Current Investigations into the Effects of Texture on IRI – RPUG 2008

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Study Objectives

- Emmanuel's Presentation confirmed texture effects on IRI in both Laboratory studies as well as pavements with textured surfaces.
- Part of his research effort was focused on guide lines to account for the effects of surface texture on IRI

Study Objectives – cont.

- Also noted in his presentation was that the Texas roughness statistic NSI was insensitive to texture.
- NSI insensitivity to texture was later confirmed in studies conducted by the Texas Smoothness Initiative (TSI)
- The current presentation focuses on why does texture affect IRI and how can the effect be minimized.

Current Solutions To Reduce Effects of Texture on IRI

- Current methods to minimize affects of texture on IRI are based around new lasers with wider footprints, line lasers, etc., and bridging filters
- Why are these methods used? What frequencies compose texture and why is IRI affected by these frequencies?

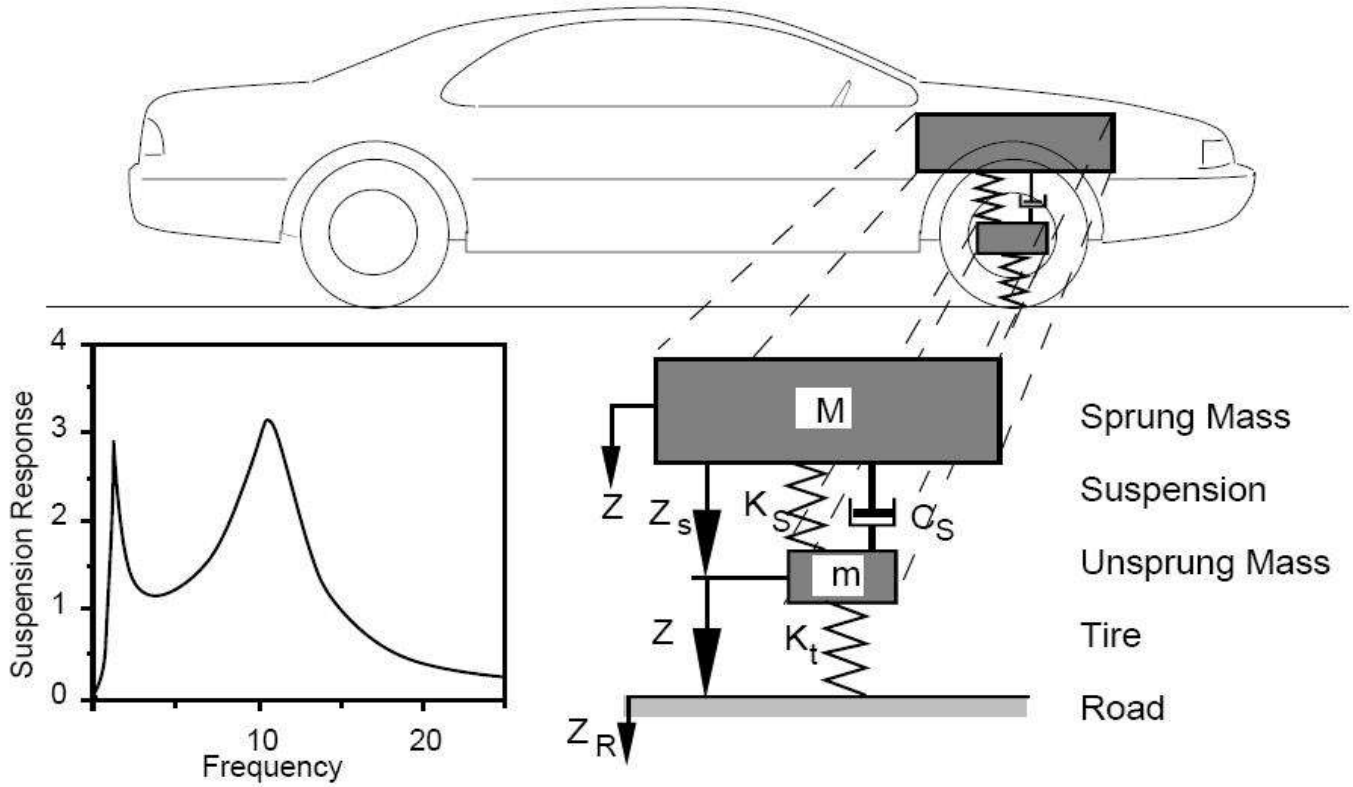
Why is The Effect of Texture on IRI Different For NSI?

- Review the characteristics of IRI.
- What are the characteristics of texture that is causing the higher IRI readings?

Review the characteristics of IRI.

- Investigate the Quarter Car Model
- Frequency Response of IRI

Investigating the Quarter Car Model



From "Little Book of Profiling"

IRI Definition

$$IRI = \frac{1}{L}\int_0^{L/V} \left|\dot{z}_s - \dot{z}_u\right| dt$$

where

L : *Profile Length*

V : *Speed*, $(80 km/h \quad or: 49.7 mph)$

State-Space Equations Used for Computing Quarter Car Model

$$\dot{\mathbf{x}} = \mathbf{A}\mathbf{x} + \mathbf{B}u, \qquad y = \mathbf{C}\mathbf{x} + \mathbf{D}u$$

$$\mathbf{x} = \begin{bmatrix} z_s \\ \dot{z}_s \\ z_u \\ \dot{z}_u \end{bmatrix}$$

$$\mathbf{A} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ -k_2 & -c & k_2 & c \\ 0 & 0 & 1 & 0 \\ k_2/\mu & c/\mu & -(k_1+k_2)/\mu & -c/\mu \end{bmatrix}$$

$$\mathbf{B} = \begin{bmatrix} 0 & 0 & 0 & k_1/\mu \end{bmatrix}^T$$

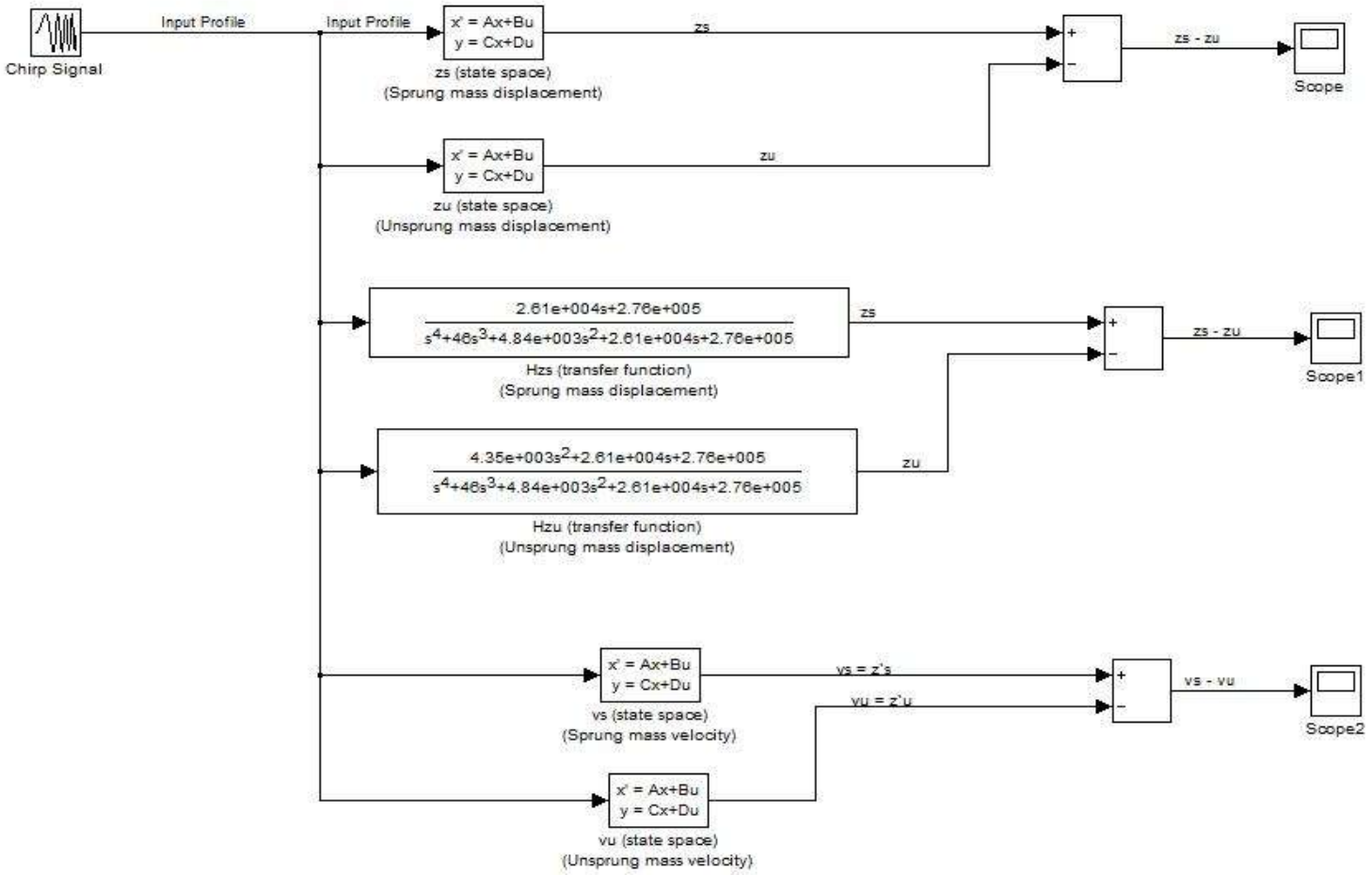
$$\mathbf{C} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}, \qquad \mathbf{D} = \mathbf{0}$$

where

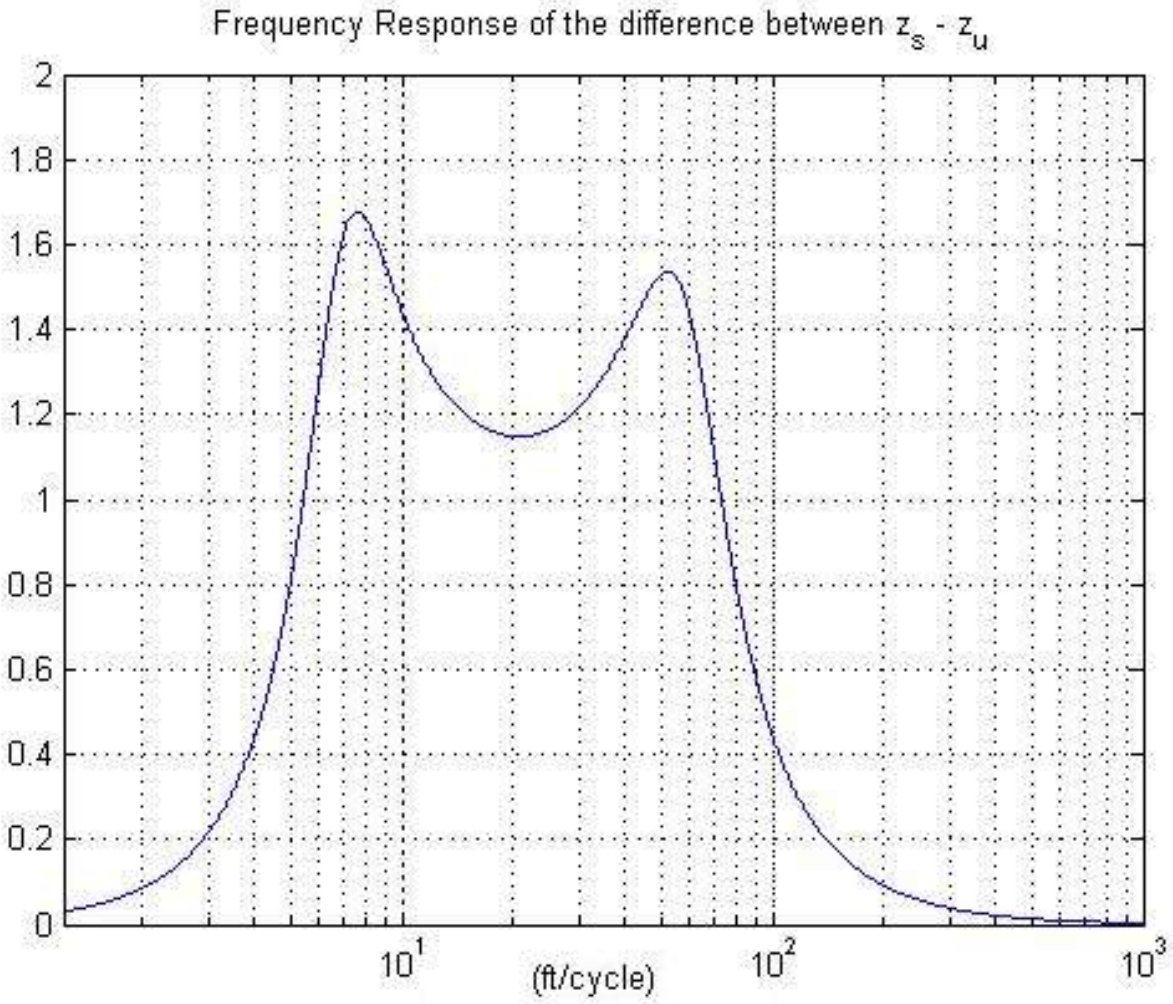
$c = c_s / m_s = 6.0, \qquad k_1 = k_t / m_s = 653,$

$\mu = m_u / m_s = 0.15, \qquad k_2 = k_s / m_s = 63.3$

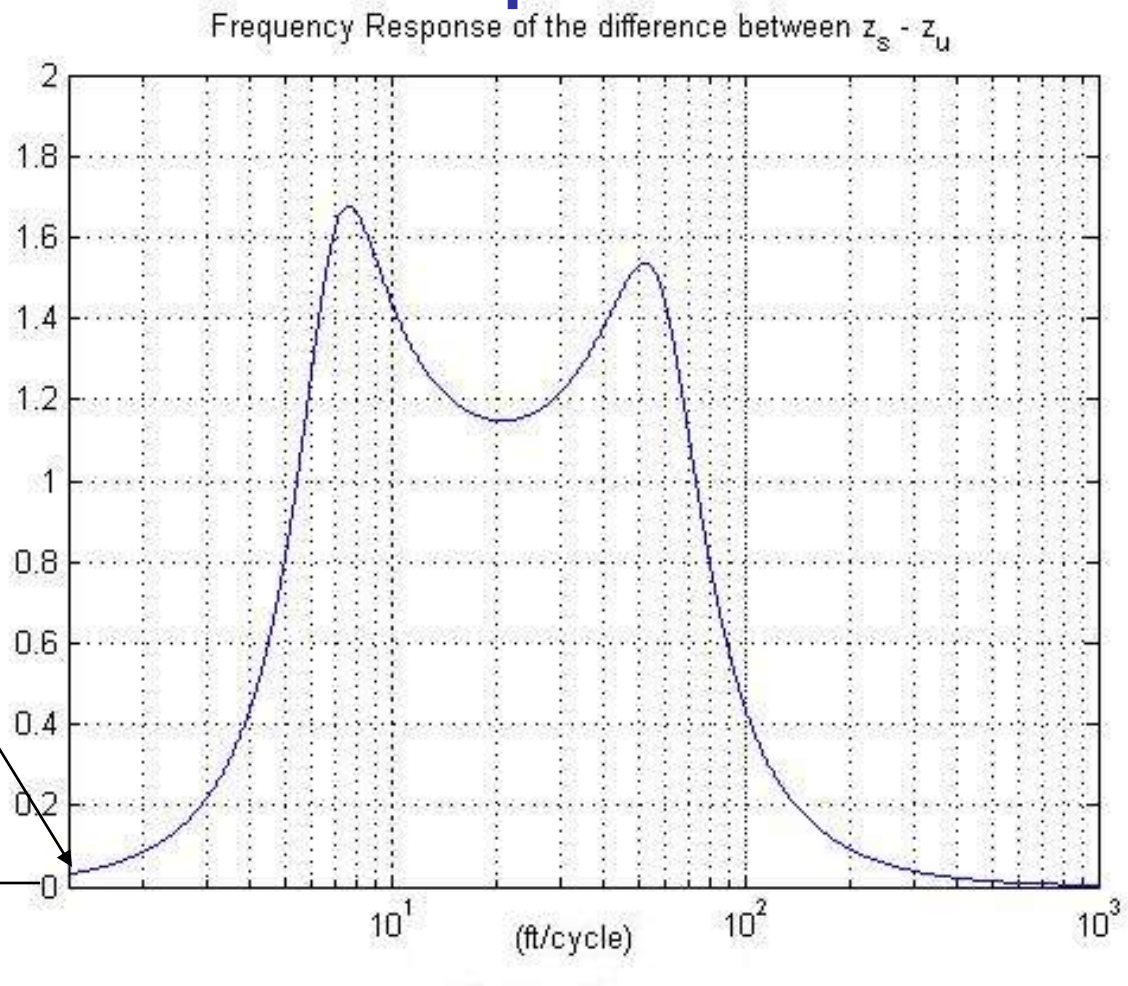
Quarter Car Simulation Model



Quarter-Car Displacement Response



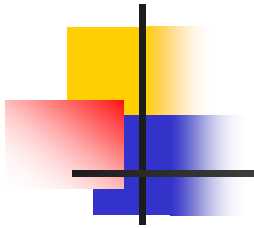
Quarter-Car Displacement Response



Need to take this out to 10^{-2} as this is high freq texture range

10^{-2} 10^{-1} 10^{0}

White Noise



- What are the primary range of frequencies in texture? Texture often referred to as band-limited white noise. The spectral density of white noise or a random signal has a flat power spectral density.
- Used Matlab to generate 'white noise' with noise magnitude equal to that of the grade 3 over 3 texture specimen.

White Noise Superimposed on Base Plate

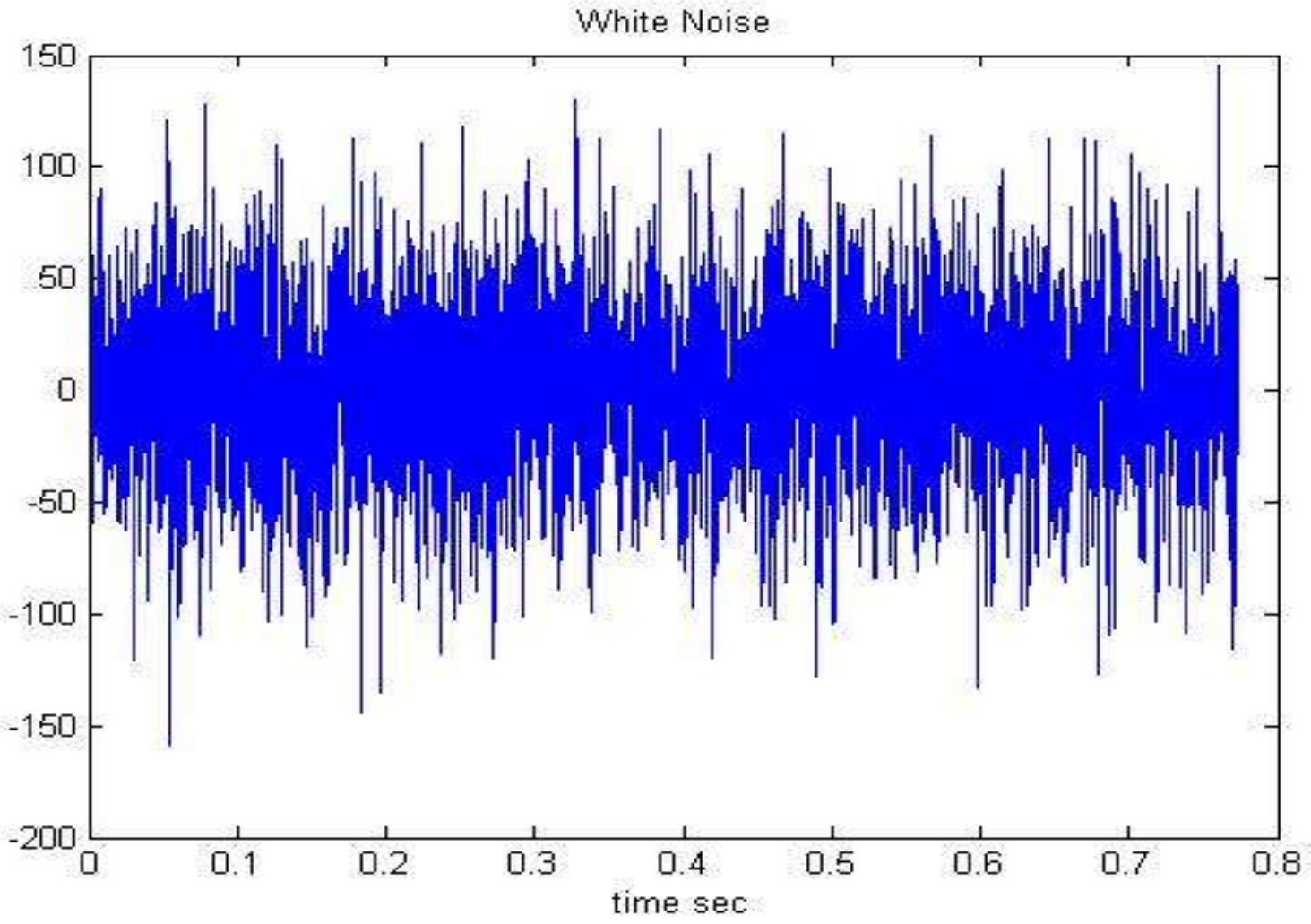
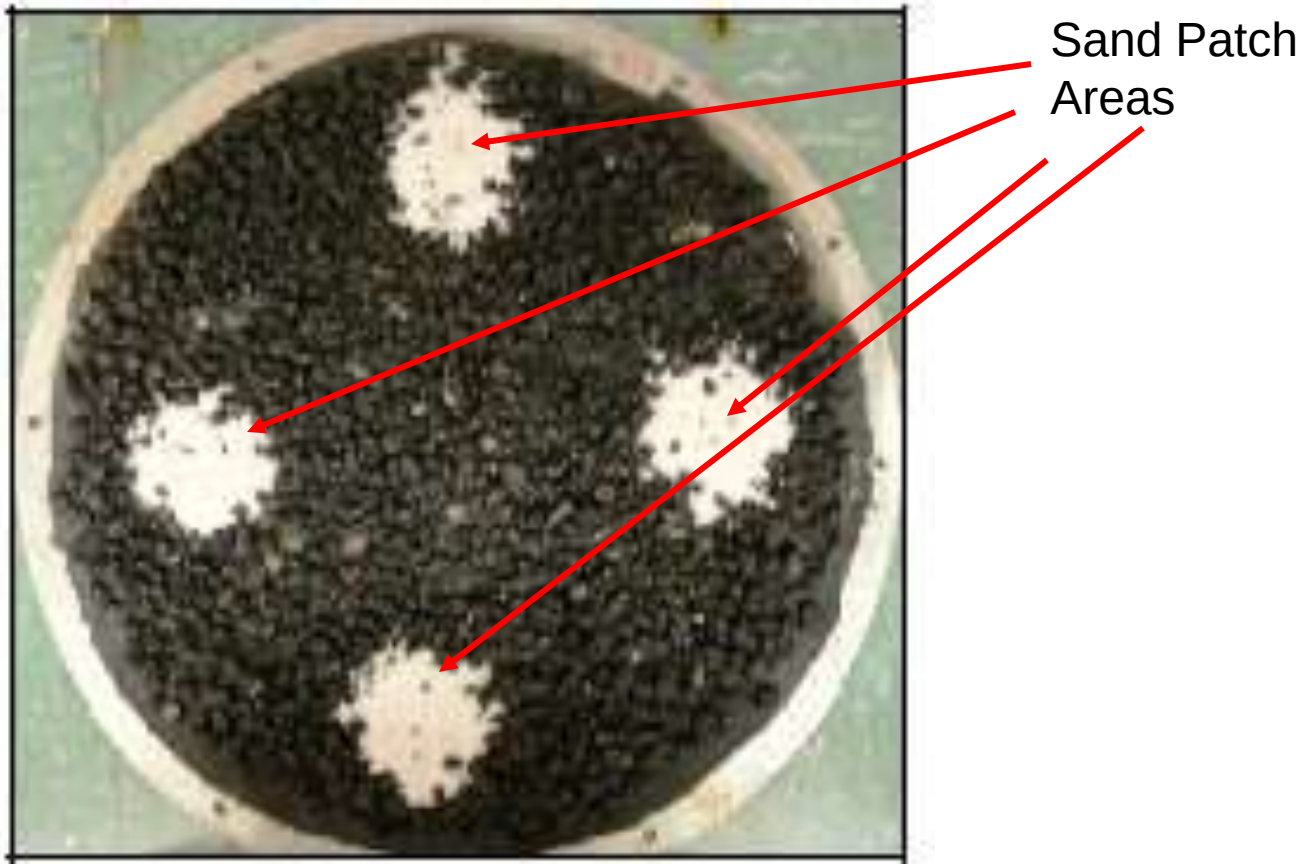


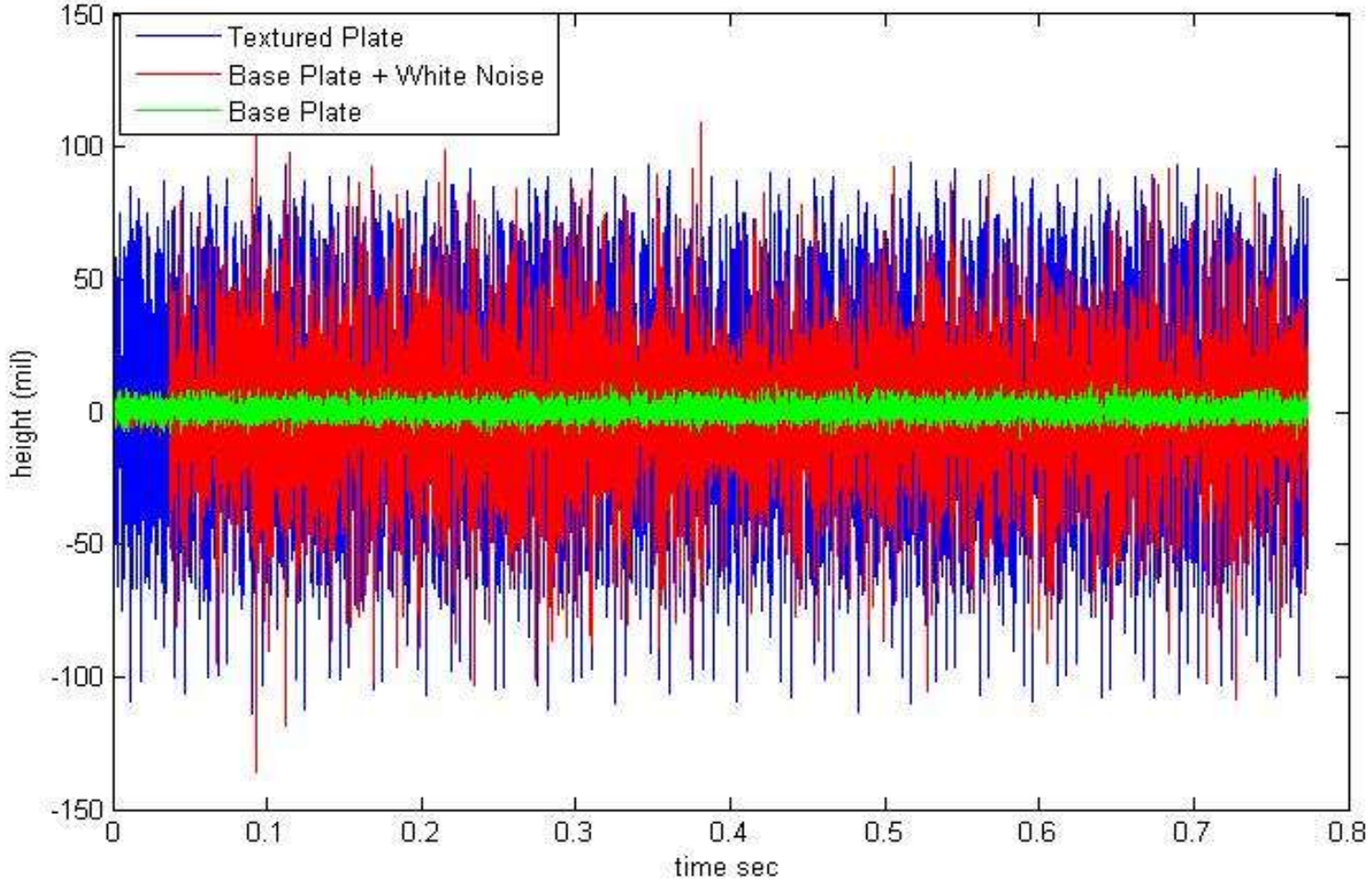
Plate Used to Hold Texture Specimens

Figure 3.3. Alignment Pin Used to Position the Test Specimen on the Platter.

Plate With Textured Biscuit



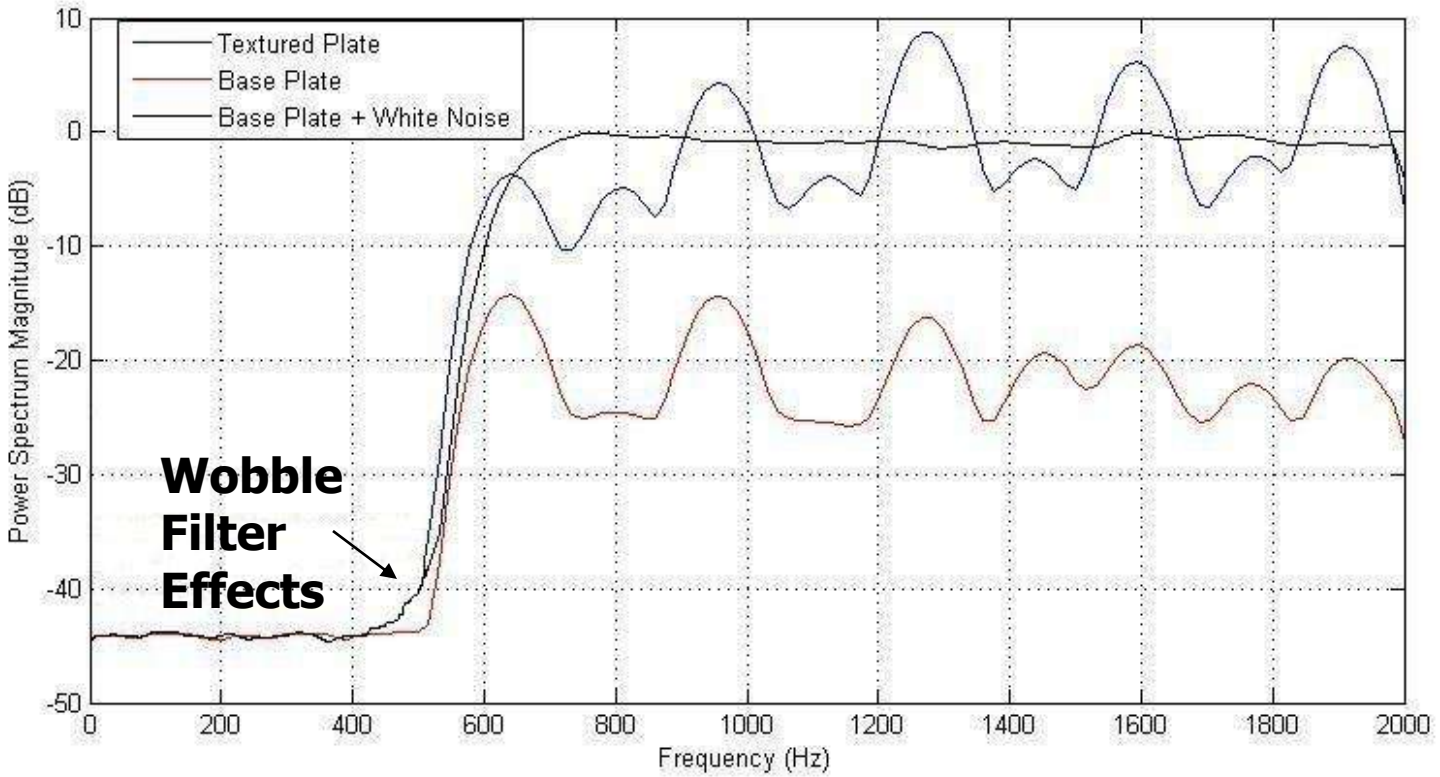
Time Plot of Laser Readings



IRI values

Profile	IRI (in/mi)
Plate	3.0
Textured Plate	10-36
Plate + White Noise	12.8

Power Spectrum of Plate With and Without Texture and White Noise



IRI values

Profile	IRI (in/mi)
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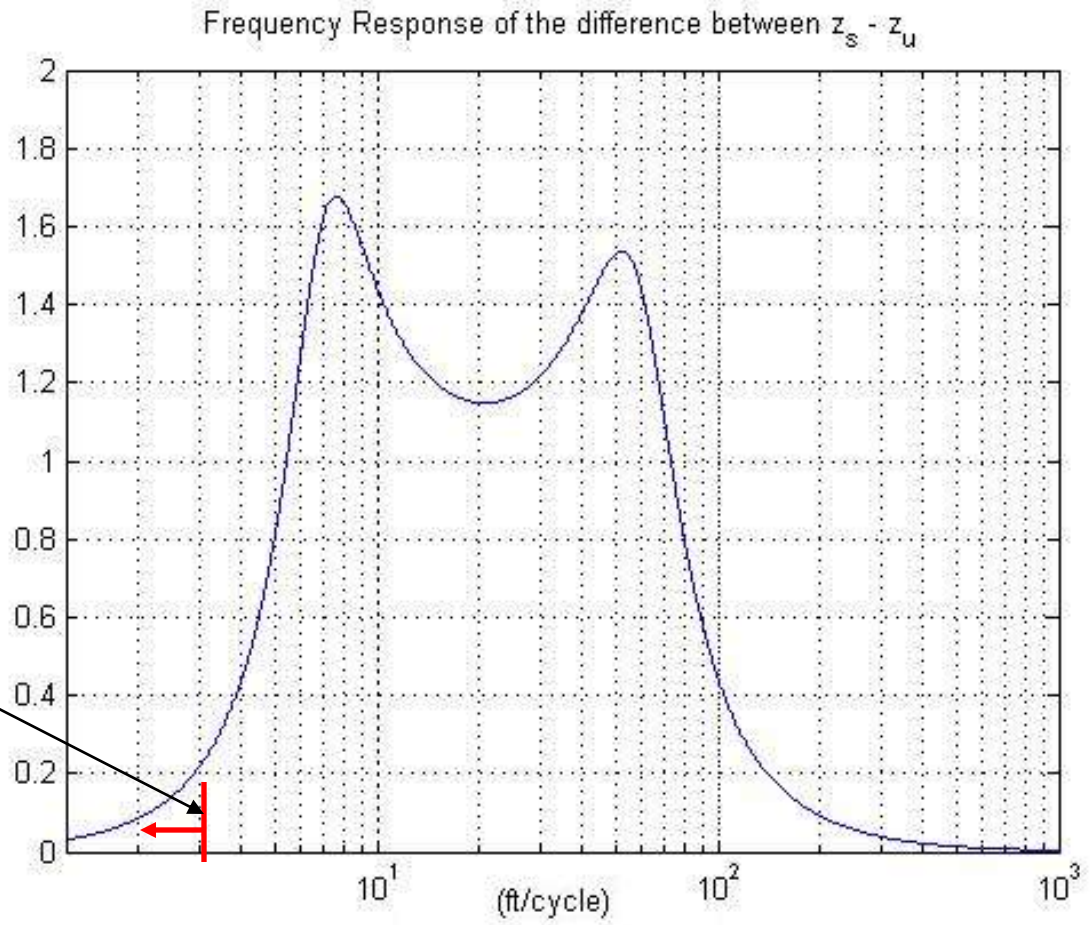
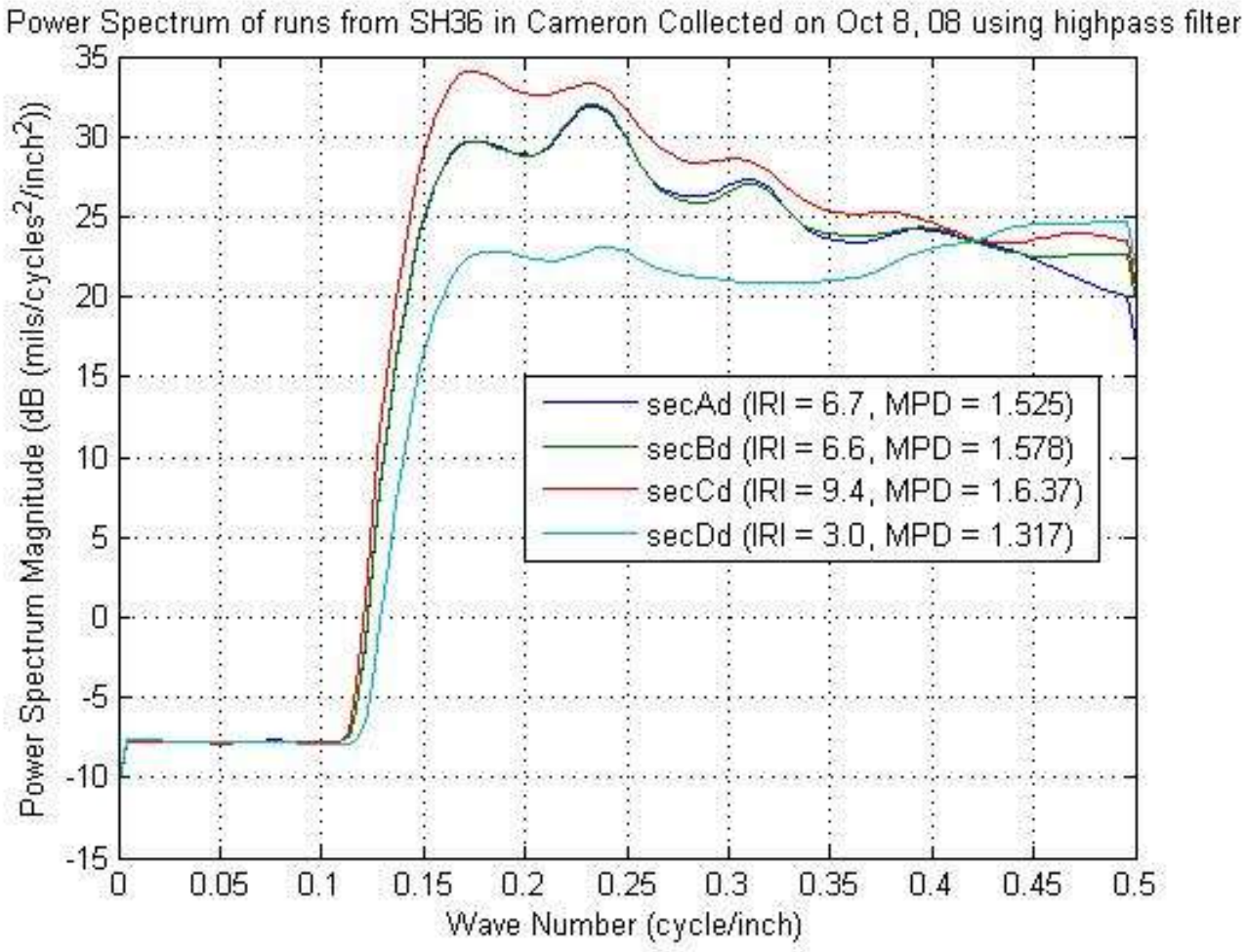
Quarter-Car Displacement Response



Texture Effects in Sample

Power Spectrum of SH36 Texture Measurements

So where do you filter to take out texture but leave profile?



Model Selected

$$PSI = 5e^{-\alpha P}$$

where:

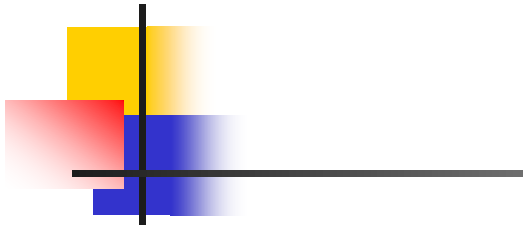
$$\alpha P = \alpha_1 P_1 + \alpha_2 P_2 + \ldots + \alpha_8 P_8$$

$$PSR' = \left[-\ln\left(\frac{PSR}{5} \right) \right]^2$$

α_i , P_i – Coefficient and Power Component for *i* = 1 to 8 meters

So What Filter Bridging Algorithm – Laser Type?

- So what filter to use that doesn't also take out profile? Is reduction in Profile frequencies really causing the reduction of IRI?
- Small amplitude band-limited white noise causes IRI increase of 8 to 10 inches per mile.
- Continue investigations of textured road sections and Concrete with tining



Thank You