PERFORMANCE OF THIN AND ULTRA‐THIN WHITETOPPING TEST SECTIONS AT MnROAD

Background

For the past 15 years, whitetopping has been increasing in popularity in the U.S. However, few rationally based design methods are available for these overlays, particularly those based on mechanistic-empirical research derived from actual field performance. The study of the performance of thin and ultra-thin concrete inlays/overlays (of distressed asphalt pavements) at the Minnesota Road Research Project (MnROAD) is working toward the development of such performance based design methods.

In 1997, three thin (TWT) and three ultra-thin (UTW) whitetopping test sections were constructed on the live interstate traffic portion of the MnROAD facility. Though not historically applied to interstate highways, these test sections were constructed to experience an accelerated rate of traffic-related distresses. By 2004, the UTW test sections had experienced enough distresses to warrant replacement. Later that year, four new thin concrete overlay test sections were constructed in their place. In 2008, one additional thin whitetopping section was built over one of the original (distressed) MnROAD full-depth asphalt sections.

Additional design details for the MnROAD test sections can be found in Table 1.

Findings

Since their construction in 1997, the MnROAD thin and ultra-thin whitetopping sections have produced some significant findings that will ultimately be used in the development of a rational design method.

Panel Size: The most significant distress experienced by the UTW sections was corner cracking of 4 foot by 4 foot panels. The 4 feet by 4 feet panel size places the edge of the ultra-thin panels near the outer wheelpath of heavy truck tires. See Photo 1. Many of the larger 10 feet (long) by 12 feet panels have experienced a mid-panel longitudinal crack. 6 feet by 6 feet seems to be the best performing, yet economical size for TWT sections.

Whitetopping

Whitetopping is the historical term used to describe concrete inlays or overlays applied to older, distressed asphalt pavements.

Thin whitetopping (TWT)

This term generally refers to concrete resurfacing with slab thicknesses ranging from 4 to 6 inches. The thin, typically 6 feet by 6 feet panels, are designed to behave as an unbonded layer, not structurally reliant on the older asphalt layers below. Typically, however, the milling process used to remove part of the older asphalt layers during construction results in at least a temporary structural bond with the underlying asphalt. Transverse joints are typically undoweled.

Ultra-thin whitetopping (UTW)

This term generally refers to concrete resurfacing with slab thicknesses ranging from 2 to 4 inches. The ultra-thin, typically less than 6 feet by 6 feet panels, are designed to behave as a bonded structural layer with the older asphalt layers below. Through composite action, the bonded layers can be used to solve asphalt shoving and rutting issues in areas with heavy vehicles, but lower traffic volumes.
Table 1. Thin (TWT) and ultra-thin (UTW) concrete overlay experimental designs at MnROAD

<table>
<thead>
<tr>
<th>Cell #</th>
<th>Type</th>
<th>PCC thickness (in)</th>
<th>HMA thickness (in)</th>
<th>Panel size (ft)</th>
<th>Sealed joints</th>
<th>Fiber reinforcement type</th>
<th>Year Start-End</th>
</tr>
</thead>
<tbody>
<tr>
<td>92</td>
<td>TWT</td>
<td>6</td>
<td>7</td>
<td>10 x 12*</td>
<td>Y</td>
<td>Polypropylene</td>
<td>1997-2010</td>
</tr>
<tr>
<td>93</td>
<td>UTW</td>
<td>4</td>
<td>9</td>
<td>4 x 4</td>
<td>Y</td>
<td>Polypropylene</td>
<td>1997-2004</td>
</tr>
<tr>
<td>94</td>
<td>UTW</td>
<td>3</td>
<td>10</td>
<td>4 x 4</td>
<td>Y</td>
<td>Polypropylene</td>
<td>1997-2004</td>
</tr>
<tr>
<td>95</td>
<td>UTW</td>
<td>3</td>
<td>10</td>
<td>5 x 6</td>
<td>Y</td>
<td>Polyolefin</td>
<td>1997-2004</td>
</tr>
<tr>
<td>96</td>
<td>TWT</td>
<td>6</td>
<td>7</td>
<td>5 x 6</td>
<td>Y</td>
<td>Polypropylene</td>
<td>1997-2010</td>
</tr>
<tr>
<td>97</td>
<td>TWT</td>
<td>6</td>
<td>7</td>
<td>10 x 12</td>
<td>Y</td>
<td>Polypropylene</td>
<td>1997-2010</td>
</tr>
<tr>
<td>60</td>
<td>TWT</td>
<td>5</td>
<td>7</td>
<td>5 x 6</td>
<td>Y</td>
<td>None</td>
<td>2004-present</td>
</tr>
<tr>
<td>61</td>
<td>TWT</td>
<td>5</td>
<td>7</td>
<td>5 x 6</td>
<td>N</td>
<td>None</td>
<td>2004-present</td>
</tr>
<tr>
<td>62</td>
<td>TWT</td>
<td>4</td>
<td>8</td>
<td>5 x 6</td>
<td>Y</td>
<td>None</td>
<td>2004-present</td>
</tr>
<tr>
<td>63</td>
<td>TWT</td>
<td>4</td>
<td>8</td>
<td>5 x 6</td>
<td>N</td>
<td>None</td>
<td>2004-present</td>
</tr>
<tr>
<td>14</td>
<td>TWT</td>
<td>6</td>
<td>Var. (5-8)</td>
<td>6 x 6**</td>
<td>N</td>
<td>None</td>
<td>2008-present</td>
</tr>
</tbody>
</table>

* Transverse joints in Cell 92 contain 1” diameter dowel bars.
** 36 slabs have panel size of 6’x12’ and flat plate dowels across transverse joints. Other joints also doweled.

Photo 1. Distress in 4 feet by 4 feet panels in MnROAD UTW Cell 94.

Panel Thickness: The 3 inch thick UTW sections experienced more than 6 million concrete equivalent single axles loads (CESALs) before they had to be reconstructed. The 1997 built 6 inch thick TWT sections (5’x 6’ panels) continue to perform with little distress, after more than 10 million CESALs.

Distress Type: Panel sizes that place wheel loads near the edge of a UTW panel, result in load induced corner cracks. When the stiffness of the bonded PCC overlay is less than that of the underlying asphalt, underlying cracks will reflect through the bonded PCC layer.

Fibers: The use of synthetic shrinkage control fibers has not shown significant improvement in the performance of TWT or UTW. Recent studies have, however, demonstrated performance benefits when using structural fibers in UTWs.

Layer Bonding: The performance of UTW sections at MnROAD confirmed the need for bonding of the PCC to the asphalt. Once a portion of UTW becomes unbonded, surface distress (cracking) develops very rapidly.

Joint Doweling: For the larger 10 feet (long) by 12 feet (wide) panels, significant transverse joint faulting occurred in the undoweled sections under interstate traffic.

Joint Sealing: Empirical observations indicate that sealing joints in TWT and UTW appears to slow layer debonding and reduce the development of joint spalling.

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