Evaluation of Aged Binder Extracted from an Old Asphalt Pavement Coated with a DP-200 Polymer Layer

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January 30, 2019

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ARIZONA STATE UNIVERSITY

Summary

This report presents results of a laboratory experiment done to compare the aging level of an asphalt binder recovered from a DP-200 Polymer-Coated pavement to that of conventional Reclaimed Asphalt Pavement (RAP) typically found in asphalt plants production. The polymer coated pavement sample was one obtained from one of the previous projects completed by DecoCoat Polymer System. The high temperature Performance-Grade (PG) was used as an indicator to compare the aging level. Binder from the DP-200 polymer-coated mixture was extracted using the centrifuge method and recovered using the Rotary Evaporator (RotoVap). After that, the Dynamic Shear Rheometer (DSR) was used to determine the high temperature parameter ($G^*/\sin\delta$) for the recovered binder under the original condition (as extracted) and the Rolling Thin Film Oven (RTFO) aged condition. The results indicated that the DP-200 Polymer-Coated binder had the lowest degree of aging when compared to other binders extracted from various RAP binders.

Procedure

Sample Preparation

The first step of the sample preparation procedure was to place a sample of the aged asphalt mixture inside a bowl, and then place the bowl in the oven at 135°C for 40 minutes, to soften the sample and at the same time to remove any moisture (Figure 1-a). After that the softened sample was placed in the centrifuge bowl to undergo extraction.

Binder Extraction

The extraction process was carried using the centrifuge method, according to ASTM D2172 "*Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt*". The loose asphalt mixture was placed in the centrifuge bowl (Figure 1-b) and then Trichlorethylene (TCE) solvent was added to extract the asphalt from the aggregates (Figure 1-c). The asphalt was kept immersed in the TCE for 1 hour to give some time for the TCE to remove the binder. After that, the centrifuge machine was ran to remove all the binder and TCE from the bowl. Figure 1-d shows the aggregates after extracting the asphalt.

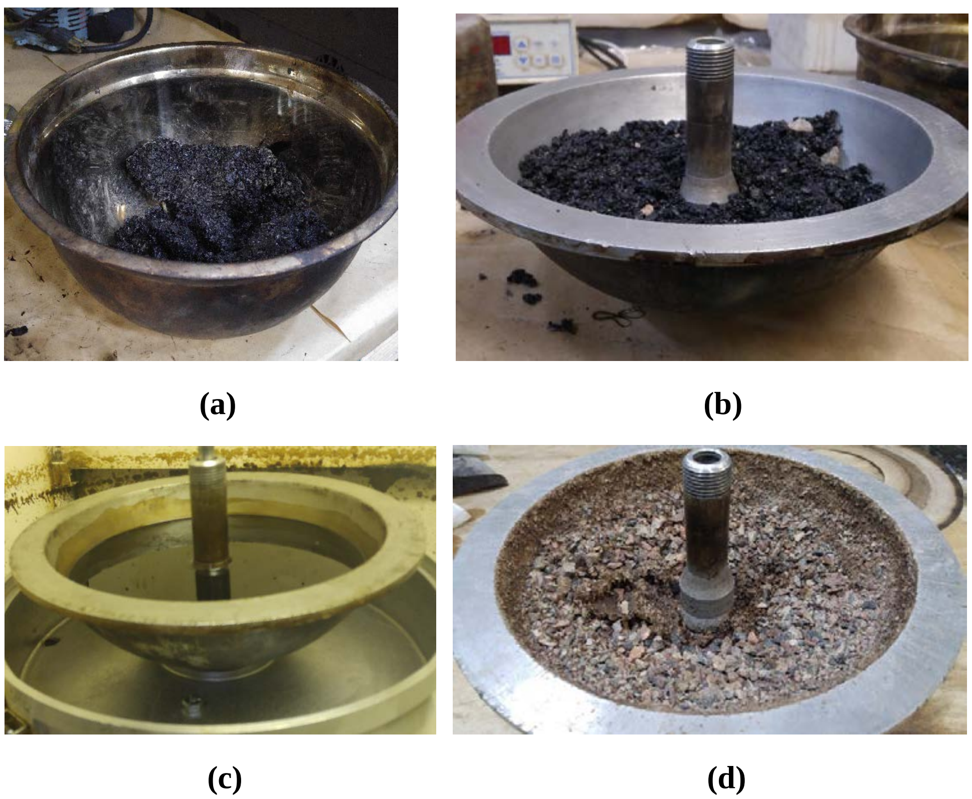
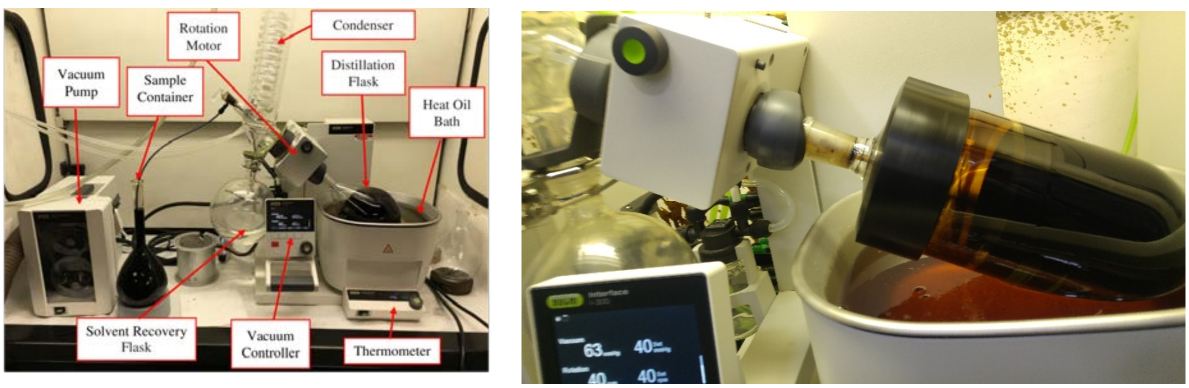


Figure 1. Asphalt Binder Extraction Process During: (a) Specimen Preparation; (b) Specimen Placement in the Bowl; (c) Addition of TCE Solvent; and (d) After Extraction

Binder Recovery

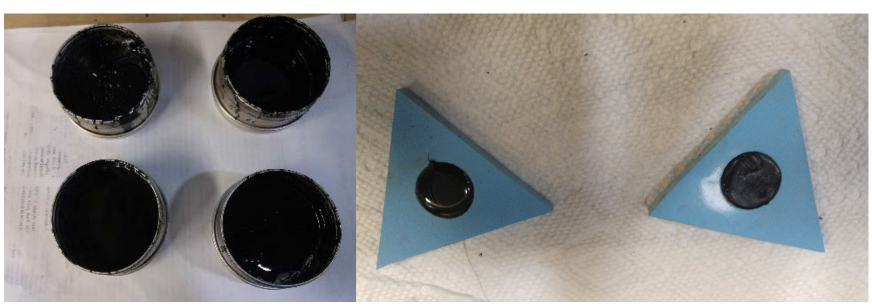
The extraction process output is binder mixed with TCE. However, in order to determine the properties of the asphalt extracted from the DP-200 Polymer-Coated pavement, the TCE must be removed. For this purpose, the RotoVap equipment (Figure 2-a) was used. In this process, the solution of TCE and asphalt was distilled by partially immersing the rotating distillation flask of the rotary evaporator in a heated oil bath while the solution is subjected to a partial vacuum and a flow of nitrogen gas to prevent binder oxidation. The recovered asphalt can then be subjected to testing as required. The process was done according to ASTM D5404 standard *"Standard Practice for Recovery of Asphalt from Solution Using the Rotary Evaporator"*. Figure 2-b shows the binder recovered from the DP-200 Polymer-Coated asphalt mixture in the flask that is immersed in a hot oil bath during the recovery process. Seven recovery processes were performed to get the needed amount of binder for further testing.



(a) **(b)**

Figure 2. Asphalt recovered from DP-200 Polymer-Coated Asphalt Mixture: (a) RotoVap Setup; and (b) Binder Flask Immersed in the Hot Oil Bath

After that, the binder was removed from the flask and poured into metal cans for RTFO aging and then DSR testing molds for original binder testing (Figure 3).



(a) **(b)**

Figure 3. Recovered Binder poured into: (a) Metal cans then (b) DSR Specimen Molds

Rolling Thin Film Oven (RTFO) Aging

In a conventional process of binder testing, RTFO simulates the short-term aging experienced by asphalt during production. Measuring the rutting parameter G*/Sin δ at the RTFO condition is required per AASHTO M 320 standard. During RTFO, a moving film of asphaltic material is heated in an oven for 85 min at 163°C (325°F). The effects of heat and air are determined from changes in physical test values as measured before and after the oven treatment. The RTFO is shown in Figure 4.

Figure 4. RTFO Equipment

The recovered asphalt was poured in the RTFO tubes as shown in Figure 5-a. The material was stiff due to the high level of aging that the binder exposed to during its service life. This caused the material handling to be very challenging as shown in Figure 5-b. After pouring the binder into the tubes, the tube was conditioned in the oven for 10 minutes at 163°C to allow the binder to cover all the tube surface, as shown in Figure 6. After that, the tubes were placed inside the RTFO for 85 minutes at 163°C per AASHTO T 240 specifications. After RTFO, the RTFO aged binder was put into the silicon molds to make it ready for testing.

(a) **(b)**

Figure 5. RTFO Tubes while: (a) Pouring the Recovered DP-200 Polymer-Coated Binder; and (b) Handling the Binder

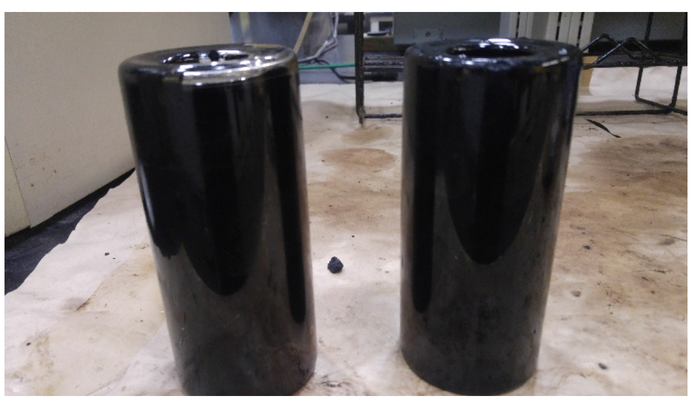
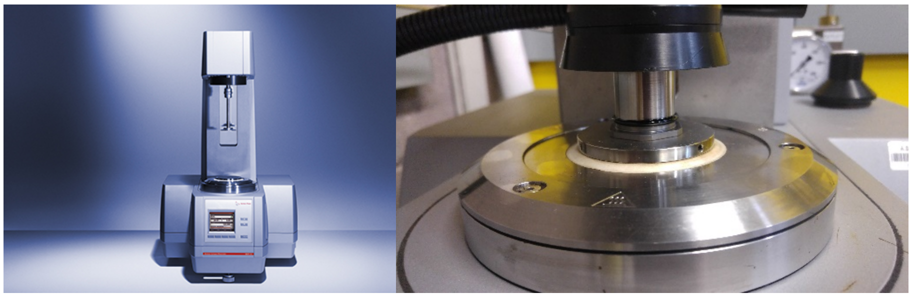


Figure 6. Recovered DP-200 Polymer-Coated Binder Distributed on the RTFO Tubes Surface

Dynamic Shear Rheometer (DSR) Testing

The DSR (Figure 7) was used to measure the complex shear modulus (G*) and the phase angle (δ) of the binder at both "as extracted" and RTFO aged conditions. For each condition, two replicates were tested, and the average value was taken. During the DSR testing, test specimens of 1 mm thick by 25 mm in diameter are formed between parallel metal plates. One of the parallel plates is oscillated with respect to the other at 10 rad/sec. The parameter G*/Sin δ is then determined. The results are shown in Table 1.



(a) **(b)**

Figure 7. (a) DSR Equipment; and (b) Recovered DP-200 Polymer-Coated Binder during DSR Testing

Table 1. DSR Results for As Extracted (Original) and RTFO Aged Binders

Temperature (°C)	G*/Sin δ (Original) KPa	G*/Sin δ (RTFO) KPa
100	4.6708	6.5265
106	2.1263	2.91165
112	1.02955	1.3726
118	0.6087	Test Stopped

Results

The high temperature PG of a binder is defined in AASHTO M 320 "*Standard Specification for Performance-Graded Asphalt Binder*" as the highest possible temperature in which G*/Sin δ at the original binder condition is greater than 1 KPa, and at the same time the parameter G*/Sin δ at the RTFO condition is greater than 2.2 KPa. The analysis is shown in Figure 8. As it can be seen from Figure 8, 106°C is the highest temperature at which the G*/Sin δ was satisfied at both aging conditions. Thus, the high temperature grading of this binder is PG 106.

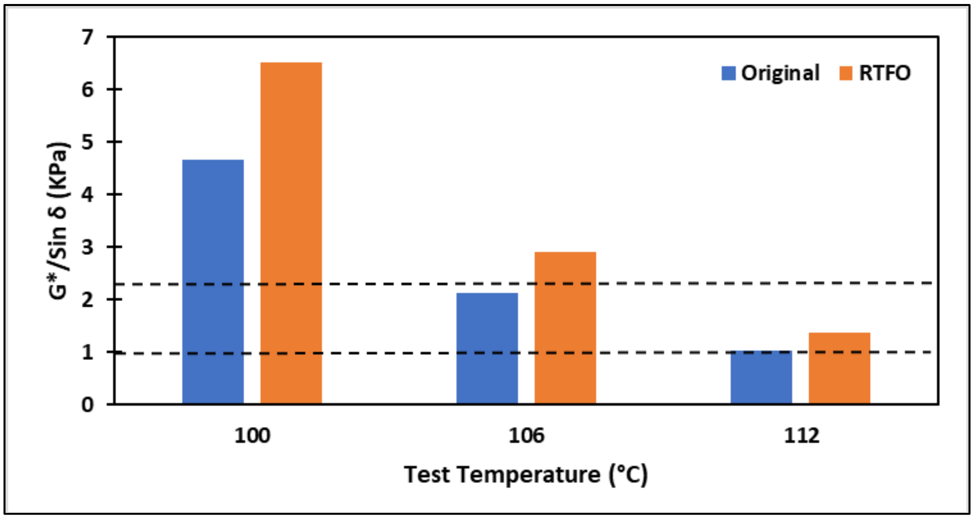


Figure 8. High Temperature PG Analysis per AASHTO M 320 Standard

Comparison Between DP-200 Polymer-Coated and Typical RAP Binders

The high temperature PG of the DP-200 Polymer-Coated binder was compared to another 5 RAP binders that were analyzed previously at ASU. The RAP samples were obtained from plant and City of Phoenix stockpiles. These stockpiles represent typical old asphalt pavements from City streets that were rehabilitated after a service life averaging 15 years. As it can be seen from Figure 9, the binder that was recovered from the DP-200 Polymer-Coated pavement has the lowest high-temperature PG, which indicates that it was the least aged (about 20% less) compared to the RAP-4 sample among the group of binders tested. Less aging in general means less cracking and longer service life.

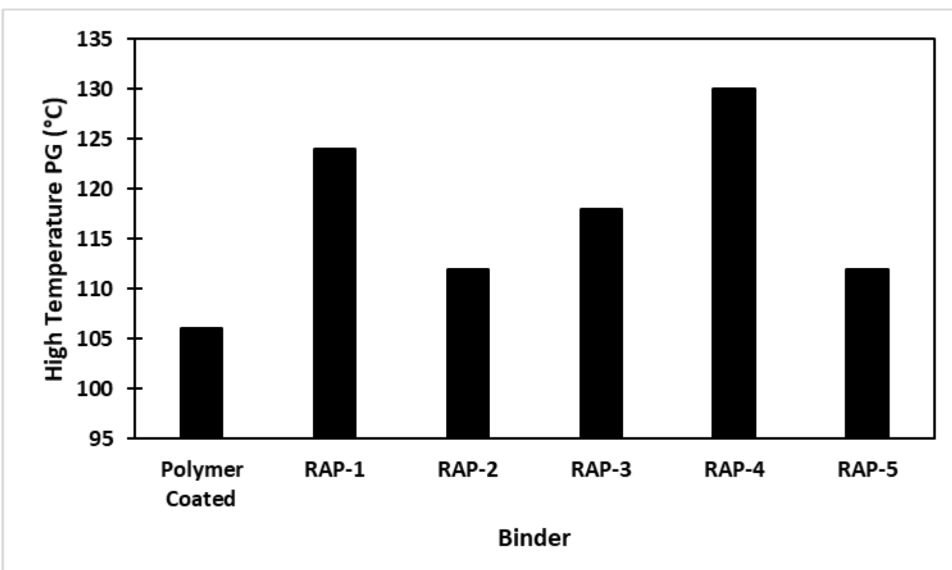


Figure 9. High Temperature PG Comparison of Binders recovered from DP-200 Polymer-Coated Pavement and Typical RAP Mixtures.

Reference

American Association of State Highway and Transportation Officials, *Standard Method of Test for Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA), AASHTO T164,* Washington, D.C.: AASHTO, 2016.

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