Development of gravel loss and other condition performance models for unsealed roads

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Outline of presentation

- Importance of performance models
- Developments in Australia
- Developments in New Zealand
- Practices to reduce gravel loss
Why update existing models?

- move from an art to a science
- better able to assess future needs
- achieving greater value
- justifying funding requirements
Making it happen in Australia
### Nominated monitoring sites on local roads (as at end March 2006)

<table>
<thead>
<tr>
<th>State/Territory</th>
<th>Number councils or organisations</th>
<th>Asphalt* road sites</th>
<th>Sealed road sites</th>
<th>Unsealed road sites</th>
<th>Total sites nominated</th>
</tr>
</thead>
<tbody>
<tr>
<td>New South Wales</td>
<td>59</td>
<td>48</td>
<td>71</td>
<td>20</td>
<td>139</td>
</tr>
<tr>
<td>Victoria</td>
<td>53</td>
<td>53</td>
<td>91</td>
<td>25</td>
<td>169</td>
</tr>
<tr>
<td>Queensland</td>
<td>40</td>
<td>21</td>
<td>42</td>
<td>22</td>
<td>85</td>
</tr>
<tr>
<td>Western Australia</td>
<td>37</td>
<td>36</td>
<td>30</td>
<td>13</td>
<td>79</td>
</tr>
<tr>
<td>South Australia</td>
<td>24</td>
<td>27</td>
<td>21</td>
<td>20</td>
<td>68</td>
</tr>
<tr>
<td>Tasmania</td>
<td>17</td>
<td>6</td>
<td>28</td>
<td>0</td>
<td>34</td>
</tr>
<tr>
<td>Australian Capital Territory</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Northern Territory</td>
<td>4</td>
<td>3</td>
<td>18</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>235</strong></td>
<td><strong>198</strong></td>
<td><strong>303</strong></td>
<td><strong>100</strong></td>
<td><strong>601</strong></td>
</tr>
</tbody>
</table>
### Performance parameters selected

<table>
<thead>
<tr>
<th>Sealed Roads</th>
<th>Unsealed Roads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cracking</td>
<td>Gravel loss</td>
</tr>
<tr>
<td>Binder hardness</td>
<td>Loss of shape</td>
</tr>
<tr>
<td>Stone loss</td>
<td>Roughness (ride quality)</td>
</tr>
<tr>
<td>Rutting</td>
<td>Loose stone</td>
</tr>
<tr>
<td>Roughness (ride quality)</td>
<td>Material Properties</td>
</tr>
<tr>
<td>Structural strength</td>
<td></td>
</tr>
</tbody>
</table>
Typical unsealed roads in Australia
Measuring gravel loss
Gravel loss model for Australia

\[ GL = D \times (F1 \times ADT + F2 \times MMP + F3 \times PF) \]

Where:
- GL = gravel thickness loss (mm)
- D = time period in hundreds of days (days/100)
- ADT = average daily vehicular traffic in both directions, in veh/day
- MMP = mean monthly precipitation, in mm/month
- PF = plasticity factor (PI \times P075)
- P075 = amount of material passing the 0.075 mm sieve, in per cent by mass
- PI = plasticity index
- F1, F2, F3 = model coefficients
Roughness model for unsealed roads

\[
\text{IRI}_{\text{TG2}} = \text{IRI}_{\text{max}} - \exp\left\{ \left[ -0.001 \times (F0 + F4 \times \text{ADT} \times \text{MMP}/1000) \right] \times (\text{TG2}-\text{TG1}) \right\} \times (\text{IRI}_{\text{max}} - \text{IRI}_{\text{TG1}})
\]

Where:
- \(\text{IRI}_{\text{TG1}}\) = roughness at time TG1, in m/km IRI
- \(\text{IRI}_{\text{TG2}}\) = roughness at time TG2, in m/km IRI
- \(\text{IRI}_{\text{max}}\) = maximum allowable roughness for specified material, in m/km IRI
- TG1, TG2 = time elapsed since latest grading, in days
- ADT = average daily vehicular traffic in both directions, in veh/day
- MMP = mean monthly precipitation, in mm/month
- F0, F4 = model coefficients
Shape loss model

\[ SL = F_0 + F_1 \times ADT + F_2 \times P_{075} \]

Where:
- \( SL \) = percentage (%) change in cross-fall per year
- \( ADT \) = average daily vehicular traffic in both directions, in veh/day
- \( P_{075} \) = amount of material passing the 0.075 mm sieve, in per cent by mass
- \( F_0, F_1, F_2 \) = model coefficients
NZ-Gravel loss background

• During 2002, Land Transport New Zealand established a gravel loss experiment in cooperation with 10 local authorities.
• Data collection on 51 sections for a period of five years
• 2007, Land Transport New Zealand Research – Development of Gravel Loss Models (MWH NZ, ARRB, University of Auckland)
Study objectives

- Developing condition deterioration models such as gravel loss
- Develop a framework for adopting the deterioration models into a decision framework for the GRMS
- Propose some strategic level best practice guidelines for managing gravel roads from a performance perspective
Survey methodology

Concrete Benchmark 1

Offset 1 = #.#m

Concrete Benchmark 2

Offset 2 = #.#m

Surface Water Channel

Iron Tube

Cross Section A

Cross Section B

Cross Section F

Cross Section G

Fence

Timber peg

Concrete Benchmark 3
Statistical analysis results
Gravel data offers a challenge to understand

Histogram of Gravel Loss

Histogram Slope Loss
A new performance indicator was developed

\[ \text{ShapeIndex} = 10 \times (\text{Slopefactor} + \text{StdDevFactor}) \]
Model development results

- Three models were developed
  - Gravel Loss
    GL = j*ADT, P75, P265, Blading Freq, Surface width
  - Slope Loss
    SI = j' plasticl, cbr, ADT, Days Since Last Blade, grade, p265, width.f
  - Shape Loss
    Shape L = j' plasticl, cbr, ADT, Days Since Last Blade, grade, p265, width.f
Impact on gravel road management

- A simple data collection process is recommended
- Have to start collecting & managing the data
- Include models to decision process
- Discontinue current monitoring – more detail monitoring for specific cases
Factors contribution to gravel loss

- poor geometric standards
- drainage provisions
- wearing course materials
- construction and maintenance practices
Geometric design standards
Drainage, drainage, drainage, drainage
Selection of a wearing course

pavement | shoulder

wearing course
base course
subgrade

Not less permeable than pavement
Construction and maintenance practices
Questions ??
Research offers great promise but there are risks

Lessons learnt

• Obtaining information from councils on site locations, can take a long time
• Council’s records at selected sites on maintenance history, traffic counts and age of seals was often very limited
• While sites nominated were well posted many councils undertook maintenance works without prior advice
• Historic pavement performance records to compliment monitoring undertaken were of little value due to a lack of adequate maintenance records
• Many variables to content with in modelling unsealed roads