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Verification of Gyration Levels in the Superpave N_{design} Table

National Center for Asphalt Technology NCAT AUBURN UNIVERSITY

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The compaction effort used in a volumetric mix design should produce laboratory samples which approximate the ultimate density of the pavement

The goal of this project is to verify the laboratory compaction efforts established in 1999 for the Superpave gyratory compactor

Overview

- Background of N_{design}
- NCAT Test Track
- NCHRP 9-9(1) Field Test Sections
- Affect of Internal Angle of Gyration
- Virginia's Experience
- Conclusions

Original SGC Compaction Effort

Design ESALs (millions)	Average Design High Air Temperature											
	<39 ºC			39 - 40 ºC			41 - 42 ºC			43 - 44 ºC		
	N_{ini}	N_{des}	N_{max}	N_{ini}	N_{des}	N_{max}	N_{ini}	N_{des}	N_{max}	N_{ini}	N_{des}	N_{max}
< 0.3	7	68	104	7	74	114	7	78	121	7	82	127
0.3 - 1	7	76	117	7	83	129	7	88	138	8	93	146
1 - 3	7	86	134	8	95	150	8	100	158	8	105	167
3 - 10	8	96	152	8	106	169	8	113	181	9	119	192
10 - 30	8	109	174	9	121	195	9	128	208	9	135	220
30 - 100	9	126	204	9	139	228	9	146	240	10	153	253
> 100	9	143	233	10	158	262	10	165	275	10	172	288

National Efforts to Address N_{design}

- Asphalt Institute - N_{design}II Experiment
  - Examined field densification of SPS-9 pavements
  - Looked at mixture stiffness (G*) with SST
- NCAT - NCHRP 9-9 Evaluation of the SGC Procedure
  - Looked at sensitivity of mix volumetrics to changes in N_{design}
- A new N_{design} Table was developed from each effort

SGC Compaction Effort 1999

ESAL's	N_{ini}	N_{des}	N_{max}	App
< 0.3	6	50	75	Light
0.3 to < 3	7	75	115	Medium
3 to < 30	8	100*	160	High
10 to <30	8	100	160	High
≥ 30	9	125	205	Heavy

Base mix *(< 100 mm)* option to drop one level, unless the mix will be exposed to traffic during construction.

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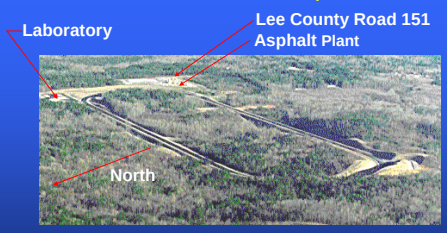
Thoughts on N_{design}

- Laboratory compaction effort should produce sample density approximately equal to ultimate pavement density
- Ultimate pavement density believed to be reached after 2-3 years of traffic
- Typically, select laboratory density of 96% of Theoretical maximum density or 4% air voids
  - Too little air voids (<2%) results in rutting
  - Too many air voids tend to cause durability problems

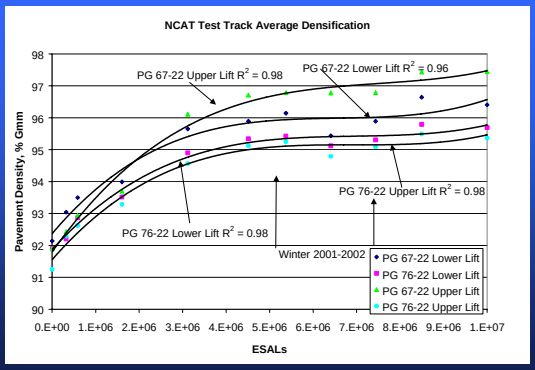
NCAT Test Track

NCAT Test Track near Auburn, Alabama U.S.A.



- 2.74 km Oval Test Track on 309 acres
- 46 Cooperatively Sponsored 61 m Test Sections
- 437 sq m Testing Laboratory
- 242 sq m Truck Maintenance Facility

Pavement Densification



Summary of Pavement Densification

- After initial consolidation/aggregate reorientation, densification only occurred when temperature above 28° C (82 °F)
- Mixes containing modified (PG 76-22) binders densified significantly less than unmodified (PG 67-22) binders (2%)
- Unmodified lower lift shows less densification (0.8%) – future trend unclear

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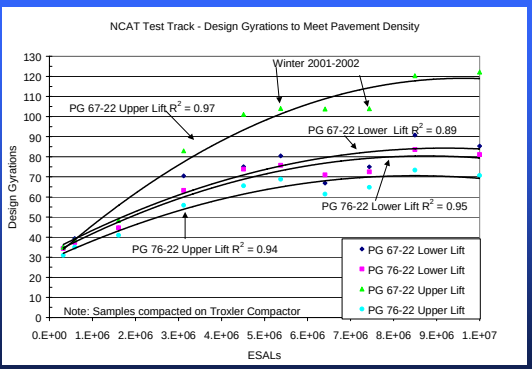
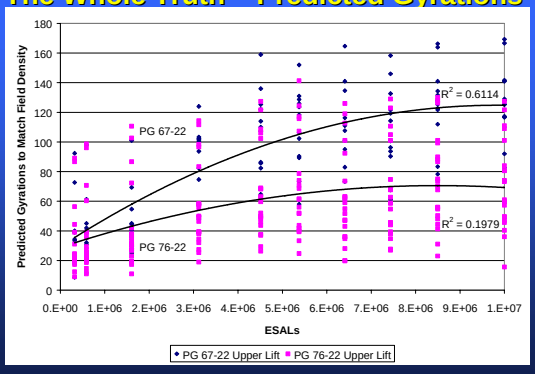
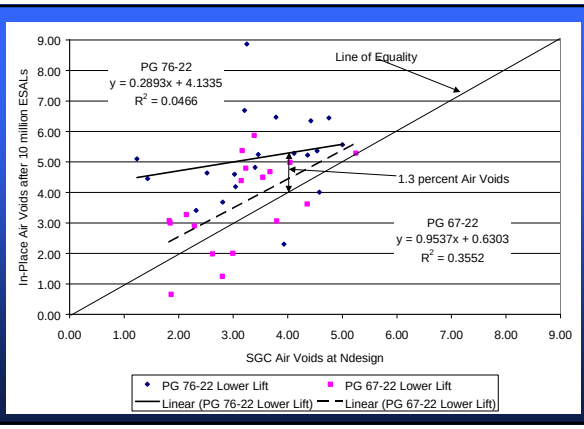
Estimation of Density at a Given Gyration Level

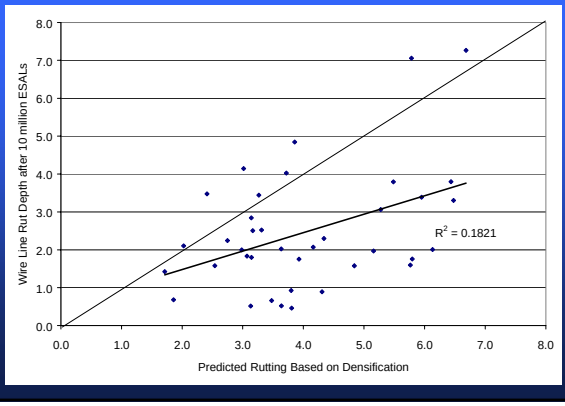
$$\text{Density at Gyration } X = \text{Density at NDesign} \times \frac{\text{Height at NDesign}}{\text{Height at Gyration } X}$$



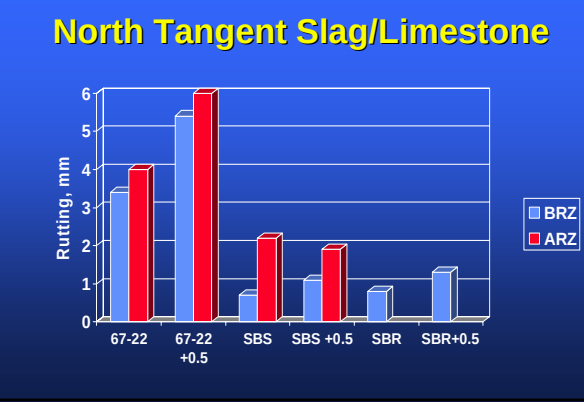
The Whole Truth – Predicted Gyrations







North Tangent Slag/Limestone



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Modified mixes (PG-76) rutted 66% less than unmodified (PG-67) mixes

Effect of 0.5% Increase in Asphalt Content

- 54% increase in rutting when mix uses non-modified asphalt
- No significant increase when mix uses modified asphalt

Note: The Superpave rule of thumbs states 1% air voids = 0.4% AC and a change in 25 gyrations results in a 1% change in air voids

Mix Design requires a balance between *Rut Resistance* and *Durability*

Typically, we design for *Rut Resistance*

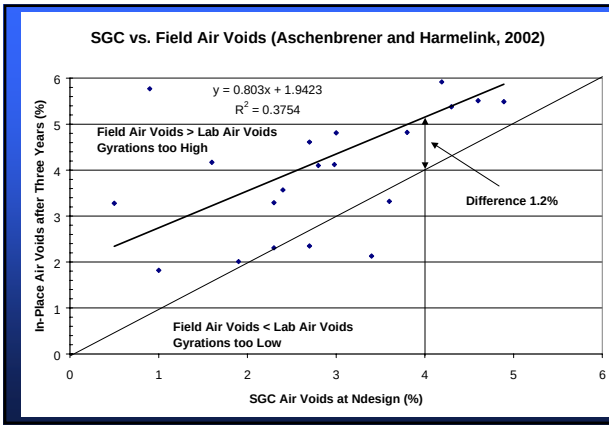
What Does This Mean for Mix Design?

- Test Track Data Indicates:
  - Modified binders densify less than unmodified binders
  - This may mean that mixes containing modified binders maybe designed at lower gyrations or higher asphalt contents to enhance durability

This may be a way to balance rut resistance and durability!

In-Place Monitoring of Hot Mix Asphalt Pavements

Colorado Department of Transportation
Research
Aschenbrener and Harmelink
2002



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CO Density Study Conclusions
Aschenbrener and Harmelink, 2002

- Mixes have not reached their design level of compaction after six years
- Six-year trend indicates they never will
- Majority of the densification occurred in the first three years
- Based on data from these 25 sections, the optimal number of gyrations is too high – mixes too stiff for climate and traffic

NCHRP 9-9(1) Field Projects

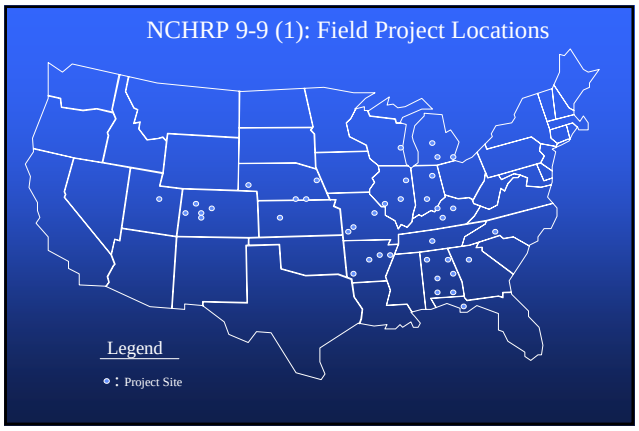
Verification of N_{design} Table

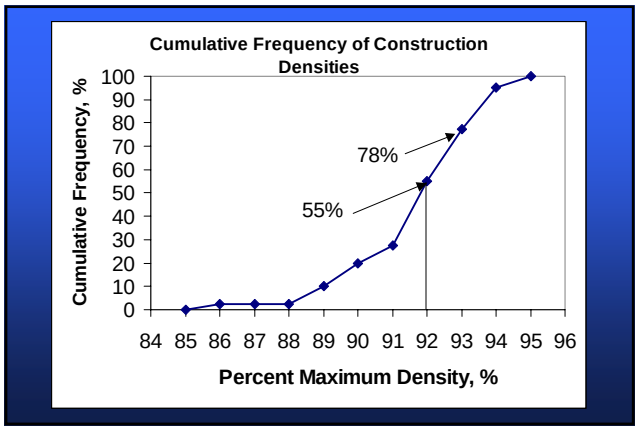
Experimental Plan

- Sample 40 pavements at the time of construction with a range of:
  - Lift Thickness to NMAS (2-4)
  - Design Gyration Level (50-125)
  - Binder Grade (Normal to +2 bumps)
  - Gradation (Fine or Coarse)

Experimental Plan

- Roadway cores taken at construction, 3 months, 6 months, 1 year and 2 years after construction from right wheel path
- Project extended to monitor projects 4 years after construction
- Goal: predict gyrations to match field density





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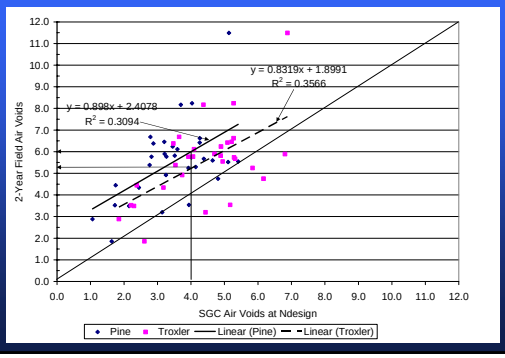
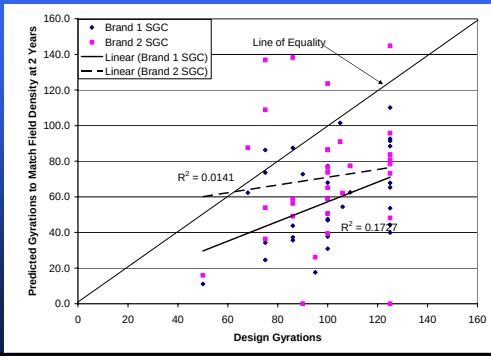
Summary of Projects with Two Years of Traffic

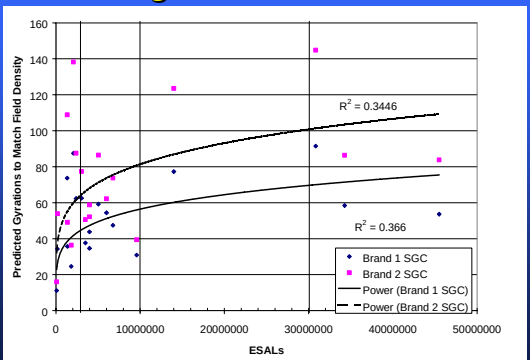
Comparison of SGC and Field Air Voids



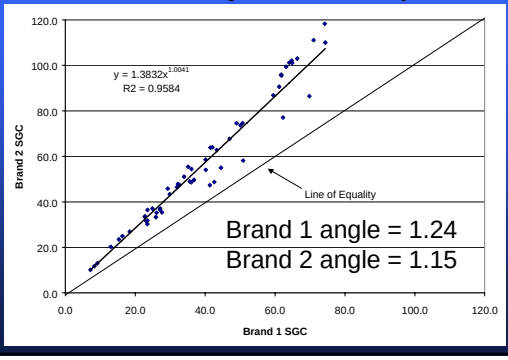
Design Vs Predicted Gyrations



Design Life Predictions



Comparison of Number of Gyrations to Match Field Density for Two Compactors



Performance Overview NCHRP 9-9(1) Two-Year Sections

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Ndesign in the Southeast

State	Traffic Level	
	Low	High
Virginia	65	65
Georgia	Second locking point or 65	Second locking point or 80
Alabama	65	80

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Summary Comments

- Need to balance rut resistance, durability and constructability
- Pavements studied have been rut resistant
- General indication that gyrations could be lowered
- States in southeast already taking action!
- Gyratory type or internal angle effect recommendations

Questions?

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Thank You!