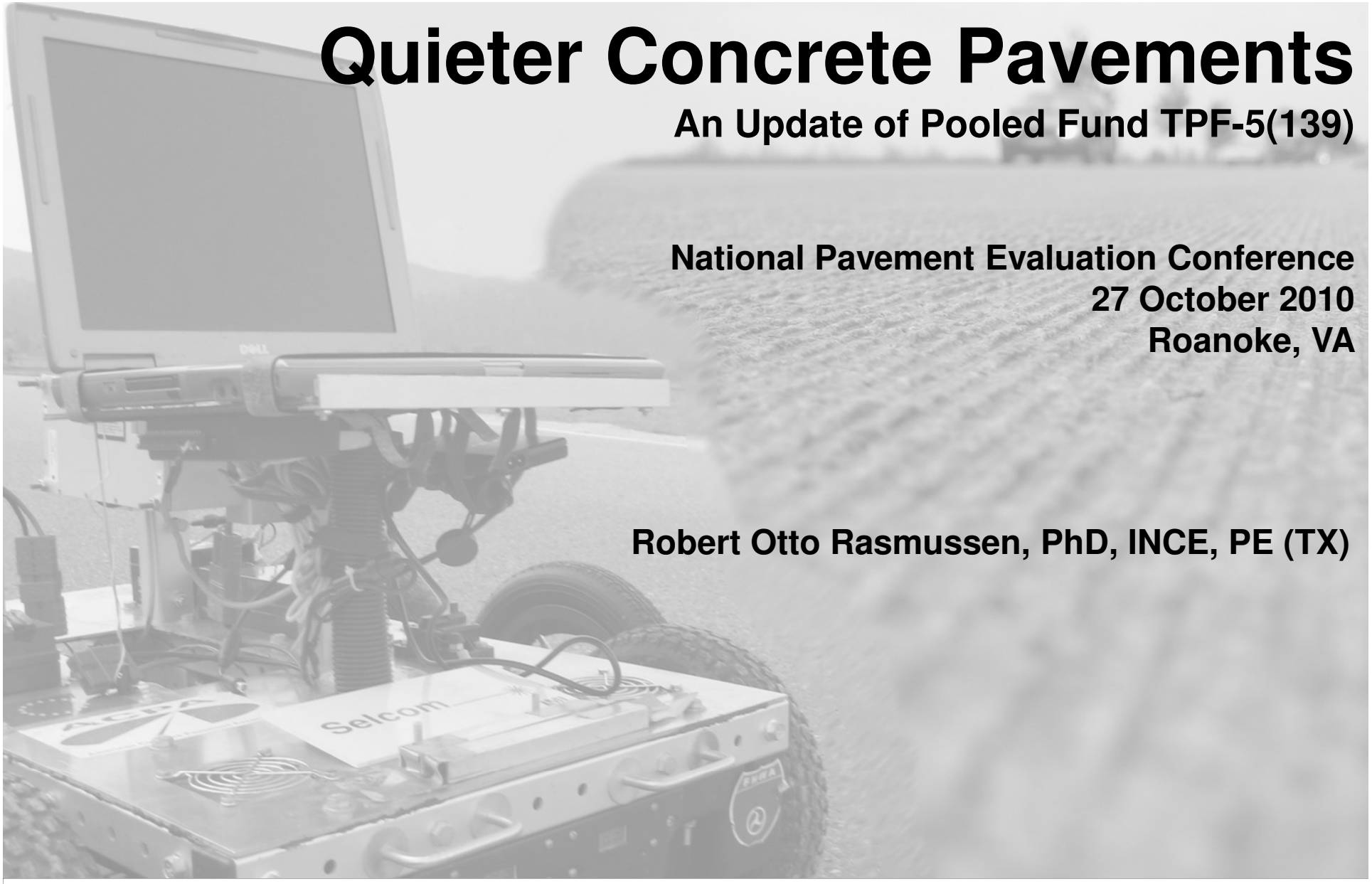
Quieter Concrete Pavements

An Update of Pooled Fund TPF-5(139)



National Pavement Evaluation Conference
27 October 2010
Roanoke, VA

Robert Otto Rasmussen, PhD, INCE, PE (TX)

THE TRANSTEC GROUP

U.S. Department of Transportation
Federal Highway Administration

ACPA

International Grooving & Grinding Association

National Concrete Pavement Technology Center
Tech Center
Uniting agencies, industry, and researchers to advance concrete pavement technology

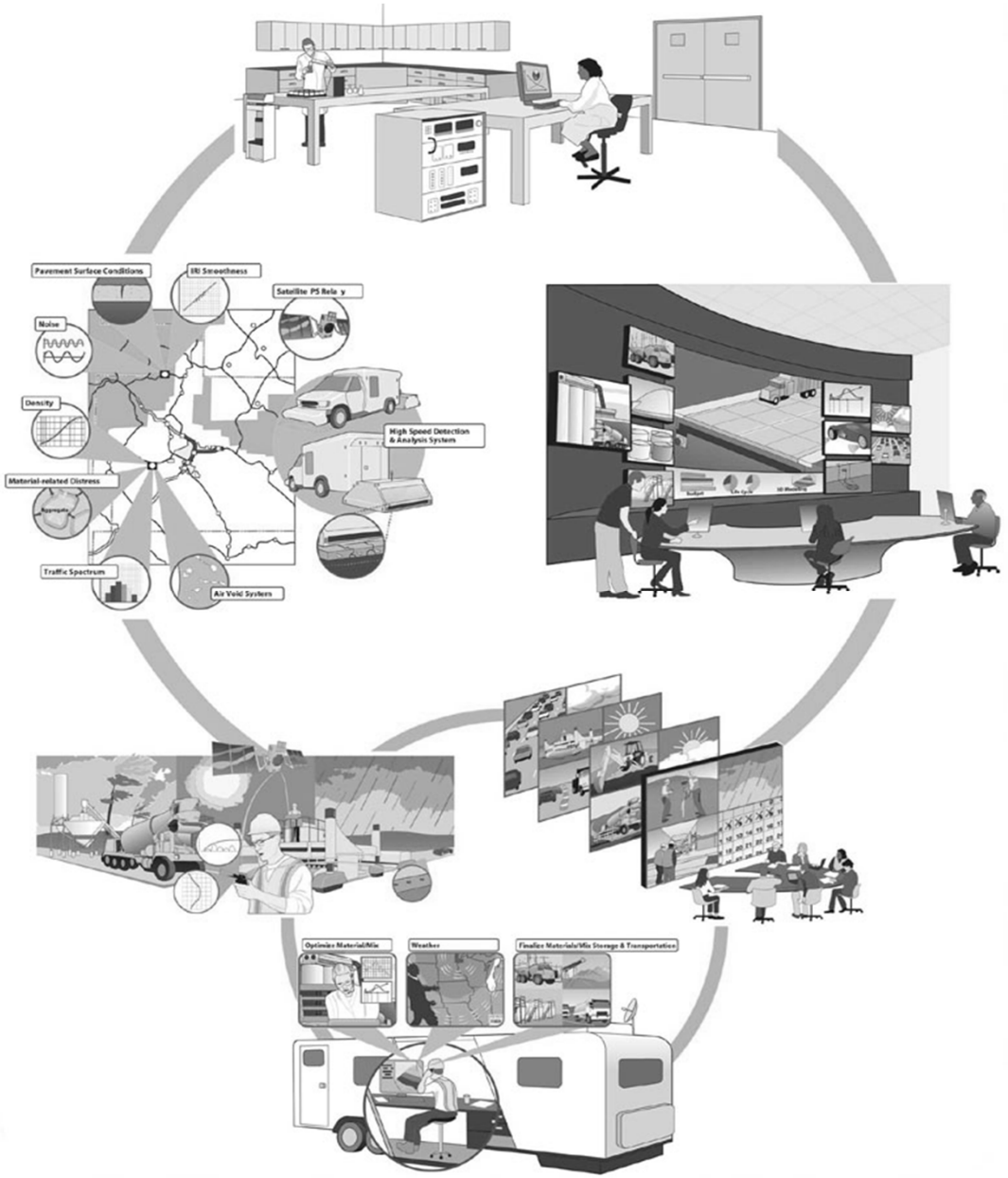
Caltrans

Texas Department of Transportation

Minnesota Department of Transportation

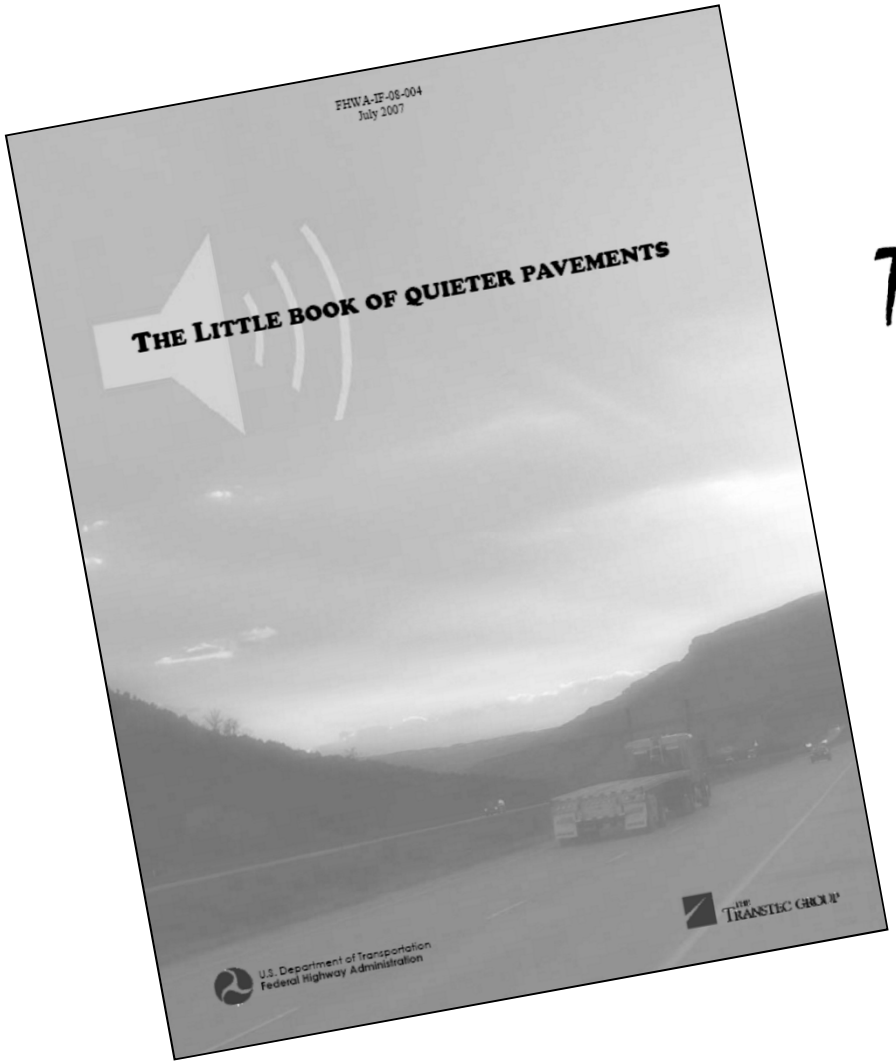
Wisconsin Department of Transportation

CP Road Map



Surface Characteristics Track

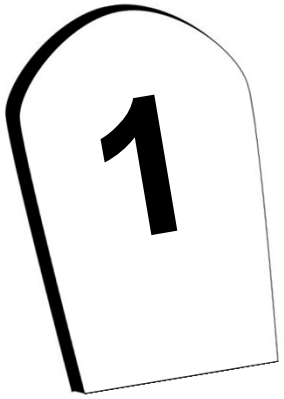
First... some fundamentals



Tire-Pavement Noise 101

Download from
www.TCPSC.com/LittleBookQuieterPavements.pdf

...for a Quieter Pavement



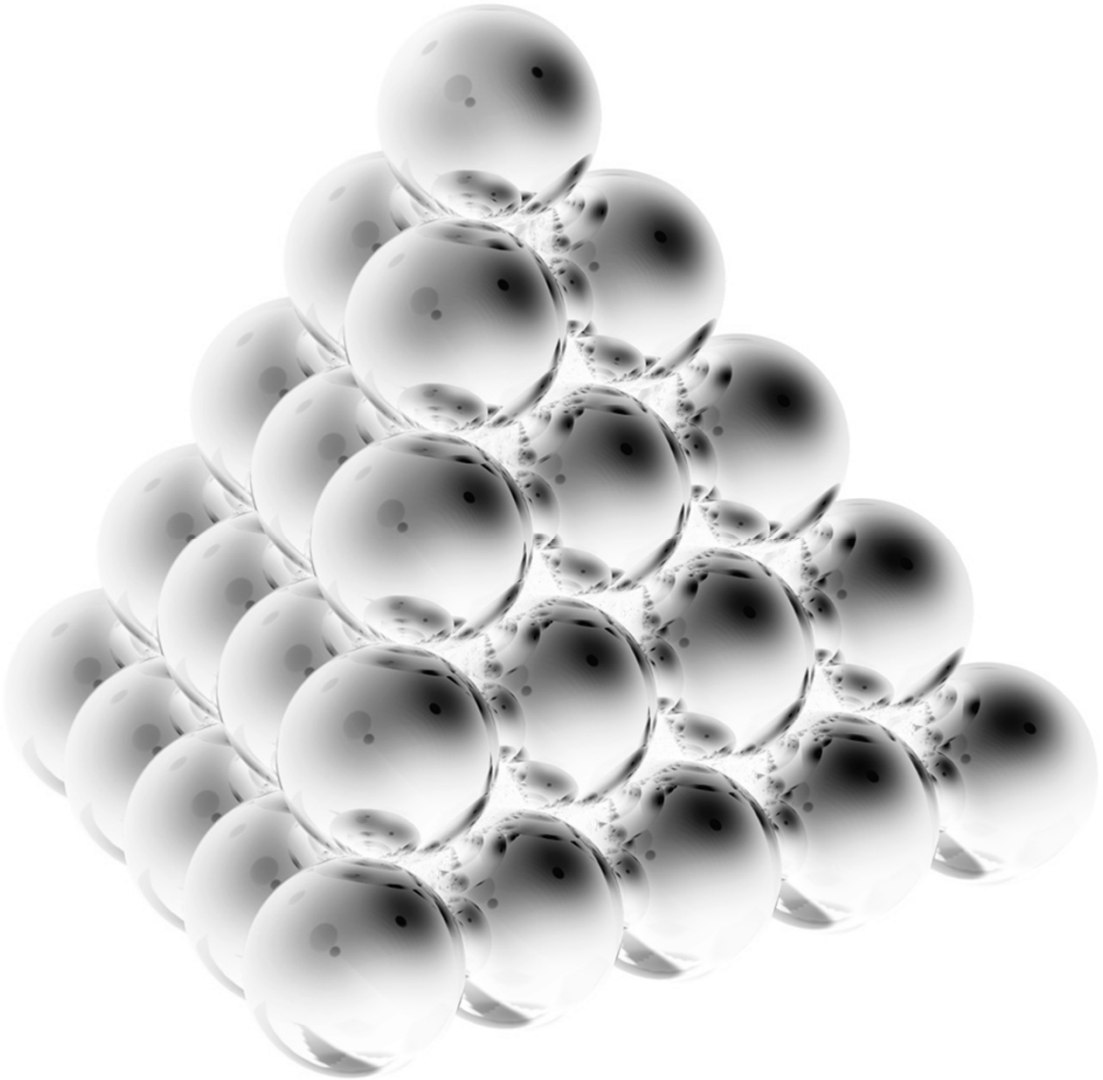
Thou shalt have Texture...

be it small and negative!

Bad

Good

Thou shalt have High Porosity!



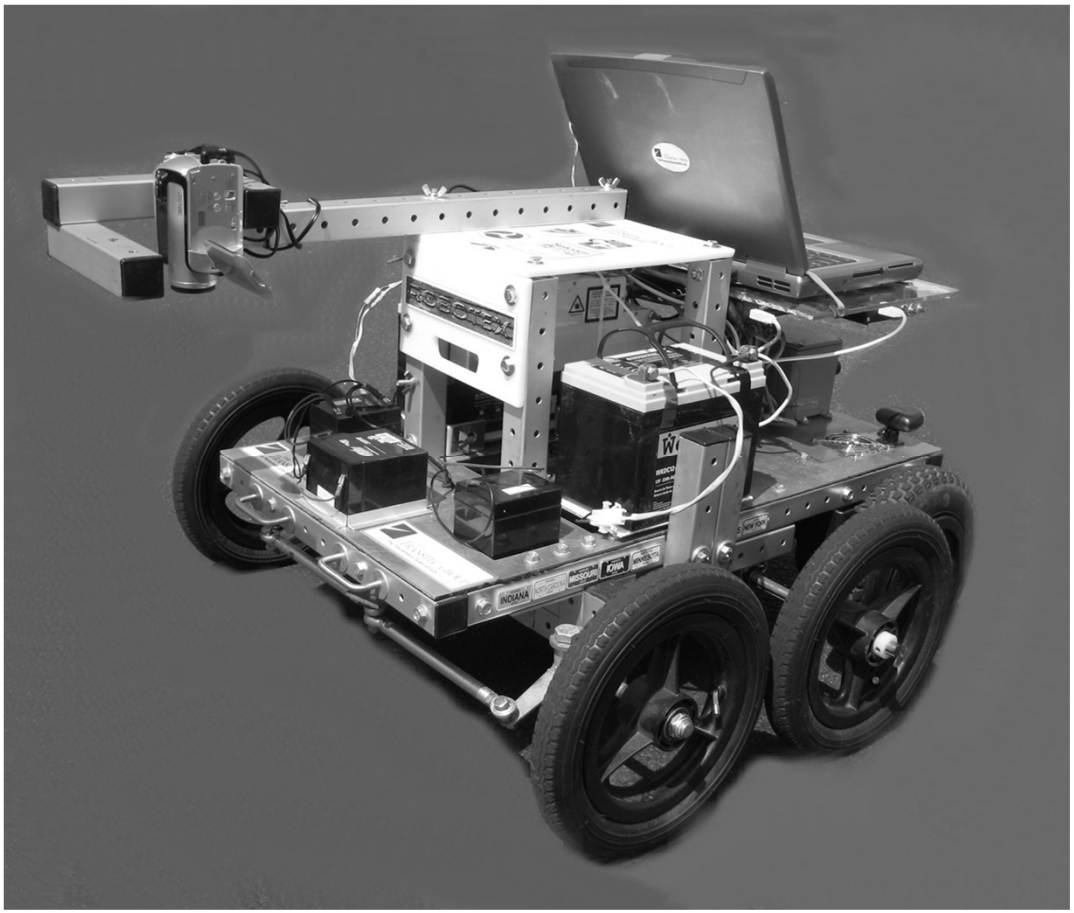
3

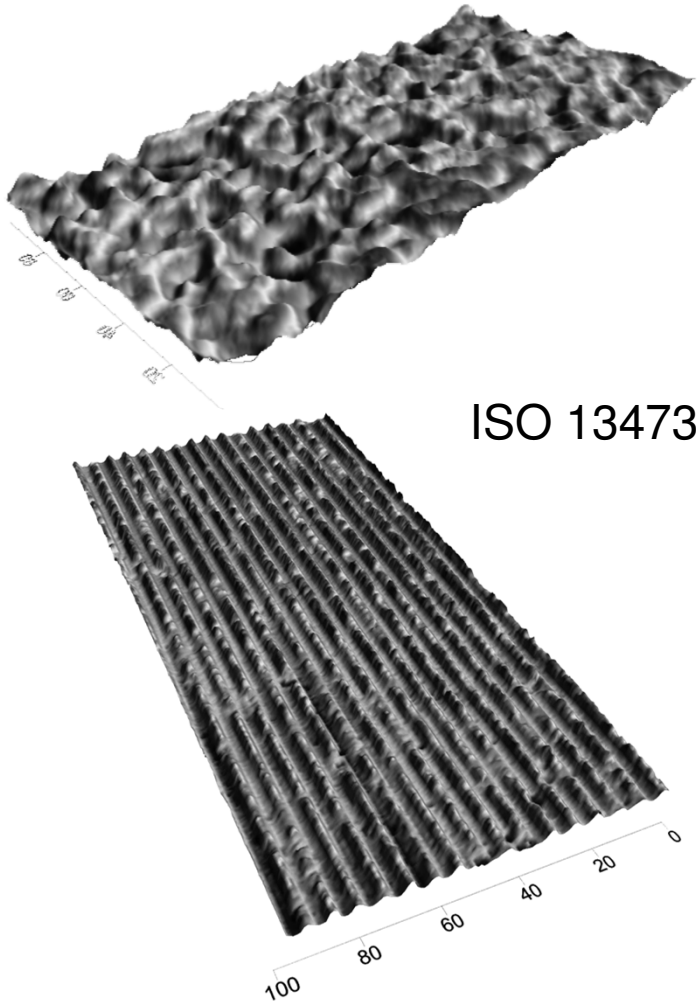
Thou shalt have Low Stiffness!

What have we built?

Texture Testing: RoboTex 2.0

- Built around LMI-Selcom RoLine Sensor
- Laser height sensor, inertial referencing
- GPS, DMI encoder, video log



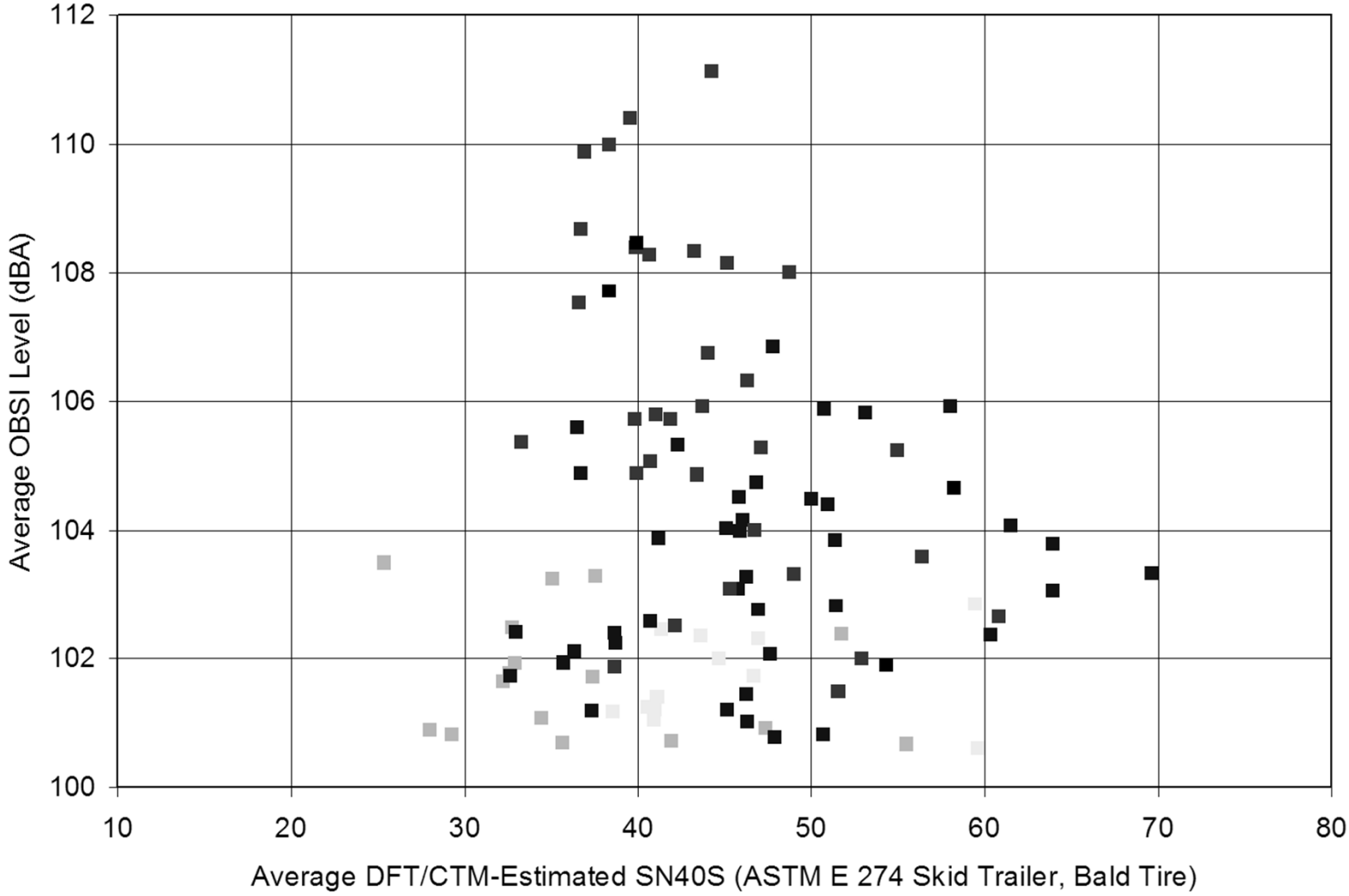


Measuring Noise using OBSI

AASHTO TP 76

Friction vs. Noise

Do Friction and Noise Relate?



CP Tech Center Test Sections

- In 5 years, over 1500 unique textures tested
  - Transverse Tining (incl. skewed and cross-tined)
  - Longitudinal Tining (incl. sinusoidal)
  - Diamond Ground
  - Grooved (longitudinal, transverse)
  - Drag (Burlap, Turf, Broom, Belt, Carpet)
  - Shot Peened
  - Exposed Aggregate
  - Porous (Pervious) Concrete
  - Milled
  - HMA and Surface Treatments
- Hundreds of miles in 20 States and 6 Countries

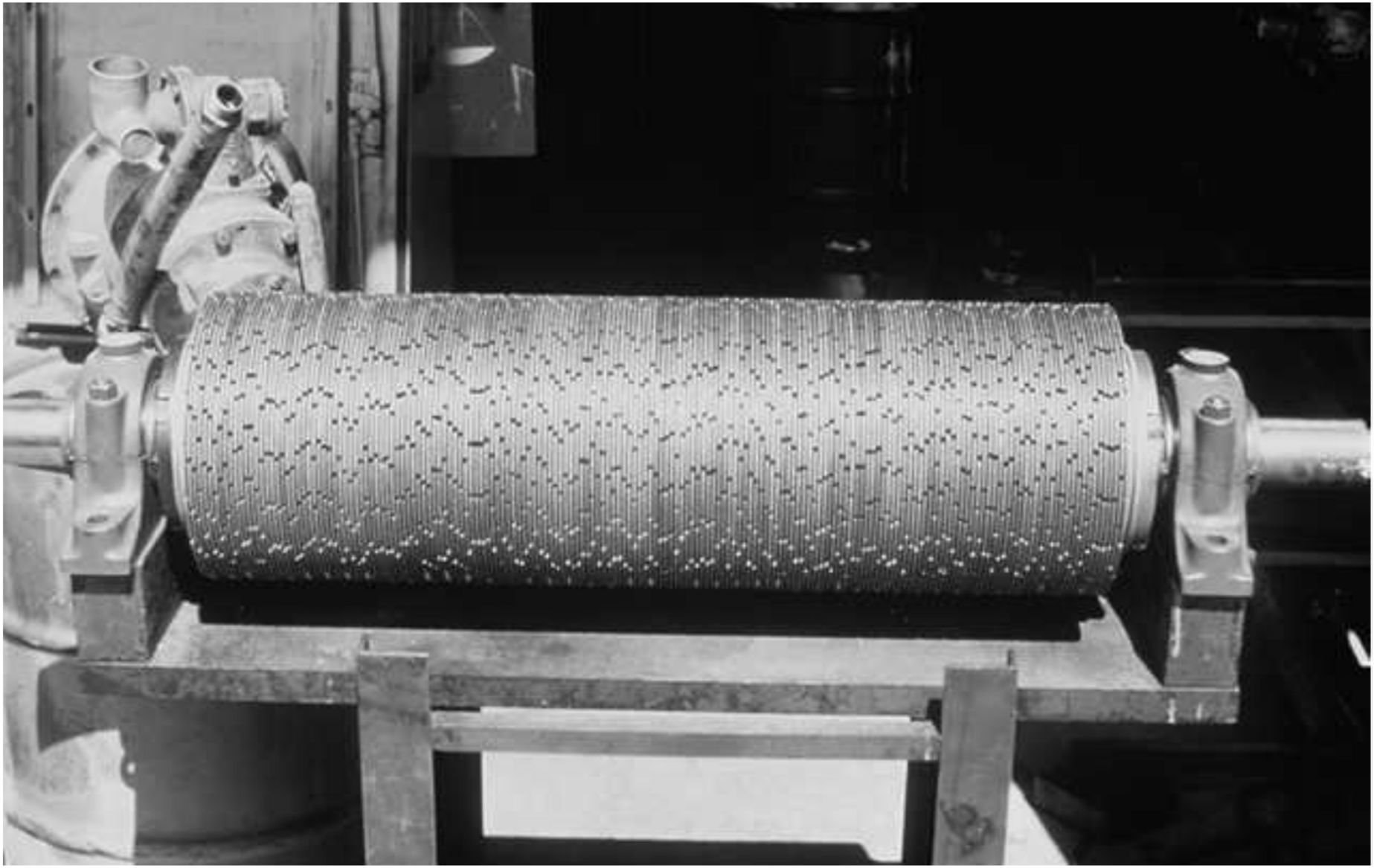
What we've learned

There is a lot of:

VARIABILITY

Variability from project to project, and variability within a given project.

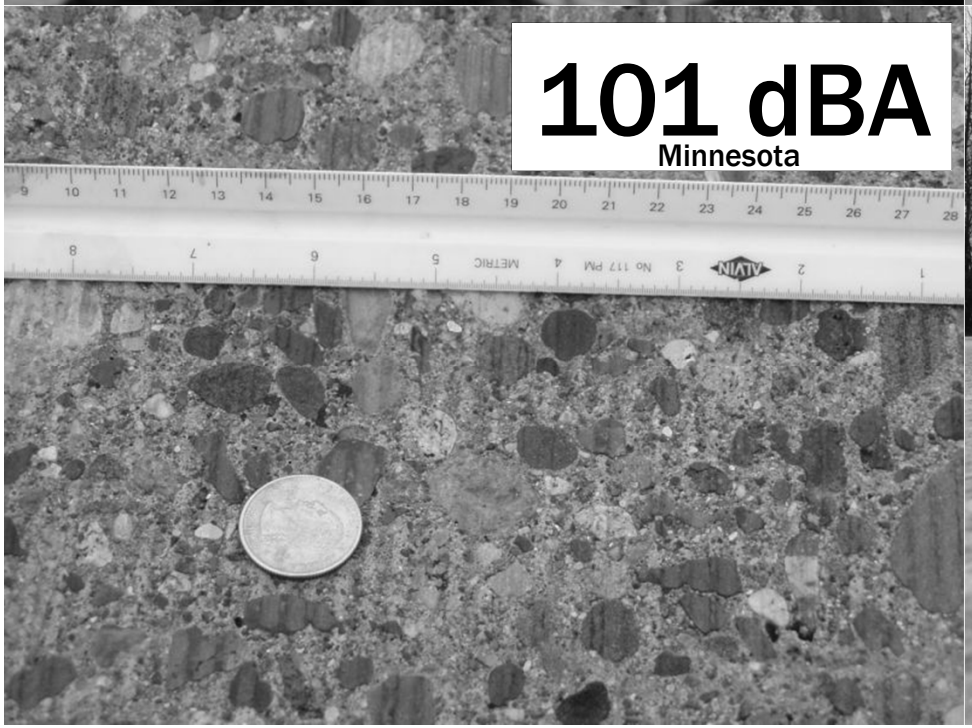
Variability: Diamond Grinding



Source: IGGA

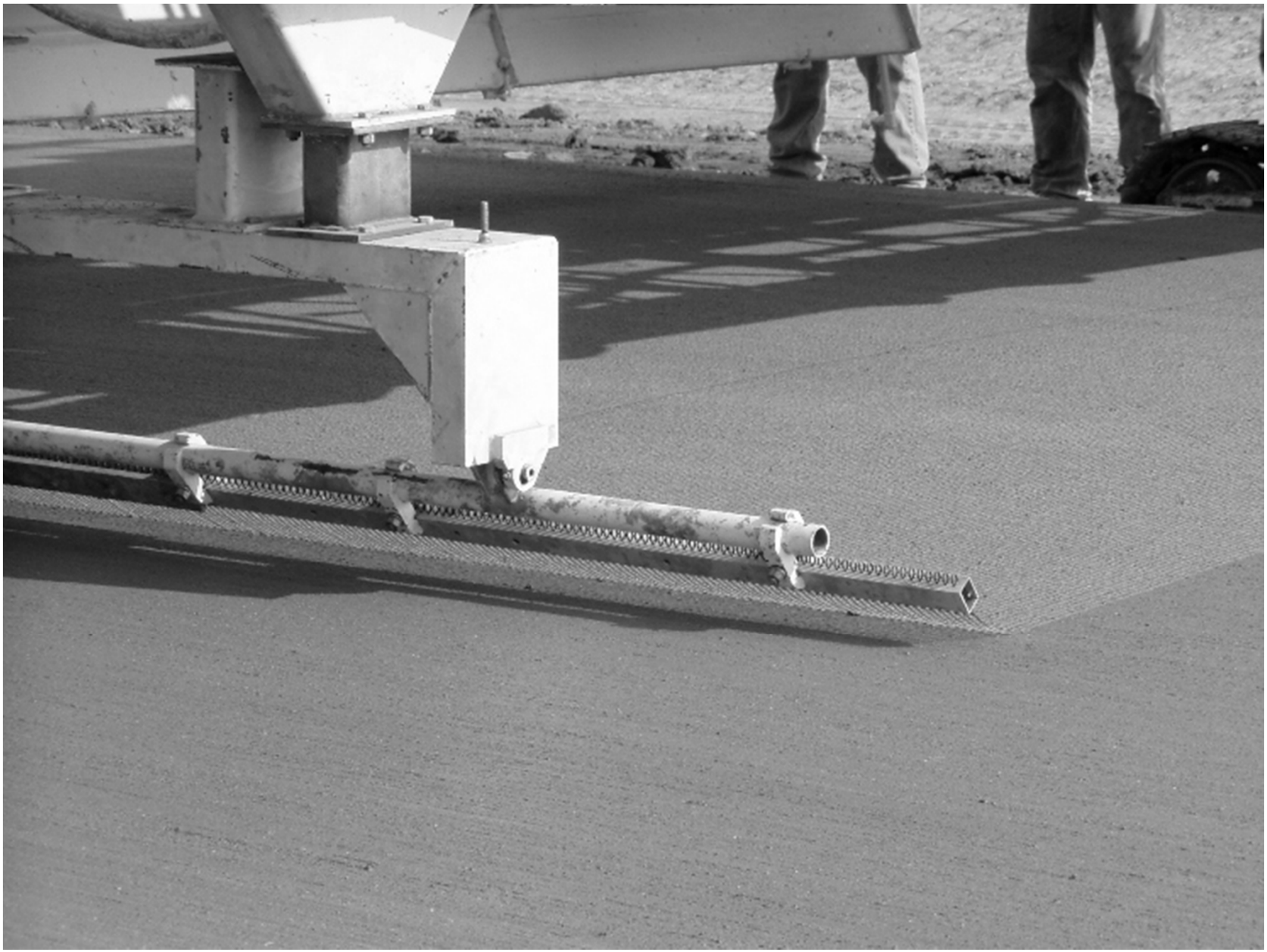

Diamond Grinding
98 dBA
Kansas

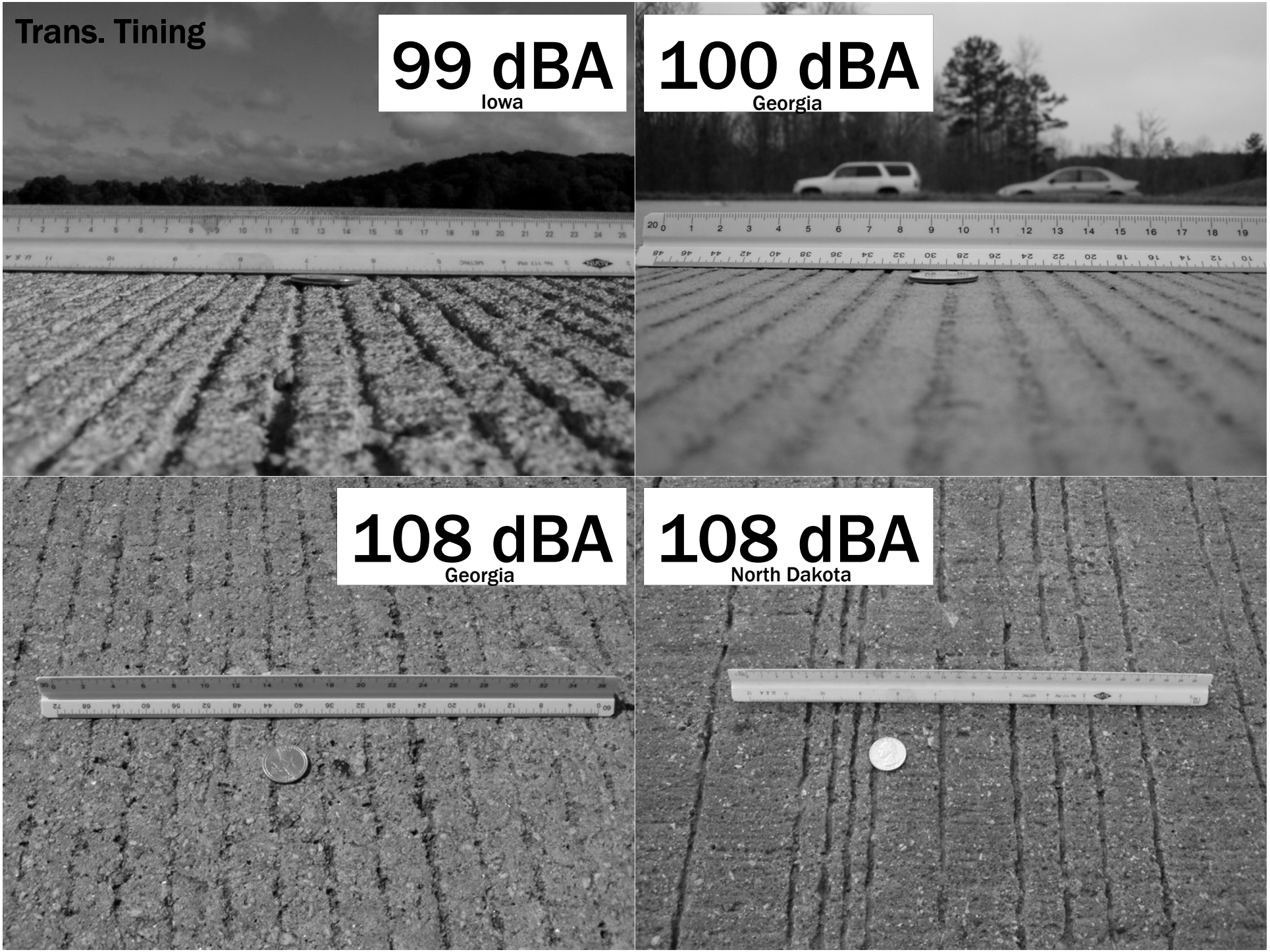

98 dBA
Colorado


101 dBA
Minnesota

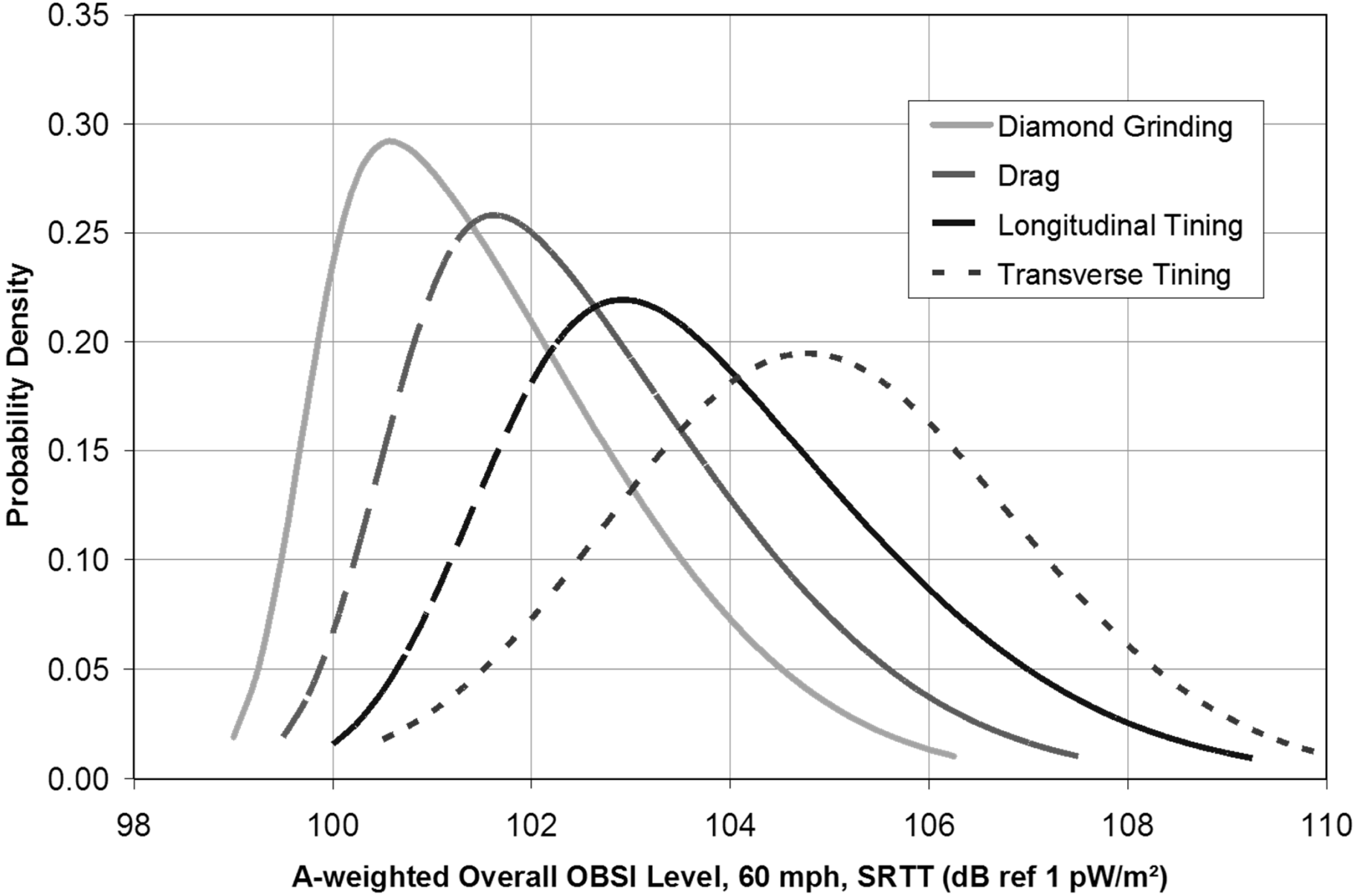

104 dBA
New York

Variability: Transverse Tining




Trans. Tining
99 dBA
Iowa
100 dBA
Georgia
108 dBA
Georgia
108 dBA
North Dakota

CP Tech Center OBSI Noise Catalog



What can we do with this knowledge?

Guide Specifications for Quieter Pavements

- *The tire-pavement noise shall not exceed **X dBA** when measured by **Z procedure** at **D days** after opening to traffic.*

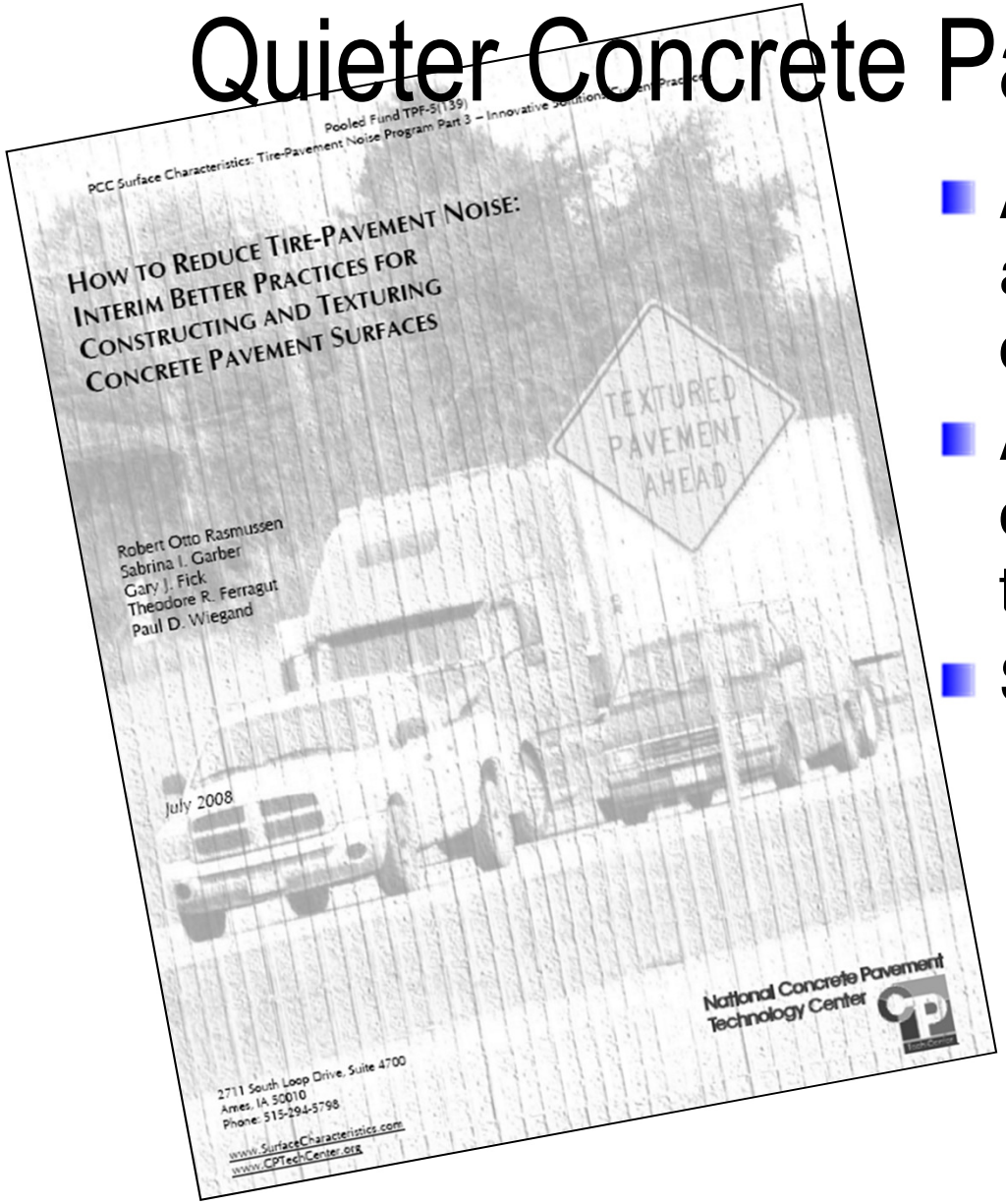
Warranty?

- *This noise threshold shall not be exceeded after **T years**.*

Note

A few States are looking for this NOW!
Guidance is needed to fill in the missing details!

Quieter Concrete Pavement Guidelines



- A “how to” guide for designing and constructing quieter concrete pavements
- Addresses all conventional concrete pavement texture types
- Simple and practical guidance

Download from www.CPTechCenter.org

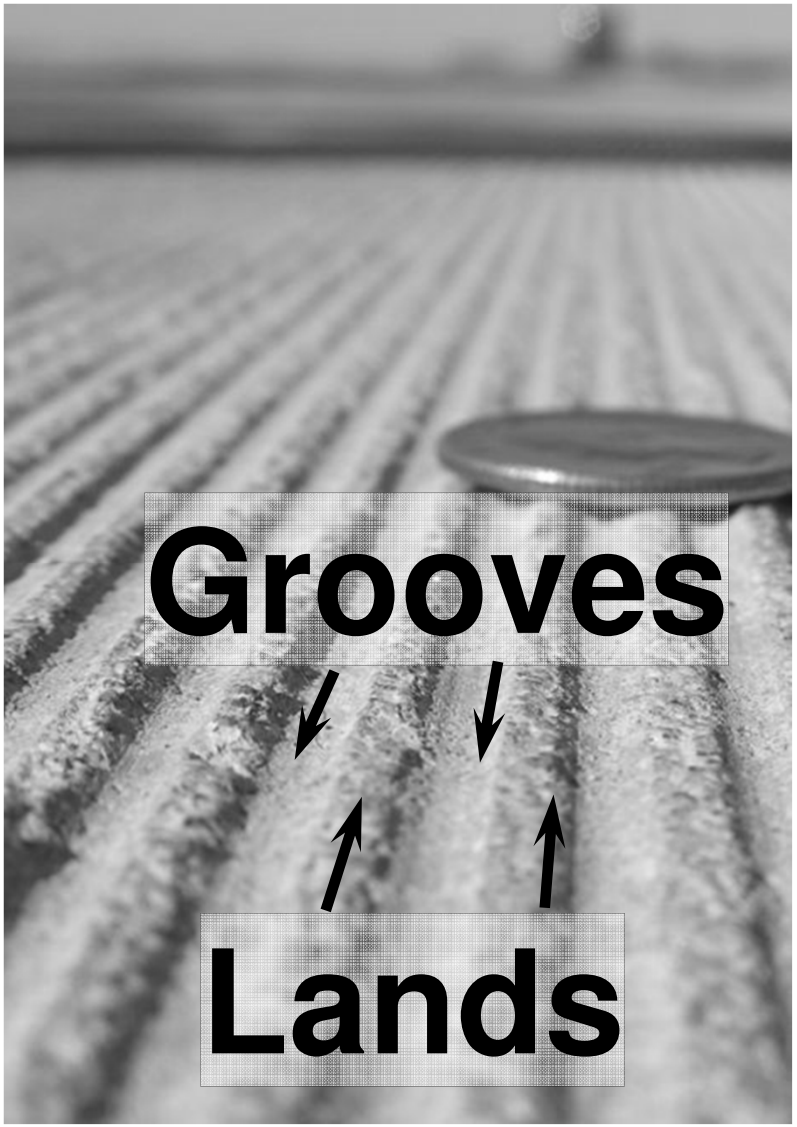
Quieter Concrete Pavement Guidelines

Surface Texture

- Avoid (flatten) texture at intervals > 1 inch
- Avoid smooth (floated or polished) surfaces
  - Some fine texture (< 0.25 inch) required
- Texture should be negative
  - Point down (grooves), not up (fins)
- Texture should be oriented longitudinally
- If transverse, texture should be closely spaced and randomized

Quieter Concrete Pavement Guidelines

Surface Texture



Quieter Concrete Pavement Guidelines

Concrete

- Strong and durable mortar
  - Mix optimized for placement, finishing, curing
- Siliceous sands for durability and friction
- For diamond grinding: hard, durable, and polish resistant coarse aggregate is ideal
- For tined and drag textures: adequate and consistent depth of mortar near the surface

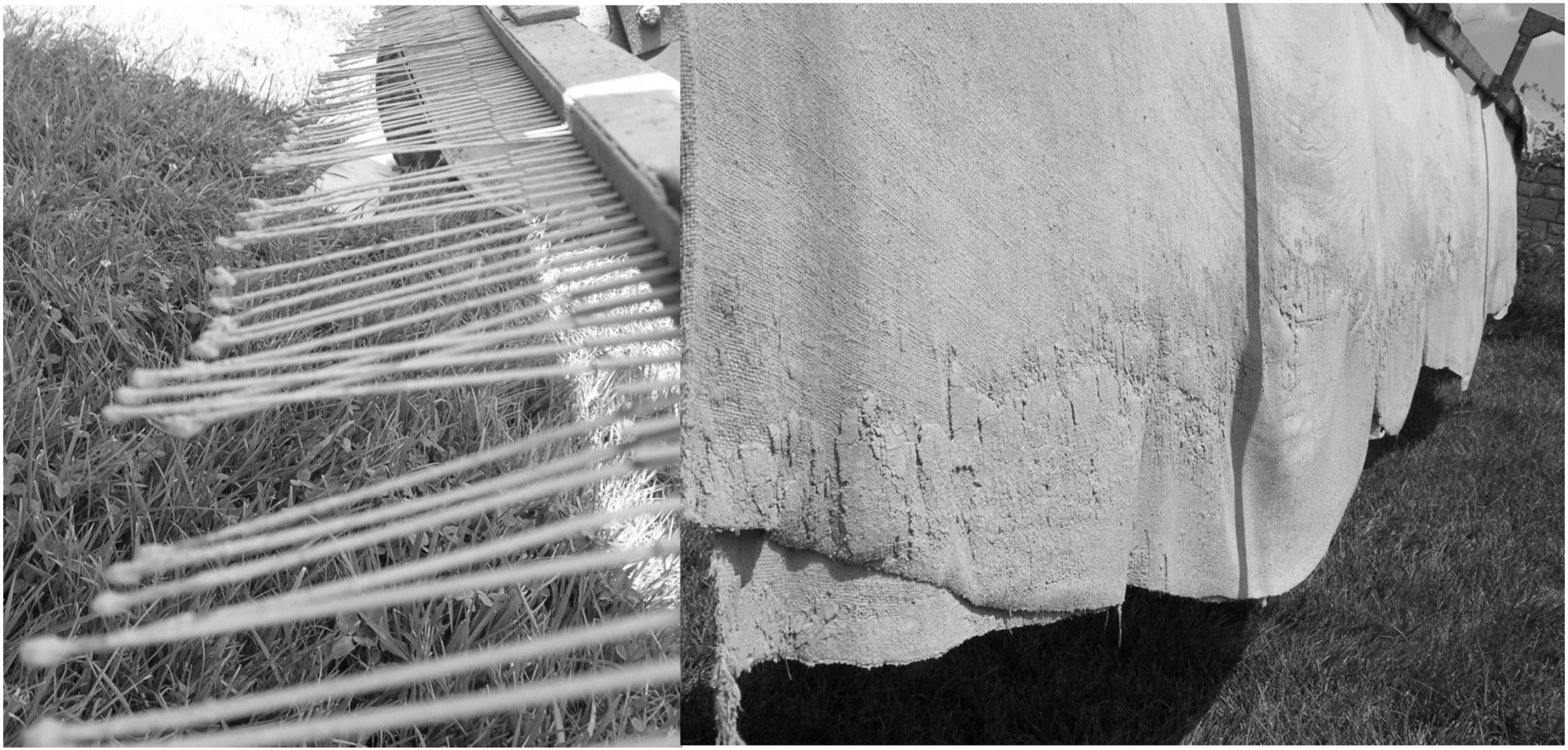
Quieter Concrete Pavement Guidelines

Concrete

Source: Guntert

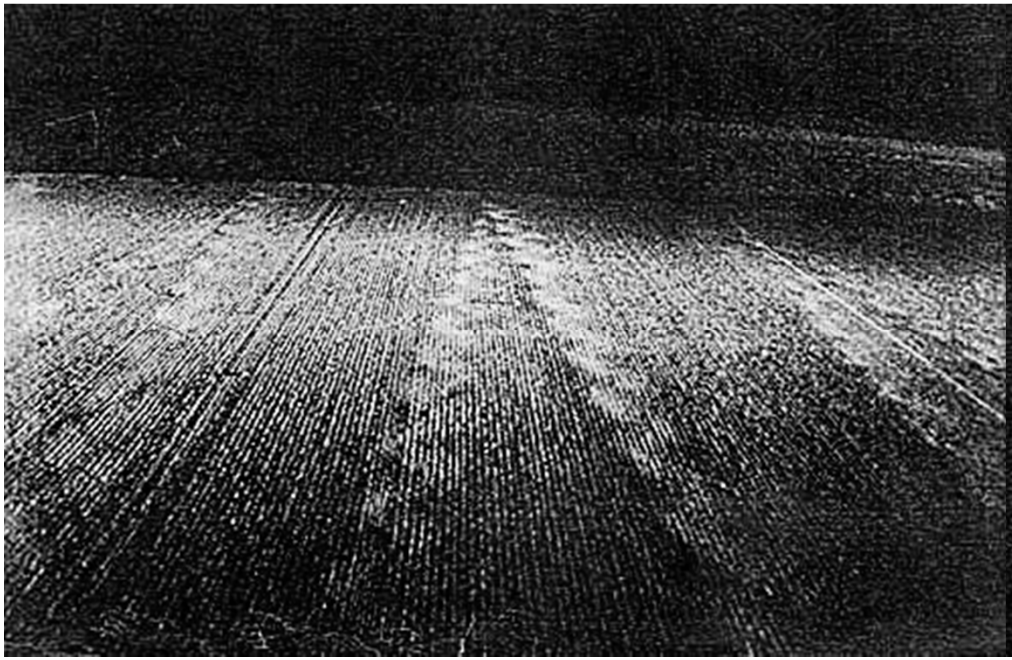
Quieter Concrete Pavement Guidelines

Paving Equipment



Quieter Concrete Pavement Guidelines

Paving Equipment



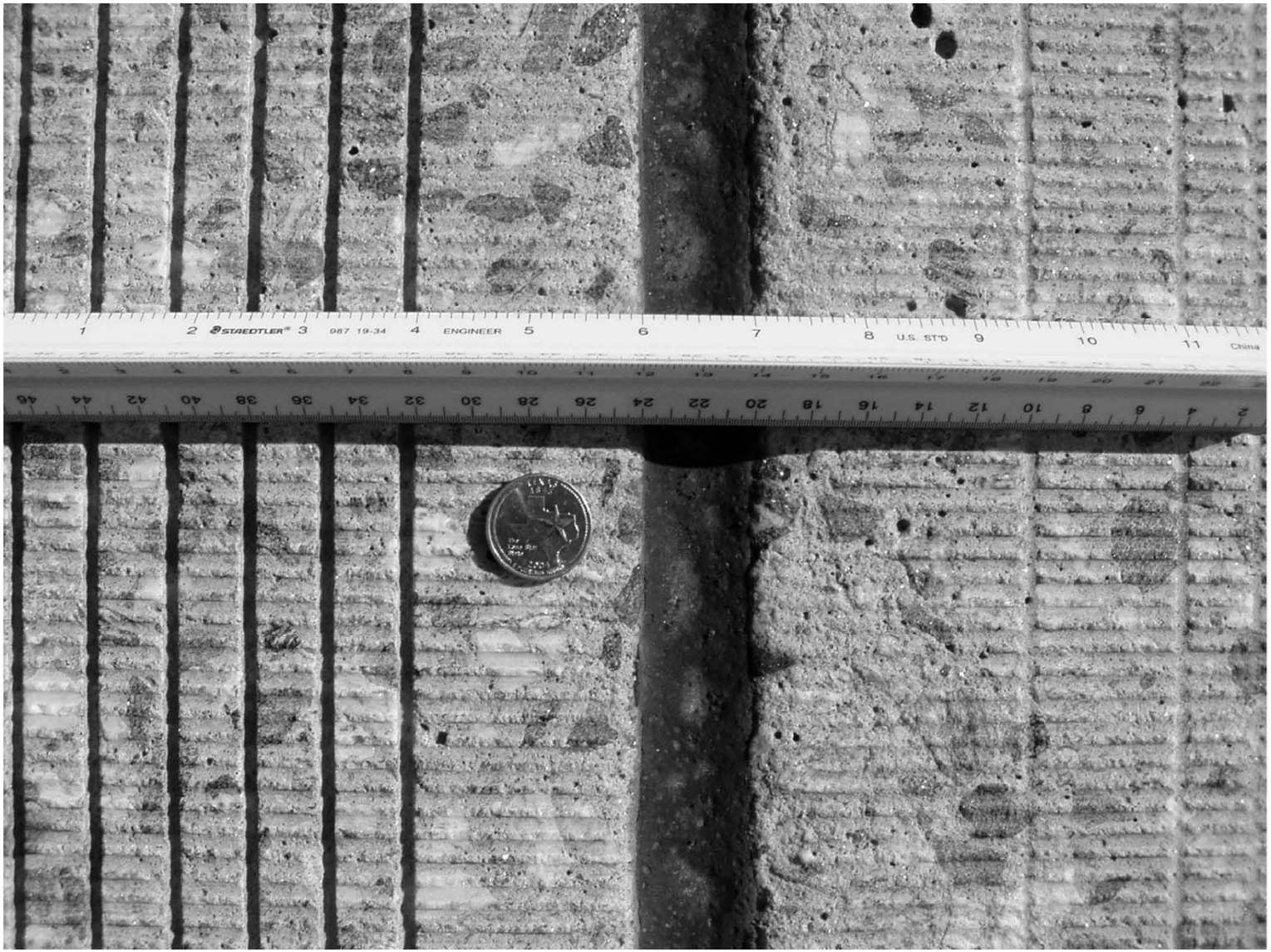
Quieter Concrete Pavement Guidelines

Joints

- Can affect noise levels and annoyance
- Narrow, single-cut joints preferred
  - Avoid widened (reservoir) cuts
- Avoid faulted joints
  - Design or retrofit adequate load transfer
- Avoid protruding joint sealant
- Avoid spalled joints
  - Design, materials selection, and construction

Quieter Concrete Pavement Guidelines

Joints



Quieter Concrete Pavement Guidelines

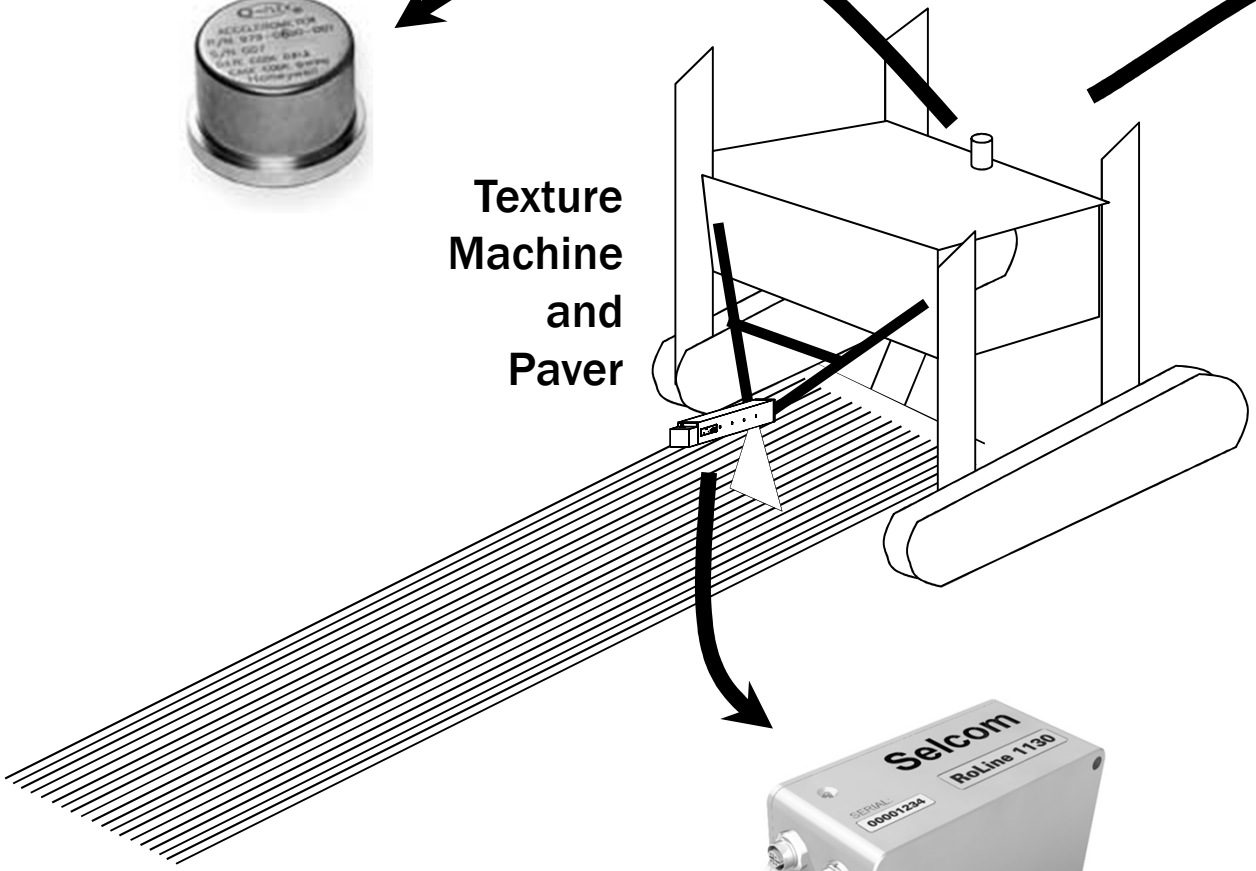
What can we do in the field?

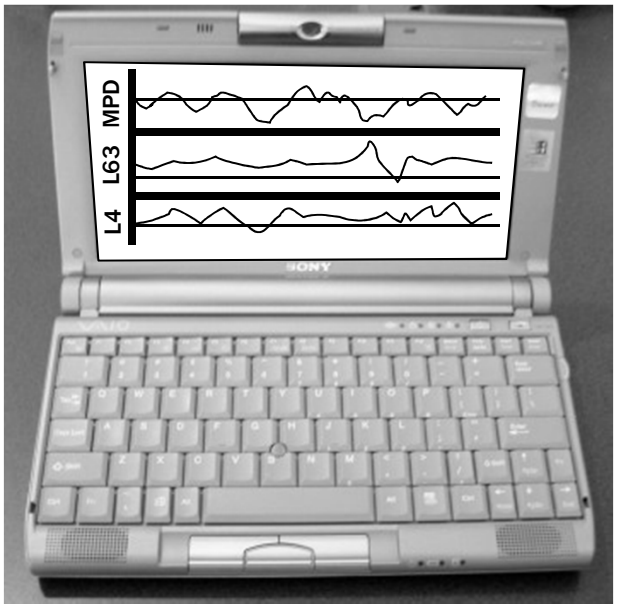
Monitor Construction Operations

Monitor Construction Operations

Accelerometers

Texture Machine and Paver

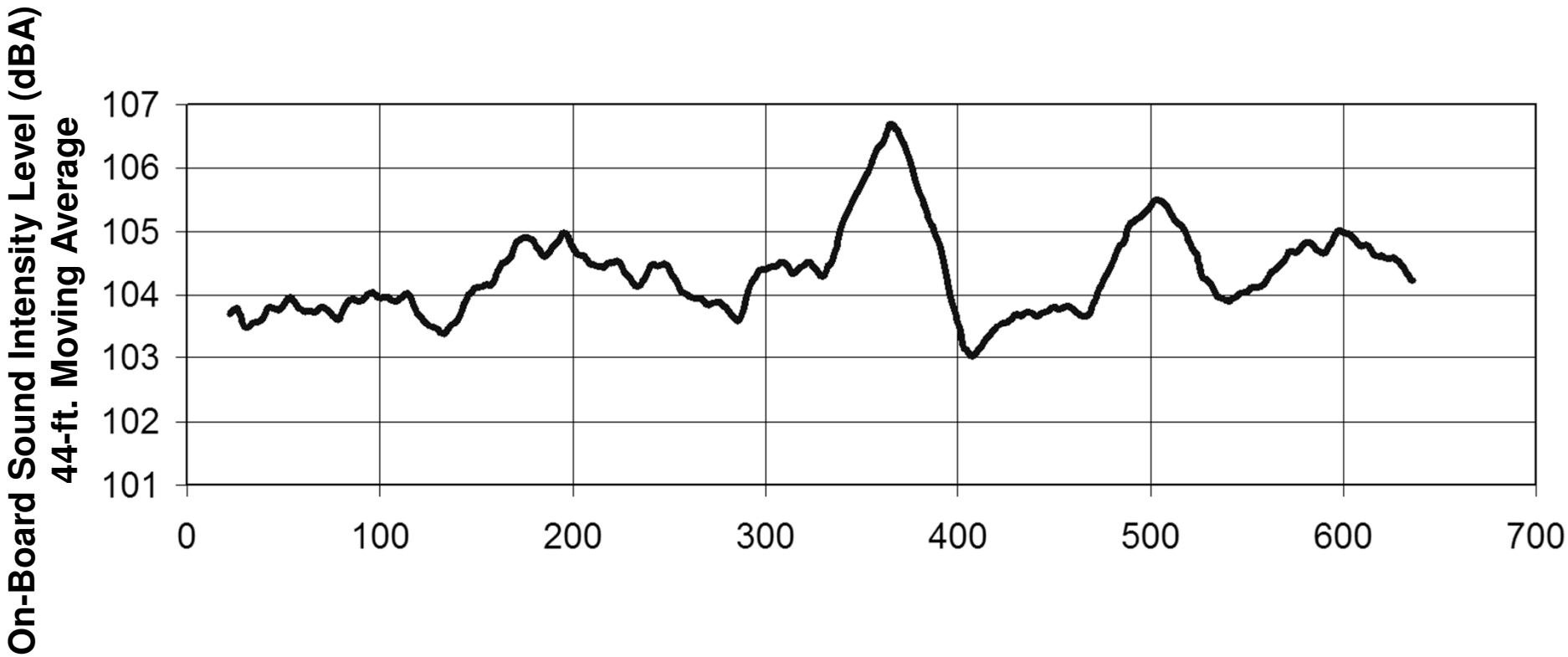




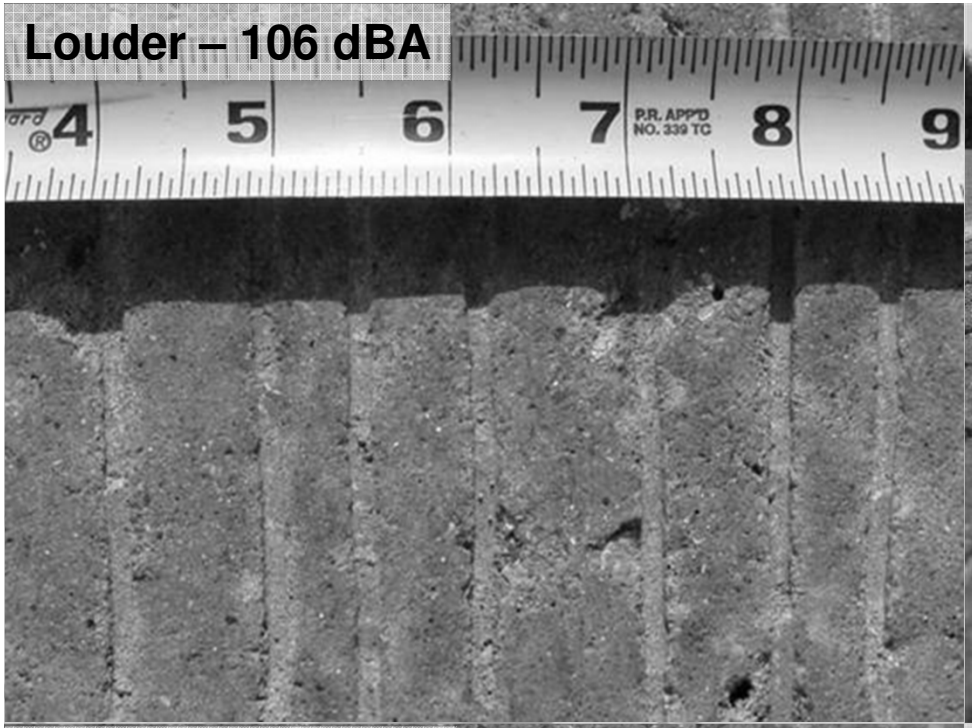
Texture and Vibration Feedback

LMI-Selcom
RoLine
Line Laser

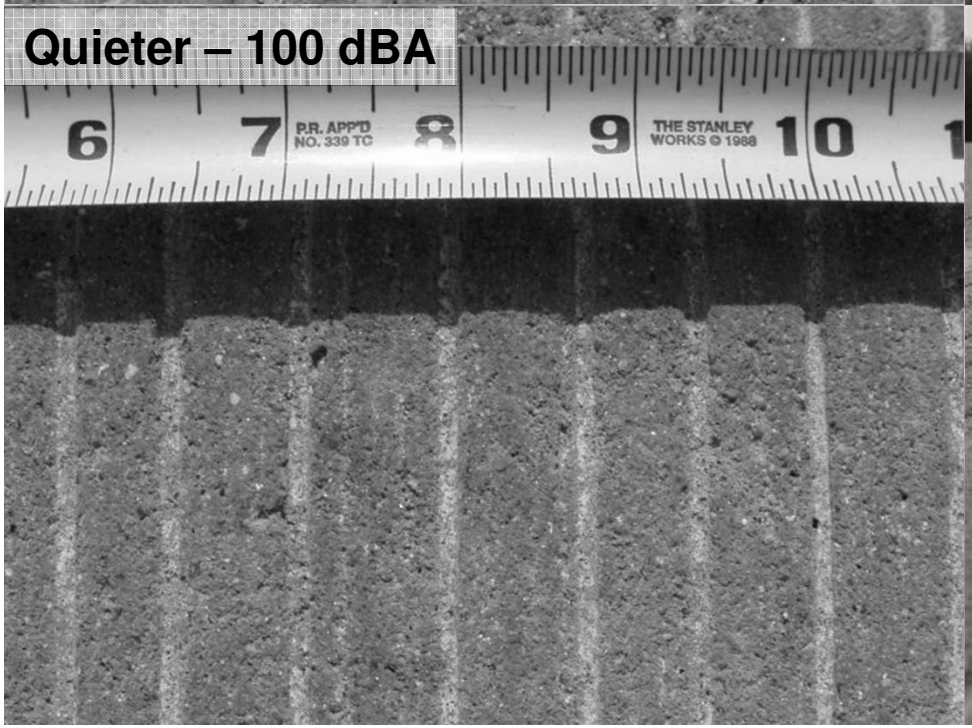
Monitor Construction Operations

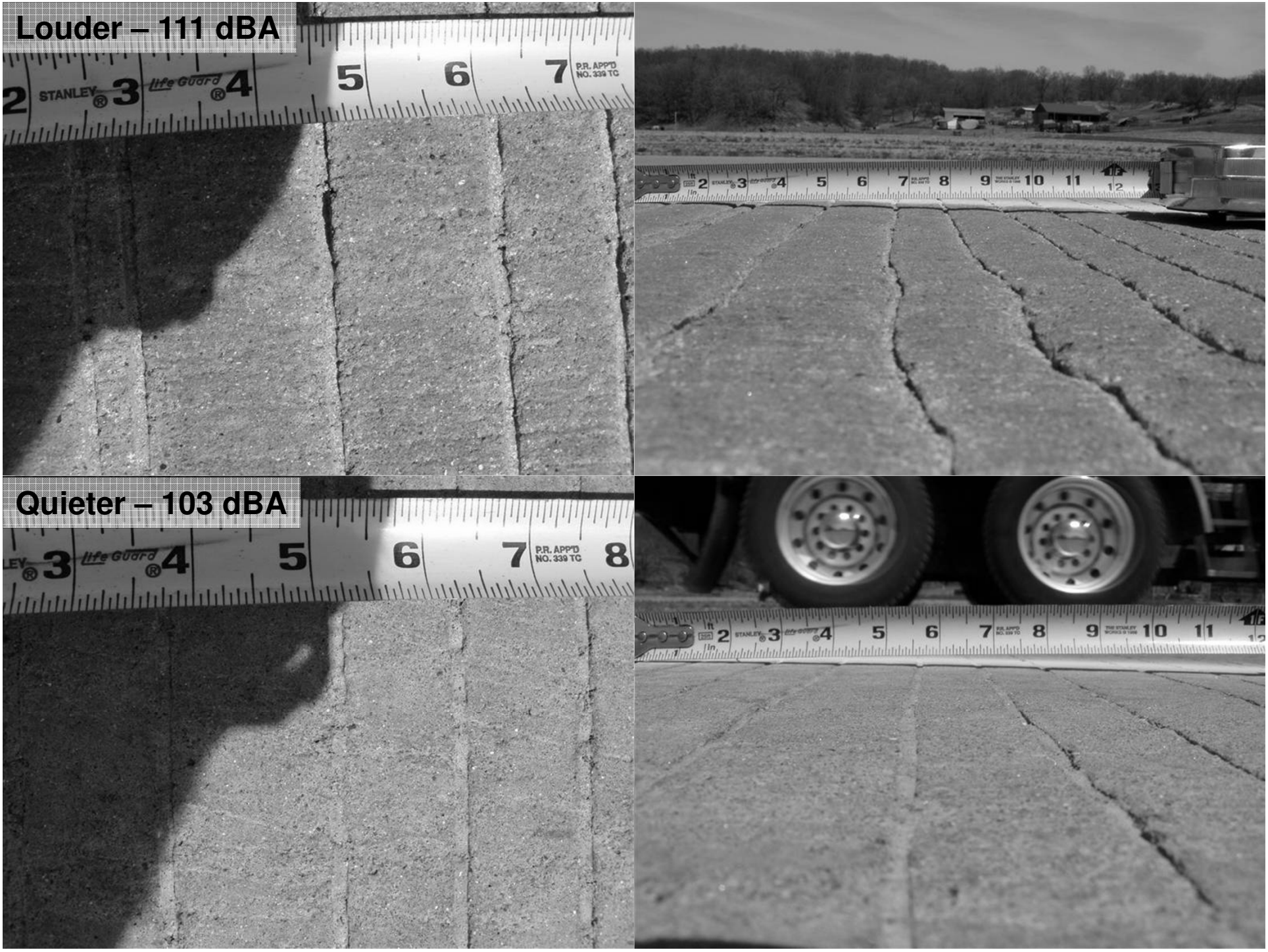


Louder – 106 dBA

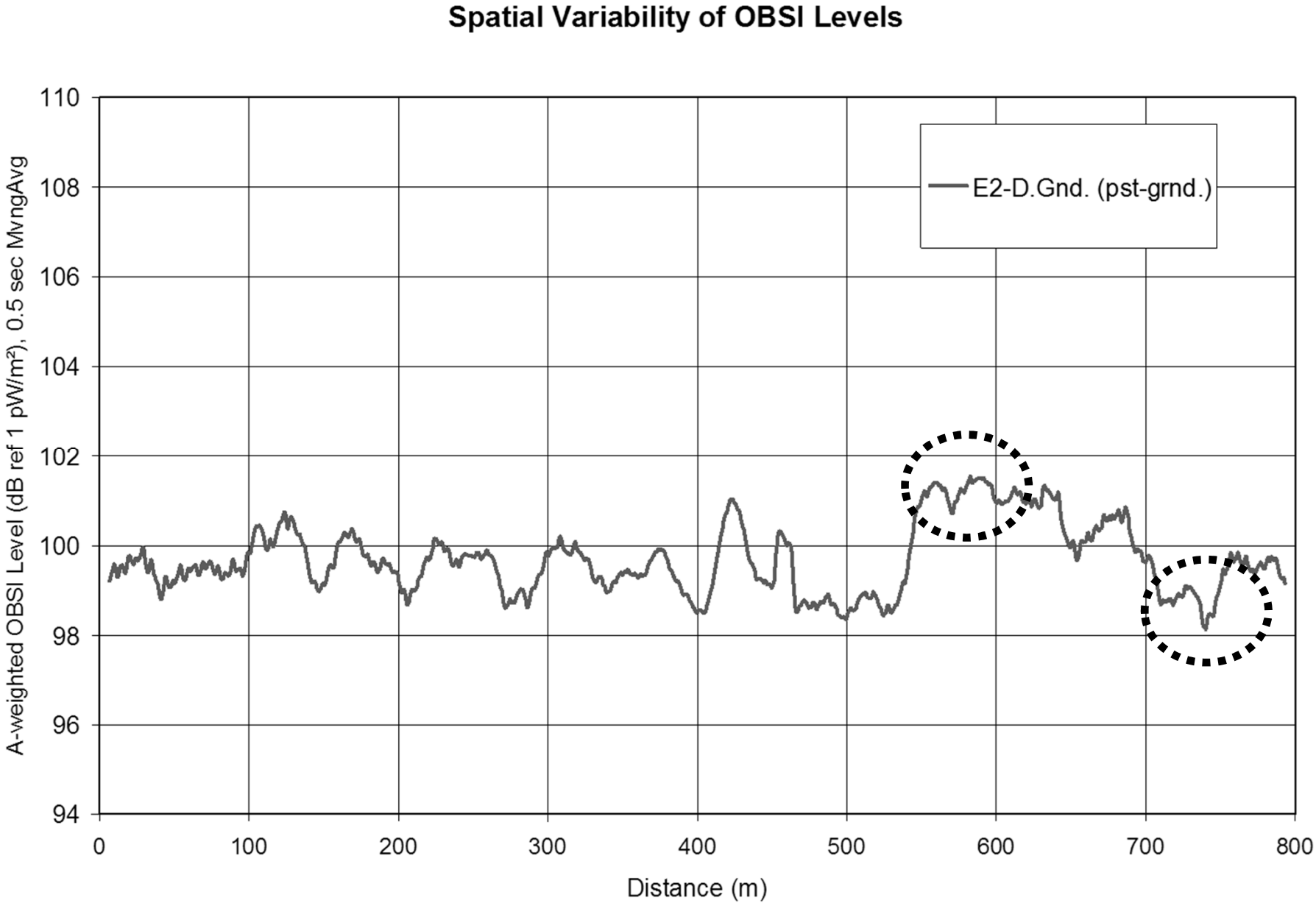


Quieter – 100 dBA

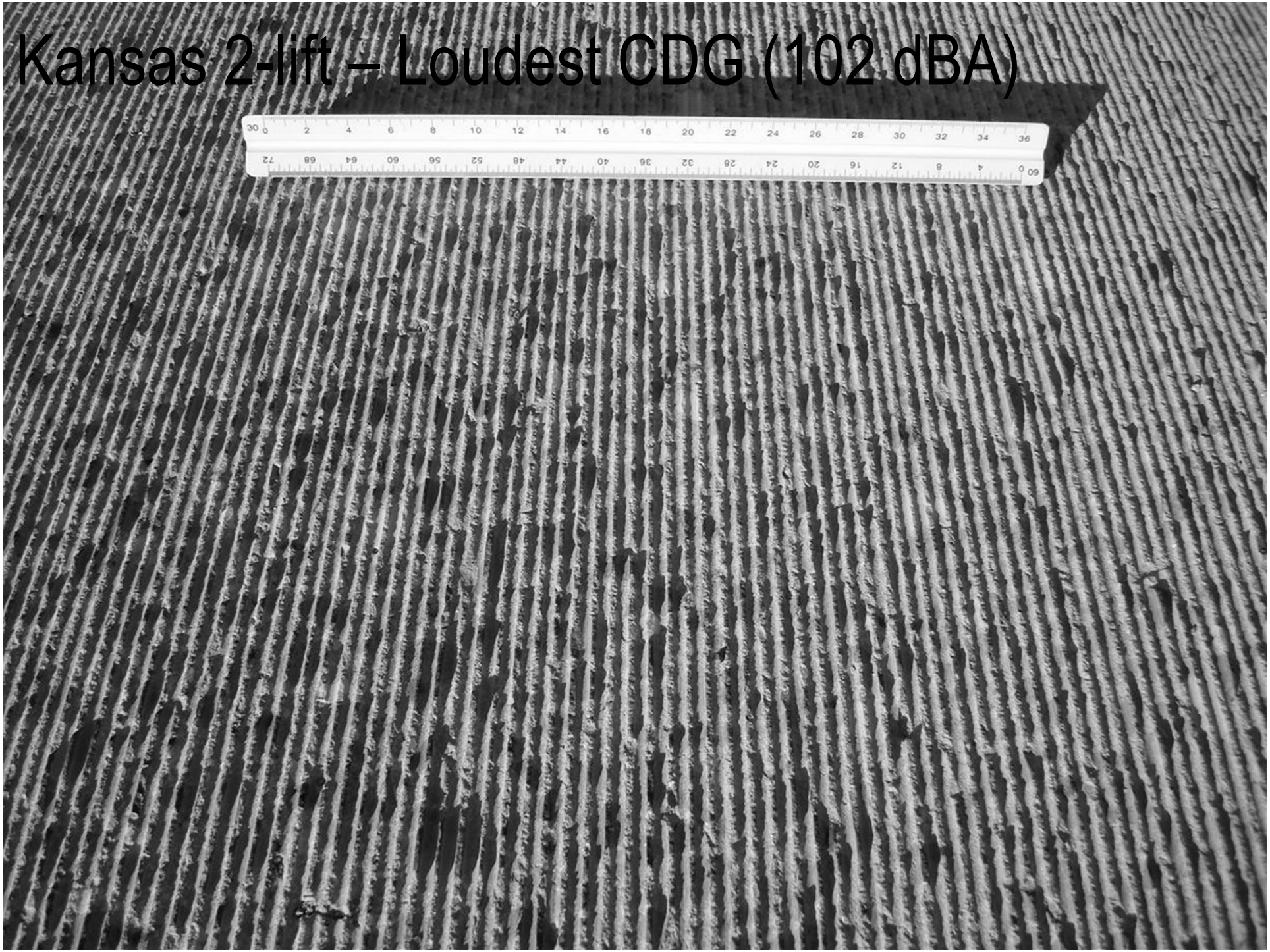



Louder – 111 dBA
Quieter – 103 dBA

Monitor Construction Operations

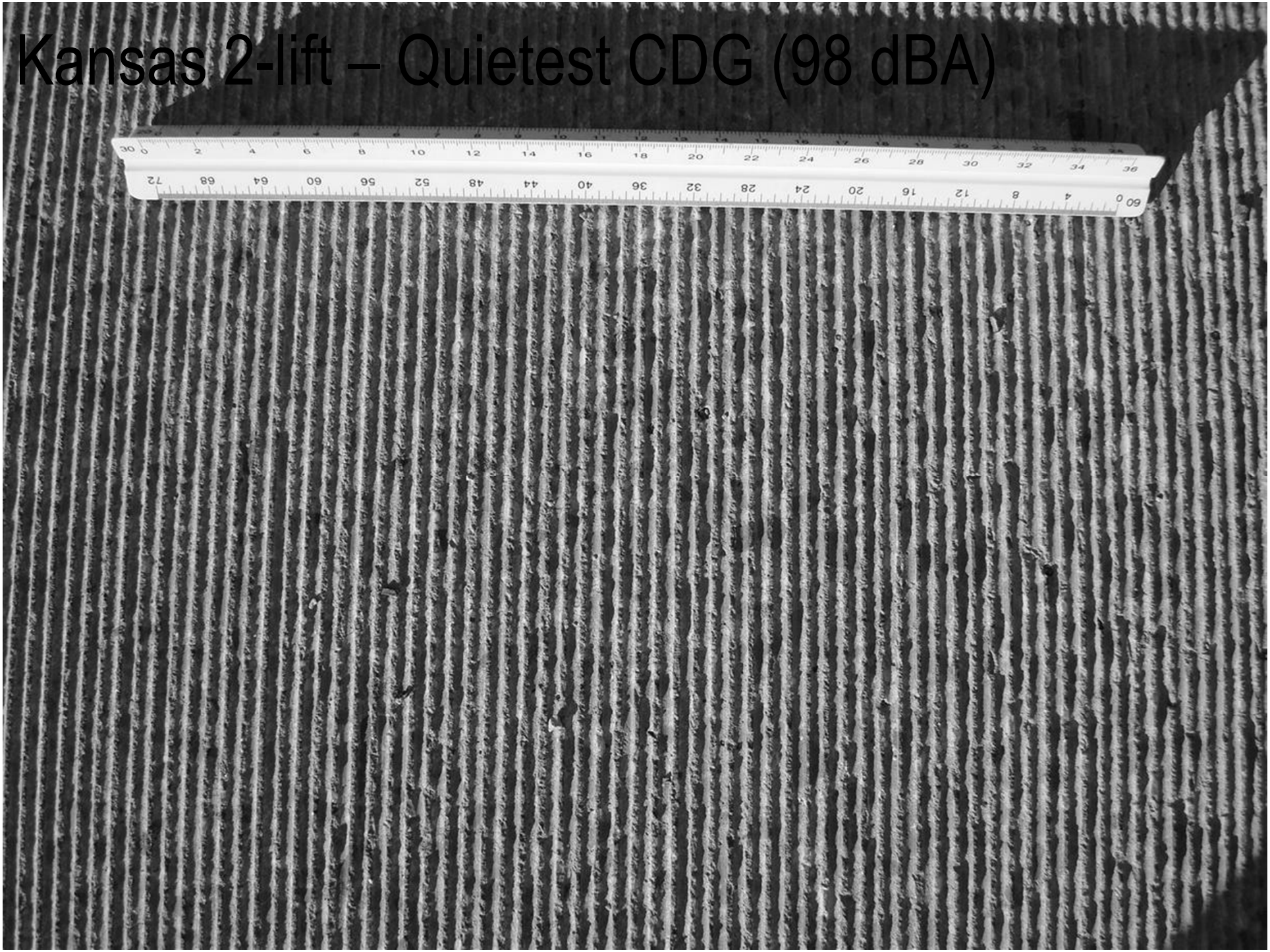


Kansas 2-lift – Loudest CDG (102 dBA)



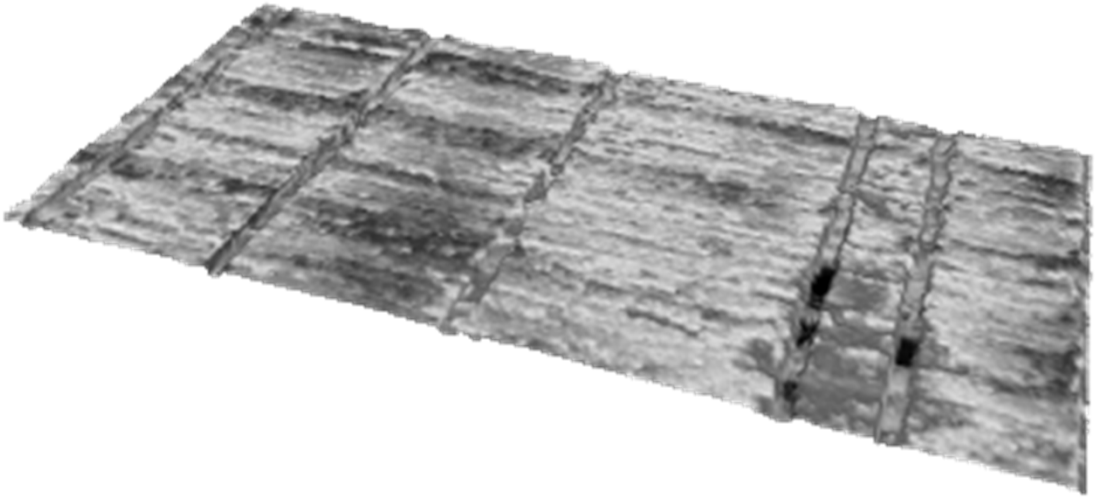
Kansas 2-lift – Loudest CDG (102 dBA)

Kansas 2-lift – Quietest CDG (98 dBA)

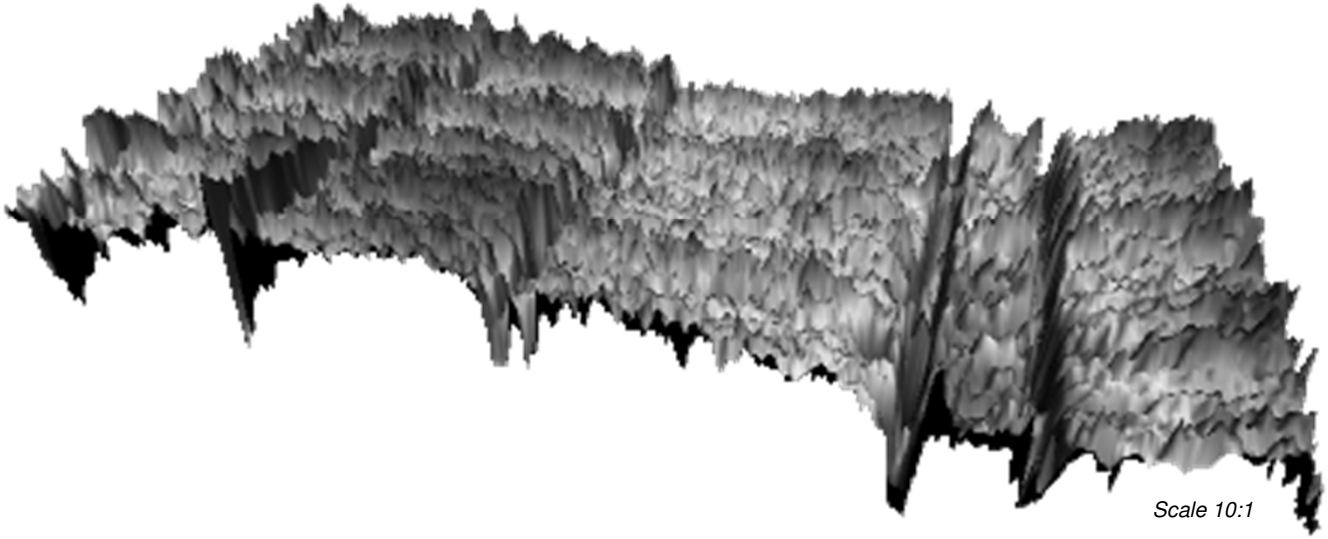


Kansas 2-lift – Quietest CDG (98 dBA)

Monitor Construction Operations



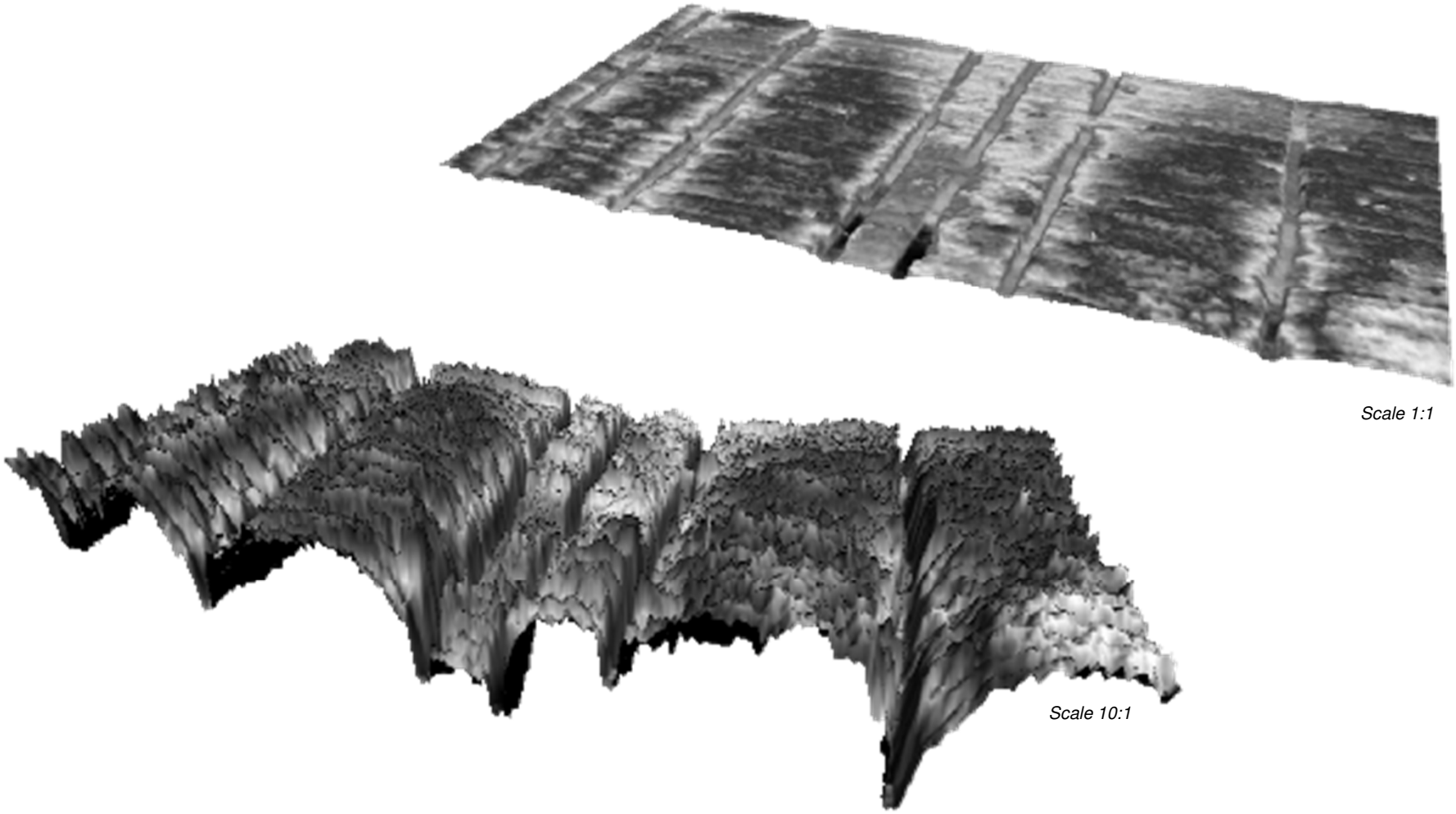
Scale 1:1



Scale 10:1

Quieter – 103 dBA

Monitor Construction Operations

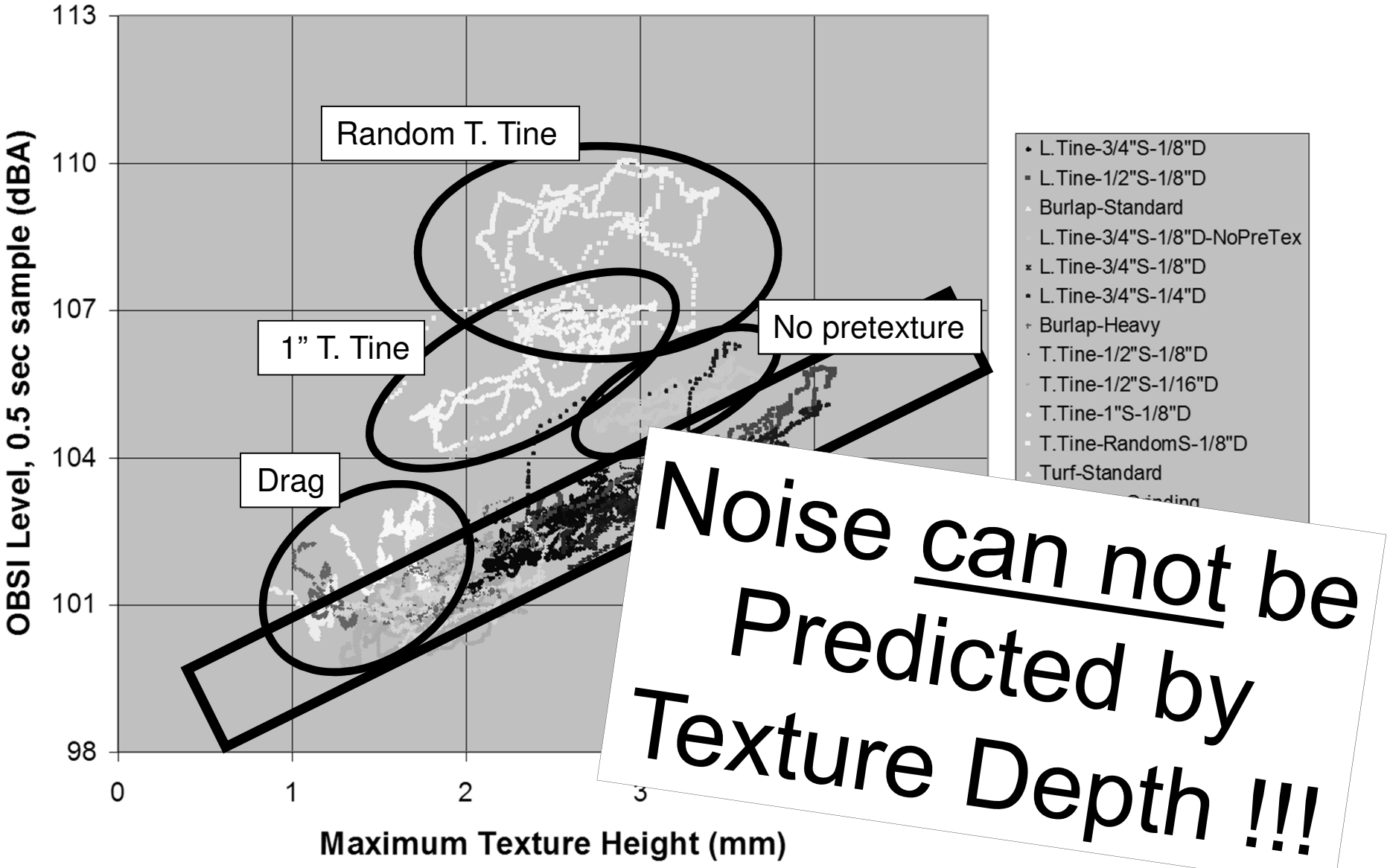


Scale 1:1

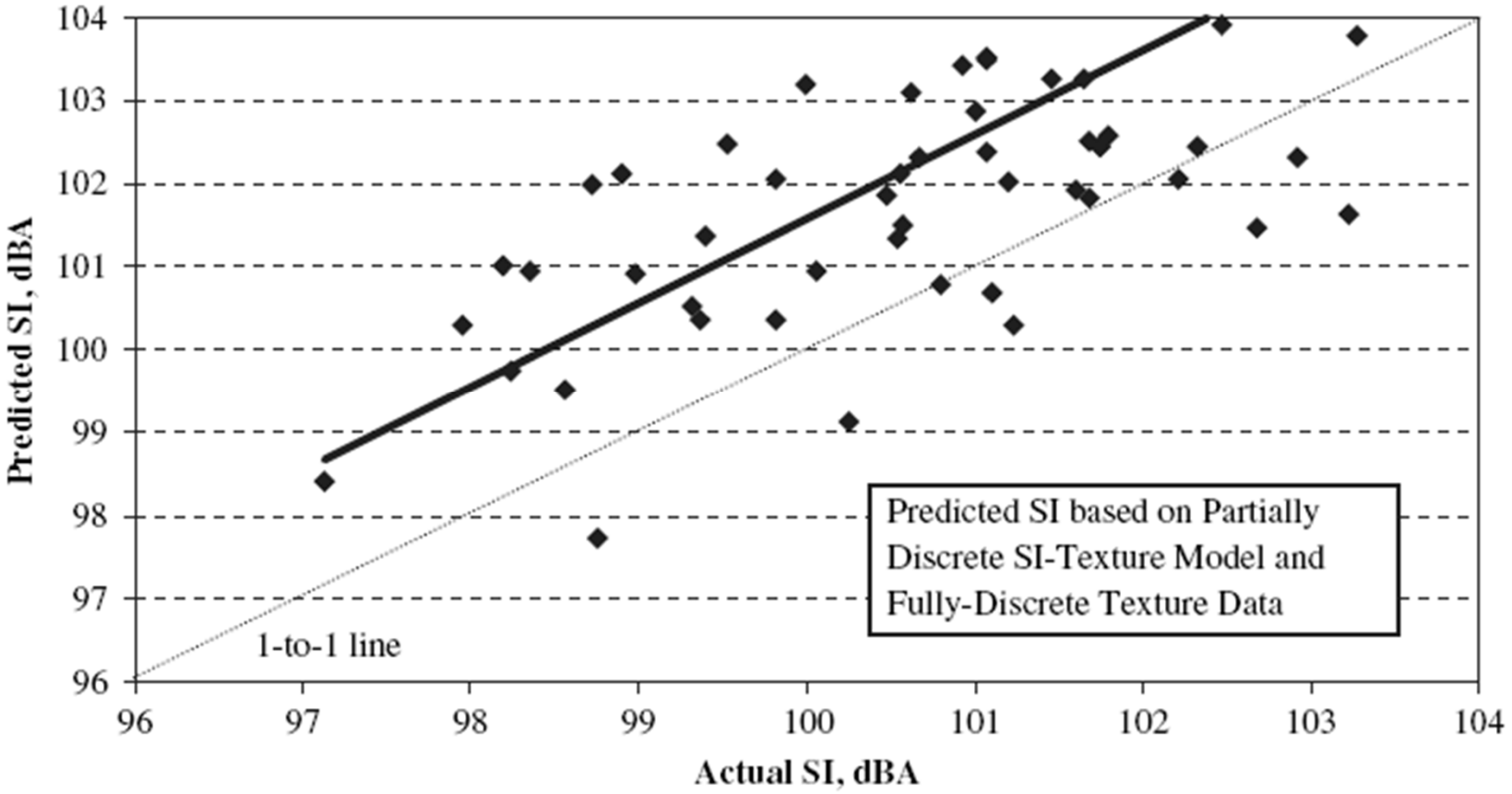
Scale 10:1

Louder – 111 dBA

Predicting Noise from Texture



Is this Predictable Noise ???!?



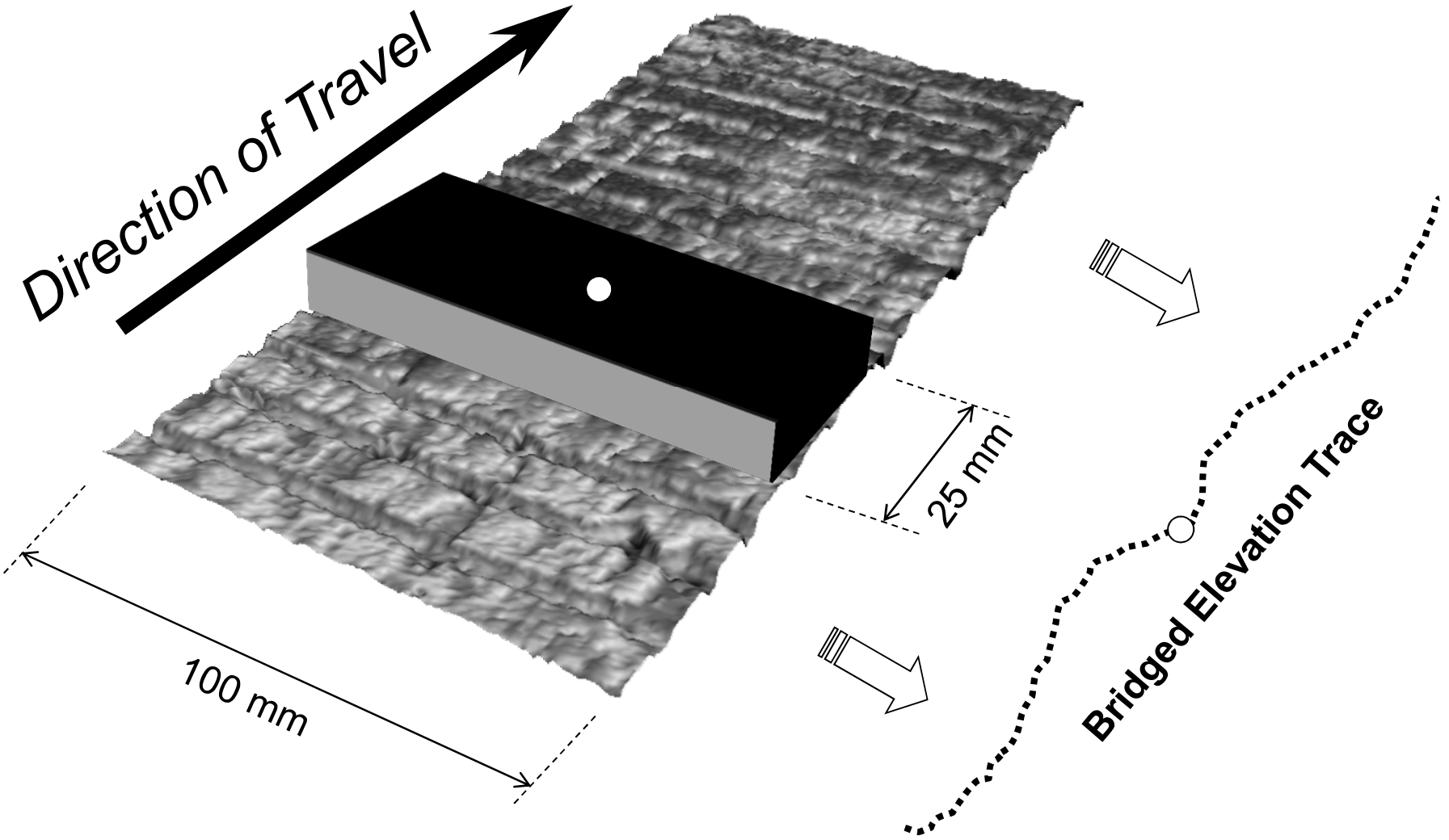
$$SI = 106.63 - 14.28 \times A_1/A_2 + 2.79 \times RMS - 1.25 \times Dir \quad \mathbf{I}$$

where

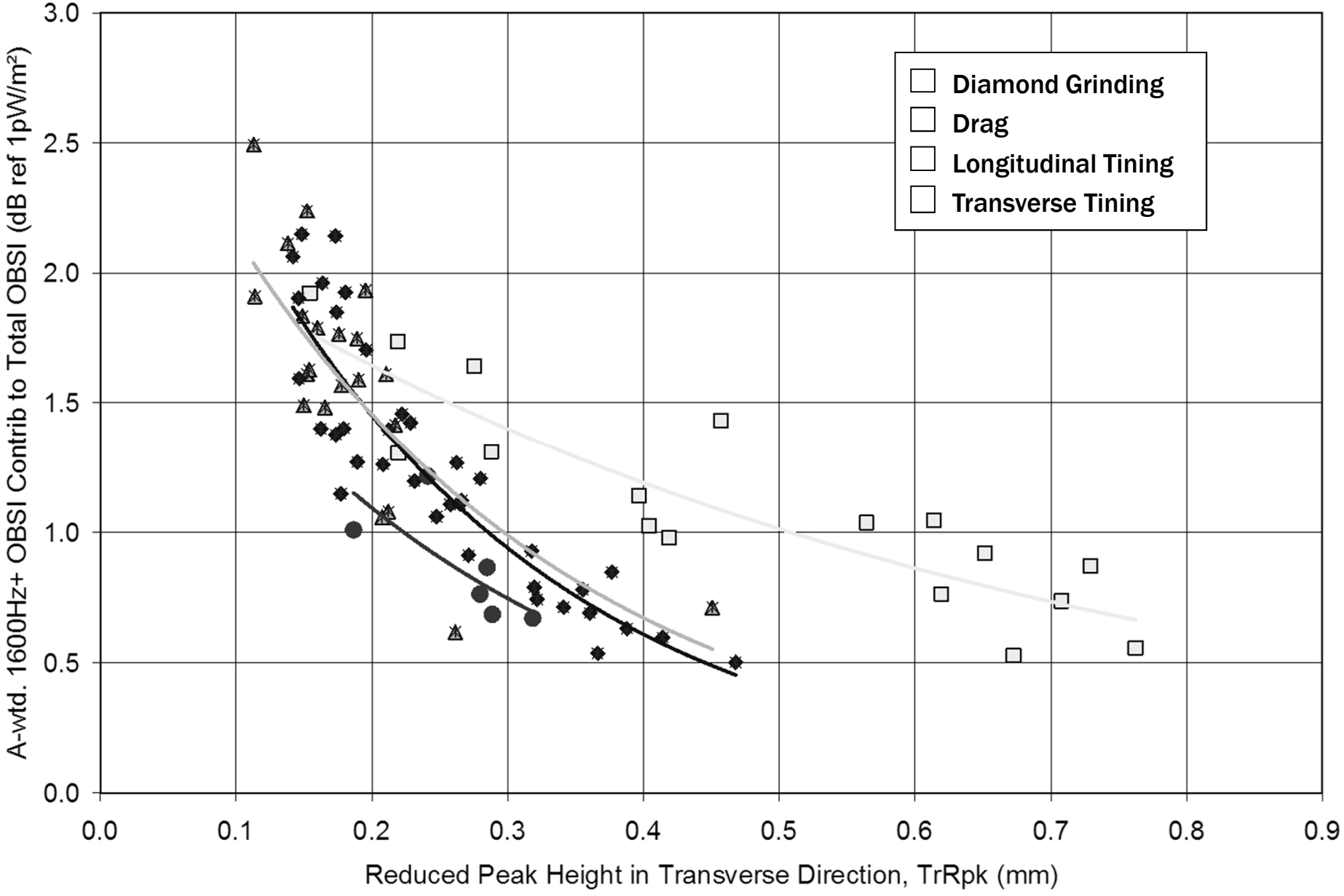
Dir = 0, for transverse or uniform/isotropic texture
= 1 for longitudinal texture.

Source: NCHRP Report 634

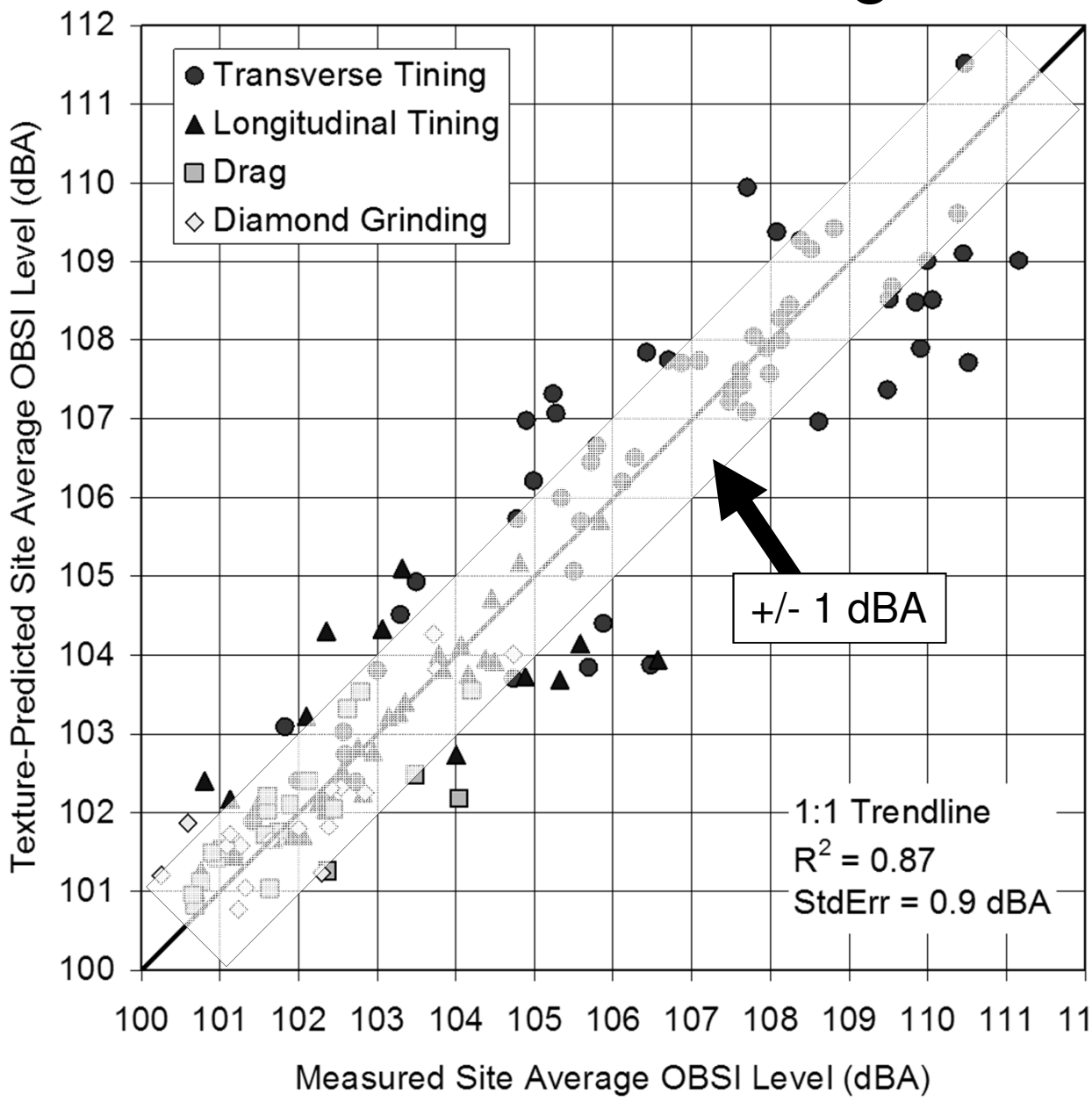
Predicting Noise from Texture



Predicting Noise from Texture



Predicting Noise from Texture



Transverse Tining

$OBSI = f\ (L_{tx,160}\ ,\ L_{tx,25}\ ,\ R_{k,TR})$

Longitudinal Tining

$OBSI = f\ (L_{tx,40})$

Diamond Grinding

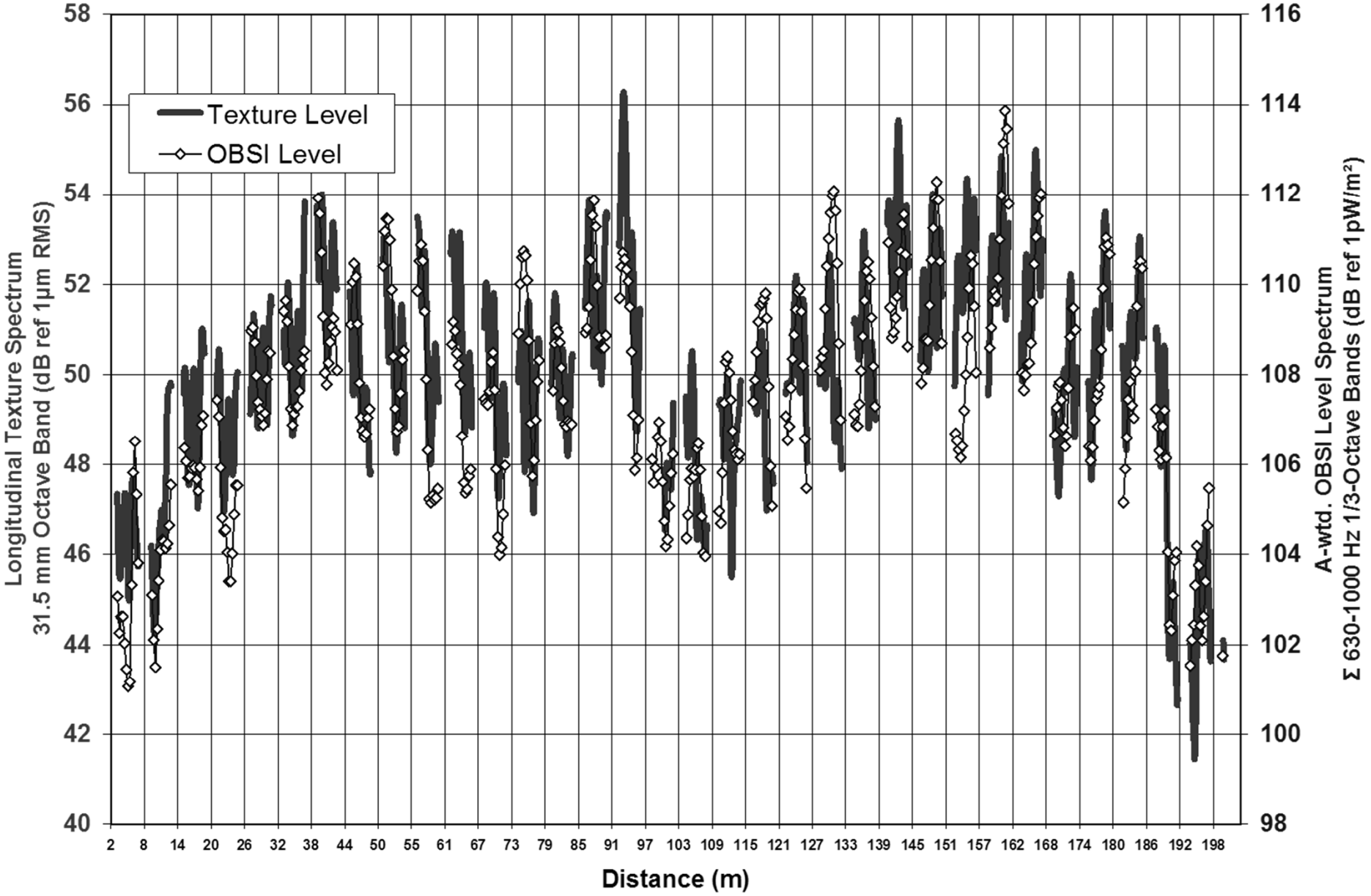
$OBSI = f\ (L_{tx,80+63+50+40}\ ,\ Skew_{TR})$

Drag

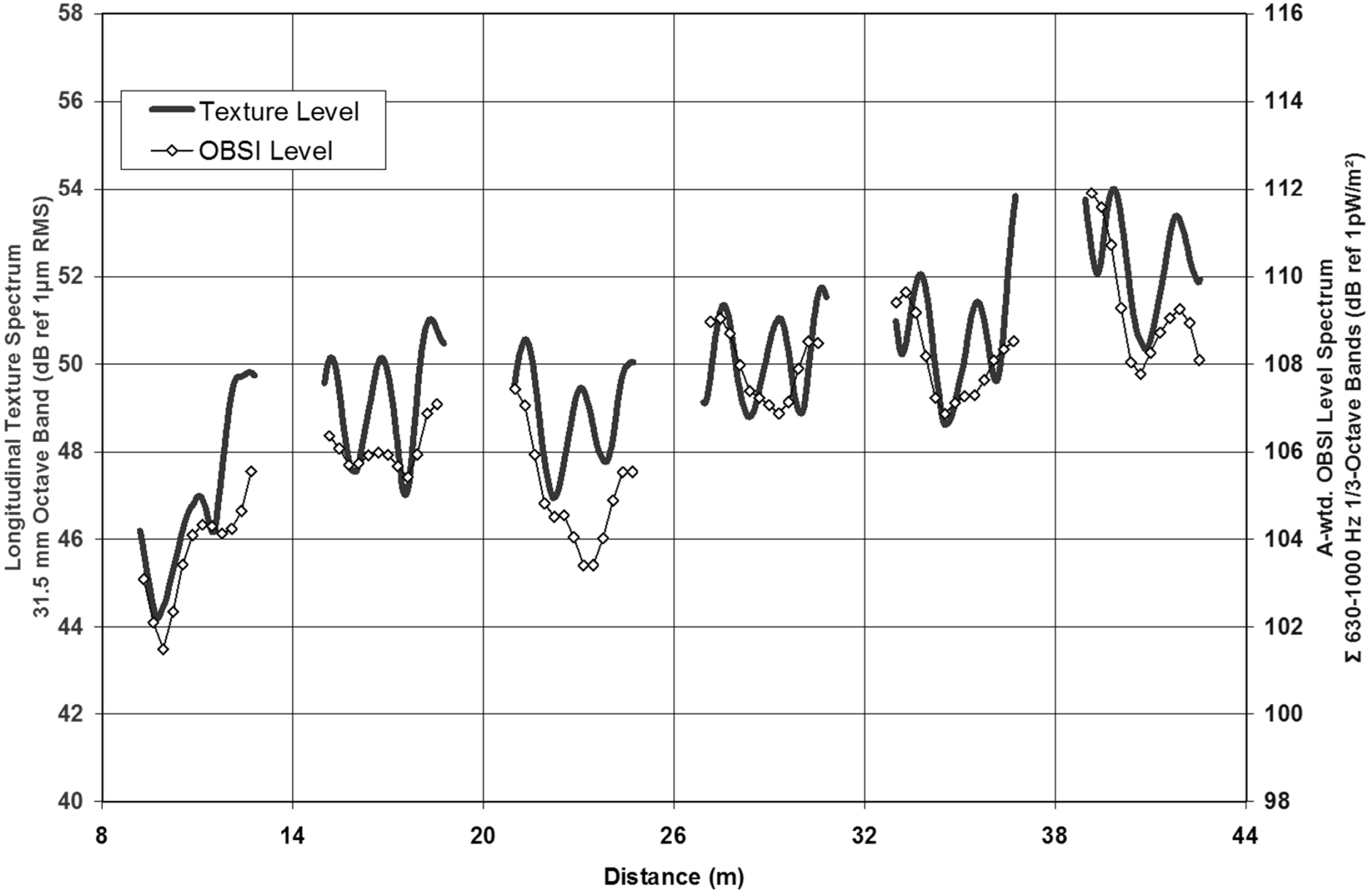
$OBSI = f\ (L_{tx,50+40}\ ,\ Skew_{TR},\ R_{k,TR})$

- L_{tx} per ISO/CD 13473-4 (Draft)
- $R_{k,TR(ansverse)}$ per ISO 13565-2
- $Skew_{TR(ansverse)}$ per ASME B46.1

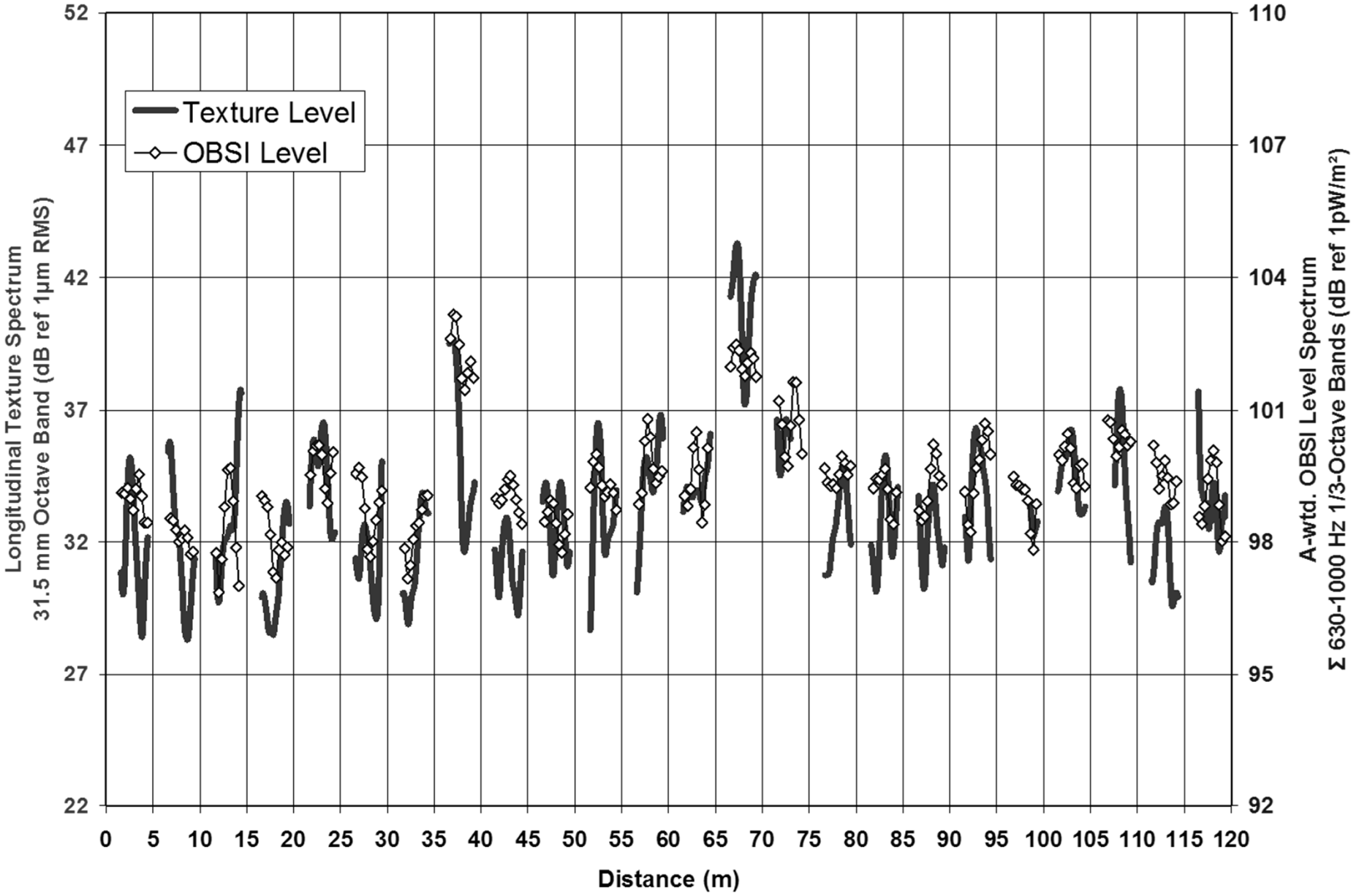
Predicting Noise from Texture



Predicting Noise from Texture



Predicting Noise from Texture



For more information, visit:

www.CP Tech Center.org

or

www.CP Road Map.org