“New” Pavement Friction Measurements

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Outcomes

- Understand vehicle, tire, geometric, and environmental factors in braking and control
- Learn what pavement surface properties control “available friction”
- Greater understanding of tire/pavement interface
- Understand how we measure “available friction” and use the data
- Questions/comments
What’s “New?”

- Our level of understanding of what’s happening at the tire/pavement interface

- Increased use of ASTM E 524 “smooth” test tire
Wet Friction Demand Factors

Environmental
- Wet versus dry
- Temperature variations
- Seasonal variations
Wet Friction Demand Factors

Highway Design/Geometric and Facility Considerations

- Design/Posted Speed
- Straight/Flat versus Curves/Super’s/Hills and Grades
- Traffic Makeup Volumes Congestion
- Intersections/Interchanges
- Water Run-off/Drainage
Wet Friction Influence Factors

Pavement Distresses
- Rutting – Ponding
- Raveling
- Bleeding/Flushing
- Cracking
- Corrugations
- Roughness
- Etc.
Wet Friction Demand Factors

Vehicle/Operator
- Speed
- Weight
- Design/Condition of Braking System
- Alertness/Reaction Time
- Tires
Wet Friction Demand Factors

Tires
- Age and Tread Depth
- Tread Pattern
- Hardness/Softness of Rubber
- Inflation Pressure
- Type and Design
Wet Pavement Surface Friction

- Strive for Sufficient Available Friction everywhere.
- Sufficient Level Varies by Location (demand level).
- Available Friction is exclusively dependent on both the microtexture and macrotexture of the surface.
Macrotexture - the texture you can see with the naked eye

- Openness of an AC surface
- Jaggedness of a chip seal
- Tining or grooving one sees on a bridge deck
- Controlled largely be the largest aggregate size in the mix
Wet Pavement
Surface Friction

**Microtexture** - the finer texture more easily felt than seen

- Fine surface texture of sand and aggregate particles and degree of polish on exposed surfaces
- Bituminous coating until worn off
- Fine surface texture of sand/cement paste on a bridge deck
Wet Pavement
Surface Friction

Microtexture

- Fine texture that interacts with tire rubber for friction (adhesion)
- Important at all speeds, more dominant at lower speeds
Wet Pavement
Surface Friction

Macrotecture

- Allows space for water to evacuate
- Decreases hydroplaning potential
- Allows tire to contact the surface when wet (lets microtextture work)
- Increasingly important at higher speeds
- Deforms tire tread – hysteresis friction
Tire in Contact with Pavement

Source: Steve Karamihas UMTRI
Longitudinal Slip, Traction

\[
\text{Slip} = \frac{V_x - R \cdot \omega}{R \cdot \omega} \cdot 100
\]

Source: Steve Karamihhas UMTRI
Braking Tire

Source: Steve Karamihas UMTRI
Longitudinal Slip, Braking

\[
\text{Slip} = \frac{V_x - R \cdot \omega}{V_x} \cdot 100
\]

Source: Steve Karamihhas UMTRI
Tire/Pavement Friction

Critical (Peak) Friction $\mu_p$

Sliding Friction $\mu_s$

Linear Range

Source: Steve Karamihhas UMTRI
Braking Tire

Source: Steve Karamihas UMTRI
ASTM E 274 in action

- DrivealongSkid1.mpg
ASTM E 274 in action

- DrivebySkid.mpg
ASTM E 274 Locked Wheel Friction Testing Units

SN = \(\frac{F_h}{F_v}\)\*100

**SN** – skid number or friction number

**Fh** – horizontal force to drag locked wheel

**Fv** – vertical or load force on locked wheel

\(r\) subscript for ribbed test tire

\(s\) subscript for smooth test tire

standard test speed = 40 mph
Test Data
Avg Spd = 40.5 MPH  SN = 56.6  % Slip @ Peak = 5.6
Peak Time = 0.5  Peak = 92.691  Lock Up Time = 0.68

File Name: [redacted]
Test Run Time & Date 10:28:47  10/28/2011  Current Date 1/30/2012
ASTM E 274 Locked Wheel Friction Testing Units

Not a direct measure of either microtexture or macrotexture but a response to both.

- 40-50 year history
- Lane closures/traffic control not req’d
- Other friction testing devices don’t measure/respond to surface texture the same
Ribbed tire – sensitive to microtexture and insensitive to macrotexture
(ribs give place to evacuate water film)

Smooth tire – sensitive to both micro and macrotexture
(relies solely on pavement to evacuate water)
ASTM E 274 Locked Wheel Friction Testing Units

A measure of the pavement’s contribution of your ability to stop when the road is wet!
Ribbed vs. Smooth test tire

- Using only one gives little insight into how much micro vs. macro
- Threshold levels – different for both
- Use one, the other, or both?
  - Safety
  - Research
  - Curiosity
Available Friction

Need sufficient level of both microtexture and macrotexture

- Insufficient macro means increased hydroplaning potential, regardless of microtexture
- Pavement and tire both have to evacuate water
- Insufficient micro means increased stopping distance regardless of macrotexture
- To a point, a high level of one can make up for a marginal level of the other
Available Friction

Need sufficient level of both microtexture and macrotexture

- Can be engineered/designed
- Must consider life of the surface
- Carefully consider level of available friction required for given location
Available Friction

Can we have too much friction?

Skidding versus Rolling over?

High levels of Macrotexture may:
  • Increase tire/pavement noise
  • splash/spray?
  • Require more snow/ice removal chemicals
  • Decrease tire life

Optimize texture for all surface properties!
Influence of surface characteristics on vehicle performance. (Ayton, 1991)
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