16 State House Station
Augusta, Maine 04333

MaineDOT

Transportation Research Division

Technical Report 98-08

Experimental Installation of Permeable Base
First Interim Report

August 2007

Transportation Research Division

Comparison of Permeable Base Performance vs. Standard MaineDOT Construction

Introduction

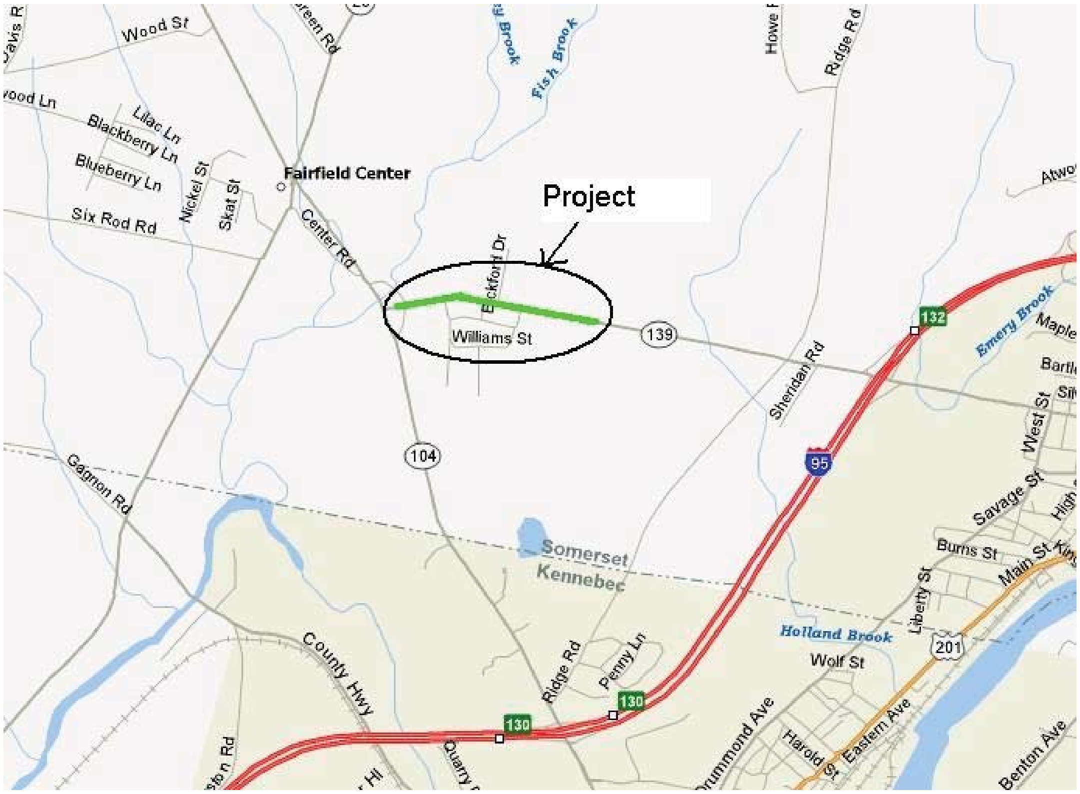
The effects of excessive water within pavement structural sections has been shown to decrease the service life of our nation's roadways. Some of the problems associated with this excessive water include premature rutting, cracking, faulting, increased roughness, and a relatively rapid decrease in the level of service ability. These problems are caused by a decrease in the ability of the structural section to transmit the dynamic loading of traffic, and also through the development of excessive pore pressure which can cause pumping of the subbase material up through the cracks in the pavement surface. Beginning in 1970, there has been an increasing interest in pavement drainage, as premature failure of pavements has become a significant problem. One treatment to increase drainage is the use of permeable base systems along with longitudinal pipe edge drains as a means to address premature pavement failure.

The National Cooperative Highway Research Program sponsored a research project to investigate the effectiveness of permeable base on pavement performance. (Project 1-34 FY '95) An interim report was published in February 1997 which includes a survey of current State pavement drainage practices. The NCHRP reports that most states that have experimented with permeable bases report improved pavement performance. The three main types of permeable bases are: untreated (PAGG, permeable aggregate), asphalt-treated (PATB, permeable asphalt-treated base), and cement treated (PCTB, permeable cement-treated base). Of the three types, asphalt-treated is the most common. Other references on permeable bases are NCHRP Synthesis 239 Pavement Subsurface Drainage Systems published in 1997, and National Asphalt Pavement Association report, Asphalt Treated Permeable Material-It's Evolution and Application published in 1994. The increased material and labor of permeable bases increases construction costs. Some research has indicated however, that due to the structural contribution of an asphalt treated permeable base, some cost offset savings can be achieved by reducing surface pavement thickness.

In an effort to gain knowledge on this method, and also to assess the potential for increasing the performance of Maine's roadways, an experimental construction project was initiated to investigate the use of a permeable base layer in the pavement structural section. The goal of this project was to determine the effectiveness of a permeable base. The areas to be investigated were to assess the ease of construction, and increased costs. Performance of the permeable base will be monitored over a period of years and the results will help to determine the overall feasibility of the method. Reductions of rutting and cracking are being evaluated. This report is an interim report on this experimental section of highway. Reference is hereby made to the original construction report, Experimental Utilization of Permeable Base, 98-08, October 1999, available on the Transportation Research Website at http://www.maine.gov/mdot/transportation-research/completed-projects.php. The report describes construction details, specifications, and the initial pavement testing.

Project Location

The project that contains the experimental base sections was a highway reconstruction project on Route 139 in Fairfield. It began at Route 104 and extended for 0.95 miles. The experimental sections begin near the intersection of Williams Street at project station 29+75 and extend to station 57+25. See map below.



Test Sections

There are two test sections and two control sections on the reconstructed highway. For additional information regarding construction see Research Experimental Construction Report 98-08. The locations of the sections are as follows:

Control 1: Section begins at station 52+25 and extends to station 57+25.

Control 2: Section begins at station 29+75 at the intersection of Route 139 and Williams Street and extends to station 34+20. During the reconstruction project the subbase was filled using recycled asphalt (RAP). This was not known by the principal investigators until several years after the project was completed, when it was discovered when cores were cut for an unrelated research project. The presence of RAP in the subbase strengthens the highway section and this fact should be taken into account when comparing performance results of the four sections.

Test 1: Test section 1 contains a permeable base with an asphalt treated aggregate. The section begins at station 43+10 and extends to station 52+25.

Test 2: Test section 2 contains a permeable base with untreated aggregate. The section begins at station 34+20 and extends to station 43+10.

Results

Tables 1 & 2 below show the rut depths and the IRI as collected by the Department's automatic road analyzer (ARAN) and also the falling weight deflectometer (FWD). Both test sections have better IRI than the control sections. The average IRI in the untreated permeable base section and asphalt treated base section are 70.85 in/mi and 66.5 in/mi respectively. The average IRI in control 1 & 2 is 86.2 in/mi and 98.05 in/mi respectively. There was little difference in rutting results between the control sections and test section 1, test section 2 however showed higher rutting values than the other three sections. The most recent FWD results show that the test sections have lower modulus values than the control sections. However historic FWD results do not consistently show that test section 1 had lower modulus values than the control sections. Test section 2 has historically shown the lowest modulus values of the four sections. Visually all sections appeared to be in fairly good shape, however there are areas of cracking and raveling. Control section 1 appeared to have the highest amount of cracking of the four sections, however the cracking was not severe. Test section 2 west has significant longitudinal cracking down the center of the lane. These can be seen in the photographs on pages 9-11.

Table 1. Rut Depths by Section and Lane
(in tenths of an inch)

Section		L-Rut (139 West)	R-Rut (139 West)	L-IRI (139 West)	R-IRI (139 West)	Section		L-Rut (139 East)	R-Rut (139 East)	L-IRI (139 East)	R-IRI (139 East)
Control 1	average	1.3	2.0	86.56	77.99	**Control 1**	average	0.8	1.2	88.91	91.25
	stdev	1.1	0.4	20.64	24.12		stdev	0.4	0.8	54.28	42.14
Control 2	average	0.3	1.7	89.19	92.91	**Control 2**	average	0.6	1.7	105.65	104.36
	stdev	0.5	0.7	41.23	39.19		stdev	0.7	0.5	54.20	46.18
Test 1	average	0.7	2.1	62.69	77.51	**Test 1**	average	0.6	1.3	61.99	81.18
	stdev	0.8	0.3	14.10	18.66		stdev	0.5	0.6	16.76	37.30
Test 2	average	0.9	5.0	55.11	86.81	**Test 2**	average	0.9	2.2	61.12	62.93
	stdev	0.7	3.7	13.08	21.67		stdev	0.6	0.4	23.98	12.03

West	Avg. Rut	Avg. IRI	East	Avg. Rut	Avg. IRI
Control 1	**1.7**	**82.3**	**Control 1**	**1.0**	**90.1**
Control 2	**1.0**	**91.1**	**Control 2**	**1.2**	**105.0**
Test 1	**1.4**	**70.1**	**Test 1**	**1.0**	**71.6**
Test 2	**2.9**	**71.0**	**Test 2**	**1.6**	**62.0**

Table 1: 2005 ARAN Data

Table 2. Average FWD 1st Sensor Deflections
(thousandths of an inch)

Control 1		Sep 1998	May 1999	May 2000	May 2003	Oct 2005	Test 1		Sep 1998	May 1999	May 2000	May 2003	Oct 2005
STATION	**Offset**			**Sensor #1**			**STATION**	**Offset**			**Sensor #1**		
52+75	R	10.21	10.19	9.17	6.68	9.1	43+75	R	11.33	9.38	8.91	7.22	8.94
53+75	R	10.45	14.96	13.58	10.14	11.01	45+75	R	11.88	10.39	8.95	7.54	8.54
54+75	R	14.10	13.67	11.55	8.87	10.06	47+75	R	10.77	7.98	8.08	6.85	7.79
55+75	R	9.23	7.65	6.35	4.61	5.88	49+75	R	10.96	9.63	9.10	7.57	8.47
56+75	R	10.30	11.27	8.15	6.38	8.79	51+75	R	11.60	9.84	9.57	8.2	9.02
57+00	L	9.93	9.63	8.69	5.65	7.98	51+00	L	9.73	12.50	10.80	7	10.66
56+00	L	13.25	15.93	7.75	4.95	8.04	49+00	L	9.26	12.16	9.99	6.6	9.08
55+00	L	13.91	14.70	14.85	9.62	11.42	47+00	L	9.96	11.16	10.06	7.29	9.79
54+00	L	10.36	9.84	12.40	8.73	10.94	45+00	L	8.73	10.55	9.81	6.49	10.1
53+00	L	11.49	9.58	10.76	6.8	7.63	43+50	L	11.98	11.86	10.33	7.56	11.32
Average		**11.32**	**11.74**	**10.33**	**7.24**	**9.09**	**Average**		**10.62**	**10.55**	**9.56**	**7.23**	**9.37**

Test 2		Sep 1998	May 1999	May 2000	May 2003	Oct 2005	Control 2		Sep 1998	May 1999	May 2000	May 2003	Oct 2005
STATION	**Offset**			**Sensor #1**			**STATION**	**Offset**			**Sensor #1**		
34+75	R	11.24	8.49	9.20	8.13	10	30+25	R	9.05	8.54	8.93	7.07	8.74
36+75	R	10.74	8.91	10.16	8.57	10.01	31+25	R	9.35	8.96	9.67	8.3	9.98
38+75	R	14.47	9.34	12.28	10.39	11.88	32+25	R	9.32	9.38	8.89	7.48	9.23
40+75	R	10.45	9.59	10.58	9.16	9.45	33+25	R	9.27	9.63	8.95	7.55	6.62
42+75	R	9.64	9.11	10.05	8.5	10.69	34+25	R	10.04	9.15	8.08	6.45	8.64
42+00	L	10.11	9.50	9.77	7.19	9.46	34+00	L	8.06	9.49	7.93	5.4	8.11
40+00	L	10.68	10.60	10.11	7.85	10.54	33+00	L	10.15	10.59	7.67	5.47	7.1
38+00	L	11.49	10.74	10.32	7.77	11.14	32+00	L	9.54	10.74	10.41	7.69	9.93
36+00	L	11.50	7.91	9.68	7.28	9.74	31+00	L	8.16	7.90	10.68	8.41	9.97
35+00	L	10.02	8.20	9.03	7.47	9.31	30+00	L	8.59	8.19	9.34	7.06	9.39
Average		**11.03**	**9.24**	**10.12**	**8.23**	**10.22**	**Average**		**9.15**	**9.26**	**9.05**	**7.09**	**8.77**

Table 2: 2000, 2003 & 2005 FWD Data

Analysis of Section Uniformity

In 1996, as part of it's Long Term Pavement Performance program (LTPP), the Federal Highway Administration, published a study on section uniformity using FWD testing. The report hypothesizes that nonuniformity of a pavement's response to a load, leads to larger tensile and shear stresses in the adjacent areas, precipitating fatigue cracking and leading to pot-holing. A statistic that can be used to assess section uniformity is the coefficient of variation (COV) of the first sensor deflection readings. The COV is a measure of the relative dispersion of a set of observations, and is useful in evaluating sets of measurements. It is generally expressed as a percentage. In many sets of data the mean and standard deviation tend to vary together with one another. The value of the COV lies in the fact that it avoids this statistical problem. It measures the relative change between the mean and standard deviation. The research literature suggests that lower COV values are associated with longer pavement life. There is, however, limited evidence to support this hypothesis. Existing evidence suggests that newly constructed pavements should have COVs below 15%, and definitely below 20%. Table 3 below shows the pavement rating scale proposed by the LTPP program.

Table 3. Pavement Rating by Coefficient of Variation

Coefficient of Variation (COV)	Classification
<10%	Excellent
>10% and <15%	Good
>15% and <20%	Fair
>20% and <25%	Fair-Poor
>25%	Poor

The following Table compares the section uniformity of the sections on this project.

Table 4. Comparison of Section Uniformity					
Control 1	**Right**	**Left**	**Test 1**	**Right**	**Left**
Average	8.97	9.20	Average	8.55	10.19
Std. Dev.	1.933	1.82	Std. Dev.	0.4892	0.8512
COV	**21.6%**	**19.8%**	**COV**	**5.7%**	**8.4%**
Test 2	**Right**	**Left**	**Control 2**	**Right**	**Left**
Average	10.41	10.04	Average	8.64	8.90
Std. Dev.	0.934	0.778	Std. Dev.	1.2484	1.256
COV	**9.0%**	**7.7%**	**COV**	**14.4%**	**14.1%**

Both Test Sections have good overall uniformity. Using the Classification from the LTPP studies mentioned above, these sections would be Excellent. The Control sections have Fair to Poor Uniformity. These results are consistent with the IRI ratings, in that both Test Sections have lower average IRI than the Control Sections, even though the average rut depths are similar. This is a significant finding; these Sections should continue to be monitored for future performance to see if this trend continues in the next few years when deterioration is expected to accelerate due to pavement aging.

Photos

The following photos were taken in 2007, and show each of the sections.

Control Section 2

Control Section 2

Test Section 2

Test Section 2

Test Section 2

Test Section 2

Test Section 2

Test Section 1

Test Section 1

Test Section 1

Test Section 1

Control Section 1

Conclusions

ARAN and FWD testing has shown some degree of performance differences between the permeable base test sections and the control sections. Visual inspection does not reveal large differences between the sections, however an analysis of section uniformity reveals that both test sections still have excellent COV ratings whereas the control sections have poor uniformity. This may lead to longer life of the test sections, however, after eight years all sections are in the expected range of IRI and rut as compared to other MaineDOT highway reconstruction projects.

There are a few construction issues that need to be considered when comparing the test sections. As noted earlier control section 2 has RAP, control section 1 does not. This may explain why control section 2 has better uniformity and lower IRI than control section 1. Control section 1 therefore may be more representative of typical highways in this age class.

Another factor was the constructability of the permeable base sections. Due to the difficulty of construction this method of construction has not been tried again at MaineDOT. The first attempt to pave on the untreated aggregate was unsuccessful due to the paver wheels sinking into the base material. A track paver was used to pave test section 2 and did not encounter any more sinking. Initial attempts to coat the aggregate in test section 1 were unsuccessful. The initial attempts used an unheated aggregate, which resulted in small clumps of bitumen in what was essentially an untreated aggregate. Heating the aggregate resolved this problem. The westbound portion of test section 1 is where the initial attempts of asphalt treated base with unheated aggregate were used.

These problems could be avoided on future permeable base trials. It is imperative that only heated asphalt is mixed with the aggregate, and in addition a tracked paver should be used to place the final pavement lifts on top of the permeable base material. This project did not realize the benefits of reduce pavement thickness as planned, however, this could again be tried on a future project.

The Fairfield Route 139 project is entering the phase of its design life when standard highway reconstruction projects begin to deteriorate exponentially. The performance of these test sections over the next four years will be crucial in determining if permeable base construction techniques improve the design life of a roadway.

Prepared by:

Timothy Soucie
Pavement Research Engineer
Maine Department of Transportation
16 State House Station
Augusta, Maine 04333-0016
Tel.207-624-3264
e-mail: timothy.soucie@maine.edu

Bill Thompson
Transportation Planning Specialist
Maine Department of Transportation
16 State House Station
Augusta, Maine 04333-0016
Tel.207-624-3277
e-mail: william.thompson@maine.us

Reviewed By:

Dale Peabody
Transportation Research Engineer
Maine Department of Transportation
16 State House Station
Augusta, Maine 04333-0016
Tel. 207-624-3305
e-mail: dale.peabody@maine.gov