Evaluation of Long-Lasting Perpetual Asphalt Pavement Using Life-Cycle Cost Analysis

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Perpetual Asphalt Pavement

• Definition
  - “an asphalt pavement designed and built to last longer than 50 years without requiring major structural rehabilitation or reconstruction, and needing only periodic surface renewal in response to distresses confined to the top of the pavement.”
  Asphalt Pavement Alliance, 2010
Perpetual Asphalt Pavement

National Asphalt Pavement Association, 2010
Perpetual Asphalt Pavement

• **Advantages**
  - Longer lifetime
  - Lower user cost
  - No structural repairs necessary
    - Shorter construction time
      - Less user delay
    - Lower repair costs

• **Disadvantages**
  - Higher initial cost
Scope

- Compare and analyze two sections of pavement
  - 14 inches thick perpetual pavement (Section N9)
  - 10 inches thick AASHTO pavement (Section N8)
- With regards to
  - Life cycle cost
  - Performance
- Sponsored by the Oklahoma Department of Transportation (OKDOT)
Methodology – Test Track

• Tests conducted 2006-2011
  - National Center for Asphalt Technology Pavement Test Track in Auburn, Alabama

• Loading simulated on the test track
  - Accelerated Pavement Testing (APT)
    – 55 years usage analyzed in 5 years
    – 20 million ESALs
  - 5 trucks drive 400 rounds per day

• Shortcomings
  - Accelerated loading
    – Aging not considered
  - Only 5 trucks used in testing
    – Does not represent actual traffic
Methodology – Life Cycle Cost Analysis

- Life cycle cost analysis performed RealCost 2.5
  - Developed by the Federal Highway Administration (FHWA)
  - Determined
    - User cost
    - Agency cost

- Pavement design using PerRoad
  - Considers different pavement materials to determine optimal thickness
Performance – Original design of N9

- 2 inches thick stone matrix asphalt surface (SMA)
- 9 inches of dense asphalt concrete layer
- 3 inches rich asphalt concrete
- 7 inches thick stiff soil base
- Aggregates and soil imported from Oklahoma for more accurate simulation
- Designed using PerRoad software
Performance – Original design of N8

- 2 inches thick stone matrix asphalt surface (SMA)
- 6 inches dense Superpave mix
- 2 inches rich asphalt concrete
  - 2% air voids in order to get high binder content
- 7 inches thick stiff soil base
- Aggregates and soil imported from Oklahoma for more accurate simulation
- Designed according to AASHTO 1993 Pavement Design Guide
Performance – Rehabilitation 1

- Surface cracks after 8.3 million ESALs
  - Rehab needed after 10 million ESALs
- Rehabilitation
  - Top 5 inches milled
  - Replaced with 2 inches SMA and 3 inches of Superpave mix with paving fabric in-between
- Performance
  - Very poor
  - Failed after 3.5 million ESALs
Performance – Failure after rehab 1
• After 13.5 million ESALS
• Rehabilitation
  - Top 5 inches milled
  - Replaced with thin layer of rich bottom of rich High-Polymer Content Mix (HPM) covered with 4 inches of HPM with 4% air voids
• Performance
  - Minimum rutting and no cracking after 5.5 million ESALs
Performance

Asphalt Strain Gauge  Earth Pressure Cell

• N8 (Non-Perpetual)  N9 (Perpetual)

Depth from Pavement Surface (in)

0  5  10  15  20  25

Original SMA
Rehab Dense
Original Dense
Rich AC
Stiff Soil Base
Subgrade
Original Construction

Rehab SMA
Depth of Mill & Inlay
Paving Fabric

Rehab Dense
Original Dense
Rich AC
Stiff Soil Base
Subgrade
Conventional Rehabilitation

HPM
HPM
Rich HPM
Original Dense
Rich AC
Stiff Soil Base
Subgrade
HPM Rehabilitation

SMA
Dense
Dense
Rich AC
Stiff Soil Base
Subgrade
Original Construction

Original Construction
Performance - Summary

- **Section N8**
  - Built 2006
  - Rehabilitation 1 in 2009 (10 million ESALs)
  - Rehabilitation 2 in 2010 (13.5 million ESALs)
  - No problems after rehabilitation 2
    - Indicates that the high-polymer mixture performs better than stone matrix asphalt

- **Section N9**
  - Built 2006
  - No treatment needed
  - Good, consistent performance
Alternatives for the Life Cycle Cost Analysis

• Alternative 1 – N8
  - Rehab 1 using SMA
  - Rehab 2 & and 3 using HPM
• Alternative 2 – N8
  - Rehab 1, 2 & 3 using SMA
• Alternative 3 – N8
  - Rehab 1, 2 & 3 using HPM
• Alternative 4 – N9
  - Rehab 1,2 & 3 using SMA
# Results

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Undiscounted sum (Agency cost)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative 1</td>
<td>$1,419,375</td>
</tr>
<tr>
<td>Alternative 2</td>
<td>$1,266,944</td>
</tr>
<tr>
<td>Alternative 3</td>
<td>$1,044,490</td>
</tr>
<tr>
<td>Alternative 4</td>
<td>$785,618</td>
</tr>
</tbody>
</table>
Results

Undiscounted sum (Agency cost)

$1600 000
$1400 000
$1200 000
$1000 000
$800 000
$600 000
$400 000
$200 000
$ 0

Alternative 1
Alternative 2
Alternative 3
Alternative 4
Conclusions

- Perpetual pavement has lower cost over the 55 year analysis period
  - Lower life cycle cost
  - Lower user delay cost
    - Only minor repairs
    - Lane closed for 1 night during rehab
  - Lower environmental impact
- High-polymer mix rehabilitations performed better and had lower life cycle cost than stone matrix asphalt
  - Oklahoma has updated their specifications according to these findings
Criticism

• Title – *Evaluation of Long-Lasting Perpetual Asphalt Pavement Using Life Cycle Cost Analysis*
  - Long-lasting and Perpetual are synonyms. No need to include both in the title
  - Very general
    • Should explain more what was done
  - Does not mention the comparison to conventional pavement

• Inconsistent use of technical terms
  - Section N8 referred to as
    • Conventional pavement
    • Thinner pavement
    • Non-perpetual pavement
Criticism

• Paper setup
  - There should be a chapter for methods
    • Partial information can be found in several places in the paper

• Abbreviations
  - FHWA never explained
    • Federal Highway Administration
  - EUAC never explained
    • Equivalent Uniform Annual Cost

• Results
  - Graphs showing cost vs. years do not represent numbers that are in the paper
    • No mention of how these numbers are found
Criticism
References

• Asphalt Pavement Alliance, 2010. *Perpetual Asphalt Pavements – A Synthesis*

Thank you for your attention

Questions?