The Role Aggregates Play in Highway Friction

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OAIMA Technical Session
November 18, 2016

Overview

- How Aggregates Influence Microtexture & Macrotexture: Friction
- How and why Micro & Macrotexture can change over time
- Mechanically Changing Surface Texture
- OH DOT utilizing more “Preservation” Treatments
- Network Macrotexture Measurement & Analysis
- Questions

How Aggregates Influence Friction

Assuming no impediments to drainage and surface water run-off & only looking at the pavement surface contribution (not the tire):

Tire/Pavement Friction and Grip (both wet & dry) is exclusively a function of the **micro and macro texture** of the pavement surface

- Microtexture – friction by "adhesion" or adhering to the tire
  - More easily felt than seen
  - Comes from the microtexture of the aggregate particles in the surface
- Macrotexture – friction by "hysteresis" or deforming the rubber in the tire; also works with tire tread pattern to evacuate water and deter hydroplaning
  - Visible voids in the surface of the asphalt concrete mat
  - Degree of how tight vs. open the mix is
  - Mechanical texturing of PCC: Tining, Grooving, Burlap or Turf Drag

How Aggregates Influence Friction

Microtexture

- a property of the aggregates
- Freshly fractured faces vs. polished
- Asphalt Concrete – Binder can play a role
- Portland Cement Concrete – Comes from sand in the paste/mortar

How Aggregates Influence Friction

Macrotexture of Asphalt Concrete surfaces

- a property of aggregate size
- a property of aggregate shape
- a property of aggregate gradation
- Influenced by binders
- Influenced by degree of segregation in the mix
- Influenced by other construction factors?
    - Compaction efforts for construction
    - Temperature of mat when opened to traffic

How Aggregates Influence Friction

Macrotexture of Portland Cement Concrete surfaces

- A direct result of mechanical texture or lack thereof imparted to the plastic concrete
  - Floats
  - Burlap drag
  - Turf drag
  - Tining
  - Diamond Grooving

Can Texture Change Over Time?

Microtexture

- Yes, propensity of aggregates to polish

Macrotexture

- Yes, wear from traffic and plow blades
- Yes, “tightening” AC surface mixes

Can Texture Change Over Time?

Raveling – loss of aggregate particles

Microtexture

- Yes, exposing new aggregate surfaces

Macrotexture

- Yes, creating more surface voids

Mechanically Improving Texture

Partial or Complete Exposure of underlying material

- Carbide Milling – Impact/Plucking Action: surface durability?
  - Micro Milling
  - Fine Milling
  - Conventional Coarse Milling
- Diamond Grinding – Abrasive Action – improves micro and macro
- Diamond Grooving – Abrasive Action – mainly improves macro
- Shot Blasting – Peening Action

Mechanically Improving Texture

Photo courtesy of
Aidan McDonnell
BOCA Construction Inc.

Mechanically Improving Texture

Carbide Milling

- Macrotexture need?
  - Influence drum choice
  - Tend to think tighter drum size reduce durability concerns
- Coarse Aggregates Prone to Polish?
  - Longevity of friction improvement
- Conventional Milling (for friction improvement) discouraged
  - Reduced section
  - Durability loss
  - Too much macrotexture accelerates polishing

Mechanically Improving Texture

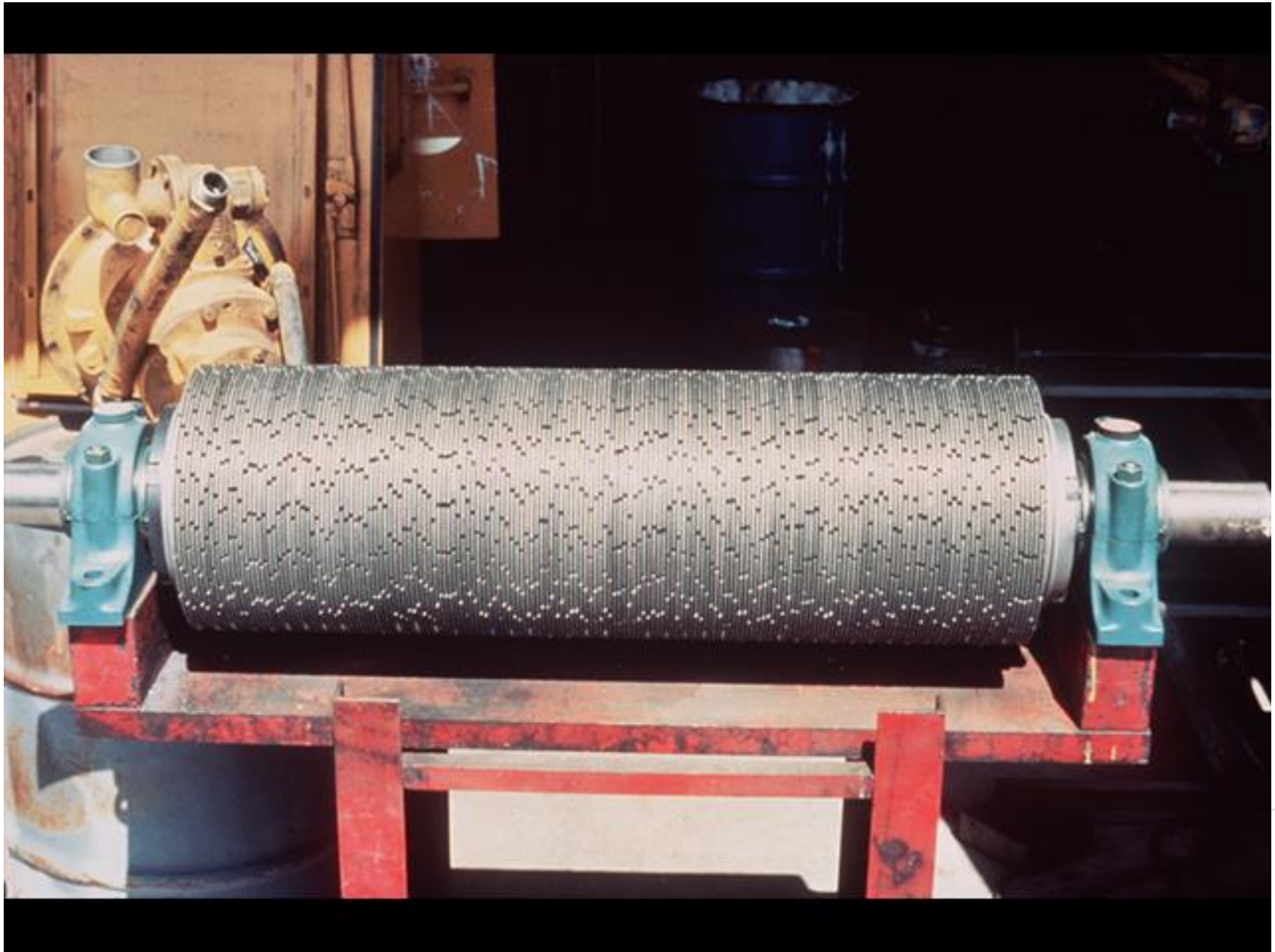


Photo courtesy of John Roberts of the IGGA

Mechanically Improving Texture

Diamond Grinding

- Macrotexture from corduroy pattern
  - Sufficient Initially
  - Can wear down over time
- Microtexture – sheared fins between saw blade
  - Exposed Aggregates Prone to Polish?
- PCC surfaces – natural sand in paste, newly exposed coarse aggregate
- AC surfaces – age and condition of surface; binder stability

Mechanically Improving Texture

Diamond Grooving

- Macrotexture from deeper and wider spaced grooves
  - Permanent macrotexture improvement
  - Continuous channels for water evacuation
- Microtexture – essentially no improvement
  - Think about current and future levels
- Added benefit of “mechanical bite” in curves
- Proven successful for both PCC and AC surfaces

More "Preservation" Treatments at OH DOT

Why?

- OH DOT Mission: "…Take Care of What We Have…"
- Reduced Capital Program in Future Years
- TAM Approach

A Single and Unified workplan synergistically merging Capital and Maintenance programs in current and future years

More “Preservation” Treatments at OH DOT

What?

- Chip Seals – AC Emulsion w/ uniformly graded chips applied and rolled in
- Microsurfacings – AC Emulsion w/ cement and well graded aggregates mixed together prior to application by squidgy
- Smoothseals – Hot Mix AC well graded ~ ¾” - 1” thick with high binder content

More "Preservation" Treatments at OH DOT

Chip Seals

- Typically used on lower truck volume routes
- Macrotexture both Positive and Negative
  - Generally sufficient through life of surface
- Microtexture – dependent on chips used and traffic

More “Preservation” Treatments at OH DOT

Microsurfacings

- Used on low volume 2 lanes to Interstates
- Eventually wears away to original surface
  - Continually exposing “new” aggregate particles
- Macrotexture on lower end but Positive and Negative
  - Too fine of gradation potential problem
  - Excessive emulsion potential problem
- Microtexture – dependent on aggregates used


Paper Mate

More "Preservation" Treatments at OH DOT

Smoothseals

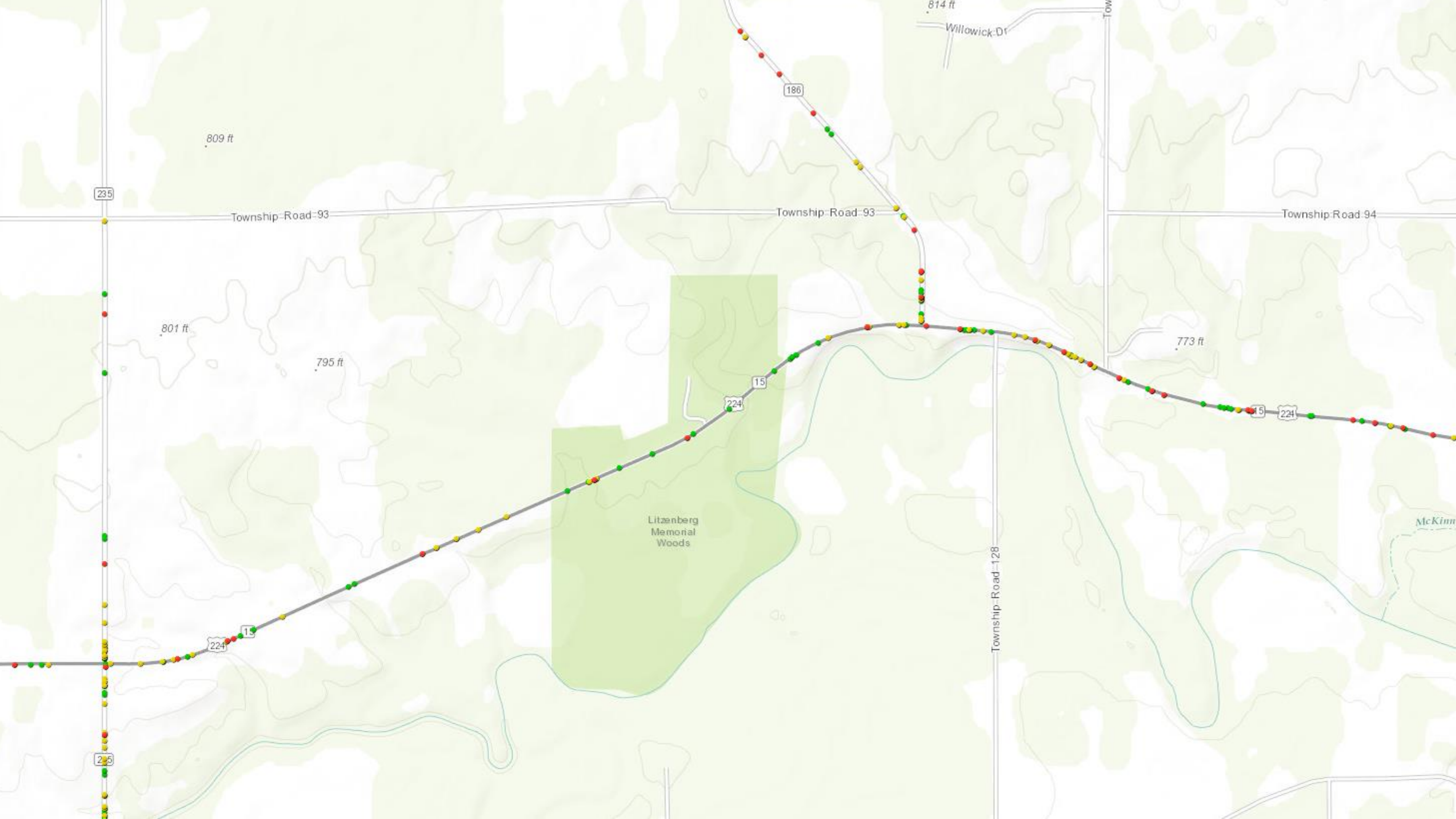
- Used on low volume 2 lanes to Interstates
- Macrotexture on lower end but Positive and Negative
  - Gradation prevents predominately negative texture from rollers
  - Higher grade binders needed
  - Too fine of gradation potential problem
  - Excessive binder potential problem
  - Mat cool when opened to traffic?
- Microtexture – dependent on aggregates used

Network Macrotexture Data

Highway Network Multi-System Data Collection Vehicle
"Pathrunner"

Network Macrotexture Data

- Required to collect IRI, Rutting, Cracking, Faulting
- Also collect 2-D Macrotexture data
  - 100 mm sample every 1 meter of travel
  - Combine with geospatial reference
  - Web map results for visualization
- Look for hotspots at high stress or high speed locations


814 ft
Willowick Dr
186
809 ft
235
Township Road 93
Township Road 93
Township Road 94
801 ft
795 ft
773 ft
15
224
Litzenberg
Memorial
Woods
Township Road 128
224
15
224
McKinn

Questions

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Conventional / Coarse Carbide Milling

Carbide Micro Milling

Photo courtesy of
Aidan McDonnell
BOCA Construction Inc.

Diamond Ground AC

Photo courtesy of
Aidan McDonnell
BOCA Construction Inc.

Photo courtesy of
Scott LeBlanc OH DOT
District 7

Diamond Grooved AC

Friction/Texture Evaluation Higher End

Example: ASTM E-274 Locked Wheel Friction Tester

ASTM E 274 Locked Wheel Friction Testing Units

$$SN = (Fh/Fv)*100$$

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

ASTM E-501 (Ribbed) Test Tire

Photos courtesy of Daniel McNeil OH DOT Tech Services

ASTM E-524 (Smooth) Test Tire

Photo courtesy of Daniel McNeil OH DOT Tech Services

Friction/Texture Evaluation Higher End
Example: ASTM E-274 Locked Wheel Friction Tester

E–501 Ribbed Tire

- More Sensitive to Microtexture as Ribs evacuate Water

E-524 Smooth Tire

- Sensitive to both Micro and Macrotexture – Relies on Pavement to evacuate Water

Response from both test tires yields an indication that the friction problem is insufficient microtexture, or insufficient macrotexture or both