Lime in Asphalt

Lime Association of Texas Workshop

Houston, TX

April 9, 2014

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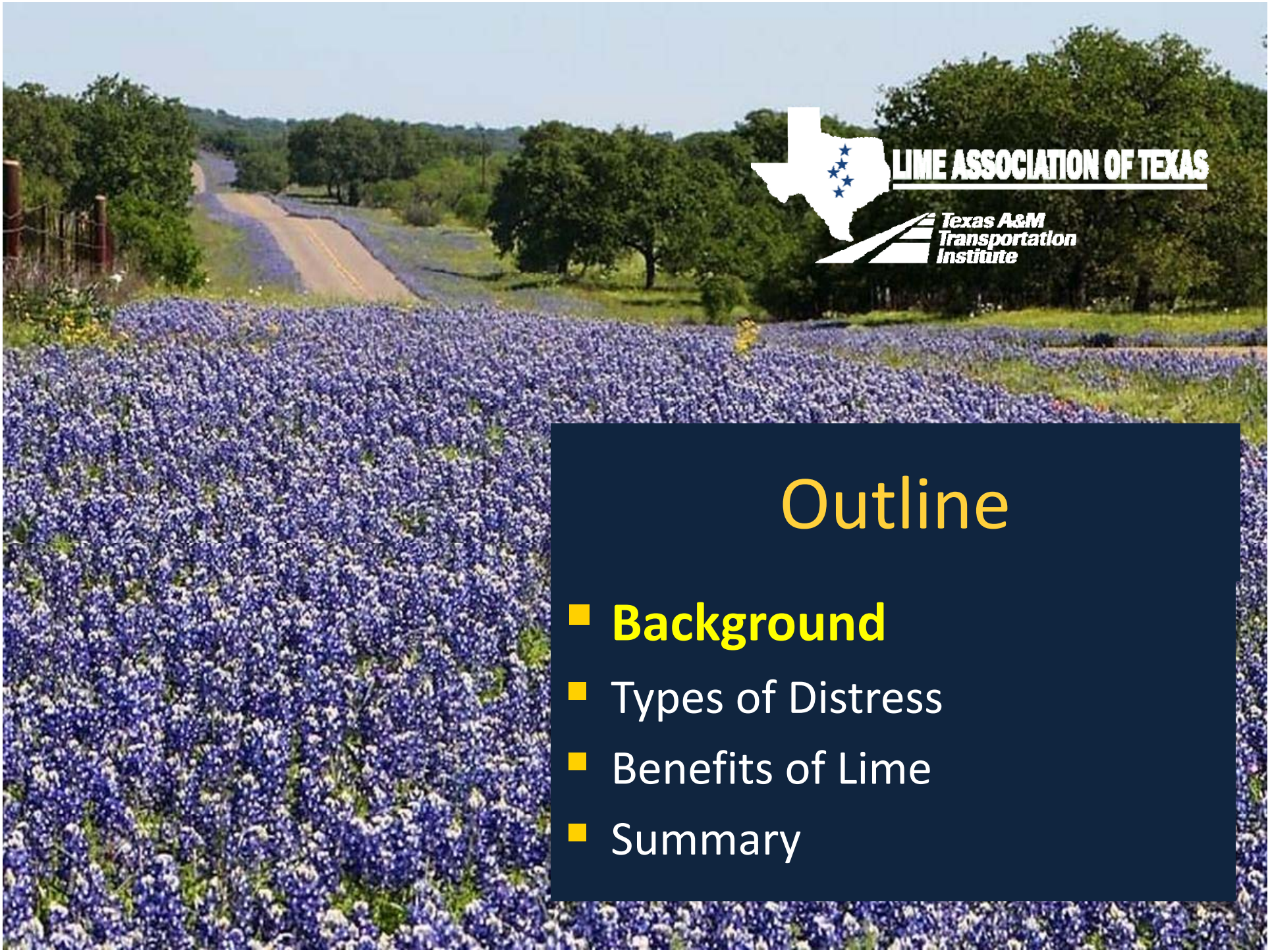

Outline

- **Background**
- Types of Distress
- Benefits of Lime
- Summary

Long Life Pavement
(5 to 40 Years Increase in Life)

- Minimize Premature Pavement Distress
- Minimize Rehabilitation and Maintenance
- Minimize User Inconvenience (Customer Focused Construction)
- Todays Technology/Materials /Contractors
- Safe Driving Surface

Design Considerations

- Safety
- Thickness
- Mixture

Safety

- Work Zone
- Surface Properties
  - Friction
  - Drainage
  - Splash and Spray
  - Noise

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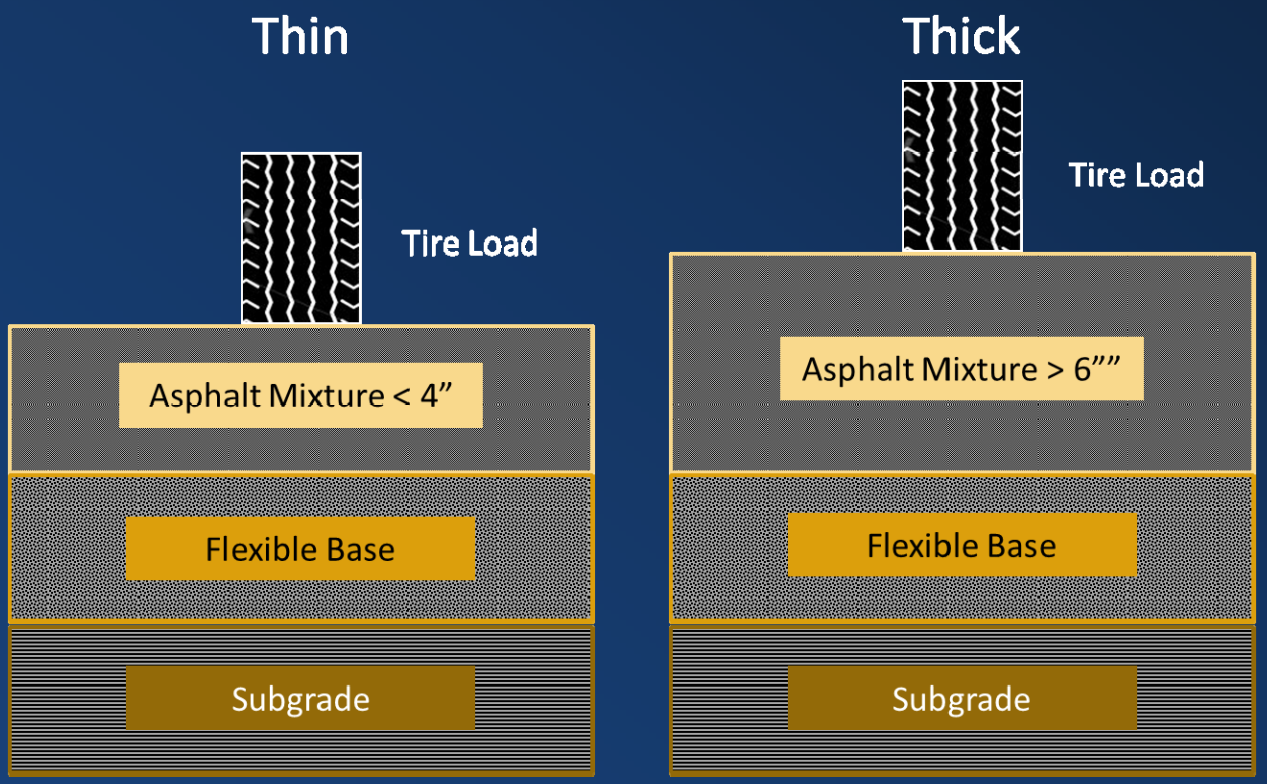
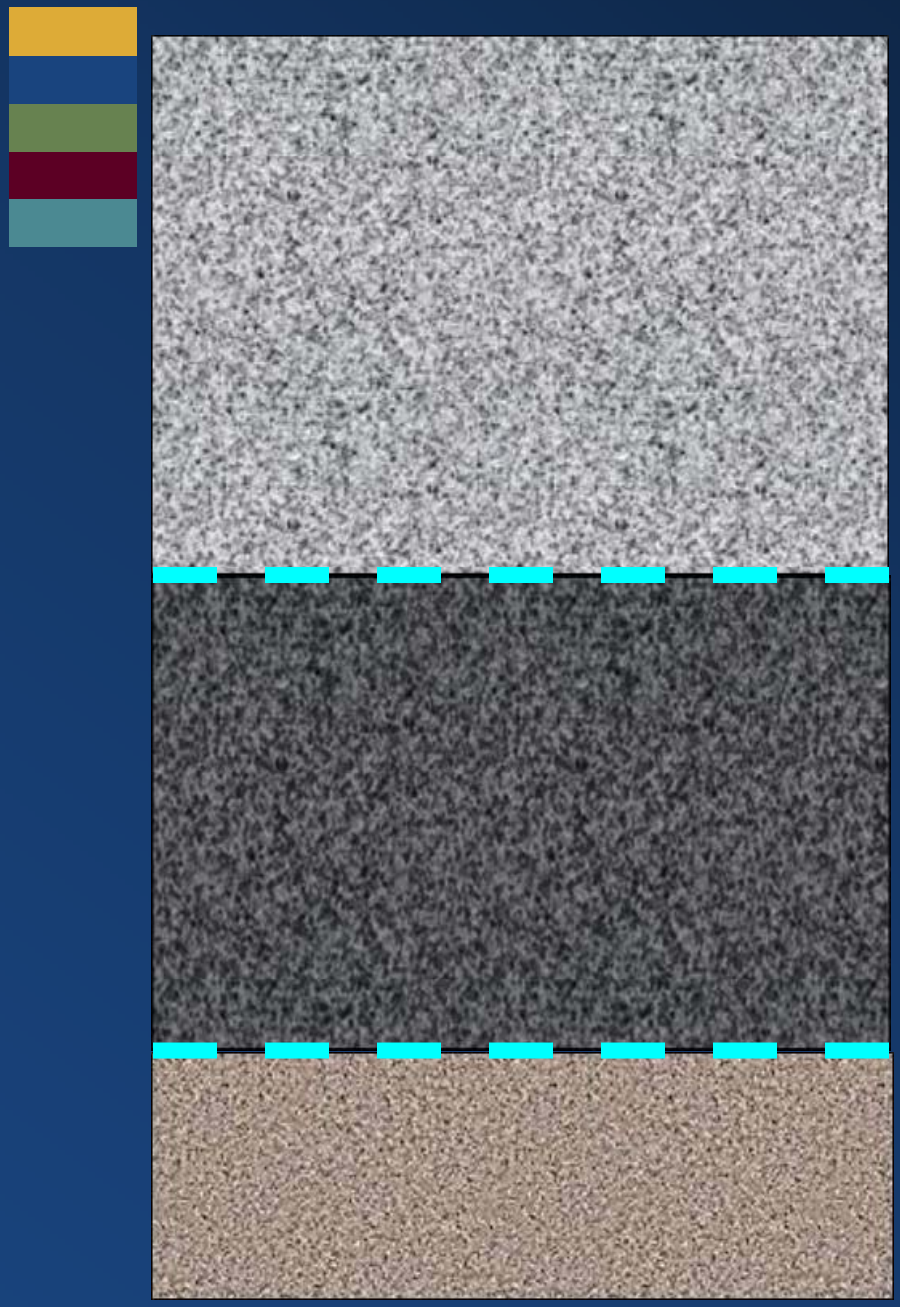
Thickness Design

- Fatigue Limit
- Select Mixture for Different Depth in Pavement Structure





- Friction/Splash/Spray /Noise
- Permanent deformation
- Thermal cracking
- Water Susceptibility

- Stiffness
- High RAP/RAS
- Permanent deformation

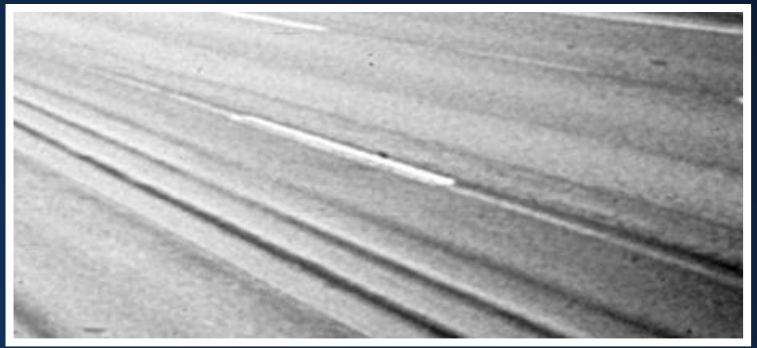
- Fatigue resistance
- Water susceptibility

MIXTURE DESIGN

- Mixture design test parameters use for structural design input
- Designs for different traffic level and climates
- Specific mixtures for different layers in pavement
- Nominal maximum aggregate size
- Proper use of recycled materials
- Lab mix-lab compacted vs plant mix-field compacted

Mixture/Structural Design

- Stiffness
- Rutting
- Fatigue
- Thermal cracking
- Water susceptibility
- Aging
- Lab mix-lab compacted vs plant mix-field compacted



Recycled Materials

- RAP/RAS binder stiffness
- Uniformity of RAP/RAS
- Cracking-fatigue, thermal, reflection
- Aging

Lime in Asphalt

- Several states require lime in all asphalt mixtures
- 5-10% of all asphalt mixtures contain lime
- 150,000 tons of lime used in asphalt mixture per year

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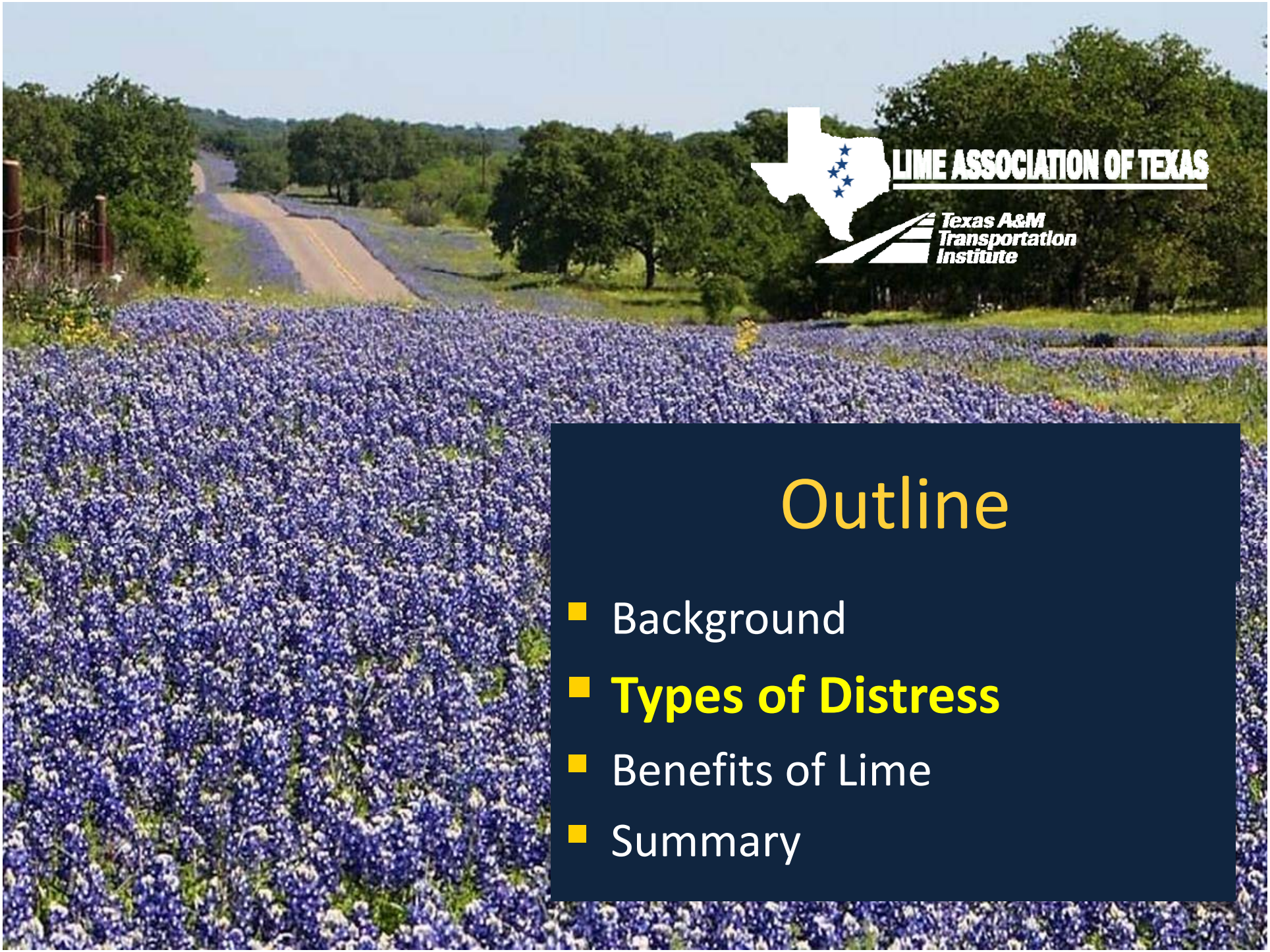
Summary-Design

- Safe surfaces-friction, drainage, splash-spray, noise
- Specific mixtures for different layers
- Proper use of recycled materials





Outline

- Background
- **Types of Distress**
- Benefits of Lime
- Summary

Pavement Performance Problems

- Raveling
- Bleeding/Flushing
- Rutting/Shoving
- Alligator Cracking
- Transverse Cracking
- Longitudinal Cracking
- Reflection Cracking
- Localized Distress

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Raveling

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Raveling

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Bleeding

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Bleeding

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Permanent Deformation

High T, Large Load,
Sustained/Slow Loading (Large t)
Decreases w/Aging

Rutting and Shoving

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Shoving

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Fatigue Cracking

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Fatigue Cracking

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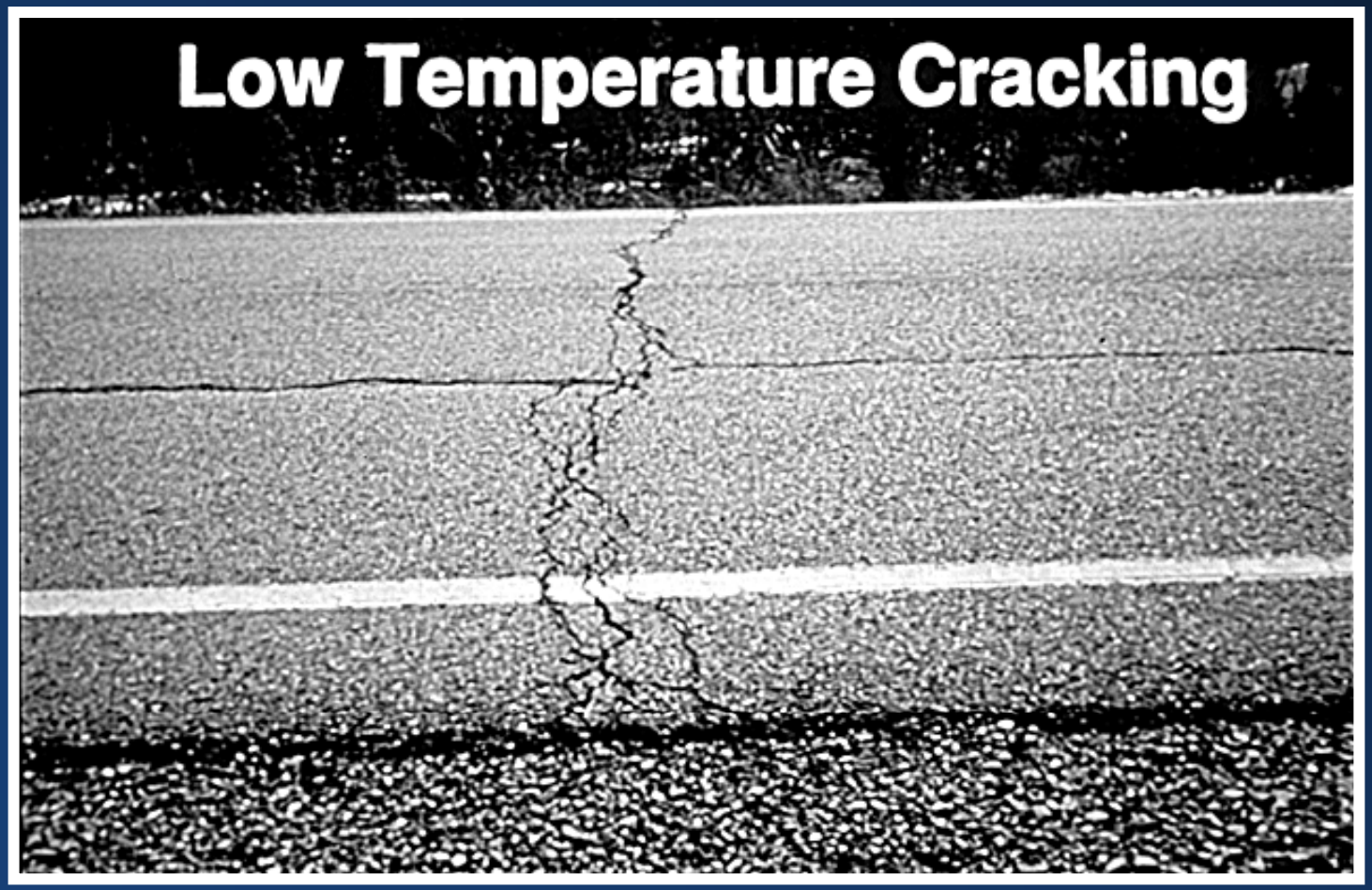
Fatigue Cracking

Intermediate T, Repeated Loading, Fast
Loading (Small t)
Increases w/Aging

Thermal Cracking



Low T, Large ΔT, Rapid Loading (Small t)
Increases w/Aging

Thermal Cracking

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Longitudinal Cracking

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Joint Reflective Cracking

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Stripping

Patching

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Crack Sealing

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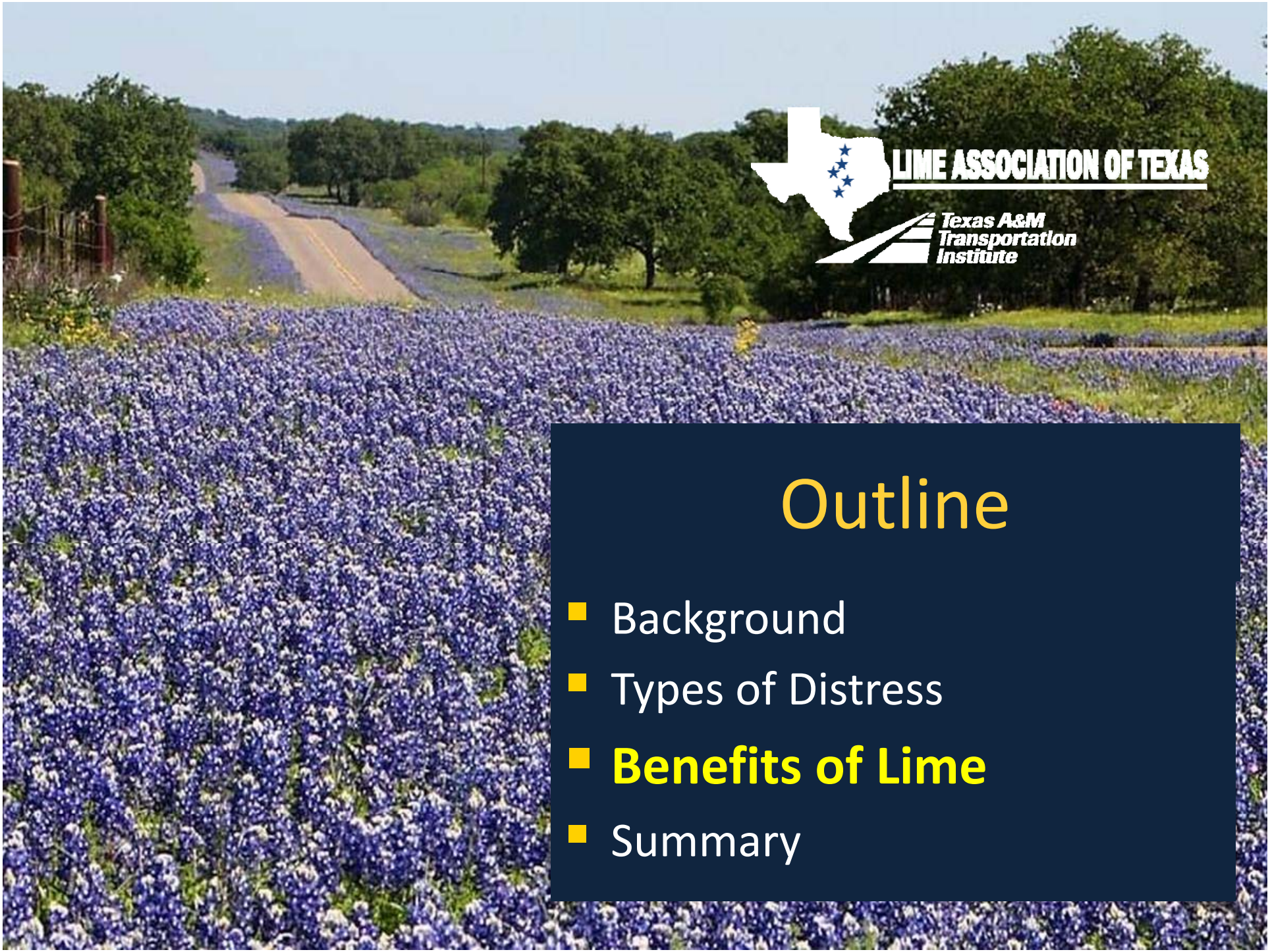

Outline

- Background
- Types of Distress
- **Benefits of Lime**
- Summary

Benefits of Using Lime

- Reduce Water Susceptibility
- Reduce Aging
- Increase Stiffness of Mixture
- Reduce Plastic Index

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Loss of Bond
Loss of Strength

- Water sensitivity
- Water susceptibility
- Stripping

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Stripping

- Loss of adhesion between aggregate surface and asphalt cement in the presence of moisture

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Stripping Potential Controlled by:

- Asphalt cement properties
- Aggregate properties
- Mixture characteristics
- Climate
- Traffic
- Construction practices
- Pavement design consideration

Asphalt Cement Properties

- Physical properties
- Viscosity
- Temperature
- Adhesive ability
- Chemical properties

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Aggregate Properties

- Shape and surface texture
- Gradation
- Fines content & properties
- Coating
- Absorption
- Surface chemistry

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Mixture Characteristics

- Asphalt cement content
- Aggregate gradation
- Air voids content
- Strength

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Hot-Wet

Southeast US

- High temperature-low viscosity
- Moisture in summer
- Bleeding
- Blistering

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Cold-Dry

Freeze-Thaw Cycles

- Several days of moisture
- Daily freeze-thaw cycles
- Water expansion
- Brittle asphalt

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Traffic

- Volume – ADT
- Heavy vehicles

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Construction Practices

- Quality control
- Compaction - air voids
- Joint density & segregation
- Time of year

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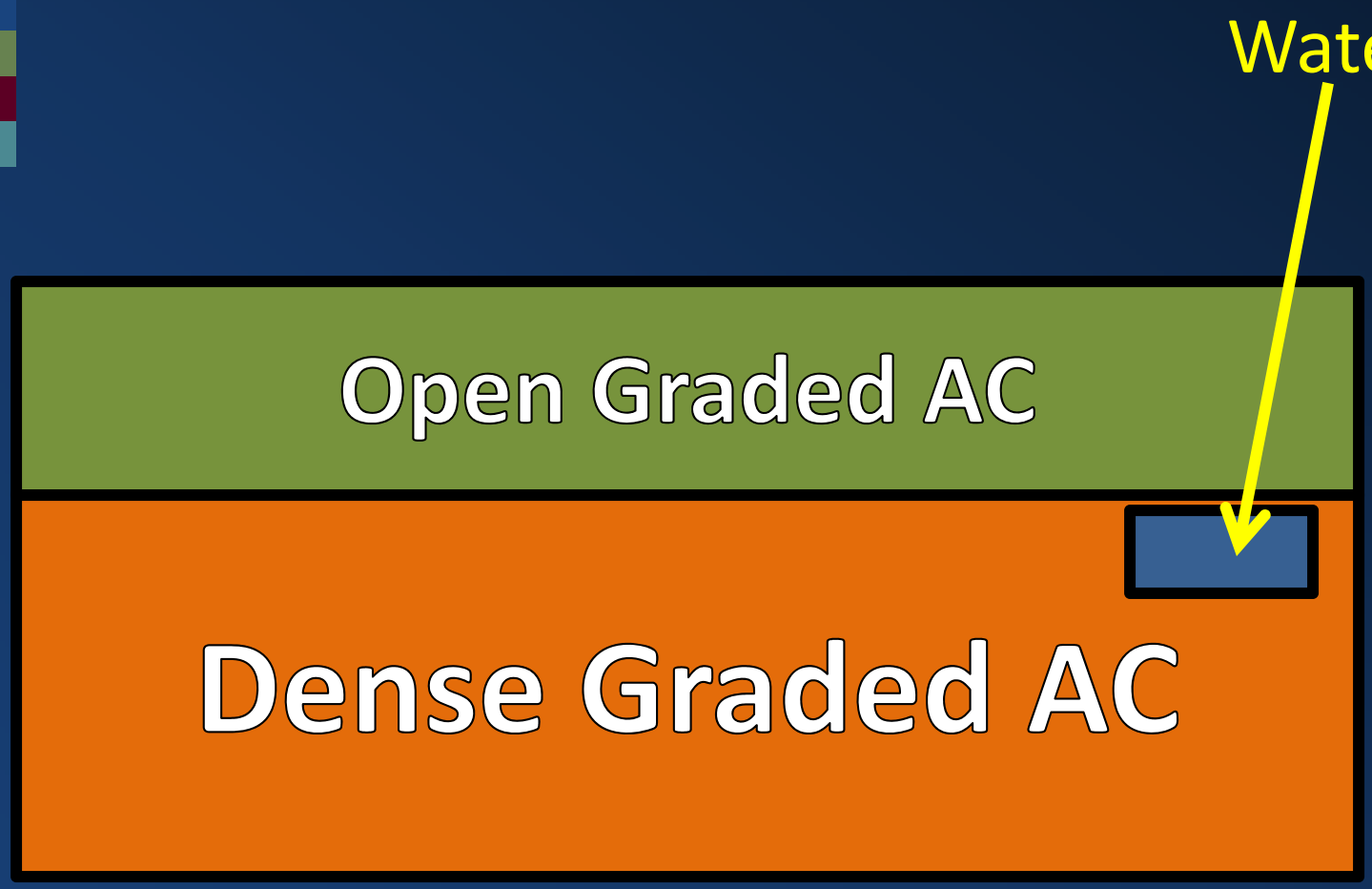

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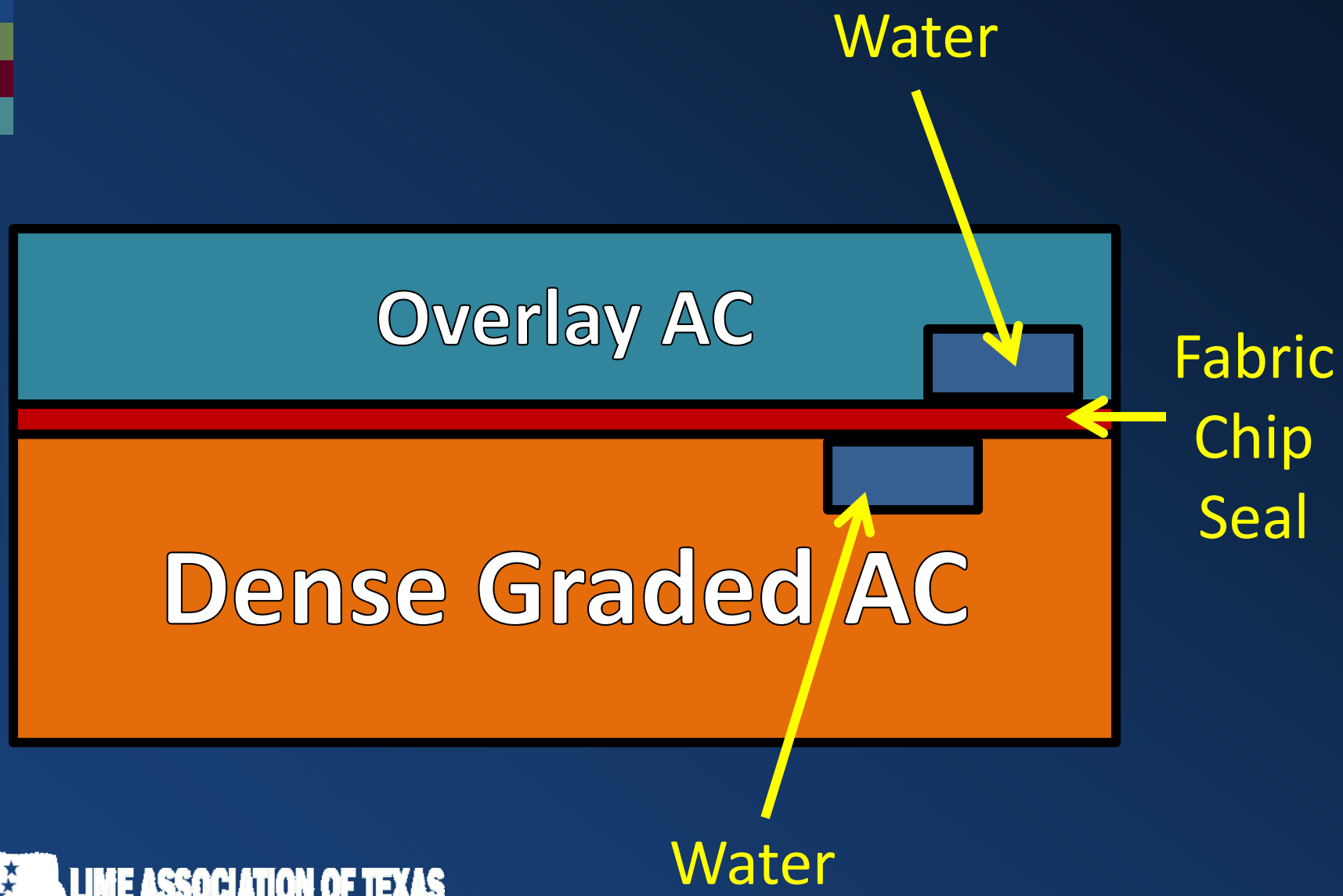

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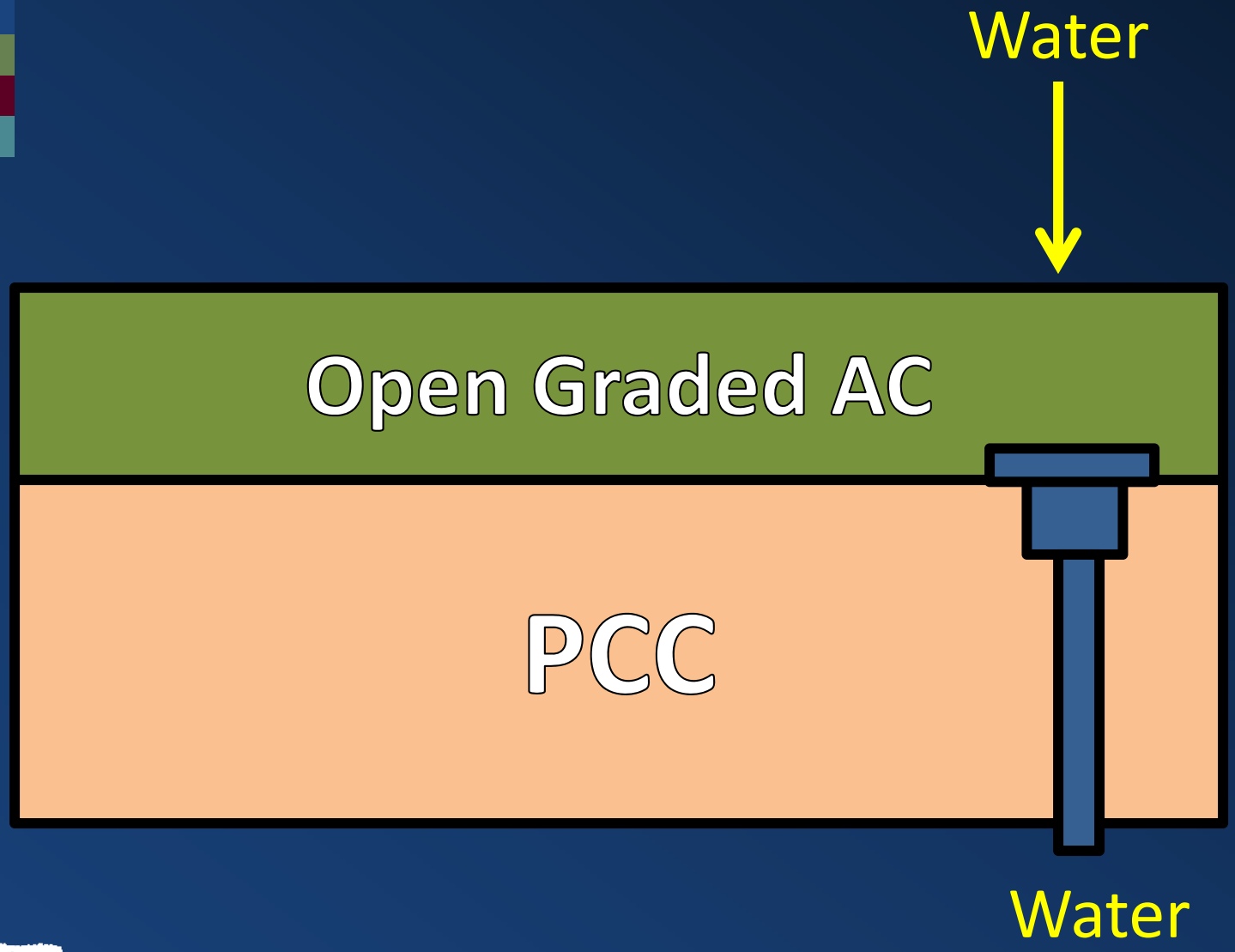

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Water Susceptibility

- Water sensitivity
- Stripping
- Water damage
- Loss of Strength in the presence of moisture
  - Adhesion between asphalt binder and aggregate
  - Loss of strength in asphalt binder

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Anti-Strip Agents

- Liquids-amines/di-amines
- Solids-lime/portland cement/by-products

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Antistrip Additives
Liquid Antistrip Agents

- Chemical Compounds Containing Amines (Basic Compounds Derived from Ammonia)
- Heat Stability
- 0.5 % Generally
- May Change AC Properties (Soften)
- Heat AC, Add Liquid Antistrip, Mix for 2 Min

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Antistrip Additives
Lime

- Hydrated Lime - Ca(OH)
- Bonding of the Calcium with the Silicates in Aggregate
- And/or Interaction or Modification of the Acidic Portions of AC
- 1 to 1.5% Generally
- Dry Mixed w/ Hot Aggregate or Damp Aggregate Immediately before AC Added and Mixed

Water Sensitivity-Tests

- Boil Test (ASTM D3625)(Tex-503-C)
- Immersion Compression (ASTM D1075)
- Tensile Strength Ratio (AASHTO T 283)
- Hamburg (Tex-242-F)

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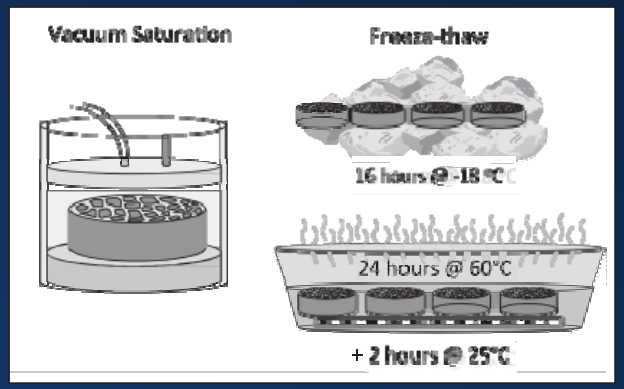
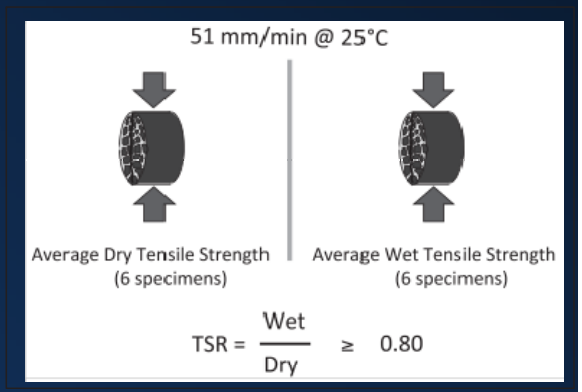
TSR and Hamburg

- AASHTO T283 Modified Lottman Test (TSR)
  - 1 Freeze-Thaw (F/T) Cycle

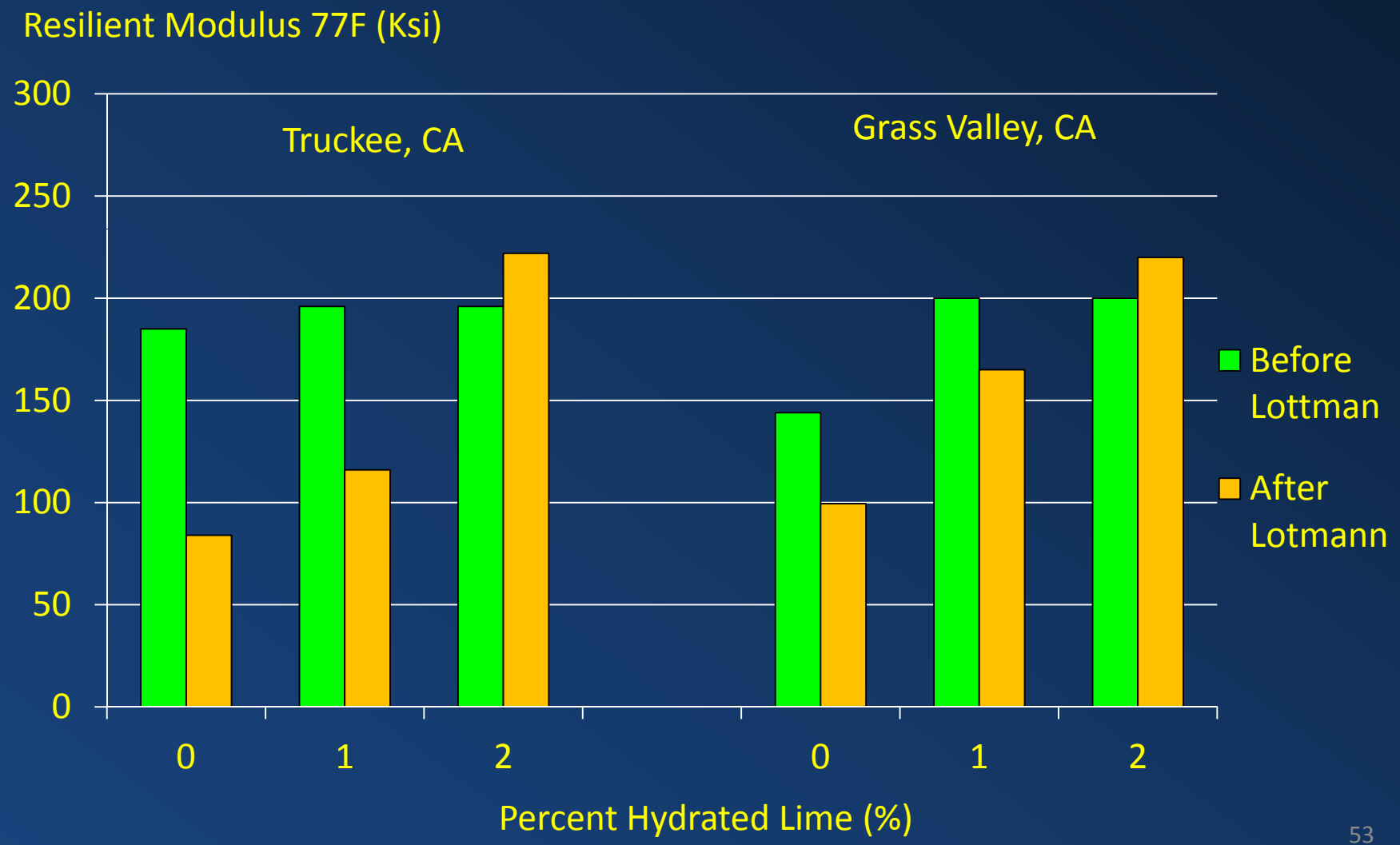




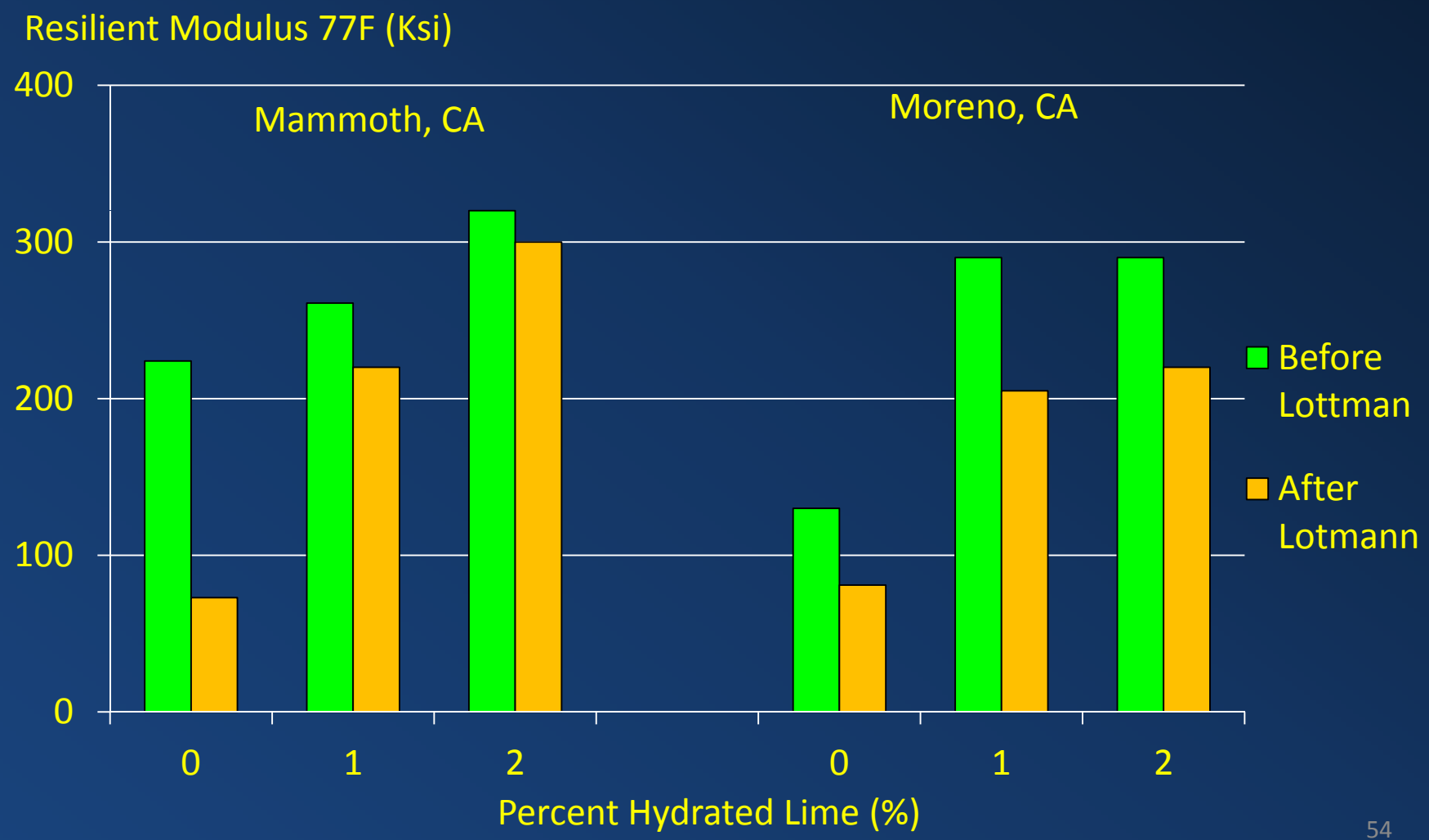
- Resilient Modulus Test (M_R)

- Hamburg Wheel-Tracking Device (HWTT)

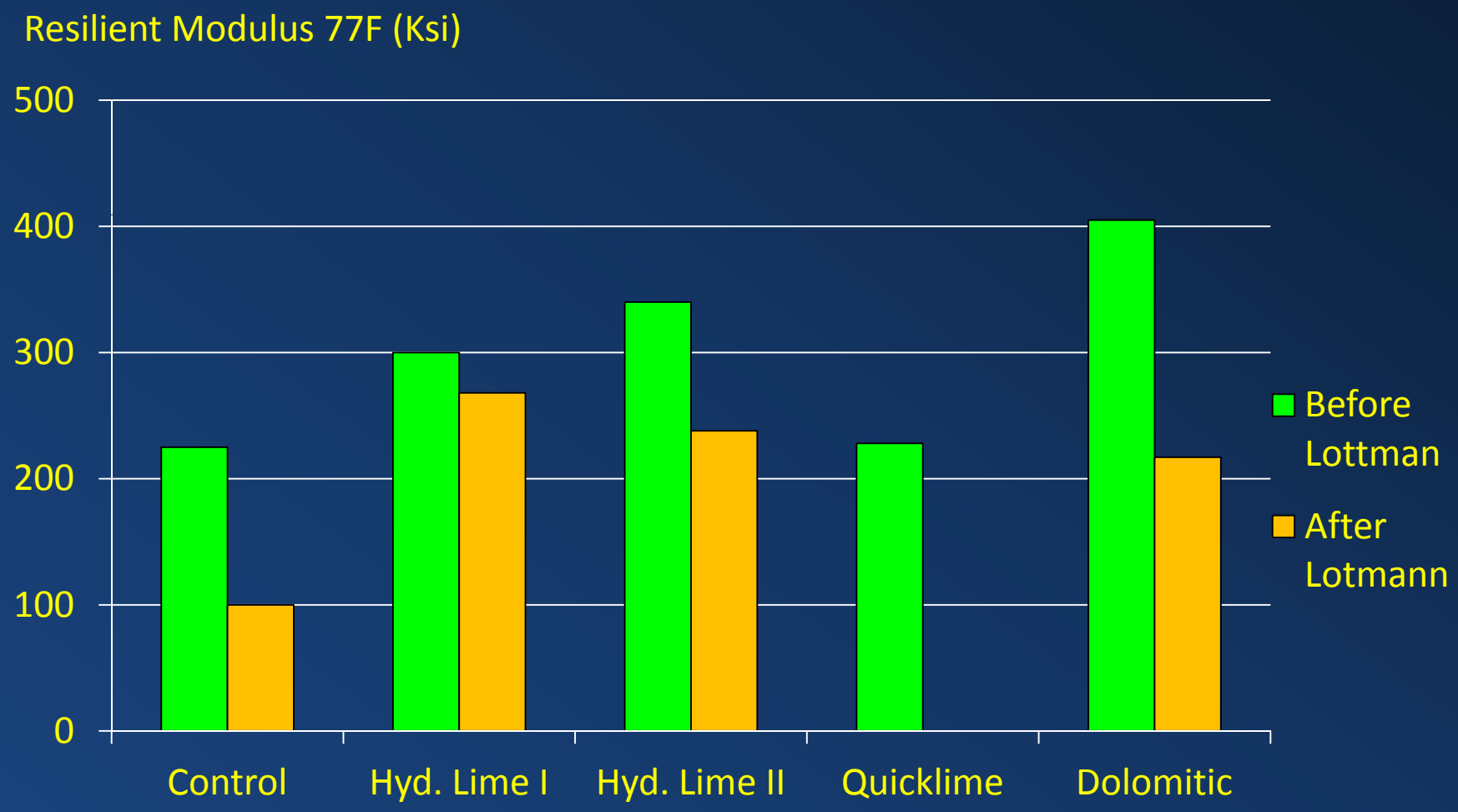
Resilient Modulus Test Results University of Nevada, Reno Study



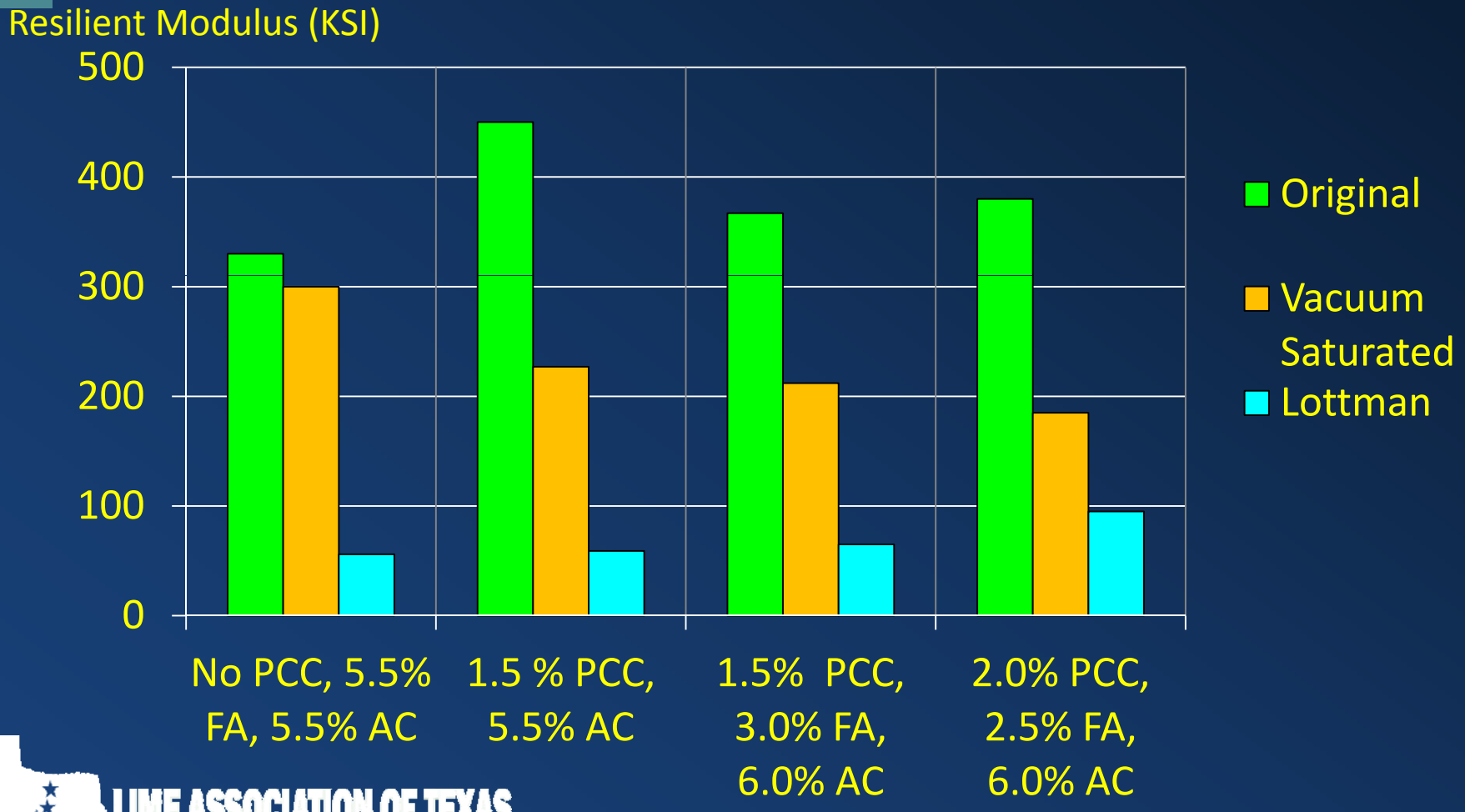
Resilient Modulus Test Results University of Nevada, Reno Study



Types of Lime Added to Dry Aggregate University of Nevada, Reno Study



Deeth Reconstruction
State of Nevada Test Results



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Water Sensitivity

- After asphalt chemistry
- After aggregate surface chemistry
- After coatings

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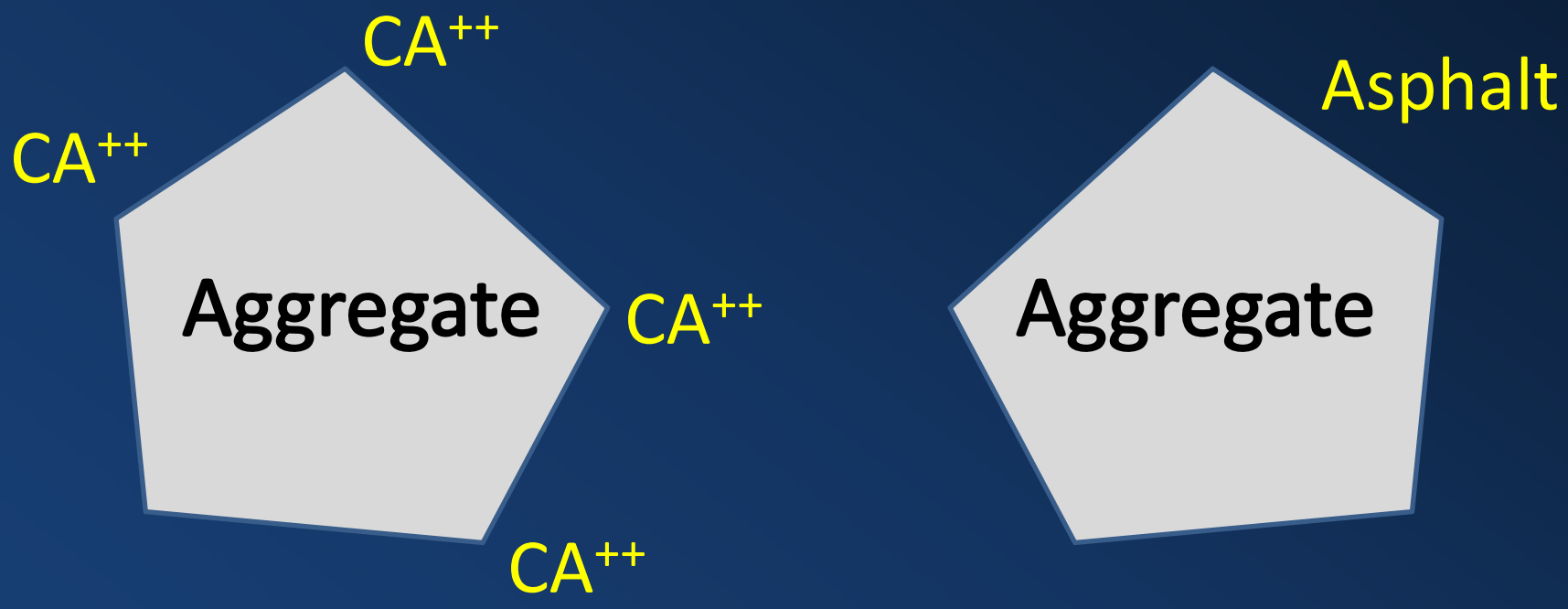
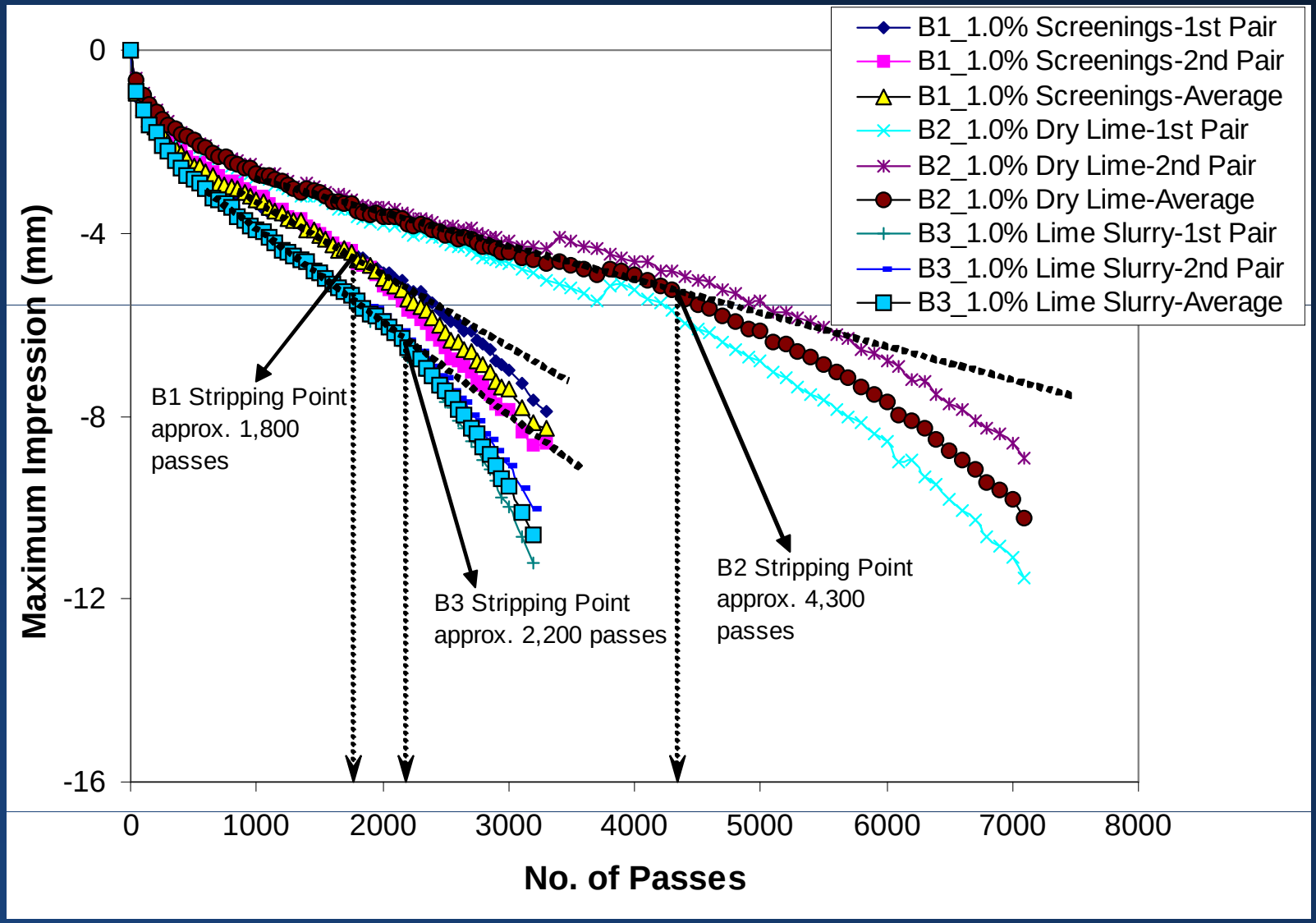
After Aggregate Surface

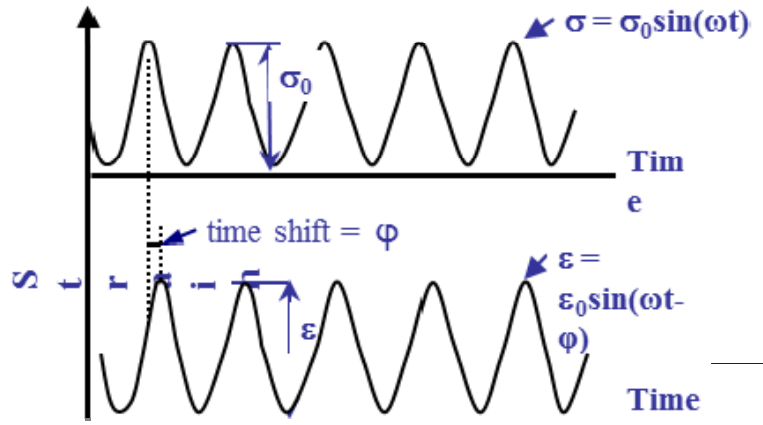


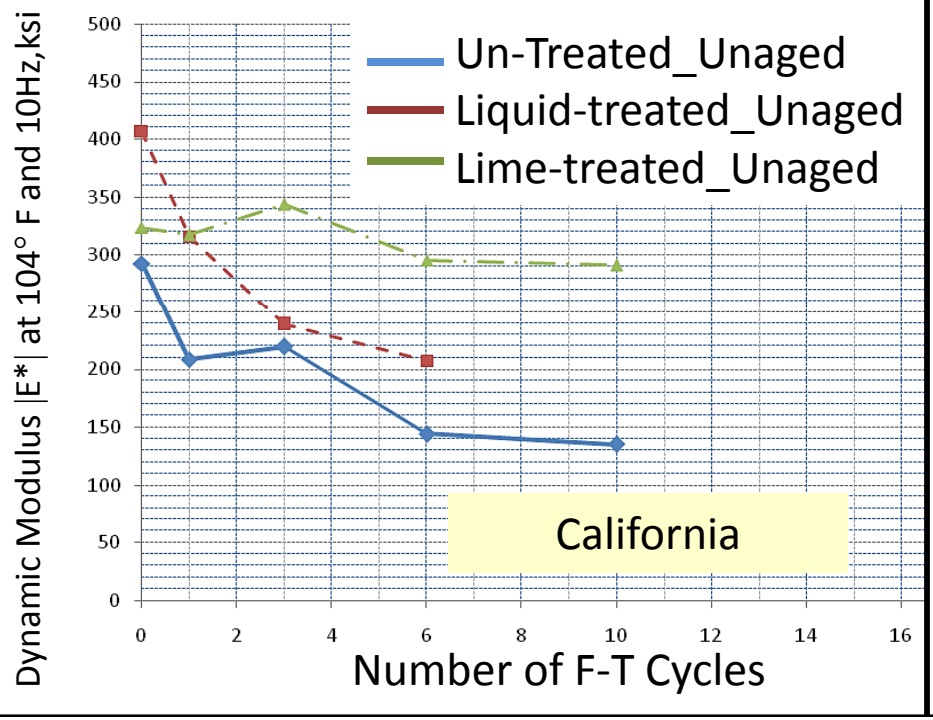
- Initial coating
- Long term coating
- Adhesion cohesion

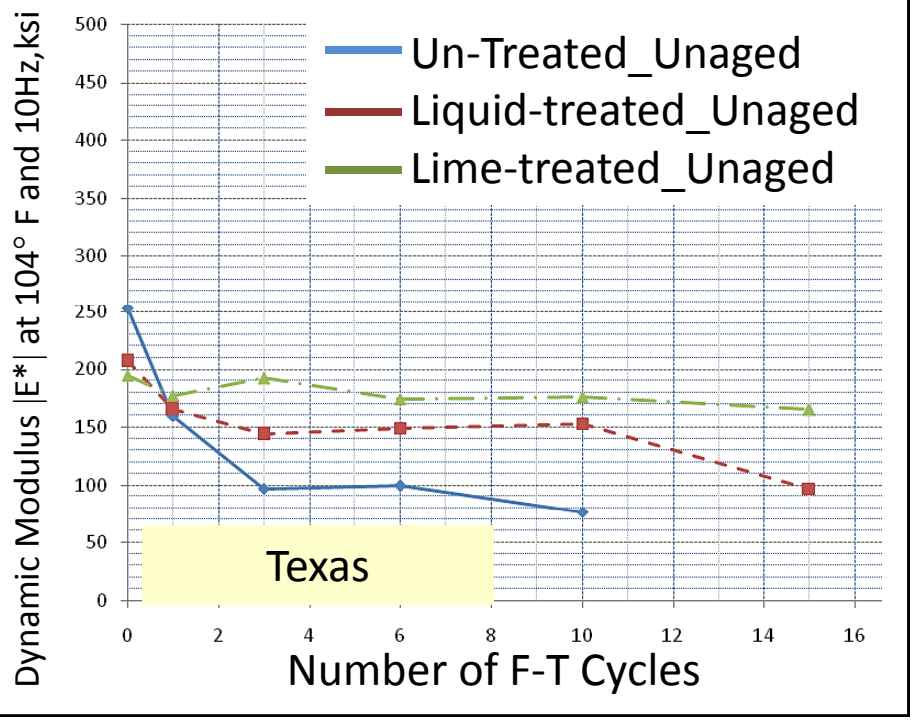
Hamburg Test Results (Nebraska Study)



Moisture Sensitivity Dynamic Modulus (E*)

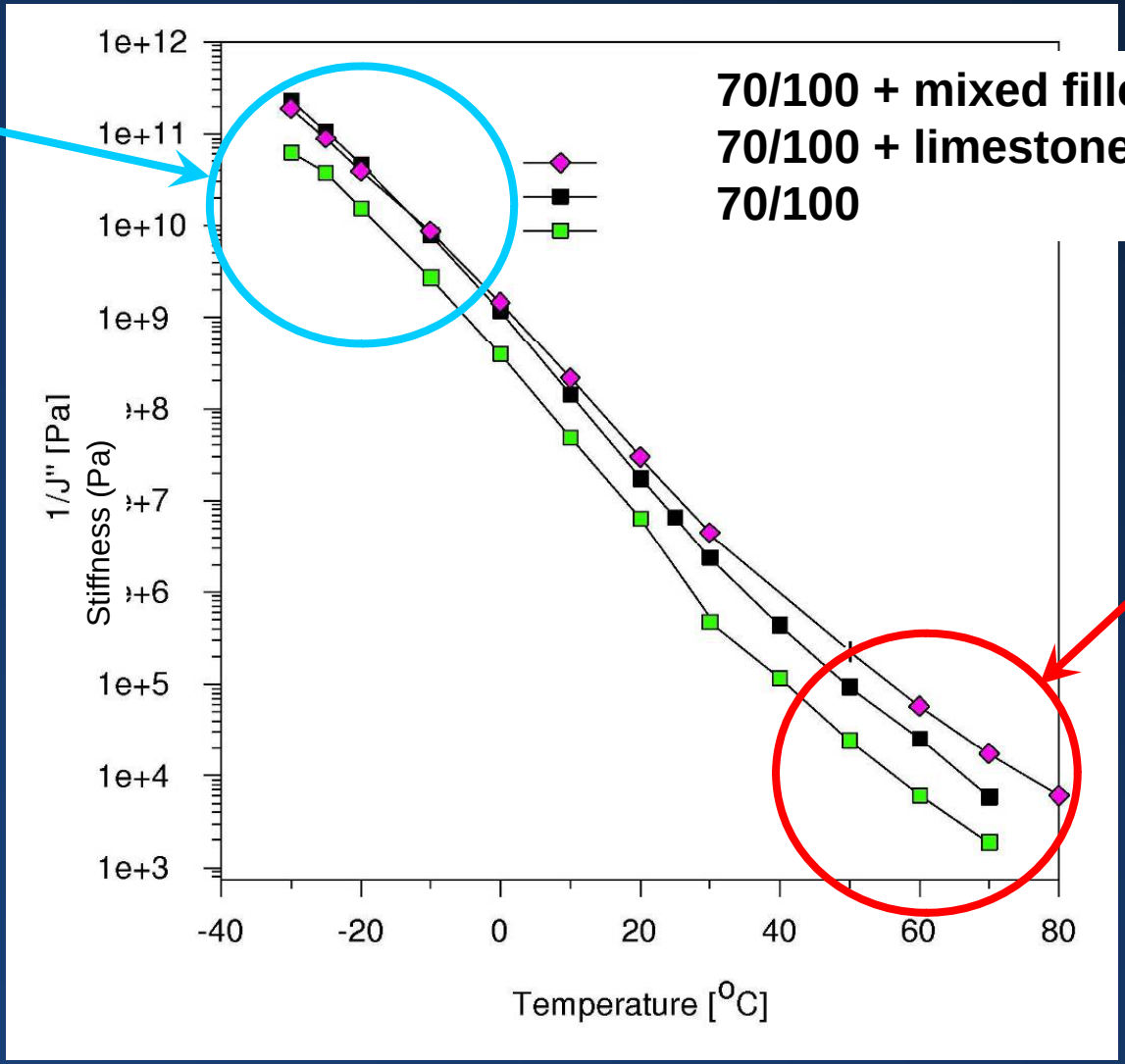






...But without Embrittlement at Low Temperature

No negative effect on cracking

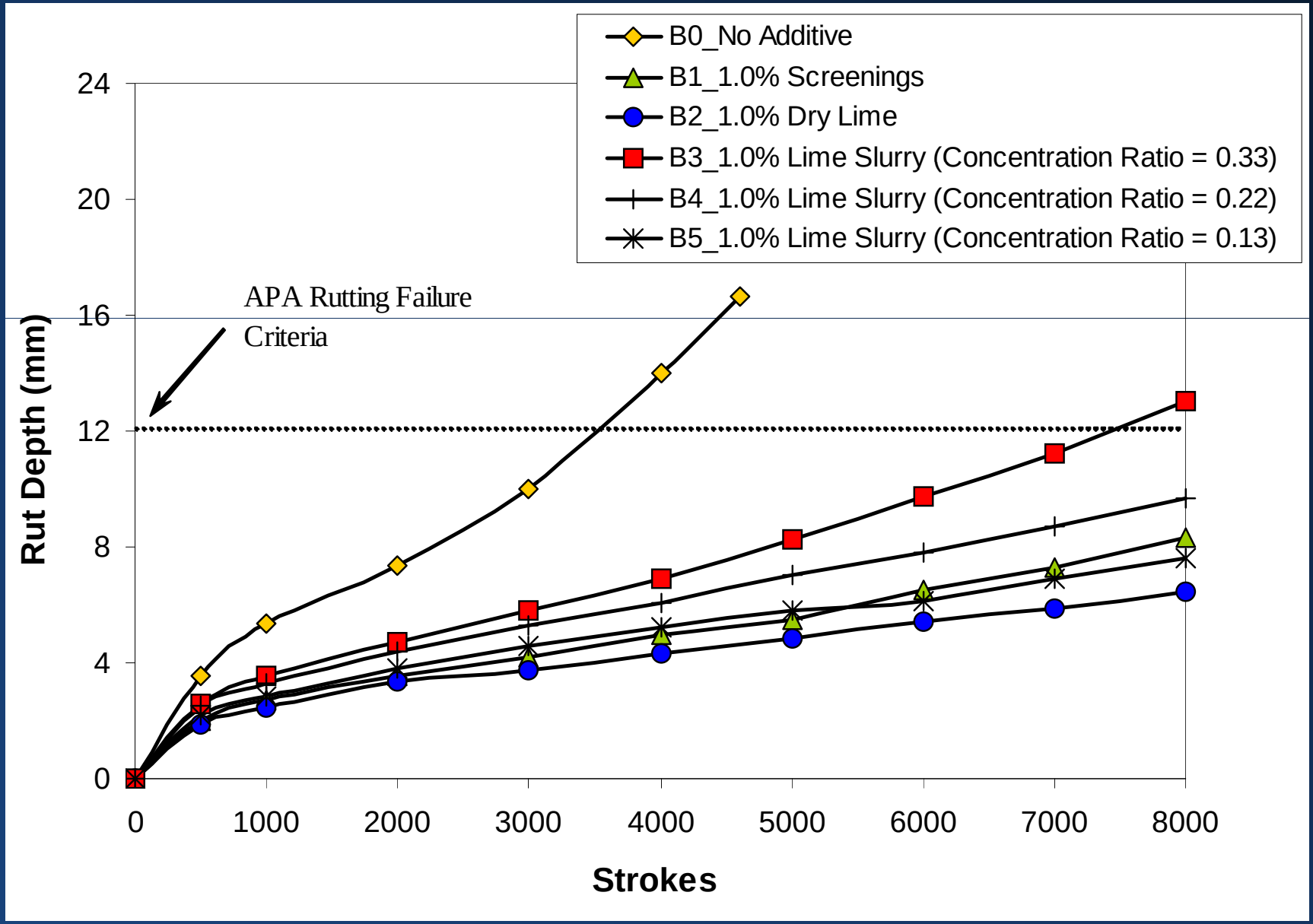


Beneficial effect on rutting

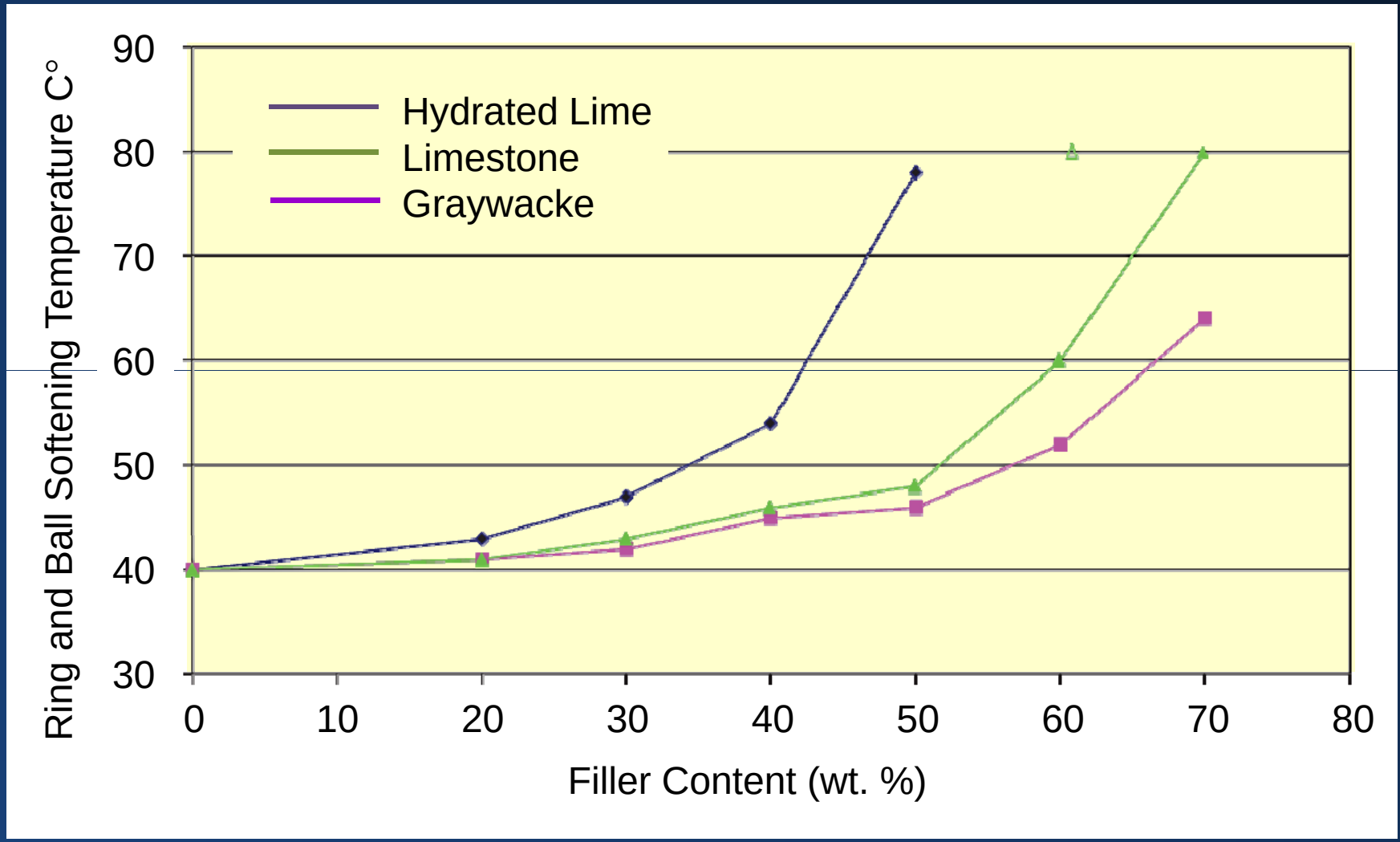
70/100 bitumen versus temperature

data from Wortelboer et al. (ESHA/LCPC), E&E 1996

APA (under Water) Test Results

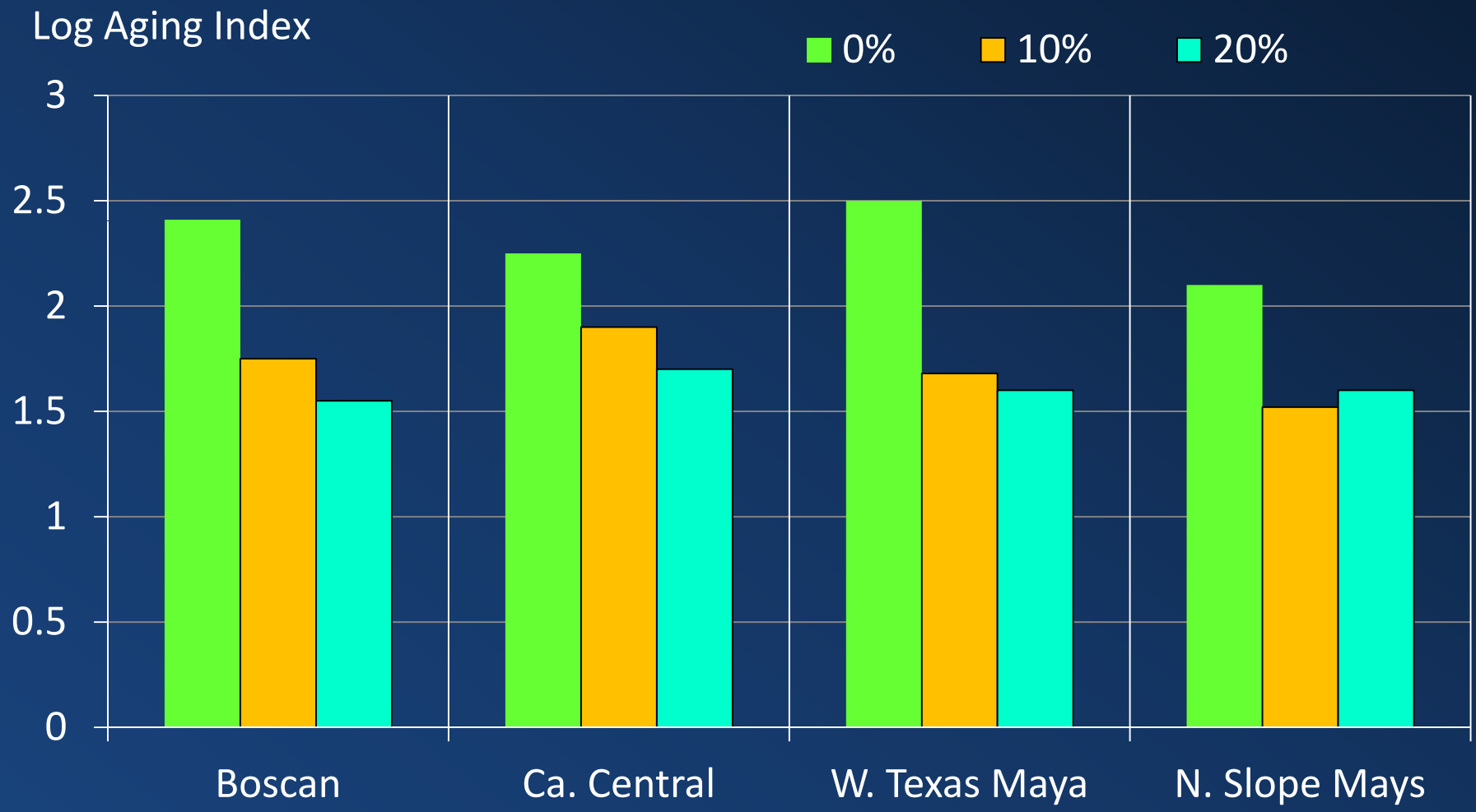


Mechanisms: Filler Effect on Softening Point

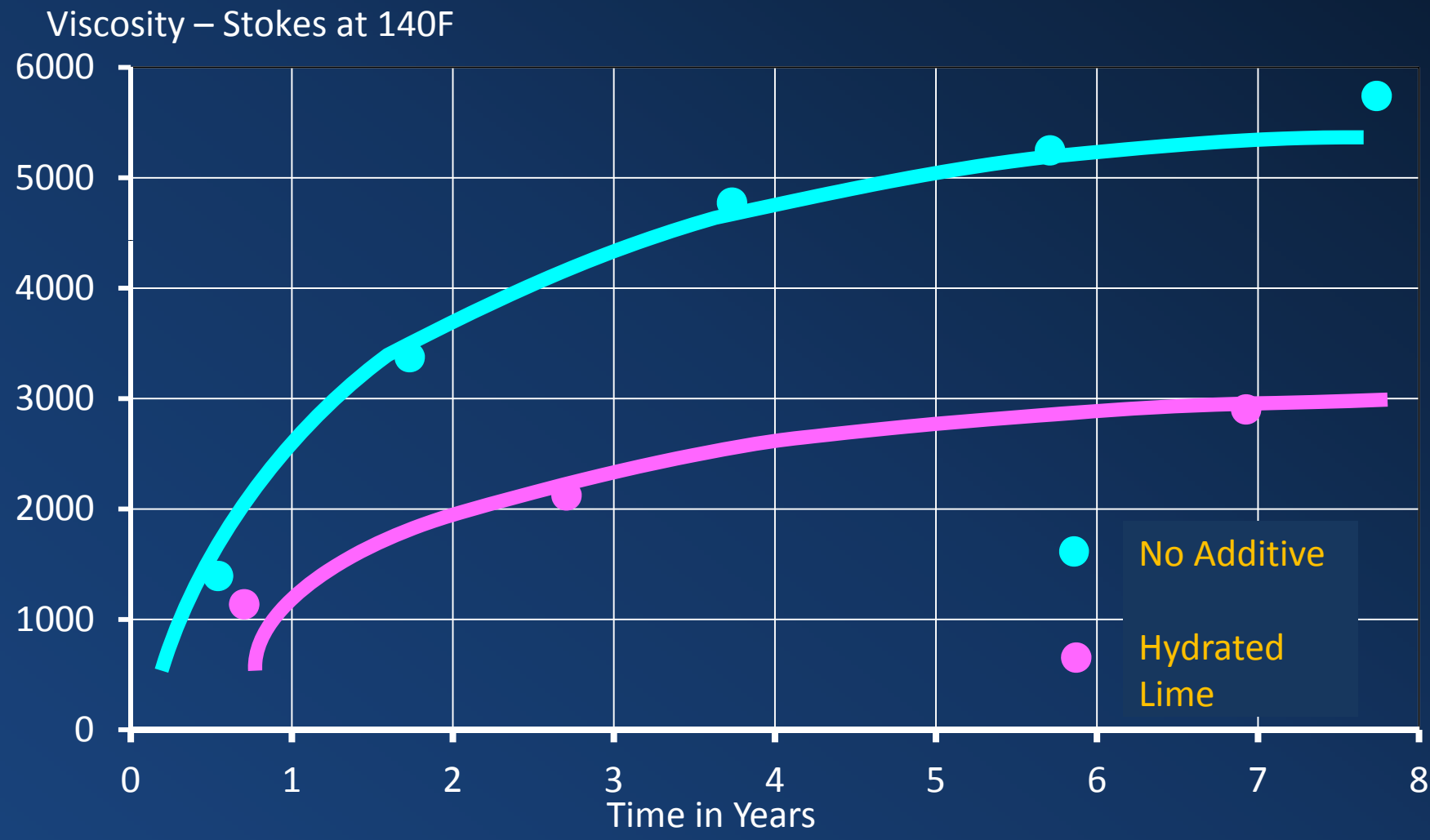


Hydrated lime added to the bitumen has a substantially greater impact in reducing the softening point of asphalt binder than does filler from graywacke or limestone source. Why?

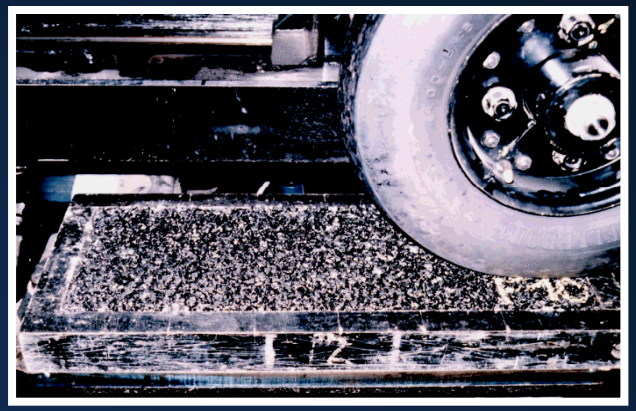
Aging Index
Western Research Institute



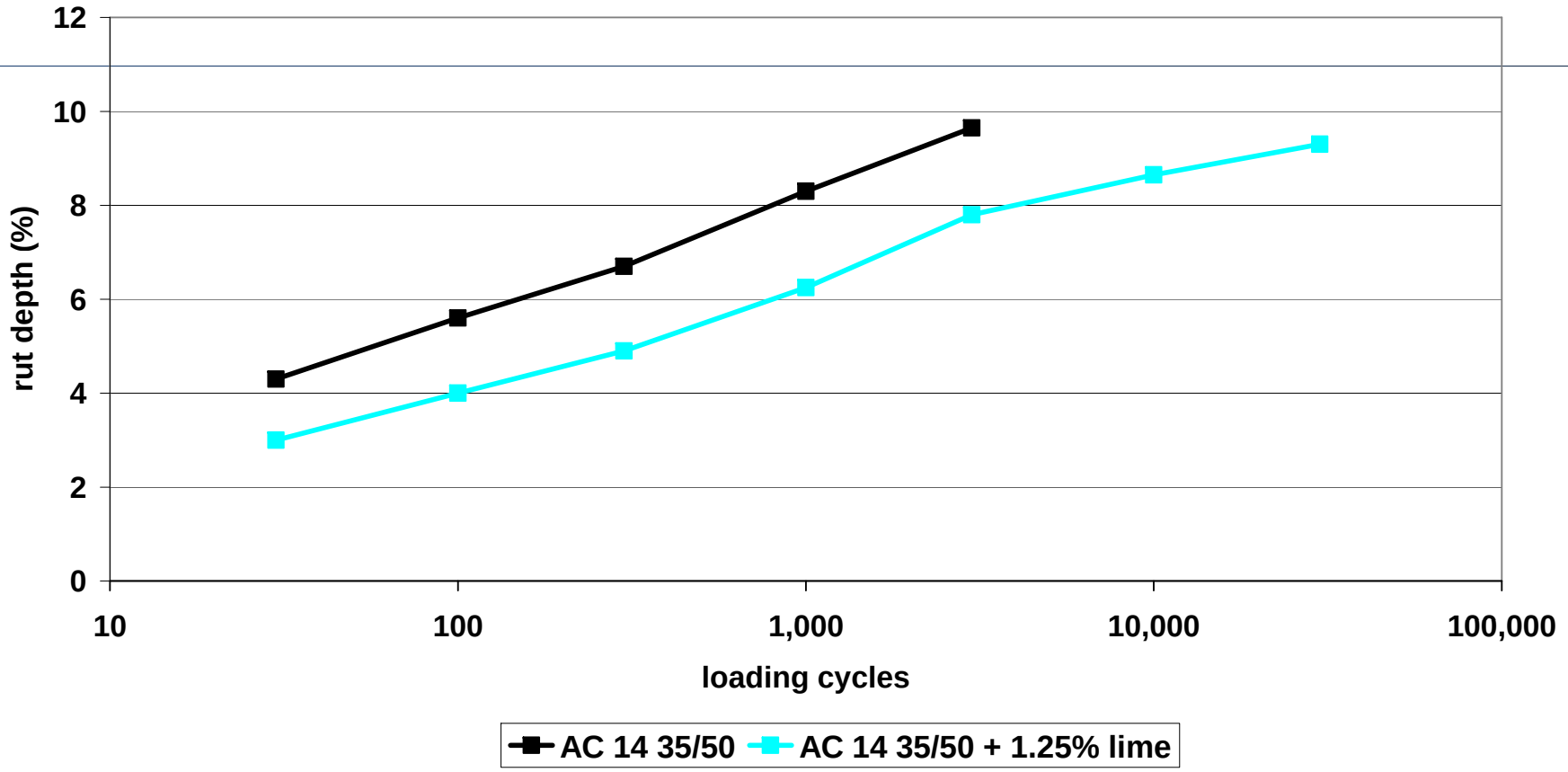
Additive Effect on the Hardening of Asphalt
Utah DOT – Field Study



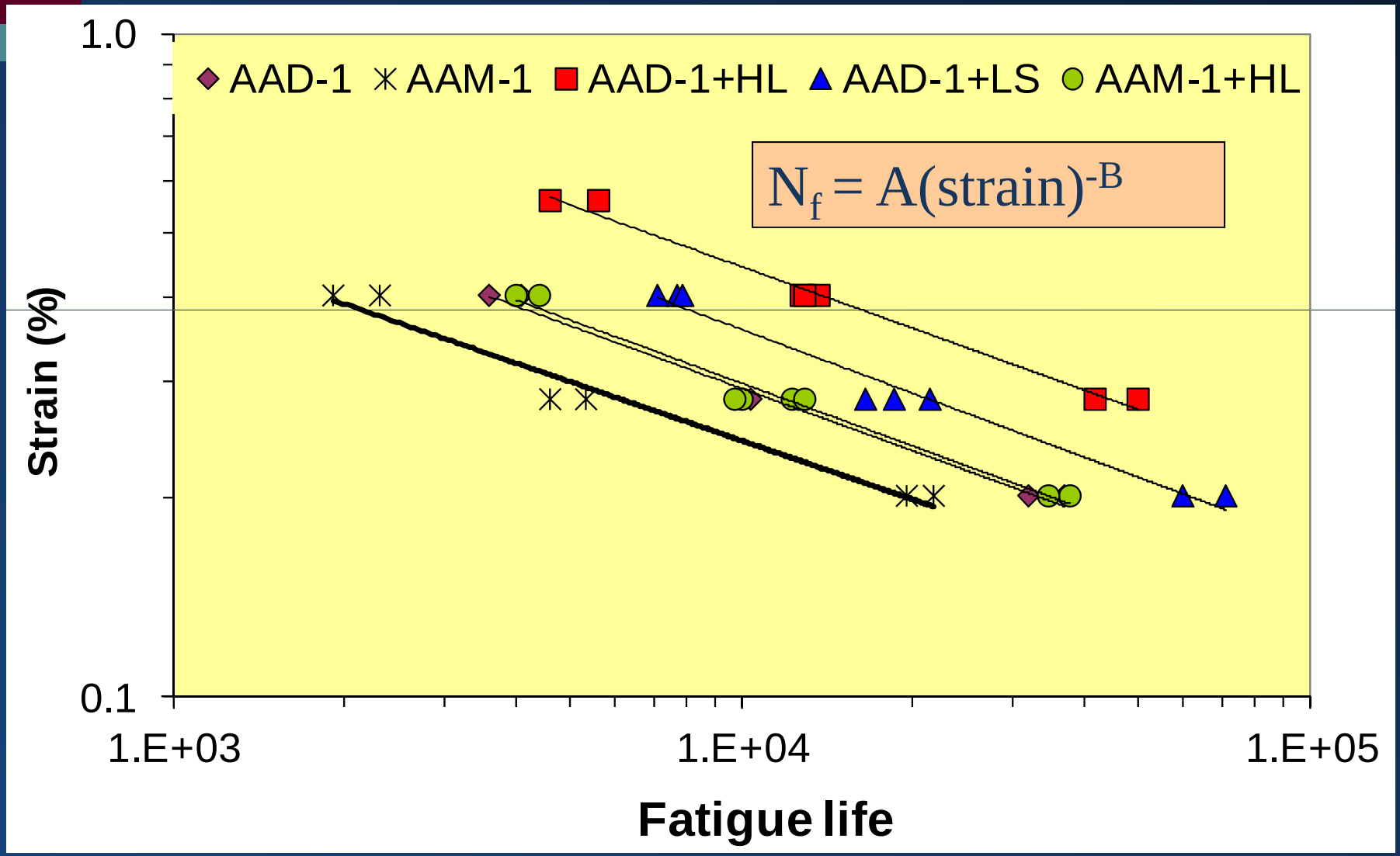
Hydrated Lime Improves Mixture Stiffness at High Temperature



Stiffening effect = better rutting resistance



Comparison of Fatigue Life



Resistance to Thermal Cracking

Thermal Stress Restrained Specimen (TSRST)

State	Mix	0 F-T		6 F-T	
		Fracture Stress (psi)	Fracture Temp (°C)	Fracture Stress (psi)	Fracture Temp (°C)
AL	Un-treated	368	-24	333	-24
	Liquid-treated	345	-26	304	-29
	Lime-treated	406	-24	424	-27
CA	Un-treated	303	-10	210	-11
	Liquid-treated	329	-11	300	-17
	Lime-treated	404	-13	381	-13
IL	Un-treated	375	-13	232	-16
	Liquid-treated	275	-14	251	-16
	Lime-treated	426	-18	377	-16

Resistance to Thermal Cracking

Thermal Stress Restrained Specimen (TSRST) (Cont'd)

State	Mix	0 F-T		6 F-T	
		Fracture Stress (psi)	Fracture Temp (°C)	Fracture Stress (psi)	Fracture Temp (°C)
SC	Un-treated	292	-19	126	-25
	Liquid-treated	268	-17	229	-28
	Lime-treated	311	-17	198	-15
TX	Un-treated	287	-19	210	-20
	Liquid-treated	277	-19	235	-20
	Lime-treated	353	-17	377	-18

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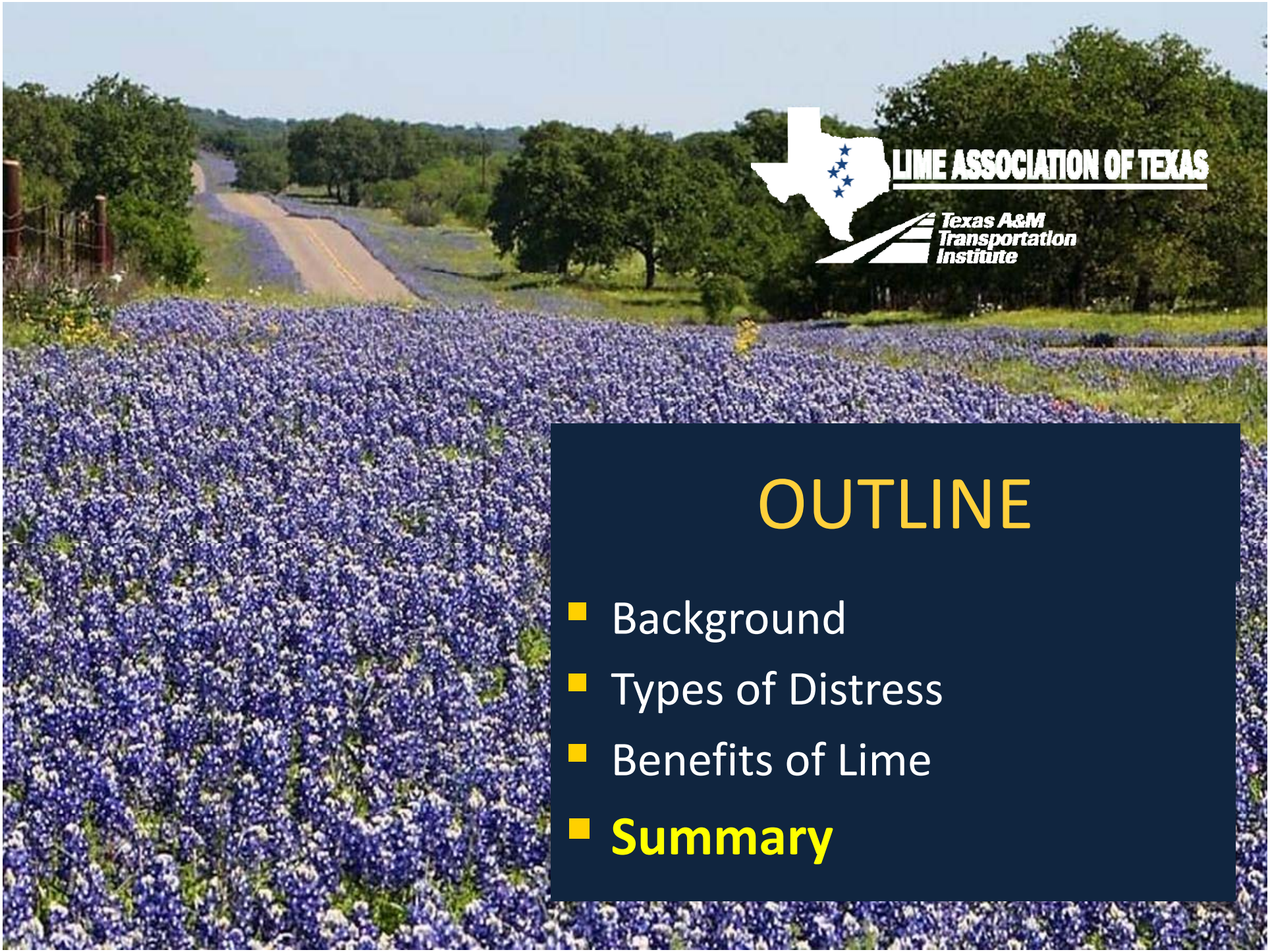

OUTLINE

- Background
- Types of Distress
- Benefits of Lime
- **Summary**

Summary

- Improve Performance
- Balance Pavement Thickness Design and Mixture Design
- Lime offers some help

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Pavement Distress	Lime Benefits
Raveling	• Reduce Aging • Improved Resistance to Water
Bleeding	• Increased Stiffness • Improved Resistance to Water
Rutting	• Increased Stiffness • Improved Resistance to Water

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Pavement Distress	Lime Benefits
Fatigue Cracking	• Increased Stiffness • Improved Resistance to Water
Thermal Cracking	• Aging
Reflective Cracking	• Aging
Stripping	• Improved Resistance to Water • Increased Stiffness

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