Skid Resistance Measurement, Evolution and Predictive Laboratory Methods

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Overview

• The New Zealand Transport Context
• NZ’s Road Safety performance & Skid Resistance
• Surface Friction Measurement in NZ
• Aggregates, Polishing and Resource Efficiency
• Accelerated Pavement Polishing in Laboratories
• Microtextural analysis & quantifying polishing
• Rubber and Temperature Effects
• The Future of Skid resistance measurement
NZ and the World

Figure 1 – Where our exports go

Based on New Zealand Trade Data 2010 from Statistics New Zealand
NZ Roads vs France

NZ vs France Context
- Land Area, 268,000 sq km vs 545,630 sq km
- Population – 5.0M vs 65M
- Pop Density – 16 vs 117 ppl per sq km

Road Length
~93,000 kms vs ~956,000 kms

Rail Length
NZ – 4138 vs 29085

Unpaved Roads
NZ – 33,000 (1/3rd) vs 0? in France

GDP $ per km of Road + Rail - NZ – $1.2M per km vs $2.1M per km – NZ ½ of France
NZ Surfacings

- Auckland Total Road Length: ~8,075 kms
- 8.6% of National network but carries > 20% of VKT
- NZ Total Road Length: ~93,000 kms
- France - ~956,000 kms
NZ Chip Sealed Surfaces
Injury crashes per vehicle and per capita

Crashes / 10,000 vehicles

Crashes / 100,000 population

Per capita

Per vehicle

Year
NZ Road Safety – The Why?
Crash Movement Classifications

Figure 12
Crash movements by crash severity

- Overtaking or lane change
- Head on
- Lost control on straight
- Lost control while cornering
- Obstruction
- Rear end
- Turning versus same direction
- Crossing no turns
- Crossing vehicle turning
- Merging
- Right turn against
- Manoeuvring
- Pedestrian crossing road
- Pedestrian other
- Miscellaneous

Percent of crashes
Wet Road Crashes by Local Road Region in NZ (not incl SH’s)

Wet road related crashes 2016 -- All of NZ
Wet crash fatalities – 16%
Wet crash injuries – 20%
Crash Contributing factors

Figure 17
Factors contributing to crashes

Factors involved in Crashes, 2016
Road crashes are now not as clustered together
NZ - Relatively low traffic vols

State Highway Traffic Volume Distribution By Network Length
(All Vehicles)

<table>
<thead>
<tr>
<th>Traffic Volume</th>
<th>Length (km)</th>
<th>% of Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-500</td>
<td>635</td>
<td>5.8%</td>
</tr>
<tr>
<td>500-1000</td>
<td>1,709</td>
<td>15.7%</td>
</tr>
<tr>
<td>1000-2000</td>
<td>2,925</td>
<td>26.8%</td>
</tr>
<tr>
<td>2000-4000</td>
<td>2,315</td>
<td>21.2%</td>
</tr>
<tr>
<td>4000-6000</td>
<td>1,251</td>
<td>11.5%</td>
</tr>
<tr>
<td>6000-10000</td>
<td>1,026</td>
<td>9.4%</td>
</tr>
<tr>
<td>10000-20000</td>
<td>774</td>
<td>7.1%</td>
</tr>
<tr>
<td>20000-30000</td>
<td>182</td>
<td>1.7%</td>
</tr>
<tr>
<td>&gt;30000</td>
<td>91</td>
<td>0.8%</td>
</tr>
</tbody>
</table>

50% < 2000 vpd
NZ Local Roads (Urban & Rural)

NZ Total Roads = 94,000 kms
SH’s = 11,000 kms
Local Sealed Roads = 52,000 kms
Unsealed > 31,000 kms

LA by ONRC ADT

50% < 1000 vpd
Aggregates, quality, cost, Resource Efficiency & Durability
### Factors Influencing Skid Resistance

<table>
<thead>
<tr>
<th>Pavement Surface Aggregate Factors</th>
<th>Load Factors</th>
<th>Environment Factors</th>
<th>Vehicle Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geological properties of the surfacing aggregate</td>
<td>Age of the surface</td>
<td>Water film thickness and drainage conditions</td>
<td>Vehicle speed</td>
</tr>
<tr>
<td><strong>Surface texture</strong>&lt;br&gt; (microtexture and macrotexture)</td>
<td>Traffic intensity and composition – equivalent vehicle loadings</td>
<td>Surface contamination</td>
<td>Angle of the tyre to the direction of the moving vehicle</td>
</tr>
<tr>
<td>Chip size and shape</td>
<td>Road geometry</td>
<td>Temperature</td>
<td>The wheel slip ratio</td>
</tr>
<tr>
<td>Type of surfacing&lt;br&gt; (concrete, asphalt mix and mix design, chip seal surface and design method)</td>
<td>Traffic flow conditions</td>
<td>The combined ‘seasonal effects’ and short-term variations</td>
<td>Tyre characteristics&lt;br&gt; (structural type, hardness and wear)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rainfall</td>
<td>Tyre tread depth and pattern</td>
</tr>
</tbody>
</table>
Skid Resistance Testing Devices in NZ
Adelia Nataadmadja & Ashkan Tatari

- Skid Resistance Prediction is complex
- Current PSV methods have been shown to be inadequate
- Research with IFSTTAR demonstrates APPD and WS method reflects in-field SR performance well
- Cost for industry for new method much lower than WS.
APPD – DFT process

The Dynamic Friction Tester

Greywacke Aggregate DFT(μ) Stage 1 and 2 Polishing

Time (mins)

DF Tester (µ)

- Unpolished Sample
- Polished Sample

Stage 1: Polishing to ESR
Stage 2: Polishing with Additives

A prepared Lab Sample

Lifting frame
Safety cage
Load weights
Water Delivery pipes

Electric motor, gear box and belt drive
Drive shaft
3 rotating pneumatic castor polishing wheels

The Dynamic Friction Tester

The Accelerated Polishing Machine

Polished Sample
1. Polish the sample for the required time
2. Water is sprayed for two minutes to clean the fine silica from the sample
3. Move the sample to the friction measuring head
4. Measure the skid resistance and record the value
5. Move the sample to the polishing head
Microtextural surface wavelength analysis methods

PhD Student - Ashkan Tatari

Volume parameters related to surface roughness

- Peak Material Volume - Vmp
- Core Material Volume - Vmc
- Core Void Volume - Vvc
- Dales Void Volume - Vvv
## WS – Polishing Microtexture

<table>
<thead>
<tr>
<th>Polishing Passes</th>
<th>0</th>
<th>1000</th>
<th>2000</th>
<th>3000</th>
<th>4000</th>
<th>5000</th>
<th>10000</th>
<th>20000</th>
<th>50000</th>
<th>90000</th>
<th>180000</th>
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</thead>
<tbody>
<tr>
<td><strong>CoF</strong></td>
<td>0.474</td>
<td>0.414</td>
<td>0.395</td>
<td>0.386</td>
<td>0.380</td>
<td>0.371</td>
<td>0.363</td>
<td>0.349</td>
<td>0.317</td>
<td>0.298</td>
<td>0.274</td>
</tr>
<tr>
<td><strong>Initial Unpolished Zone 1</strong></td>
<td>1.00</td>
<td>0.87</td>
<td>0.83</td>
<td>0.81</td>
<td>0.80</td>
<td>0.78</td>
<td>0.77</td>
<td>0.74</td>
<td>0.67</td>
<td>0.63</td>
<td>0.58</td>
</tr>
</tbody>
</table>

WS After Polishing 180,000 cycles - ESR Zone 1

WS After Polishing 180,000 cycles - ESR Zone 2

Initial Unpolished Zone 2
Microtextural analysis parameters at various stages of polishing

- **Sq**
- **Sa**
- **Sdq**
- **Ssc**
SCRIM tyre rubber and temperature effects

• An experiment measured skid resistance with a pendulum tester
• Three rubber sliders were used
• Two test surfaces were used
• Two temperature conditions were used
  - Rubber slider temperature changing from 5 to 50 °C
  - Test surface temperature changing from 5 to 50 °C
Skid resistance measurement and temperature effects

Fig. 1. Suggested temperature correction for 'skid resistance' values to allow for changes in resilience of the slider rubber.
• Instrumented vehicles
• Big Data analytics
• Decision making
• How much data is needed?

We need to improve skills in our industry
• New vehicle & connected infrastructure technologies, AI data analytics can help in being able to get almost real time information on surface condition but how we make good decisions from this data is still in its infancy.
Summary

• Sparsely populated country’s (like NZ) have a significant challenge ahead in improving historical infrastructure that was not designed for today’s demands

• Road crashes are now increasing, complex and do not necessarily cluster together – more unpredictability and multi factored crashes are occurring – more difficult to target $

• Natural raw materials (aggregates) are not consistent in quality, nor evenly spread in supply / demand – need more sustainable use & reuse of resources with improved methods

• Laboratory methods of prediction of aggregate performance is complex but is possible with lower cost devices c.f. eg. APPD vs Wehner Schulze

• Microtextural analysis by non contact methods are showing promise yet understanding of how and where to use these methods is not clear

• What skills will our future engineers need?
Merci... des questions

Au revoir