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Evaluation of Resistance to Rutting and Moisture Susceptibility on High RAP content Asphalt Concretes using Hamburg Wheel Tracking Device

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In order to evaluate rutting resistance and moisture susceptibility by mix type, RAP contents, binder type, and test temperature, we collected the following data:

1. Maximum improvement (rut depth: mm)
2. Creep slope (passes)
3. Strip slope (passes)
4. Stripping Inflection Point (passes)

### RESULTS AND DISCUSSION

#### 1. Volumetric Properties of Asphalt Concretes

<table>
<thead>
<tr>
<th>Source</th>
<th>Mix-type</th>
<th>RAP Content (%)</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
</tr>
</thead>
</table>

#### 2. Rut Depth by Pass Number and Inflection Points

<table>
<thead>
<tr>
<th>Mix-type</th>
<th>Temp. (C)</th>
<th>Rut Depth by RAP content (%)</th>
<th>Inflection point by binder type</th>
</tr>
</thead>
<tbody>
<tr>
<td>25s(5)</td>
<td>50C</td>
<td>1.95 (M)</td>
<td>64</td>
</tr>
<tr>
<td>9.5T1(U)</td>
<td>20.06 (U)</td>
<td>1.95 (M)</td>
<td>64</td>
</tr>
<tr>
<td>9.5T2(U)</td>
<td>8.33 (U)</td>
<td>1.95 (M)</td>
<td>64</td>
</tr>
</tbody>
</table>

#### 3. Testing Temperature Influence on Rut Depth and Inflection Points

- Rut depths of the mixes without RAP, using modified or unmodified binders, tested at 50C, were all less than 5mm, very small. Mixes using modified binders were less in rut depth than those unmodified.
- Rut depths of the mixes with RAP, tested at 64C, were still very low, less than 12.5mm. The mixes without modified asphalt have rut depths larger than 12.5mm. The mixes using modified binder have less rut depth than those unmodified, less than 4mm.
- The increase in rutting temperature from 50C to 64C led to rut depths about 3 times larger with a range of 2.5mm per 5°C. The increase in rut depth due to temperature can more easily be seen in Control samples with RAP.
- When tested at 50C, only one out of 6 mixes containing RAP with modified binder was found an inflection point at 4.000,000 passes while both of the two controls were found inflection point at 14,000,000 and 14,500 passes for 19UC and 9.5T1(U), respectively.
- No mixes containing RAP with modified binder was found inflection point.
- When tested at 64C, 6 of the mixes containing RAP with unmodified binders were all found an inflection points ranging from 14,000 to 6,000 passes, depending on the mix. But, there is no inflection point found to any of the three mixes with RAP and modified binder.

#### 4. Influence of Binder Type on Rut Depth and Inflection Points

- All mixes containing RAP using modified binder appeared very lower rut depth than mixes containing RAP using unmodified binder at 64C as those mixes were manufactured using same maximum aggregate.
- Increasing test temperature from 50C to 64C increased the rut depth of mixes with RAP using modified binder.
- When tested 64C, mixes with RAP using unmodified asphalt inflection point rise and increasing temperature 50C to 64C decreasing inflection point rise from 14,000 to 6,000 passes. Mixes containing RAP using modified binder did not appear inflection point at 50C and 64C.

#### 5. Aggregate Size Influence on Rut Depth and Inflection Points

- When tested 50C, mixes containing RAP using unmodified binder increased slightly rut depth with increasing aggregate maximum size at a range from 1.95 to 4.95mm.
- When tested 64C, mixes containing RAP using unmodified binder except 25.5 mix significantly increased rut depth with increasing aggregate maximum size at a range from 3.72 to 15.9mm depending on mix.
- RAP mixes with RAP using unmodified binder irrespective maximum aggregate size increased rut depth 1.5 - 3.2 times as increasing temperature from 50C to 64C.
- When tested 50C, 25, 19, 12.5U mix with RAP using unmodified binder didn’t appear inflection point and 9, 5T2, 12.5U mixes appeared inflection point. And decreasing maximum aggregate size, inflection point decreased noticeable.

#### 6. Rut Depth by max. aggregate size

- All mixes containing RAP using modified binder appeared very lower rut depth than mixes containing RAP using unmodified binder at 64C as those mixes were manufactured using same maximum aggregate.
- Increasing test temperature from 50C to 64C increased the rut depth of mixes with RAP using modified binder.
- When tested 64C, mixes with RAP using unmodified binder inflection point rise and increasing temperature 50C to 64C decreasing inflection point rise from 14,000 to 6,000 passes. Mixes containing RAP using modified binder did not appear inflection point at 50C and 64C.

**CONCLUSIONS**

Based on the partial test results, the following finding were observed

1) Control mixes without RAP showed low durability (higher rut depth) to rutting in both 50C and 64C test temperatures.
2) The RAP included mixes with modified asphalt (PG76-22) showed very high durability (lower rut depth) to rutting in 50C and 64C temperatures. And the RAP mixes with unmodified asphalt (PG64-22) show relatively lower durability (higher rut depth) to rutting in 50C and 64C test temperatures as compared to modified asphalt.
3) Mixes containing RAP using unmodified binder except 25.5 mix significantly increased rut depth with decreasing aggregate maximum size at a range from 3.72 to 15.9mm at high temperature.
4) Even though there is little rut depth in the RAP mixes, stripping distress was observed to some degree.

**ACKNOWLEDGEMENT**

This Project is sponsored by Georgia Department of Transportation and the test program and data analysis are currently on going. This paper contains only part of the research results.