Evaluation of a Field Permeameter as a Longitudinal Joint Quality Indicator

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16. Abstract

Premature distress along the longitudinal construction joint in asphalt pavements occurs when adequate density or tightness is not achieved during construction. The objective of this research project was to evaluate a field permeameter as a tool to evaluate the quality of longitudinal joints. As part of the study, a field permeameter that can simultaneously test three locations; along the joint and one foot into both mats, was developed. The permeameter was used to test longitudinal construction joints on pavement projects around New England. Pavements that were tested as part of the study had nominal maximum size aggregate (NMSA) raging from 9.5 mm to 25 mm; base, binder, and surface courses were tested, and various joint construction techniques were used, including infrared heating and various joint sealants. Field cores at most test sites were taken for air void and strength testing in the laboratory and performance of the joints over the course of the project was monitored for several sites. Results of the study show that a permeability or infiltration criterion for longitudinal joint quality is promising. However, more refinements need to be made to the permeameter to reduce the variability in test results. The research team suggests returning to a single standpipe permeameter (air or water) to improve variability. The study also shows that improved construction techniques, such as joint sealants or use of a joint heater, improve the short term performance of the longitudinal joint.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimetres	mm
ft	feet	0.305	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
		AREA		
in^2	square inches	645.2	millimetres squared	mm^2
ft^2	square feet	0.093	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometres squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	Litres	L
ft^3	cubic feet	0.028	metres cubed	m^3
yd^3	cubic yards	0.765	metres cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3

Symbol	When You Know	Multiply By	To Find	Symbol
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celcius temperature	°C

* SI is the symbol for the International System of Measurement

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
		AREA		
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometres squared	0.386	square miles	mi^2
		VOLUME		
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m^3	metres cubed	35.315	cubic feet	ft^3
m^3	metres cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C+32	Fahrenheit temperature	°F

°F 32 98.6 212

-40 0 40 80 120 180 200 °F

-40 -20 0 20 40 60 80 100 °C

°C 37 °C

Abstract

Premature distress along the longitudinal construction joint in asphalt pavements occurs when adequate density or tightness is not achieved during construction. The objective of this research project was to evaluate a field permeameter as a tool to evaluate the quality of longitudinal joints. As part of the study, a field permeameter that can simultaneously test three locations; along the joint and one foot into both mats, was developed. The permeameter was used to test longitudinal construction joints on pavement projects around New England. Pavements that were tested as part of the study had nominal maximum size aggregate (NMSA) raging from 9.5 mm to 25 mm; base, binder, and surface courses were tested, and various joint construction techniques were used, including infrared heating and various joint sealants. Field cores at most test sites were taken for air void and strength testing in the laboratory and performance of the joints over the course of the project was monitored for several sites. Results of the study show that a permeability or infiltration criterion for longitudinal joint quality is promising. However, more refinements need to be made to the permeameter to reduce the variability in test results. The research team suggests returning to a single standpipe permeameter (air or water) to improve variability. The study also shows that improved construction techniques, such as joint sealants or use of a joint heater, improve the short term performance of the longitudinal joint.

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1.0 Introduction

1.1 Background

The construction of hot mix asphalt (HMA) pavements requires the use of longitudinal joints when the width of the pavement exceeds the capability of the paver. The longitudinal joint is created between adjacent paving lanes and can be difficult to construct. During compaction of the first lane, the material along the joint cools quicker than the bulk of the mat and is unconfined, making it more difficult to compact adequately. When the next lane is constructed, the material along the joint cannot maintain adequate temperature and therefore does not get compacted as well as the mat. A poorly compacted or constructed joint will allow water and other materials to penetrate the pavement surface, leading to premature degradation. Water infiltration into the joint and subsequently freezing causing damage to the pavement is of particular concern in New England. HMA with low density will also experience more rapid aging of the asphalt binder due to oxidation and will become more susceptible to fatigue and thermal cracking. A poorly constructed or compacted joint can lead to a variety of distresses including weakening of the underlying layers, fatigue cracking, stripping, and raveling at the longitudinal joint. These premature distresses necessitate costly repairs and maintenance on the pavement. Hence, there is a need to ensure that a longitudinal joint with adequate tightness and density is achieved during construction.

Agencies and contractors have developed various joint construction techniques to achieve adequate density along longitudinal joints. Additional new and innovative methods for constructing longitudinal joints that will perform satisfactorily continue to be developed and researched around the country; these include an infrared joint heater and various joint sealants and compounds. These efforts are focused on improving the construction and resulting performance of the joint itself, however, the overall quality of the longitudinal joints needs to be evaluated in the field, regardless of construction technique.

The density of the HMA at the longitudinal joint is related to the quality and performance of the joint *(1)*. Density can be measured using a nuclear gage or by obtaining cores from the pavement and measuring density in the laboratory. The permeability of the longitudinal joint is also a measure of quality, as a less permeable joint will not allow the intrusion of water and foreign matter that lead to some premature distresses. Studies *(2-6)* have shown a correlation between the field permeability and in-place density of HMA mixtures. The potential exists for the use of a field permeameter as a tool to evaluate the quality of longitudinal joints. Establishing test equipment, a test procedure, testing frequency and acceptance criteria for using a field permeameter to evaluate the quality of longitudinal joints in HMA pavements will allow agencies in New England to better estimate the overall pavement performance and more accurately plan maintenance and rehabilitation strategies, saving valuable resources and improving serviceability to the traveling public.

1.2 Research Objectives

The main objective of this research was to evaluate a field permeameter as a tool to evaluate the quality of longitudinal joints. This was accomplished by performing field permeability testing using a permeameter developed as part of the study. Permeability and core testing was performed at various construction projects around New England.

2.0 Literature Review

A literature review on the use of a permeameter for longitudinal joints conducted at the beginning of this project revealed only two references. Pretorius et al (*7*) describes the Marvil test for determination of quality of joint construction in airports. The Marvil test is essentially a flow test that is used in South Africa to determine the water permeability of asphalt and base course layers. The equipment consists of a circular weight and an acrylic tube with volume markings. A pressure head of 380 mm is used to measure flow of water through a 175 mm diameter circular area. Pretorius et al reports that untreated joints had permeabilities 10 times greater than the layers; permeability values of 30 l/h to 250 l/h have been cited. In the same paper, the authors mention a decreased permeability for joints with improved construction techniques (below 3 l/h).

Although no formal study has been done, Cooley (*8*) conducted some preliminary tests with the National Center for Asphalt Technology (NCAT) permeameter (*5*), and has commented on the feasibility of using this permeameter for determination of quality of joint construction.

3.0 Development of the Longitudinal Joint Permeameter

The objective was to construct a falling head permeameter suitable for use on HMA pavement longitudinal joints and capable of testing three locations simultaneously: the joint and locations on the mat one foot to either side of the joint. The longitudinal joint permeameter was developed by modifying the field permeameter developed at Worcester Polytechnic Institute (WPI) (*4*). The permeameter developed at WPI was based on the NCAT field permeameter *(6)*. The WPI device (Figure 1) has three tiers, a flexible base, and five donut shaped weights. A scale is attached to the top two tiers for reading the level of water. The three tiers were recommended *(5)* for testing pavements with a wide range of permeability, and hence different rates of water flow. A flexible closed-cell sponge rubber is used as the base because of its non-absorptive nature and its ability to prevent flow of water through the macrostructure of the pavement surface. The donut shaped weights (total of 47 kg or 110 lb) resist the uplift forces exerted by the introduction of water into the device and maintain a good seal with the pavement surface. Use of this sealing system allows for cores to be taken at the exact spot that testing is conducted.

Figure 2 shows a schematic cross-section view of the longitudinal joint permeameter developed in this project. Two inch thick PVC plastic was chosen for the base of the permeameter due to its rigidity, ease of machining, and natural resistance to water. No painting, sealing, or other maintenance is required. This base plate was mounted to an appliance hand truck which not only allows ease of movement along the roadway but also provides some of the weight required to seal the permeameter to the pavement. Holes were cut along the center line of the base plate to accommodate three clear Lexan standpipes. The standpipe design for this permeameter deviates from the WPI device in that it is a straight pipe instead of tiered. Lack of use of the bottom two tiers in the WPI permeameter and simplified construction were the main reasons for this design change. The inside diameter of the pipe is 2.5 inches and the length of each pipe is 24 inches, resulting in a volume of roughly 60 in^3 which is sufficient for the increased flow rates over the longitudinal joint.

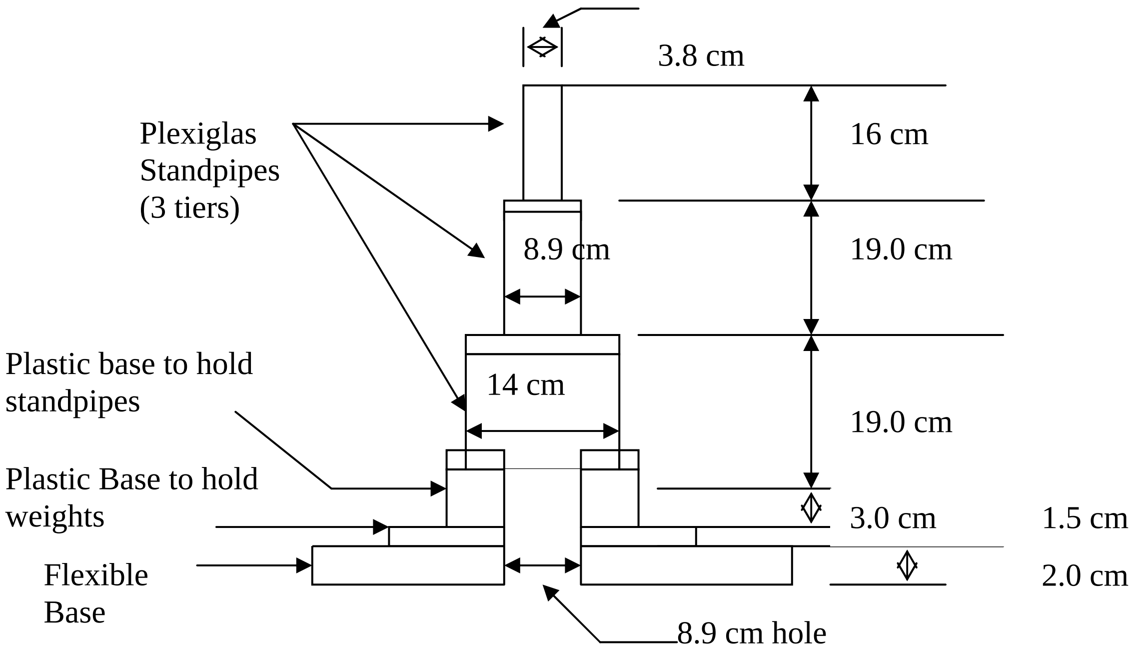


Figure 1. Sketch and photo of the WPI permeameter

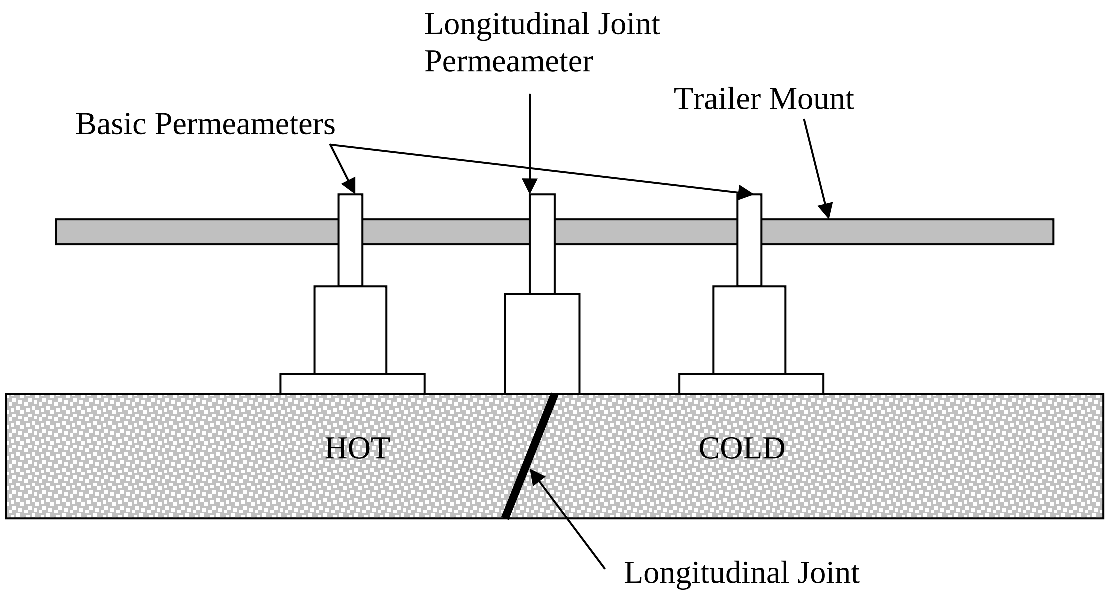


Figure 2. Schematic Diagram of Longitudinal Joint Permeability Trailer

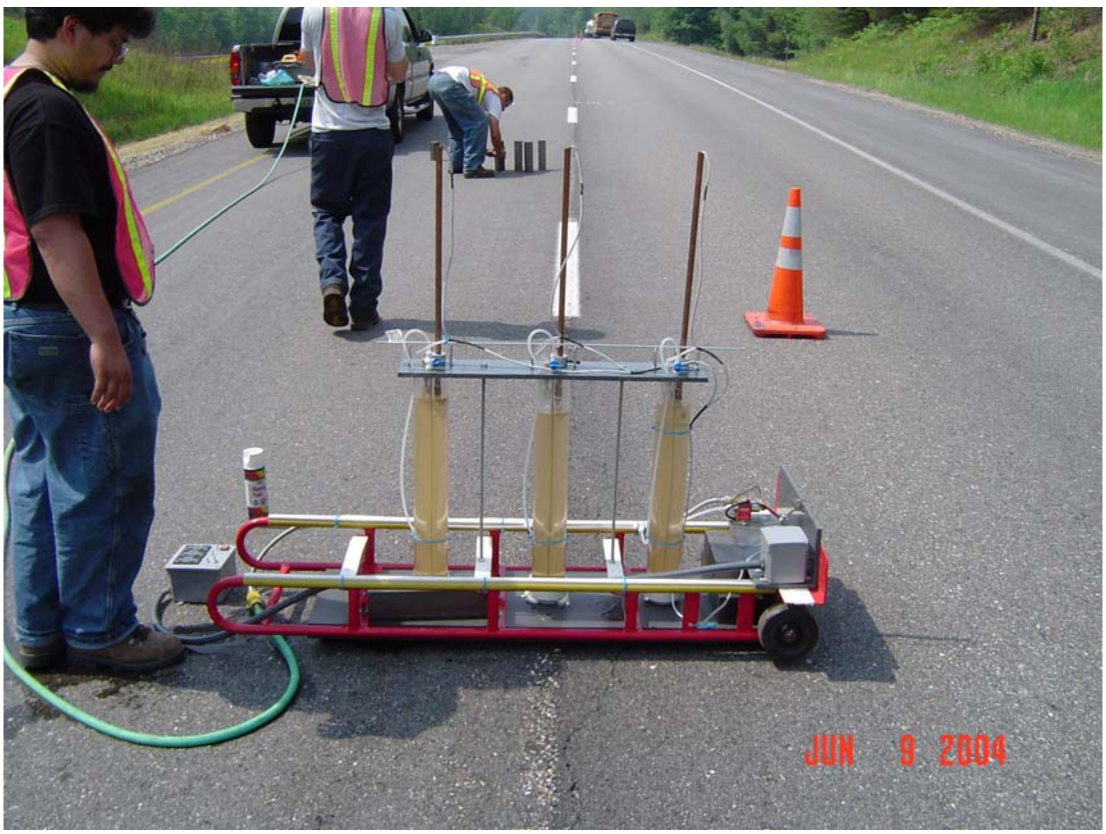
The WPI permeameter used a 55 gallon drum to feed the device, relying on natural pressure and gravity heads to fill the permeameter. While this system was adequate, it was a slow process that took even longer when the drum was nearly empty or when the pavement was highly permeable. It was theorized that the pavement could become saturated to varying degrees that would be difficult to measure in the field. To remedy this, the longitudinal joint permeameter was designed with a 2 inch PVC ball valve at the bottom of the standpipe so that the water flow could be stopped while the pipe was filled with water and opened instantly when flow was desired. However, it was found that valves of this size and construction are difficult to operate quickly and it would be nearly impossible to operate three of them simultaneously via a linkage system. Brass ball valves were considered but the cost was deemed to be too high. A simple, low cost solution was found in the rubber ball flaps used in toilet tanks. These flaps are cheap, easy to use, and maintenance free. The conical-shaped piece of soft rubber seals perfectly against a 3 inch to 2 inch PVC reducing coupling, and three of them were easily mounted to a linkage to allow simultaneous operation.

Included in the revised design was a twelve volt water pump to assist the flow of water from the 55 gallon drum to the permeameter. To power the pump a twelve volt tractor battery was strapped to the bottom of the hand truck. Also, an automatic timing system was designed to make timing measurements more consistent and repeatable. The design employed two liquid-level float switches and a digital timer for each standpipe. When the water level dropped below the top switch the timer was activated. The timer ran until the water level dropped below the bottom switch at which point the timer stopped and held the elapsed time until the timer was manually reset by the operator. This allowed all three locations to be tested at the same time by one operator, even if the permeability of the pavement under each standpipe was vastly different.

The distance between the two level switches was also adjustable so that the operator could shorten or lengthen the test time if required. The only drawback to this setup was the switches and their associated holders occupied some of the volume inside the standpipe. The revised design of the longitudinal joint permeameter also included different profiles under the center standpipe that could be swapped in a matter of minutes in the field. An area under the center standpipe was milled to a depth of 0.5 inch and four PVC plastic plates were machined with different sized slots and designed to bolt into this area. One of the plates employed a circular hole that is the same size as the side standpipes. The other three plates had rectangular slots of various dimensions milled in them so that the water would flow over the longitudinal joint and nowhere else.

During preliminary testing, it was found that additional weight, beyond the self weight of the device, was required to achieve an adequate seal with the pavement surface. An adequate seal is achieved when no leaking is observed around the foam ring in contact with the pavement surface. Steel weights were placed on top of the hand truck once it had been put in place over the measurement location. Different thicknesses of foam base are needed under each of the standpipes to account for any crown or slope in the road. A method of quickly attaching various thicknesses of base foam was developed to allow for adjusting to different pavement profiles at each measurement location. After preliminary tests, the automatic timing system was abandoned due to operational problems. It was just as efficient to manually open and close the standpipe valves with the system linkage for a specified length of time and record the water head before and after in each standpipe. Figure 3 shows the completed permeameter being used in the field.

(a) (b)



(c)

Figure 3. (a) Permeameter taken down from truck; (b) Filling with water; (c) close-up of permeameter on joint

4.0 Testing

4.1 Longitudinal Joint Testing Sites

Over the course of this project, longitudinal joint testing was performed on joints in all New England states except RI, on mixtures with NMSA ranging from 25 mm down to 9.5 mm, and joint types that included conventional construction methods and improved techniques such as heating the joint and joint sealers. There were several opportunities to test in RI, however malfunctioning equipment and conflicting schedules prevented testing from actually taking place for this project. Table 1 provides a summary of each testing site. The sites were selected with the assistance of DOT personnel in each state. One of the biggest challenges in this project was finding sites that had appropriate traffic control to allow the joint testing to take place. This was the limiting factor in the number of sites that could be tested.

4.2 Testing Procedure

At each testing site, three to five testing locations were selected for each joint type (if more than one joint type was represented at that site). At each testing location, three to five replicate measurements were performed. The procedure for performing the test at each location was as follows:

1. Place permeameter at testing location and determine the approximate crown in the road.
2. Attach appropriate thickness foam disks under each standpipe to account for crown.
3. Replace permeameter on testing location and add steel weights.
4. Fill standpipes with water and open valves to make sure there is no leaking at pavement surface.
5. Refill standpipes if needed and record initial head.
6. Open valves for specified time (30-60 seconds).
7. Record final head, check for leaks.
8. Repeat steps 5-7 for desired number of replicates.
9. Unload weights, mark coring locations (if applicable) and move permeameter to next testing location.
10. Repeat steps 1-9 for desired number of test locations.

Table 1. Summary of Longitudinal Joint Testing Sites

State	Site Details	Date Tested	Date Paved	NMSA (mm)	Joint Type(s)	Cores Taken	Notes
NH	Intermediate course on I-93 Southbound Lanes between Exits 26&27 in Plymouth	6/9/04	June 2003	19	Conventional, Infrared Heater	At the test locations	Initial Testing with permeameter, both circular and rectangular bottom plates were used for the joint
NH	Intermediate course on I-93 Southbound Lanes between Exits 26&27 in Plymouth	7/29/04	June 2003	19	Conventional, Infrared Heater	At other locations	Testing with the circular plate only. Testing done as close as possible to the cores taken in June 2003
NH	Surface course on I-93 Southbound Lanes between Exits 26&27 in Plymouth	8/10/04	8/2/04	12.5	Conventional, Infrared Heater	At other locations	Testing with the circular plate only. Testing done as close as possible to the cores taken on 8/2/04
NH	Base course on Rt 153 in Farmington	7/12/04	7/12/04	25	Conventional	At the test locations	Testing with the circular plate only.
NH	Base course on Rt 25 in Effingham	8/4/04	8/4/04	19	Conventional	At the test locations	Testing with the circular plate only.
ME	Surface course on I-95	9/1/04	Aug/Sept 1999	12.5	Rubberized joint sealer, Emulsified asphalt sealer HFMS-1, Koch SealerProduct # 900S-HV Joint Adhesive	At the test locations	Circular plate
CT	Surface course on Rt 44 in Pomfret	11/19/04	7/27/04	12.5	Pinched joint	At the test locations	
CT	Surface course on Rt 17 in Glastonbury	11/18/04	7/26/04	12.5	Pinched joint	At the test locations	
CT	Surface course on Rt 17 in Middletown	11/18/04	7/27/04	12.5	Pinched joint	At the test locations	
ME	Surface course I-95	6/9/05	6/9/05	19	Rubber joint sealer with overlapping joint	At the test locations	

State	Site Details	Date Tested	Date Paved	NMSA (mm)	Joint Type(s)	Cores Taken	Notes
MA	Surface course I-95 North	7/13/05	7/18/05	12.5	Pinched joint	At the test locations	
CT	Middletown	8/8/05	7/27/04	12.5	Pinched joint	At the test locations	10ft north of original sites
CT	Glastonbury	8/8/05	7/26/04	12.5	Pinched Joint	At the test locations	10ft north of original sites
CT	Pomfret	8/10/05	7/27/04	12.5	Pinched Joint	At the test locations	10ft east of original test sites
VT	Surface course on I91, north of mile 101	9/28/05	9/27/05	12.5	1/3 taper with tack	QC/QA cores	
ME	Rt 5 in Lovell	10/17/05	10/17/05	9.5	1” overlap, conventional with tack	At the test locations	Nuke gage readings at test locations

4.3 Core Testing

In most cases, cores were taken at the longitudinal permeameter test locations after testing was complete. For other cases, cores were obtained at other locations or results from QC/QA cores taken by the state were used. The volumetric properties of the core samples were evaluated in the laboratory using the following test procedures:

- ASTM D 3549 - Method for Determining Thickness or Height of Compacted Bituminous Paving Mixture Specimens.
- AASHTO T 166 – Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface Dry Specimens.
- AASHTO T 269 – Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures.

In addition, the Modified AASHTO TP 9 – Standard Test Method for Determining the Creep Compliance and Strength of Hot Mix Asphalt using the Indirect Tension Test Device was performed on some of the cores to determine the Indirect Tensile Strength (ITS). Cores were aligned such that the joint was vertical, testing the strength of the joint.

5.0 Analysis

5.1 Calculation of Permeability and Infiltration

The permeability of the HMA for each replicate test was calculated using equation (1).

$$k = \left(\frac{aL}{At}\right)\ln\left(\frac{h_1}{h_2}\right) \qquad (1)$$

where:

k = coefficient of permeability, cm/s
a = inside cross sectional area of standpipe, cm^2
L = thickness of HMA course, cm
A = cross sectional area of hole through which water flows, cm^2
t = elapsed time between h_1 and h_2, s
h_1 = initial head in permeameter, cm
h_2 = final head in permeameter, cm

The thickness of the HMA course for sites where a core was not taken at the same location as the permeameter testing was determined by averaging the thickness of up to 5 cores closest to that station. The averages of the replicate readings for the joint and both mat standpipes at each location were calculated and used in further analysis. This data is summarized in Appendix A.

The flow of water into the pavement from the permeameter is not restricted to one-dimensional flow, as assumed in equation (1). The water from the permeameter can flow in all three dimensions, so that a measure of infiltration may be more appropriate for analysis. Infiltration values from replicate measurements at each test location were calculated using equation (2).

$$Inf = \frac{a(h_1 - h_2)}{At} \qquad (2)$$

where:

Inf = infiltration, cm/hr
a = inside cross sectional area of standpipe, cm^2
h_1 = initial head in permeameter, cm

h_2 = final head in permeameter, cm
A = cross sectional area of hole through which water flows, cm^2
t = elapsed time between h_1 and h_2, hr

The average infiltration measurements at each location are summarized in Appendix B.

A relationship exists between the permeability and infiltration values, as shown in Figure 4.

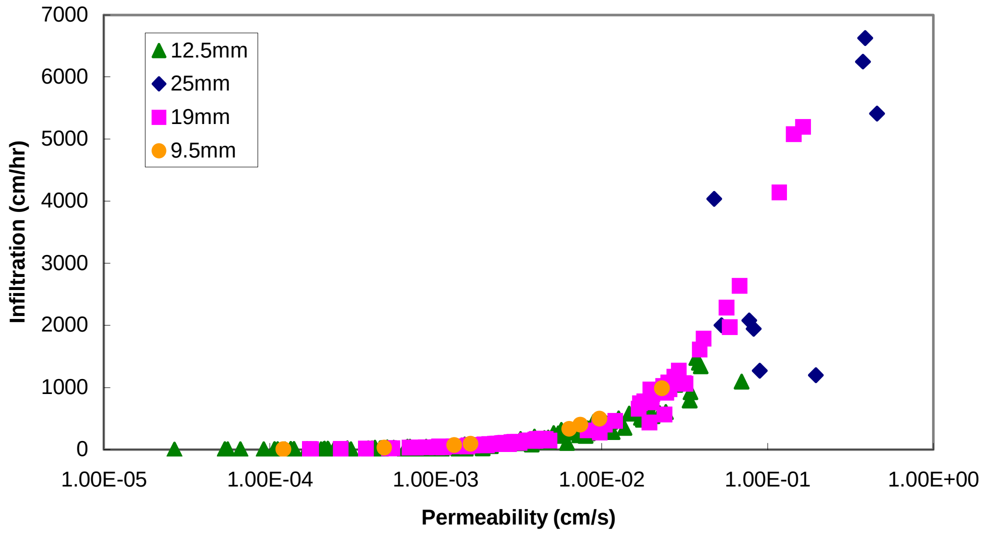


Figure 4. Relationship between Permeability and Infiltration for all Test Locations

In addition to calculating the average permeability and infiltration values under each standpipe at each location, the joint measurements as a percentage of the average mat measurements were calculated, as shown in equation (3). This was done to normalize the data and allow for comparison between different projects.

$$\frac{Jt}{Mat}\% = \frac{Jt.measurement}{\left(\frac{Mat_1\ meas + Mat_2\ meas}{2}\right)} * 100\% \qquad (3)$$

Figure 5 shows the average joint permeability as a percentage of the mat permeability for each test site (average of all testing locations at each site). The different patterns indicate the different NMSA mixtures; starting with the 25 mm mixture on the left and decreasing to the 9.5 mm mixture on the right. The smaller the bar, the closer the joint permeability is to the mat permeability. A value of 100 indicates the permeability of the joint and the mat are the same. The 12.5 mm Maine sites where various joint sealers were used have values below 100, indicating that the joint is less permeable than the mat. The graph also shows the effect of improved construction technique; the 19mm and 12.5mm NH I 93S sites have higher permeabilities than the NH I 93S heat sites, where the infrared joint heater was used.

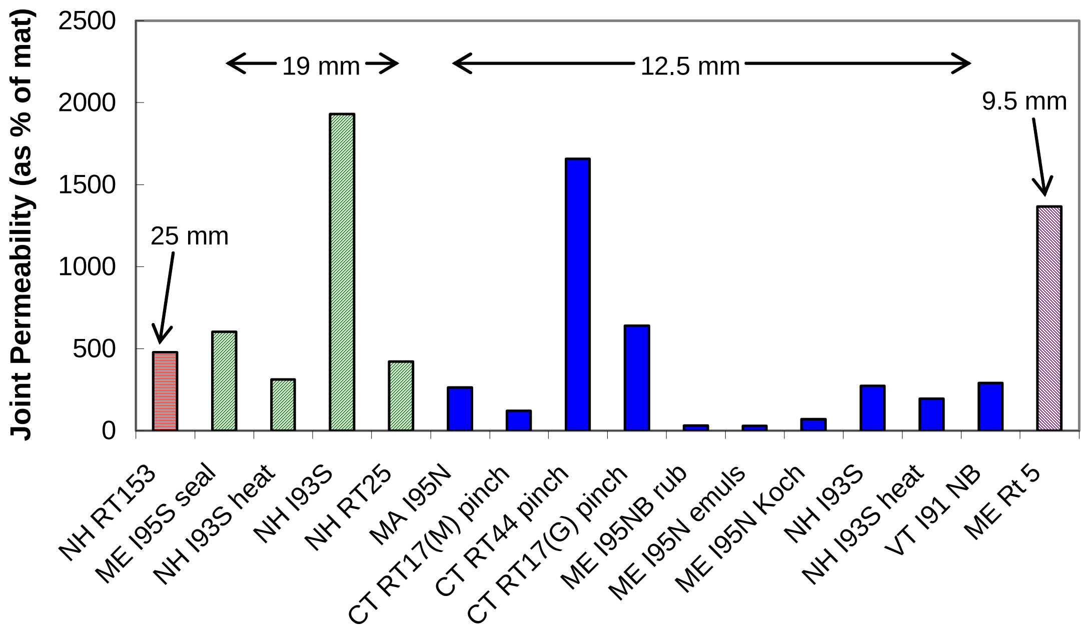


Figure 5. Average Joint Permeability as a Percentage of Average Mat Permeability

The average joint infiltration as a percentage of the mat infiltration for each test site is shown in Figure 6. The same patterns and trends observed from the permeability measurements can be seen with the infiltration measurements. The relative ranking among all of the sites is the same whether permeability or infiltration measurements are used.

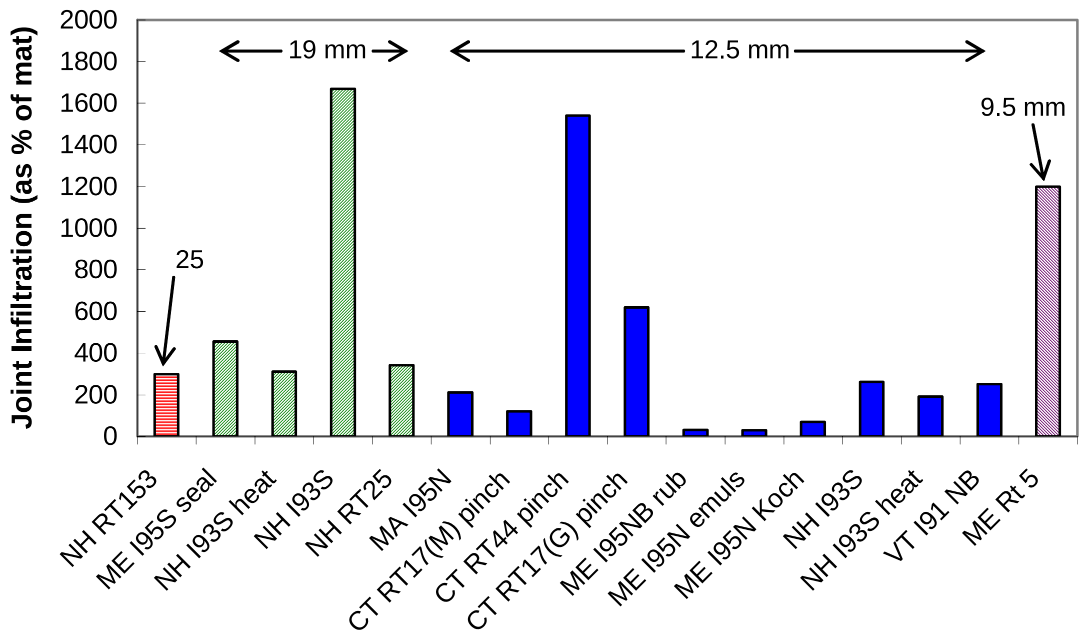


Figure 6. Average Joint Infiltration as a Percentage of Average Mat Infiltration

5.2 Circular vs Rectangular Opening for Joint Measurement

Preliminary tests were conducted with rectangular (6 inch by 0.5 inch) and circular (2.5 inch diameter) base plate openings under the center standpipe at the same locations along the 19 mm NH I93S test site. The results are shown in Figure 7. In all but one case, the permeabilities are very similar, with the circular plates measuring a slightly higher permeability than the rectangular plates. The measurement on the joint at station 76+10 with the rectangular plate is higher, likely due to inadequate seal with the pavement surface. In the field, it was difficult to consistently place the rectangular base plate to make the opening center coincide with the center of the joint. Also, the circular plate opening not only covered part of the "joint" but a small area on the sides, which are equally important. Therefore, the plate with the circular opening was used exclusively for the remainder of the project testing.

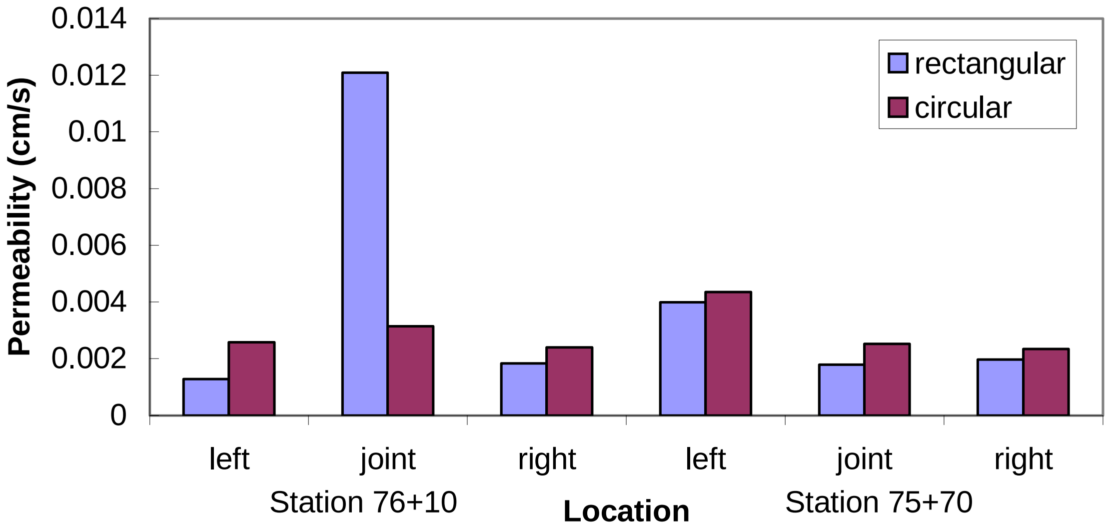


Figure 7. Permability Measured using Rectangular and Circular Base Plate Opening

5.3 Individual Permeameter Measurements

At each test location, three to five replicate measurements were made. From these individual measurements, the average (mean), standard deviation and sample variance were calculated for each location. This statistical analysis was performed on the permeability measurements. The data is summarized in Appendix A.

Figure 8 shows the relationship between the average permeability and the sample variance at all testing locations. The filled symbols represent the measurements on the mat and the open symbols represent the measurements on the joint. Sites where the average permeability was measured as zero have zero variance and are not plotted on the graph. The general trend shows that the sample variance increases with higher permeability measurements. Also, the coarse mixtures show higher permeability measurements, as would be expected.

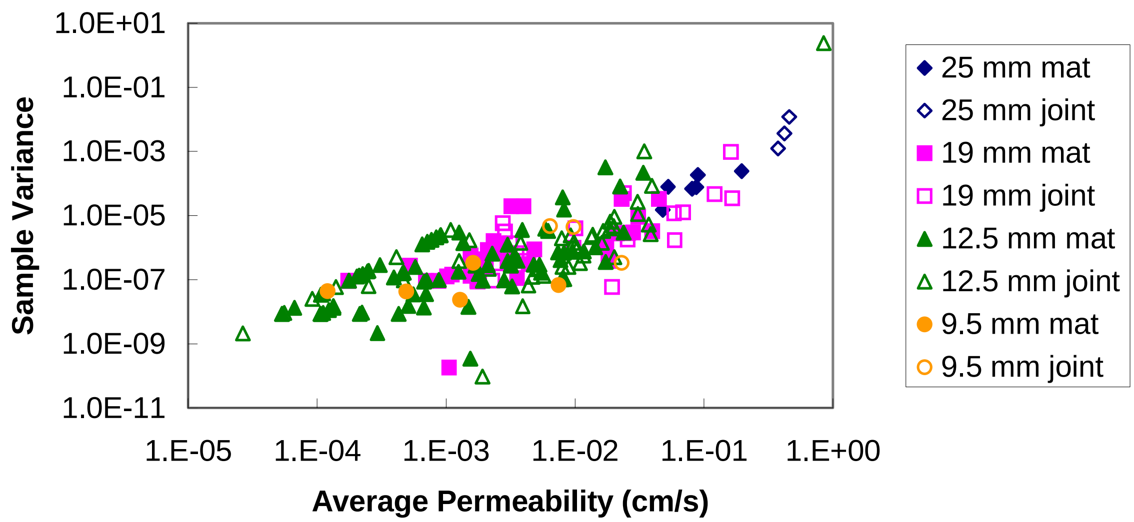


Figure 8. Sample Variance versus Average Permeability for All Test Locations

The standard deviation as a function of the average permability is shown in Figure 9. The same trends observed with the sample variance are seen. It is also important to determine the magnitude of the standard deviation with respect to the mean value by looking at the coefficient of variability (COV). Figure 10 shows this data. There are no trends with respect to gradation size or mat versus joint measurements. However, there is a large range of values; with COV ranging from less than 10% to over 100%.

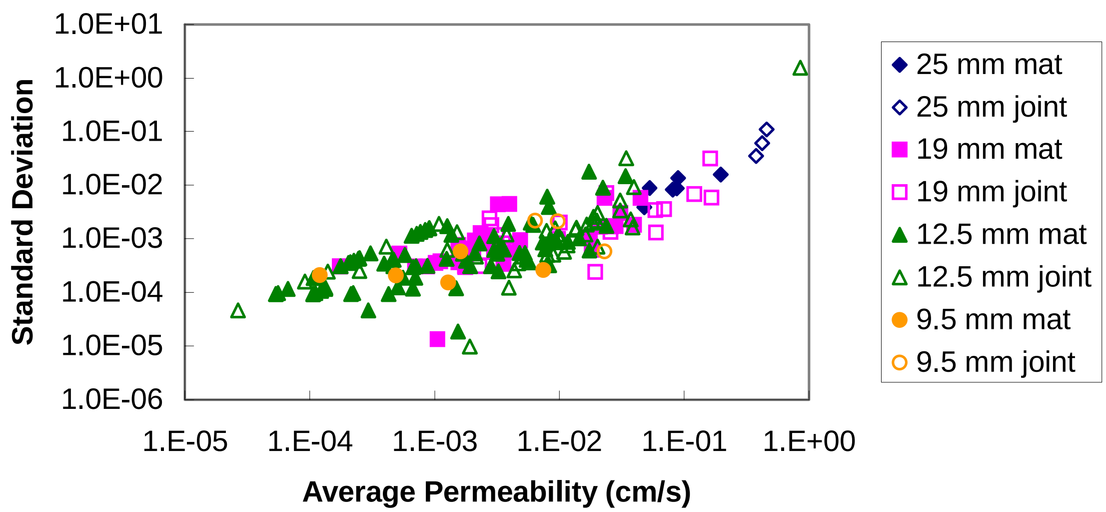


Figure 9. Standard Deviation versus Average Permeability for All Test Locations

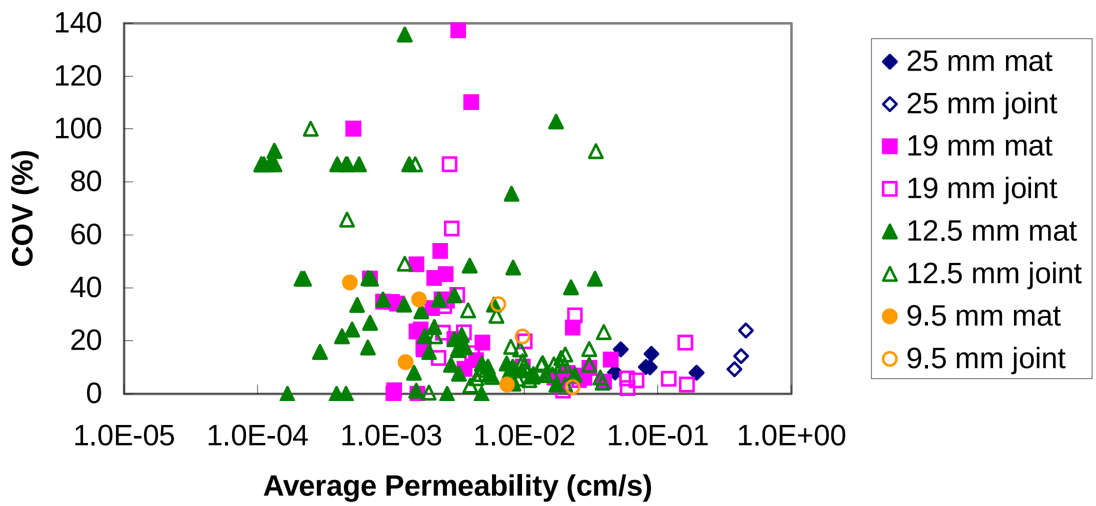


Figure 10. COV versus Average Permeability for All Test Locations

Statistical analysis using a t-test with 95% confidence was performed to determine if there was a statistical difference between the mat and joint measurements at each test location. This data is summarized in Tables 2-5 for the different NMSA mixtures. A "S" indicates that the replicate measurements from the two different standpipes are from a different population, or that the measured permeabilities are different. A "NS" indicates that they are from the same population, or the measured permeabilities are statistically the same. There are only a few tests sites where the statistical analysis of all the test locations agree as to whether there is a statistical difference between the measurements. This could be due to variability in the replicate measurements, or could reflect true construction variability along the site. If there is a significant difference between the mat and joint measurements, one may expect performance problems with the joint. However, these measurements must be related to the actual performance of the joint over time to develop criteria for acceptance. This is discussed further in section 6.

Table 2. Statistical Analysis of Permeability Measurements for 9.5 mm Test Locations

Test Site	Location	Significant Difference Between Measurements? S= Significant; NS = not significant		
		Mat 1 vs Joint	Mat 2 vs Joint	Mat 1 vs Mat 2
ME Rt 5	1	S	S	NS
	2	S	S	S
	3	S	S	S

Table 3. Statistical Analysis of Permeability Measurements for 12.5 mm Test Locations

Test Site	Location	Significant Difference Between Measurements? S= Significant; NS = not significant		
		Mat 1 vs Joint	Mat 2 vs Joint	Mat 1 vs Mat 2
MA 95NB	1	NS	NS	NS
	2	S	NS	S
	3	NS	NS	S
CT Rt 17 Middletown 2004	1	S	NS	S
	2	NS	NS	NS
	3	NS	NS	NS
	4	NS	NS	NS
	5	NS	NS	NS
CT Rt 17 Middletown 2005	1	NS	NS	NS
	2	NS	NS	NS
	3	NS	NS	NS
	4	NS	NS	NS
	5	NS	NS	NS
CT Rt 44 2004	1	S	S	NS
	2	S	S	S
	3	S	S	NS
	4	S	S	NS
	5	S	S	NS
CT Rt 44 2005	1	S	S	NS
	2	S	S	S
	3	S	S	NS
	4	S	S	NS
	5	S	S	NS
CT Rt 17 Glastonbury 2004	1	S	S	S
	2	S	S	S
	3	S	S	NS
	4	NS	NS	S
	5	S	S	S
CT Rt 17 Glastonbury 2005	1	NS	NS	NS
	2	S	S	NS
	3	NS	NS	NS
	4	S	S	NS
	5	S	S	NS
ME I95 NB Rubberized	1	NS	NS	NS
	2	NS	NS	NS
	3	S	NS	NS
ME I95 NB Emulsified	1	S	NS	S
	2	S	S	S
	3	NS	NS	NS
ME I95 NB Koch	1	NS	NS	S
	2	NS	NS	NS

	3	NS	NS	NS
NH I93 SB Control	1	S	S	S
	2	S	S	S
	3	S	S	S
	4	S	S	NS
	5	S	S	S
NH I93 SB Heater	1	NS	S	NS
	2	S	S	S
	3	S	NS	S
	4	NS	S	S
	5	S	S	S
VT I91 NB	1	S	S	S
	2	S	S	S
	3	S	S	S

Table 4. Statistical Analysis of Permeability Measurements for 19 mm Test Locations

Test Site	Location	Significant Difference Between Measurements? S= Significant; NS = not significant		
		Mat 1 vs Joint	**Mat 2 vs Joint**	**Mat 1 vs Mat 2**
ME I95 SB	1	S	S	NS
	2	S	S	NS
	3	S	S	NS
	4	NS	S	S
	5	NS	NS	S
NH I93 SB Control	1	NS	NS	S
	2	S	S	S
	3	S	S	NS
	4	S	S	NS
	5	S	S	S
NH I93 SB Heater	1	S	NS	S
	2	S	NS	NS
	3	S	S	NS
	4	S	S	S
	5	S	S	S
NH Rt 25	1	S	S	NS
	2	S	S	S
	3	S	S	NS
	4	S	S	S
	5	S	S	S

Table 5. Statistical Analysis of Permeability Measurements for 25 mm Test Locations

Test Site	Location	Significant Difference Between Measurements? S= Significant; NS = not significant		
		Mat 1 vs Joint	Mat 2 vs Joint	Mat 1 vs Mat 2
NH Rt 153	1	S	S	S
	2	S	S	NS
	3	S	S	S

5.4 Overall Test Site Permeameter Measurements

In addition to the statistical analysis in section 5.3, all permeability measurements made from each standpipe on a particular test site were pooled to determine if there was a significant difference in the permeabilities measured on each mat and on the joint on an overall basis for that site. This analysis includes construction variability that happens along the area of the project spanned by the permeability test locations. The t-test was used with 95% confidence to determine if the measurements were statistically different or not. The data for all project sites is summarized in Table 6 below. A "S" indicates a significant difference, a "NS" indicates there is not a significant difference between the two data sets. A significant difference between the mat and joint measurements could be an indicator of potential joint problems, depending upon the magnitude of the difference. This information of significant difference in permeability measurements should be combined with the quantitative measurements and observations of field performance over time to develop quality control criteria.

Table 6. Statistical Analysis of Permeability Data Pooled from all Testing Locations for each Project Test Site

NMSA	Project Test Site	Significant Difference Between Measurements? S= Significant; NS = not significant		
		Mat 1 vs Joint	Mat 2 vs Joint	Mat 1 vs Mat 2
9.5 mm	ME Rt 5	S	S	NS
12.5 mm	MA I95 NB	NS	NS	NS
	CT Rt 17 (M) '04	NS	NS	NS
	CT Rt 17 (M) '05	NS	NS	NS
	CT Rt 44 '04	S	S	NS
	CT Rt 44 '05	S	S	NS
	CT Rt 17 (G) '04	S	S	S
	CT Rt 17 (G) '05	S	S	NS
	ME I95 NB Rubber	NS	S	NS
	ME I95 NB Emuls	S	NS	NS
	ME I95 NB Koch	NS	NS	S
	NH I93 SB Contr	S	S	S
	NH I93 SB Heater	S	S	NS
	VT I91 NB	S	S	S
19 mm	ME I95 SB	S	S	S
	NH I93 SB Contr	S	S	S
	NH I93 SB Heater	S	S	NS

	NH Rt 25	S	S	NS
25 mm	NH Rt 153	S	S	NS

5.5 Core Data

The indirect tensile strength (ITS) and the air void content of cores taken from the testing sites were measured and the data is presented in this section. The core data for each site is summarized in Appendix B.

5.5.1 Relationship with Permeability

Figure 11 shows the air void content as a function of the measured permeability values. The permeability values are the average of the replicate values measured at that particular location. Only test sites where the cores were taken at the permeability test locations are shown on this graph. Due to the logarithmic scale in the figure, permeability measurements of zero are plotted as 1.0 x10^{-6}; these points all appear on the y-axis. There is a very general trend of increasing permeability with increasing air void content, as would be expected. However, the scatter in this relationship is significant. The 25 mm, 19 mm, and 9.5 mm NMSA data appear to be clustered together whereas the 12.5 mm data is more scattered. This could be due to the fact that there are more 12.5 mm testing sites. The 25 mm and 9.5 mm points each only represent one testing site. There is also a wide range of air void contents measured at locations where permeability was measured as zero. This indicates that air content by itself cannot explain the variation in permeability, since both surface voids/texture as well as air voids are known to affect permeability.

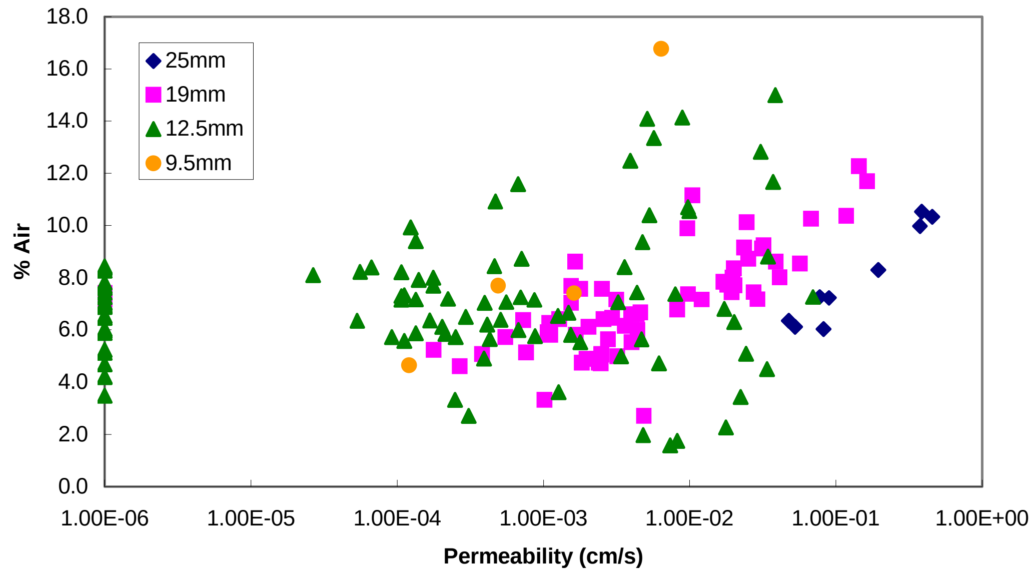


Figure 11. Air Void Content versus Permeability

The ITS measured from each core as a function of the average permeability at that location is shown in Figure 12. Permeability measurements of zero are plotted as values of 1.0 x 10^{-6} on the logarithmic scale. The expected trend of decreasing ITS with increasing permeability is seen, with a significant amount of scatter. Also, there is a wide range of ITS strengths measured for locations at which the permeability was measured as zero.

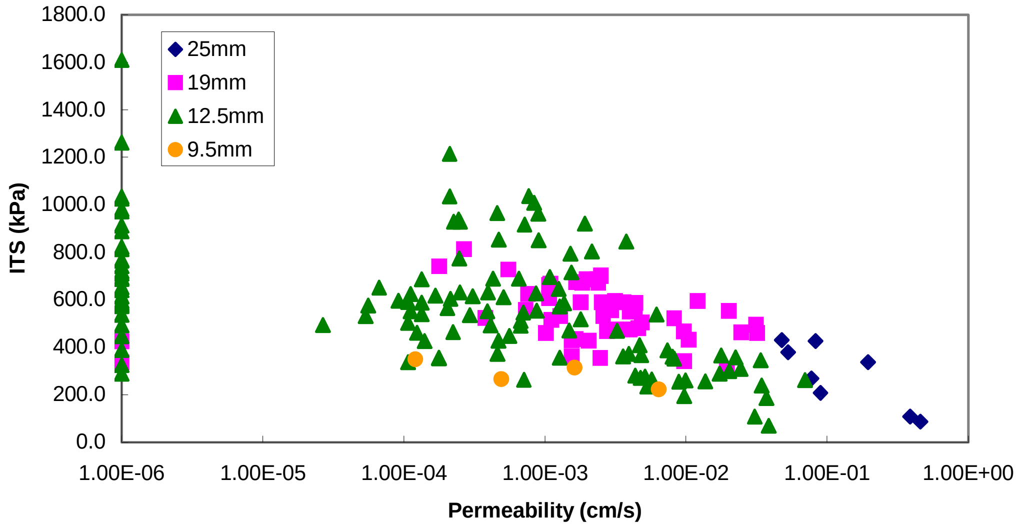


Figure 12. Indirect Tensile Strength versus Permeability

Figure 13 shows the relationship between ITS and air void content for the cores. The higher air void content cores have lower ITS strength, as expected. There is one 12.5 mm core that measured exceptionally high strength; the reason for this is unknown.

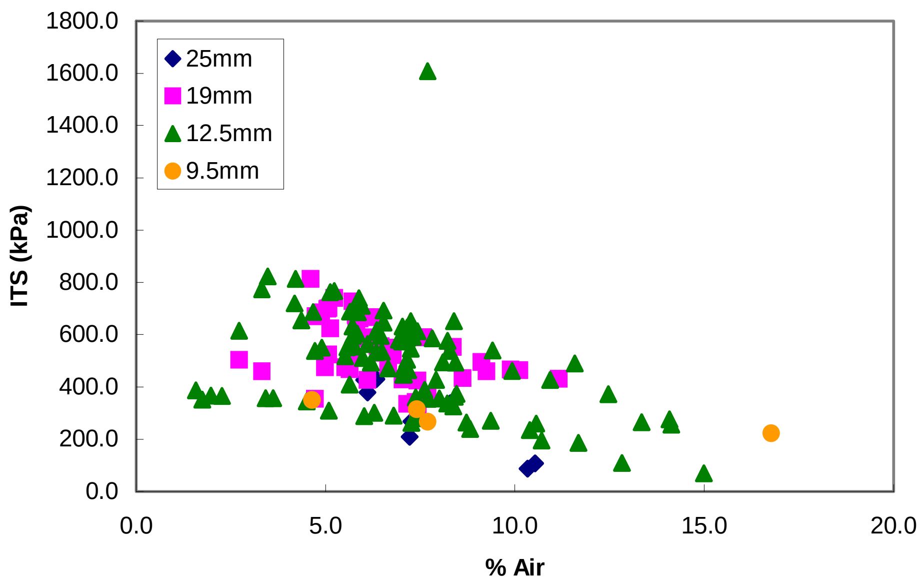


Figure 13. Indirect Tensile Strength versus Air Void Content

5.5.2. Statistical Analysis of Core Data

Statistical analysis of the ITS and air void data was performed and the data can be found in Appendix C. The sample variance as a function of the average values for the ITS and air void data are shown in Figures 14 and 15, respectively. The 12.5 mm mixtures show a trend of increasing variance with increasing ITS, but the other mixtures do not show that trend or do have enough data points to determine a trend. The air void data does not show any trend with sample variance for any of the mixtures.

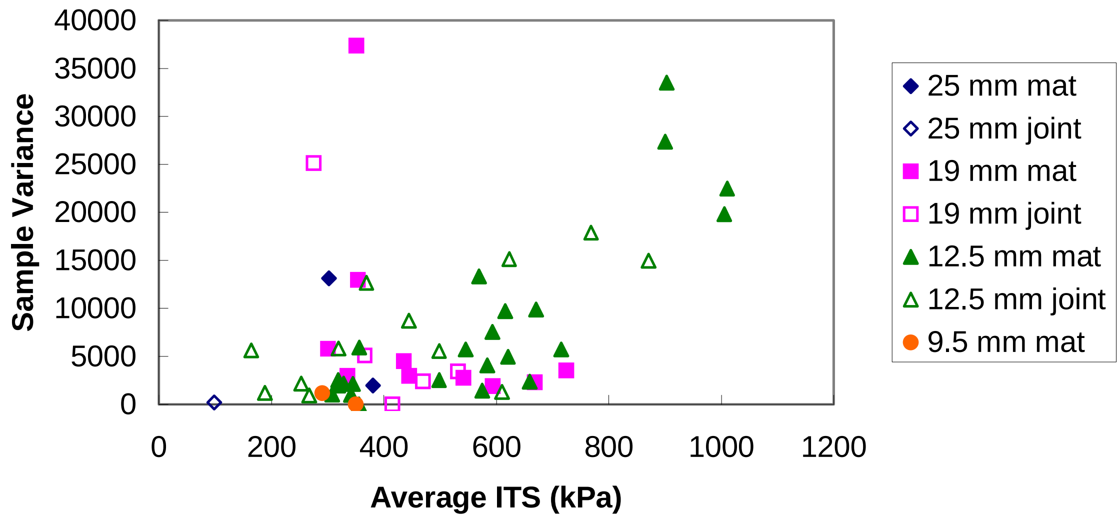


Figure 14. Sample Variance versus Average Indirect Tensile Strength

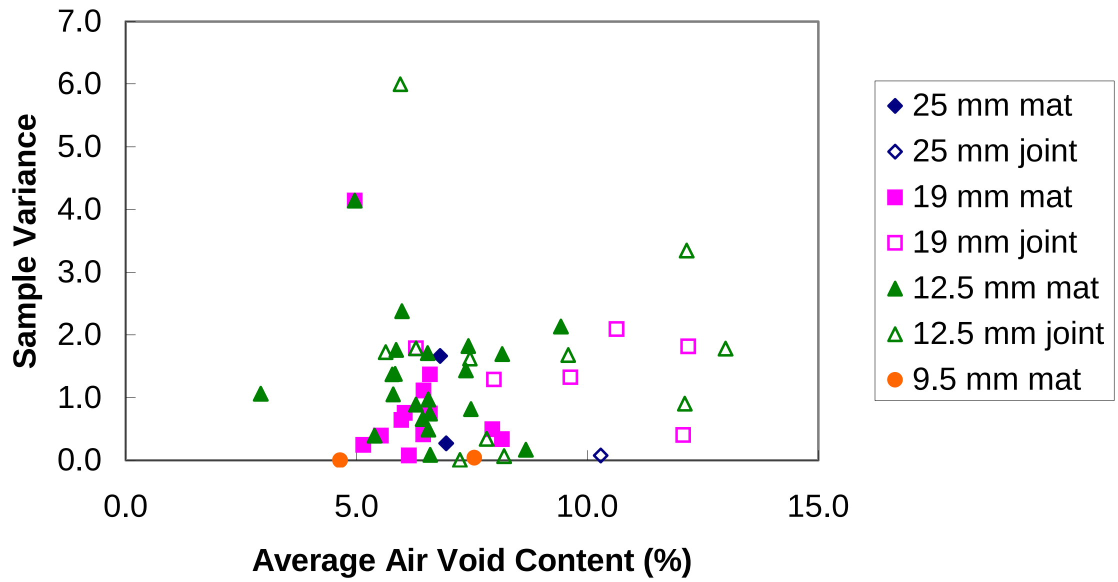


Figure 15. Sample Variance versus Average Air Void Content

Figures 16 and 17 show the relationship between COV and ITS and air void content, respectively. There are no trends for the various mixtures. The COV for the ITS data ranges from 0% to 60% and from 0% to 40% for the air void data. These COV ranges are smaller than those reported for the permeability measurements.

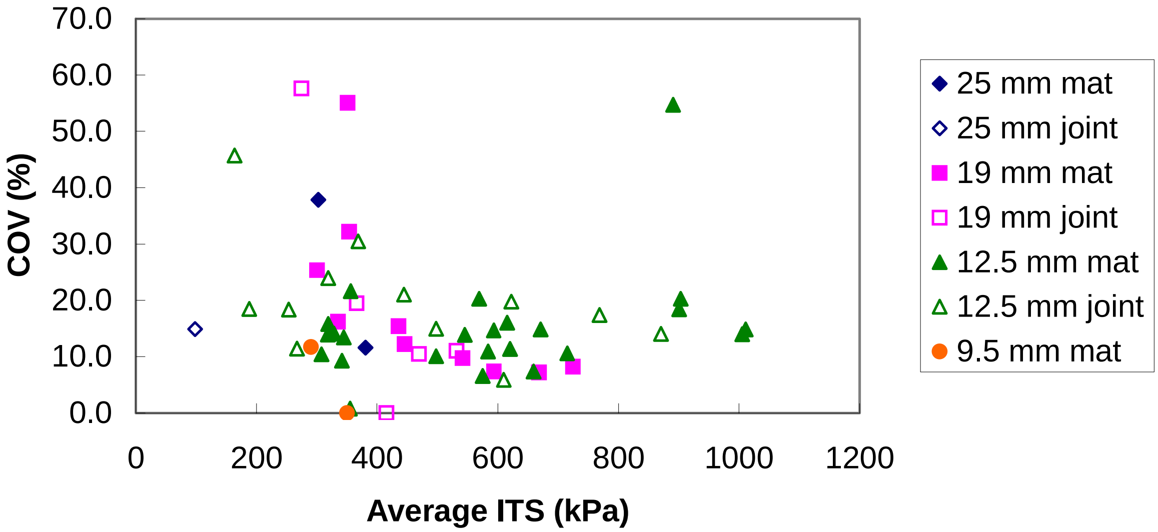


Figure 16. Coefficient of Variability versus Average Indirect Tensile Strength

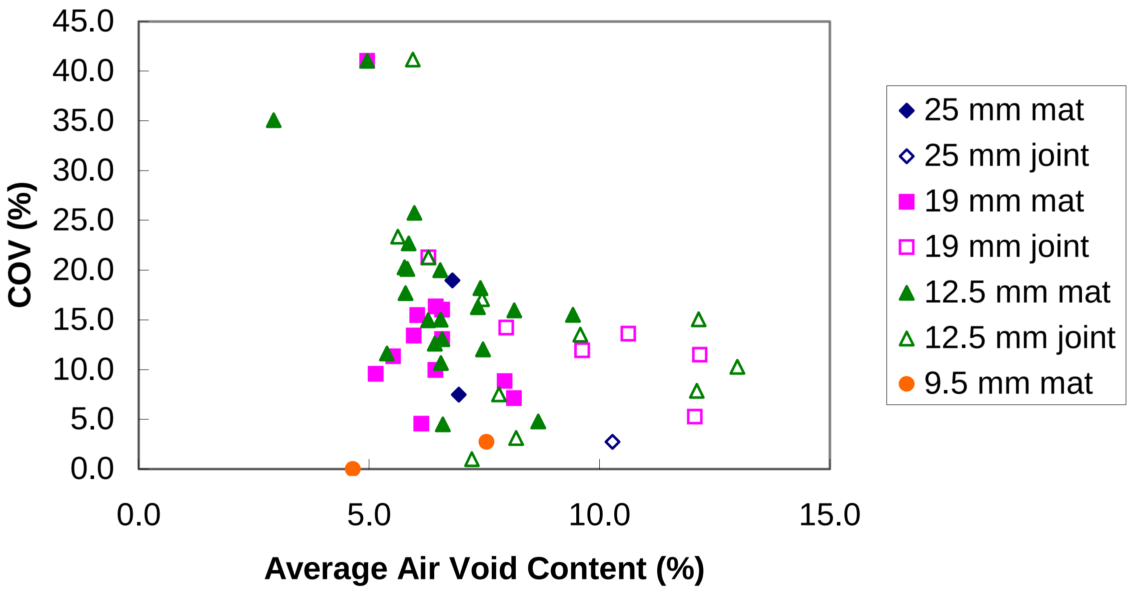


Figure 17. Coefficient of Variability versus Average Air Void Content

5.5.3. Comparison of Test Sites

The average ITS measured from the joint cores as a percentage of the mat cores for each project was calculated using equation (3) on pg XX. The data is presented in Figure 18. There are two sites (NH Rt 25 and VT I91) where ITS test data was not available. All but one of the sites have values below 100, indicating that the joint cores were weaker than the mat cores. One site, 19 mm NH I93S, has a value greater than 100. Only one joint core (of 8) at this site survived the coring and transportation process, so this value only represents the results of one test.

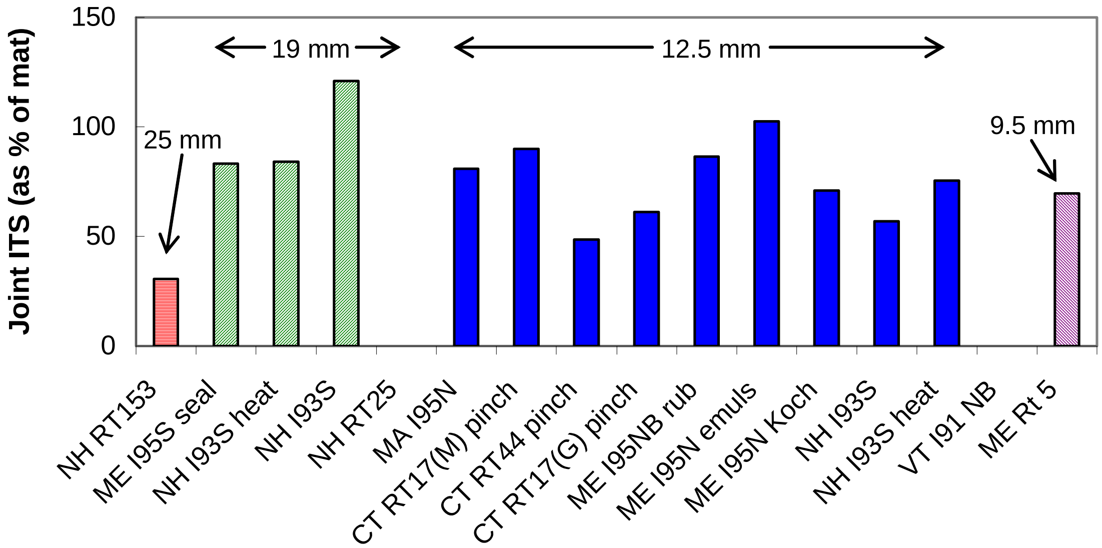


Figure 18. Joint Indirect Tensile Strength as a Percentage of Mat Indirect Tensile Strength

Figure 19 shows the average air voids measured from the joint cores as a percentage of the mat cores for each project, calculated using equation (3). The closer the values are to 100, the more similar the mat and joint air void contents. The ranking between the various projects for the ITS and air void data are not the same; also these rankings are different than the rankings determined from the permeability and infiltration analysis presented in section 5.1.

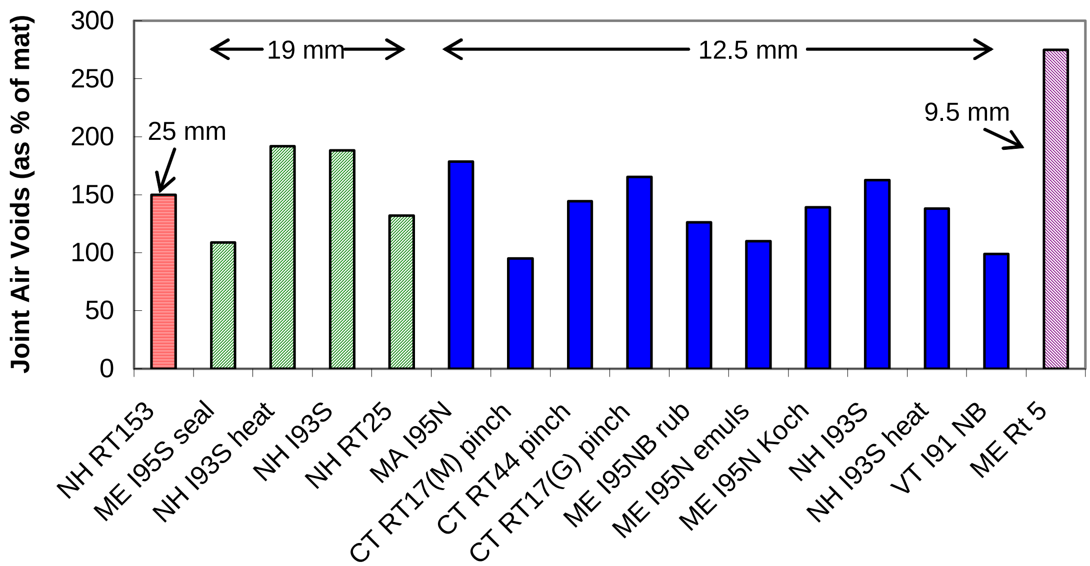


Figure 19. Joint Air Void Content as a Percentage of Mat Air Void Content

6.0 Development of Quality Control (QC) Criterion

One of the objectives of this project was to develop acceptance criteria for use of the permeameter as a quality control tool. To accomplish this objective, the performance of the longitudinal joints must be monitored over time. Within the time and logistical constraints of this project, there were seven test sites for which performance data was available. These are the 19mm NH I 93 SB control and joint heater sections, the 12.5 mm NH I 93 SB control and joint heater sections, and the three 12.5 mm ME I 95 joint sealer sections.

For the available sites, performance was measured in terms of the linear length of longitudinal joint cracking observed as a percentage of the overall section length. The performance data and timing of the permeameter testing for the various test sites is summarized in Table 7 below. At five of the test sites, the permeameter testing was performed at least one year after construction. Therefore, the permeability measurements may be different than those that would have been measured immediately after construction; particularly if the joint has shown some deterioration. In the case of the 19 mm NH control mix, locations away from the cracked joint were tested because it is difficult to obtain a good seal with the pavement surface along a cracked section. However, because so much of the joint was cracked, the sections that were tested likely are not a true representation of the overall permeability of that joint. The Maine sections showed very little cracking even after 5 years in service, so random locations along the sections were chosen. It should be noted that most of the cracking along the rubberized and Koch sections has been attributed to construction issues and is not indicative of the true joint performance (9).

Table 7. Summary of Longitudinal Joint Performance Data

Test Site	Age of Pavement when Permeameter Testing Was Performed	% cracking of longitudinal Joint & age of pavement
19 mm NH I93 SB control	1 yr	93% at 1 yr
19 mm NH I93 SB heater	1 yr	17% at 1 yr
12.5 mm NH I93 SB control	1 week	42.4% at 2 yrs
12.5 mm NH I93 SB heater	1 week	1.7% at 2 yrs
12.5 mm ME I95 rubberized	5 yrs	1.9% at 5 yrs
12.5 mm ME I95 emulsion	5 yrs	0.5% at 5 yrs
12.5 mm ME I95 Koch	5 yrs	1.7% at 5 yrs

In developing a permeability criterion for quality control use, the data from different sites need to be normalized to a unitless parameter because the permeability value itself may not give enough information with respect to the overall pavement. For example; a performance difference would be expected between two sites where the permeability of the joints were the same value but the permeabilites of the corresponding mats were different. If the joint permeability is significantly greater than that measured in the mat, joint cracking could be expected. If the mat and joint permeabilities are similar; there may be overall good or bad performance expected of the whole pavement. Therefore, the criterion examined in this project is the joint permeability as a percentage of the mat permeability, as calculated using equation (3). In addition to permeability, criteria using infiltration, air void content, and ITS strength were investigated.

Another important component to developing a quality control criterion is the definition of an unacceptable level of performance, i.e. cracking, at a certain point in time. Different agencies may have different tolerances for the amount of longitudinal cracking for different types of projects. It is also important to monitor the condition of the longitudinal joints over a period of several years to determine the best criterion; good performance after one year is not sufficient. The long term monitoring of the joints tested was beyond the scope of this project, but is strongly recommended for future work.

Figures 20 through 23 show the joint/mat permeability, infiltration, air void content, and ITS strength as a function of the percentage of longitudinal joint cracking observed, respectively. The criteria for joint permeability, infiltration, and air void content should be a maximum value whereas the criteria for ITS should be a minimum value. The permeability and infiltration figures (20 and 21, respectively) are very similar and appear to indicate that a criteria could be established; particularly for the 19 mm mixtures. The air void and ITS figures (22 and 23, respectively) show that the joints with different performance have similar values, making it difficult to establish a quality control criterion.

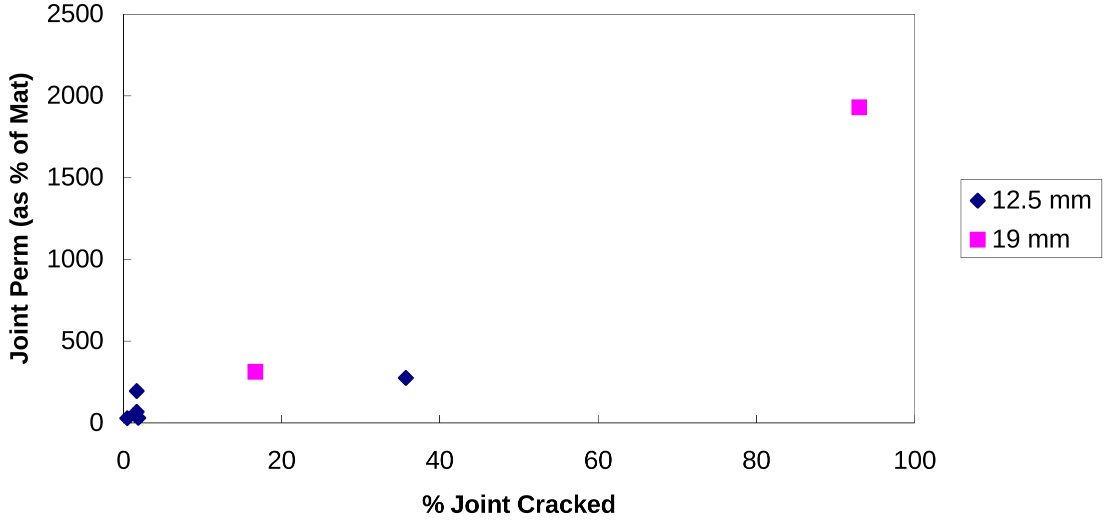


Figure 20. Joint Permeability as % of Mat Permeability versus % Longitudinal Joint Cracking

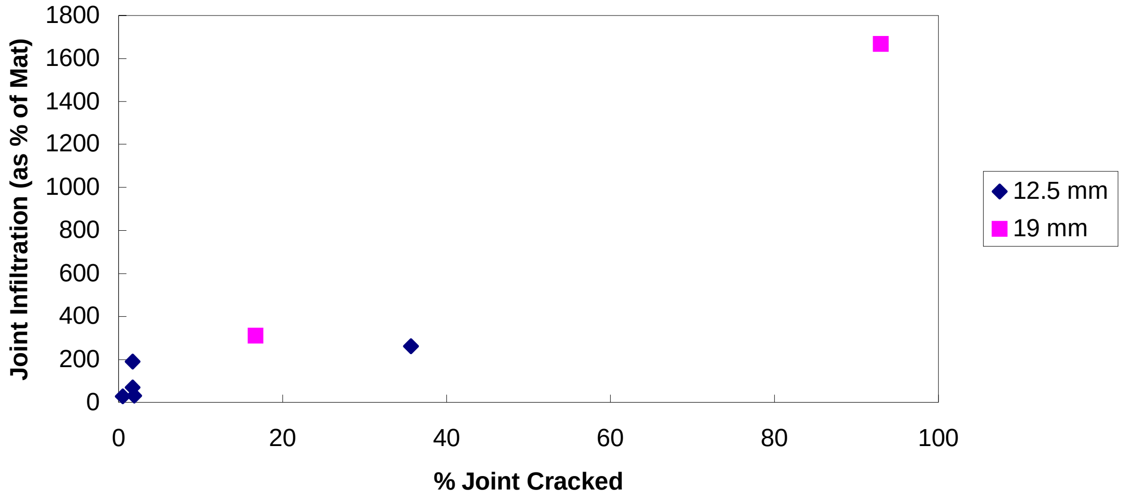


Figure 21. Joint Infiltration as % of Mat Infiltration versus % Longitudinal Joint Cracking

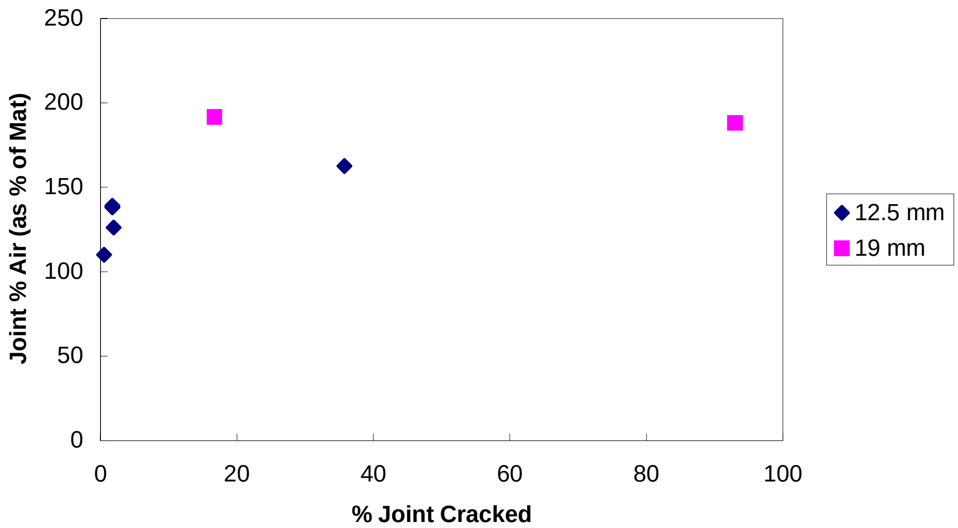


Figure 22. Joint Air Voids as % of Mat Air Voids versus % Longitudinal Joint Cracking

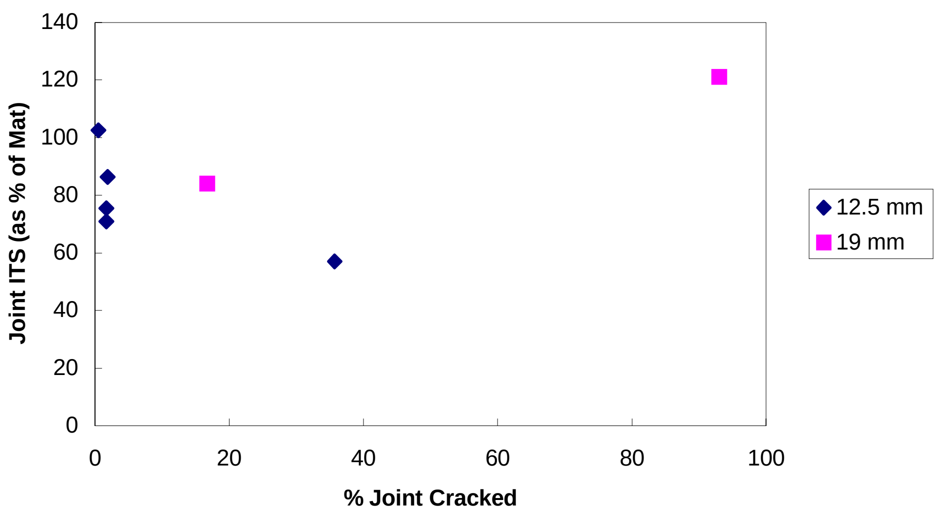


Figure 23. Joint ITS as % of Mat ITS versus % Longitudinal Joint Cracking

Table 8 presents the numerical values shown in Figures 20-23 as well as the statistical analysis of the mat versus joint measurements for permeability, air voids, and ITS. A significant difference in the mat and joint measurements would be expected to indicate possible performance problems with the joint if that criteria were directly related to the joint performance and the magnitude of the difference between the mat and joint measurements were significant. The ITS clearly does not identify the difference in performance between the two 19 mm sections, however there was only one joint core tested for the control section and this will impact the results. The air void measurements indicate there should be performance problems with two of the Maine sections when there is not. The Maine sites in particular show the advantage of using the permeameter measurement as a quality control criterion for sealed joints. The sealing of the joint during construction does not necessarily improve the density of the joint but improves the water tightness of the joint and hence the performance.

Table 8. Significant Difference between Mat and Joint Measurements

Test Site	% cracking	Comparison of Mat and Joint					
		Permeability		Air Voids		ITS	
		Jt/Mat	Diff?	Jt/Mat	Diff?	Jt/Mat	Diff?
19 mm NH I93 SB control	93	1930	S	188	S	121[2]	NS
19 mm NH I93 SB heater	17	313	S	192	S	84	NS
12.5 mm NH I93 SB control	42.4	275	S	162	S	57	S
12.5 mm NH I93 SB heater	1.7	194	S	138	S	75	S/NS[1]
12.5 mm ME I95 rubberized	1.9	30	S/NS[1]	126	S	86	NS
12.5 mm ME I95 emulsion	0.5	28	S/NS[1]	110	NS	102	NS
12.5 mm ME I95 Koch	1.7	69	NS	139	S	71	S/NS[1]

[1]Difference seen with one mat and not the other mat
[2]Represents results of only one core

In addition to the average value of the permeability criteria, the variability of the value must also be considered. Figures 24 and 25 show the average joint permeability criteria values versus the percent cracking for the 19 mm and 12.5 mm test sections, respectively. The error bars on each data point represent one standard deviation. When the variability of the data is considered, it is apparent that a quality control criterion cannot be established with statistical confidence at this time. Even though the average values show a difference, the variation is too high (for example in Figure 24, the low error bar for the control section incorporates the average value for the heater section). Further refinements in the permeameter measurements must be made to reduce the variability. Regardless, the use of the permeameter as a quality control tool for longitudinal joints shows great promise. Recommendations for further research and development are discussed below.

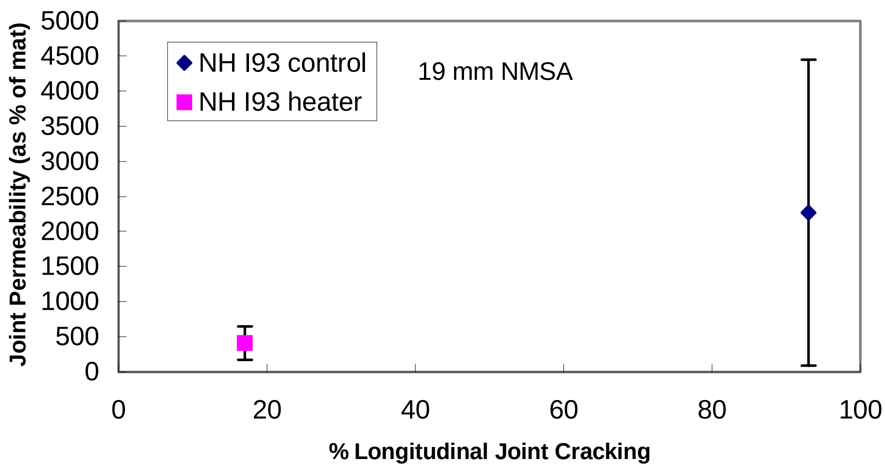


Figure 24. Joint Permeability Criteria versus % Cracking for 19 mm Sections

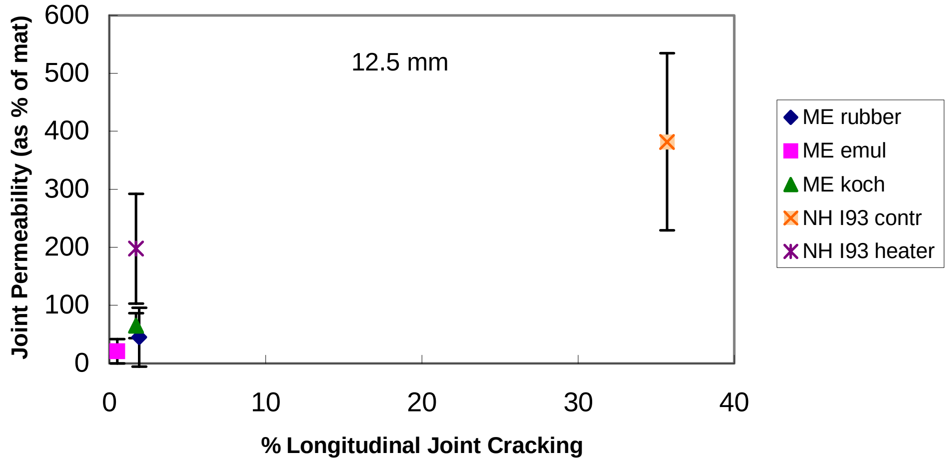


Figure 25. Joint Permeability Criteria versus % Cracking for 12.5 mm Sections

7.0 Recommendations for Future Work

The major recommendation for future work is to refine the permeameter to reduce the variability in measurements and allow for easier and more efficient testing. Several issues that arose during the course of this project are as follows:

- It is difficult to achieve an adequate seal to the pavement surface with all three standpipes when there is a crown in the road.
- The permeameter overhangs the joint on both sides. Typically, one lane is open to traffic so there needs to be adequate traffic control and extra care must be taken by the operator of the permeameter.
- The additional weights required to resist the uplift pressure necessitate more than one operator for timely measurements to be taken at several locations along a site.

The research team recommends returning to a single standpipe permeameter that can truly be setup and run by a single operator. The single standpipe would eliminate the problems in testing pavements with a crown, most traffic control issues, and the complications of additional weights. Testing of one mat could be done prior to construction of the joint and then testing of the joint and second mat could be done within the typical traffic control setup for compaction. The amount of time required to test the three locations separately would likely be about the same as that needed to use the existing permeameter because of the additional time to adjust to the crown of the road and add all the additional weights.

Recent research in Wisconsin (10) has investigated the use of an air permeability device on pavements. The results indicate that air permameters are promising, although more work must be done. The researchers in Wisconsin also report a decreasing trend in subsequent permeability measurements made using an NCAT permeameter; indicating that steady state flow was not obtained. This needs to be investigated further before a water permeameter can be implemented as a quality control tool.

In addition to improvements to the testing device, long term monitoring of longitudinal joint performance and quantification of acceptable joint performance (i.e. percent cracking at x number of years) must be done to develop a quality control criterion. It is recommended that more testing be done on a larger number of sites and the performance monitored annually. Some testing can be performed on joints that have shown good performance over time, however joints with good and poor performance need to be tested to establish acceptable permeability or infiltration ranges for QC/QA purposes. The testing will be easier to accomplish with a single standpipe permeameter (air or water), but the issue of annual condition assessment will have to be addressed.

8.0 Summary and Conclusions

The objective of this research was to evaluate a field permeameter as a tool to evaluate the quality of longitudinal joints. As part of the project, a field permeameter that can simultaneously test three locations, the longitudinal joint and one foot into both mats, was developed. The field permeameter was then used to test various longitudinal joints around New England. At most test locations, field cores were taken for additional laboratory testing that included measurement of air void content and indirect tensile strength. Where possible, the performance of the longitudinal joints that were tested during construction was monitored over the course of the project so that quality control criteria based on the permeameter testing could be developed.

The main conclusions from this project are:

- The use of a water tightness criterion for longitudinal joint quality control/quality acceptance is promising.
- Density and/or strength criteria can not identify the improvement in joint performance when joint sealants are used.
- There are construction techniques/methods that produce longitudinal joints that perform well in New England. Specifically, the longitudinal joints tested in this project where the joint was heated or joint sealers were used performed well.
- More equipment development and refinement is necessary to reduce the amount of variability in the results obtained with the field permeameter. Single standpipe air or water permeameters should be explored further.
- Long term performance data and a quantification of what constitutes acceptable joint performance is necessary before a quality control/quality assurance criterion can be established.

9.0 References

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9. Colson, S. "Longitudinal Joint Treatment Final Report", Maine DOT Technical Report 00-18, March 2006.

10. Menard, J. and J.A. Crovetti. "Comparative Analysis of Field Permeability Testing of Compacted Hot-Mix Asphalt Pavements Using Air and Water Permeameters." Paper 06-0777, Annual Meeting of the Transportation Research Board, Washington, D.C., 2006.

Appendix A: Individual Permeability Readings

NETC 03-5
NMAS 25mm

Project: NH Rt153
Joint Type: Control

STA. 603+75

	K (cm/s)		
Reading Number	**Cold**	**Center**	**Hot**
#1	1.017E-01	5.755E-01	6.188E-02
#2	9.192E-02	4.344E-01	5.219E-02
#3	7.493E-02	3.604E-01	4.419E-02
Average	8.952E-02	4.568E-01	5.276E-02
Std Dev	1.355E-02	1.093E-01	8.856E-03
Sample Variance	1.836E-04	1.194E-02	7.843E-05

STA. 603+45

	K (cm/s)		
Reading Number	**Cold**	**Center**	**Hot**
#1	8.861E-02	4.862E-01	9.708E-02
#2	8.238E-02	4.071E-01	8.445E-02
#3	7.224E-02	3.687E-01	8.033E-02
Average	8.108E-02	4.207E-01	8.729E-02
Std Dev	8.261E-03	5.991E-02	8.727E-03
Sample Variance	6.824E-05	3.589E-03	7.616E-05

STA. 603+25

	K (cm/s)		
Reading Number	**Cold**	**Center**	**Hot**
#1	4.901E-02	4.071E-01	2.093E-01
#2	5.089E-02	3.826E-01	1.978E-01
#3	4.343E-02	3.381E-01	1.785E-01
Average	4.777E-02	3.760E-01	1.952E-01
Std Dev	3.881E-03	3.498E-02	1.558E-02
Sample Variance	1.506E-05	1.224E-03	2.428E-04

NETC 03-5
NMAS 19mm

Project: Maine S95
Joint Type: Rubber Joint Sealer

STA. 1745

Reading Number	Cold	Center	Hot
	K (cm/s)		
#1	8.708E-03	2.603E-02	8.279E-03
#2	0.000E+00	1.602E-02	6.612E-04
#3	3.270E-03	2.967E-02	6.648E-04
Average	3.993E-03	2.391E-02	3.202E-03
Std Dev	4.399E-03	7.066E-03	4.397E-03
Sample Variance	1.935E-05	4.993E-05	1.934E-05

STA. 1740

Reading Number	Cold	Center	Hot
	K (cm/s)		
#1	1.326E-03	1.075E-02	1.973E-03
#2	1.341E-03	9.735E-03	2.006E-03
#3	6.761E-04	8.763E-03	6.761E-04
Average	1.114E-03	9.751E-03	1.551E-03
Std Dev	3.796E-04	9.953E-04	7.583E-04
Sample Variance	1.441E-07	9.906E-07	5.750E-07

STA. 1735

Reading Number	Cold	Center	Hot
	K (cm/s)		
#1	1.973E-03	1.914E-02	2.682E-03
#2	1.333E-03	1.956E-02	1.364E-03
#3	1.348E-03	1.956E-02	2.075E-03
Average	1.551E-03	1.942E-02	2.040E-03
Std Dev	3.649E-04	2.421E-04	6.597E-04
Sample Variance	1.331E-07	5.861E-08	4.352E-07

STA. 1730

Reading Number	Cold	Center	Hot
	K (cm/s)		
#1	0.000E+00	3.023E-03	1.212E-03
#2	0.000E+00	2.474E-03	6.107E-04
#3	0.000E+00	1.890E-03	1.231E-03
Average	0.000E+00	2.462E-03	1.018E-03
Std Dev	0.000E+00	5.666E-04	3.527E-04
Sample Variance	0.000E+00	3.210E-07	1.244E-07

STA. 1725

Reading Number	Cold	Center	Hot
	K (cm/s)		
#1	0.000E+00	4.068E-03	5.615E-03
#2	0.000E+00	4.211E-03	5.138E-03
#3	0.000E+00	0.000E+00	3.810E-03
Average	0.000E+00	2.760E-03	4.854E-03
Std Dev	0.000E+00	2.391E-03	9.355E-04
Sample Variance	0.000E+00	5.717E-06	8.752E-07

Project: NH S93 (7-29-04)
Joint Type: Joint Heater

STA. 92+13

Reading Number	Cold	Center	Hot
	K (cm/s)		
#1	0.000E+00	4.790E-03	3.709E-03
#2	0.000E+00	3.709E-03	2.637E-03
#3	5.229E-04	3.709E-03	2.637E-03
Average	1.743E-04	4.069E-03	2.995E-03
Std Dev	3.019E-04	6.242E-04	6.186E-04
Sample Variance	9.113E-08	3.896E-07	3.827E-07

STA. 78+43

Reading Number	Cold	Center	Hot
	K (cm/s)		
#1	1.048E-03	3.709E-03	3.172E-03
#2	1.048E-03	2.105E-03	1.576E-03
#3	5.229E-04	2.105E-03	1.576E-03
Average	8.730E-04	2.640E-03	2.108E-03
Std Dev	3.032E-04	9.258E-04	9.217E-04
Sample Variance	9.193E-08	8.572E-07	8.496E-07

STA. 74+62

Reading Number	Cold	Center	Hot
	K (cm/s)		
#1	1.048E-03	4.248E-03	1.048E-03
#2	0.000E+00	3.709E-03	0.000E+00
#3	5.229E-04	2.637E-03	5.229E-04
Average	5.236E-04	3.532E-03	5.236E-04
Std Dev	5.240E-04	8.199E-04	5.240E-04
Sample Variance	2.746E-07	6.722E-07	2.746E-07

STA. 68+53

Reading Number	Cold	Center	Hot
	K (cm/s)		
#1	1.048E-03	1.576E-03	0.000E+00
#2	1.048E-03	2.105E-03	5.229E-04
#3	1.048E-03	1.576E-03	0.000E+00
Average	1.048E-03	1.752E-03	1.743E-04
Std Dev	0.000E+00	3.059E-04	3.019E-04
Sample Variance	0.000E+00	9.356E-08	9.113E-08

STA. 62+03

Reading Number	Cold	Center	Hot
	K (cm/s)		
#1	1.048E-03	2.637E-03	0.000E+00
#2	5.229E-04	2.105E-03	0.000E+00
#3	5.229E-04	2.105E-03	0.000E+00
Average	6.979E-04	2.283E-03	0.000E+00
Std Dev	3.032E-04	3.072E-04	0.000E+00
Sample Variance	9.193E-08	9.440E-08	0.000E+00

Appendix A – 19 mm sites

Project: NH S93 (7-29-04)
Joint Type: Conventional

STA. 131+57

	K (cm/s)		
Reading Number	Cold	Center	Hot
#1	0.000E+00	4.899E-03	1.611E-03
#2	0.000E+00	2.105E-03	2.105E-03
#3	0.000E+00	1.576E-03	1.576E-03
Average	0.000E+00	2.860E-03	1.764E-03
Std Dev	0.000E+00	1.785E-03	2.962E-04
Sample Variance	0.000E+00	3.188E-06	8.775E-08

STA. 122+82

	K (cm/s)		
Reading Number	Cold	Center	Hot
#1	1.071E-03	1.235E-02	3.793E-03
#2	1.048E-03	9.214E-03	3.172E-03
#3	1.048E-03	8.652E-03	3.709E-03
Average	1.056E-03	1.007E-02	3.558E-03
Std Dev	1.351E-05	1.991E-03	3.368E-04
Sample Variance	1.824E-10	3.964E-06	1.134E-07

STA. 120+34

	K (cm/s)		
Reading Number	Cold	Center	Hot
#1	1.576E-03	1.798E-02	0.000E+00
#2	1.576E-03	1.617E-02	0.000E+00
#3	1.576E-03	1.617E-02	0.000E+00
Average	1.576E-03	1.677E-02	0.000E+00
Std Dev	0.000E+00	1.042E-03	0.000E+00
Sample Variance	0.000E+00	1.085E-06	0.000E+00

STA. 114+34

	K (cm/s)		
Reading Number	Cold	Center	Hot
#1	1.048E-03	6.043E-02	1.048E-03
#2	1.048E-03	5.957E-02	1.048E-03
#3	1.048E-03	5.787E-02	1.048E-03
Average	1.048E-03	5.929E-02	1.048E-03
Std Dev	0.000E+00	1.304E-03	0.000E+00
Sample Variance	0.000E+00	1.701E-06	0.000E+00

STA. 108+80

	K (cm/s)		
Reading Number	Cold	Center	Hot
#1	0.000E+00	2.678E-02	2.105E-03
#2	5.229E-04	2.613E-02	1.576E-03
#3	0.000E+00	2.420E-02	1.311E-03
Average	1.743E-04	2.570E-02	1.664E-03
Std Dev	3.019E-04	1.342E-03	4.043E-04
Sample Variance	9.113E-08	1.802E-06	1.634E-07

Project: NH Rt 25
Joint Type: Control

STA. 1033+45

	K (cm/s)		
Reading Number	Cold	Center	Hot
#1	1.863E-02	7.181E-02	1.863E-02
#2	1.863E-02	7.045E-02	1.755E-02
#3	1.755E-02	6.510E-02	1.648E-02
Average	1.827E-02	6.912E-02	1.756E-02
Std Dev	6.211E-04	3.545E-03	1.073E-03
Sample Variance	3.858E-07	1.256E-05	1.152E-06

STA. 1034+85

	K (cm/s)		
Reading Number	Cold	Center	Hot
#1	2.967E-02	6.247E-02	2.298E-02
#2	2.855E-02	5.731E-02	2.080E-02
#3	2.630E-02	5.603E-02	1.971E-02
Average	2.818E-02	5.861E-02	2.116E-02
Std Dev	1.715E-03	3.410E-03	1.667E-03
Sample Variance	2.942E-06	1.163E-05	2.780E-06

1024+00

	K (cm/s)		
Reading Number	Cold	Center	Hot
#1	3.425E-02	1.269E-01	2.967E-02
#2	2.967E-02	1.135E-01	1.971E-02
#3	2.855E-02	1.218E-01	1.971E-02
Average	3.082E-02	1.207E-01	2.303E-02
Std Dev	3.019E-03	6.788E-03	5.753E-03
Sample Variance	9.113E-06	4.607E-05	3.310E-05

STA. 1025+00

	K (cm/s)		
Reading Number	Cold	Center	Hot
#1	2.742E-02	1.686E-01	5.101E-02
#2	2.630E-02	1.686E-01	4.248E-02
#3	2.409E-02	1.585E-01	4.009E-02
Average	2.594E-02	1.652E-01	4.453E-02
Std Dev	1.699E-03	5.867E-03	5.740E-03
Sample Variance	2.885E-06	3.442E-05	3.295E-05

STA. 1026+00

	K (cm/s)		
Reading Number	Cold	Center	Hot
#1	4.128E-02	1.950E-01	2.630E-02
#2	4.009E-02	1.545E-01	2.409E-02
#3	3.774E-02	1.340E-01	2.298E-02
Average	3.970E-02	1.612E-01	2.446E-02
Std Dev	1.804E-03	3.106E-02	1.692E-03
Sample Variance	3.254E-06	9.650E-04	2.862E-06

Project: NH I-93 (6-9-04) (Circle)

Joint Type: Joint Heater

STA. 76+10

Reading Number	K (cm/s) Left	Center	Right
#1	3.888E-03	4.454E-03	3.325E-03
#2	2.206E-03	2.764E-03	2.206E-03
#3	1.651E-03	2.206E-03	1.651E-03
Average	2.582E-03	3.141E-03	2.394E-03
Std Dev	1.165E-03	1.170E-03	8.526E-04
Sample Variance	1.357E-06	1.370E-06	7.269E-07

STA. 75+70

Reading Number	K (cm/s) Left	Center	Right
#1	4.902E-03	3.245E-03	1.611E-03
#2	4.347E-03	2.698E-03	1.611E-03
#3	3.795E-03	1.611E-03	3.795E-03
Average	4.348E-03	2.518E-03	2.339E-03
Std Dev	5.536E-04	8.316E-04	1.261E-03
Sample Variance	3.065E-07	6.916E-07	1.589E-06

NETC 03-5

NMAS 12.5mm

Project: MA NB 95 (Saugus)

Joint Type:

STA. 3,4,5

	K (cm/s)		
Reading Number	Cold (3)	Center (4)	Hot (5)
#1	4.078E-02	7.422E-02	0.000E+00
#2	7.430E-04	0.000E+00	1.429E-03
#3	6.903E-03	2.204E-02	0.000E+00
#4	2.062E-02	4.115E-02	3.648E-03
Average	1.726E-02	3.435E-02	1.269E-03
Std Dev	1.774E-02	3.145E-02	1.723E-03
Sample Variance	3.148E-04	9.892E-04	2.968E-06

STA. 6,7,8

	K (cm/s)		
Reading Number	Cold (6)	Center (7)	Hot (8)
#1	0.000E+00	2.381E-02	2.225E-02
#2	0.000E+00	1.728E-02	1.581E-02
#3	0.000E+00	1.822E-02	1.627E-02
#4	0.000E+00	2.149E-02	3.509E-02
Average	0.000E+00	2.020E-02	2.235E-02
Std Dev	0.000E+00	3.008E-03	8.981E-03
Sample Variance	0.000E+00	9.049E-06	8.066E-05

STA. 10,11,12

	K (cm/s)		
Reading Number	Cold (10)	Center (11)	Hot (12)
#1	1.562E-02	4.717E-02	9.355E-03
#2	3.303E-02	5.000E-02	3.288E-03
#3	3.509E-02	1.120E-01	7.567E-03
#4	5.152E-02	3.190E+00	1.272E-02
Average	3.382E-02	8.497E-01	8.233E-03
Std Dev	1.468E-02	1.560E+00	3.929E-03
Sample Variance	2.156E-04	2.435E+00	1.544E-05

STA. 1,2,9,13

	K (cm/s)			
Reading Number	Center of Mat (1)	Center of Mat (2)	Center of Mat (9)	Center of Mat (13)
#1	7.042E-03	4.899E-03	2.723E-02	2.769E-02
#2	6.086E-03	4.241E-03	1.461E-02	2.233E-02
#3	7.145E-03	5.295E-03	1.565E-02	3.094E-02
#4	9.176E-03		1.352E-02	1.636E-02
Average	7.362E-03	4.811E-03	1.776E-02	2.433E-02
Std Dev	1.300E-03	5.325E-04	6.379E-03	6.389E-03
Sample Variance	1.690E-06	2.836E-07	4.070E-05	4.082E-05

Project: CT Rt 17 12-15-04 (Middelton)

Joint Type:

STA. 1244

	K (cm/s)		
Reading Number	Cold	Center	Hot
#1	1.032E-03	0.000E+00	0.000E+00
#2	1.741E-03	0.000E+00	0.000E+00
#3	9.883E-04	0.000E+00	0.000E+00
Average	1.253E-03	0.000E+00	0.000E+00
Std Dev	4.224E-04	0.000E+00	0.000E+00
Sample Variance	1.784E-07	0.000E+00	0.000E+00

STA. 1245

	K (cm/s)		
Reading Number	Cold	Center	Hot
#1	0.000E+00	1.238E-03	0.000E+00
#2	0.000E+00	0.000E+00	0.000E+00
#3	0.000E+00	0.000E+00	0.000E+00
Average	0.000E+00	4.126E-04	0.000E+00
Std Dev	0.000E+00	7.147E-04	0.000E+00
Sample Variance	0.000E+00	5.108E-07	0.000E+00

STA. 7009

	K (cm/s)		
Reading Number	Cold	Center	Hot
#1	0.000E+00	5.021E-04	0.000E+00
#2	0.000E+00	2.505E-04	0.000E+00
#3	0.000E+00	0.000E+00	0.000E+00
Average	0.000E+00	2.509E-04	0.000E+00
Std Dev	0.000E+00	2.510E-04	0.000E+00
Sample Variance	0.000E+00	6.302E-08	0.000E+00

STA. 1246

	K (cm/s)		
Reading Number	Cold	Center	Hot
#1	0.000E+00	0.000E+00	0.000E+00
#2	0.000E+00	2.756E-04	0.000E+00
#3	0.000E+00	0.000E+00	0.000E+00
Average	0.000E+00	9.186E-05	0.000E+00
Std Dev	0.000E+00	1.591E-04	0.000E+00
Sample Variance	0.000E+00	2.531E-08	0.000E+00

STA. 9006

	K (cm/s)		
Reading Number	Cold	Center	Hot
#1	0.000E+00	0.000E+00	0.000E+00
#2	0.000E+00	0.000E+00	0.000E+00
#3	0.000E+00	0.000E+00	0.000E+00
Average	0.000E+00	0.000E+00	0.000E+00
Std Dev	0.000E+00	0.000E+00	0.000E+00
Sample Variance	0.000E+00	0.000E+00	0.000E+00

Appendix A – 12.5 mm sites

Project: CT Rt 17 '05 (Middelton)
Joint Type:

STA. 1244

Reading Number	K (cm/s) Cold	Center	Hot
#1	2.043E-03	0.000E+00	0.000E+00
#2	2.054E-03	0.000E+00	0.000E+00
#3	0.000E+00	0.000E+00	0.000E+00
Average	1.365E-03	0.000E+00	0.000E+00
Std Dev	1.183E-03	0.000E+00	0.000E+00
Sample Variance	1.398E-06	0.000E+00	0.000E+00

STA. 1245

Reading Number	K (cm/s) Cold	Center	Hot
#1	0.000E+00	1.908E-03	0.000E+00
#2	2.149E-03	1.918E-03	0.000E+00
#3	0.000E+00	1.928E-03	1.958E-03
Average	7.163E-04	1.918E-03	6.527E-04
Std Dev	1.241E-03	9.812E-06	1.131E-03
Sample Variance	1.539E-06	9.627E-11	1.278E-06

STA. 7009

Reading Number	K (cm/s) Cold	Center	Hot
#1	0.000E+00	0.000E+00	0.000E+00
#2	2.519E-03	2.266E-03	2.305E-03
#3	0.000E+00	2.292E-03	0.000E+00
Average	8.396E-04	1.519E-03	7.682E-04
Std Dev	1.454E-03	1.316E-03	1.331E-03
Sample Variance	2.115E-06	1.731E-06	1.771E-06

STA. 1246

Reading Number	K (cm/s) Cold	Center	Hot
#1	0.000E+00	0.000E+00	2.718E-03
#2	0.000E+00	2.702E-03	0.000E+00
#3	0.000E+00	0.000E+00	0.000E+00
Average	0.000E+00	9.006E-04	9.061E-04
Std Dev	0.000E+00	1.560E-03	1.569E-03
Sample Variance	0.000E+00	2.433E-06	2.463E-06

STA. 9006

Reading Number	K (cm/s) Cold	Center	Hot
#1	0.000E+00	0.000E+00	0.000E+00
#2	0.000E+00	3.254E-03	0.000E+00
#3	0.000E+00	0.000E+00	0.000E+00
Average	0.000E+00	1.085E-03	0.000E+00
Std Dev	0.000E+00	1.879E-03	0.000E+00
Sample Variance	0.000E+00	3.530E-06	0.000E+00

Project: CT Rt 44 12-15-04 (Pomfret)
Joint Type:

STA. 1298

Reading Number	K (cm/s) Cold	Center	Hot
#1	4.770E-03	3.942E-02	5.855E-03
#2	4.770E-03	3.660E-02	5.311E-03
#3	4.770E-03	3.942E-02	4.770E-03
Average	4.770E-03	3.848E-02	5.312E-03
Std Dev	0.000E+00	1.628E-03	5.426E-04
Sample Variance	0.000E+00	2.652E-06	2.944E-07

STA. 1297

Reading Number	K (cm/s) Cold	Center	Hot
#1	4.312E-03	3.449E-02	0.000E+00
#2	3.220E-03	2.905E-02	5.311E-04
#3	3.220E-03	2.838E-02	0.000E+00
Average	3.584E-03	3.064E-02	1.770E-04
Std Dev	6.304E-04	3.351E-03	3.066E-04
Sample Variance	3.974E-07	1.123E-05	9.402E-08

STA. 1296

Reading Number	K (cm/s) Cold	Center	Hot
#1	4.610E-04	1.112E-02	0.000E+00
#2	4.610E-04	9.606E-03	0.000E+00
#3	4.610E-04	9.105E-03	0.000E+00
Average	4.610E-04	9.944E-03	0.000E+00
Std Dev	0.000E+00	1.050E-03	0.000E+00
Sample Variance	0.000E+00	1.102E-06	0.000E+00

STA. 1295

Reading Number	K (cm/s) Cold	Center	Hot
#1	0.000E+00	3.956E-02	0.000E+00
#2	0.000E+00	3.692E-02	0.000E+00
#3	0.000E+00	3.499E-02	0.000E+00
Average	0.000E+00	3.716E-02	0.000E+00
Std Dev	0.000E+00	2.298E-03	0.000E+00
Sample Variance	0.000E+00	5.280E-06	0.000E+00

STA. 1294

Reading Number	K (cm/s) Cold	Center	Hot
#1	1.064E-03	1.107E-02	0.000E+00
#2	5.311E-04	8.776E-03	5.311E-04
#3	5.311E-04	9.345E-03	0.000E+00
Average	7.089E-04	9.730E-03	1.770E-04
Std Dev	3.079E-04	1.193E-03	3.066E-04
Sample Variance	9.482E-08	1.424E-06	9.402E-08

Appendix A – 12.5 mm sites

Project: CT Rt 44 '05 (Pomfret)
Joint Type:

STA. 1298

Reading Number	K (cm/s) Cold	Center	Hot
#1	1.986E-03	1.552E-02	4.255E-03
#2	1.342E-03	1.306E-02	2.919E-03
#3	2.040E-03	1.254E-02	2.989E-03
Average	1.790E-03	1.371E-02	3.388E-03
Std Dev	3.886E-04	1.595E-03	7.517E-04
Sample Variance	1.510E-07	2.543E-06	5.650E-07

STA. 1297

Reading Number	K (cm/s) Cold	Center	Hot
#1	1.523E-03	7.485E-03	0.000E+00
#2	1.542E-03	7.953E-03	0.000E+00
#3	1.561E-03	8.483E-03	0.000E+00
Average	1.542E-03	7.973E-03	0.000E+00
Std Dev	1.869E-05	4.996E-04	0.000E+00
Sample Variance	3.494E-10	2.496E-07	0.000E+00

STA. 1296

Reading Number	K (cm/s) Cold	Center	Hot
#1	5.920E-04	4.642E-03	0.000E+00
#2	0.000E+00	4.140E-03	0.000E+00
#3	5.951E-04	4.302E-03	6.116E-04
Average	3.957E-04	4.361E-03	2.039E-04
Std Dev	3.427E-04	2.561E-04	3.531E-04
Sample Variance	1.174E-07	6.558E-08	1.247E-07

STA. 1295

Reading Number	K (cm/s) Cold	Center	Hot
#1	0.000E+00	8.272E-03	0.000E+00
#2	0.000E+00	5.014E-03	7.446E-04
#3	0.000E+00	5.247E-03	0.000E+00
Average	0.000E+00	6.178E-03	2.482E-04
Std Dev	0.000E+00	1.817E-03	4.299E-04
Sample Variance	0.000E+00	3.302E-06	1.848E-07

STA. 1294

Reading Number	K (cm/s) Cold	Center	Hot
#1	8.624E-04	4.801E-03	0.000E+00
#2	8.683E-04	4.989E-03	9.251E-04
#3	0.000E+00	4.312E-03	~~0.000E+00~~
Average	5.769E-04	4.701E-03	3.084E-04
Std Dev	4.996E-04	3.492E-04	5.341E-04
Sample Variance	2.496E-07	1.219E-07	2.853E-07

Project: CT Rt 17 12-15-04 (Glastonbury)
Joint Type:

STA. 1946

Reading Number	K (cm/s) Cold	Center	Hot
#1	0.000E+00	5.299E-03	7.462E-04
#2	1.854E-04	5.929E-03	5.585E-04
#3	1.854E-04	5.929E-03	3.716E-04
Average	1.236E-04	5.719E-03	5.588E-04
Std Dev	1.070E-04	3.636E-04	1.873E-04
Sample Variance	1.146E-08	1.322E-07	3.510E-08

STA. 1945

Reading Number	K (cm/s) Cold	Center	Hot
#1	2.004E-04	4.615E-03	1.627E-03
#2	2.004E-04	5.504E-03	1.421E-03
#3	0.000E+00	5.280E-03	1.421E-03
Average	1.336E-04	5.133E-03	1.490E-03
Std Dev	1.157E-04	4.624E-04	1.192E-04
Sample Variance	1.339E-08	2.138E-07	1.421E-08

STA. 1944

Reading Number	K (cm/s) Cold	Center	Hot
#1	0.000E+00	4.072E-03	3.916E-04
#2	0.000E+00	3.860E-03	3.916E-04
#3	0.000E+00	3.860E-03	3.916E-04
Average	0.000E+00	3.931E-03	3.916E-04
Std Dev	0.000E+00	1.225E-04	0.000E+00
Sample Variance	0.000E+00	1.502E-08	0.000E+00

STA. 1943

Reading Number	K (cm/s) Cold	Center	Hot
#1	0.000E+00	8.067E-04	1.215E-03
#2	2.004E-04	4.017E-04	8.067E-04
#3	0.000E+00	2.004E-04	6.038E-04
Average	6.681E-05	4.696E-04	8.753E-04
Std Dev	1.157E-04	3.088E-04	3.114E-04
Sample Variance	1.339E-08	9.537E-08	9.700E-08

STA. 1942

Reading Number	K (cm/s) Cold	Center	Hot
#1	8.067E-04	8.512E-03	3.526E-03
#2	6.038E-04	8.751E-03	3.098E-03
#3	6.038E-04	9.477E-03	3.098E-03
Average	6.714E-04	8.913E-03	3.241E-03
Std Dev	1.172E-04	5.024E-04	2.474E-04
Sample Variance	1.373E-08	2.524E-07	6.123E-08

Appendix A – 12.5 mm sites

Project: CT Rt 17 '05 (Glastonbury)
Joint Type:

STA. 1946

Reading Number	K (cm/s) Cold	Center	Hot
#1	0.000E+00	1.890E-03	0.000E+00
#2	0.000E+00	1.277E-03	6.332E-04
#3	6.332E-04	6.434E-04	0.000E+00
Average	2.111E-04	1.270E-03	2.111E-04
Std Dev	3.656E-04	6.232E-04	3.656E-04
Sample Variance	1.337E-07	3.884E-07	1.337E-07

STA. 1945

Reading Number	K (cm/s) Cold	Center	Hot
#1	0.000E+00	1.221E-02	6.877E-04
#2	6.761E-04	1.075E-02	0.000E+00
#3	0.000E+00	1.181E-02	6.916E-04
Average	2.254E-04	1.159E-02	4.598E-04
Std Dev	3.903E-04	7.545E-04	3.982E-04
Sample Variance	1.524E-07	5.693E-07	1.585E-07

STA. 1944

Reading Number	K (cm/s) Cold	Center	Hot
#1	0.000E+00	0.000E+00	0.000E+00
#2	7.339E-04	7.038E-04	7.524E-04
#3	0.000E+00	7.080E-04	0.000E+00
Average	2.446E-04	4.706E-04	2.508E-04
Std Dev	4.237E-04	4.076E-04	4.344E-04
Sample Variance	1.796E-07	1.661E-07	1.887E-07

STA. 1943

Reading Number	K (cm/s) Cold	Center	Hot
#1	0.000E+00	2.376E-03	0.000E+00
#2	0.000E+00	1.611E-03	0.000E+00
#3	0.000E+00	2.457E-03	0.000E+00
Average	0.000E+00	2.148E-03	0.000E+00
Std Dev	0.000E+00	4.672E-04	0.000E+00
Sample Variance	0.000E+00	2.182E-07	0.000E+00

STA. 1942

Reading Number	K (cm/s) Cold	Center	Hot
#1	0.000E+00	2.988E-03	0.000E+00
#2	0.000E+00	5.151E-03	0.000E+00
#3	0.000E+00	3.200E-03	0.000E+00
Average	0.000E+00	3.780E-03	0.000E+00
Std Dev	0.000E+00	1.192E-03	0.000E+00
Sample Variance	0.000E+00	1.422E-06	0.000E+00

Project: ME I95 NB 9-1-04
Joint Type: Rubberized

STA. 197+014

Reading Number	K (cm/s) Left	Center	Right
#1	3.354E-04	4.197E-04	1.015E-03
#2	0.000E+00	0.000E+00	5.042E-04
#3	0.000E+00	0.000E+00	5.042E-04
Average	1.118E-04	1.399E-04	6.745E-04
Std Dev	1.936E-04	2.423E-04	2.950E-04
Sample Variance	3.749E-08	5.871E-08	8.700E-08

STA. 197+047

Reading Number	K (cm/s) Left	Center	Right
#1	0.000E+00	0.000E+00	1.673E-04
#2	0.000E+00	1.673E-04	1.673E-04
#3	0.000E+00	0.000E+00	0.000E+00
Average	0.000E+00	5.577E-05	1.115E-04
Std Dev	0.000E+00	9.660E-05	9.660E-05
Sample Variance	0.000E+00	9.332E-09	9.332E-09

STA. 197+069

Reading Number	K (cm/s) Left	Center	Right
#1	3.354E-04	0.000E+00	1.673E-04
#2	1.673E-04	0.000E+00	1.673E-04
#3	1.673E-04	0.000E+00	1.673E-04
Average	2.233E-04	0.000E+00	1.673E-04
Std Dev	9.703E-05	0.000E+00	0.000E+00
Sample Variance	9.414E-09	0.000E+00	0.000E+00

Appendix A – 12.5 mm sites

Project: ME I95 NB 9-1-04
Joint Type: Emulsified

STA. 197+819

	K (cm/s)		
Reading Number	**Left**	**Center**	**Right**
#1	6.454E-04	1.603E-04	1.603E-04
#2	4.830E-04	0.000E+00	0.000E+00
#3	4.021E-04	2.408E-04	2.408E-04
Average	5.102E-04	1.337E-04	1.337E-04
Std Dev	1.239E-04	1.226E-04	1.226E-04
Sample Variance	1.535E-08	1.502E-08	1.502E-08

STA. 197+856

	K (cm/s)		
Reading Number	**Left**	**Center**	**Right**
#1	3.213E-04	1.603E-04	8.085E-04
#2	3.213E-04	0.000E+00	8.085E-04
#3	2.408E-04	1.603E-04	4.830E-04
Average	2.945E-04	1.069E-04	7.000E-04
Std Dev	4.653E-05	9.257E-05	1.879E-04
Sample Variance	2.165E-09	8.569E-09	3.530E-08

STA. 197+894

	K (cm/s)		
Reading Number	**Left**	**Center**	**Right**
#1	0.000E+00	0.000E+00	1.603E-04
#2	0.000E+00	0.000E+00	0.000E+00
#3	0.000E+00	0.000E+00	0.000E+00
Average	0.000E+00	0.000E+00	5.344E-05
Std Dev	0.000E+00	0.000E+00	9.257E-05
Sample Variance	0.000E+00	0.000E+00	8.569E-09

Project: ME I95 NB 9-1-04
Joint Type: Koch Sealer

STA. 199+570

	K (cm/s)		
Reading Number	**Left**	**Center**	**Right**
#1	0.000E+00	3.213E-04	4.830E-04
#2	0.000E+00	0.000E+00	4.830E-04
#3	0.000E+00	0.000E+00	3.213E-04
Average	0.000E+00	1.071E-04	4.291E-04
Std Dev	0.000E+00	1.855E-04	9.335E-05
Sample Variance	0.000E+00	3.442E-08	8.714E-09

STA. 199+596

	K (cm/s)		
Reading Number	**Left**	**Center**	**Right**
#1	0.000E+00	1.603E-04	3.213E-04
#2	1.603E-04	0.000E+00	1.603E-04
#3	0.000E+00	1.603E-04	1.603E-04
Average	5.344E-05	1.069E-04	2.140E-04
Std Dev	9.257E-05	9.257E-05	9.296E-05
Sample Variance	8.569E-09	8.569E-09	8.641E-09

STA. 199+618

	K (cm/s)		
Reading Number	**Left**	**Center**	**Right**
#1	0.000E+00	8.008E-05	0.000E+00
#2	0.000E+00	0.000E+00	0.000E+00
#3	0.000E+00	0.000E+00	0.000E+00
Average	0.000E+00	2.669E-05	0.000E+00
Std Dev	0.000E+00	4.624E-05	0.000E+00
Sample Variance	0.000E+00	2.138E-09	0.000E+00

Appendix A – 12.5 mm sites

Project: NH I93 8-10-04 (Surf. Course)
Joint Type: Control

STA.136+50

	K (cm/s)		
Reading Number	Left	Center	Right
#1	5.334E-03	2.105E-02	1.381E-02
#2	4.248E-03	1.981E-02	1.381E-02
#3	4.790E-03	1.981E-02	1.558E-02
Average	4.791E-03	2.022E-02	1.440E-02
Std Dev	5.430E-04	7.143E-04	1.021E-03
Sample Variance	2.948E-07	5.102E-07	1.043E-06

STA. 131+11

	K (cm/s)		
Reading Number	Left	Center	Right
#1	8.093E-03	1.149E-02	3.709E-03
#2	7.536E-03	9.779E-03	2.637E-03
#3	8.093E-03	9.779E-03	2.637E-03
Average	7.907E-03	1.035E-02	2.995E-03
Std Dev	3.215E-04	9.874E-04	6.186E-04
Sample Variance	1.034E-07	9.750E-07	3.827E-07

STA. 124+30

	K (cm/s)		
Reading Number	Left	Center	Right
#1	8.093E-03	2.230E-02	1.264E-02
#2	7.536E-03	1.981E-02	1.149E-02
#3	6.430E-03	1.798E-02	1.092E-02
Average	7.353E-03	2.003E-02	1.168E-02
Std Dev	8.464E-04	2.168E-03	8.795E-04
Sample Variance	7.164E-07	4.700E-06	7.735E-07

STA. 119+20

	K (cm/s)		
Reading Number	Left	Center	Right
#1	2.637E-03	1.498E-02	2.637E-03
#2	2.637E-03	1.322E-02	4.248E-03
#3	2.637E-03	1.206E-02	2.105E-03
Average	2.637E-03	1.342E-02	2.997E-03
Std Dev	0.000E+00	1.470E-03	1.116E-03
Sample Variance	0.000E+00	2.161E-06	1.245E-06

STA. 113+53

	K (cm/s)		
Reading Number	Left	Center	Right
#1	3.172E-03	3.627E-02	1.035E-02
#2	2.105E-03	2.941E-02	9.779E-03
#3	1.576E-03	2.613E-02	8.652E-03
Average	2.284E-03	3.061E-02	9.593E-03
Std Dev	8.131E-04	5.177E-03	8.623E-04
Sample Variance	6.612E-07	2.680E-05	7.436E-07

Project: NH I93 8-10-04 (Surf. Course)
Joint Type: Joint Heater

STA. 82+78

	K (cm/s)		
Reading Number	Left	Center	Right
#1	4.790E-03	1.149E-02	3.709E-03
#2	4.248E-03	1.092E-02	2.637E-03
#3	1.498E-02	1.035E-02	3.172E-03
Average	8.008E-03	1.092E-02	3.173E-03
Std Dev	6.048E-03	5.714E-04	5.357E-04
Sample Variance	3.658E-05	3.265E-07	2.870E-07

STA. 78+82

	K (cm/s)		
Reading Number	Left	Center	Right
#1	2.105E-03	1.859E-02	1.035E-02
#2	1.576E-03	1.617E-02	8.652E-03
#3	2.637E-03	1.498E-02	9.779E-03
Average	2.106E-03	1.658E-02	9.593E-03
Std Dev	5.310E-04	1.834E-03	8.623E-04
Sample Variance	2.819E-07	3.365E-06	7.436E-07

STA. 74+77

	K (cm/s)		
Reading Number	Left	Center	Right
#1	4.248E-03	2.167E-02	1.737E-02
#2	8.093E-03	1.798E-02	1.798E-02
#3	5.334E-03	1.677E-02	1.677E-02
Average	5.892E-03	1.881E-02	1.737E-02
Std Dev	1.982E-03	2.552E-03	6.030E-04
Sample Variance	3.929E-06	6.514E-06	3.636E-07

STA. 64+54

	K (cm/s)		
Reading Number	Left	Center	Right
#1	8.093E-03	9.214E-03	2.105E-03
#2	8.652E-03	8.093E-03	2.105E-03
#3	8.093E-03	6.430E-03	1.576E-03
Average	8.279E-03	7.913E-03	1.929E-03
Std Dev	3.230E-04	1.401E-03	3.059E-04
Sample Variance	1.043E-07	1.963E-06	9.356E-08

STA. 57+84

	K (cm/s)		
Reading Number	Left	Center	Right
#1	3.172E-03	1.737E-02	8.093E-03
#2	2.637E-03	1.617E-02	8.093E-03
#3	2.637E-03	1.498E-02	6.982E-03
Average	2.816E-03	1.618E-02	7.723E-03
Std Dev	3.086E-04	1.194E-03	6.415E-04
Sample Variance	9.524E-08	1.426E-06	4.115E-07

Appendix A – 12.5 mm sites

Project: VT I91 NB

Joint Type: Conventional

STA. A

	K (cm/s)		
Reading Number	**Passing**	**Joint**	**Travel**
#1	5.569E-03	1.103E-02	3.733E-03
#2	5.018E-03	8.715E-03	3.100E-03
#3	5.808E-03	8.064E-03	2.690E-03
Average	5.465E-03	9.270E-03	3.174E-03
Std Dev	4.051E-04	1.559E-03	5.255E-04
Sample Variance	1.641E-07	2.430E-06	2.762E-07

STA. B

	K (cm/s)		
Reading Number	**Passing**	**Joint**	**Travel**
#1	9.128E-03	2.098E-02	1.946E-03
#2	7.956E-03	1.726E-02	2.032E-03
#3	7.504E-03	1.780E-02	1.082E-03
Average	8.196E-03	1.868E-02	1.687E-03
Std Dev	8.379E-04	2.009E-03	5.253E-04
Sample Variance	7.021E-07	4.037E-06	2.759E-07

STA. C

	K (cm/s)		
Reading Number	**Passing**	**Joint**	**Travel**
#1	2.509E-02	5.467E-02	7.242E-03
#2	2.551E-02	3.869E-02	3.325E-03
#3	2.251E-02	3.955E-02	3.031E-03
#4	2.215E-02	3.261E-02	2.843E-03
#5	X	3.169E-02	2.998E-03
Average	2.381E-02	3.944E-02	3.888E-03
Std Dev	1.731E-03	9.208E-03	1.883E-03
Sample Variance	2.997E-06	8.478E-05	3.545E-06

NETC 03-5
NMAS 9.5mm

Project: ME Rt 5

Joint Type: Conventional

STA. A

	K (cm/s)		
Reading Number	**NB**	**Joint**	**SB**
#1	7.292E-04	8.839E-03	3.620E-04
#2	3.690E-04	5.552E-03	0.000E+00
#3	3.744E-04	4.764E-03	0.000E+00
Average	4.909E-04	6.385E-03	1.207E-04
Std Dev	2.064E-04	2.161E-03	2.090E-04
Sample Variance	4.260E-08	4.672E-06	4.368E-08

STA. B

	K (cm/s)		
Reading Number	**NB**	**Joint**	**SB**
#1	1.465E-03	1.205E-02	0.000E+00
#2	1.188E-03	9.129E-03	0.000E+00
#3	1.213E-03	7.976E-03	0.000E+00
Average	1.289E-03	9.717E-03	0.000E+00
Std Dev	1.537E-04	2.098E-03	0.000E+00
Sample Variance	2.362E-08	4.402E-06	0.000E+00

STA. C

	K (cm/s)		
Reading Number	**NB**	**Joint**	**SB**
#1	1.107E-03	2.241E-02	7.226E-03
#2	2.247E-03	2.333E-02	7.356E-03
#3	1.516E-03	2.349E-02	7.729E-03
Average	1.623E-03	2.308E-02	7.437E-03
Std Dev	5.773E-04	5.827E-04	2.610E-04
Sample Variance	3.333E-07	3.395E-07	6.810E-08

Appendix B: Average Measurements at Each Test Location

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air(%)	infiltration (cm/hr)
25mm	NH RT153	control	603+75	hot	5.28E-02	378.7	6.1	1999
				center	4.57E-01	88.0	10.3	5413
				cold	8.95E-02	208.8	7.2	1268
				avg mat	7.11E-02	293.8	6.7	1634
				jt/mat	642	30	155	331
			603+45	hot	8.24E-02	426.4	6.0	1946
				center	3.88E-01	108.7	10.5	6628
				cold	7.73E-02	268.3	7.3	2078
				avg mat	7.99E-02	347.4	6.6	2012
				jt/mat	486	31	159	329
			603+25	hot	1.95E-01	338.1	8.3	1200
				center	3.76E-01	~	10.0	6247
				cold	4.78E-02	430.1	6.3	4038
				avg mat	1.21E-01	384.1	7.3	2619
				jt/mat	309		136	239
			averages	hot	1.10E-01	381.1	6.8	1715
				center	4.07E-01	98.4	10.3	6096
				cold	7.15E-02	302.4	6.9	2461
				avg mat	9.08E-02	341.7	6.9	2088
				jt/mat	479	31	150	300

Appendix B – 19 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
19mm	maine s 95	rubber joint sealer	1745	hot	3.99E-03	475.0	5.5	139
				center	2.39E-02	~	~	563
				cold	3.20E-03	474.7	5.0	110
				avg mat	3.60E-03	474.9	5.2	124
				jt/mat	665	#VALUE!	#VALUE!	453
			1740	hot	1.11E-03	514.6	5.8	37
				center	9.75E-03	341.5	7.4	271
				cold	1.55E-03	361.7	7.7	51
				avg mat	1.33E-03	438.1	6.8	44
				jt/mat	732	78	109	617
			1735	hot	1.55E-03	428.4	7.0	51
				center	1.94E-02	301.1	7.4	439
				cold	2.04E-03	427.1	6.1	66
				avg mat	1.80E-03	427.8	6.6	59
				jt/mat	1081	70	113	750
			1730	hot	0.00E+00	424.1	7.4	0
				center	2.46E-03	354.5	4.7	88
				cold	1.02E-03	459.6	3.3	37
				avg mat	5.09E-04	441.9	5.4	18
				jt/mat	484	80	88	480
			1725	hot	0.00E+00	335.6	7.2	0
				center	2.76E-03	467.7	5.6	88
				cold	4.85E-03	503.8	2.7	146
				avg mat	2.43E-03	419.7	4.9	73
				jt/mat	114	111	114	120
			averages	hot	1.33E-03	435.6	6.6	45
				center	1.17E-02	366.2	6.3	290
				cold	2.53E-03	445.4	5.0	82
				avg mat	1.93E-03	440.5	5.8	64
				jt/mat	603	83	109	455

Appendix B – 19 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
19mm	nh93sb 7-29-04	joint heater	92+13	hot	1.74E-04	~	~	7
				center	4.07E-03	~	~	168
				cold	2.99E-03	~	~	124
				avg mat	1.58E-03	~	~	66
				jt/mat	257	~	~	256
			78-43	hot	8.73E-04	~	~	37
				center	2.64E-03	~	~	110
				cold	2.11E-03	~	~	88
				avg mat	1.49E-03	~	~	62
				jt/mat	177	~	~	176
			74+62	hot	5.24E-04	~	~	22
				center	3.53E-03	~	~	146
				cold	5.24E-04	~	~	22
				avg mat	5.24E-04	~	~	22
				jt/mat	674	~	~	667
			68+53	hot	1.05E-03	~	~	44
				center	1.75E-03	~	~	73
				cold	1.74E-04	~	~	7
				avg mat	6.11E-04	~	~	26
				jt/mat	287	~	~	286
			62+03	hot	6.98E-04	~	~	29
				center	2.28E-03	~	~	95
				cold	0.00E+00	~	~	0
				avg mat	3.49E-04	~	~	15
				jt/mat	654	~	~	650
Cores taken at different locations from			averages	hot	6.63E-04	353.8	6.1	28
permeameter testing.				center	2.86E-03	275.0	12.1	119
Average values calculated from all cores.				cold	1.16E-03	300.5	6.6	48
				avg mat	9.12E-04	327.2	6.3	38
				jt/mat	313	84	192	312

Appendix B – 19 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
19mm	nh93sb 7-29-04	conventional	131+57	hot	0.00E+00	~	~	0
				center	2.86E-03	~	~	117
				cold	1.76E-03	~	~	73
				avg mat	8.82E-04	~	~	37
				jt/mat	324	~	~	320
			122+82	hot	1.06E-03	~	~	44
				center	1.01E-02	~	~	402
				cold	3.56E-03	~	~	146
				avg mat	2.31E-03	~	~	95
				jt/mat	437	~	~	423
			120+34	hot	1.58E-03	~	~	66
				center	1.68E-02	~	~	658
				cold	0.00E+00	~	~	0
				avg mat	7.88E-04	~	~	33
				jt/mat	2129	~	~	2000
			114+34	hot	1.05E-03	~	~	44
				center	5.93E-02	~	~	1968
				cold	1.05E-03	~	~	44
				avg mat	1.05E-03	~	~	44
				jt/mat	5657	~	~	4483
			108+80	hot	1.74E-04	~	~	7
				center	2.57E-02	~	~	973
				cold	1.66E-03	~	~	69
				avg mat	9.19E-04	~	~	38
				jt/mat	2796	~	~	2533
Cores taken at different locations from			averages	hot	7.71E-04	351.0	6.4	32
permeameter testing.				center	2.29E-02	415.3	12.1	824
Average values calculated from all cores.				cold	1.61E-03	335.3	6.5	67
Only one joint core was tested.				avg mat	1.19E-03	343.2	6.4	49
				jt/mat	1930	121	188	1668

Appendix B – 19 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
19mm	NH RT25	control	1033+45	hot	1.81E-02	~	7.7	775
				center	6.78E-02	~	10.3	2633
				cold	1.70E-02	~	7.8	746
				avg mat	1.76E-02	~	7.8	761
				jt/mat	386	~	132	346
			1034+85	hot	2.74E-02	~	7.4	1170
				center	5.67E-02	~	8.5	2282
				cold	2.03E-02	~	7.7	892
				avg mat	2.38E-02	~	7.6	1031
				jt/mat	238	~	113	221
			1024+00	hot	2.91E-02	~	7.2	1273
				center	1.18E-01	~	10.4	4140
				cold	1.97E-02	~	8.0	966
				avg mat	2.44E-02	~	7.6	1119
				jt/mat	482	~	137	370
			1025+00	hot	2.52E-02	~	8.7	1083
				center	1.64E-01	~	11.7	5194
				cold	4.13E-02	~	8.0	1785
				avg mat	3.32E-02	~	8.4	1434
				jt/mat	492	~	140	362
			1026+00	hot	3.89E-02	~	8.6	1609
				center	1.44E-01	~	12.3	5077
				cold	2.35E-02	~	9.2	1024
				avg mat	3.12E-02	~	8.9	1317
				jt/mat	462	~	138	386
			averages	hot	2.77E-02	~	7.9	1182
				center	1.10E-01	~	10.6	3865
				cold	2.44E-02	~	8.1	1083
				avg mat	2.61E-02	~	8.0	1132
				jt/mat	422	~	132	341

Appendix B – 19 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
19mm	NH I-93 6/9/04	control	132+02	left	7.30E-04	556.1	6.4	29
	rect			center	1.04E-02	431.0	11.2	402
				rt	5.49E-04	727.6	5.7	22
				avg mat	6.39E-04	641.9	6.0	26
				jt/mat	1633	67	185	1571
			131+67	left	3.60E-03	589.2	6.2	143
				center	9.66E-03	466.8	9.9	373
				rt	1.10E-03	666.7	6.3	44
				avg mat	2.35E-03	628.0	6.2	93
				jt/mat	411	74	159	400
			131+38	left	2.95E-03	555.5	6.5	117
				center	1.65E-03	433.9	8.6	66
				rt	1.67E-03	674.1	5.8	66
				avg mat	2.31E-03	614.8	6.1	91
				jt/mat	72	71	141	72
			131+04	left	1.07E-03	661.0	5.9	44
				center	2.46E-02	463.0	10.1	914
				rt	1.78E-04	740.8	5.2	7
				avg mat	6.25E-04	700.9	5.6	26
				jt/mat	3932	66	182	3571
			130+50	left	1.07E-03	606.8	5.8	44
				center	2.01E-02	552.1	8.4	761
				rt	2.68E-04	813.8	4.6	11
				avg mat	6.69E-04	710.3	5.2	27
				jt/mat	3001	78	160	2773
			averages	left	1.89E-03	593.7	6.1	75
				center	1.33E-02	469.4	9.6	503
				rt	7.51E-04	724.6	5.5	30
				avg mat	1.32E-03	659.2	5.8	53
				jt/mat	1008	71	165	956

Appendix B – 19 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
19mm	NH I-93 6/9/04	joint heater	77+24	left	4.60E-03	479.4	6.7	168
	rect			center	3.20E-02	460.2	9.2	1057
				rt	4.39E-03	585.6	6.0	161
				avg mat	4.50E-03	532.5	6.3	165
				jt/mat	713	86	146	642
			76+78	left	3.80E-04	523.3	5.1	15
				center	3.13E-02	495.1	9.1	1068
				rt	2.49E-03	701.7	5.1	95
				avg mat	1.44E-03	612.5	5.1	55
				jt/mat	2178	81	180	1947
			76+47	left	7.60E-04	623.5	5.1	29
				center	8.22E-03	521.1	6.8	307
				rt	2.49E-03	699.5	5.0	95
				avg mat	1.62E-03	661.5	5.1	62
				jt/mat	507	79	133	494
			76+10	left	1.28E-03	531.1	6.4	51
				center	1.21E-02	594.1	7.2	461
				rt	1.84E-03	670.2	4.7	73
				avg mat	1.56E-03	600.6	5.6	62
				jt/mat	775	99	129	741
			75+70	left	3.98E-03	550.0	6.6	161
				center	1.79E-03	588.8	7.6	73
				rt	1.97E-03	685.4	4.9	80
				avg mat	2.98E-03	617.7	5.7	121
				jt/mat	60	95	132	61
			averages	left	2.20E-03	541.5	6.0	85
				center	1.71E-02	531.8	8.0	593
				rt	2.64E-03	668.5	5.1	101
				avg mat	2.42E-03	605.0	5.6	93
				jt/mat	706	88	144	639
	circle		76+10	left	2.58E-03	531.1	6.4	102
				center	3.14E-03	594.1	7.2	124
				rt	2.39E-03	670.2	4.7	95
				avg mat	2.49E-03	600.6	5.6	99
				jt/mat	126	99	129	126
			75+70	left	4.35E-03	550.0	6.6	176
				center	2.52E-03	588.8	7.6	102
				rt	2.34E-03	685.4	4.9	95
				avg mat	3.34E-03	617.7	5.7	135
				jt/mat	75	95	132	76
			averages	left	3.46E-03	540.5	6.5	139
				center	2.83E-03	591.5	7.4	113
				rt	2.37E-03	677.8	4.8	95
				avg mat	2.92E-03	609.2	5.7	117
				jt/mat	97	97	130	97

Appendix B – 12.5 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
12.5mm	Mass N95 Saugus		5	hot	1.27E-03	356.8	3.6	38
			4	center	3.44E-02	239.8	8.8	927
			3	cold	1.73E-02	289.7	6.8	516
				avg mat	9.26E-03	323.2	5.2	277
				jt/mat	371	74	169	335
			8	hot	2.24E-02	357.2	3.4	587
			7	center	2.02E-02	300.4	6.3	538
			6	cold		288.8	6.0	
				avg mat	2.24E-02	323.0	4.7	587
				jt/mat	90	93	133	92
			12	hot	8.23E-03	352.0	1.7	263
			11	center	6.97E-02	262.7	7.3	1097
			10	cold	3.38E-02	344.8	4.5	790
				avg mat	2.10E-02	348.4	3.1	527
				jt/mat	332	75	233	208
			1	ctr of mat	7.36E-03	386.7	1.6	230
			2	ctr of mat	4.81E-03	366.4	2.0	124
			9	ctr of mat	1.78E-02	365.6	2.3	483
			13	ctr of mat	2.43E-02	309.4	5.1	609
			averages	hot	1.06E-02	355.3	2.9	296
				center	4.14E-02	267.6	7.5	854
				cold	2.55E-02	307.8	5.8	653
				avg mat	1.75E-02	331.5	4.4	464
				jt/mat	264	81	178	212

Appendix B – 12.5 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
12.5mm	CT RT17 middleton		1244	east	1.25E-03	645.1	6.5	55
				center	0.00E+00	573.1	7.0	0
				west	0.00E+00	537.0	8.3	0
				avg mat	6.27E-04	591.1	7.4	27
				jt/mat	0	97	95	0
			1245	east	0.00E+00	640.5	7.3	0
				center	4.13E-04	492.0	6.2	18
				west	0.00E+00	763.5	5.1	0
				avg mat	0.00E+00	702.0	6.2	0
				jt/mat	#DIV/0!	70	100	#DIV/0!
			7009	east	0.00E+00	767.6	5.2	0
				center	2.51E-04	630.9	5.7	11
				west	0.00E+00	594.8	6.5	0
				avg mat	0.00E+00	681.2	5.8	0
				jt/mat	#DIV/0!	93	98	#DIV/0!
			1246	east	0.00E+00	709.5	6.0	0
				center	9.19E-05	594.9	5.7	4
				west	0.00E+00	740.1	5.9	0
				avg mat	0.00E+00	724.8	5.9	0
				jt/mat	#DIV/0!	82	97	#DIV/0!
			9666	east	0.00E+00	813.4	4.2	0
				center	0.00E+00	822.9	3.5	0
				west	0.00E+00	719.1	4.2	0
				avg mat	0.00E+00	766.3	4.2	0
				jt/mat	#DIV/0!	107	83	#DIV/0!
			averages	east	2.51E-04	715.2	5.8	11
				center	1.51E-04	622.8	5.6	7
				west	0.00E+00	670.9	6.0	0
				avg mat	1.25E-04	693.1	5.9	5
				jt/mat	121	90	95	120

Appendix B – 12.5 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
12.5mm	Ct RT17 Middleton 05		1244	hot	0.00E+00			0
				center	0.00E+00	980.7535		0
				cold	1.37E-03	585.1805		15
				avg mat	6.83E-04	585.2	#DIV/0!	7
				jt/mat	0	168	#DIV/0!	0
			1245	hot	6.53E-04	687.9794		7
				center	1.92E-03	920.652		22
				cold	7.16E-04	917.348		7
				avg mat	6.85E-04	802.7	#DIV/0!	7
				jt/mat	280	115	#DIV/0!	300
			7009	hot	7.68E-04	1036.803		7
				center	1.52E-03	793.991		15
				cold	8.40E-04	1008.079		7
				avg mat	8.04E-04	1022.4	#DIV/0!	7
				jt/mat	189	78	#DIV/0!	200
			1246	hot	9.06E-04	850.4335		7
				center	9.01E-04	962.096		7
				cold	0.00E+00	972.3417		0
				avg mat	4.53E-04	911.4	#DIV/0!	4
				jt/mat	199	106	#DIV/0!	200
			9666	hot	0.00E+00	1026.3		0
				center	1.08E-03	694.8179		7
				cold	0.00E+00	1033.64		0
				avg mat	0.00E+00	1030.0	#DIV/0!	0
				jt/mat	#DIV/0!	67	#DIV/0!	#DIV/0!
			averages	east	4.65E-04	900.4	#DIV/0!	4
				center	1.08E-03	870.5	#DIV/0!	10
				west	5.84E-04	903.3	#DIV/0!	6
				avg mat	5.25E-04	901.8	#DIV/0!	5
				jt/mat	207	97	#DIV/0!	200

Appendix B – 12.5 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
12.5mm	CT RT44 Pomfret		1298	hot	5.31E-03	235.5	10.4	219
				center	3.85E-02	70.2	15.0	1397
				cold	4.77E-03	271.0	9.4	198
				avg mat	5.04E-03	253.2	9.9	208
				jt/mat	763	28	152	670
			1297	hot	1.77E-04	353.9	7.7	7
				center	3.06E-02	109.1	12.8	1127
				cold	3.58E-03	362.1	8.4	146
				avg mat	1.88E-03	358.0	8.1	77
				jt/mat	1629	30	159	1467
			1296	hot	0.00E+00	446.0	7.0	0
				center	9.94E-03	260.1	10.6	454
				cold	4.61E-04	372.8	8.5	22
				avg mat	2.30E-04	409.4	7.8	11
				jt/mat	4315	64	136	4133
			1295	hot	0.00E+00	388.8	7.6	0
				center	3.72E-02	186.3	11.7	1478
				cold	0.00E+00	324.9	8.4	0
				avg mat	0.00E+00	356.9	8.0	0
				jt/mat	#DIV/0!	52	146	#DIV/0!
			1294	hot	1.77E-04	356.2	8.0	7
				center	9.73E-03	195.1	10.7	388
				cold	7.09E-04	263.7	8.7	29
				avg mat	4.43E-04	310.0	8.4	18
				jt/mat	2196	63	128	2120
			averages	hot	1.13E-03	356.1	8.2	47
				center	2.52E-02	164.2	12.1	969
				cold	1.90E-03	318.9	8.7	79
				avg mat	1.52E-03	337.5	8.4	63
				jt/mat	1658	49	144	1540

Appendix B – 12.5 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
12.5mm	CT RT 44 Pomfret 05		1298	hot	1.79E-03	517.3	5.5	59
				center	1.37E-02	256.6	Broken	351
				cold	3.39E-03		5.0	102
				avg mat	2.59E-03	517.3	5.2	80
				jt/mat	529	50	#VALUE!	436
			1297	hot	1.54E-03	715.4	5.8	44
				center	7.97E-03	360.4	7.4	219
				cold	0.00E+00	1609.0	7.7	0
				avg mat	7.71E-04	1162.2	6.8	22
				jt/mat	1034	31	109	1000
			1296	hot	3.96E-04	630.8	7.0	15
				center	4.36E-03	280.7	7.4	139
				cold	2.04E-04	564.0	6.1	7
				avg mat	3.00E-04	597.4	6.6	11
				jt/mat	1455	47	113	1267
			1295	hot	0.00E+00	613.4	7.4	0
				center	6.18E-03	537.9	4.7	110
				cold	2.48E-04	774.1	3.3	7
				avg mat	1.24E-04	693.7	5.4	4
				jt/mat	4978	78	88	3000
			1294	hot	8.65E-04	626.3	7.2	15
				center	4.70E-03	409.2	5.6	124
				cold	3.08E-04	614.4	2.7	7
				avg mat	5.87E-04	620.4	4.9	11
				jt/mat	801	66	114	1133
			averages	hot	9.19E-04	620.7	6.6	26
				center	7.38E-03	369.0	6.3	189
				cold	8.30E-04	890.4	5.0	25
				avg mat	8.74E-04	755.5	5.8	26
				jt/mat	845	49	109	737

Appendix B – 12.5 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
12.5mm	CT RT 17 Glastonbury		1946	hot	5.59E-04	447.3	7.1	33
				center	5.72E-03	264.9	13.3	318
				cold	1.24E-04	461.0	9.9	7
				avg mat	3.41E-04	454.2	8.5	20
				jt/mat	1676	58	157	1582
			1945	hot	1.49E-03	470.3	6.7	80
				center	5.13E-03	276.3	14.1	267
				cold	1.34E-04	539.6	9.4	7
				avg mat	8.12E-04	504.9	8.0	44
				jt/mat	632	55	175	608
			1944	hot	3.92E-04	550.5	4.9	22
				center	3.93E-03	372.1	12.5	212
				cold	0.00E+00	585.8	7.8	0
				avg mat	1.96E-04	568.2	6.4	11
				jt/mat	2007	65	196	1933
			1943	hot	8.75E-04	554.0	5.8	48
				center	4.70E-04	426.9	10.9	26
				cold	6.68E-05	650.5	8.4	4
				avg mat	4.71E-04	602.2	7.1	26
				jt/mat	100	71	154	100
			1942	hot	3.24E-03	469.3	7.1	172
				center	8.91E-03	255.1	14.1	446
				cold	6.71E-04	490.0	11.6	37
				avg mat	1.96E-03	479.7	9.3	104
				jt/mat	456	53	152	428
			averages	hot	1.31E-03	498.3	6.3	71
				center	4.83E-03	319.1	13.0	254
				cold	1.99E-04	545.4	9.4	11
				avg mat	7.55E-04	521.8	7.9	41
				jt/mat	640	61	165	620

Appendix B – 12.5 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
12.5mm	CT Glastonbury 05		1946	hot	2.11E-04	1035.2		7
				center	1.27E-03	570.7		44
				cold	2.11E-04	1213.7		7
				avg mat	2.11E-04	1124.4	#DIV/0!	7
				jt/mat	602	51	#DIV/0!	600
			1945	hot	2.25E-04	929.4		7
				center	1.16E-02			285
				cold	4.60E-04	965.6		15
				avg mat	3.43E-04	947.5	#DIV/0!	11
				jt/mat	3384	0	#DIV/0!	2600
			1944	hot	2.45E-04	938.5		7
				center	4.71E-04	853.4		15
				cold	2.51E-04	929.6		7
				avg mat	2.48E-04	934.0	#DIV/0!	7
				jt/mat	190	91	#DIV/0!	200
			1943	hot	0.00E+00	889.0		0
				center	2.15E-03	804.5		59
				cold	0.00E+00	912.3		0
				avg mat	0.00E+00	900.6	#DIV/0!	0
				jt/mat	#DIV/0!	89	#DIV/0!	#DIV/0!
			1942	hot	0.00E+00	1261.0		0
				center	3.78E-03	845.6		80
				cold	0.00E+00			0
				avg mat	0.00E+00	1261.0	#DIV/0!	0
				jt/mat	#DIV/0!	67	#DIV/0!	#DIV/0!
			averages	hot	1.36E-04	1010.6	#DIV/0!	4
				center	3.85E-03	768.6	#DIV/0!	97
				cold	1.84E-04	1005.3	#DIV/0!	6
				avg mat	1.60E-04	1007.9	#DIV/0!	5
				jt/mat	2404	76	#DIV/0!	1886

Appendix B – 12.5 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
12.5mm	ME I95 NB 9/1/04	rized joint s	197+014	left	1.12E-04	551.4	5.6	7
				center	1.40E-04	426.7	7.9	9
				right	6.74E-04	510.5	6.0	44
				avg mat	3.93E-04	530.9	5.8	26
				jt/mat	36	80	137	36
			197+047	left	0.00E+00	692.4	6.5	0
				center	5.58E-05	575.2	8.2	4
				right	1.12E-04	624.4	7.3	7
				avg mat	5.58E-05	658.4	6.9	4
				jt/mat	100	87	119	100
			197+069	left	2.23E-04	463.7	7.2	15
				center	0.00E+00	492.0	8.4	0
				right	1.67E-04	616.9	6.4	11
				avg mat	1.95E-04	540.3	6.8	13
				jt/mat	0	91	125	0
			averages	left	1.12E-04	569.1	6.4	7
				center	6.52E-05	498.0	8.2	4
				right	3.18E-04	583.9	6.6	21
				avg mat	2.15E-04	576.5	6.5	14
				jt/mat	30	86	126	30

Appendix B – 12.5 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
12.5mm	ME I95 NB 9/1/04	ulsified sea	197+819	left	5.10E-04	609.9	6.4	35
				center	1.34E-04	588.0	7.2	9
				right	1.34E-04	685.3	5.9	9
				avg mat	3.22E-04	647.6	6.1	22
				jt/mat	42	91	117	42
			197+856	left	2.94E-04	534.8	6.5	20
				center	1.07E-04	590.6	7.3	7
				right	7.00E-04	546.1	7.3	48
				avg mat	4.97E-04	540.4	6.9	34
				jt/mat	21	109	106	22
			197+894	left	0.00E+00	579.7	6.9	0
				center	0.00E+00	651.5	7.2	0
				right	5.34E-05	~	~	4
				avg mat	2.67E-05	579.7	6.9	2
				jt/mat	0	112	105	0
			averages	left	2.68E-04	574.8	6.6	18
				center	8.02E-05	610.0	7.2	5
				right	2.96E-04	615.7	6.6	20
				avg mat	2.82E-04	595.3	6.6	19
				jt/mat	28	102	110	29

Appendix B – 12.5 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
12.5mm	ME I95 NB 9/1/04	koch sealer	199+570	left	0.00E+00	654.4	4.4	0
				center	1.07E-04	503.0	7.1	7
				right	4.29E-04	688.1	5.6	29
				avg mat	2.15E-04	671.2	5.0	15
				jt/mat	50	75	143	50
			199+596	left	5.34E-05	531.6	6.3	4
				center	1.07E-04	336.8	8.2	7
				right	2.14E-04	603.3	5.8	15
				avg mat	1.34E-04	567.4	6.1	9
				jt/mat	80	59	135	80
			199+618	left	0.00E+00	~	6.9	0
				center	2.67E-05	493.2	8.1	2
				right	0.00E+00	686.5	4.7	0
				avg mat	0.00E+00	686.5	5.8	0
				jt/mat	#DIV/0!	72	140	#DIV/0!
			averages	left	1.78E-05	593.0	5.9	1
				center	8.02E-05	444.3	7.8	5
				right	2.14E-04	659.3	5.4	15
				avg mat	1.16E-04	626.1	5.6	8
				jt/mat	69	71	139	69

Appendix B – 12.5 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
12.5mm	NH I-93	Control	136+50	left	4.52E-03	~	~	187
	Surface course			center	1.98E-02	~	~	768
	8/10/2004			right	1.47E-02	~	~	582
				avg mat	9.61E-03	#DIV/0!	#DIV/0!	384
				jt/mat	206	#VALUE!	#VALUE!	200
			131+11	left	7.81E-03	~	~	318
				center	9.78E-03	~	~	395
				right	2.64E-03	~	~	110
				avg mat	5.23E-03	#DIV/0!	#DIV/0!	214
				jt/mat	187	#VALUE!	#VALUE!	185
			124+30	left	6.98E-03	~	~	285
				center	1.89E-02	~	~	735
				right	1.12E-02	~	~	450
				avg mat	9.09E-03	#DIV/0!	#DIV/0!	368
				jt/mat	208	#VALUE!	#VALUE!	200
			119+20	left	2.64E-03	~	~	110
				center	1.26E-02	~	~	505
				right	3.18E-03	~	~	132
				avg mat	2.91E-03	#DIV/0!	#DIV/0!	121
				jt/mat	435	#VALUE!	#VALUE!	418
			113+53	left	1.84E-03	~	~	77
				center	2.78E-02	~	~	1042
				right	9.22E-03	~	~	373
				avg mat	5.53E-03	#DIV/0!	#DIV/0!	225
				jt/mat	502	#VALUE!	#VALUE!	463
			averages	left	4.76E-03	341.0	7.5	195
Cores taken at different locations from permeameter				center	1.78E-02	188.0	12.1	689
testing. Average values calculated from all cores.				right	8.19E-03	319.0	7.4	329
				avg mat	6.47E-03	330.0	7.5	262
				jt/mat	275	57	162	263

Appendix B – 12.5 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
12.5mm	NH I-93	joint heater	82+78	left	9.62E-03	~	~	384
	Surface course			center	1.06E-02	~	~	428
	8/10/2004			right	2.90E-03	~	~	121
				avg mat	6.26E-03	#DIV/0!	#DIV/0!	252
				jt/mat	170	#VALUE!	#VALUE!	170
			78+82	left	2.11E-03	~	~	88
				center	1.56E-02	~	~	614
				right	9.22E-03	~	~	373
				avg mat	5.66E-03	#DIV/0!	#DIV/0!	230
				jt/mat	275	#VALUE!	#VALUE!	267
			74+77	left	6.71E-03	~	~	274
				center	1.74E-02	~	~	680
				right	1.74E-02	~	~	680
				avg mat	1.20E-02	#DIV/0!	#DIV/0!	477
				jt/mat	144	#VALUE!	#VALUE!	143
			64+54	left	8.37E-03	~	~	340
				center	7.26E-03	~	~	296
				right	1.84E-03	~	~	77
				avg mat	5.11E-03	#DIV/0!	#DIV/0!	208
				jt/mat	142	#VALUE!	#VALUE!	142
			57+84	left	2.64E-03	~	~	110
				center	1.56E-02	~	~	614
				right	7.54E-03	~	~	307
				avg mat	5.09E-03	#DIV/0!	#DIV/0!	208
				jt/mat	306	#VALUE!	#VALUE!	295
			averages	left	5.89E-03	345.0	6.5	239
Cores taken at different locations from permeameter				center	1.33E-02	254.0	9.6	527
testing. Average values calculated from all cores.				right	7.77E-03	328.0	7.4	312
				avg mat	6.83E-03	336.5	7.0	275
				jt/mat	194	75	138	191

Appendix B – 12.5 mm sites

NMSA	Site	Joint type	Station	section	K (cm/s)	ITS (kPa)	Air (%)	infiltration (cm/hr)
12.5mm	VT I91 NB	convent	A	pass	5.465E-03			263
				center	9.270E-03			395
				travel	3.174E-03			117
				avg mat	4.320E-03			190
				jt/mat	215			208
			B	pass	8.196E-03			344
				center	1.868E-02			666
				travel	1.687E-03			73
				avg mat	4.941E-03			208
				jt/mat	378			319
			C	pass	2.381E-02			933
				center	3.944E-02			1343
				travel	3.888E-03			176
				avg mat	1.385E-02			554
				jt/mat	285			242
Air voids from QC/QA cores taken at .			averages	pass	1.25E-02	#DIV/0!	#DIV/0!	513
different locations from perm testing				center	2.25E-02	#DIV/0!	6.0	801
Avgerage values calculated from all available data				travel	2.92E-03	#DIV/0!	#DIV/0!	122
				avg mat	7.70E-03	#DIV/0!	6.0	318
				jt/mat	292	#DIV/0!	99	252

Appendix B – 9.5 mm sites

										Nuke Gage	
NMSA	**Site**	**Joint type**	**Station**	**section**	**K (cm/s)**	**ITS (kPa)**	**Air(%)**	**infiltration (cm/hr)**		**%Gmm**	**% Air**
9.5mm	ME Rt 5	conventiona	A	NB	4.91E-04	266.3	7.7	29		92.83	7.17
				center	6.39E-03	222.8	16.8	336		90.71	9.29
				SB	1.21E-04	349.9	4.6	7		92.63	7.37
				avg mat	3.06E-04	308.1	6.2	18		9.27E+01	7.27E+00
				jt/mat	2088	72	272	1840		98	128
			B	NB	1.29E-03			73		93.96	6.04
				center	9.72E-03			497		91.9	8.1
				SB	0.00E+00			0		92.3	7.7
				avg mat	6.44E-04			37		9.31E+01	6.87E+00
				jt/mat	1508			1360		99	118
			C	NB	1.62E-03	314.5	7.4	95		92.3	7.7
				center	2.31E-02			988		91.31	8.69
				SB	7.44E-03			402		94.56	5.44
				avg mat	4.53E-03			249		9.34E+01	6.57E+00
				jt/mat	509			397		98	132
			averages	NB	1.13E-03	290.4	7.6	66		93.0	7.0
				center	1.31E-02	222.8	16.8	607		91.3	8.7
				SB	2.52E-03	349.9	4.6	137		93.2	6.8
				avg mat	1.83E-03	320.2	6.1	101		93.1	6.9
				jt/mat	1369	70	275	1199		98	126

Appendix C: Individual Core Data and Statistics

Project: NH RT153

Joint Type

	ITS (kPa)		
Station	**Mat 1**	**Center**	**Mat 2**
603+75	378.7	88.0	208.8
603+45	426.4	108.7	268.3
603+25	338.1		430.1
Average	381.1	98.4	302.4
COV	11.6	14.9	37.9
mple Variar	1953.2	215.0	13121.4

	Air (%)		
Station	**Mat 1**	**Center**	**Mat 2**
603+75	6.1	10.3	7.2
603+45	6.0	10.5	7.3
603+25	8.3	10.0	6.3
Average	6.8	10.3	6.9
COV	19.0	2.7	7.5
mple Variar	1.7	0.1	0.3

Appendix C – 19 mm sites

Project: NH I-93 SB
Joint Type Joint Heater
*cores taken at different locations from permeameter testing
blank cells indicate no data available (no core/broken core)

	ITS (kPa)		
Core	Mat 1	Center	Mat 2
1	235.7	489	430.4
2	391.9		335.9
3	333.9		324.7
4	422.4	195	320.1
5	319.2	460	192.0
6	235.9	226	222.3
7	307.7	470	248.5
8	584.1	256	329.8
9			
10			
11		64	
12		188	
13		128	
14			
Average	353.8	275.0	300.5
COV	32.2	57.6	25.3
mple Variar	12960.5	25114.4	5793.7

	Air (%)		
Core	Mat 1	Center	Mat 2
1	5.9	12.3	5.0
2	4.7	12.5	5.3
3	5.1	11.8	8.6
4	5.7	12.3	6.9
5	6.6	12.0	7.4
6	7.3	9.3	6.1
7	6.4	11.1	6.3
8	6.7	9.5	7.1
9		13.9	
10		13.3	
11		13.2	
12		13.2	
13		13.6	
14		12.1	
15		12.6	
Average	6.1	12.2	6.6
COV	15.5	11.5	16.0
mple Variar	0.8	1.8	1.4

Project: NH I-93 SB
Joint Type Control
*cores taken at different locations from perme
blank cells indicate no data available (no core

	ITS (kPa)		
Core	Mat 1	Center	Mat 2
1	301.8		291.0
2	235.6		342.8
3	273.7	415.3	371.7
4	842.4		299.2
5	374.9		249.2
6	247.9		362.3
7	314.0		423.4
8	369.1		342.4
9	199.5		
10			
11			
12			
13			
14			
Average	351.0	415.3	335.3
COV	55.1	#DIV/0!	16.2
Sample Variar	37380.7	#DIV/0!	2941.5

	Air (%)		
Core	Mat 1	Center	Mat 2
1	6.1	13.1	7.9
2	7.0	11.6	4.9
3	7.0	11.1	6.1
4	5.9	11.2	6.7
5	6.1	11.5	7.2
6	7.1	12.4	5.4
7	5.4	12.9	5.9
8	7.2	12.5	7.5
9	6.2	11.9	
10		12.7	
11		11.6	
12		11.8	
13		12.5	
14		12.2	
Average	6.4	12.1	6.5
COV	10.0	5.2	16.3
Sample Variar	0.4	0.4	1.1

Appendix C – 19 mm sites

Project: maine s 95

Joint Type rubber joint sealer

	ITS (kPa)		
Station	**Mat 1**	**Center**	**Mat 2**
1745	475.0		474.7
1740	514.6	341.5	361.7
1735	428.4	301.1	427.1
1730	424.1	354.5	459.6
1725	335.6	467.7	503.8
Average	435.6	366.2	445.4
COV	15.4	19.5	12.2
mple Variar	4495.4	5095.6	2955.1

	Air (%)		
Station	**Mat 1**	**Center**	**Mat 2**
1745	5.5		5.0
1740	5.8	7.4	7.7
1735	7.0	7.4	6.1
1730	7.4	4.7	3.3
1725	7.2	5.6	2.7
Average	6.6	6.3	5.0
COV	13.1	21.3	41.0
mple Variar	0.7	1.8	4.1

Project: NH RT25

Joint Type

	ITS (kPa)		
Station	**Mat 1**	**Center**	**Mat 2**
1033+45			
1034+85			
1024+00			
1025+00			
1026+00			
Average	#DIV/0!	#DIV/0!	#DIV/0!
COV	#DIV/0!	#DIV/0!	#DIV/0!
Sample Variar	#DIV/0!	#DIV/0!	#DIV/0!

	Air (%)		
Station	**Mat 1**	**Center**	**Mat 2**
1033+45	7.7	10.3	7.8
1034+85	7.4	8.5	7.7
1024+00	7.2	10.4	8.0
1025+00	8.7	11.7	8.0
1026+00	8.6	12.3	9.2
Average	7.9	10.6	8.1
COV	8.8	13.6	7.1
Sample Variar	0.5	2.1	0.3

Project: NH I-93 6/9/04
Joint Type control

	ITS (kPa)		
Station	**Mat 1**	**Center**	**Mat 2**
132+02	556.1	431.0	727.6
131+67	589.2	466.8	666.7
131+38	555.5	433.9	674.1
131+04	661.0	463.0	740.8
130+50	606.8	552.1	813.8
Average	593.7	469.4	724.6
COV	7.3	10.4	8.2
mple Variar	1897.2	2404.1	3532.1

	Air (%)		
Station	**Mat 1**	**Center**	**Mat 2**
132+02	6.4	11.2	5.7
131+67	6.2	9.9	6.3
131+38	6.5	8.6	5.8
131+04	5.9	10.1	5.2
130+50	5.8	8.4	4.6
Average	6.1	9.6	5.5
COV	4.5	11.9	11.3
mple Variar	0.1	1.3	0.4

Project: NH I-93 6/9/04
Joint Type heater

	ITS (kPa)		
Station	**Mat 1**	**Center**	**Mat 2**
77+24	479.4	460.2	585.6
76+78	523.3	495.1	701.7
76+47	623.5	521.1	699.5
76+10	531.1	594.1	670.2
75+70	550.0	588.8	685.4
Average	541.5	531.8	668.5
COV	9.7	11.0	7.2
Sample Variar	2773.6	3433.2	2306.1

	Air (%)		
Station	**Mat 1**	**Center**	**Mat 2**
77+24	6.7	9.2	6.0
76+78	5.1	9.1	5.1
76+47	5.1	6.8	5.0
76+10	6.4	7.2	4.7
75+70	6.6	7.6	4.9
Average	6.0	8.0	5.1
COV	13.4	14.2	9.6
Sample Variar	0.6	1.3	0.2

Appendix C – 12.5 mm sites

Project: NH I-93 SB

Joint Type: Joint Heater

*cores taken at different locations from permeameter testing
blank cells indicate no data available (no core/broken core)

	ITS (kPa)		
Core	**Mat 1**	**Center**	**Mat 2**
1	402.6	284.1	307.5
2	287.0	281.9	259.0
3	398.6	216.6	269.7
4	303.6	304.3	389.0
5	312.7	369.9	353.5
6	316.4	269.1	339.2
7	387.2	270.8	339.4
8	348.1	229.5	370.7
9		205.5	
10		243.9	
11		224.5	
12		205.5	
13		210.6	
14		234.0	
Average	344.5	253.6	328.5
COV	13.4	18.3	14.1
Sample Variance	2129.9	2163.0	2145.5

	Air (%)		
Core	**Mat 1**	**Center**	**Mat 2**
1	5.0	8.8	7.7
2	8.9	9.3	8.4
3	5.8	10.4	9.2
4	7.7	8.6	6.0
5	7.2	5.7	6.4
6	6.1	9.5	7.0
7	5.3	9.7	8.2
8	6.4	10.0	6.1
9		10.7	
10		10.0	
11		10.0	
12		10.2	
13		10.6	
14		10.8	
Average	6.5	9.6	7.4
COV	20.0	13.5	16.3
Sample Variance	1.7	1.7	1.4

Project: NH I-93 SB

Joint Type Control

*cores taken at different locations from perme
blank cells indicate no data available (no core

	ITS (kPa)		
Core	**Mat 1**	**Center**	**Mat 2**
1	368.7	240.2	381.1
2	331.4	152.7	287.9
3		160.0	356.7
4	382.8	177.5	269.9
5	301.8	229.3	317.7
6	313.4		256.7
7	350.1		324.6
8			353.6
9		202.8	
10		211.7	
11		208.4	
12		174.9	
13		189.2	
14		124.0	
Average	341.4	188.2	318.5
COV	9.3	18.4	13.9
Sample Variar	997.9	1203.4	1965.9

	Air (%)		
Core	**Mat 1**	**Center**	**Mat 2**
1		10.4	5.2
2	7.0	12.6	8.5
3	7.9	12.7	6.2
4		12.8	8.8
5	6.1	10.7	7.0
6	8.4	11.3	9.1
7	8.4	13.2	7.3
8	7.1	12.0	7.3
9		12.5	
10		12.2	
11		11.1	
12		12.0	
13		12.4	
14		13.7	
Average	7.5	12.1	7.4
COV	12.1	7.8	18.2
Sample Variar	0.8	0.9	1.8

Appendix C – 12.5 mm sites

Project: ME I95 NB
Joint Type emulsified sealer

	ITS (kPa)		
Station	**Mat 1**	**Center**	**Mat 2**
197+819	609.9	588.0	685.3
197+856	534.8	590.6	546.1
197+894	579.7	651.5	~
Average	574.8	610.0	615.7
COV	6.6	5.9	16.0
mple Variar	1429.5	1291.7	9700.9

	Air (%)		
Station	**Mat 1**	**Center**	**Mat 2**
197+819	6.4	7.2	5.9
197+856	6.5	7.3	7.3
197+894	6.9	7.2	~
Average	6.6	7.2	6.6
COV	4.5	1.0	15.0
mple Variar	0.1	0.0	1.0

Project: ME I95 NB
Joint Type koch sealer

	ITS (kPa)		
Station	**Mat 1**	**Center**	**Mat 2**
199+570	654.4	503.0	688.1
199+596	531.6	336.8	603.3
199+618	~	493.2	686.5
Average	593.0	444.3	659.3
COV	14.6	21.0	7.4
Sample Variar	7538.7	8700.8	2353.6

	Air (%)		
Station	**Mat 1**	**Center**	**Mat 2**
199+570	4.4	7.1	5.6
199+596	6.3	8.2	5.8
199+618	6.9	8.1	4.7
Average	5.9	7.8	5.4
COV	22.7	7.5	11.6
Sample Variar	1.8	0.3	0.4

Project: ME I95 NB
Joint Type rubberized joint seal

	ITS (kPa)		
Station	**Mat 1**	**Center**	**Mat 2**
197+014	551.4	426.7	510.5
197+047	692.4	575.2	624.4
197+069	463.7	492.0	616.9
Average	569.1	498.0	583.9
COV	20.3	14.9	10.9
Sample Variar	13311.1	5539.3	4062.5

	Air (%)		
Station	**Mat 1**	**Center**	**Mat 2**
197+014	5.6	7.9	6.0
197+047	6.5	8.2	7.3
197+069	7.2	8.4	6.4
Average	6.4	8.2	6.6
COV	12.6	3.1	10.7
Sample Variar	0.7	0.1	0.5

Appendix C – 12.5 mm sites

Project: CT RT 17 '04 Glastonbury

Joint Type ________________

	ITS (kPa)		
Station	Mat 1	Center	Mat 2
1946	447.3	264.9	461.0
1945	470.3	276.3	539.6
1944	550.5	372.1	585.8
1943	554.0	426.9	650.5
1942	469.3	255.1	490.0
Average	498.3	319.1	545.4
COV	10.1	23.9	13.9
mple Variar	2512.6	5823.0	5726.9

	Air (%)		
Station	Mat 1	Center	Mat 2
1946	7.1	13.3	9.9
1945	6.7	14.1	9.4
1944	4.9	12.5	7.8
1943	5.8	10.9	8.4
1942	7.1	14.1	11.6
Average	6.3	13.0	9.4
COV	15.0	10.3	15.5
mple Variar	0.9	1.8	2.1

Project: CT RT44 '04 Pomfret

Joint Type ________________

	ITS (kPa)		
Station	Mat 1	Center	Mat 2
1298	235.5	70.2	271.0
1297	353.9	109.1	362.1
1296	446.0	260.1	372.8
1295	388.8	186.3	324.9
1294	356.2	195.1	263.7
Average	356.1	164.2	318.9
COV	21.6	45.7	15.8
Sample Variar	5924.8	5627.9	2537.9

	Air (%)		
Station	Mat 1	Center	Mat 2
1298	10.4	15.0	9.4
1297	7.7	12.8	8.4
1296	7.0	10.6	8.5
1295	7.6	11.7	8.4
1294	8.0	10.7	8.7
Average	8.2	12.1	8.7
COV	16.0	15.1	4.8
Sample Variar	1.7	3.3	0.2

Project: CT Rt 17 '04 (Middelton)

Joint Type ________________

	ITS (kPa)		
Station	Mat 1	Center	Mat 2
1244	645.1	573.1	537.0
1245	640.5	492.0	763.5
7009	767.6	630.9	594.8
1246	709.5	594.9	740.1
9666	813.4	822.9	719.1
Average	715.2	622.8	670.9
COV	10.6	19.7	14.8
Sample Variar	5726.0	15112.2	9857.8

	Air (%)		
Station	Mat 1	Center	Mat 2
1244	6.5	7.0	8.3
1245	7.3	6.2	5.1
7009	5.2	5.7	6.5
1246	6.0	5.7	5.9
9666	4.2	3.5	4.2
Average	5.8	5.6	6.0
COV	20.1	23.3	25.8
Sample Variar	1.4	1.7	2.4

Appendix C – 12.5 mm sites

Project: CT Rt 17 '05 (Middelton)
Joint Type

	ITS (kPa)		
Station	Mat 1	Center	Mat 2
1244		980.8	585.2
1245	688.0	920.7	917.3
7009	1036.8	794.0	1008.1
1246	850.4	962.1	972.3
9666	1026.3	694.8	1033.6
Average	900.4	870.5	903.3
COV	18.4	14.0	20.3
mple Variar	27358.5	14944.7	33532.8

	Air (%)		
Station	Mat 1	Center	Mat 2
1244			
1245			
7009			
1246			
9666			
Average	#DIV/0!	#DIV/0!	#DIV/0!
COV	#DIV/0!	#DIV/0!	#DIV/0!
mple Variar	#DIV/0!	#DIV/0!	#DIV/0!

Project: CT RT44 '05 Pomfret
Joint Type

	ITS (kPa)		
Station	Mat 1	Center	Mat 2
1298	517.3	256.6	
1297	715.4	360.4	1609.0
1296	630.8	280.7	564.0
1295	613.4	537.9	774.1
1294	626.3	409.2	614.4
Average	620.7	369.0	890.4
COV	11.4	30.5	54.7
Sample Variar	4962.4	12667.6	237522.3

	Air (%)		
Station	Mat 1	Center	Mat 2
1298	5.5		5.0
1297	5.8	7.4	7.7
1296	7.0	7.4	6.1
1295	7.4	4.7	3.3
1294	7.2	5.6	2.7
Average	6.6	6.3	5.0
COV	13.1	21.3	41.0
Sample Variar	0.7	1.8	4.1

Project: CT RT 17 '05 Glastonbury
Joint Type

	ITS (kPa)		
Station	Mat 1	Center	Mat 2
1946	1035.2	570.7	1213.7
1945	929.4		965.6
1944	938.5	853.4	929.6
1943	889.0	804.5	912.3
1942	1261.0	845.6	
Average	1010.6	768.6	1005.3
COV	14.8	17.4	14.0
Sample Variar	22472.9	17864.4	19792.0

	Air (%)		
Station	Mat 1	Center	Mat 2
1946			
1945			
1944			
1943			
1942			
Average	#DIV/0!	#DIV/0!	#DIV/0!
COV	#DIV/0!	#DIV/0!	#DIV/0!
Sample Variar	#DIV/0!	#DIV/0!	#DIV/0!

Appendix C – 12.5 mm sites

Project: VT I91 NB

Joint Type

	Air (%)	
Core	**Mat 1**	**Center**
1	4.4	6.5
2	6.79	2.4
3	5.73	7.9
4	7.13	7.1
5	5.61	
6	5.1	
Average	5.8	6.0
COV	17.7	41.1
mple Variar	1.0	6.0

Project: Mass N95 Saugus

Joint Type

	ITS (kPa)		
Station	**Mat 1**	**Center**	**Mat 2**
345	356.8	239.8	289.7
678	357.2	300.4	288.8
101112	352.0	262.7	344.8
Average	355.3	267.6	307.8
COV	0.8	11.4	10.4
Sample Variar	8.3	936.4	1030.0

	Air (%)		
Station	**Mat 1**	**Center**	**Mat 2**
345	3.6	8.8	6.8
678	3.4	6.3	6.0
101112	1.7	7.3	4.5
Average	2.9	7.5	5.8
COV	35.1	17.1	20.3
Sample Variar	1.1	1.6	1.4

Appendix C – 9.5 mm sites

Project: ME Rt 5

Joint Type ____________

	ITS (kPa)		
Station	**Mat 1**	**Center**	**Mat 2**
A	266.3	222.8	349.9
B			
C	314.5		
Average	290.4	222.8	349.9
COV	11.7	#DIV/0!	#DIV/0!
mple Variar	1160.4	#DIV/0!	#DIV/0!

	Air (%)		
Station	**Mat 1**	**Center**	**Mat 2**
A	7.7	16.8	4.6
B			
C	7.4		
Average	7.6	16.8	4.6
COV	2.7	#DIV/0!	#DIV/0!
mple Variar	0.0	#DIV/0!	#DIV/0!