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DATA ESTABLISHING THE IMPORTANCE OF THE DROP IN PENETRATION OF ASPHALTS DURING THE FIVE-HOUR HARDENING TEST

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The tendency for asphaltic materials to become harder, more brittle, to lose the capacity to resist shock and abrasion, is too well-known to require further proof. Investigations conducted by the Standard Oil Company of Ohio, by the Shell organization in Holland, and by the states of Michigan, Arizona, and California, have all demonstrated that without exception asphaltic materials recovered from the pavement are harder than when first introduced into the mixture.

Furthermore, the rate of hardening may vary considerably between the various asphalts. The differences are such that those asphalts which harden most rapidly have too short a life, and are definitely unsatisfactory for pavement construction. On the other hand, existing products which change most slowly are satisfactory, and serviceable asphaltic pavements over twenty years in age demonstrate that bituminous materials can have the requisite durability and long life.

Therefore, the problem confronting the highway departments of virtually all the states is to devise test methods which will detect in advance of construction those asphalts whose tendency to harden and become brittle is so great as to be detrimental to the life of the pavement. It is further agreed by virtually

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all paving technologists that the existing tests, such as the various fluidity factors, low temperature ductilities, solubilities in carbon tetrachloride and naptha, and penetration at various temperatures, are not measures of quality, and show little, if any, correlation with the durability of asphaltic pavements.

Tests on recovered asphalt made in the state of California have shown that the asphalt in pavements only three years old has in some cases dropped from 50-60 penetration to as low as 8 penetration. It seems to be frequently true that asphalts may lose more than half of the original penetration during the mixing operation alone, and most investigations indicate that when the asphalt in the pavement falls below 30 penetration, then undue cracking and the various difficulties attendant on brittleness become evident.

It has been noted that there is a rather definite tendency for asphalts which have been over-heated in refining to give poor service behavior. Therefore, in some quarters there has been a tendency to adopt the Oliensis Spot Test, in spite of the fact that Oliensis strongly emphasized that it was not a quality test, but merely served to distinguish between heterogeneous and homogeneous asphalts. We are all familiar with the recent improvement in this test procedure developed by the Standard Oil Company as part of the work of this Technical Group. We should not lose sight of the fact, however, that in certain cases asphalts showing a positive spot have been found to give satisfactory service, and while the Xylene equivalent furnishes means for a quantitative classification of asphalts according to the

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degree of heterogeneity, there still remains the uncertainty as to complete correlation between this determination and actual performance.

As the State of California cannot continue to build asphaltic pavements and risk expensive reconditioning treatment at an early date, it is absolutely essential that some means be adopted which will eliminate the bulk of those asphalts which have an undue tendency to harden in use. As preface to a proposal for another means of detecting poor asphalt, I might add that our highway design department considers that any high type pavement should have an economic life of at least twenty years.

In the year 1934, and again in 1937, an extensive survey was made of asphaltic concrete pavements in District VII (headquarters in Los Angeles). This study involved a walking survey of some forty jobs in the district, and all pertinent data was compiled, such as construction dates, material sources, grading of aggregate, and weather conditions. Quoting from this report, the conclusions drawn by Mr. Lackey are as follows:

1. Half of the asphaltic concrete pavements in the district may need to be resurfaced within 8 or 10 years.

2. The condition of the various projects did not seem to be seriously influenced by high or low asphalt content.

3. Pavements laid since 1934 on which compensation was made in the amount of asphalt used based on the percentage of asphalt soluble in petroleum ether, appeared to be better than pavements laid without this correction.

4. Projects to the number of 15 on which the best results were obtained in construction showed a Hubbard-Field test average of 2750 pounds, whereas on 12 projects showing the poorest condition, the Hubbard-Field test averaged 3255 pounds.

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I may add here that, other things being equal, high Hubbard-Field results definitely reflect a harder asphalt. Variation in Hubbard-Field results with the various penetrations of asphalt can be demonstrated without difficulty.

Among the data assembled for comparison, is the hardening of asphalt during the five-hour loss test (A.S.T.M. D5-25). Taking the tabulation of the present condition of the pavements, and classifying into the two groups - Group A, "good to excellent," Group B, "poor to fair," shows that the asphalts in Group A retain from 82% to 92% of their original penetration in the loss at 325°F., while in the poor to fair sections, the asphalts had shown only from 70% to 88% of the original penetration. It is not surprising that there is not a clear-cut separation, inasmuch as the age of the pavements vary, as well as certain local conditions, subgrade, etc.

It seems clear that if we are to avoid all difficulty, a 90% requirement is necessary. However, it is our present proposal that no asphalts shall be used which retain less than 85% of their original penetration after 5 hours heating at 325°F.

As further confirmation of this relationship, I wish to quote from a paper entitled "Some Recent Research in Asphalt Pavements" by Raschig and Doyle of the Standard Oil Company of Ohio, printed in the 1937 Proceedings of the Asphalt Paving Technologists. Among other conclusions is the following:

> "It would appear that certain tests commonly used in refinery control work for identification purposes, such as fluidity factors, low temperature, ductilities, solubilities in carbon tetrachloride and 86° naptha, and 115° and 32°F. penetrations,

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> are not measures of quality as has been supposed in the past..... Of all the physical tests on different asphalts, the drop in penetration during the 5 hour loss test and the original penetration at 77°F. seem to be the most relevant, the others being merely guides to uniform plant control."

During the course of studies recently initiated in the California laboratory, briquettes were formed using several types of asphalt mixed with Ottawa sand, which were subjected to light treatment from an Eveready Sunshine carbon arc. After exposure, compressed briquettes were subjected to abrasion tests in a standard DeVal machine and the per cent of loss taken to indicate the degree of resistance to abrasion and shock. These results were reported in a recent issue of the "Asphalt Forum."

At the time the tests were made, samples of each of the asphalts were placed in a 325°F. oven for 96 hours, using 8-ounce tins containing approximately 175 grams of asphalt, on which the penetration was determined at intervals. The results are shown herewith, indicating that the asphalts which showed the greatest hardening in the 325°F. oven were the ones which gave the greatest loss in the abrasion test on the briquettes.

It is, of course, evident from the test that using an asphalt of softer initial penetration is beneficial, and we have already taken steps to secure the advantage of softer asphalts, inasmuch as the new Standard Specifications will stipulate that all asphalts shall be 70 penetration or higher.

Even though softer asphalts will be used, however, it is evident that a 70 penetration asphalt may have hardened to 40

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penetration by the time the pavement is laid, and according to all evidence, a further 10 point hardening places a pavement in a critical range. It is therefore essential that we not only use an asphalt of proper consistency before construction, but that we assure ourselves that it has no undue tendency to oxidize, coagulate, form a definite structure, or otherwise alter in an undesirable manner.

While it is by no means believed that loss at 325°F. is the best means that can be devised, it nevertheless permits use of existing standard technique with its background of results on present materials, and the test is, at least to some degree, a direct measure of the tendency to harden, which appears to be the direct cause of most of the difficulties.

A change in specification limits from the present allowance of 60% of the original penetration to not less than 85% is urged at the present time, pending the completion of present studies using accelerated weathering tests, which may lead to better test procedures.

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