VISCOSITY GRADING FOR ASPHALT CEMENTS

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The development of tests for measuring consistency of paving-grade asphalts in the range of 40 to 325 F has led to the development of specifications for specifying grade requirements at 140 F. The purpose of these requirements is to provide uniformity in asphalt viscosity during placement and rolling operations and in service resistance to rutting. It is well known that paving-grade asphalts change in viscosity during mixing operations and that asphalts from different sources change at different rates under the same conditions. Results presented show that a series of asphalts having original viscosities at 140 F within a narrow band had a very wide range in viscosity after a test that simulates hot-mix hardening. Studies on the relation between asphalt consistency and field "setting" properties of the paving mixture are presented. These studies involved the use of 6 paving-grade asphalts on one contract. The field setting properties showed a good correlation with the recovered asphalt viscosity at 140 F. The best correlation coefficient with the recovered asphalt viscosity is the viscosity at 140 F after tests simulating mixing, namely the standard thin-film oven test or the rolling thin-film oven test.

•PAVING-GRADE asphalt is a thermoplastic material. This very important property of this adhesive makes it possible to coat aggregate particles at elevated temperature and to spread and properly compact the resulting mixture to form a pavement. On the other hand, this same property may lead to detrimental increases in viscosity of the binder at low temperatures with failures caused by cracking of the pavement.

The change in consistency with temperature has been termed "temperature susceptibility" by asphalt technologists, and a great amount of research has been expended in developing test methods for measuring consistency over the broad range of temperatures encountered in the use of paving-grade asphalt. Methods have been developed to measure consistency in absolute units over a temperature range from below 40 to 325 F. However, not all of these methods are useful for control testing, especially below 77 F.

We presently measure temperature susceptibility of the asphalt at completion of manufacture. Many tend to ignore the fact that the consistency at any specified temperature and the slope of the temperature-susceptibility line change during mixing, laying, and service life. This means that asphalts weathering in the field at even a normal rate may have low-temperature characteristics completely different from those found immediately after manufacture. Because different asphalts weather at different rates under identical field conditions, the rate of change of their low-temperature characteristics will also vary even though they may all have equivalent characteristics after manufacture. It is, therefore, logical to conclude that the original temperature-susceptibility curve does not provide sufficient information of value in determining the service life viscosity-temperature relationships of the binder.

The paving engineer first becomes interested in the properties of the binder at the time of application to the aggregate in the mixer box. It is important that a properly coated mixture be attained, and consistency at the mixing temperature is a critical

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factor. His next interest is in the laying and compaction of the mixture. It is well known that the consistency in the range of compaction temperatures (breakdown, pneumatic, and finish rolling) will influence the densification process. Further problems involving setting of the paving mixture following compaction are partly influenced by the consistency of the binder at the time of and following compaction. This paper will present a laboratory and field study on viscosity grading after a test that simulates hot-mix hardening.

CONSISTENCY AND THE SETTING PROBLEM OF ASPHALT CONCRETE

"Certain types of paving mixtures may be difficult to compact properly and after rolling may remain 'tender' for periods of up to two weeks. The 'tenderness' of the pavement immediately after construction produces problems when traffic must be carried through the work" (1).

Studies by the California Division of Highways indicate that one of the factors influencing the setting properties of a paving mixture is the consistency of the asphalt during placement and rolling. Previous studies (1) indicate that an asphalt viscosity range of 4,000 to 6,000 poises at 140 F will provide a satisfactory asphalt. This is based on field correlation involving currently used 85 to 100 grade asphalt. Independent studies by Schmidt and associates (3) have confirmed these requirements.

It is important to note that our studies as well as those of Schmidt are based on the actual viscosity of the asphalt in the paving mixture. This viscosity at any specified temperature will be different from the value for the asphalt as manufactured. Further, the rate of change is different for asphalts from different sources. This is shown in Figure 1, which shows the viscosities of residues from the rolling thin-film oven test (RTFOT), a test that simulates hot-mix hardening. We note that this series of asphalts was manufactured to comply to the AC-20 grade, which has a relatively narrow band for the viscosity at 140 F. However, after the RTFOT, the range in viscosity at 140 F is 4,500 to 12,000 poises. It appears that the asphalts in this group will provide different degrees of "set" in the same paving mixture.

Either the RTFOT or the AASHO standard thin-film oven test (STFOT), developed by the Federal Highway Administration, may be used for simulating the mixing operation. Hveem et al. (1) and Skog (2) show a good correlation between these 2 tests. Further, Hveem et al. (4) showed an excellent correlation between the STFOT results and hardening during mixing. This confirms previous work by the Federal Highway Administration. The RTFOT was also independently correlated with field-mix hardening (1, 2).

Further field studies, subsequent to publications of reports by Hveem (1) and Skog (2), have been performed in the attempt to confirm previous findings on the importance of the viscosity parameter in field setting. The most important of these test sections was one placed on a road through the desert area of southern California during June 1967. This test section was placed as part of contract 08-039334, road 08-SBd-40-R28.4/42.1, and as part of a Federal Highway Administration's proposal to study field performance of viscosity-graded asphalts.

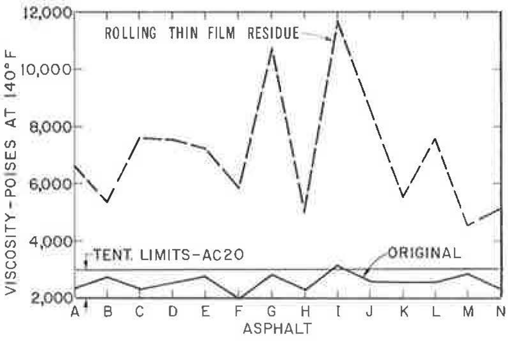

Figure 1. Change in kinematic viscosity after California RTFOT, AC Series, Grade AC-20.

A number of California-produced asphalts with fairly wide ranges in viscosity for a constant penetration and a range in penetration for a constant viscosity were chosen for study. Also 2 special asphalts manufactured in connection with a California tentative specification (2) were included.

The original viscosity-penetration relationships for these asphalts are given in Table 1, and the viscosity results after

TABLE 1

ORIGINAL VISCOSITY-PENETRATION RELATIONSHIPS

Asphalt	Grade	Penetration at 77 F	Viscosity at 140 F
1	AC-12	84	1,102
2	AC-12	119	1,029
3	85 to 100	90	1,471
4	85 to 100	80	1,042
5	Special	75	1,734
6	Special	107	1,067

TABLE 2

VISCOSITY RESULTS AFTER THIN-FILM OVEN TESTS

Asphalt	Grade	Viscosity at 140 F	
		RTFOT	STFOT
1	AC-12	1,801	1,889
2	AC-12	2,884	3,273
3	85 to 100	3,955	4,545
4	85 to 100	2,397	2,881
5	Special	4,346	4,316
6	Special	2,688	2,767

the RTFOT and the STFOT are given in Table 2. All asphalts were used in a California Standard Specification Type A, ¾ in., medium-grading mix. The resulting mix was spread and rolled with equivalent equipment. Test sections containing asphalts 1, 2, 3, and 4 were paved on one day and asphalts 5 and 6 about 3 weeks later. In all cases the weather was dry and fairly warm, 66 to 100 F, with morning temperatures of 66 to 87 F.

Setting of the paving mixture containing the various asphalts was judged by observation during rolling and by asking the opinion of the breakdown roller operators. Asphalt 1 was the only asphalt that showed definite signs of slow setting. There was "sticking" to both the breakdown and pneumatic rollers, and the roller operators complained that the mix felt "mushy." There was a tendency for the roller operators to "lay back" in attempting to roll the mixture. None of these observations was noted with asphalts 2, 3, 4, 5, and 6. The same roller man commented that asphalt 5 rolled out in an excellent manner.

The field setting ratings compared with the original viscosity, viscosities after tests simulating the mixer hardening, and recovered asphalt from mix immediately after mixing are given in Table 3. Also given in the table are the original and recovered penetration results. We note the good correlation between the recovered asphalt viscosity at 140 F and the field setting properties. The best correlation coefficient with the recovered asphalt viscosity is the viscosity after tests simulating mixing, the standard and rolling thin-film oven tests (Table 4).

Other field trials appear to indicate that an asphalt having a viscosity range, after a simulated mixer hardening test, of 3,500 to 5,500 poises at 140 F and a viscosity range of 300 to 700 centistokes at 275 F should provide paving mixtures of satisfactory setting qualities during paving under high atmospheric temperatures. One of the real advantages of this proposal is the uniformity of asphalt viscosity during laying and compaction. It also permits the producer to start with a harder or softer grade in order to make an asphalt of common viscosity range during paving operations.

The proposal to grade asphalts at elevated temperatures either in the original state or after tests that simulate mixer hardening has been criticized on the basis that con-

TABLE 3

COMPARISON OF PENETRATION AND VISCOSITY RESULTS WITH FIELD SETTING EVALUATION

Asphalt	Grade	Original Penetration at 77 F	Viscosity at 140 F			Abson Recovery Test Results		Field Setting Evaluation
			Original	After STFOT	After RTFOT	Penetration at 77 F	Viscosity at 140 F	
1	AC-12	84	1,102	1,889	1,808	59	2,014	Slow
2	AC-12	119	1,029	3,273	2,884	68	3,732	Satisfactory
3	85 to 100	90	1,471	4,545	3,955	47	4,909	Fast
4	85 to 100	80	1,042	2,881	2,397	50	2,914	Satisfactory
5	Special	75	1,734	4,316	4,346	50	5,165	Fast
6	Special	107	1,067	2,767	2,688	66	3,136	Satisfactory

trol is lost over low-temperature consistency. This may be responsible for cracking of asphalt concrete pavements under low-temperature conditions.

We are in agreement that some form of low-temperature consistency requirement is needed and that the currently used penetration test at 77 F is the best test available for routine control. However, we also believe that there is a need for a minimum penetration after a test that simulates hot-mix hardening. This will provide an effective means to prevent the manufacture of asphalts that comply with elevated viscosity requirements but that have high temperature susceptibility leading to very high viscosities at low temperature.

TABLE 4

CORRELATION COEFFICIENTS

Item	Recovered Viscosity	Recovered Penetration
Viscosity		
Original	0.833	0.648
After STFOT	0.985	0.546
After RTFOT	0.992	0.491
Penetration, original		0.834

In summary, the paving engineer should be provided with asphalts that are within a uniform range of consistency during laying and compaction operations. We believe that this can only be done by specifying consistency measurements on the asphalt after it has been subjected to simulated hot-mix hardening.

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