National Seminar on Moisture Sensitivity of Asphalt Pavements

TOPIC 4

TREATMENTS

Eric Berger

Jim Anagnos

February 4-6, 2003

Types of Treatments

- Applied to Asphalt Binder
- Applied to Aggregate

Applied to Asphalt Binder

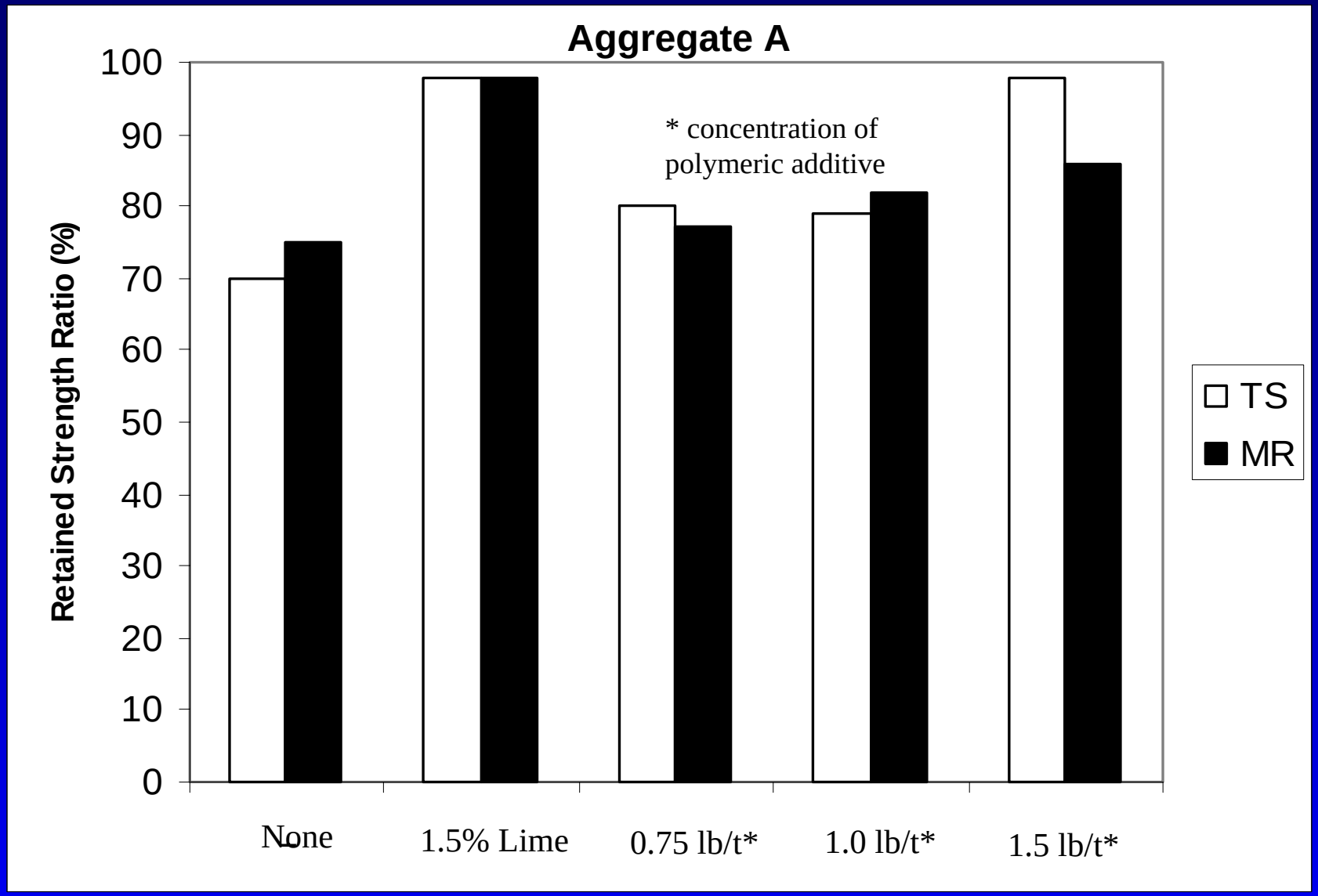
- Alkyl Amines (most common)
- Polymers
- Other Chemicals

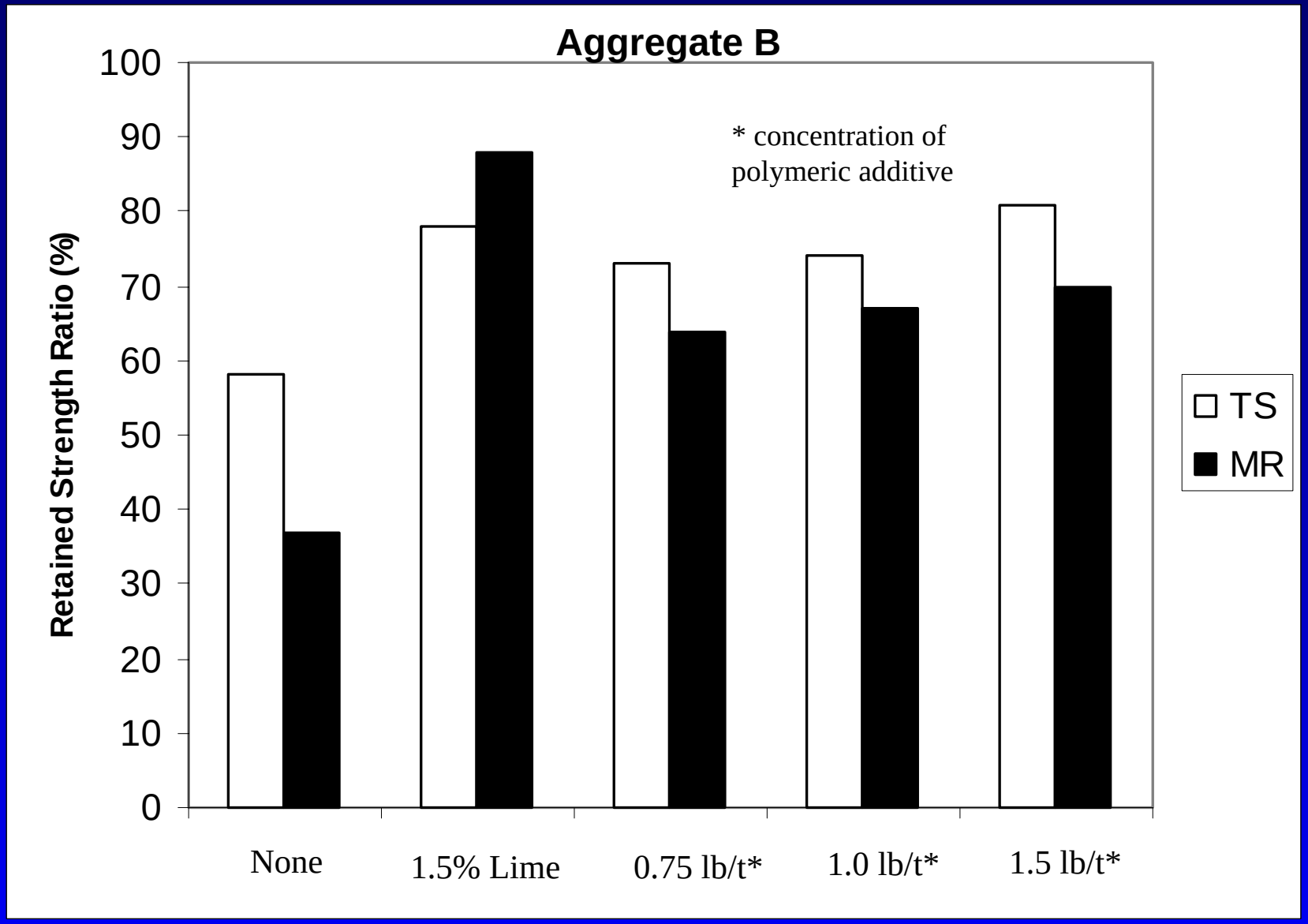
Applied to Aggregates

- Lime (most common)
- Portland Cement
- Fly Ash
- Flue Dust
- Polymers
- Other Chemicals

Polymers

- Applied to Asphalt Binders
- Applied to Aggregates


Aggregate A
Retained Strength Ratio (%)
100
90
80
70
60
50
40
30
20
10
0
* concentration of polymeric additive
TS
MR
None
1.5% Lime
0.75 lb/t*
1.0 lb/t*
1.5 lb/t*


Aggregate B
Retained Strength Ratio (%)
100
90
80
70
60
50
40
30
20
10
0
* concentration of
polymeric additive
TS
MR
None
1.5% Lime
0.75 lb/t*
1.0 lb/t*
1.5 lb/t*

Treatment Type Effectiveness

- Asphalt Binder Type
- Aggregate Type
- Concentration
- HMA Design
- Time and Temperature of Storage
- Test Method Used for Evaluation
- Short Term Properties
- Long Term Properties

NATIONAL SEMINAR
On
MOISTURE SENSITIVITY OF ASPHALT PAVEMENTS

TOPIC 4
TREATMENTS

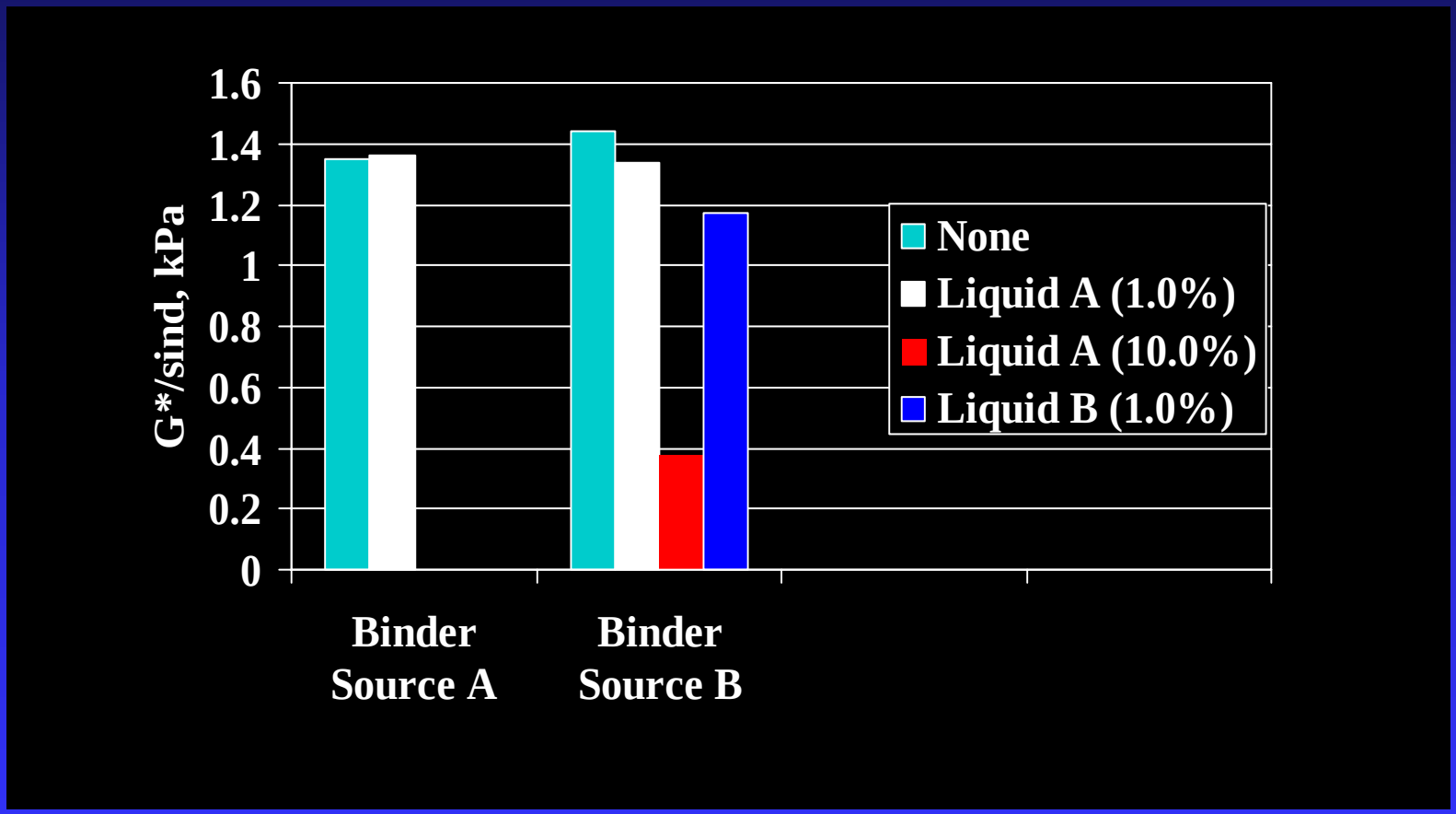
February 4-6, 2003

San Diego, California

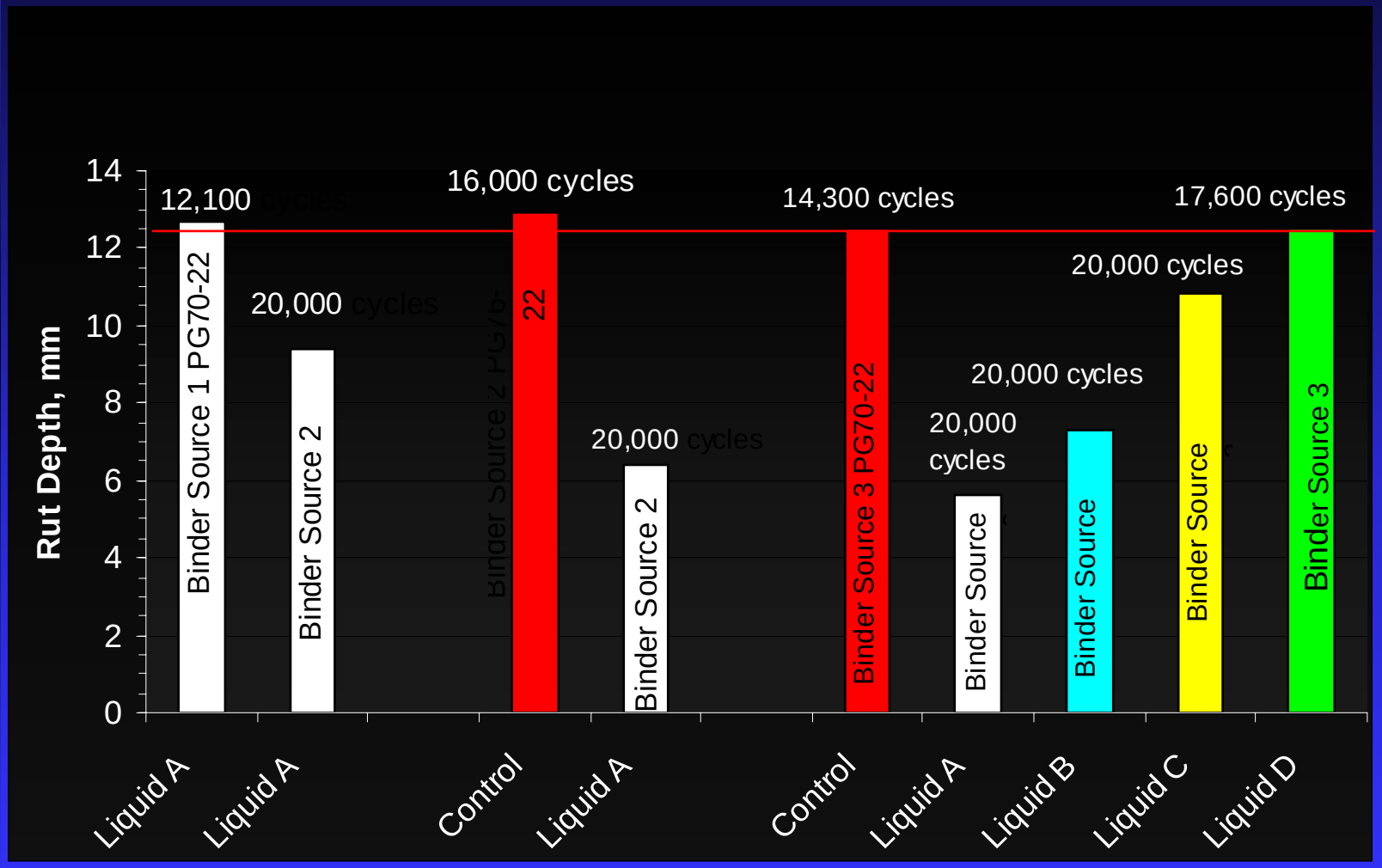
Treatment of Asphalt Mixtures with Liquid Anti-Stripping Agents

James N. Anagnos
Consultant
Akzo Nobel

SHRP DSR Binder Effect With High Performance Liquids



Hamburg Test Results @ 50°C

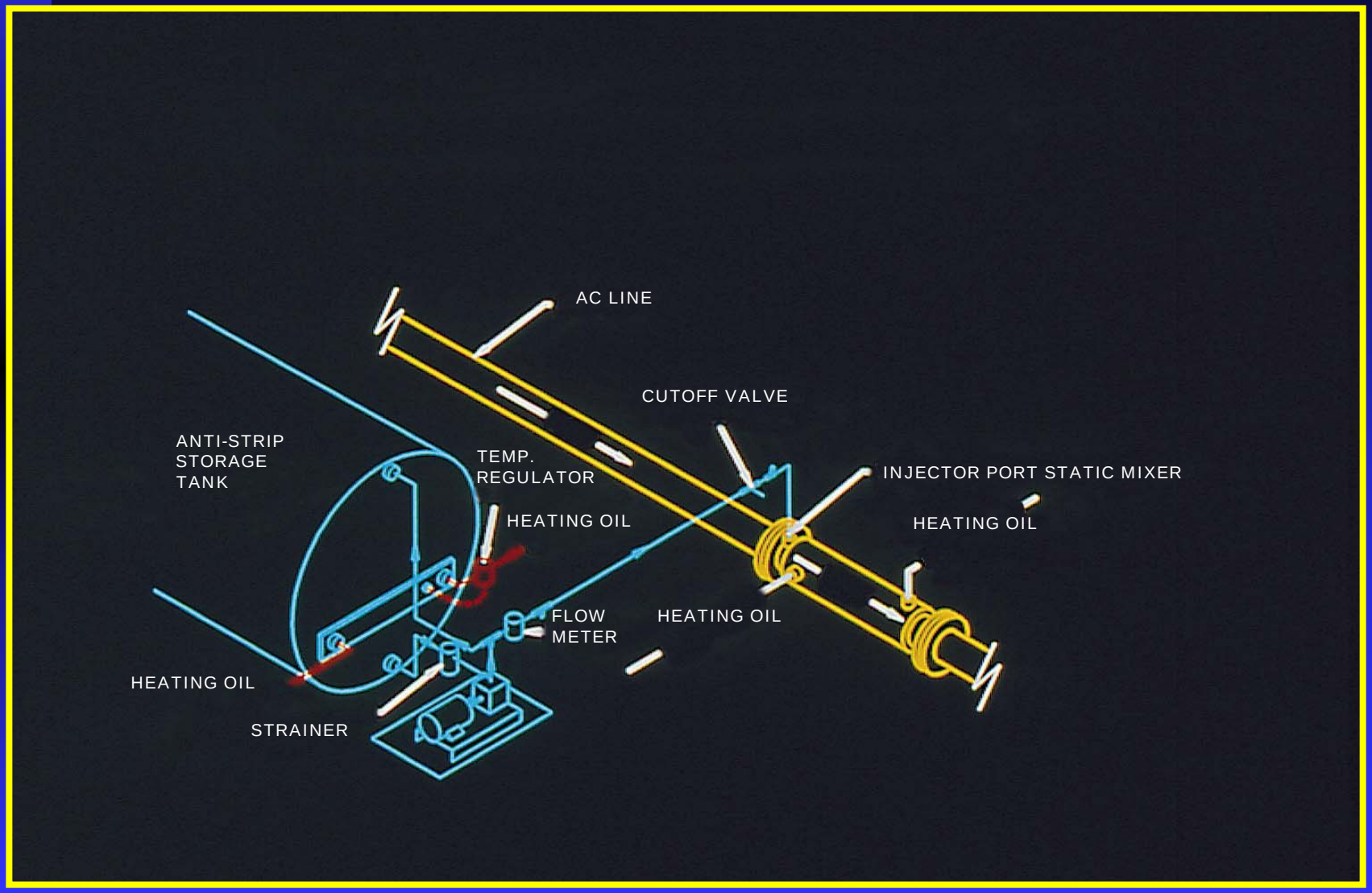


LAS

Applied to Asphalt Cement

- Refinery
- On-job-site

Block Diagram



Field System

Field System

Louisiana Field Study

- Location: LA 450
- Date Placed: July 1990
- Contractor: Barrier Construction
- Testing Agency: Barry Moore & Associates

Materials

- Aggregate: Crushed gravel
  Local field sand
- Asphalt: Exxon AC-30
- Additives: LAS agents
  Hydrated lime

Additives

▪ Liquid A, %	0.8
▪ Hydrated Lime, %	1.4
▪ Liquid B, %	0.8
▪ Liquid C, %	0.8
▪ **Lime/Liquid B, %**	**1.4/0.8**

Louisiana Test Methods

- Ross Count
- Boiling Water
- Modified Lottman

Ross Count

- Plant mixed material
- Percent coating of +No. 4 agg.

Ross Count

Boiling Water Test

- Plant mixed material
- Boil 10-minutes in distilled water
- Drain and air dry
- Visually determine stripping

Typical Results

Fail

Pass

Modified Lottman AASHTO T283

- Freeze – Thaw Cycles
- One, Three, Five, and Ten cycles

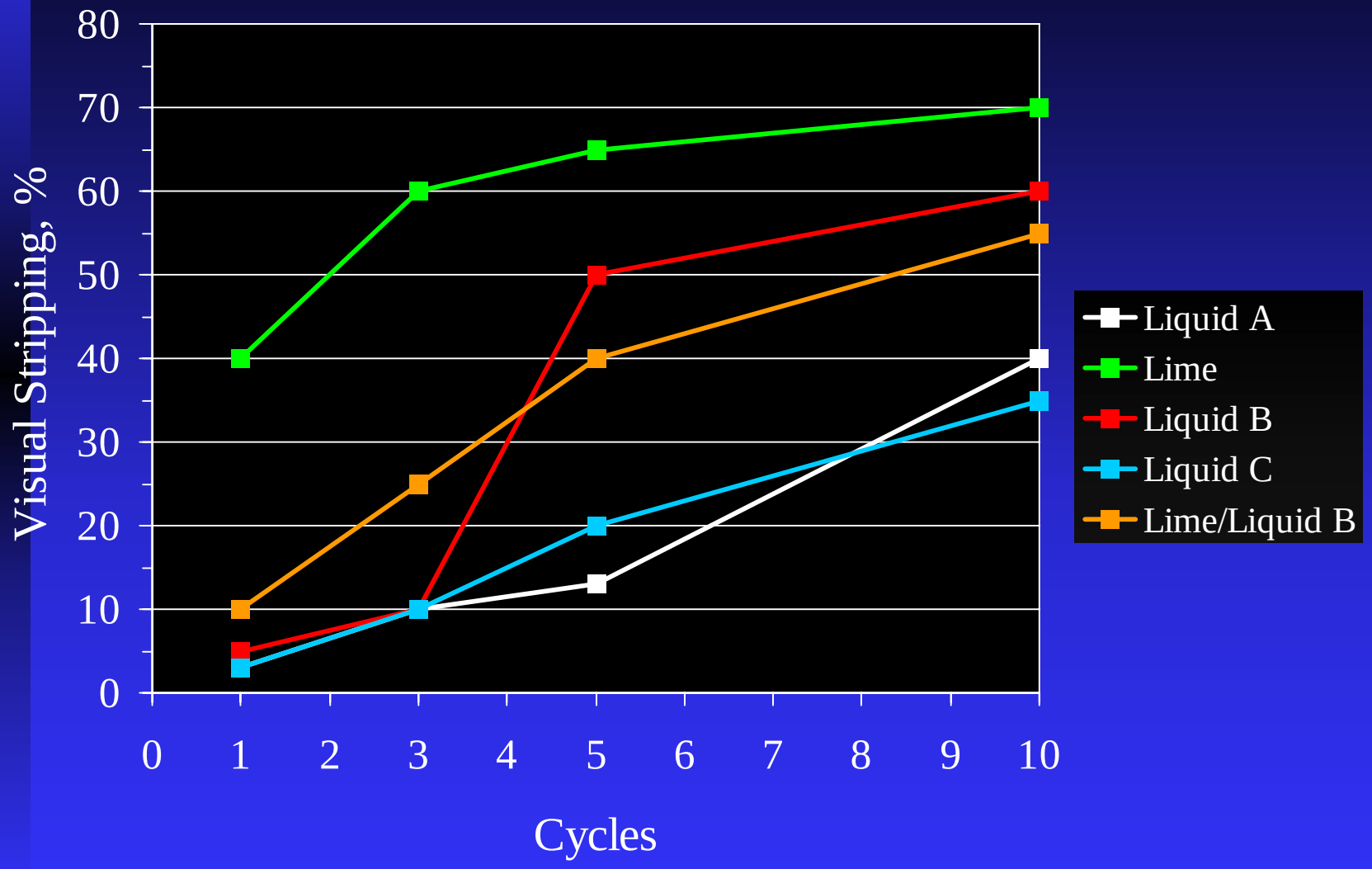
Modified Lottman Parameters Evaluated

- Tensile Strength
- Tensile Strength Ratio
- Air Voids
- Visual Stripping after testing

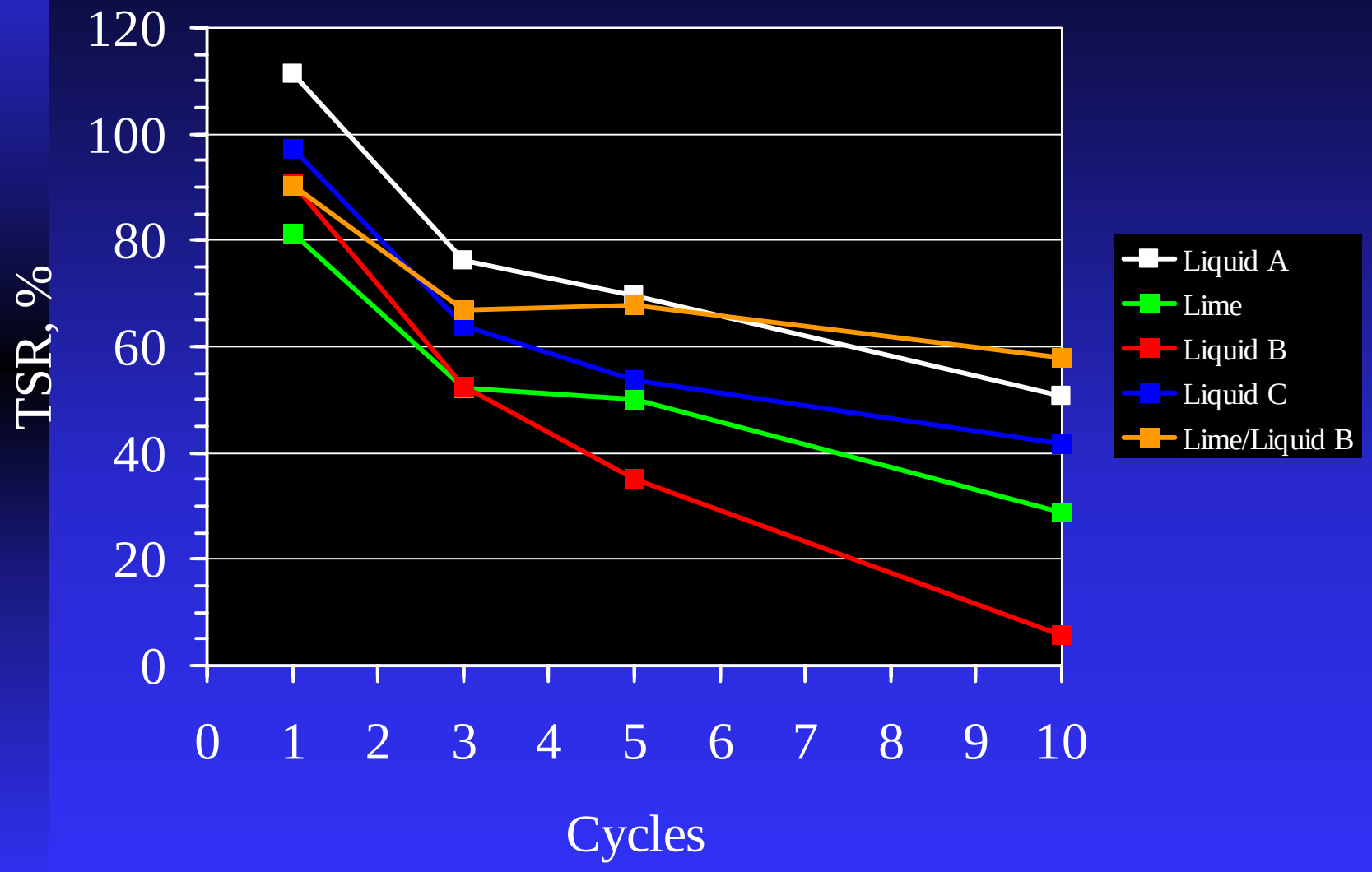
Typical Appearance

Fail Pass

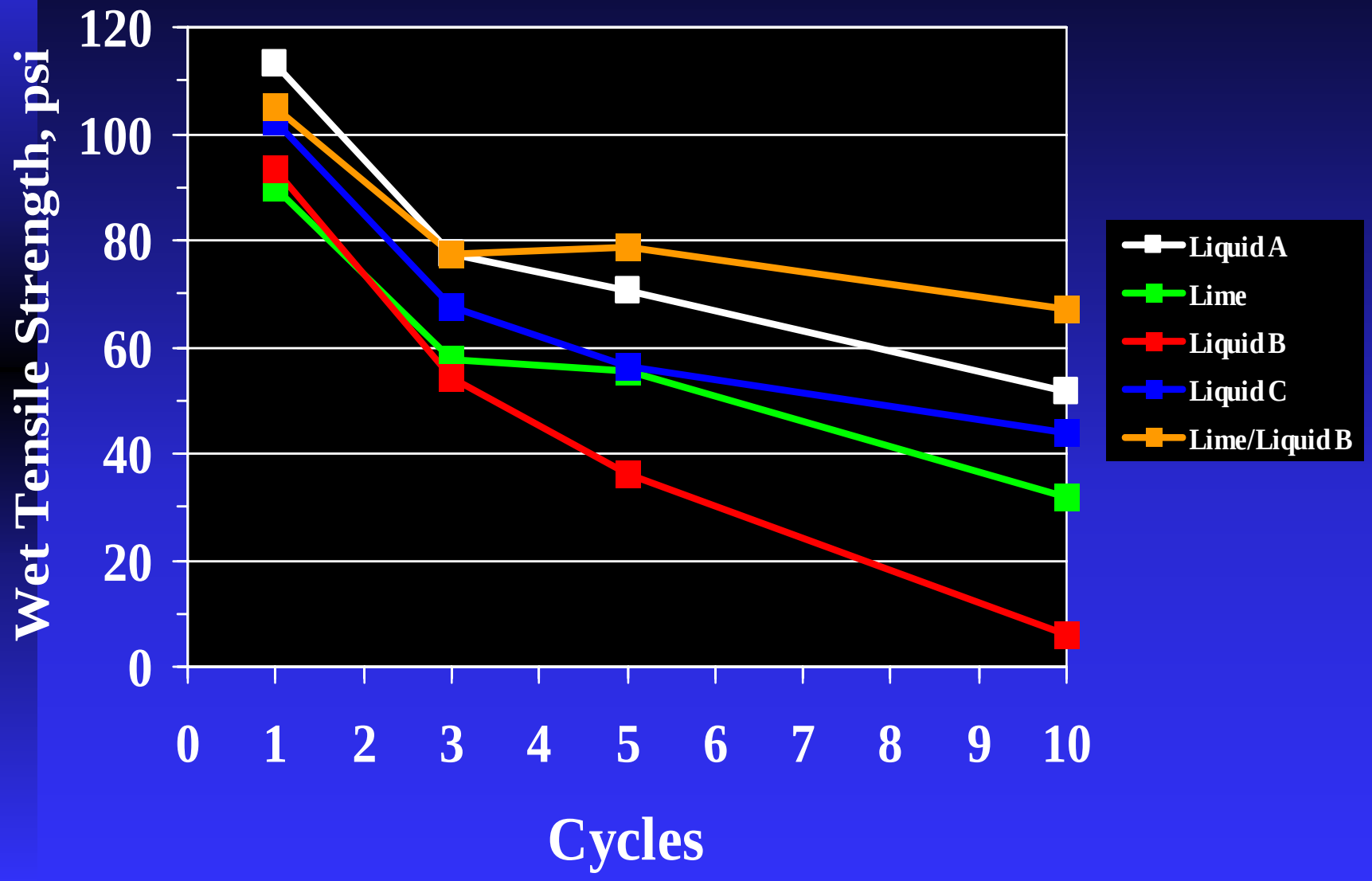
Visual Stripping vs Freeze-Thaw Cycles



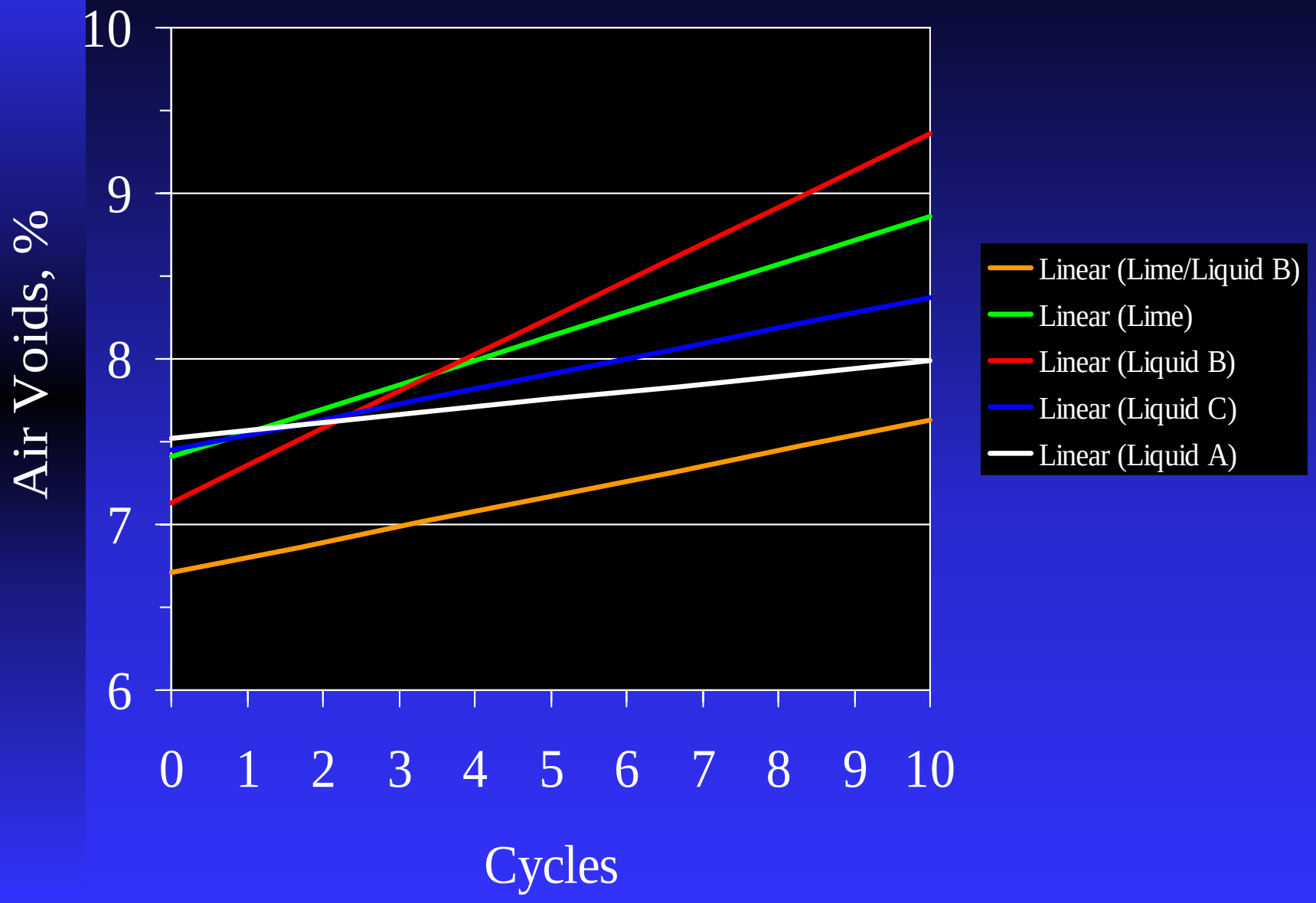
Tensile Strength Ratio vs Freeze-Thaw Cycles



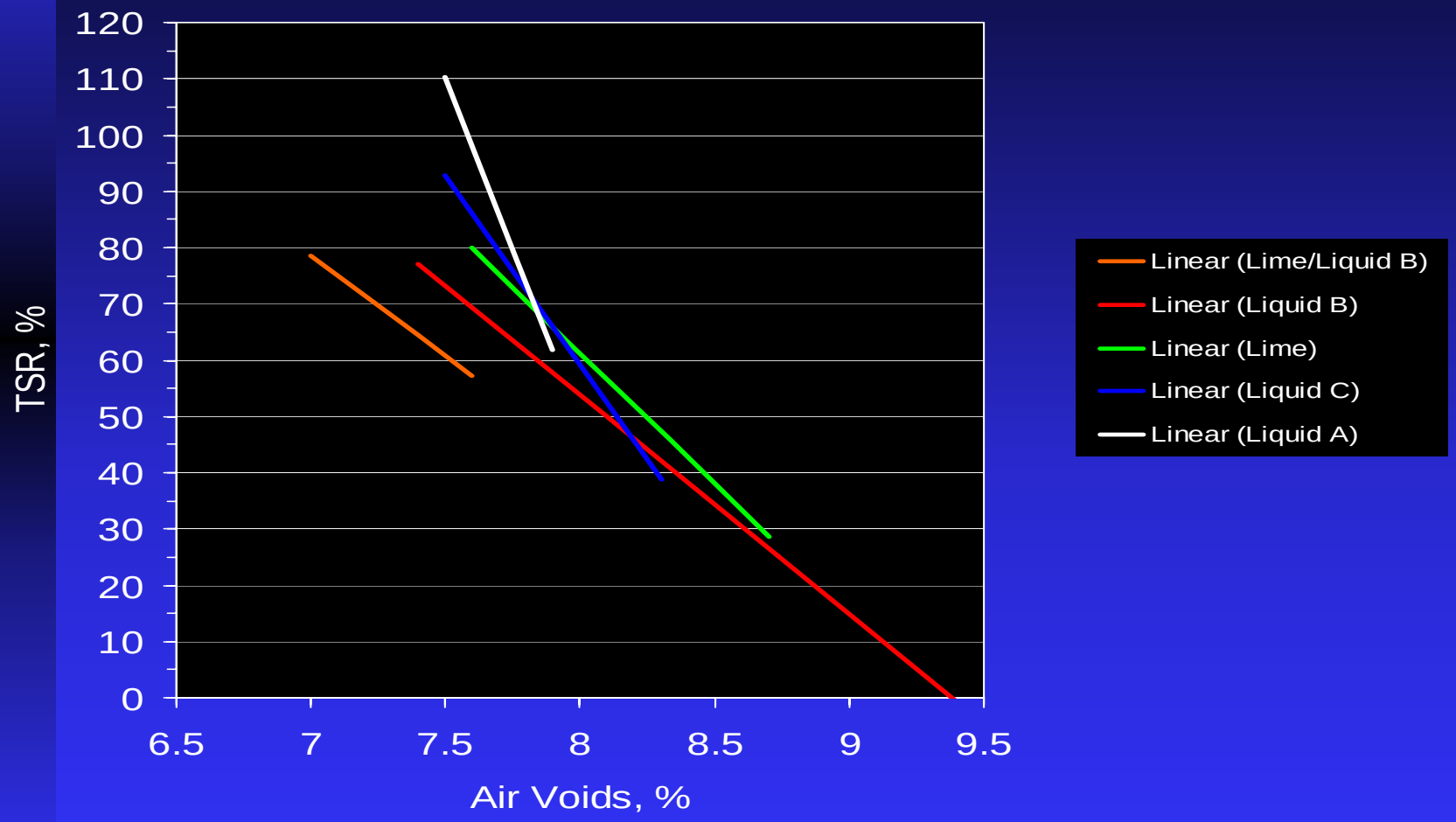
Wet Tensile Strength vs Freeze-Thaw Cycles



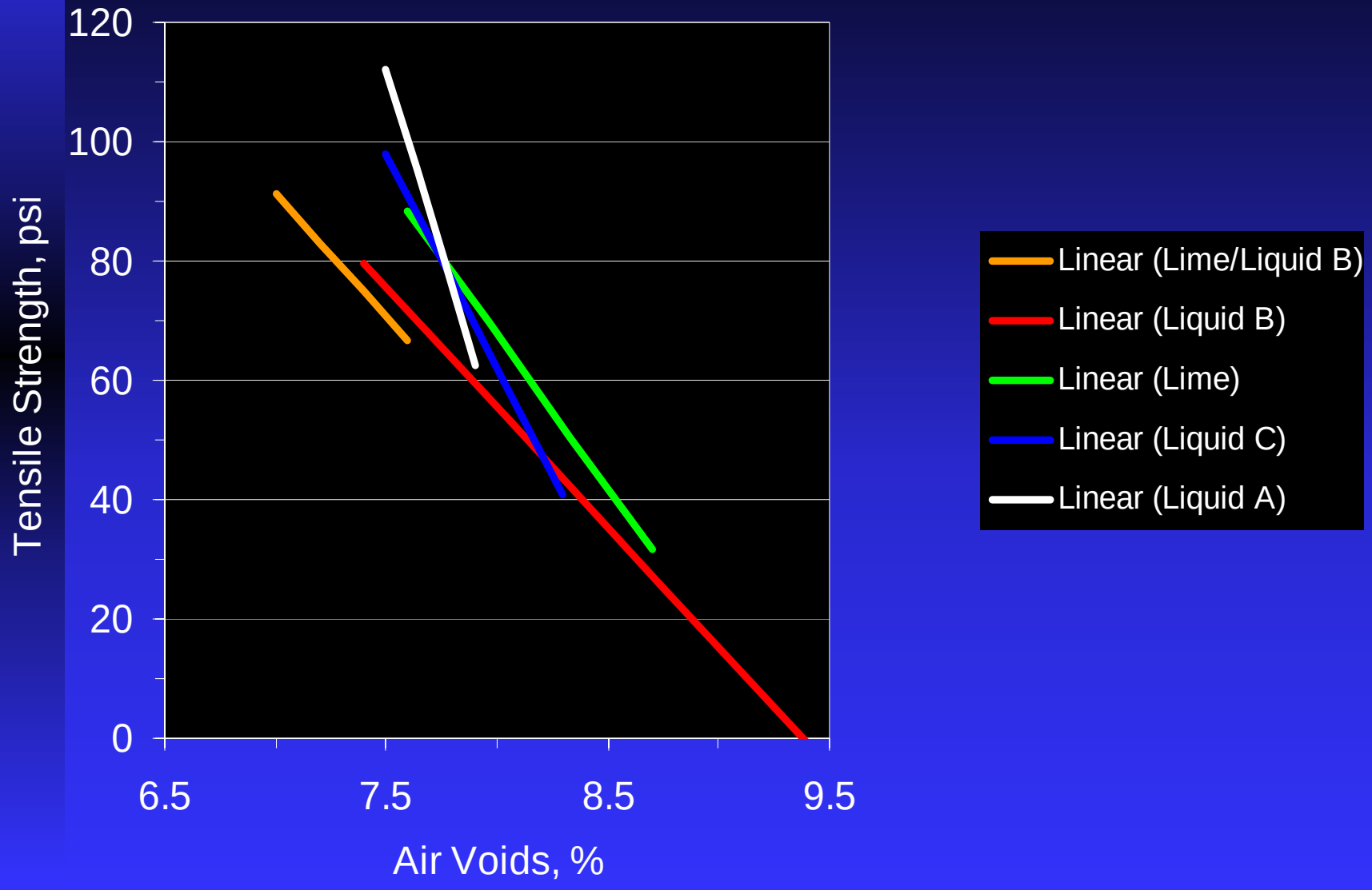
Air Voids vs Freeze-Thaw Cycles



Tensile Strength Ratio vs Air Voids



Tensile Strength vs Air Voids



2001

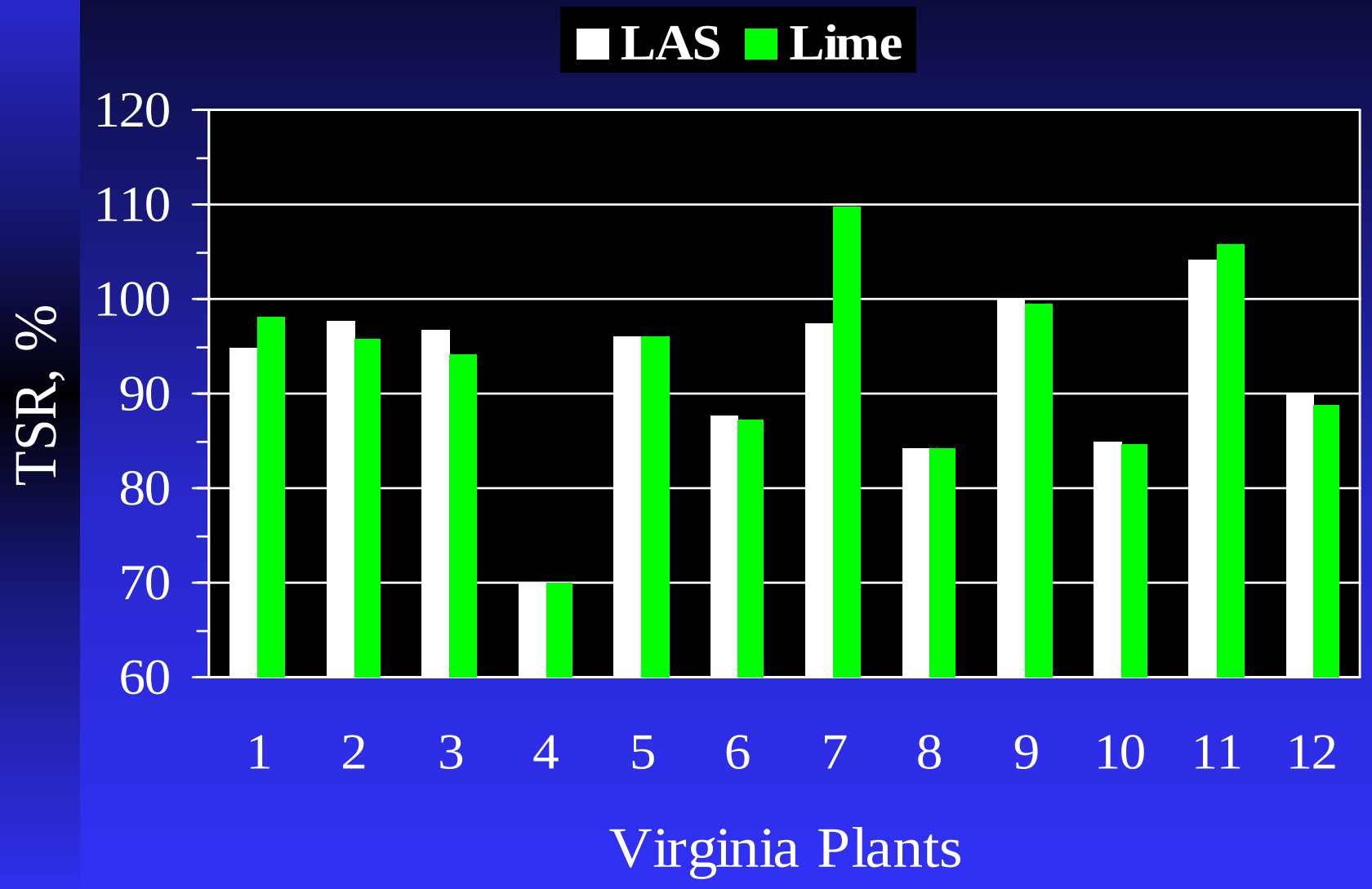
Virginia Test Method for Moisture Damage

Root-Tunnicliff Version

of

Modified Lottman

Tensile Strength Ratio - Virginia



Costs

Liquid Anti-strip Agent

- $0.45 to $0.75 per pound of liquid or
- $6.75 to $11.25 per ton of asphalt binder or
- $0.30 to $0.70 per ton of hot mix

In-line Blending Equipment

- $10,000 to $25,000

Conclusions

Liquid Anti-stripping Additives

- Effective – high performance additives
- Easy to use
- Added at refinery or hot mix plant
- Minimal Cost - $0.50 to $0.80/ton of hot mix

National Seminar on Moisture Sensitivity of Asphalt Pavements

Topic 4
Treatments – Hydrated Lime

Eric Berger

Chemical Lime
A Lhoist Group Company

Moisture Sensitivity - Stripping

- **Adhesion - Poor stone/bitumen bond**
  - Problem aggregate types - siliceous, igneous
    - Incompatibility with bitumen
  - Mechanical loading – fatigue
    - Pore pressure & scour
- **Cohesion – Fracture within mastic**
  - Plastic deformation – rutting
    - Binder stiffness/ excessive loading
  - Environmental conditions – oxidative aging
    - Hardening >> fracture
- **Bitumen chemistry increasingly variable**

Chemical Lime
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Benefits of Hydrated Lime

- **Chemically active filler**
  - Adhesion
    - Mitigate aggregate surface charge/bitumen conflict
    - Stiffen mix reducing effects of mechanical abrasion
      - 1% by aggregate weight often increases full PG grade
  - Cohesion
    - Reacts with polar molecules that promote stripping
      - Forms insoluble calcium salts
    - Fine particles intercept microcracks extending fatigue life

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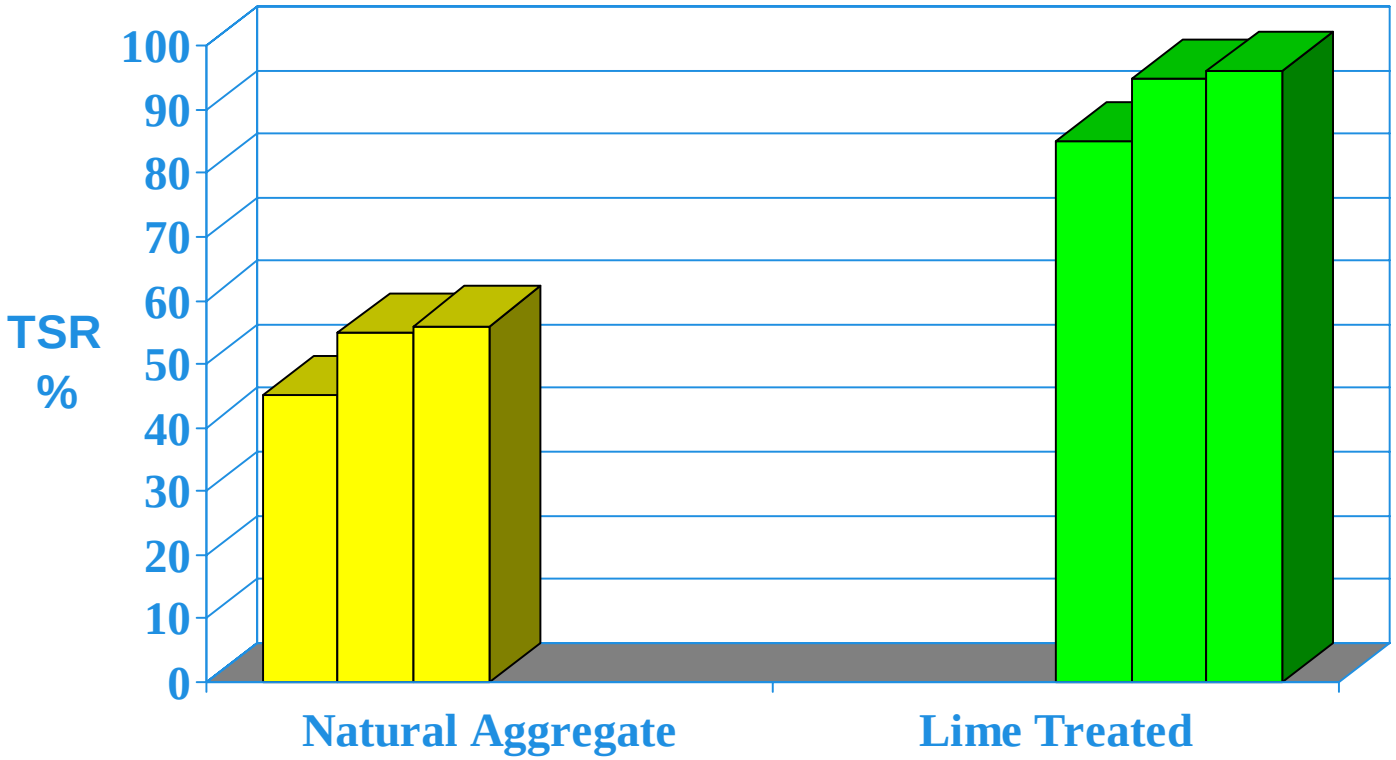
Moisture Sensitivity – Tensile Strength Ratio



T-283 results - three Mississippi aggregates

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Influence of HL on Binder Stiffness

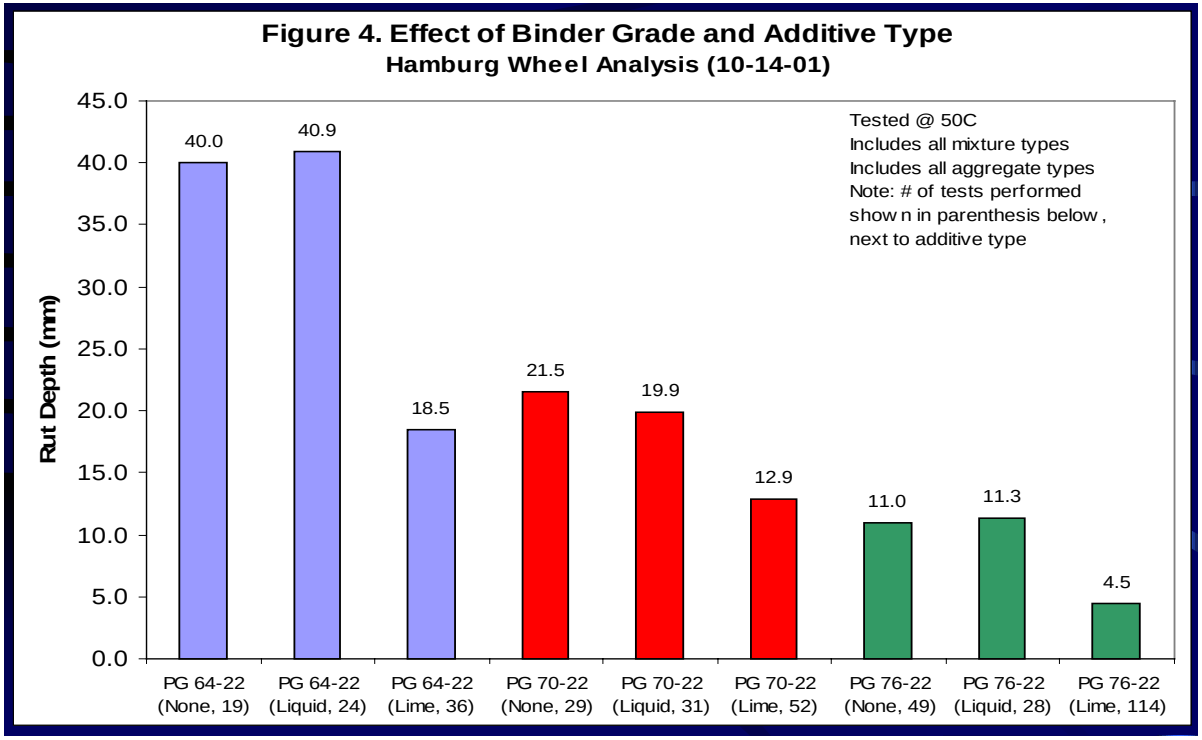

Table 6. Inflence of Binder Type on Hamburg results

Binder	Additive	No. of Mixes	Rut Depth, mm
PG 64-22	None	19	40
	Lime	36	18.5
PG 70-22	None	29	21.5
	Lime	52	12.9
PG 76-22	None	49	11
	Lime	114	4.5

Source: Texas DOT/ Tahmoressi

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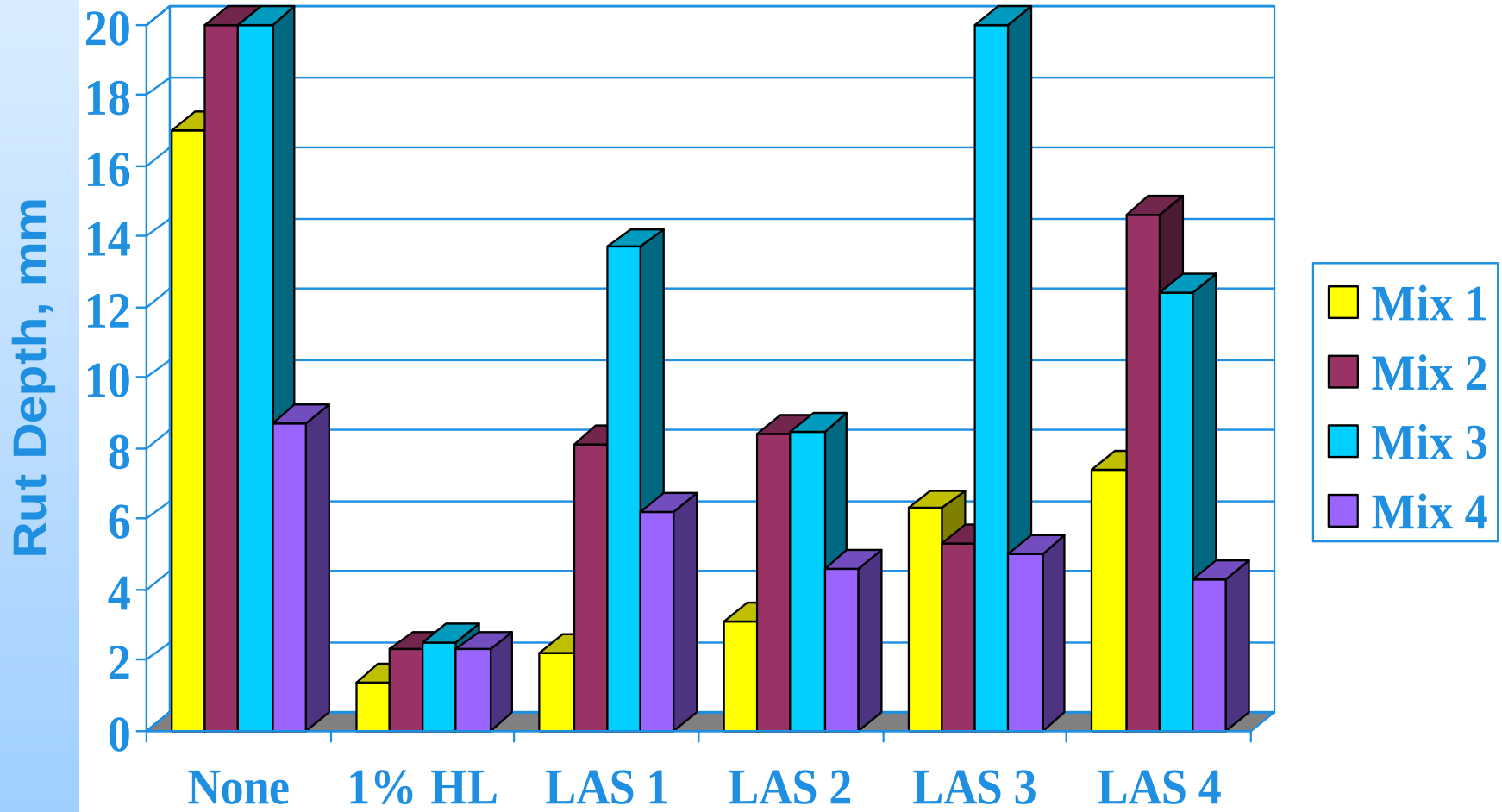
Hamburg Wheel Test
20,000 cycles (40°C)



Source: Colorado DOT

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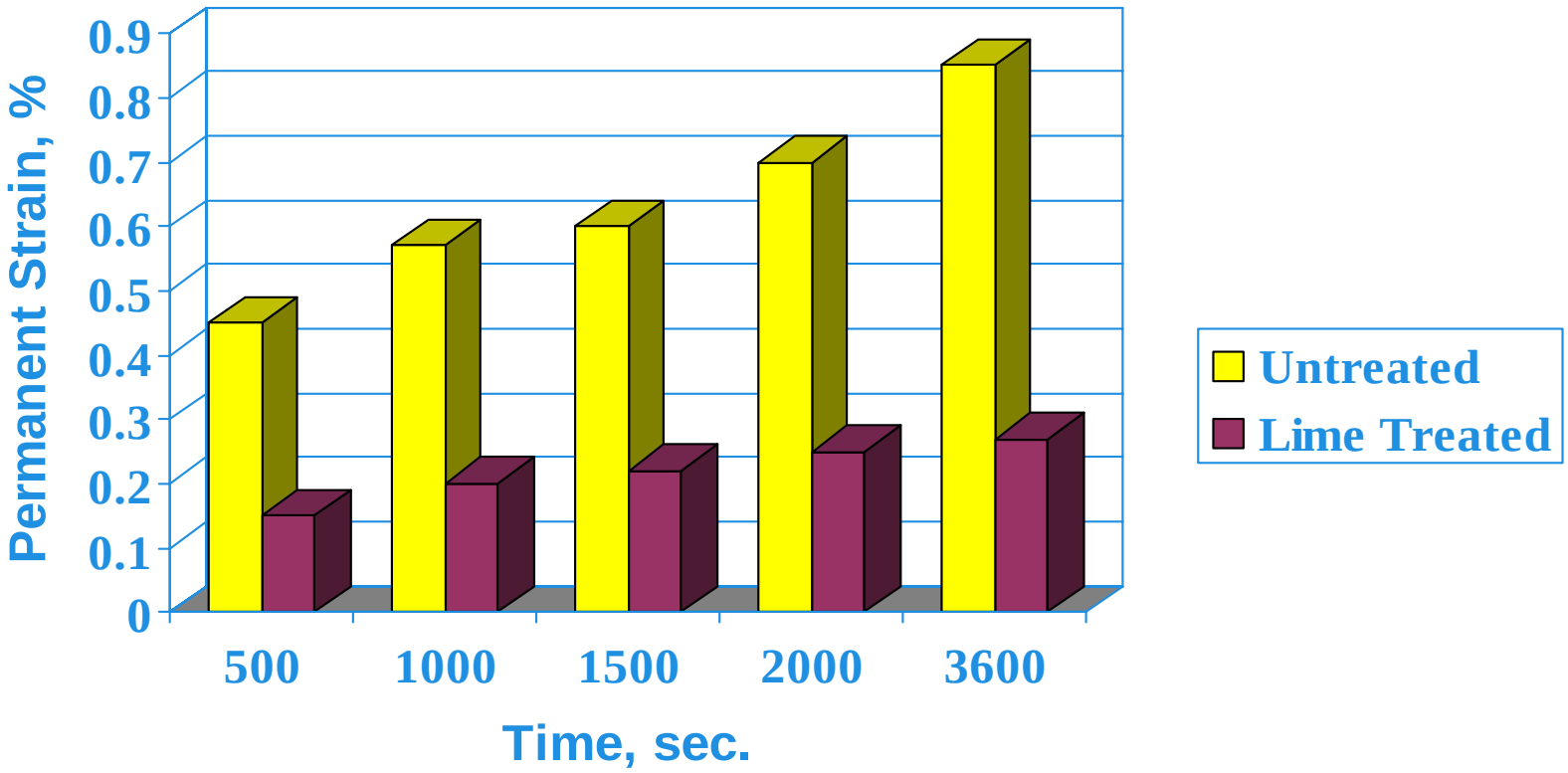
Permanent Strain/ Fracture Toughness



Bending Beam Rheometer (BBR)

Source: Mississippi DOT

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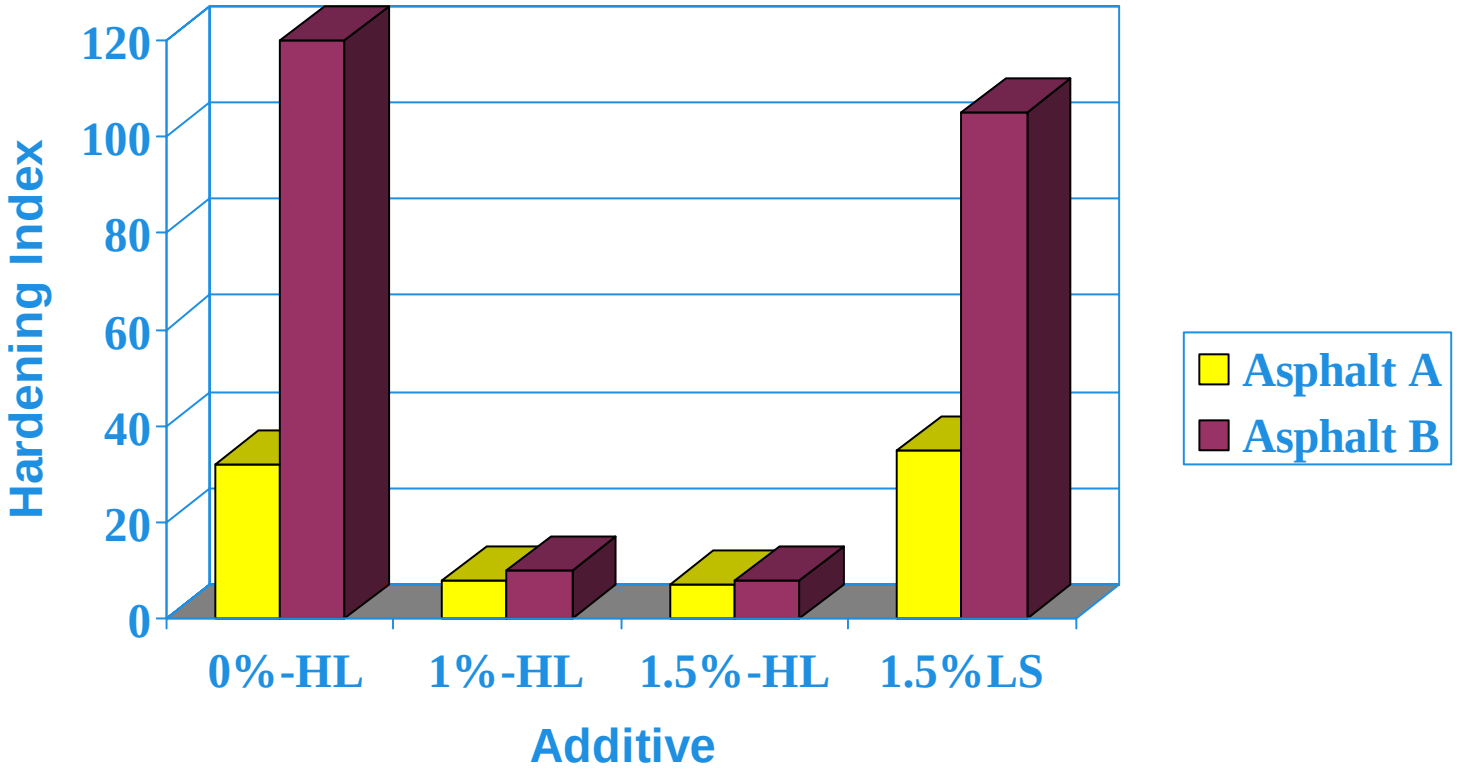
Effect of Lime on Age Hardening



HL=hydrated lime; LS=limestone

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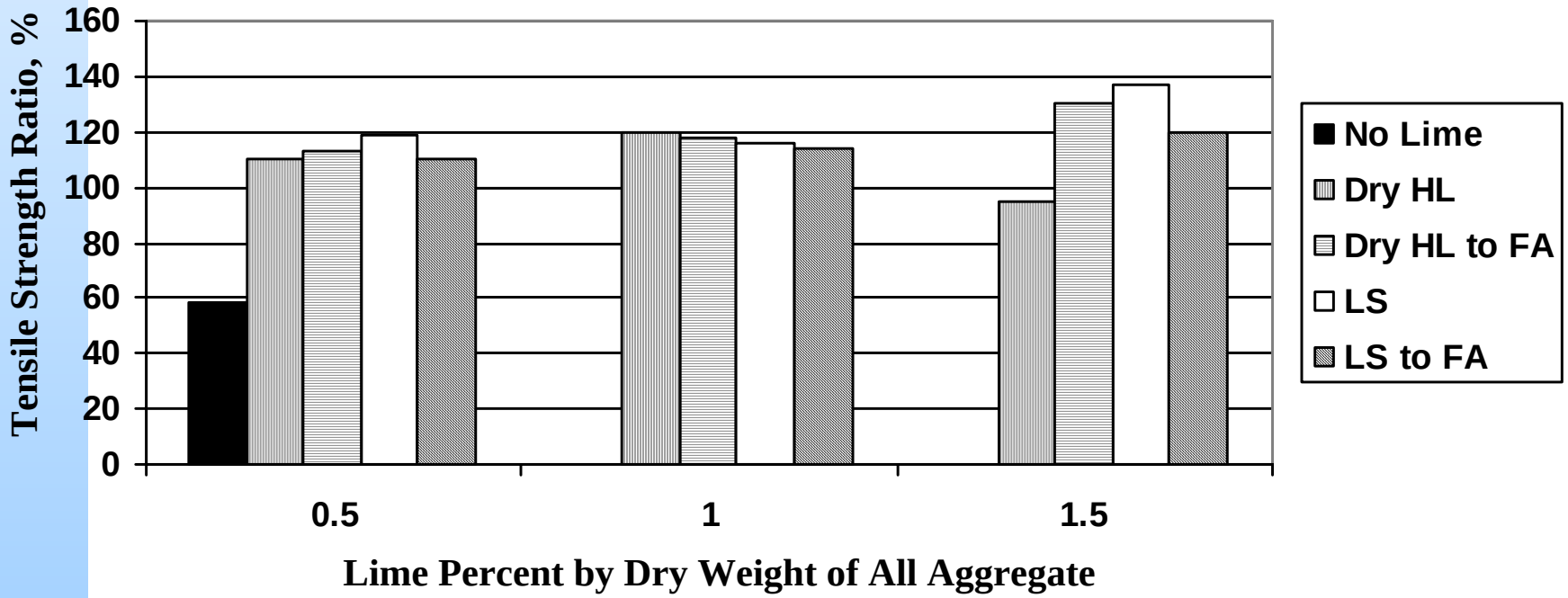
Quantities of HL & Methods of Additon



Effect of method of lime marination and percent lime added to granite aggregate [after Hansen et al (1993), ref. 47]

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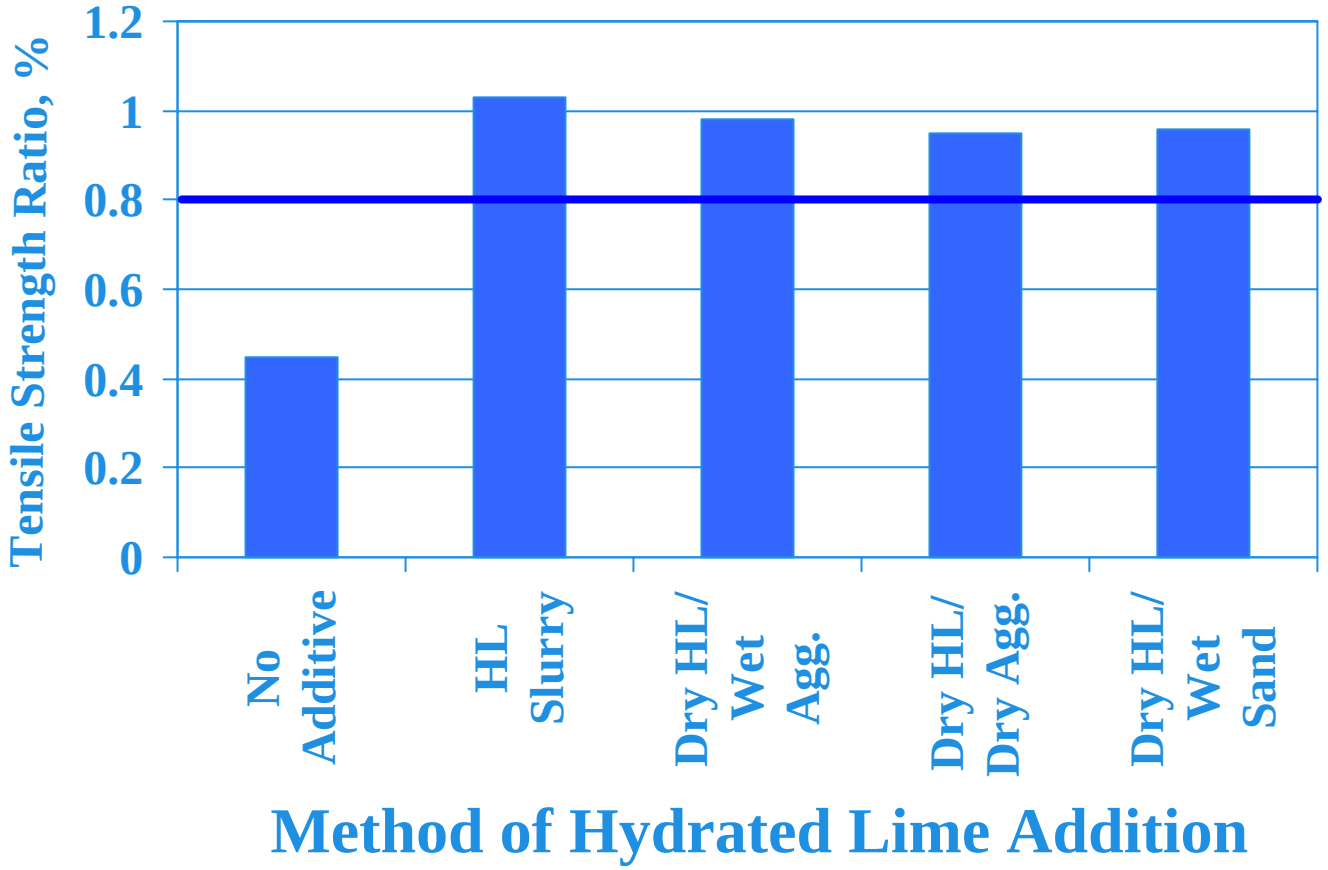
Comparison of TSR



Source: Texas DOT

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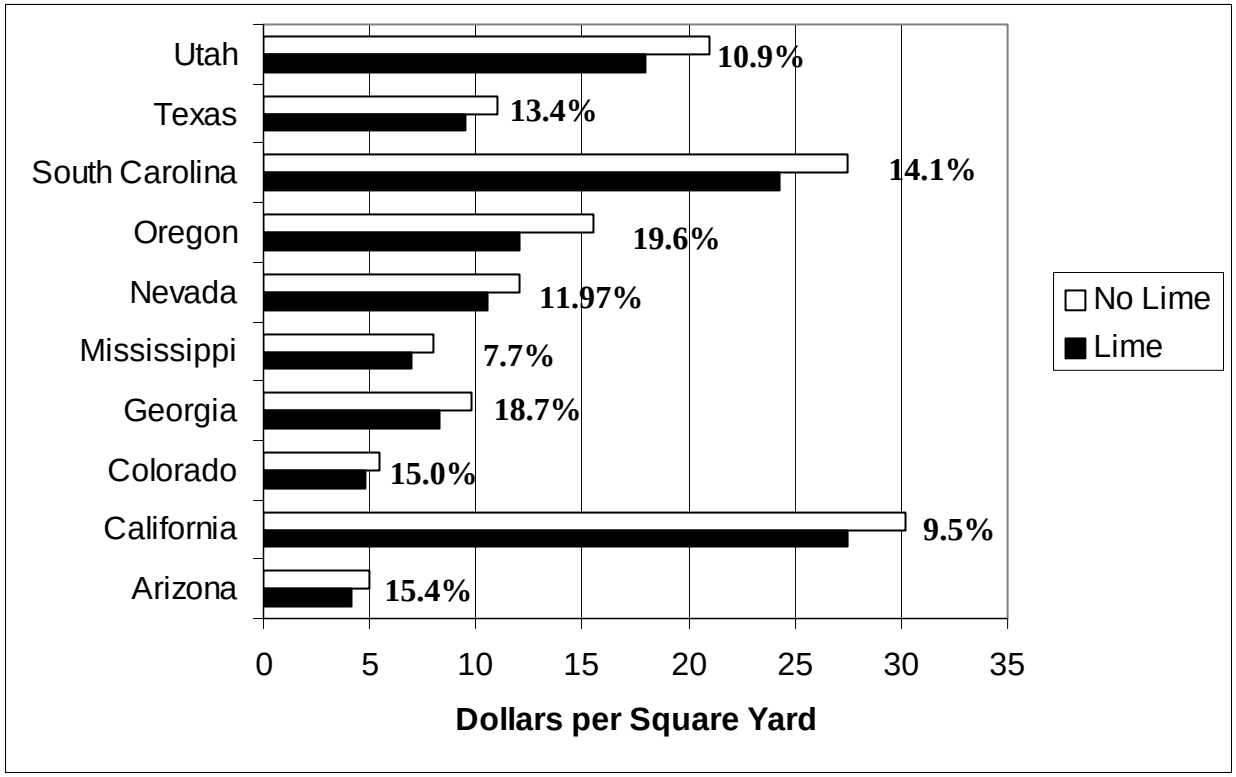
LCCA Cost Savings



Life cycle cost analysis of using lime for various states [after Hicks et al. (2001), ref. 49]

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Summary

- Hydrated lime improves performance of HMA
  - Moisture sensitivity
  - Rheology
- Moisture sensitivity
  - Proven best long term performer
  - Adhesion between mastic and stone
  - Improved viscosity - stiffness and resilience
- Rheology
  - Toughness at high and low temperatures
  - Active filler - captures polar molecules
  - Reduces oxidation and aging
- Synergistic benefits

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