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# Variability in Temperature Susceptibility of Asphalt Cement

*An NCHRP staff digest of the essential findings from the interim report on NCHRP Project 1-20, "Influence of Asphalt Temperature Susceptibility on Pavement Construction and Performance," by J.W. Button, J.A. Epps, D.N. Little, and B.M. Gallaway, Texas Transportation Institute, College Station, Texas*

## THE PROBLEM AND THE SOLUTION TO IT

On the basis of an AASHTO survey and reports of field experience, there appears to be an increase in the occurrence of such problems as compaction difficulties, excessive displacement under traffic, thermal cracking, raveling, and stripping of asphaltic concrete pavements placed in recent years. This development results in higher maintenance and rehabilitation costs, shorter service life, and criticism by the public. Although asphalt cement properties, aggregate characteristics, mixture design, and construction techniques are among the factors believed to influence the problem, the Texas Transportation Institute of Texas A&M University was limited in carrying out Project 1-20 to study only the influence of asphalt cement's temperature susceptibility on the placement, compaction, and short-term performance of asphaltic concrete pavements. The project was established as a two-phased endeavor, the first phase of which concluded with submission of an interim report; the second of which is now under way.

For the purposes of this study, the temperature susceptibility of an asphalt cement was defined as the rate of change in viscosity, or other measure of asphalt consistency, with temperature. On the basis of a thorough analysis of available data from other studies of the past 40 years on asphalt cement's characteristics, plus a limited amount of laboratory testing on recently obtained asphalt samples, it was determined that, in general, the range of values of temperature susceptibility and other physical properties have not changed appreciably over the years. However, there does appear to be an increase in the short-term variability of these properties from a given producer or sources of supply. Any correlation between variability of asphalt cement's properties, including temperature susceptibility, and field construction problems is for the most part masked by variability in aggregate properties and construction control techniques. Consequently, advance identification of potential field construction and short-term performance problems should be based on mixture tests rather than on asphalt cement's properties.

## FINDINGS

Temperature susceptibility of asphalt cement is an important control parameter during the mixing, placing, compaction, and performance of asphaltic concrete. Early methods of measuring this characteristic involved the use of needle penetration devices. Viscosity began to appear in specifications in the 1920's. Today's specifications often make use of viscosity and penetration measurements at 140 F and 275 F both before and after laboratory aging. Recent testing equipment developments have made low temperature (20 F) viscosity measurements possible, adding to the ability to determine temperature susceptibility of asphalt cements. There does not appear to be one generally accepted measurement method for this particular characteristic of asphalts; however, the report describes several methods that have been used.

The primary task of the study--to collect and analyze temperature susceptibility data--was accomplished by (1) the review and summarization of data from several published reports by such agencies as The Pennsylvania State University, the Federal Highway Administration, the Asphalt Institute, and several states; and (2) the laboratory testing of selected asphalt cements from individual refineries and field construction projects.

The published literature indicates that the physical properties, including temperature susceptibility, of asphalt cements produced in recent years have the same range of values as those produced in 1964 and during the 1965-1973 preembargo period. Mean values and their distributions for particular physical and chemical properties have varied over the years on a national and regional basis. However, the published literature contains little information on relationships between the variations in asphalt cement properties and pavement construction and performance problems.

Detailed asphalt test data were obtained from 5 states representing 23 refineries in all regions of the United States. A statistical analysis of the data indicates a significant variability with time of temperature susceptibility of the asphalts. This does not imply that the temperature susceptibility varied to such an extent that pavement construction and performance were affected.

In addition to the data that were available for analysis, 16 different asphalt cements were obtained from 10 refineries and tested in the laboratory to determine their rate of change in consistency with temperature. The asphalts were from refineries having good, poor, and intermediate reputations regarding asphalt-related construction difficulties. Test data for these asphalts are given in Table 1. In Figure 1, the data have been plotted with

Table 1. Properties of original asphalts.

| Asphalt Code | Grade | Viscosity | | | Penetration, dmm | | | R&B Softening Point °F (°C) |
|---|---|---|---|---|---|---|---|---|
| | | 77°F (25°C), Poises x $10^5$ | 140°F (60°C), Poises | 275°F (135°C), Poises | 77°F (25°F) 100 gm @ 5 sec | 39°F (4°C) 100 gm @ 5 sec | 39°F (4°C) 200 gm @ 60 sec | |
| A1 | AC-5 | 3.5 | 494 | 2.48 | 176 | 22 | 50 | 107 (41) |
| A2 | AC-10 | 10.3 | 1218 | 3.6 | 106 | 14 | 34 | 116 (47) |
| A3 | AC-20 | 35.0 | 2363 | 4.0 | 58 | 5 | 16 | 124 (51) |
| B1 | AR1000 | 3.2 | 556 | 1.3 | 131 | 8 | 38 | 105 (41) |
| B2 | AR2000 | 8.3 | 1037 | 1.8 | 85 | 5 | 22 | 112 (45) |
| B3 | AR4000 | 21.0 | 2142 | 2.4 | 50 | 1 | 8 | 120 (49) |
| C | AR2000 | 6.5 | 554 | 1.89 | 111 | 5 | 26 | 110 (43) |
| D | AC-20 | 37.0 | 2140 | 3.99 | 58 | 6 | 19 | 126 (52) |
| E | AR2000 | 24.0 | 736 | 1.83 | 60 | 4 | 14 | 124 (51) |
| F1 | AR4000 | 9.2 | 1571 | 3.55 | 80 | 8 | 23 | 116 (47) |
| F2 | AC-20 | 12.5 | 1717 | 3.47 | 75 | 7 | 25 | 118 (48) |
| H | AC-10 | 8.5 | 1124 | 5.33 | 106 | 8 | 24 | 116 (47) |
| J | 85-100 | 10.5 | 780 | 2.25 | 93 | 7 | 27 | 116 (47) |
| K | AR2000 | 3.6 | 810 | 2.57 | 143 | 18 | 52 | 111 (44) |
| L1 | AC-10 | 8.5 | 1036 | 3.2 | 115 | 11 | 30 | 108 (42) |
| L2 | AC-20 | 14.0 | 1705 | 3.6 | 80 | 9 | 21 | 121 (49) |

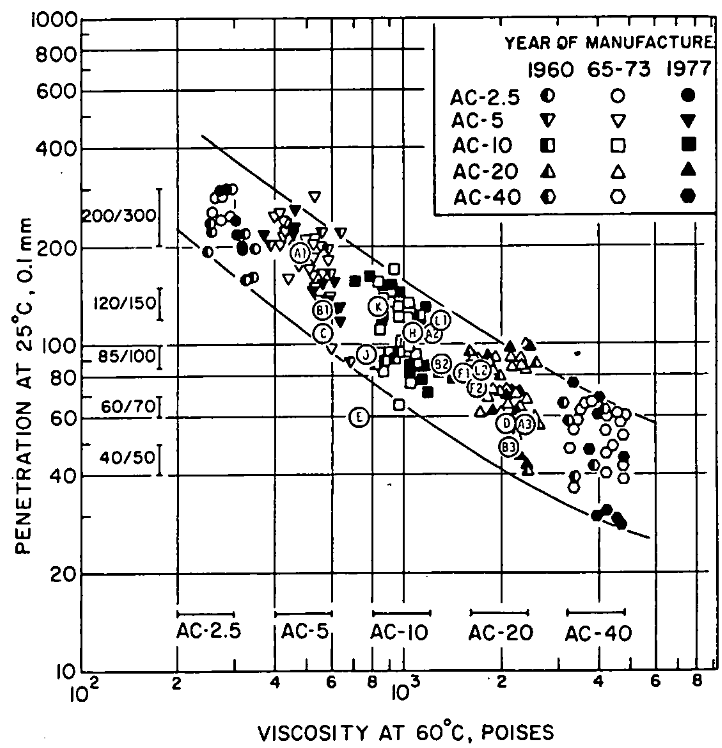


Figure 1. Relationship between viscosity at 140 F (60 C) and penetration at 77 F (25 C) for asphalt cements (after Puzinauskas (1)).

data for asphalts produced up to 20 years ago and presented in a report by V.P. Puzinauskas (1). With the exception of asphalt E, the relationships between viscosity at 140 F and penetration at 77 F are quite similar. Seven different methods were used to compute temperature susceptibility of original asphalts and TFOT- and RTFOT-aged asphalts for the 16 asphalt samples previously described. Figure 2 relates penetration-viscosity number (PVN) and viscosity-temperature susceptibility (VTS) of the 16 asphalts and the 68 asphalts tested by Puzinauskas (1). Fairly good correlation between these two parameters is indicated. The 16 new asphalts had lower value of PVN and VTS than those tested up to 20 years earlier. These tests also indicated that oven aging generally has an effect on the temperature susceptibility of asphalts but in an inconsistent manner. In some cases it was increased and in other cases it was decreased. TFOT and RTFOT aging resulted in the same change in temperature susceptibility of individual asphalts.

It was originally intended that asphalt samples would be obtained from paving projects experiencing placement difficulties and tested for determination of their characteristics. Because this plan did not work out, it was revised to that of obtaining pavement cores from projects already completed, with and without placement difficulties. Testing included the determination of properties of the cores as received and of the aggregates and asphalt cements extracted from the cores.

The data from the cores are very limited and generally indicate an interaction between aggregates, asphalt cements, and their mixtures. On the basis of discussions with state highway construction and materials engineers, the asphalts more highly susceptible to temperature are likely to be associated with difficulties in placement of asphaltic concrete pavements, but satisfactorily performing pavements can be built with these asphalts by making adjustments in mix design, placement temperature, and other construction techniques.

## APPLICATIONS

While the study has not yet produced any findings of major import to practice, the interim findings are useful in helping to identify and understand asphalt-related difficulties encountered in constructing asphaltic concrete pavements. Indications are that asphalt cements delivered to the job site today may be more variable than in previous years as regards temperature susceptibility, even though this and other characteristics are within specification limits. This variability results in a need for close monitoring of desired and actual mixing, placing, and compacting temperatures. Experienced construction and materials personnel should be able to determine the necessary adjustments on the job.

Continuation of the project by TTI involves further attempts to identify construction projects experiencing placement difficulties to exhaust all possibilities of carrying out the original first-phase plan. In any case, it is anticipated that the project's end product will be implementable guidelines that, when coupled with the experience of construction and materials personnel, will be useful to all field personnel in resolving the problems of variability in asphalt cement characteristics during mix design and placement.

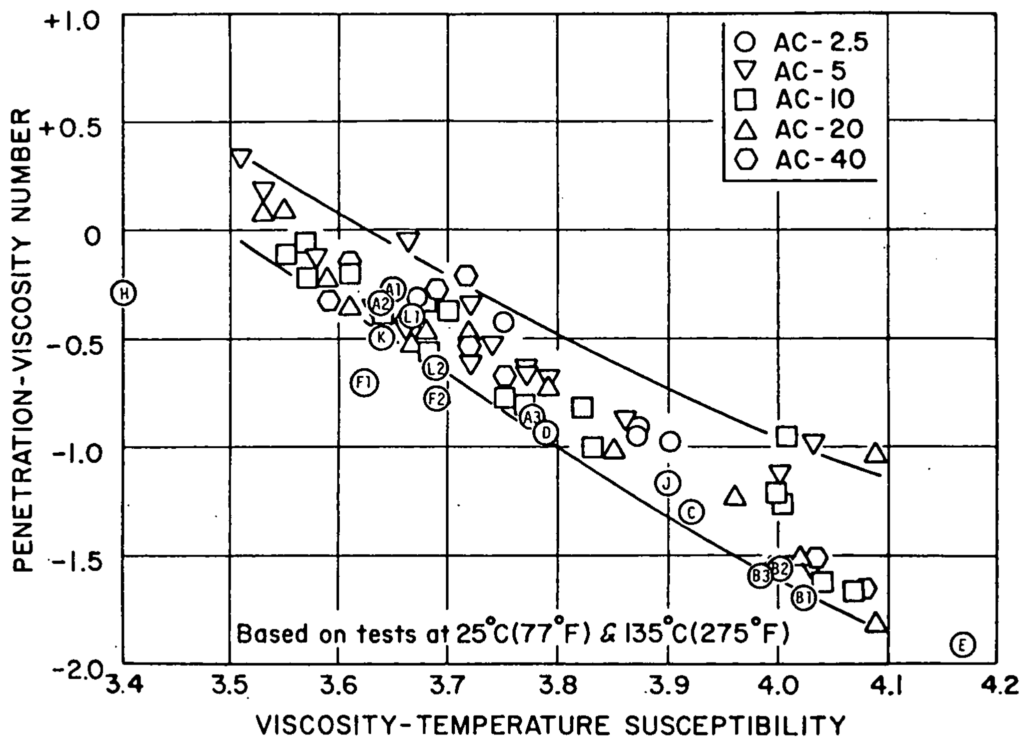


Figure 2. Relationship between viscosity-temperature susceptibility and PVN for asphalt cements (after Puzinauskas (1)).

## REFERENCES


1. Puzinauskas, V. P., "Properties of Asphalt Cements," Proceedings, Association of Asphalt Paving Technologists, Vol. 48, 1979.

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JAMES W HILL
RESEARCH SUPERVISOR

IDAHO TRANS DEPT DIV OF HWYS
P O BOX 7129 3311 W STATE ST
BOISE ID 83707