Background Knowledge of Asphalt Binder

This Lecture

- What is specification of AC binder
- Specification tests
- Penetration grading system
- Viscosity grading system

Petroleum-Based Asphalt Binders

- Asphalt binder is waste product from refinery processing of crude oil
  - Sometimes called the “bottom of the barrel”
- Properties depend on:
  - Refinery operations
  - Composition crude source-dependent

Petroleum-Based Asphalt Binders

Barrel of Crude Oil

Gasoline
Kerosene
LL. Gas Oil
Diesel
Motor Oils
Asphalt
Purchasing of Asphalt Binders

- Need to be able to specify desirable characteristics
- “Desirable characteristics” have evolved over time and with increasing technological advances
- Purchasing requires specifications

Early Specifications

- Lake Asphalts
  - Appearance
  - Solubility in carbon disulfide
- Petroleum asphalt binders (early 1900’s)
  - Consistency
    - Chewing
    - Penetration machine
      - Measure consistency

Penetration Testing

- Sewing machine needle
- Specified load, time, temperature

Initial

\[\text{Penetration in 0.1 mm}\]

After 5 seconds

\[100 \, \text{g}\]
Penetration Specification

- Five Grades
  - 40 - 50
  - 60 - 70
  - 85 - 100
  - 120 - 150
  - 200 - 300

Penetration Gradation Specification

- Uses penetration results to specify
- Adds
  - Flash point test
  - Ductility
  - Solubility
  - Thin film oven aging
    - Penetration
    - Ductility

Flash Point (Safety)

Thermometer
Cup filled with asphalt binder
Wand attached to gas line
Typical Penetration Specifications

<table>
<thead>
<tr>
<th></th>
<th>Penetration 40 - 50</th>
<th>Penetration 200 - 300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flash Point, F</td>
<td>450+</td>
<td>350+</td>
</tr>
<tr>
<td>Ductility, cm</td>
<td>100+</td>
<td>100+</td>
</tr>
<tr>
<td>Solubility, %</td>
<td>99.0+</td>
<td>99.0+</td>
</tr>
<tr>
<td>Retained Pen., %</td>
<td>55+</td>
<td>37+</td>
</tr>
<tr>
<td>Ductility, cm</td>
<td>NA</td>
<td>100+</td>
</tr>
</tbody>
</table>

Temperature

25C (77F) Temperature

Advantages

- Grades asphalt binders near average in-service temp.
- Fast
- Can be used in field labs
- Low capital costs
- Precision well established
- Temp. susceptibility can be determined
Disadvantages

- Empirical test
- Shear rate
  - High
  - Variable
- Mixing and compaction temp.
  information not available
- Similar penetrations at 25C (77F) do not reflect wide differences in asphalts

Viscosity Graded Specifications

Definition

Viscosity: the ratio between the applied shear stress and the rate of shear.

\[ \eta = \frac{\tau}{\gamma} \]
### Types of Viscosity Tubes

- **Asphalt Institute Tube**
  - U-shaped tube with timing marks & filled with asphalt binder
  - Placed in 60°C bath
  - Vacuum used to pull asphalt through tube
  - Time to pass marks
  - Visc. in Pa s (Poise)

- **Ziętฤch Cross-Arm Tube**
  - Cross arm tube with timing marks & filled with asphalt
  - Placed in 135°C bath
  - Once started gravity moves asphalt through tube
  - Time to pass marks
  - Visc. in mm²/s (centistoke)

### Testing

- **Absolute viscosity**
- **Kinematic viscosity**
Viscosity Grade Specifications

- ASTM D3381
- Three specifications
  - Table 1
    - Original properties
  - Table 2
    - Original properties
  - Table 3
    - Rolling thin film oven aging

Table 1 & 2 Tests

- Viscosities at 60 and 135°C
- Penetrations at 25°C
- Flash point
- Solubility
- TFO aged residue
  - Viscosity at 60°C
  - Ductility at 25°C

Table 1 & 2 Grades

- Table 1
  - AC 2.5, AC 5, AC 10, AC 20, AC 40
- Table 2
  - AC 2.5, AC 5, AC 10, AC 20, AC 30, AC 40
Table 1 Example

<table>
<thead>
<tr>
<th></th>
<th>AC 2.5</th>
<th>AC 40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visc, 60C</td>
<td>250 ± 50</td>
<td>4,000 ± 800</td>
</tr>
<tr>
<td>Visc, 135C</td>
<td>80+</td>
<td>300+</td>
</tr>
<tr>
<td>Penetration</td>
<td>200+</td>
<td>20+</td>
</tr>
<tr>
<td>Visc, 60C</td>
<td>&lt;1,250</td>
<td>&lt;20,000</td>
</tr>
<tr>
<td>Ductility</td>
<td>100+</td>
<td>10+</td>
</tr>
</tbody>
</table>

Table 2 Example

<table>
<thead>
<tr>
<th></th>
<th>AC 2.5</th>
<th>AC 40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visc, 60C</td>
<td>250 ± 50</td>
<td>4,000 ± 800</td>
</tr>
<tr>
<td>Visc, 135C</td>
<td>125+</td>
<td>400+</td>
</tr>
<tr>
<td>Penetration</td>
<td>220+</td>
<td>40+</td>
</tr>
<tr>
<td>Visc, 60C</td>
<td>&lt;1,250</td>
<td>&lt;20,000</td>
</tr>
<tr>
<td>Ductility</td>
<td>100+</td>
<td>25+</td>
</tr>
</tbody>
</table>

Table: Temperature, Viscosity, Penetration, Ductility
Mixing/Compaction Temps

Advantages (Original AC Visc. Grade)
- Fundamental property
- Wide range of temperatures
- Based on max. pavement surface temp.
- Wide range of instruments
- Test method precision established
- Temperature susceptibility is controlled
- Limits aging
- Information on mixing & compaction temps.

Disadvantages (Original AC Visc. Grade)
- More expensive
- Longer testing time
- More technician skill needed
- Not applicable for Non-Newtonian materials
- Wide range of properties for same grade
Table 3

- AR Grades
  - AR 1000, AR 2000, AR 4000, AR 8000, AR 16000
- Tests on RTFO aged residue
  - Viscosities at 60 and 135°C
  - Penetrations at 25°C
  - % of Original Penetration
  - Ductility
  - Properties of unaged asphalt binders
    - Flash point and solubility

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Table 3 Specification

<table>
<thead>
<tr>
<th></th>
<th>AR 1000</th>
<th>AR 16,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visc, 60°C</td>
<td>1,000 ± 250</td>
<td>16,000 ± 4,000</td>
</tr>
<tr>
<td>Visc, 135°C</td>
<td>140+</td>
<td>550+</td>
</tr>
<tr>
<td>Pen.</td>
<td>65+</td>
<td>20+</td>
</tr>
<tr>
<td>% Orig. Pen</td>
<td>NS</td>
<td>52+</td>
</tr>
</tbody>
</table>
Advantages (AR Visc. Grade)

- Represents asphalt binder properties after mixing
- Fundamental properties
- Covers wide range of temperatures
- Limits aging

Disadvantages (AR Visc. Grade)

- Highly regional
- Requires different testing equipment
- Longer testing time
- No consistency test on original Asphalt Binder
- Not applicable for Non-Newtonian materials
- Wide range of properties for same grade
Questions?

The Beginning
Keeping roads good with asphalt paving materials

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