Tire - Pavement Noise Evaluation

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UNIVERSITY of CALIFORNIA Davis • Berkeley | PAVEMENT RESEARCH CENTER

CALIFORNIA DEPARTMENT OF TRANSPORTATION

My Presentation Today

- California Quiet Pavement Research
  - Caltrans QP Policy

- QPR Research Results
  - Flexible, 5 years
  - Rigid, 3 years
    - Next Generation Concrete Surface pilot projects
- OBSI Testing in California
  - Issues with Long-Term Monitoring

Quieter Pavement Research (QPR)

- Growing awareness of highway noise

- Pavement Surface Characteristics

  more than friction

- Pavement Preservation / Maintenance

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QPR Objectives

- Understand long-term acoustic properties
- Understand quieter surface performance with time
  - Noise, smoothness, safety, durability
- Identify new surfaces treatments, materials, construction methods
- Providing quieter pavements that are also safe, durable, and cost-effective

- $1.3+ million per mile
- Maintenance problems (graffiti)
- Can not be used everywhere
- Limits future highway expansion
- Not necessarily effective
- Block views

Quiet Pavement Research

- Flexible pavements
  - Started in 2006
- Rigid pavements & Bridge decks
  - Started in 2008
- Collaboration to share knowledge and methods of implementation
  - Caltrans Quiet Pavement Research Task Group
  - Danish Road Institute

QP Policy Bulletin - October 2009

- *Mandatory Application in Noise Sensitive Areas of Frequent Human Use.*

Quieter pavement strategies shall be used in noise sensitive areas of frequent human use that meet all of the following criteria:

- **In urban locations**
- **In roadways with speed limit of 40 mph or greater**
- **When traditional noise abatement measures, such as sound walls or buffer zones, are either not existing or feasible.**

Approved Quieter Pavement Surfaces

- Flexible/Composite Pavements
  - Rubberized Open-Graded Hot Mix
  - Open-Graded Friction Course
- Rigid Pavements
  - Diamond grind
  - Rubberized Open-Graded Hot Mix, High Binder

Before Applying Approved Surfaces

- Replace failed areas
- Replace broken slabs
- Seal cracks
- Repair spalls
- Grind faulting
- Address poor Load Transfer Efficiency
- <u>Basically, correct for rough ride</u>

Surfaces for New Pavement

- Flexible / Composite Pavements
  - Use ½” maximum aggregate size or smaller
  - Use polymer or rubber modified binders
- Rigid Pavements
  - Longitudinally tined
  - Diamond ground
  - Burlap drag, longitudinal broom, astroturf drag*
  - Transverse joints - single cut, 1/8” wide

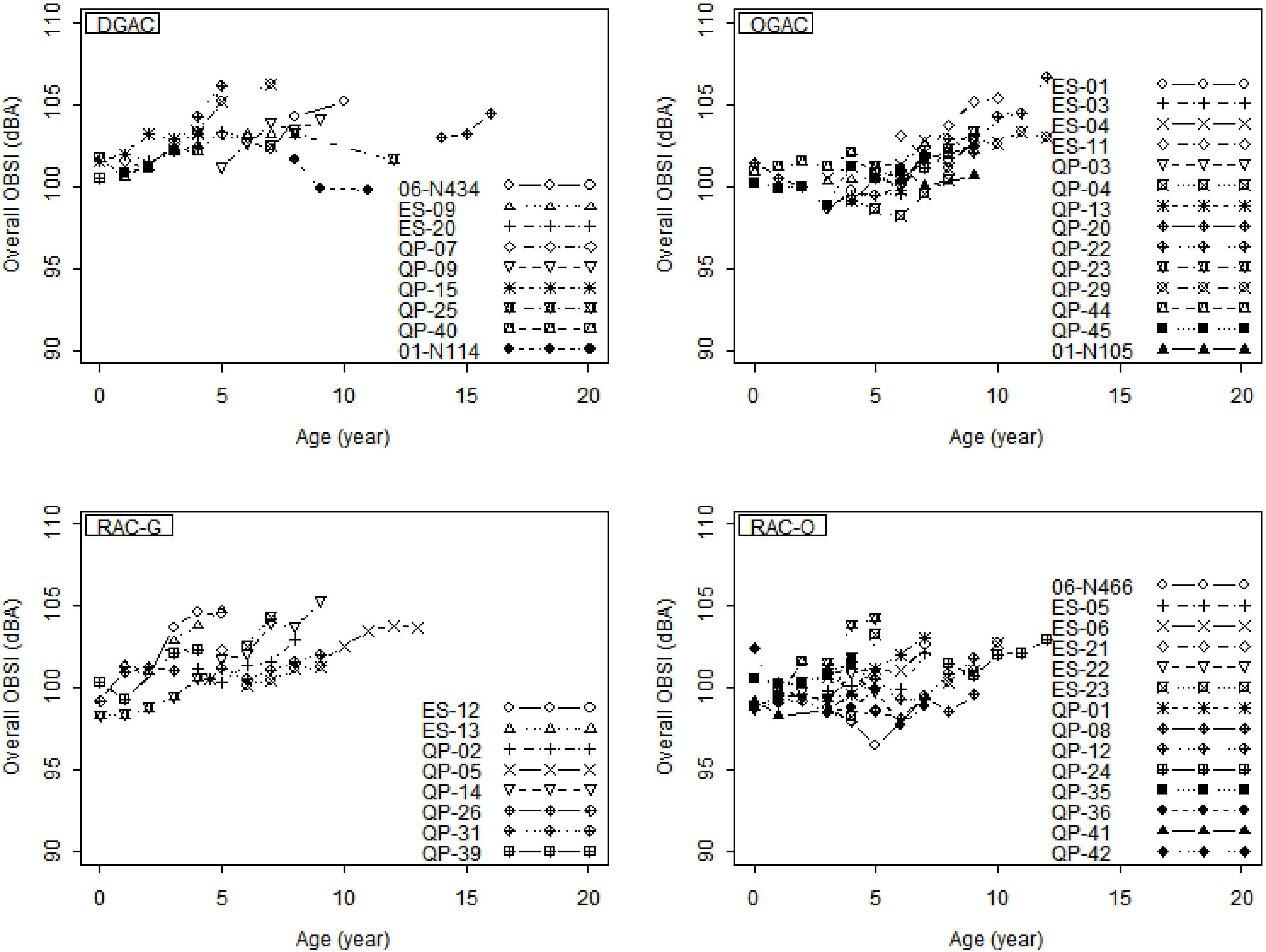
* requires approval from HQ

OBSI Testing in California

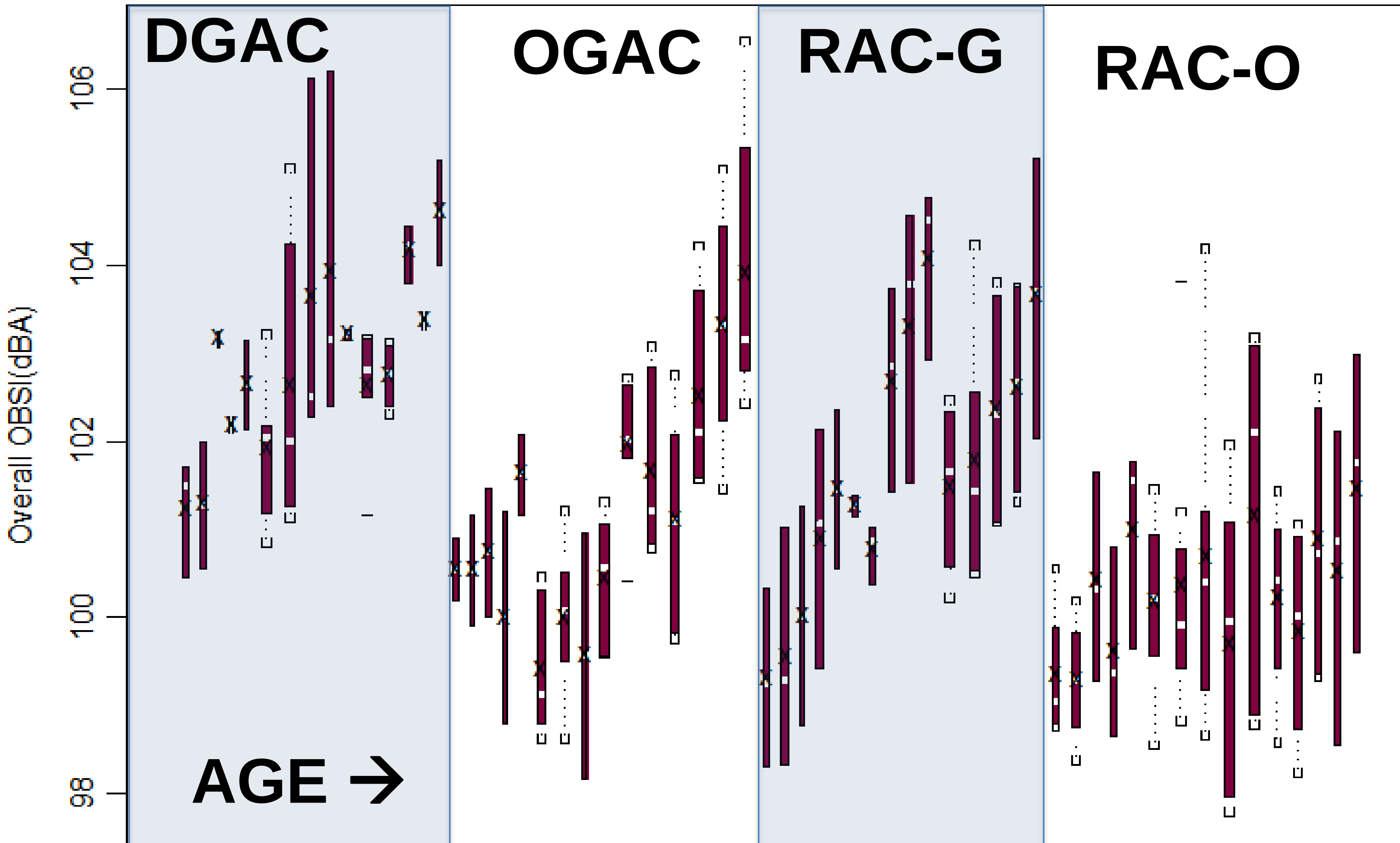
Measures OBSI, IRI, macro-texture

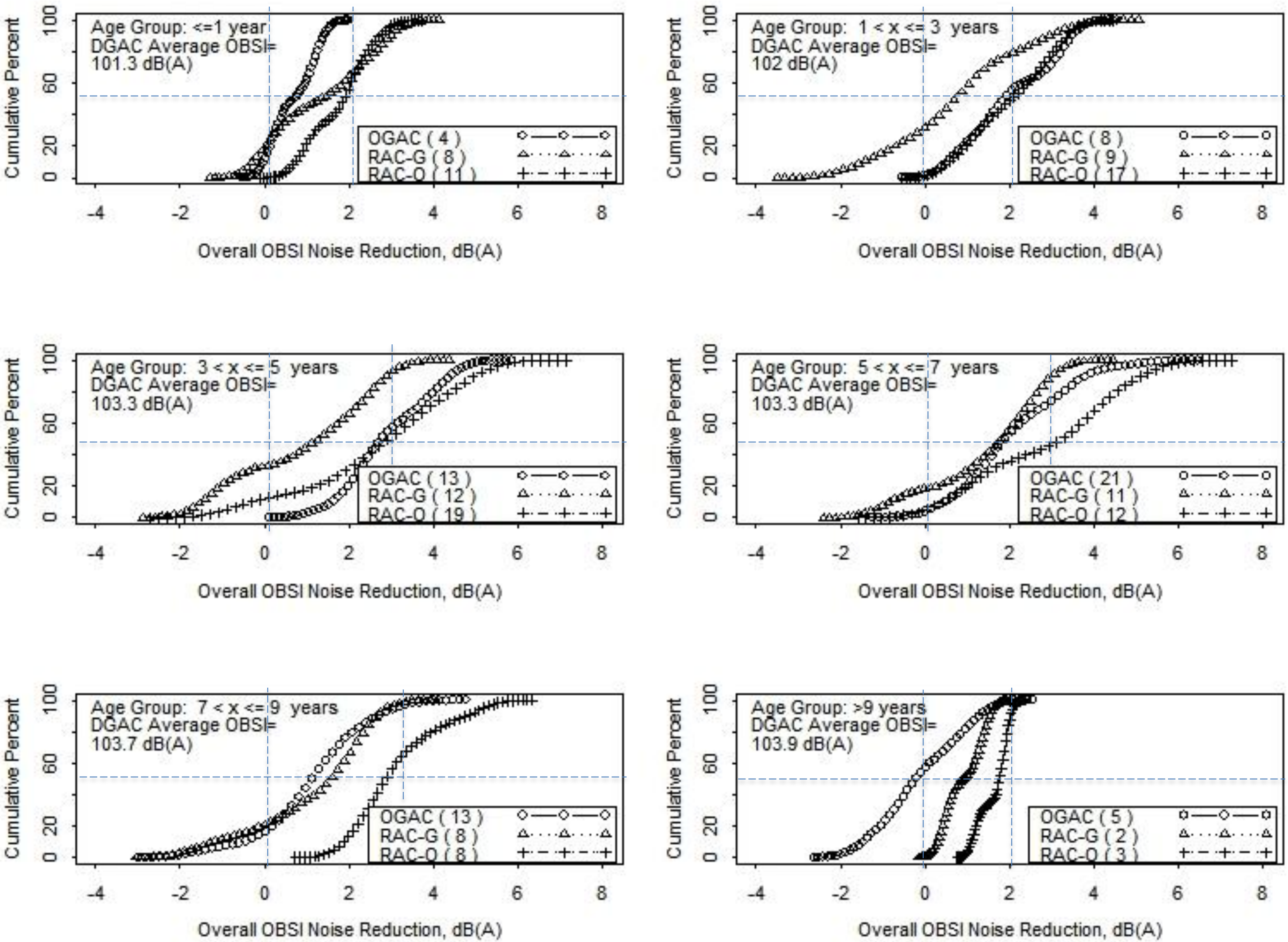
Flexible Experiment Design

- Factorial experiment
  - Mix type: DGAC, OGAC, RAC-O, RAC-G
  - Age categories (< 1 year; 1-4 years; 4-8 years)
  - Traffic level (< 32,000 AADT)
  - Rainfall level (< 24 inches/year)
- Not controlled
  - Maximum aggregate size (3/8”, 1/2”, 3/4”)
  - Polymer vs. conventional binders in OGAC
- Included environmental sections for long-term monitoring


DGAC
06-N434
ES-09
ES-20
QP-07
QP-09
QP-15
QP-25
QP-40
01-N114
OGAC
ES-01
ES-03
ES-04
ES-11
QP-03
QP-04
QP-13
QP-20
QP-22
QP-23
QP-29
QP-44
QP-45
01-N105
RAC-G
ES-12
ES-13
QP-02
QP-05
QP-14
QP-26
QP-31
QP-39
RAC-O
06-N466
ES-05
ES-06
ES-21
ES-22
ES-23
QP-01
QP-08
QP-12
QP-24
QP-35
QP-36
QP-41
QP-42
Overall OBSI (dBA)
Age (year)
90
95
100
105
110
0
5
10
15
20

OBSI values over 5 years



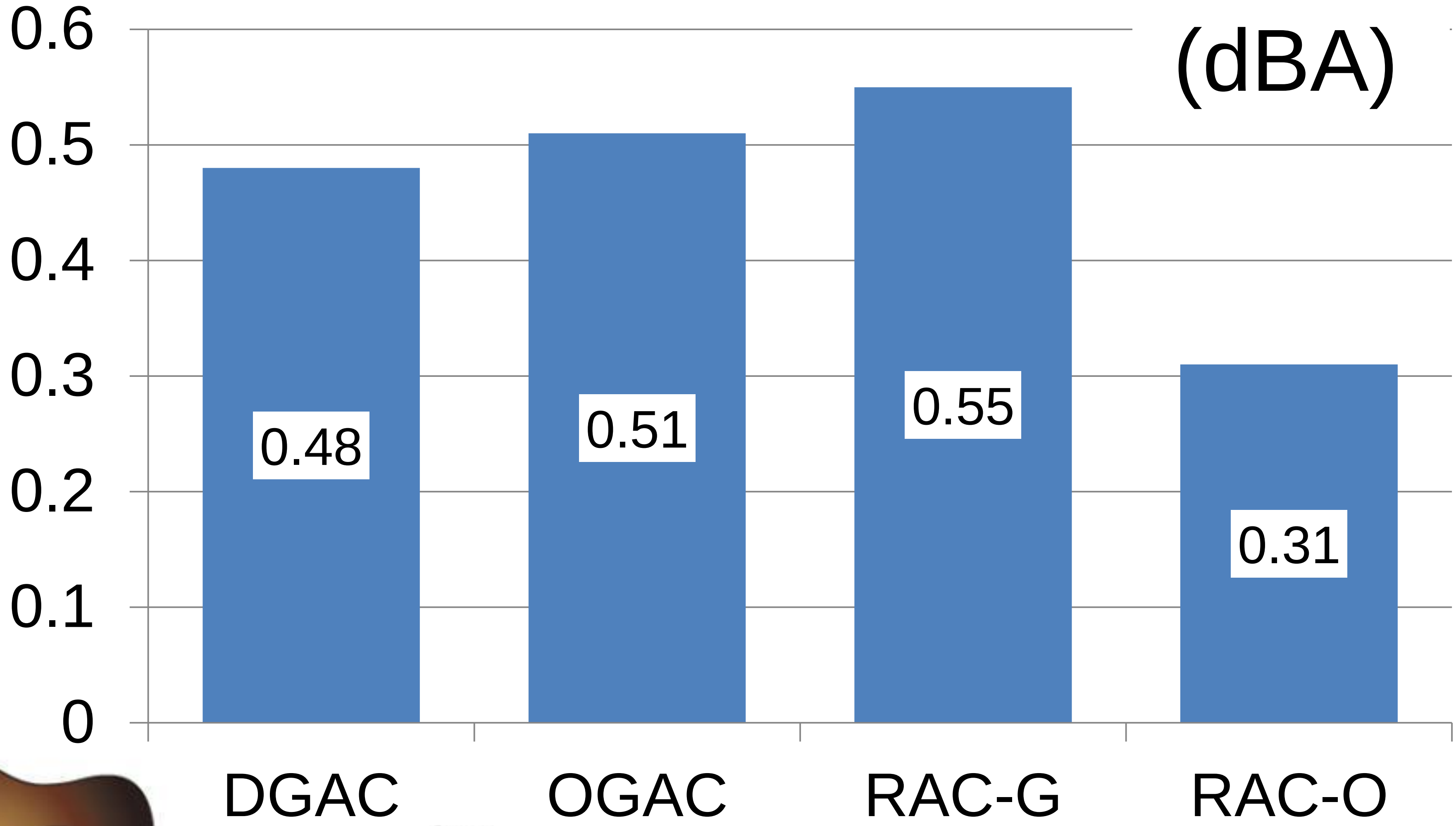


Age Group: <=1 year
DGAC Average OBSI=
101.3 dB(A)
OGAC (4)
RAC-G (8)
RAC-O (11)
Age Group: 1 < x <= 3 years
DGAC Average OBSI=
102 dB(A)
OGAC (8)
RAC-G (9)
RAC-O (17)
Age Group: 3 < x <= 5 years
DGAC Average OBSI=
103.3 dB(A)
OGAC (13)
RAC-G (12)
RAC-O (19)
Age Group: 5 < x <= 7 years
DGAC Average OBSI=
103.3 dB(A)
OGAC (21)
RAC-G (11)
RAC-O (12)
Age Group: 7 < x <= 9 years
DGAC Average OBSI=
103.7 dB(A)
OGAC (13)
RAC-G (8)
RAC-O (8)
Age Group: >9 years
DGAC Average OBSI=
103.9 dB(A)
OGAC (5)
RAC-G (2)
RAC-O (3)
Cumulative Percent
0
20
60
100
Overall OBSI Noise Reduction, dB(A)
-4
-2
0
2
4
6
8

Statistical analysis of 5 years of data

- Permeability of surface reduces noise
  - Air-void contents of 10 - 15 %; open-gradation
  - Permeability decreases with traffic, time
- High macro-texture can increase noise
  - Reduce maximum aggregate size
- Distress & roughness generally increases noise
- Other factors affecting tire/pavement noise:
  - Tire type, Temperature, Vehicle speed

Annual Change in Sound Intensity



Rigid Experiment Design

- Single Factor experiment
  - Texture: Longitudinal Tine, Longitudinal Broom, Burlap drag, Diamond Grind, Grooving
  - Age: New, Aged, Worn Out
- Not controlled
  - Traffic level
  - Rainfall level
- < 30% of CA highway miles are rigid

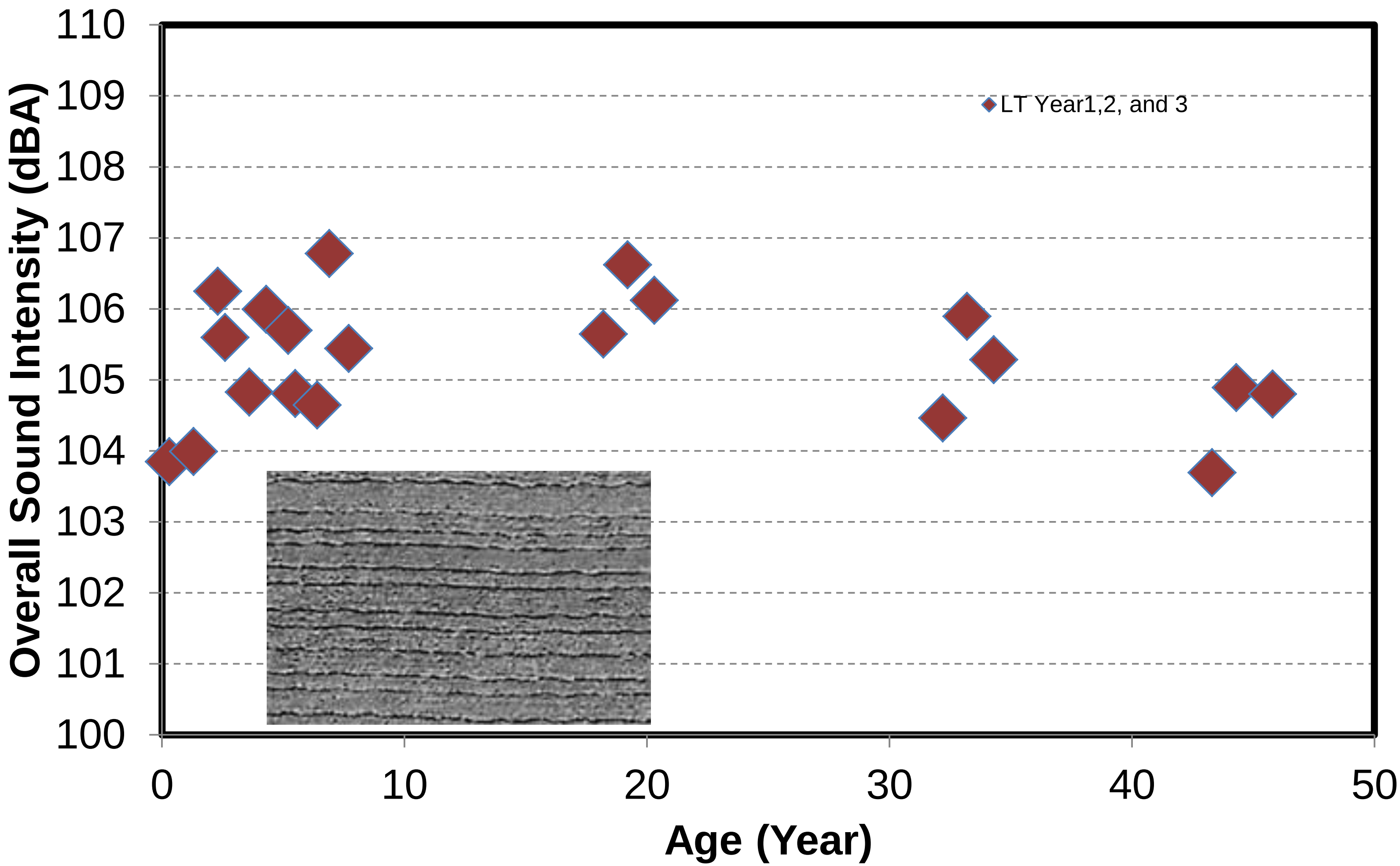
Rigid Experiment Design

- Single Factor experiment
  - Texture: Longitudinal Tine, Longitudinal Broom, Burlap drag, Diamond Grind, Grooving
  - Age: New, Aged, Worn Out
- Now controlled
  - Traffic level (< 32,000 AADT)
  - Rainfall level (< 24 inches/year)
- Augmented for Phase 4

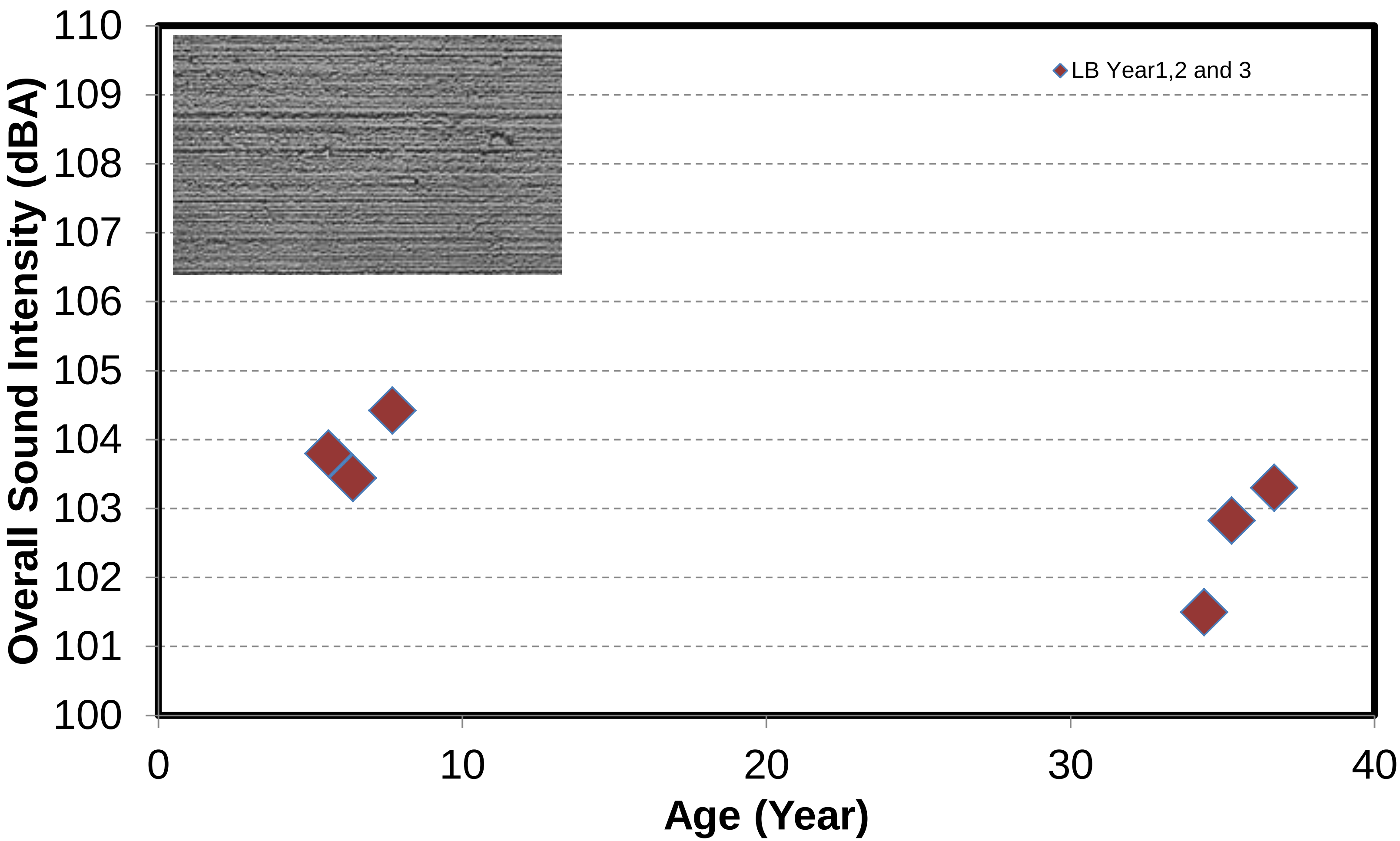
Texture types and conditions

Texture Type	Texture Condition	Year 1		Year 2		Year 3	
		Locations	Sections	Locations	Sections	Locations	Sections
LT (21)	New	2	6	2	3	2	3
	Aged	5	12	5	12	5	12
	Worn out	1	3	1	3	1	3
LB (10)	New	0	0	0	0	0	0
	Aged	2	4	2	4	2	4
	Worn out	2	6	0	0	0	0
BD (37)	New	0	0	0	0	0	0
	Aged	4	10	3	7	3	7
	Worn out	9	27	8	24	8	24
DG (32)	New	3	6	3	6	0	6
	Aged	10	26	7	18	8	21
	Worn out	0	0	0	0	0	0
Gr (19)	New	0	0	0	0	0	0
	Aged	6	19	2	7	2	7
	Worn out	0	0	0	0	0	0

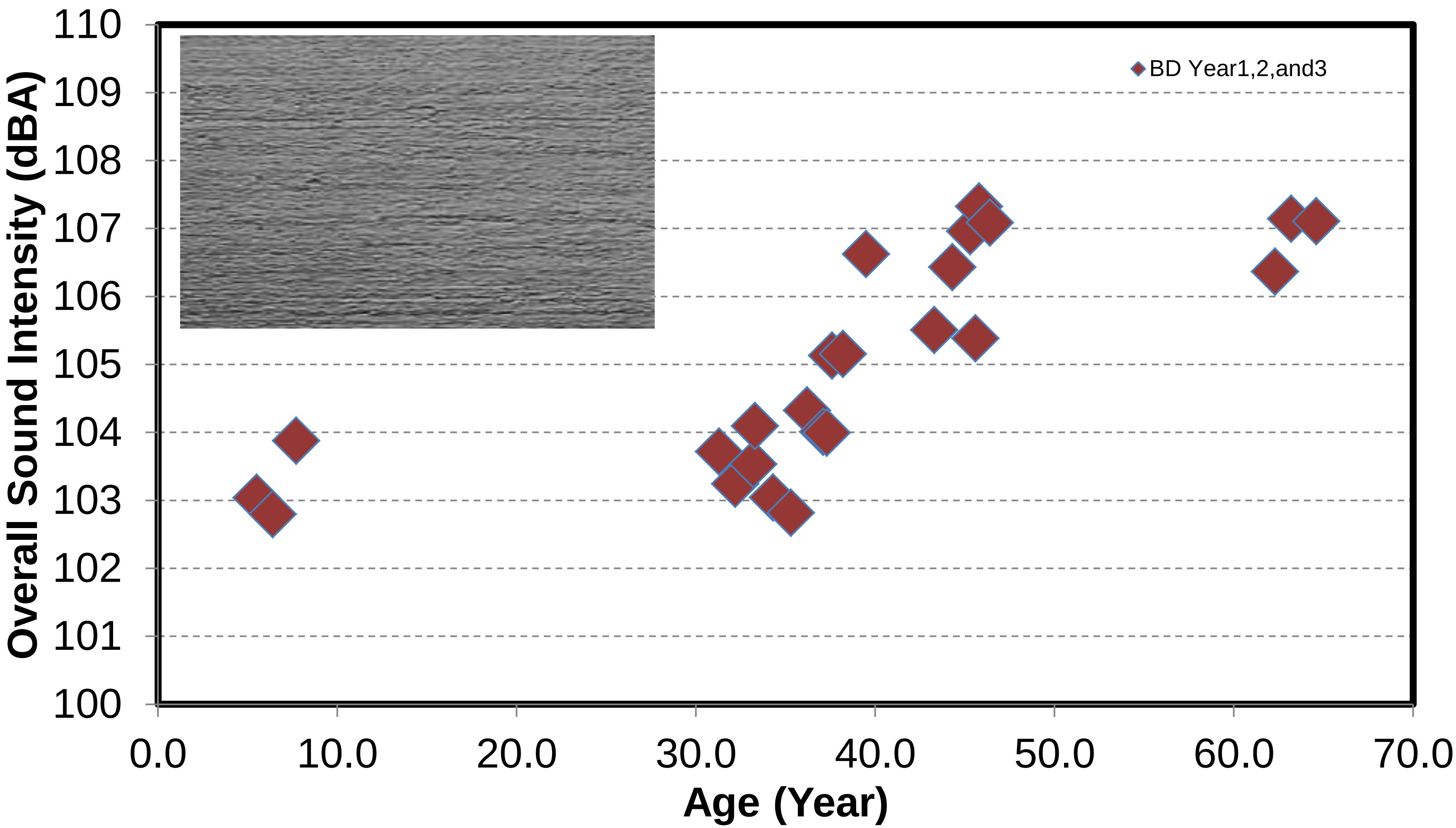
Longitudinal Tine



Longitudinal Broom

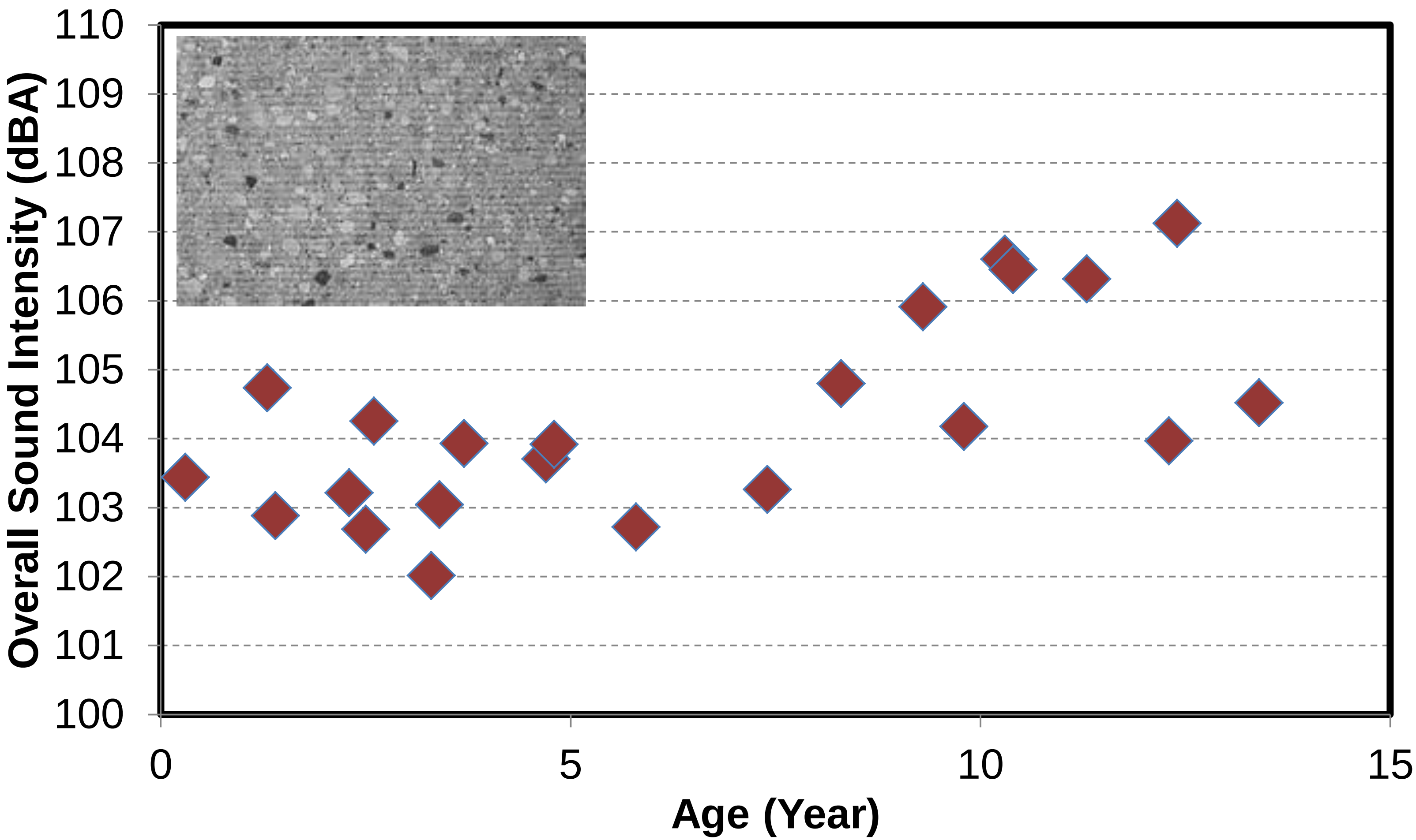


Burlap Drag

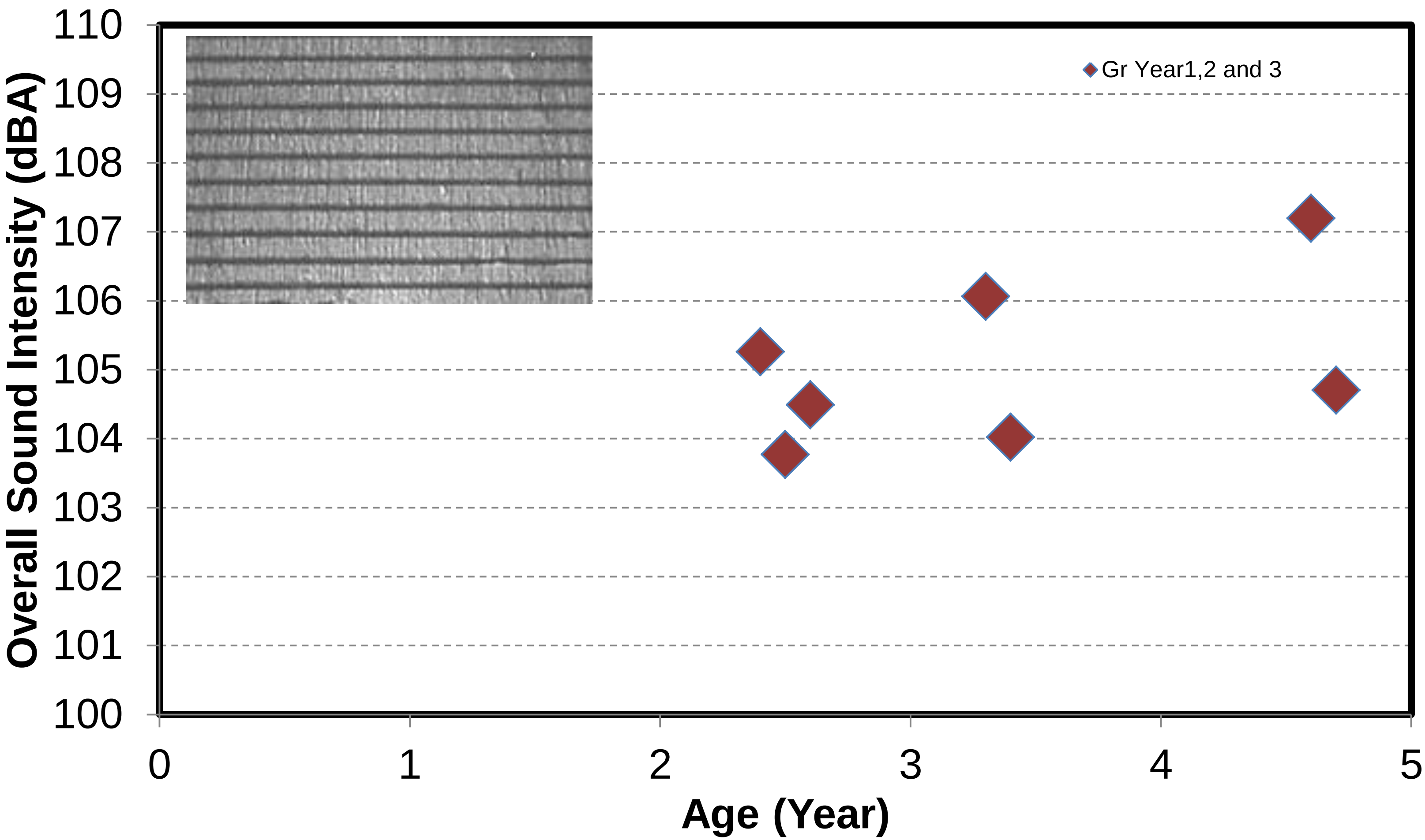


Overall Sound Intensity (dBA)
110
109
108
107
106
105
104
103
102
101
100
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
Age (Year)
BD Year1,2,and3

Diamond Grind

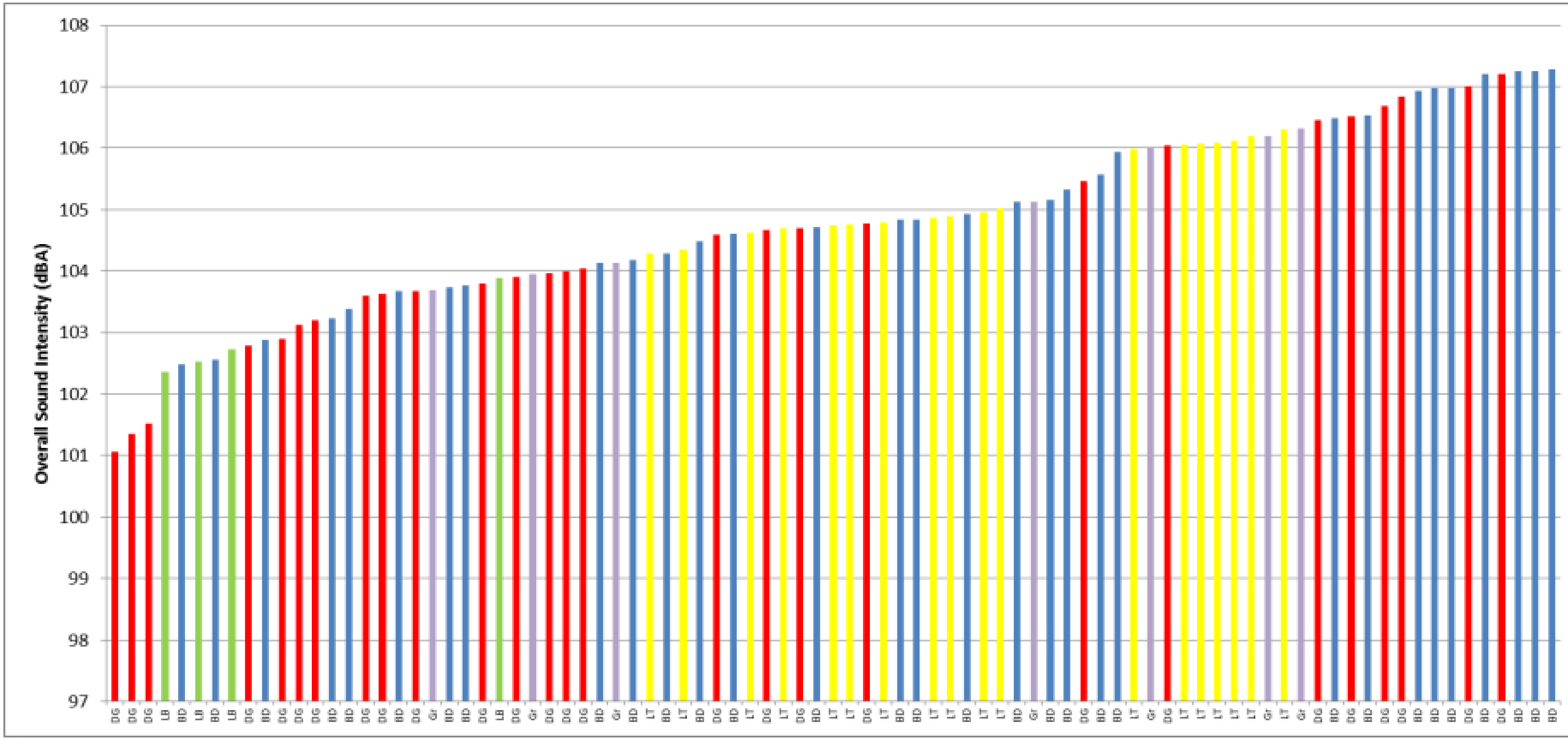


Grooved

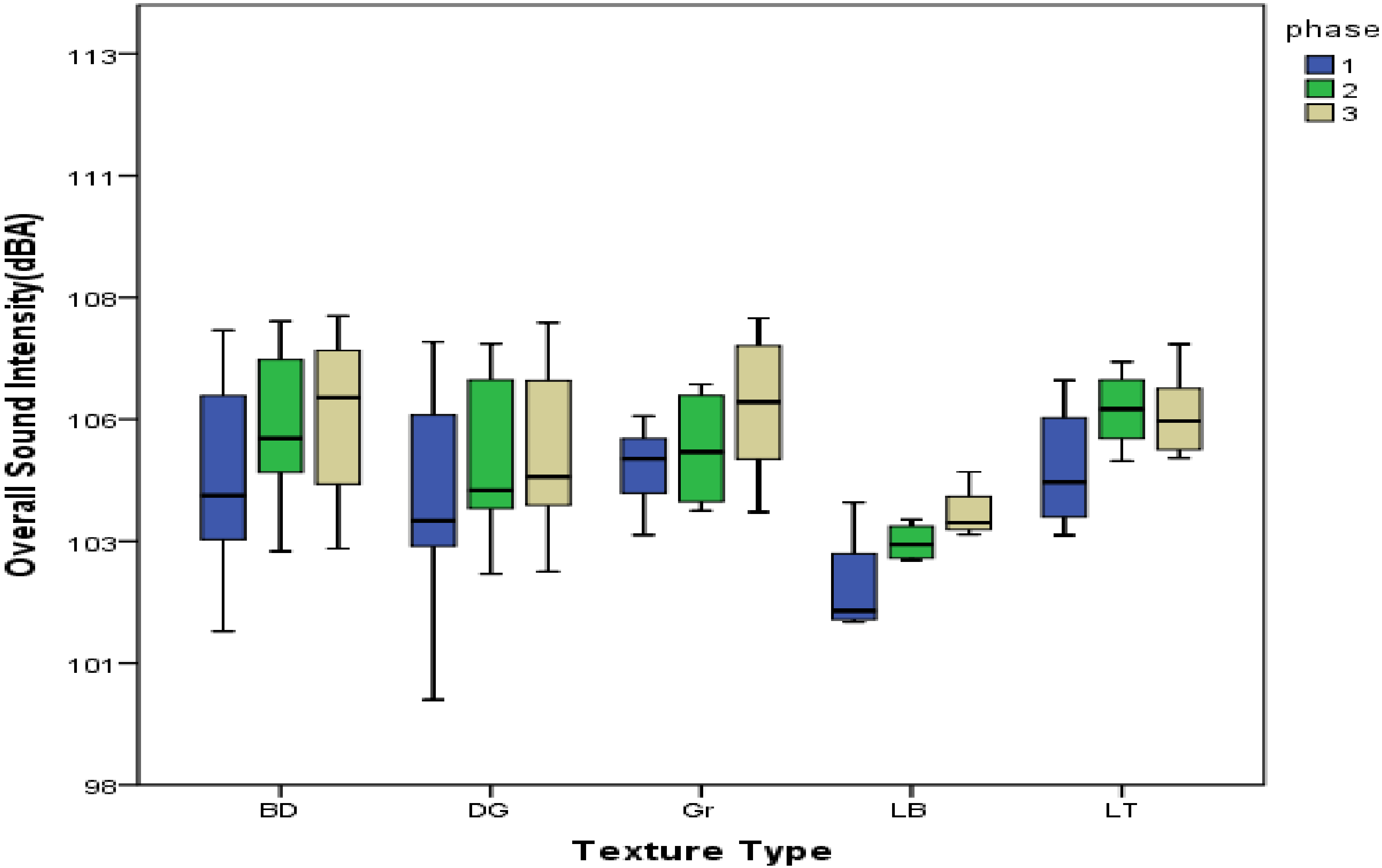


Overall Sound Intensity (dBA)
110
109
108
107
106
105
104
103
102
101
100
0
1
2
3
4
5
Age (Year)
Gr Year1,2 and 3

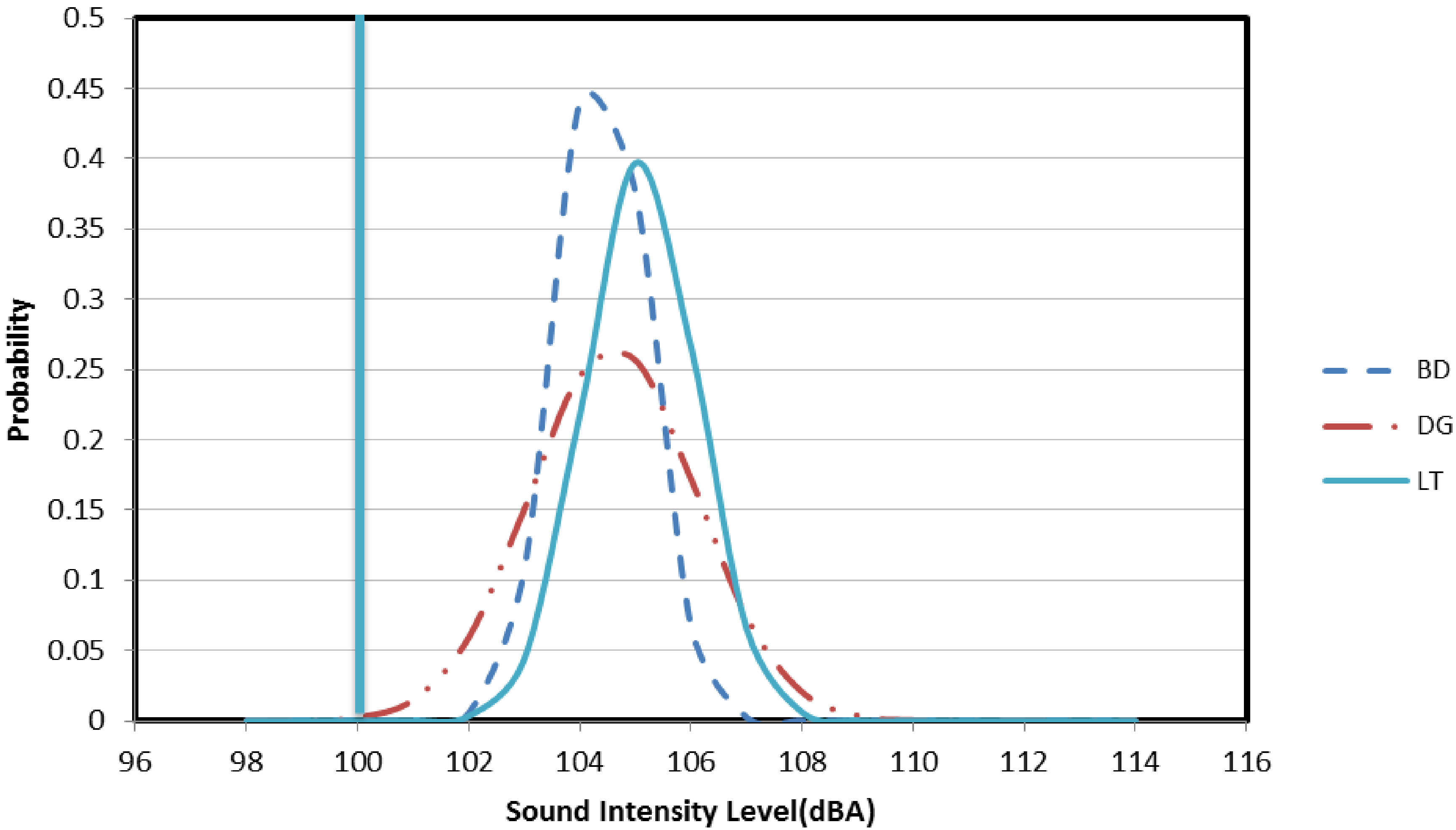
Combined 3-yr results - ***aged*** textures



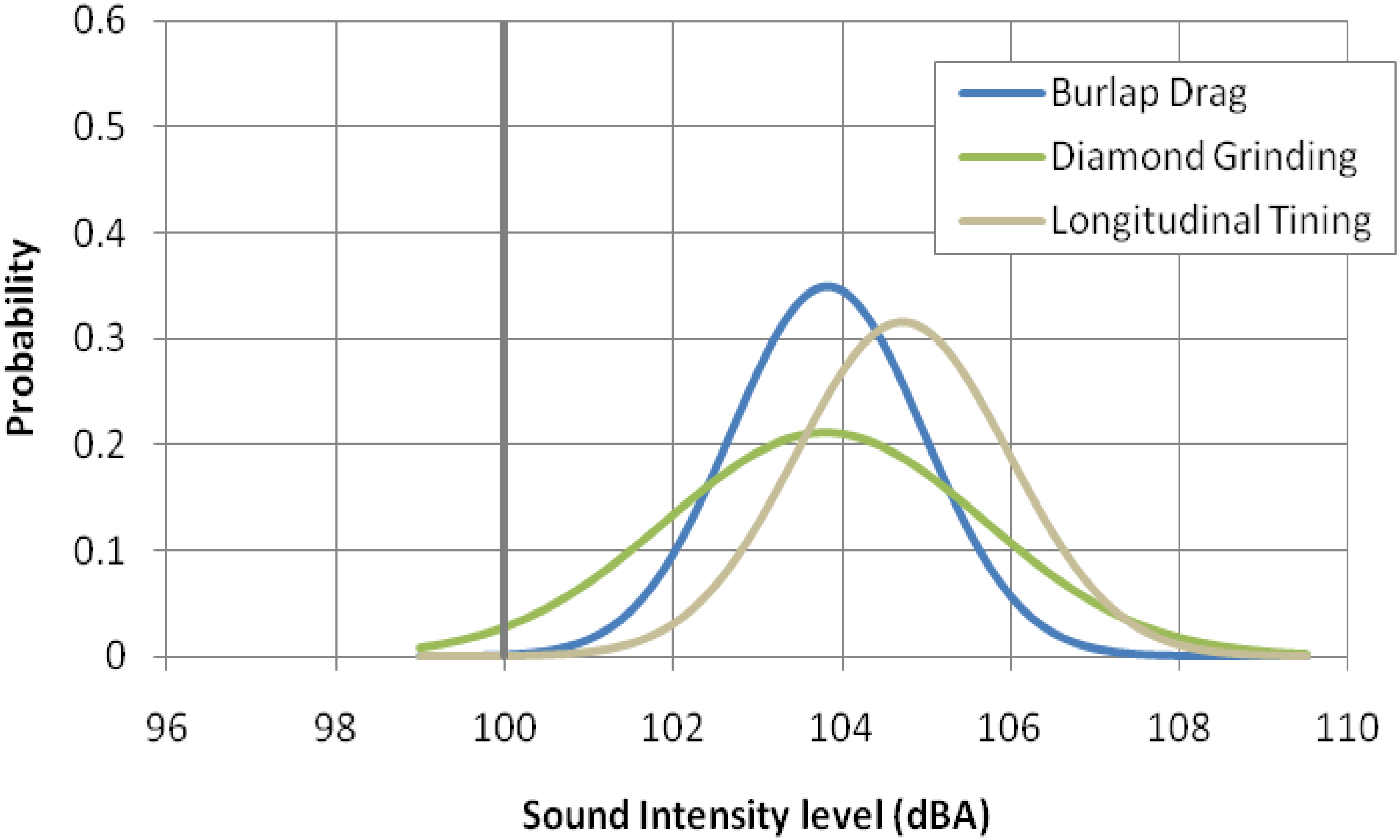
Sections common to all three years



Results after three years



With larger sample size



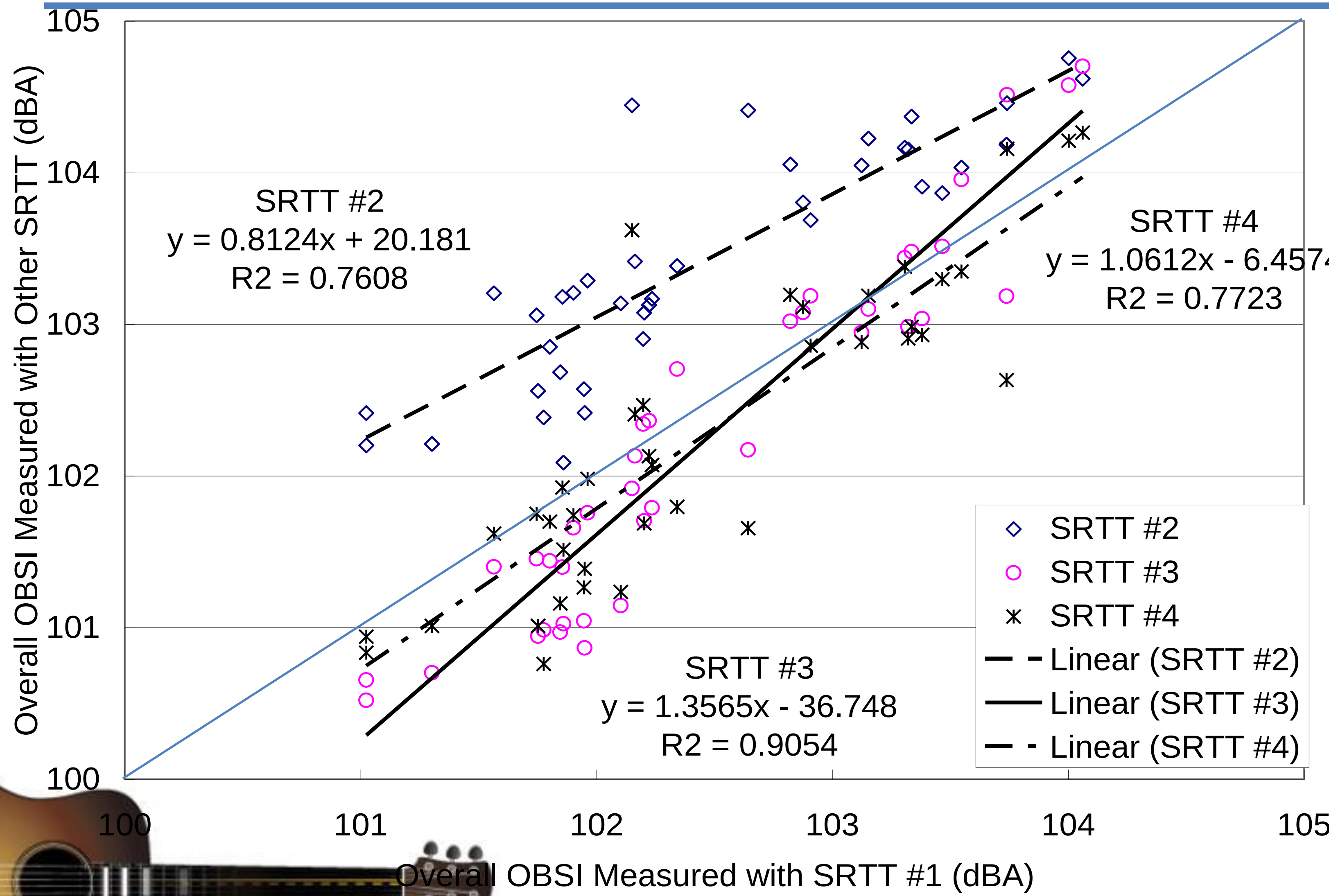
Rankings after 3 years

- Longitudinally broomed (small sample size, 102.5, *101.1 to 104.4)*
- Burlap drag (104.3, *102.8 to 105.9)*
- Diamond ground (104.4, *101.2 to 107.5)*
- Diamond grooved (104.8, *102.1 to 107.6)*
- Longitudinal tined (105.0, *102.7 to 106.8)*

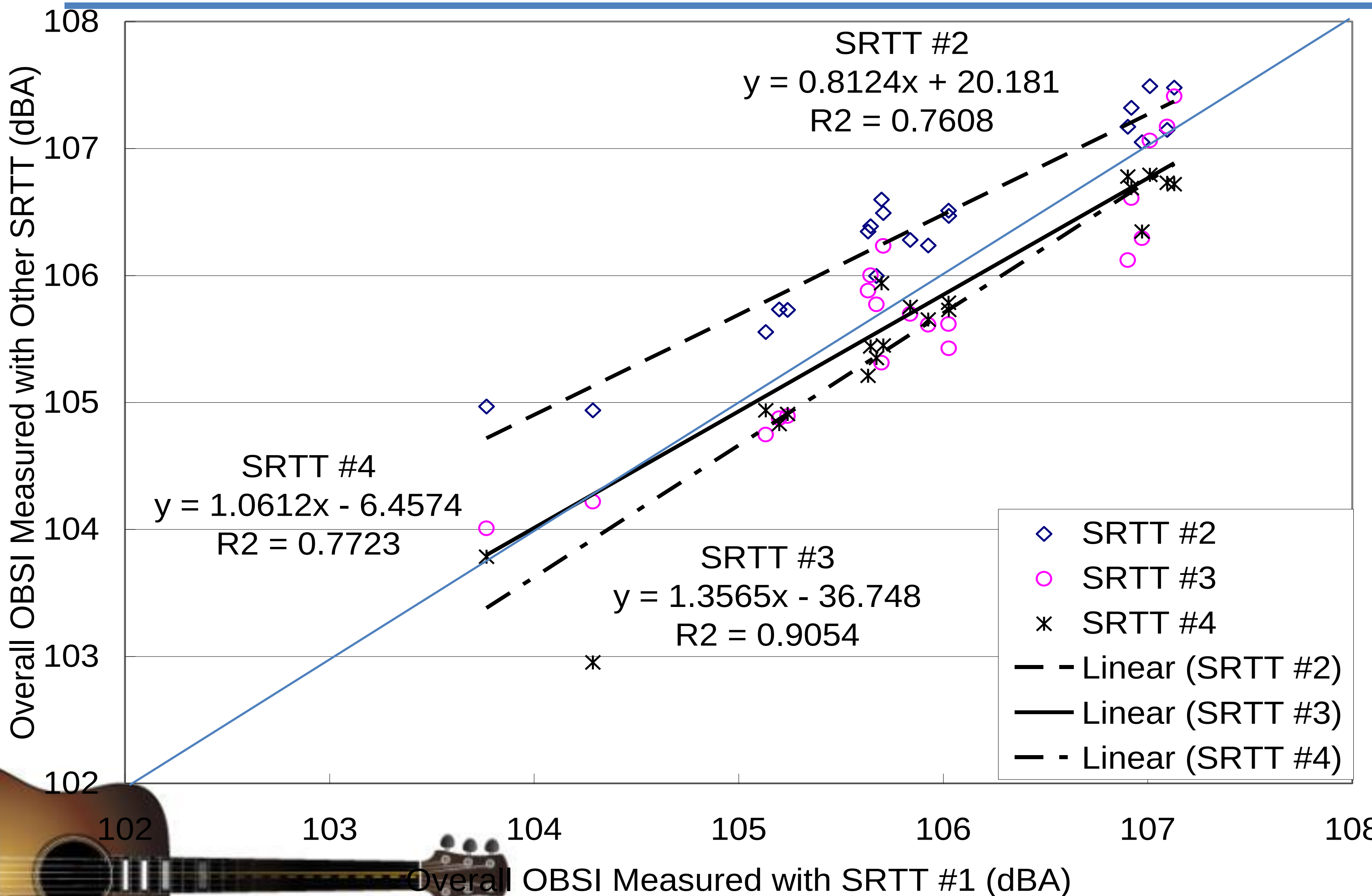
OBSI Testing in California

OBSI Testing in California

SRTT Effect on OBSI on AC



SRTT Effect on OBSI on PCC



Recommended Tire Criteria

- Change tire if half the criteria are met

- > 4 years old
- > 11,000 miles
- > 68 durometer hardness
- < 7.2 mm tread depth

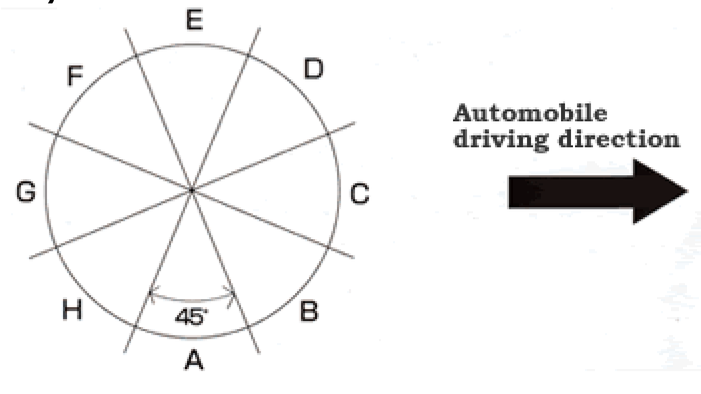
QPR Surface Characterization

- Texture Tests
  - Circular Texture Meter (ASTM E 2157)
  - Outflow Meter (ASTM E 2380)
  - Laser Texture Scanner
  - NCAT Permeameter
- Friction Tests
  - Dynamic Friction Tester (ASTM E 1911)
  - California Portable Skid Tester (CTM 342)
  - Towed Skid Trailer (ASTM E 274)
    - Ribbed (ASTM E 501) & Smooth (ASTM E 524) Tires
- Noise Tests
  - On Board Sound Intensity (AASHTO TP-76)

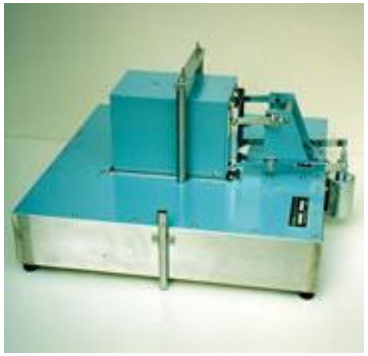
Tests require Traffic Control

Texture and Friction Tests

- Circular Texture Meter
  - measures Mean Profile Depth, MPD



- Dynamic Friction Tester
  - measures Coefficient of Friction



Texture and Friction Tests

- Outflow Meter
  - estimates Mean Texture Depth

- Laser Texture Scanner
  - measures Mean Profile Depth
  - estimates Mean Texture Depth

- NCAT Permeameter
  - measures asphalt permeability

Texture and Friction Tests

- California Portable Skid Tester
  - Measures Coefficient of Friction
  - Requires traffic control

Noise and Friction Tests

- Skid Trailer
  - Measures Coefficient of Friction
  - Requires no traffic control

Next Generation Concrete Surface

- Developed at Purdue in study of variability in noise levels from surface textures
- Benefits of longitudinal saw-cut grooves
  - Stable
  - Quiet
- Investigating the immediate and long-term effects on pavement surface properties

Concrete Surface Comparison

- Conventional Diamond Grinding

- Next Generation Concrete Surface

NGCS Pilot Projects in California

County	Route	Project Limits	NGCS Limits	Evaluation Limits
San Diego	5	PM R36.3 - R37.4	NB & SB PM R36.3 - R37.4	NB & SB PM R35.8 - R37.9
Sacramento	5	PM 17.2 - 22.8	NB PM 18.7 - 22.4	NB & SB PM 20.0 - 21.5
Sacramento	5	PM 0.0 - 17.2	NB PM 1.1 - PM 3.1	NB & SB PM 1.5 - 3.0
Sacramento	80	PM 12.4 - 18.0	EB PM 12.8 - 17.6 WB PM 12.9 - 18.0	EB & WB PM 13.0 - 14.0
Sacramento	50	PM R12.2 - R14.2	WB PM 12.8 - 14.2	EB & WB PM 13.0 - 14.0
San Joaquin	99	PM 29.0 - 30.8 NB	NB PM 29.0 - 30.8	NB PM 29.5 - 30.8
Yolo	113	PM R0.0 - R11.1	NB PM R0.20 - R1.5 SB PM R0.25 - R1.5	NB & SB PM 0.5 - 2.5

Evaluation Schedule

- Texture and Friction Tests – Traffic control required
  - Before any grinding
  - After conventional diamond grind
  - After flush grind
  - After grooving
- Noise and Friction Tests – Traffic control not required
  - Before any grinding
  - After conventional diamond grind
  - After grooving
  - Annually after grooving

NGCS Grinder

OBSI Testing Summary

OBSI Sound Intensity (dBA)	Existing Surface	Diamond Grind	NGCS
Sac5-PM20.0/21.5 Lane 1	104.7[1]	102.9[2]	101.4[3]
Sac5-PM20.0/21.5 Lane 4	105.5[1]	104.4[2]	102.7[3]
Sac80-PM13.0/14.0 L2 & L5	105.1[1]	103.1[1]	101.4[1]
Sac5-PM1.5/3.0 L1 & L2	104.6	103.7	101.5[3]
SD5-PM37.15/36.80 SB L2	103.7	101.7	100.6

1. Both directions 2. Southbound Only 3. Northbound Only

Sacramento I-5 PM 18.6 Lane 1

***Example data**	Before Grind	After Grind	After Flush	After Groove
CTM 342 (μ)	-	0.390	0.236	0.350
DFT (μ)	0.633	0.912	0.616	0.647
CTM (MPD)	0.625	1.187	0.308	1.052
Outflow (ETD)	1.153	1.852	0.788	1.499
LTS (MPD)	0.544	0.425	0.124	0.272
LTS (ETD)	0.635	0.540	0.299	0.417

Quiet Pavements Research Team

- Caltrans
  - Linus Motumah, Bill Farnbach (concrete)
  - Rupinder Dosanjh, Peter Vacura (asphalt)
  - John Drury (structures)
  - Bruce Rymer (acoustics)
- UCPRC
  - John Harvey, Principle Investigator
  - Irwin Guada, Project Manager
  - Arash Rezaei, Project Scientist/Noise analyst
  - Mark Hannum, OBSI Operator

THANK YOU !

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FHWA for CTM & DFT
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Questions?

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