THE UNIVERSITY OF TEXAS AT AUSTIN
CENTER FOR TRANSPORTATION RESEARCH

Field Investigation of Relationship between Pavement Surface Texture and Friction

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Sareh Kouchaki

Hossein Roshani

Jorge A. Prozzi

Natalia Zuniga-Garcia

Joaquin Bernardo Hernandez

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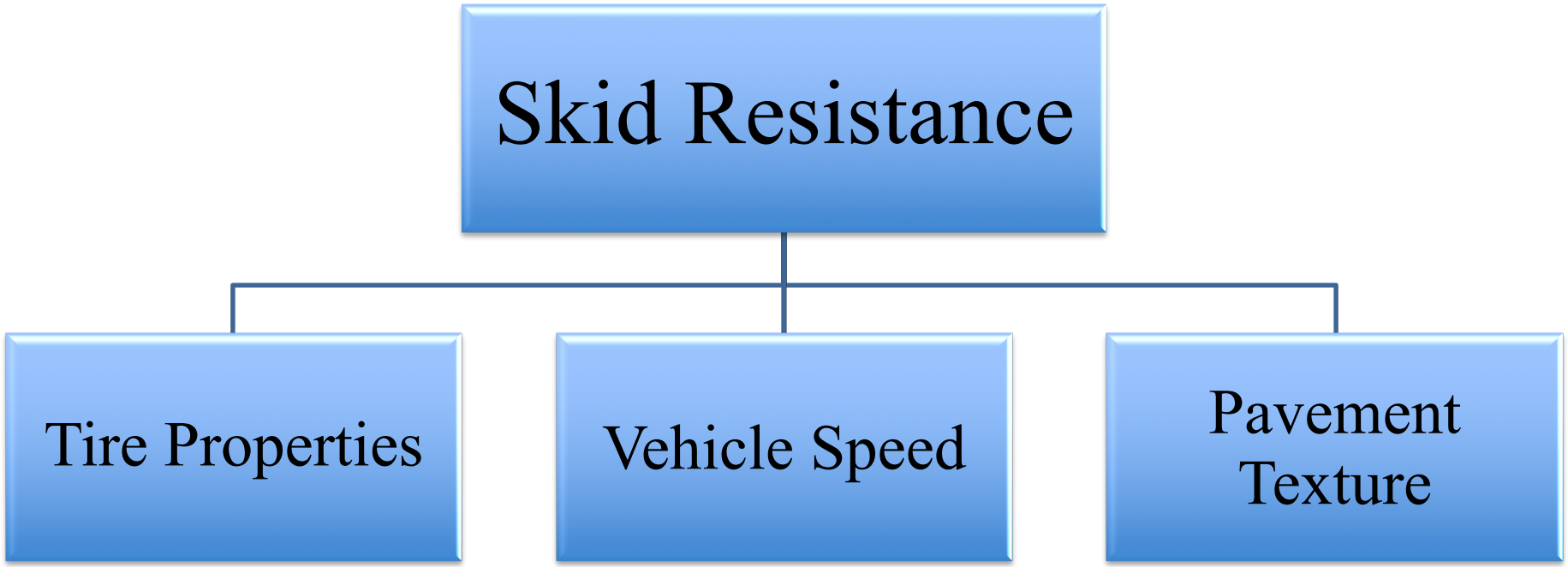
Outline

- Introduction
- Goals & Objectives
- Measurement of Pavement Friction
- Measurement of Pavement Surface Texture
- Field-Data Collection
- Results & Discussions
- Conclusions

Introduction

Skid Resistance

Ability of the traveled surface to prevent the loss of tire traction.



Introduction

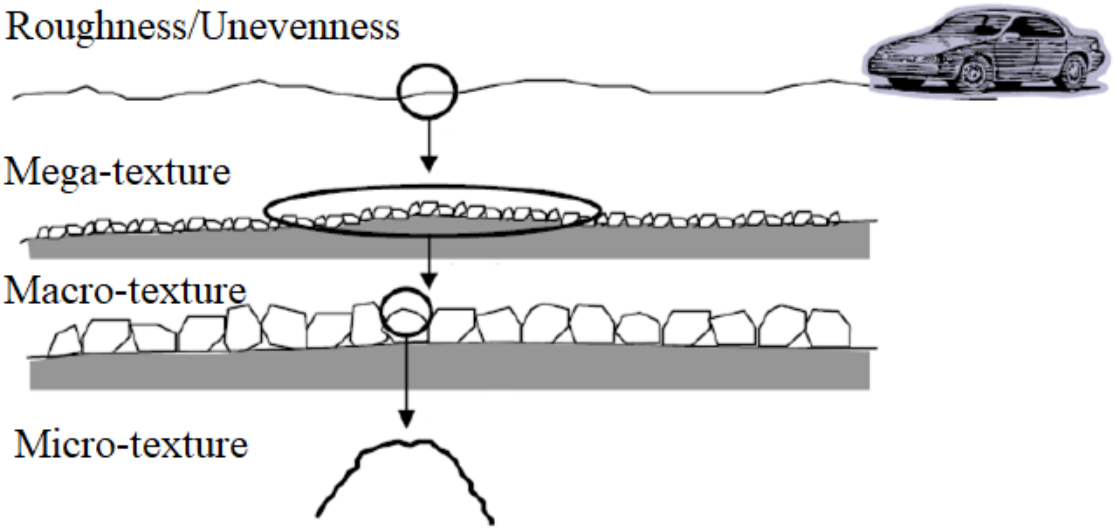
Pavement Texture at Different Levels

$0.5\ m < \lambda < 50\ m$

$50\ mm < \lambda < 500\ mm$

$0.5\ mm < \lambda < 50\ mm$

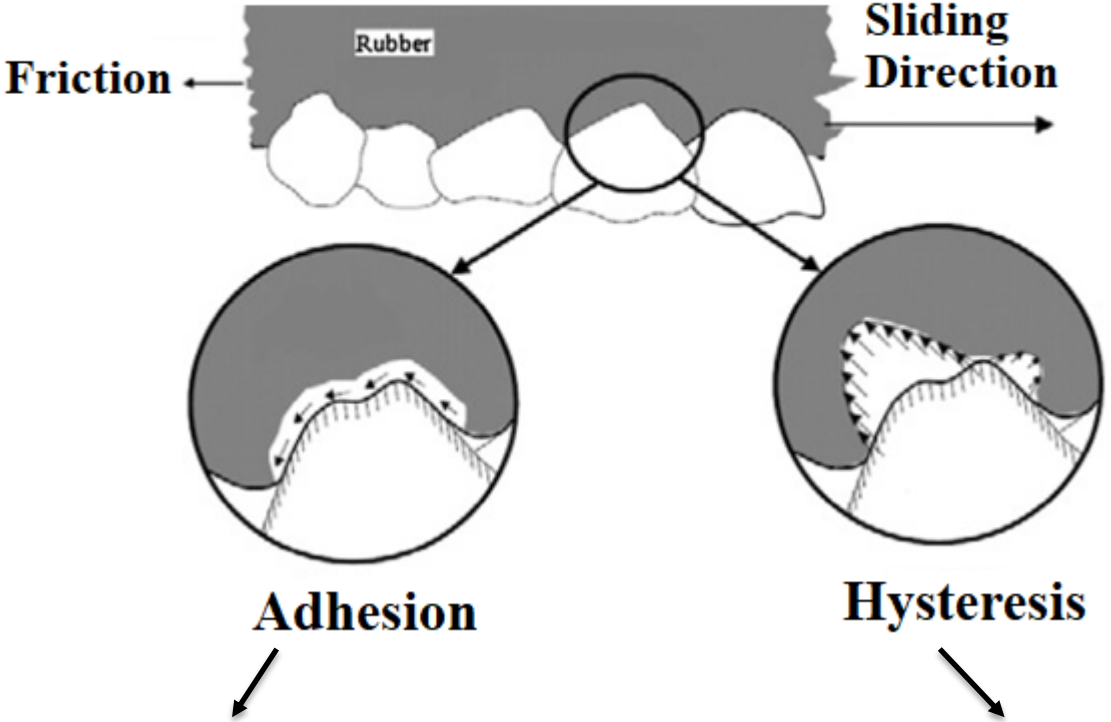
$\lambda < 0.5\ mm$



- **Macro-texture: Aggregate particles size and arrangement**
- **Micro-texture: Aggregate particles texture and mineralogy**

Introduction

In Pavement-Tire Interface



Small scale bonding
Micro-texture

Energy loss due to deformation
Macro-texture

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Goals and Objectives

Goal:

Finding the correlation between field-measured texture and friction data.

Objectives:

- Developing an accurate texture measurement device, called a line laser scanner (LLS) prototype, and evaluate its performance.
- Using the Grip-Tester to collect continuous friction data at traffic speed and compare it to the Dynamic Friction Test (DFT) at **two different speeds**.
- Establish correlations between texture and friction based on the field data.

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Friction Measuring Principles:

❖ Longitudinal Friction Coefficient (LFC)

- Measures friction when a vehicle is traveling forward in a straight line
- Slip ratio of 1: fully locked wheel which slides over the surface
- LFC devices with either a fixed or a variable slip ratio

❖ Transverse Friction

- Measures friction when the vehicle is travelling on a horizontal curve and the vehicle wheels are turned.

❖ Stationary or slow-moving

- Used in compact devices found in the laboratory or still testing
- British Pendulum Tester (BPT) and Dynamic Friction Tester (DFT)

LFC Measuring Devices

Device Name	Theoretical water film thickness (WFT), Speed, Measurement interval (Interval)	Assembly	Device Picture
ADHERA	TWFT: 1 mm Speed: 40–120 km/h Interval: 20 m Country of Use: France	Assembly: Trailer that can be hooked up to vehicle Commercially Available: No	
ROAR NL	TWFT: 0.5 mm Speed: 50–70 km/h Interval: 5–100 m Country of Use: Netherlands	Assembly: Three-axle tanker truck with two measuring systems mounted at the rear of the chassis. Commercially available: No	
SRM	TWFT: 0.5 mm Speed: 40–80 km/h Interval: 20 m Country of Use: Germany	Assembly: The test wheels are mounted on the back of a tanker vehicle at the approximate location of a vehicle tire paths. Commercially available: No	
Grip-Tester	TWFT: 0.5 mm Speed: 5–100 km/h Interval: 10 or 20 m Countries of Use: United States, United Kingdom, etc.	Assembly: Trailer that can be hooked up to vehicle. Commercially available: Yes	

Friction Measurement Machines Used in this Study

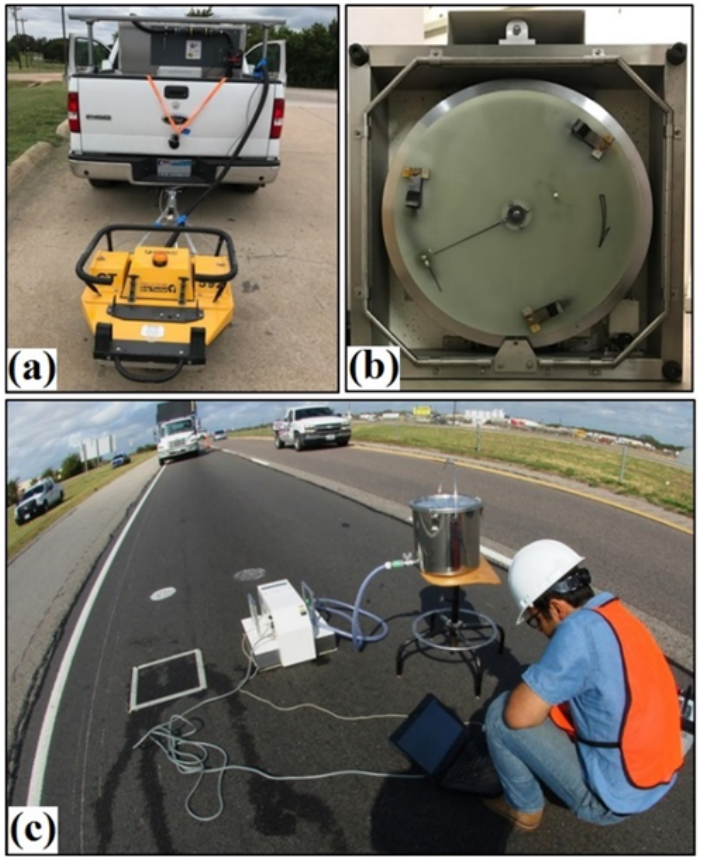
❖ Grip-Tester

- Wider range of test speed
- Better repeatability and reproducibility
- Greater efficiency in water usage
- Commercial availability

❖ Dynamic Friction Tester (DFT)

- ASTM E1911
- Measures the friction of the pavement at different speeds

1. 50 km/h
2. 70 km/h



a) The Grip-Tester attached to a vehicle,
b) Bottom view of the DFT, and
c) The DFT connected to a water tank

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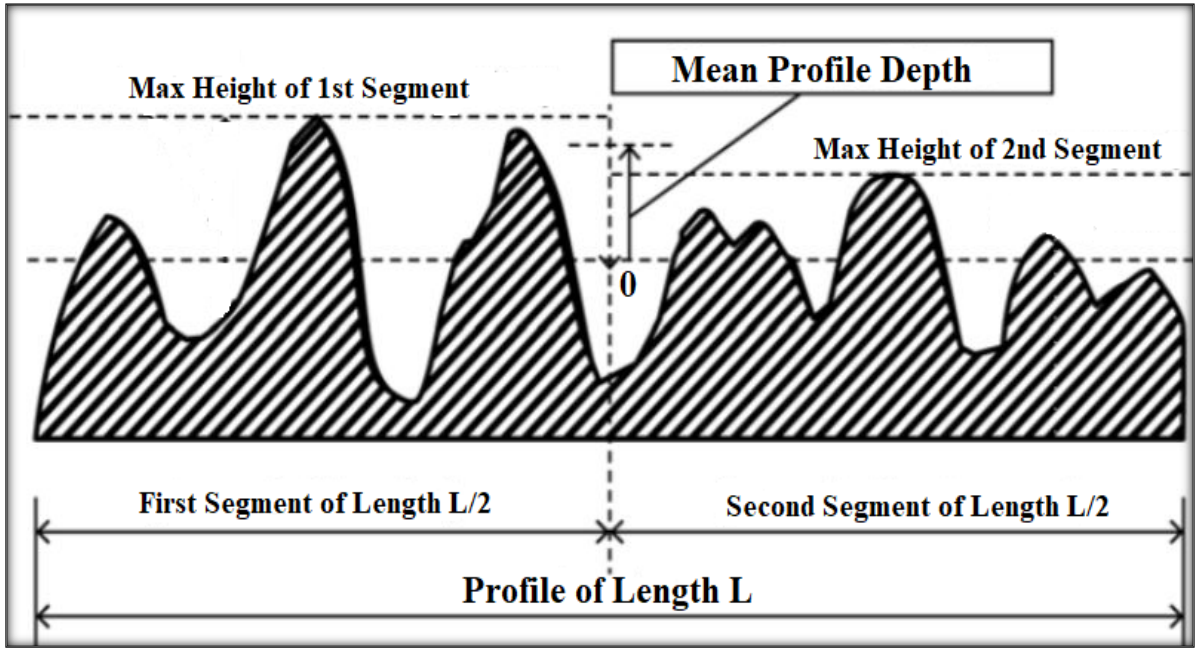
❖ Mean Profile Depth (MPD)

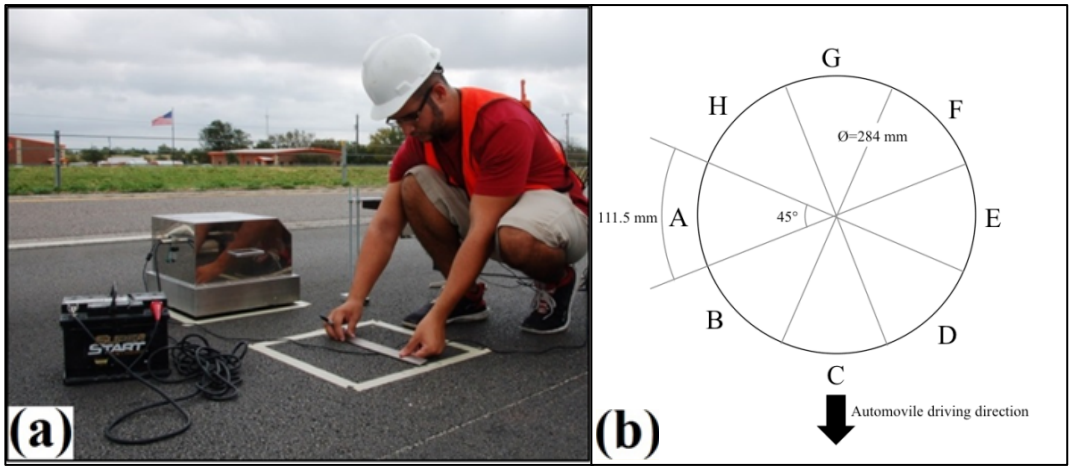
- Is Known as the best pavement macro-texture indicator.
- Is estimated from the surface height profile – ASTM E1845



$$MPD = \frac{(\text{Max Height of 1st Segment} + \text{Max Height of 2nd Segment})}{2}$$

❖ Circular Track Meter (CTM)

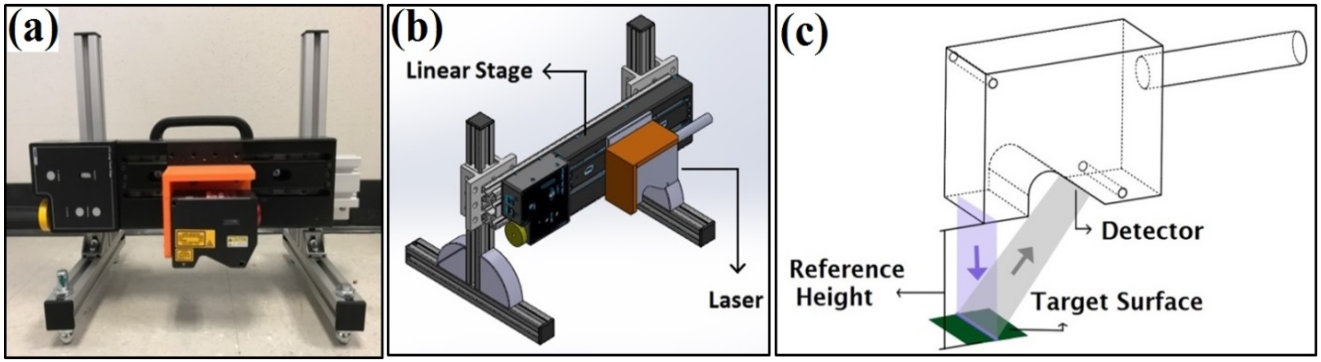
- A common static method to measure the macro-texture of the pavement surface - ASTM E2157.
- Consists of a laser-displacement sensor that rotates over a circle.
- Measures the profile of pavement surface at an interval of 0.87 mm.



a) The CTM powered by a battery and, b) CTM Segments.

❖ Developed Line Laser Scanner (LLS) Prototype

- Two-dimensional non-contact laser sensor
- A prototype, called LLS, was developed to enable the laser to travel and capture three-dimensional data.
- Captures small changes in the height due to the texture irregularities.
- Can measure a surface profile at an interval of 0.025 mm.



Different views of the LLS

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Field-Data Collection

Test sections and pavement type

- **Bastrop** (Mix design: Porous Friction Course (PFC))
- **Bryan** (Mix design: Dense-Graded Type C)
- **Fort Worth** (Mix design: Dense-Graded Type D)

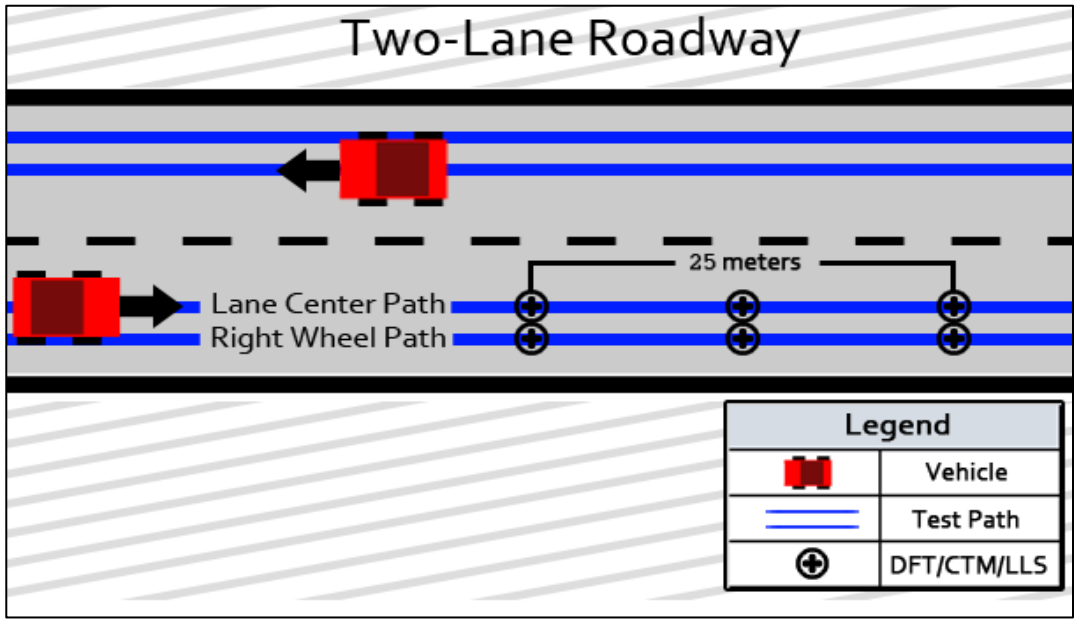
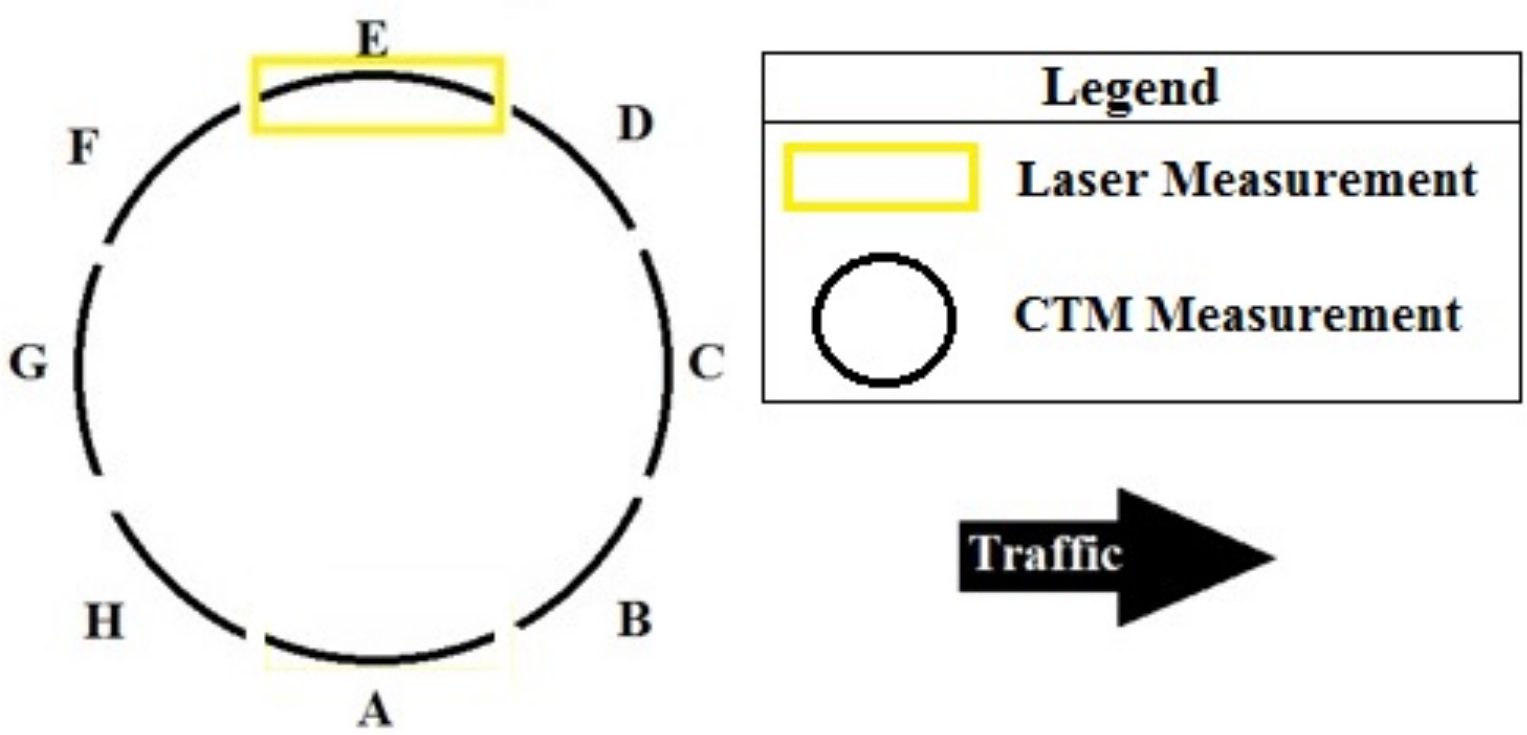


Illustration of test section and test location

Consistency of CTM and LLS Measurements



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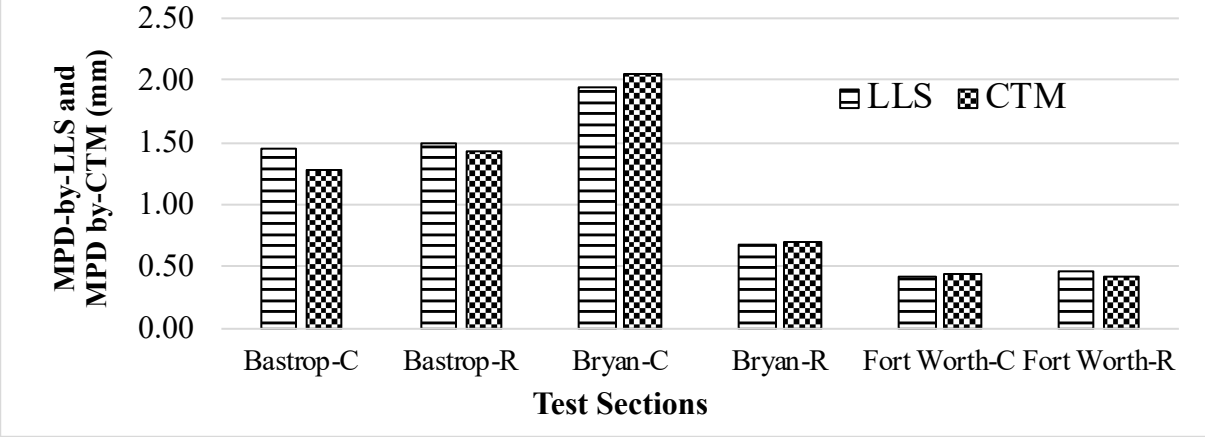
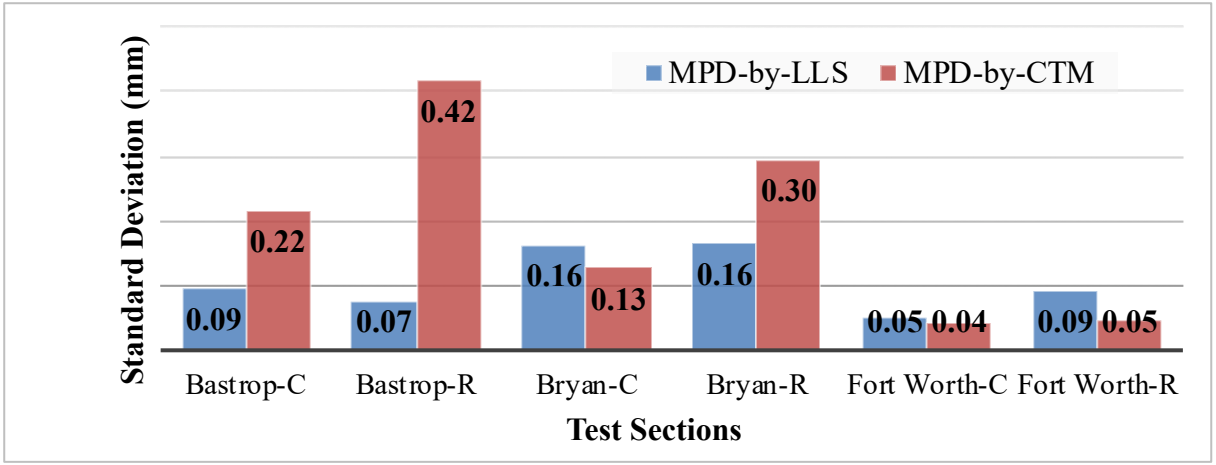
Repeatability of Developed LLS Prototype

Comparison of mean MPD values obtained from developed LLS prototype and CTM



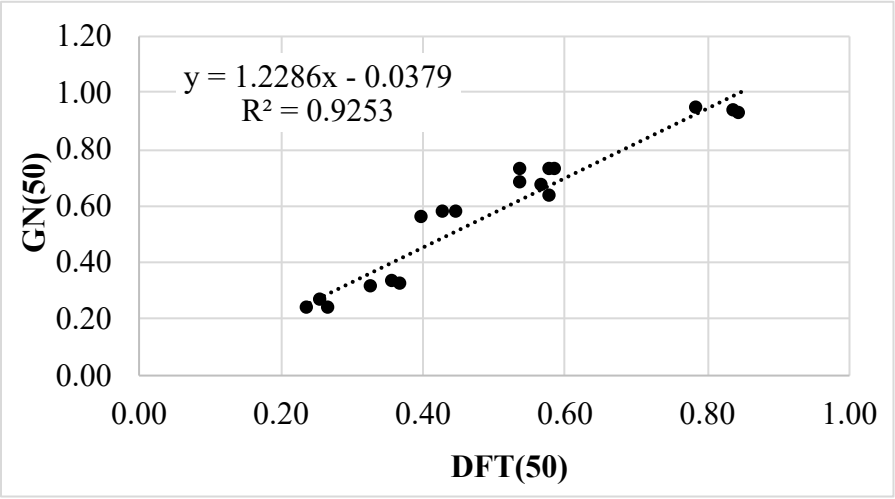
Accurate

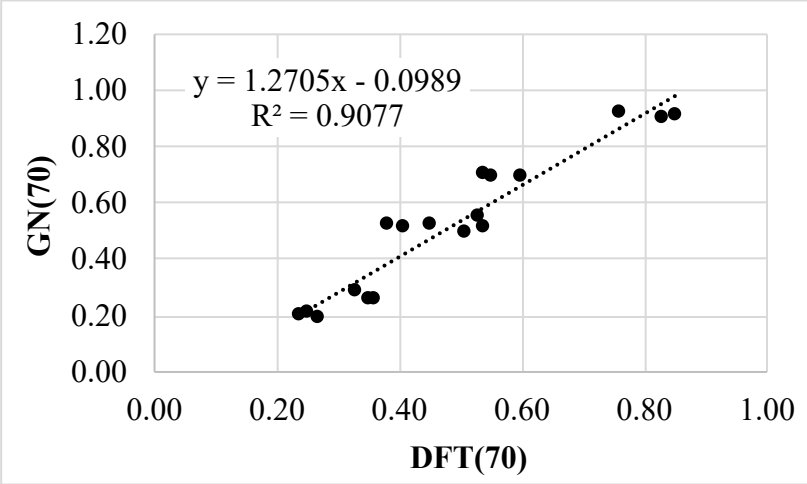
Standard deviation of MPD values measured by LLS and CTM at six test sections



Precise

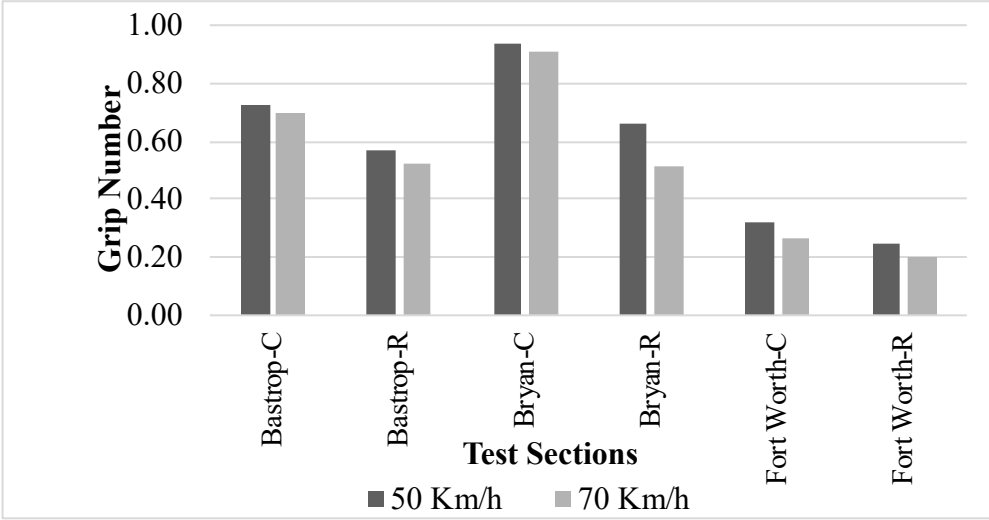
Grip-Tester Results





Grip-Tester

- **Safe**
- **Efficient**
- **Continuous Friction Measure**

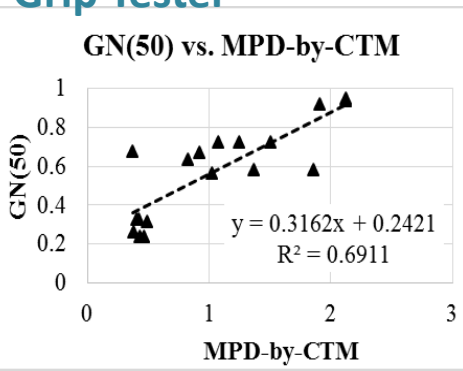


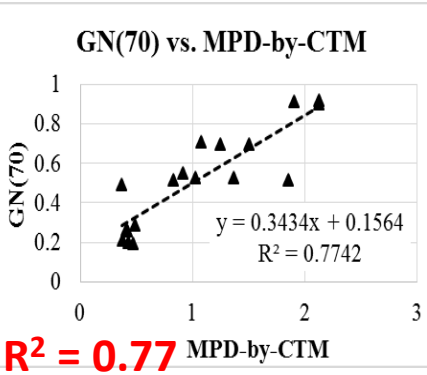
GN decreased when the speed increased

Relationship between the Texture and Friction

CTM

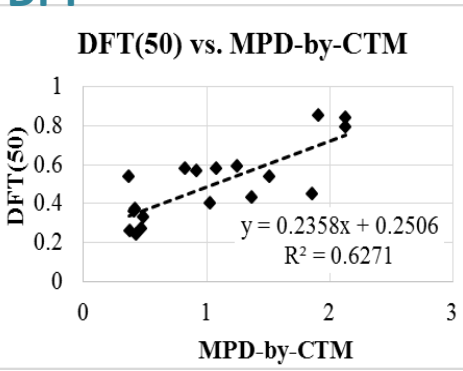
Grip Tester

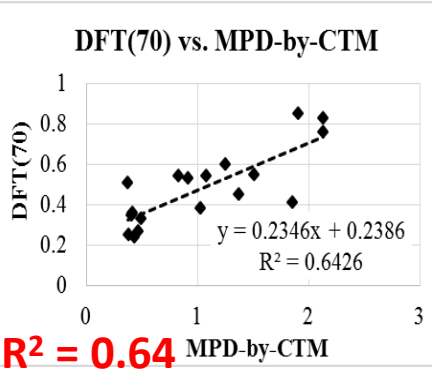




$R^2 = 0.77$

DFT

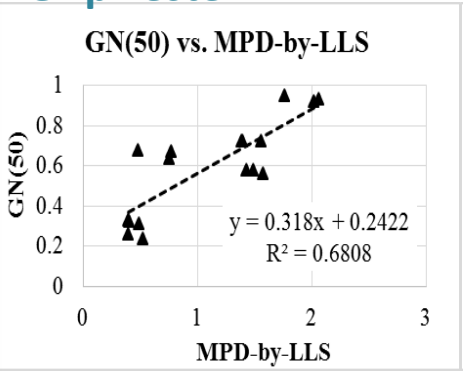


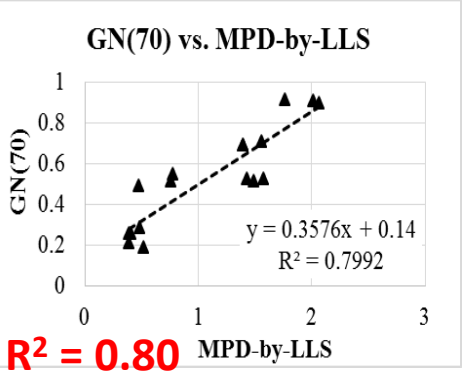


$R^2 = 0.64$

LLS

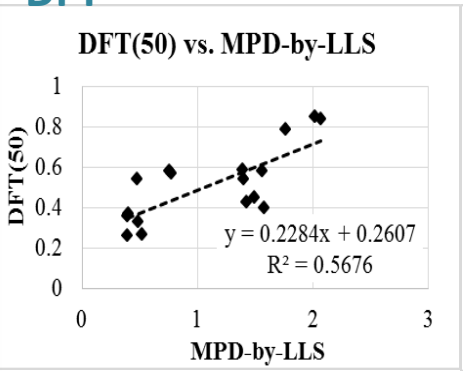
Grip Tester

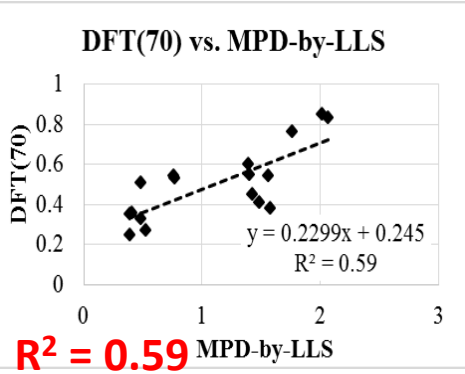




$R^2 = 0.80$

DFT





$R^2 = 0.59$

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Conclusions

- **High reliability** of the developed LLS prototype in terms of repeatability – **Efficient alternative to the CTM.**
- **Strong correlation** between the friction number measured by the Grip-Tester and DFT.
- Sensitivity of GN to the test speed – **Importance of testing with constant speed.**
- **Strong positive linear correlation** between texture and friction in pavements – **Accurate friction prediction.**

Questions or Comments?

THANKS