The LTPP SPS-2 Experiment
**The Nations Largest
Concrete Research Effort**

Larry Scofield, P.E.
International Grooving and Grinding Association
Bellefontaine, Ohio 1925

Main Street paved in 1891.
1st concrete street in America
BELLEFONTAINE, O.
In the Beginning: SHRP (1987-1993)

- **Strategic Highway Research Effort ($150M):**
  - It was a five-year $150 million research program managed by TRB and funded by a set-aside of state-apportioned federal aid highway funds.
  - The program was carefully developed and defined as; “A time-specific, concentrated, short-term and results oriented research effort aimed at closing specific technological gaps that have impeded the effective advancement of the highway program.”
  - The goal was to deliver practical results for use by transportation agencies within five years.
SHRP Program Areas (5 Year Effort)

- Asphalt
- Long Term Pavement Performance (LTTP) ($50M) (20 yr)
- Concrete and Structures
- Winter Maintenance
- Highway Operations
LTPP’s GOAL is...
to provide answers to **HOW** and **WHY** pavements perform as they do!
Long Term Pavement Performance (LTPP)
GPS and SPS Test Sections

LTPP GPS and SPS Pavement Sites
LTPP SPS Program Areas

- **SPS-1**: Structural Factors for AC Pavements
- **SPS-2**: Structural Factors for Concrete Pavements
- **SPS-3**: Preventive Maintenance for AC Pavements
- **SPS-4**: Preventive Maintenance for Concrete Pavements
- **SPS-5**: Rehabilitation of AC Pavements
- **SPS-6**: Rehabilitation of Concrete Pavements
- **SPS-7**: Bonded Concrete Overlays
- **SPS-8**: Study of Environmental Factors
Designed to Evaluate Relative Influence of 5 Design Factors and 3 Site Factors on Long Term Performance

- Concrete Thickness (8” & 11”)
- Base Type (LCB, DGA, PATB, PATB/DGA)
- Flexural Strength (550 & 900)
- Lane Width (12’ & 14’)
- Drainage (with and without)

- Site Factors
  - Temperature
  - Precipitation
  - Subgrade
Location of SPS-2 Test Sites
<table>
<thead>
<tr>
<th>State</th>
<th>Year</th>
<th>Drainage</th>
<th>Base Type</th>
<th>Drainage</th>
<th>Base Type</th>
<th>Drainage</th>
<th>Base Type</th>
<th>Drainage</th>
<th>Base Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michigan (93)</td>
<td>8</td>
<td>550</td>
<td>No</td>
<td>AGG</td>
<td>LCB</td>
<td>PATB</td>
<td>Yes</td>
<td>AGG</td>
<td>LCB</td>
</tr>
<tr>
<td>North Carolina (93)</td>
<td>8</td>
<td>550</td>
<td>No</td>
<td>AGG</td>
<td>LCB</td>
<td>PATB</td>
<td>Yes</td>
<td>AGG</td>
<td>LCB</td>
</tr>
<tr>
<td>North Dakota (94)</td>
<td>8</td>
<td>550</td>
<td>No</td>
<td>AGG</td>
<td>LCB</td>
<td>PATB</td>
<td>Yes</td>
<td>AGG</td>
<td>LCB</td>
</tr>
<tr>
<td>Ohio (96)</td>
<td>8</td>
<td>550</td>
<td>No</td>
<td>AGG</td>
<td>LCB</td>
<td>PATB</td>
<td>Yes</td>
<td>AGG</td>
<td>LCB</td>
</tr>
<tr>
<td>Washington (95)</td>
<td>8</td>
<td>550</td>
<td>No</td>
<td>AGG</td>
<td>LCB</td>
<td>PATB</td>
<td>Yes</td>
<td>AGG</td>
<td>LCB</td>
</tr>
<tr>
<td>Wisconsin (97)</td>
<td>8</td>
<td>550</td>
<td>No</td>
<td>AGG</td>
<td>LCB</td>
<td>PATB</td>
<td>Yes</td>
<td>AGG</td>
<td>LCB</td>
</tr>
</tbody>
</table>

Similar SPS-2 Experiments Nationally
The Arizona SPS-2 Experiment
Design Features On ADOT SPS-2

- **21** Test Sections
- PCCP Thickness (8, 11, **12.5**)
- Base Type (AB, PATB, LCB, PATB/AB, **AC**)
- Drained and Undrained Base
- Lane Width (12 ft 14 ft)
- Doweled and **Undoweled**

- **LTPP** Design Feature
- **ADOT** Design Feature
ADOT Test Section Investment

1.5 M 2.4 M

1993 2013
Test Section Layout

Base Types
- Dense Graded Aggregate Base (4" & 6")
- Permeable Bituminous Treated Base (4")  Note: These are the only Sections with Edge Drains
- Lean Concrete Base (6")
- Bituminous Treated Base (4")

Shoulder Types
- 12 ft Shoulder Width
- 14 ft Shoulder Width

LTTP

900 psi Flexural Strength

550 psi Flexural Strength

State Supplemental @550 psi Flexural Strength

Un Dowelled Sections
Comparison of Doweled to Undoweled

Base Types
- Dense Graded Aggregate Base (4" & 6")
- Permeable Bituminous Treated Base (4")  Note: These are the only Sections with Edge Drains
- Lean Concrete Base (6")
- Bituminous Treated Base (4")

Shoulder Types
- 12 ft Shoulder Width
- 14 ft Shoulder Width

900 psi Flexural Strength
- 214
- 222
- 218
- 220
- 224
- 216

550 psi Flexural Strength
- 215
- 223
- 219
- 217
- 221
- 213

State Supplemental @ 550 psi Flexural Strength
- 262
- 263
- 264
- 265
- 266
- 267
- 268

Un Dowelled Sections
• Removing Existing EB AC and Constructing Detour onto WB
• Over Excavating Existing Subgrade 1 ft and Recompacting
• Constructing Edge Drains
• Constructing Aggregate Base, Lean Concrete Base, and Permeable Base
• Constructing 8”, 11” and 12.5” Thick PCCP
• Constructing 550 and 900 psi Flexural Strength PCCP
• Constructed Doweled and Undoweled PCCP
Arizona I-10 EB SPS-2 Construction
Subgrade Compaction
Edge Drain Outlet
Subgrade/Base Trimming
## PATB Compaction

<table>
<thead>
<tr>
<th>Coarse Agg.</th>
<th>Sieve Size</th>
<th>% Pass</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>3/4</td>
<td>87</td>
<td></td>
</tr>
<tr>
<td>1/2</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>3/8</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>No.4</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fine Agg.</th>
<th>Sieve Size</th>
<th>% Pass</th>
</tr>
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<tbody>
<tr>
<td>No. 8</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>No. 10</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Mix temp = 225 F  
Compaction = 170 – 150 F
Lean Concrete Base
PCCP Paving

- Night Paving September 1993
- Three Mixes Used (1" & 1.5")
- All LTPP Sections Doweled
## LTPP Concrete Mix Designs

### LTPP 550 Mix Design

<table>
<thead>
<tr>
<th>Material</th>
<th>%</th>
<th>Type</th>
<th>Weight</th>
<th>Misc.</th>
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</thead>
<tbody>
<tr>
<td>Cement</td>
<td></td>
<td>Type II</td>
<td>400</td>
<td>Class F</td>
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<tr>
<td>Fly Ash</td>
<td></td>
<td>Cholla</td>
<td>100</td>
<td>Class F</td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td></td>
<td>232</td>
<td>.47 w/c</td>
</tr>
<tr>
<td>Fine Agg</td>
<td></td>
<td>ASTM</td>
<td>1285</td>
<td></td>
</tr>
<tr>
<td>Coarse Agg</td>
<td>1&quot;</td>
<td></td>
<td>1939</td>
<td>#57 Pioneer</td>
</tr>
<tr>
<td>Water Reducer</td>
<td></td>
<td>WRDA-82</td>
<td></td>
<td>25 oz/cy</td>
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<tr>
<td>Air Entraining</td>
<td></td>
<td>Daravair-m</td>
<td>2 oz/cy</td>
<td></td>
</tr>
</tbody>
</table>

### LTPP 900 Mix Design

<table>
<thead>
<tr>
<th>Material</th>
<th>%</th>
<th>Type</th>
<th>Weight</th>
<th>Misc.</th>
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</thead>
<tbody>
<tr>
<td>Cement</td>
<td></td>
<td>Type II</td>
<td>811</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td></td>
<td>292</td>
<td>0.36</td>
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<tr>
<td>Fine Agg</td>
<td>40</td>
<td>ASTM</td>
<td>1207</td>
<td>#57 Pioneer</td>
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<tr>
<td>Coarse Agg</td>
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<td>1&quot;</td>
<td>1826</td>
<td></td>
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<tr>
<td>Water Reducer</td>
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<td>WRDA-82</td>
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<td>40 oz/cy</td>
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<tr>
<td>Air Entraining</td>
<td></td>
<td>Daravair-m</td>
<td></td>
<td></td>
</tr>
</tbody>
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## Testing

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Number of Samples</th>
<th>Sampling Year(s)</th>
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</thead>
<tbody>
<tr>
<td>4&quot; Core</td>
<td>262</td>
<td>1993, 1994, 2005</td>
</tr>
<tr>
<td>6&quot; Core</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>12&quot; Core</td>
<td>15</td>
<td>2005</td>
</tr>
<tr>
<td>Bulk (Subgrade)</td>
<td>28</td>
<td>1993, 2005</td>
</tr>
<tr>
<td>Bulk (Granular Base)</td>
<td>14</td>
<td>1993, 2005</td>
</tr>
<tr>
<td>Bulk (Treated Base)</td>
<td>10</td>
<td>1993</td>
</tr>
<tr>
<td>Beam (PCC)</td>
<td>45</td>
<td>1993</td>
</tr>
<tr>
<td>Cylinder (PCC)</td>
<td>72</td>
<td>1993</td>
</tr>
<tr>
<td>Cylinder (LCB)</td>
<td>18</td>
<td>1993</td>
</tr>
</tbody>
</table>
Lessons Learned from National Experiment

- 20 Year Report Due Out Early Next Year
- Base Type Effects Resulting Distresses
- Widened Slab Improves Performance (13ft)
- Longitudinal Cracking Influenced by Base Type and thickness
- Thicker Slabs Resulted in More Initial Roughness than Thinner Slabs
- Sections with Drainage Exhibited Less Roughness Development than Sections Without Drainage
- 900 psi Sections Exhibited Map Cracking
- Most Distress Exhibited on Sections with LCB Base
Process of Local Calibration

- **Verification** — the process of checking whether the MEDesign “National” models works as intended in Arizona.

- **Calibration** — If not, then changing MEDesign model “National coefficients” to “AZ local coefficients” that make distress & IRI predictions match AZ field measurements

- **Validation** — the process of checking that the ME Design “local Arizona” models works as intended in Arizona (independent data)
Example of Measured & Predicted IRI (LTTP 262)
AZ Slab Cracking Vs Fatigue Damage

\[ R^2 = 0.72 \]
\[ \text{SEE} = 7.0\% \text{ slabs} \]
\[ N = 198 \]
Curl and Warp Study- 11” PCCP (215)
Curl and Warp Study- 8” PCCP (213)

Right IRI (in/mi)

- IRI
- Curl Influence Removed

Time (years)
20 Year Old Silicone Sealed Joint
Shoulder Separation
LTPP Benefits

The LTPP program has generated a wide range of benefits all across the pavement engineering and performance spectrum.
Thank You

Questions?