Shingle Study Objectives

- Shingle Only Mixes
- Effect on Mix & Binder
- Difference with control
<table>
<thead>
<tr>
<th>CORE TYPE</th>
<th>SHINGLE %</th>
<th>%AC</th>
<th>PG HIGH TEMP</th>
<th>PG LOW TEMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>WEAR</td>
<td>5% MW Wear</td>
<td>6.5</td>
<td>64.4</td>
<td>-30.9</td>
</tr>
<tr>
<td>BASE</td>
<td>5% MW Base</td>
<td>6.7</td>
<td>64.6</td>
<td>-30.3</td>
</tr>
<tr>
<td>WEAR</td>
<td>10% MW Wear</td>
<td>6.6</td>
<td>68.4</td>
<td>-29.6</td>
</tr>
<tr>
<td>WEAR</td>
<td>No Shingles</td>
<td>6.4</td>
<td>58.9</td>
<td>-30.7</td>
</tr>
<tr>
<td>BASE</td>
<td>No Shingles</td>
<td>6.6</td>
<td>58.5</td>
<td>-30.0</td>
</tr>
<tr>
<td>WEAR</td>
<td>5% TOSS Wear</td>
<td>6.9</td>
<td>65.9</td>
<td>-30.4</td>
</tr>
<tr>
<td>WEAR</td>
<td>10% TOSS Wear</td>
<td>8</td>
<td>72.8</td>
<td>-25.7</td>
</tr>
<tr>
<td>WEAR</td>
<td>10% TOSS/52-34 Wear</td>
<td>7.7</td>
<td>70.3</td>
<td>-27.5</td>
</tr>
</tbody>
</table>
Hassan Twp Shingle Mix Gradations

Percent Passing vs. Sieve to the .45 power

Virgin Base, Virgin Wear, 5% MW Base, 5% MW Wear, 5% Toss Wear, 10% MW Base, 10% Toss Wear, 10% Toss/52-34 AC Wear
## Hassan Twp Project

<table>
<thead>
<tr>
<th>% AC</th>
<th>5% MW Wear</th>
<th>5% MW Base</th>
<th>5% TOSS Wear</th>
<th>10% MW Wear</th>
<th>10% Toss Wear</th>
<th>10% Toss/52-34 AC Wear</th>
<th>No Shingles Base</th>
<th>No Shingles Wear</th>
</tr>
</thead>
</table>
Shingle Mix  HT PG Grade

Hassan Twp Mixes

High PG Temp (deg C)

- 5% MW Wear
- 5% MW Base
- 5% TOSS Wear
- 10% TOSS Wear
- 10% TOSS/52-34 Wear
- No Shingles Wear
- No Shingles Base
Shingle Mix LT PG

Hassan Twp Mixes

Low PG Temp (deg C)

5% MW Wear  5% MW Base  5% TOSS Wear
10% TOSS Wear  10% TOSS/52-34 Wear  10% MW Wear
No Shingle Wear  No Shingle Base
High Temp PG by % Shingles

Ht PG vs % Shingles graph

- Toss
- MW
LT PG by % Shingles
Inplace Voids

Hassan Twp Core Inplace Voids

Mix

- Virgin A
- Virgin B
- 5% MW A
- 5% MW B
- 10% MW A
- 10% MW B
- 5% TOSS A
- 5% TOSS B
- 10% TOSS A
- 10% TOSS B
- 10% TOSS 52 A
- 10% TOSS 52 B
Deleterious Materials

![Graph showing percentage of deleterious materials for different materials.

Legend:
- Certainteed 1
- Certainteed 2
- DemCon Tear Off 1
- DemCon Tear Off 2
- Tear Offs 1
- Tear Offs 2
- MW Shingles 1
- MW Shingles 2
- Omann Plant 1
- Omann Plant 2
- Bauerly]
Binder Testing Conclusions

- Difference in AC related to % shingle binder
- PG Grade-5% Toss/MW- not much difference
- 10% Toss- HT 2 ½ grades, LT- ½ grade
- Soft binder-decrease both ½ grade- close to PG 58-28
Gradation Conclusions

- Mix gradations uniform
- Processed product significant differences
- Deleterious Material—plastic, paper
- TSR Failure—swelling of pucks
TH 10 Shingle HMA- SP 0502-09

- PG 64-28/30% RAP - PG 69.5-29.8
- PG 64-28 /27% RAP and 3 % shingles PG 72.5-25.0
- PG 64-28/5% shingles/25% RAP- PG 75.8-25.5

- Adding 3% shingles it increases stiffness on both ends by ½ grade over that of the 30% RAP.
- Adding an additional 2% for a total of 5% increases the high end by an additional ½ grade but doesn't effect the low temp grade
- Major cracking
Issues

- New AC/Film thickness
- Mix designers push limit
- Pavement Failures after 1 yr
- Sizing of processed shingles
- Amount of total recycled product in mix
- Mix temperature/mixing time
  - More effect from shingles