Penetration of Bituminous Materials

Lab Experiment #5

Submitted to:

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CE 361: Highways Materials Laboratory

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II. Results

Table 2.1 describes the results of the penetration test:

Table 2.1: Results, Errors, and Penetration Grade from the penetration test. Test Numbers 1-6 were conducted at a temperature of 74 F, while test number 8 was conducted with the specimen at a temperature of 75-80 F

Test Number	Final Reading (*10 ^ -1 mm)	Initial Reading (*10 ^ -1 mm)	Total Penetration (*10 ^ -1 mm)
1	437.5	242.5	195
2	438	242	196
3	395.5	234.5	161
4	437.5	229.5	208
5	336.5	100.5	236
6	323	94	229
7	335	90	245
@ a warmer temp:			
8	334	81	253

Calculations

Average Penetration (from tests 5-7):	237(*10 ^ -1 mm)
Maximum variation in penetration (from tests 5-7):	16(*10 ^ -1 mm)
max dP/dT (*10 ^ -1 mm per degree F):	16
min dP/dT (*10 ^ -1 mm per degree F):	2.7
Max Error (% per degree F):	6.75
Min Error (% per degree F):	1.15

III. Discussion

Procedure

In this study, the penetration test was used to study the consistency of an asphaltic material. The asphalt cement which was tested had previously been prepared from a distillation test. The residue taken from the distillation test was taken and poured in a container to a depth of about 1 inch. The cement was then taken, placed on the shelf, and allowed to dry for a period of two weeks.

At a temperature of 74 F, the specimen was tested on the penetrometer apparatus. 77 F was 3 degrees lower than the specified 77 F, which may have caused a degree of error in the test. (see ***Possible Errors***). The specimen was tested by placing the needle on the penetrometer immediately above the specimen and loading it with 50 gram weight, creating a total of 100 grams. After recording the initial reading on the penetration gage, the 100-gram needle was released on the specimen for a period of 5 seconds. The final gage reading was obtained. The initial gage reading was subtracted from the final gage reading to obtain the total penetration:

Total Penetration = Final Gage Reading - Initial Gage Reading

After obtaining the total penetration of the specimen, the penetrometer needle was cleaned. The test was conducted four times, but the penetrometer needle touched the bottom of the specimen container the first, third, and fourth times. Because of possibly inaccurate readings, the test was conducted three more times to obtain more accurate results. By adjusting the penetrometer needle, more accurate results were obtained.

Finally, the specimen was tested to observe the error which is caused by a variation in the temperature of the specimen. After the specimen was placed in a 122 F water bath for approximately 25 seconds, it was tested again. A somewhat higher total penetration was the result of the test at the higher temperature. It was roughly estimated that the specimen at the higher temperature was at 75-80 F.

Answers to "Observations and Discussion"

1. Why must the specimen be immersed in a constant temperature bath for an hour?

By immersing the specimen in water, it is much easier to cool it to a specified temperature than when the specimen is in air. The temperature of the air is easily changed, but water can be retained at a constant temperature relatively easily. And by immersing the asphaltic specimen in a water bath, the desired temperature can be obtained and retained.

2. Approximately what magnitude of error in penetration is involved if the temperature of the specimen is 10 degrees from that prescribed?

The range of possible error per degree was calculated as shown in the ***Calculations and Data*** section. Since the exact elevation of temperature was not measured in the final test at the higher temperature, the error per degree F is only an approximation. The range of error was calculated to be between 1.15% and 6.75% per degree F. Multiplying these numbers by 10, it is possible to obtain between 11.5% and 67.5% error for a 10 degree rise in temperature.

This result suggests that it is necessary to maintain the specified temperature of the material during the penetration test. This can be done, as stated above, by the use of a water bath kept at 77 F. Failure to maintain the specified temperature of the specimen can result in a large degree of error, ranging from 1.15% to 6.75% penetration per degree F.

3. To which penetration grade does the sample belong?

Specifications*

Specified Penetration of Asphaltic residue at temperature of 77 F: (for MC-250)

120-250

*Penetration of asphaltic residue in **test #8**:*

253**

*From Garber and Hoel, *Traffic and Highway Engineering*, p. 741

**although the penetration value of the residue was above the specifications, the high value of penetration may have resulted from a large amount of solvent left in the residue after the distillation test.

It was discovered that the asphaltic material tested was a type MC-250 in the distillation test, and the specified penetration values for this type of asphalt is located in the above listing. The asphaltic residual material belongs in the 200-300 penetration grade since both the average penetration value of the test (237) and the penetration at the elevated temperature (253) were between 200 and 300.

Uses of the test

The penetration test is used to determine the penetration grading of an asphaltic material. The penetration of a material is simply the distance in 1/10 of mm that a standard needle will penetrate a given sample, under specific conditions of loading, time, and temperature. This is an indication of the consistency of a material, and the lower the penetration value, the more viscous the asphaltic material. The consistency properties of an asphalt can be used to determine the type of asphalt. Asphaltic materials can be graded according to their consistency properties.

Advantages/Disadvantages

Advantages:

1. The penetration test is effective for measuring consistency in *solid* asphaltic materials, while the kinematic viscosity and Saybolt Furol tests may only be used for *liquid* asphaltic cutbacks.

2. The penetration test may be used under different sets of loading conditions, among which are the following:

Load on Needle	Duration of Loading	Temperature of Test
200 g	60 s	32 F
100 g	5 s	77 F
50 g	5 s	115 F

Of these, the most commonly used is the load of 100 grams, duration of 5 seconds, and the temperature of 77 F.

Disadvantages:

1. If the penetrometer is not working correctly, or is not lubricated, the penetrometer readings may be inaccurate.

2. The specimen must be maintained at a constant temperature of 77 F, or an inaccurate reading may result.

3. More fundamental consistency tests are now being substituted for the penetration test.

4. The material can only be tested a few times before it must be remolded in its container.

5. Only solid or semisolid asphalts can be tested. No liquid asphalts can be tested.

Possible Errors

The possible sources of error from the penetration test include the following:

1. The average consistency reading was inaccurate because the temperature was not maintained in a water bath at 77 F. The percent error in penetration per degree Fahrenheit has been calculated to be between 1.15% and 6.75%.

2. The variation between tests 5-7 was 16 X 10 ^ -3 mm of penetration, which was significantly larger than the specified variation of 4 X 10 ^ -3 mm.

3. In test numbers 1, 2, and 4, the needle touched the bottom of the container, while in test 3, the needle became stuck for about 1 second when penetrating the asphalt. This resulted in inaccurate penetration values in these tests. These values were not considered in the average penetration or in evaluation of the data.

Limitations of this Lab

The chief limitation of the penetration test is that it cannot be used to test liquid asphaltic materials. Also, more fundamental measures of consistency and viscosity are now being substituted for the penetration test, as penetration values may be highly variable. Finally, the temperature must be carefully controlled, as slight changes in temperature may cause inaccurate penetration data.

IV. Conclusions

Properties of the paving material

From this study, it was determined that the asphaltic material had an average penetration value of 237. In this value, the maximum variation in penetration was found to be 16 * .1 mm of penetration. In addition, the change in penetration per degree Fahrenheit was found to be between 2.7 and 16, or between 1.15% and 6.75%. The first values were based on the assumption that the temperature of the specimen rose 1 F in test #8 and the second value is based on the assumption that the temperature of the

specimen rose 6 F in test #8. It was determined that the MC-250 asphaltic material had a 200-300 penetration grade.

Engineering Significance of this lab

The penetration values of an asphaltic material, combined with its viscosity, have been used for several decades to determine the grade of asphalt being tested. Both the variation of consistency with temperature and the consistency at a specified temperature may be determined by the penetration and viscosity tests. The variation of consistency with temperature is important in determining the possible effects of large temperature changes on the material. The consistency at a specified temperature may be used to predict the properties of a material under certain conditions, such as when the asphalt is exposed to a desert sun and large axle loads.

V. Appendix

The following book was used for reference:

Garber, Nicholas J. and Lester A. Hoel. ***Traffic and Highway Engineering***. West Publishing Company, 1988.

Calculations and Data on Next Page.