

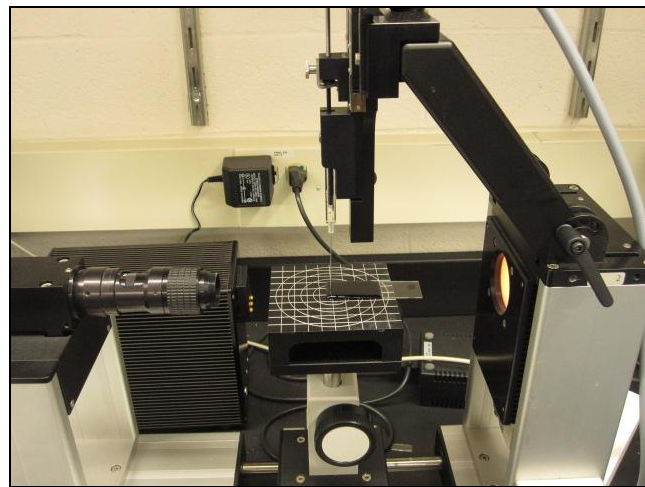
Work element M1a: Affinity of Asphalt to Aggregate

Work Done This Quarter

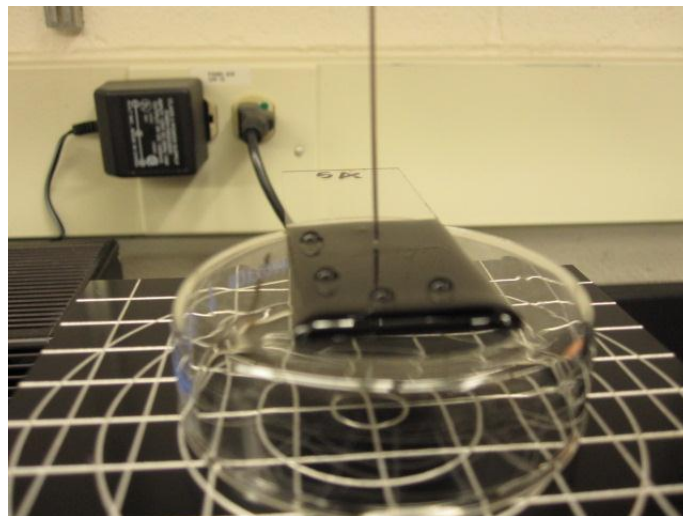
This quarter the research team explored the use of the Sessile Drop Method to measure contact angle of asphalt binders and aggregates. Measurements of the contact angle at the surface of the binders and aggregates with three different liquids, with known surface energy, will allow for the estimation of surface energy. Efforts were focused in the development of an appropriate procedure for reliable contact angle measurements. In this quarter, the team used only distilled water for contact angle measurements and future work will include the use of other liquids with known surface energy. Figure M1a.1 shows binders and aggregate samples as well as the equipment used for contact angle testing.



(a)



(b)



(c)

Figure M1a.1. Photograph. (a) Binder and aggregate samples for Sessile Drop Testing, (b) Sessile Drop Test Device, (c) Zoom-in of Sessile Drop Testing of binders.

The materials used for Sessile Drop testing are described in Table M1a.1. Two aggregate surfaces as well as two neat and five modified binders were tested. Figure M1a.2 shows typical results for binder CRM 58-28 neat and the limestone aggregate. Note that the contact angle is measured with respect to the horizontal base line. The contact angle is an indication of the potential wettability of the liquid (i.e., drop) in the surface (e.g., binder or aggregate). The lower the contact angle, the better is the wettability of the liquid in that surface.

Table M1a.1. Materials used for Contact Angle testing with Sessile Drop device.

Solution	Distilled Water
Aggregate	Limestone and Granite
Asphalt Binders	FH 64-22 & CRM 58-28
Modified Asphalt Binders	FH 64-22 +1% Polyphosphoric Acid (PPA), FH 64-22+0.7% Elvaloy+0.17% PPA CRM 58-28 +1% PPA CRM 58-28+0.7% Elvaloy+0.17% PPA CRM 58-28 +2% Linear Styrene-Butadiene-Styrene

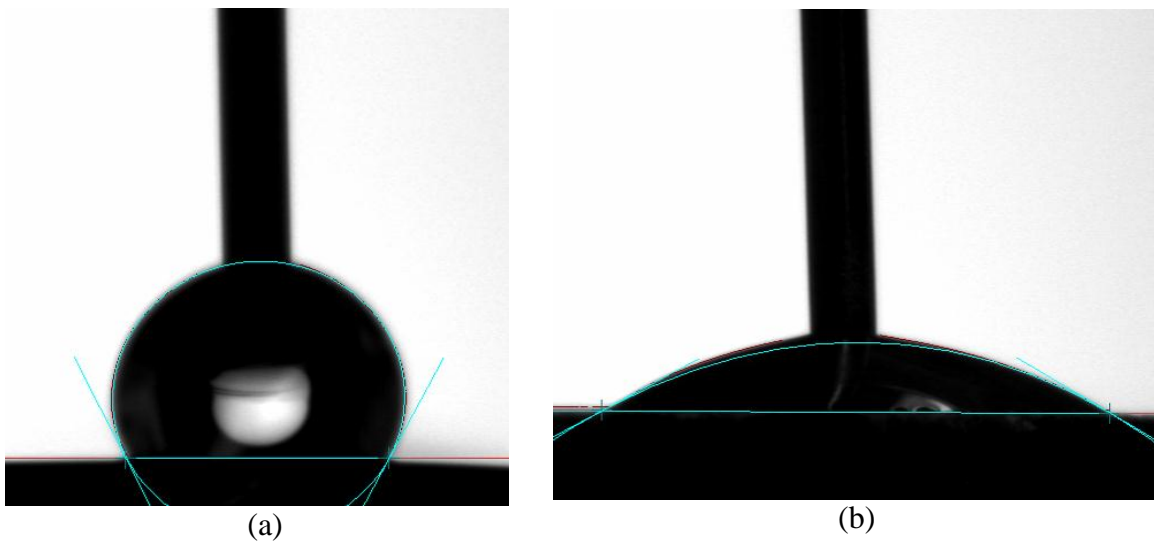


Figure M1a.2. Photograph. (a) Sessile Drop Testing of Binder CRM 58-28 Neat with distilled water, (b) Sessile Drop Testing of Limestone with distilled water.

Significant Results

The research team obtained promising results with the Sessile Drop device. Table M1a.2 and M1a.3 show the contact angle measurements with distilled water for the asphalt binders and aggregates, respectively. It can be seen that the coefficient of variation of the test results is very low for asphalt binders (i.e., < 5%) and acceptable for aggregates (i.e., < 17%). The variation of the results for the aggregates is expected due to surface heterogeneity (i.e., different minerals).

Table M1a.2. Sessile Drop results for asphalt binders.

Contact Angle (°)			
Sample	Average	Std	CV (%)
FH 64-22 Neat	113	1.69	1.49
FH 64-22 +1% PPA	93	2.54	2.72
FH 64-22+0.7% Elvaloy+0.17% PPA	98	2.39	2.45
CRM 58-28 Neat	117	2.87	2.46
CRM 58-28 +1% PPA	105	5.95	5.68
CRM 58-28+0.7% Elvaloy+0.17% PPA	106	4.48	4.24
CRM 58-28 +2%LSBS	106	3.00	2.82

Table M1a.3. Sessile Drop results for aggregates.

Contact Angle (°)			
Sample	Average	Std	CV (%)
Granite	65	8.33	12.76
Limestone	32	5.06	16.05

Figure M1a.3 and M1a.4 show the results for contact angle of the asphalt binders and aggregates, respectively. It can be seen that neat binders have a significantly different contact angle compared to the modified binders. Furthermore, it seems that the addition of PPA increase the potential for wettability of the binders. Contact angle measurements for the aggregate indicate their hydrophilic (i.e., limestone) and hydrophobic (i.e., granite) nature. Lower contact angle with distilled water indicates more affinity of the limestone aggregate for water.

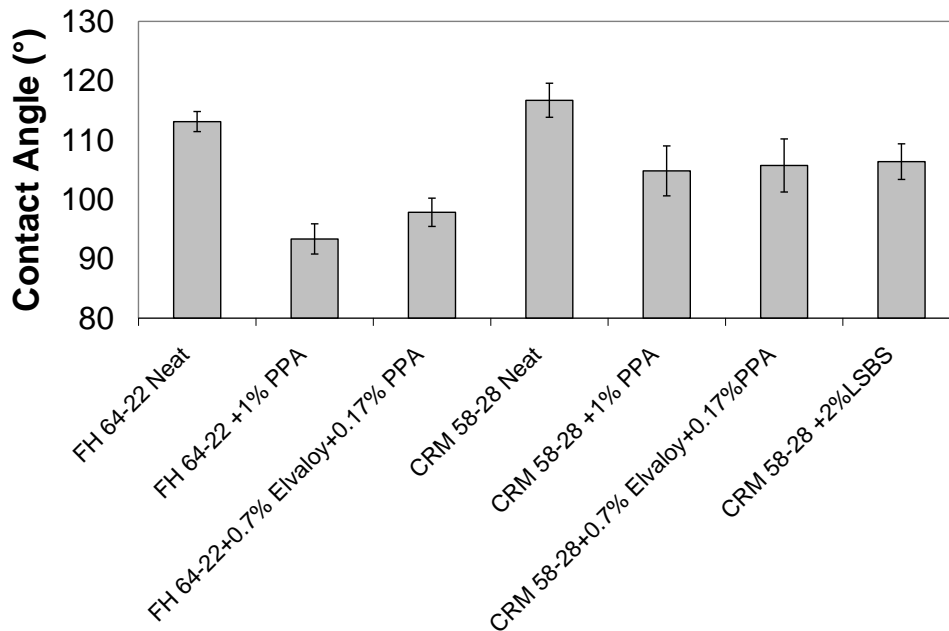


Figure M1a.3. Graph. Contact angle for binders using Sessile Drop with distilled water.

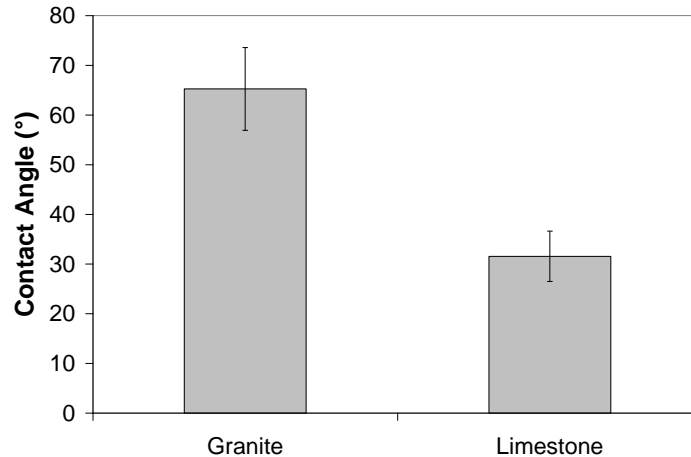


Figure M1a.4. Graph. Contact angle for aggregates using Sessile Drop with distilled water.

Work Planned Next Quarter

Next quarter, efforts will focus on the estimation of surface energy for both binders and aggregates indirectly with the contact angle measurements. Three different liquids with known surface energy will be used to estimate free surface energy. These measurements will be then compared with experimental results from the Bitumen Bond Strength (BBS) test to indicate that the BBS can be used as surrogate test for surface energy measurements.

Also, the research team will continue working on the validation of the BBS procedure by performing moisture damage tests of mixtures by means of the Tensile Strength Ratio (TSR).

Papers and Poster **Accepted/Published** and Presentation Given in the Last Quarter

Moraes, R., Velasquez, R., and Bahia, H., Measuring Effect of Moisture on Asphalt-Aggregate Bond with the Bitumen Bond Strength Test, Accepted for poster presentation and publication in the Transportation Research Board (TRB) 2011 Annual Meeting.