Road Safety & Pavement Materials Research – *Past, Present and Future at The University of Auckland*

Presentation to REAAA AGM Forum – Auckland

22 May 2013

PART TWO
The Prediction of Pavement Surface Aggregate Wear and Microtextural Polishing

Student name: **Adelia D. Nataadmadja** (PhD Candidate)
Starting date: October 2011
Supervisor: **Dr. Douglas Wilson** and **Dr. Seosamh Costello**

- **Objectives:**
  to find an alternative method to Polished Stone Value (PSV) test and to standardise the Auckland Pavement Polishing Device (APPD)

- **Current Work:**
  Testing 8 aggregates in IFSTTAR laboratories, Nantes France with Wehner Schulze – developing textural spectral analysis techniques

- **Future Work:**
  Comparative studies between results obtained from the APPD, PSV, and Wehner/Shulze.

- **Project Aim:**
  to have an alternative laboratory test methodology so that a more accurate prediction of road surface performances can be obtained.
The Prediction of Pavement Surface Aggregate Wear and Microtextural Polishing

Adelia Nataadmadja (PhD candidate)
28 May 2013

## Materials Used

<table>
<thead>
<tr>
<th>Aggregates</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Greywacke</td>
<td></td>
</tr>
<tr>
<td>Coarse</td>
<td>2</td>
</tr>
<tr>
<td>Fine</td>
<td>1</td>
</tr>
<tr>
<td>Basalt</td>
<td></td>
</tr>
<tr>
<td>Coarse</td>
<td>2</td>
</tr>
<tr>
<td>Fine</td>
<td>1</td>
</tr>
<tr>
<td>Artificial</td>
<td>2</td>
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Wehner Schulze German Laboratory Polishing Device...

- Polishing Workstation
- Polishing rollers
- Polycarbonate shield
- Quartz abrasive + water mixing tank
- Friction Measuring Workstation
- Feet with rubber pads
- Polycarbonate shield
- Specimen mounted in mould
- Round Table mounted on runner
Wehner Schulze German Laboratory Polishing Device

- Rubber rollers
- Rubber feet to measure friction
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
Primary vs. Roughness

**PRIMARY**
- Profile Length - $l$
- Depth – $z$ (mm)

**ROUGHNESS**
- Profile Length - $l$
- Depth – $z$ (µm)
Parameters

- $Pa/Ra/Wa$: Average height of profile
- $Pq/Rq/Wq$: Root-Mean-Square height of profile
- $Pt/Rt/Wt$: Maximum peak to valley height of primary profile
- $Pz/Rz/Wz$: Mean peak to valley height of primary profile
- $Pmax/Rmax/Wmax$: Maximum peak to valley height of primary profile within a sampling length
- $Pp/Rp/Wp$: Maximum peak height of primary profile
- $Pv/Rv/Wv$: Maximum valley height of primary profile
- $Pe/Rc/Wc$: Mean height of profile irregularities of primary profile
Profile Length - \( l \)

Depth – \( z \) (\( \mu \text{m} \))

<table>
<thead>
<tr>
<th>Primary</th>
<th>Roughness</th>
<th>Waviness</th>
<th>Description</th>
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<tr>
<td>( P_k )</td>
<td>( R_k )</td>
<td>( W_k )</td>
<td>Core roughness depth</td>
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<tr>
<td>( P_{pk} )</td>
<td>( R_{pk} )</td>
<td>( W_{pk} )</td>
<td>Reduced peak height</td>
</tr>
<tr>
<td>( P_{vk} )</td>
<td>( R_{vk} )</td>
<td>( W_{vk} )</td>
<td>Reduced valley height</td>
</tr>
<tr>
<td>( P_{mr1} )</td>
<td>( R_{mr1} )</td>
<td>( W_{mr1} )</td>
<td>Peak material ratio 1 component in %</td>
</tr>
<tr>
<td>( P_{mr2} )</td>
<td>( R_{mr2} )</td>
<td>( W_{mr2} )</td>
<td>Peak material ratio 2 component in %</td>
</tr>
<tr>
<td>( - )</td>
<td>( L_c )</td>
<td>( L_c )</td>
<td>LambdaC</td>
</tr>
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Skid Resistance deterioration by Wehner Schulze

![Graph showing skid resistance deterioration over number of passes for different samples.](image-url)
Skid Resistance Deterioration Trend

\[ \mu = a (N + b)^c \]

- Experimental Skid Resistance
- Calculated Skid Resistance
- Slope at 0
- Slope at 180000

The University of Auckland
New Zealand
28 May 2013
Aggregate Polishing

Surface Profile Before and After Polishing

(Ni Passes)

Surface Profile Before and After Polishing

(90000 Passes)

Surface Profile Before and After Polishing

(180000 Passes)
The Correlation between rutting and loss of control crashes on NZ State Highways

28 May 2013

Ming Yun Chan and Karl Yuan (BE Civil) Year 4 project - 2012
Project supervisor: Dr. Douglas Wilson
Second supervisor: Dr. Tam Larkin
Combining data

Crash rate (CR) = \( \frac{\text{No of crashes} \times 10.6}{\text{AADT} \times 365 \times T} \)
Graph 2: Rut depth and skid resistance distribution
Northland 2009

- Throughout NMA
- At crash locations
Graph 1: Rut depth and crash rate distribution at Northland crash sites 2007-2011

Crash rate (crashes/10^6 veh-km)

Max Rut depth (mm)

\[ y = 0.0049x + 0.6465 \]

\[ R^2 = 0.0021 \]
Single Variable Analysis Results

Graph 2: Maximum rut depth
all Northland State Highways
2007 - 2011

- Deep ruts: 3%
- Moderate ruts: 53%
- Shallow ruts: 44%

Graph 3: Maximum rut depth at
Northland crash sites only
2007 - 2011

- Deep ruts: 15%
- Moderate ruts: 45%
- Shallow ruts: 40%
Graph 5: Northland Loss of control crashes on dry roads 2007 - 2011
Graph 6: Northland Loss of control crashes on wet roads 2007 - 2011

Crash rate (crashes/10^6 veh-km)

- <9mm
- 9-16mm
- >16mm

Skid resistance (ESC)
- >0.6
- 0.35-0.6
- <0.35

Maximum Rut depth (mm)
Research Conclusions

- No correlation between rut depth and crash rate:
  - When only rutting was considered by itself
  - When roads had good skid resistance (> 0.35 ESC) regardless of wet or dry road conditions

- Correlation found:
  - Data suggests increasing rut depth increases crash rate for wet roads with low skid resistance (< 0.35 ESC)
MOTORWAY CRASH ANALYSIS USING GIS:
A Case Study of St Marys Bay, Auckland

- Identify crash rates on a lane by lane and movement type basis
- Investigate road and environment factors contributing to these crashes
- Investigate the potential for using a geographical information system to analyse crashes on multilane roads

Joshua Aldridge, Ross Harper
Supervisors: Douglas Wilson / Roger Dunn
MOTORWAY CRASH ANALYSIS USING GIS:

Crash Type
- NOSE TO TAIL
- LOST OF CONTROL
- LANE CHANGE
- LANE CHANGE
- OTHER

St Marys Bay – Crash Rate by Lane and Type

28 May 2013

Joshua Aldridge, Ross Harper
The Development of a Multi-Faceted Evaluation Framework of Shared Spaces

Student name: Auttapone Karndacharuk (PhD Candidate)
Starting date: June 2010
Supervisor: Dr. Douglas Wilson and AP Roger Dunn

- **Objectives:**
  to develop an evaluation framework for shared spaces / streets, taken into account quantitative and qualitative performance measures of pedestrians, cyclists and vehicles.

- **Current Work:**
  Qualitative ‘before and after’ data analysis of three case studies in Auckland city centre.

- **Future Work:**
  Quantitative data collection and analysis (perception surveys) and testing of the framework, using a multi-criteria decision analysis.

- **Project outcome:**
  The evaluation framework and performance index that can be used to measure effectiveness of different shared space environments.
The Performance of Unbound Aggregates for the Purposes of Permeable Pavements

Student name: **Pritesh Karan** (PhD)  
Starting date: March 2012  
Supervisor: **Dr. Douglas Wilson** and **Dr. Tam Larkin**

- **Objectives:**
  To determine the effects on engineering performance of simulated traffic loading on unbound granular basecourse materials under saturated conditions.

- **Current Work:**
  Refurbishing large-scale Repeated Load Triaxial (RLT) gear and literature review of previous RLT tests.

- **Future Work:**
  Undertake laboratory RLT tests to simulate permeable pavement performance.

- **Project outcome:**
  To determine the suitability of permeable pavements in the New Zealand road network.
The sand equivalent test and it’s ability to accurately determine the suitability of fine aggregates and sands – Jason Lowe (ME Thesis)

- Evaluate the effectiveness of the Sand Equivalent Test versus Clay Index Test
- Determine SE settlement curves for NZ rock types
- Analyse the ultra fines to identify size fraction influences
- Offer suggestions on modifying current test methods or accepting limitations within specifications

![Sand Equivalent vs. Clay Index](image1)

- Multiple Quarries and Products
  - Sample size = 400
  - 24% of samples ≥40 (Sand Equivalent)
  - 74% of samples ≤3 (Clay Index)

![SE Settlement Curves](image2)

- Number of Tests 400
- Number of Companies 2
- Number of Rock Types 2
- Number of Quarries 8

Figure 1: Comparison of sand equivalent v clay index of North Island greywacke aggregates

Figure 2: Full settlement curves for a North Island greywacke pap7 aggregate
Student name: Jawad Hussain (PhD Scholar)
Time Duration: August 2008 - 2013
Supervisor: Dr. Douglas Wilson and Dr. Theunis F. P. Henning

• Objectives:
  To find the performance of unbound aggregates used in basecourse layer of the pavements in wet conditions and to verify how well we simulate their behaviour in laboratory.

• Experimental Work:
  The experimental work was divided into three categories: Mineralogical Testing, Repeated Load Triaxial (RLT) Testing, and Full Scale Accelerated Pavement Testing.

• Project outcome:
  Better understanding of the moisture susceptibility of aggregates and the effects of grading, A new permanent deformation statistical model including stress and number of loading cycles for RLT test data.
The Performance of Improvement Techniques on Marginal Unbound Granular Aggregates Using a Large Scale Repeat Load Triaxial Test

Student name: Wentao Li (PhD Candidate)
Starting date: April 2012
Supervisor: Dr. Douglas Wilson and Dr. Tam Larkin

- **Objectives:**
  to optimize the improvement techniques based on collating and analysing methods to improve local Auckland based marginal material and critiquing the practice of RLT test worldwide which is applied in unbound granular aggregates

- **Preparation:**
  Literature review, collect the data on engineering performance of local Auckland based marginal material and be familiar with RLT test

- **Research outcome:**
  a) to find factors which influence the property of Auckland marginal materials using RLT test
  b) to get a technique to improve the performance of marginal unbound granular aggregates
The Fatigue Behaviour of Asphalt Mixtures and the Influence of Binder/Aggregate Interaction

Student names: Fidez Oreta and Catherine Mills (Undergraduate Research)
Starting date: 2012 & 2013
Supervisor: Dr. Douglas Wilson and Dr. Tam Larkin

• Objectives:
  To compare the effect of nominal aggregate size and binder composition on fatigue performance of asphalt.

• Current Work:
  2 new students this year looking at temperature effects on asphalt under constant static loads.

• Future Work:
  Develop methodology to continue cyclic load testing, conduct cyclic fatigue testing and stereoscope imaging of failure surface.

• Project outcome:
  To investigate a relationship between nominal aggregate size and fatigue life. To determine whether failure is caused by adhesion (aggregate/binder interface) or cohesion (binder).
In-situ pavement response monitoring system (PRMS) – an analysis of strain / temp / traffic loads

Student names: Mike Zhou and Joanne Duan (Undergrad Research)
Starting date: 2012
Supervisor: Dr. Douglas Wilson and Dr. Tam Larkin

- Objectives:
  To design and install an array of pavement instrumentation to measure dynamic strain, temperatures and pressures in a ‘live’ road structural asphalt pavement structure.

- Current Work:
  2 new students in 2013 looking at temperature variation with strain for various traffic loads and effects of speed.

- Future Work:
  Analyse dynamic pavement responses by variation in load, temperature, wheel path wander and compare against laboratory test behaviour and pavement design models

- Project outcome:
  To gain field strain data and relationships with environment to better relate laboratory specimens / design models to real traffic induced strain in typical NZ Asphalt mixes
Modelling Dynamic Friction Tester Data

Student name: **Bernard Jacobsen** (ME Candidate)
Starting date: June 2011
Supervisor: **Dr. Douglas Wilson**

- **Objectives:**
  Determine the response of the Dynamic Friction Tester to microtexture and macrotexture rich surfaces

- **Current Work:**
  Looking at the application of the Penn State University and IFI Friction models to the DFT data

- **Project outcome:**
  To obtain a model that adequately describes the response of the DFT to the influences of surface macrotexture and microtexture
Modelling Flushing on Thin Flexible Surfaced Pavements in New Zealand

Student name: Sachi Kodippily (PhD Candidate)
Starting Date: June 2009
Supervisors: Dr. Theunis Henning & A/Prof Jason Ingham

- **Objectives:**
  To develop a model to determine the initiation and progression of flushing on thin flexible surfaced pavements.

- **Experimental Work:**
  Two main components:
  Laboratory testing and CT scanning of pavement samples to investigate the micromechanics of air voids reduction in relation to flushing, and analysis of pavement performance data.

- **Project outcome:**
  Mechanistic understanding of the development of flushing and a data-based model that can forecast flushing occurrence on thin flexible surfacings.
Thank you for your support…
We look forward to continuing to work in partnership with industry!
Points to ponder / discuss?
How industry can help

- Continued access to data / information
- Operational funding to continue on a research case by case basis….
- Support in kind with research students
- Student scholarships
- Strategic Transport Funding ??
- Joint High Level Transport / Materials Research Laboratories at Newmarket ??
- Research Needs of the future?
Questions??
<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Supervisors</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAUDHRY, Mohsin Shahzad</td>
<td>“Micro-simulation: An alternative to Analytical Methods for Capacity and Delay Estimates”, Supervisors, Dr. Prakash Ranjitkar and Dr. Douglas Wilson</td>
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<tr>
<td>BEZUIDENHOUT, Johannes Jurgens (Urie)</td>
<td>“The influence of a new signal offset optimiser on travel reliability and drivers’ route choices” Supervisors, Dr. Prakash Ranjitkar and Dr. Judith Wang</td>
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<tr>
<td>CHOWDHURY, Subeh.</td>
<td>“Public-Transport User Perception of the Importance of Coordination of Service and Willingness to Act Upon”, Supervisors, Professor Avi Ceder and Assoc. Professor Roger Dunn</td>
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<td>HASSOLD, Stephan.</td>
<td>“Modelling Different Vehicle Types for Public Transport Timetables and Vehicle Scheduling with Even Loads and Headways”, Supervisors, Professor Avi Ceder and Assoc. Professor Roger Dunn</td>
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<tr>
<td>KODIPPLY, Sachi.</td>
<td>“Modelling the Flushing Mechanism of Thin Flexible Surfed Pavements in New Zealand”, Supervisors, Dr. Theuns Henning and Dr. Jason Ingham</td>
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<tr>
<td>SCHLOTJES, Megan.</td>
<td>“The Risk Associated with Pavement Failure in New Zealand”, Supervisors, Dr. Theuns Henning, Dr. John St George and Dr. Michael Borrow (University of Birmingham).</td>
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<tr>
<td>MILLER, Gary.</td>
<td>“Methods of Improving Productivity in Construction &amp; Engineering: Information Flow and Innovation” Supervisors, Dr Theuns Henning, Dr Jim Bentley and Dr Andrea Raith.</td>
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<tr>
<td>KARNDACHARUK, Auttapone.</td>
<td>“Performance and Perception of Shared Space Schemes in New Zealand” Supervisors, Dr Douglas Wilson and Associate Professor Roger Dunn</td>
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<tr>
<td>RASHIDI ,Soroush</td>
<td>“Evaluate Reliability of ITS Tools for Travel Time Estimation and Prediction on Road Networks” Supervisor, Dr Prakash Ranjitkar and Dr Douglas Wilson</td>
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<tr>
<td>PhD – Adelia Natadmadja –</td>
<td>“The Prediction of Pavement Surface Aggregate Wear and Microtextural Polishing” Supervisors - Dr Doug Wilson &amp; Dr Seosamh Costello</td>
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Recent ME (Civil) Students (Transportation)

- **LOWE, Jason**, “The Quality of fine Aggregates, Sands and Basecourses in New Zealand”, Supervisor Dr Doug Wilson
- **JACOBSEN, Bernard**, “Modelling Dynamic Friction Tester Data” Supervisor Dr Doug Wilson
- **KARAN, Pritesh**, “The RLT Performance of Unbound Granular Pavements for the purposes of Permeable Pavements” Supervisor Dr Doug Wilson
- **WANG, Angela**, “Investigation on the Curing Rate of a Storable Foamed Bitumen Stabilised Mix” Supervisor Dr Doug Wilson
- **SHI, James Kefei**, “Relative Repeatability of Different Detector Systems on Auckland’s Motorways” Supervisor Assoc. Prof. Roger Dunn.
- **SHAHIN, Amin**, “An Investigation into the Variability of the NZ Vibrating Hammer Compaction Test” Supervisor Dr Doug Wilson
- **ZAFAR, Rabia**, “Crash Risk and Traffic flows on Auckland Motorways” Supervisor Dr Doug Wilson
- **YUVARAJAN, Dushyanthan**, “Crash Barriers and Motorcycle Injuries” Supervisor Dr Doug Wilson
- **WOO, May**, "Guidelines to calibrate and validate micro-simulation model", Supervisor Dr Prakash Ranjitkar
- **YUKICH, Hollie**, "A study on critical and follow up gaps at priority controlled intersections in New Zealand”, Supervisor Dr Prakash Ranjitkar
- **PAUDEL, Kripa**, "Improving Techniques for Roughness Measurement Reporting “, Supervisor, Dr Theuns Henning,
- **TRUONG, Ngan Soai.** "Synchronization and Prediction of User Travel Time and Incident on Motorway Network based on Multi-Detector Data”, Supervisor Dr. Prakash Ranjitkar
- **MA, Carol.** “Site Specific Analysis on the LTPP Programme”, Supervisor Dr TFP Henning
Recent MEngSt (Transportation) Research Projects

<table>
<thead>
<tr>
<th>Name</th>
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<tr>
<td>HINTON, Matthew</td>
<td>&quot;Developing a Time Charge Approach to gain Transport Efficiency in the Auckland CBD&quot;</td>
<td>Assoc. Professor Roger Dunn</td>
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<td>MUSLIM, Laith</td>
<td>&quot;Speed estimation using single loop detector&quot;</td>
<td>Dr. Prakash Ranjitkar</td>
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<td>RAMASUBRAMANIAM, Prakash</td>
<td>&quot;Safety and Geometrics: Optimising Cost and Benefit of Improvements in a Rural Environment&quot;</td>
<td>Dr Doug Wilson</td>
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<td>BURROWES, Ben</td>
<td>&quot;The Development of an Asset Management System for Temporary Traffic Signs&quot;</td>
<td>Dr Doug Wilson</td>
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<td>NEWCOMBE, Daniel</td>
<td>&quot;Auckland Bus lanes and Vulnerable Road User Crashes&quot;</td>
<td>Dr Doug Wilson</td>
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<td>SALARPOUR, Hassan</td>
<td>&quot;Evaluation and Validation of High Speed Instrumented Vehicle for measuring Road Geometry data&quot;</td>
<td>Dr Doug Wilson</td>
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<td>ZHANG, Xu (Sam)</td>
<td>&quot;Improving Bus-Rail Coordination and Connectivity in Auckland&quot;</td>
<td>Professor Avi Ceder</td>
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<td>TAO Yi, Joanne</td>
<td>&quot;Improving Reliability of Public-Transport Journey in Auckland&quot;</td>
<td>Professor Avi Ceder</td>
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<td>JAGLAL, Marisha</td>
<td>&quot;The Safety and Efficiency of Left Turn Treatments at Signalised Intersections&quot;</td>
<td>Dr Doug Wilson</td>
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<td>KAMALI, Gul</td>
<td>&quot;The Weathering of Aggregates&quot;</td>
<td>Dr Doug Wilson</td>
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