Changes in Asphalts

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ABSTRACT

A review of recently published literature indicates that changes in asphalts are of considerable concern to those responsible for designing, constructing, and managing pavements. Data indicate that the ranges of properties of asphalts have not changed significantly, but recent world petroleum supply and economic climate may have caused more rapid changes in asphalt from certain sources. New refining or manufacturing techniques may also affect asphalt properties, but these causes probably account for a smaller portion of reported changes than variations in feedstocks that are primarily petroleum crude oils. There appears to have been a statistically significant but small change to a population of more temperature-susceptible asphalts, which may have been a result of specification changes and greater use of high smoke point asphalts (that may generally have higher temperature susceptibilities) with the use of increased mixing temperatures in drum mixers. Preferred methods of measuring low temperature performance are through the use of low temperature consistency measurements. Chemical analyses reported to date have not correlated well with performance because of the complex nature of asphalts. The changes in asphalt properties with use of antistripping additives is discussed and some factors affecting paving construction and pavement performance, which may be perceived as changes in asphalts, are listed.

Do asphalts really change? This probably depends on what is perceived as the material called asphalt. To the extent that most asphalts are sold to meet an accepted specification, it might be said that asphalts do not change, only specifications change. However, to the contractor, engineer, supervisor, or laborer responsible for constructing an asphalt concrete pavement, the mixture does change. This mixture of about 95 percent aggregate and 5 percent asphalt does have different behaviors at times, and, because the mixture is generally black in appearance, it might appear logical to say that the asphalt has changed. Not only are the persons responsible for constructing the pavement concerned about possible changes in asphalts, but the persons responsible for the management of the pavements are concerned that these reported changes in asphalts may have some harmful effect on the pavement's performance. The literature abounds with articles on this subject of changes in asphalts and also confirms the significance of the subject to the industry.

The Asphalt Institute's laboratory conducted a comprehensive survey of 68 asphalt cements supplied from several different crude sources, manufacturers, and refineries in 1977. The results of their evaluations of these 1977 asphalts were reported by Puzinauskas at the 1979 Association of Asphalt Paving Technologists meeting (1) and compared with asphalts manufactured in 1960 and others manufactured from 1965 to 1973. Puzinauskas concluded from this work that asphalts did not differ substantially over these periods of time. However, he also concluded that asphalts, within a given grade, differ substantially in their properties but the magnitudes of these differences appear to be similar for the asphalts manufactured during the different time periods. Puzinauskas also concluded that (a) the source of parent oil from which the asphalt is produced and its method of manufacture affect the physical properties of the asphalt; (b) asphalts' response to heating is highly variable; (c) different methods used to evaluate temperature susceptibility correlate rather poorly; and (d) measurement of paving mixture properties may be a more rational approach than measurement of individual components to explain behavior in mixes.

Puzinauskas' work showed that the physical properties of asphalts have remained within the ranges experienced for many years and that the 1973 Arab oil embargo and other effects on crude supply did not significantly alter this range of physical properties. However, his work did show that if two asphalts of the same grade, but manufactured from different crude sources, were employed on the same job, significant differences in the physical properties of the asphalt on hot mixed aggregate could be experienced. Puzinauskas reported a range of thin film oven (TFO) heat aging indexes of 1.55 to 3.80 for the viscosity at 140°F of samples, which would have complied with the original 140°F viscosity range of 800 to 1,200 poises specified for AC-10. Assuming that the TFO test simulates the heat hardening that can be experienced when mixing at 325°F, a difference of 2,300 poises with a range of 1,422 to 3,722 poises of viscosity on the aggregate could have been experienced for the 15 different asphalts reported in the AC-10 range of original viscosity. Using the 275°F viscosity data from Puzinauskas' work, the ranges of TFO residue viscosity are 247 to 492 centistokes or differences of 323 centistokes for the AC-10 grade samples.

Considered individually, these numbers probably do not mean much, but they do indicate that the different heat hardening effects between sources may be of a similar magnitude to a grade change from the same source. Use of mixing temperatures of less than 325°F would lessen these differences for original grading systems, but then the problem occurs with residue grading systems. Although differences in manufacturing technique may have an effect, most single sources do not change their manufacturing techniques frequently; therefore, the largest single influence on the properties of an asphalt are the feedstocks used to produce the asphalt. For the most part, these feedstocks are crude oils. Some new solvent extraction resid refining processes, notably the ROSE process, have recently been developed. These processes may permit asphalt manufacture from crudes that have not previously been used to produce asphalt, but because the asphalts must meet commonly accepted specifications, their physical properties will probably not be outside the ranges of asphalts produced in the past.

Corbett (2) advised in 1980 that there were more than 1,500 different crude sources of which about 1,100 were being used in North America, and of these sources, about 260 were possibly suitable for the production of asphalts. The Oil and Gas Journal reported in 1983 that of 223 refineries in the United States, 78 (or 35 percent) report the production of asphalt (3). This would appear to confirm that in many refineries, more than one crude stream is used to produce asphalts. [The 78 refineries had a reported total use of 260 crudes (2,3).] It is also apparent that certain refineries may operate on the same crude source or sources for many years, and the properties of asphalts from this refinery may change little with time.

Anderson and Dukatz (4) reported in 1980 on a statistical evaluation of the properties of asphalts obtained by different laboratories from 1950 to 1980 with specific emphasis on changes in physical and chemical properties before and after the 1973 Arab oil embargo. They concluded that there were statistically significant differences in chemical and physical properties of asphalt sampled between 1950 and 1980, and that temperature susceptibility of the sampled asphalts increased over this same period. The methodologies of statistical comparison and the precision of the multi-laboratory data used in this study are the subject of much contention by asphalt technologists, especially regarding the significance of the chemical tests. These same authors (with Rosenberger) used these data, and data they had gained from additional samples during the interim, in a 1983 report (5) to conclude that except for an increase in temperature susceptibility, they did not measure any asphalt properties relating to a decrease in asphalt quality from 1950 to 1981. (This period included the time before and after the 1973 Arab oil embargo.) The conclusion by Anderson et al. that temperature susceptibility has changed is based on their calculations showing an increase in the average penetration-viscosity number (PVN) of -0.39 to -0.79 from 1950 to 1981. They do not believe this change warrants the inclusion of a PVN requirement in current general specifications, but they do believe some control of temperature susceptibility may be justified in regions of the country where thermal cracking may be a problem. They calculate that this difference in PVN may equate to a difference of 6°C (11°F) in limiting stiffness temperatures.

It is unfortunate that the data bank does not include penetration measurements at two temperatures so that the stiffness could be measured according to procedures reported by Gaw (6), which indicated that the PVN method is suitable only for predicting low temperature performance for asphalts for which the penetration-temperature and viscosity-temperature consistency relationship is linear. This is not the case with asphalts having wax contents greater than 2 percent and for air-blown asphalts. A procedure for predicting asphalt stiffness at low temperatures from penetration measurements at two different temperatures is recommended by the Asphalt Institute (7), especially if waxy or air-blown asphalts are involved such as could be expected from the large samplings involved in these studies.

The effect that changing of specifications from penetration grading systems in 1950 to largely viscosity-based systems by 1981 may have had on these reported changes is unknown. Temperature susceptibility was controlled in penetration-based specifications in some regions and not in others. For example, the Uniform Pacific Coast penetration grading system used before January 1974, contained a penetration ratio as well as a minimum viscosity at the 275°F requirement. Current AASHTO and ASTM penetration grading systems do not have controls on temperature susceptibility. Most viscosity grading systems that grade at 140°F do have controls on consistency at 77°F and viscosity at 275°F.

Button et al. (8) evaluated the effect of temperature susceptibility of asphalts on the tenderness of the pavements and concluded that highly temperature-susceptible asphalts have been related to tender pavements, but that both aggregate (grading, top size, particle shape, and particle surface characteristics) and the asphalt binder (viscosity, temperature susceptibility, and chemical make-up) contribute to tenderness.

The increased use of drum mixers has had an effect in increasing the average population of asphalts toward more temperature susceptibility by eliminating from use some of the low smoke point asphalts that also may have low temperature susceptibility. Asphalts represented by Corbett's (see elsewhere in this Record) crude type A would have high smoke points and perform quite satisfactorily from a blue smoke emissions standpoint when used in a drum mixer; however, many asphalts in crude type A tend to have high temperature susceptibilities. On the other hand, asphalts represented by Corbett's crude type E may have lower smoke points and their use may result in the generation of blue smoke emissions in drum mixers operating in the range of 300°F mixing temperatures. Therefore, use of drum mixers at high mixing temperatures--approximately 300°F or higher--may exclude use of many of the less temperature-susceptible group of asphalts represented by Corbett's crude type E in order to comply with air pollution control regulations.

The use of antistripping additives has been prevalent in many areas recently. Mixes using these additives may demonstrate tenderness due to the effect of the additives in lowering the original viscosity of the asphalt and the heat aging characteristics of the additive-asphalt mixture (9). This effect may be perceived as a change in the asphalt supply, especially in the many instances where the additives are required to be added by the asphalt supplier.

Two comprehensive studies (10,11) were conducted to determine, among other things, the procedures for accommodating or controlling temperature susceptibility of asphalts, assuming temperature susceptibility is a major problem. The results of this study are eagerly anticipated.

From a review of this literature, it becomes apparent that there have been no significant changes in the range of physical properties of asphalts over the past 30 years, and that the perceived belief that asphalts have changed is probably the result of differences in the temperature susceptibilities of asphalts produced from different crudes or blends of crudes as certain refineries make changes in their crude slates. Because the type of crude slate chosen by a refiner is generally an economic decision, tighter controls placed on the refiner in terms of restrictive asphalt specifications will, in all probability, have economic consequences. The controls applied, if any, should therefore be meaningful.

Relationships of performance with chemical tests may be found for a limited number of asphalts; however, the complex nature of all asphalts produced is such that generalized correlations have been found to be difficult to make. Perhaps this is aptly stated by Anderson et al. (5):

> A significant lesson to be learned from analyzing the massive amount of data in the files is that asphalt cement is a very complicated material, and it is not likely that its behavior will be pre-

dicted from one or two simplistic tests. Correlations made with limited data sets, data from a specific region, or data from a particular crude do not extrapolate with acceptable precision to large data sets as studied in this paper.

It is not intended here to reduce efforts to find good generalized correlations of any type of analysis with performance, but it should be understood that asphalt is very complex chemically and is also only a part of the paving system.

Perhaps, as suggested by Puzinauskas, more effort should be spent on how all aspects of the paving system affect performance of asphalt pavements. Because the mixture is black, the effect of other factors on performance may often be overlooked. Some factors affecting paving construction and pavement performance that may be perceived as changes in asphalts could be:

1. The effect of antistripping additives on asphalt consistency, temperature susceptibility, and hardening, especially during mixing.
2. The effect of mixing temperatures on asphalt consistency when combined with asphalts of different heat hardening characteristics, and the lack of understanding of the effect of mix temperature on mix consistency and its effect on placing and compaction characteristics of the mix.
3. The effect of insufficient aggregate gradation control and asphalt content.
4. The effect of mix characteristics of higher moisture contents sometimes permitted in field mixes that are not considered in the mix design, and the interaction of moisture and asphalt on compactive effort and performance.
5. The effect of different fuels and improperly adjusted burners that may leave unburned fuel in the mix.
6. The effect of the fine and coarse portion of fillers on the asphalt film consistency and durability.
7. The effect of the frequent use of low-cost rounded sands resulting in tender mixes that may be very sensitive to asphalt content.

A summary of the possible factors (real or perceived) affecting changes in asphalt follows:

1. Crude oil economics and availability,
2. Refining processing methods,
3. Specifications,
4. Low temperature performance requirements,
5. Antistrip additives,
6. Condensed fuels during aggregate heating,
7. Drum mixer blue smoke requirements,
8. Fine particulate management,
9. Mixing and laying mix temperatures,
10. Mix moisture contents, and
11. Oversanded mixes.

REFERENCES

1. V.P. Puzinauskas. Properties of Asphalt Cements. Proc., Association of Asphalt Paving Technologists, Vol. 48, 1979, pp. 646-710.
2. L.W. Corbett and H.E. Schweyer. Composition and Rheology Consideration in Age Hardening of Bitumen. Proc., Association of Asphalt Paving Technologists, Vol. 50, 1981, pp. 571-582.
3. Annual Refining Report. Oil and Gas Journal, Vol. 81, No. 12, March 21, 1983, pp. 132-150.
4. D.A. Anderson and E.L. Dukatz. Asphalt Properties and Composition: 1950-1980. Proc., Association of Asphalt Paving Technologists, Vol. 49, 1980, pp. 1-29.
5. D.A. Anderson, E.L. Dukatz, and J.L. Rosenberger. Properties of Asphalt Cement and Asphalt Concrete. Presented at meeting of the Association of Asphalt Paving Technologists, Feb. 28-March 2, 1983.
6. W.J. Gaw. The Measurement and Prediction of Asphalt Stiffness at Low and Intermediate Pavement Service Temperatures. Proc., Association of Asphalt Paving Technologists, Vol. 47, 1978, pp. 457-494.
7. The Asphalt Institute. Design Techniques to Minimize Low-Temperature Asphalt Pavement Transverse Cracking. Research Report 81-1, 1981.
8. J.W. Button, J.A. Epps, D.N. Little, and R.M. Galloway. Asphalt Temperature Susceptibility and Its Effect on Pavements, Phase 1. In Transportation Research Record 843, TRB, National Research Council, Washington, D.C., 1982, pp. 118-126.
9. D.A. Anderson, E.L. Dukatz, and J.C. Petersen. The Effect of Antistrip Additives on the Properties of Asphalt Cement. Proc., Association of Asphalt Paving Technologists, Vol. 51, 1982, pp. 299-317.
10. J.W. Button, D.N. Little, and R.M. Galloway. Influence of Asphalt Temperature Susceptibility and Its Effect on Pavement Construction and Performance. NCHRP Report 268. TRB, National Research Council, Washington, D.C., Dec. 1983, 62 pp.
11. J.A. Epps, J.W. Button, and B.M. Galloway. Paving with Asphalt Cements Used in the 1980's. NCHRP Report 269. TRB, National Research Council, Washington, D.C., Dec. 1983, 28 pp.

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