MICHIGAN
STATE HIGHWAY DEPARTMENT
Lansing 13
Charles M. Ziegler
State Highway Commissioner

INTEROFFICE COMMUNICATION

October 26, 1951

TO: W. K. Parr

SUBJECT: Cooperative Research on Bituminous Materials; Stripping Tests on 18 Asphalt Cements
Research Project 51 C-6
Report No. 162

BY: L. A. Fickes and Ellis Airola

The eighteen asphalt cement samples which we received from your laboratory with a request to develop a quantitative test which would evaluate their anti-stripping characteristics have been incorporated into asphaltic concrete mixes and tested by an immersion-compression test in line with your recommendation. In this test, compacted briquettes of asphalt concretes were tested for Marshall stability before and after prolonged immersion in water. The degree of retention of stability after soaking was regarded as a measure of the degree of anti-stripping property of the particular asphalt involved.

In addition to the immersion-compression tests, an attempt was made to study anti-stripping properties on the basis of wetting characteristics. Contact angles of small drops of the asphalts were measured on polished stone surfaces. From a theoretical viewpoint, an asphalt forming a low contact angle with a stone surface shows a high wetting power for the stone surface, and should be relatively difficult to be displaced by water.

The results of the immersion-compression tests indicated that there was a wide variance in the anti-stripping properties of the asphalts tested, but no significant correlation could be found between the results of the immersion-compression test and those of the qualitative stripping test which had been run at Ann Arbor. Furthermore, no definite correlation was found between results of the immersion-compression tests and any of the physical properties of the asphalt cements that were tested by the Ann Arbor laboratory. It was noted, however, that mixes containing crushed gravel usually retained more stability than those containing crushed dolomite.

The results of the contact angle studies gave evidence that the wetting powers of the asphalts varied to some extent but, as with the immersion-compression results, there was no definite correlation with other physical properties of the asphalts.

In general, lower contact angles were formed on quartzite surfaces than on dolomitic limestone surfaces.

Results

The results of the immersion-compression tests are given in attached Table I, and are expressed as "Index of Retained Stability," calculated as follows:

$$\frac{S_2}{S_1} \times 100 \quad \text{(where } S_1 = \text{stability before soaking} \quad S_2 = \text{stability after soaking)}$$

Each stability value in the table represents an average of three determinations.

It is obvious, from examination of the data, that water has less deleterious effect, in general, on asphalt concretes prepared from mixed gravel than on those prepared from dolomite.

No individual asphalts, among those tested, were outstanding in promoting either high or low index of retained stability with either gravel or dolomite, except 50 BR-11, an LOA type asphalt cement produced by the Standard Oil Company of Baltimore. This material produced a high index in both cases. There was no apparent correlation between retention of stability of asphalt-dolomite mixes and mixes of gravel with corresponding asphalts.

CONTACT ANGLE STUDIES

Experimental Details

In the contact angle studies, small drops of asphalt were placed on highly polished stone surfaces inside a special thermostatically controlled oven maintained at 280 ±1° F. Prior to placing the drops, both stone and asphalt were brought to 280° F. inside the oven. The drops were placed by means of a 3-ml. hypodermic syringe fitted with a 22-gauge needle.

After placing a drop, its profile was photographed through a window in the oven. The developed negative was used as a slide, and projected onto a piece of white ruled paper and the necessary measurements made on the image for calculation of the contact angle.

The contact angle is defined as that angle measured from the surface of the solid through the liquid to the tangent to the drop's surface at the point of contact of the surfaces of the drop and of the solid. In the case of acute contact angles, as were all those in this investigation, the angle is calculated as twice the angle whose tangent is the ratio of the altitude of the drop to one-half its base diameter.

Results

The results of the contact angle studies are also given in attached Table I. The contact angle ranges in the table represent the lowest and highest angle obtained for each asphalt when three drops were placed on each of three polished specimens of the same aggregate; the averages were obtained by calculating the mean angle of all nine drops in each case.

Since the contact angle ranges appeared rather wide, extra determinations were made in which duplicate runs of each COA type asphalt were made on the same stone, placing and measuring the angle of three drops each time. This represents the placing of six drops of an asphalt on one stone. In this case the range of angles was considerably lower for each stone, as is shown in Table II.

TABLE II
REPRODUCIBILITY OF CONTACT ANGLE TEST RESULTS

Asphalt Identification No.	Range of Angles (deg.) Limestone	Quartzite
50 BR-1	13-17	12-16
-2	13-17	16-18
-3	10-13	11-13
-4	13-18	12-15
-9	16-18	10-14
-20	23-26	10-13
-21	13-15	10-11

Thus the wide ranges shown in Table I were apparently caused by variations in specimens of the same aggregate, rather than by lack of reproducibility of the test.

It was found that there were small differences in magnitude of contact angle formed by the different asphalts on both limestone and quartzite. With 15 of the 18 asphalts higher contact angles were obtained on limestone than on quartzite. This might be related in a general way to the immersion-compression results, which indicated more stripping with dolomite, a material chemically and physically similar to limestone, than with mixed gravel, a material containing relatively large amounts of quartzite and other siliceous materials.

Although slight indications of correlation were found for corresponding asphalts in the immersion-compression and contact angle methods of investigating anti-stripping properties, closer correlation might have been obtained had limestone and 100-percent quartzite gravels been used in both investigations.

Any further information regarding our testing methods or our interpretation of the results of the tests will gladly be furnished on request.

E. A. Finney
Ass't Testing & Research Engr.
in charge of Research

EAF:LAF:mw

cc: W. W. McLaughlin

TABLE I
RESULTS OF IMMERSION-COMPRESSION TESTS AND
CONTACT ANGLE STUDIES

Type of Asphalt and ientification Number	Producer	Immersion-Compression Results: Dolomite: Stability, Lb. Before Immersion	Dolomite: Stability, Lb. After Immersion	Dolomite: Index of Retained Stability	Gravel: Stability, Lb. Before Immersion	Gravel: Stability, Lb. After Immersion	Gravel: Index of Retained Stability	Contact Angle Results: On Limestone: Range of Angles, deg.	On Limestone: Average Angle, deg.	On Quartzite: Range of Angles, deg.	On Quartzite: Average Angle, deg.
[illegible]OA:											
50 BR-10	American Liberty Oil Co.	1075	1100	102	1825	1600	88	9-24	14	7-28	14
-11	Producers Refining Co.	1525	1625	106	1650	1850	112	16-24	19	9-27	17
-12	Lion Oil Co.	1475	900	61	1250	1325	106	13-26	20	8-26	15
-13	Std. Oil Co., Baltimore	1275	1175	92	1575	1550	98	9-22	14	9-13	10
-14	Lion & Producers Blend	1800	1500	83	1800	1600	89	13-23	17	9-23	14
-15	Lion Oil Co.	1150	1050	91	1325	1525	115	9-13	11	9-12	11
SOA:											
50 BR- 5	Lion Oil Co.	* -	-	-	1675	1625	97	16-22	20	12-19	15
- 6	Shell Oil Co.	1400	1275	91	1725	1725	100	12-24	18	12-21	17
- 7	Shell Oil Co.	1350	1075	83	1525	1650	108	14-20	15	10-14	11
- 8	Std. Oil Co., Baltimore	1525	1375	90	1750	1450	83	17-23	19	10-19	15
-19	Std. Oil Co., Illinois	1350	1200	89	1775	1800	101	12-29	20	10-18	14
COA:											
50 BR- 1	Std. Oil Co., Indiana	1750	1725	98	1850	1900	103	13-23	16	12-22	16
- 2	Lion Oil Co.	1425	1275	89	1500	1700	113	13-27	19	16-24	20
- 3	Std. Oil Co., Baltimore	1600	1725	108	2125	1950	92	10-13	11	9-13	11
- 4	Shell Oil Co.	2400	2450	102	2350	2025	86	13-22	18	12-22	15
- 9	Seneca Petroleum	1675	1350	80	1975	1775	90	16-27	21	10-18	13
-20	Std. Oil Co., Illinois	1400	1225	88	1925	1775	92	14-26	20	10-20	14
-21	Std. Oil Co., Indiana	1600	1550	97	2025	1950	95	13-24	17	10-19	12

* Insufficient material to complete tests