The National Academies of
SCIENCES • ENGINEERING • MEDICINE

TRB
TRANSPORTATION RESEARCH BOARD

TRB WEBINAR PROGRAM

Texture Measurements and Their Correlation with Pavement Functional Performance

Thursday, April 27, 2017
2:00-3:30 PM ET

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Providers Program. Credit earned on completion of this program will be reported to RCEP. A certificate of completion will be issued to participants that have registered and attended the entire session. As such, it does not include content that may be deemed or construed to be an approval or endorsement by RCEP.

RCEP

REGISTERED CONTINUING EDUCATION PROGRAM

Purpose

Discuss how pavement texture measurements correlate with functional performance

Learning Objectives

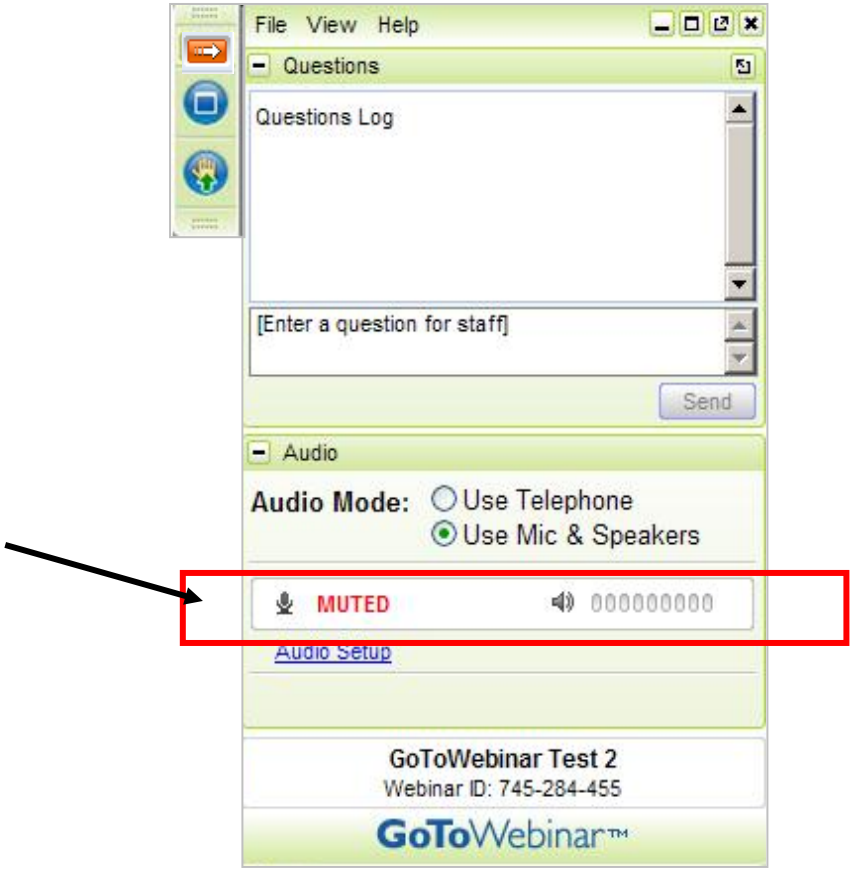
At the end of this webinar, you will be able to:

- Define pavement texture metrics
- Identify present texture measurements and interpretation techniques
- Understand how to assess future usage of texture to predict noise, friction, and splash and spray

PDH Certificate Information

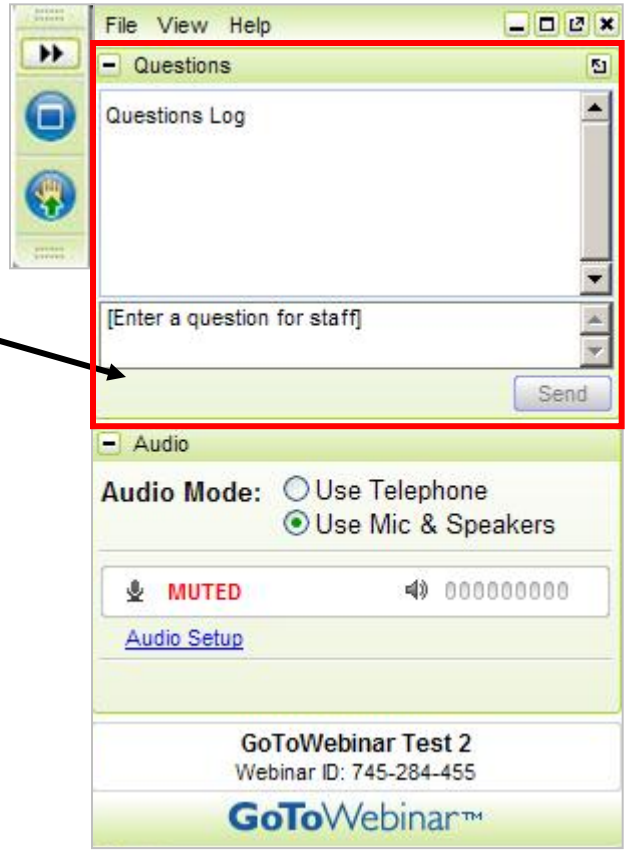
- This webinar is valued at 1.5 Professional Development Hours (PDH)
- Instructions on retrieving your certificate will be found in your webinar reminder and follow-up emails
- You must register and attend as an individual to receive a PDH certificate
- TRB will report your hours within one week
- Questions? Contact Reggie Gillum at RGillum@nas.edu

All Attendees Are Muted



Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



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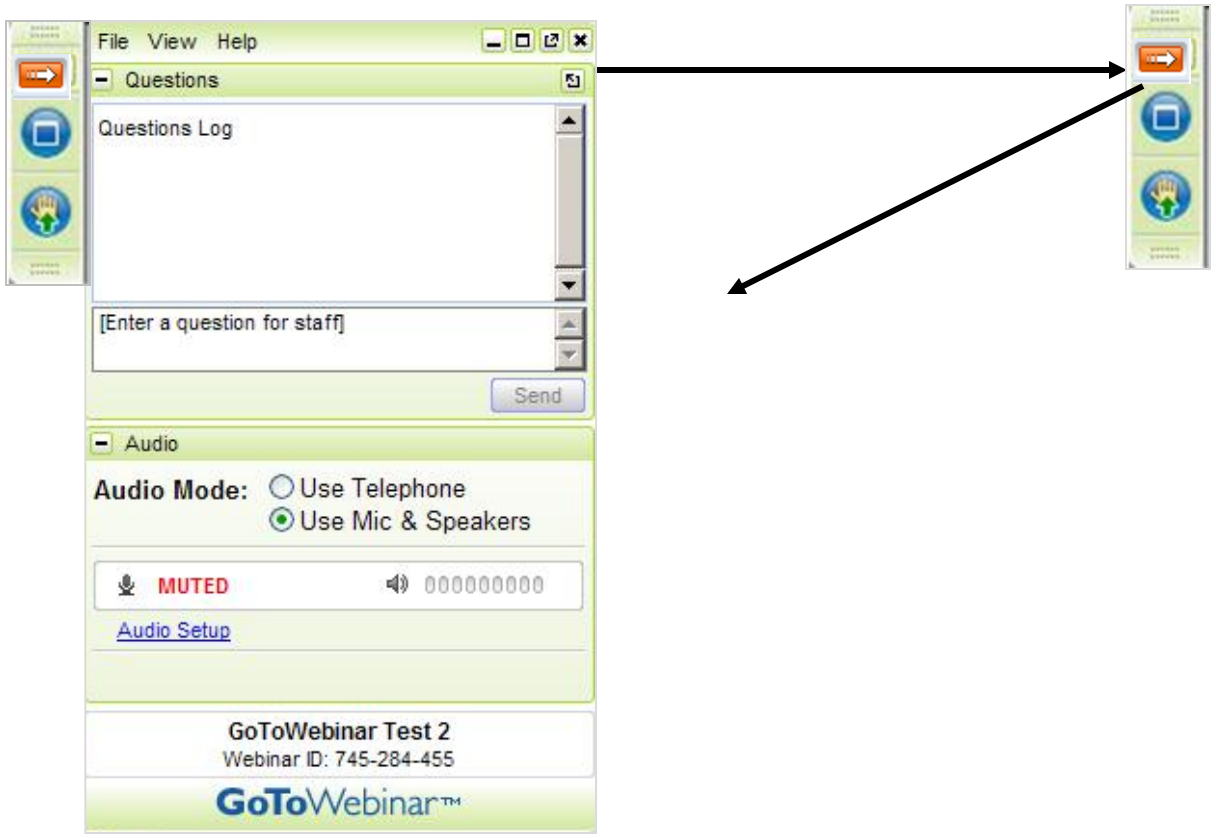
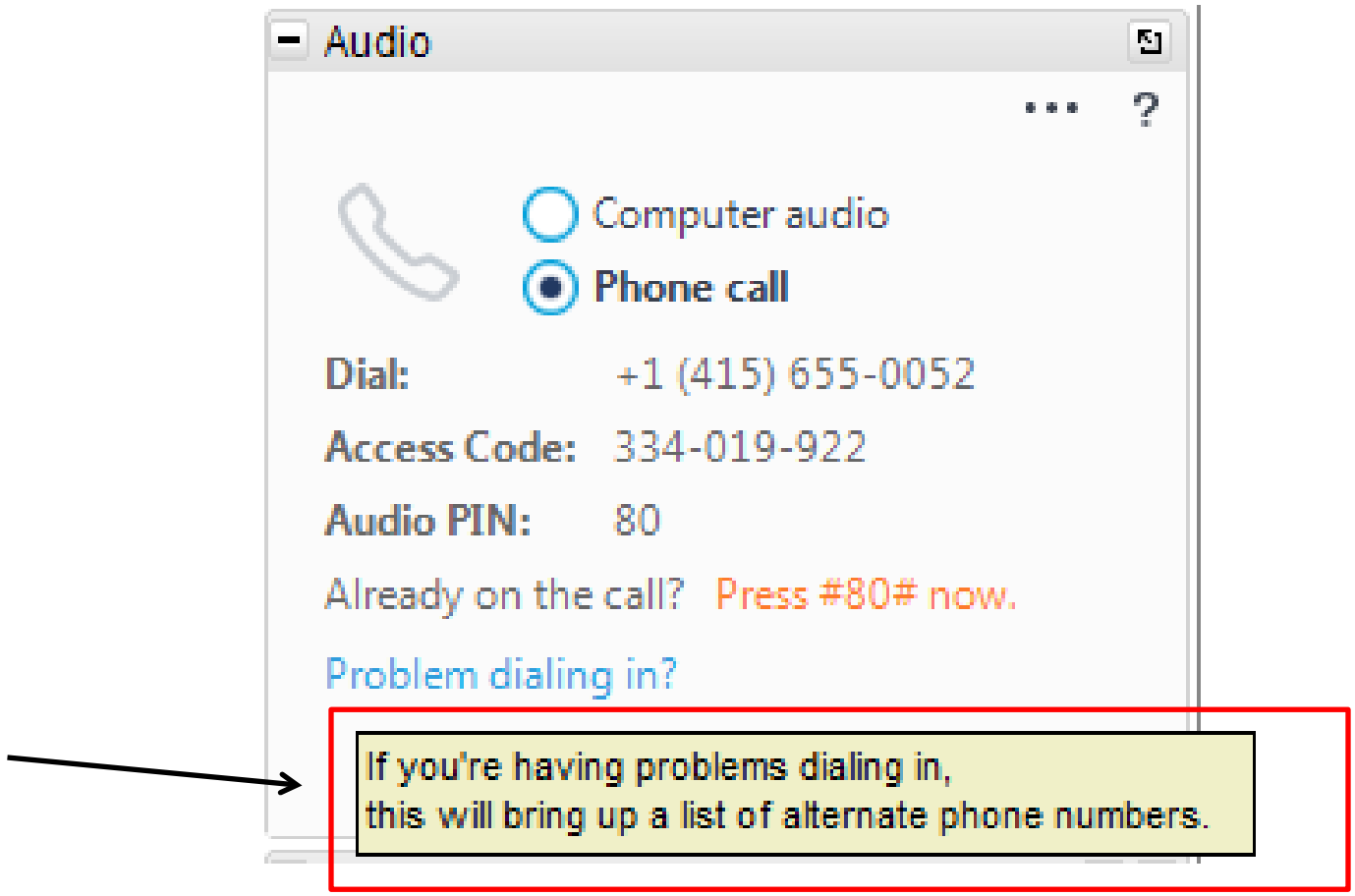


Having Trouble Logging On?



Panelists Presentations

http://onlinepubs.trb.org/onlinepubs/webinars/170427.pdf

After the webinar, you will receive a follow-up email containing a link to the recording

Today's Participants

- Robert Rasmussen, *Transtec Group,* Robotto@TheTranstecGroup.com
- Charles Holzschuher, *Florida Department of Transportation,* charles.holzschuher@dot.state.fl.us
- Magdy Mikhail, *Texas Department of Transportation,* Magdy.Mikhail@txdot.gov

THE TRANSTEC GROUP
The World's Pavement Engineering Specialists

FDOT

Get Involved with TRB

- Getting involved is free!
- Join a Standing Committee (http://bit.ly/2jYRrF6)
  - AFD90 (Pavement Surface and Vehicle Interaction)
- Become a Friend of a Committee (http://bit.ly/TRBcommittees)
  - Best way to become a member
  - Ultimate networking opportunity
- For more information: www.mytrb.org
  - Create your account
  - Update your profile

97th TRB Annual Meeting: January 7-11, 2018

Fundamentals of Pavement Texture: Construction, Measurement, and Interpretation

TRB Webinar on Texture Measurements and Their Correlation with Pavement Functional Performance

Robert Otto Rasmussen, PhD, INCE, PE

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Robotto@TheTranstecGroup.com • www.TheTranstecGroup.com

27 April 2017

What is Texture?

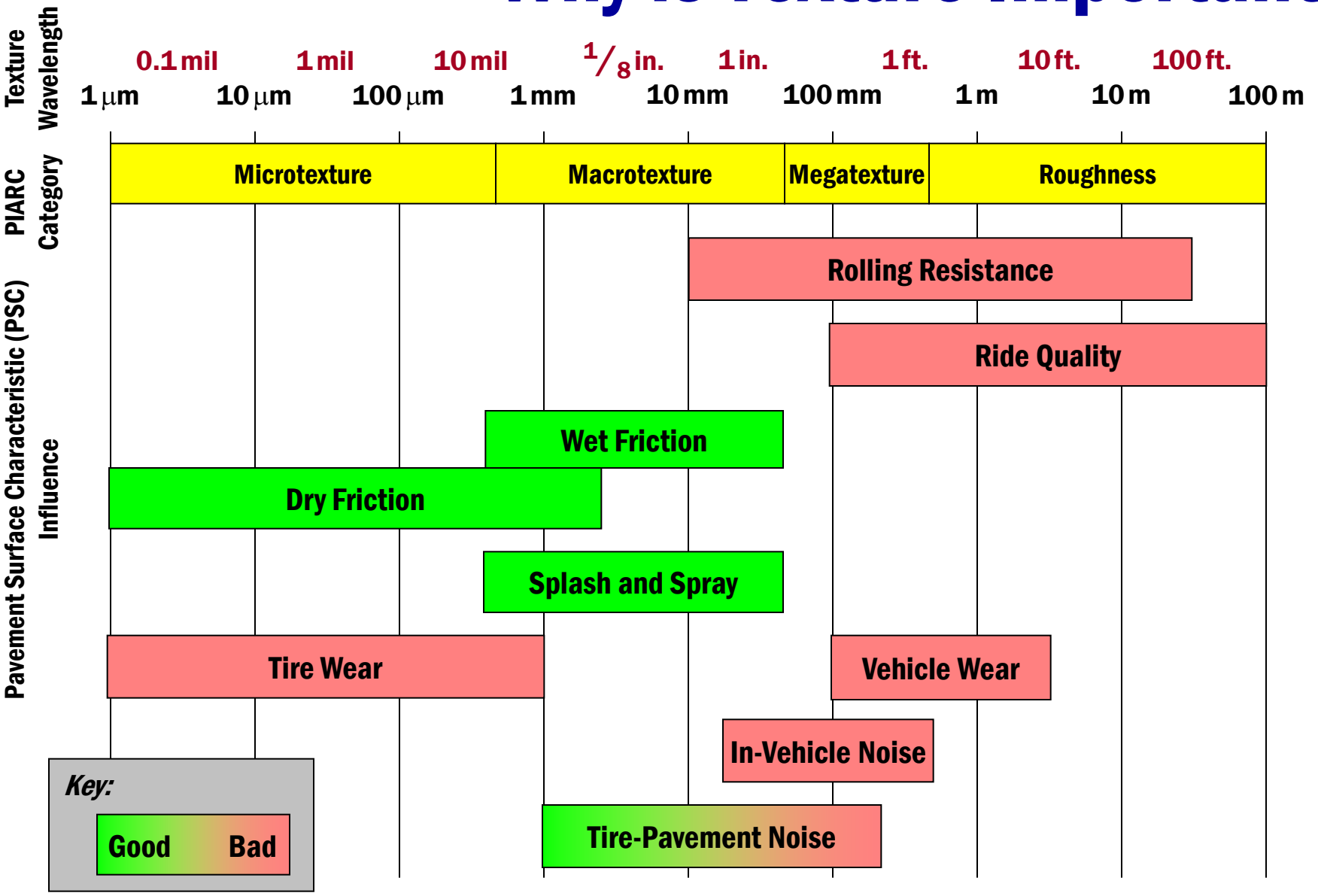
Roughness (IRI)

Megatexture (L_{ME})

Macrotexture (MPD)

Microtexture (μ)

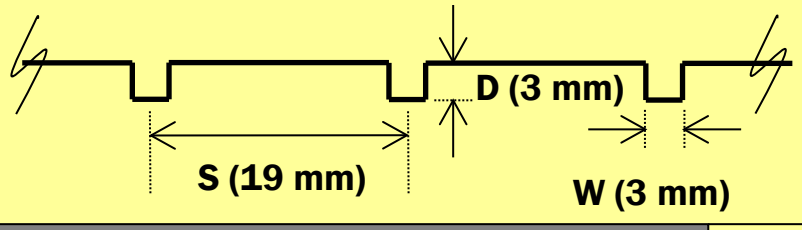
Why is Texture Important?



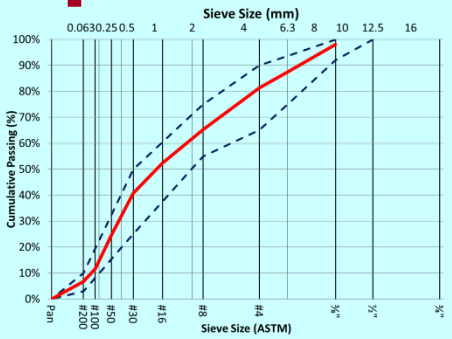
Source: PIARC

How is Texture Specified?

Concrete

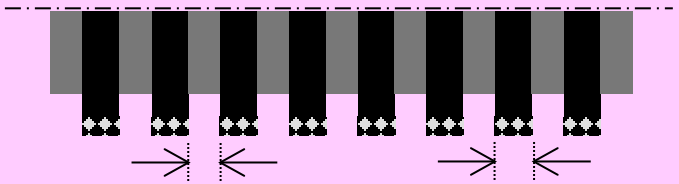


Asphalt



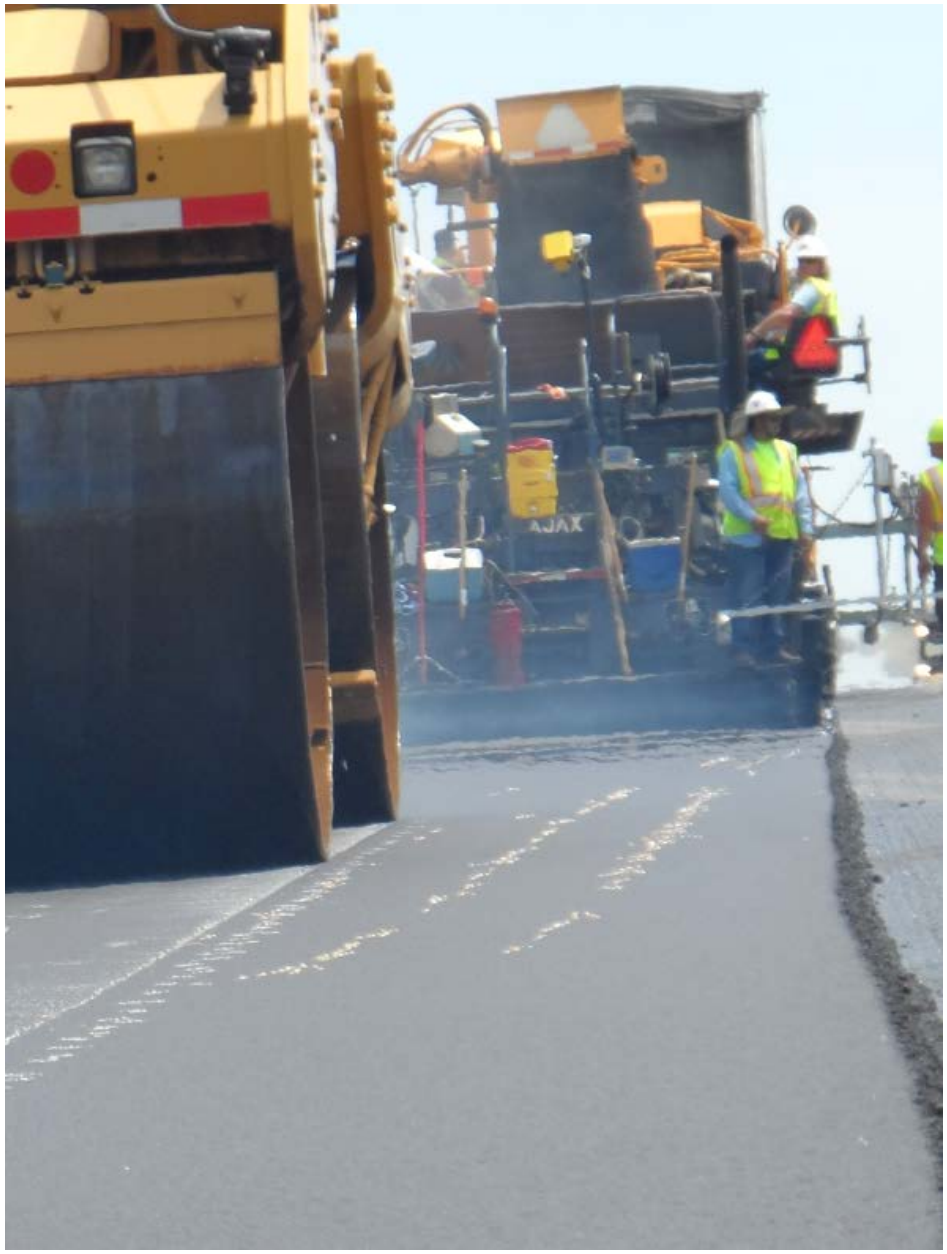
Job Mix Formula

Diamond Grinding



How is Texture Constructed?

How is Texture Constructed?



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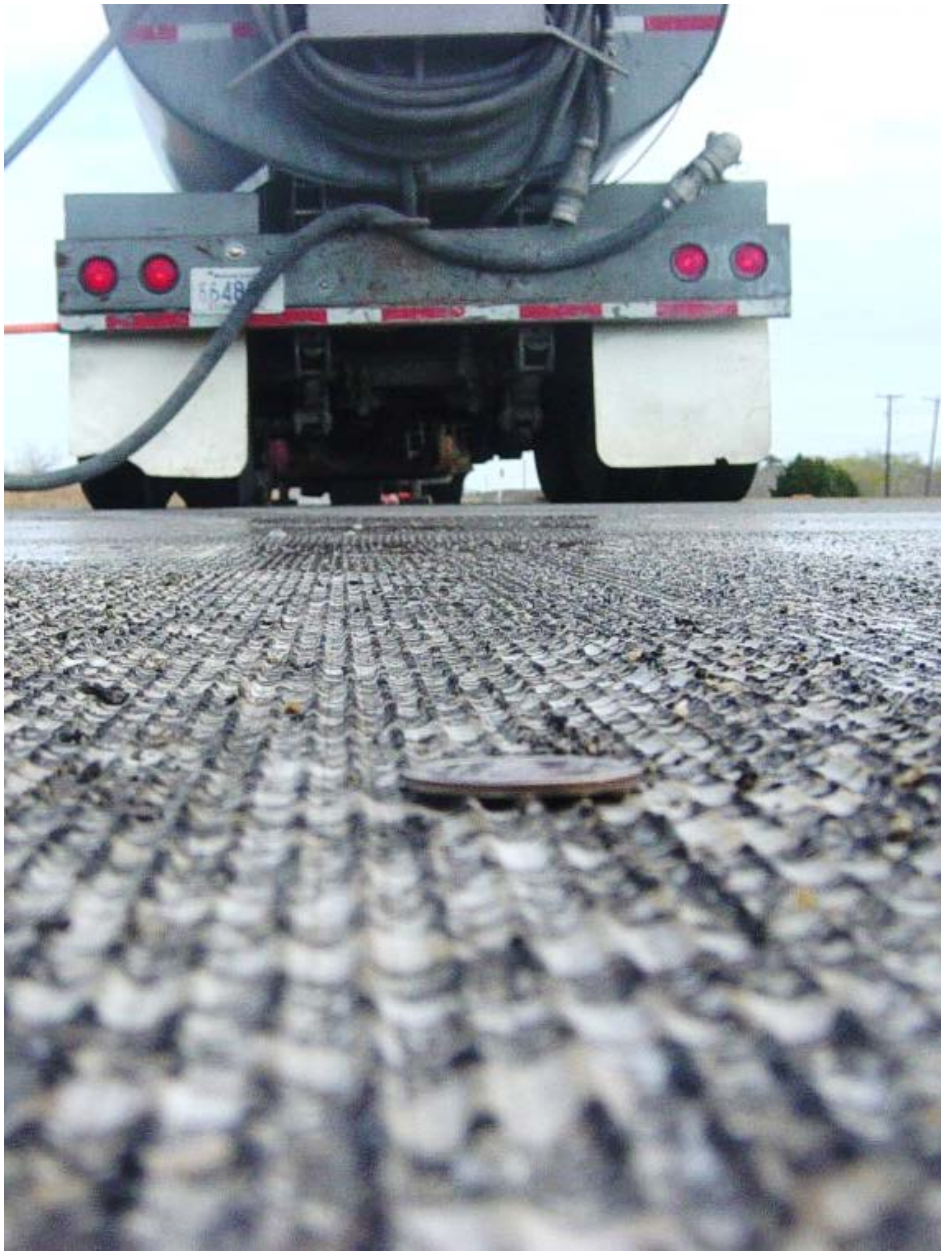
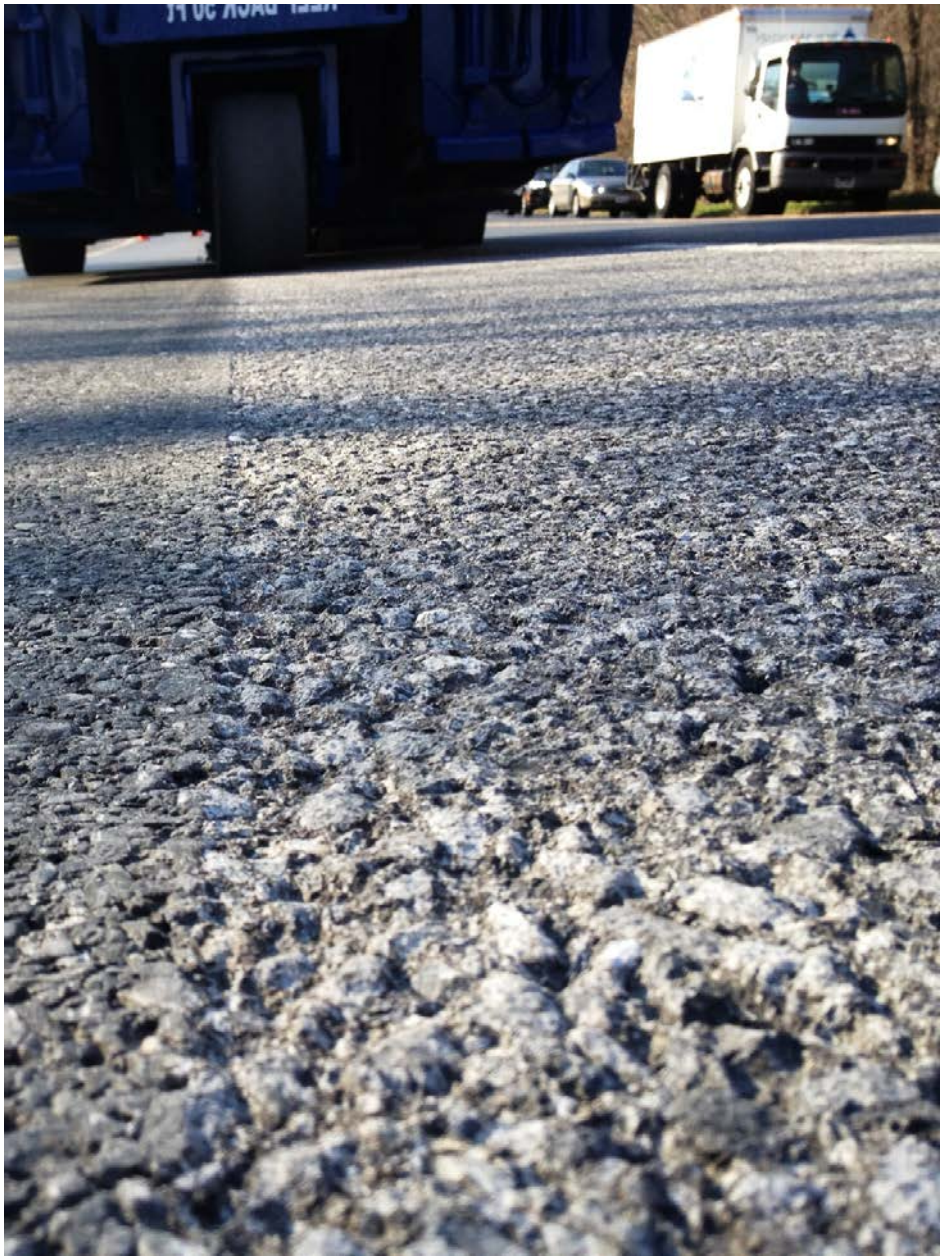
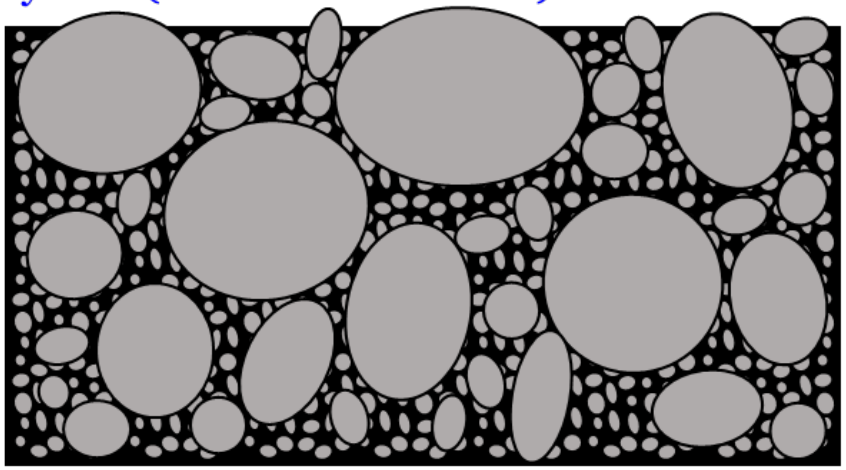




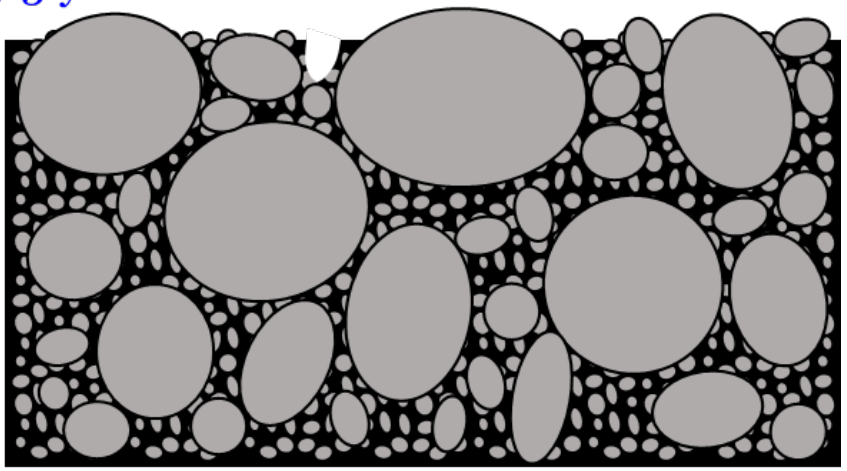
How is Texture Constructed?

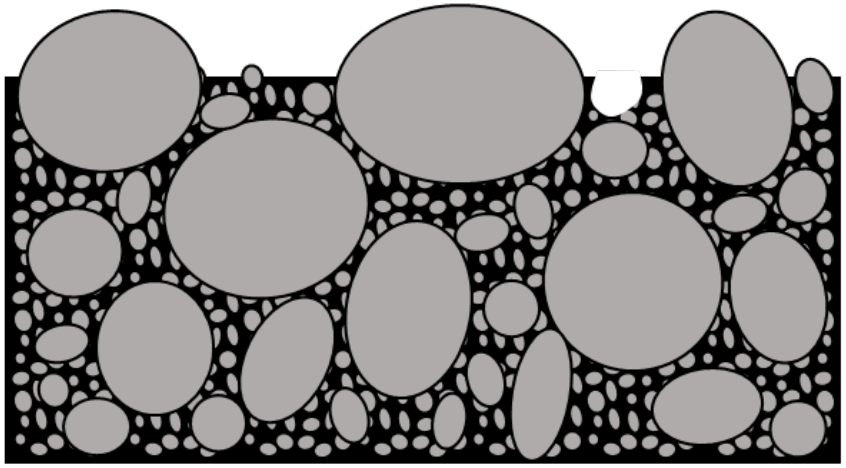
How does Texture Change?

0 years (after construction)

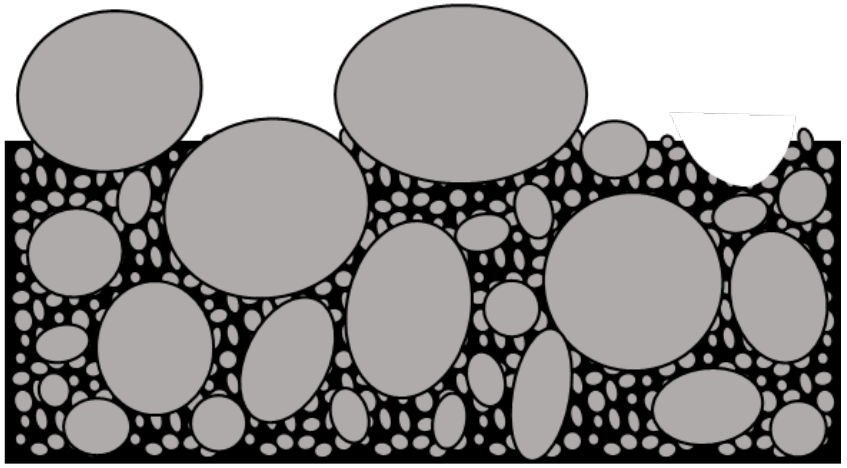


3-5 years





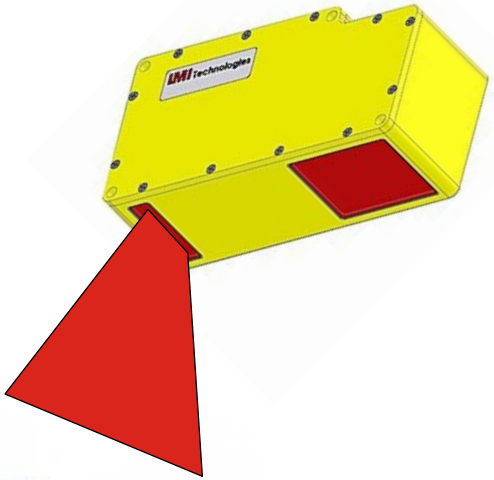
10-20 years



> 20 years (end of life)

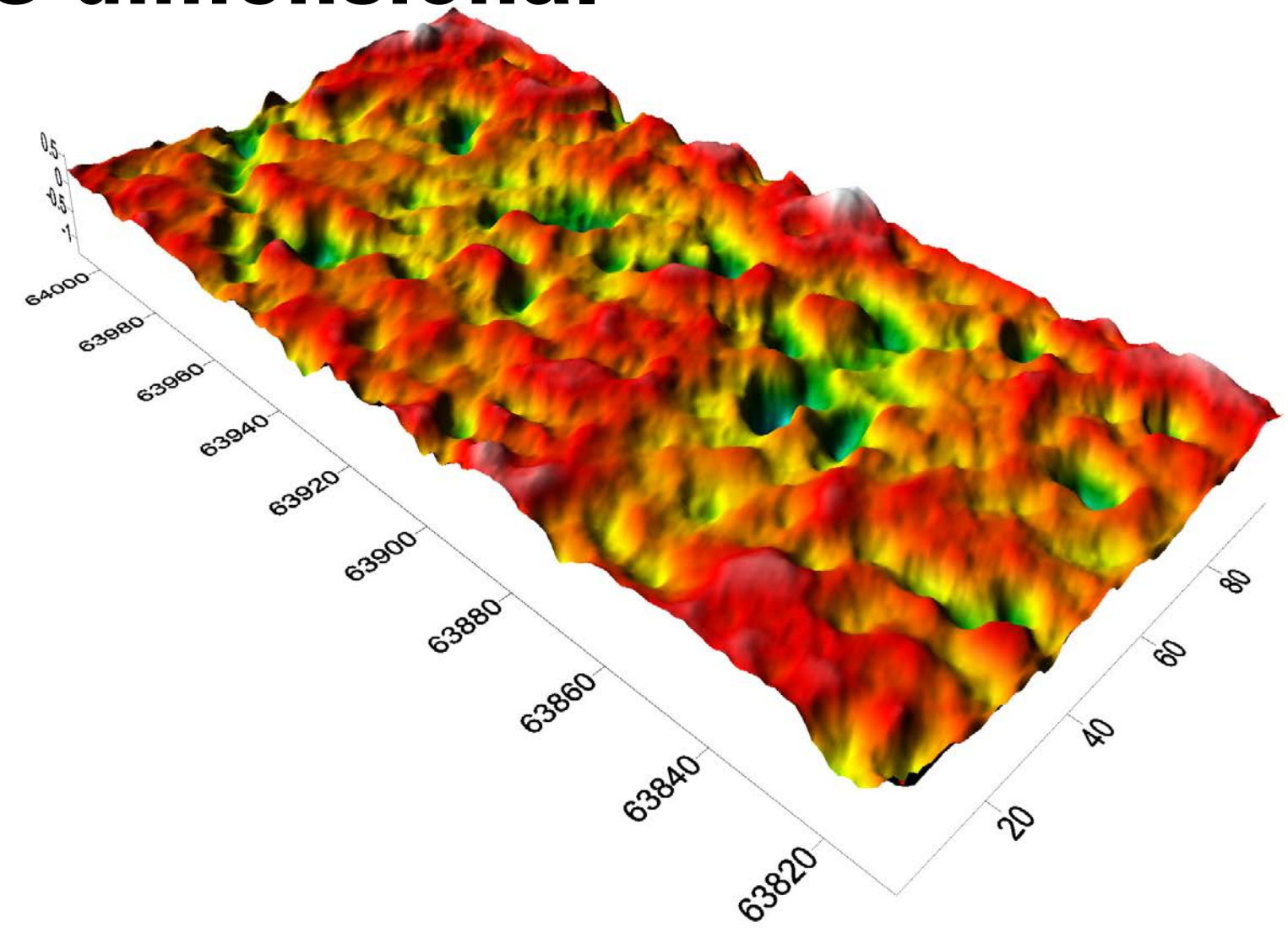
How is Texture Measured?

3-dimensional



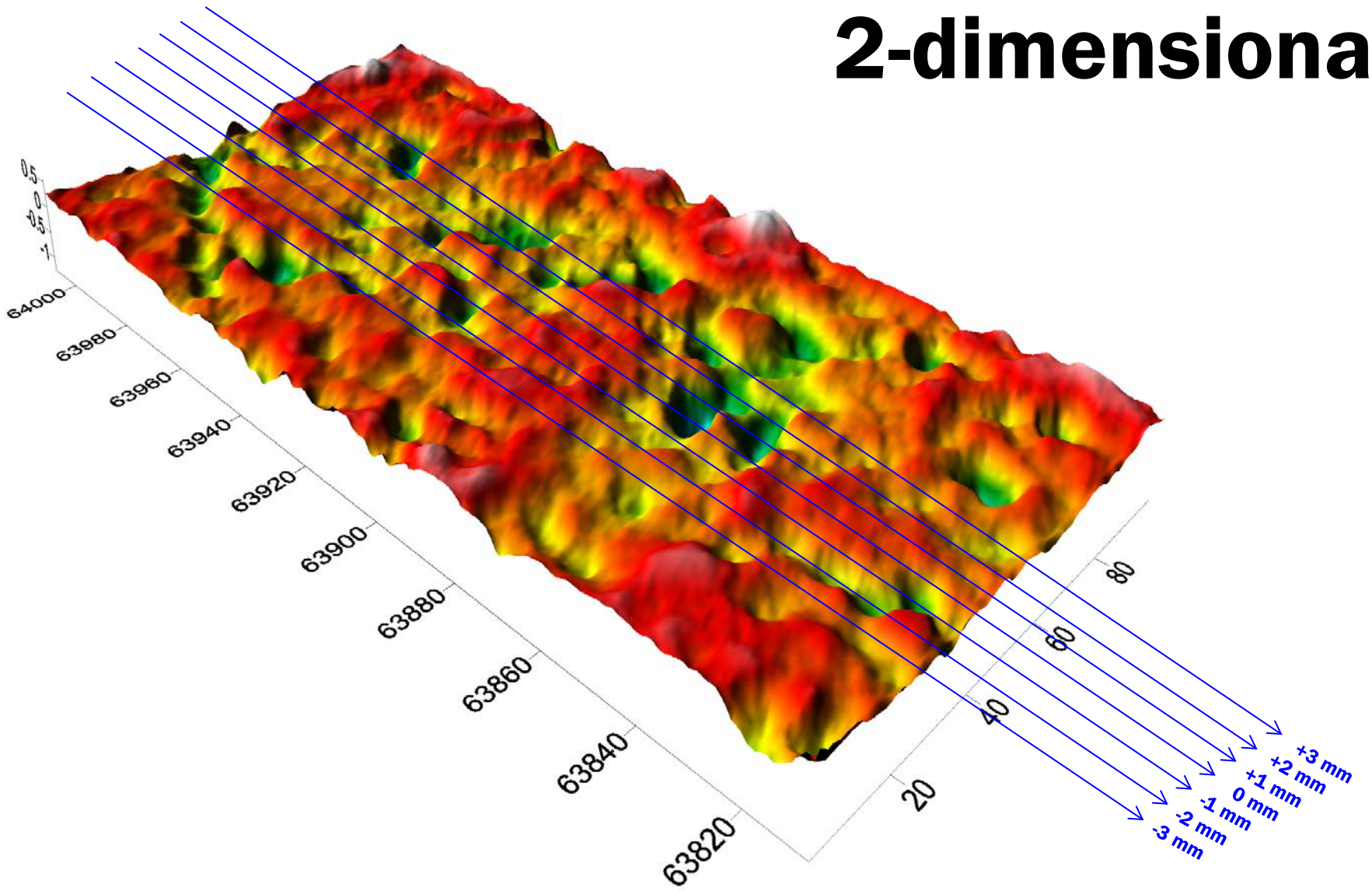
How is Texture Measured?

3-dimensional

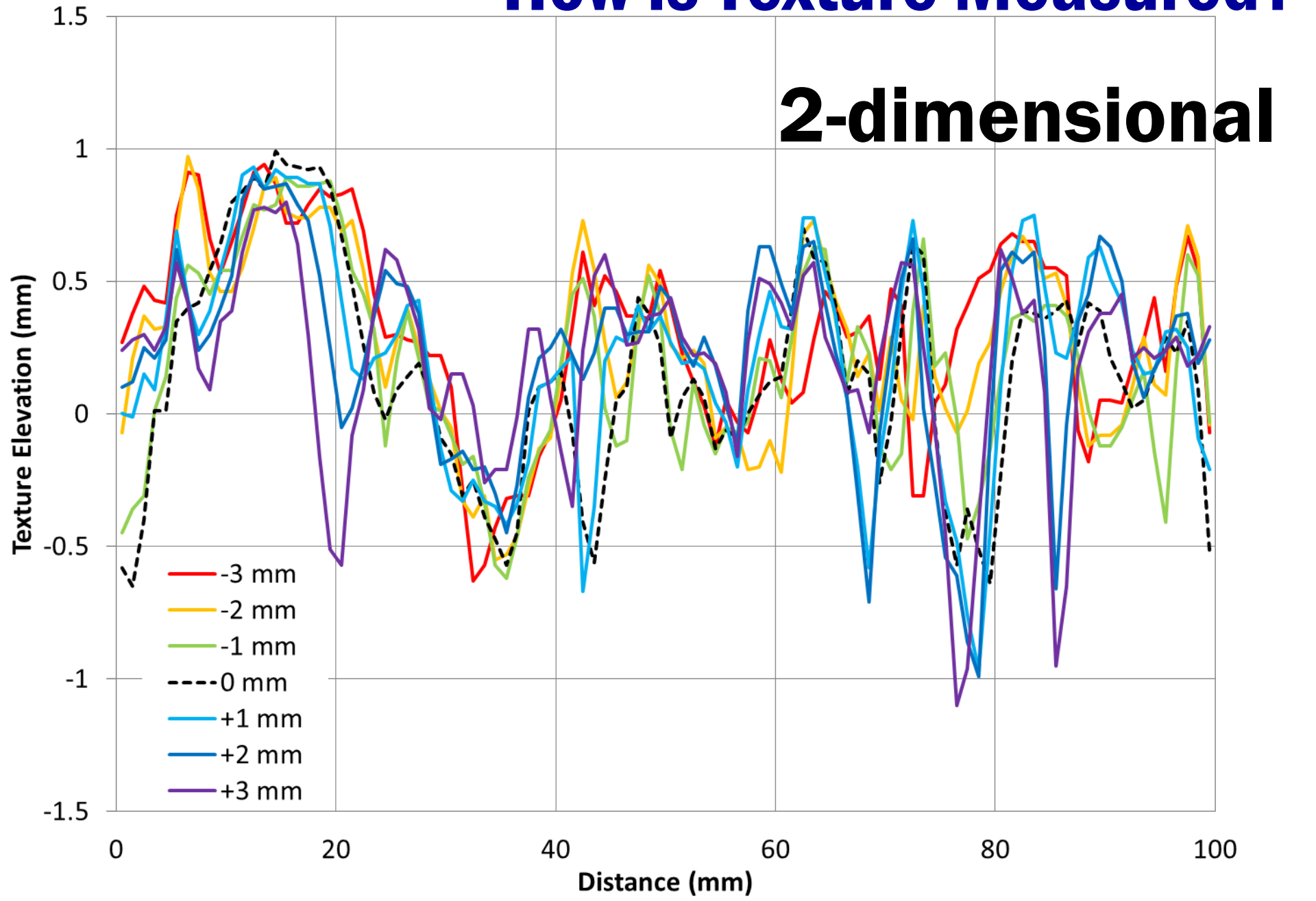


How is Texture Measured?

2-dimensional



How is Texture Measured?

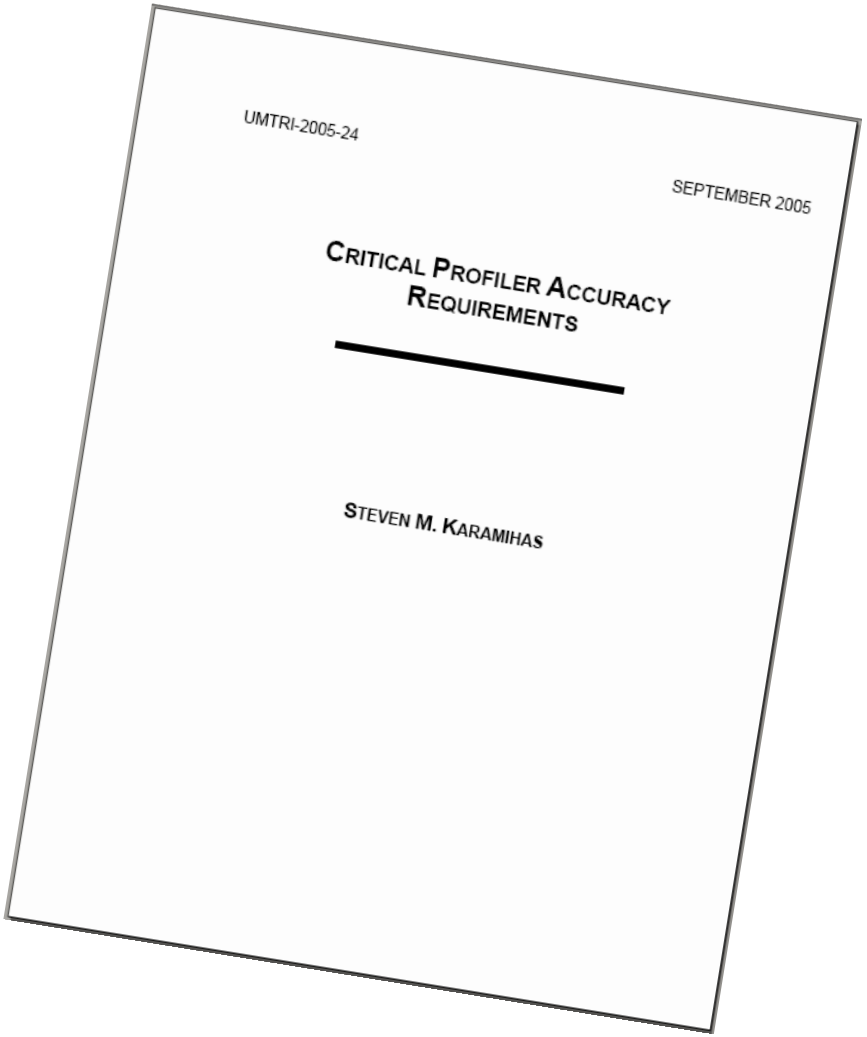


How is Texture Evaluated?

- Texture “frequency”
- Texture “depth”
- Texture “geometry”

RELEVANCE is key !!

- Tire dynamics
- Drainage
- Aerodynamic



UMTRI-2005-24

SEPTEMBER 2005

CRITICAL PROFILER ACCURACY REQUIREMENTS

STEVEN M. KARAMIHAS

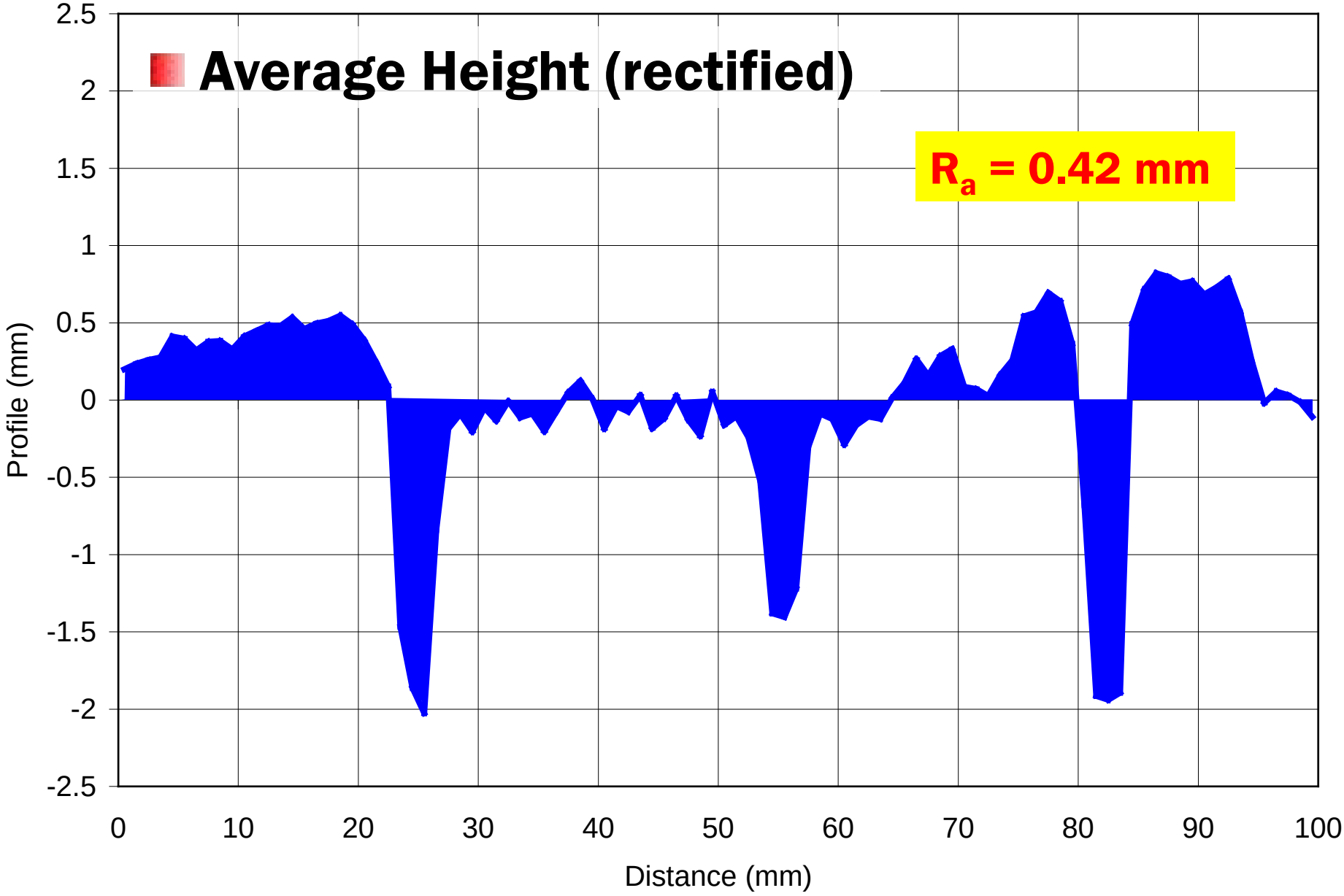
Describing Texture

- Height (Amplitude)
- Spacing
- Spectral
- Functional

Describing Texture

- **Height (Amplitude)**
- Spacing
- Spectral
- Functional

Describing Texture – Height



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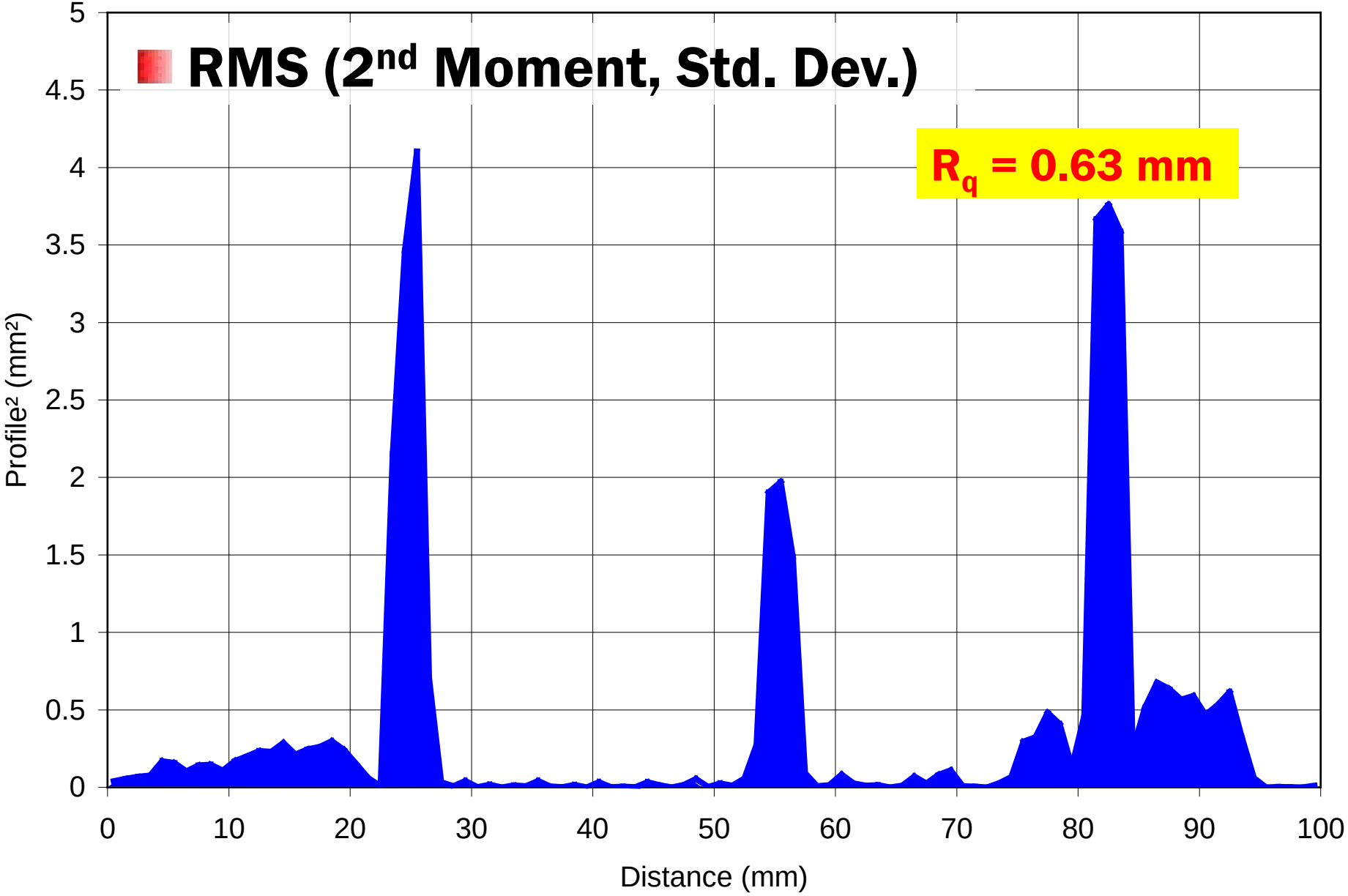

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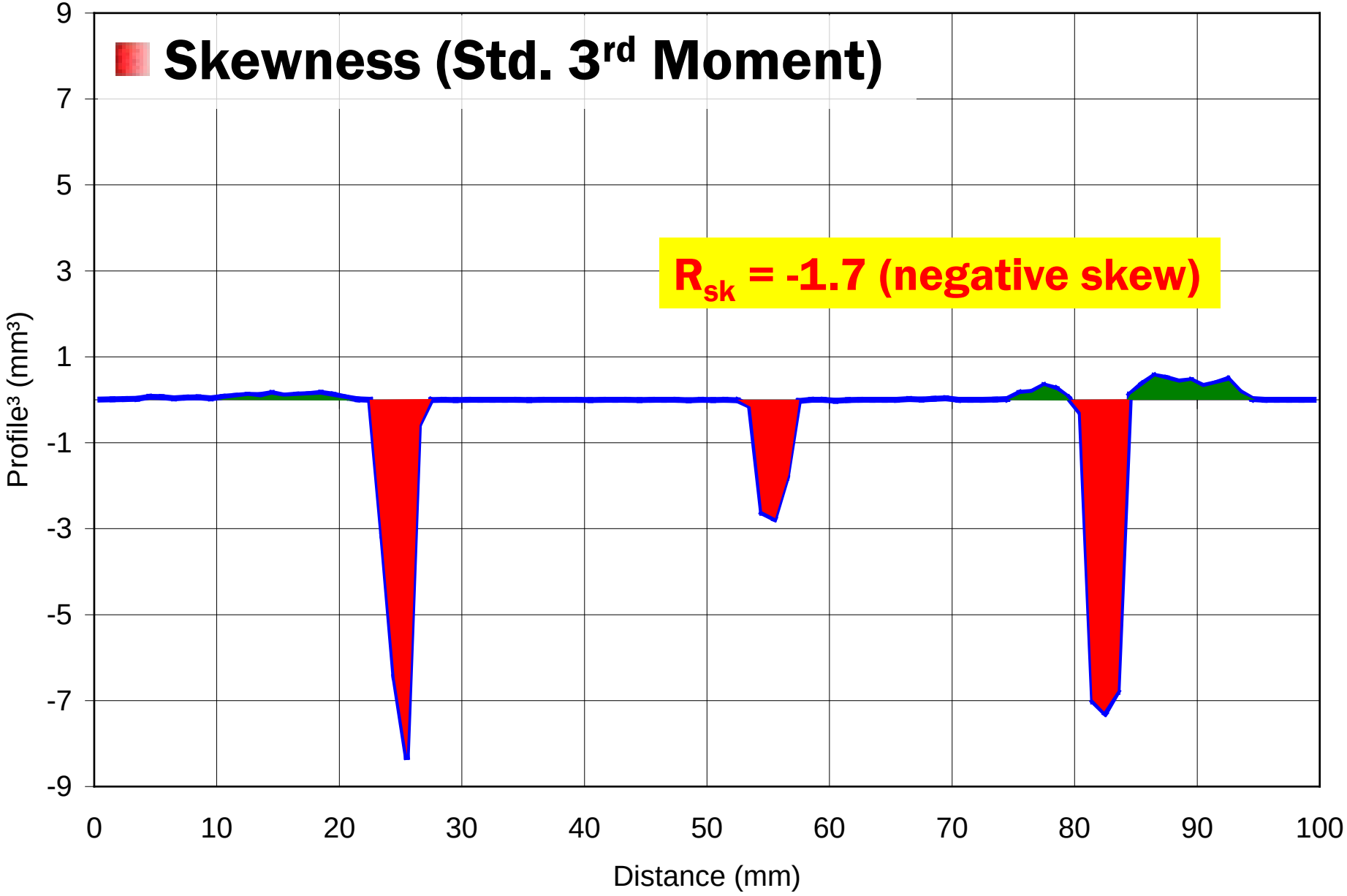

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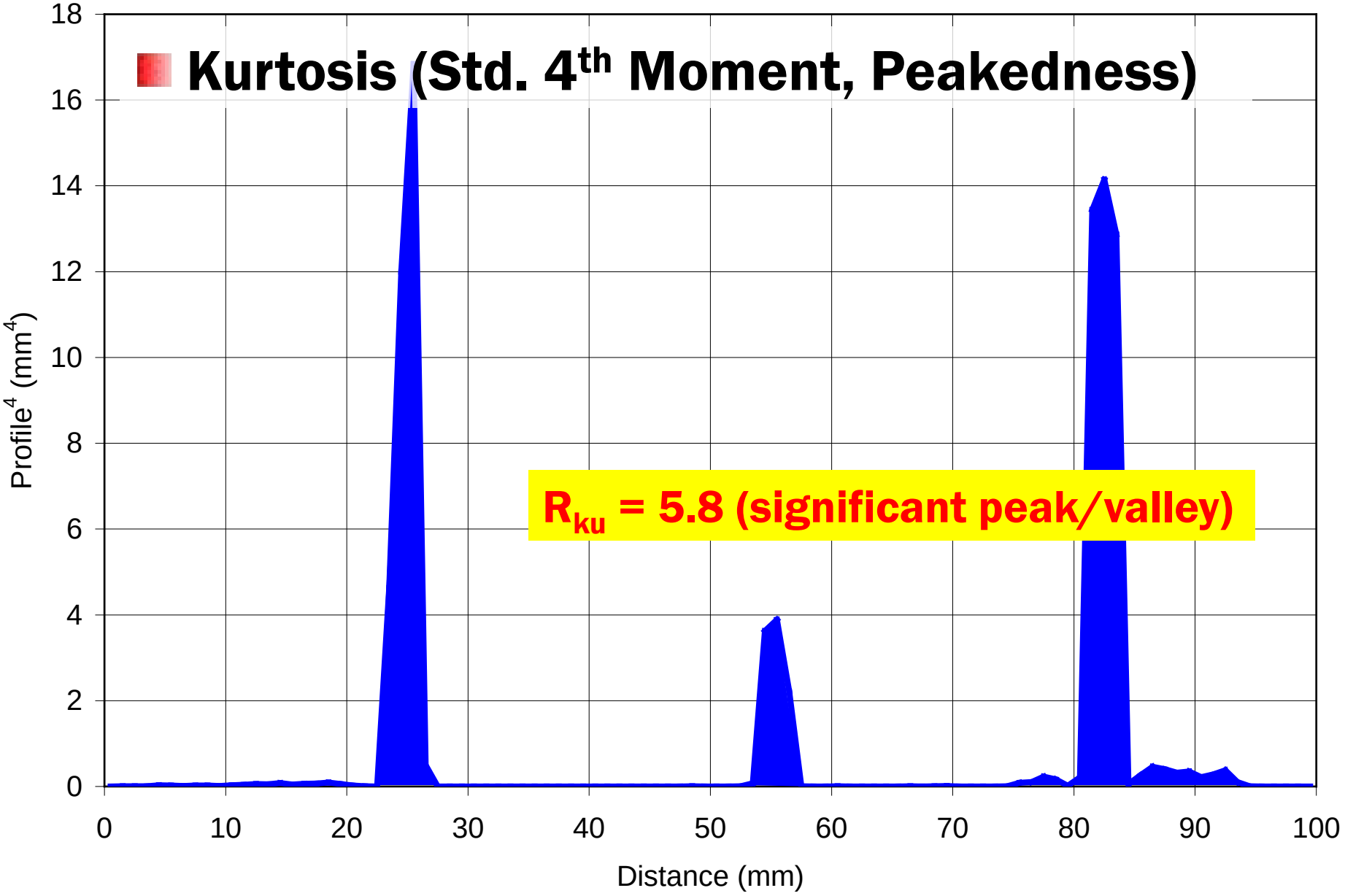

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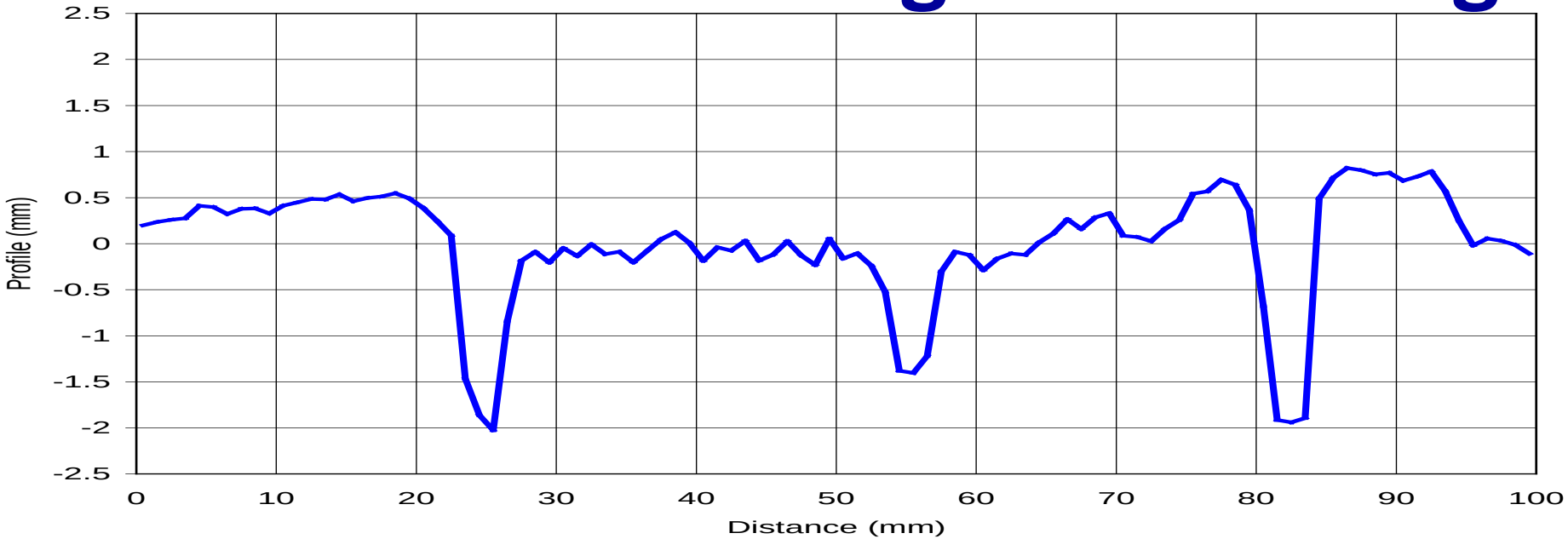
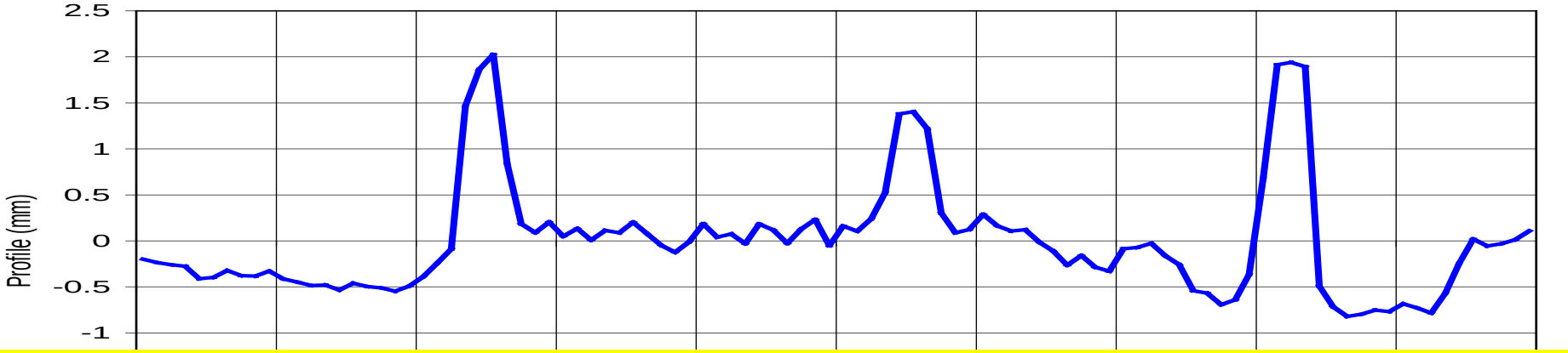
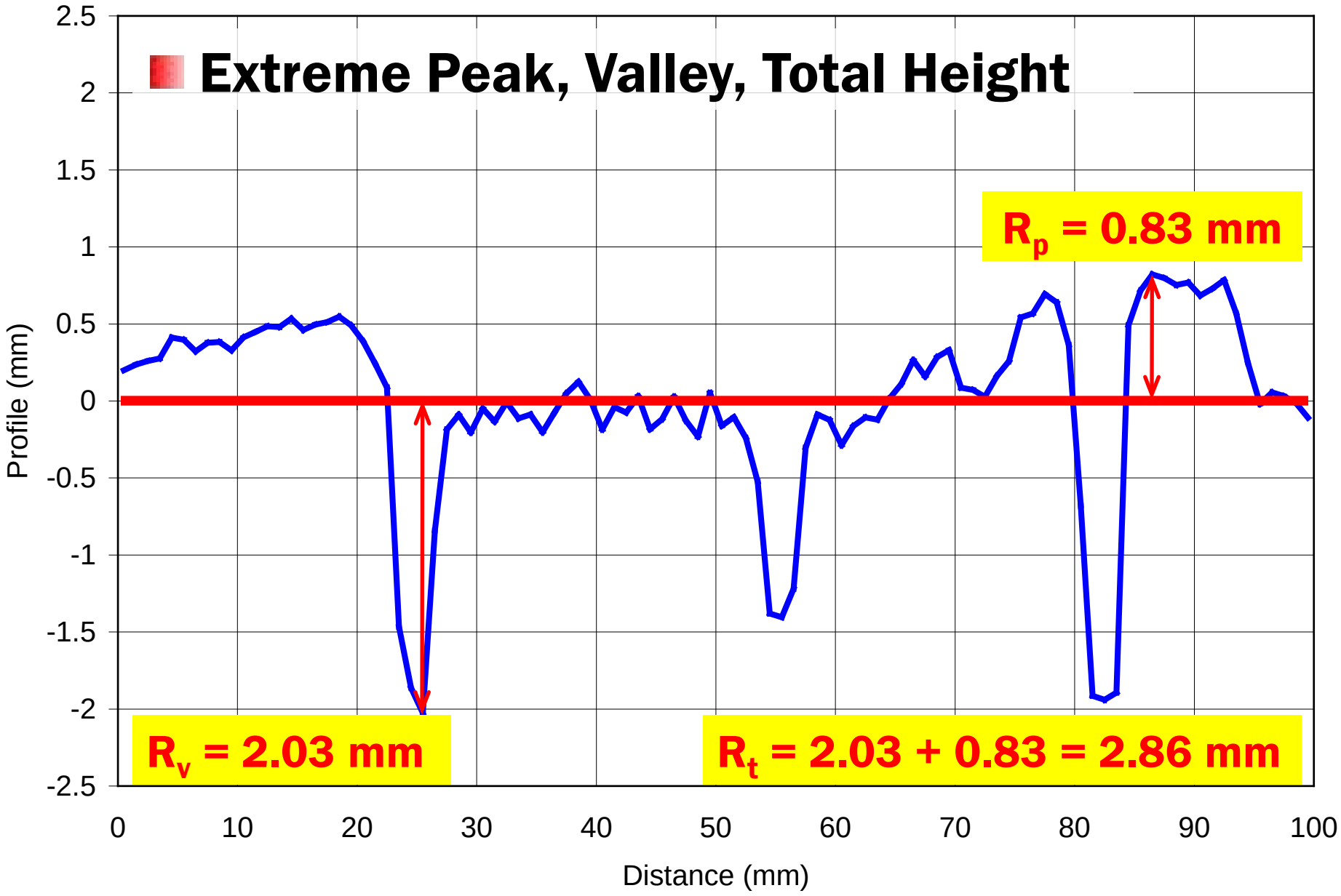




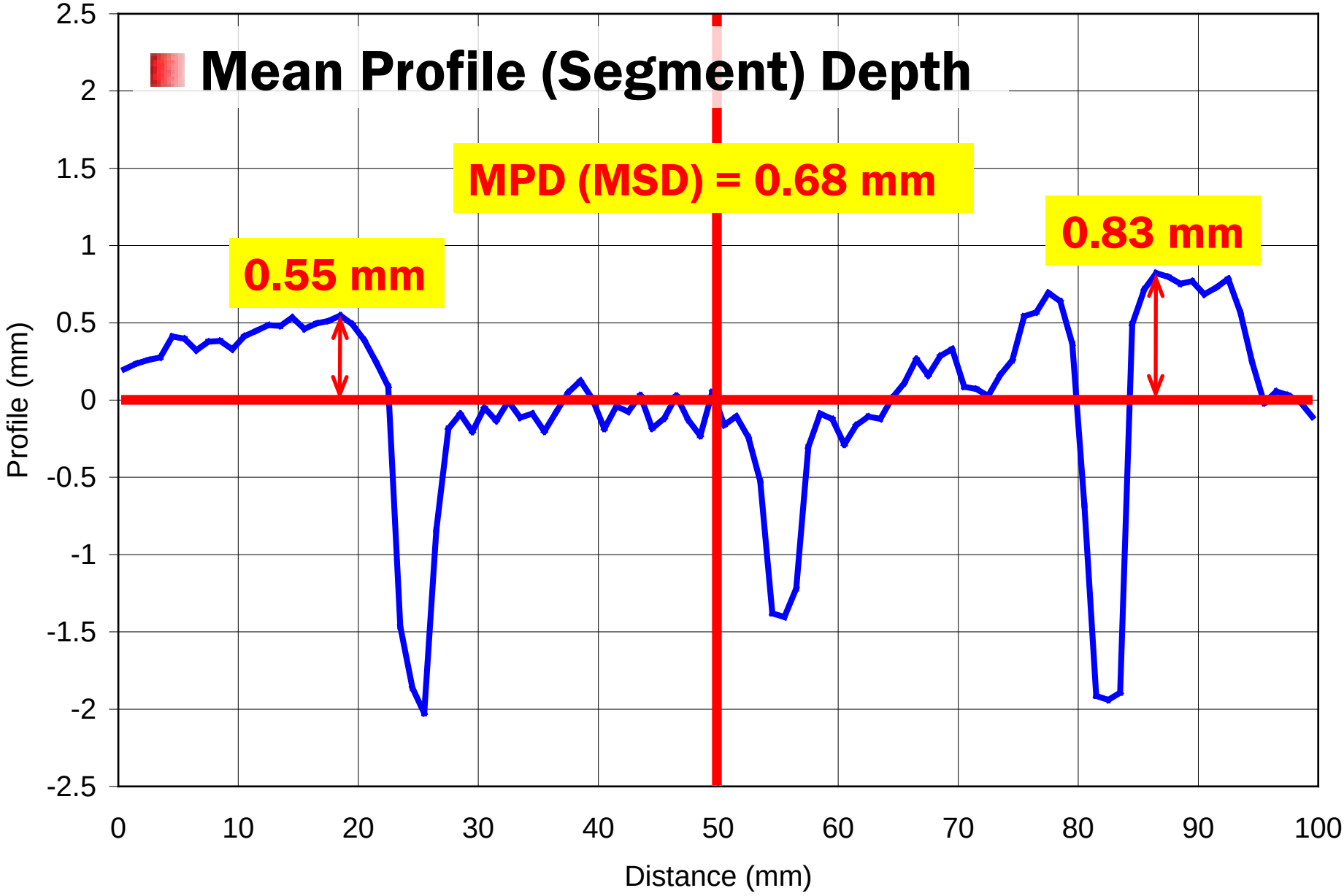
Same Average Height, RMS, Kurtosis, but…

Skewness is opposite sign.

Describing Texture – Height



Describing Texture – Height



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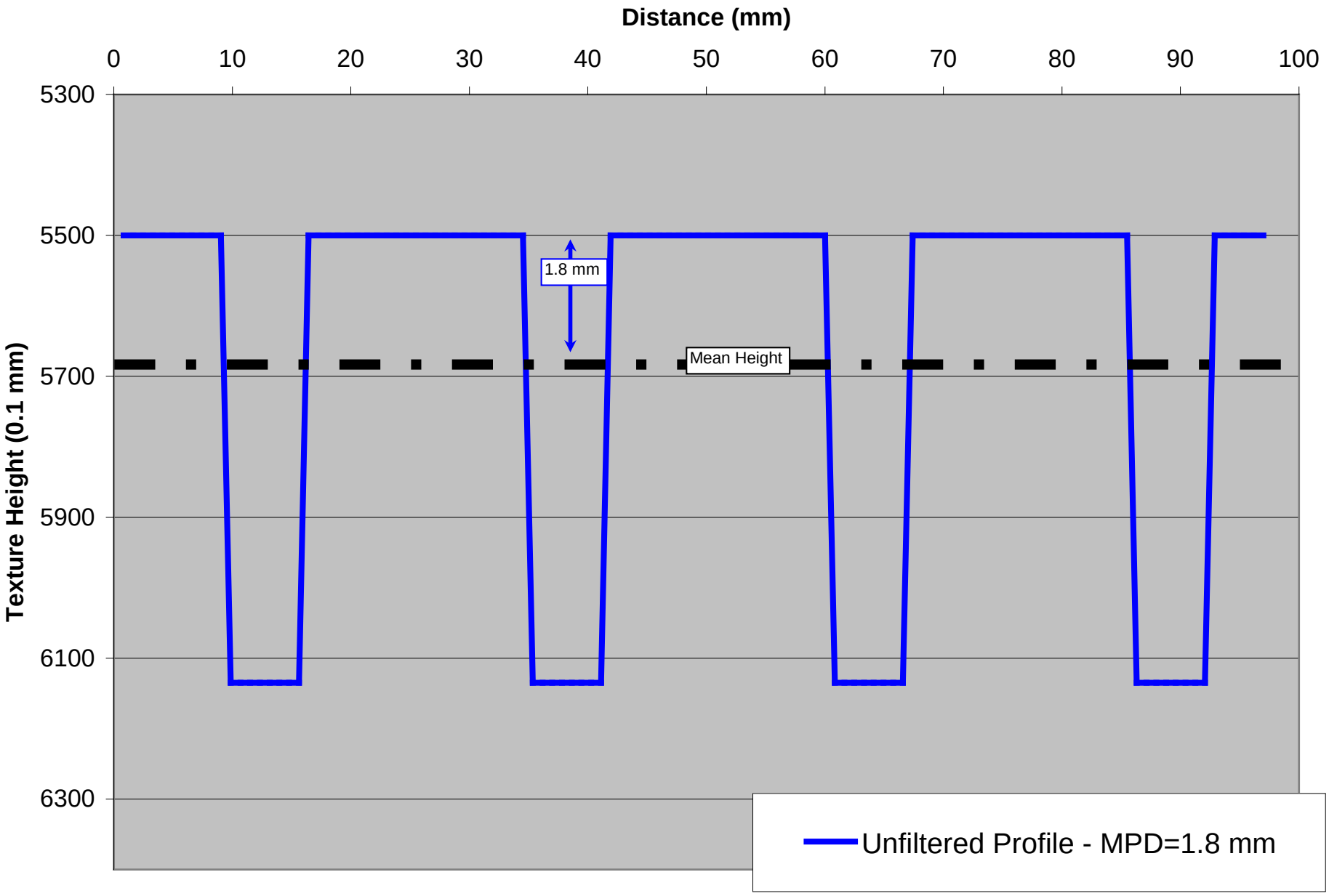
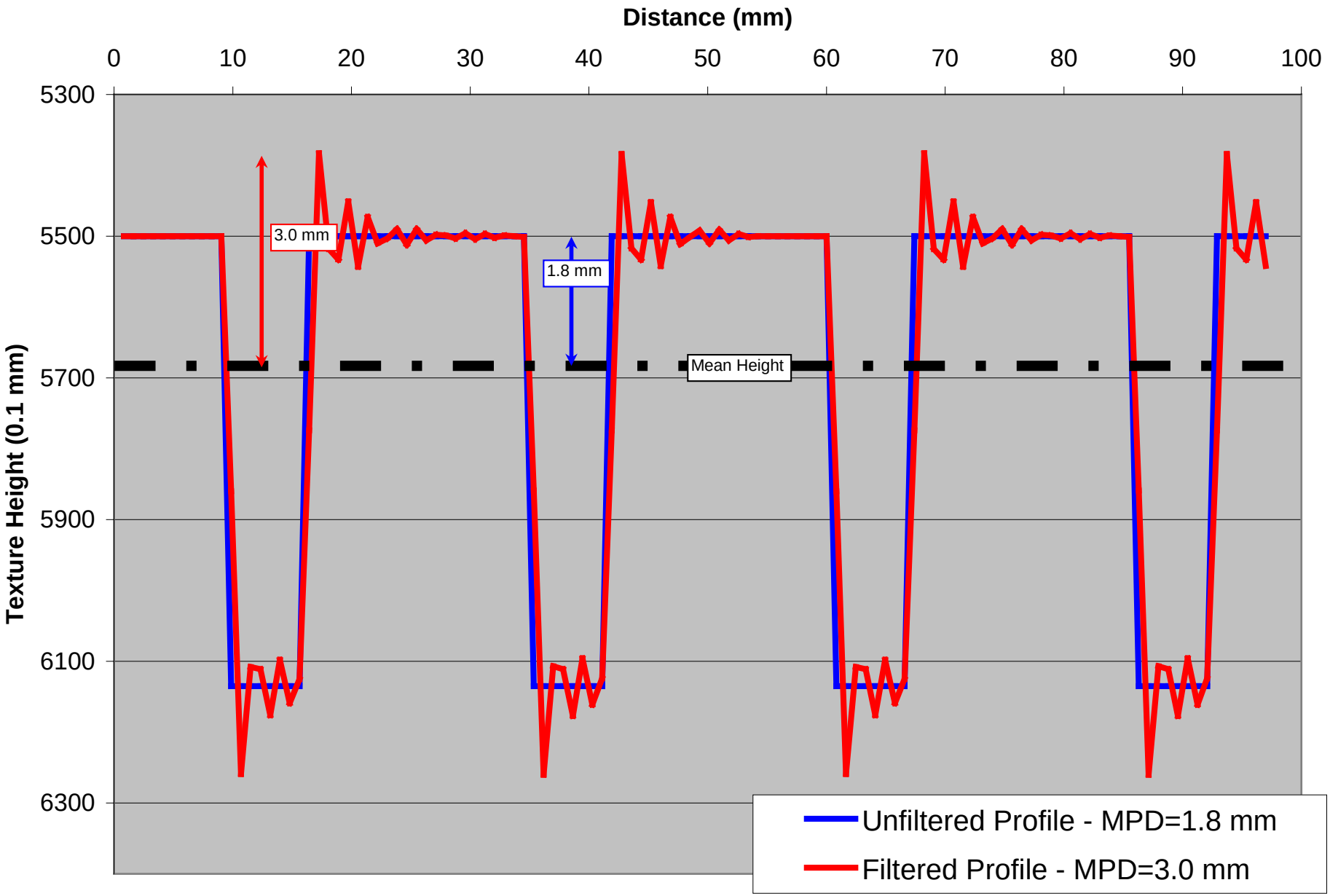


Describing Texture – Height



Describing Texture – Height

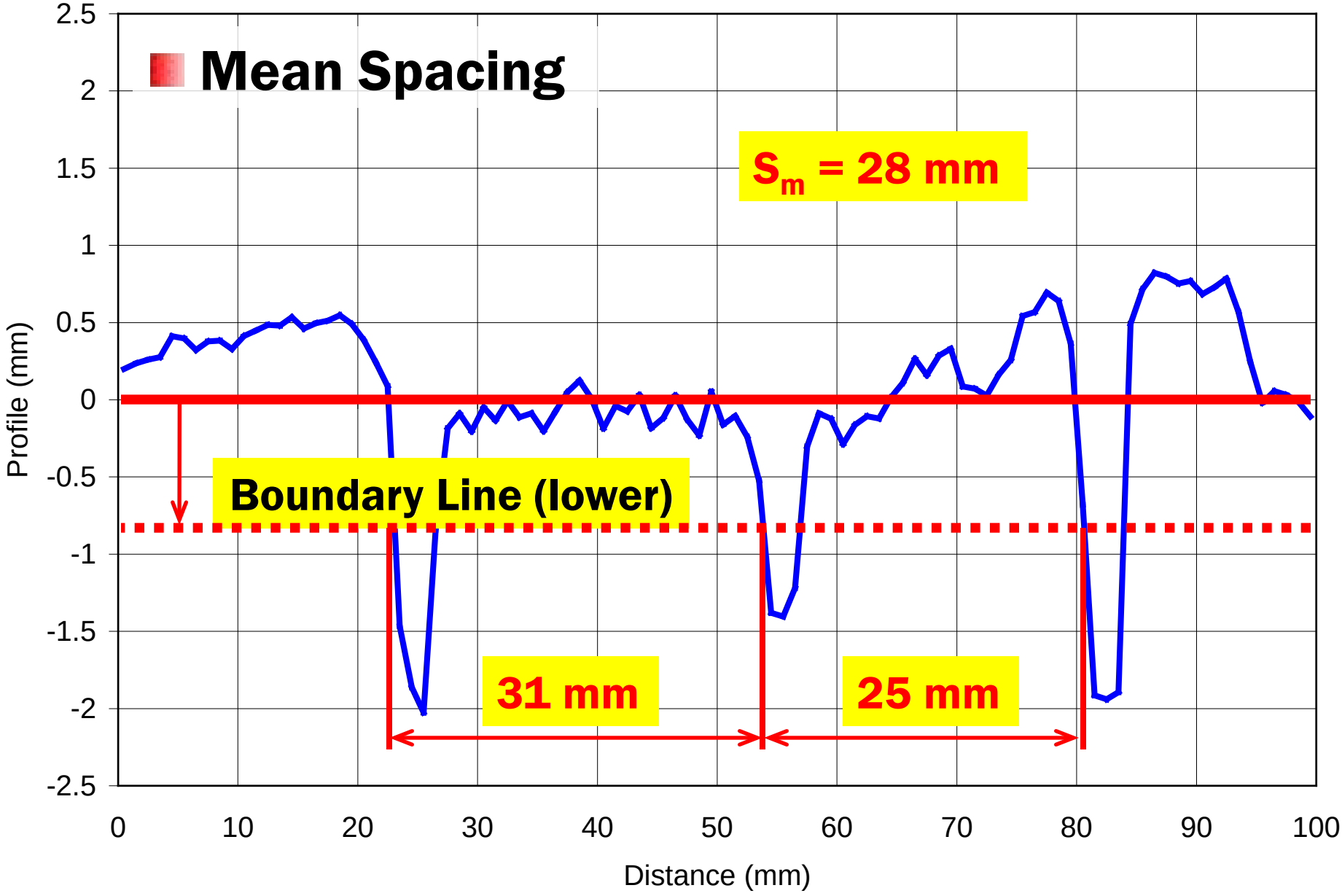
Skewness, Kurtosis, and MPD are sensitive to "extreme" peaks…

…both real or artifacts from the measurement or analysis.

Describing Texture

- Height (Amplitude)
- **Spacing**
- Spectral
- Functional

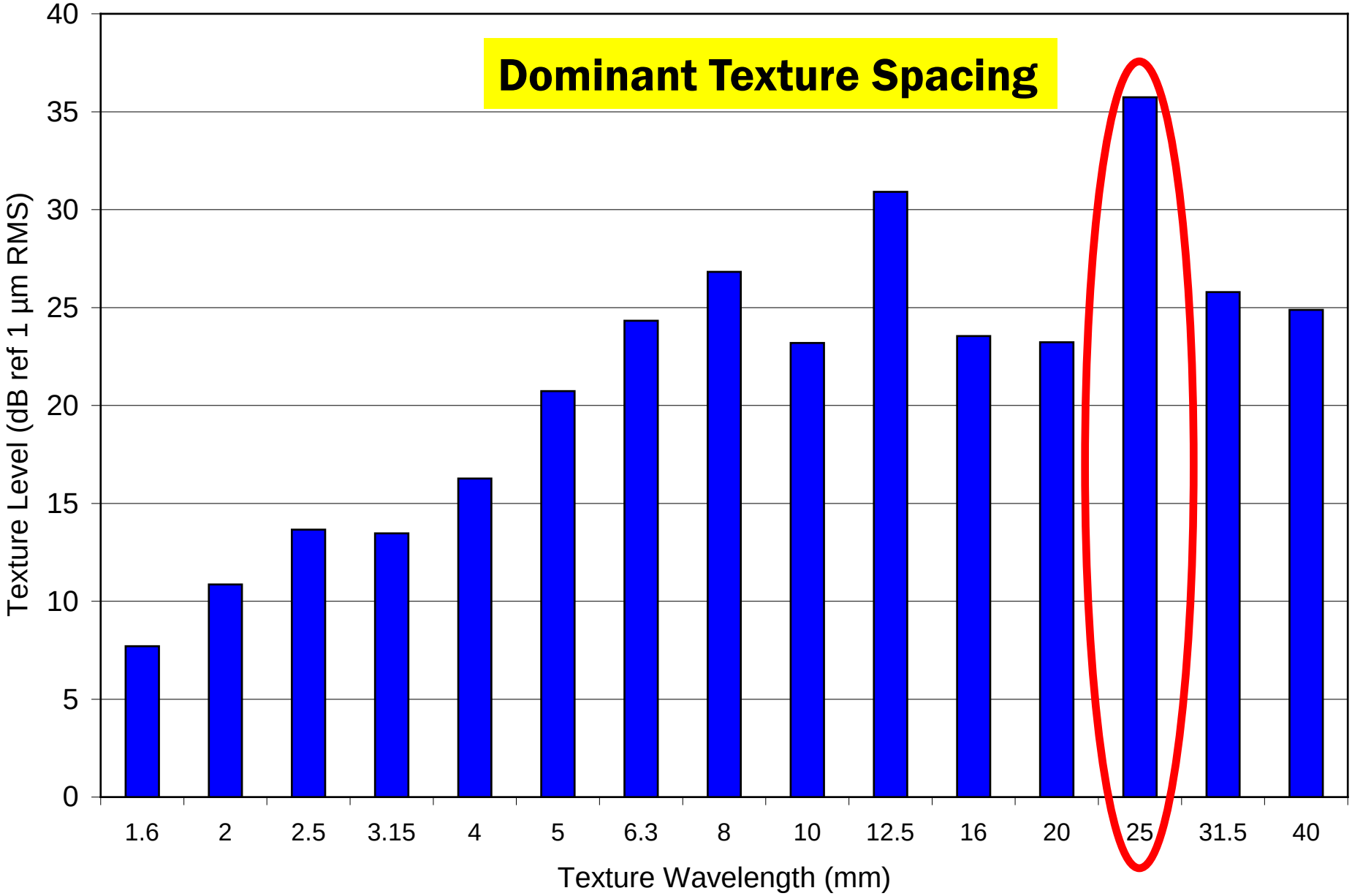
Describing Texture – Spacing



Describing Texture

- Height (Amplitude)
- Spacing
- **Spectral**
- Functional

Describing Texture – Spectral

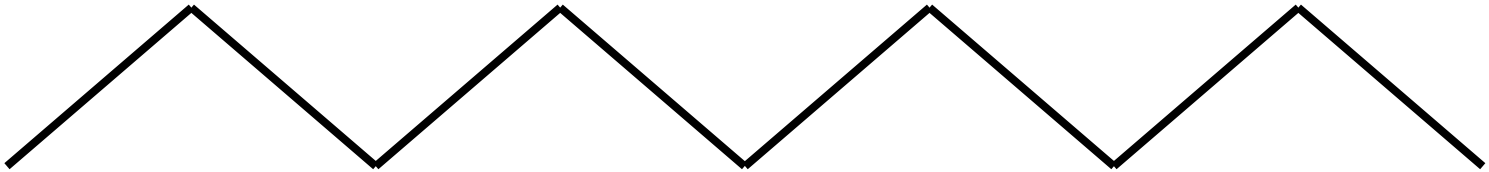


Describing Texture

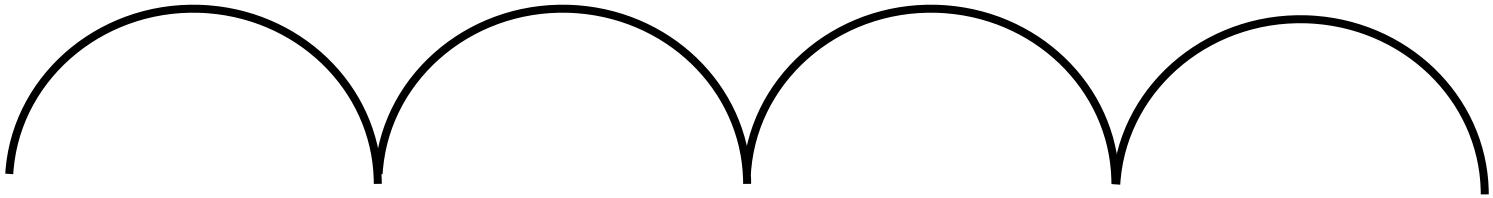
- Height (Amplitude)
- Spacing
- Spectral
- **Functional**

Describing Texture – Functional

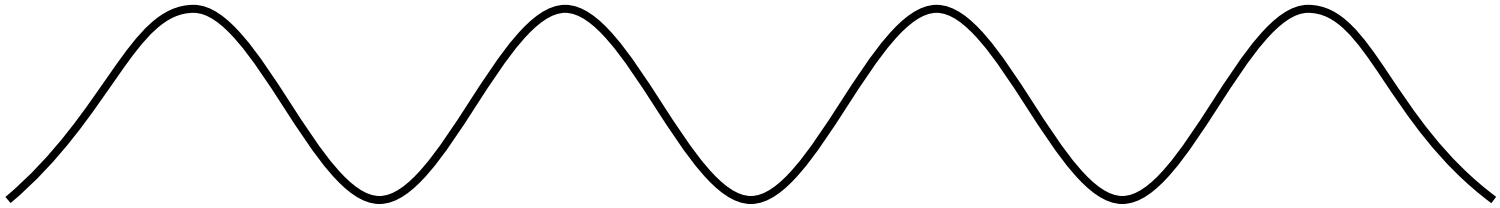
Pavement Surface 1



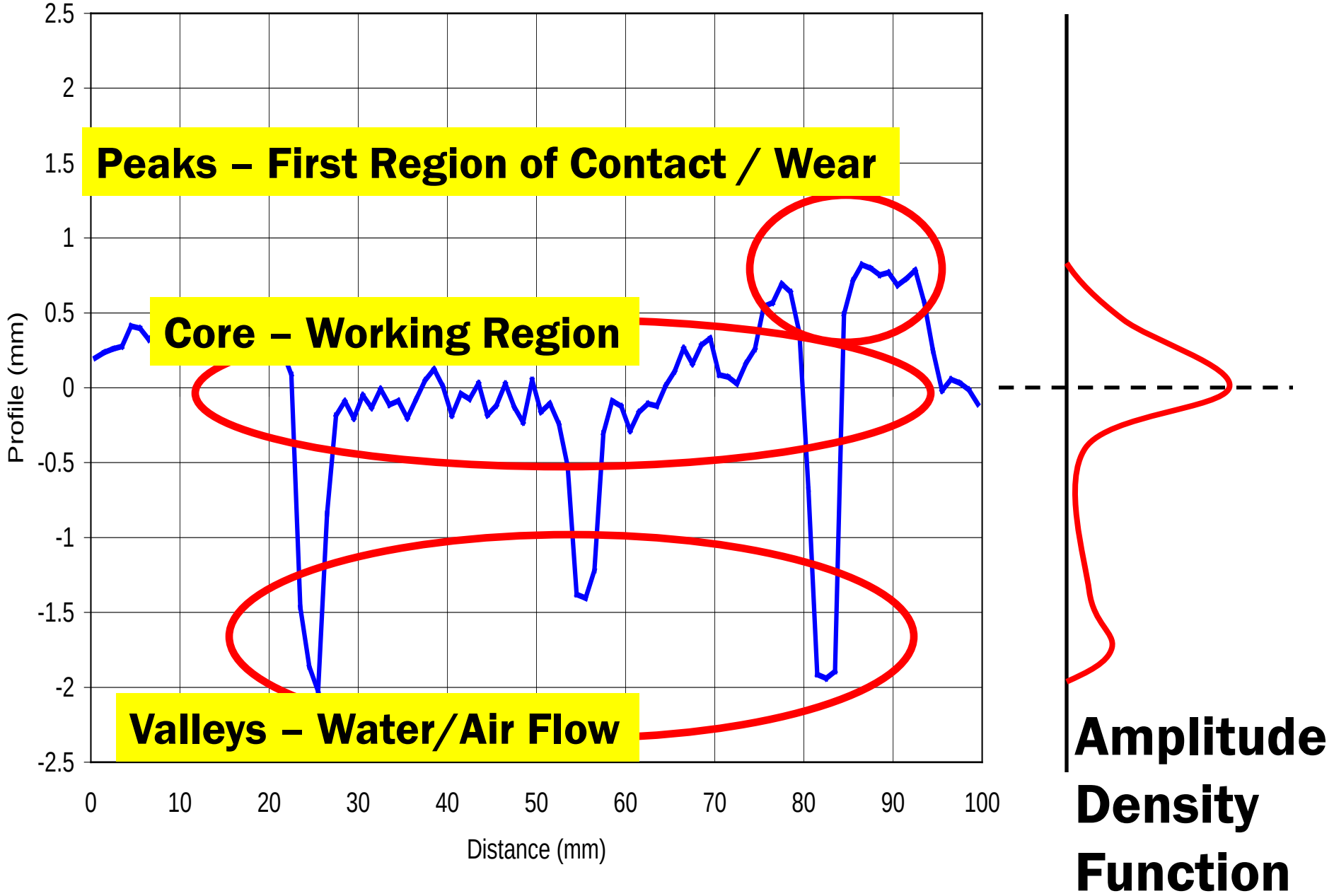
Pavement Surface 2



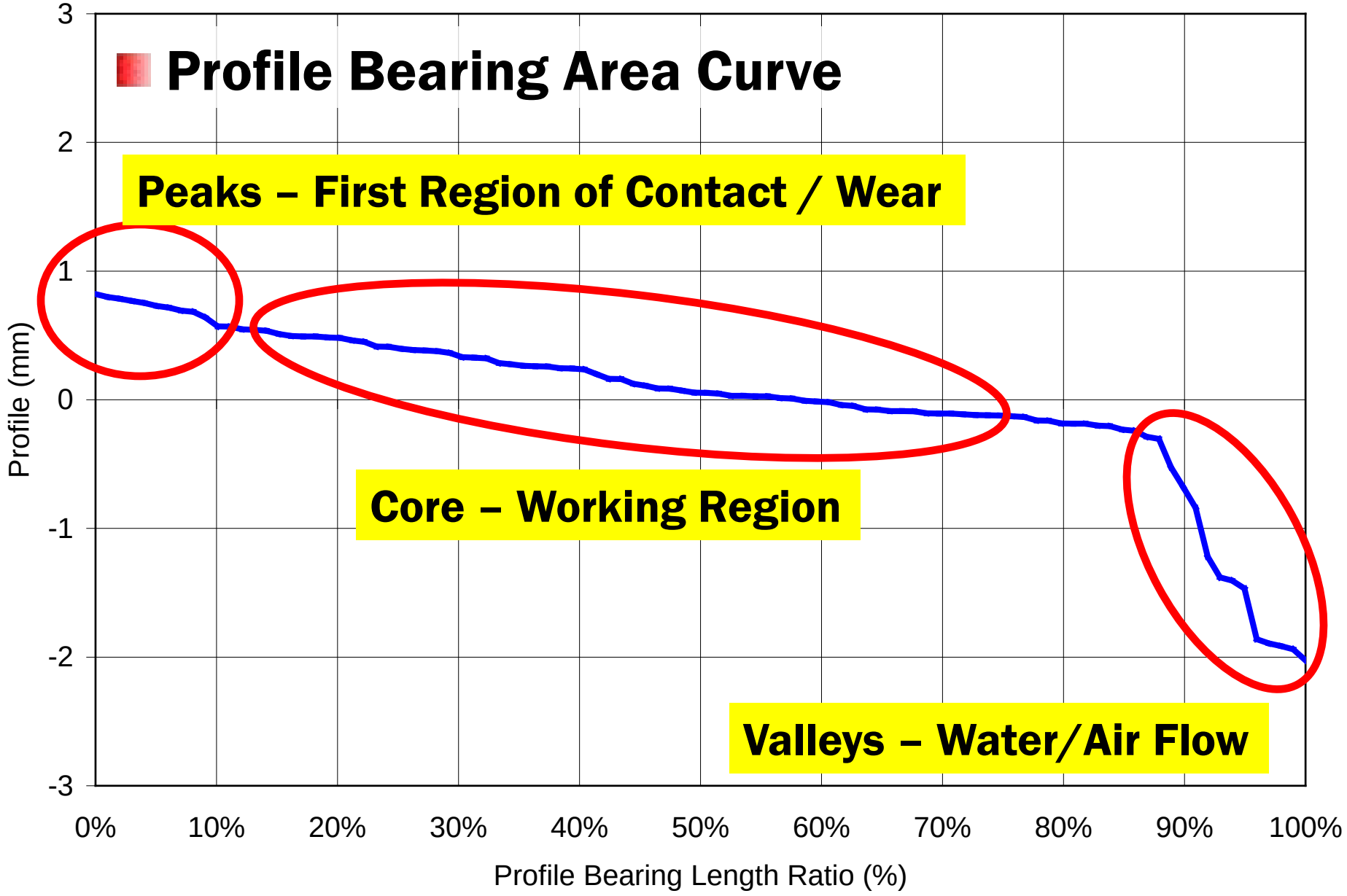
Pavement Surface 3



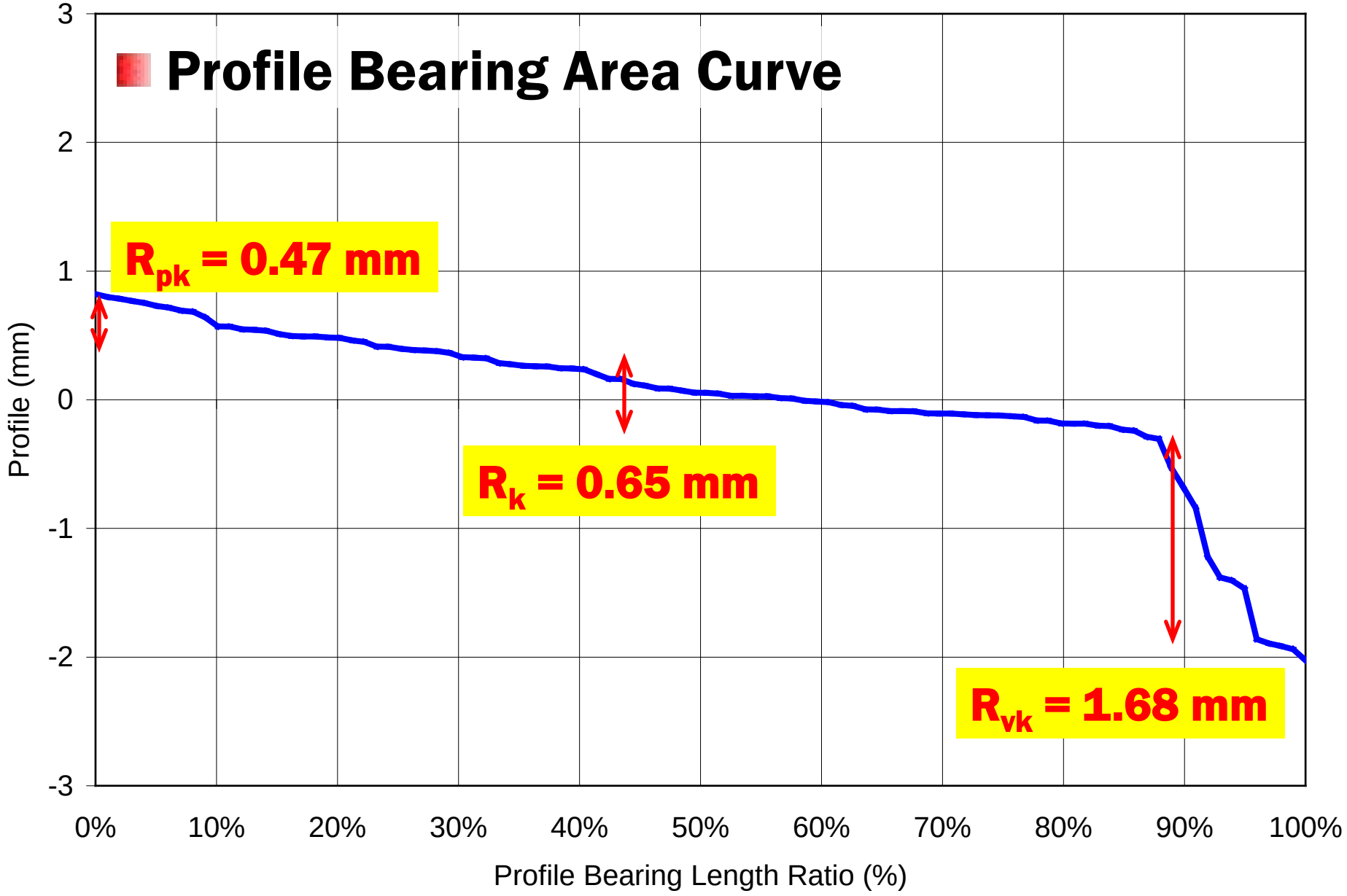
Describing Texture – Functional



Describing Texture – Functional

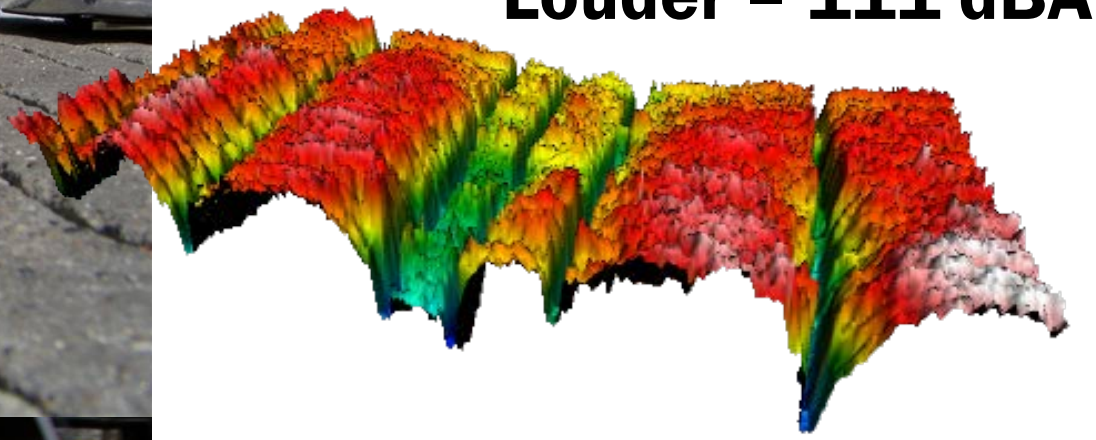


Describing Texture – Functional

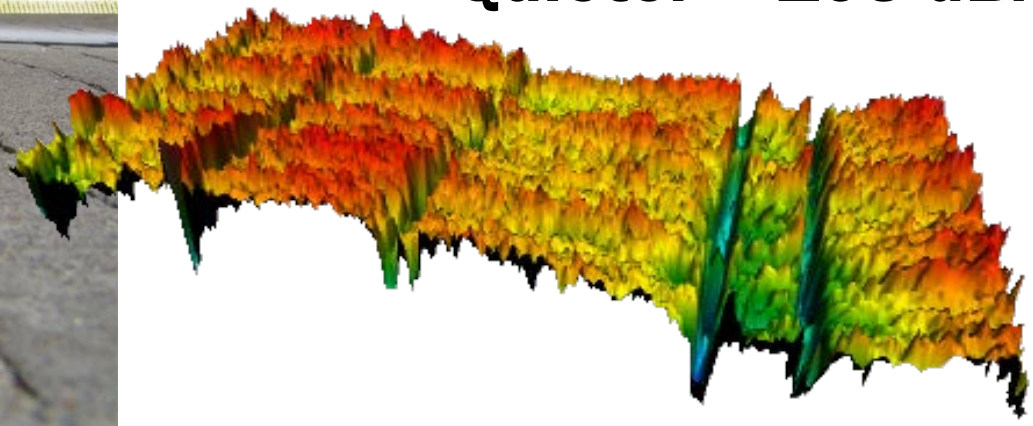


Relevance

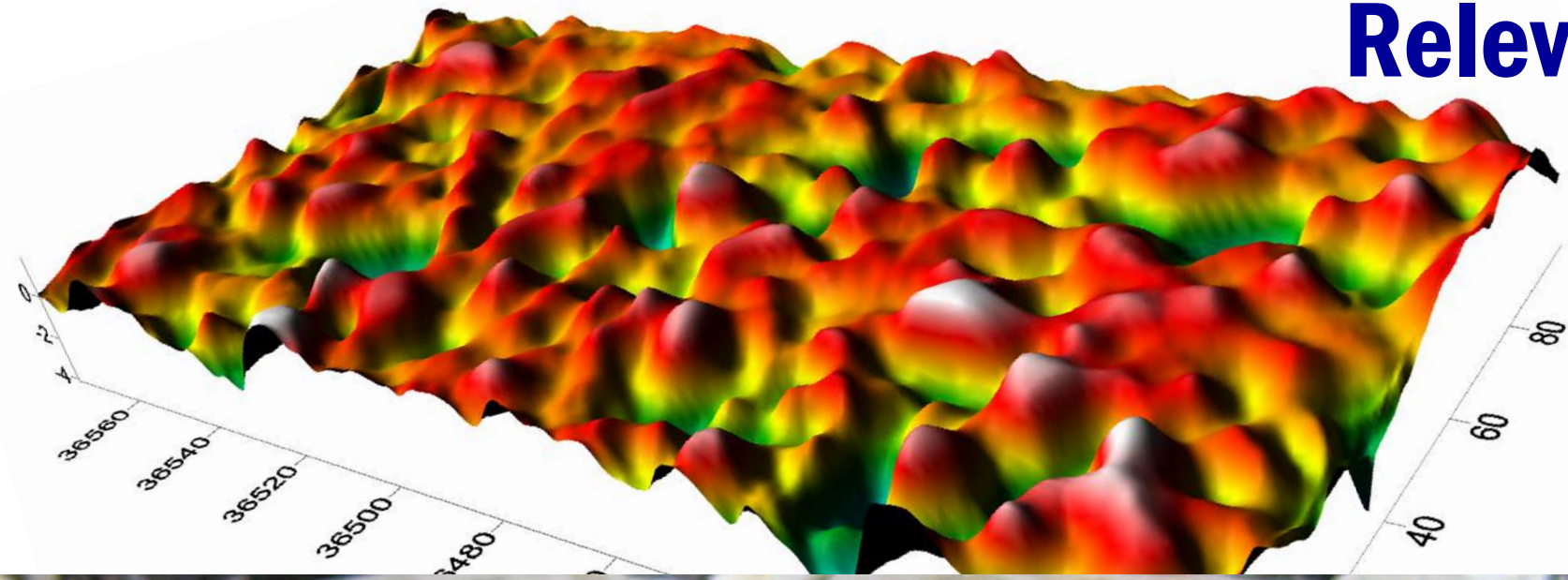
Louder – 111 dBA



Quieter – 103 dBA

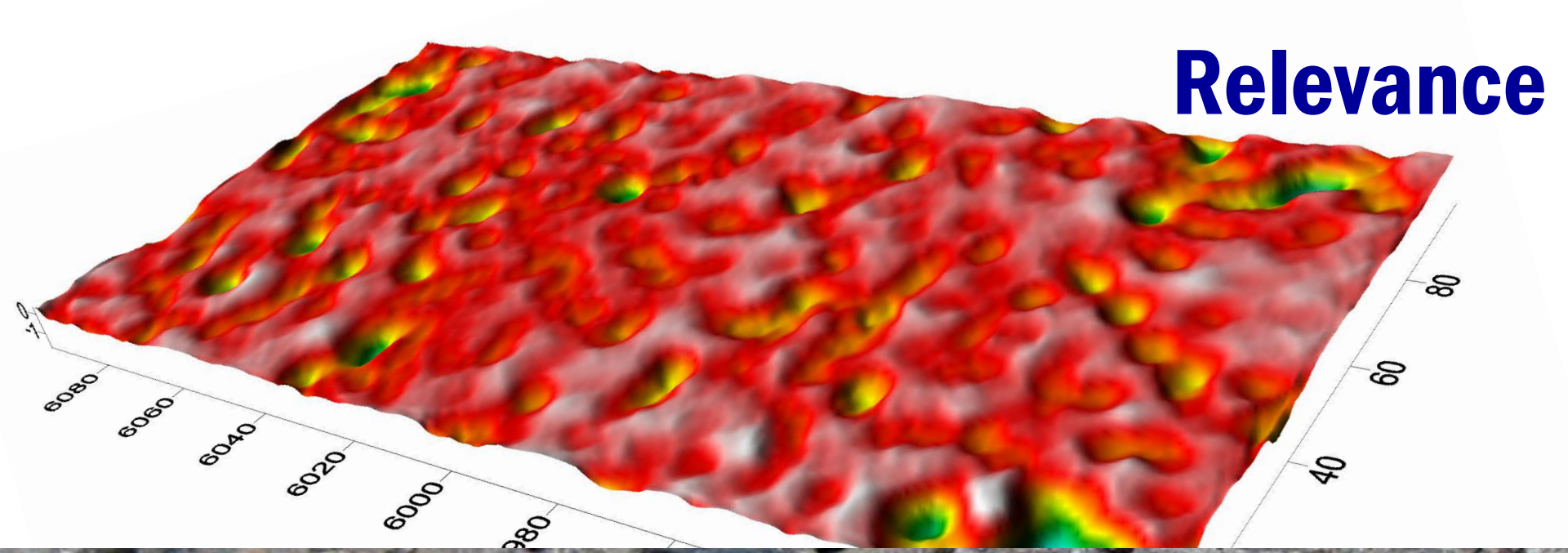


Relevance



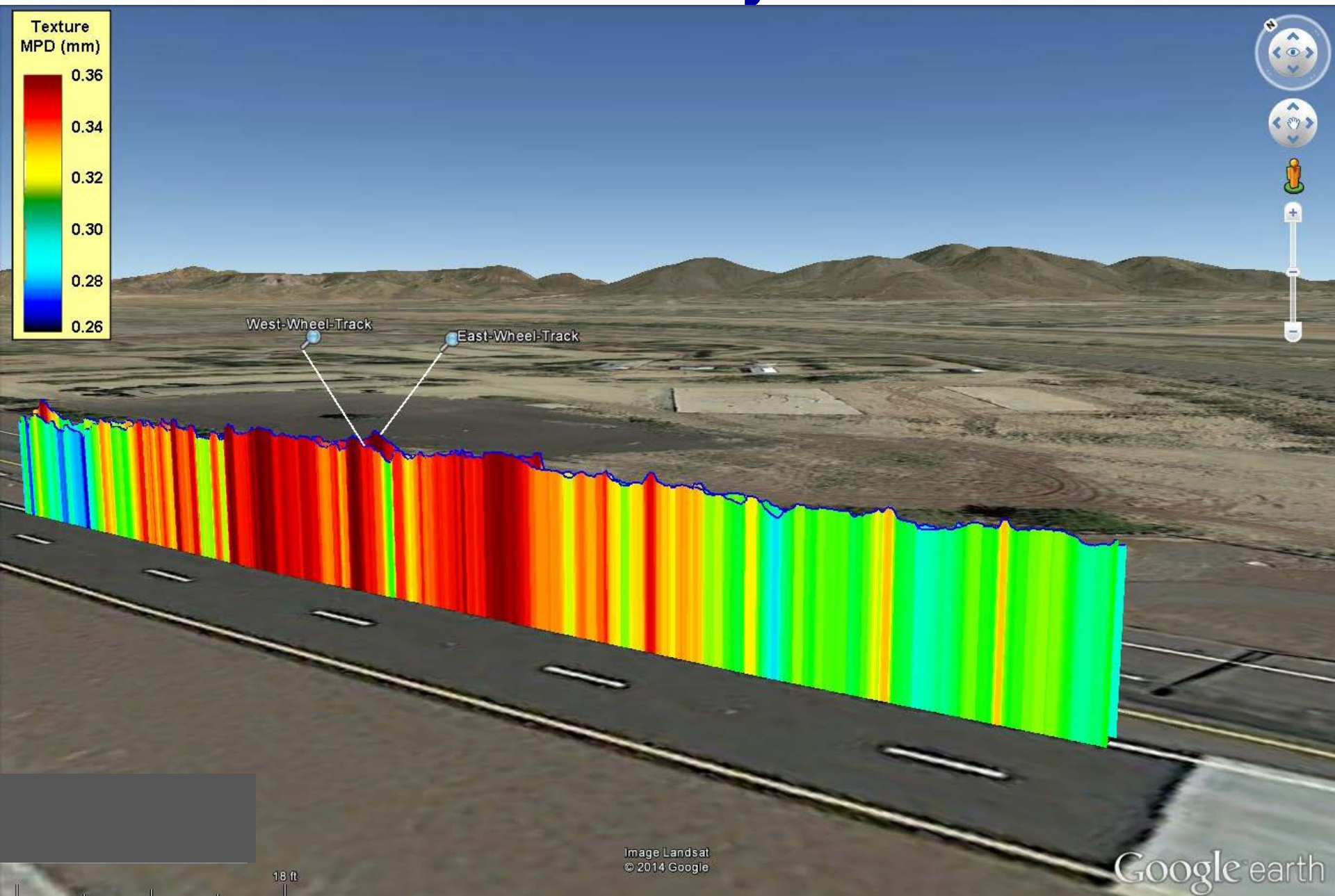
Higher Rolling Resistance

Relevance



Lower Rolling Resistance

Variability and Visualization



Some Closing Thoughts

- Texture can be specified for construction or rehab
  - Material selection (aggregates), construction methods
  - Micromilling, grinding, grooving, shotblast, waterblast …
  - Prescriptive vs. Performance (End Product)
- Measurement methods and metrics
  - 3-D measurements are here; more relevant information
  - Measurement accuracy: 1 mm is most often not enough
  - MPD & IRI not enough to predict functional performance
- Challenges
  - Measurement of porous or deep textures, glossy surfaces
  - Calibration and validation of texture measurements
- Standards
  - ISO TC 43/SC 1/WG 39, ASTM E17, CEN/TC 227

Thank You !

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Florida Texture Characteristics Review

Texture Measurements and Its Correlation with Pavement Functional Performance

Charles Holzschuher, P.E.

April 27, 2017

State of Florida

- 2017 Population: 20 million
  - 3rd most populous state in the US behind CA & TX
- 94 million annual visitors
- State Highway System (FDOT Maintained)
  - Ensure Safety
  - Adequate FN & Texture
  - Roadway Departures

Florida Texture Overview

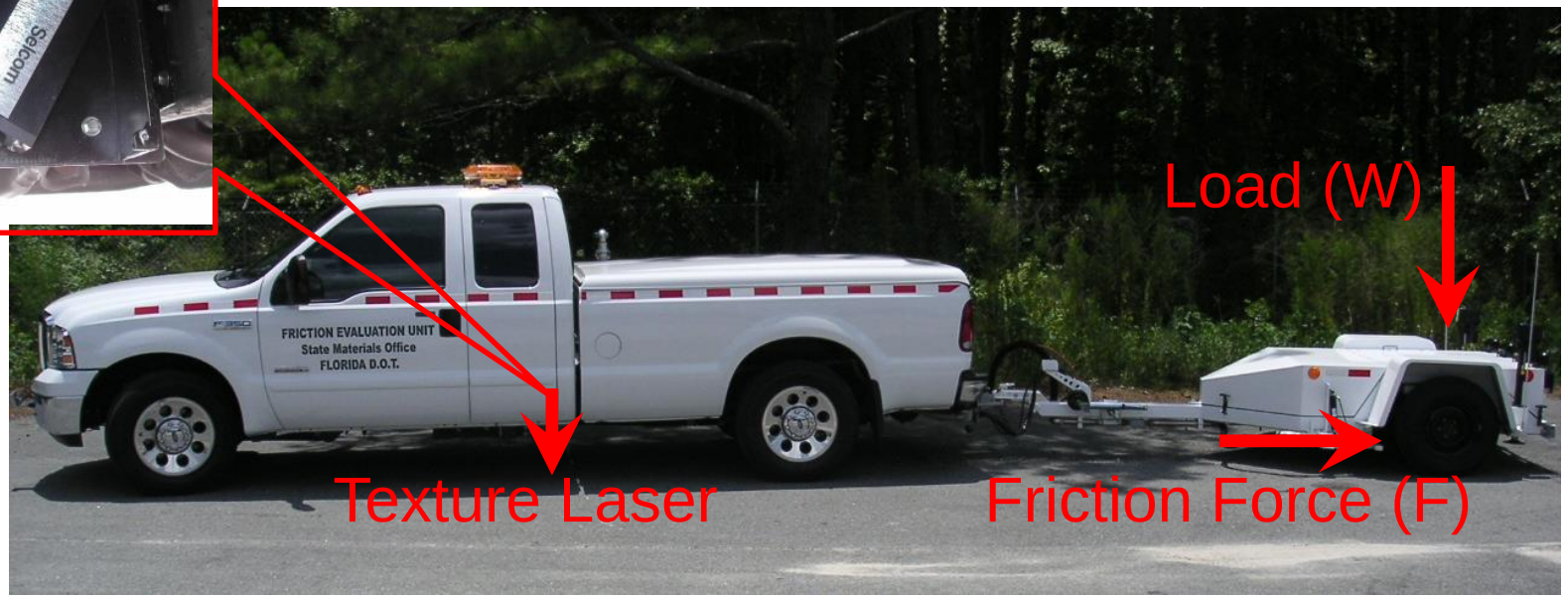
- Texture Equipment
- Friction
- Texture
- Smoothness
- Noise
- Texture Projects

Florida Texture Equipment

- Monitor Performance and Safety of Roadways
- Tools
  - High Speed (non-contact)
  - Site Specific

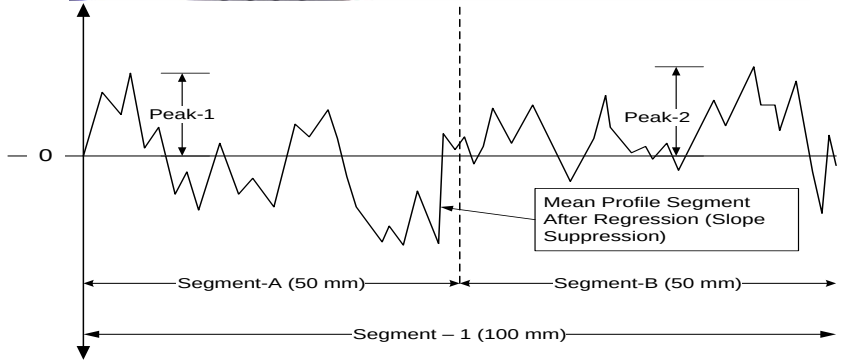
Roadway – Locked Wheel Tester

- Friction - ASTM E-274
- Texture Laser (64 kHz) below Tow Vehicle
- High Speed



Locked Wheel Tester (Point Laser)

- ASTM E 1845
  - Standard Practice for Calculating Pavement Macrotexture Mean Profile Depth
  - 3 Second Sample
  - Continuous



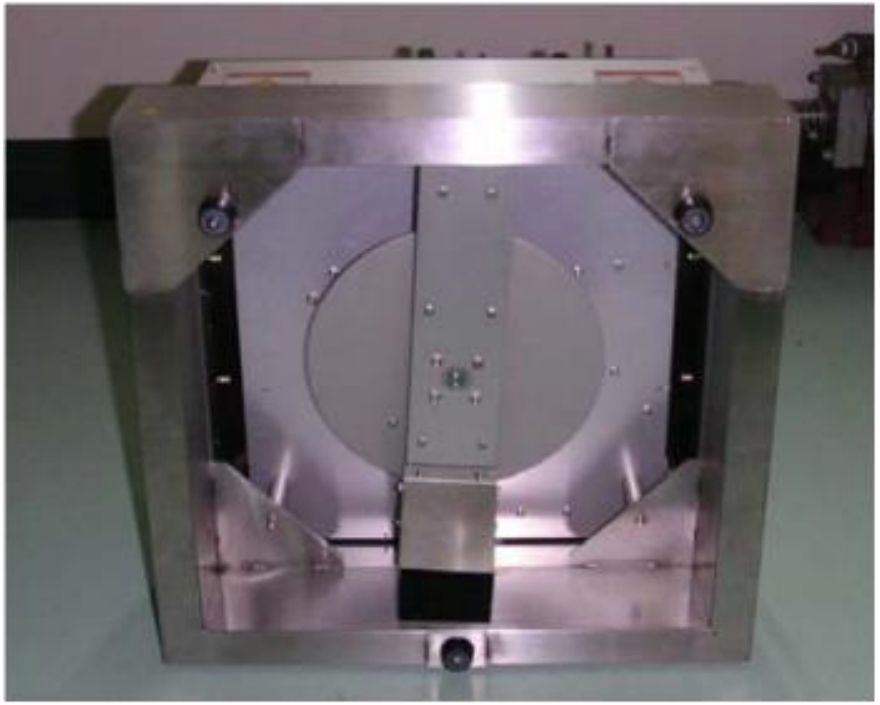
ASTM E 1845-01: Standard Practice for Calculating Pavement Macrotexture Mean Profile Depth

Mean Segment Depth $_{Segment\text{-}1}$ = (Peak-1 + Peak-2)/2

$$MeanSegmentDepth_{Section} = \frac{\sum_{1}^{n} MeanSegmentDepth_{Segment-i}}{n}$$

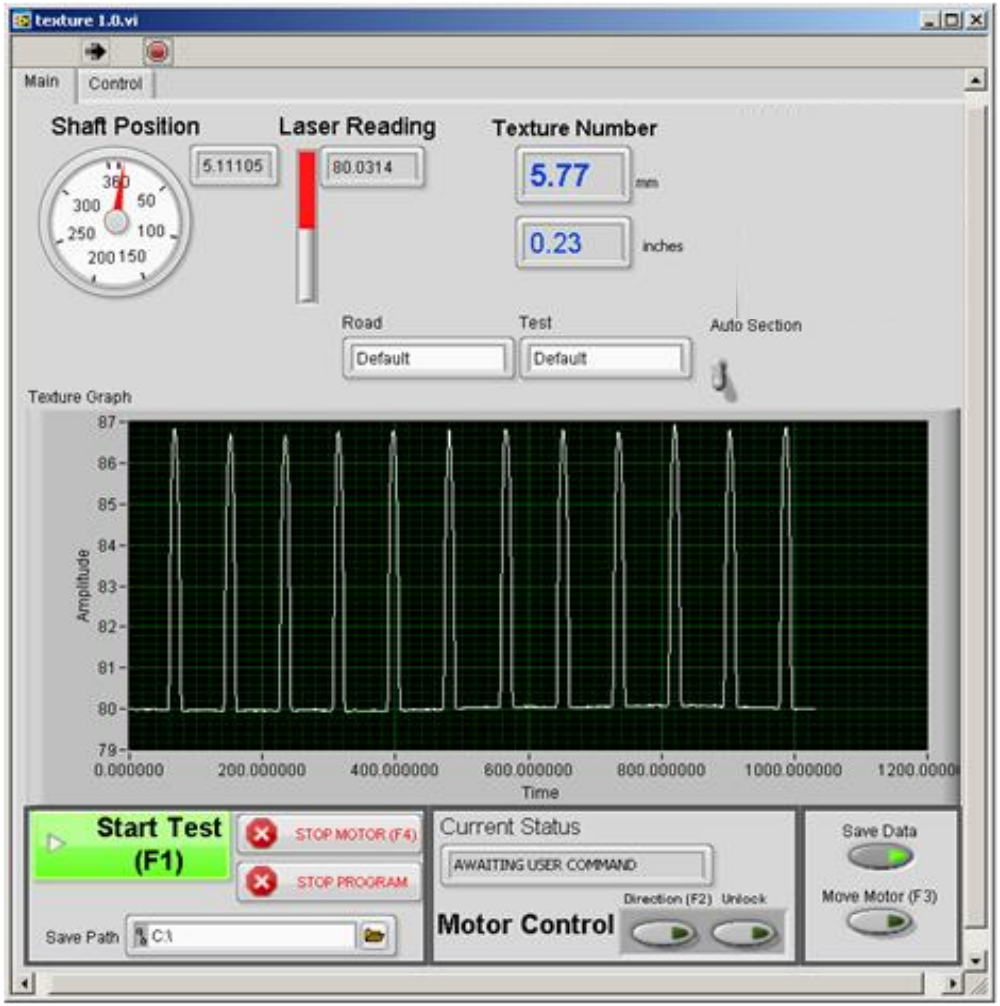
Circular Track Meter

- ASTM E 2157 – Pavement Macrotexture - CTM
- ASTM E 1845 – Pavement Macrotexture - MPD



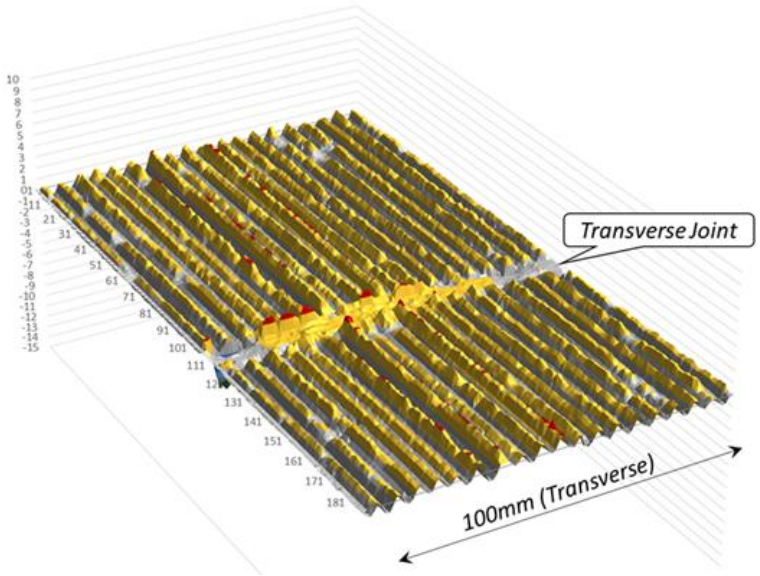
Florida Texture Meter

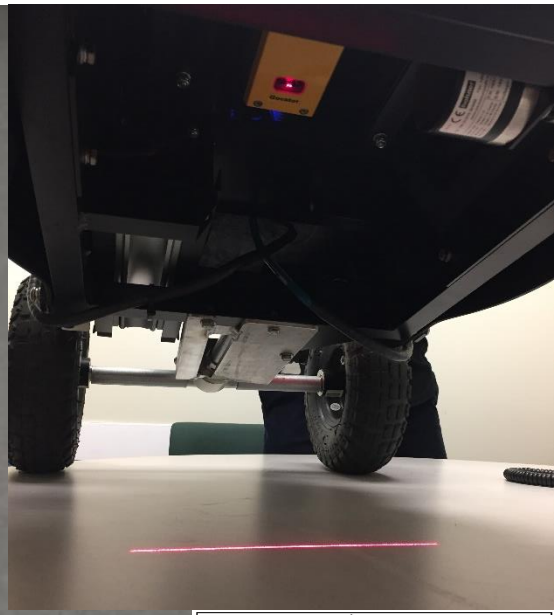
- Built based on ASTM E 1845
- In-House Software
- MPD obtained along a circular path

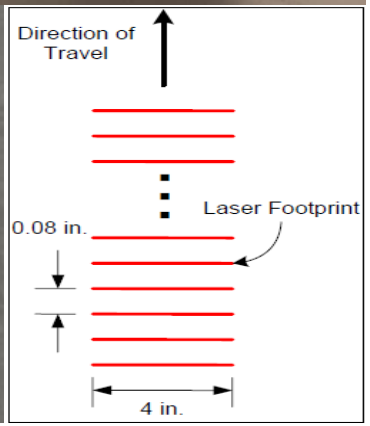


Walking Texturemeter (TM2)

- Measures pavement texture in accordance with ISO 13473
- Continuous at walking speed
- MPD collected at every 0.08 in. and reported at desired interval (> 3.5 inch)







Mean Profile Depth – ASTM E-1845

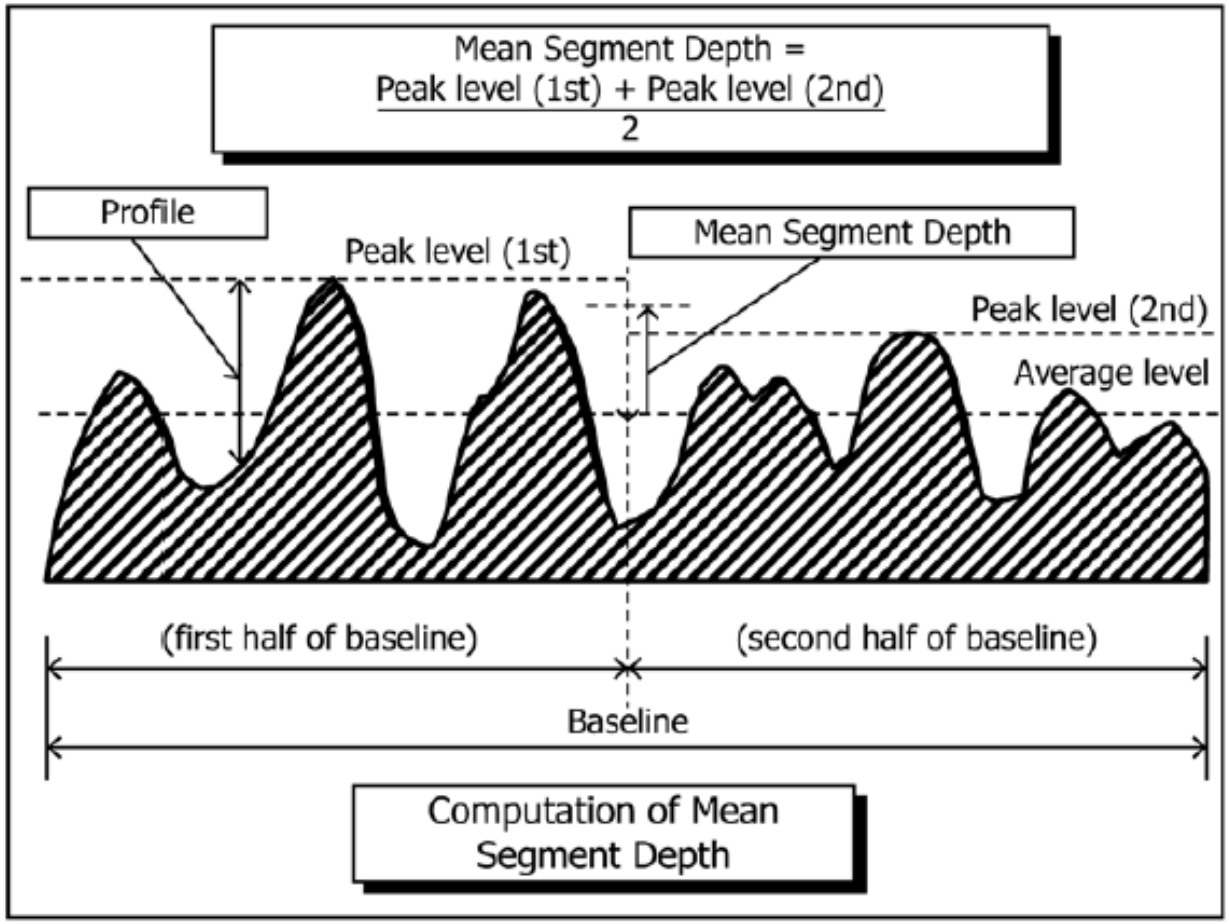


FIG. 1 Procedure for Computation of Mean Segment Depth

E2157 – 15

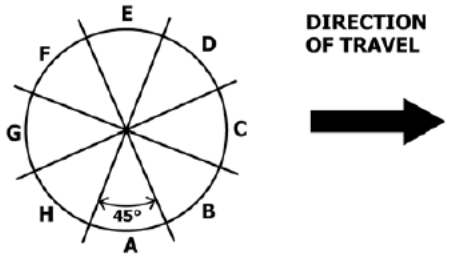
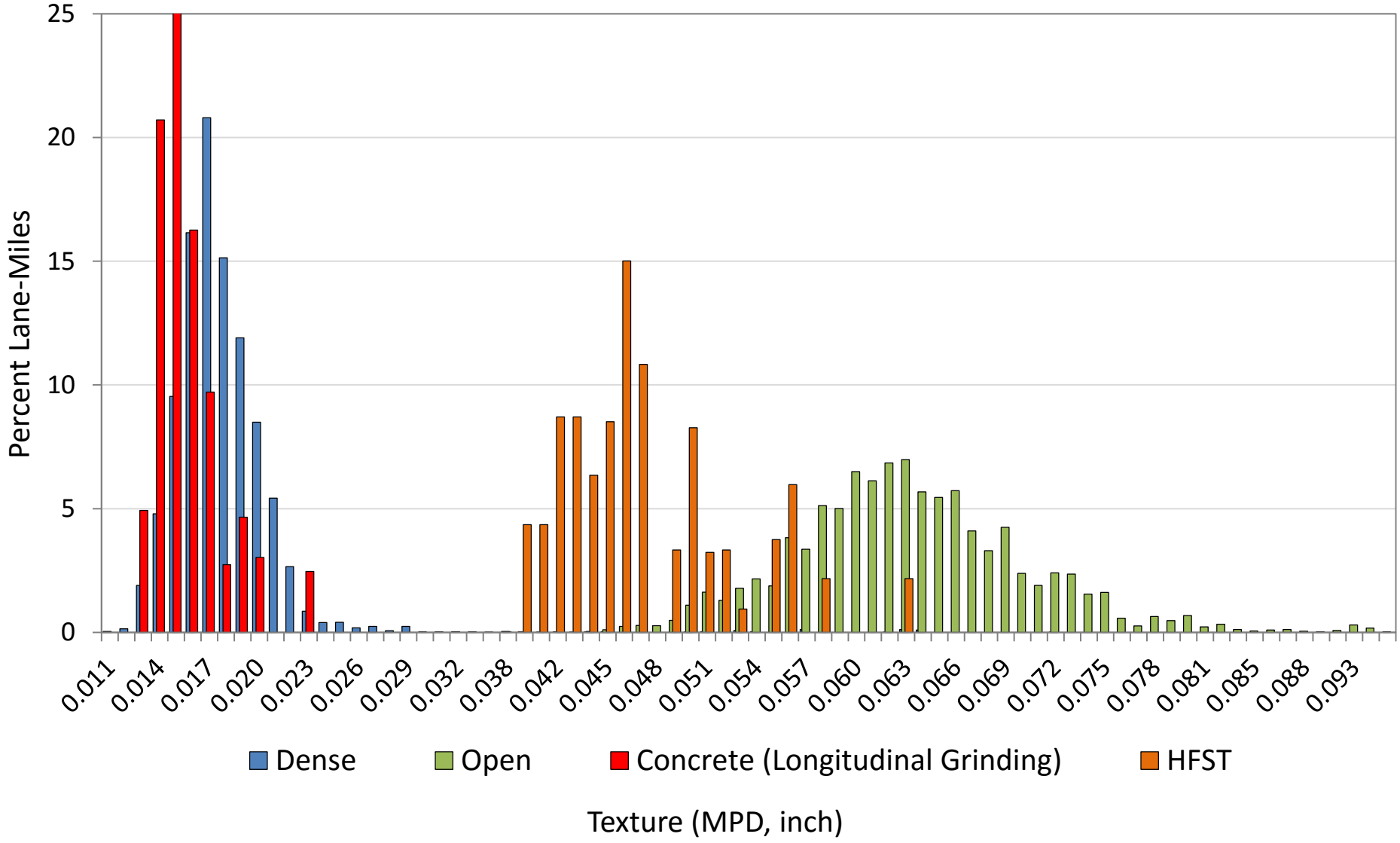


FIG. 1 Segments of the Circular Track Profile

Florida Texture Catalog

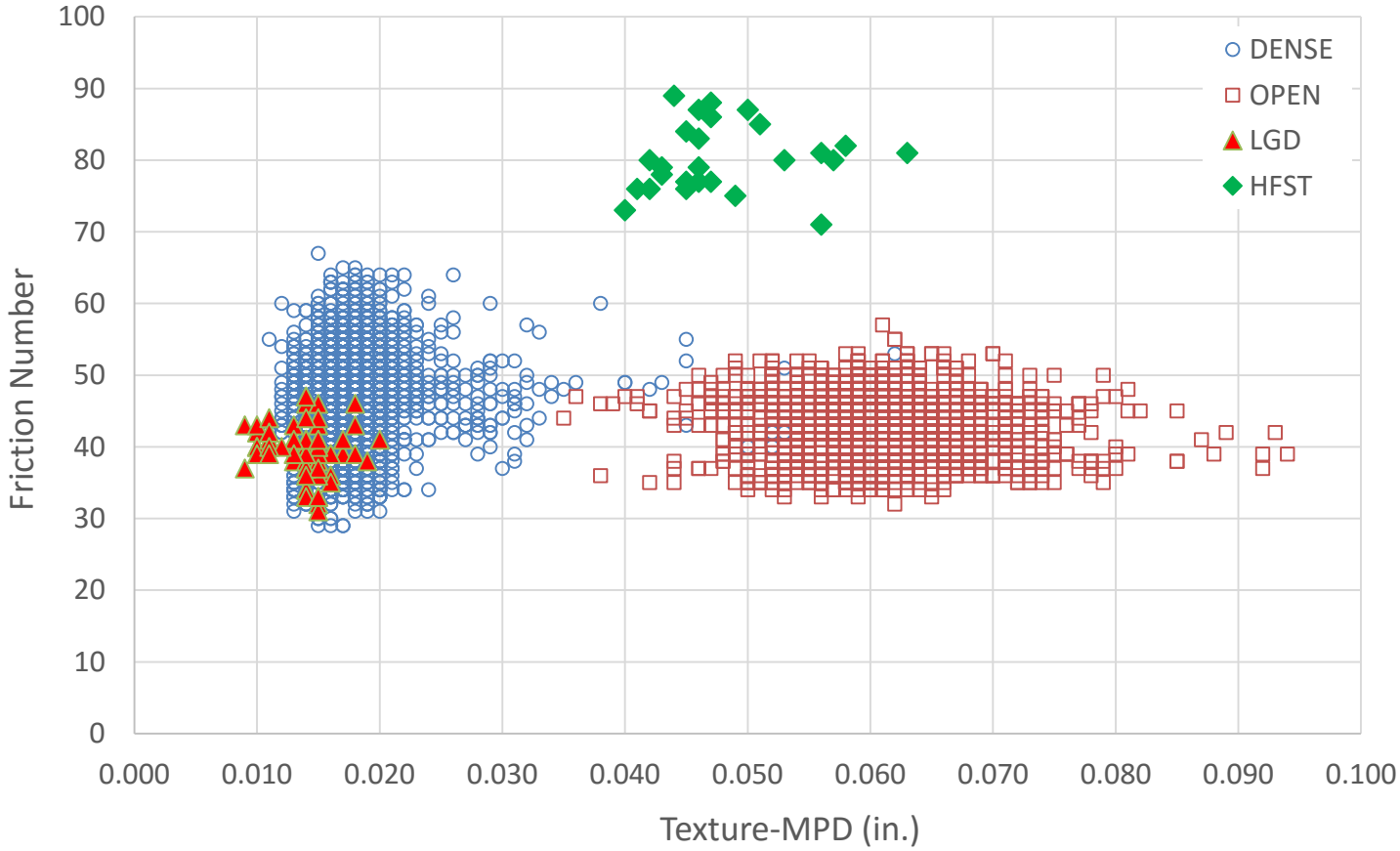
- Collect FN and MPD
  - New Construction
  - Overlay
  - Inventory (new)
- Surface Types Include
  - OGFC
  - DGFC
  - Concrete (Mainline & Bridge)
  - HFST

Five Year (2010-2015) Statewide MPD Statistics

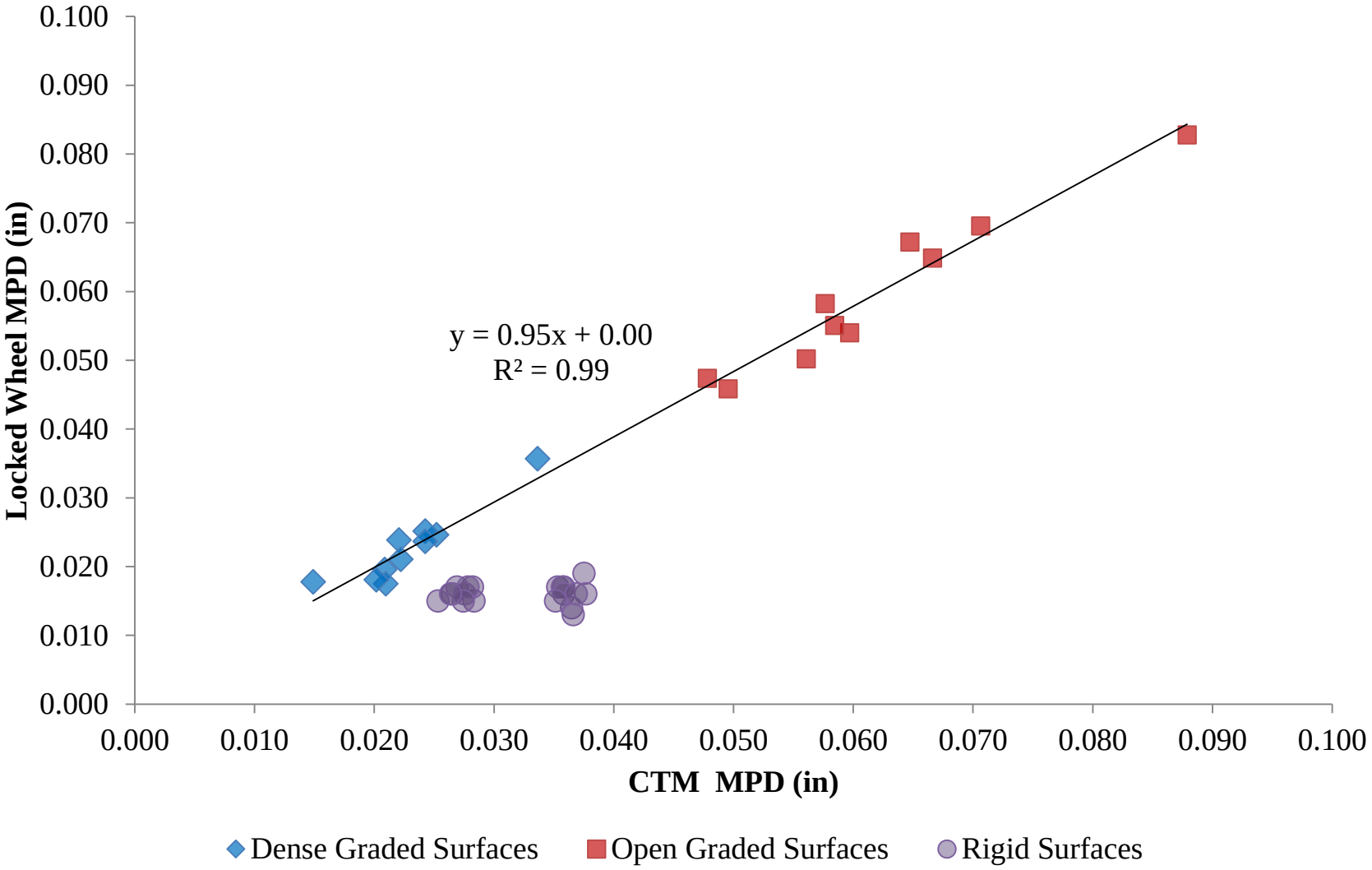


Five Year (2010-2015) Statewide MPD Statistics (Cont.)

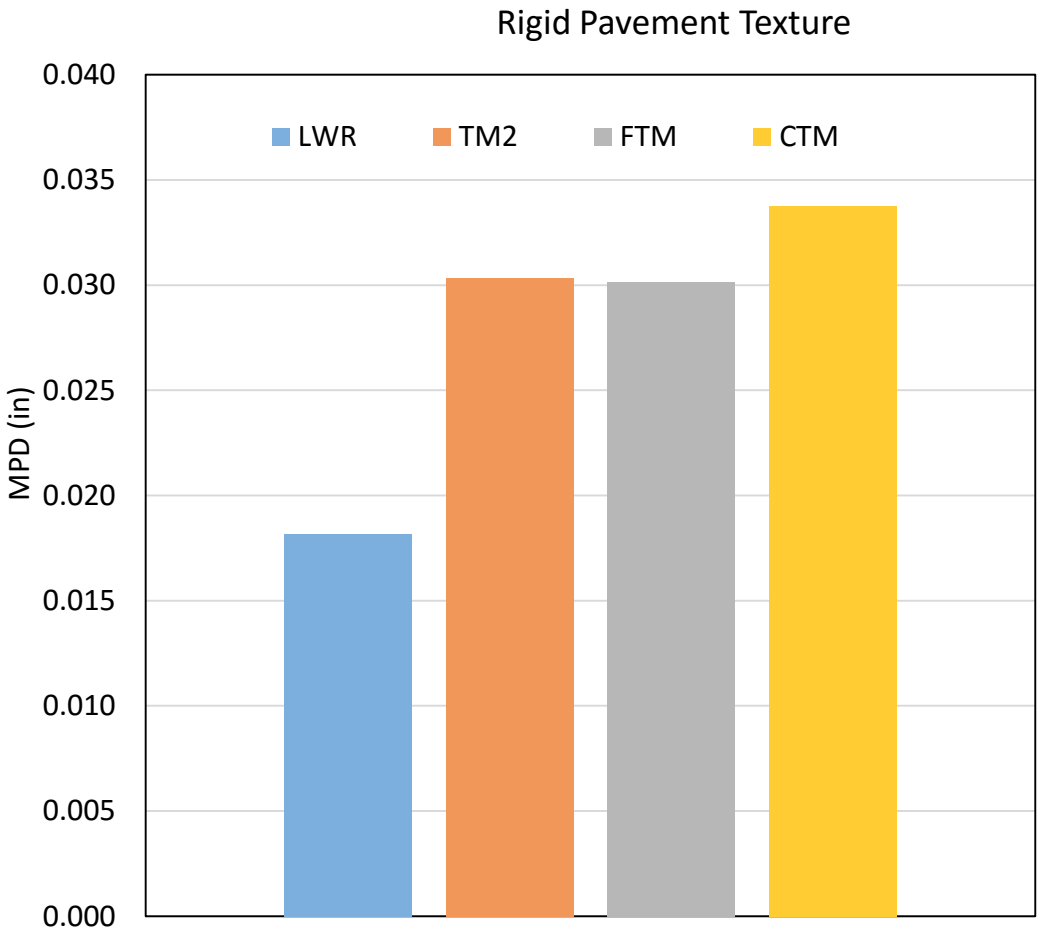
- **MPD vs Friction**



High Speed vs Site Specific Texture

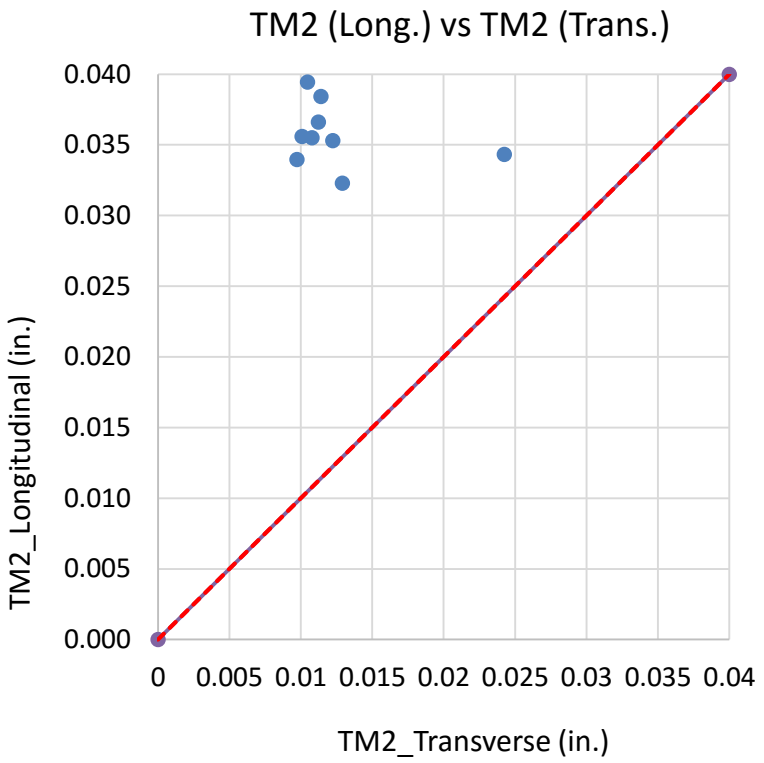


Rigid Pavement Texture Challenges



- LGD - Point Laser Underestimates (43%)
- Artificial Orientation
- High Speed Surveys Difficult

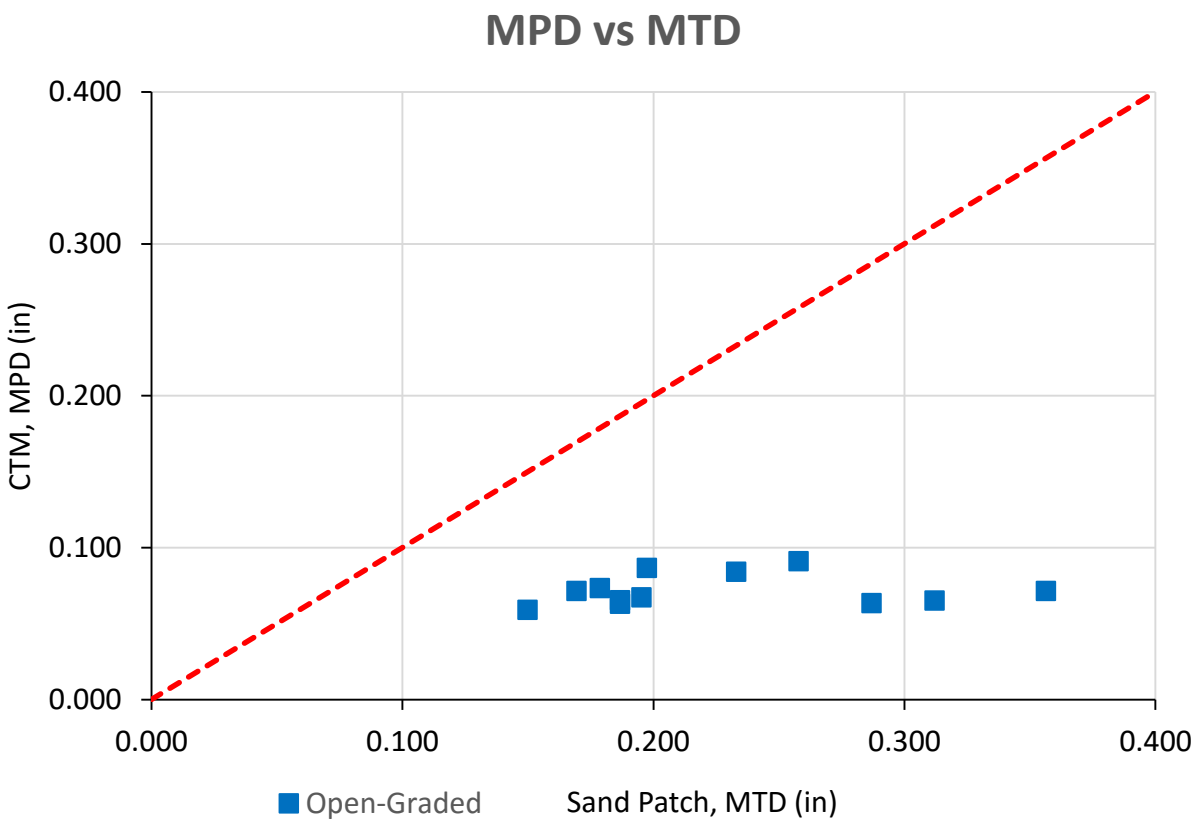
Rigid Pavement Texture Challenges (Cont.)



Flexible Pavement Texture Challenges

- OGFC
- MPD vs MTD
- Texture vs Porosity

Sand Patch - OGFC



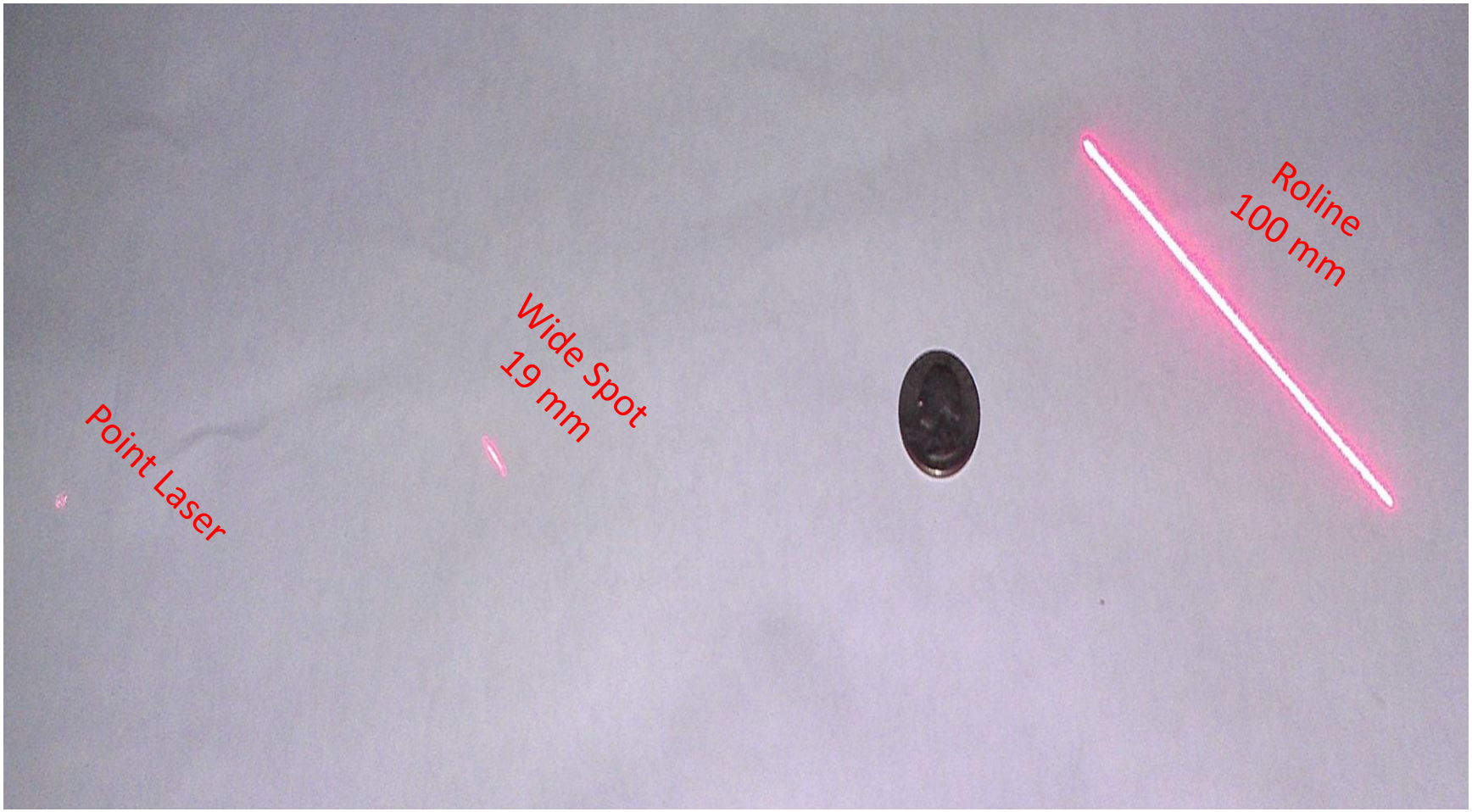
Roadway Smoothness

- Laser Based Sensor Evaluation for Profilers
- IRI Smoothness Specifications
- Rigid and Flexible
- Texture Effects
  - ✓Age of Pavement
  - ✓% Diff. in IRI
  - ✓Repeatability

Multi-Laser Profiler

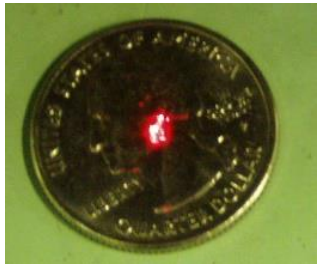
- 3-Sensor Type
  - Point
  - Wide Spot
  - Roline
- Wheel Path
- High Speed

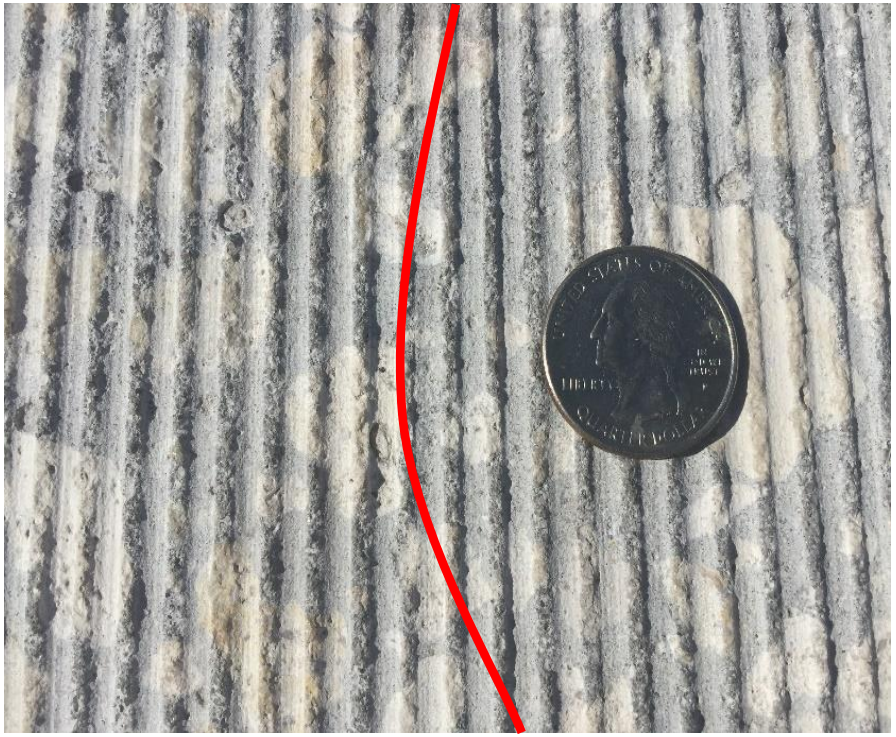
Laser Footprint for Pavement Smoothness



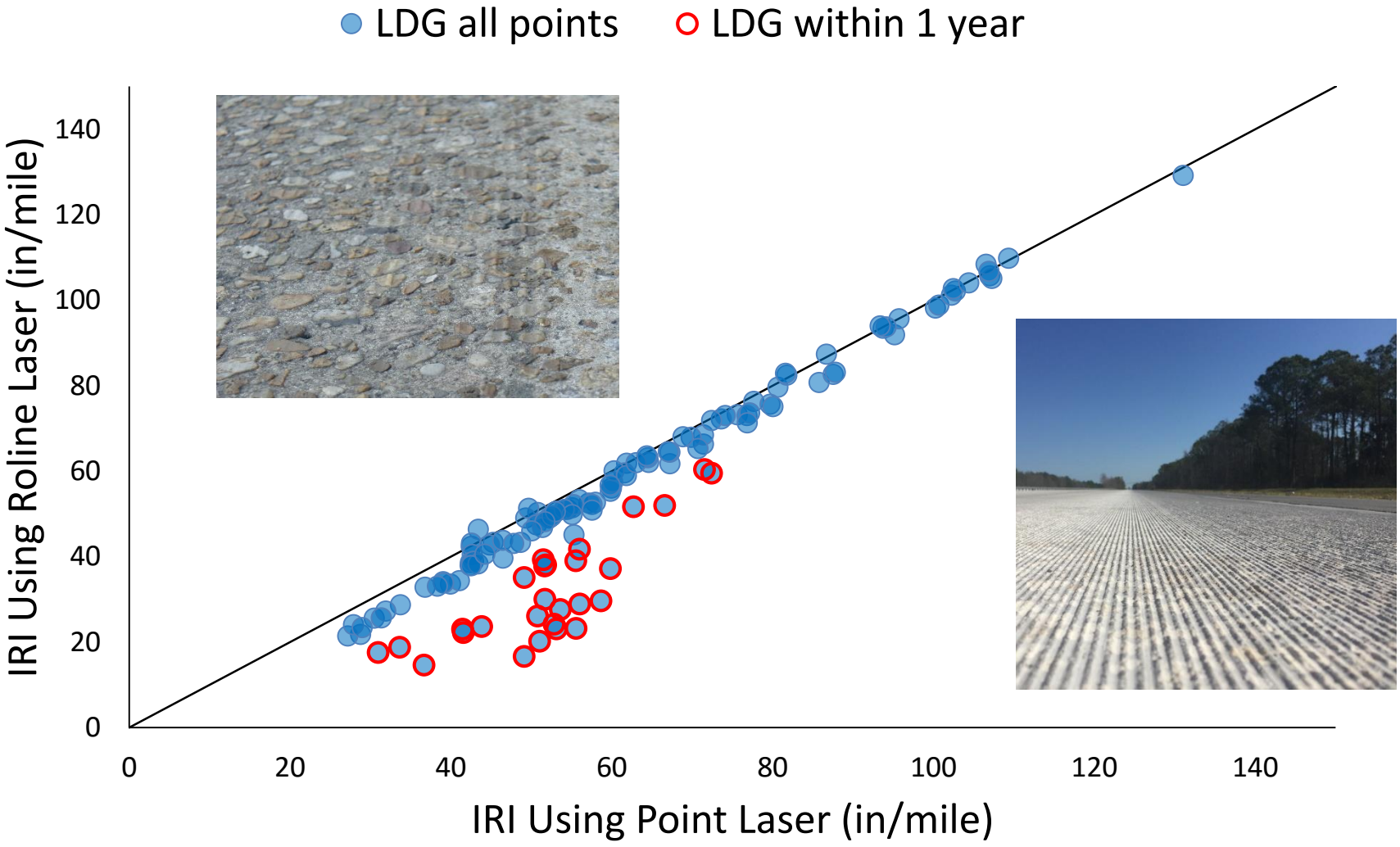
Concrete Pavement Smoothness

- All new concrete pavements are longitudinally ground
- LGD surface texture improves drainage and friction
- Artificial texture has challenges for lasers with a small footprint
- 14 locations





Rigid Pavement Summary



Rigid Pavement Summary

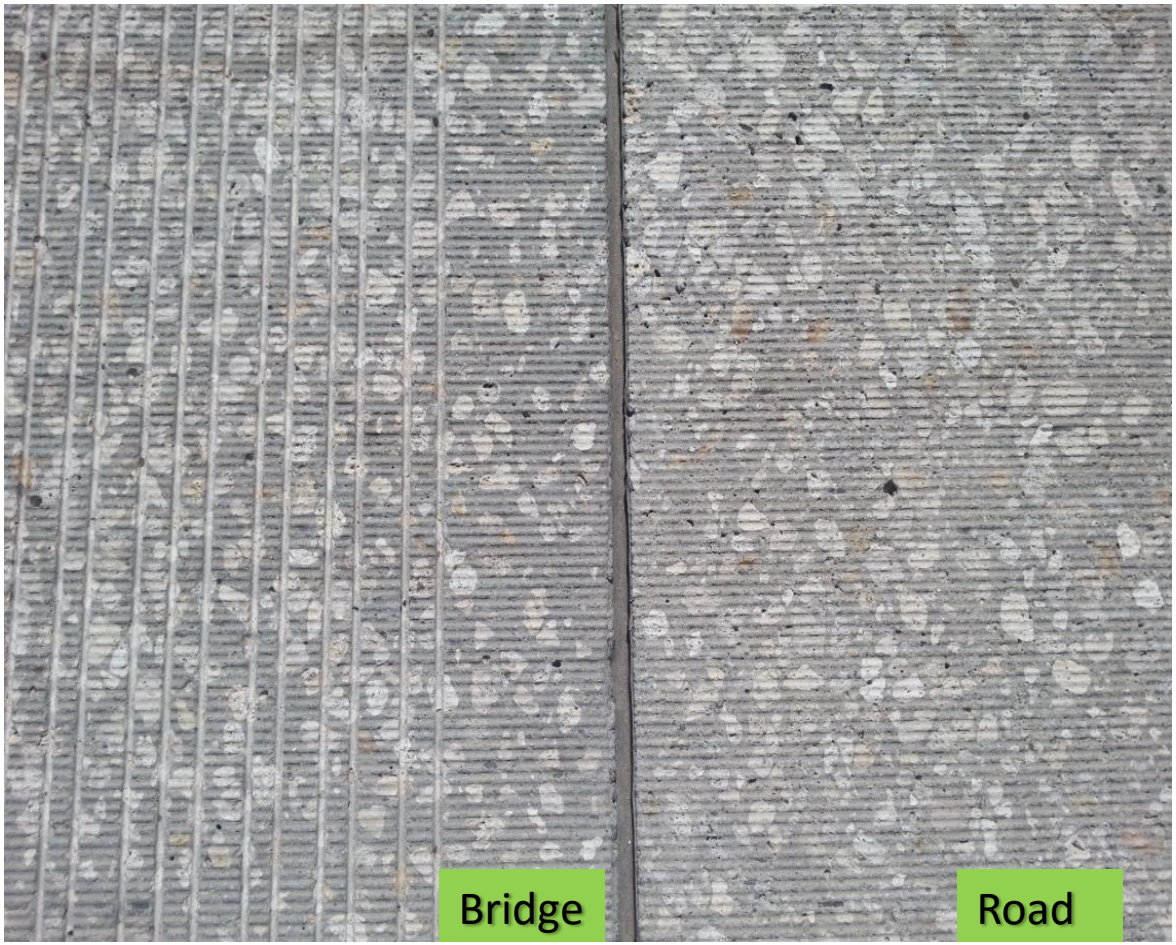
Surface Type	Pooled Standard Deviation of Three Repeat Runs (in/mile)		
	Point	Wide Spot	Roline
LDG > 1 year	2.73	2.68	2.51
LDG < 1 Year	3.51	1.76	1.17
All Projects	2.71	2.21	1.89

- All Lasers Repeatable
- Large Difference with Point Laser
- Texture Wear Noted

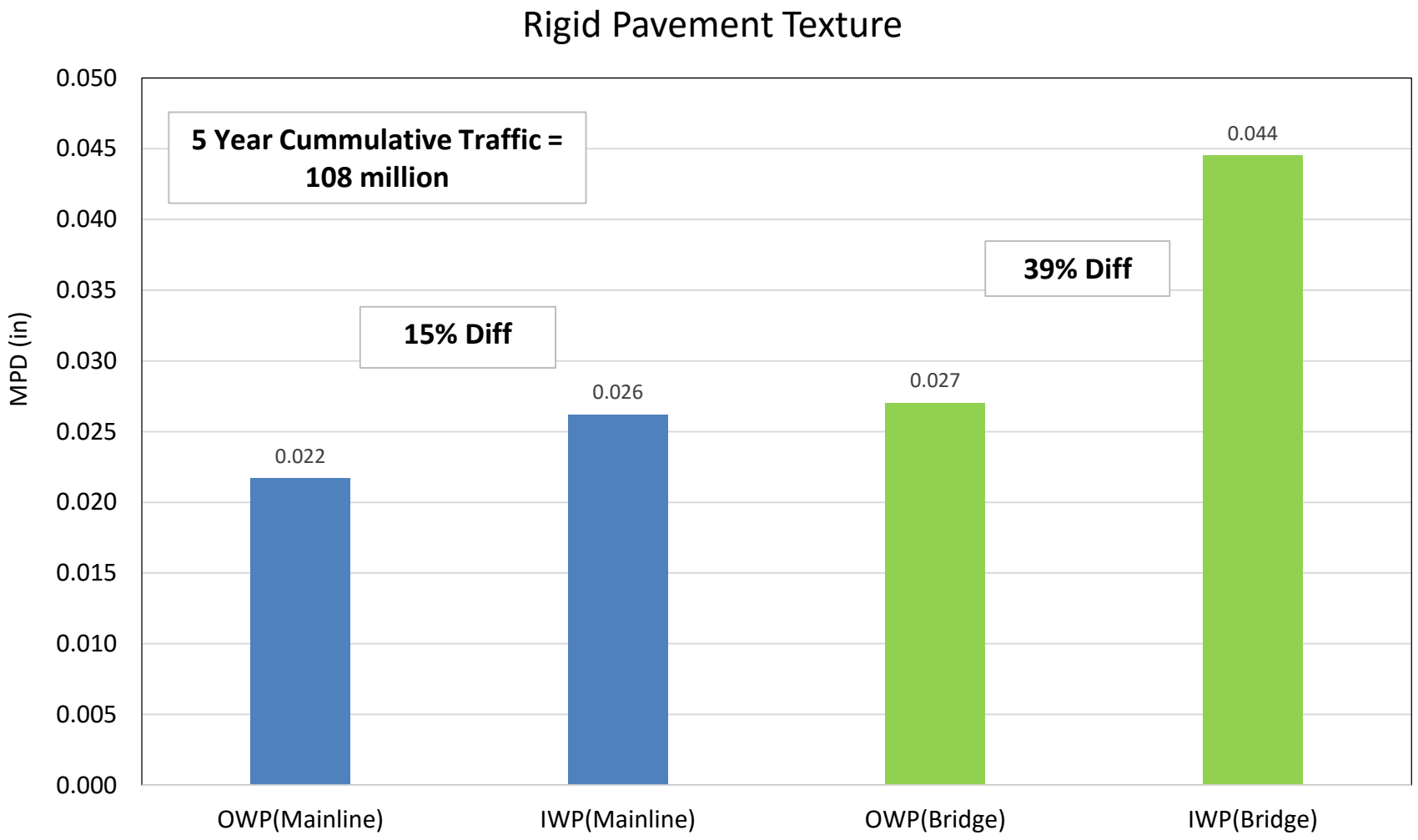
Section	Comparison	Avg. IRI Difference (in/mile)	95% Confidence Interval or IRI Differences (in/mile)	
			Lower Limit	Upper Limit
LDG > 1 year	Point vs. Wide Spot	2.34	2.00	2.67
	Point vs. Roline	2.90	2.44	3.37
	Wide Spot vs. Roline	0.56	0.28	0.85
LDG < 1 year	Point vs. Wide Spot	18.08	14.69	21.48
	Point vs. Roline	20.17	17.01	23.34
	Wide Spot vs. Roline	2.09	1.36	2.82
All Projects	Point vs. Wide Spot	5.51	4.22	6.80
	Point vs. Roline	6.38	5.00	7.76
	Wide Spot vs. Roline	0.87	0.59	1.16

Traffic Effects - Texture Wear (Rigid)

- Interstate Project
  - Bridge
  - Roadway
- Monitor Texture
  - Wheel Path
  - Between Wheel Path
- ADT



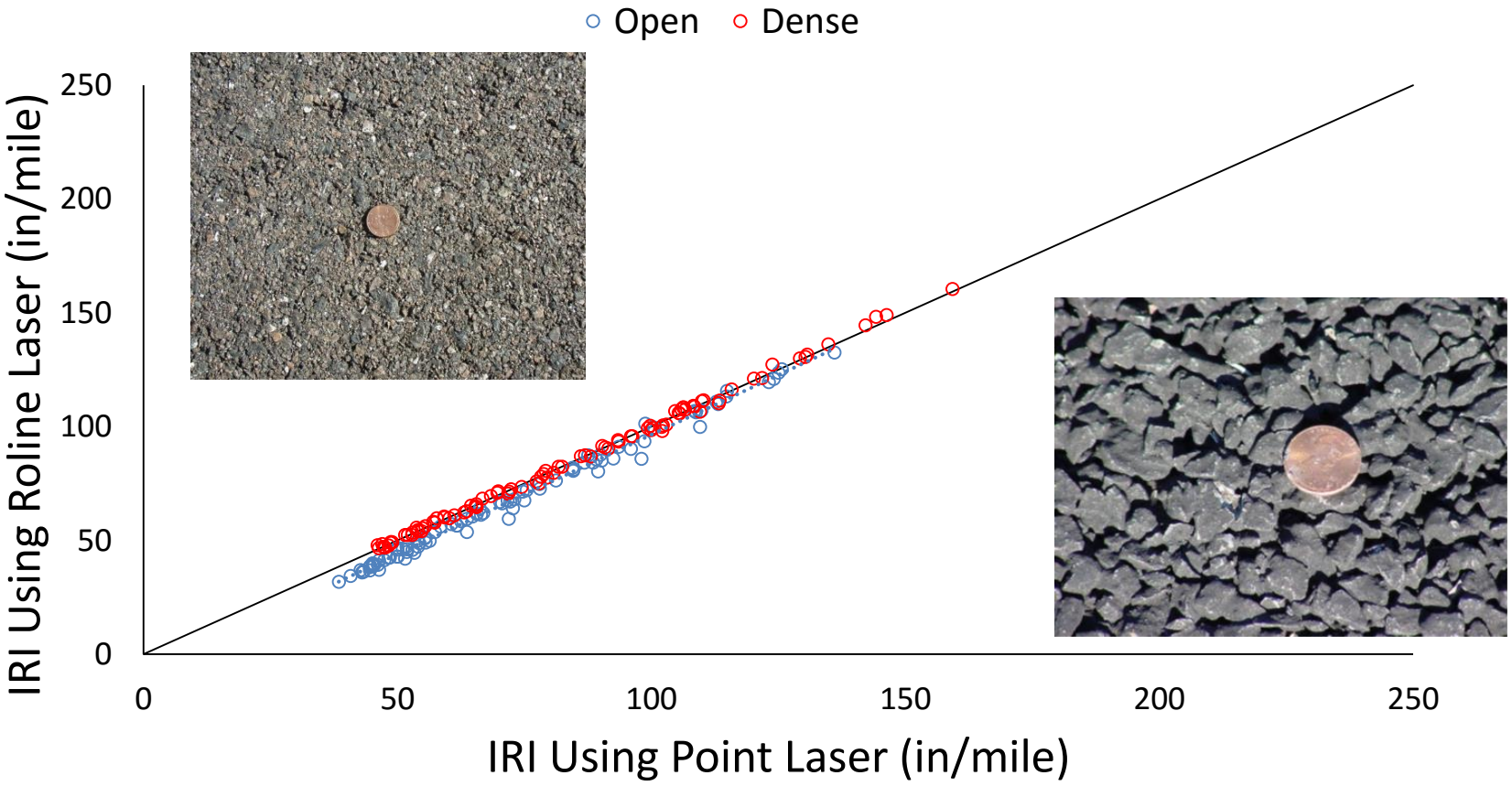
Traffic Effects - Texture Wear (Rigid)



Flexible Pavement Summary

- OGFC – 50 mph or over divided roadways
  - Drainage
  - Splash/Spray
- DGFC – 2 lanes up to 60 mph
- Sections
  - 10 OGFC
  - 10 DGFC

Flexible Pavement Summary



Flexible Pavement Smoothness

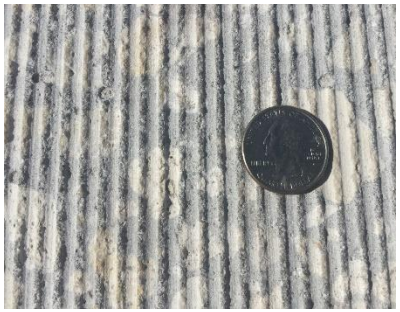
Surface Type	Pooled Standard Deviation of Three Repeat Runs (in/mile)		
	Point	Wide Spot	Roline
Dense	2.03	2.00	1.90
Open	3.35	3.22	3.25
All Projects	2.81	2.72	2.70

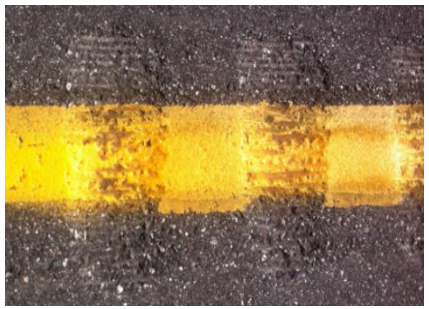
- All Lasers Repeatable
- Minimal IRI Difference
  - Mix Type
  - Laser Type
  - No Texture Wear

Section	Comparison	Avg. IRI Difference (in/mile)	95% Confidence Interval or IRI Differences (in/mile)	
			Lower Limit	Upper Limit
Dense	Point vs. Wide Spot	1.19	0.91	1.48
	Point vs. Roline	-0.43	-0.70	-0.16
	Wide Spot vs. Roline	-1.63	-1.86	-1.40
Open	Point vs. Wide Spot	2.61	2.31	2.92
	Point vs. Roline	4.84	4.32	1.70
	Wide Spot vs. Roline	2.23	5.37	2.76
All Projects	Point vs. Wide Spot	1.98	1.74	2.21
	Point vs. Roline	2.42	1.93	2.92
	Wide Spot vs. Roline	0.45	0.03	0.86

Noise Evaluation - Texture

- How do pavement types and surface texture effect tire-pavement interaction noise?



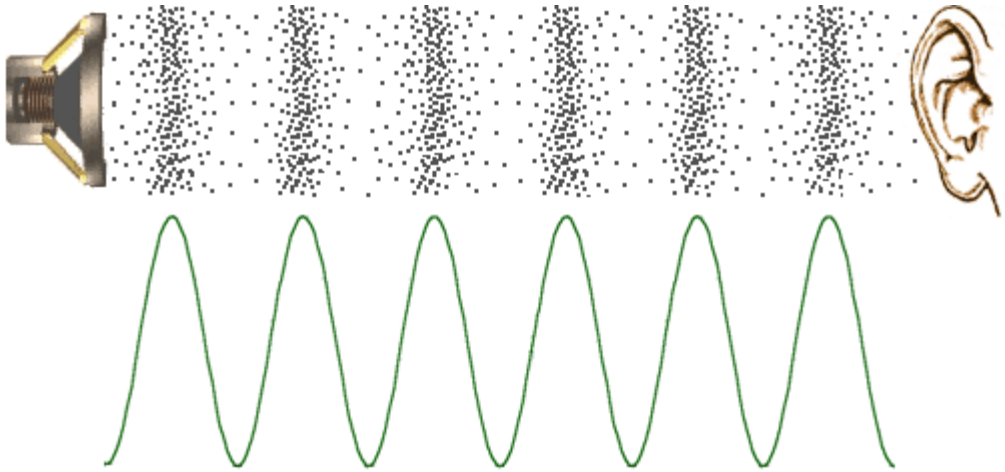


Noise Trailer

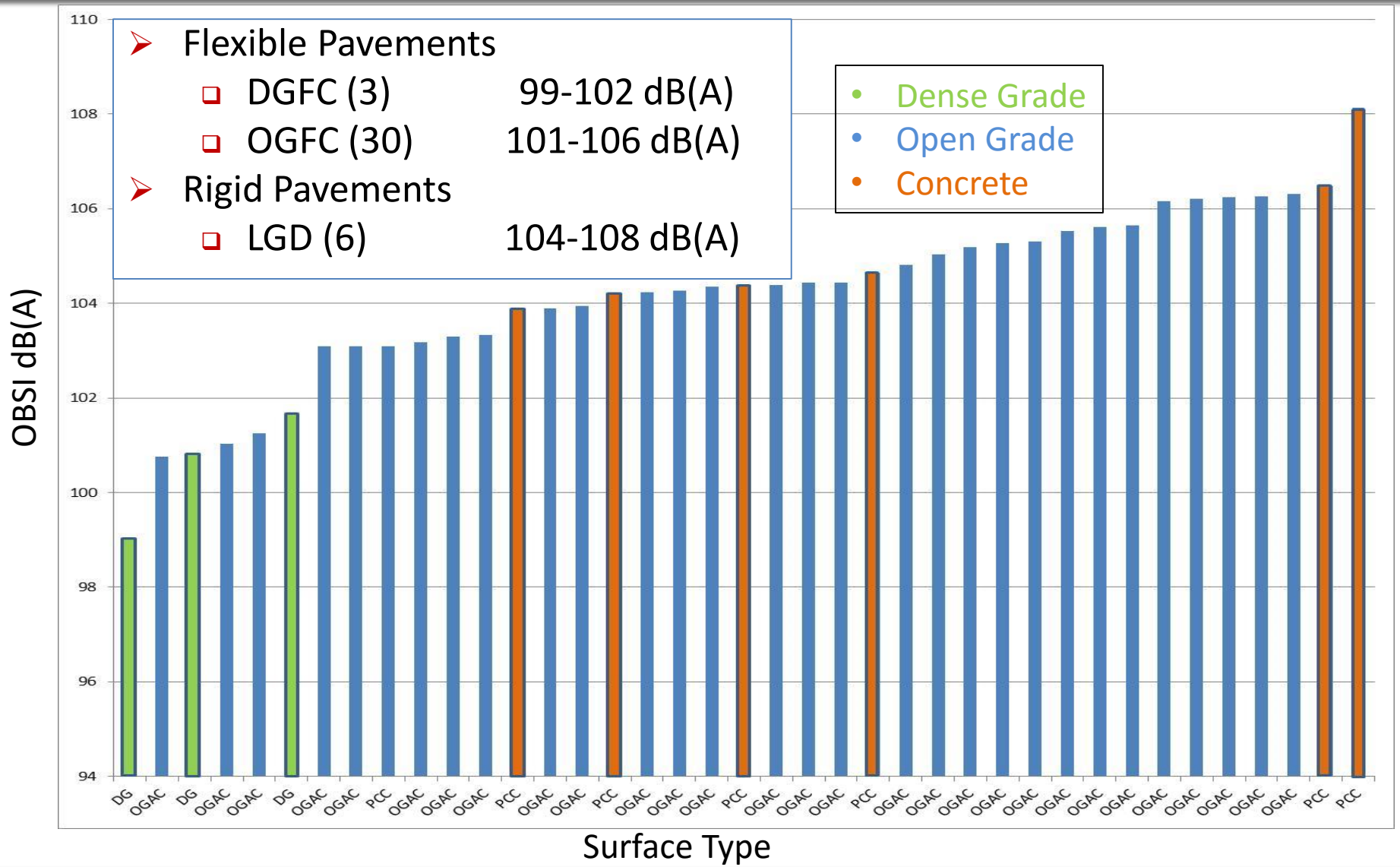
- FDOT Noise Trailer (OBSI)
  - High Speed (60 mph)
  - AASHTO TP 76-15
  - Predict Wayside measurements
  - Quantify Noise (Various Textures):
    - ✓Flexible (OGFC & DGFC)
    - ✓Rigid
    - ✓Rumble/Audible Striping

Human Perception of Decibel Level

Perceptions of Increases in Decibel Level	
Imperceptible Change	1dB
Barely Perceptible Change	3dB
Clearly Noticeable Change	5dB
About Twice as Loud	10dB
About Four Times as Loud	20dB



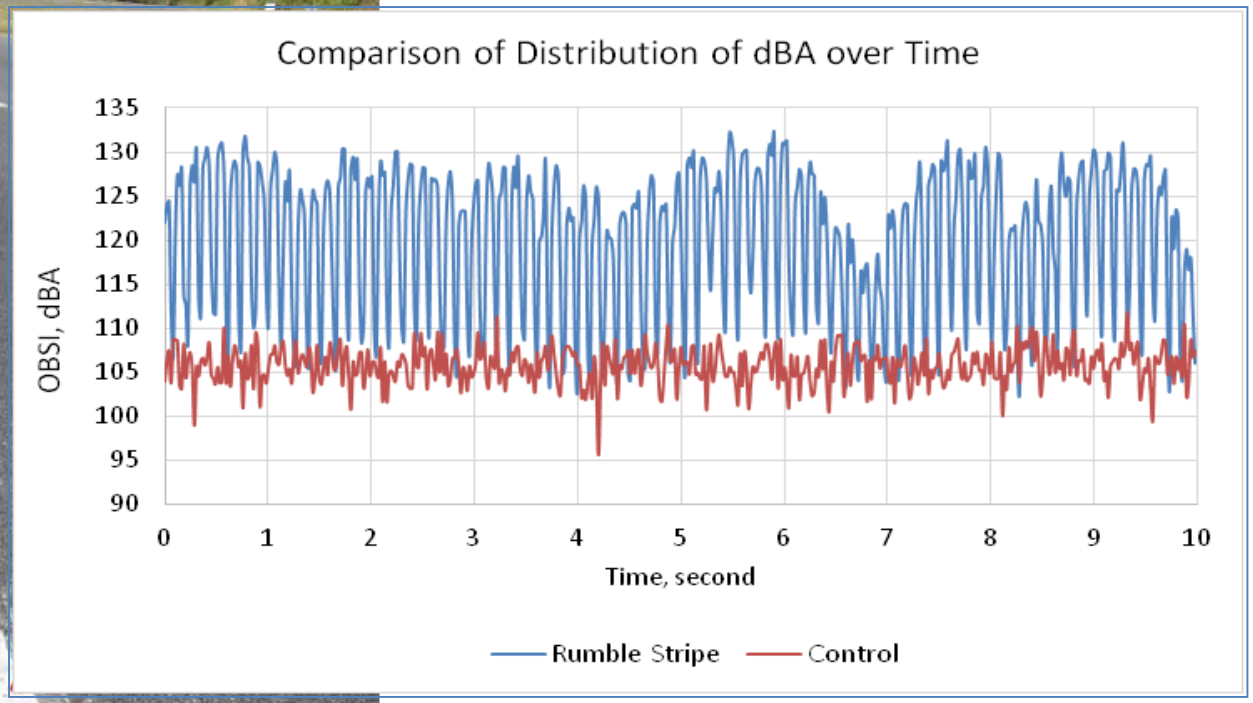
Florida Acoustic Inventory (OBSI)



Rumble Stripes

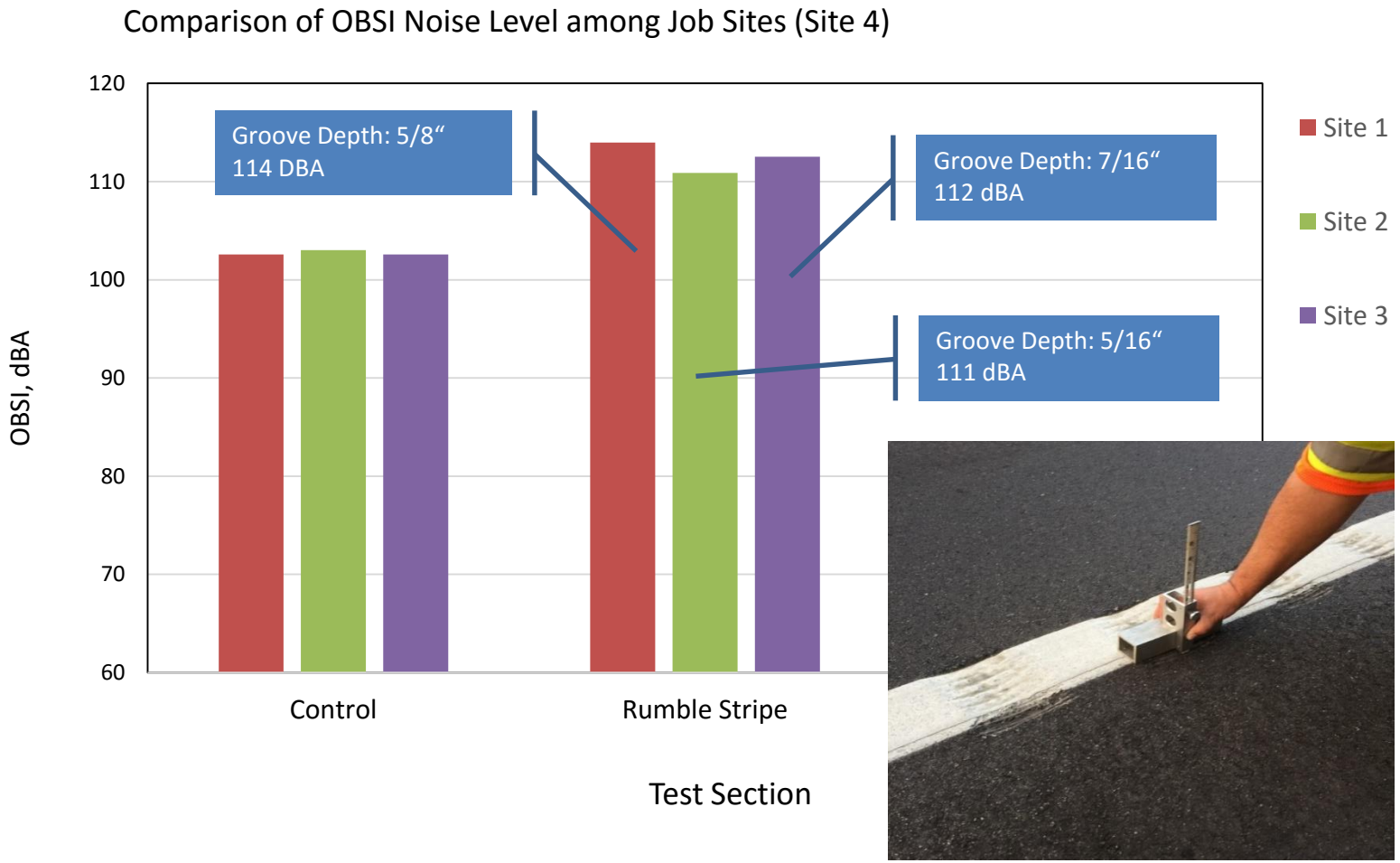
- Roadway Departure Safety
- Megatexture (0.02 to 2 in.)
- Effects of Depth - Noise

Rumble Stripe Challenges



- Control (107 dBA)
- Rumble (122 dBA)

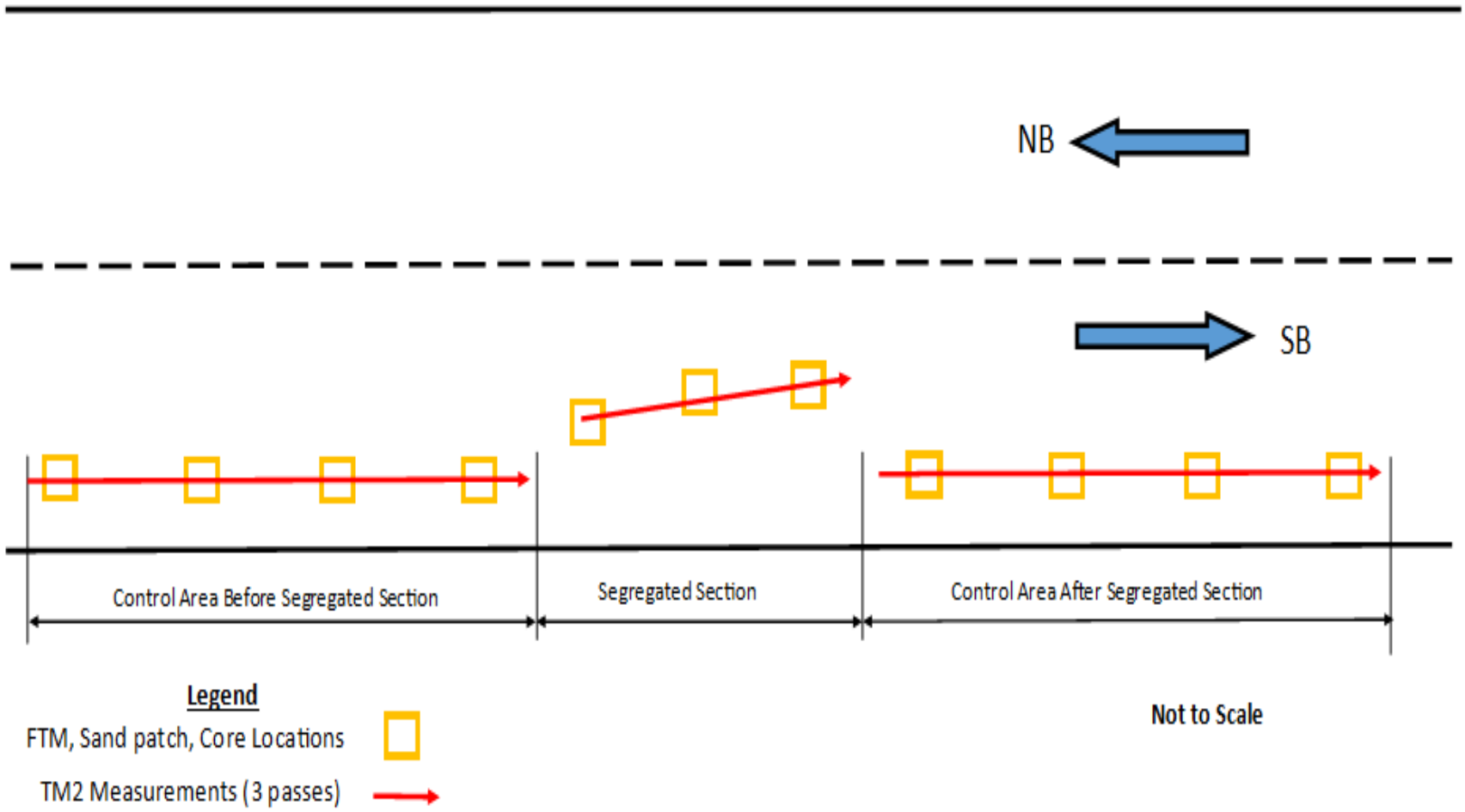
Groove Depth on Rumble Stripe Noise Levels



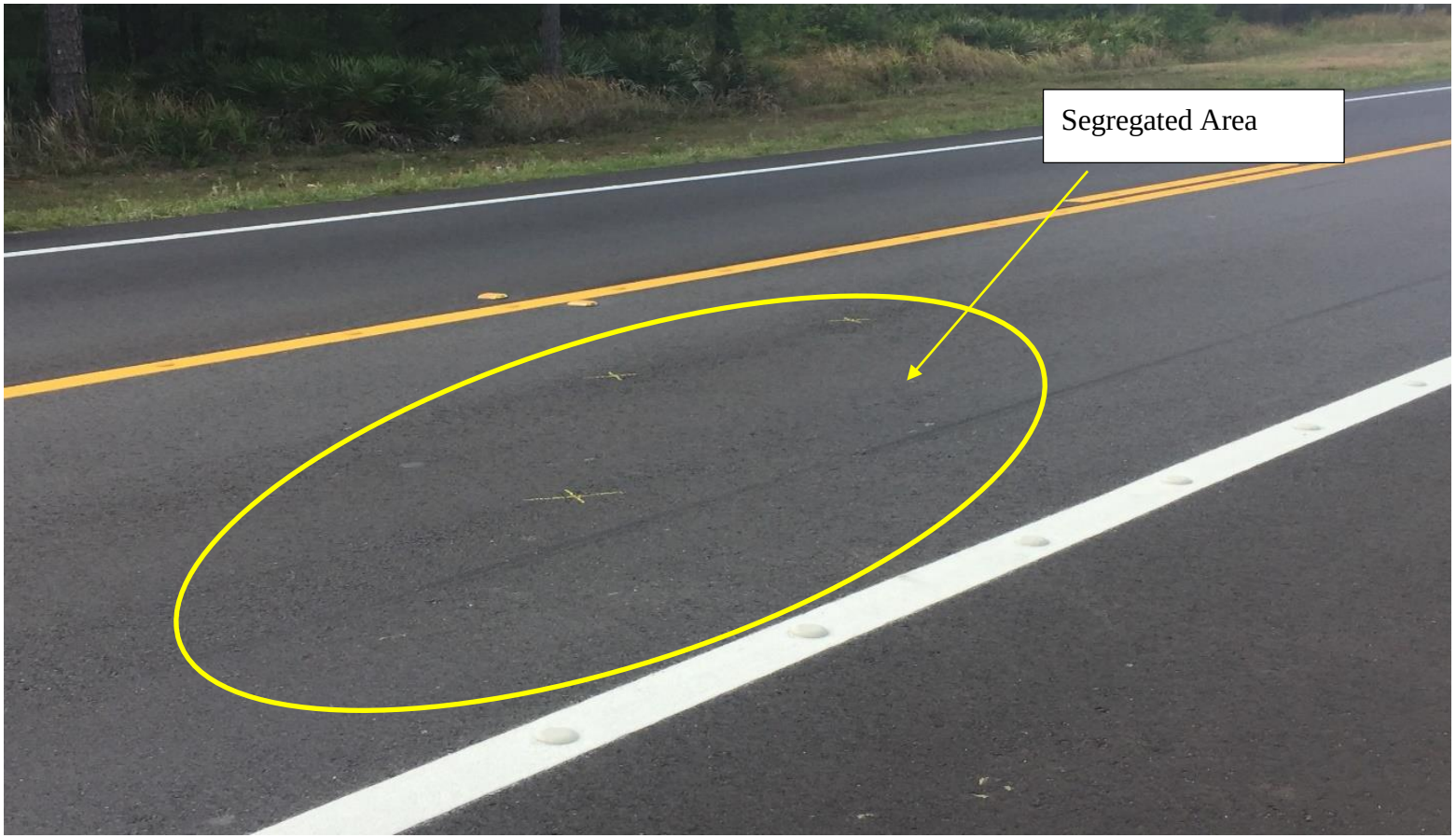
FDOT Segregation

- Develop Visual Assessment Tool
  - Verify Segregation
  - Objective
  - Pass/Fail

Test Matrix


NB
SB
Control Area Before Segregated Section
Segregated Section
Control Area After Segregated Section
Legend
FTM, Sand patch, Core Locations
TM2 Measurements (3 passes)
Not to Scale

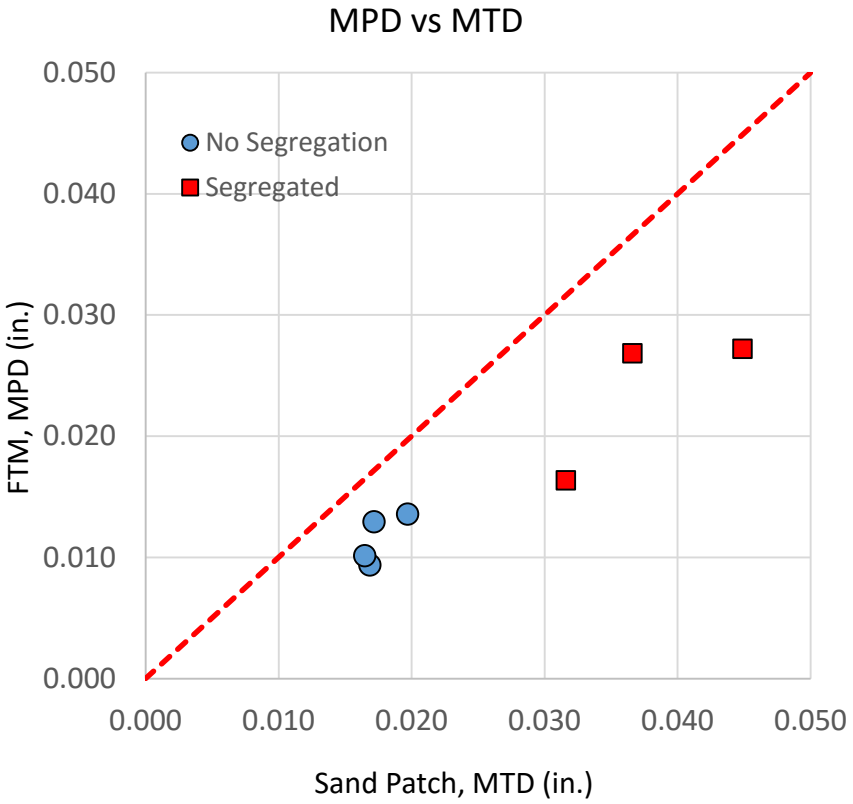
Segregated Area

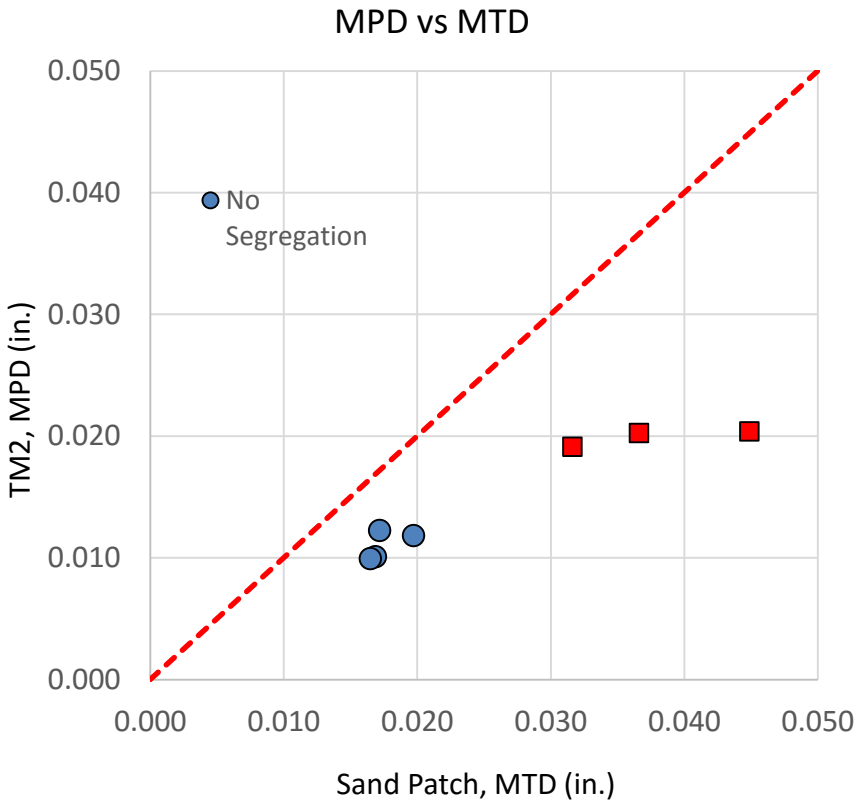


Texture Equipment

- Good/Poor Areas - Cored
- Confirmation of Segregation

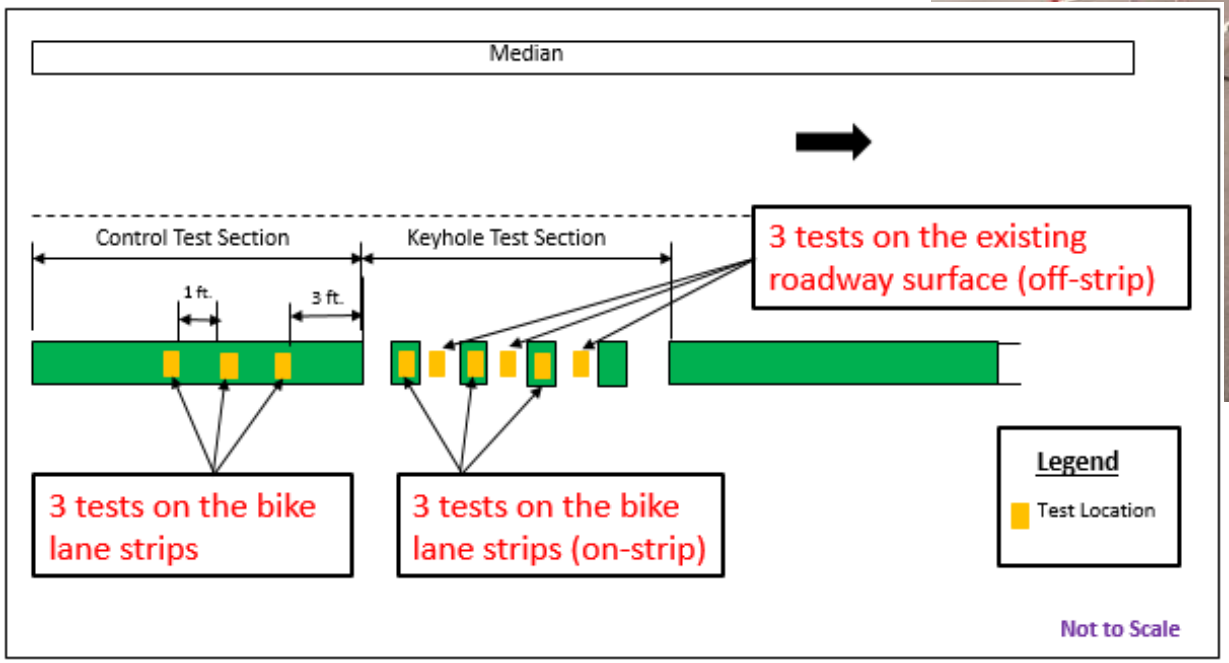
Segregation - Texture



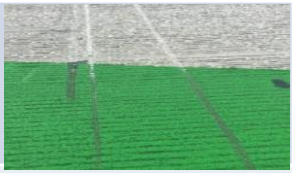


Green Bike Lanes

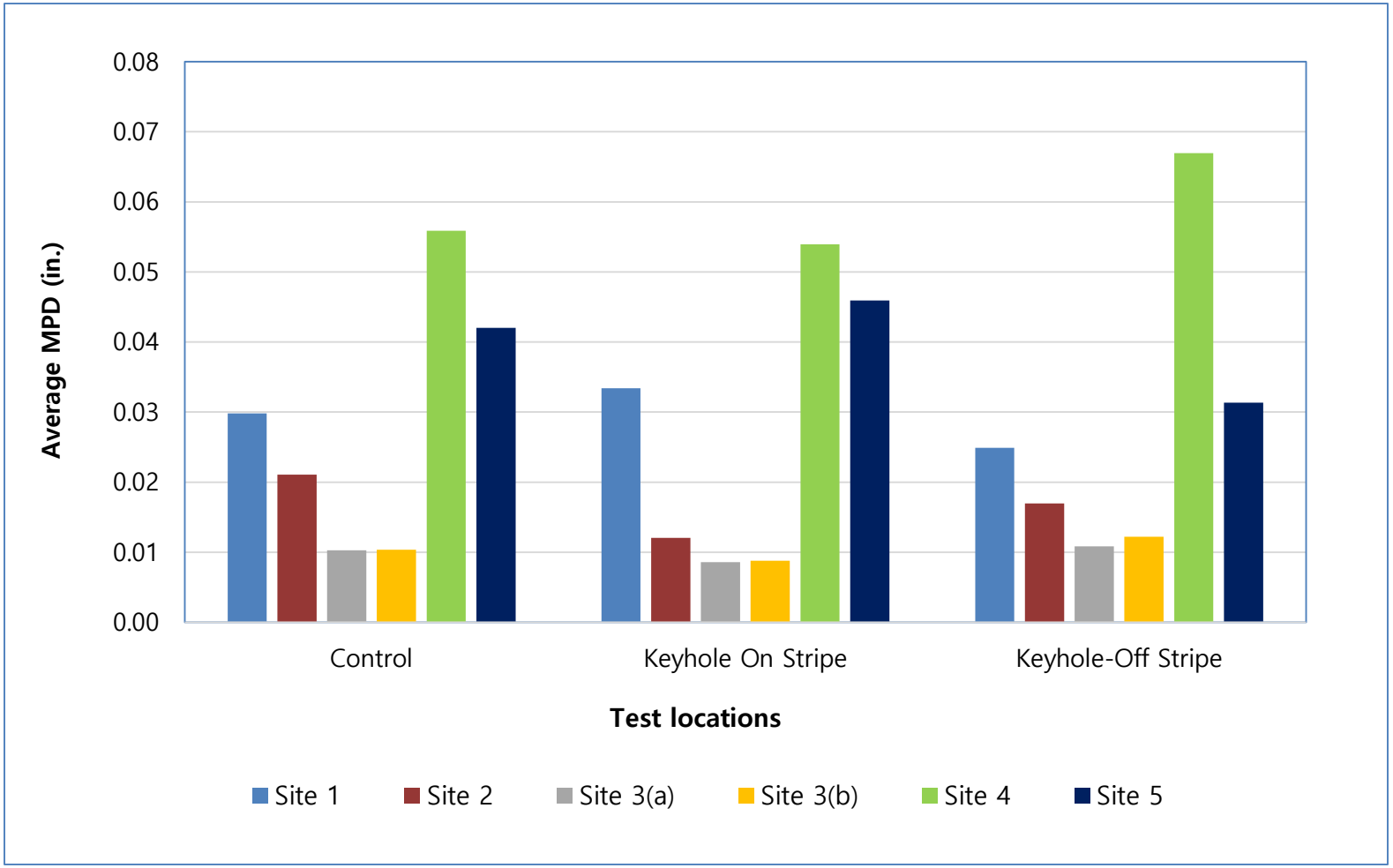
- DFT/CTM (5 – Sites)
- Long Term Performance



Green Colored Bicycle Lane Test Matrix

Test Location	Existing Surface Type	Treatment Type	Field Photos	DFT	CTM
Site 1	Rigid Pavement, Transverse Grooved	Epoxy Modified Coating		9	9
Site 2	Dense Graded AC	Epoxy Modified Coating		9	9
Site 3	Dense Graded AC	Thermoplastic		18	18
Site 4	Open Graded AC	High Friction Surface Treatment (HFST)		9	9
Site 5	Open Graded AC	Epoxy Modified Coating		9	9

Green Bike Lane Texture Comparison



Questions?