Colorado Department of Transportation Bituminous Laboratory

Presented By:
Ed Trujillo, Mike Smith
REFERENCES

- THE ASPHALT HANDBOOK, Asphalt Institute., MS-4 7th Edition
- CDOT Laboratory Manual of Test Procedures 2012.
- CDOT Standard Specifications
State Highway Department

- 1931- The City and County of Denver ran all of the materials testing for the State Highway Department.
- 1937- The State Highway Dept. set up the first materials division. Located at the original KOA radio station site., East Colfax.
- Started to run the materials testing for themselves.
1956- Built a new site for the materials laboratories located at Louisiana and Colorado Blvd. The materials laboratory was made up with the following laboratories:

- Aggregate Stability Section
- Asphalt Pavement Design/ Bituminous
- Chemical Laboratory
- Soils Laboratory
- Concrete Laboratory
1968-The State Highway Department changed to CDOH.

Bituminous Laboratory ran the following tests:

- Penetration
- Ductility
- Viscosity
- Testing of Recovered Asphalts
- Joint Sealants
- Lubricating Oils
Where we are today

- 1991 Colorado Department of Highways adopted the new CDOT.
- SHRP (Strategic Highway Research Program) testing was introduced for the Binder Material.
- 2005, 2006, Moved to the new location at 4670 North Holly St. Denver CO.
Where Does the Asphalt Binder

- Geologic Formations
- Naturally Formed Lakes
- Refined from Crude oil
Hard Asphalt in Geologic Formations

- Gilsonite deposit in UTAH.
- KyRock in Kentucky.
- White Mines in Southwestern Texas.
Natural Asphalt

- Trinidad Lake asphalt in Trinidad.
- The Trinidad lake binder was used in the Glenwood Canyon in early 2000; the product is still there.
- Bermudez asphalt in Venezuela. (This deposit covers 1,100 acres estimated to contain 6 million tons of asphalt)
Petroleum Asphalt
Three Types of Asphalt Cement

- Asphalt Cements or Binder; used in the Hot Mix Asphalt HMA. Can be modified.
- Emulsified Asphalts; Mixture of asphalt and water/detergents. Used in chip seals, tack, FDR and Cold in Place Recycling.
- Cutback Asphalt; is no longer used for CDOT projects (AC10, AC20....)
The Three Grading Systems

- Penetration Grading System
- Viscosity Grading System
- Superpave System

Grading system is used to classify the binder into three classes: hard, medium and soft material.
Penetration Grading System

- Established in 1947, classified the binder into grades according to the penetration value.

<table>
<thead>
<tr>
<th>Temp 77°F</th>
<th>Hard</th>
<th>Medium</th>
<th>Soft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unaged binder</td>
<td>40-50 deci-mm</td>
<td>85-100 deci-mm</td>
<td>200-300 dici-mm</td>
</tr>
</tbody>
</table>

Only measures asphalt at room temperature so the cold and hot temperatures cannot be measured.
Penetration Test

100 grams of weight

Asphalt Cement 25°C

Start

In units of 0.1 mm

Asphalt Cement 25°C

After 5 Seconds

100 grams of weight
**Penetration Grading**

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Viscosity Tests

- Absolute viscosity test; Used with a vacuum and calibrated tubes.
- Kinematic viscosity test; Used with gravity and calibrated tubes.
- Rotational viscosity test; Used with a hanging bob at temperature and measured Rounds per minute.
Rotational Viscosity Test
Viscosity Grading System


- The numerical values in the grade denotes the viscosity of the binder in hundreds of poises (cP) at 140°F.

- The average AC-10 would have a viscosity of (800-1200 cP at 140°F)

- Which would be the same as a medium penetration grade asphalt or a PG 58-28 SHRP binder test.

- The test was done on unaged binder, still not enough information for the mix designer, and hot, cold climate information not given.
Viscosity Grading System


Just like the AC system the numerical value in the grade is the viscosity in cP at 140°F.

The difference is that the asphalt was aged using the Rolling Thin Film Oven Test.

AR-4000 grade would have a viscosity of 3000 to 5000 cP similar to a medium penetration of 85/100, AC-10, or PG 58-28.

This grading system was better but still not enough information for the designers and the freeze/thaw cycles in the weather still a problem.
SHRP Binder Grading System

- This grading system is what CDOT uses today.
- Recognizing the deficiencies of the first two grading systems SHRP came up with the Performance Grading System (Superpave).
- Using the average 7 day maximum pavement design temp and the minimum pavement design temperature in 6 degree increments.
- Tests performed on the binder represent the different stages of the binder in production.
- Stage 1- Transporting, Storage and Handling.
- Stage 2- Mix production, and Construction.
- Stage 3- In-service aging of the binder over a long period of time (7 to 10 years).
### Table 1: Performance Graded Asphalt Binder Specifications (from AASHTO, 2001)

<table>
<thead>
<tr>
<th>Performance Grade</th>
<th>PG 46</th>
<th>PG 52</th>
<th>PG 56</th>
<th>PG 64</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average 7-day Maximum Pavement Design Temperature, °C</td>
<td>≤ 46</td>
<td>≤ 52</td>
<td>≤ 58</td>
<td>≤ 64</td>
</tr>
</tbody>
</table>

#### ORIGINAL BINDER

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash Point Temp, T-48, Minimum (°C)</td>
<td>230</td>
</tr>
<tr>
<td>Viscosity, ASTM D-4402,* Maximum, 3.34 l/s Test Temp, °C</td>
<td>135</td>
</tr>
<tr>
<td>Dynamic Shear, TP 5°</td>
<td>46</td>
</tr>
<tr>
<td>0°sinθ, Minimum, 1.00 kPa Test Temp @ 90 rad/s, °C</td>
<td></td>
</tr>
</tbody>
</table>

#### ROLLING THIN FILM OVEN RESIDUE (T 240)

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass Loss, Maximum percent</td>
<td>1.00</td>
</tr>
<tr>
<td>Dynamic Shear, TP 5°</td>
<td>46</td>
</tr>
<tr>
<td>0°sinθ, Minimum, 2.20 kPa Test Temp @ 90 rad/s, °C</td>
<td></td>
</tr>
</tbody>
</table>

#### PRESSURE AGING VESSEL RESIDUE (PP 1)

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAV Aging Temperature, °C</td>
<td>90</td>
</tr>
<tr>
<td>Dynamic Shear, TP 5°</td>
<td>10</td>
</tr>
<tr>
<td>0°sinθ, Maximum, 5000 kPa Test Temp @ 90 rad/s, °C</td>
<td></td>
</tr>
<tr>
<td>Physical Hardening</td>
<td>Report</td>
</tr>
<tr>
<td>Creep Stiffness, TP 1</td>
<td>-24</td>
</tr>
<tr>
<td>Determine the critical cracking temperature as described in PP 92.</td>
<td></td>
</tr>
<tr>
<td>Direct Tension, TP 3</td>
<td>-24</td>
</tr>
<tr>
<td>Determine the critical cracking temperature as described in PP 42.</td>
<td></td>
</tr>
</tbody>
</table>
### SuperPave

<table>
<thead>
<tr>
<th>Performance Grade</th>
<th>PG 70</th>
<th>PG 76</th>
<th>PG 82</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average 7-day Minimum Pavement Design Temperature, °C</td>
<td>10</td>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>Minimum Pavement Design Temperature, °C</td>
<td>28</td>
<td>34</td>
<td>40</td>
</tr>
</tbody>
</table>

#### ORIGINAL BINDER

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash Point Temp, T-49, Minimum (°C)</td>
<td>230</td>
</tr>
<tr>
<td>Viscosity, ASTM D 4402</td>
<td>135</td>
</tr>
<tr>
<td>Dynamic Shear, TP 5, 0°F/strain², Minimum, 1.00 kPa</td>
<td>70</td>
</tr>
<tr>
<td>Test Temp @ 10 rads, °C</td>
<td>76</td>
</tr>
</tbody>
</table>

#### ROLLING THIN FILM OVEN RESIDUE (T 240)

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>Mass Loss, Maximum, percent</td>
<td>1.00</td>
</tr>
<tr>
<td>Dynamic Shear, TP 5, 0°F/strain², Minimum, 2.20 kPa</td>
<td>70</td>
</tr>
<tr>
<td>Test Temp @ 10 rads, °C</td>
<td>76</td>
</tr>
</tbody>
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#### PRESSURE AGING VESSEL RESIDUE (PP 1)

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAV Aging Temperature, °C</td>
<td>100 (110)</td>
</tr>
<tr>
<td>Dynamic Shear, TP 5, 0°F/strain², Maximum, 5000 kPa</td>
<td>34</td>
</tr>
<tr>
<td>Test Temp @ 10 rads, °C</td>
<td>31</td>
</tr>
</tbody>
</table>

#### Physical Hardness Report

- Creep Stiffness, TP 1
  - Determine the critical cracking temperature as described in PP-42
  - 0 - 6 - 12 - 18 - 24 - 30
- Direct Tension, TP 3
  - Determine the critical cracking temperature as described in PP-43
  - 0 - 6 - 12 - 18 - 24 - 30
PG Grading

Low Temperature Performance Grade

PG 58-28

High Temperature Performance Grade
CDOT Standard Binders

- PG 58-28- Base Binder
- PG 58-34-
- PG 64-22- Base Binder
- PG 64-28- Rubber Polymer modified
- PG 70-28-
- PG 76-28- Plastimer Polymer modified
SHRP Binder Conditioning Tests

- **Rolling Thin Film Oven** aging test, Checking for Oxidation and Volatilization that occurs during use in the Hot Plant mixing facility.
- **Short Term Aging**
- **Stage 1**: Transporting, Storage and Handling.
Rolling Thin Film Oven Test
Dynamic Shear Rheometer Test

- Tests the high temp of a Performance Graded binder for rutting resistance.
- Unaged and Aged testing of the binder properties.
- **Stage 2**: Mix production and Construction.
Pressurized Aging Vessel Test

- Test is used to expose the sample to heat and pressure for 20 hours at 100°C and 2.10 kPa. (Same as 7 to 10 years in service).

- Stage 3: Simulate long term in-service aging of the binder.
Bending Beam Rheometer Test

- Test is used to calculate creep stiffness (S-value) and creep rate (m-value).
- Basically the test will evaluate the binder properties at the cold temperatures. (tests for the cold temperature critical cracking of the binder).
**BENDING BEAM RHEOMETER**

**CONSTANT LOAD OF 980 MILLINEWTONS FOR 60 SECONDS**
Testing for the Polymers

- **Elastic Recovery Test** - Unaged and Aged binder is molded and stretched in a bath at a set temperature and rate. The sample is cut in the middle and allowed time to recover.

- Testing for the Elastomeric Properties of a binder in this case the Plastimer Polymers in a Binder.
Elastic Recovery Test
Elastic Recovery Test
Elastic Recovery Test
Elastic Recovery Test
Ductility Test

- Test is used to check for the Elastomeric properties of a binder in this case rubber Polymers. The sample is molded and stretched at a set temp and rate.

- The test is similar to the elastic recovery except the sample is stretched until failure.
Ductility Test
Toughness and Tenacity Test

- This test will check the elastomeric properties of a binder.
- The PG 64-28 will be tested for rubber polymers.
Toughness and Tenacity Test

Thursday, April 19, 2012
Toughness and Tenacity Test
Emulsions

- **Emulsion**-Method used to liquefy the binder so it can be pumped or sprayed. The emulsion will evaporate and leave behind the binder.

- **Cutback (Solvent)** is not used as an emulsion due to environmental restrictions.

- **Water/detergent** is now the accepted practice.
CDOT Standard Emulsions

- CRS-2P
- CRS-2R
- CMS-2P
- HFRS-2P
- HFMS-2sP
- ARA
Classification of Emulsions

CSS-1h

- Cationic
- Slow Setting
- Viscosity
- Hardness Penetration Grading
Classification of Emulsions

HFMS-2sP

- Polymer or R is Latex
- High Float nonionic
- Medium Set
- Viscosity
- Soft Penetration grade
Emulsion Testing

- Saybolt Furol Viscosity test - used to test the emulsion at a set temperature for pump ability and viscosity.
Saybolt Viscosity Test
Particle Charge Test

- Test is used to identify the Cationic asphalt emulsions.
- Basically the aggregate has positive or negative charge and the emulsion asphalt has a positive or negative charge.
- Cationic is a positive charged emulsion.
- Anionic is a negative charged emulsion.
Particle Charge Test
Distillation Test

- The emulsion is distilled to check the relative proportion of the binder to the water/detergent mixture.
- The residue is then tested using the conventional tests.
- Penetration, Float test, softening point.
Distillation Test
Ring and Ball Softening Point

- This test is used to check the consistency of an emulsion residue.
- Basically to check if the binder properties are still combined and haven’t separated.
Softening Point Test
Crack Sealant Testing

- CDOT will only test the sealant if the project requests it.
- Usually the project will receive a Certified Test Report from the Supplier that we have approved.
- Project can check the CDOT approved product list.
Crack Sealant Testing
Bond Test
AMRL Accredited Lab

- Every 18 months to 2 years we are inspected and accredited by the ASSHTO MATERIALS LABORATORY.
- We are a member of the Western Cooperative Test Group.
Reporting

- Test Reports are distributed to the project for review. We must maintain a database for 7 years.
- Failures will be retested and verified; the project will follow the CDOT standard procedures for price reduction or removal or dispute testing.
CDOT Approved Products List

- The Material Suppliers must be certified annually by CDOT.
- A Quality Control Plan must be approved and split samples will be tested and approved.
- The Material Suppliers will then be placed in the CDOT APL for one year.
Questions?
Colorado Department of Transportation

- 4670 North Holly Street
- Denver, Colorado 80216

- Steve Olson Asphalt Unit Manager
  - 303-398-6576
- Ed Trujillo Bituminous Lab Manager
  - 303-398-6530