The Use of GPS-Based Distress Mapping to Improve Pavement Management

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Introduction

- **Goal**: Enhancement of long-term pavement management practices
- **Method**: Distress mapping using GPS-referenced tablets

- Presented here are examples from recent surveys of portland cement concrete (PCC) pavements
Survey Process

• Additional mapping required prior to surveying
• A reference grade GPS unit tracks the location
• Distress type, severity, quantity are recorded like traditional PCI survey
  ▪ Includes location within a slab
  ▪ Also represents the physical characteristics of each distress
# Distress Mapping Legend

<table>
<thead>
<tr>
<th>LOW</th>
<th>MED</th>
<th>HIGH</th>
<th>DISTRESS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Low Distress Icon]</td>
<td>![Medium Distress Icon]</td>
<td>![High Distress Icon]</td>
<td>61</td>
<td>BLOWUP</td>
</tr>
<tr>
<td>![Low Distress Icon]</td>
<td>![Medium Distress Icon]</td>
<td>![High Distress Icon]</td>
<td>62</td>
<td>CORNER BREAK</td>
</tr>
<tr>
<td>![Low Distress Icon]</td>
<td>![Medium Distress Icon]</td>
<td>![High Distress Icon]</td>
<td>63</td>
<td>CRACK - LONGITUDINAL, TRANSVERSE &amp; DIAGONAL</td>
</tr>
<tr>
<td>![Low Distress Icon]</td>
<td>![Medium Distress Icon]</td>
<td>![High Distress Icon]</td>
<td>66/67</td>
<td>PATCHING</td>
</tr>
<tr>
<td>![Low Distress Icon]</td>
<td>![Medium Distress Icon]</td>
<td>![High Distress Icon]</td>
<td>68</td>
<td>POPOUTS</td>
</tr>
<tr>
<td>![Low Distress Icon]</td>
<td>![Medium Distress Icon]</td>
<td>![High Distress Icon]</td>
<td>69</td>
<td>PUMPING</td>
</tr>
<tr>
<td>![Low Distress Icon]</td>
<td>![Medium Distress Icon]</td>
<td>![High Distress Icon]</td>
<td>70</td>
<td>SCALING</td>
</tr>
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## Distress Mapping Legend (cont.)

<table>
<thead>
<tr>
<th>LOW</th>
<th>MED</th>
<th>HIGH</th>
<th>DISTRESS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Low" /></td>
<td><img src="image" alt="Medium" /></td>
<td><img src="image" alt="High" /></td>
<td>71</td>
<td>SETTLEMENT</td>
</tr>
<tr>
<td><img src="image" alt="Low" /></td>
<td><img src="image" alt="Medium" /></td>
<td><img src="image" alt="High" /></td>
<td>72</td>
<td>SHATTERED SLAB</td>
</tr>
<tr>
<td><img src="image" alt="Low" /></td>
<td><img src="image" alt="Medium" /></td>
<td><img src="image" alt="High" /></td>
<td>73</td>
<td>SHRINKAGE CRACKS</td>
</tr>
<tr>
<td><img src="image" alt="Low" /></td>
<td><img src="image" alt="Medium" /></td>
<td><img src="image" alt="High" /></td>
<td>74</td>
<td>SPALLING - JOINT</td>
</tr>
<tr>
<td><img src="image" alt="Low" /></td>
<td><img src="image" alt="Medium" /></td>
<td><img src="image" alt="High" /></td>
<td>75</td>
<td>SPALLING - CORNER</td>
</tr>
<tr>
<td><img src="image" alt="Low" /></td>
<td><img src="image" alt="Medium" /></td>
<td><img src="image" alt="High" /></td>
<td>76</td>
<td>ASR</td>
</tr>
</tbody>
</table>
Distress Mapping Benefits

- Distress pattern identification
- Quality control during survey is substantially easier
- Section re-segmentation after survey
- Track distresses and repairs over time
- Determine localized maintenance repair quantities
Distress Mapping Benefits (cont.)

- Locate repairs within section
- Evaluate impact of repairs
- Choose appropriate rehabilitation methods
- Apply identified deficiencies to future construction projects
DISTRESS PATTERN IDENTIFICATION
Case Study 1 Overview

• Pavement overloaded in late fall
• Distresses mapped soon after overloading
• Pavement re-mapped 6 months later
  ▪ Significant freeze-thaw and daily temperature cycling between inspections
• Would distresses from overloading propagate between inspections?
Distress Maps

Initial

Follow-up
Case Study 1 Benefits

- Possible to see change in general condition and specific distresses
- Track progression of distresses
- Illustrate relationships between distresses within and across slabs
- Depicts deterioration versus stabilization of pavement over time
CHOOSING APPROPRIATE REHABILITATION METHODS
Case Study 2 Overview

- Distress mapping allows for:
  - Localization of maintenance needs
  - Improved accuracy of cost estimates
  - Tracking the effectiveness of repairs
  - Greater insight for selecting the proper rehabilitation method
• Weigh rehabilitation and reconstruction options for best combination of:
  ▪ Future pavement condition
  ▪ Cost
  ▪ Operational requirements
Slab Replacement Alternatives

- Create multiple repair maps with varying quantities of slab replacements
- Repair maps depict slabs replaced
- PCI increase calculated for each map
- Repair maps and PCI increase weighed against the estimated costs
Examples of Slab Replacement

Differences

- Two sections in same network with:
  - Same PCI (58)
  - Same age
  - Same cross section (11-inch PCC)
  - Similar traffic patterns
Section B
Case Study 2 Summary

• Slab replacement recommendations and resulting PCIs differ
  ▪ 18% of slabs replaced and 21-point PCI increase
  ▪ 10% of slabs replaced and 10-point PCI increase
LOCALIZED MAINTENANCE REPAIR QUANTITIES
Case Study 3 Overview

- Localized repair needs determined during pavement management projects
- Repair quantities and costs calculated using traditional PCI survey methods
- Distress mapping improves:
  - Accuracy of calculated repair quantities for localized maintenance needs
  - Identification of specific locations where repairs are needed
Maintenance and Repair Quantities from Traditional PCI

- Only provides number of affected slabs of each distress/severity combination for a sample unit
- Only one distress of each type at highest severity per slab recorded
- Maintenance quantities computed via conversion factors
- May or may not be an appropriate repair quantity depending on specific pavement conditions
Maintenance and Repair Quantities from Distress Mapping

- Customized conversion factors used to calculate repair quantities
- Conversion factors adjusted and are based on actual distress size and pattern
- If repairs are mapped, no conversion factors are needed
## Repair Quantity Example I

<table>
<thead>
<tr>
<th>Distress</th>
<th>Severity</th>
<th>PAVER™ Repairs</th>
<th>Distress Map Repairs</th>
<th>Units</th>
<th>Difference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corner Break</td>
<td>M</td>
<td>41</td>
<td>58.7</td>
<td>ft²</td>
<td>-30.2%</td>
</tr>
<tr>
<td>Joint Spall</td>
<td>M</td>
<td>19.4</td>
<td>50.6</td>
<td>ft²</td>
<td>-62.5%</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>5.4</td>
<td>7.5</td>
<td>ft²</td>
<td>-24.9%</td>
</tr>
<tr>
<td>Large Patch</td>
<td>M</td>
<td>293</td>
<td>1,477</td>
<td>ft²</td>
<td>-80.2%</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>1,465</td>
<td>7,385</td>
<td>ft²</td>
<td>-80.2%</td>
</tr>
<tr>
<td>Linear Crack</td>
<td>M</td>
<td>683</td>
<td>668</td>
<td>ft</td>
<td>2.3%</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>15.1</td>
<td>6.2</td>
<td>ft</td>
<td>137.6%</td>
</tr>
<tr>
<td>Small Patch</td>
<td>M</td>
<td>5.4</td>
<td>4.3</td>
<td>ft²</td>
<td>39.5%</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>3.2</td>
<td>4.3</td>
<td>ft²</td>
<td>-41.0%</td>
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</tbody>
</table>
## Repair Quantity Example II

<table>
<thead>
<tr>
<th>Distress</th>
<th>Severity</th>
<th>PAVER™ Repairs</th>
<th>Distress Map Repairs</th>
<th>Units</th>
<th>Difference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corner Break</td>
<td>M</td>
<td>80.7</td>
<td>69.9</td>
<td>ft²</td>
<td>15.4%</td>
</tr>
<tr>
<td>Joint Spall</td>
<td>M</td>
<td>80.7</td>
<td>107.6</td>
<td>ft²</td>
<td>-25.0%</td>
</tr>
<tr>
<td>Large Patch</td>
<td>M</td>
<td>1,495</td>
<td>175</td>
<td>ft²</td>
<td>752.1%</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>197</td>
<td>37.7</td>
<td>ft²</td>
<td>422.9%</td>
</tr>
<tr>
<td>Linear Crack</td>
<td>M</td>
<td>288.4</td>
<td>111.2</td>
<td>ft</td>
<td>159.3%</td>
</tr>
<tr>
<td>Small Patch</td>
<td>M</td>
<td>73.2</td>
<td>67.8</td>
<td>ft²</td>
<td>7.9%</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>24.8</td>
<td>9.7</td>
<td>ft²</td>
<td>155.6%</td>
</tr>
</tbody>
</table>
Case Study 3 Summary

• Repair quantities and costs can impact localized maintenance planning
• Recognition of the actual repair quantities allow for proper allocation of funding across the network
APPLYING IDENTIFIED DEFICIENCIES TO FUTURE CONSTRUCTION PROJECTS
Case Study 4 Overview

- Factors impacting pavement condition:
  - Pavement structure/design
  - Climate
  - Traffic
  - Construction techniques
  - Materials
- Using distress mapping, it is possible to consider these factors, along with actual distresses, to improve future projects
Possible Improvements

- Existing distresses can assist in identifying the need to modify:
  - Design practices
  - Construction techniques
  - Repair methods
Taxiway Rehabilitated

- Parallel taxiway recently rehabilitated
  - Used by wide-body aircraft
- Cross section and slab size vary
- Section 1, PCI = 98
- Section 2, PCI = 95
- Section 3, PCI = 52
  - 85% of distresses are load-related
Taxiway Distress Map
Cross Sections

Section 1 Cross Section
19-inch PCC
2-inch HMA bond breaker
6-inch RCA

Section 2 Cross Section
21-inch PCC
2-inch HMA bond breaker
6-inch RCA
6-inch HMA (existing)

Section 3 Cross Section
8-inch bonded PCC Overlay
21-inch PCC (existing)
6-inch HMA (existing)
Wheel Loading

![Graph showing slabs and direction of travel for different aircraft sizes.]

- Keel slabs 12.5 feet wide
- Outer slabs 25 feet wide

Direction of travel:
- Airbus A380 (327)
- Boeing 747 (133)
- Boeing 757 (629)
- Boeing 767 (1,471)
- Boeing 777 (961)
- Boeing 787 (1,378)
Case Study 4 Conclusions

- Theorized that the top layer of PCC in Section 3 did not bond properly
  - Acts as if independent rather than monolithic
  - Top layer not able to withstand wide-body aircraft loading
- Cross section and paving practices
  - Additional analysis needed for Section 3
  - Section 1 and 2 designs have performed well
Distress Mapping Considerations

- Slight increase in time to evaluate each sample unit
- 100% sample coverage recommended for distress mapping
- Benefits include a more efficient and robust pavement management program
Distress Mapping Benefits

- Analyze distress patterns
- Identify specific repair locations
- Track performance over time
- Determine accurate maintenance and repair quantities
- Identify issues in design, construction, or repair methods
Thank You!

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