Two-Lift Paving

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What is Two-Lift Paving?

• Placing two different layers of concrete, wet on wet

• The first (bottom) layer is relatively thick
  – Typically contains lower quality local aggregates, recycled concrete aggregates, recycled asphalt, and/or less cement,

• The top layer is relatively thin
  – Higher quality aggregates (often imported), more cement, higher skid resistance, higher durability, and reduced noise.
Two-lift paving
History of Two-Lift Paving

- Not new
- 1894: Bellefontaine, OH
- 1914: Belknap Place, San Antonio
History

• After being conceptualized and first built in the U.S., it became more common in Europe.
• Used most frequently in Germany since 1930.
• Since 1977 in U.S:
  – FL U.S 41  1977
  – MI I 75  1993
  – KS SH 96  1997
  – FL 2001
  – KS I 70  2008
  – MnRoad 2010
  – MO SH 141 2011
Background

• TxDOT Research Study 6749 *Feasibility Study of Two-Lift Concrete Paving* was performed by Texas State and CTR in 2012-13.

• Workshop was held with over 50 in attendance in person and by webinar.

• Paving contractors, equipment manufacturers, DOTs, consultants, European representative, TxDOT reps, aggregate manufacturers, association reps
Why should TxDOT be interested?

• To make greater use of local materials
  – Permit use of manufactured sands in lower lift
  – Use of coarse aggregates with high coefficient of thermal expansion (CoTE) values in lower lift
Manufactured Sands

Natural River Sand

Depletion

Coefficient of Thermal Expansion (microstrain/F) (COTE)

Legend

- Major Roads
- LA Counties
- AR Counties
- NM Counties
- OK Counties
- TX Counties

COTE Values

- 0.0 - 4.0
- 4.0 - 5.0
- 5.0 - 5.5
- > 5.5

FOR INFORMATION ONLY:
Acceptance based on individual project samples.

Natural River Sand Depletion
• Natural sands are being depleted in the Metroplex.

• Good news—there are many sources of good manufactured sands—they make good quality concrete

• Bad news—nearly all of them are limestone and they polish much faster than natural sands.

• From a recent research study on skid resistance of manufactured sands for pavements, we found the following:
100% manufactured sand test section

Note polishing in wheel paths
Comparison between in wheel path and between wheel path
Field Sections – Blended silicious and LS vs. 100% LS
TxDOT Specification Limits

• Concrete subject to direct traffic requires the use of fine aggregates or blends to have an acid insoluble residue (A.I.) greater than 60%.

• Limits the use of 100% manufactured limestone sands
High CoTE coarse aggregates

- Pavements with high CoTE aggregates result in surface distresses
Spalling in concrete pavements
Coarse Aggregate CoTE Values

- Unacceptable for use in CRCP
- Acceptable for use in CRCP

25% above Limit

CoTE, microstrain/F
High CoTE Aggregates
How can two-lift paving help these problems?

• By using high CoTE and manufactured sands in the thicker, e.g. 9” bottom lift
• And using low CoTE and natural sands in the thinner, e.g. 3” top lift
Lower CoTE Concrete
Or
Concrete with Natural Sands

Higher CoTE Concrete
Or
Concrete with Man. Sands
Other Benefits

• Lower lift.
  – Recycled materials and low skid resistance aggregates
  – Lower cement contents
  – Less durable materials
• Top lift
  – High quality fine aggregates for good skid resistance
  – Exposed aggregate finish
  – Quieter
  – High durability
  – Special materials, e.g. titanium oxide for reducing air pollution
  – Pervious concrete to minimize hydroplaning
Barriers

• Two paving trains
• Batching control
• In Kansas, they used colored cards on trucks and at batch plants to denote lower and upper lift
• Concerns about time between paving trains (usually 30 to 60 min.—Belgium allows up to 2 hrs.)
Gomaco Paver with two chambers
Barriers

• Cost
  – Incremental cost increment can be small
  – Life cycle cost analyses has indicated savings
Economic Benefits of Two-Lift Pavements—Illinois Toll Way

<table>
<thead>
<tr>
<th>’13 Composite Bid Prices</th>
<th>’04 – ’09 JPCP Bid Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 3,000,000 Sq. Yds. of JPCP Built System-wide</td>
<td>&gt; 700,000 Sq. Yds. to be built on I-90 in 2013</td>
</tr>
<tr>
<td>11.25” JPCP - $61.00/SY</td>
<td>11.25” – $40.66/SY</td>
</tr>
<tr>
<td>12” JPCP - $65.00/SY</td>
<td>12” - $45.92/SY</td>
</tr>
<tr>
<td>13” JPCP - $70.00/SY</td>
<td>13” - $49.70/SY</td>
</tr>
</tbody>
</table>
## Cost comparison of two-lift pavements in several states

<table>
<thead>
<tr>
<th>Pavement Type</th>
<th>Thickness</th>
<th>Concrete Cost</th>
<th>Paving Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Michigan I-75, 1993</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>2.5&quot;+7.5&quot;</td>
<td>-</td>
<td>-</td>
<td>$37.58/sy</td>
</tr>
<tr>
<td>2LCP</td>
<td>11&quot;</td>
<td>-</td>
<td>-</td>
<td>$87.76/sy</td>
</tr>
<tr>
<td><strong>Kansas I-70, 2008</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard</td>
<td>12&quot;</td>
<td>$57/cy</td>
<td>$99/cy</td>
<td>$33/sy</td>
</tr>
<tr>
<td>Durable</td>
<td>12&quot;</td>
<td>$102/cy</td>
<td>$144/cy</td>
<td>$48/sy</td>
</tr>
<tr>
<td>2LCP</td>
<td>2&quot;+10&quot;</td>
<td>$64.5/cy</td>
<td>$122/cy</td>
<td>$41/sy</td>
</tr>
<tr>
<td><strong>Minnesota I-94, 2010</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>9&quot;</td>
<td>$71.07/cy</td>
<td>$2.61/sy</td>
<td>$20.38/sy</td>
</tr>
<tr>
<td>2LCP</td>
<td>3&quot;+6&quot;</td>
<td>$62.66/cy</td>
<td>$4.28/sy</td>
<td>$19.94/sy</td>
</tr>
<tr>
<td><strong>Illinois Tollway, 2012</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>12&quot;</td>
<td>-</td>
<td>-</td>
<td>$65.00/sy</td>
</tr>
<tr>
<td>2LCP</td>
<td>3.5&quot;+8&quot;</td>
<td>-</td>
<td>-</td>
<td>$45.92/sy</td>
</tr>
</tbody>
</table>
## Summary of previous experiences and past performance of two-lift pavements

<table>
<thead>
<tr>
<th></th>
<th>Top Lift</th>
<th>Bottom Lift</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Avg.</td>
<td>Stdev</td>
</tr>
<tr>
<td><strong>Thickness</strong></td>
<td>2.6”</td>
<td>0.9”</td>
</tr>
<tr>
<td><strong>Cement Content</strong></td>
<td>579 pcy</td>
<td>108 pcy</td>
</tr>
<tr>
<td><strong>w/c</strong></td>
<td>0.42</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Slump</strong></td>
<td>1.6”</td>
<td>0.9”</td>
</tr>
<tr>
<td><strong>Air</strong></td>
<td>6.0%</td>
<td>1.8%</td>
</tr>
<tr>
<td><strong>f’c</strong></td>
<td>4,600psi</td>
<td>922psi</td>
</tr>
<tr>
<td><strong>MOR</strong></td>
<td>640psi</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Aggregate Type</strong></td>
<td>High quality aggregate (granite, rhyolite, basalt, etc.)</td>
<td>Local aggregates (limestone sand, river gravel, RCA, RAP, etc.)</td>
</tr>
</tbody>
</table>
Barriers

• The unknown—need to get up the learning curve
• Lack of experience
• Lack of specifications
  – Illinois Tollway has specifications.
Where do we go from here?

• Need to construct test sections
• Develop experience
• Develop specifications