LOSS OF DURABILITY IN BITUMINOUS PAVEMENT SURFACES—IMPORTANCE OF CHEMICALLY ACTIVE SOLAR RADIATION

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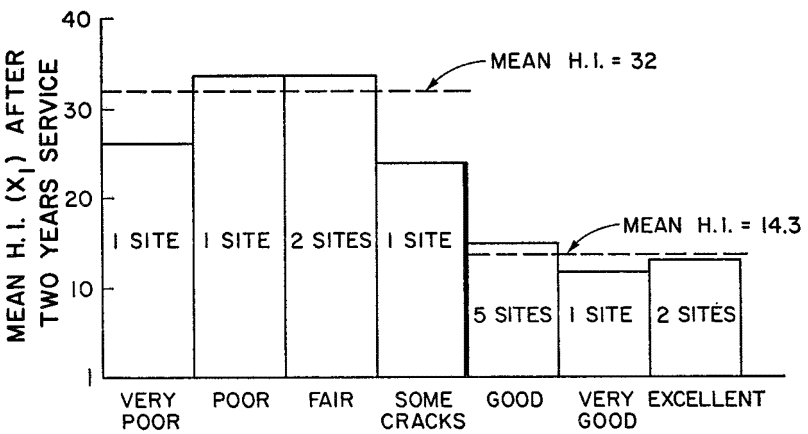

Subjective Rating of Pavement Sites versus Mean Hardening Index, HI (X_1), for 13 asphalts after two years service.

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Loss of Durability in Bituminous Pavement Surfaces—Importance of Chemically Active Solar Radiation

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Excessive hardening of certain asphalts used in the surface courses of bituminous pavements is to a great extent responsible for deterioration of the wearing surface and thus for excessive maintenance costs.

A cooperative research program, on this phase of bituminous highway construction, was initiated by the Texas Highway Department and the Texas Transportation Institute in 1963. Work is progressing with additional cooperation from the Federal Highway Administration.

Phase I

Evaluations of the original asphalt cements used at 13 sites in Texas, and the properties of the asphalts extracted and recovered from the pavements at intervals up to two or three years in service, are given in detail in Progress Report 9-11, Study 2-8-59-9, dated October 1967.

A Hardening Index, $HI(X_1)$, was obtained for each asphalt at each of the established intervals up to two years in service. $HI(X_1)$ was determined by dividing the viscosity of each recovered asphalt by the viscosity of the original asphalt before becoming a part of the pavement. All viscosities were determined in poises at 77° F using the thin film sliding plate type viscometer.

Subjective ratings of the pavement surfaces were made by experienced Texas Highway Department personnel. A graph prepared from these ratings and mean $HI(X_1)$ values is shown on the cover of this summary report. A most interesting correlation appears between conditions obtained by visual inspections and Hardening Indices of the asphalts from sites used in this investigation.

Phase II

A laboratory test for evaluating hardening of asphalts by the combined action of time, heat, and air has been used for several years. In this procedure, a 15-micron film of asphalt is

placed on 4 cm x 4 cm glass plates and exposed for two hours in a dark oven at 225° F. Viscosity of the hardened asphalt is determined and the value obtained is divided by the viscosity of the original asphalt at the same temperature. The resulting quotient is Hardening Index, HI(X_3). This index indicates how many fold the asphalt is hardened by the test conditions.

A linear regression equation established between HI(X_1) and HI(X_3) gave a correlation coefficient of 0.52.

Phase III

The experimental results mentioned above indicate that some important environmental factor, in addition to time, heat, and air (oxygen), has a pronounced effect on the hardening of the asphalt in the surface of a bituminous pavement.

It is well-known that the shortwave length components of solar radiation have a powerful deteriorating effect on most organic materials. Thus, a new laboratory test was developed in which a 10-micron film of asphalt was formed on 4 cm x 4 cm glass plates and then exposed in air to 1,000 microwatts per cm^2 of 3,660 Angstrom wave length radiation for 18 hours at 95±2° F. As in the test mentioned in Phase II, the hardened asphalt was measured for viscosity in poises at 77° F and the value obtained was divided by the viscosity of the original asphalt. The resulting quotient is Hardening Index, HI(X_2), which includes the effect of the shortwave length, chemically active (actinic) solar radiation on the asphalt.

Figure 1 is a plot of HI(X_2) versus hardening of the asphalt during two years in service, HI(X_1).

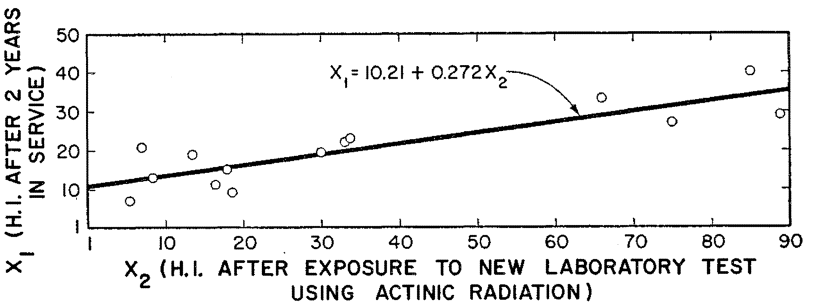

Figure 1. Hardening Index, X_2, versus Hardening Index, X_1, on 14 asphalts.

Linear regression analyses yield a correlation coefficient of 0.87, which is much better than the value of 0.52 obtained from the old laboratory test which does not include the hardening (deteriorating) effect of actinic sunlight.

To further quantitatively evaluate the effect of shortwave solar radiation, the new test was applied to about 50 asphalts in addition to those used in the field tests. These additional asphalts were from different petroleum sources and numerous manufacturers who used different methods of processing. The Hardening Indices, HI(X_2), for the 60 odd asphalts varied from 5.5 to 277.

Phase IV

The results presented above naturally raised the question as to why one asphalt is more resistant than another to hardening by the combined effects of time, heat, air, and actinic solar radiation.

Since certain metals in small quantities are known to stimulate numerous different chemical reactions, it was decided to determine if the metal content of a particular asphalt has any relationship to its susceptibility to hardening as measured by the new laboratory test. A number of asphalts were tested for cobalt, magnesium, nickel, and vanadium.

The results obtained indicated that vanadium was the most effective in respect to the hardening caused by time, air, and actinic solar radiation.

Thermal Neutron Activation was used to determine vanadium content of the 13 asphalts used in the field tests discussed in Phase I. A non-linear regression analysis was made using the Hardening Index, HI(X_2), and vanadium contents in parts per million by weight. This analysis gave a correlation coefficient of 0.95. Figure 2 is a plot of the data.

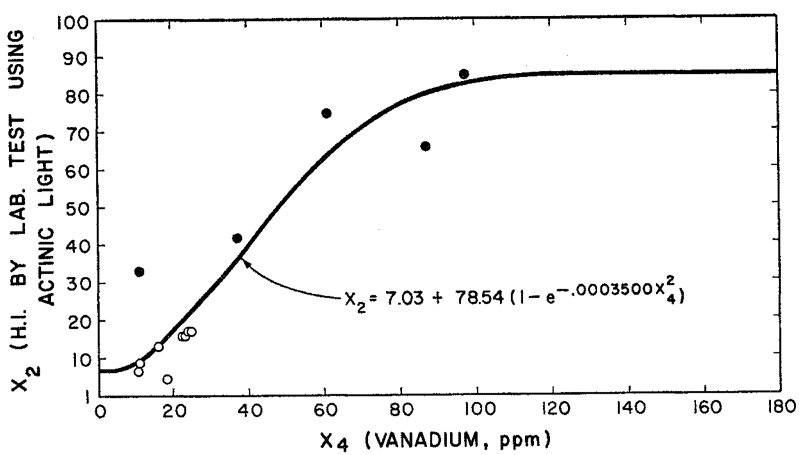

Figure 2. Vanadium Content, X_4, versus Hardening Index, X_2, on 13 asphalts.

A similar regression analysis made on about 50 asphalts, not used in field tests, gave a correlation coefficient of 0.88.

Further Work

Considerable experimental work is underway on the use of additives (known as ultraviolet inhibitors or metal deactivators) to overcome or reduce the destructive action of short-wave length (actinic) solar radiation. Also, further investigations are planned for field work on the problem of asphalt durability under the environmental conditions affecting the surface courses of bituminous pavements.

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