Superpave5: Constructing Asphalt Pavement with Road Air Voids Equal to Design Air Voids

Webinar being sponsored by; AFH60, Asphalt Pavement Construction and Reconstruction

Lee Gallivan, Chair

Today’s Webinar Includes

- Three Sessions will cover the following
  - Present the principles of constructing asphalt mixture to the same *compaction* level as the mixture design
  - Describe research to modify design requirements as listed in AASHTO M 323.
  - Describe construction of experimental mixture including production, placement and compaction.
  - Describe the results of the comparison of road cores taken from regular and experimental mixture.

Presenters

- Gerry Huber, P.E. – Director of Research, Heritage Research Group, Indianapolis, Indiana (23 years), Asphalt Institute (5 years), Saskatchewan – Highways (10 years)

- John Haddock, PhD, P.E. - Professor of Civil Engineering & Director, Indiana Local Technical Assistance Program, Purdue University, Lafayette, Indiana (15 years)

- Matt Beason, P.E. - State Materials Engineer (just appointed), Office of Materials Management- Indiana Department of Transportation, Indianapolis, Indiana (8 years)

Questions

- Questions can be posed though anytime using the questions box and I will be monitoring them as they come in but will be answered at the end.

- Follow instructions for your PDH hours.

Subcommittee AFH60
Flexible Pavement Construction and Rehabilitation

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Laboratory Design at Five Percent Air Voids (Superpave5)

Gerry Huber
Heritage Research Group

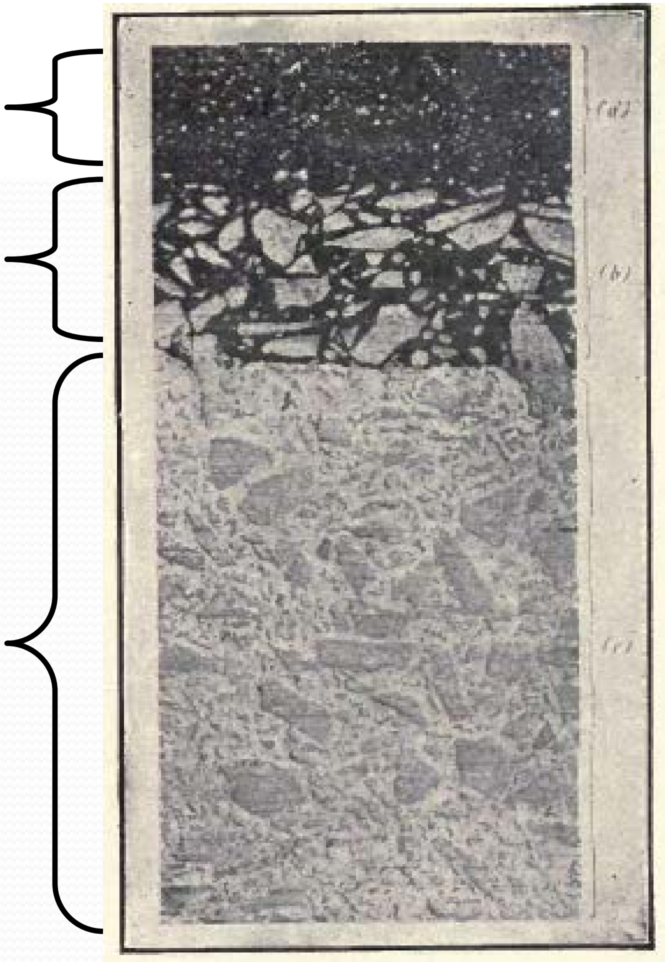
Mix Design Historical Perspective

Understand where we have been

To see where we should go

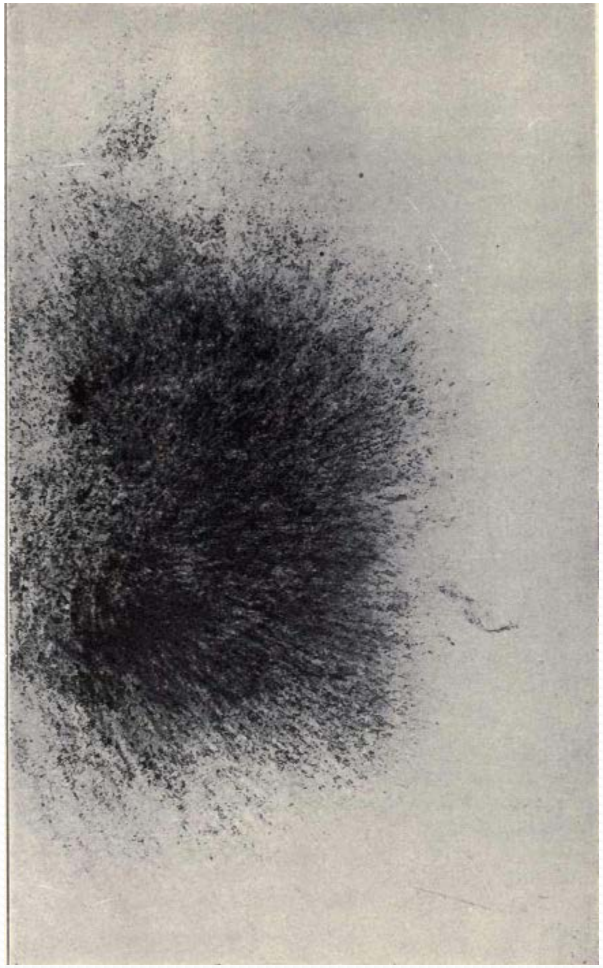
Typical 1900s Pavement

- Surfacing Mix
- Asphaltic Concrete
- Hydraulic Cement Stabilized Aggregate



Surface Recipe Design

- Components (typical)
  - 78% sand
  - 12% lime
  - 10% asphalt
- Sand heated to 300ºF
  - Asphalt added
  - Lime added cold
    - Amount adjusted visually
- Paper Pat Test
  - Brown paper
  - Mixture dumped on to paper



Surface Mix

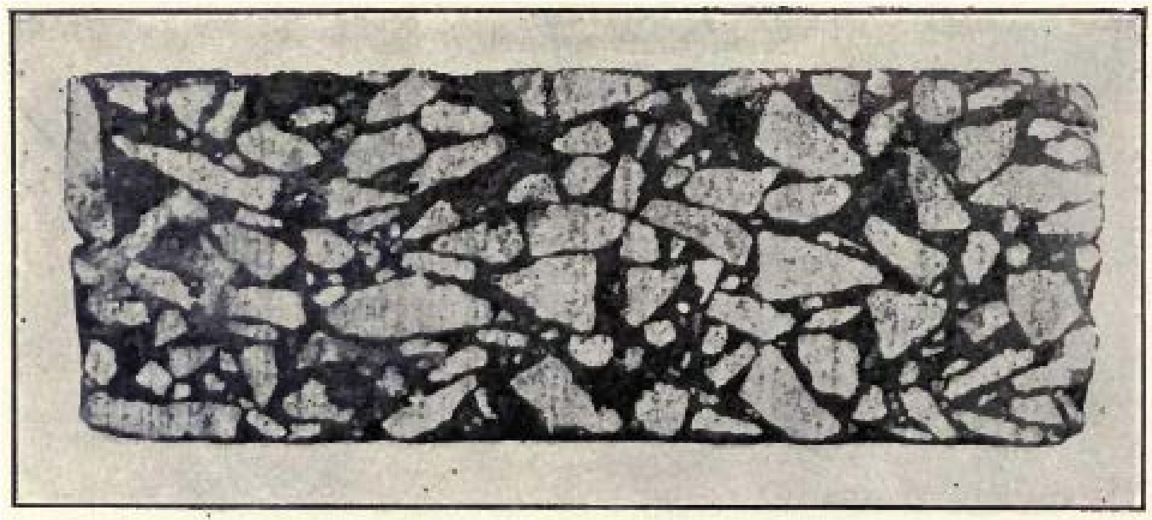
- Asphalt Content 11%
- Gradation
  - #10 100
  - #40 87%
  - #80 49%
  - #200 15%
- Air Voids approx. 0%

City Street 1890s

Asphaltic Concrete Mixture

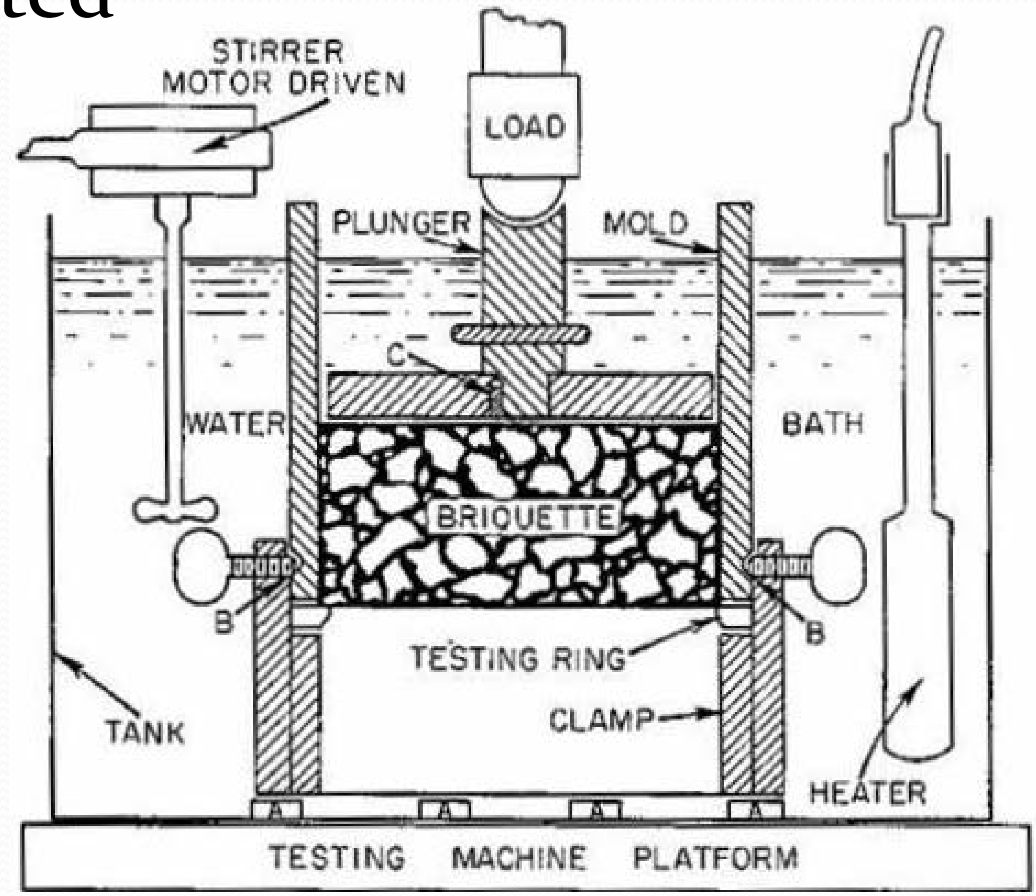
- Asphalt 7.4%
- Air voids 0(?)%
- VMA 13.2%

"Not suitable for Surface Mix"



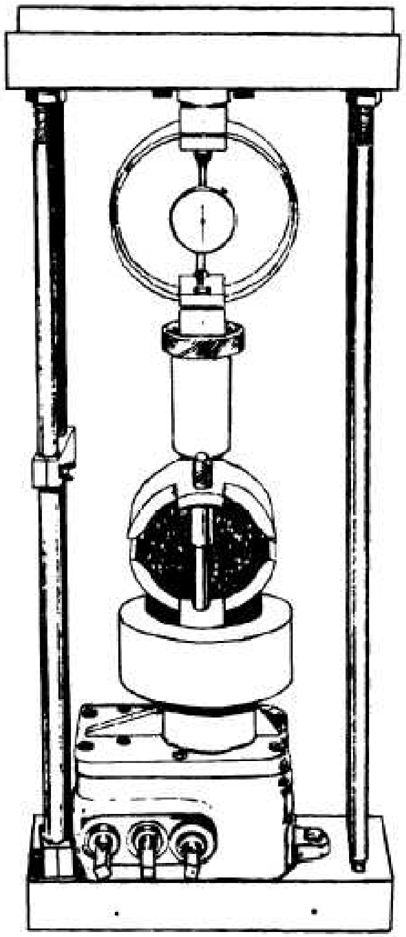
Hubbard Field Mix Design (1920s)

- Mixture Compacted with rammer
- Specifications
  - Air voids
  - Voids in compacted aggregate
  - Hubbard Field Stability



Marshall Method of Mix Design (1930s)

- Bruce Marshall of Mississippi Department of Highways
  - 1943 joined U.S. Army Corps of Engineers
- Design used for airfields in World War II
  - Post WWII method was “civilianized”



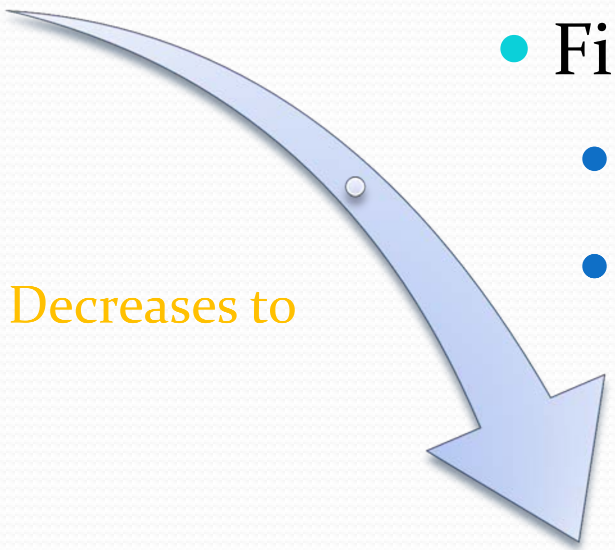
Marshall Mix Design

- Used drop hammer instead of hand rammer
- Air voids calculated
- Stability test
  - Geometry different than Hubbard Field
- No VMA
- No absorption

Added in 1962

Design Air Voids

Construction (8%)



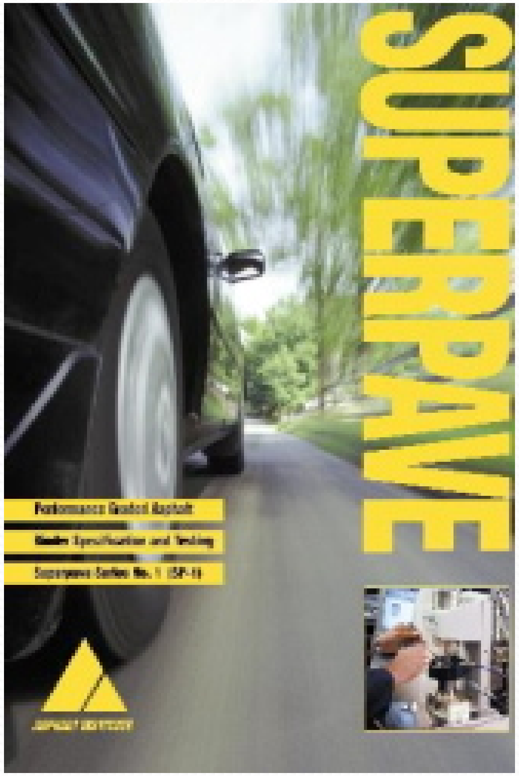
Decreases to

Service Life (4%)

- Marshall Mix Design
  - Design voids set at 3 to 5%
- Field Compaction
  - "Standard" rolling train used
  - 8% will densify under traffic to 4%
    - "Density at end of life = Design Density"

Strategic Highway Research Program

- “Marshall” carried forward
- Design air voids fixed at 4%
- Recommended compaction
  - Set at 92% Gmm



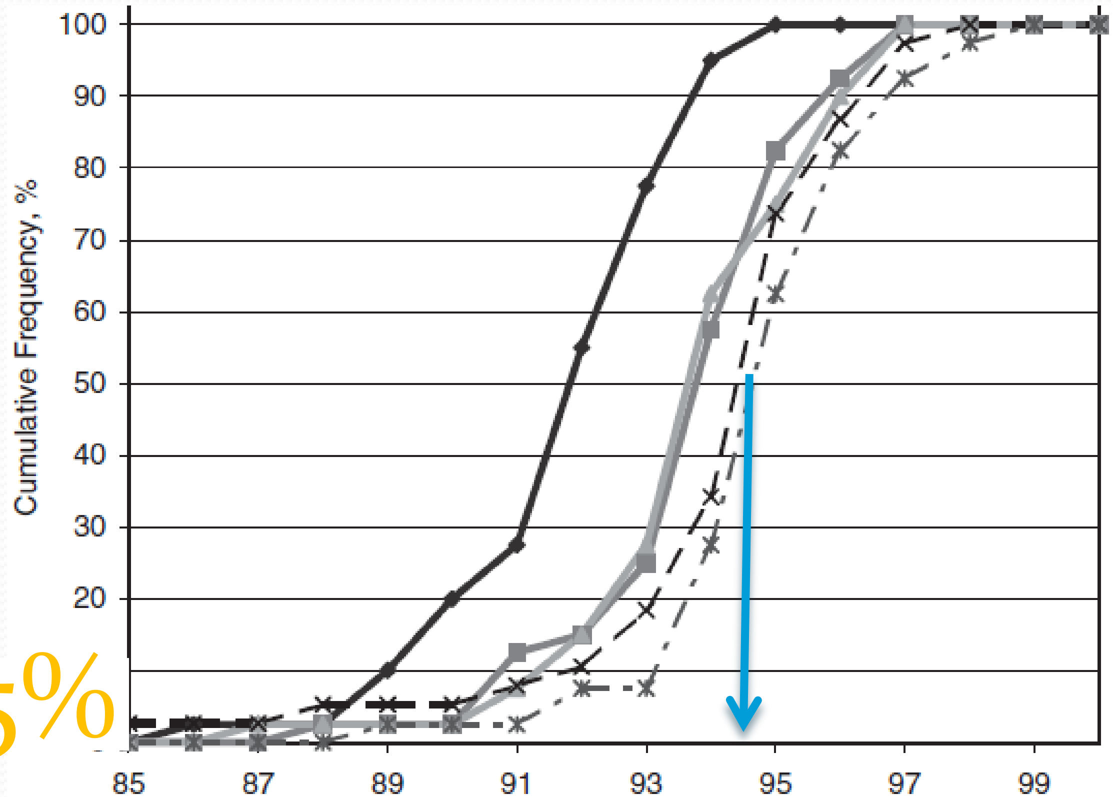
Design Air Voids

- NCHRP Report 573

Construction (8%)

Decreases to

Service Life 5.5%



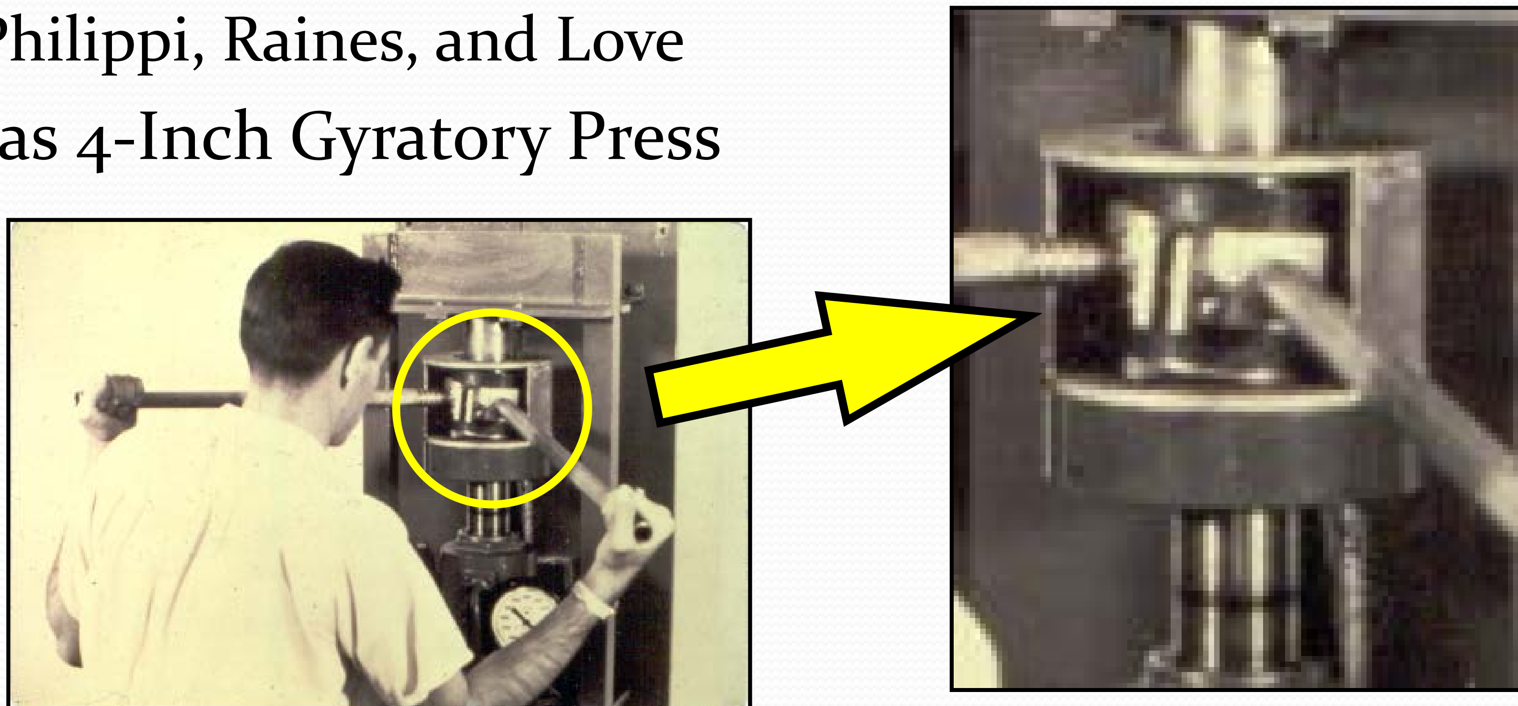
BUT WAIT!!

- 1959
  LCPC visit to Texas

- Developed LCPC gyratory compactor

Early Texas Gyratory Compaction

- 1939, Texas Highway Department
  - Philippi, Raines, and Love
- Texas 4-Inch Gyratory Press



LCPC Gyratory Compactor

- Models
  - Texas-type press
  - 1968, 2nd prototype
  - 1973, PCG1
  - 1985, PCG2

LCPC Developed Mix Design Method


Design to 5%


Construct to 5%

Performance Good

Superpave5

- Inspired by LCPC
- Designed in America

Superpave5

Concept

- Design at 5% air voids
- Compact to 5% (95% Gmm)

- Increase air voids by 1%
    - 5% instead of 4%
- Increase VMA by [illegible]%

- Aggregate specifications stay same
- Lift thickness stays same

Design Gyration Must Change

Mix Designs (4% Air Voids)

	125 gyrations	100 gyrations	75 gyrations
125 gyrations	15.2 VMA		
100 gyrations		15.4 VMA	
75 gyrations			15.3 VMA

Gradation IS Different!

Asphalt Content @ 4% Air Voids

	125 gyrations	100 gyrations	75 gyrations
125 gyrations	5.8%		
100 gyrations		5.7%	
75 gyrations			5.7%

Superpave5

Benefit

- Asphalt content stays same
- Higher in-place density
- Lower permeability
- Reduced aging (?)

- No(?) increase in cost


Thank You
Flu Shots
The Little Clinic
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7 Days a Week
Kroger
ROAD CLOSED
Greetings from Billy Bob

Superpave 5: Constructing Asphalt Pavement with Road Air Voids Equal to Design Air Voids

John E. Haddock, PhD, PE
Professor of Civil Engineering
Director, Indiana Local Technical Assistance Program
Purdue University

Background

- Indiana 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

Concept

- Lower air voids in the field to improve durability
- Do not sacrifice rutting resistance
- 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

Objective

- Modify laboratory asphalt mixture design compaction as it relates to field compaction in order to increase in-place durability without sacrificing rutting performance

Scope

- Design 3 standard 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)

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

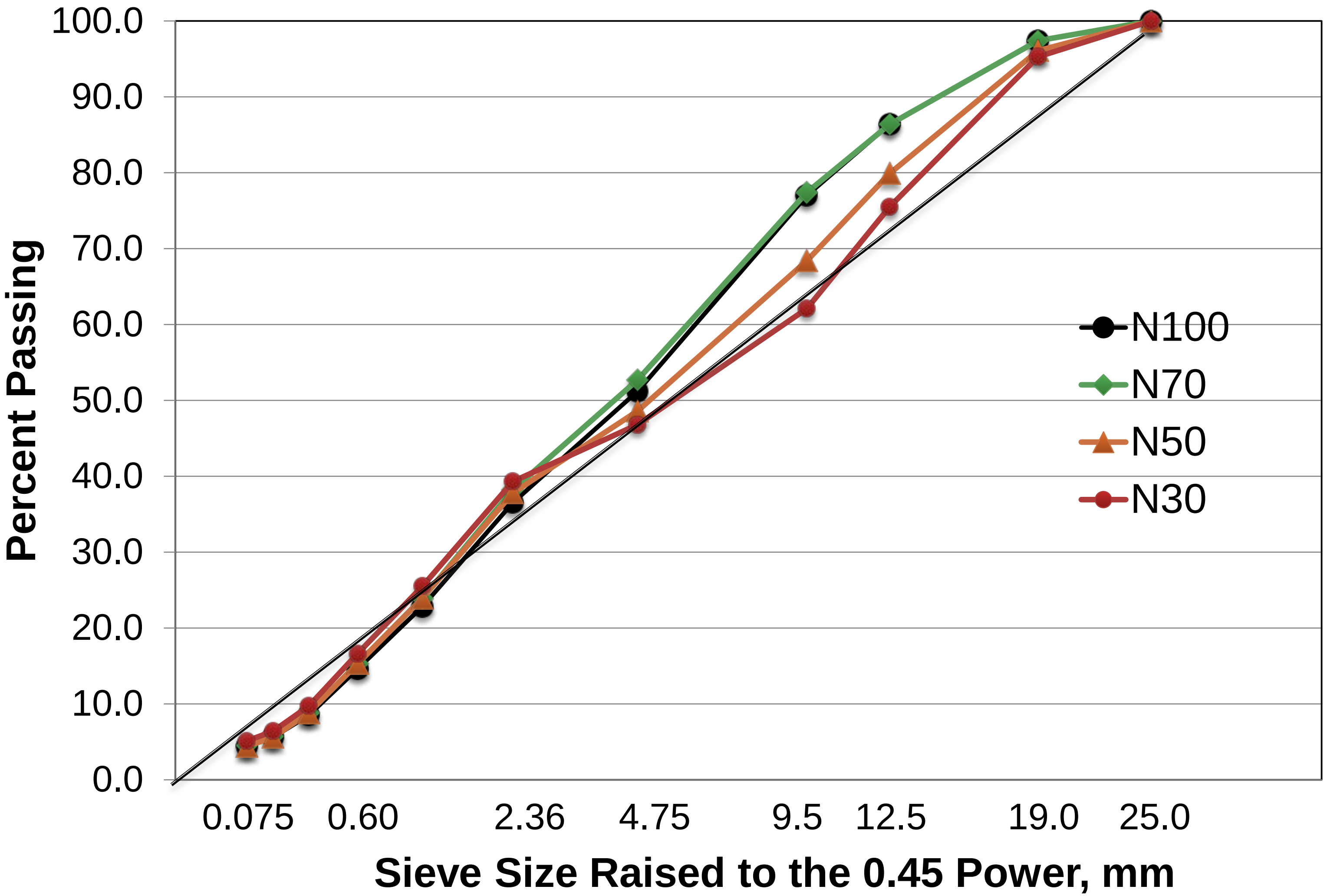
Materials

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

Category 4, 19.0-mm Designs

	N100	N70	N50	N30
P_b, %	4.7	4.7	5.1	5.1
P_{be}, %	4.1	4.1	4.1	4.3
V_a, %	4.0	4.9	4.9	4.9
VMA, %	13.6	14.5	14.4	14.9
VFA, %	70.6	66.3	66.0	67.2

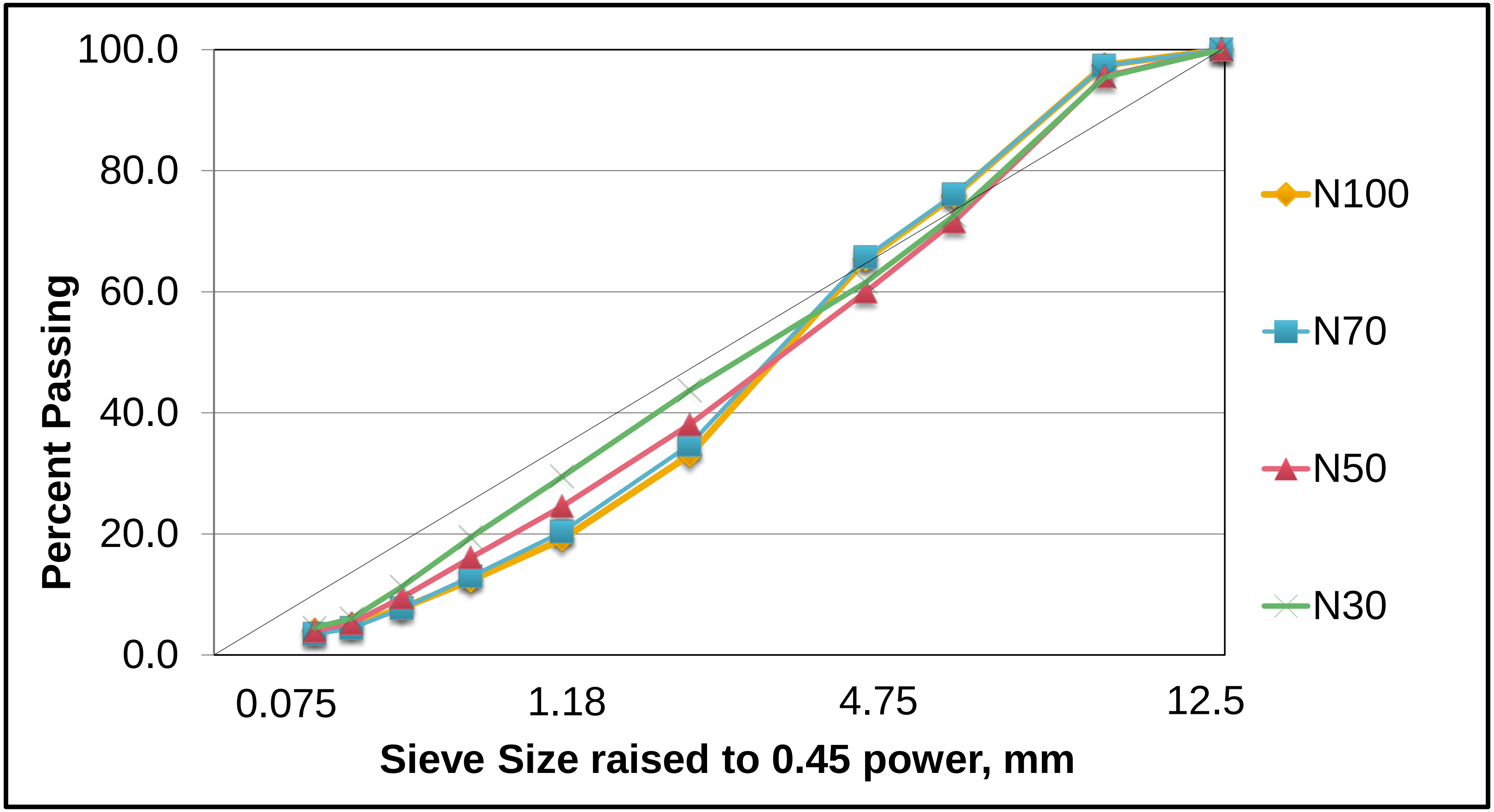
Category 4, 19.0-mm



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

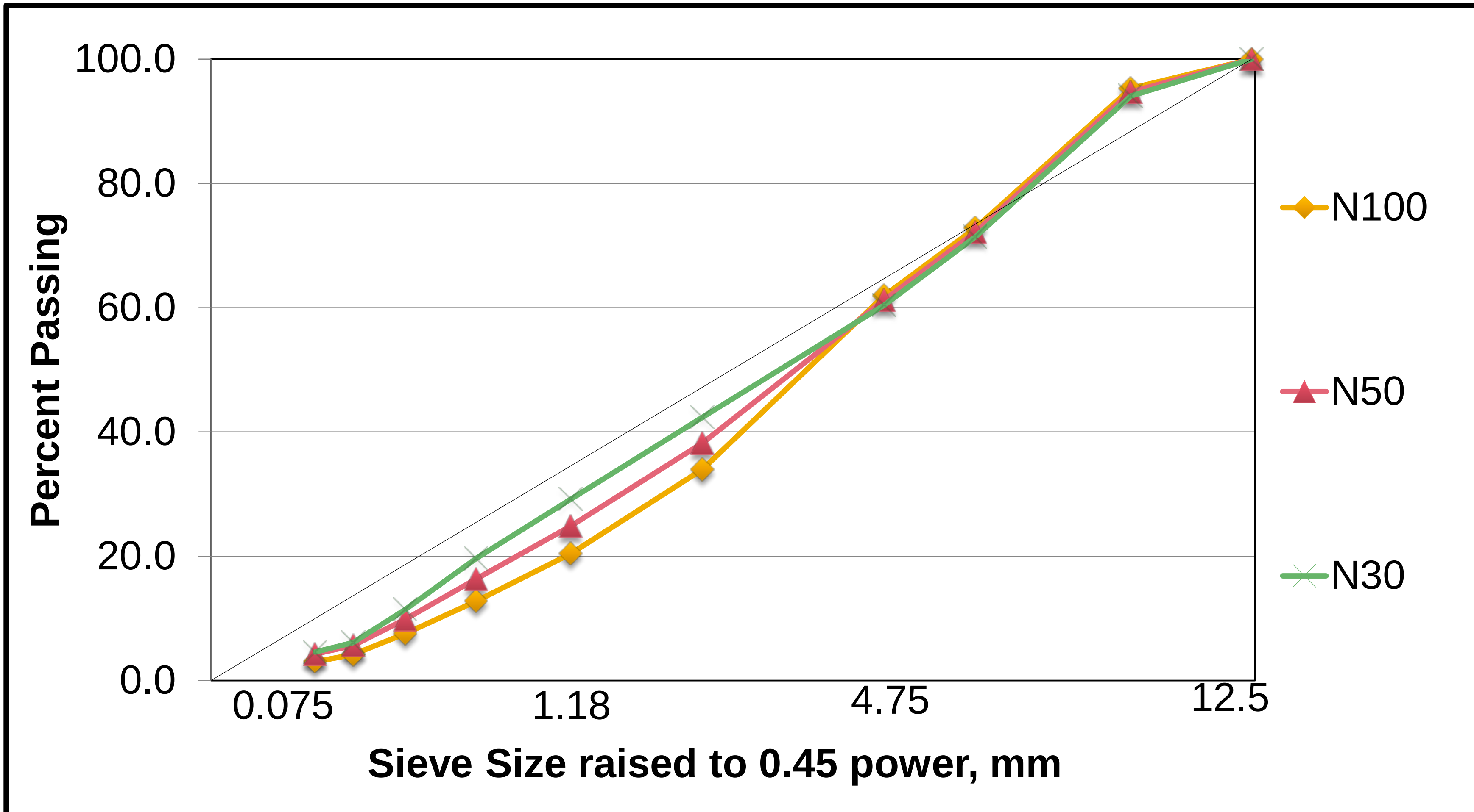
Category 3, 9.5-mm



Category 4, 9.5-mm Designs

	N100	N50	N30
P_b, %	6.5	6.4	6.4
P_{be}, %	4.8	5.0	5.0
V_a, %	3.8	4.9	5.0
VMA, %	15.0	16.4	16.4
VFA, %	74.9	70.0	69.6

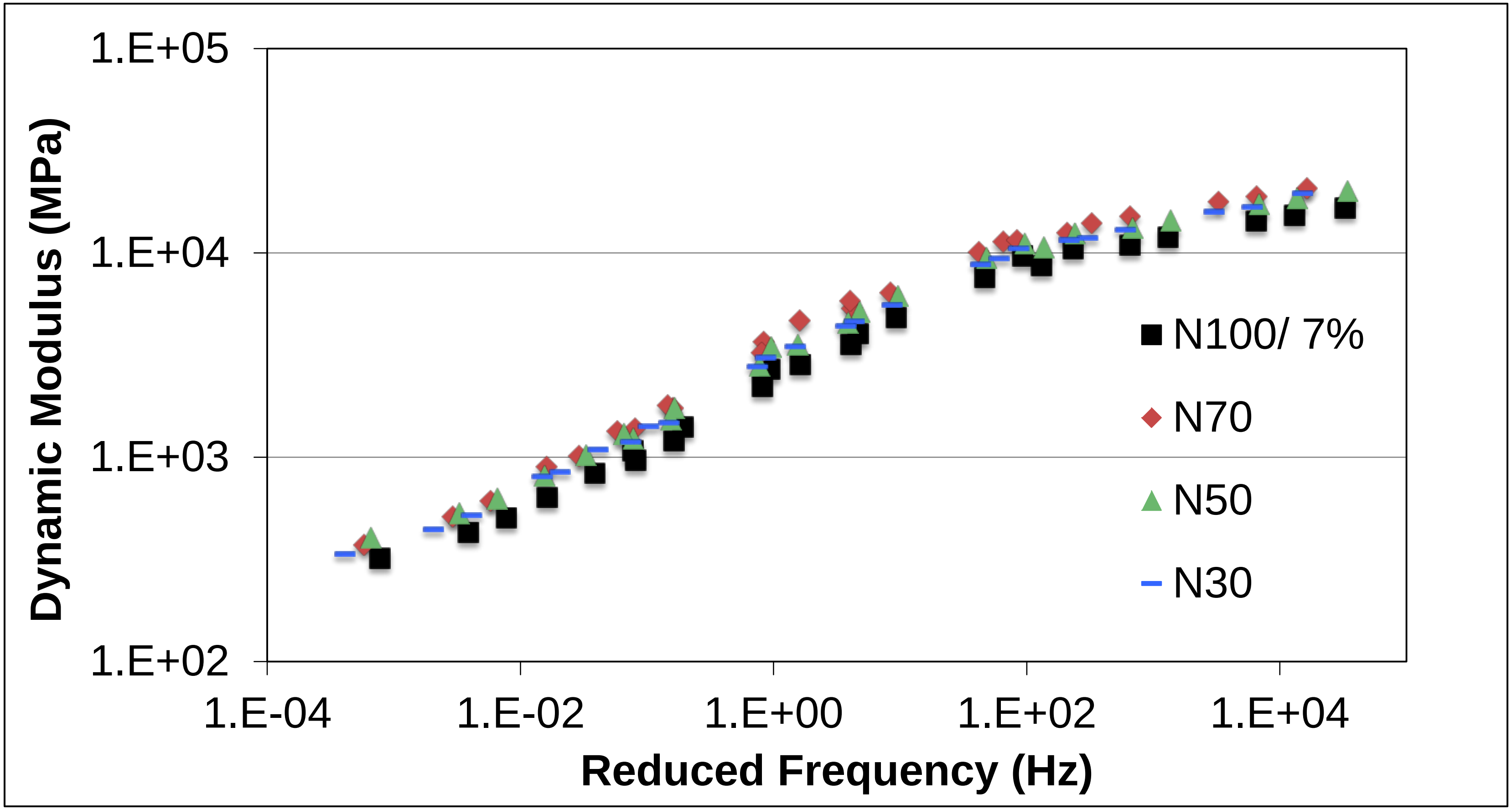
Category 4, 9.5-mm



Laboratory Mixture Testing

- Dynamic modulus
- Flow number

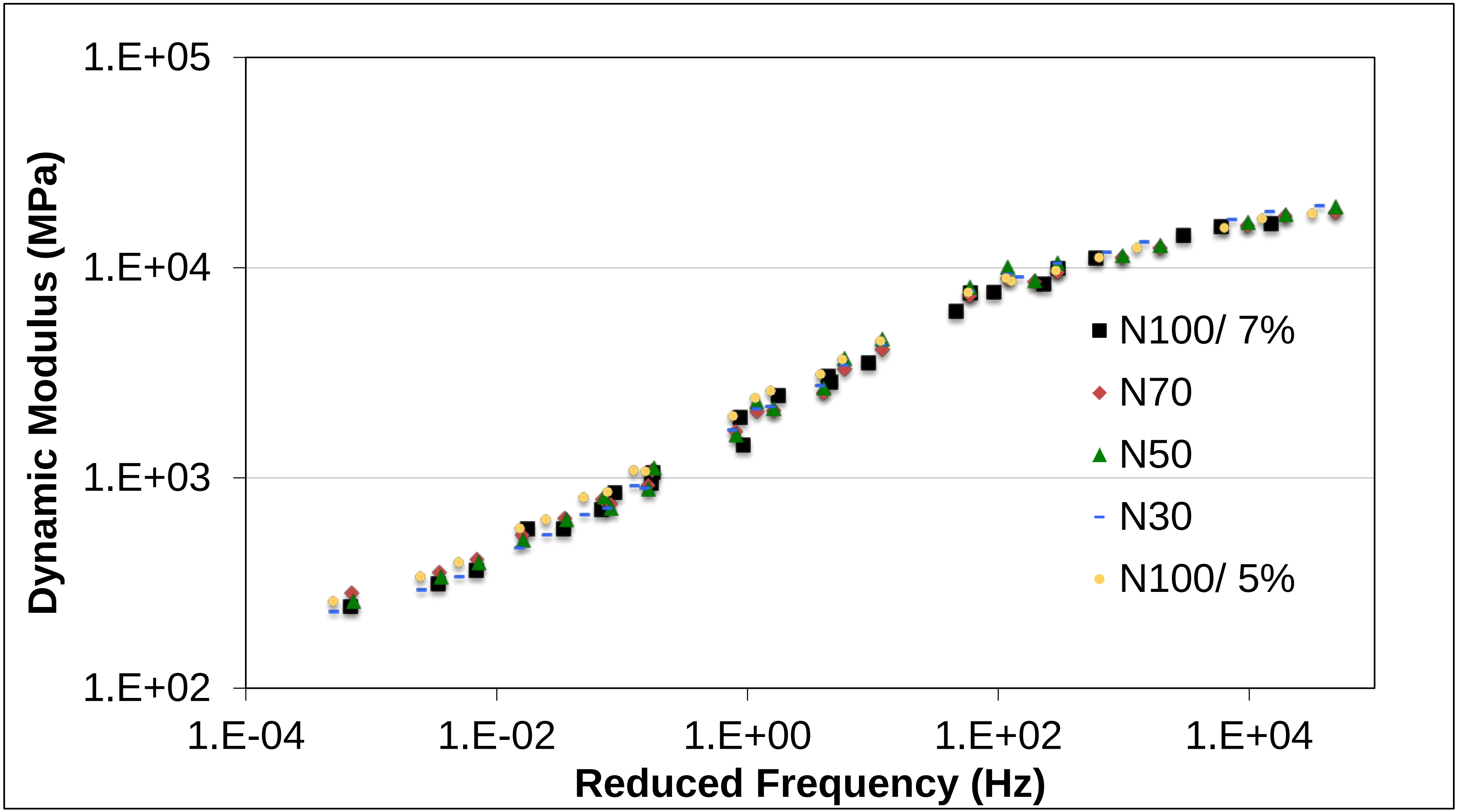
Category 4, 19.0-mm



Category 4, 19.0-mm

Gyrations	Average Flow Number	Average Strain at FN (µm)
100	162	23,983
70	386	18,269
50	348	19,882
30	185	22,090

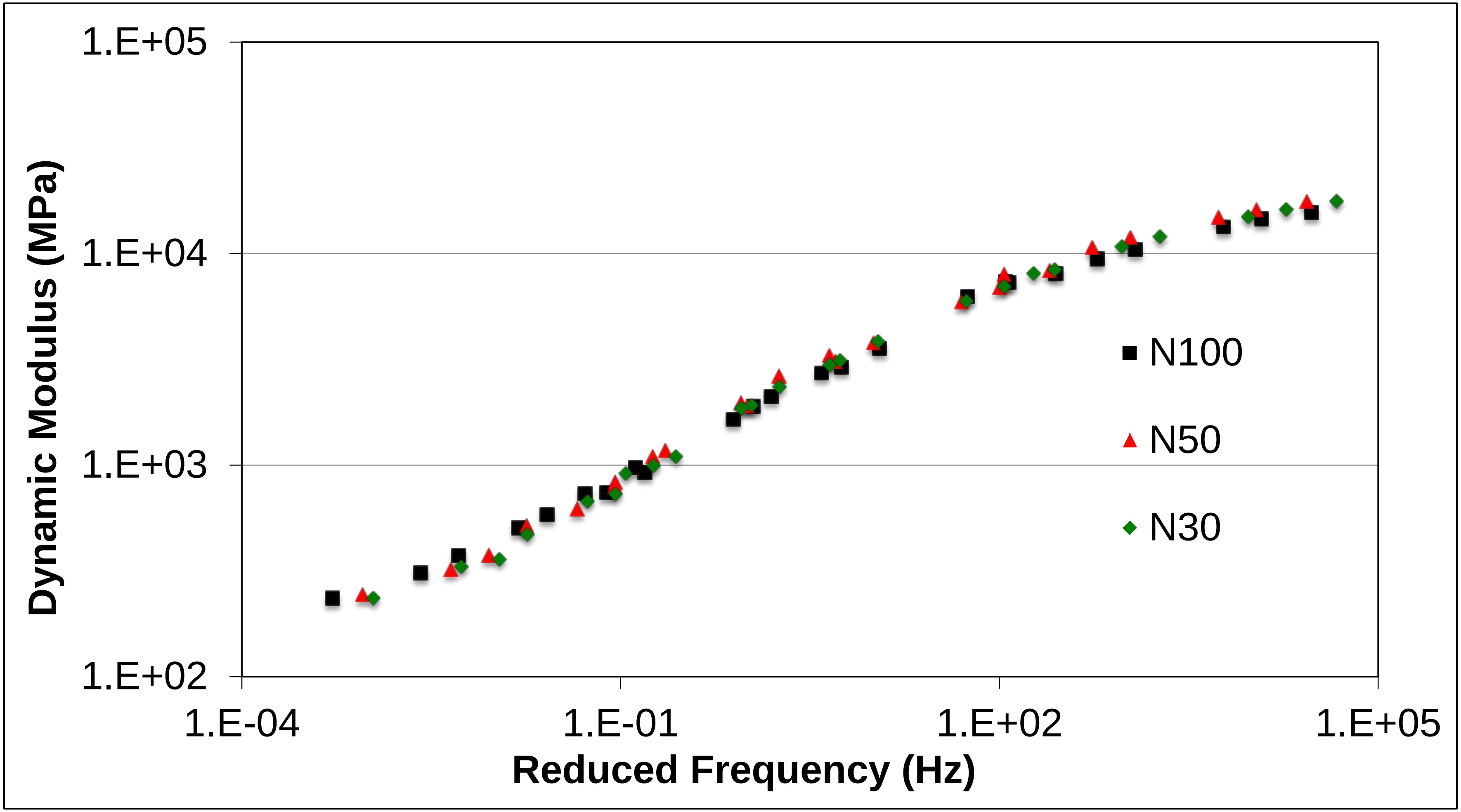
Category 3, 9.5-mm



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

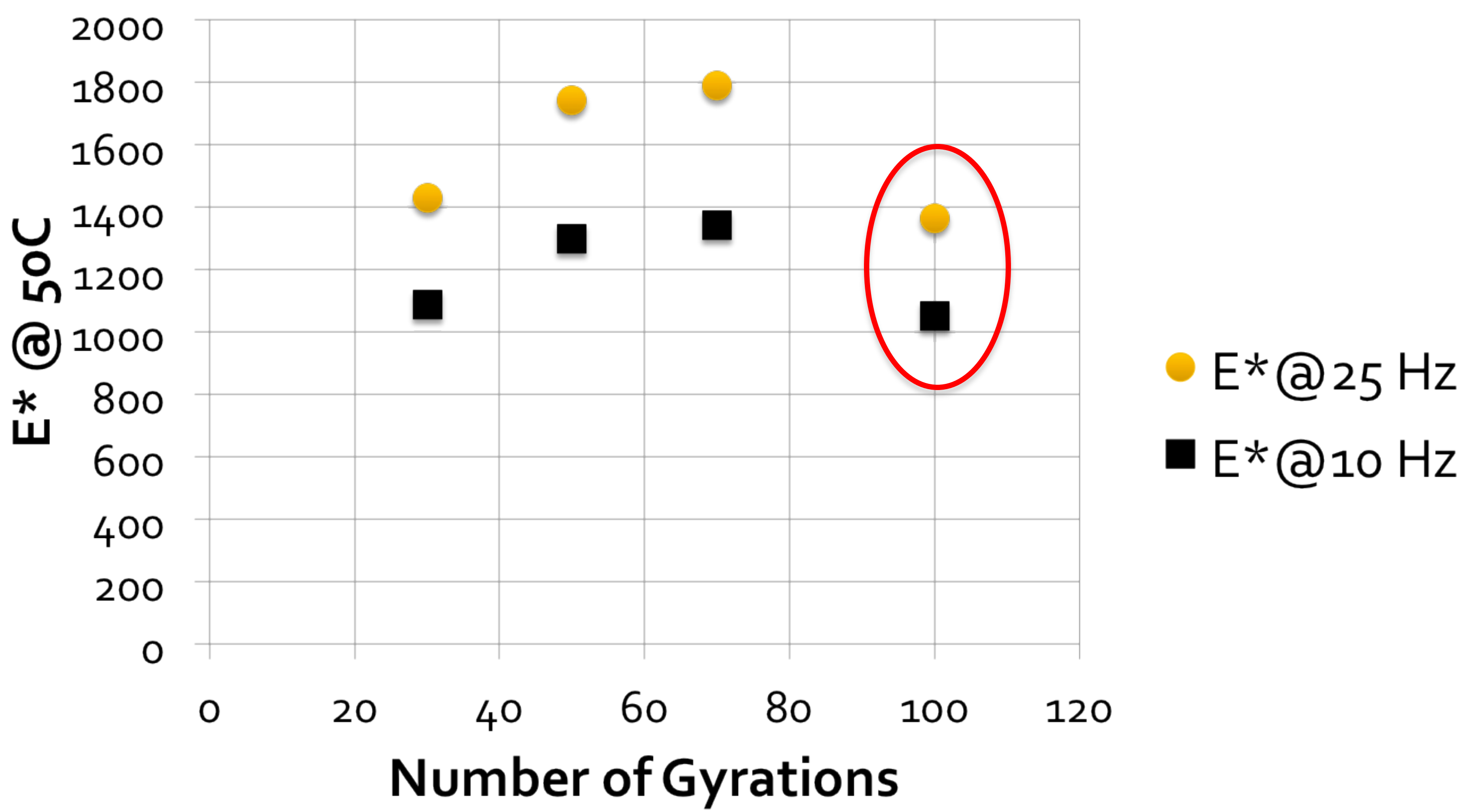
Category 4, 9.5-mm



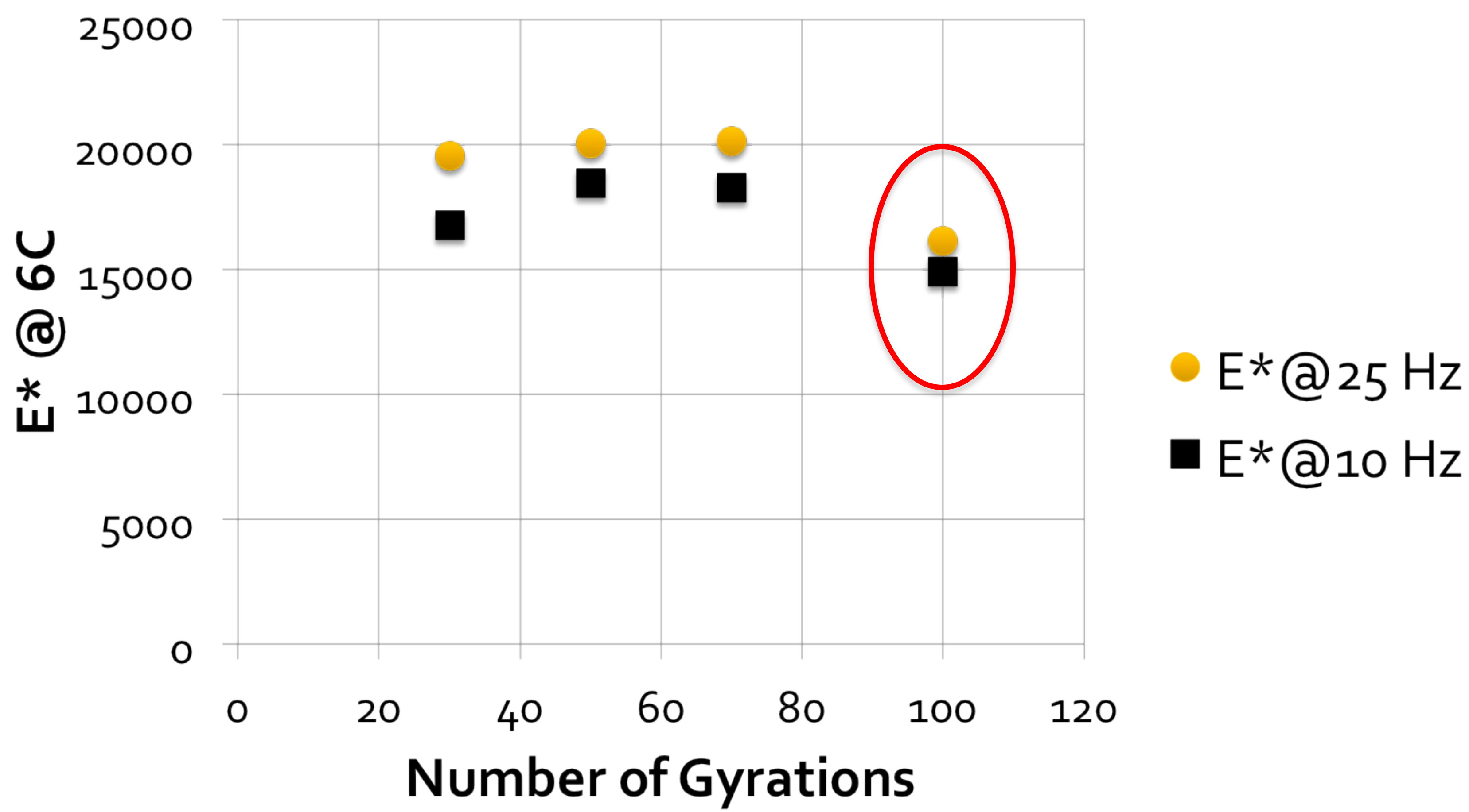
Category 4, 9.5-mm

Gyrations	Average Flow Number	Average Strain at FN (µm)
100	160	23,983
50	253	20,935
30	211	21,033

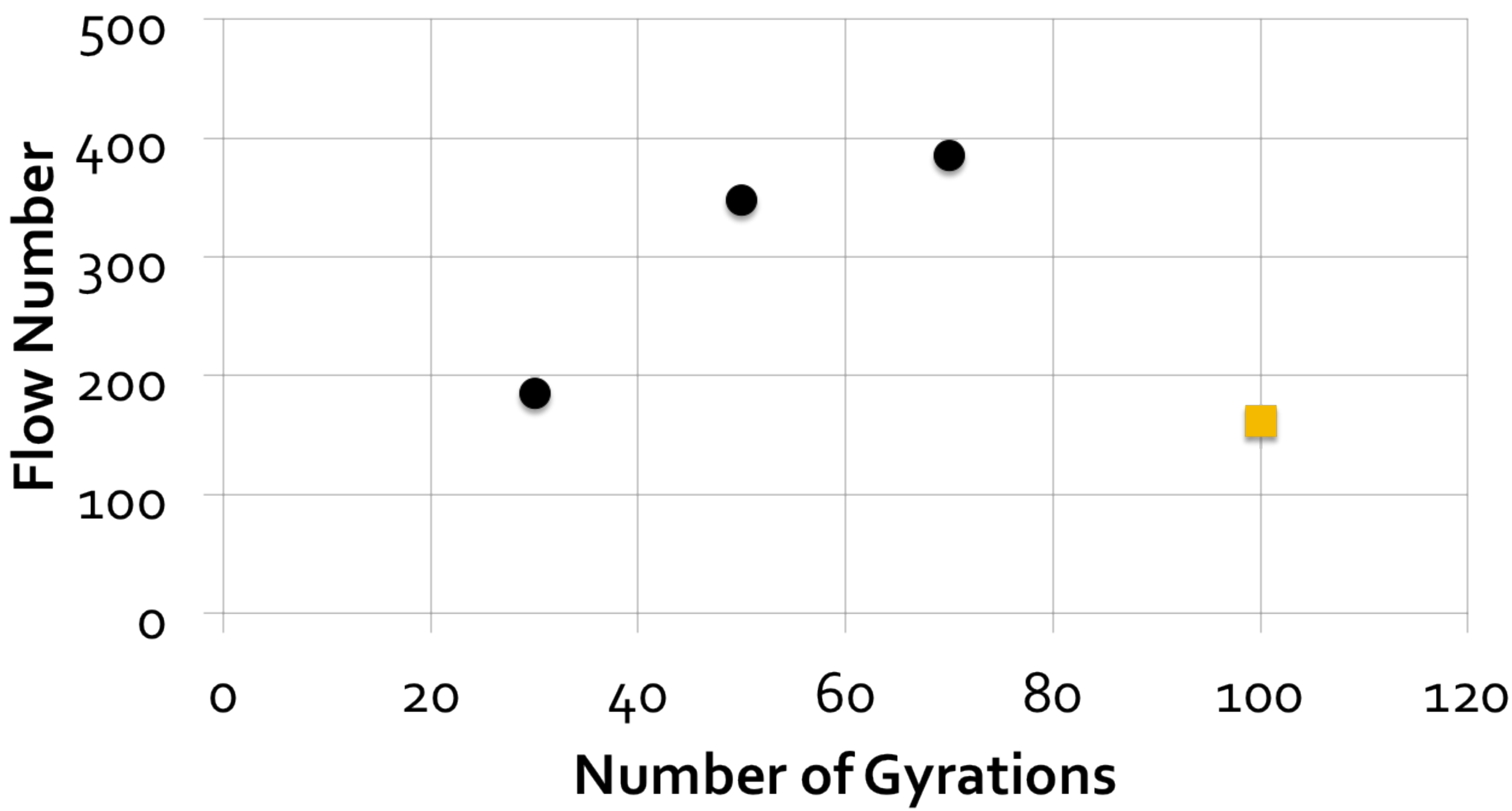
Category 4, 19.0-mm



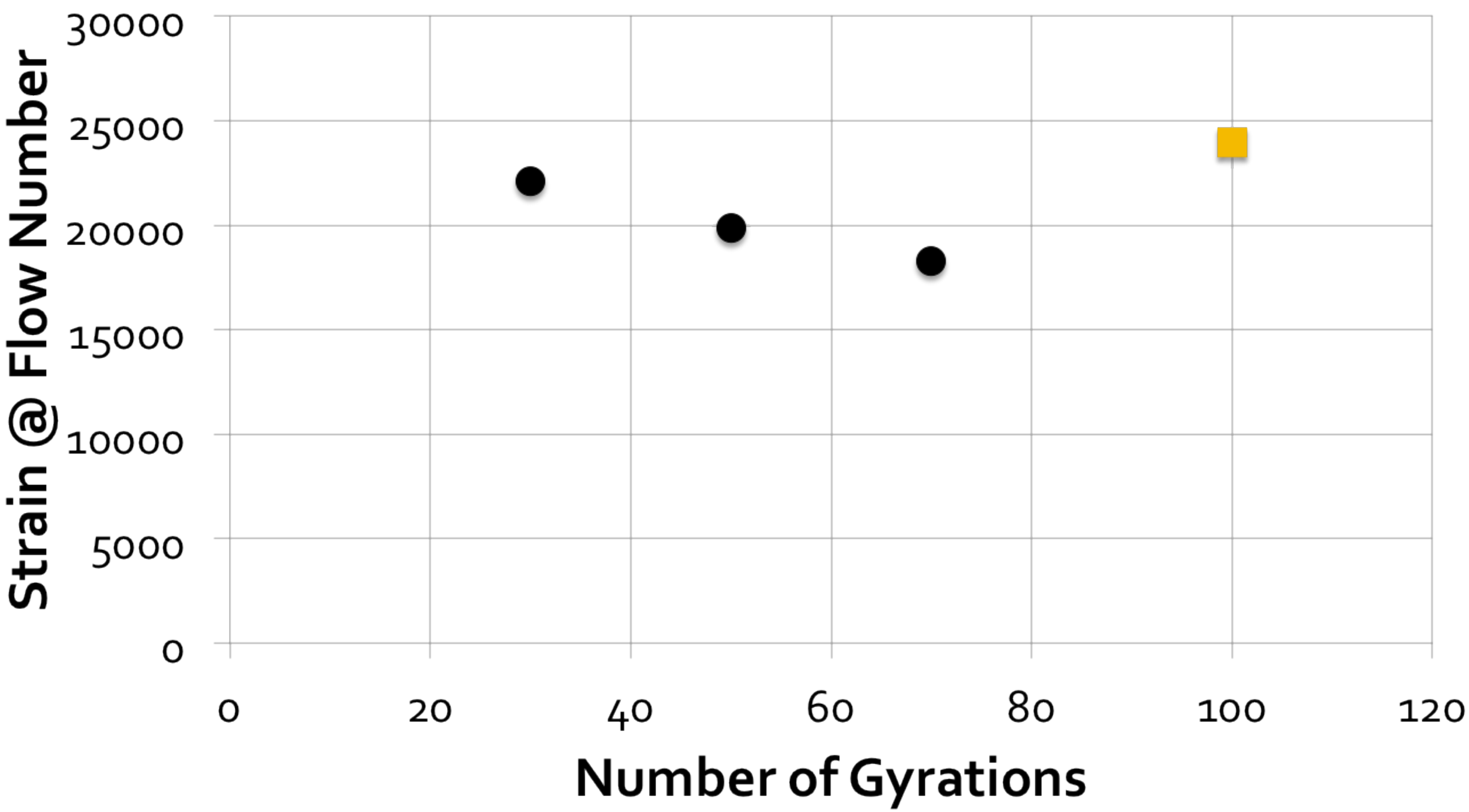
Category 4, 19.0-mm



Category 4, 19.0-mm



Category 4, 19.0-mm



Conclusions

- Mixtures can be designed at 5% air voids without lowering effective binder content
- Mixtures designed and tested at 5% air voids can have equivalent dynamic modulus and flow numbers as those designed at 4% and tested at 7% air voids
- Results suggests if asphalt mixtures were designed at 5% air voids and placed in service at 5% air voids, they could potentially outperform mixtures designed and placed in a more conventional manner

Recommendations

- Fatigue and low-temperature testing, as well as moisture susceptibility testing, should be completed
- Future work should include additional traffic levels, mixtures containing RAP, RAS, or both, additional binder grades, aggregate types, mixture sizes
- Place field projects

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

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

Thank You!

Superpave5 Field Trials

Matt Beeson, PE
State Materials Engineer
Indiana Department of Transportation

INDOT Concerns

- Benefit
- Cost
- Constructability
- Rutting
  - 30 gyrations sounds “scary”

Superpave5 Field Trial #1

Indiana SR 13

- Middlebury, IN
- 1.5” Mill and Fill
- Trial Mix
  - 9.5-mm NMAS
  - 165 lb/yd^2 (1.5 inches)

Trial Mix

- 9.5 mm
- Steel slag coarse aggregate
- PG 70-22 Binder
- 7% RAS
  - 20.2% Binder Replacement

QC Volumetric Properties

	Superpave5			
	DMF	Sub-lot 1	Sub-lot 2	Sub-lot 3
%AC	5.2	5.61	5.47	5.45
Air Voids	5.0	5.1	4.8	4.7
VMA	17.0	17.2	16.6	17.2

QA Volumetric Properties

	Superpave5				Superpave4
	DMF	Sub-lot 1	Sub-lot 2	Sub-lot 3	Average
%AC	5.2	5.1	5.1	5.4	5.1
Air Voids	5.0	4.5	4.6	3.4	3.8
VMA	17.0	16.8	15.8	17.4	14.8

Core Density

	Superpave5			Superpave4
	Sublot 1	Sublot 2	Sublot 3	Average
Gmm	2.750	2.761	2.737	2.754
Core Gmb 1	2.538	2.584	2.636	2.528
Core Gmb 2	2.600	2.614	2.646	
%Gmm 1	92.3	93.6	96.3	91.8
%Gmm 2	94.5	94.7	96.7	
Air Voids 1	7.7	6.4	3.7	
Air Voids 2	5.5	5.3	3.3	
Average AV	**5.3**			**8.2**


CARLSON


SPEED LIMIT
45

Superpave5 Field Trial

Georgetown Road

Georgetown Road

- Reconstruction and widening
- Trial Mix
  - 19-mm NMAS
  - 330 lb/yd^2 (3 inches)

Trial Conditions

- December 12 & 13, 2014
  - Loose samples
  - Cores
- Temperature
  - 34°F to 46°F
  - Light wind

Paving Train


Paving Train
SHUTTLE BUGGY
ROADTEC

N30 (Superpave5) Mix


N30 (Superpave5) Mix


N30 (Superpave5) Mix

Field Density Quality Control


Research Cores


N30 (5% Air Void) Mix

Plate Sample from Road for QA


Loose Research Samples

Research Samples (N30 and N100)

QA Volumetric Properties

	Superpave5			Superpave4	
	DMF	Sub-lot 1	Sub-lot 2	DMF	Sub-lot 1
% Asphalt	4.8	4.44	4.76	4.6	4.68
Gmm	2.480	2.505	2.494	2.494	2.523
Gmb	2.356	2.362	2.367	2.394	2.411
Air Voids	5.0	5.8	5.2	4.0	4.4
VMA	15.1	14.5	14.7	13.4	12.9

QA Core Density

	Superpave5			Superpave4	
	DMF	Sublot 1	Sublot 2	DMF	Sublot 1
Gmm		2.505	2.494		2.521
Core Gmb 1		2.412	2.345		2.351
Core Gmb 2		2.418	2.398		2.300
%Gmm 1		96.3	94.0		93.2
%Gmm 2		96.5	96.2		91.2
Air Voids 1		3.7	6.0		6.8
Air Voids 2		3.5	3.8		8.8

What's Next?

- Promising Concept
  - Constructible
  - Performs in the field
    - No rutting to date
  - Research shows a benefit
- Additional Pilot Projects
  - Various ESAL categories
  - Broader Industry representation

Thank you!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