Progress Report

PROGRESS REPORT

BEHAVIOR OF ASPHALTS

in the

PRODUCTION OF ASPHALTIC CONCRETE

Project HR-107
Iowa Highway Research Board

Project 540-S
Engineering Experiment Station
Iowa State University

by

Ladis H. Csanyi
Professor in Charge
Bituminous Research Laboratory
Iowa State University
Ames, Iowa

April, 1965

IOWA
ENGINEERING
EXPERIMENT
STATION

IOWA STATE UNIVERSITY
of Science and Technology / Ames, Iowa

BEHAVIOR OF ASPHALTS IN THE PRODUCTION OF ASPHALTIC CONCRETES

Project 540-S of the Iowa Engineering Experiment Station (Project HR-107, Iowa Highway Research Board) was started in June, 1964. During the year ten 2-gallon samples of asphalt cement and ten 100-lb samples of asphaltic concrete were studied by the personnel of the Bituminous Research Laboratory, Iowa State University. The samples were from tanks and mixers of asphalt plants at various Iowa State Highway Commission paving jobs.

The laboratory's research was in two phases:

1. To ascertain if properties of asphalt cement changed during mixing operations.

2. To determine whether one or more of the several tests of asphalt cements were enough to indicate behavior of the heated asphalt cements. If the reliability of one or more tests could be proved, the behavior of asphalts would be more simply and rapidly predicted.

Table I. Samples of Asphalt Cement and Asphaltic Concrete Mixes

Sample No.	Paving Contract	County	1HC Mix No.	1HC Asphalt Cement No.
1	S-462(9)	Adair	ABC4-705	AB4-155
2	FN-712	Appanoose	ABC4-922	AB4-171
3	FN-292	Clinton	ABC4-1201	AB4-181
4	FN-103	Delaware	ABC4-1109	AB4-180
5	FN-32	Des Moines	ABC4-709	AB4-156
6	FN-172(3)	Fayette	ABC4-618	AB4-150
7	FN-111(2)	Kossuth	ABC4-1135	AB4-157
8	FN-321 & 221	Muscatine	ABC4-444	AB4-126
9	---	---	---	AB4-120
10	FN-150	Wayne	ABC4-2555	AB4-260

TEST PROCEDURE

Phase 1.

The asphalt cements were tested as follows:

1. Penetration at 77°F
2. Softening point, ring and ball
3. Loss on heat, thin film including usual tests on residue
4. Shell thin film viscosity
5. Surface tension
6. Ductility
   Standard at 77°F and 50°F
   Micro at 77°F and 50°F
7. Olieusis spot test
8. Asphaltene content.

The asphaltic concrete samples were tested as follows:

1. Extraction of the asphalt cement from the samples by the Colorado Method.
2. Refinement of the asphalt cement by the Absen Method.
3. The recovered asphalt cements were compared in quality with the original asphalt cements.

Phase II.

Specimens of asphalt cement samples No. 2 and No. 10, selected by Iowa Highway Commission engineers, were heated for 24 hours in a controlled temperature oven at 250°F, 300°F, 350°F, 400°F and 450°F. Specimens were contained in small beakers during heating to reduce area exposed to air.

After being heated each specimen was tested by the same methods used for asphalt cements in Phase I.

TEST RESULTS

A detailed tabulation of test results is not included in this report. Detailed tabulations of results with graphs will be shown in the final report.

DISCUSSION OF RESULTS

Phase I.

Asphalt Cement from Plants.

The test results indicate that the several asphalt cements varied widely in some physical properties.

Specific Gravities ranged between 0.993 and 1.029.

Loss on Heat: Thin film varied between a loss of weight of 0.23% and a gain in weight of 0.19%.

The softening point, ring and ball ranged from 105°F and 120°F.

Penetration ranged from 74 to 91 with seven of the ten asphalts being below 85.

Ductility standard at 77°F. All specimens had a ductility in excess of 150cm. When this test was conducted at 50°F the results ranged from 24cm to 38cm.

Ductility micro at 77°F ranged between 63 and 77cm and at 50°F the variation was between 3 and 7cm.

The Oliensis spot test showed all asphalts to be negative.

Viscosities, shell thin film varied from 8×10^5 to 5.7×10^5 poisse.

Surface tension results were fairly uniform.

Asphaltene content ranged from 10.6% to 18.4%.

The results of the tests conducted on the residue obtained from the loss on heat, thin film tests varied as follows:

The specific gravity increased in all cases except in asphalts No's 5 and 7 where a decrease was observed. It was noted that in these two cases the Loss on Heat test indicated a gain rather than a loss in weight.

Penetration tests showed a loss in all cases. The loss ranged from 19 to 47%.

Oliensis Spot Test showed that all residues remained negative.

Viscosity shell thin film indicated an increase in viscosity in all material tested.

Asphaltene content tests showed an average increase of about 3% except in asphalt No. 4, where the increase was 9%, and in asphalts 5 and 8, where the increase was 1%. These variations cannot be correlated with other test results. They are no doubt due to differences in chemical changes in the asphalts.

Asphalt Cements recovered from Asphalt Mixes.

These test results show wide variances in the behavior of the several asphalts.

In the specific gravity tests all asphalts except asphalt 3 increased in specific gravity over the original. Asphalt 3 showed a slight decrease.

In the loss on heat tests all recovered asphalts lost weight. The amount of loss ranged from 0.06 to 0.33%.

In the softening point tests all asphalts increased in softening point. The amount of increase varied from 3 to 16%.

Penetration tests show a loss in penetration of 6 to 42 or a range of 9 to 50% loss.

Ductility: due to the limited quantity of asphalt recovered from the plant mixes only the micro ductility tests at 77°F were conducted on recovered asphalt. These tests show that all the asphalt except asphalts 3 and 5 increased in ductility. The exceptions decreased. The amounts of increase ranged from 3% to 62%. The decrease for asphalt 3 was 22% and that for asphalt 5 was 9%. The cause of the increase in ductility can not be directly correlated with changes in other physical properties noted.

In the Oliensis spot tests recovered asphalts No's. 5, 6, 9 and 10 remained negative, and the rest were positive.

In the viscosity, thin film tests all the recovered asphalt increased in viscosity over the original asphalts. The change in viscosity as indicated by the ratio of the viscosity of the recovered asphalt divided by the viscosity of the original asphalt ranges from 1.7 for asphalt No. 1 to 4.3 for asphalt No. 7.

In the asphaltene content tests all of the recovered asphalts, except asphalt No. 5 increased in asphaltene content over the original asphalt. The increase for most of the asphalts was generally about 3%. Asphalt No. 5 decreased about 3%. The increase in asphaltene content for six of the ten recovered, asphalts No's. 1, 2, 3, 7, 9 and 10 were very nearly the same as the increases found for the residue of the loss on heat test of the original asphalts.

The tests of the residue obtained from the loss on heat test of the recovered asphalts disclosed the following results.

Specific Gravity: Except for asphalts No's. 3 and 8 all of the asphalts show a loss in specific gravity. This behavior is rather odd, especially when it is noted that decreases in penetration, and increases in viscosity and asphaltene content occur at the same time. These changes would usually predict an increase in specific gravity. No doubt some pronounced change in chemical composition of the recovered asphalt occurred in the loss on heat test.

Penetration: All asphalts showed a further loss in penetration ranging from 1.2 to 31%.

Oliensis Spot Test: Asphalts No's. 5 and 9 changed from negative to positive. The others retained the same polarity as before the loss on heat test of the recovered asphalts.

Asphaltene Content: All asphalts showed a further increase in asphaltene content. This increase was from 1% to 3.6%.

The test results indicate that the asphalts vary widely and inconsistently in behavior in the tests. No common behavior for the asphalts could be found. This indicates that the asphalts contain different chemical compositions and that various chemical constituents react differently to the tests.

If the reasons for the behavior noted are to be determined, more information concerning the chemical composition, the character and quantity of flux contained, the rate of combination with oxygen, and the changes in chemical composition during handling and mixing are necessary. The behavior of asphalts could be predicted with such information.

HEAT TREATMENT OF ASPHALTS

Specimens of two asphalt cements, No's. 2 and 10, were heated in constant temperature ovens at 250°F, 300°F, 350°F, 400°F and 450°F for twenty-four hours. While being heated the asphalts were in small beakers with comparatively small surface areas exposed to air in order to reduce oxidation effect as much as possible.

After being heated each specimen was subjected to a series of tests. The results of these tests are as follows:

Specific Gravity: Both asphalts increased in specific gravity when heated up to 350°F. When heated above this temperature both decreased in specific gravity, which indicates that evaporation of flux oils had ceased and chemical changes were occurring.

Loss on heat, thin film: Both asphalts showed a loss up to 300°F then they began to gain weight rapidly at higher temperatures. This indicates that loss of flux oils cease at slightly over 300°F and chemical changes begin to occur. Asphalt 2 changed more rapidly than Asphalt 10, suggesting that the chemical changes were more drastic.

Softening point, ring and ball: Both asphalts gradually increased in softening point as the temperature of heating increased. Both reached the softening point noted for the recovered asphalt at 400°F.

Penetration: Both asphalts decreased in penetration with increase in heating temperature. Both reached a loss in penetration about equal to that noted for the recovered asphalt when heated to 450°F.

The residue from the loss on heat test showed further loss in penetration, indicating the effect of further exposure to air. The additional loss amounted to about 42% for specimens heated to 350°F. At 450°F the additional loss was about 33%, suggesting a reduced rate of oxygenation.

Ductility: Heating specimens to higher temperatures had no apparent effect on standard ductility at 77°F. All test results were 150+.

Standard ductility tests at 50°F showed a gradual loss in ductility from about 33cm to 10cm with the increase in temperature.

Micro ductility tests at 77°F were not consistent. When run at 50°F they showed a gradual loss in ductility with increase in heating. However, the range of loss was too small to be significant.

The standard ductility tests conducted at 50°F yield the most significant effects of heating.

Oliensis spot test: All specimens remained negative after being heated to elevated temperatures. The residue from the loss on heat test for asphalt No. 10 remained negative, while that of asphalt No. 2 turned positive at temperatures of 350°F and above.

Viscosity, thin film: The viscosity of the asphalts increased gradually with temperatures up to 350°F. There they bagen to increase sharply with further increase in temperature. The viscosities approached those of the recovered asphalts from field mixes when heated to 400°F and above. The limited exposure to air during heating may account for this.

Asphaltene content: Both asphalts showed a gradual increase in asphaltene content with increase in heating temperature.

CONCLUSIONS

An analysis of the results of the tests leads to the following conclusions:

1. The several asphalts studied vary widely with regard to their reactions to and the results secured from the tests performed.

2. No common test property or characteristic of the asphalts could be found upon which their behavior and reaction to heating or mixing could be predicted.

3. The loss on heat, thin film test appears to be the most critical in denoting a material difference between the asphalts studied.

4. Asphalts gained in weight in the loss on heat test and appeared to have a marked loss in penetration during mixing in a plant.

5. Apparently chemical changes in the several asphalts have a marked effect upon their properties.

6. None of the tests conducted provide a basis for classifying and predicting the behavior of asphalts in the manufacture of asphaltic mixes.

7. Tests indicating the chemical composition, quantity and rate of loss of flux oils, rate and quantity of combination with oxygen in air would provide the data upon which the characteristics and behavior of asphalts may be more confidently based and predicted.