Stone Matrix Asphalt and Perpetual Pavements
In Illinois we Perpetually Recycle our Politicians
I-84: Garrity to Ten Mile Rd. in Meridian, ID
"Asphalt, more than any other single product, sustains the nation's highway system and facilitates the flow of commerce."
AGGREGATE AND ASPHALT
I-84: Garrity to Ten Mile Rd. in Meridian, ID
West bound near EOJ
Independent Assurance Audit

Goal is to bring People and Ideas Together in an effort to implement a successful asphalt system.
Why Audit?

Continue to:

- Advance the success rate of producing hot mix asphalt.
- Improve asphalt in-use performance for the tax payers of Idaho.
Perpetual Pavement Defined

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.
Perpetual Pavement Defined
Perpetual Design

Figure 2. Simplified Flowchart of Perpetual Pavement Design

- Materials Inputs
- Traffic Inputs
- Pavement Layer Thicknesses
- Analytical Model
- Pavement Responses $\sigma, \varepsilon, \delta$
- $\sigma, \varepsilon, \delta > \text{Limit?}$
- Yes
- No
- % Responses Over Limits
- % Responses Over Limits Acceptable?
- Yes
- Final Design
- Increase Layer Thickness

From APA
M-E Design

- Seasonal pavement moduli and annual coefficient of variation (COV),
- Seasonal resilient moduli of unbound materials and annual COV,
- Thickness of bound and unbound materials and COV,
- Load spectrum for traffic,
- Location for pavement response analysis,
- Magnitude of limiting pavement responses, and
- Transfer functions for pavement responses exceeding the user specified level for accumulating damage.
Figure 3. Perpetual Pavement Design Concept

(Newcomb et al, 2000)

- Zone of High Compression: 4" to 6"
- High Quality HMA or OGFC: 1.5" to 3"
- High Modulus Rut Resistant Material: 4" to 7"
- Durable, Fatigue Resistant Material: 3" to 4"
- Pavement Foundation

From APA
Why Audit?

- Update the perpetual pavement specification currently in use in Idaho.
- Develop a “How to design and build perpetual pavements in Idaho” manual.
Independent Assurance Audit

- Specifications
- Mix Designs
- Process Control
- IA and Verification Testing
- Site Visit
TEAM Approach

- Meeting with all parties involved (ITD, J-U-B Engineers, Inc., and Idaho Sand & Gravel).
- Reviewing engineering reports available, including:
  - ESAL determination (M. Dehlin),
  - Thickness design and typical section (M. Dehlin, HDR, and Terracon),
  - Mix selection (Terracon, M. Dehlin, and T. Murphy),

(Cont’d.)
TEAM Approach

- Reviewing engineering reports available, including:
  - Specification writing (M. Dehlin),
  - Mix design verification versus Acceptance Test strips versus Production (ITD HQ, and GeoTek),
  - Paving equipment requirements versus actual (JUB and ITD D3), and
  - Job specific variations for materials, machinery, and methods, particularly the impact of change orders and construction issues (JUB and ITD D3).
Loading

Equivalent Single Axle Loadings (ESAL’s) and thickness design was performed using PerRoad. PerRoad uses the mechanistic-empirical (M-E) design philosophy.
Pavement Design Findings

- Consideration should be given to the inclusion of Stone Matrix Asphalt thickness and corresponding Poisson Ratios for the total thickness design.

- Investigation by ITD specific to traffic volumes and typical truck load factors is appropriate as values used for double and triple trailers significantly influence the ultimate thickness required.
Building the Roadway
I-84 Field Review of 2010

- Site review reveals acceptable ride, lane configuration, and performance to date.
- Allow use of any acceptable material transfer device provided that volumetric measures and smoothness are achieved.
I-84 Field Review of 2010
The Job Mix Formula

Voids, VMA, and VFA; The Building Blocks of Hot Mix Asphalt
Laboratory Mix Designs vs. Plant - Produced Mixture

Measure Volumetrics
Rich Bottom Base

- 1.5” top size.
- Variable test results.
Asphalt Content

Air Voids

½” Gradation
Potential Solutions

- Eliminate the 37.5-mm mix,
- Specify that all 37.5-mm mixtures will be fine graded (i.e. above the maximum density line on the #4 and #8 sieves),
- Revisit sampling and splitting techniques.
What Surface Mixture to Use?
Strategy consists of four steps:

- Assess the opportunity
- Ensure structural adequacy
- Select high-performance materials and confirm the mixture design
- Use proper construction techniques
Use aggregates with:

- High crush
- Hard particles
- Consistent gradation (clean) and gravity
- Proper Quality Control (QC)
World’s Strongest Intersection
(Williams & Margaret in Thornton, IL)
Comparison
SMA vs. Dense-Graded

Stone Matrix Asphalt
Dense-graded Asphalt
Mix Properties, Job-Mix Formula

Mixture Composition

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>¾&quot; (19.0 mm)</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>½&quot; (12.5 mm)</td>
<td>90</td>
<td>99</td>
</tr>
<tr>
<td>⅜” (9.5 mm)</td>
<td>50</td>
<td>85</td>
</tr>
<tr>
<td>#4 (4.75 mm)</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>#8 (2.36 mm)</td>
<td>16</td>
<td>28</td>
</tr>
<tr>
<td>#200 (0.075 mm)</td>
<td>8</td>
<td>12</td>
</tr>
</tbody>
</table>

Typically +6% Polymerized AC
SMA vs. Dense-Graded
Resilient Asphalt with Polymers

Polymers plus Asphalt Binder
An evaluation of the 1997 pavement fix was performed in 2013. After 16 years, and the application of almost 16+ million equivalent single axle loads (ESALs), the intersection of Williams and Margaret streets has required no essentially no maintenance and quietly continues its amazing performance as “the world’s strongest intersection”.
STRONG + DURABLE = SUSTAINABLE

Idaho Said, ‘YES!’
STRONG + DURABLE = SUSTAINABLE
Rolling Pattern on I-84
Ballast Rollers
Utilize Three Wheel Rollers
Findings

- SMA surface mixture voids did not trend about the target of 4.0% for the entire project.
- Voids actually average close to 5.0%, the upper limit for voids.
- Density was difficult to achieve.

Recommended

Higher VMA and Lower Voids = More AC
Acceptance by AMRL Laboratory is Required

FHWA Acceptance Program

Quality Assurance

- Independent Assurance
- Quality Control
- Verification Sampling & Testing
Sound Specifications

- Scientifically and mathematically sound,
- Related to performance,
- Easy to understand and apply,
- Provide strong incentives to produce good quality,
- Provide strong disincentives for poor quality, and
- Take into account construction phases.
Successful HMA QA
Workmanship Items
Dense-graded = Mat − 2%
SMA = 92.0%+
Echelon Paving, Part II
Be Determined in Achieving Your Goals

It Takes Teamwork!!!
Time for questions

Timothy R. Murphy, Murphy Pavement Technology