J. Basic. Appl. Sci. Res., 3(3)394-399, 2013
© 2013, TextRoad Publication

ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Evaluation of Permeability Rate on Porous Asphalt Mixtures and Hot Mix Asphalt

Mansour Fakhri[1], Nariman BaraziJomoor[2], Mahmoud R. Keymanesh[3]

[1]Assistant professor in Road &Transportation Engineering, Dept of Civil Engineering, KN TOOSI University of Technology, Tehran, Iran
[2]Lecturer, Dept. of Technical Engineering, Payamenoor University, Iran
[3]Assistant professor, Dept. of Technical Engineering, Payamenoor University, Iran

ABSTRACT

Open-Graded Friction Course (OGFC) or porous asphalt mixes are mixtures with open gradated combination, although having less application against the heavy traffic loads, they have many benefits such as reduction of pavement noise, hydroplaning and glare and improvement of permeability and skid resistance as well.
In order to improving indirect tensile strength of mixtures against fatigue phenomena and according to this fact that the life time pavement is one of the important factors to design of pavement structure based on economic analysis, SBS (styrene butadiene styrene) polymer modified bitumen are used to produce this kind of mixtures.
This paper document was conducted to evaluate the effect of two types of bitumen: SBS polymer modified bitumen and AC 85-100 Bitumen on two different aggregate gradations in terms of permeability rate of Porous Asphalt mixtures and conventional Hot Mix Asphalt. A total, four different OGFC mixtures with two types of conventional Hot Mix Asphalt were evaluated. The result indicates that OGFC mixes containing SBS Bitumen have better performance in permeability rate compared to OGFC mixes containing AC 85-100 Bitumen.
KEYWORDS: Open-Graded Friction Coarse, permeability, SBS polymer modified Bitumen.

1. INTRODUCTION

In each country, roads network plays an important role in communication of cities and different areas in the field of economical, cultural and social development. In asphalt pavement road, the surface layer protects road body and transfers compressive stresses from the upper layers to the lower ones. This layer is one of the determining factors in the safety of passengers and vehicles which is considered as one of the most important factors in design of asphalt mixes, as a result, pavement with good quality and suitable lifetime has been of high significance. Therefore, cases which are conducive to the increase of stability, quality of pavement, reduction of pavement noise level, lifetime of asphalt pavement and prevention of premature distresses of asphalt layers have been highly considered by researchers of science of pavement and road construction. Regarding the mentioned things, porous asphalt mix is an alternative which can be used in rainy areas because of its property of high drainage [1].

Technology of porous asphalt mixes goes back to the late decade of 1950 and the beginning decade of 1960, but its extensive use started from the decade of 1980[2].
This kind of pavement has been used in most European countries such as Netherlands, Spain, Belgium, France…, and also in most American states and other countries like Canada, Australia, South Africa, South Korea and Hong Kong.

Due to having high air void content (nearly 20%), Porous Asphalt pavements have shorter lifetime compared to Conventional Hot Mix Asphalt pavements. Regarding the fact that the lifetime of pavement is an important factor in design of pavement, and also because of weathering phenomena in bitumen materials of porous asphalt mixes which causes high deterioration of bitumen materials against heavy traffic loads, the effect of usage of the type of bitumen in Conventional Hot Mix Asphalt and Porous Asphalt mixes is evaluated, and also performance of samples made from original bitumen and SBS polymer modified bitumen is compared by conducting the test of permeability rate.

***Corresponding Author:** Mansour Fakhri, Assistant professor in Road & Transportation Engineering, Dept of Civil Engineering, KN TOOSI University of Technology, Tehran, Iran.E-mails: Fakhri@kntu.ac.ir

2. Specification of material in this work

This experimental study was conducted to evaluate the effect of two types of bitumen: SBS (styrene butadiene styrene) polymer modified bitumen and AC 85-100 Bitumen on two different aggregate gradations as well as the properties of OGFC mixtures. A total of four different OGFC mixtures with two types of conventional Hot Mix Asphalt were evaluated.

This test has been done for Conventional Hot Mix Asphalt with gradation No 4 of code 234 (Iran Asphalt Pavement Roads Code) [9] and for porous asphalt mixes gradation No 1 of code 234 and the used gradation in field project of Amoul [8] which are called HMA, PFC1 and PFC2 respectively.

In this study, coarse aggregate materials are used from broken river materials provided from a job which is located 5 kilometres far from Shahriyar. It is necessary to explain that fine aggregate materials used in this project are completely provided from Armalat Co and Filler is hydrated lime.

Also, AC 85-100 bitumen is used from Pasargad Oil Co and SBS polymer modified bitumen is used from Varziran Co, which their bitumen's specification illustrated in Table 3.

The gradation of HMA and gradation of PFC1 and PFC2 for Porous Asphalt illustrated in Tables 1 and 2.

For achieving the parameter of Marshall Test for HMA gradation from MS-2 [5] and for PFC1 and PFC2 gradations from ASTM D-7064 are used.

Table 1: Sieve size analysis of aggregate for Hot Mix Asphalt and porous asphalt used in this research

Sieve Spec	Size of Sieve (mm)	Hot Mix Asphalt		Porous Asphalt			
		HMA		PFC1		PFC2	
		Spec of code 234	Percent passing %	Spec of code 234	Percent passing %	Project Spec	Percent passing %
3/4 inch	19	100	100	100	100	100	100
1/2 inch	12.5	90-100	95	90-100	95	92	92
3/8 inch	9.5	---	---	60-100	80	66	66
3/16 inch	4.75	44-74	59	15-40	27.5	19	19
No 8	2.36	28-58	43	4-12	8	13	13
No 50	0.3	5-21	14	---	---	7	7
No 200	0.075	2-10	6	2-5	3.5	3.5	3.5

Table 2: Filler gradation materials used in this research

Sieve Spec	Size of Sieve (mm)	Filler	
		Spec of code 234	Percent passing %
No 16	1.18	---	100
No 30	0.5	100	99.7
No 50	0.3	95-100	97.6
No 200	0.075	70-100	78.7

Table 3: Characteristics of bitumen

Bitumen characteristics	Penetration	Ring & Ball (Softening point)	Viscosity	
			135°C	165°C
AC 85-100 bitumen	92	49	375	---
Polymer modified bitumen	60	80	1263	370

3- Determining of permeability rate of porous asphalt specimen in laboratory

To determine permeability rate of laboratory specimen of porousasphaltmixtures is used from fixed head water test (Fig1) which is done on the basis of relations dominating Darcilaws. In this case, due to the similarity of laboratory specimen with pavements made in field works with asphalt cutting device, the test is done by dividing 4 inches marshal specimens into two equal parts while its thickness becomes 1-1.5 inches. Then, these specimens are put in a special mold of permeability test with fixed head water and also around the specimen arewaterproofedto prevent penetration of water from specimen sides, and mold of specimenis connected to fixed head water. Because of permeability of this kind of asphalt mixture in less than a few seconds, in other words, immediately after saturationofspecimen, it is observed that water goes out of specimens.

Summary of this test is showed in Tables4 to 7and Figs2 to 5.

Fig 1: Device of permeability test with fixed head

Table4: Permeability rate setting for PFC1 gradation (85-100 bitumen)

Bitumen Percent%	4.5		5	
Specimen number	**No 1**	**No 2**	**No 1**	**No 2**
Specimen diameter D_0 (cm)	10.10	10.15	10.00	10.15
Specimen height H_0(cm)	3.67	3.62	3.10	3.60
Specimen Area A_0	37.07	36.76	31.00	36.54
Hydraulic Height (cm) H	171.45	171.45	171.45	171.45
Difference of hydraulic height and specimen height	167.78	167.83	168.35	167.85
time(sec)	15	15	15	15
volume of water accumulated in container	500	510	470	475
Exit Flow Water (cm^3/sec)	33.33	34.00	31.33	31.67
Hydraulic gradient (H_1/H_0)	45.72	46.36	54.31	46.63
Permeability coefficient (cm/sec) $k = \frac{Q*H_0}{h*A_0}$	$1.967*10^{-2}$	$1.996*10^{-2}$	$1.861*10^{-2}$	$1.859*10^{-2}$
	$1.982*10^{-2}$		$1.860*10^{-2}$	
	$1.921*10^{-2}$			

Table5: Permeability rate setting for PFC1 gradation (polymer bitumen)

Bitumen Percent%	4.5		5	
Specimen number	**No 1**	**No 2**	**No 1**	**No 2**
Specimen diameter D_0 (cm)	10.10	10.15	9.95	10.10
Specimen height H_0 (cm)	3.85	3.68	3.70	3.60
Specimen Area A_0	38.50	37.35	36.82	36.36
Hydraulic Height (cm) H	171.45	171.45	171.45	171.45
Difference of hydraulic height and specimen height	167.60	167.77	167.75	167.85
time(sec)	15	15	15	15
volume of water accumulated in container	530	540	530	540
Exit Flow Water (cm^3/sec)	35.33	36.00	35.33	36.00
Hydraulic gradient (H_1/H_0)	45.53	45.59	45.38	46.63
Permeability coefficient (cm/sec) $k = \frac{Q*H_0}{h*A_0}$	$2.124*10^{-2}$	$2.117*10^{-2}$	$2.114*10^{-2}$	$2.108*10^{-2}$
	$2.121*10^{-2}$		$2.111*10^{-2}$	
	$2.116*10^{-2}$			

Table 6: Permeability rate setting for PFC2 gradation (85-100 bitumen)

Bitumen Percent%	**4.5**		**5**	
Specimen number	No 1	No 2	No 1	No 2
Specimen diameter D_0 (cm)	10.15	10.10	10.00	10.10
Specimen height H_0 (cm)	3.65	3.65	3.56	3.55
Specimen Area A_0	37.05	36.68	35.60	35.86
Hydraulic Height (cm) H	171.45	171.45	171.45	171.45
Difference of hydraulic height and specimen height	167.80	167.80	167.89	167.90
time(sec)	15	15	15	15
volume of water accumulated in container	550	545	510	515
Exit Flow Water (cm^3/sec)	36.67	36.33	34.00	34.33
Hydraulic gradient (H_1/H_0)	45.97	45.97	47.16	47.30
Permeability coefficient (cm/sec) $k = \frac{Q*H_0}{h*A_0}$	$2.153*10^{-2}$	$2.144*10^{-2}$	$2.025*10^{-2}$	$2.025*10^{-2}$
	$2.149*10^{-2}$		$2.025*10^{-2}$	
	$2.090*10^{-2}$			

Table 7: Permeability rate setting for PFC2 gradation (polymer bitumen)

Bitumen Percent%	**4.5**		**5**	
Specimen number	**No 1**	**No 2**	**No 1**	**No 2**
Specimen diameter D_0 (cm)	10.15	10.00	9.95	10.00
Specimen height H_0 (cm)	3.65	3.65	3.55	3.55
Specimen Area A_0	37.05	36.50	35.32	35.50
Hydraulic Height (cm) H	171.45	171.45	171.45	171.45
Difference of hydraulic height and specimen height	167.80	167.80	167.90	167.90
time(sec)	15	15	15	15
volume of water accumulated in container	545	535	560	560
Exit Flow Water (cm^3/sec)	36.33	36.67	37.33	37.33
Hydraulic gradient (H_1/H_0)	45.97	45.97	47.30	47.30
Permeability coefficient (cm/sec) $k = \frac{Q*H_0}{h*A_0}$	$2.133*10^{-2}$	$2.126*10^{-2}$	$2.235*10^{-2}$	$2.224*10^{-2}$
	$2.130*10^{-2}$		$2.230*10^{-2}$	
	$2.180*10^{-2}$			

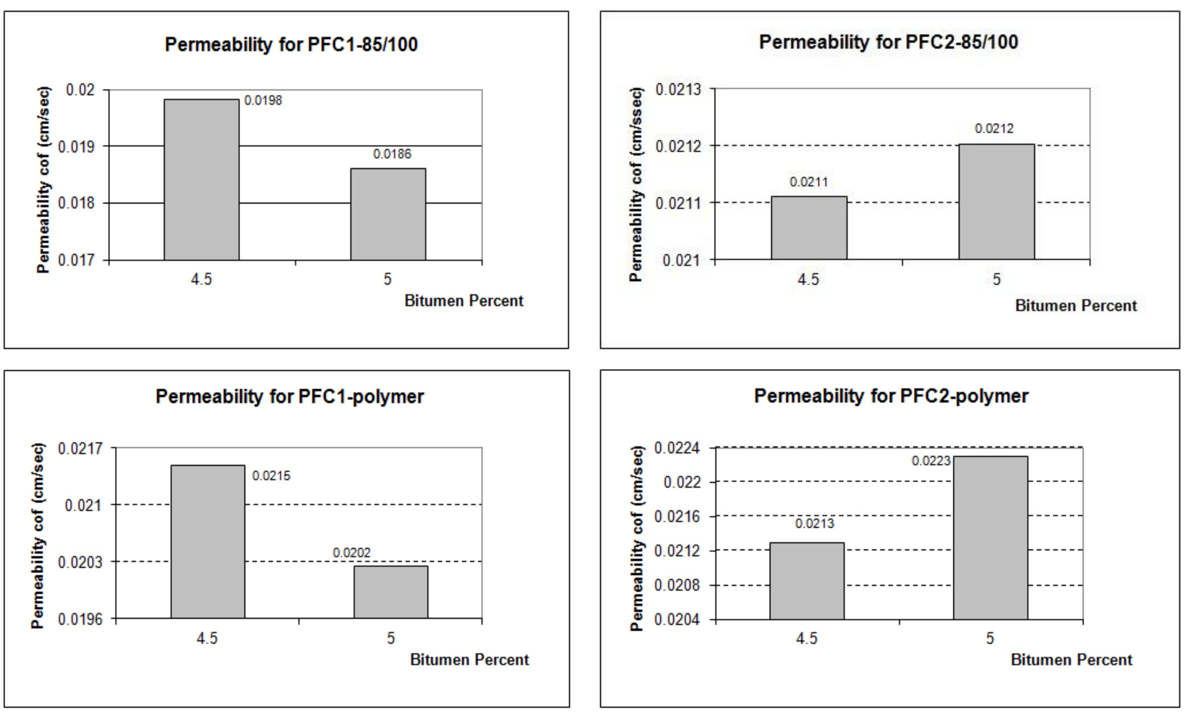

Fig 2: Permeability coefficient rate for asphalt made of PFC1, PFC2 gradation with different bitumens

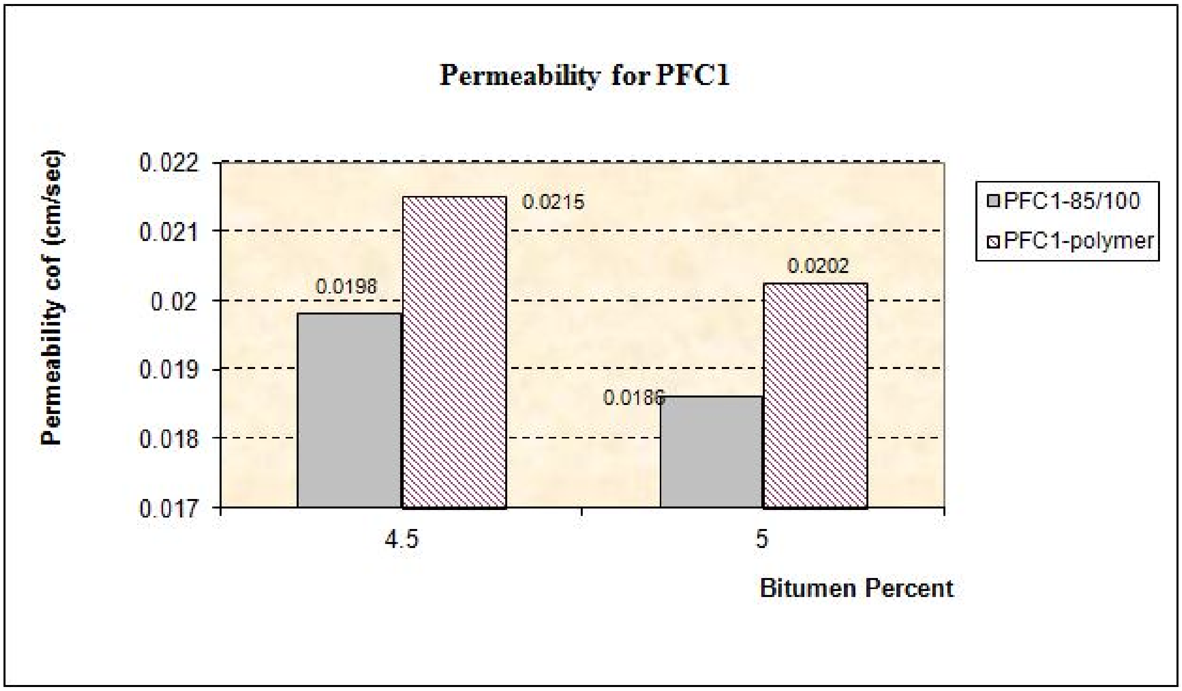

Fig 3: Comparison of permeability coefficient for asphalt made of PFC1gradation with different bitumen's

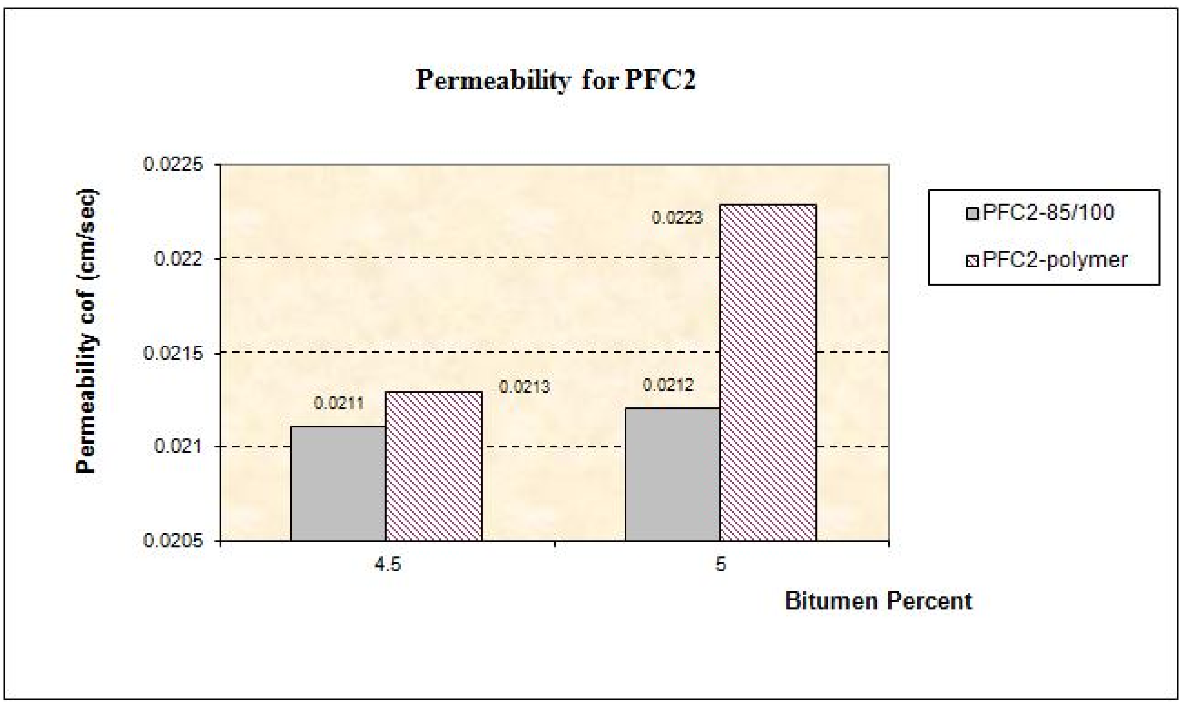

Fig 4: Comparison of permeability coefficient for asphalt made of PFC2 gradation with different bitumen's

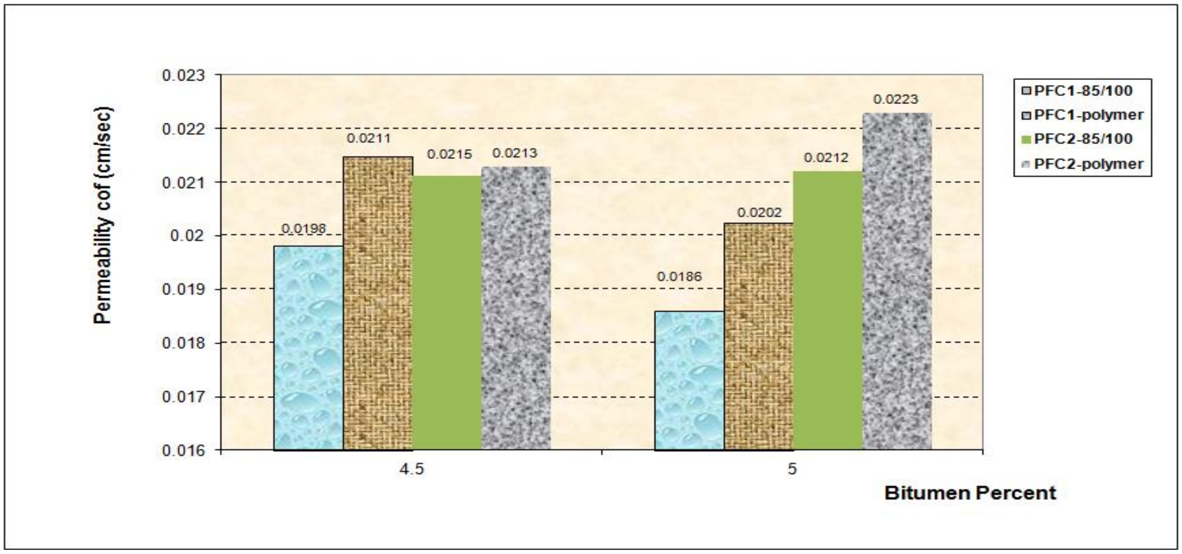

Fig 5: Comparison of permeability coefficient for asphalt made of PFC1, PFC2 gradation with different bitumen's

Discussion about the result of permeability test.

The rate of permeability coefficient of laboratory specimens made of porous asphalt mixtures that has been done by permeability device with fixed head on the basis of Darcilaws is very high.

Regarding the results of table 4 to 7 and also diagrams drawn in figure 2 to 5, it can be concluded that permeability coefficient made of polymer bitumen and AC bitumen for PFC2 gradation is more than permeability coefficient of specimens made of that kind of bitumen for PFC1 gradation.

For the effective use of polymer modified bitumens in long term permeability of pavements made of porous asphalt mixtures and their field operatinin comparison with pavements made of porous asphalt bitumen with modified bitumens which have less capability againsttraffic load and hole clogged and cutting of aggregate.

Some tests can be done(if available, field projects) , and then evaluate operation of these mixtures after their performance; regarding tostudies conducted in the field, it can be concluded that permeability coefficient of these kinds of pavements reduce after a while due to the lack of suitable performance and breaking ofaggregatein mixtures made of purified bitumen.

REFERENCES

1- NarimanBaraziJomoor, Mansour Fakhri, Mahmoud R Keymanesh "*Comparing the Effect of Skid Resistance on Porous Asphalt Mixes and Conventional Hot Mix Asphalt*". Journal of Basic and Applied Scientific Research. ISSN: 2090-4304. Vol 3, No 2, February 2013

2- Nicholls, J.C.; 1998. *Asphalt Surfacing: Porous Asphalt Surface Course*. pp: 185-217.

3- Ruiz, A.; Alberola, R.; Perez, F.; Sanchez, B. 1990. *Porous Asphalt Mixtures in Spain*.TRR No. 1265.

4- American Society for Testing and Materials. ASTM D-7064.*Standard Practice for Open-Graded Friction Course (OGFC) Mix Design.*

5- 1997. Asphalt Institute: *MS2 Mix Design Methods for Asphalt Concrete and other Hot Mix Types*, 6th Edition.

6- Birgisson, Bjorn; Roque, Reynaldo; Varadhan, Arvind; Thai, Tung; Jaiswal, Lokendra. 2006 *Evaluation of Thick Open Graded and Bonded Friction Courses for Florida.*

7- American Society for Testing and Materials. ASTM D6931-07.*Standard Test Method for Indirect Tensile (IDT) Strength of Bituminous Mixtures.*

8- Fakhri. M and Naderi.A, "*The Role of Porous Asphalt Pavement in Reducing Noise and Improving Driving Safety in Urban Areas*", 5th Symposium on Pavement Surface Characteristics (SURF), Canada, 2004.

9- Iran Asphalt Pavement Roads Code, Publication No 234, management and planning organization.