Effectiveness of Flexible Pavement Rehabilitation Treatments – Evidence from a National Experiment

Anwaar Ahmed
Samuel Labi
Zongzhi Li
Outline

- Introduction, Study Background, Scope
- Description of the SPS-5 Experiment
- Study Methodology
- Results
- Conclusions
Introduction

Current highway environment:
- funding limitations, aging facilities, and increasing user expectations

Pavement managers seek to:
- Identify best maintenance and rehabilitation treatments
- Ascertaining the service lives of planned preservation treatments
- Adopt optimal preservation practices based on LCCA
Study Background

Rehabilitation of Flexible Pavements

- Is a key pavement management activity
- Involves resurfacing of existing pavement to ...
  - mitigate the effects of rutting, cracking, and other distresses
  - improve pavement condition & ride quality
  - extend pavement life
- There are several alternative treatments for flexible pavement rehabilitation
- **Question:** How effective are the different treatments?
  - Effectiveness info is needed for holistic cost-effectiveness analysis
Study Scope

- Western SHRP Region (AB, AZ, CA, CO, MT)
- LTPP’S SPS-5 experiment

http://www.ltpp.org/links.shtml
Specific Pavement Study - 5

- Goal: Effectiveness of ACP Rehabilitation Treatments

- 18 Test Sites, Each Site has:
  - Eight test sections
  - One control section

- 4 SHRP Regions (we used only 1 region)

- 8 Rehabilitation Alternatives, differ by:
  - Extent of pavement surface preparation prior to overlay
  - Type of AC used
  - Thickness of AC overlay
## Specific Pavement Study 5

### The 8 Treatments

<table>
<thead>
<tr>
<th>Treatment Code</th>
<th>Surface Preparation</th>
<th>AC Mix</th>
<th>Overlay Thickness (Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>502</td>
<td>Minimal</td>
<td>Recycled</td>
<td>2</td>
</tr>
<tr>
<td>503</td>
<td>Minimal</td>
<td>Recycled</td>
<td>5</td>
</tr>
<tr>
<td>504</td>
<td>Minimal</td>
<td>Recycled</td>
<td>5</td>
</tr>
<tr>
<td>505</td>
<td>Minimal</td>
<td>Recycled</td>
<td>2</td>
</tr>
<tr>
<td>506</td>
<td>Intensive</td>
<td>Virgin</td>
<td>2</td>
</tr>
<tr>
<td>507</td>
<td>Intensive</td>
<td>Virgin</td>
<td>5</td>
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<tr>
<td>508</td>
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<td>Virgin</td>
<td>5</td>
</tr>
<tr>
<td>509</td>
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<td>Virgin</td>
<td>2</td>
</tr>
</tbody>
</table>

- “Minimal” means Patching, Level-up course for ruts > 0.5 inches
- “Intensive” means Patching, Crack sealing, Milling (1.5 - 2 inches)
- “Recycled” means 30 % Recycled Material
Study Objective

To analyze the short-term and long-term effectiveness of the 8 treatments for flexible pavement rehabilitation using data from the Western SHRP Region
Data Collection

- LTPP DataPave Online

- SPS-5 Data for five States:
  - Alberta - 1990 to 2006
  - Arizona - 1990 to 2006
  - California - 1991 to 2007
  - Colorado - 1991 to 2000
  - Montana - 1991 to 2000
STUDY METHODOLOGY

A. Estimate short-term and long-term effectiveness of each treatment

B. For each treatment, assess impact of initial pavement condition on:
   - roughness progression
   - Short-term effectiveness
   - Long-term effectiveness
Performance Indicator

- **Record of Pavement Distress - LTPP Data Base**
  - Cracking
  - International Roughness Index (IRI)
  - Rutting

- **Possible Performance Indicators**
  - IRI
  - RUT
  - PCR
  - Agency Customized

- **For this study: IRI in m/km**

- **Why IRI?**
  - Commonly used by many agencies
  - Reflects user perception of ride quality
  - Collected regularly for various LTPP sites
Measure of Effectiveness

- Short Term
  - Performance Jump

- Long Term
  - Treatment Service Life
  - Area bounded by treatment performance curve
Measure of Effectiveness

- **Performance Model**
  \[ IRI = e^{(A + \beta \times t)} \]

- **Treatment Service Life**
  \[ t = \frac{(\ln IRI_{Critical} - A)}{\beta} \]

- **Area bounded by treatment performance curve**
  \[ AOC = IRI_{Critical} \times t - \int_{t_0}^{t} e^{[A+\beta \times t]} \]
Results
Short-term Effectiveness (in terms of IRI-Drop)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>502</th>
<th>503</th>
<th>504</th>
<th>505</th>
<th>506</th>
<th>507</th>
<th>508</th>
<th>509</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRI (Initial)</td>
<td>2.05</td>
<td>1.82</td>
<td>1.75</td>
<td>1.59</td>
<td>1.91</td>
<td>1.96</td>
<td>1.72</td>
<td>1.89</td>
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<tr>
<td>IRI Drop</td>
<td>1.03</td>
<td>0.85</td>
<td>0.74</td>
<td>0.70</td>
<td>1.03</td>
<td>0.90</td>
<td>0.87</td>
<td>0.97</td>
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<tr>
<td>Overlay (Inch)</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Preparation</td>
<td>Minimal</td>
<td>Minimal</td>
<td>Minimal</td>
<td>Minimal</td>
<td>Intensive</td>
<td>Intensive</td>
<td>Intensive</td>
<td>Intensive</td>
</tr>
<tr>
<td>Mix Type</td>
<td>Recycled</td>
<td>Recycled</td>
<td>Virgin</td>
<td>Virgin</td>
<td>Virgin</td>
<td>Virgin</td>
<td>Recycled</td>
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</table>
ST Effectiveness (IRI-Drop) vs. Initial Condition

IRI Drop vs. Pre-Rehab IRI

Y = 0.19e^{0.84X}
R² = 0.74
## Long-term Effectiveness (Treatment Service Life)

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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Service Life</td>
<td>11</td>
<td>17</td>
<td>19</td>
<td>11</td>
<td>17</td>
<td>23</td>
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<td>10</td>
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<tr>
<td>Overlay (Inch)</td>
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<td>5</td>
<td>5</td>
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<td>2</td>
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![Graph showing the long-term effectiveness of different treatments](attachment:image.png)
## Long-term Effectiveness (Area bounded by treatment performance curve)

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<th>508</th>
<th>509</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOC (IRI-YEARS)</td>
<td>6.93</td>
<td>9.24</td>
<td>7.34</td>
<td>4.4</td>
<td>9.59</td>
<td>11.33</td>
<td>12.48</td>
<td>6.28</td>
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<tr>
<td>Overlay (Inch)</td>
<td>2</td>
<td>5</td>
<td>5</td>
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![Bar chart showing long-term effectiveness for treatments 502 to 509.]
Effectiveness Comparison: 2-inch vs. 5-inch Overlay Thickness

Treatment Service Life

Area Bounded by Performance Curve
Minimal vs. Intensive Surface Preparation

Treatment Service Life

Area Bounded by Performance Curve
Recycled vs. Virgin Mix

Treatment Service Life

Area Bounded by Performance Curve
Effect of Initial Pavement Condition on Roughness Progression - Young Pavements

Initial Pavement Condition vs. Total Increase in IRI After Rehab (Treatment Age - 9 Years)

Total Increase in IRI in 9 Years

Pre-Rehabilitation IRI (m/km)

Y = 0.21X - 0.04
R² = 0.09
Effect of Initial Pavement Condition on Treatment Effectiveness - Old Pavements

Plot of Pre-Rehab IRI Vs Total Increase in IRI after Rehab (Treatment Age - 15 Years)

\[ Y = 1.07X - 1.06 \]

\[ R^2 = 0.29 \]
Roughness Progression Trends

ARIZONA

Treatment Age (years)

IRI (m/km)
Roughness Progression Trends

CALIFORNIA

Pavement Age (years)

IRI (m/km)
Roughness Progression Trends

![Graph showing roughness progression trends for Alberta with different treatments and their progression over years.](image-url)
Condition of SPS-5 Test Sections (AB-2006)

Good Performer- Section 504 (MSP, 5-Inch VAC Overlay)

http://www.transportation.alberta.ca
Condition of SPS-5 Test Sections (AB-2006)

Bad Performer - Section 502 (MSP, 2-Inch RAC Overlay (Overlaid in 2006))

http://www.transportation.alberta.ca
Bad Performer- Section 509 (ISP, 2-Inch RAC Overlay (Overlaid in 2006))
Conclusions from Present Study
Conclusions

- Increases in rehabilitation treatments roughness is relatively gradual over the initial life of the treatment. However it shows rapid increase in later stage of life (close to end of service life)

- The correlation between the pre-rehab IRI and total increase in IRI is not significant during early age of treatments. It become significant when treatments are relatively old (approximately 14-15 years)

- Treatments having lower pre-rehab IRI, generally maintain a lower IRI values over treatment service life as compared to treatments having higher pre-rehab IRI
Conclusions

- Pre-treatment pavement condition is a significant predictor of short-term effectiveness (IRI drop)
  - Pavements in poorer pre-treatment condition yielded greater short term effectiveness (drops in IRI) upon treatment

- Layer thickness and surface preparation have significant impact on long-term effectiveness of the treatments
  - Treatments involving 5 inches overlay yielded superior effectiveness as compared to 2 inches overlay
  - Treatments involving intensive surface preparation yielded superior effectiveness as compared to minimum surface preparation
Thank You

Questions?