Cracking - A Tale Of Two Systems

24th Annual RPUG Meeting in Minneapolis

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ARRB Group, Australia
Outline of presentation

• The need for quality data
• Measurement techniques
• Two automated crack measurement systems
• Comparative performance
• Summary
• A couple of things
‘What you need’

• Cracking data that is
  – accurate & objective
  – repeatable
  – useable
  – economic
  – complete (total coverage of network)
‘Why you need’

• For making informed decisions
Traditional methods

- From window of slow moving vehicle
- Walking the pavement
Area view & line scan cameras

- vehicle and roadside shadows
- clouds, tunnels etc.
- fish-eye lens effects
- manual assessment
Automated crack detection - RoadCrack

Current system

New trailer version with profiler
RoadCrack

- Developed by RMS NSW in conjunction with CSIRO in mid 1990s
- Real time crack measurement system
- Designed and proven to measure 1mm+ cracks on all surfaces
- > 20,000 km surveyed annually
CSIRO truck installation
Cameras and lighting
Camera configuration

- 4 x line-scan cameras, single transverse scan every 1mm
- 1mm per pixel, longitudinally and transverse
- exposure adjusted for surface reflectivity, 4–20 µS
- packaged into 500mm long frames
RoadCrack lighting

- 8 x 1500W quartz iodide lamps with reflectors
Angled lighting

Lamp with reflector

Crack width

Shadowing produces high contrast images
RoadCrack lighting
Only as much power as a...
RoadCrack tanning
Pavement images – sprayed seal
3D imaging (LCMS)

- 5 mm sampling
- range accuracy 0.5 mm
- lateral resolution 1.0 mm
LCMS test platform
3D imaging

Range

3D

Intensity
3D imaging

Range  
Intensity  
3D
Need to ensure....
Comparison issues

• No standard report formatting
• Difference in width of measurement
• 4 images vs 1
• 500 mm vs 5 m
LCMS cracking results
Overlay grid

- Overlaid grid to simulate RoadCrack analysis areas
Emulation of RoadCrack results

- No. of cracked frames = 23
- Reported as cracked frames per 100 m
Dense graded asphalt – crack images

LCMS

RoadCrack
Cracks to same scale

LCMS

RoadCrack
Test surfaces

DGA
Sprayed seal

Tynned concrete
Dense graded asphalt (DGA)
# DGA – internal repeatability

## LCMS

<table>
<thead>
<tr>
<th></th>
<th>Run 1</th>
<th>Run 2</th>
<th>Run 3</th>
<th>Run 4</th>
<th>Run 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastbound</td>
<td>0.968</td>
<td>0.997</td>
<td>0.972</td>
<td>0.983</td>
<td>0.992</td>
</tr>
<tr>
<td>Westbound</td>
<td>0.994</td>
<td>0.992</td>
<td>0.929</td>
<td>0.992</td>
<td>0.992</td>
</tr>
</tbody>
</table>

## RoadCrack

<table>
<thead>
<tr>
<th></th>
<th>Run 1</th>
<th>Run 2</th>
<th>Run 3</th>
<th>Run 4</th>
<th>Run 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastbound</td>
<td>0.966</td>
<td>0.975</td>
<td>0.977</td>
<td>0.986</td>
<td>0.974</td>
</tr>
<tr>
<td>Westbound</td>
<td>0.994</td>
<td>0.989</td>
<td>0.993</td>
<td>0.994</td>
<td>0.996</td>
</tr>
</tbody>
</table>
DGA – RoadCrack vs LCMS correlation

Westbound

<table>
<thead>
<tr>
<th></th>
<th>Eastbound</th>
<th>Westbound</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r^2$</td>
<td>0.79</td>
<td>0.92</td>
</tr>
</tbody>
</table>
Comparison with manual rating

- (insert picture from MH)

Percentage cracked (%) vs Distance (m)

- Dante
- Richard
- Lois
- LCMS 5m
Sprayed seals – internal repeatability

<table>
<thead>
<tr>
<th>System</th>
<th>Northbound</th>
<th>Southbound</th>
</tr>
</thead>
<tbody>
<tr>
<td>RoadCrack</td>
<td>$r^2$</td>
<td>0.70</td>
</tr>
</tbody>
</table>

![Graph showing cracked frames per 100 m section versus distance (km). The graph includes two runs: Run 1 and Run 2, with a checkmark indicating agreement.](image)
Sprayed seals – internal repeatability

<table>
<thead>
<tr>
<th>System</th>
<th>Northbound</th>
<th>Southbound</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCMS</td>
<td>$r^2$</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.96</td>
</tr>
</tbody>
</table>

Graph showing cracked frames per 100 m section against distance (km) for Run 1 and Run 2.
Sprayed seals – correlation

<table>
<thead>
<tr>
<th></th>
<th>Northbound</th>
<th>Southbound</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r^2$</td>
<td>0.17</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Observed differences

- Mainly ‘false positives’
- Shoulder widening
- Out of range???
Observed differences
r^2 > 0.97 for internal repeatability
Concrete surface - LCMS
# Data size

<table>
<thead>
<tr>
<th>System</th>
<th>Data per km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area scan</td>
<td>140 MB</td>
</tr>
<tr>
<td>Line scan</td>
<td>340 MB</td>
</tr>
<tr>
<td>LCMS</td>
<td>530 MB</td>
</tr>
<tr>
<td>RoadCrack (save all images)</td>
<td>750 MB</td>
</tr>
<tr>
<td>RoadCrack (real-time)</td>
<td>2 kB</td>
</tr>
</tbody>
</table>
Advantages and limitations - RoadCrack

For

• Real time outputs. Results are small text files
• Proven and optimised for Asphalt, Spray Seals and Concrete
• Detects, classifies and measures
• Images save options: none, all or just the cracked ones

Against

• Pavement images limited to 2.4 m width
• Large trailer and generator required
• Manual intervention required for concrete surfaces
• High maintenance of quartz halogen globes and reflectors
Advantages and limitations - LCMS

For

- Relatively compact, installed on normal vehicle
- Full Lane width measurement
- 3D information as well as intensity
- Lane marking identification, rut measurement etc.

Against

- Not yet optimised for sprayed seals or concrete
- Crack co-ordinates available, but classification and analysis needs to be done by integrator. Maybe also a +ve
- Very large data volumes to be handled. Slow processing
Conclusions

• Comparisons can be difficult
• Both systems have advantages and limitations
• RoadCrack well established and proven
• LCMS Identified significant potential and opportunity for development with LCMS
• More extensive trialling following improvements to algorithms
A final word from INXS

• That's why you need *(useable data)*
• That's why this is what you need *(high quality imaging)*
• I'll give you what you need *(see the vendors)*
Thank you

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Mads Genefke, ARRB Group

Richard Wix, ARRB Group
Email: richard.wix@arrb.com.au
Are moose really this big?
Two things I do know.....
Green Bay was robbed!!!!