FIELD RESULTS OF HIGH AIR VOID-DESIGNED MIXES

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Missouri Asphalt Conference

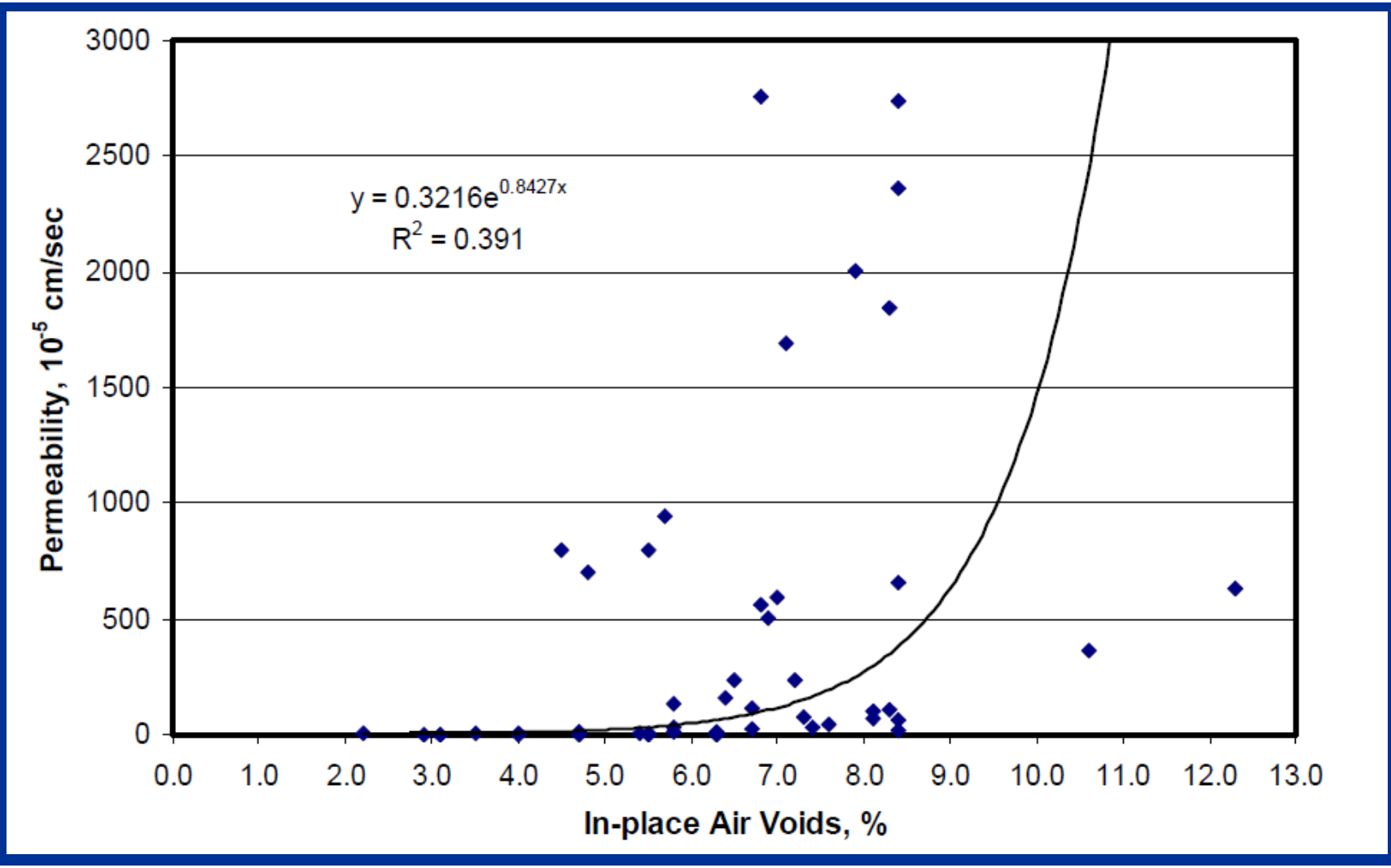
Rolla, MO

December 3, 2013

Recall the Background

- Indiana pavements generally fail because of durability issues after 15-20 years
- Reducing permeability (to air) decreases rate of binder aging, improves durability
- Mixes can be placed in the field at lower densities, with air voids >9%
- Above 8% air, permeability increases rapidly
  - *Each 1% increase over 7% reduces life by ~1 year*

NCAT Study (Report 03-02, Mallick et al.)



How to Decrease Voids and Increase Durability?

- Increase field density while maintaining effective binder content and VMA
- Mixes need to be more compactable

Concept

- Make changes in mix design to make mixes easier to compact in field
- Design and compact mixes to 5% air
- French mixes have no traffic densification

Changing Gyration Levels

- With same aggregate stockpiles
  - Same crushed faces, FAA and hardness
- Decreasing gyrations→
  - Change in gradation
  - Lower mix stiffness in lab
  - Easier compaction in field
- Need equal or better final mechanical properties to prevent traffic densification

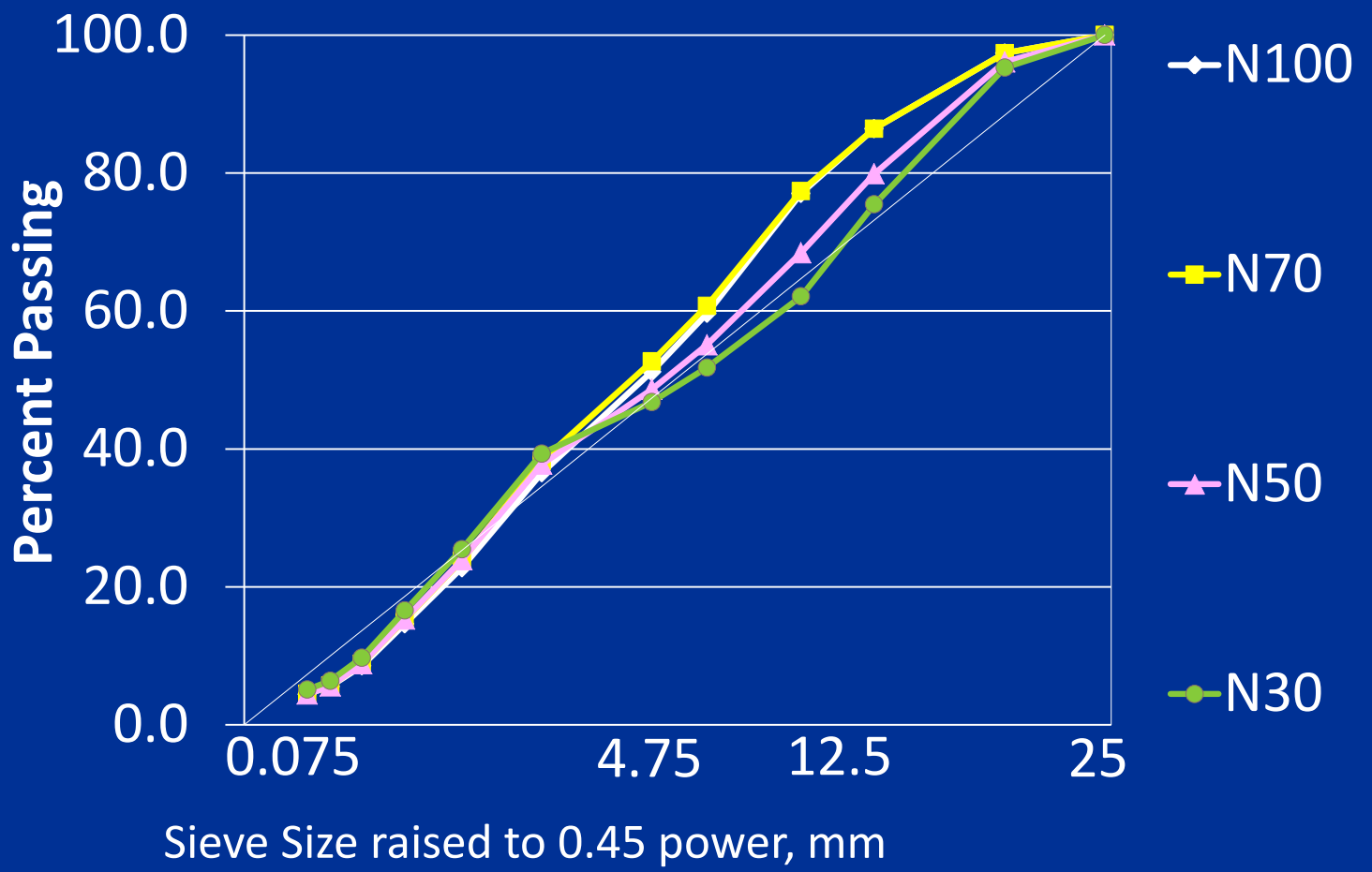
Experimental Matrix

Traffic Level	No of Gyrations	Mixture Type	
		9.5 mm	19.0 mm
3 – 10 million	30	X	
	50	X	
	70	X	
	100	X	
10 – 30 million	30	X	X
	50	X	X
	70		X
	100	X	X

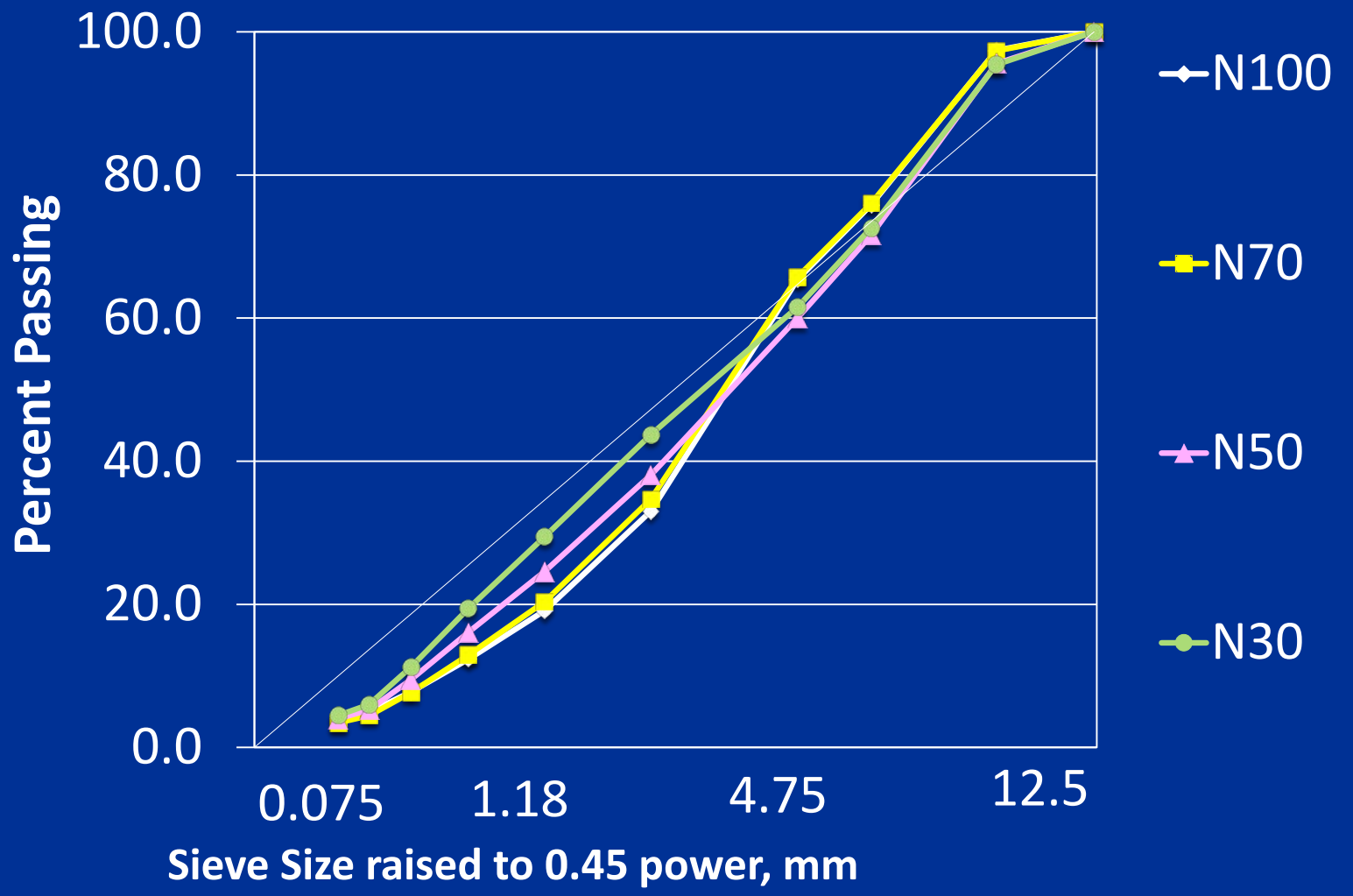
About the Mixes

- Designed for 3 to 30 million ESALs
  - 50% of INDOT work
- PG 64-22
- Coarse graded mixes
- Limestone, dolomite and ACBF slag coarse aggs
- Limestone, dolomite and natural fine aggs plus baghouse fines
- No RAP or RAS

19.0 mm Mixture Gradations



9.5 mm Mixture Gradations



9.5 mm, Cat 3 Mix Volumetrics

	Original	Re-Designed		
Gyrations	100	70	50	30
V_a, %	4.1	5.1	4.9	5.3
VMA, %	15.0	16.0	15.8	16.3
VFA, %	72.9	67.9	68.9	67.6
P_{be}, %	4.6	4.6	4.6	4.7
PCS (2.36 mm)	33.0	34.7	38.1	43.7

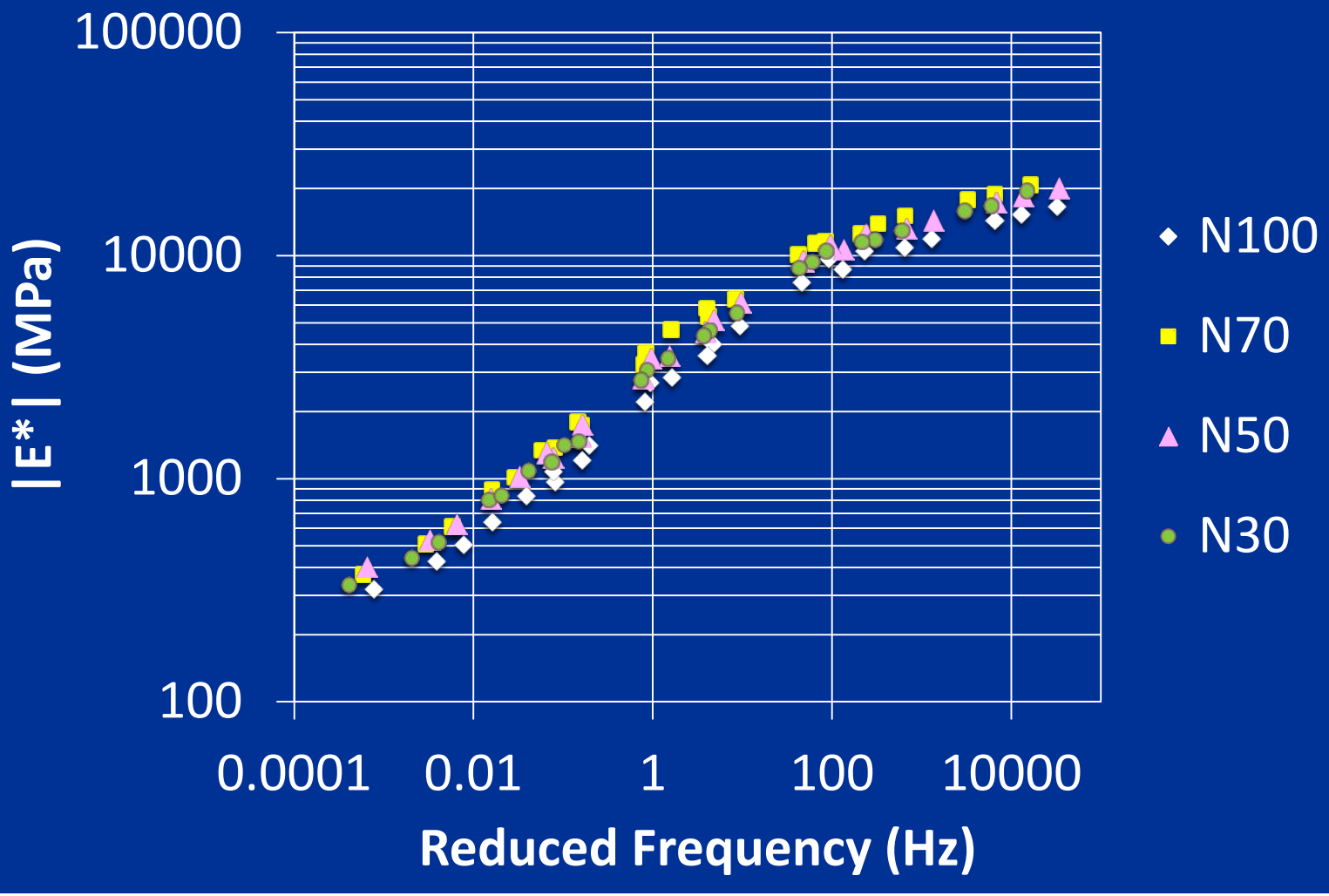
Testing

- Dynamic Modulus Test
  - Stiffness
  - Rutting
- Flow Number Test
  - Rutting

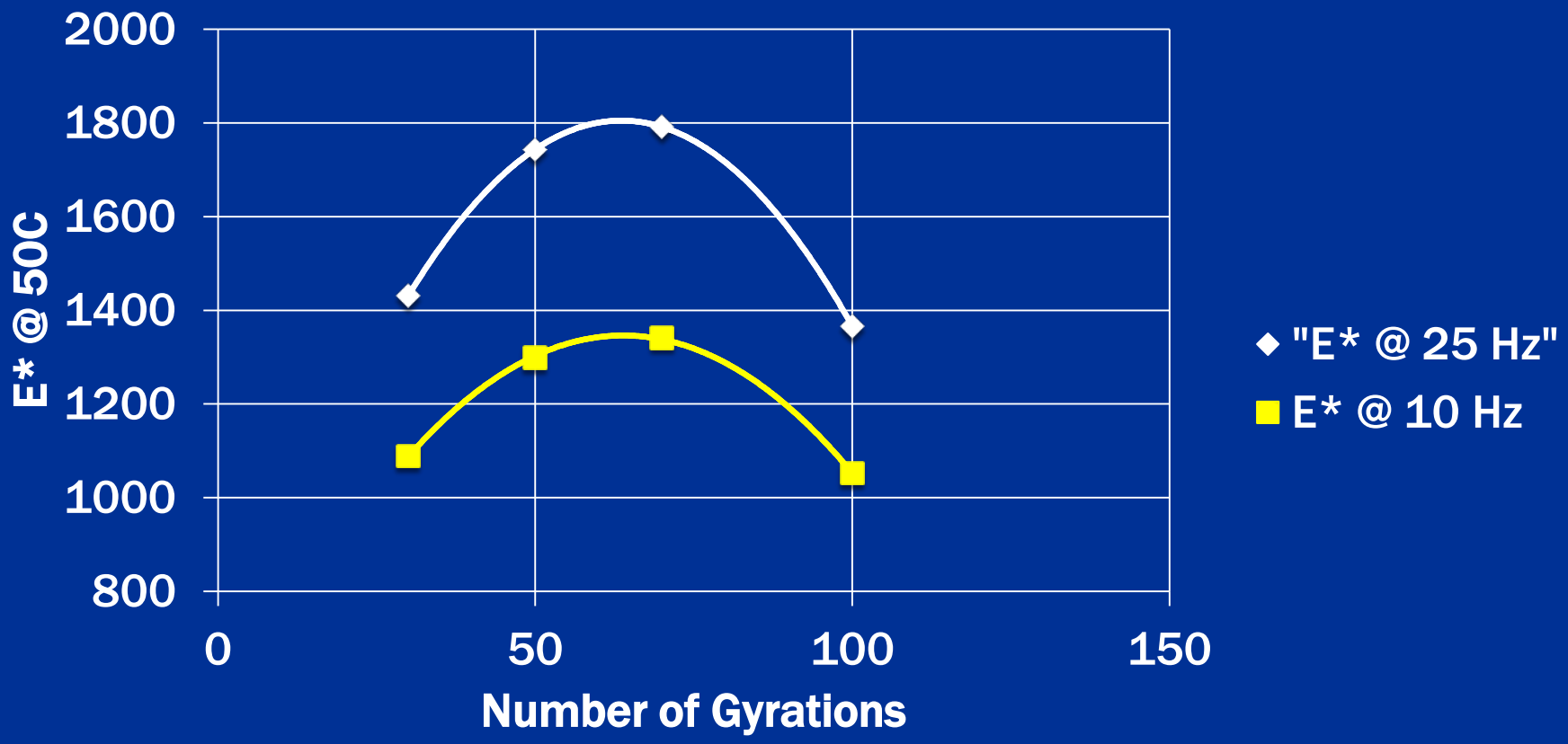
- 100 gyration mix tested at 7% air, redesigned mixes at 5% air (field compaction level)

Dynamic Modulus Results

19.0 mm Mixes

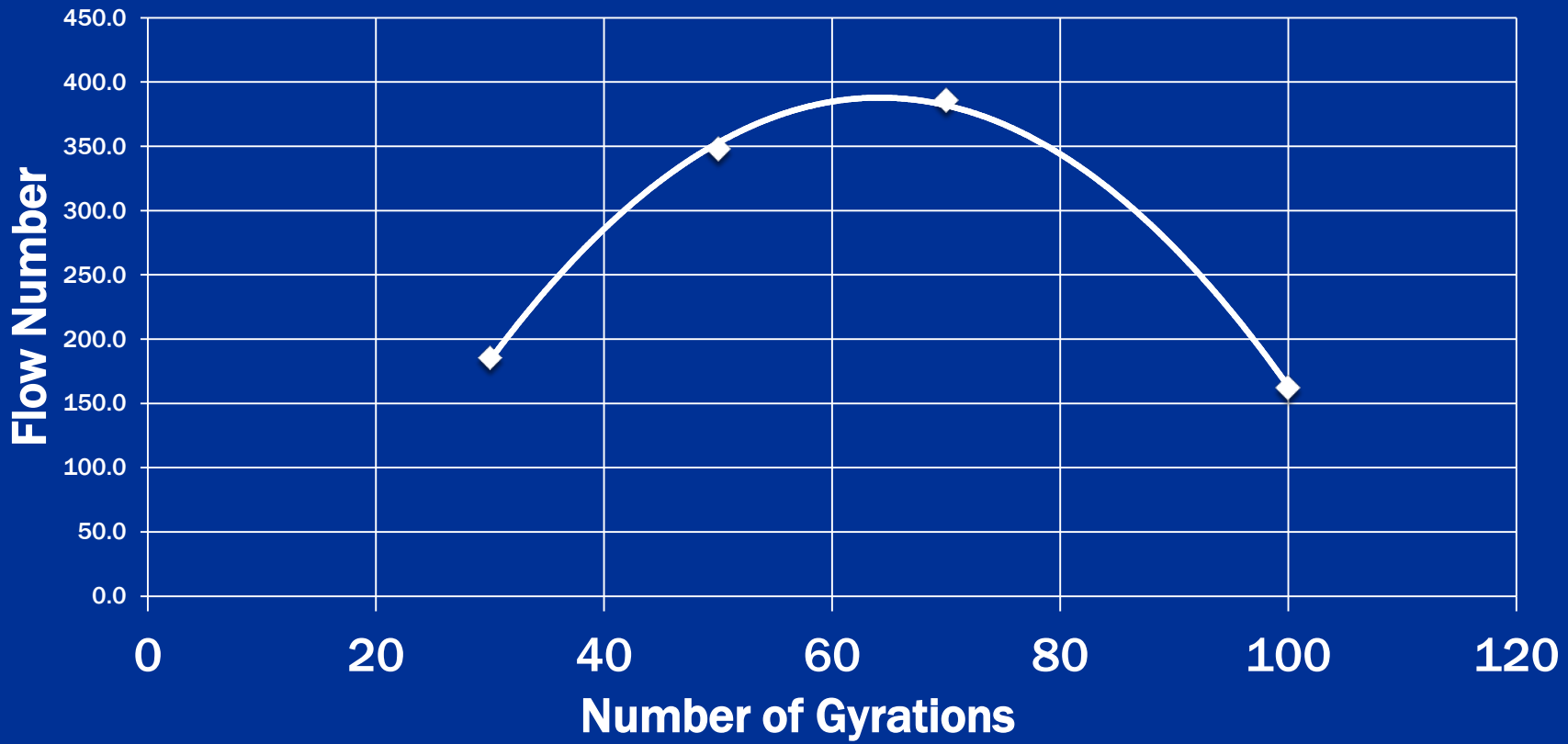


Change in Dynamic Modulus (19.0 mm)



Peaks at 63-64 gyrations.

Change in Flow Number (19.0 mm)



Peaks at 66 gyrations.

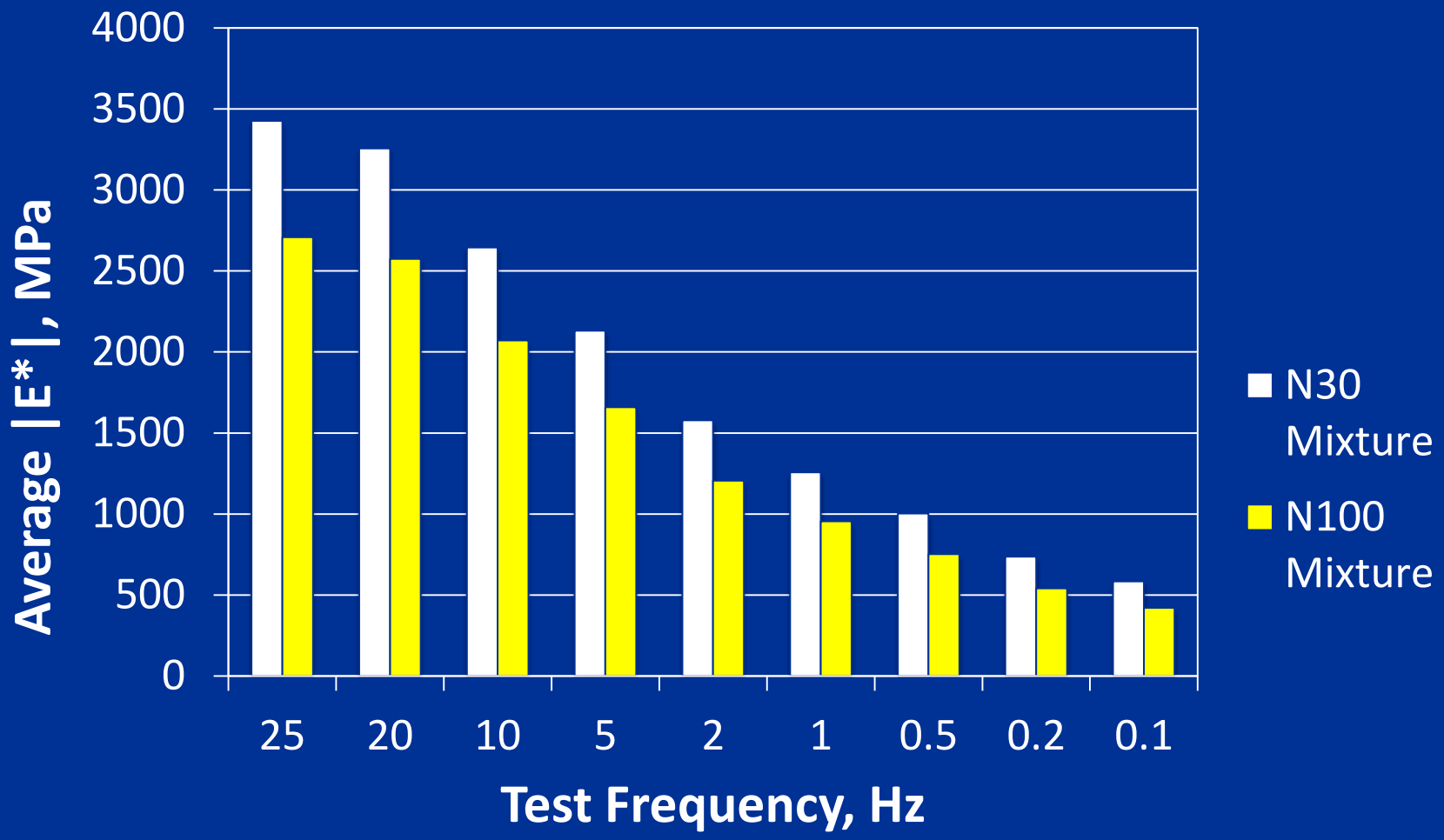
Lab Findings

- With changes in gradation, mixes can be designed at 5% air voids in the lab
- Re-designed mixes at 5% air can have higher stiffnesses and higher rut resistance than mixes designed at 4% air and compacted to 7% air
- Concept looks promising
- Field trial recommended and identified

Field Trial

- Mill and overlay on state road (SR13)
- 9.5 mm surface for 10-30 million ESALs
  - Steel slag and limestone coarse agg
  - Manufactured and natural sands
  - 7% RAS
- N100 mix re-designed at 30 gyrations
  - Changed during production to N50

SR13 Mix Designs



SR13 Mix Design FN Test

Original (N100) mix – FN = 841

N30 mix – FN = 1181

- Bigger is better, more rut resistant
- Air voids ~1% low on both mixes
- Statistically significant difference

- Things look promising

Plant Production

- One sample at 160 tons of each mix
  - Binder content of plant lab samples high
  - Gradation slightly off
  - Stockpile percentages adjusted (more sand, RAS)
- Sampled again at 380 tons
  - At 30 gyrations, binder content, air voids and VMA were high
  - Compacted to 50 gyrations, air voids were closer to target (5.5%); VMA a little high (perhaps because of steel slag variation)

Plant Production

- ~1100 more tons produced (1500 total)
- Binder content was a little high
- VMA at or near target
- Air voids 1-1.5% low (lab compacted, 50 gyrations)

- *Change to N50 probably should not have been done*.

Estimated Properties at N30

Property	Sublot 1	Sublot 2	Sublot 3	Average
Air Voids, %	5.1	4.8	4.7	4.9
VMA, %	17.2	16.6	17.2	17.0

Based on field data and Bailey method calculations.

Was the mix compactable?

Field Compaction

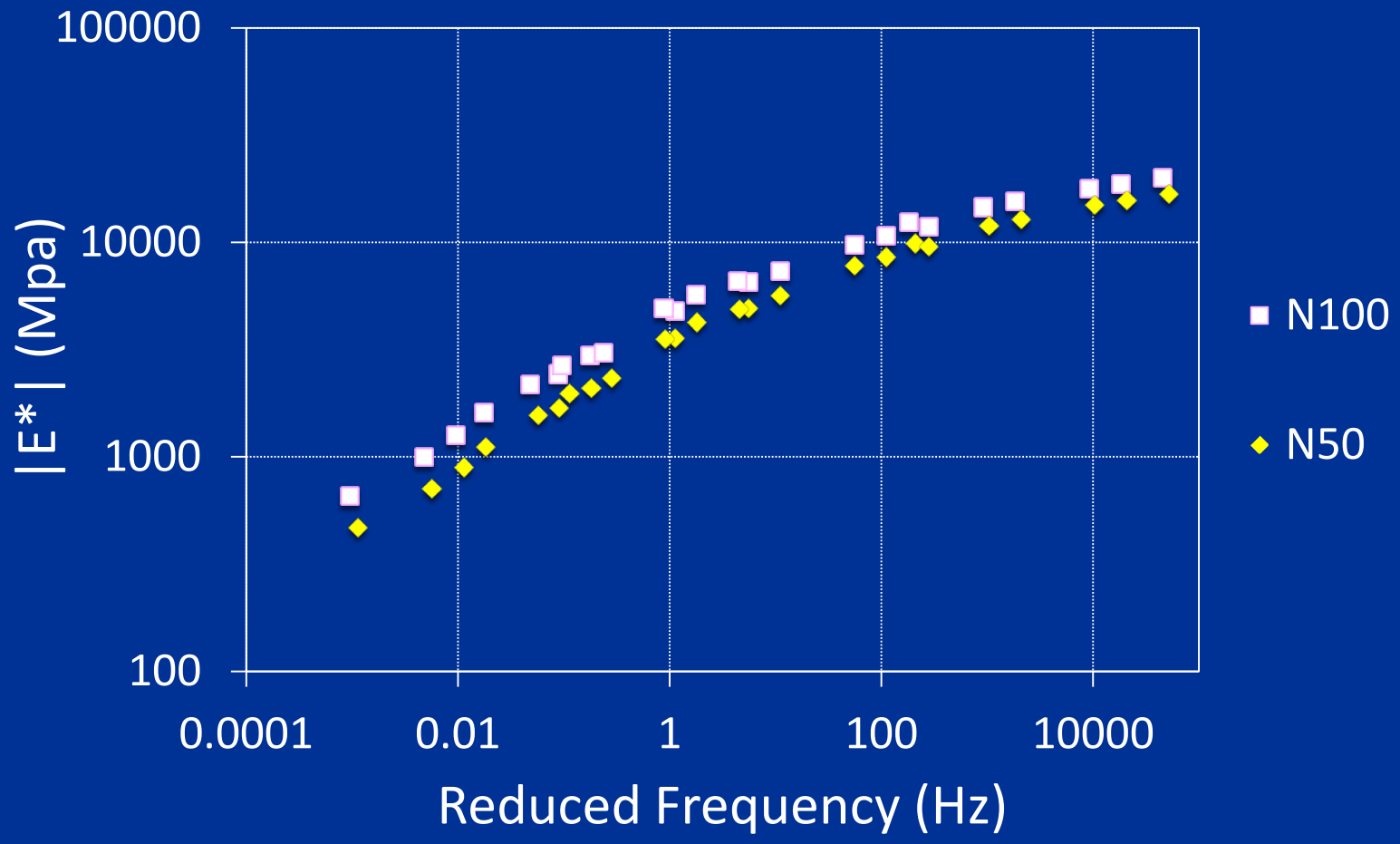
Sublot	Density 1	Density 2	Average
1	92.30	94.53	93.42
2	93.59	94.68	94.13
3	96.29	96.69	96.49

Overall Average Core Density = 94.7%

Target 95%

No change in compaction equipment nor patterns!

Plant Produced Mix Tests



Plant Produced Mix Results

- N100 was stiffer than N50
  - Statistically significant difference
  - Both mixes were reheated
- N100 had higher flow number and lower strain than N50
- Contrary to lab and mix design results
  - Does not necessarily mean N50 will rut
  - Time will tell…

Conclusions

- It is possible to design mixes at 5% air voids and maintain effective binder using same materials
- Mixes designed with lower gyrations can have properties equal to or better than conventional designs
- Optimum gyrations levels ~42-53 for these mixes

Conclusions

- Mixes designed at 5% air in lab can be compacted to 5% in the field with minimal to no changes in compaction process
- Results of testing reheated plant produced mixes did not agree with lab research nor mix design
- Field trial will show if rutting develops

Anticipated Benefits

- Potential 2-3 years of increased service life
- Potential savings of $20-30 million a year
  - Based on $300 million HMA rehab budget and that 50% of the HMA pavements reaching end of life do so because of durability problems

Bottom Line

Concept of designing at higher voids (lower gyrations) still appears promising

Time will tell how the field trial performs

Need more field trials and tests of more mixes

Concept deserves further evaluation

Thanks to Gerry Huber, Bill Pine, HRG, Walsh & Kelly, Milestone Contractors, INDOT, Study Advisory Committee

QUESTIONS?

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