Improving Performance of Local Agency pavements

by

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Rolling Joints?

Performance varies widely

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Durability and cracking issues are too prevalent

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We can do better- a lot better

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No silver bullets

Focus on sound fundamentals

- # 1 most important thing you can do to improve performance is to get lower in-place air voids
- #2 most important thing you can do is to get more binder in your mixes
- #3 most important thing you can do is to use softer binders

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In-place Air voids

- What are In-place air voids and why are they so important?

- Va = 100 – % compaction

- % compaction = bulk density/maximum density

Why so important?

- Increased cracking resistance
- Reduced permeability
- Reduced rates of aging and oxidation
- Increased strength and stiffness
- Reduced potential for raveling
- Reduced rutting potential

Get lower in-place air voids

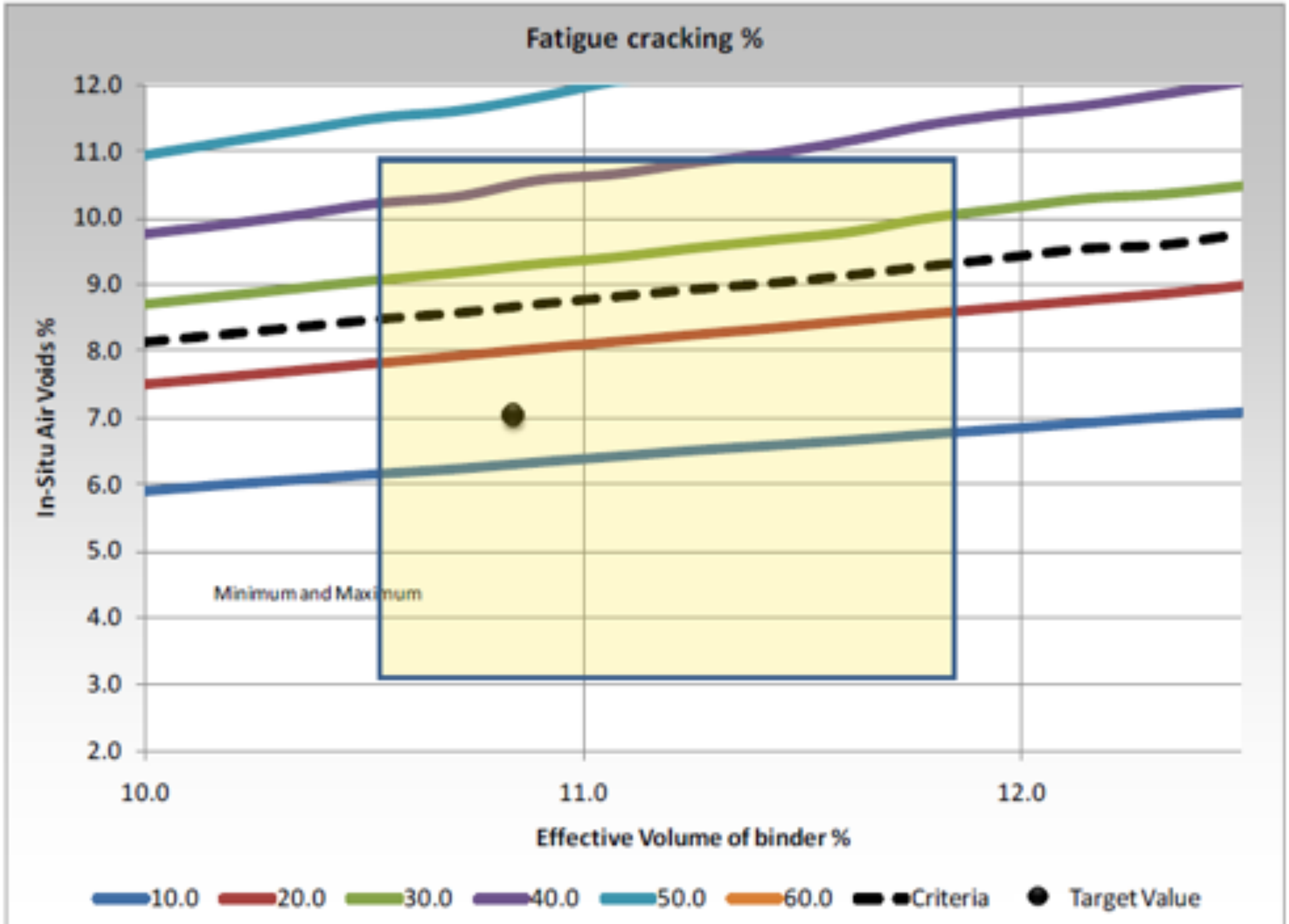

Figure 13. Output Chart for Fatigue Cracking.

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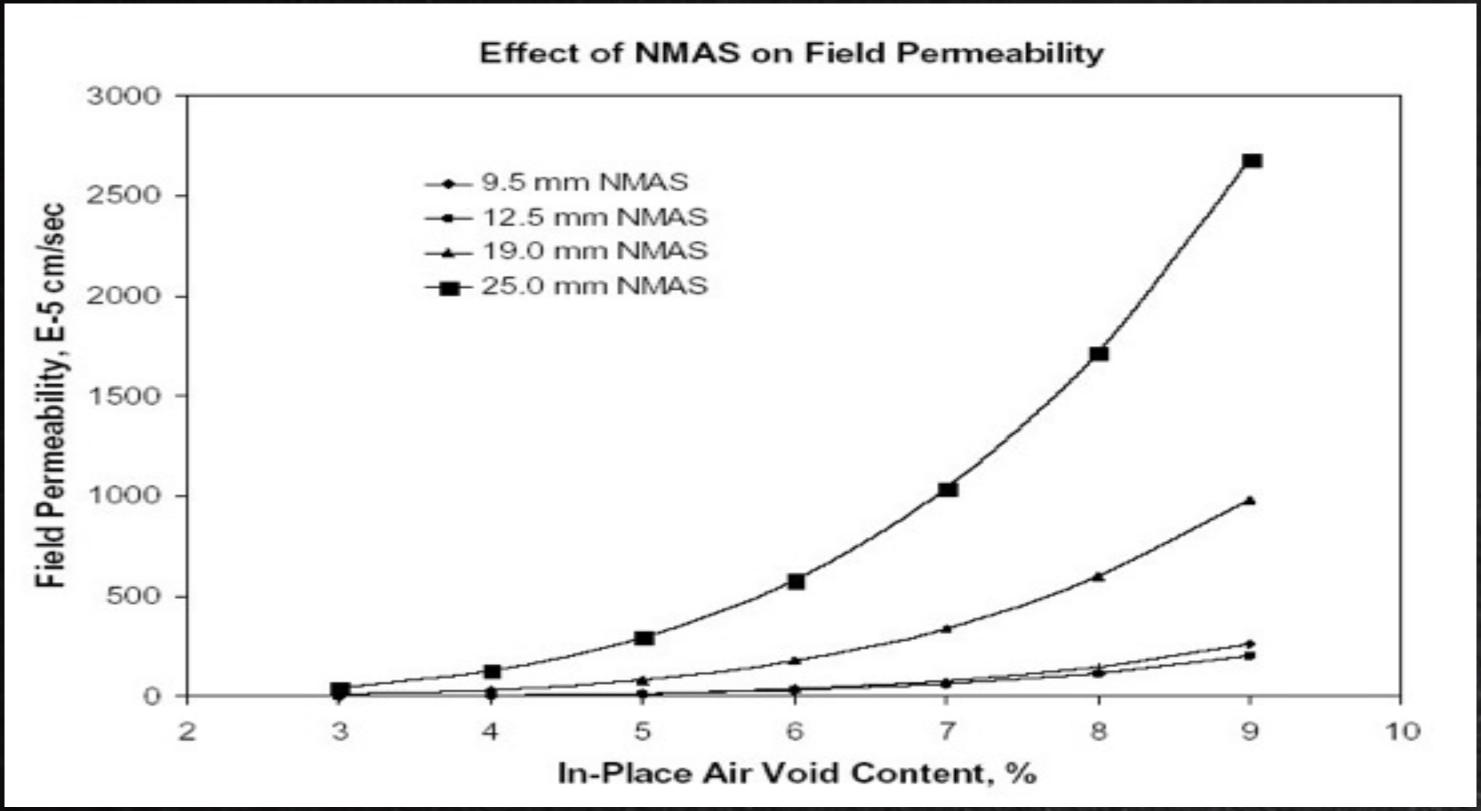
Permeability



Effect of NMAS on the Permeability Characteristics of HMA pavements

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In-place Air voids

- What is the right number?
- How do you get there?

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Background

The mix design process for dense-graded mixtures attempts to model the "In-Place" density of an asphalt pavement <u>after</u> it stabilizes under actual traffic loading.

The Theory

Pavements constructed to <u>*92%*</u> density should continue to compact under traffic and eventually stabilize around <u>*96%*</u> density during that 2 to 3 year period.

(*Note:* 96% density equates to 4% Air Voids)

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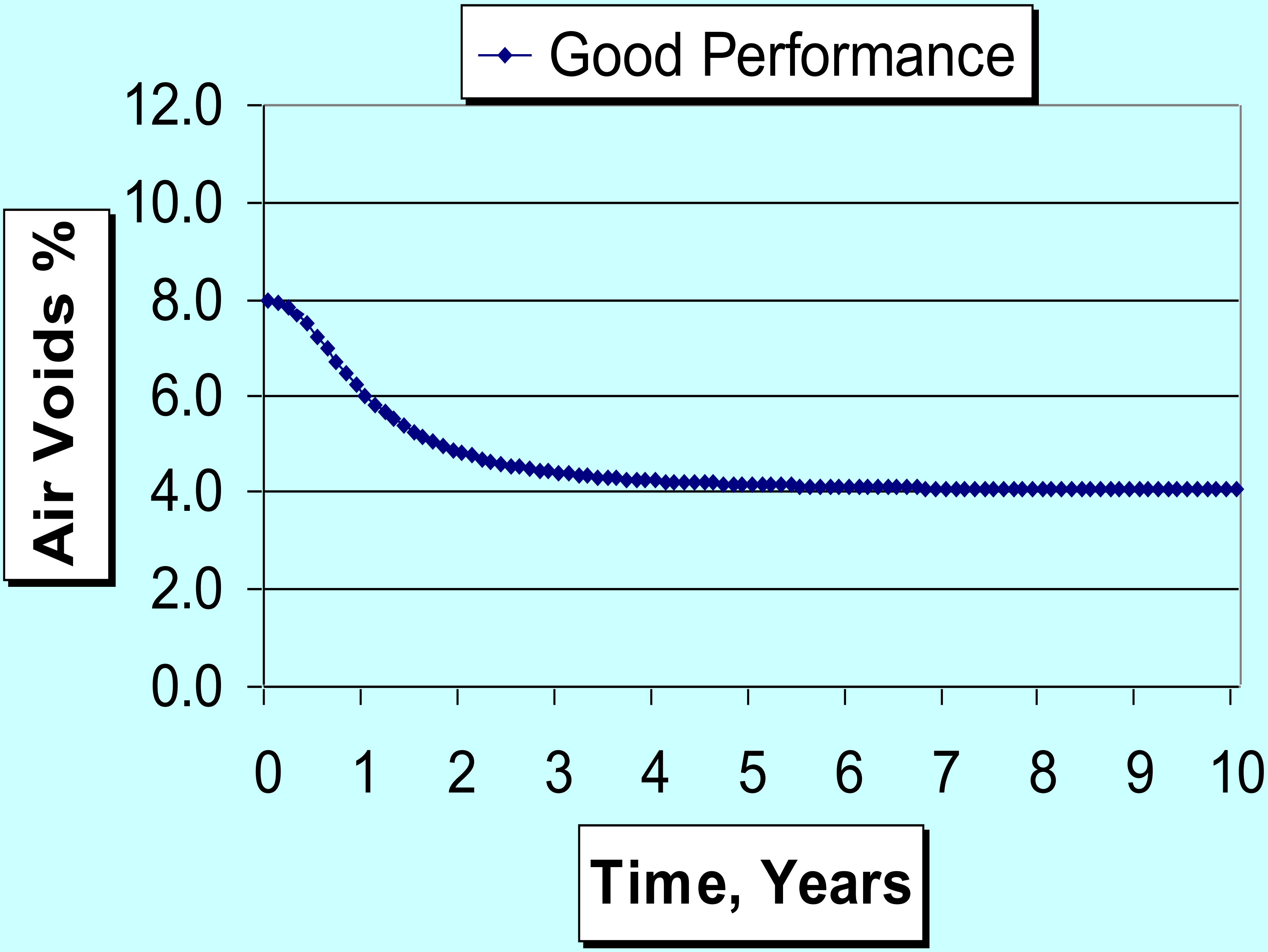

Good Performance
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Air Voids %
0
1
2
3
4
5
6
7
8
9
10
Time, Years

The Problem

- We are not getting 4% secondary compaction with current mixes and binders even on heavy truck traffic highways
- Local agency pavement get little to no secondary compaction

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What is the right number?

We should be shooting for in-place air voids of 5-6% to get the best overall performance

Getting 2% lower in-place air voids will Increase cracking resistance 75-100%

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How do we do it?

- Mix designs that can be compacted to lower in-place voids
- Make sure you have lift thicknesses that are adequate
- Site conditions conducive to good compaction

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Materials, Mix Selection and Mix Design (con't)

- Mix Design Levels
  - Level 1
  - Level 2
  - Level 3
  - Level 4
- It is important to work at the right level and the right void content.

Mix Design

The mix design level establishes the amount of energy imparted to the laboratory specimens in the SuperPave™ system. The energy comes from the gyrations used in the gyratory compactor. The number of gyrations for a given design level is designated N_{design}

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Mix Design Levels

Level	Traffic Type	20 Yr EALs
1	Low traffic, few or no trucks, 1 / day	0 - 30,000
2	Moderate truck traffic, < 140 /day	30,000 - 3 million
3	Heavy truck traffic	3 - 30 million
4	Very heavy truck traffic	> 30 million

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Mix Design

- Specify mix design binder content selected at 3.0-3.5% air voids rather than 4.0
- Superpave allows 3.0-5.0, ODOT chose 4.0 for various reasons
- Designing at lower air voids allows compaction to lower in-place voids and increases volume of binder

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Mix Design

- Selecting the binder at 3.0-3.5% air voids would add 0.2-0.4% binder to the mix ($1.5 - $2.0 per ton of mix)
- The added binder will increase film thickness and increase density 1% or more
- Couple the change with a minimum compaction increase to 93%, aim for mean density of 94-95%

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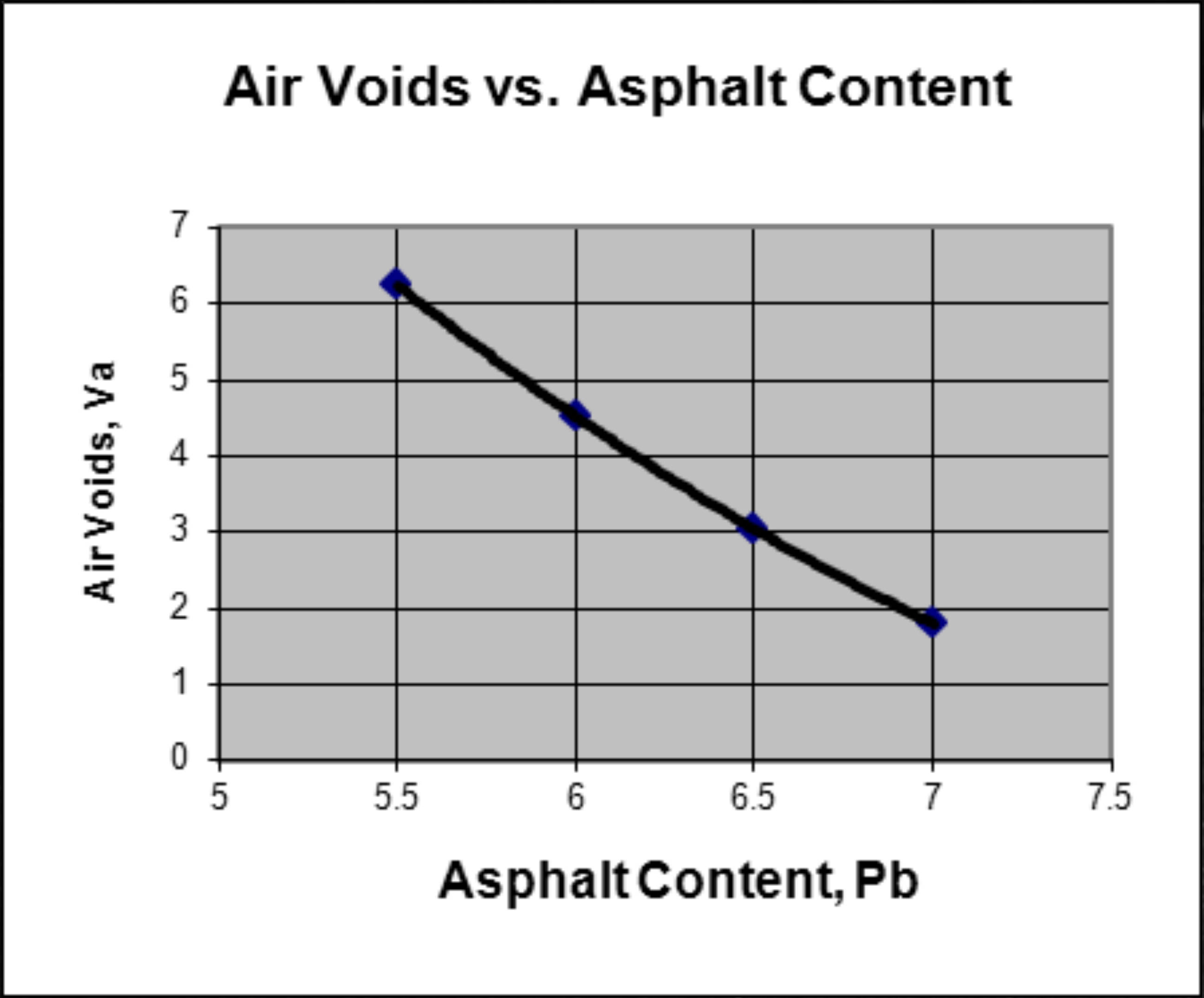
Air Voids vs. Asphalt Content
Air Voids, Va
Asphalt Content, Pb
7
6
5
4
3
2
1
0
5
5.5
6
6.5
7
7.5

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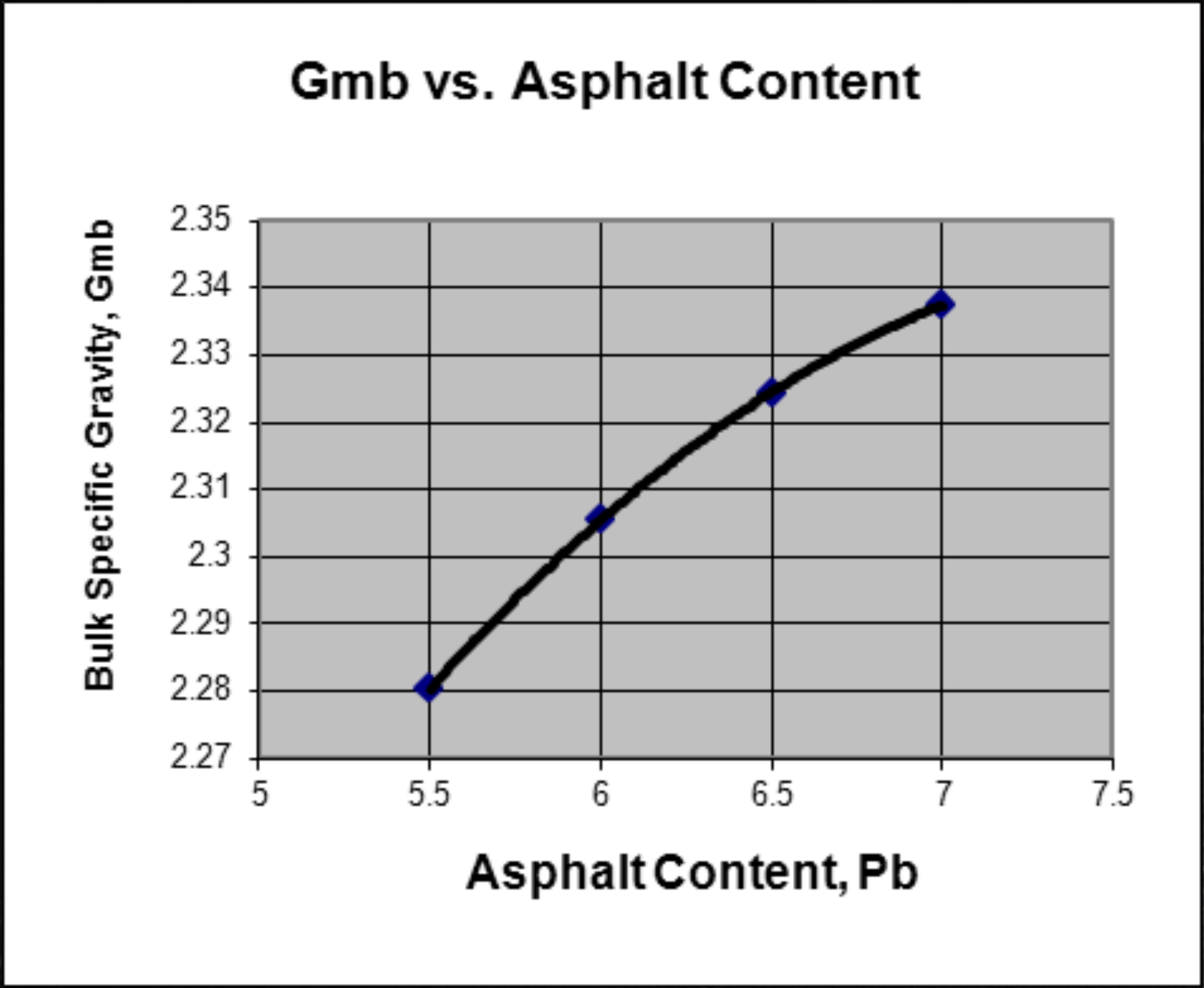
Gmb vs. Asphalt Content
Bulk Specific Gravity, Gmb
2.35
2.34
2.33
2.32
2.31
2.3
2.29
2.28
2.27
5
5.5
6
6.5
7
7.5
Asphalt Content, Pb

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@ 4% air voids Gmb = 2.306 or 143.89 pcf

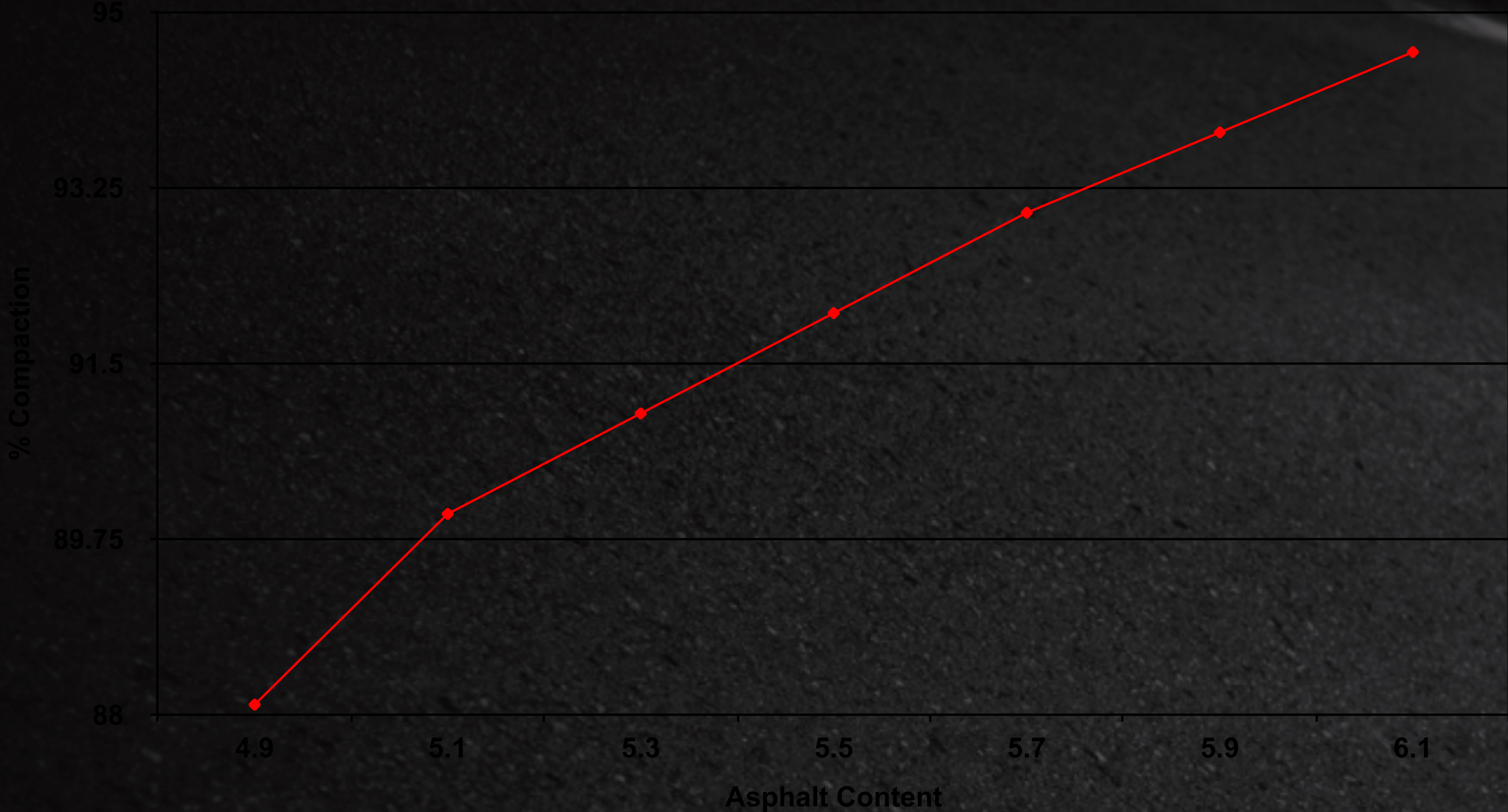
The 143.89 has 8.92 pounds of asphalt and 134.97 pounds of rock

@ 3% air voids Gmb = 2.325 or 145.08 pcf

The 145.08 has 9.43 pounds of asphalt and 135.65 pounds of rock

Compaction

Asphalt Content



Get lower in-place air voids

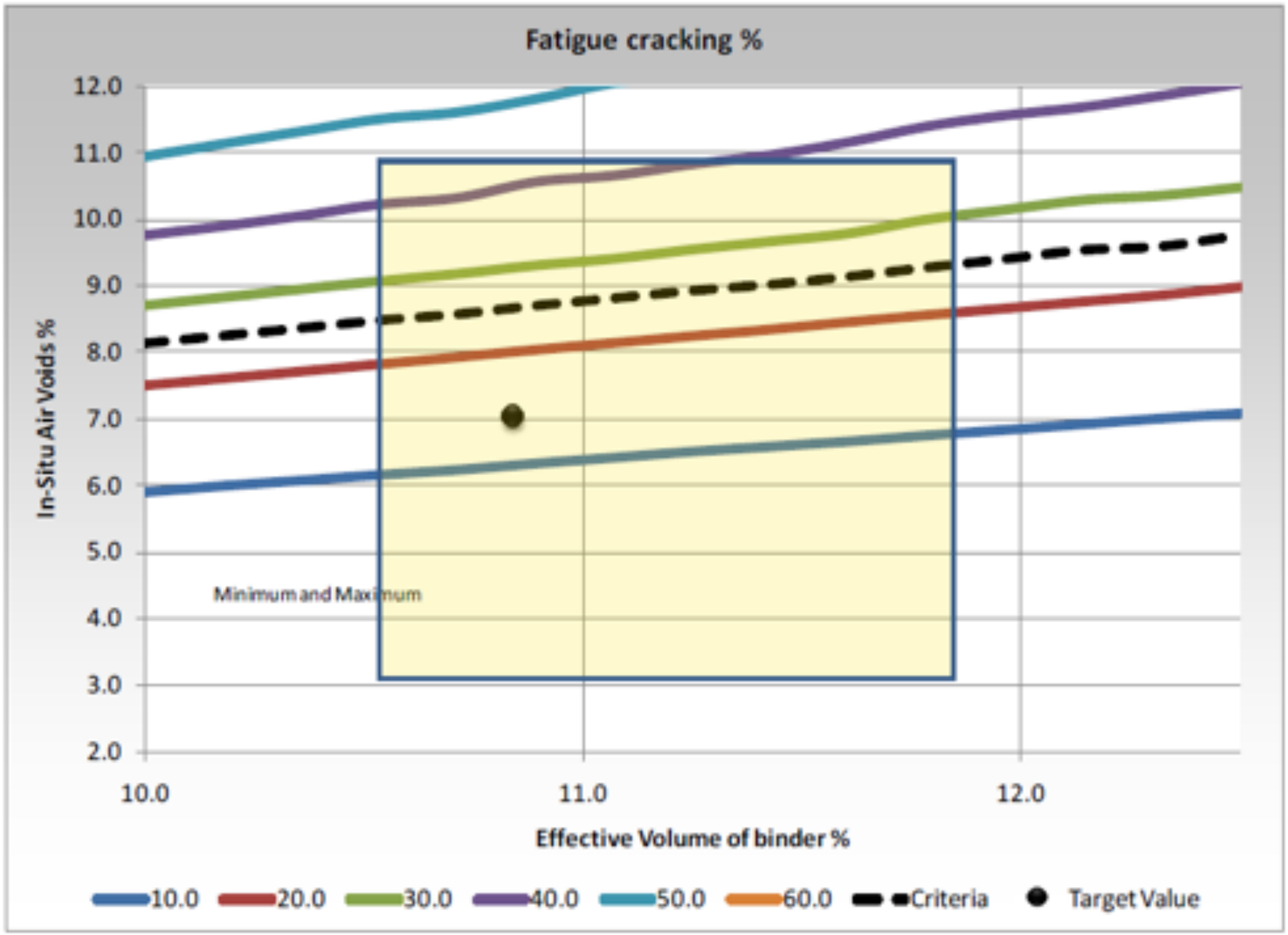


Figure 13. Output Chart for Fatigue Cracking.

Oxidation

- Oxidation rates are highly influenced by binder content, in-place air voids and binder properties

- Cracking occurs when binders become too brittle from oxidation

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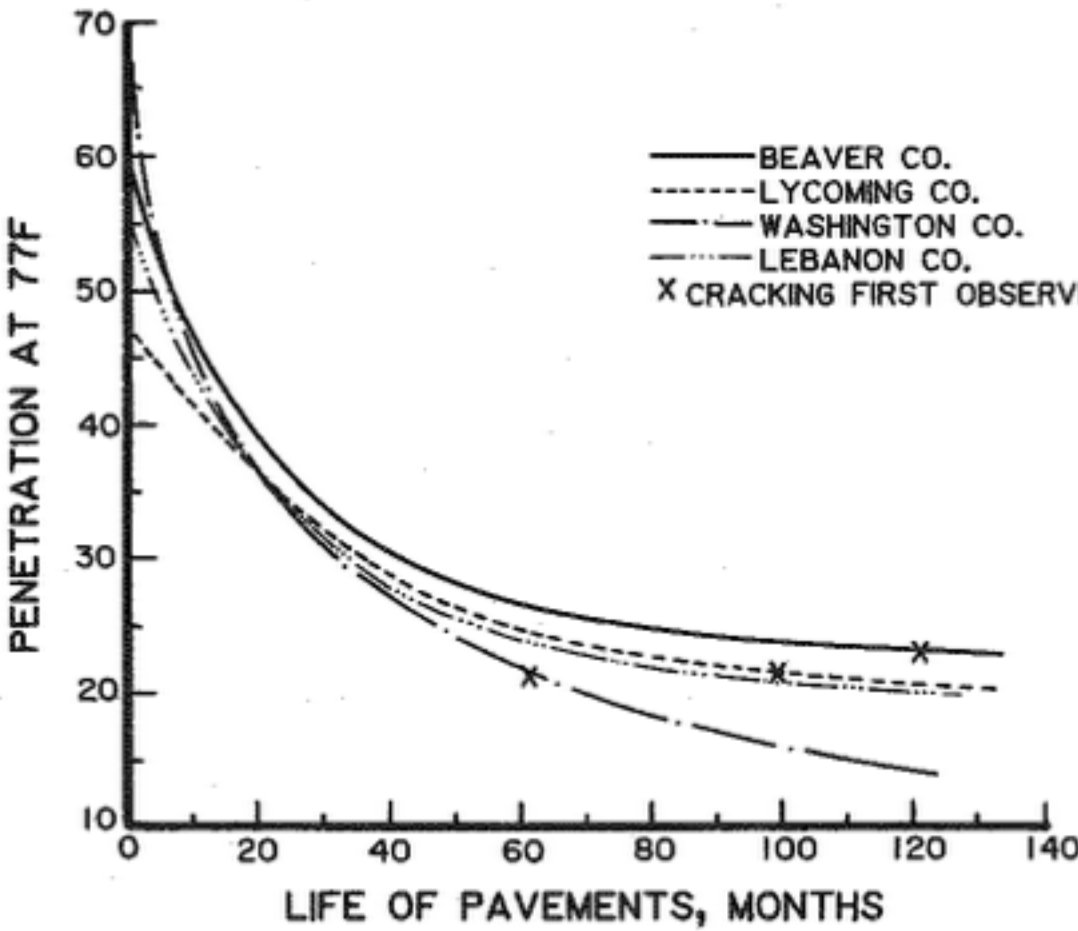

Figure 2-33. Penetration Versus Time in Months (after Kandhal, *34*)

Use Softer binders

High resistance to cracking may occur when a mixture is well designed and properly compacted and the penetration of the asphalt cement is well above 30.

To ensure long life, one should use as soft an asphalt cement as possible without reducing stability below the minimum required to prevent displacement under traffic.

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Selecting the Binder Grade

- Climate - High and Low <u>Pavement</u> Temp
- Speed of traffic
- Volume of traffic
- RAP content

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PG Grades used in Oregon

- Dense Graded Mixes - Western Oregon
  - PG 64 - 22
  - PG 70 - 22 High Traffic or Slow Traffic
  - PG 76 - 22 In selected locations/applications

- Dense Graded Mixes - Central & Eastern
  - PG 64 - 28
  - PG 70 - 28 High Traffic or Slow Traffic
  - PG 76 - 28 In selected locations/applications

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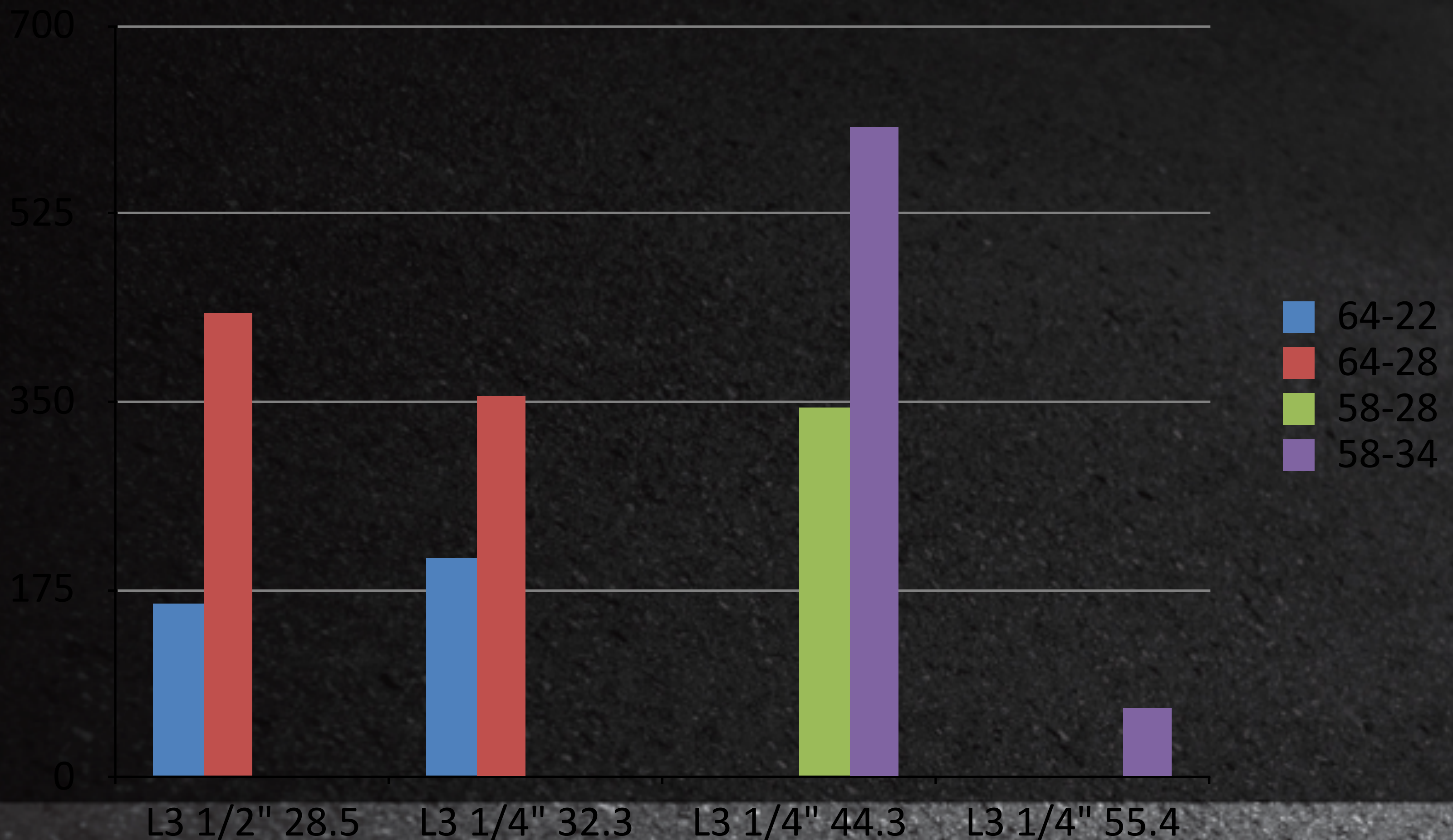
Binder Selection

- Intermediate temperature is where fatigue and reflective cracking occur not at extreme low and high temperatures
- Which number (low temp or high temp) best represents the fatigue and reflective cracking susceptibility?

Overlay Crack Test Results



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Crack resistance

- The cold temperature grade is the best indicator of cracking resistance
- Going 1 grade lower can increase crack resistance by 100% or more
- More than offsets stiffening impact of RAP and RAS as well

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Compactibility

- Using lower high temperature grade binders will make mixes easier to compact
- RAP and RAS will increase grade and offset impact on rutting

Impacts of RAP

- RAP known to stiffen mix and binder
- ODOT policy allows up to 30% RAP with no change in binder grade
- Works for ODOT because thick pavements and high compaction

Impacts of RAP

- For local agency applications ODOT policy is inadequate
- For RAP content of 20% or higher assume mix is stiffened one high temperature grade
- Use PG 58 or 64 for most all applications
- For extreme loading and extreme high temp applications use PG 70 base grade

Constructability

- Insure adequate lift thickness
- Prepare adequate foundation

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If Layer Thickness is too thin then it will be very difficult to obtain Adequate Compaction

- Bridging of aggregates
- Cooling of mixture

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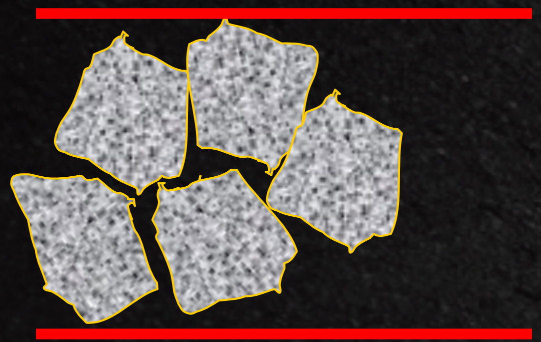
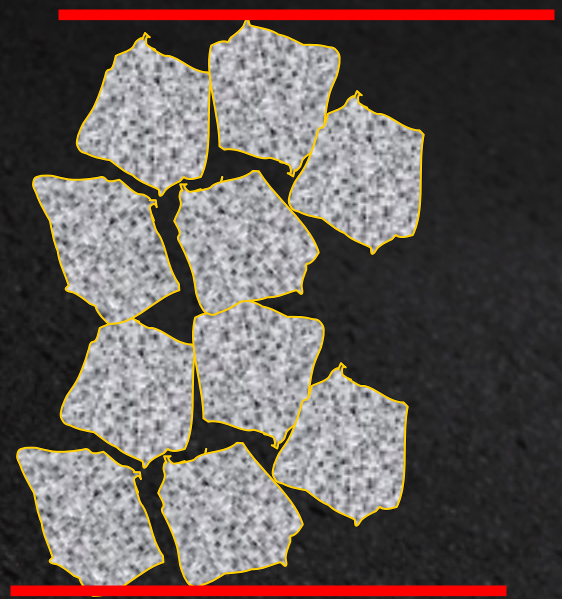
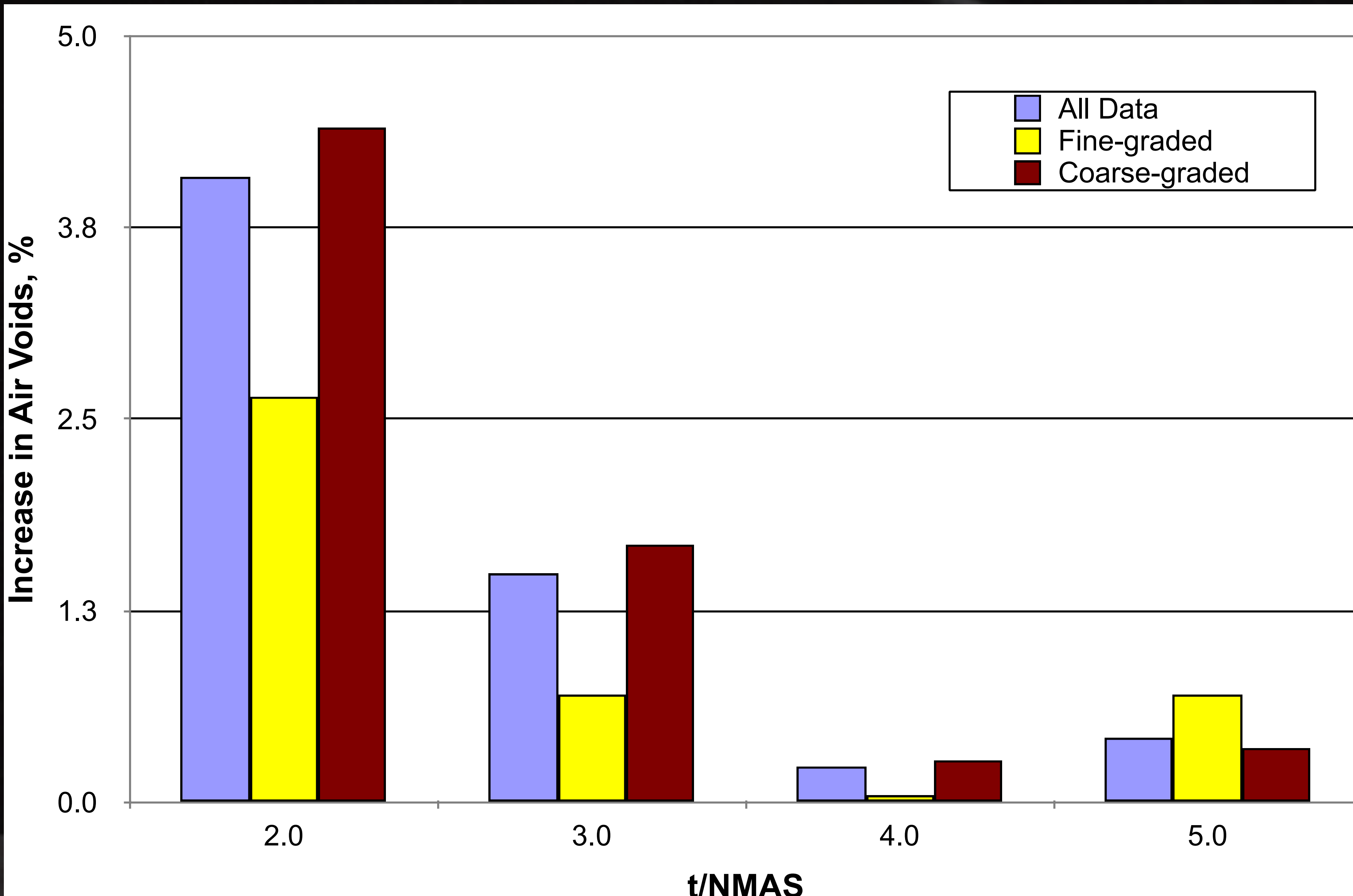
Background



Ratio of thickness/NMAS = 2



Ratio of thickness/NMAS = 4



All Data
Fine-graded
Coarse-graded
5.0
3.8
2.5
1.3
0.0
Increase in Air Voids, %
2.0
3.0
4.0
5.0
t/NMAS

Findings

- For fine graded mixes the t/NMAS should be at least three for best compaction
- For coarse graded mixes the t/NMAS should be at least four for best compaction
- 3 inch lifts are always better especially first lift on aggregate base

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Summarize

- Specify mix design asphalt content be selected at 3.0-3.5% air voids
- Couple that with a density requirement 1-1.5% higher than current (if currently 92 min go to 93 – 93.5% min)
- Use one grade softer low temp binder
- Use 58 or 64 high temp grade to ensure compactibility

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Case Study

- Recently worked with City of Bend on reconstruction of failed roundabout
- Designed a perpetual pavement

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Bend Roundabout

- Asphalt selected for time of construction and life cycle cost
- Concrete would take 3.5+ weeks to build and local businesses would not tolerate that impact
- Asphalt alternate was constructed in 58 hours for 20% less
- Perpetual design will never require major rehab

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Bend Roundabout

- Total asphalt thickness 9”
- Constructed in 3 lifts each 3”
- Bottom 2 lifts designed at 3.5% air voids
- Top lift 4.0% air voids and polymer modified binder


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Performance Prediction

- No bottom up cracking ever
- Surface should last 20+ years
- Simple mill and fill will completely restore to new condition
- The low in-place air voids will increase crack resistance 3-4 times compared to past Bend performance
- All cracking will be top down

Questions?