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Fog Seal Performance on Asphalt Mixture Longitudinal Joints

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1 INTRODUCTION

Due to the nature of construction, it is common for longitudinal joints in asphalt pavements to have low density and high permeability. This condition causes the pavement to be more susceptible to air and water penetration thus having an accelerated deterioration.

Fog seals applied to longitudinal joints are believed to reduce asphalt pavement permeability to air and moisture, thus enhancing a pavement's waterproofing abilities and decreasing its susceptibility to oxidation and moisture induced damage. A fog seal is defined as:

"A light spray application of dilute asphalt emulsion used primarily to seal an existing asphalt surface to reduce raveling and enrich dry and weathered surfaces."
(The Asphalt Institute, A Basic Asphalt Emulsion Manual, Manual Series No. 19, Lexington Kentucky, 1999)

The success of an initial fog seal treatment project led the Indiana Department of Transportation (INDOT) in 2012 to begin requiring longitudinal joints to be fog sealed with a 2-ft wide band centered along the construction joint. However, no data have been collected to quantitatively support the observation that the lives of longitudinal joints have been improved.

2 OBJECTIVES

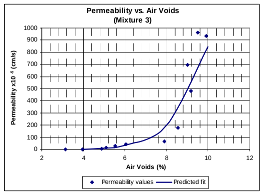
The objectives of this project were to:
1. Determine if applying fog seals to the longitudinal joints of new asphalt surface mixtures improves the performance of the joints
2. Determine the preferred type of fog seal materials for use in sealing the longitudinal joints
3. Determine if the fog seals need to be reapplied and if so, at what intervals

3 BACKGROUND

In asphalt pavement construction, multiple lane roadways are typically paved one lane at a time. Consequently, the free edge of the previously paved lane is difficult to fully compact. As a result, construction joints may be less dense than the interior of the lane.

Although density has traditionally been the primary measure of joint quality, the fundamental failure mechanisms are more directly related to permeability, which can be defined as a mixture's ability to transmit air and water and is determined by air void content and the inter-connectedness of the air voids.

Because the entrance of air and water into an asphalt mixture contribute to oxidation, moisture damage, and other distresses, water related properties, such as permeability should be considered when determining the quality of asphalt pavements.



(del Pilar Vivar, E., and J. E. Haddock. HMA Pavement Performance and Durability. Publication FHWA/IN/JTRP-2005/14)

The permeability of asphalt mixtures increases as the air void content increases. Studies have shown that asphalt mixtures become permeable at critical air void contents of approximately 8 percent. At this level, air and water can penetrate the mixture and cause oxidation and moisture damage. Due to the difficult nature of longitudinal joint construction, joints often have greater than 10 percent air voids thus making them permeable to air and moisture.

Fog seal application is easy, does not delay construction, and requires less labor and heavy equipment than other construction techniques. Consequently, many types of joint sealants/adhesives have been used with the intent of preventing air and water entrance and preserving joint integrity. INDOT currently uses undiluted tack emulsions, SS-1h and AE-NT, for longitudinal fog seals at a rate of 0.13L/m² (0.03 gal/yd²).

4 EXPERIMENTAL METHODOLOGY

Using a PG 64 asphalt mixture meeting INDOT mix design requirements for a 9.5mm ESAL Category 3 mixture design, (15) laboratory permeability specimens were prepared with air void contents of 7 ±1 percent, which it typical of longitudinal joints.

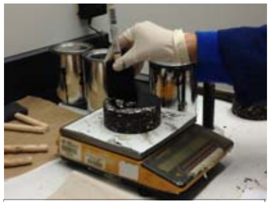
The initial permeability of each sample was determined in general accordance with FM 5-565 Florida *Test Method for Measurement of Water Permeability of Compacted Asphalt Paving Mixtures*.

The (15) samples were then divided into three groups of five such that each group had similar average air void content and permeability with as similar standard deviations as possible.

The first group received no treatment. The second group was treated with an SS-1h emulsion while the third group was treated with an AE-NT emulsion, both at the standard INDOT fog seal rate of 0.13L/m² (0.03 gal/yd²). The fog seals were applied evenly with a foam brush and allowed to sit at room temperature for a minimum of 24 hours to allow the emulsion to fully break. Permeability testing was then repeated.

Treatment	Sample	Air Void (%)	Permeability Coefficient, k (cm/s)
No Treatment	1	7.0%	1.43E-04
	2	7.2%	1.90E-04
	3	6.7%	1.29E-04
	4	7.8%	2.29E-04
	5	6.3%	1.05E-04
	Average	7.0%	1.59E-04
	Std Dev	0.59%	5.01E-05
SS-1h	6	6.3%	1.08E-04
	7	7.2%	7.18E-05
	8	6.8%	1.50E-04
	9	7.5%	1.72E-04
	10	7.0%	2.56E-04
	Average	7.0%	1.52E-04
	Std Dev	0.47%	7.01E-05
AE-NT	11	6.1%	1.11E-04
	12	6.9%	2.09E-04
	13	7.3%	1.61E-04
	14	7.6%	5.71E-05
	15	7.3%	2.58E-04
	Average	7.0%	1.59E-04
	Std Dev	0.58%	7.89E-05
Average		7.0%	1.57E-04
Std Dev		0.51%	6.25E-05

PERMEABILITY TESTING



FOG SEAL APPLICATION

SAMPLES AFTER TESTING

LABORATORY AGING

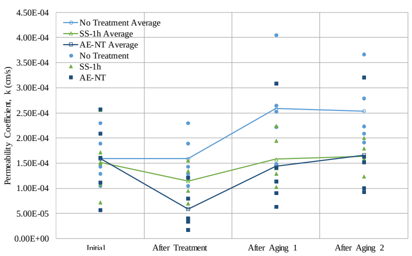
All (15) samples were subjected to long-term aging treatment in general accordance with AASHTO R30 *Mixture Conditioning of Hot Mix Asphalt*

After cooling, permeability testing was repeated followed by a second long-term aging treatment and a fourth permeability test.

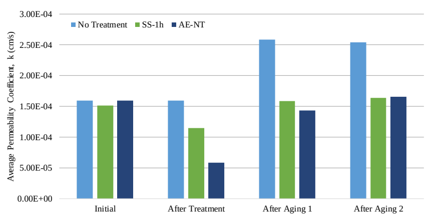
Statistical analyses were performed to evaluate and compare the performance of the fog seal treatments, which included a two-way analysis of variance (ANOVA) to determine if the interaction between the treatment type and asphalt condition was significant and also to determine if significant differences existed between the three treatment types, and between the four asphalt conditions. The standard statistical significance value of 0.05 was used.

5 RESULTS

There was a reduction in permeability associated with the application of both the SS-1h and AE-NT emulsion treatments. Specifically, the SS-1h and AE-NT treatments exhibited average reductions in permeability of 24% and 63%, respectively.



After the first aging round, the permeability of all three groups increased and the permeability of the untreated samples was higher than of the treated samples. The permeability of all three groups after the second aging round was comparable to those after the first aging round. This indicates that that there is a plateau in the effects of aging on permeability.



The ANOVA indicated that both the treatment type and asphalt condition were statistically significant and that the interaction between the two independent variables was not significant. The low p-values indicate a statistically significant difference between the samples that received a fog seal treatment and those that did not. However, there was not a statistically significant difference between the two fog seal types. The only statistically significant differences in asphalt condition were between the samples after treatment with the samples after both aging rounds.

Asphalt Condition Interaction		*p*-value
Initial	After Treatment	0.250
	After Aging 1	0.613
	After Aging 2	0.419
After Treatment	Initial	0.250
	After Aging 1	0.016
	After Aging 2	0.006
After Aging 1	Initial	0.613
	After Treatment	0.016
	After Aging 2	0.989
After Aging 2	Initial	0.419
	After Treatment	0.006
	After Aging 1	0.989

Treatment Interaction		*p*-value
No Treatment	SS-1h	0.016
	AE-NT	0.002
SS-1h	No Treatment	0.016
	AE-NT	0.750
AE-NT	No Treatment	0.002
	SS-1h	0.750

6 CONCLUSIONS & RECOMMENDATIONS

1. The presence of fog seals can improve the performance of longitudinal joints with respect to permeability. In this research, the fog seal treatments reduced the asphalt permeability and kept it lower than the untreated asphalt samples after aging.
2. There was no statistical difference between the performance of the two fog seal types evaluated in this experiment on asphalt permeability. Therefore, the benefits of using fog seals may be obtained from either emulsion type.
3. The fog seal treatment was no longer in effect after the second aging round. If laboratory aging is estimated to simulate 5-7 years of in service aging, than additional fog seal applications are recommended at 5-7 year intervals.

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