Strategic Highway Research Program Properties of Asphalt Cement

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In the spring of 1993 the Strategic Highway Research Program (SHRP) asphalt research program was completed. As the result of that effort a new specification for asphalt cements was developed along with new testing procedures. The results of a study of asphalts being used in the southeastern United States in which the asphalts were tested by using the current capillary tube testing technology and the new SHRP technology are presented. Fifty-eight asphalt cements from throughout the United States were tested. Viscosity of neat asphalt cements (60°C) showed strong correlations with dynamic shear rheometer stiffness at 60°C and 70°C. For the asphalt cements tested, the value of the slope of the log stiffness-versus-time curve obtained from regressed stiffness *S*-versus-*m* data from bending beam rheometer tests corresponding to an *S* value of 300 MPa was found to be 0.27.

In the spring of 1993 one of the largest research efforts ever conducted on asphalt cement and hot-mix asphalt mixtures ended. This effort, which involved 5 years of intensive study by many researchers, was the $50 million Strategic Highway Research Program (SHRP) on asphalts. In August 1993 the AASHTO Subcommittee on Materials approved a new provisional specification for asphalt cement and test procedures to support that specification. There was a desire to develop an understanding of how asphalt cements being used throughout the United States related to the SHRP specification. Thus, the National Center for Asphalt Technology (NCAT) tested and analyzed a number of the asphalt cements from throughout the United States.

OBJECTIVES

The objective of the present work was to develop a data base of asphalts being used throughout much of the United States graded by using the new SHRP procedures and to determine how asphalts graded by SHRP procedures relate to those being graded by the current viscosity grading system.

SCOPE

This report provides data and an analysis of the results for the 58 asphalts currently being supplied. These asphalts come from 20 states throughout the United States. The asphalts were tested by both the conventional penetration and capillary tube viscosity tests and the new SHRP test procedures.

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DESCRIPTION OF MATERIALS AND EXPERIMENTAL PROCEDURES

In January 1994 a request was made of a number of state highway agencies and refineries for test data and 4-L (1-gal) samples of the asphalt cements currently being used or supplied. No modified asphalts were included in the study. Work conducted on modified asphalts will be included in the data bank at a later date. In response to that request a total of 58 asphalt cements were sent to NCAT for testing.

The state highway agencies were requested to provide specific data on each of the asphalt cements supplied. The data requested included

1. Grade and source of the asphalt (refinery and supplier);
2. The following properties on the unaged or neat asphalt cement:
   a. Viscosity at 60°C,
   b. Viscosity at 135°C,
   c. Penetration at 4°C,
   d. Penetration at 25°C,
   e. Ductility at 25°C, and
   f. Softening point; and
3. The following properties on the asphalt cement after aging in the thin film oven:
   a. Viscosity at 60°C,
   b. Viscosity at 135°C,
   c. Penetration at 4°C,
   d. Penetration at 25°C,
   e. Ductility at 25°C,
   f. Softening point, and
   g. Percent loss

After receipt of the samples at NCAT they were broken down into 1-L (1-qt)-size samples for testing. Each sample was heated and stirred before it was poured into the containers. The samples were not heated more than once before testing. Some of the samples were obtained directly from the refiners and on those samples the testing described earlier was accomplished by NCAT.

All of the samples received were tested by using the procedures described in the AASHTO Provisional Standards described elsewhere (1–4). The following tests were performed on each sample:

1. Stiffness on the original or neat asphalt, as determined by the dynamic shear rheometer (DSR) at 64°C and 70°C.
2. Stiffness of the asphalt after aging in the rolling thin film oven (RTFO), as determined by the DSR at 64°C and 70°C.
3. Stiffness on the asphalt after aging in the RTFO and the pressure aging vessel (PAV), as determined by the DSR at 7°C, 10°C, and 13°C.

4. Stiffness on the asphalt after aging in the RTFO and the PAV as determined by the bending beam rheometer at −6°C, −12°C, and 18°C.

A specification-grade Bohlin rheometer for dynamic shear testing and a Cannon bending beam rheometer were used for these tests.

DISCUSSION OF TEST RESULTS

Table 1 presents the detailed test data showing the properties of the asphalt cement as determined by both the current testing technology and the SHRP testing procedures.

All seven AC-10 asphalt cements tested graded to be performance grade PG 58–22. On the upper-temperature regime 20 of the AC-20 asphalt cements graded to be PG 64 and 4 graded to be PG 58. On the cold-temperature regime 16 of the AC-20 asphalt cements graded to be PG -22, 4 graded to be PG -16, and 3 graded to be PG -28. On the upper-temperature regime 23 of the AC-30 asphalt cements graded to be PG 64 and 1 graded to be PG 70. On the cold-temperature regime 16 of the AC-30 asphalt cements graded to be PG -22, 6 graded to be PG -16, 1 graded to be PG -28, and 1 graded to be PG -34. In summary, of the 48 AC-20 and AC-30 asphalt cements tested, 29 of them graded to be PG 64–22, 8 graded to be PG 64–16, 2 graded to be PG 58–16, 2 graded to be PG 58–16, 5 graded to be PG 64–28, 1 graded to be PG 64–34, and 1 graded to be PG 70–22.

Table 2 presents the averages for the various properties determined from testing the AC-10, AC-20, and AC-30 asphalt cements. For the AC-10 asphalt cements the average viscosity was 1130 P, which correlated to a DSR complex modulus of 0.593 kPa at 64°C and a bending beam stiffness of 231 MPa and slope of the log stiffness-versus-time curve value, (*m*-value) of 0.28 at −18°C. For the AC-20 asphalt cements the average viscosity was 2051 P, which correlated to a DSR complex modulus of 1136 MPa at 64°C, a bending beam stiffness of 335.5 MPa, and an *m*-value of 0.276 at −18°C. For the AC-30 asphalt cements the average viscosity was 3107 P, which correlated to a DSR complex modulus of 1.715 at 64°C, a bending beam stiffness of 345 MPa, and an *m*-value of 0.263 at −18°C.

Properties of Asphalt Cement by SHRP Techniques

Viscosity versus G/sin δ*

Figure 1 shows the absolute viscosity at 60°C of the neat asphalt cement plotted against the $G^*/\sin\delta$ (stiffness) at 64°C and 70°C for all of the asphalts tested. $G^*\sin\delta$ where G^* is the complex shear modulus and δ is the phase angle) increases as the viscosity increases. The relationship at 64°C is very strong, with an R^2 value of 0.85. It can be seen from the best-fit lines through the plotted data that for the asphalts tested in the present study an AC-16 asphalt cement would typically meet the requirements of a PG 64 and that an AC-40 asphalt cement would meet the requirements of a PG 70.

Comparison of Aging Properties

Figure 2 shows the absolute viscosities at 60°C and 70°C of the asphalt cement after TFOT aging versus $G^*/\sin\delta$ at 64°C after

TABLE 1 SHRP Asphalt Data Base

STATE	AL	AL	AL	AL
GRADE OF AC	AC-20	AC-20	AC-20	AC-20
CODE	1	2	3	4
Vis @ 60°C, P	2302	2347	2082	2154
Vis @ 135°C, cST	367	396	476	406
Pen @ 4°C	3	2	2	28
Pen @ 25°C	71	70	75	96
Ductility @ 25°C, mm	100	100	100	-
Softening Pt., C	47	48	48	47
TFO RESIDUE				
Vis @ 60°C, P	4434	5043	6851	4659
Vis @ 135°C, cST	539	585	759	570
Pen @ 4°C	2	1	1	21
Pen @ 25°C	50	44	42	63
Softening Pt., C	52	53	54	51
% Loss	0.26	0.34	0.23	0.22
SHRP				
Grade	PG 64-22	PG 64-22	PG 64-22	PG 64-28
DSR-Original 64°C, KPa	1.07	1.25	1.11	1.125
DSR-Original 70°C, KPa	0.49	0.59	0.56	0.52
DSR-RTFO-64°C, KPa	2.64	3.22	6.72	2.341
DSR-RTFO-70°C, KPa	1.25	1.49	3.16	1.07
DSR-PAV-13°C, MPa	5.02	4.37	3.51	-
Flexural Creep-18°C MPa	471	383	296	219
m	0.27	0.29	0.27	0.3

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TABLE 1 *(continued)*

STATE	AR	AR	AR	AR	CO
GRADE OF AC	AC-30	AC-30	AC-30	AC-20	AC-10
CODE	1	2	3	4	1
Vis @ 60°C, P	2690	3087	2795	2128	1190
Vis @ 135°C, cST	392	552	520	652	284
Pen @ 4°C	18	13	18	21	30
Pen @ 25°C	60	56	56	76	97
Ductility @ 25°C, mm	150+	150+	-	-	-
Softening Pt., C	54	55	50	48	47
TFO RESIDUE					
Vis @ 60°C, P	5593	7249	4298	4853	3180
Vis @ 135°C, cST	576	860	558	523	413
Pen @ 4°C	16	18	15	16	21
Pen @ 25°C	44	39	42	52	57
Softening Pt., C	56	57	57	56	52
% Loss	0.125	0.06	0	0.1	-
SHRP					
Grade	PG 64-22	PG 64-22	PG64-22	PG64-22	PG 58-22
DSR-Original 64°C, KPa	1.57	1.69	1.63	1.28	0.630
DSR-Original 70°C, KPa	0.73	0.81	0.78	0.63	1.433
DSR-RTFO-64°C, KPa	3.25	4.03	3.08	2.63	1.578
DSR-RTFO-70°C, KPa	1.45	1.89	1.38	1.22	3.794
DSR-PAV-10°C, MPa	8.45	7.27	7.41	6.50	-
Flexural Creep-18°C	532.0	355.0	427.5	444.5	224
MPa					
m	0.24	0.24	0.25	0.27	0.285

STATE	FL	FL	FL
GRADE OF AC	AC-30	AC-30	AC-30
CODE	1	2	3
Vis @ 60°C, P	3272	-	-
Vis @ 135°C, cST	638	-	-
Pen @ 4°C	24	-	-
Pen @ 25°C	64	-	-
Ductility @ 25°C, mm	1004	-	-
Softening Pt., C	51	-	-
TFO RESIDUE			
Vis @ 60°C, P	11512	-	-
Vis @ 135°C, cST	998	-	-
Pen @ 4°C	18	-	-
Pen @ 25°C	39	-	-
Softening Pt., C	58	-	-
% Loss	0.31	-	-
SHRP Grade	PG 64-22	PG 70-22	PG 64-16
DSR-Original 64°C, KPa	1.93	1.98	1.86
DSR-Original 70°C, KPa	0.96	1.01	0.97
DSR-RTFO-64°C, KPa	4.67	6.41	4.51
DSR-RTFO-70°C, KPa	2.16	3.16	10.08
DSR-PAV-10°C, MPa	6.06	5.10	7.63
Flexural Creep-18°C	307.0	257.5	419.5
MPa			
m	0.24	0.25	0.24

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TABLE 1 *(continued)*

STATE	GA	GA	GA	GA	GA
GRADE OF AC	AC-20	AC-30	AC-30	AC-20	AC-30
CODE	1	2	3	4	5
Vis @ 60°C, P	1943	3343	3317	2333	2733
Vis @ 135°C, cST	408	543	557	392	443
Pen @ 4°C	21	25	26	20	17
Pen @ 25°C	66	60	67	67	56
Ductility @ 25°C, mm	150+	150+	150+	150+	150+
Softening Pt., C	50	50	50	50	50
TFO RESIDUE					
Vis @ 60°C, P	5191	7969	9341	4890	5274
Vis @ 135°C, cST	551	704	852	538	539
Pen @ 4°C	17	18	17	13	20
Pen @ 25°C	40	36	43	55	37
Softening Pt., C	57	59	57	55	59
% Loss	13	.02	0.27	0.08	0.03
SHRP					
Grade	PG 64-16	PG 64-22	PG 64-22	PG 64-16	PG 64-16
DSR-Original 64°C, KPa	1.02	1.78	1.40	1.04	1.23
DSR-Original 70°C, KPa	0.49	0.84	0.69	0.52	0.62
DSR-RTFO-64°C, KPa	2.28	3.50	3.13	2.31	2.77
DSR-RTFO-70°C, KPa	1.10	1.67	1.52	1.13	1.29
DSR-PAV-10°C, MPa	-	-	-	-	-
Flexural Creep-18°C MPa	424	302	324	382	437
m	0.24	0.27	0.29	0.26	0.25

STATE	GA	GA	GA	GA	GA
GRADE OF AC	AC-20	AC-20	AC-30	AC-20	AC-30
CODE	6	7	8	9	10
Vis @ 60°C, P	2162	2172	3172	2225	3196
Vis @ 135°C, cST	397	497	573	538	460
Pen @ 4°C	96	17	23	32	28
Pen @ 25°C	109	91	67	76	67
Ductility @ 25°C, mm	150+	150+	150+	150+	150+
Softening Pt., C	48	51	51	49	51
TFO RESIDUE					
Vis @ 60°C, P	5761	6643	9555	5961	8386
Vis @ 135°C, cST	534	843	892	664	806
Pen @ 4°C	26	54	19	20	18
Pen @ 25°C	60	23	30	52	42
Softening Pt., C	58	54	57	55	56
% Loss	0.25	0.36	0.34	0.15	0.22
SHRP					
Grade	PG 64-28	PG 64-28	PG 64-16	PG 64-22	PG 64-22
DSR-Original 64°C, KPa	1.06	1.32	1.84	1.39	1.88
DSR-Original 70°C, KPa	0.53	0.67	0.92	0.69	0.96
DSR-RTFO-64°C, KPa	2.76	3.21	4.52	3.56	6.16
DSR-RTFO-70°C, KPa	1.29	1.6	2.21	1.66	3.09
DSR-PAV-10°C, MPa	-	5.44	6.27	4.93	5.62
Flexural Creep-18°C MPa	-	251.5	628.8	538.7	260.5
m	-	0.33	0.23	0.25	0.27

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TABLE 1 *(continued)*

STATE	LA	LA	LA
GRADE OF AC	AC-30	AC-30	AC-30
CODE	1	2	3
Vis @ 60°C, P	3298	3370	3570
Vis @ 135°C, cST	557	481	484
Pen @ 4°C	9	6	18
Pen @ 25°C	66	58	84
Ductility @ 25°C, mm	150+	150+	150+
Softening Pt., C	41	54	51
TFO RESIDUE			
Vis @ 60°C, P	7634	7640	7933
Vis @ 135°C, cST	708	613	707
Pen @ 4°C	8	5	13
Pen @ 25°C	48	37	63
Softening Pt., C	57	57	58
% Loss	0.09	0.17	0.04
SHRP			
Grade	PG 64-22	PG 64-16	PG 64-34
DSR-Original 64°C, KPa	1.78	2.00	1.74
DSR-Original 70°C, KPa	0.85	0.93	0.87
DSR-RTFO-64°C, KPa	4.81	4.71	4.16
DSR-RTFO-70°C, KPa	2.31	2.10	2.00
DSR-PAV-10°C, MPa	6.23	10.23	1.61
Flexural Creep-18°C	347.7	513.6	75.4
MPa			
m	0.277	0.237	0.31

STATE	MI	MI	MI	MI
GRADE OF AC	AC-1	AC-2.5	AC-5	AC-10
CODE	1	2	3	4
Vis @ 60°C, P	-	-	541	1240
Vis @ 135°C, cST	-	-	212	311
Pen @ 4°C	-	-	49	25
Pen @ 25°C	-	-	185	105
Ductility @ 25°C, mm	-	-	-	-
Softening Pt., C	-	-	40	45
TFO RESIDUE				
Vis @ 60°C, P	-	-	1350	3190
Vis @ 135°C, cST	-	-	316	445
Pen @ 4°C	-	-	40	22
Pen @ 25°C	-	-	94	61
Softening Pt., C	-	-	46	52
% Loss	-	-	-	-
SHRP Grade	PG 40-40	PG 46-34	PG 52.50	PG 58-22
DSR-Original 52°C, KPa	0.27	0.83	1.468	0.589
DSR-Original 58°C, KPa	-	0.41	0.806	1.301
DSR-RTFO-52°C, KPa	0.29	2.55	3.905	1.554
DSR-RTFO-58°C, KPa	-	-	1.806	3.621
DSR-PAV-10°C, MPa	-	2.14	2.789	-
Flexural Creep-24°C	106	265	573	248
MPa				
m	0.355	0.300	0.280	0.290

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TABLE 1 (continued)

STATE	MN	MN	MS	MS	MS	MS
GRADE OF AC	AC-5	AC-10	AC-30	AC-30	AC-30	AC-30
CODE	1	2	1	2	3	4
Vis @ 60°C, P	597	1090	3015	3118	2744	3184
Vis @ 135°C, cST	217	300	542	548	482	465
Pen @ 4°C	42	31	-	-	-	-
Pen @ 25°C	173	113	55	61	96	58
Ductility @ 25°C, mm	-	-	150+	150+	150+	150+
Softening Pt., C	40	46	51	49	51	48
TFO RESIDUE						
Vis @ 60°C, P	1440	2850	8195	7065	12726	13528
Vis @ 135°C, cST	316	449	810	634	849	854
Pen @ 4°C	33	21	-	-	-	-
Pen @ 25°C	85	63	38	40	57	36
Softening Pt., C	46	52	57	55	57	58
% Loss	-	-	0.06	0.22	0.4	0.01
SHRP						
Grade	PG 52-28	PG58-22	PG 64-22	PG 64-22	PG 64-28	PG 64-22
DSR-Original 64°C, KPa	1.352	0.536	1.89	1.69	1.62	1.70
DSR-Original 58°C, KPa	0.653	1.192	0.93	0.80	0.83	0.83
DSR-RTFO-64°C, KPa	4.060	1.385	4.47	3.65	5.69	6.73
DSR-RTFO-58°C, KPa	1.930	3.146	2.11	1.67	2.84	3.30
DSR-PAV-10°C, MPa	2.865	4.089	7.10	7.66	1.95	5.77
Flexural Creep-18°C MPa	565	223	375.5	548.9	77.5	284.0
m	0.290	0.285	0.26	0.26	0.31	0.26

STATE	SC	SC	SC	TX	TX	TX	TX
GRADE OF AC	AC-20S	AC-30	AC-20S	AC-20	AC-20	AC-20	AC-20
CODE	1	2	3	1	2	3	4
Vis @ 60°C, P	2364	3278	2011	1937	1647	1840	1765
Vis @ 135°C, cST	427	500	391	417	311	369	350
Pen @ 4°C	25	24	21	26	20	16	22
Pen @ 25°C	79	65	74	66	59	57	63
Ductility @ 25°C, mm	100+	100+	100+	150+	150+	150+	150+
Softening Pt., C	---	---	---	48.8	49.4	50	51.1
TFO RESIDUE							
Vis @ 60°C, P	5665	9436	4930	4080	3228	3293	4610
Vis @ 135°C, cST	631	778	561	534	485	495	515
Pen @ 4°C	18	18	15	20	16	14	19
Pen @ 25°C	48	43	41	44	39	46	40
Softening Pt., C	---	---	---	53	54	53	58
% Loss	0.17	0.21	0.02	0.2	0.2	0.01	0.2
SHRP							
Grade	PG 64-28	PG 64-22	PG 64-22	PG 64-22	PG 58-22	PG 58-16	PG 58-16
DSR-Original 64°C, KPa	1.288	1.641	1.142	1.171	0.982	0.934	0.950
DSR-Original 70°C, KPa	0.641	0.792	0.564	0.579	-	-	-
DSR-RTFO-64°C, KPa	2.949	6.382	2.867	2.396	2.201	2.136	1.450
DSR-RTFO-70°C, KPa	1.386	3.033	1.356	1.106	-	-	-
DSR-PAV-10°C, MPa	5.761	5.062	5.273	4.904	8.59	5.065	5.818
Flexural Creep-18°C MPa	300.0	263.5	324.5	321.5	424	-	-
m	0.31	0.27	0.25	0.26	0.24	-	-

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TABLE 1 (*continued*)

STATE	VA	VA	VA	VA	VA
GRADE OF AC	AC-20	AC-20	AC-20	AC-20	AC-20
CODE	1	2	3	4	5
Vis @ 60°C, P	1865	1835	1800	2357	2005
Vis @ 135°C, cST	393	400	393	388	417
Pen @ 4°C	-	-	-	-	-
Pen @ 25°C	62	79	88	66	80
Ductility @ 25°C,mm	150+	150+	150+	150+	150+
Softening Pt.,C	50	48	47	48	49
TFO RESIDUE					
Vis @ 60°C, P	5241	4770	4416	5044	5280
Vis @ 135°C, cST	578	604	583	535	621
Pen @ 4°C	-	-	-	-	-
Pen @ 25°C	48	48	53	44	49
Softening Pt., C	58	54	53	54	55
% Loss	<.03	<.16	<.02	<.30	<.13
SHRP					
Grade	PG 64-22	PG 64-22	PG 58-22	PG 64-22	PG 64-22
DSR-Original 64°C, KPa	1.023	1.143	0.983	1.246	1.128
DSR-Original 70°C, KPa	0.499	0.566	-	0.575	.554
DSR-RTFO-64°C, KPa	2.566	3.268	2.822	2.675	2.914
DSR-RTFO-70°C, KPa	1.228	1.510	1.338	1.202	1.358
DSR-PAV-10°C, MPa	6.273	3.694	3.157	7.033	4.117
Flexural Creep-18°C MPa	340.5	239	185.5	443	242
m	0.25	0.29	0.29	0.27	0.27

STATE	VA	VA	VA	VA	VA
GRADE OF AC	AC-30	AC-30	AC-30	AC-30	AC-30
CODE	6	7	8	9	10
Vis @ 60°C, P	3028	2999	3593	2982	2751
Vis @ 135°C, cST	489	489	543	561	493
Pen @ 4°C	-	-	-	-	-
Pen @ 25°C	48	57	61	67	65
Ductility @ 25°C, mm	150+	150+	150+	150	150
Softening Pt., C	53	50	53	50	51
TFO RESIDUE					
Vis @ 60°C, P	8226	7836	10793	7833	7679
Vis @ 135°C, cST	696	738	860	761	731
Pen @ 4°C	-	-	-	-	-
Pen @ 25°C	30	38	57	45	40
Softening Pt.,C	58	57	58	54	57
% Loss	<.006	<.15	<.11	<.30	<.11
SHRP					
Grade	PG 64-16	PG 64-16	PG 64-22	PG 64-22	PG 64-22
DSR-Original 64°C, KPa	1.67	1.56	1.71	1.66	1.72
DSR-Original 70°C, KPa	0.807	0.77	0.88	0.85	.89
DSR-RTFO-64°C, KPa	4.61	4.99	5.40	4.90	4.71
DSR-RTFO-70°C, KPa	2.09	-	-2.55	2.33	2.22
DSR-PAV-10°C, MPa	6.80	4.94	4.97	6.02	5.23
Flexural Creep-18°C MPa	379.5	318	233.5	336	276.4
m	0.23	0.25	0.28	0.29	0.28

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TABLE 1 (*continued*)

STATE	WV	WV	WV	WV	WY	WY	WY
GRADE OF AC	AC-20	AC-20	AC-10	AC-20	85-100	AC-10	AC-10
CODE	1	2	3	4	1	2	3
Vis @ 60°C, P	2035	1875	1163	2143	1710	1000	1100
Vis @ 135°C, cST	525	412	333	424	370	285	276
Pen @ 4°C	44	42	40	37	23	27	30
Pen @ 25°C	91	83	100	75	84	90	101
Ductility @ 25°C, mm	145	142	115	146	-	-	-
Softening Pt., C	-	-	-	-	48	47	47
TFO RESIDUE							
Vis @ 60°C, P	5050	4983	2492	5183	4120	2180	3490
Vis @ 135°C, cST	621	572	416	599	537	380	423
Pen @ 4°C	20	25	28	24	23	15	30
Pen @ 25°C	53	49	67	47	54	57	57
Softening Pt., C	-	-	-	-	54	51	52
% Loss	0.07	0.10	0.04	0.03	-	-	-
SHRP							
Grade	PG 64-28	PG 64-22	PG 64-22	PG 64-22	PG 58-22	PG 58-22	PG 58-22
DSR-Original 64°C, KPa	1.19	1.16	0.72	1.24	0.827	0.548	0.535
DSR-Original 70°C, KPa	0.60	0.65	0.37	0.62	1.876	1.261	1.213
DSR-RTFO-64°C, KPa	3.12	2.88	1.43	2.44	2.186	1.162	1.548
DSR-RTFO-70°C, KPa	1.48	1.39	0.71	1.16	5.245	2.770	3.681
DSR-PAV-10°C, MPa	3.47	4.66	4.3	4.99	5.412	-	-
Flexural Creep-18°C MPa	187.5	237.0	261.5	275.5	249	321	215
m	0.30	0.29	0.28	0.28	0.280	0.260	-

- NOT AVAILABLE

TABLE 2 Properties of AC-10, AC-20, and AC-30 Asphalt Cements

PROPERTY	AC-10		AC-20		AC-30	
	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
Viscosity @ 60C, P	1130	77	2051	207	3107	259
Viscosity @ 135C, cST	298	19	425	69	508	45
Pen @ 4C	30	5	25	20	18	10
Pen. @ 25 C	101	7	75	12	63	10
Pen. Index	-	-	3.83	4.43	3.22	2.13
PVN	-	-	-0.48	0.28	-0.32	0.25
Ductility @ 25C, MM	-	-	137	21	147	10
Soft Pt., C	46	17	49	17	51	15
TFO Viscosity 60C, P	2897	446	5017	836	8294	2117
TFO Viscosity 135C, cST	421	22	588	78	739	105
TFO Pen. 4C	22	5	16	7	13	7
TFO Pen. 25C	60	4	48	5	42	8
TFO Pen. Index	-	-	3.9	3.6	5.1	3.1
TFO PVN	-	-	-0.28	0.27	0.02	0.40
TFO Soft. Pt., C	52	17	54	16	57	11
TFO, % Loss	-	-	0.15	0.10	0.14	0.11
DSR Original 64C, KPa	0.59	0.06	1.14	0.12	1.72	0.17
DSR Original 70C, KPa	-	-	0.58	0.06	0.85	0.09
DSR RTFO 64C, KPa	3.39	0.37	2.87	0.94	4.54	1.19
DSR RTFO 70C, KPa	-	-	1.42	0.043	2.64	1.75
DSR PAV 10C, MPa	-	-	5.27	1.32	6.06	1.89
DSR PAV 13C, MPa	-	-	4.44	1.26	4.71	1.50
Flexural Creep, 18C, MPa	281	37	335	97	345	129
m	0.28	0.01	0.27	0.02	0.26	0.02

- NOT AVAILABLE

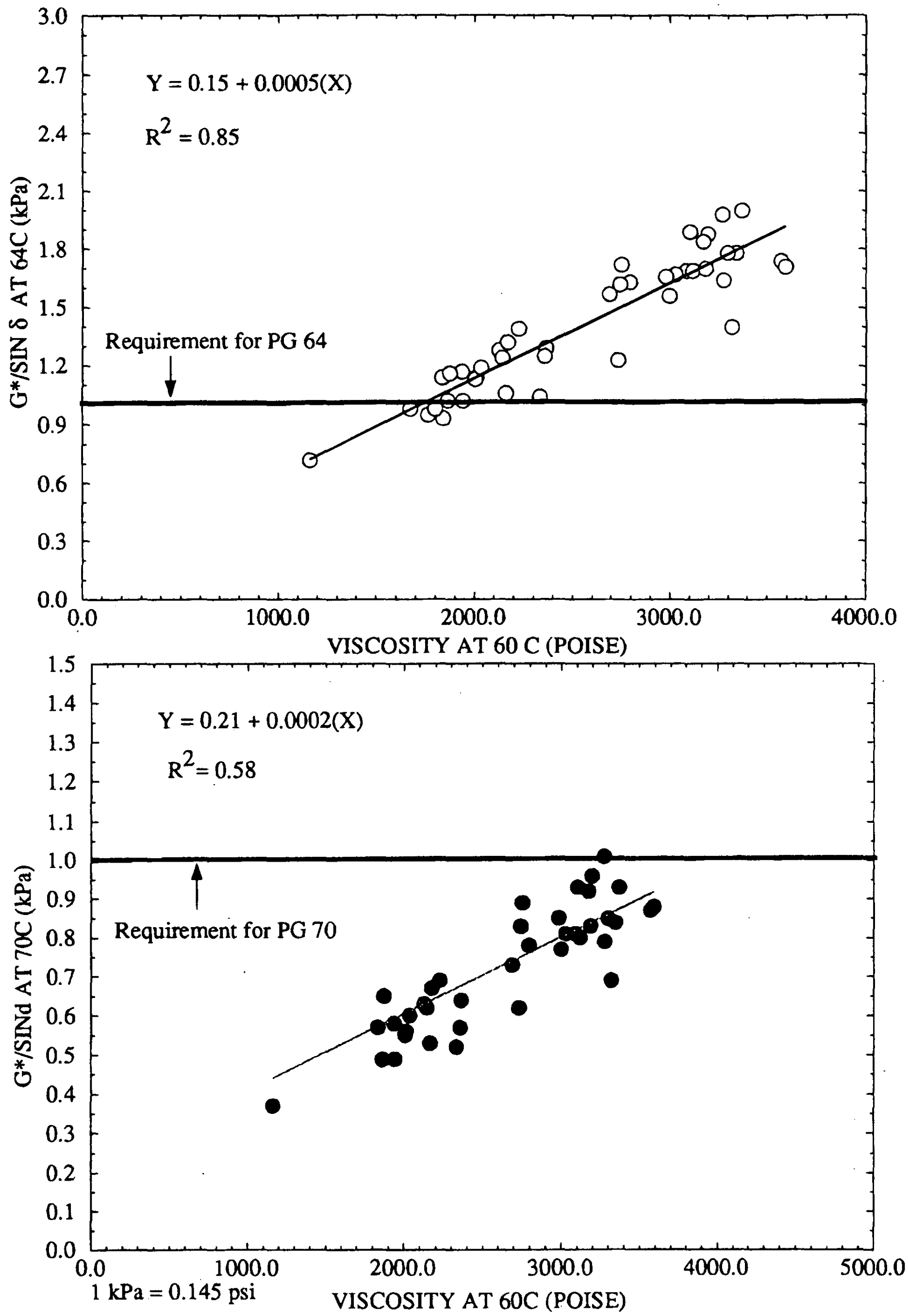


FIGURE 1 Viscosity at 60°C versus *G/sin δ for original asphalt cement.**

RTFOT aging. Even though the relationship is strong ($R^2 = 0.79$) for both 64°C and 70°C, it is weaker than that observed for the neat asphalt cement. This may be explained in part by the different aging characteristics of the two aging procedures, TFOT versus RTFOT. As Zupanick (*5*) pointed out the TFOT and the RTFOT tests are not interchangeable. He also pointed out that the results will vary with the asphalts being tested.

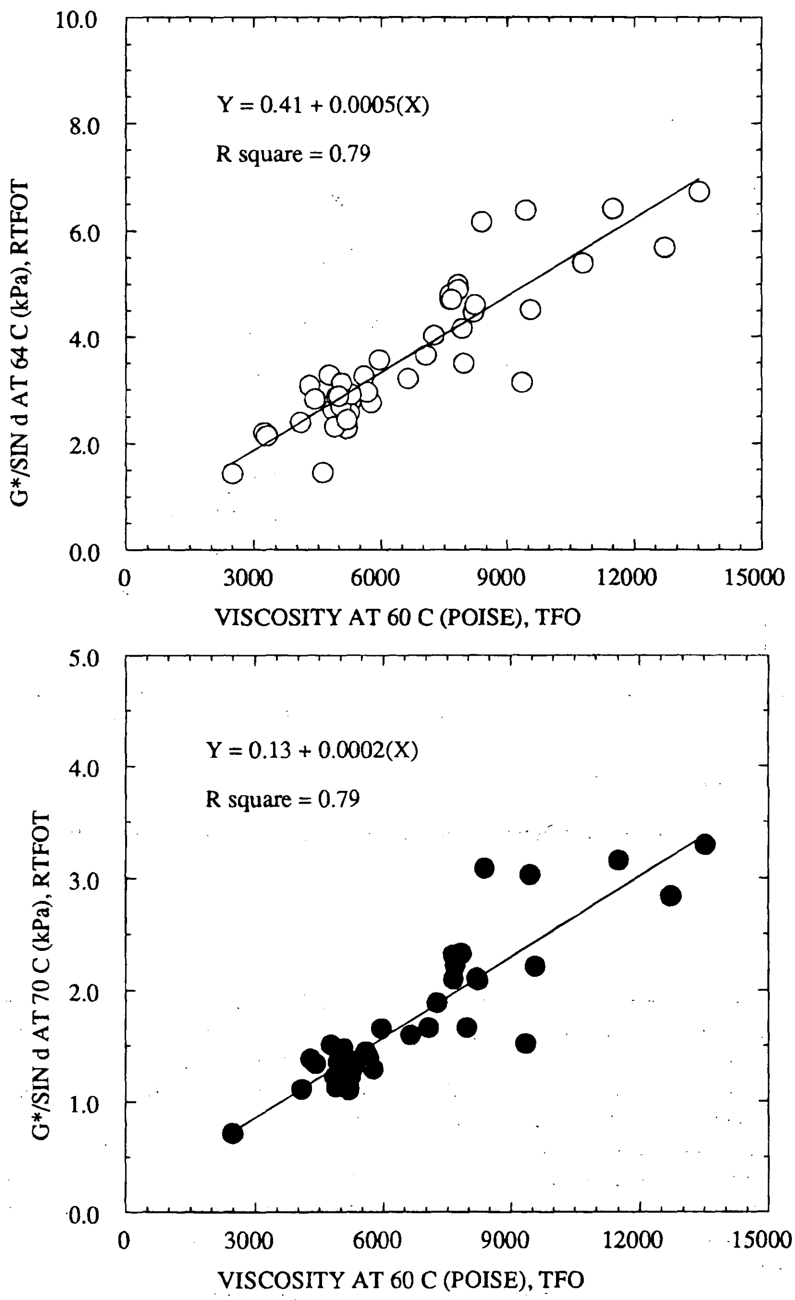
Bending Beam Rheometer Stiffness Versus m.

There has been considerable discussion about the concept of changing the temperature requirements in the AASHTO specification for cold temperatures. The current requirement is that the relaxation modulus (stiffness) determined by the bending beam rheometer (in megapascals) be less than 300 and that the *m*-value be more than

0.30. It has been proposed that the *m*-value be reduced from 0.30 to something less. Figure 3 provides a plot of *m* versus the relaxation modulus (stiffness) for all asphalts and all test temperatures evaluated in the study. A best-fit curve was drawn through the points. The relationship is found to be very strong (R^2 = 0.84). The data indicate that for a stiffness of 300 MPa the corresponding stiffness is 0.274. The best-fit curve presented here is not meant for actual use but to justify the experimentally obtained correlation. Thus, based on the asphalt tested in the present study, the *m*-value will control the specification limits. Because of the limited number of asphalts tested, no adjustment in the specification is recommended here. These data do not support a specification change.

Difference Between High and Low

To assess the availability of asphalt cements both the high-temperature and the low-temperature properties of the asphalt cement must be considered. A rule of 90 has been discussed a great deal throughout the industry. This rule states that if an agency wants



1 kPa = 0.145 psi

FIGURE 2 Viscosity at 60°C (TFOT) versus $G^*/\sin\delta$ for RTFOT asphalt cement.

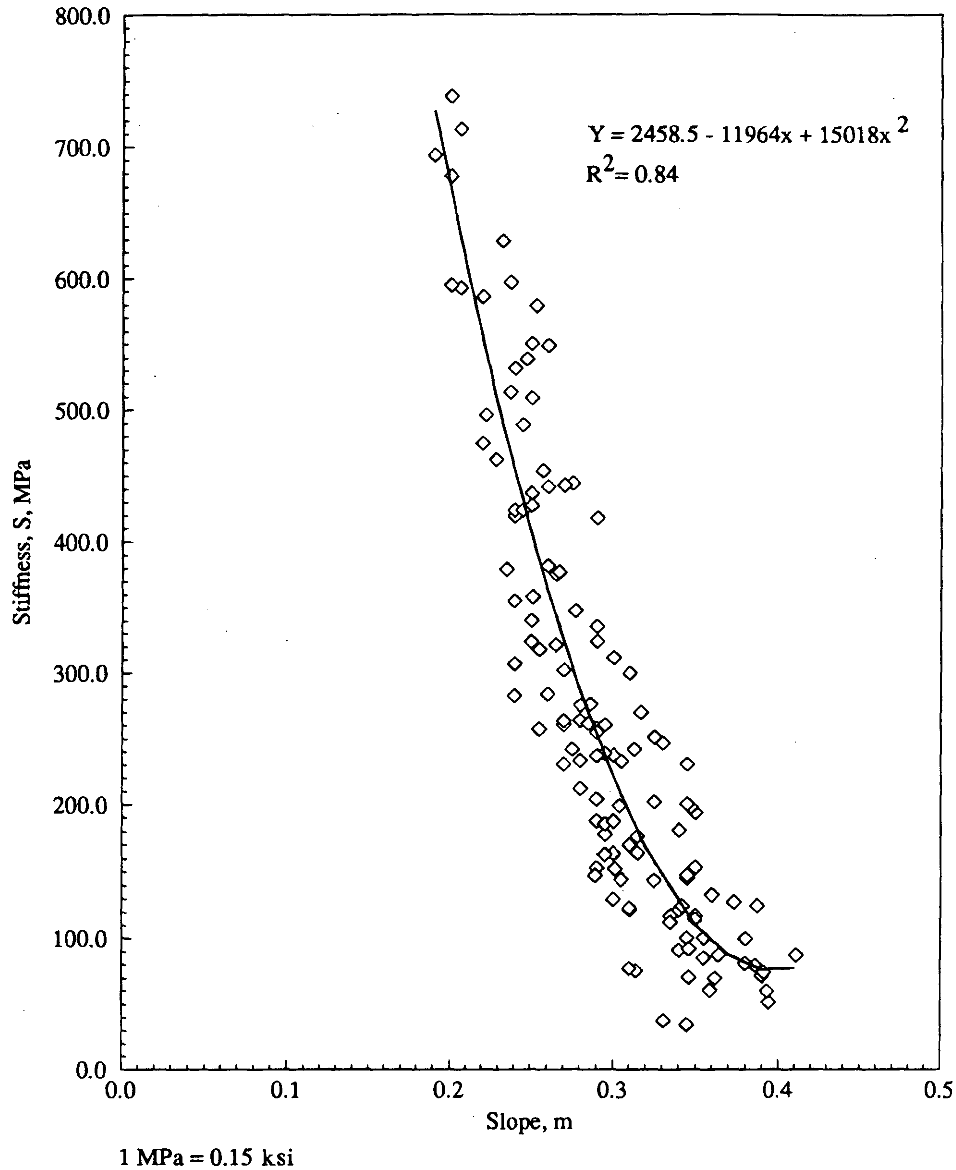


FIGURE 3 Bending beam rheometer stiffness versus bending beam rheometer slope.

to limit its asphalts to unmodified asphalt cements the difference between the top and bottom range for the asphalts must be less than 90°C. For example, a PG 64–22 would have a difference of 86°C, which would mean that an agency could probably obtain an unmodified asphalt cement that would meet that requirement. If the agency specified a PG 76–22 the difference would be 98°C, which would mean that the agency would probably need to purchase a modified asphalt cement to meet this specification.

To test this hypothesis the temperature at which each of the asphalt cements tested where they met the requirement for high temperature [stiffness (*S*) = 1 kPa] and where they met the temperature at which each of the asphalts tested met the requirement for low temperature ($m = 0.30$) was determined. Table 3 presents the results of this analysis. To assess the specification 10°C must be added to the difference. This is required because the cold test temperature is 10°C higher than the specification temperature. A review of the data in Table 3 shows that for an AC-20 asphalt cement the average specification difference would be 89.2°C, with a range of 96.2°C to 82.7°C. For an AC-30 asphalt cement the average specification difference would be 92.3°C, with a range of 99.7°C to 84.3°C. Thus, it would appear that the rule of 90, on average, is a good approximation. Depending on the asphalt cements being used, however, it may not apply.

CONCLUSIONS

Based on the research conducted in the present study it is concluded that:

TABLE 3 Difference Between High and Low Temperatures

VISCOSITY GRADE	AVG. TEMP @ DSR STIFF. 1 KPa, C	AVG. TEMP @ m 0.3,C	AVG. DIFF. BETWEEN HIGH & LOW	MAXM. DIFF. BETWEEN HIGH & LOW	MINM. DIFF. BETWEEN HIGH & LOW
AC-5*	55.1	22.4	75.5	75.5	75.5
AC-10*	60.0	15.6	75.7	77.7	72.5
AC-20	65.0	14.2	79.2	86.2	72.7
AC-30	68.6	14.2	82.3	89.7	74.3

*** Based on very limited testing**

1. The asphalt cements tested as part of the study will generally fall into the following categories:

- AC-5 is PG 52–28,
- AC-10 is PG 58–22,
- AC-20 is PG 64–22, and
- AC-40 is PG 70–16.

2. The viscosity of neat asphalt cement (60°C) shows a fairly strong correlation with DSR stiffness ($G^*/\sin\delta$ at 64°C and 70°C).

3. For the asphalt cements tested in the study the *m*-value was found to be about 0.27 for the corresponding *S* value of 300 MPa. Thus, the currently specified *m*-value of 0.3 is generally the controlling value for this specification.

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