Highway Engineering Materials - CE 400
Spring 2009
Binder Labs
Draft Due April 1, 2009
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February 25th to March 25th, 2008

T1) AASHTO T240: Rolling Thin Film Oven (RTFO)

Test Summary:

This test simulates the aging (hardening of binders due to evaporation of light compounds) that takes place during hot mix operations. Samples of 35-gr are poured into glass jars that rotate and turn in a heated oven at 163 °C/325 °F, which is the typical mixing temperature at the mix plant, for a period of 75 minutes while air is blown into the jars. The effect of hardening is quantified by measuring the mass loss caused by aging.

Equipment needed:

RTFO apparatus, glass jars, weigh scale, oven, and cleaning supplies (Neugenic).

Procedure:

1. Obtain up to 8 samples of 35 gr of binder that has been heated so it can flow into the jars (heat to about 100 °C with the lids of their containers open to avoid pressure build up). Each group will create two samples.
2. Pour each sample into an RTFO glass tube, weigh it and place it into the sample holder in the RTFO, which should be preheated to 163 °C.
3. Wait about 10 minutes until the 163 °C temperature has been reached again with the RTFO loaded.
4. Turn on the sample rotator and the air blower (4000ml/min) and age material for 75 minutes.
5. At the conclusion of the test, weigh each RTFO tube and aged sample and determine the % loss in sample mass due to aging.
6. Pour sample off each glass sample holder (without scraping) into containers that can be used directly for PAV.
7. CLEAN UP THE RTFO GLASS TUBES USING NEUGENIC.

T2) AASHTO TP48: Brookfield Viscosity Measurements

Test Summary:

This test provides direct measurements of binder viscosity be measuring the torque required to rotate a spindle immersed in the binder contained in a narrow metal tube. The resistance in spindle rotation comes from the shearing of the binder between the spindle and the sides of the metal tube.

Equipment needed:

Brookfield apparatus, metal sample holders, spindles and thermocell controlling the temperature of the sample at 135 °C.

Procedure:

1. Preheat binder and metal holders to about 100 °C,
2. Pour ~30g of binder in the metal holders and place into the thermocell using a pair of pliers,
3. Wait until the temperature in the thermocell has stabilized at 135 °C,
4. Dial the spindle number into the keypad,
5. Immerse the pre-heated spindle into the sample,
6. Start taking viscosity measurements and wait until they stabilize. This is caused by the cooling of the binder due to the immersion of the cooler spindle,
7. Report viscosity measurement as read from the screen (cP),
8. CLEAN UP the metal holders and the spindles

One test is to be performed by each group and the measurements exchanged. Tabulate your findings and compare the values between the groups.

T3) ASTM D454: Aging of Binders by the Pressure Aging Vessel (PAV)

Test Summary:

This test simulates the aging (hardening of binders due to evaporation of light compounds) that takes place throughout the service life of asphalt pavements. It is done by exposing the RTFO-aged binder to 2.1 MPa (about 300 psi) pressure at temperatures of 90, 100 or 110 °C (the actual temperature depends on the geographic region, for our lab will use 100 °C) for a period of 20 hours.

Equipment needed:

PAV apparatus and dishes, oven, and cleaning supplies (Neugenic).

Procedure:

1. Use the RTFO-aged samples you produced in the previous test to fill 1 PAV pan per group (pans fit up to 50-gr), with only one of the RTFO samples
2. Stack the PAV pans in to the PAV cylinder which should be pre-heated to 100 °C,
3. Seal the lid of the PAV vessel and place the entire apparatus into the oven,
4. Wait about 10 minutes for the temperature to stabilize then apply the 2.1 MPa pressure and keep it on for 20 hours,
5. Release pressure slowly and remove PAV apparatus from oven,
6. Place the samples in a 163 ^{o}C oven for 30 minutes to remove any air bubbles,
7. Remove PAV from oven to cool down,
8. Store samples for later testing and CLEAN UP.

T4) AASHTO TP5: Dynamic Shear Rheometer (DSR)

Test Summary:

This test gives information on the shear stiffness of asphalt binders at high and intermediate temperatures. It is conducted by shearing a thin film of binder by the relative rotation of 2 plates (2 sizes are used with diameters of 25 mm and 8 mm for the original/RTFO-aged binder and the RTFO+PAV-aged binder, respectively). Typically, the test is run in a strain-controlled mode, whereby the pulsation amplitude of the upper plate is pre-selected and the torque it takes to rotate the upper plate with respect to the lower is measured to produce shear stress. The test is conducted at a rotational frequency of 10 rad/sec (1.59 Hz) and at temperatures that correspond to the highest and intermediate temperature within an HMA slab at a particular region. The output of the test is the Dynamic Shear Modulus G^* and the phase angle of the binder δ. Superpave requirements are prescribed as follows:

- ✓ Original binder: $G^*/\sin\delta > 1.0$ kPa to prevent rutting, assuming that little aging took place during mixing.
- ✓ RTFO-aged binder: $G^*/\sin\delta > 2.2$ kPa to prevent rutting immediately after construction.
- ✓ RTFO+PAV-aged binder: $G^* \sin\delta < 5000$ kPa to prevent fatigue cracking throughout the pavement life.

Equipment needed:

DSR apparatus, plates, and oven to preheat the sample attached to the upper plates.

Procedure:

1. Move the upper plate/with the pre-prepared binder sample from the oven to the DSR apparatus and attach it to the torque drive.
2. Turn system on, which should be preheated to +64 ^{o}C and observe the pulsation, while making sure that no warnings appear on the screen about slippage of binder from the plates. Save data on disk.
3. Remove sample.
4. Repeat the test at the intermediate temperature of 22 ^{o}C for the fatigue cracking analysis. This sample must have been aged using both the RTFO and PAV.
5. Remove sample and CLEAN UP.

Test is performed by TA. Compare the DSR measurements with the Superpave requirements. Would this binder pass PG 64-28 requirements for rutting and fatigue cracking?

T5) AASHTO TP1: Bending Beam Rheometer (BBR)

Test Summary:

This test gives information on the stiffness of the binder as a function of loading time. It is a beam with a constant mid-point test conducted at low temperatures. The mid-span vertical deflection is measured and the stiffness of the binder is computed using beam theory. Superpave requirements are prescribed as follows:

- ✓ S(60)<300 MPa and m(60)>0.3 conducted at a temperature 10 °C higher than the low-end grade temperature.

Equipment needed:

BBR apparatus, molds for making the beams, and a fridge to keep them at low temperature.

Procedure:

1. Heat the binder at a sufficiently high temp so it flows.
2. Pour it into the beam mold (this is a delicate operation) and put it in the fridge to cool.
3. Remove and gently place beam using a pair of thongs into the temp-controlled BBR bath set at –18 ^oC.
4. Apply the load by turning the pneumatic actuator knob.
5. Observe data on the computer screen and save them on disk.
6. CLEAN UP.

What is the stiffness and m-value at 60 seconds? Compare the results with the Superpave requirements. Would this binder pass PG 64-28 requirements for low temperature cracking?

Q1) The following data are recorded from a Bending Beam Rheometer test on asphalt binder:

- Test temperature = -18.0 ^oC
- Beam width = 12.70 mm
- Beam Thickness = 6.35 mm
- Distance between beam support = 102 mm.

Time (sec)	Deflection (mm)	Stiffness S(t) MPa	m-value
8	0.1877		
15	0.2231		
30	0.2730		
60	0.3364		
120	0.4152		
240	0.5327		

Assuming the load and length of the beam are constants throughout the test:

a) Plot the relationship between deflection and time.
b) Plot the relationship between Log (S(t)) and Log (Time) and fit a second degree polynomial regression equation.
c) Use the regression equation to find the rate at which the creep stiffness changes with loading (m(t)) at the time increments shown in the above table.
d) Determine if this asphalt meets the Superpave requirements for low temperature cracking.