REPORT OF COMMITTEE ON CHARACTERISTICS OF ASPHALTS

By E F Kelley, *Chairman*

Chief, Division of Tests, U S Bureau of Public Roads

SYNOPSIS

A questionnaire relating to the service of asphaltic road materials was addressed to various organizations and individuals having to do with the use of asphalt in highway construction Ninety-one replies were received and these indicated that failures of asphaltic surfaces due to the quality of the asphalt are prevalent and merit serious attention Failures were reported from all sections of the country and were associated with many types and grades of asphalt On the basis of these replies a program of asphalt research is recommended

During 1937, ten laboratories cooperated in a study of film stripping in bituminous mixtures containing various types and grades of asphaltic road materials Widely varying results with different aggregates indicated aggregate character to be of major importance in connection with film stripping As for the bituminous materials, resistance to stripping increased with consistency and cracked materials were more resistant than uncracked The curing of samples was found to have an important effect on test results Modifications of the test procedure are suggested

Summary Report on Questionnaire

During the latter part of 1936 the committee prepared a questionnaire to be submitted to various organizations and individuals, replies to which it was hoped might serve to define the more important problems having to do with characteristics of asphalts as related to unsatisfactory service results

This questionnaire was distributed by the Director of the Highway Research Board to 189 individuals, including 5 consulting engineers, 4 university laboratories, 48 state contact men, 66 county officials and 66 city officials Ninety-one replies were received

From the standpoint of obtaining detailed information which would be of assistance to the committee in developing a program of work, the results of this questionnaire were disappointing However, certain facts were indicated which it is believed are of sufficient interest to summarize as follows

1 The basic question No 1 was "Have you or your organization noted any failures or unsatisfactory results in asphaltic highway construction or surface treatment under your supervision, which you believe to be due to the use of asphaltic material of poor quality? Out of the 91 replies received, 79 gave definite answers to this question Of these, 34 reported that asphalt of inferior quality had been responsible for failures It seems apparent from these reports that *failures or unsatisfactory results in asphaltic highway construction attributable to the use of asphaltic material of poor quality are sufficiently prevalent to merit serious consideration*

2 *The occurrence of failures or unsatisfactory results from this cause is not localized but is found in practically all sections of the country* Thus, of the 26 states east of the Mississippi, six—Massachusetts, North Carolina, Florida, Alabama, Mississippi and Wisconsin—reported unfavorably and of the 22 states west of the Mississippi, eight—California, Idaho, Arizona, New Mexico, Colorado, Kansas, Missouri and Minnesota—reported unfavorably Twenty states just as widely scattered reported favorably

3 *Trouble with the use of cracked asphaltic products appears to be more*

prevalent than with uncracked products Out of the 34 reports of unsatisfactory results, 17 specifically mentioned cracked or probably cracked asphalts and but 9 specifically mentioned uncracked asphaltic products.

4 *Among the asphalt cements the harder grades appear to be the chief source of such unsatisfactory results as reported* Thus out of 26 unfavorable reports, 21 mentioned asphalt cements of 60 penetration or less

5 *Trouble with the liquid asphaltic products is not limited to any particular types or grades but appears to be more prevalent with cracked than with uncracked products* Out of 25 unfavorable reports, 12 covered cut backs (RC and MC) and 13 slow curing (SC) material Sixteen of the replies specifically mentioned cracked or probably cracked products and 7 specifically mentioned uncracked products

6 *Cracking of the asphalt construction or treatment, and drying out with ravelling or dusting seem to be the principal types of failure attributed to poor quality of the asphaltic products* Out of 51 definite statements of character of failure, 23 specifically mentioned "cracked" and 16 "raveled, dried out and dusted"

Cracking appears to be most prevalent in hot mix construction, 18 out of 19 reports of unsatisfactory results with this type specifically mentioning cracking Both coarse and fine aggregate mixtures were included Raveling, drying out and dusting appear to be the most prevalent trouble in those types of construction and treatment employing liquid asphaltic products

7 *Hardening and increased brittleness of the asphalt were the most frequently observed changes in the asphalt producing unfavorable results* Thus among 22 replies on observable changes in the asphalt, 10 mentioned hardening and 10 brittleness

CONCLUSIONS

From this summary it would seem that the most promising lines of research dealing with control of quality of asphaltic products are·

1 Development or standardization of some rapid laboratory method of determining the relative resistance of asphaltic products to hardening and other changes

2 Correlation of such a test with service behavior of asphalts in the various types of asphalt surface courses

3 Selection of limiting values for such a test which could be specified so as to exclude material likely to prove inferior for any given type of construction

4 Producers could then investigate the possibilities of improvement in quality through selection of raw materials and variations in refining methods

Resistance of Bituminous Mixtures to Film Stripping

A digest of the results obtained in a cooperative study conducted in 1937 by the Project Committee on the Characteristics of Asphalts of the Highway Research Board

This cooperative investigation was undertaken to study the resistance to the stripping of bituminous films from hydrophilic aggregates in mixtures containing various types and grades of asphaltic road materials, to determine if the different asphaltic products show any marked difference in resistance to stripping A supply of altered rhyolite of No 8—$\frac{3}{8}$-in size and having definite hydrophilic properties was furnished through the courtesy of the Massachusetts Department of Public Works and a quantity of this was furnished to each cooperating laboratory Each laboratory agreed to make stripping tests according to a standard procedure with this aggregate, and any others that it might desire to study, in mixtures containing as great

a variety of asphaltic materials as might be readily available

The instructions furnished, regarding the test method to be used, were as follows

TEST PROCEDURE

A weighed sample of the material is mixed with approximately 5 percent by weight of the asphaltic product under investigation If the asphaltic product is a liquid at normal atmospheric temperature, the mixture is then spread out in a thin layer and allowed to air season overnight

A 50-gram sample of the mixture is separated as nearly as possible into individual fragments or small clumps and placed in a 250-cc Erlenmeyer flask with 175 cc of distilled water

The flask and contents is then placed in the frame of the agitating machine (see page 43, January, 1932, Proceedings, the Association of Asphalt Paving Technologists) and rotated at a speed of 45 r p m for a period of 15 minutes at room temperature At the end of this period the sample is examined for evidence of film stripping and the observation recorded

Rotation of the sample for an additional 15 minutes at room temperature is then made and notation made of any film stripping which may have occurred If little or no stripping has been noted at room temperature, the test is repeated for another period of 15 minutes at 100° F , the water bath being maintained at this temperature throughout the period of test

If little or no stripping has been noted at 100° F , the test is then repeated at 120° F

It is suggested that in the cooperative test, irrespective of the extent of stripping which may have occurred at lower temperatures, the entire procedure involving a total agitation of one hour be carried through

The test is not quantitative in nature and observations as to extent of stripping may vary with individual operators It is therefore suggested that the following general classification be adopted for reporting observations at the end of each period of agitation

1 No stripping
2 Slight stripping
3 Bad stripping

Note It is suggested that if apparently 25 percent or more of the surface area of the aggregate particles has been stripped, the results be reported as bad stripping

A DIGEST OF THE REPORTS SUBMITTED BY THE COOPERATING LABORATORIES [1]

Apparatus In general, the apparatus used conformed to that suggested by the committee Several laboratories made slight modifications such as the addition of heating coils, bath insulation and rate of rotation The variation in rate of rotation was between 38 and 45 r p m and one laboratory which used both 38 and 45 r p m reported no difference in results due to this variable There were some expressions of dissatisfaction with the glass Erlenmeyer flask because of breakage and difficulty of handling the material through the narrow mouth Figure 1 gives a general view of the testing equipment used by one laboratory

[1] Reports were submitted by

1 R R Thurston and B Weetman, Technical Division, Texas Company
2 Joseph Zapata, Wisconsin State Highway Commission
3 J E Myers, Division of Engineering, Department of Public Works, Albany, N Y
4 H P Rue, Bureau of Mines, Laramie, Wyo
5 H Allen and W E Gibson, State Highway Commission, Kansas
6 The Asphalt Institute, New York City
7 H W Skidmore, Chicago Testing Laboratory, Chicago, Ill
8 The Department of Highways, Minnesota
9 D H Jenks, Ashland Oil & Refining Co , Ashland, Ky
10 The Division of Tests, Bureau of Public Roads

Preparation of the Test Sample: One investigator made allowances for solvent and water in proportioning mixtures with cutbacks and emulsions to yield mixtures having 5 percent of actual bitumen. The other investigators proportioned the test mixtures without making allowance for loss of solvent.

Several investigators studied the effect of additional curing beyond that suggested by the committee. Variations therefore covered air curing for periods of 1, 2, 4, 7, 12, 20 and 27 days and oven curing at 140° F. for 24 hours.

Conducting the Stripping Test: Minor variations in the method of conducting the test included: observation of stripping at 1, 3, 5 and 10 minutes by one investigator in addition to the suggested observations at 15-minute intervals; quantitative estimation of the degree of stripping by several investigators in terms of percentage of the total surface stripped; and the introduction, by some, of intermediate arbitrary degrees of stripping between the three degrees suggested by the committee.

Aggregates Used in the Tests: While all the cooperating laboratories used the altered rhyolite (felsite), several included other aggregates in their tests. These additional materials included quartzite, traprock, limestone, gravel, granite and sandstone.

In testing these other aggregates, the laboratories, with one exception, used approximately the same size and grading as that of the aggregate that was furnished. It is believed that the $\frac{3}{8}$-in. maximum-size aggregate used in these tests is as large as can be satisfactorily tested with the present apparatus. Larger particles tend to break the glass containers. One laboratory found that the elimination of the fines by washing facilitated coating the aggregate when preparing the mix and also facilitated the observation of the test results.

Table 1 gives the approximate size and grading of the rhyolite and of the other types of aggregates used in the study.

TABLE 1

SIZE AND GRADING OF AGGREGATES

	Percent
Retained on $\frac{3}{8}$-in. sieve	0.0
Passing $\frac{3}{8}$-in. sieve, retained on No. 4 sieve	61.4
Passing No. 4 sieve, retained on No. 8 sieve	35.6
Passing No. 8 sieve, retained on No. 10 sieve	1.6
Passing No. 10 sieve	1.4

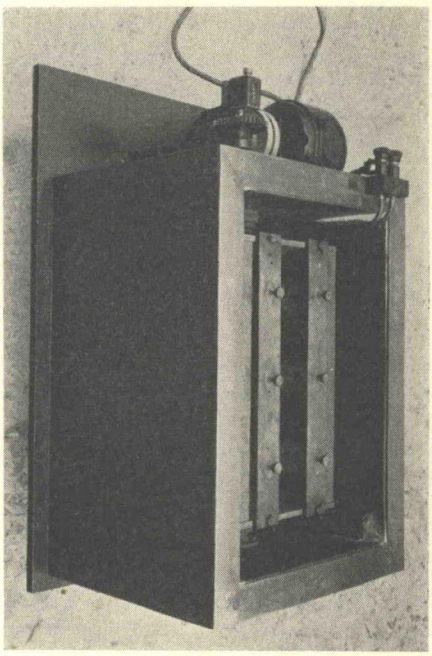

Figure 1. Shaking Machine

Bituminous Materials Used in the Tests: The study covered a wide range in types and grades of asphaltic materials from various sources. These included both straight-run and cracked residuals covering the various grades of SC, MC and RC materials as well as emulsions and the penetration grades of asphalt.

Results of the Tests: The results obtained by the cooperating laboratories were in agreement on the effect of the

more important variables These results indicated that the test as outlined was somewhat severe for a number of the liquid asphaltic materials that are now in satisfactory use in dense graded surfacing mixtures since they showed early and in some cases complete stripping One laboratory definitely stated that the test is too severe and another found it necessary to make earlier observations during the first 15 minutes of rotation in order to differentiate between some of the less viscous materials This objection to the test would, it appears, be largely eliminated by providing for considerably more curing of the mixture than that suggested in the original outline of procedure

The wide difference in results obtained with the various aggregates tested by the cooperating laboratories shows the type and character of the aggregate to be of major importance in connection with film stripping Of all the aggregates tested the rhyolite proved the least resistant to stripping In some instances there was also a wide difference in this quality for the same type of aggregate from different sources The quality of the aggregate in its relation to stripping therefore cannot be taken for granted even for any one type of material

For the bituminous materials, particularly those of the liquid type, consistency was shown to have a major effect on the resistance to stripping In general, the resistance to stripping was found to increase with increased consistency. Although there were indications that this also occurred with the penetration grades, the effect of consistency here was of minor importance

The test brought out a substantial difference in the behavior of the cracked and uncracked asphaltic materials The cracked materials possessed much greater resistance to stripping than did the uncracked The difference in this respect was very marked for the slow curing liquid asphaltic materials and to a lesser degree with the cutbacks, emulsions and the penetration asphalts

Of all the bituminous materials tested, the slow curing, residual oils, were the least resistant to stripping while the penetration grades were the most resistant The emulsions and the cutbacks developed resistance to stripping only after they had been allowed to cure thoroughly

The source of the asphaltic materials did not seem to have any appreciable effect on stripping

The overnight air curing suggested in the committee's outline of procedure proved highly insufficient for mixtures containing the liquid asphaltic materials particularly the cutback asphalts and emulsions For the test to be practical for these materials, the test mix must be cured to such a degree that the asphalt approximates the consistency obtained in the mix on the road at the time the pavement is considered finished and ready for traffic As the more viscous, semi-solid materials were not appreciably affected by increased curing they need not be considered in selecting the time or conditions of curing for the test

Both air and oven curing were used in the study Air curing proved ineffective except over long periods of time Oven curing at 140° F for a period of 24 hours or longer appears to be more suitable on account of the shorter curing period required

The results seem to indicate the need for certain modifications in the test procedure In addition to the change suggested for curing of the test specimens, which has already been discussed, removal of the fines from the aggregate by washing seems important The development of a more definite method of determining the amount of stripping and the establishment of limits for differentiating between satisfactory and unsatisfactory resistance to stripping for the

different types of surfacing are other important factors which should be studied

The results of this study bear an important relation to the design, construction and field behavior of bituminous surfaces They account for certain types of road failure and they establish certain important principles which should be followed in design and construction

A well-known fact in construction, not always followed, is that in the use of materials which contain a volatile fraction, the conditions and procedure should be such that a major portion of the solvent evaporates before the mix is laid and consolidated Field experience shows numerous failures where cold laid surfaces have been constructed late in the season when conditions were unfavorable to the evaporation of the solvent The almost total lack of resistance to stripping possessed by the materials containing volatile solvents when insufficiently cured strikingly coincides in respect with their field behavior

Type of construction has much to do with film stripping and its effects A dense type of surfacing provides greater mechanical resistance to stripping, and stripping, when it occurs, is not as serious a matter as it is in the more open type of surface which requires a comparatively high degree of bond between the particles to prevent raveling This explains the fairly satisfactory behavior of the western dense road and plant-mix type where slow curing asphaltic materials are used These materials have poor resistance to stripping in the test and cannot be used satisfactorily in the more open type of surfacing The reported satisfactory service of highly hydrophilic aggregates such as the rhyolite used in these tests in conjunction with a dense type of surfacing and a highly viscous asphaltic material, indicates to what degree lack of resistance to stripping may often be overcome by a proper selection of the design and the type and grade of bituminous material