Proliferation of Paving Grade Asphalt Cement Specifications in Oregon

CHRIS A. BELL and JAMES E. WILSON

ABSTRACT

Oregon is currently the only state in the United States to use all three major grading systems for specifying paving grade asphalt cements. This situation has occurred because of geographic location and the economics of asphalt supply. Oregon changed to an asphalt residue (AR) grading system in 1974 along with other Pacific Coast states. However, due to various developments, specifications used by Oregon or adjacent states are now based on three grading systems with four distinct grading requirements, two AR versions, an asphalt concrete (AC) version, and a penetration version. To ensure the maximum number of options for asphalt supply, Oregon presently uses all four alternate specifications. The developments leading to this situation are outlined and some consequences are examined. It is shown that there are significant differences between the existing specifications and that it is possible for asphalts with the same specification grade or with nominally the same specification to have distinctly different properties (e.g., AR-4000 versus AR-4000W). This is primarily due to the way in which each specification controls temperature susceptibility. The wide variety of properties that may occur can lead to problems such as selecting mixing and compaction temperatures other than the optima for mixtures using a particular asphalt. This could be overcome by adopting a uniform specification, but the current situation can be dealt with by adequate application of the test results from routine specification tests, in the mix design process, and by recommending optimum temperatures for each phase of the construction process.

Oregon is currently the only state in the United States that accepts asphalt cements specified by three different grading methods, as shown in Figure 1 (1). Many states allow the use of two grading systems, but the majority is using only the AC grading system [AASHTO M226-80, Table 1 or 2 (2)]. The situation in Oregon has occurred because of the geographic location (neighboring states use different asphalt specifications) and the economics of asphalt supply. The asphalt residue (AR) specification used in this state is based on the Uniform Pacific Coast Asphalt Specification, as are those of California, Nevada, and Washington. These specifications are similar to those of AASHTO M226-80, Table 3 (2).

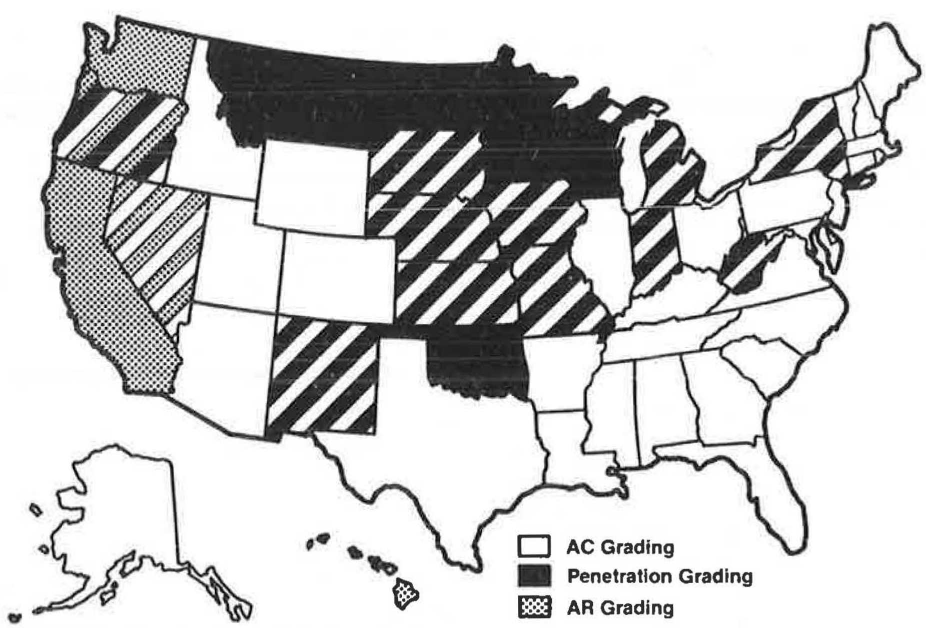

FIGURE 1 Use of grading methods in the United States, 1983 [based on Chevron (1)].

However, each state may change these specifications to meet its particular requirements, and indeed the Washington and Oregon AR specifications are different. In addition, to the east of Oregon, Idaho uses an AC grading system and Montana uses a penetration grading system. Hence, a situation exists in which Oregon must consider asphalts graded in several ways in order to ensure a sufficient supply because the market is such that maintaining only one grading system when the demand is high could restrict the supply.

The amount of construction work in Oregon, as in most states, has increased considerably as a result of the 1982 Transportation Assistance Act. This factor in particular has led to an increase in demand for asphalt. However, the supply of asphalt is not plentiful, as a result of the economics of petroleum refining. Whereas the manufacture of residual fuel oil used to be the principal alternate for the bottom of the barrel other than the production of asphalt, there are now more options thanks to improvements in refinery technology. Some of these options could be more economical if the cost of producing asphalt to restrictive specifications becomes too high. Hence, it is vital that users learn to use the available asphalts while cooperating with the producers to ensure the highest quality possible in the product.

Background information on the proliferation of asphalt specifications in Oregon is presented, and how these specifications developed is discussed. Changes that occurred in the specifications and asphalt properties during the 1970s will be outlined. The current specifications will be presented in detail and compared, and the distribution of asphalts supplied to each specification will be given. The problems associated with the use of the alternate specifications will be described and methods of dealing with these problems will be suggested.

DEVELOPMENT OF ASPHALT CEMENT SPECIFICATIONS IN OREGON

Historic Review

A summary of the development of specifications in Oregon is given in Table 1. These are described more fully later. Oregon has traditionally been consistent with other western states, particularly the neighboring Pacific Coast states of California and Washington, in engineering practice concerning pavements. In matters concerning asphalt, the Uniform Pacific Coast Asphalt Specifications (UPCAS) form the basis of specifications for asphalt cements as well as other types of asphalt. The minutes of the Pacific Coast Conferences on Asphalt Specifications (3) document the development of the AR specifications. This conference was initiated in 1956 and to date there have been 19 meetings involving participants from user agencies and asphalt producers. The activities of the conference led to the adoption of an AR grading system by seven states (Alaska, Arizona, California, Hawaii, Nevada, Oregon, and Washington) on January 1, 1974. These activities occurred concurrently with nationwide debate on the adoption of viscosity-graded asphalts (in 1970) by the American Association of State Highway Officials (AASHO). Although the recurring theme of the Pacific Coast Conference has been uniform specifications, the AR specifications were adopted instead of the AC specifications that had resulted from the efforts of the Asphalt Institute and various committees of the then Highway Research Board (HRB), American Society for Testing and Materials (ASTM), and AASHO.

TABLE 1 Summary of Development of Asphalt Cement Specifications in Oregon, 1957-1984

Dates	Specifications in Use or Change Introduced
1957 to 12/31/73	Uniform Pacific Coast Asphalt Specifications—penetration graded
1/1/74 to 12/31/76	Uniform Pacific Coast Asphalt Specifications—AR grading system
1/1/77	Modification of previous AR specification with the return of the loss on aging requirement and the Pensky-Martens flash test
	Washington alternates for AR grading introduced
1/1/82	AC-graded alternates introduced
1/1/83	Penetration-graded alternates introduced

Even though the UPCAS introduced five AR grades, the state of Washington modified these slightly to suit climatic conditions, which in certain regions are substantially different than those of California, where the specifications were initially developed. After 3 years of using the AR specifications, Oregon introduced modifications that included a maximum limit for the amount of loss on heating and changing the flash test to the Pensky-Martens closed cup instead of the Cleveland open cup. These changes were introduced on January 1, 1977, in an attempt to return to asphalts similar to those used before 1974 and to correct slow setting and tender pavement problems that had occurred since the AR grading system was introduced. Alternate specifications identical to those used in Washington were also introduced at this time. No further changes have been made in Oregon to either type of AR specifications, but the AC specifications were added on January 1, 1982, and the penetration specifications were reintroduced on January 1, 1983. It is ironic that the penetration specification, which will allow occasional use of asphalt from Montana, is exactly the same as that replaced by the AR specification in 1974. It is also ironic that the failure of the members of the Pacific Conference to use uniform specifications appears to have restricted supply in some areas because each state's adoption of its own version of the specification could favor the larger producers. Hence, Oregon now has four specifications instead of one in an attempt to improve supply.

Philosophy of the AR Grading System

The asphalt residue (AR) grading system is based on viscosity at 60°C (140°F) for asphalts aged in a rolling thin film oven (RTFO). The RTFO is intended to simulate the hardening that occurs during mixing. The specifications will be defined later and compared with other grading systems, but it should be noted that the controlling point for these specifications is 60°C. This temperature was chosen to correspond to the highest temperature that might occur in the pavement during hot weather, and in conjunction with a viscosity control at 135°C (275°F) to ensure uniformity of mixtures during laydown and compaction.

The AR grading approach was adopted by Oregon and the other states implementing the UPCAS AR specification because it emphasizes the aged properties of the asphalt, unlike the AC or penetration specifications that emphasize the original properties. A system based on viscosity measurements was preferred to one based on penetrations because of the fundamental nature of the former as opposed to the empirical nature of the latter. However, it should be noted that both AR and AC specifications use penetration at 25°C (77°F) as a control because there is still no convenient method of measuring low-temperature viscosity on a routine basis.

CURRENT OREGON SPECIFICATIONS (1984)

General

Oregon State Highways Division (OSHD) issues specifications for asphalt materials on January 1 each year. Those for asphalt cements for 1984 are shown in Tables 2-5. As described previously, Oregon has its own version of the UPCAS viscosity specification (AR in Table 2) and alternates comprising the Washington AR (AR-W) specifications (Table 3), AC-based specifications (Table 4), and penetration-based specification (Table 5).

Consistency Control

The control of consistency (viscosity and penetration) for each alternate is shown in Figure 2. It should be noted that the Oregon and Washington AR specifications (Figure 2c) emphasize aged properties, whereas the penetration (Pen) and AC grades (Figures 2a and 2b) emphasize original properties. All four specifications have controls on the aging oꜰ the ashalt, but this occurs at only one temperature, namely the penetration at 25°C (77°F) for the AR, AR-W, and Pen specifications, and the viscosity at 60°C (140°F) for the AC specification. Essen-

TABLE 2 OSHD Standard Specifications for Asphalt Cements—AR Grades

Characteristic	AASHTO Test Method	Viscosity Grade (based on residue from RTFOT)				
Tests on RTFO residue	T 240[a]	AR-1000	AR-2000	AR-4000	AR-8000	AR-16000
Viscosity, 60°C (140°F), poise	T 202	1000±250	2000±500	4000±1000	8000±2000	16000±4000
Viscosity, 135°C (275°F), Cs-minimum	T 201	140	200	275	400	550
Loss in weight, % maximum	T 240[a]	1.50	1.00	0.85	0.80	0.75
Penetration, 25°C (77°F), 100 g, 5-sec, minimum	T 49	65	40	25	20	20
Percentage of original penetration, 25°C (77°F), minimum	T 49	–	40	45	50	52
Ductility, 25°C (77°F), 5 cm per min, cm-minimum	T 51	100[b]	100[b]	75	75	75
Tests on original asphalt						
Flash point, PMCT, °F, minimum	T 73	400	425	440	450	460
Solubility in trichloroethylene, % minimum	T 44	99.0	99.0	99.0	99.0	99.0

Note: A general requirement is that the asphalt cement furnished under this specification shall be petroleum asphalt prepared by the refining of crude petroleum. It shall be homogeneous and free from water, and it shall not have been distilled at a temperature high enough to injure by burning or high enough to produce flecks of carbonaceous matter. It shall meet the preceding requirements at the time of use when tested in accordance with the methods herein enumerated. For asphalt containing an antistripping additive, requirements will be extended 5 percent for all characteristics except solubility in trichloroethylene.

[a]AASHTO T 179 (thin film oven test) may be used, but AASHTO T 240 shall be the referee method.
[b]If ductility is less than 100, material will be accepted if ductility at 15.6°C (60°F) is 100.

TABLE 3 OSHD Standard Specifications for Asphalt Cements—AR-W Alternates

Characteristic	AASHTO Test Method	Viscosity Grade (based on residue from RTFO)		
Tests on RTFO residue	T 240[a]	AR2000W	AR4000W	AR8000W
Viscosity, 60°C (140°F), poise	T 202	1500-2500	2500-5000	6000-10,000
Viscosity, 135°C (275°F), Cs-minimum	T 201	200	275	400
Penetration, 25°C (77°F), 100 g, 5-sec, minimum	T 49	50	40	30
Percentage of original penetration, 25°C (77°F), minimum	T 49	40	45	50
Ductility, 25°C (77°F), 5 cm per min, cm-minimum	T 51	–	–	75
Ductility, 7°C (45°F), 1 cm per min, cm-minimum	WSHD 213A[b]	20	10	–
Tests on original asphalt				
Flash point, COC, °F, minimum	T 48	425	440	450
Solubility in trichloroethylene, % minimum	T 44	99.0	99.0	99.0

Note: This specification may be used as an alternate for furnishing asphalt cements to the state of Oregon based on viscosity-graded asphalt cement at 140°F (60°C) on RTFC residue. For asphalt containing an antistripping additive, requirements will be extended 5 percent for all characteristics except solubility in trichloroethylene.

[a]AASHTO T 179 (thin film oven test) may be used, but AASHTO T 240 shall be the referee method.
[b]Washington State Highway Department Test Method 213A.

TABLE 4 OSHD Standard Specifications for Asphalt Cements—AC Alternates

Characteristic	AASHTO Test	Viscosity Grade (based on original asphalt)			
Tests on Original Asphalt		AC-2.5	AC-5	AC-10	AC-20
Viscosity, 60°C (140°F), poise	T 202	200-300	400-600	800-1200	1600-2400
Penetration, 25°C (77°F), minimum	T 49	210	130	80	50
Viscosity, 135°C (275°F), Cs-minimum	T 201	100	130	170	230
Flash point, COC, °F, minimum	T 48	325	350	425	450
Solubility in trichloroethylene, % minimum	T 44	99.0	99.0	99.0	99.0
Tests on residue from RTFO	T 240				
Viscosity, 60°C (140°F), poise, maximum	T 202	1000	2000	4000	8000
Ductility, 25°C (77°F), 5 cm per min, cm-minimum	T 51	100[a]	100	75	75

Note: This specification may be used as an alternate for furnishing asphalt cements to the state of Oregon based on viscosity-graded asphalt cement at 140°F (60°C) on original asphalt. For asphalt containing an antistripping additive, requirements will be extended 5 percent for all characteristics except solubility in trichloroethylene.

[a]If ductility is less than 100, material will be accepted if ductility at 15.6°C (60°F) is 100 minimum.

TABLE 5 OSHD Standard Specifications for Asphalt Cements—Penetration Graded

Characteristic	AASHTO Test Method	Penetration Grade 40-50	60-70	85-100	120-150	200-300
Penetration of original sample at 77°F, 100 g, 5 sec	T 49	40-50	60-70	85-100	120-150	200-300
Flash point, Pensky-Martens closed tester, °F, minimum	T 73	460	450	440	425	400
Penetration ratio[a]	T 49	25	25	25	25	25
Viscosity, kinematic at 275°F, centistokes	T 201	240-860	200-650	170-520	140-420	100-300
Solubility in trichloroethylene, % minimum	T 44	99.0	99.0	99.0	99.0	99.0
Thin film-oven test	T 179					
Loss in weight, % maximum		0.75	0.80	0.85	1.00	1.50
Penetration of residue (at 77°F, 100 g, 5 sec), % of original penetration, minimum	T 49	52	50	47	44	40
Ductility of residue at 77°F, cm, minimum	T 51	50	50	75	75	75

Note: This specification may be used as an alternate for furnishing asphalt cement to the state of Oregon based on penetration-graded asphalt cement at 77°F (25°C) on original asphalt. For asphalt containing an antistripping additive, requirements will be extended 5 percent for all characteristics except solubility in trichloroethylene.

[a][(penetration 39.2°F, 200 g, 60 sec)/(penetration 77°F, 100 g, 5 sec)] x 100 min.

tially, aging control by penetration limits the reduction in penetration from 40 to 50 percent of original penetration, whereas control by viscosity limits the increase in viscosity to within a fourfold increase.

A comparison of the four specifications with regard to consistency values is best accomplished by plotting them together for initial and aged properties where possible, as shown in Figures 3 and 4. Figure 3 shows aged viscosities plotted for AR, AR-W, and AC specifications, from which it is clear that there can be a distinct relation between AC and AR grades. For example, AC-10 corresponds to AR4000W. For original asphalt properties, each specification involves a penetration at 25°C (77°F) and, for AC and Pen grades, viscosity limits at 135°C (275°F). These are plotted in Figure 4, which shows significant differences between the various grades. For example, AC-20 is closer to AR4000 than is AC-10, which does however correspond closely with AR-4000W. These differences are due to the differences in the minimum penetration specified with each system. In particular, the AR and AR-W grades, which are nominally the same, have different minima, resulting in different temperature susceptibilities.

Other Properties

Requirements for flash point and loss in weight after aging limit the amount and type of volatile materials allowed in an asphalt, which must be con-

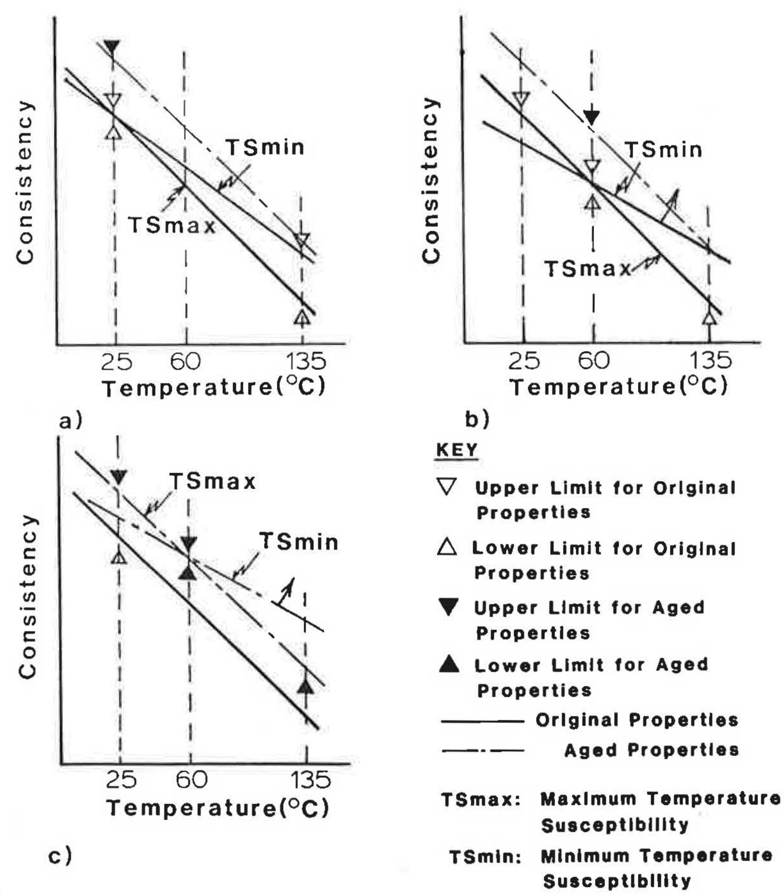

FIGURE 2 Illustration of consistency temperature susceptibility and aging control in each grading system: (a) penetration grading, (b) AC grading, and (c) AR and AR-W grading.

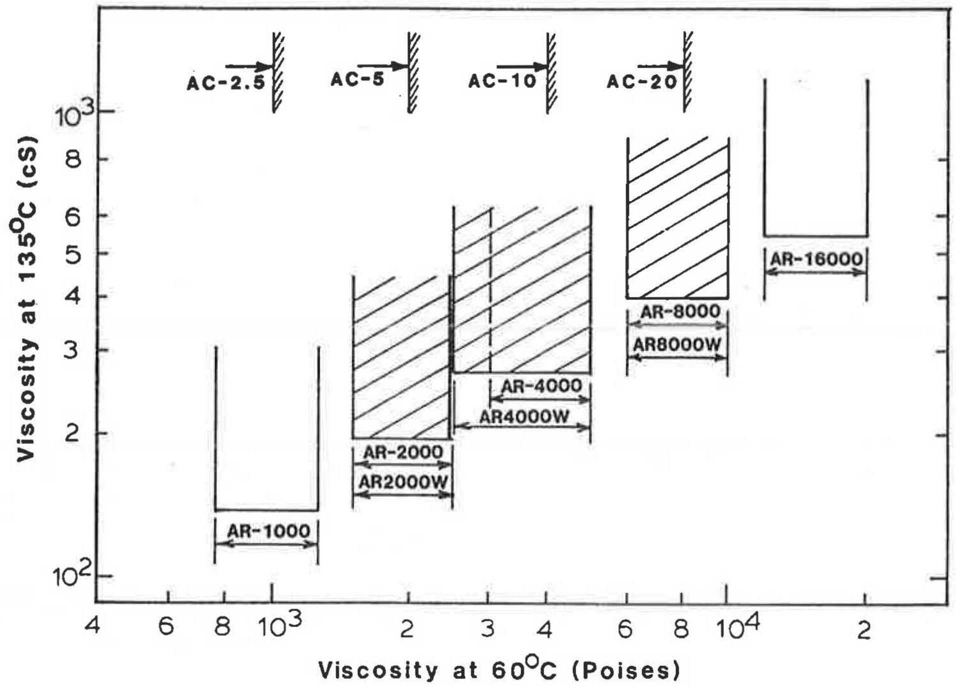

FIGURE 3 Viscosity limits for AC and AR grades after aging.

trolled from a safety standpoint and to limit adverse effects on asphalt performance. Ductility and purity (solubility in trichlorethylene) are important characteristics to control and relate to adhesion and cementing properties. Examination of Tables 2-5 shows that all four specifications use the same purity test [AASHTO T44-81 (4)], and for all grades, a minimum of 99 percent solubility is required. Also, each specification uses a ductility test [AASHTO T51-81 (4)], at 25°C (77°F) on the residue after aging, but the minimum requirements vary. The AR and AC specifications both require a ductility test at 15.6°C (60°F) if the requirement at 25°C is not met, and the AR-W specification requires a minimum ductility at 7°C (45°F). The loss in weight requirement is included only in the Oregon AR and Pen specifications and is identical for equivalent grades. Finally, the Oregon AR and Pen specifications use the Pensky-Martens closed cup tester [AASHTO T73-81 (4)] for flash point determination

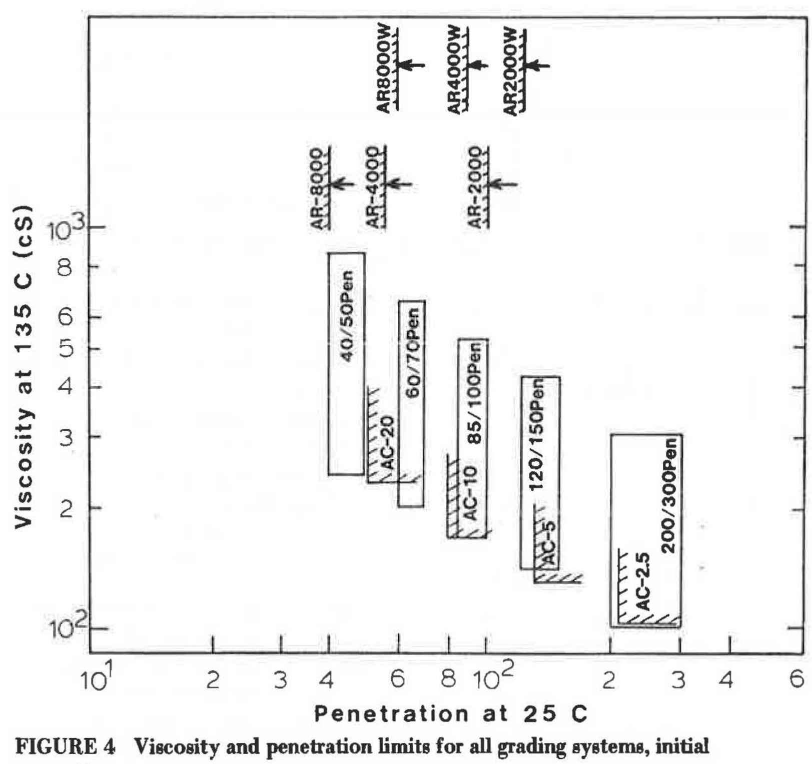

FIGURE 4 Viscosity and penetration limits for all grading systems, initial properties.

instead of the Cleveland open cup [AASHTO T48-81 (4)].

Comparison with National Specifications

None of the Oregon specifications are the same as any of the AASHTO specifications (M226-80 for viscosity-graded asphalts, M20-70 for penetration graded) or ASTM specifications [D3381-81 for viscosity graded, D946-82 for penetration graded (5)], which are essentially the same. A summary of the differences, which are similar to those discussed in previous sections, is given in Table 6.

USE OF OREGON SPECIFICATIONS

Since the 1970s, Oregon has used at least 1 million tons of hot mix per year and the current usage is about 2 million tons. At an average of 6 percent asphalt content, current use of asphalt cements is about 100,000 tons per year. The State Highways Division does a specification compliance test (complete test) for every job that uses more than 100 tons of asphalt cement. In addition, one identification test is required for each 100 tons of asphalt used and one complete test for each 25,000 tons of mix. Each test requires the supply of a quart of asphalt from the paving plant asphalt tank supply line.

Oregon State University is developing a computerized data base of asphalt properties obtained from the complete tests because the amount of data collected is substantial. To date, data from January 1, 1981, through July 1984 have been processed. A sample page of output is shown in Figure 5 for AR-4000W asphalt cements from one supplier. The total output for the period from January 1, 1981, to July 31, 1984, comprised tests on 376 separate samples.

The distribution among grades of asphalts supplied since January 1, 1981, is given in Table 7 for each producer. These results illustrate the dynamic nature of the supply with the number of suppliers varying and the distribution of the grades changing each year. The AR-W specification has been the most commonly used and the use of the AC specification is increasing. Use of penetration-graded asphalts has been very low, less than 2 percent in 1982 and none in any other year. There is currently no use of AR-8000 grade that has been completely replaced by AC-20. This is not necessarily replacing like with like because the AC-20 usually has a lower viscosity at 60°C after aging than does the AR-8000.

TABLE 6 Differences Among Oregon, AASHTO, and ASTM Specifications

Oregon Specification	AASHTO & ASTM Specification	Differences
AR	AASHTO M226-80, Table 3	Nomenclature is different (e.g., Oregon uses AR4000, AASHTO uses AR-40) Oregon includes the maximum loss on aging requirement (see Table 2); AASHTO has no such requirement Oregon requires the Pensky-Martens closed tester for flash point; AASHTO requires the Cleveland open cup
	ASTM D3381-81, Table 3	Differences are the same as for the AASHTO specifications, except that there is no difference in nomenclature
AR-W	AASHTO M226-80, Table 3	Nomenclature differs, as for AR grades Oregon uses only three grades; AASHTO uses five grades The range of viscosity of 60°C (140°F) on RTFO residue is different for the AR4000W grade The minimum penetrations are higher for each of the AR-W grades The AR-W grade has the additional ductility requirement at 7°C (45°F)
	ASTM D3381-81, Table 3	Differences are the same as for the AASHTO specifications, except for nomenclature
AC	AASHTO M226-80, Table 1	Oregon specifies only four grades; AASHTO specifies five AASHTO specifies that the thin film oven test be used for aging, whereas Oregon specifies the rolling thin film oven Minimum penetrations are higher in the Oregon specifications Minimum viscosities at 135°C (275°F) are higher in the Oregon specifications AASHTO includes an optional spot test; Oregon includes none
	ASTM D3381-81, Table 1	Differences are the same as noted for the AASHTO specifications except that ASTM does not include a spot test
PEN	AASHTO, M20-70	Oregon specifies the use of the Pensky-Martens closed test; AASHTO specifies the Cleveland open cup Ductility requirements are different Loss on heating requirements differ slightly Penetration of residue requirements differ Oregon includes a penetration ratio for tests at 25°C and 4°C; AASHTO has none Oregon includes a range of kinematic viscosity AASHTO includes an optional spot test; Oregon does not
	ASTM D946-82	Differences are similar to those for AASHTO, but those for retained penetration are different and there is no optional spot test

EFFECTS OF PROLIFERATION OF SPECIFICATIONS

Engineering Properties

As demonstrated in previous sections, there are significant differences between the four alternate specifications with respect to consistency and other properties. Because there has been little use of penetration-graded asphalts, there are really only three major specification types used in Oregon. Frequent changes in the specifications and in the producers supplying asphalts result in frequent changes in the properties of asphalts, as do alternate specifications. A typical problem is that the temperature susceptibility of the AR and AC grades can be higher than that of the AR-W grades. Another is that an asphalt can be quite close to meeting both AR-2000 and AR-4000W specifications but considerably different from an AR-4000 asphalt. Hence, identifying asphalts with certain typical properties according to similar nomenclature can be extremely erroneous.

Some examples to illustrate possible problems are shown in Figures 6 and 7. Figure 6 shows the consistency values before and after aging for three different samples of AR-4000. The asphalt shown in Figure 6a meets the AR-4000, AC-20, and 40/50 Pen specifications, whereas that in Figure 6b meets the AR-4000, AR-4000W, AC-10, and 120/150 Pen specifications, and that in Figure 6C meets the AR-4000, AC-10, and 85/100 Pen specifications. These differences are due to the differences in temperature susceptibility of the asphalts. This phenomenon can also result in asphalts that meet different AR specifications all being quite close to one grade, based on the penetration grading system, as shown in Figure 7. Some of these overlaps between specifications could be eliminated by including maximum and minimum consistency limits at more than one temperature so that temperature susceptibility could be controlled. This would also serve to control the properties of

TABLE OF ASPHALT PROPERTIES COLLECTED
BY THE OREGON STATE HIGHWAYS DIVISION
(GROUPED BY SPECIFICATION/GRADE/DATE)

BRAND: [redacted]

DATE	LAB#	SPEC/GRD	FLASH	SOLUB	PEN (DEG F) (77)	PEN (DEG F) (39)	PEN RATIO	LOSS	KINEMATIC VISCOSITY initial	/ aged	ABSOLUTE VISCOSITY initial	/ aged	RESIDUE PEN	RESIDUE %ORIG	DUCTILITY (77)	DUCTILITY (45)
3/26/81	3585	ARW 4	520	99.97	116	39	34	1.08	393	/ 651	1258	/ 4168	56	48	100	40
3/26/81	3632	ARW 4	475	99.93	123	43	35	1.12	396	/ 685	1247	/ 4496	62	50	100	38
3/31/81	1480	ARW 4	480	99.87	110	37	34	1.12	396	/ 697	1400	/ 4734	56	51	100	40
4/ 9/81	3519	ARW 4	510	99.95	123	39	32	1.27	396	/ 718	1257	/ 4775	58	47	100	48
4/14/81	4270	ARW 4	595	99.95	71	22	31	.47	400	/ 579	1751	/ 4444	40	56	100	15
4/30/81	4677	ARW 4	600	99.62	86	25	29	.79	360	/ 562	1416	/ 3935	44	51	100	19
5/11/81	5446	ARW 4	575	99.94	82	25	30	.59	360	/ 536	1471	/ 3724	48	59	100	29
6/ 2/81	6834	ARW 4	530	99.95	82	25	30	.63	358	/ 527	1405	/ 3564	46	56	100	22
6/ 2/81	7710	ARW 4	600	99.99	79	21	27	.56	355	/ 542	1434	/ 3780	45	57	0	0
6/ 2/81	7016	ARW 4	560	99.98	81	23	28	.48	355	/ 522	1358	/ 3340	48	59	100	0
7/ 1/81	8398	ARW 4	555	99.97	82	25	27	.85	349	/ 564	1279	/ 3818	48	52	0	0
7/31/81	9253	ARW 4	555	99.99	92	26	32	.44	354	/ 501	1403	/ 3279	47	57	100	36
8/ 4/81	9322	ARW 4	565	99.99	77	21	27	.62	348	/ 498	1427	/ 3477	46	60	100	31
8/ 4/81	9323	ARW 4	560	99.97	87	27	31	.68	337	/ 515	1315	/ 3324	43	49	100	23
8/ 4/81	10344	ARW 4	560	99.99	81	28	35	.72	318	/ 498	1307	/ 3870	41	51	100	19
8/ 6/81	10703	ARW 4	580	99.95	83	25	30	.58	327	/ 498	1284	/ 3409	45	54	100	25
8/ 6/81	10709	ARW 4	575	99.96	85	25	29	.66	294	/ 458	1162	/ 3118	45	53	100	22
9/ 3/81	12367	ARW 4	530	99.21	86	22	26	.89	260	/ 396	1138	/ 3151	42	49	100	19
9/ 8/81	11632	ARW 4	545	99.77	92	28	34	.93	283	/ 433	1144	/ 3099	43	52	100	15
9/ 8/81	12609	ARW 4	555	99.85	85	23	30	.89	276	/ 458	1132	/ 3262	43	52	100	21
9/ 8/81	11796	ARW 4	540	99.54	87	22	25	.89	301	/ 448	1211	/ 3838	41	47	100	13
9/ 8/81	12377	ARW 4	555	99.92	79	23	29	.98	301	/ 418	1167	/ 2856	45	57	100	21
9/ 8/81	12172	ARW 4	570	99.58	83	24	29	.94	282	/ 441	1157	/ 3656	42	51	100	16
9/ 8/81	13285	ARW 4	545	99.95	75	20	27	1.03	260	/ 485	1146	/ 3079	40	53	100	19
9/ 8/81	12570	ARW 4	550	99.89	84	23	27	.86	308	/ 457	1120	/ 3081	46	55	100	20
9/ 8/81	12827	ARW 4	555	99.92	77	19	25	.94	275	/ 412	1155	/ 3024	39	51	100	20
9/30/81	14042	ARW 4	555	99.96	75	17	23	1.12	264	/ 426	1225	/ 3633	34	45	100	13
9/30/81	14110	ARW 4	530	99.96	75	17	23	.99	263	/ 437	1281	/ 3550	38	52	100	14
10/ 9/81	14536	ARW 4	535	99.98	73	16	22	.50	262	/ 397	1284	/ 3409	37	51	100	16
10/14/81	14557	ARW 4	530	99.95	66	15	23	.89	272	/ 432	1400	/ 3707	35	53	100	13
10/21/81	15163	ARW 4	550	99.97	67	11	16	.96	275	/ 456	1436	/ 4513	32	48	100	11
10/21/81	15113	ARW 4	520	99.99	66	13	20	.92	284	/ 440	1454	/ 3880	35	53	100	12
10/22/81	15303	ARW 4	570	99.97	74	16	22	1.00	279	/ 451	1384	/ 3941	39	53	100	12
10/28/81	15321	ARW 4	575	99.98	67	16	24	.87	269	/ 443	1363	/ 3491	36	54	100	16
10/29/81	15610	ARW 4	545	99.98	74	16	22	.86	274	/ 448	1315	/ 3508	39	53	100	16
10/29/81	15378	ARW 4	500	99.98	65	13	23	1.13	224	/ 414	1429	/ 4036	31	48	100	12
10/29/81	15264	ARW 4	515	99.95	75	17	23	1.31	272	/ 468	1517	/ 4072	31	41	100	17
10/29/81	15519	ARW 4	510	99.97	75	18	24	1.01	270	/ 454	1505	/ 3824	31	41	100	16
10/32/81	15429	ARW 4	500	99.95	71	15	21	.95	280	/ 396	1371	/ 3647	34	48	100	12
				MEAN:	82.28	22.70	27.18	.86	312.78/	494.43	1326.68/	3608.75	42.63	51.78		
				ST DEV:	14.09	7.28	4.52	.22	49.05/	84.09	136.80/	475.33	7.52	4.32		

FIGURE 5 Sample output from computerized data base for asphalt properties.

TABLE 7 Distribution of Asphalts Supplied in Oregon by Grade and Producer, 1981-1984

		Number of Asphalt Samples Tested by Grade									
Year	Producer	AR2000	AR4000	AR8000	AR2000W	AR4000W	AR8000W	AC-10	AC-20	85/100PEN	Total
1981	A	–	–	–	–	–	–	–	–	–	–
	B	–	–	–	–	–	–	–	–	–	–
	C	2	–	1	–	39	–	–	–	–	42
	D	–	–	–	–	13	–	–	–	–	13
	E	–	1	–	–	–	–	–	–	–	1
	F	–	–	–	–	–	–	–	–	–	–
	G	–	–	–	–	–	–	–	–	–	–
	H	3	4	2	–	–	–	–	–	–	9
	I	–	–	–	–	–	–	–	–	–	–
	J	–	–	4	–	9	–	–	–	–	13
	K	–	–	–	–	–	–	–	–	–	–
	L	13	3	1	–	–	–	–	–	–	17
Total		18	8	8	0	61	0	0	0	0	95
1982	A	–	–	–	–	–	–	–	–	–	–
	B	–	–	–	–	–	–	1	–	2	3
	C	2	–	1	7	49	2	–	1	–	62
	D	–	–	–	–	4	1	–	–	–	5
	E	1	–	–	–	–	–	–	–	–	1
	F	–	1	1	–	–	–	1	1	–	4
	G	–	–	–	–	–	–	–	–	–	–
	H	2	7	1	–	–	–	–	–	–	10
	I	–	1	–	–	–	–	–	–	–	1
	J	–	–	1	1	1	–	–	–	–	3
	K	–	–	–	–	–	–	–	–	–	–
	L	6	6	1	–	–	–	–	–	–	13
Total		11	15	5	8	54	3	2	2	2	102
1983	A	–	–	–	–	–	–	–	–	–	–
	B	–	–	–	–	–	–	–	–	–	–
	C	–	–	–	7	60	2	–	11	–	80
	D	–	–	–	–	–	–	–	–	–	–
	E	–	–	–	–	–	–	–	–	–	–
	F	–	–	–	–	–	–	–	–	–	–
	G	–	–	–	–	2	–	–	–	–	2
	H	1	1	–	1	–	–	–	–	–	3
	I	1	–	–	–	–	–	–	–	–	1
	J	–	–	–	–	3	–	–	–	–	3
	K	–	–	–	–	2	–	–	–	–	2
	L	–	–	–	–	–	–	–	–	–	–
Total		2	1	0	8	67	2	0	11	0	91
1984	A	–	–	–	–	1	–	–	–	–	1
	B	–	–	–	–	–	–	–	–	–	–
	C	8	3	–	4	33	–	1	14	–	63
	D	–	–	–	–	–	–	–	–	–	–
	E	–	–	–	–	–	–	–	–	–	–
	F	1	1	–	–	–	–	–	–	–	2
	G	–	–	–	–	–	–	–	–	–	–
	H	–	–	–	–	1	–	–	–	–	1
	I	–	–	–	1	4	–	–	–	–	5
	J	–	–	–	–	1	–	–	–	–	1
	K	–	1	–	–	3	–	–	–	–	4
	L	–	1	–	–	–	–	–	–	–	1
Total		9	6	0	5	43	0	1	14	0	78

asphalts meeting a certain grade over a period of years, which has been a problem in the past in Oregon, as shown in Figure 8, which was reported by Wilson and Hicks (6). This problem is not as pronounced now, as shown in Figure 9, which gives average properties from one producer for two of the most commonly used asphalt grades in Oregon in the 1980s. It is interesting to note that this figure shows similar low temperature behavior for the aged AC-20 and AR-4000W asphalts, but the original properties are different and so are the temperature susceptibilities resulting in significant differences in consistency at high temperature. The penetration grading system (Table 5) does not have maximum and minimum limits for both penetration at 25°C (77°F) and viscosity at 135°C (275°F), but this is generous in the range of temperature susceptibility allowed.

The examples discussed and presented in Figures 6-9 illustrate the variability that can occur with asphalts of the same grade, or the similarity that can occur between different grades. Clearly, the properties of an asphalt should not be assumed, nor should they be associated with those typical of a particular grade. Such assumptions could lead to decisions to make inappropriate use of an asphalt.

Control Testing

Because of the use of different specifications, a greater variety of testing procedures needs to be used in routine control testing. For example, not all specifications require initial and aged consistency values at each of the three usual temperatures, and different flash tests are used. This requires more investment in apparatus and more experienced technicians.

One effect in Oregon has been that some tests that are not needed to verify the grade are carried out routinely, such as determination of the initial viscosities at 60°C (140°F) and 135°C (275°F) for AR grades. Although this results in more information being available about the asphalts, particularly complete definition of temperature susceptibility

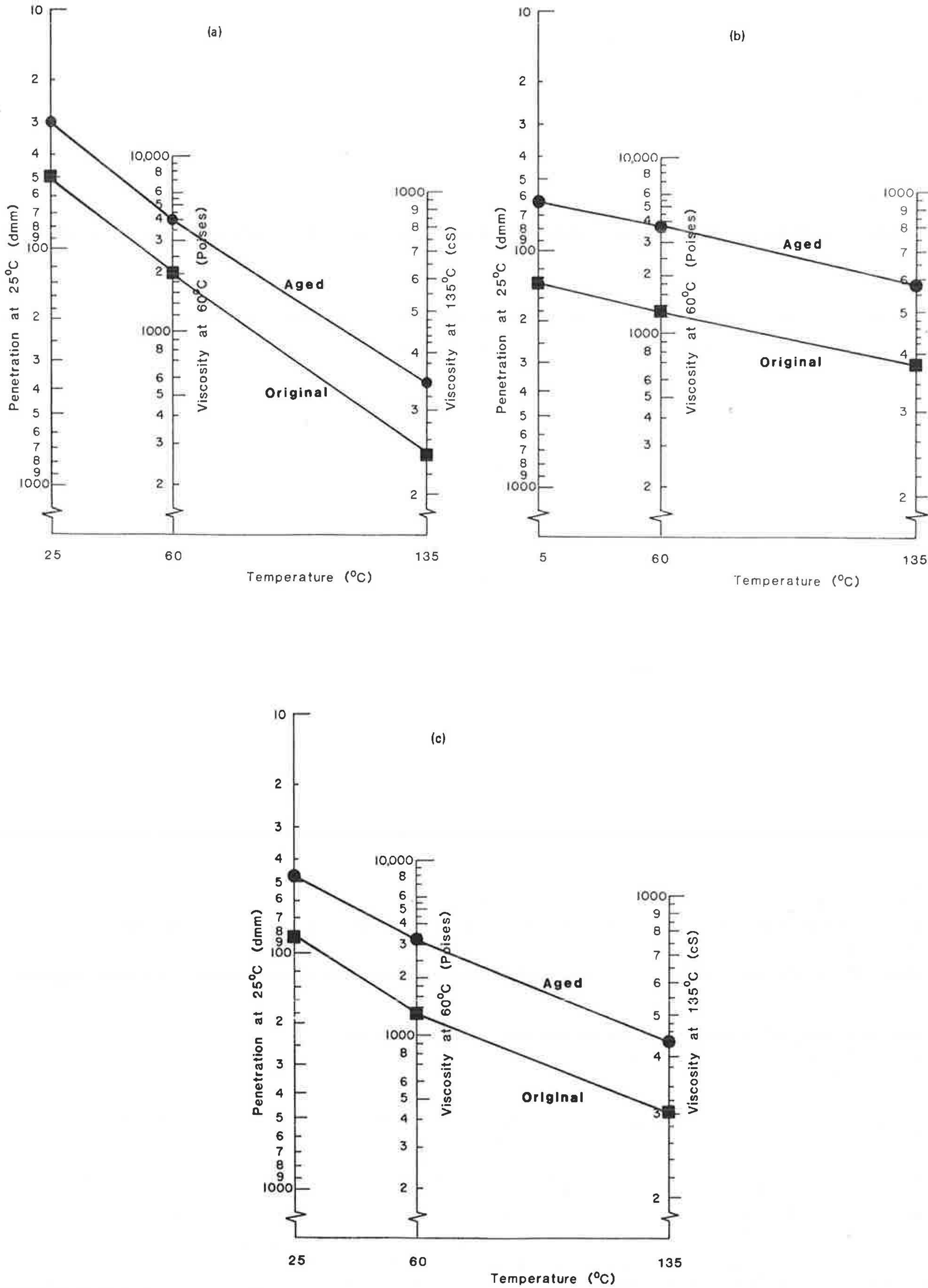

FIGURE 6 Variation in properties of AR-4000 asphalts supplied in Oregon, 1980: (a) Brand X—AR-4000, AC-20, 40/50 Pen, (b) Brand Y—AR-4000, AC-10, 120/150 Pen, and (c) Brand Z—AR-4000, AR-4000W, AC-10, 85/100 Pen.

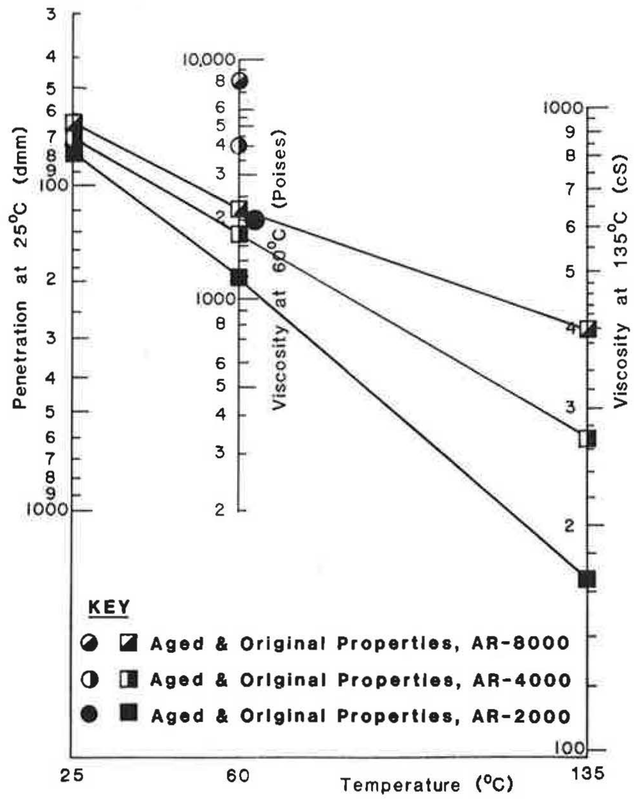

FIGURE 7 Comparison of properties of asphalts of different grades from one supplier, 1977.

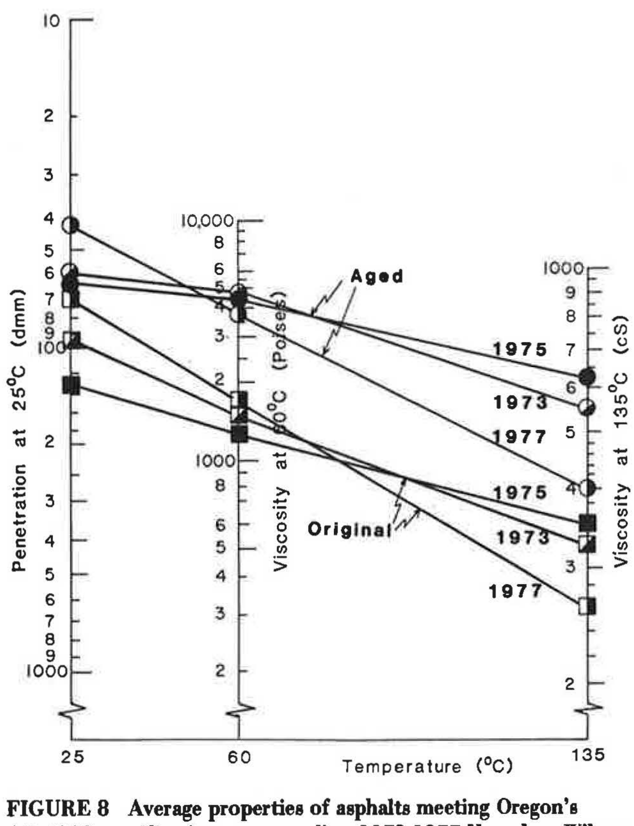

FIGURE 8 Average properties of asphalts meeting Oregon's AR-4000 specification, one supplier, 1973-1977 [based on Wilson and Hicks (6)].

before and after aging, most of the data are not used directly in controlling the use of asphalt. For example, the recommended mixing, laydown, and compaction temperatures could be given on the basis of such data, whereas only a laydown temperature is recommended. Unless these extra data are to be used,

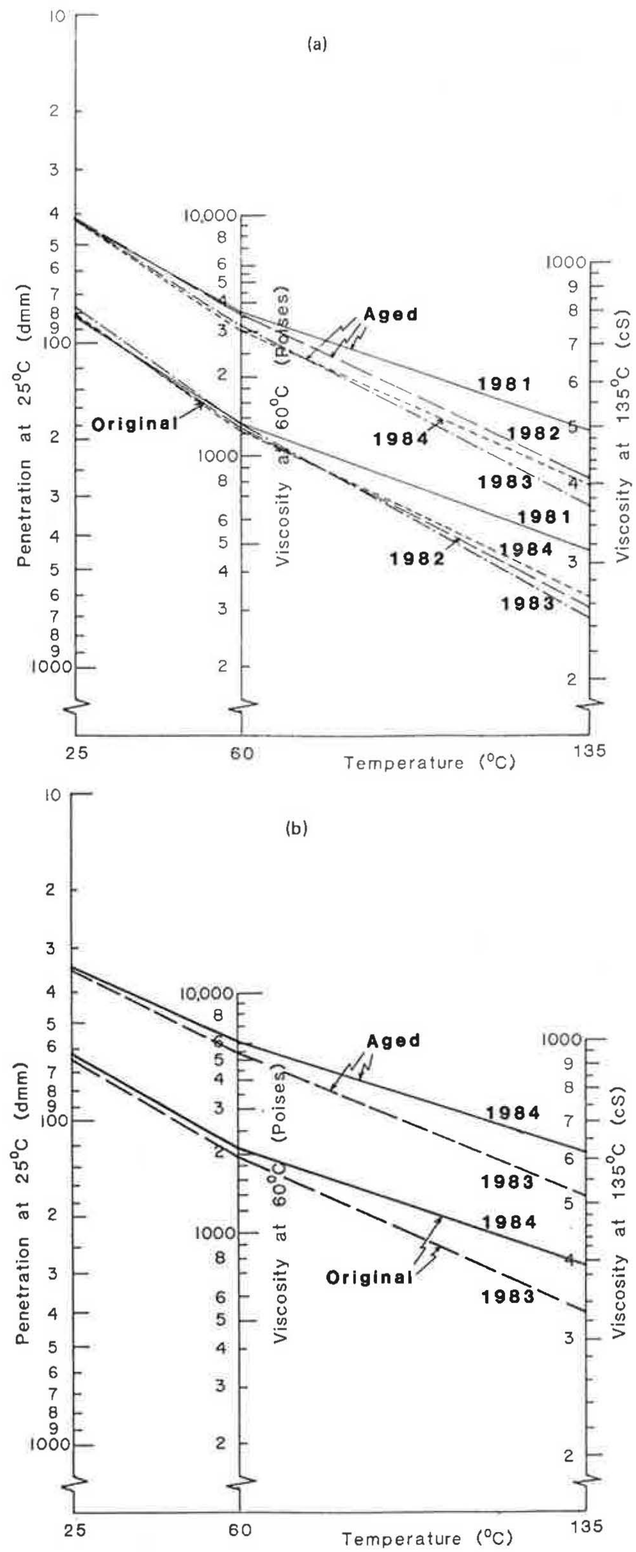

FIGURE 9 Average properties of asphalts from one supplier in the 1980s: (a) AR-4000W, 1981-1984 and (b) AC-20, 1983 and 1984.

a considerable amount of time is wasted in their collection.

Improved use of data is currently under investigation. If asphalt testing and mix design testing can be coordinated (a difficult problem in a busy construction season), optimum temperatures for mixing, laydown, and compaction could be recommended.

Field Performance of Mixtures

There have been problems associated with the use of drum mixers, including less hardening of asphalt compared to batch mixes. The hardening (or aging) problem in drum mixers has been addressed by Lund and Wilson (7), who presented a method of controlling hardening during the mixing process. Their study indicated that problems were always encountered in projects where the amount of hardening during construction, as assessed by a "C" factor, was less than 30 percent. The C factor is defined as follows:

$$C = [(R - A)/(B - A)] \times 100 \text{ percent}$$

where

- A = absolute viscosity of the original asphalt,
- B = absolute viscosity of the RTFO residue of the original asphalt, and
- R = absolute viscosity of the asphalt recovered from the mixture.

The average C factor determined was 54 percent, which indicates that the asphalt is typically in a condition midway between that implied by specifications that grade according to original or aged properties. This tends to give more confidence in specifications based on original properties because the aged properties achieved by the RTFC are rarely achieved in the short term in the field.

The lower hardening usually associated with drum mixers is principally due to lower mixing temperatures (7-9) compared to batch plants. These lower temperatures may also result in lower densities, as observed by Von Quintus and Kennedy (10), and subsequent higher field aging that might occur in such circumstances. It is obvious that adequate control of temperatures for mixing, laydown, and compaction could alleviate the lack-of-aging problems during construction or the high aging problem after construction. The recently published NCHRP Reports 268 and 269 (8,9) provide excellent information on the effects of temperature susceptibility variations of asphalt cements. In particular, the effects on mixing and compaction temperatures are illustrated. For example, it is shown that typical variations of properties for AC-20 asphalts in one market area could change optimum mixing and compaction temperatures by about 20°C (36°F) during one construction season. Similar information could be derived from the data shown in Figure 5, where the variability of the properties would cause the optimum mixing and compaction temperature to vary by about 15°C for the period the data represent.

Variability of asphalt properties is more likely when a variety of specifications is in use and, hence, it is even more important to use the data from the control testing of asphalt cements in the control of mixture production and in paving. Figure 10 shows a bitumen test data chart (11) that has lines representing the typical extremes of aged properties of AR-4000W asphalts used in Oregon in 1 year. Work is in progress (12) to establish viscosities appropriate to each phase of construction for each type of plant so that the data from routine as-

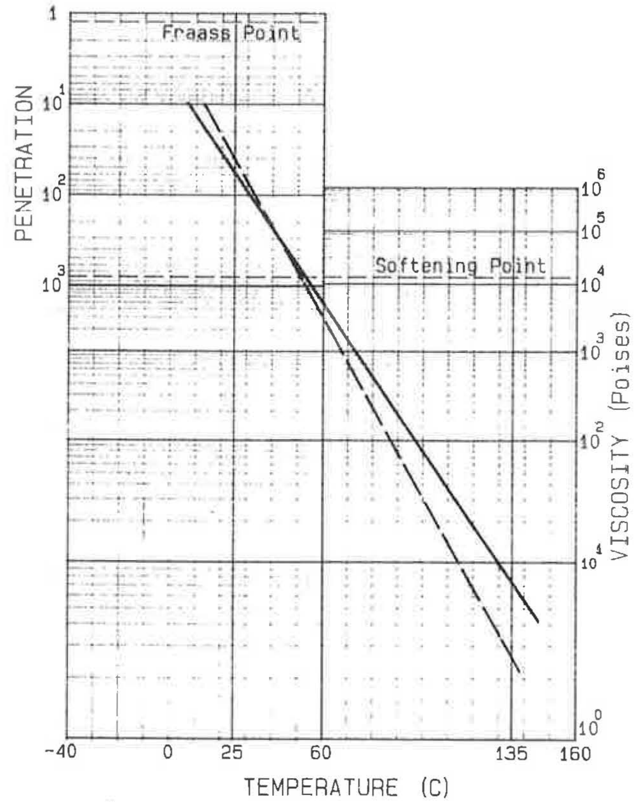

FIGURE 10 Bitumen test data chart showing seasonal variation in aged asphalt properties (AR-4000W).

phalt tests can be used with such a chart to recommend appropriate mixture temperatures during each phase. This chart also has the advantage that all consistencies (penetrations and viscosities) can be plotted and the entire range of performance evaluated.

General Comments

Specification proliferation in Oregon has been the result of supply and demand forces and of attempts to improve the performance of asphalt mixtures. The proliferation has occurred during a significant period with respect to some other factors. The oil embargo of 1973 led to significant changes in the supply of asphalt. Consequently, the product tended to vary somewhat in the following years. At the same time, drum mixers were introduced and their use is now comparable with that of batch mixers in Oregon. There have been problems associated with their use (6), as discussed earlier.

Examination of the information presented in this paper suggests that proliferation breeds proliferation. Smaller producers of asphalt struggle to supply asphalts that meet the different specifications required by different agencies. If the specifications were uniform, their options would be much more flexible. Consequently, there have been many changes in the producers supplying asphalt as indicated in Table 7. Only the producer supplying the largest amount of asphalt has been a constant force during the last 4 years. The introduction of AC and Pen grades was mostly due to an attempt to broaden sources of supply, which may help the smaller suppliers.

An irony of the proliferation is that although at present few people have a complete understanding of all the nuances of the specifications and the properties of asphalts that meet them, the confusion should ultimately lead to order. It is clear that Oregon's engineers need comprehensive training to improve their understanding of asphalt behavior, and indeed this has already been initiated (1), prompted by the confusion experienced by many because of the specification proliferation. This should ultimately result in improved use of asphalt cements. Therefore, there are some positive aspects to the proliferation.

Finally, the question of the adequacy of the various specifications should be raised. Perhaps with a thorough understanding of each current specification and the alternate options available, engineers will be able to select an asphalt most appropriate for a given situation with greater confidence than if just one of the current specifications were in use. In effect, various options for temperature susceptibility occur with the current situation. No one specification controls this property closely, even though it probably has the most influence on the performance of the asphalt and asphalt mixtures. Routine testing of asphalts provides sufficient data to define temperature susceptibility, and, as mentioned previously, this information could be better used by supplying recommended temperatures for both the mix design and the construction processes.

CONCLUSIONS

Major conclusions from the information presented in this paper follow:

1. Oregon State Highway Division is the only state agency in the United States to use AR-, AC-, and penetration-graded specifications.
2. There is little uniformity in asphalt specifications among the Pacific Coast states.
3. The proliferation of specifications is due to attempts to improve the supply of asphalts and to the performance of mixtures in Oregon.
4. There can be significant differences in properties of asphalt cements within the same specification grade, or quite similar properties of those produced to different specifications.
5. Current specifications do not provide much control of temperature susceptibility.
6. The data obtained for routine specification testing of asphalt cements could be better used to supply recommended mixing and compaction temperatures for mix designs and construction.

ACKNOWLEDGMENTS

Some of the data presented in this paper were provided by Oregon Department of Transportation Highway Division. The authors are grateful to Doug Eakin for his help in supplying these data. They are also grateful to Nancy Brickman whose low temperature susceptibility was an asset in typing this paper.

The opinions expressed in this paper are those of the authors and not of the Oregon State Highway Division.

REFERENCES

1. Asphalt Composition, Manufacture and Performance. Chevron Research Company Seminar, Salem, Ore., June 27-28, 1984.
2. Standard Specifications for Transportation Materials and Methods of Sampling and Testing, Part 1: Specifications, 13th ed. AASHTO, Washington, D.C., July 1982.
3. Minutes of Meetings. Pacific Coast Conference on Asphalt Specifications. San Francisco, Calif., 1956-1984.
4. Standard Specifications for Transportation Materials and Methods of Sampling and Testing, Part 2: Tests, 13th ed. AASHTO, Washington, D.C., July 1982.
5. Annual Book of ASTM Standards, Section 4, Vol. 4.03, Road and Paving Materials: Travelled Surface Characteristics. ASTM, Philadelphia, Pa., 1983.
6. J.E. Wilson and R.G. Hicks. Evaluation of Construction and Short-Term Performance Problems in Oregon. Proc., Association of Asphalt Paving Technologists, Vol. 48, Feb. 1979.
7. J.W. Lund and J.E. Wilson. Evaluation of Asphalt Aging in Hot Mix Plants. Proc., Association of Asphalt Paving Technologists, Vol. 53, April 1984.
8. J.W. Button, D.N. Little, B.M. Galloway, and J.A. Epps. Influence of Asphalt Temperature Susceptibility on Pavement Construction and Performance. NCHRP Report 268. TRB, National Research Council, Washington, D.C., Dec. 1983.
9. J.A. Epps, J.W. Button, and B.M. Galloway. Paving with Asphalt Cements Produced in the 1980's. NCHRP Report 269. TRB, National Research Council, Washington, D.C., Dec. 1983.
10. H.L. Von Quintus and T.W. Kennedy. Drum Mix Versus Batch Plants: Pavement Performance Comparisons. Proc., Association of Asphalt Paving Technologists, Vol. 52, Feb. 1983.
11. W. Heukelom. An Improved Method of Characterizing Asphaltic Bitumens with the Aid of Their Mechanical Properties. Proc., Association of Asphalt Paving Technologists, Vol. 42, Feb. 1973.
12. L.E. Santucci, D.D. Allen, and R.L. Coats. The Effects of Moisture and Compaction on the Quality of Asphalt Pavements. Submitted for presentation at the Annual Meeting of the Association of Asphalt Paving Technologists, San Antonio, Tex., Feb. 1985.

Publication of this paper sponsored by Committee on Characteristics of Bituminous Materials.