# Seeking Increased Pavement Performance Through Increased Density

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# Background

- Flexible pavements generally reach end of service because of durability issues after 15-20 years
  - Caused in part by oxidized binder
  - Rutting has been significantly reduced
- Reducing permeability decreases rate of binder aging

# Background

- Increase initial in-service density by 1% (Tran et al., 2016):
  - 8.2% - 43.8% fatigue performance improvement
  - 7.3% - 66.3% rutting resistance improvement
  - 10% - 30% increase in the pavement service life

# Concept

- Lower initial in-service air voids to improve pavement durability
- Do not sacrifice asphalt mixture mechanical properties
- Design at 5% air voids, field compact to 5% air voids
- Keep effective binder content the same
- No increase in compaction effort
- Increase pavement in-service life

# Scope

- Laboratory study (proof of concept)
  - Use 3 standard asphalt mixtures
  - Re-design each mixture at 5% air voids
    - Maintain effective binder content
    - Use 70, 50, 30 gyrations
  - Test all mixtures for dynamic modulus and flow number (anticipated in-service air voids)
- Place field projects

# Experimental Matrix

| Traffic (MESAL) | No. Gyrations | 9.5-mm | 19.0-mm |
|---|---|---|---|
| Category 3 (3-10) | 30 | X | |
| | 50 | X | |
| | 70 | X | |
| Category 4 (10-30) | 30 | X | X |
| | 50 | X | X |
| | 70 | X | X |

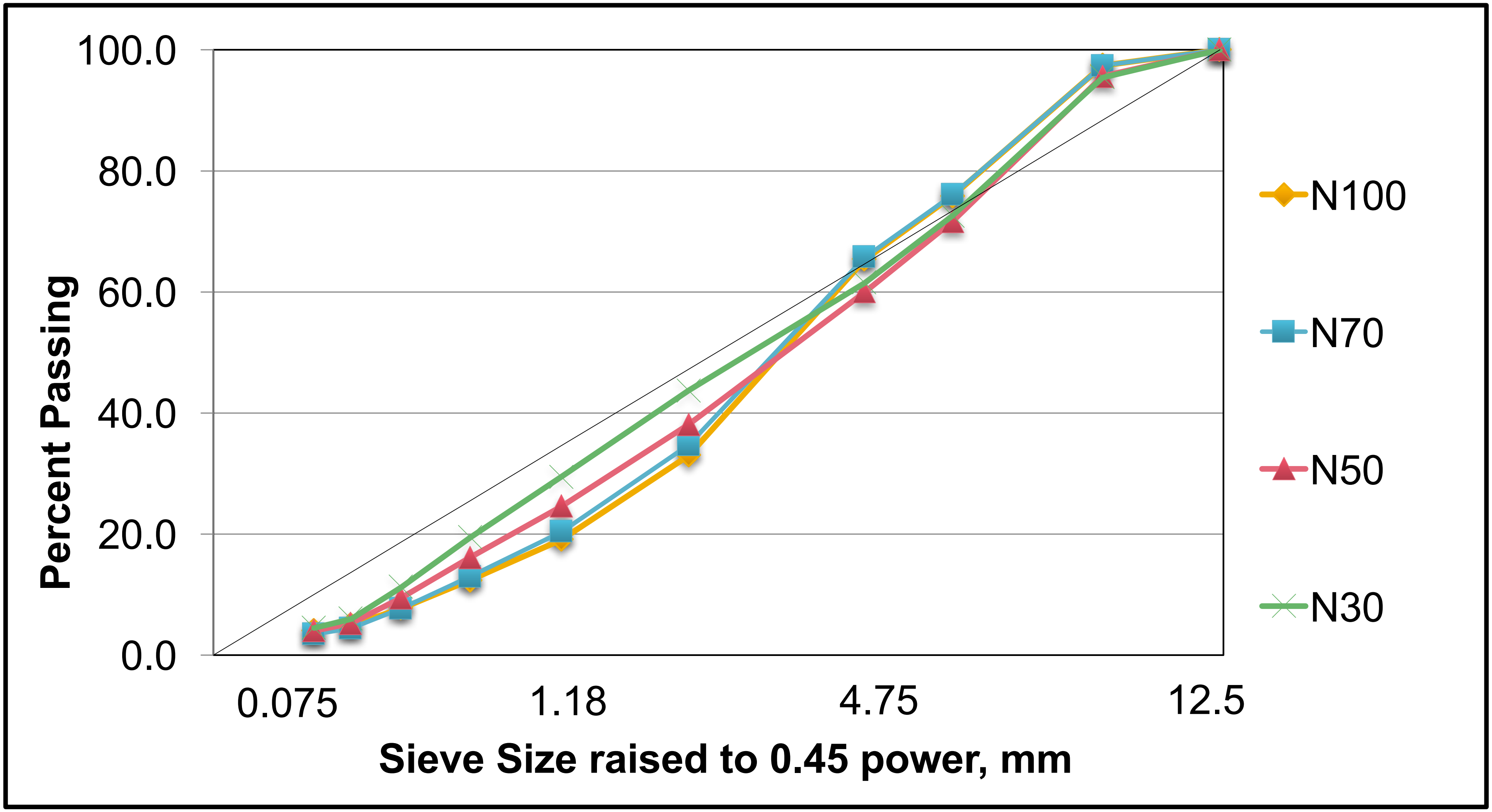
# Materials

- Coarse aggregates
  - Limestone, dolomite, blast furnace slag
- Fine aggregates
  - Limestone, dolomite, natural sand
- PG 64-22
- No recycled materials

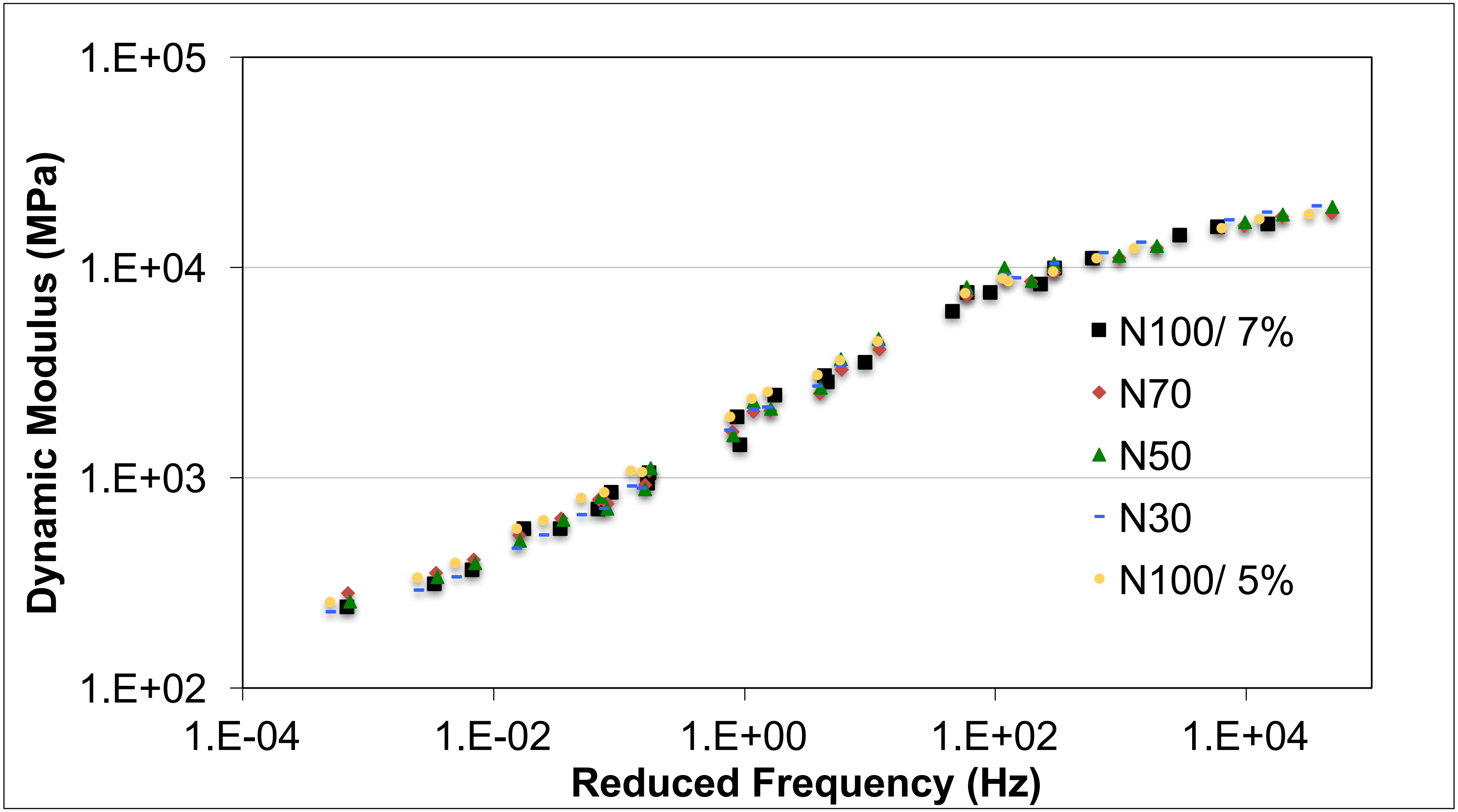
# Category 3, 9.5-mm Designs

| | N100 | N70 | N50 | N30 |
|---|---|---|---|---|
| $P_b$, % | 5.9 | 5.9 | 6.0 | 6.0 |
| $P_{be}$, % | 4.6 | 4.6 | 4.6 | 4.7 |
| $V_a$, % | 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 |

# Category 3, 9.5-mm



# Category 3, 9.5-mm



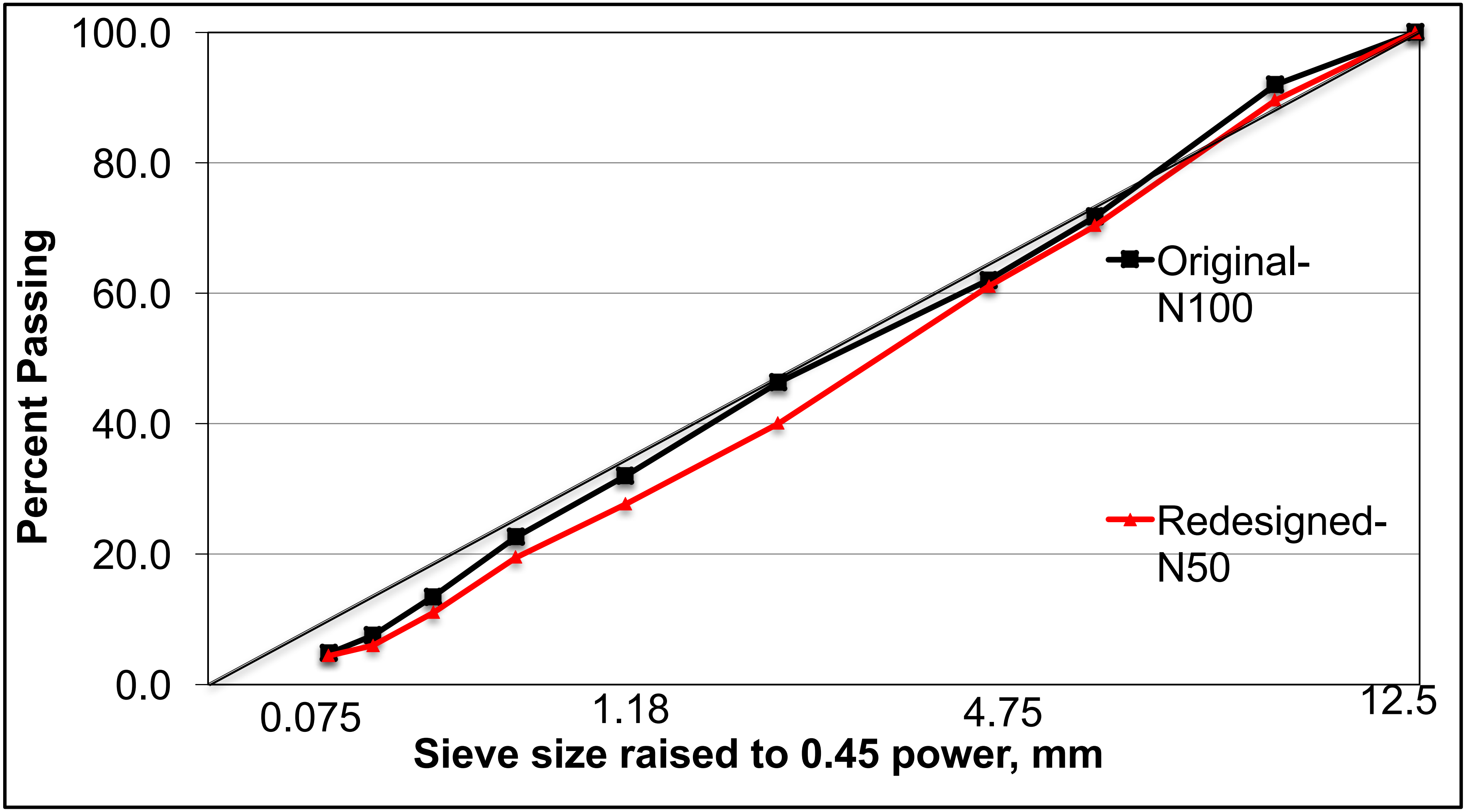
# Category 3, 9.5-mm

| Gyrations | Average Flow Number | Average Strain at FN (µm) |
|---|---|---|
| 100- 7% | 91 | 18,114 |
| 100- 5% | 166 | 18,174 |
| 70 | 167 | 17,704 |
| 50 | 163 | 20,300 |
| 30 | 156 | 19,204 |

# Field Trial 1

- SR-13 near Ft. Wayne, IN
- New overlay, Category 4, 9.5-mm
- Original design, N100, 4%, 7%
- Redesigned, N50, 5%, 5%
- Steel slag and limestone coarse aggregates, limestone and natural sands, RAS, PG 70-22

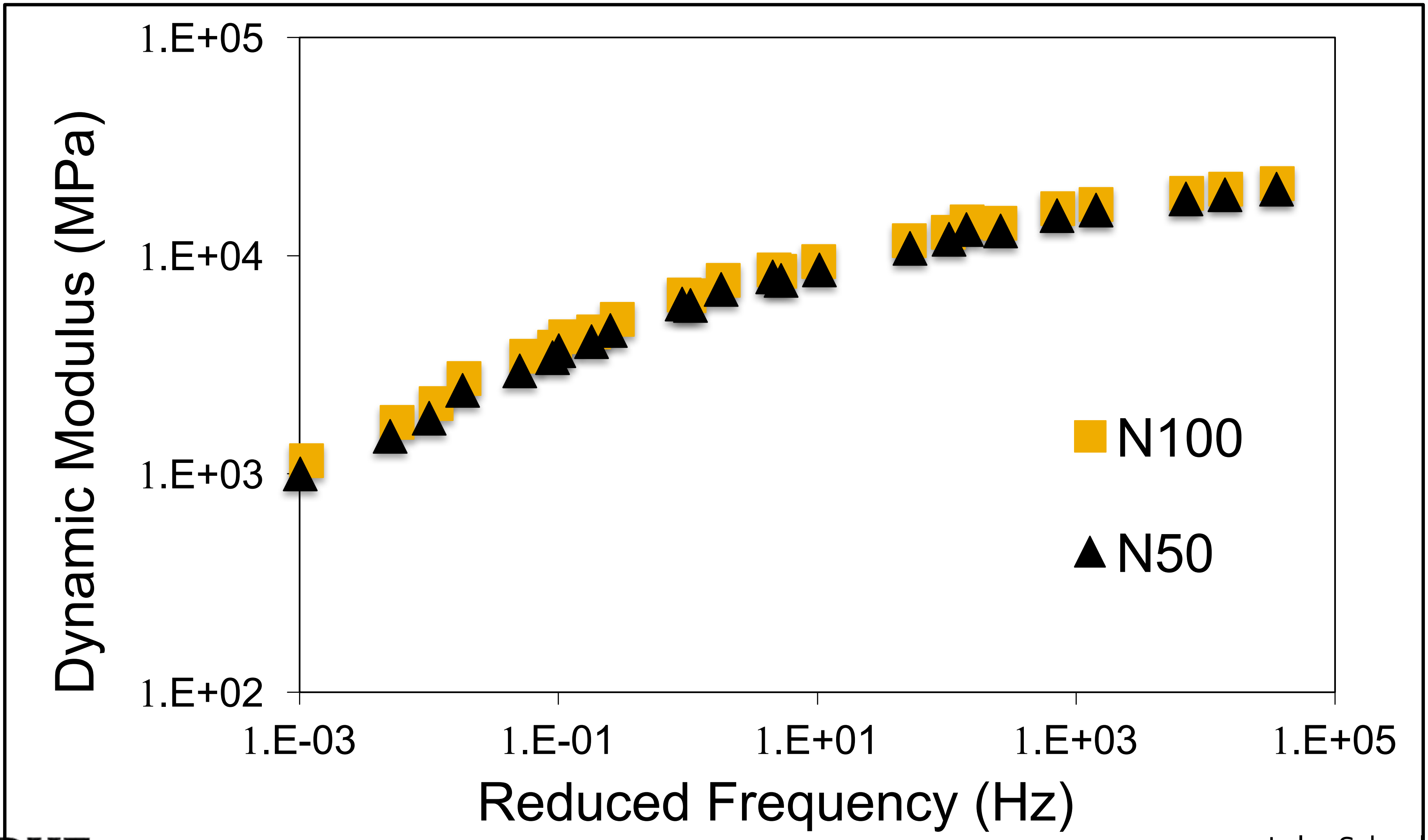
# Mixture Gradations



# In-place Densities

- N100, 18 cores, average density 91.8%
- N50, 6 cores, average density 94.7%
- Same rollers and rolling patterns

# Dynamic Modulus Results



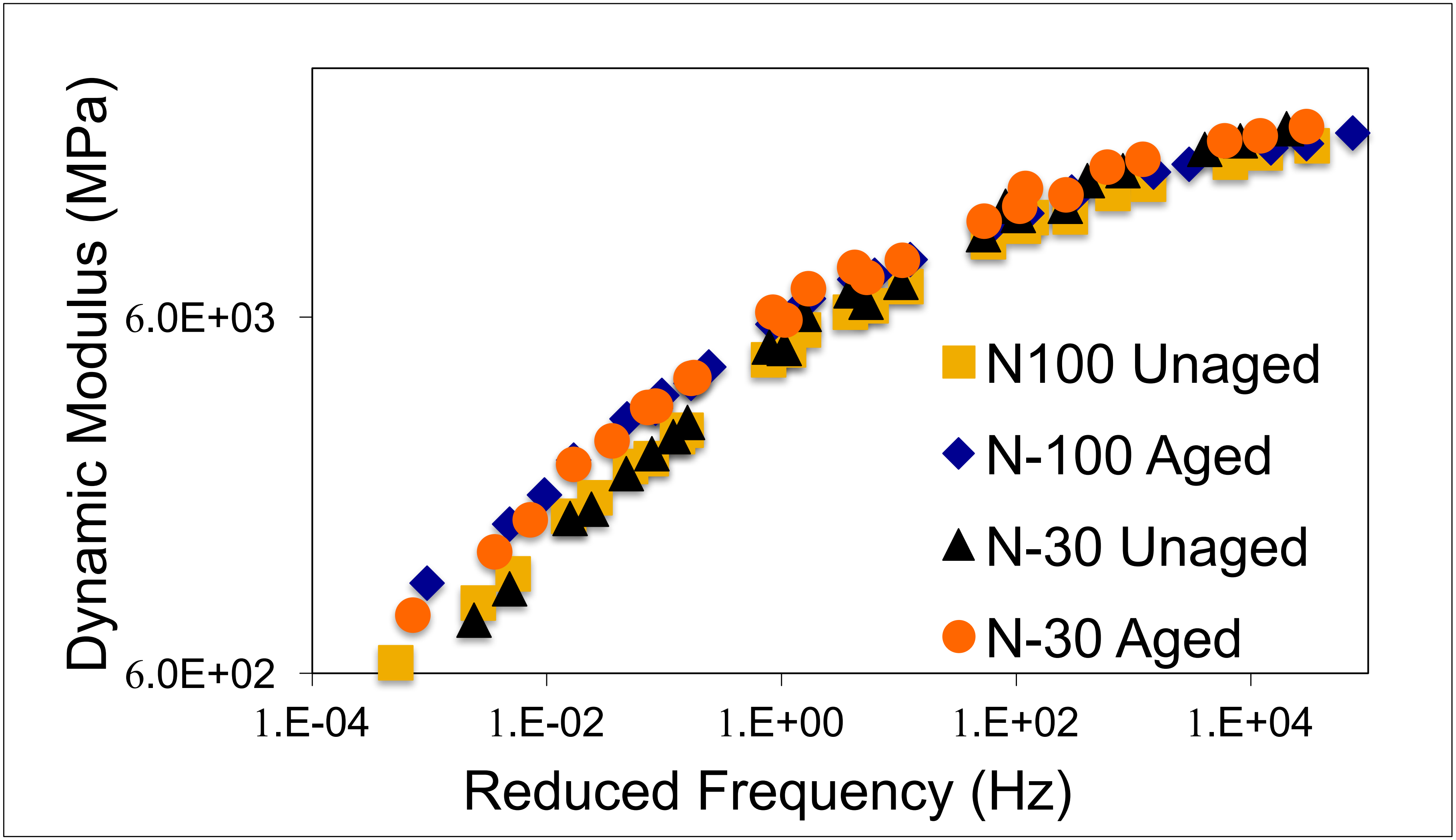
# Field Trial 2

- Georgetown Road, Indianapolis , IN
- Intermediate layer, Category 3, 19.0-mm
- Original design, N100, 4%, 7%
- Redesigned, N30, 5%, 5%
- Limestone coarse aggregates, dolomite sand, RAS, RAP, PG 64-22

# In-place Densities

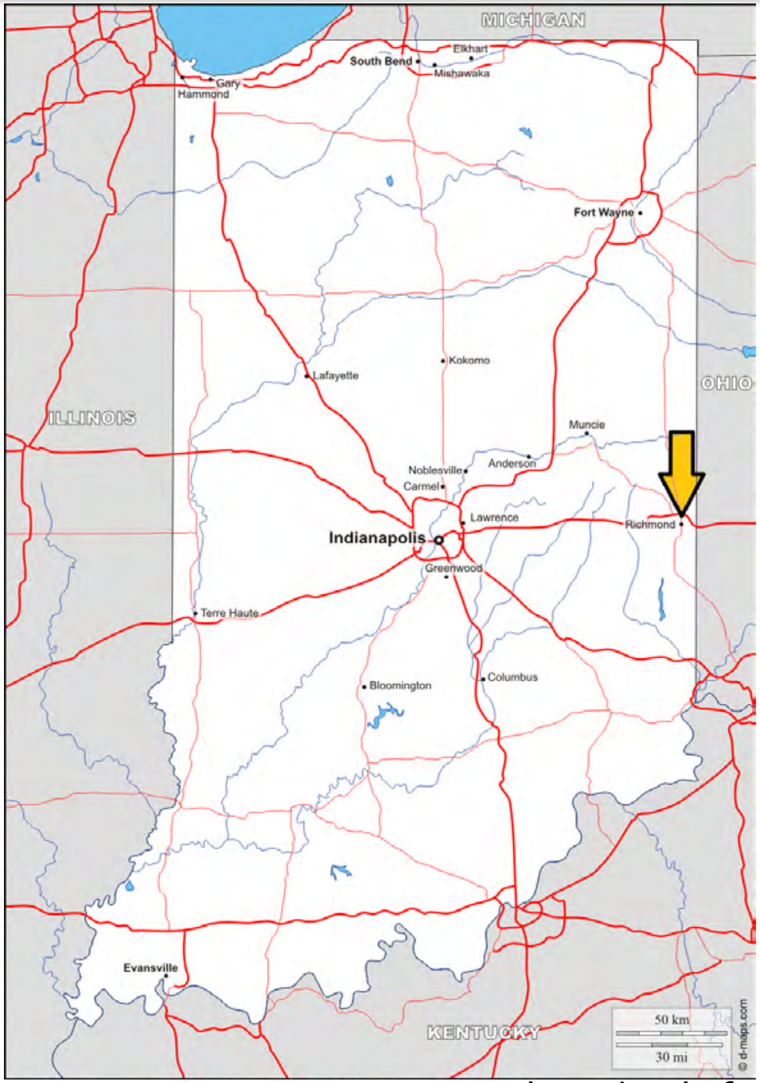
- N100, 20 cores, average density 94.0%
- N30, 20 cores, average density 95.2%
- Same rollers and rolling patterns

# Dynamic Modulus Results



# US-40 Field Project

- INDOT demonstration project
  - US 40, Richmond, IN (1.8 miles)
  - Mill and replace 1.5 in. of asphalt surface
  - Control section using best practices
  - Test section using new technique



# Materials

- Limestone coarse aggregate
- Natural sand
- Crushed gravel sand (test mixture only)
- RAP
- RAS
- PG 70-22

# Mixture Design

| Volumetric Property | Control Mixture | Test Mixture |
|---|---|---|
| Number of design gyrations | 100 | 50 |
| $V_a$ @ $N_{des}$, % | 4.0 | 5.0 |
| Design $P_b$, % | 6.7 | 7.1 |
| Design $P_{be}$, % | 5.2 | 5.2 |
| VMA, % | 15.6 | 16.7 |
| Target in-place density, % | 94.0 | 95.0 |

# Quantities

- 5300 tons of asphalt mixture placed
  - Control mixture lot = 2650 tons
    - 5 sublots, 530 tons each
  - Test mixture lot = 2650 tons
    - 5 sublots, 530 tons each

# Production and Placement

- Drum mix facility
- Mixing temperature, 315 ± 25°F
- Plant production, 210 tons/hour
- Emulsified tack coat
- Mixture temperature at the paver, 290 ± 25°F
- Compaction temperature, 260 ± 25°F

# Roller Information

| | Breakdown | Finish |
|---|---|---|
| Rollers | 2 (echelon) | 1 |
| Vibratory passes | 5 | 0 |
| Static passes | 2 | 5 |
| Operating weight, tons | 13 | 12 |
| Drum width, in. | 77 | 67 |

# Rollers



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# Field Testing

- Plate samples
  - 6 samples/sublot
  - Air voids, asphalt binder content, and VMA
- Core samples
  - 4 samples/sublot
  - In-place density

# Average Densities

- Average in-place density:
  - Control mixture = 93.3% (SD 1.0)
  - Test mixture = 95.3% (SD 0.8)

# Conclusions

- Mixtures can be designed at 5% air voids without lowering effective binder content
- Mixtures designed and placed at 5% air voids can have mechanical properties equivalent to traditional Superpave-designed mixtures
- Asphalt mixtures designed at 5% air voids can be field compacted to 95% density without additional compaction effort

# Implementation

- 50 design gyrations for medium to high traffic levels
- 30 design gyrations for low traffic levels
- Place and monitor additional field projects
- Provisional specification written, up to three projects let next year
- IMP will monitor construction and report results

# Thank You!