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Asphalt Chemistry

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Abstract- The students were taught to generate oil (binder) from recycled asphalt pavement (aggregate) using a Buchi Rotavapor R-15 for submission for elemental analysis (C, N, H, O) and engineering rheology testing and microbial growth. We obtained 18 samples from Oklahoma Department of Transportation divisions and two construction companies to compare the physical and chemical properties of these samples.

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Asphalt Chemistry

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Subject: comparison of various samples of recycled asphalt pavement.

I. Introduction

We collected eighteen samples from 5 Oklahoma Department of Transportation divisions and 2 construction companies. The objective of this research was to generate the oil (binder) from recycled asphalt pavements (aggregate) samples using the BuchiRotavapor R15. We were able to determine the age of the sample by observing the physical properties of the sample. We sent the samples to Galbraith Laboratory for carbon, nitrogen, hydrogen, and oxygen elemental analysis. They learned to independently use the Rotavapor and the Humboldt to process samples from the beginning to final product of generating binder. I learned the protocol from mixing samples to recovering binder.

II. Problem Statement

Recycled Asphalt Pavement (RAP) contains valuable binder and therefore, RAP should be used with new millings on surface roads and not just to patch up holes. Today the oil being produced from refineries is not as rich and of as good of quality as the oil produced twenty years ago or the roads being laid down these days would not have potholes and cracks so soon.

Roads in the United States disintegrate over a shorter period due to increasing traffic. So a focus in today's society is repairing and replacing these roads which cost a significant amount of money. The government is taking available funds and stretching them to meet our restoration needs. Recycled asphalt pavement can save money for the government, create additional business opportunities from research, save energy, and conserve diminishing resources of aggregate. Over the past decades RAP usage has increased. It is the most recycled material in the US. It has been proven that mixtures with RAP can perform as well as mixtures made with virgin binder. Increasing the usage of RAP in new mixtures can reduce the amount of new material being added.

III. Background

Once all of the binder is removed from RAP, engineers are then able to perform rheology testing. Rotational Viscosity test, Performance Grading test to include the following: Dynamic Shear Rheometer, Rotational Thin Film Oven, Pressure Aging Vessel, and Bending Beam Rheometer. You can analyze binder properties from Mechanical Empirical Pavement Design Procedures (MEPDP).

Once all the binder is removed from the RAP, the original aggregate remains for sieve analysis of extracted aggregate, specific gravity of fine and coarse aggregates, Los Angeles Abrasion test, Micro Deval Abrasion test and sand equivalent.

IV. Protocol

It is the American Association of State Highway and Transportation Officials (AASHTO) designation: T 164-08, test method B. Crush RAP to generate a weight of 300 grams and put in a 1000 ml beaker. Add Trichloroethylene (TCE) to reach the 900 ml beaker level, actually 750 ml TCE. Saturate RAP with TCE by stirring with a spatula. Allow RAP to soak in the TCE for an hour while stirring randomly. To filter the fines such as small aggregate, use the Humboldt Reflux Extractor H-149S. We used 2 sieves with appropriately wetted filter paper and set inside of the Humboldt. Connect two radiator hoses to the lid on Humboldt. One end of the lid had a hose connected to a water source. The other end of the lid had a hose connected to allow flow of water into the trough. Heat the hot plate to 120°C. Pour RAP/TCE into the top funnel. Turn on water. Continue filtration until all the binder collects into the bottom of the Humboldt. All the aggregate and fines collected into the top two sieve.

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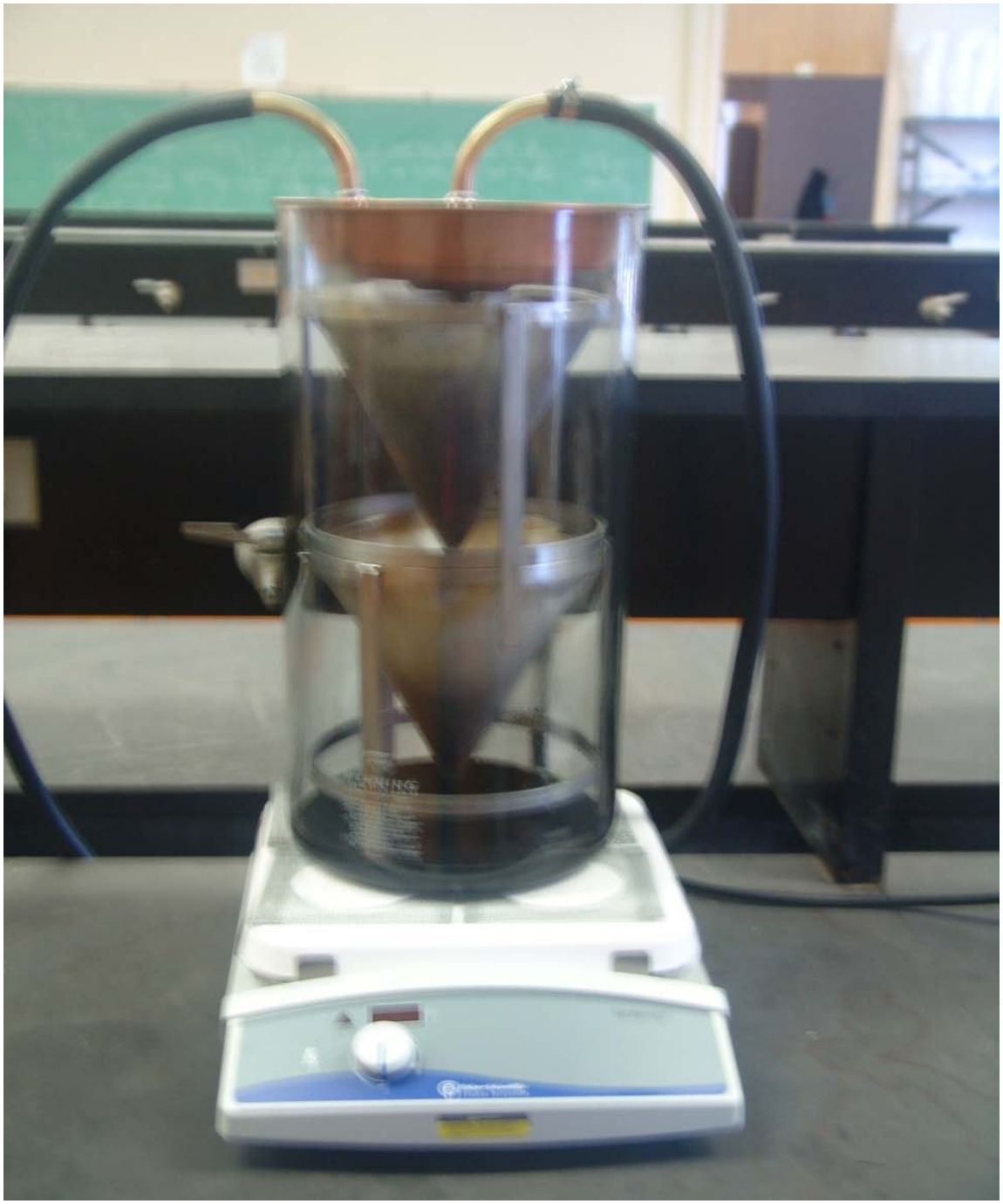
Figure#1-Humboldt



After the Humboldt activities are complete, we are no longer handling RAP/TCE. At this point, we are handling binder/TCE. Decant the binder/TCE mixture into a 2 L evaporating flask. Connect the evaporating flask to the Rotavapor. Put fresh ice into ice trap. Replace distilled water in the water bath. Turn on the pressure unit where the pressure decreases from 970 mbar to 63-67 mbar. Lower the flask into water bath and start rotating the flask at 135 rpm or higher. Every hour, depressurize the system to remove the thawed ice from the cold trap. The TCE is condensed from the binder/TCE mixture into the solvent collecting flask. When solvent stopped collecting in the collecting flask, the system is depressurized, and the flask is removed. The binder is recovered by placing the flask in an oven for ten minutes and setting it upside down over a tin can.

Figure #2-Rotavapor R15

V. Results

There are two result tables. Table #1 reflects the sources of the samples and the conditions. Where you see gaps between starting the sample and processing the sample, the Rotavapor was incapacitated. The menu on the Rotavapor recommends 33mbar pressure for TCE. However, the binder/TCE would boil and reflux into the collecting flask. After troubling shooting the protocol, we noticed that 63-37mbarr worked. Also we had a problem with the water in the water bath boiling the sample even when the temperature of the water was room temperature. Increasing the pressure solved this problem also. The instructions for the Rotavapor states that optimal conditions included having a 40 point difference between the water setting and the pressure. We came very close to that requirement after much troubleshooting.

Table#1 : Sources and Conditions in the order of work performed

	Source	Date	Pressure	Bath Temp	Results
Sample #1	Sq#1	9/26/14	67mbarr	20°C	8 grams 11/20/14
Sample #2	Hwy75 Okmulgee County	10/7/14	67mbarr	20°C	19 grams 11/19/14
Sample #3	Muskogee County	9/26/14	67mbarr	20°C	10 grams 11/19/14
Sample #4	Haskell County	9/24/14	67mbarr	20°C	11 grams 11/18/14
Sample #5	HL Norman Medium RAP	9/12/14	63mbarr	20°C	10 grams 11/14/14
Sample #6	Seq. County	10/1/14	63mbarr	20°C	8 grams

					11/14/14
Sample #7	HL East Plant Medium RAP	9/10/14	63mbarr	20°C	8 grams 11/13/14
Sample #8	Haskell Lemon 5% shingles, no RAP	9/3/14	66mbarr	23°C	5 grams 9/3/14
Sample #9	Haskell Lemon 5% shingles, no RAP	9/3/14	66mbarr	23°C	82 grams 9/3/14
Sample #10 Crust	Haskell Lemon 5% shingles, no RAP	9/3/14	66mbarr	23°C	37 grams 9/3/14
Sample #11	Division 7 (Chickashe, OK)	2/17/14	68mbarr	19°C	10 grams 4/1/14
Sample #12	No sample				
Sample #13 Binder	Haskell Lemon 25% Rap with 5% shingles	8/28/14	100mbarr	23°C	12 grams 8/28/14
Sample #14 Crust	Haskell Lemon 25% Rap with 5% shingles	8/28/14	100mbarr	23°C	47 grams 8/28/14
Sample #15	Haskell Lemon East Plant Medium RAP with Aggregate	3/31/14	68mbarr	27°C	4 grams
Sample #16	Division 5 (Hydro, OK)	8/21/14	68mbarr	19°C	16 grams 8/27/14
Sample #17	Haskell Lemon West Plant	2/18/14	67mbarr	27°C	6 grams
Sample #18	Division 4 (Quapaw)	2/17/14	60mbarr	40°C	8 grams

Table #2 reflects the elemental analysis. The procedure used for elemental analysis was GLI ME-14 for carbon, hydrogen, and nitrogen. The procedure used for oxygen was GLI E8-4. Some of the samples were special. Samples #8 & #9 are together. This was an interesting looking sample. It looked grainy, thick, and viscous before running through the Humboldt. Four hundred grams of shingles collected on the first filter paper of the Humboldt. Once removing the shingles, crust not binder was removed from the filter paper. Sample # 7 was very fluid. Sample #13 had a lot of sand but very little aggregate. All of the liquid part of the sample was put in the Humboldt. The student patiently poured the RAP/TCE trying not to pour any of the sand into the first seive of the Humboldt. All of the sample flowed through the first filter immediately. It took forever for the sample to flow through the second filter paper.

Table #2 : Elemental Analysis

	Source	%Carbon	%Hydrogen	%Nitrogen	%Oxygen
Sample#1 Binder	Sq#1	81.93	10.05	.51	3.52
Sample#2 Binder	Hwy75 Okmulgee County	83.36	10.48	.52	2.75
Sample #3 Binder	Muskogee County	9.44	.51	<.5	18.53
Sample#4 Binder	Haskell County	83.90	10.52	.50	2.51
Sample #5 Binder	HL Norman Medium RAP	79.94	10.04	.65	4.29
Sample #6 Binder	Seq. County	1	2	3	4
Sample #7 Binder	HL East Plant Medium RAP	10.74	,.5	<.5	24.87
Sample #8 Binder	Haskell Lemon 5% shingles, no RAP (5grams)	75.98	9.42	<.5	2.32
Sample #9 Binder	Haskell Lemon 5% shingles, no RAP (82 grams)	81.56	10.11	2.06	
Sample #10 Crust	Haskell Lemon 5% shingles, no RAP The weight of the crust remaining on filter paper was 37 grams of from Samples #8 & #9)				
Sample #11	Division 7	82.75	10.20	.52	2.31

Binder	(Chickashe, OK)				
Sample #12	Miss count				
Sample #13 Binder	Haskell Lemon 25% Rap with 5% shingles	84.33	10.50	<.50	2.48
Sample #14 Crust	Haskell Lemon 25% Rap with 5% shingles **The weight of the crust left on the filter paper was 47 grams.**				
Sample #15 Binder	Haskell Lemon East Plant Medium Rap with Aggregate				
Sample #16 Binder	Division 5 (Hydro, OK)	82.67	10.60	.53	2.23
Sample #17 Binder	Haskell Lemon West Plant				
Sample #18 Binder	Division 4 (Quapaw)	74.41	8.95	<0.5	2.23

VI. Conclusion

This research is beneficial to the work of engineers because they would be able to perform rheology testing: Rotational Viscosity test, Performance Grading test, Dynamic Shear Rheometer, using Rotational Thin Film Oven, Pressure Aging Vessel, and Bending Beam Rheometer. In conclusion, we used the Rotavapor to extract binder from different sources to perform carbon, hydrogen, nitrogen, and oxygen elemental analysis data.

VII. Anticipated Benefits

The anticipated benefit is to present this analysis to the eight ODOT divisions in Oklahoma so that they will realize that RAP is more valuable to them than usage as a black rock. We recommend that the ODOT divisions start using RAP at various percentages with virgin aggregate on surface roads. They must first start separating RAP sources from various projects.

VIII. Acknowledgements

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