62nd Illinois Bituminous Paving Conference
Profile Measurement and Interpretation

Steven M. Karamihas
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Road Profile Measurement and Interpretation

C = c_s/m_s = 6.0 sec^{-1}
K_1 = k_u/m_s = 653 sec^{-2}
K_2 = k_s/m_s = 63.3 sec^{-2}
\mu = m_u/m_s = 0.15
B = 250 mm

IRI
Motivation

Federal Aid Rated Pavement Conditions
State - State of Michigan, All Roads, 2018 - 2019

- Lane Miles Good: 35,122.4 (38.6%)
- Lane Miles Fair: 19,477.5 (21.4%)
- Lane Miles Poor: 36,491.7 (40.1%)

Federal Aid Rated Pavement Conditions
State - State of Michigan, All Roads, Estimated 2019 - 2020

- Lane Miles Good: 18,749.1 (21.4%)
- Lane Miles Fair: 37,045.9 (42.4%)
- Lane Miles Poor: 31,620 (36.2%)

http://www.mcgi.state.mi.us/mitrp/tamcDashboards
Outline

• Profiler Measurement Principal
• International Roughness Index (IRI)
• Roughness Profiles
• Certification/Cross Correlation
• Technical Challenges
  – Braking/Stops
  – Low-Speed/Urban Roughness Index
  – 3-D Systems
Inertial Profiler, Principle of Operation

Bounce Test

Height (in)

Distance (ft)

Height Sensor

Accelerometer

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Golden Car Model Gain

Golden Car Model Gain (-)

- Body Bounce
- Puke
- Axle Hop

IRI Generality

Frequency response depends on:

- Response type
- Vehicle type
- Position within the vehicle
Sample Profile: New AC Surface

Left Elevation (in)

Distance (ft)
Raw IRI Filter Output

Left IRI Response (in/mi)

Distance (ft)
The average over this 1000 feet is the IRI for the 1000-ft lot.
Roughness Profile

Continuous Roughness Report (in/mi)
Profiler Certification

Source: 2013 Benchmark Profiler Experiment
Certification/Cross Correlation (= 0.98)

Certification

- Agreement in both IRI and profile are required to ensure accurate production measurements.
- Many profilers that performed well on smooth texture performed poorly on coarse textures.
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Stop and Go: Accelerometer Alignment

\[ a^w_{zp} + g \]

Tilted due to longitudinal deceleration

\[ a^b_{zp} = a^w_{xp} \sin(\theta) + \left( a^w_{zp} + g \right) \cos(\theta) - g \]

\[ a^b_{zp} - a^w_{zp} = a^w_{xp} \sin(\theta) + \left( a^w_{zp} + g \right) \left( \cos(\theta) - 1 \right) \]


2013 Philadelphia County Road Survey, Courtesy of Pennsylvania DOT
11-Second Long Stop

Reference Run:
Segment IRI = 100 in/mi

Long Stop:
Segment IRI = 13,134 in/mi
Peak IRI = 209,075 in/mi
Braking, Stop-and-Go

• Mitigate errors with better processing algorithms.
• Mitigate or eliminate errors using additional sensors.

Urban/Low-Speed Roughness

- Measured profile and passenger accelerations simultaneously.
- Tested on urban and low-speed roadways
  (That is, we rated ride the way auto companies do it.)
Urban/Low-Speed Roughness

- Below 35 mph, a change in “Golden Car” simulation speed was needed to maximize correlation between roughness and ride.
- A temporal index (in/sec) was more successful than a spatial index (in/mi).
- Transient events (that is, localized roughness) was very important.

Source: Pennsylvania DOT

The Little Book of Profiling

http://www.umtri.umich.edu/content/LittleBook98R.pdf

stevemk@umich.edu