A Performance Prediction Model to Manage flushing of Sprayed Seal Pavements

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NEW ZEALAND
Te Whare Wānanga o Tamaki Makaurau
Introduction

- Sprayed seal = Chipseal
- Economical ➔ Ideal for low volume roads
Flushed wheel path

Flushing

- Full or partial covering of surface aggregates
- Predominant surfacing problem in New Zealand

<table>
<thead>
<tr>
<th>Condition</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flushing</td>
<td>50%</td>
</tr>
<tr>
<td>Binder brittle</td>
<td>6%</td>
</tr>
<tr>
<td>Scabbing</td>
<td>2%</td>
</tr>
<tr>
<td>Cracking</td>
<td>11%</td>
</tr>
<tr>
<td>SCRIM</td>
<td>10%</td>
</tr>
<tr>
<td>Other</td>
<td>21%</td>
</tr>
</tbody>
</table>
Presentation Outline

• Research objectives
• Data analysis and model development
• Experimentation:
  ▪ Lab experiments; 3D analysis; Air voids analysis
• Flushing assessment framework
• Conclusions
Objectives

• Develop an assessment technique to effectively predict flushing on chipseal pavements
• Develop a data-driven prediction model to identify the presence and quantity of flushing
• Establish chipseal performance characteristics that indicate flushing potential
FLUSHING PREDICTION MODEL
NZ LTPP Programme

• 14 years of survey data
• 58 State Highways sites and 83 local authority sites
• Data items in the LTPP database:
  ▪ Pavement characteristics, eg, pavement and surface age, surface thickness and materials,
  ▪ Traffic volumes
  ▪ Structural condition as identified from visual recordings of distresses
  ▪ Maintenance records
Flushing Assessment in LTPP

- Flushing measurements are based on visual inspections – light, moderate, severe

Light flushing  Moderate flushing  Severe flushing
Shortfalls of Existing Flushing Assessments

- Need a systematic procedure to effectively identify flushing patterns
- Overcome limitations of visual and indirect management methods
- A pavement deterioration model is an efficient and accurate method of flushing management
Deterioration Phases for Flushing

Distress

Pre-intervention phase

Point of intervention for distress

Point of initiation of flushing

Gradual progression of distress

Time
Flushing vs Surface Age/Surface Thickness

- Flushing initiated: 0 - no; 1 - yes

- Surface age (years)

- Surface Thickness (mm)
Flushed Initiating

\[ p(\text{FlushedInitiated}) = \frac{1}{1 + e^{-(0.293 \text{surfage} + 0.046 \text{Surfthickness} - 2.913)}} \]
IN-DEPTH MATERIALS ANALYSIS
The Flushing Mechanism

- The volumetric balance between bitumen, aggregate and air voids is vital to flushing development.

\[
\begin{align*}
\text{Total volume of air voids, } V_a \\
\text{Total volume of bitumen, } V_b \\
\text{Effective volume of bitumen, } V_{be} \\
\text{Volume of bitumen absorbed by aggregate, } V_{ba} \\
\text{Effective volume of aggregate, } V_{se} \\
\text{Total volume of aggregate, } V_t
\end{align*}
\]
Chipseal Deformation

- Two distinct deformation patterns are present in multiple chipseal layers:
Computed-Tomography Scanning

Source: http://www.radiology-equipment.com/detail.CFM?LineltemID=762
3D Model of Chipseal

a) 3D reconstruction of untracked sample
b) Air voids structure of untracked sample
c) 3D reconstruction of tracked sample
d) Air voids structure of tracked sample

Distance from bottom of sample (mm)

Volume of air voids (%)
Air Voids & Flushing Trends

Reduction in air void volume calculated from CT scan images (%)

Flushing measured after wheel tracking test (%)

$y = 0.703x + 13.837$

$R^2$ Linear = 0.820
Flushing Analysis Framework

Flushing prediction

Flushing initiated?

Yes - Predict quantity of flushing

No - Continue monitoring

Wheel tracking analysis

Deformation pattern

Stable deformation - flushing present?

Yes - Conduct internal visualisation assessment

Air voids present in wheel tracked area?

Yes - Stability due to stone-on-stone state

Use water blasting

No - Stability due to complete reduction of air voids

Need for rehabilitation

Unstable deformation - flushing present?

Yes - Need for rehabilitation

No - No maintenance needed. Continue to monitor

No - Continue monitoring
Conclusions

- Flushing prediction model based on LTPP data
- The flushing model predicts flushing initiation at an accuracy of 76%
- Laboratory testing, and internal analysis is vital to confirming model predictions
- Assessment framework to identify flushing from a network level down to volumetrics
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THANK YOU