Final Report VTRC 11-R7

Virginia Transportation Research Council

research report

Examination of an Implemented Asphalt Permeability Specification

http://www.virginiadot.org/vtrc/main/online_reports/pdf/11-r7.pdf

G. W. Maupin, Jr., P.E.
Principal Research Scientist

Virginia Transportation Research Council, 530 Edgemont Road,
Charlottesville, VA 22903-2454, www.vtrc.net, (434) 293-1900

Standard Title Page—Report on State Project

Report No.: VTRC 11-R7	Report Date: October 2010	No. Pages: 9	Type Report: Final	Project No.: 73171
			Period Covered: 1-1-05 through 8-30-10	Contract No.:

Title:
Examination of an Implemented Asphalt Permeability Specification

Key Words:
Asphalt, hot mix, permeability, specification

Author(s):
G. W. Maupin, Jr.

Performing Organization Name and Address:
Virginia Transportation Research Council
530 Edgemont Road
Charlottesville, VA 22903

Sponsoring Agencies' Name and Address:
Virginia Department of Transportation
1401 E. Broad Street
Richmond, VA 23219

Supplementary Notes:

Abstract:

Much research had been conducted and reported regarding the permeability of asphalt mixtures in Virginia. Because of the susceptibility of many mixtures to the entrance of water, a new permeability specification for approval of asphalt job mixtures was implemented by the Virginia Department of Transportation (VDOT) in 2005 in an attempt to eliminate permeable mixtures. A testing program was conducted during the year of implementation to examine the effectiveness of the new specification, and those results are reported herein.

The purpose of the study was to determine if the contractors had to change the mixture designs so that the mixture would comply with the new permeability requirement and whether the specification produced pavements with acceptable permeability. Contractors were asked to indicate voluntarily whether mixture designs had to be redesigned because of permeability issues. In addition, each district materials engineer in the nine VDOT districts was asked to sample and test at least two surface mixtures to determine the level of permeability being achieved in the pavement.

Some mixtures had to be redesigned in 2005 to comply with the new specification. Generally, pavements that had been designed in accordance with the new specification and complied with density specifications had satisfactory permeability. The new specification appears to be performing as intended, and no changes are needed. As a consequence, the results of this research were implemented.

FINAL REPORT

EXAMINATION OF AN IMPLEMENTED ASPHALT PERMEABILITY SPECIFICATION

G. W. Maupin, Jr., P.E.
Principal Research Scientist

Virginia Transportation Research Council
(A partnership of the Virginia Department of Transportation
and the University of Virginia since 1948)

Charlottesville, Virginia

October 2010
VTRC 11-R7

DISCLAIMER

The contents of this report reflect the views of the author, who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Virginia Department of Transportation, the Commonwealth Transportation Board, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation. Any inclusion of manufacturer names, trade names, or trademarks is for identification purposes only and is not to be considered an endorsement.

ABSTRACT

Much research had been conducted and reported regarding the permeability of asphalt mixtures in Virginia. Because of the susceptibility of many mixtures to the entrance of water, a new permeability specification for approval of asphalt job mixtures was implemented by the Virginia Department of Transportation (VDOT) in 2005 in an attempt to eliminate permeable mixtures. A testing program was conducted during the year of implementation to examine the effectiveness of the new specification, and those results are reported herein.

The purpose of the study was to determine if the contractors had to change the mixture designs so that the mixture would comply with the new permeability requirement and whether the specification produced pavements with acceptable permeability. Contractors were asked to indicate voluntarily whether mixture designs had to be redesigned because of permeability issues. In addition, each district materials engineer in the nine VDOT districts was asked to sample and test at least two surface mixtures to determine the level of permeability being achieved in the pavement.

Some mixtures had to be redesigned in 2005 to comply with the new specification. Generally, pavements that had been designed in accordance with the new specification and complied with density specifications had satisfactory permeability. The new specification appears to be performing as intended, and no changes are needed. As a consequence, the results of this research were implemented.

FINAL REPORT

EXAMINATION OF AN IMPLEMENTED ASPHALT PERMEABILITY SPECIFICATION

G. W. Maupin, Jr., P.E.
Principal Research Scientist

INTRODUCTION

Permeability of asphalt mixtures has been a concern over the last few years, especially since the implementation of Superpave in the late 1990s. Coarser gradations tended to be used in Superpave, which tended to yield more permeable mixtures. Much work has been done nationally, and the Virginia Transportation Research Council (VTRC) [1-3] has completed considerable research concerning the issue. A relatively simple falling head test can be used to measure the permeability of specimens made in the laboratory or cores taken from the pavement.[3] A similar falling head device can be used to measure the permeability of the pavement in place.[4]

Early in the implementation of Superpave, the Florida Department of Transportation identified a maximum permeability level of approximately 100 x 10^{-5} cm/sec that prevents excessive water from infiltrating the pavement system.[5] That value was later increased to 125 x 10^{-5} cm/sec. It was believed that pavements with permeability that was less than this value would perform satisfactorily.

The early experience of Virginia Department of Transportation (VDOT) engineers and contractors' personnel indicated that permeability tests on cores from numerous field projects in Virginia indicated excessive permeability, often because of excessive air voids. There were some cases where the mixture design involving gradation, binder content, or aggregate materials needed to be changed to achieve satisfactory permeability. As expected, the fine mixtures that usually have less interconnected voids were generally the least permeable.

A method was devised to incorporate permeability into the laboratory mixture design phase of asphalt construction to help ensure that field permeability was satisfactory.[1] In this method, multiple specimens of the proposed mixture are made at a range of air voids and the permeability is determined with the falling head permeameter. A regression plot of permeability versus air voids is used to predict the minimum required pavement density to achieve acceptable permeability. Considerable training was conducted for contractors and VDOT employees regarding how to perform the permeability test. A VDOT specification was implemented in 2005 requiring that surface mixtures be tested prior to construction and that the test results not exceed a specified value.[6]

PURPOSE AND SCOPE

The purpose of this study was to determine if surface mixture designs had to be changed to comply with the requirements of the new VDOT specification and whether adherence to the specification produced mixtures with acceptable permeability in the field.

The district materials engineers in the nine VDOT districts were asked to gather information on two surface mixtures being placed in 2005 in their district, and all contractors were asked to comment on how many of their surface mixtures placed in 2005 had to be redesigned to comply with the new VDOT permeability specification.

METHODS

Mixture Redesigns

Contractors were asked by the VDOT district materials personnel in 2005 to furnish information voluntarily relating to any of their surface mixtures that had to be redesigned because of having unacceptably high permeability. This information was intended to indicate the likelihood of producing mixtures with excessive permeability in the absence of the new specification.

Effectiveness of New Permeability Specification

Personnel at the nine VDOT district materials laboratories were asked to examine materials at two locations in their district to determine the effectiveness of the specification in producing pavement surfaces with low permeability. The mixtures were sampled and tested in the district or VTRC laboratory for permeability as described here. Cores were also taken from the pavement where the sampled mixtures had been placed, and the cores were taken to the laboratory and tested for density and permeability.

Laboratory Tests

Specimens were made in the Superpave gyratory compactor over a range of air voids believed to be occurring in the pavement and were tested for permeability in accordance with Virginia Test Method 120 (VTM 120): Method of Test for Measurement of Permeability of Bituminous Paving Mixtures Using the Flexible Wall Permeameter.[7] The results were plotted, and the resultant regression was used to determine the permeability of the specimens at 7.5 percent air voids (Figure 1). VTM-120 was also used to determine the permeability of the field cores .

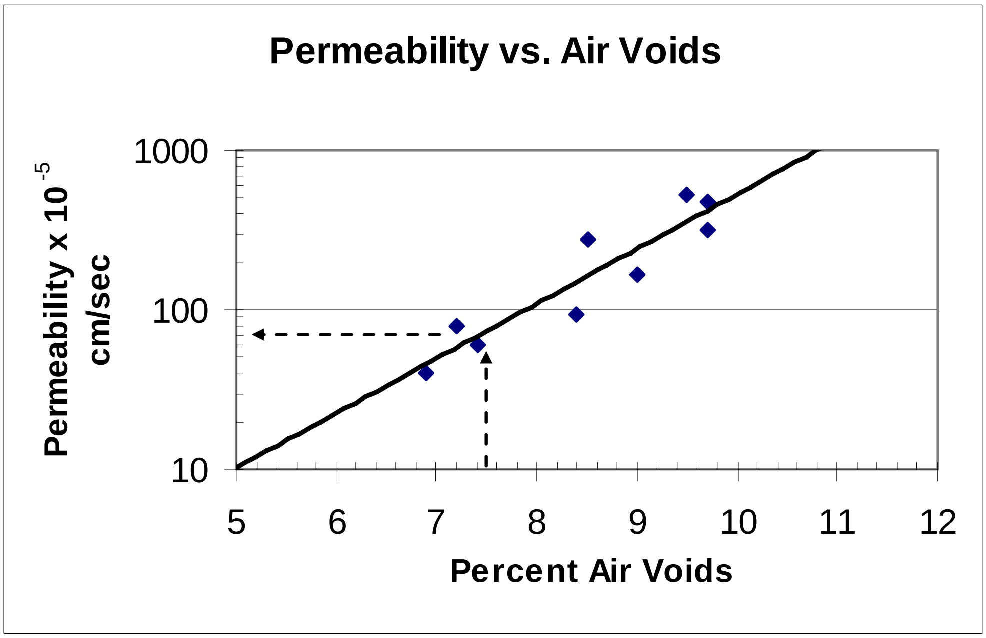

Figure 1. Example of Determination of Permeability at 7.5% Air Voids

RESULTS

Mixture Redesigns

Three of the nine VDOT districts reported that some mixtures had to be redesigned because the permeability of the mixtures did not comply with the specifications. According to the reports, 12 mixtures in the state were redesigned to ascertain whether the acceptable specification limit had been attained. Although it was not specified that stone matrix asphalt (SMA) maintain a particular permeability value, SMA was checked in one district because of permeability problems encountered the previous year. Based on information received from the districts, approximately 165,000 tons of surface mixture was placed at a cost of $7.5 million in 2005 that would likely have had a permeability deficiency if the specification had not existed and mixtures had not been redesigned One district required all Superpave surface mixtures to be redesigned as a general policy; therefore, it is possible that additional deficient mixtures would have been detected during the design phase. The mixtures from that district are not included in the tonnage discussed here.

Effectiveness of New Permeability Specification

Table 1 lists the results of the permeability tests performed on the mixture specimens and the cores; in some cases, the results of tests conducted on the original mixture design supplied by the contractor are provided. VDOT requires that the permeability at 7.5 percent or greater air voids not exceed 150 x 10^{-5} cm/sec.[6] Although the Florida Department of Transportation uses an upper limit of 125 x 10^{-5} cm/sec,[8] VDOT uses the 150 x 10^{-5} cm/sec limit to allow contractors

Table 1. Results of Permeability Tests

I.D.	VDOT District	Mixture Type	% Air Voids			Permeability x 10^{-5} cm/sec		
			Design[a]	Mixture[b]	Cores[c]	Design[a]	Mixture[b]	Cores[c]
1	Bristol	12.5D		8.1			120	
2	Bristol	9.5D		7.5			59	
3	Bristol	9.5D		8.1	7.1		41	65
4	Bristol	12.5A		7.8	8.3		128	402
5	Culpeper	9.5A		7.5	6.5		20	105
6	Fredericksburg	12.5A	8.0	7.5	7.5	115	40	76
7	Fredericksburg	12.5A	7.5	7.5	8.4	80	150	339
8	Hampton Roads	9.5D		7.5	9.9		50	106
9	Northern Virginia	12.5E		7.5	4.4		200	6
10	Northern Virginia	9.5E		7.5	6.4		70	100
11	Lynchburg	9.5D	7.5	7.5	8.6	46	30	504
12	Lynchburg	12.5D	7.6	7.5	10.4	47	55	337
13	Richmond	12.5D	7.5	7.5	7.6	66	80	126
14	Salem	9.5A	7.5	7.5	10.6	139	70	505
15	Salem	9.5A	7.5	7.5	9.9	30	40	72
16	Fredericksburg	12.5A		7.5	12.3		130	1135
17	Staunton	9.5A		7.5	10		40	618

Shaded cells indicate either that the % air voids was higher than allowed (7.5%) in the control strip or that the permeability was higher than the specification design limit of 150 x 10^{-5} cm/sec.
[a]Original mixture design (results supplied by contractor).
[b]Mixture collected during construction.
[c]Cores from pavement.

some variance because of the normal variability of the permeability test In seven cases, the permeability of pavement cores was higher than allowable, ranging from 337 to 1135 x 10^{-5} cm/sec. In all of those cases, the air content of the cores was more than the specified average control strip value of 7.5 percent. With one exception, the permeability of the mixtures sampled from the paving projects was satisfactory. However, the permeability of the pavement cores from that project was satisfactory.

DISCUSSION

Some mixtures were redesigned for 2005 because of failing permeability. Comments by some contractors indicated that mixtures had to be made finer or asphalt had to be added in order for the mixture to comply with the permeability specification. These mixtures would undoubtedly have suffered damage because of the entrance of surface water that would have resulted in a shortened service life. Therefore, the new specification prevented permeable mixtures from being constructed.

The evaluations of cores in this study represented small samples and may not indicate the average permeability of the mixture on a project. In some cases, the high permeability might have been a result of the average density being low, but in other cases, it might have been related to normal individual sample variability. It must be realized that void levels greater than the target average requirement of 7.5 percent will likely produce high permeability whether a result of normal or abnormal variability.

The permeability failure of the pavement cores was directly related to the lack of density (high air voids). Since permeability complied with the specification on tests performed on the mixture sampled during construction, unsatisfactory values obtained on cores cannot be blamed on mixture deficiency. If it assumed that this modest sampling of field projects represents hot-mix production in Virginia and that the correct air void content is maintained, it can be concluded that the new permeability design system is resulting in surface mixtures that can be constructed with an average low permeability.

CONCLUSIONS

- Some mixtures had to be redesigned during the first year (2005) of the implementation of the new permeability specification because of high permeability.
- Generally, mixtures produced during 2005 that were designed to comply with the requirements of the new permeability specification and complied with density specifications had satisfactory pavement permeability.
- The new permeability specification appears to be effective, and no changes are needed.

RECOMMENDATION

1. *VDOT's Materials Division should continue the current permeability specification requiring a maximum permeability of 150 x 10^{-5} cm/sec to ensure the construction of asphalt mixtures with low permeability.* The results of this research have already been implemented.

COSTS AND BENEFITS ASSESSMENT

During 2005, approximately 165,000 tons of hot-mix asphalt that had to be redesigned because of permeability problems was placed at a cost of $7.5 million. If the current permeability specification had not been in place, these mixtures would have been placed with high permeability. It is reasonable to assume that the service life would have been shortened by 15 percent because of the high permeability. Therefore, VDOT's savings for 2005 as a result of the new specification would have been 0.15 x $7.5 million = $1,125,000. These savings continue to be achieved each year because asphalt mixtures with high permeability are not placed.

ACKNOWLEDGMENTS

Thanks are extended to the project panel consisting of W.R. Bailey III, David Lee, Haroon Shami, and Richard Schreck for their guidance and suggestions in the planning and carrying out of the research. In addition, Trenton Clark and Alex Apeagyei helped review the final report. Special thanks go to Troy Deeds and Aaron Dupont of the VTRC laboratory staff who conducted the testing for the project.

REFERENCES

1. Maupin, G.W., Jr. *Investigation of Test Methods, Pavements, and Laboratory Design Related to Asphalt Permeability.* VTRC 00-R24. Virginia Transportation Research Council, Charlottesville, 2000.

2. Maupin, G.W., Jr. *Asphalt Permeability Testing Between Laboratories.* VTRC 05-R24. Virginia Transportation Research Council, Charlottesville, 2005.

3. Maupin, G.W., Jr. Asphalt Permeability Testing in Virginia. In *Transportation Research Record: Journal of the Transportation Research Board, No. 1723*. Transportation Research Board of the National Academies, Washington, D.C., pp. 83-91.

4. Mallick, R.B., Cooley, L.A., Jr., Teto, M.R., Bradbury, R.L., and Peabody, D. *An Evaluation of Factors Affecting Permeability of Superpave Designed Pavements.* NCAT Report 03-02. National Center for Asphalt Technology, Auburn, Ala., 2003.

5. Choubane, B., Page, G.C., and Musselman, J.A. Investigation of Water Permeability of Coarse Graded Superpave Pavements. *Journal of the Association of Asphalt Paving Technologists,* Vol. 67, 1998, pp. 254-276.

6. Virginia Department of Transportation. *Road and Bridge Specifications.* Richmond, 2007.

7. Virginia Department of Transportation. Virginia Test Method 120: Method of Test for Measurement of Permeability of Bituminous Paving Mixtures Using a Flexible Wall Permeameter. Richmond, 2005.

8. Prowell, B.D. *Investigation of Pavement Permeability: Old Bridge Road.* VTRC 02-TAR5. Virginia Transportation Research Council, Charlottesville, 2001.