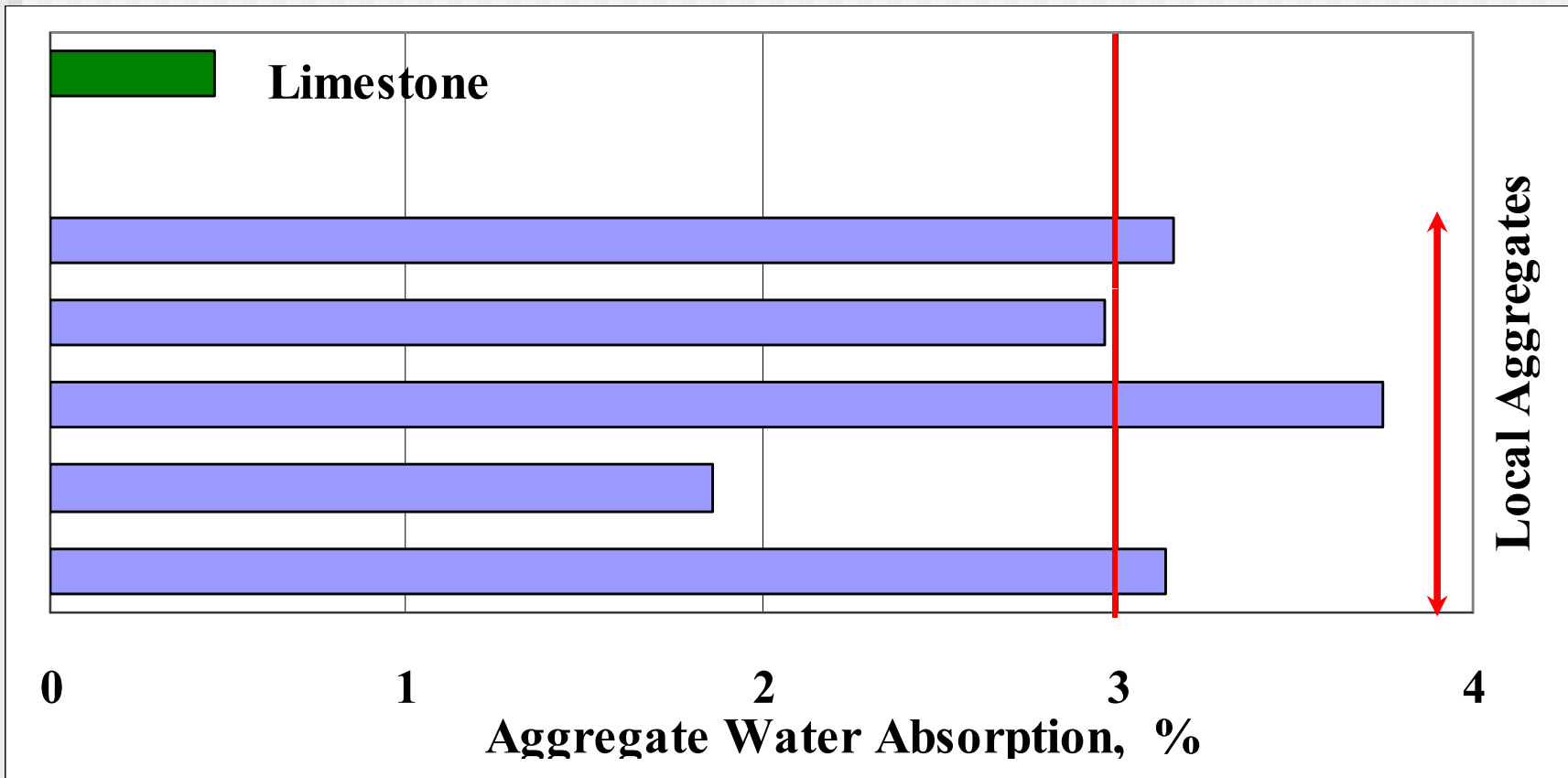


# Aggregates to Be Evaluated

---

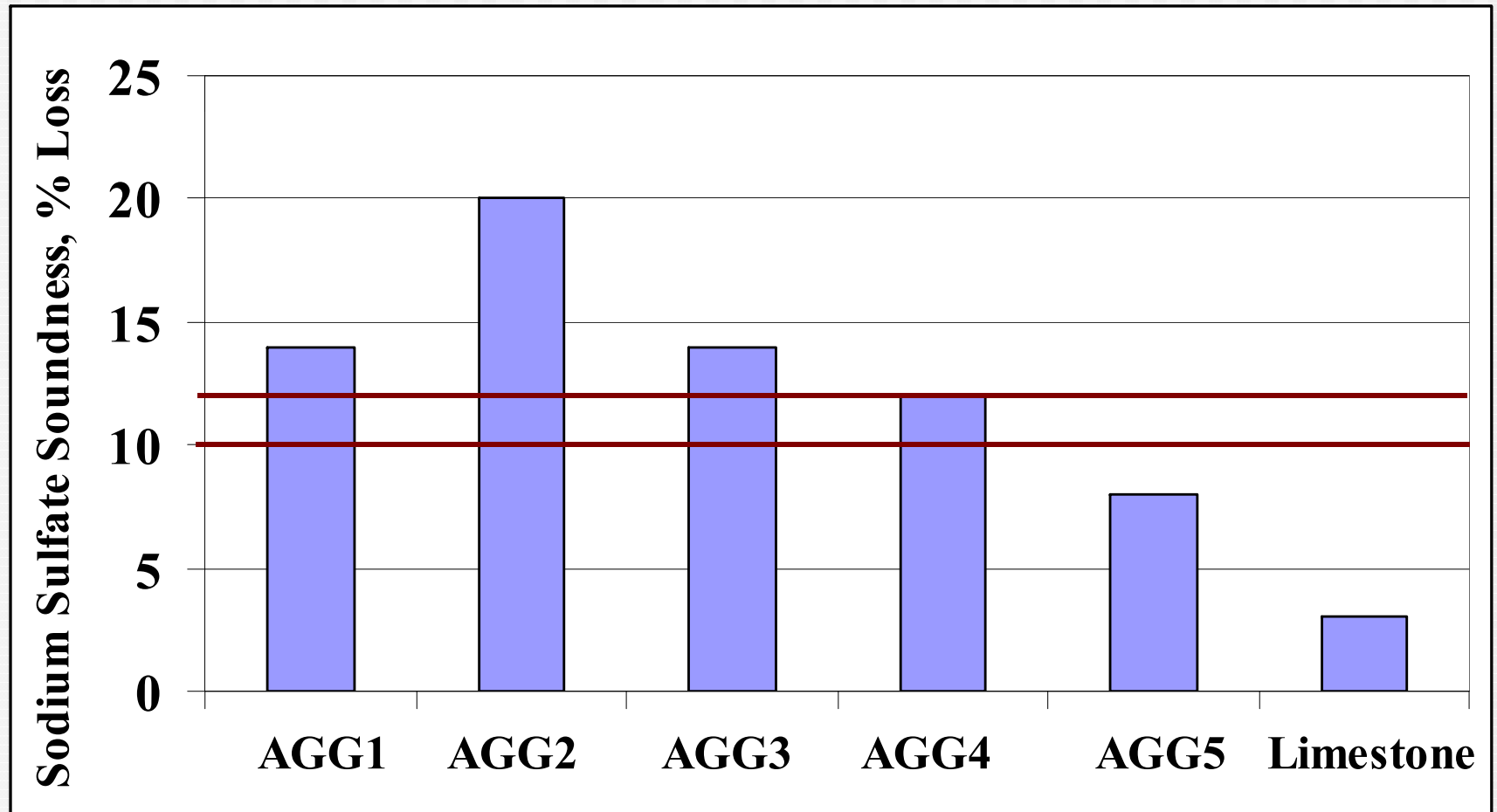


# Aggregate Quality



# Aggregate Quality

---



# Testing Program

---

- **AASHTO T-283 (PennDOT Version)**
- **Model Mobile Load Simulator (MMLS3)**
- **Dynamic Modulus (Repeated Freeze-Thaw Cycles)**
- **Environmental Conditioning + Dynamic Modulus?**

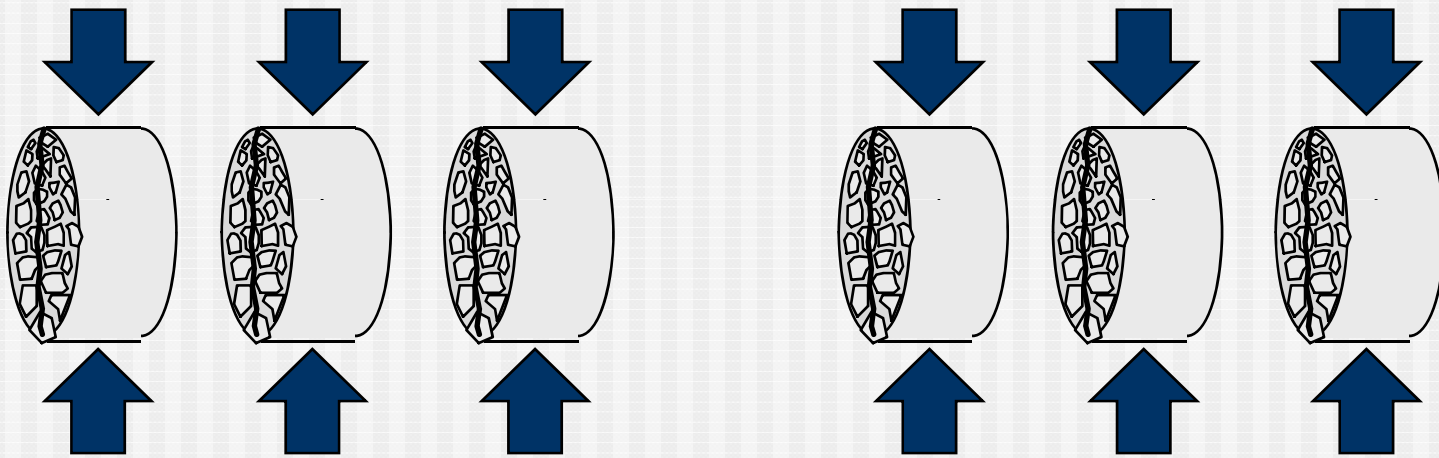




# Moisture Sensitivity (AASHTO T-283)

---

*51 mm / min @ 25 °C*



Avg **Dry** Tensile Strength

Avg **Wet** Tensile Strength

$$\text{TSR} = \frac{\text{Wet}}{\text{Dry}} \geq 85 \%$$



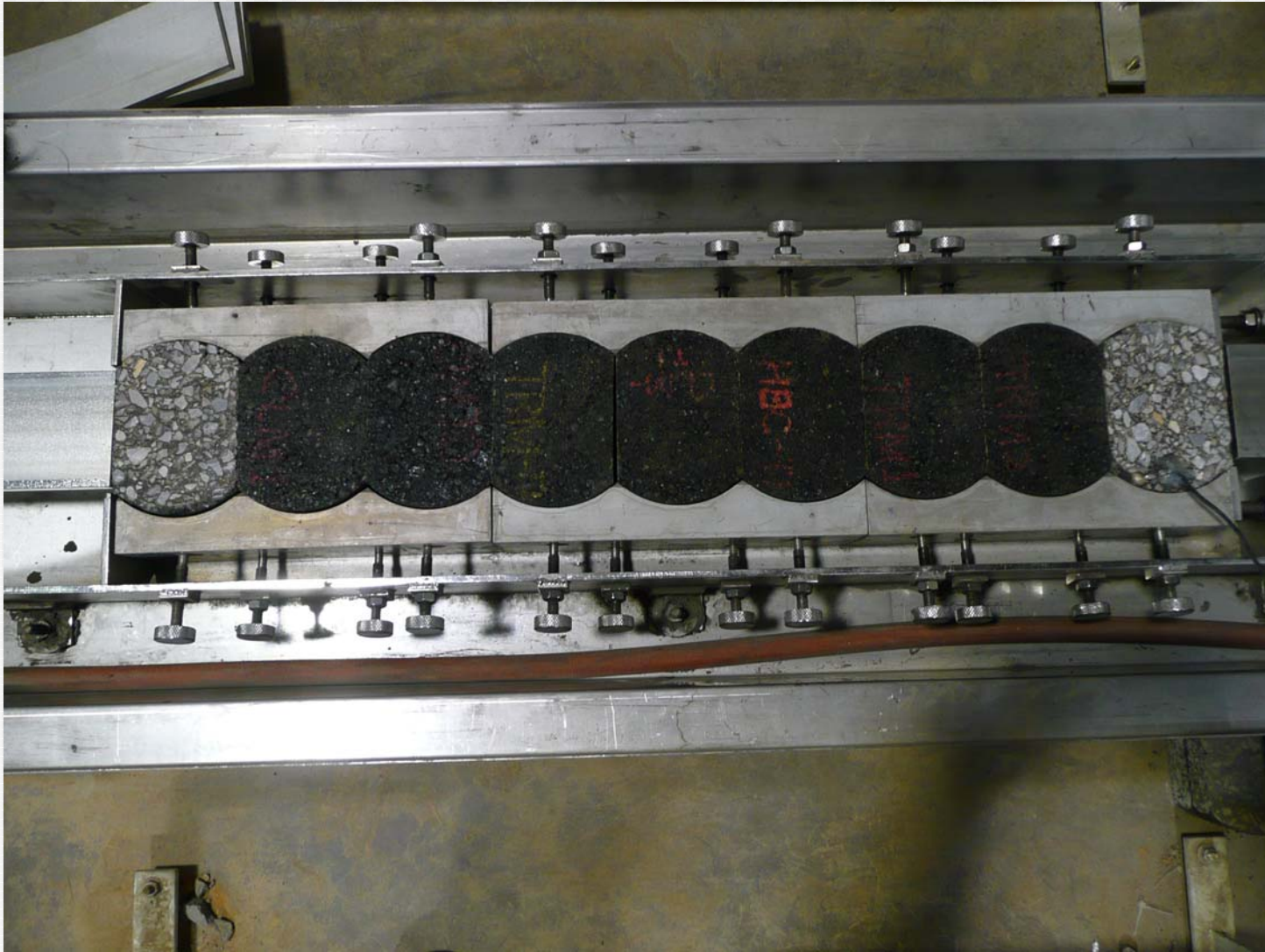
# MMLS3

---



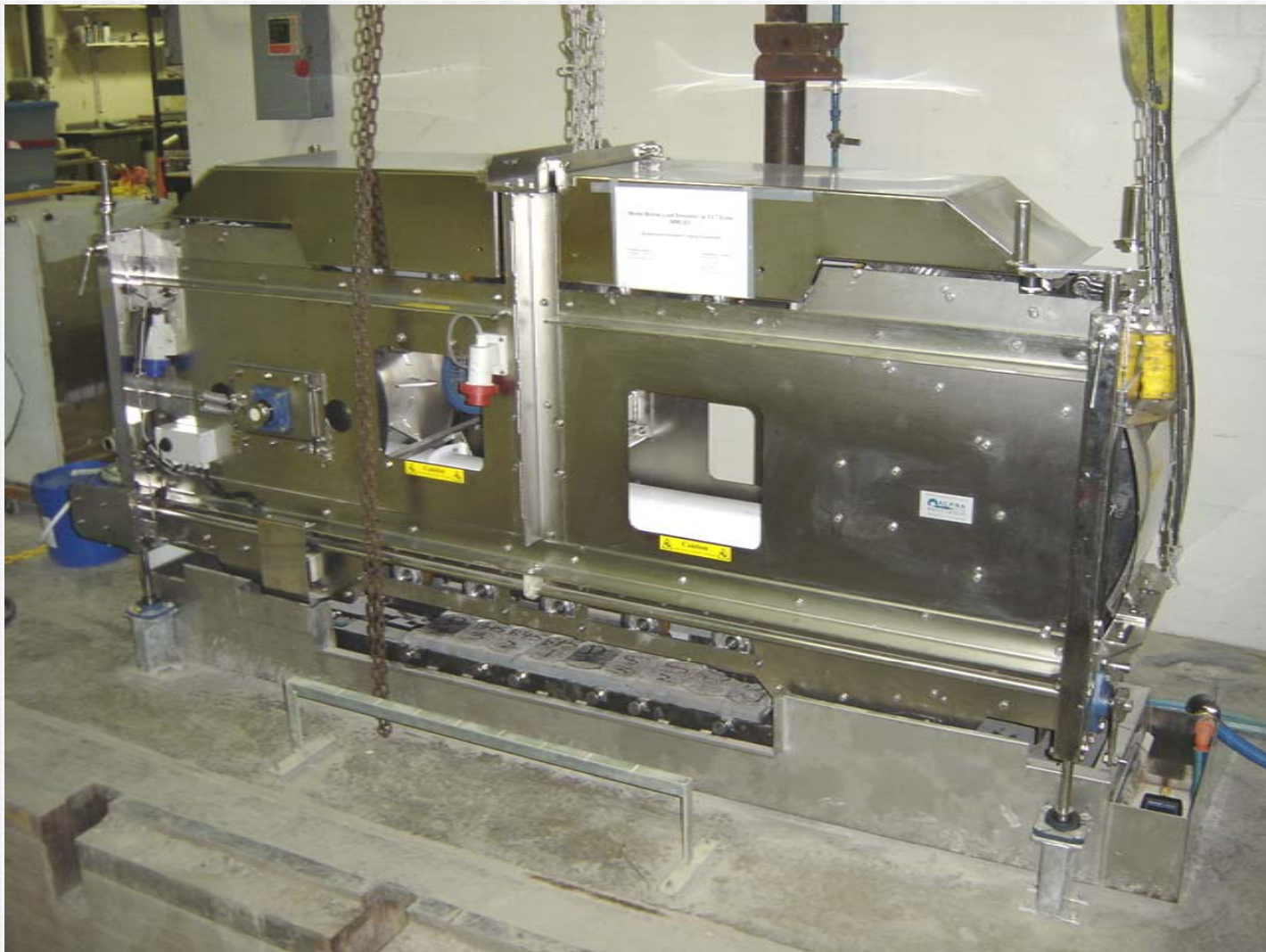
# MMLS3 – Specimen Set-Up

---



# MMLS3- Dry/Wet Testing

---



# MMLS3 – Profile Measurements

---



# MMLS3 – Wet Testing

---



**T = 52 °C**

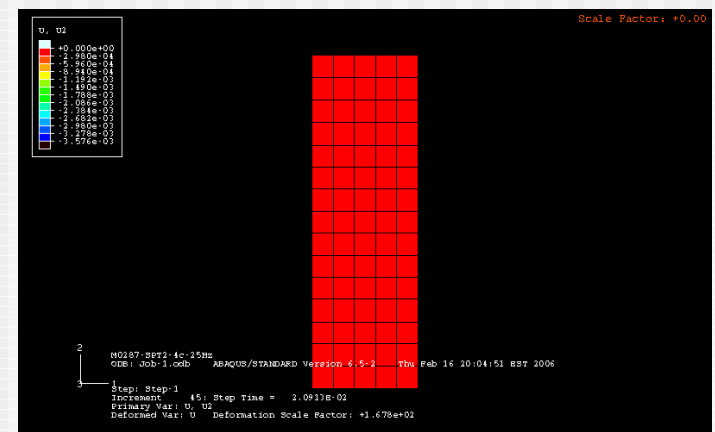
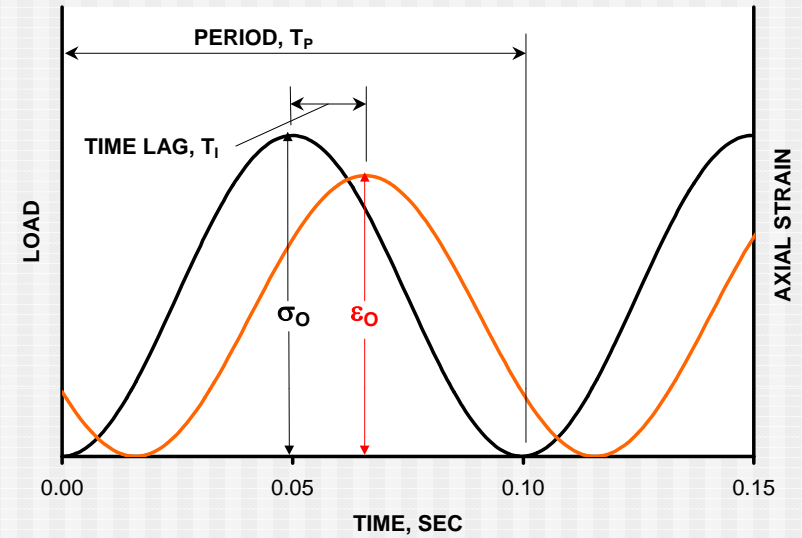
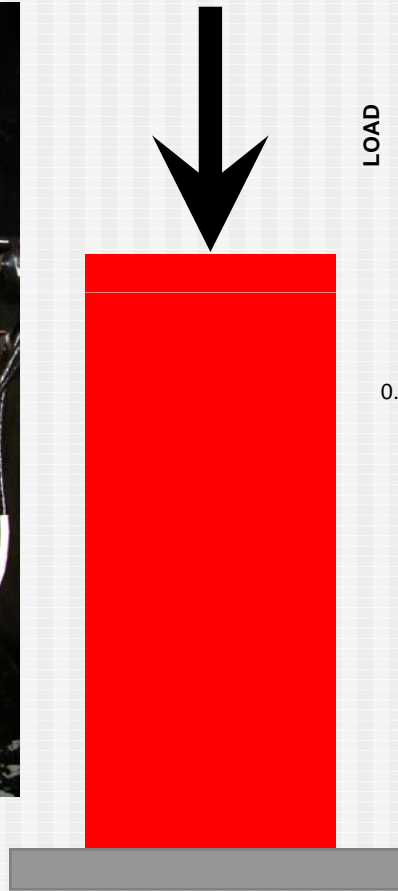


# Dynamic Modulus Testing

---



# Dynamic Modulus Test





---

**1** Why This Research?

**2** Approach & Testing Program

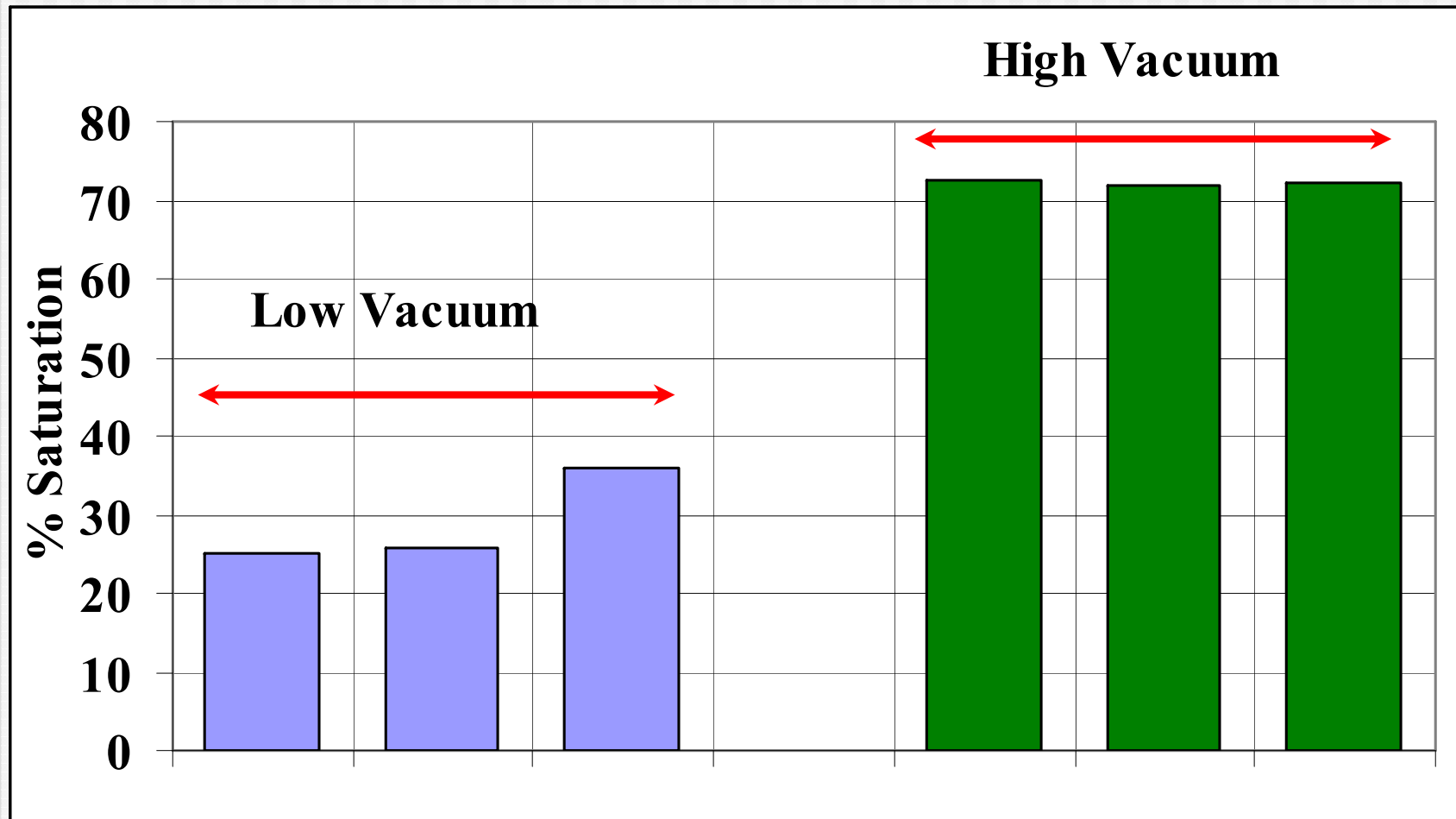
**3** Analysis/Discussion

**4** Future Work

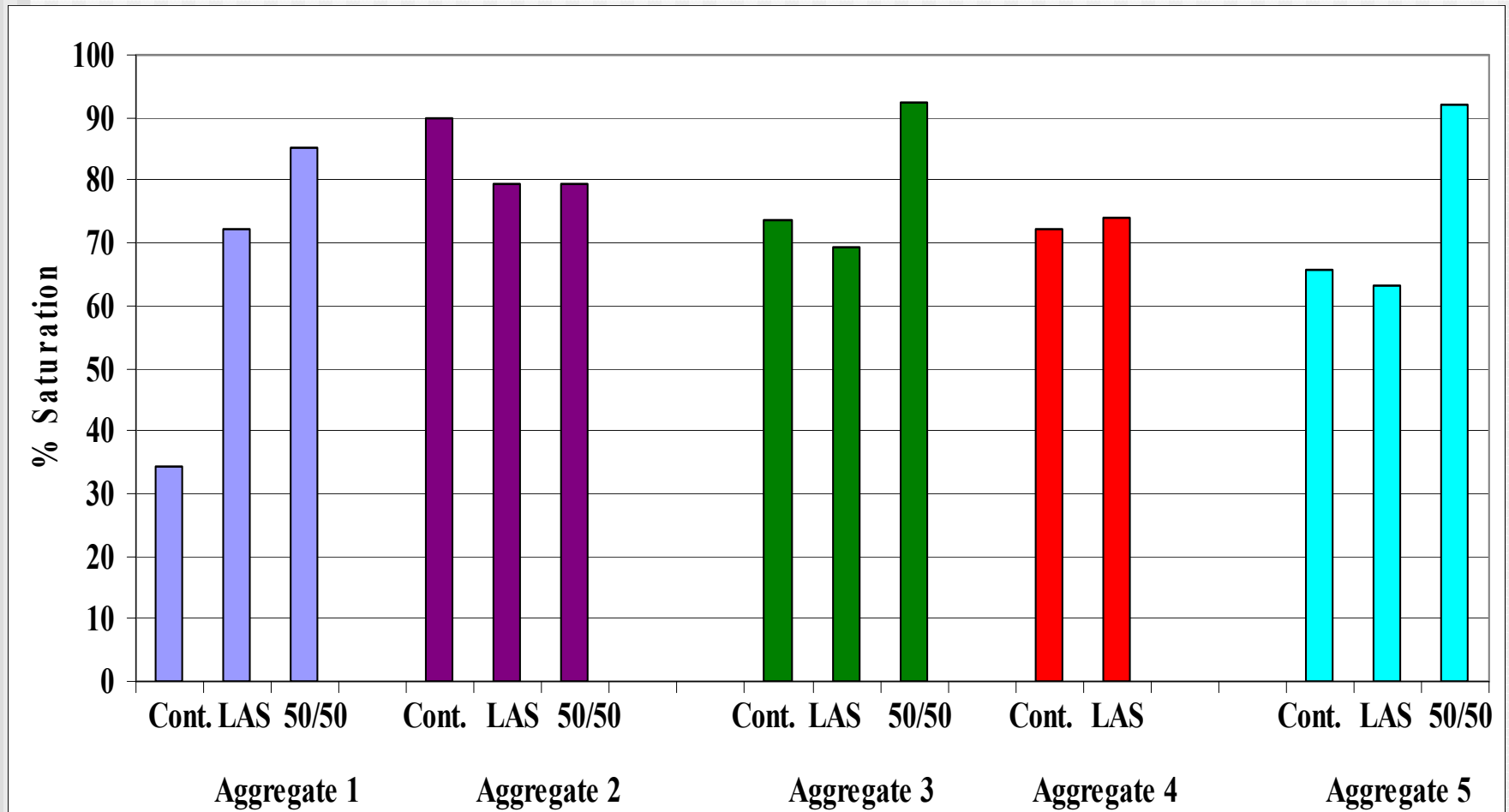
**5** Summary



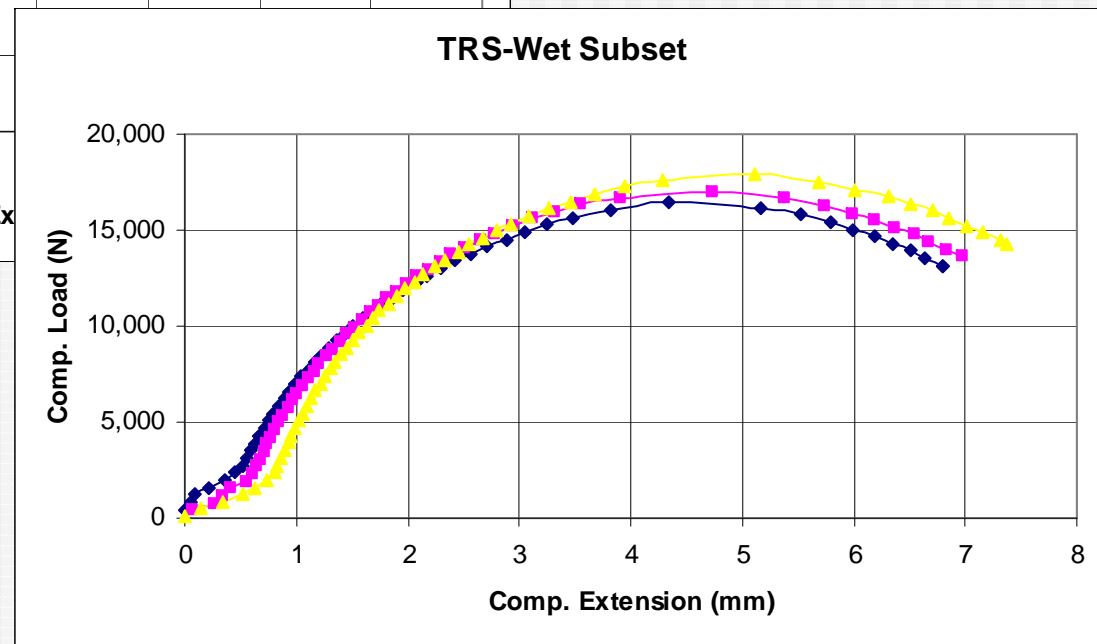
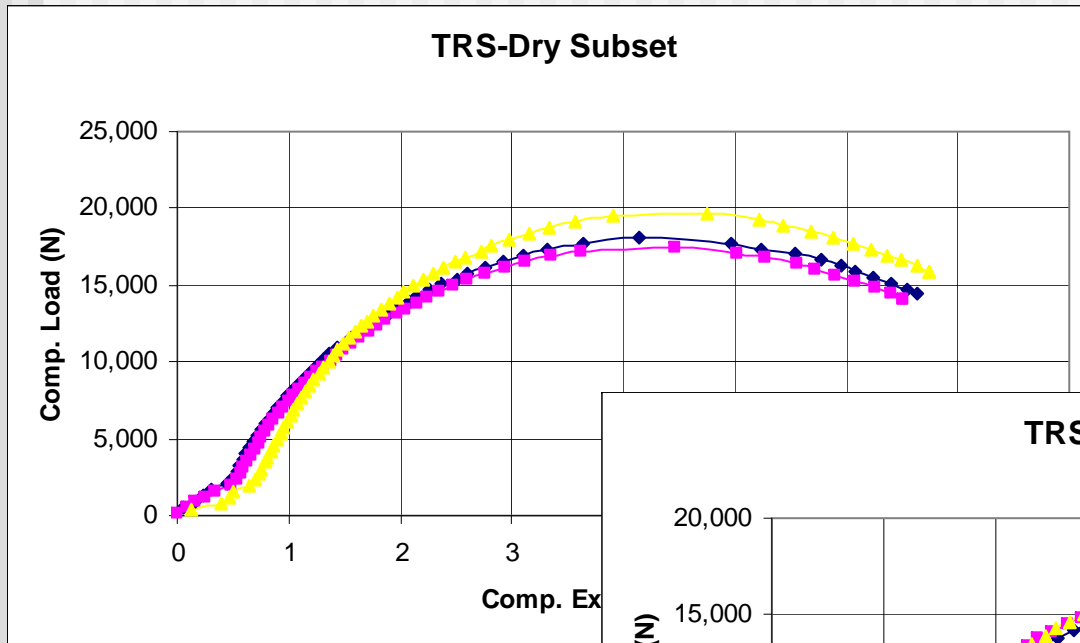
# Conditioning under Vacuum



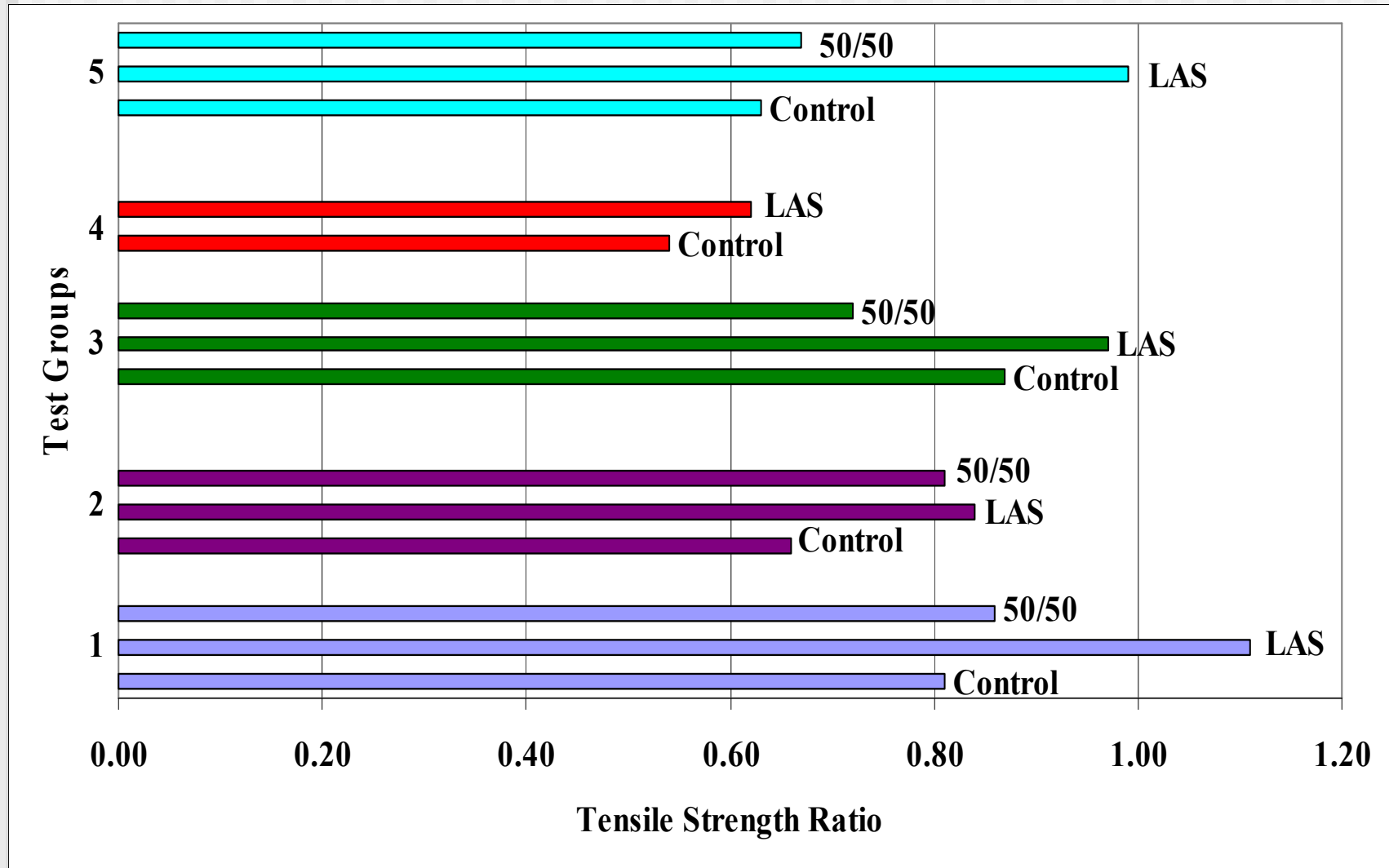
# Saturation Levels



# Tensile Strength Results



# TSR Results



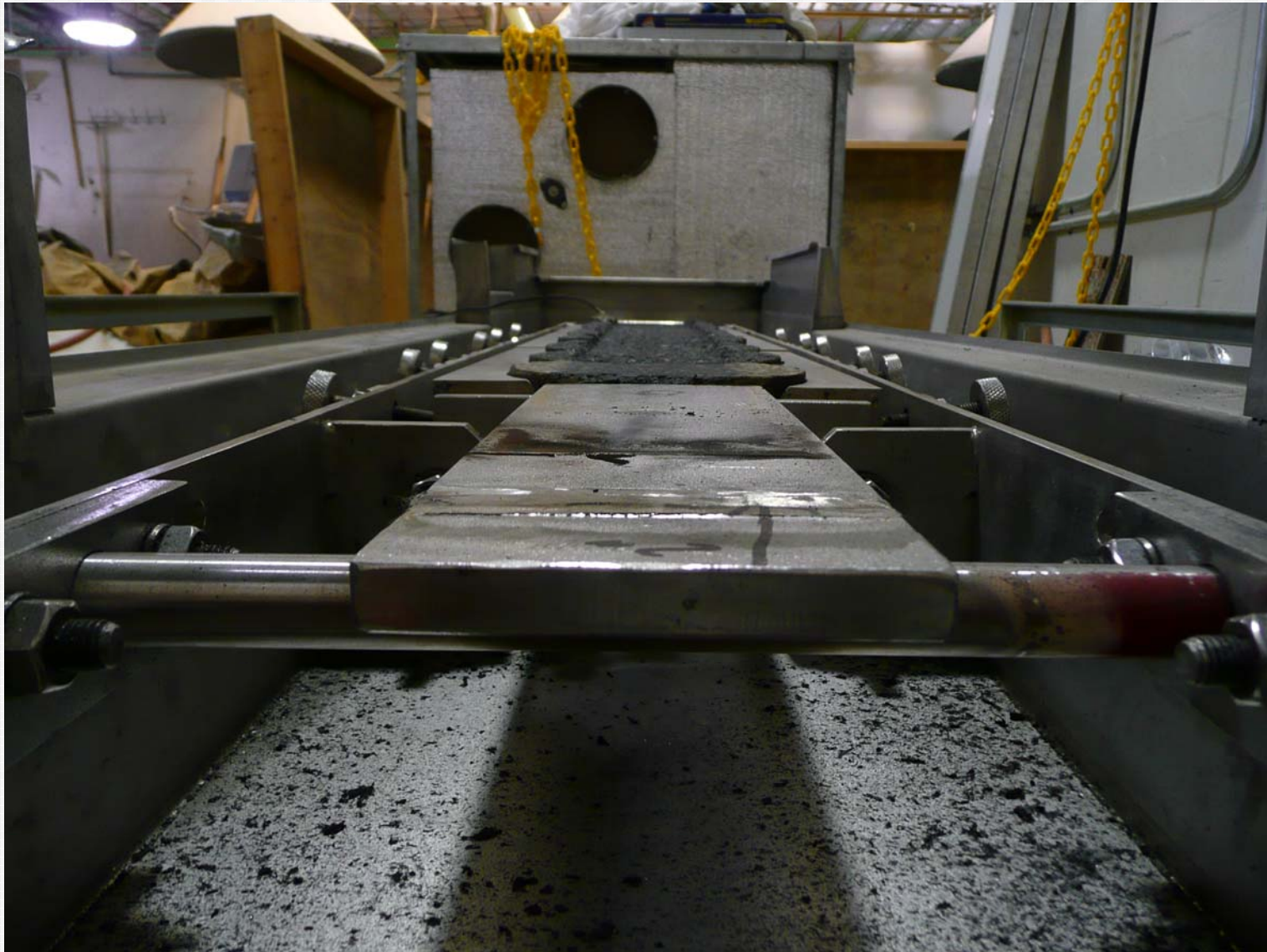
---

# **Model Mobile Load Simulator (MMLS3)**



# MMLS3 – Dry Testing

---



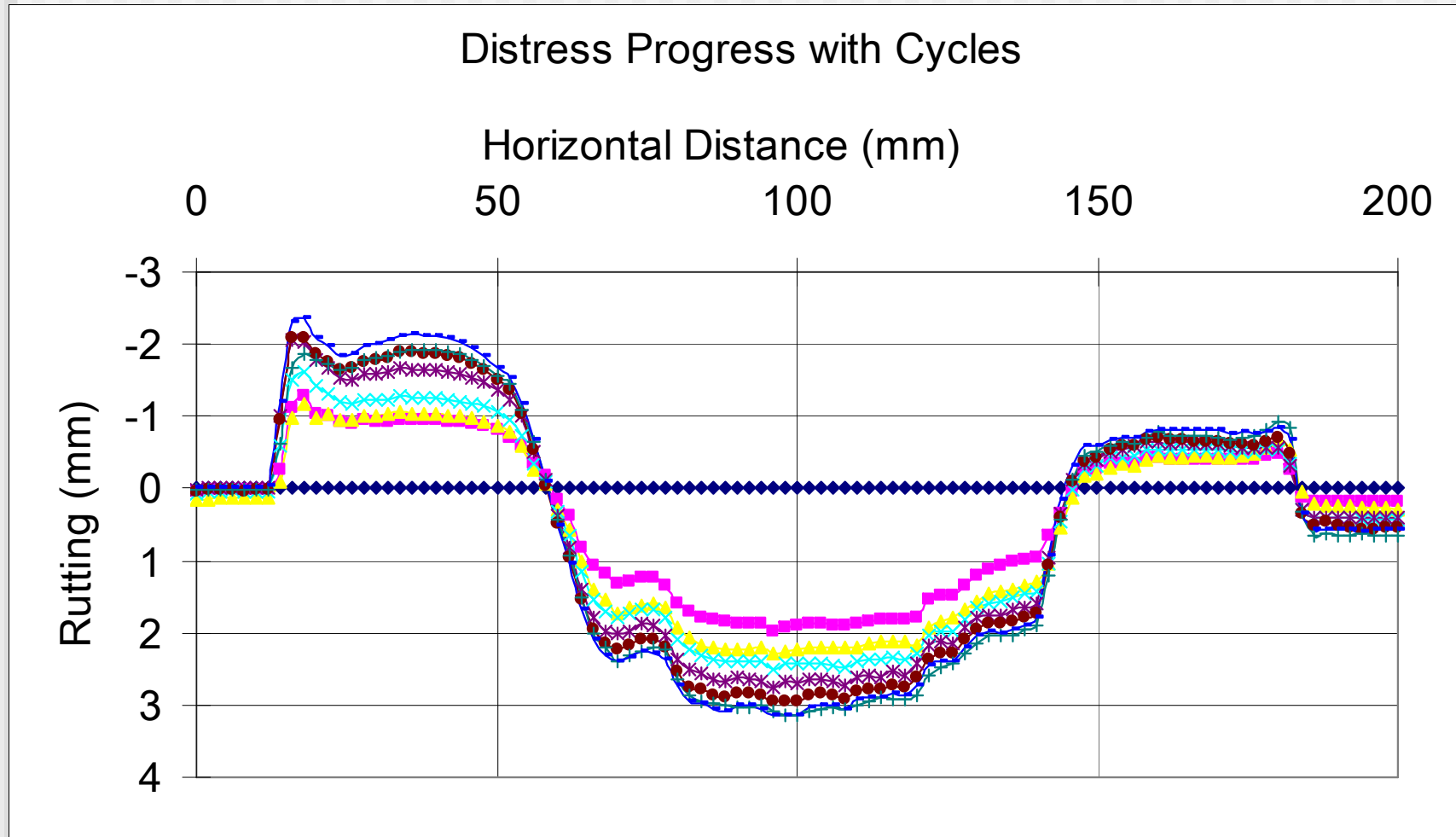
# MMLS3- Wet Testing

---





# MMLS3 – Rut Measurement

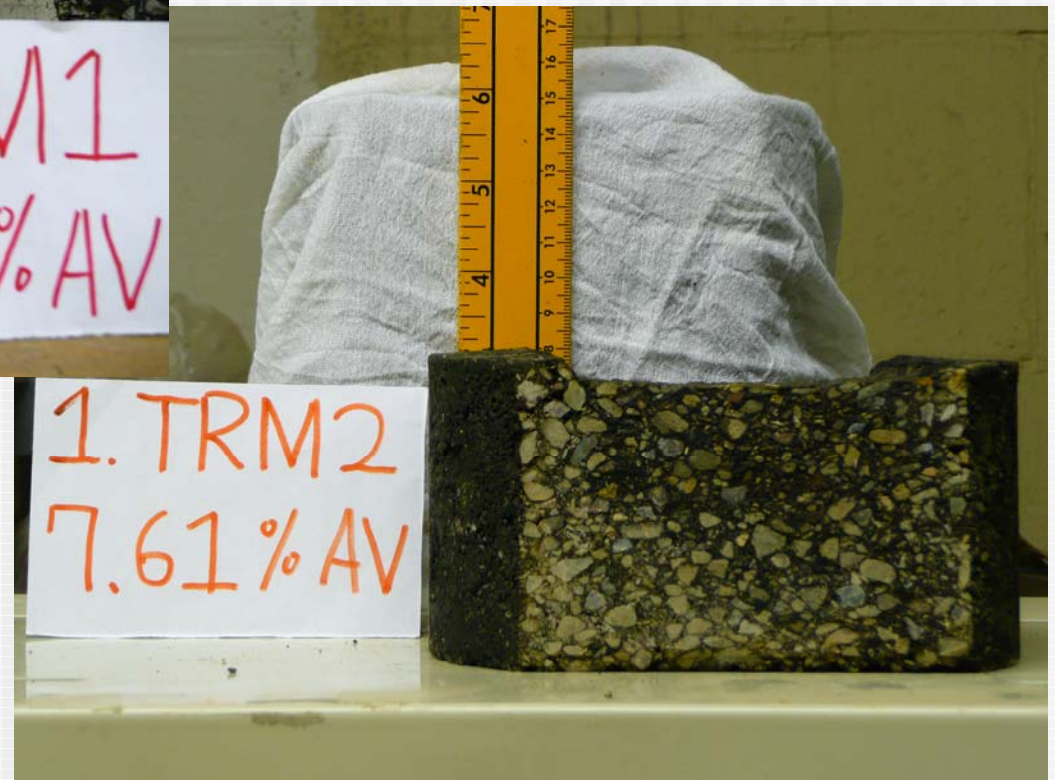


# Distress Evaluation

---



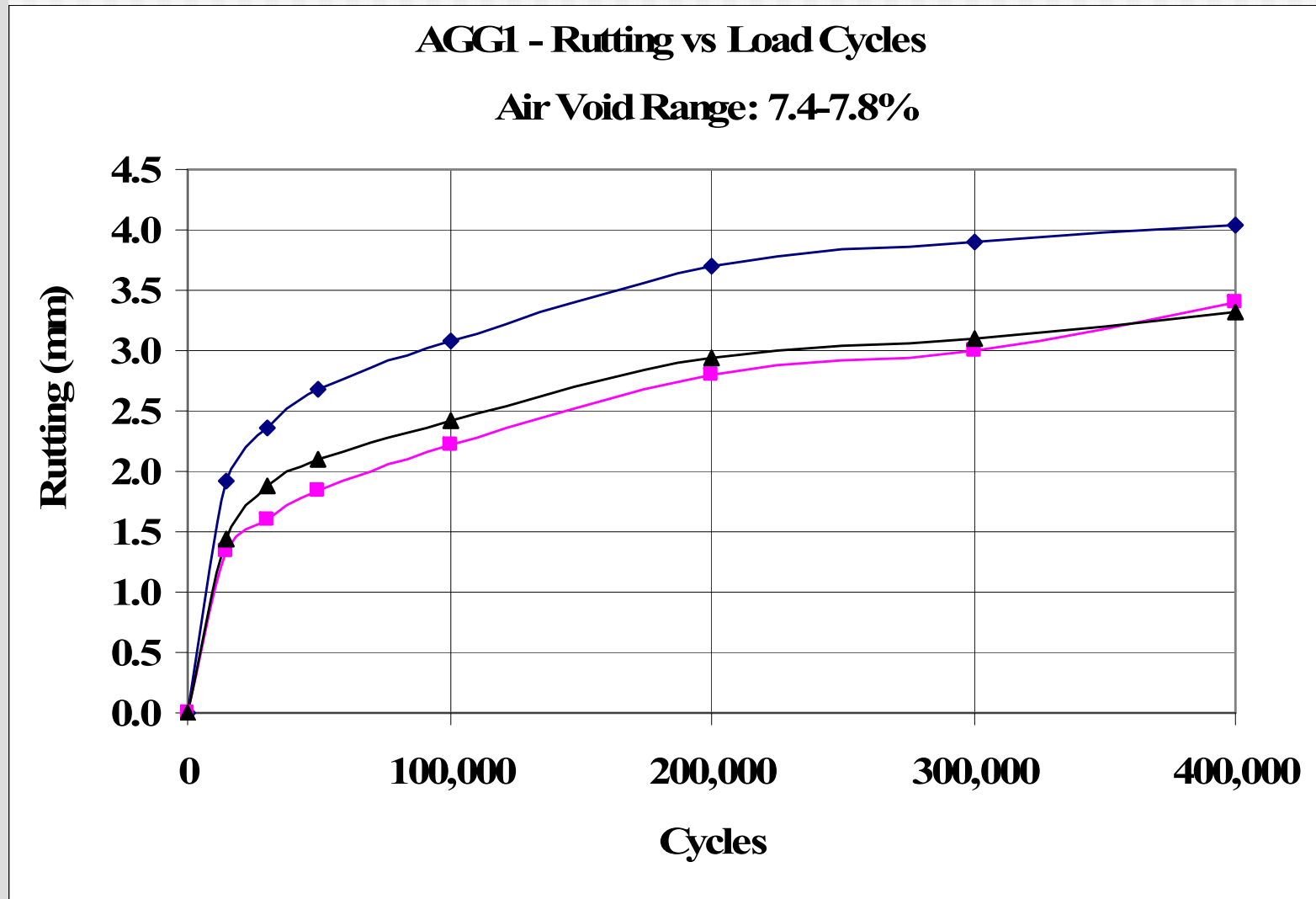
**DRY**



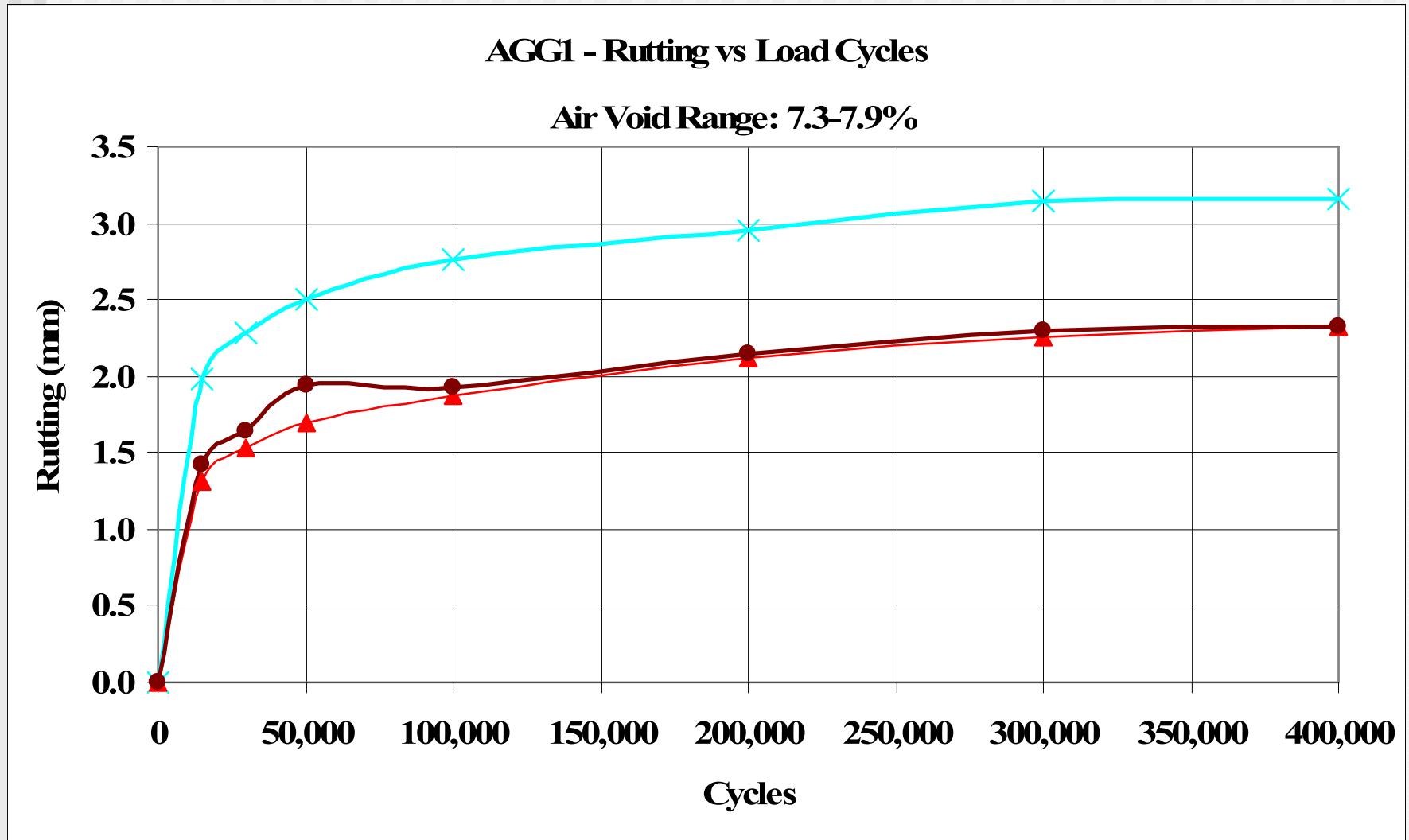
**WET**



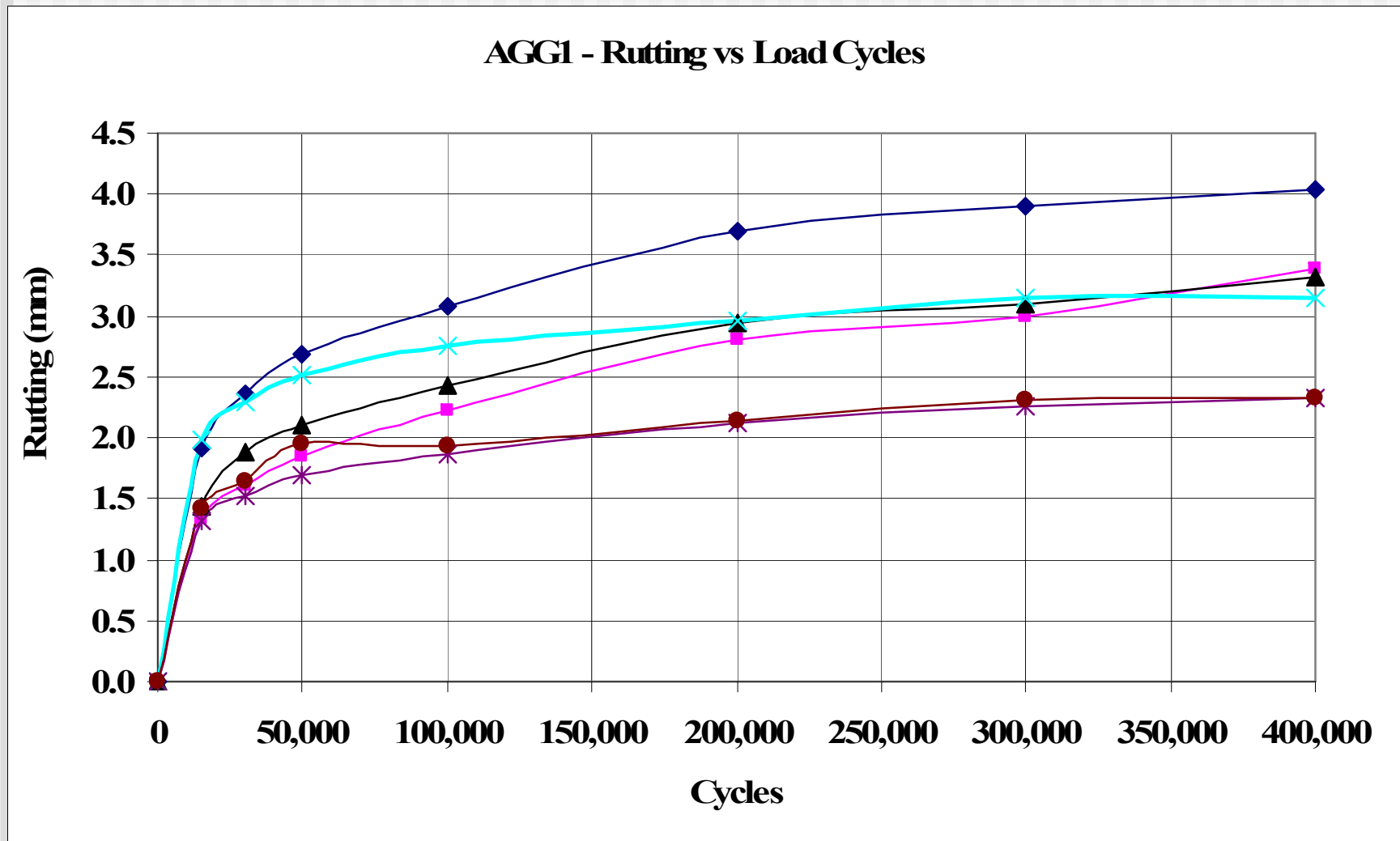
# MMLS3 – Wet Testing



# MMLS3 – Dry Testing



# MMLS3 – Dry/Wet Comparison



---

**1** Why This Research?

**2** Approach & Testing Program

**3** Analysis/Discussion

**4** Future Work

**5** Summary



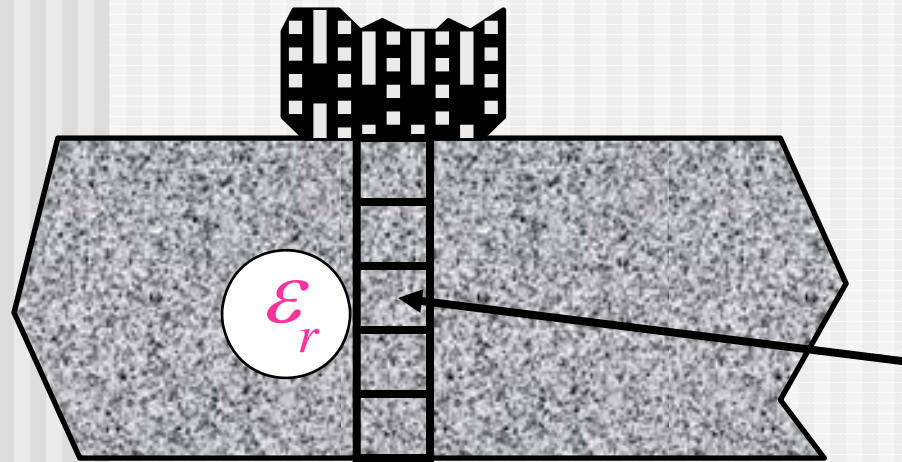
# Further Analysis with Dyn. Mod.

---

- **Modulus is the primary input to the AASHTO MEPDG rutting and fatigue models**
- **Impact of Repeated Freeze-Thaw Cycles on Modulus**
- **Effect of Levels of Moisture Damage on Pavement Life**
- **How much more rutting and cracking for a 10, 20, 30, etc percent reduction in modulus?**



# AASHTO MEPDG Rutting Model



*Field Calibrated Coefficients*

$$\epsilon_p = \epsilon_r (a_1 T^{a_2} N^{a_3})$$

*From Layered  
Elastic Analysis  
Depends on  $E^*$*

$$RD = \sum_{i=1}^k (\epsilon_p)_i h_i$$



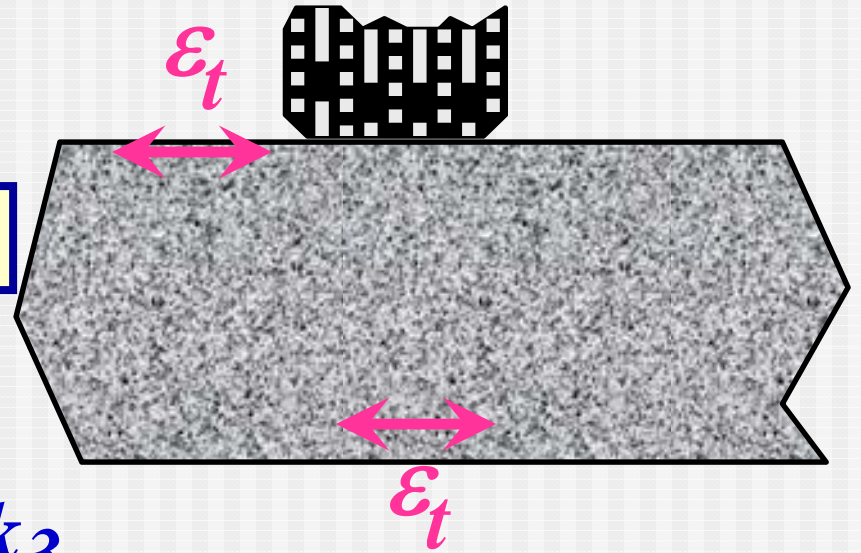


# AASHTO MEPDG Fatigue Model

*Field Calibrated Coefficients*

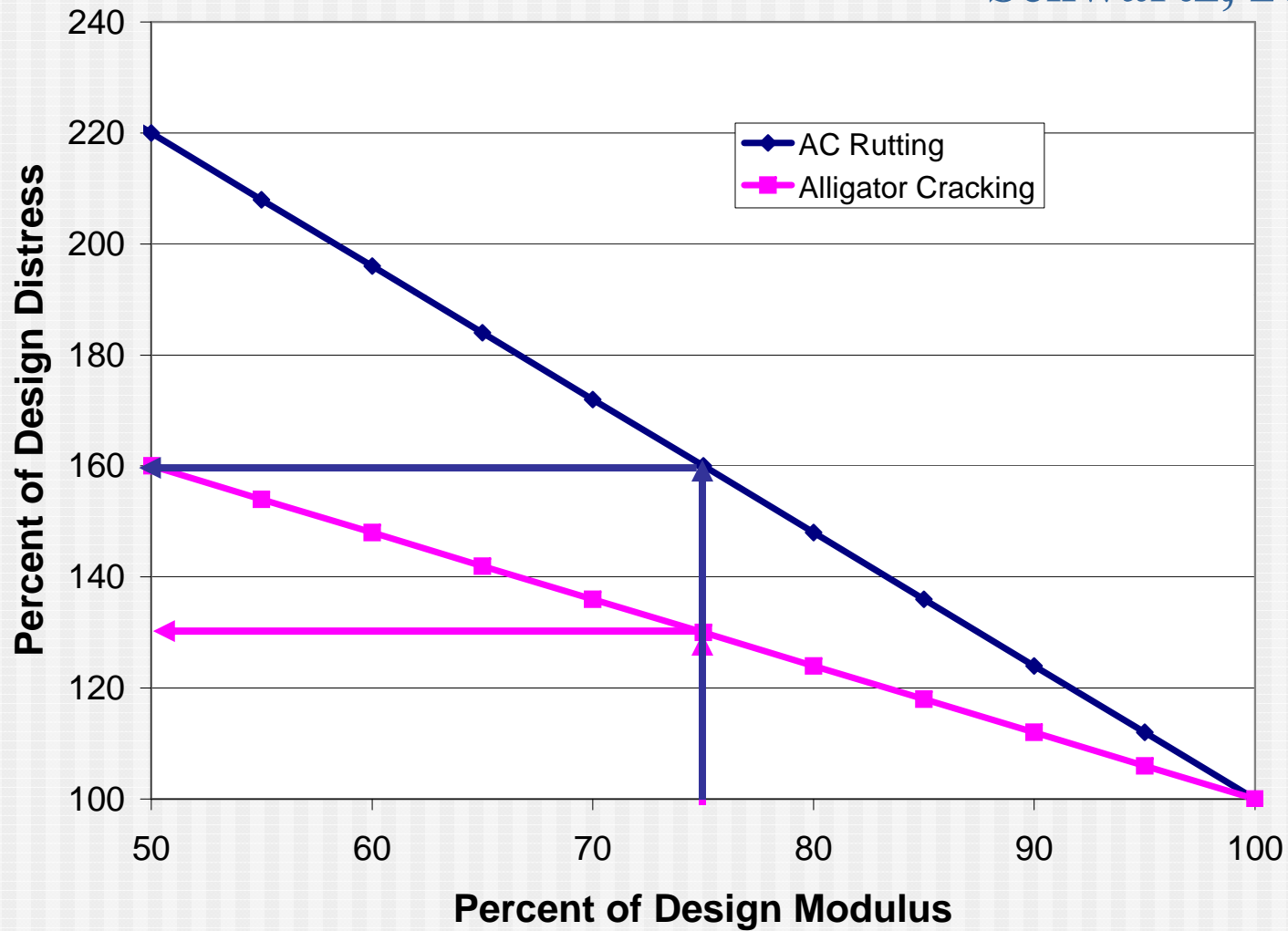
$$N_f = k_1 \left( \frac{1}{\epsilon_t} \right)^{k_2} \left( \frac{1}{E} \right)^{k_3}$$

*Stress Level Effect  
Increases With Decreasing  $E^*$*



# Further Analysis

Schwartz, 2004



# Using ECS/DM Test Set-Up?



---

**1 Why This Research**

**2 Approach & Testing Program**

**3 Analysis/Discussion**

**4 Future Work**

**5 Summary**



# Summary

---

- Type A Aggregate is Depleting in District 1-0
- Could We Utilize Type B and C Aggregates?
- Laboratory Evaluation of 5 Local Aggregates
  - Tensile Strength Ratio
  - Model Mobile Load Simulator
  - Dynamic Modulus after Repeated Freeze/Thaw



# Summary

---

- Significant Improvement with LAS
- Some Improvement with 50/50 Blend
- Evaluate Modulus Reduction with Repeated Freeze/Thaw
- Analysis of MMLS3 Data
- Utilize ECS/Dyn Mod System?



---

*Thank You!*

