Proceedings of the Eastern Asia Society for Transportation Studies, Vol. 5, pp. 762 - 771, 2005

EFFECT OF MIXING TYPE ON PERFORMANCE OF RUBBERISED POROUS ASPHALT

Herda Yati KATMAN
Postgraduate Student
Dept. Of Civil Engineering
University Malaya
50603 Kuala Lumpur
Malaysia
Tel: 603 – 79675203 / 5339
Fax: 603 – 79552182/79675318
E-mail: herdayati@um.edu.my

Mohamed Rehan KARIM
Professor
Dept. Of Civil Engineering
University Malaya
50603 Kuala Lumpur
Malaysia
Tel: 603 – 79675201 / 5339
Fax: 603 – 79552182/79675318
E-mail: rehan@um.edu.my

Mohd. Rasdan IBRAHIM
Lecturer
Dept. Of Civil Engineering
University Malaya
50603 Kuala Lumpur
Malaysia
Tel: 603 – 79676881
Fax: 603 – 79552182/79675318
E-mail: rasdan@um.edu.my

Abdelaziz MAHREZ
Research Associate
Dept. Of Civil Engineering
University Malaya
50603 Kuala Lumpur
Malaysia
Tel: 603 – 79675339
Fax: 603 -79552182
E-mail: Aziz112@hotmail.com

Abstract: Generally, the physical properties of the rubberized-bitumen are affected by the type of rubber and the quantity of the rubber added into the bitumen. Literature reviews showed the rubberized bitumen has better temperature susceptibility and less susceptible to temperature changes compared with unmodified bitumen. Rubberized bitumen also has a better resistance to deformation and higher tenacity compared to unmodified bitumen. These improvements and changes however depend critically on the type, amount and method of dispersion of the rubber. Other relevant factors, such as the environment, ease of processing and cost also have to be considered in deciding the suitability of using rubber.

In general, two basic processes have been used to incorporate rubber in asphaltic mix viz. wet and dry process. In the wet process the rubberized bitumen were prepared by blending the rubber additives with bitumen before mixing the resultant rubberized bitumen with aggregate. In the dry process the rubber additives are either blended with the aggregate before adding the bitumen or the rubber additives are added after the aggregates are coated with bitumen.

The main objective of this study is to evaluate the performance of rubberized porous mixes with different type of methods for incorporating the rubber additives, i.e. wet and dry process. Several types of tests were performed to evaluate the effect of both processes on the performance of the rubberized porous asphalt such as Cantabro Test on Air Cured Samples, Cantabro Test on Water Cured Samples and Falling Head Permeability Test. The laboratory test results appear to indicate that the samples prepared using a dry process give better performance compared to samples prepared by a wet process. In this research, variation percentages of rubber contents were used to identify the optimum rubber content before the performance of rubberized porous began to deteriorate.

Key words: rubberized bitumen, rubberized asphalt, porous asphalt

1. INTRODUCTION

1.1 Introduction

Porous asphalt is the most well-known low noise, open-textured road surfacing. It has been used since 1950s in different parts of the United States to improve the surface frictional resistance of asphalt pavements (Mallick *et al.,* 2000). It was first used on military and civil runways to minimize the risk of aircraft aquaplaning on wet runway surfaces. Subsequently, porous asphalt is a special-purpose mixture that is increasingly used in pavement surfaces around the world.

Porous asphalt is a gap-graded bituminous mixture that consists largely of single-sized crushed stone, and that contains a relatively large percentage of air voids which usually more than 20% (Khalid *et al.,* 1999). Generally, the materials and construction costs of porous asphalt are higher than conventional, continuous-graded mixtures. However, cost benefit analyses and practical experience has shown that the benefits of this type of riding surface outweigh the extra construction costs.

Based on literature search, the advantages of porous asphalt can be identified as followed:

1. Avoid the phenomena of aquaplaning and water splashing, pervious asphalt which contains a high proportion of pores (>20%).
2. Improved vehicle adherence and visibility. Water drained into the top layer of the pavement and discharged at the road edge, therefore reducing the risk of accidents during rainfall events.
3. Lower pavement noise levels: An improvement 3-4 dB, and the noise that is present tends to be less aggressive.
4. Reduced the water contamination
5. Improved skid resistance at high speeds, especially during wet weather
6. Minimization of hydroplaning effects
7. Reduced splash and spray
8. Improved night visibility of painted pavement markings during wet weather (less glare)

The combination of the above benefits significantly improved safety and reduce traffic accidents, especially during wet weather. Porous asphalt provides excellent performance especially on the drainage ability if properly designed, constructed and maintained.

The large and interconnected air voids in porous asphalt permits effective drainage for water, thus reducing splash and spray and eliminating aquaplaning. Due to the open texture of the pavement and the absence of surface water; light reflection and glare does not occur. Thus, visibility of pavement markings on wet porous asphalt surfaces is excellent.

The degree of acoustic absorption is a function of the air voids and of the maximum stone size of the porous asphalt surface. Smaller stone sizes at the surface tend to produce less noise while more air voids absorb noise more efficiently.

This paper presents the results of a laboratory study that investigates the effect of the mixing process of rubberized bituminous asphalt on the performance of road pavement.

2. EXPERIMENTAL

2.1 Materials

The materials used in this research are bitumen with 80/100 penetration, rubber crumb, rubberized bitumen, aggregates with porous gradation and Portland cement filler. Porous gradation used in this research is shown in Figure 1.

2.2 Experiments

The performance parameters studied are as follows:

1. The air void content (ASTM D 3203-91)
2. The air abrasion loss (BS EN 12697-17:2004)
3. The water abrasion loss (by means of the Cantabro Test on water soaked samples)
4. The permeability coefficient (by means of the Falling Head Permeability Test on Water Cured Samples)

Figure 1. Aggregate Gradation for the Porous Asphalt

2.3 Samples Preparations

Samples were prepared using two different mixing types, namely wet process and dry process.

2.3.1 Samples Prepared by Wet Process

Rubberized bitumen was prepared by mixing 80/100 penetration-grade bitumen with various percentages of fine rubber crumbs passing 40-mesh sieve. Four levels of rubber crumb content were used, namely 3%, 6%, 9% and 12% by weight of bitumen. The rubberized bitumen was prepared using propeller mixer. Mixing was done at 160°C and a speed of 150 rpm. The mixing time is one hour.

Bituminous mixes were prepared by mixing the resultant rubberized bitumen with hot aggregates (porous graded aggregates) and filler. Portland cement is used as filler with 2% by weight of mix. The binder content in the mixture was fixed to 6.0%.

Specimens were prepared using a Marshall Compactor. The number of compaction was 75 blows for each side of the specimens. The mixing temperature was between 160^oC to 180^oC while the compaction temperature was 140^oC.

2.3.2 Samples Prepared by Dry Process

Bituminous mixes were prepared by blended the rubber additives with hot aggregates before the binder (80/100 penetration bitumen) was added. The other properties on the samples preparation were similar to the samples prepared by wet process.

2.4 Tests Method

2.4.1 Permeability Test

The specimens were tested before extrusion to take advantage of the tight bond between the bituminous mix and the mould. Samples were conditioned by immersing in the water at 25^oC for 2 hours. A water permeability based on the falling head principle was used to quantify the coefficient of permeability.

2.4.2 Cantabro Test on Air Cured Samples

Cantabro Test on air-cured samples was used to measure the resistance of the mixes to raveling.

The initial weight of the Marshall specimen was recorded. Specimen was placed in a Los Angeles Machine (ASTM Method C131) without the steel balls. The total number of rotations considered in this research was three hundred. After three hundred rotations, the weight of the sample was recorded. Test performed at temperature of 25^oC and speed of 30 to 33 rpm.

2.4.3 Cantabro Test on Water Soaked Samples

Cantabro Test was performed on water soaked samples to evaluate the resistance to stripping of the mix.

In this test the initial weight of the Marshall specimen was recorded. The samples were then placed in a water bath at 49$\pm$1^oC for four days. On the fifth day the samples were taken out of the bath and allowed to drain for 18 hours. Using Los Angeles Machine (ASTM Method C131) the testing procedure conducted was similar to the Cantabro test on air cured samples.

3. RESULTS AND DISCUSSION

3.1 Voids in the Mix (VIM) Results

Figure 2 shows consistent results concerning the effect of rubber contents on the VIM for dry process and wet process. Samples prepared by dry process showed that the increase of the rubber contents in the mix is followed by a decrease of VIM. This is because rubber additives in the mix act as filler or fine aggregates, filling the voids between the aggregates and make the aggregates gradation finer. Therefore, increase rubber contents in the mix lead to a decrease in the VIM.

Samples prepare by wet process shows that VIM results increases as rubber contents increases. This is due to the rubberized bitumen which is a more viscous binder than ordinary bitumen. The nature of the rubber additives (inside the rubberized bitumen) that swells and absorb the binder may not adequately coat the aggregates, thus resulting in the increase of voids between the aggregates.

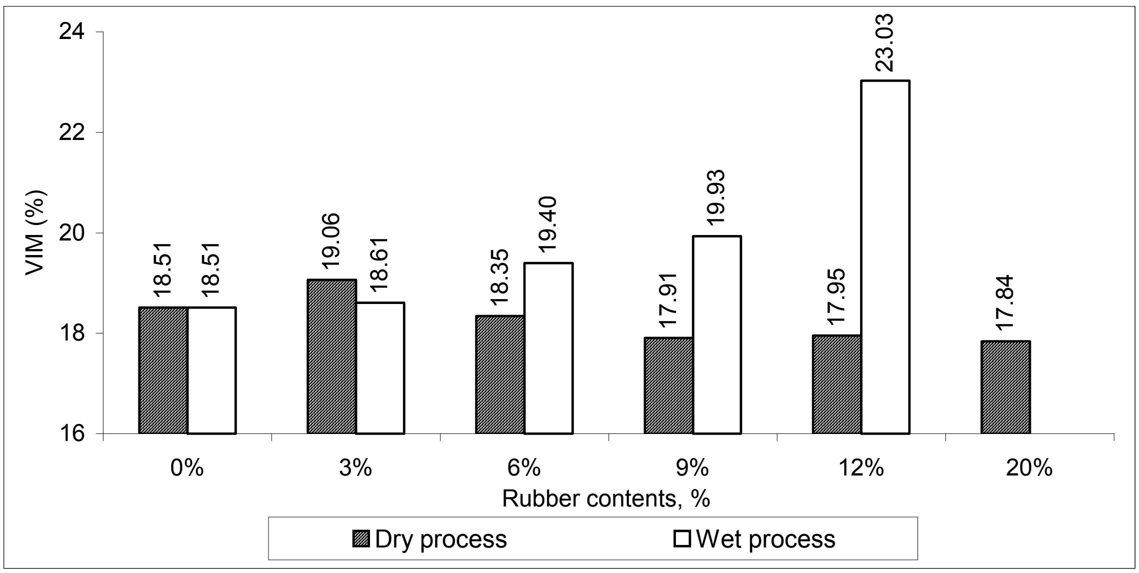

Figure 2. Voids in the Mix Result for Different Rubber Contents

3.2 Abrasion Loss Results – Air Cured Samples

Figure 3 shows the air abrasion loss for both process (dry and wet process) corresponding to different percentages of rubber contents.

Air abrasion loss results for samples prepared by wet process shows that the air abrasion loss increases as rubber content increases. The wetting of the aggregate surfaces is affected due to the very viscous rubberized bitumen. The decrease in the aggregate bonding facilitates mix disintegration.

Air abrasion loss in dry process shows inconsistent results. However, samples prepare by dry process always show a lower abrasion loss compared to control samples and samples prepare by wet process. In dry process, rubber additives play a role as filler in aggregates gradation. The rubber additives fill the voids contents between the aggregates and increase the viscosity of the binder without jeopardizing the wetting of the aggregate surfaces by the ordinary binder.

Figure 4 shows the abrasion loss results increases as a void contents increases. It is clearly shown by samples prepared by wet process. It was shown previously in the VIM results that the VIM increases as rubber contents increases. Thus, results shown in Figure 4 must correspond with the rubber contents in the mix. Since the large amount of rubber increases the VIM, therefore the contact points between the aggregates is reduce and wetted aggregate surface is also reduced. This results in the loose aggregate skeleton in the mix, thus succumbing to the raveling process (abrasion loss).

Skvarka, 1996 and Spanish study used the Maximum Permissible Air Abrasion Loss for Porous Mixes fixed at 30% of initial weight at 25^{o}C testing temperature. In this study, none of the samples exceed the Maximum Permissible Air Abrasion Loss.

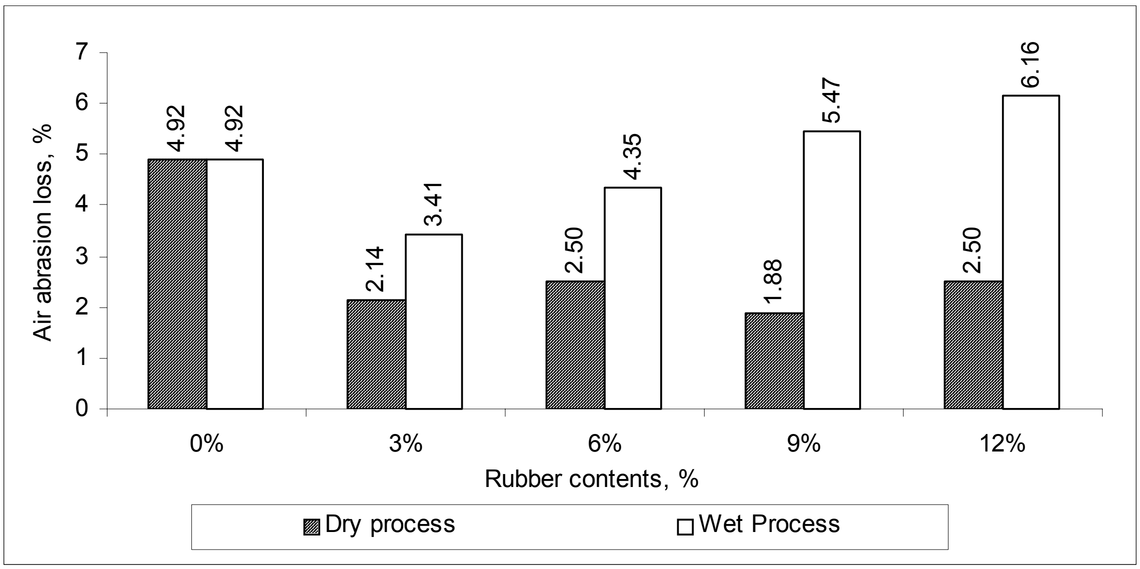

Figure 3. Air Abrasion Loss Results at 300 Revolutions for Different Rubber Content

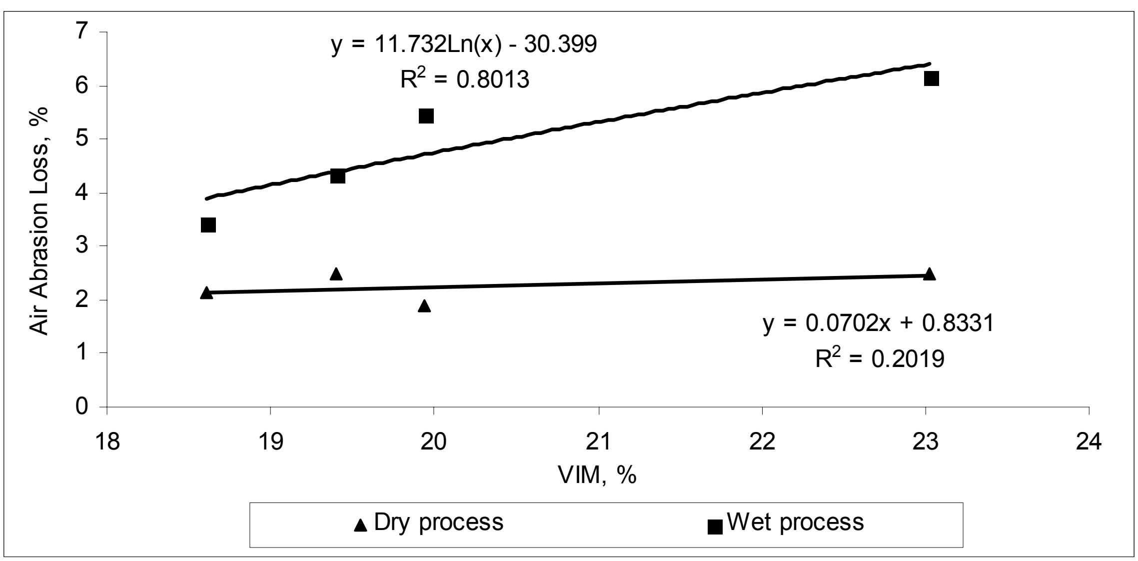

Figure 4. Air Abrasion Loss Results at 300 Revolutions for Different VIM Percentages

3.3 Abrasion Loss Results – Water Cured Samples

The water abrasion loss results for samples prepared using the dry process and wet process are shown in Figure 5. Abrasion results in water cured samples shows similar results with abrasion loss in air cured samples. However the abrasion loss results in water cured samples is higher than abrasion loss results in air cured samples. Therefore it can be seen that water is a serious factor in effecting the stripping process.

According to Skvarka, 1996, the maximum permissible water abrasion loss value for porous mixes is 40%. Figure 5 shows that all the samples are under the water abrasion loss limit except a sample prepares by wet process with 12% rubber content; the water abrasion loss is 43.11%.

Figure 6 clearly shows that the water abrasion loss increases as VIM increases in both processes. These occur when water fills the voids between the aggregates and facilitate to the stripping process, thus reducing the performance of the mixes.

3.4 Falling Head Permeability Test Results

Figure 7 shows the Falling Head Permeability Test results for both mixing processes. Samples prepare by wet process shows the increasing permeability coefficient to a certain limit before the permeability coefficient began to decrease. Therefore there appears to be a limit on the rubber contents beyond which the voids continuity began to be affected and the water permeability began to decrease.

Samples prepare by dry process shows inconsistent results in the permeability coefficient as rubber contents increase. The rubber additives in the mix disturb the voids distribution, thus effect the water permeability.

Figure 8 shows the effect of voids contents in the permeability coefficient. Both processes show that the permeability coefficient increases as voids contents increases.

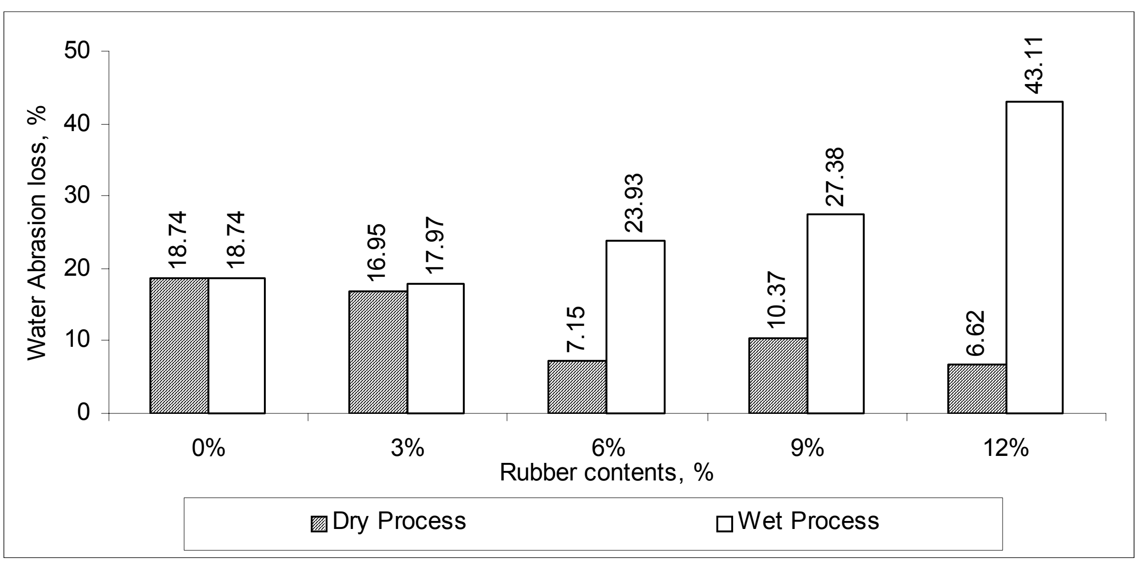

Figure 5. Water Abrasion Loss Results at 300 Revolutions for Different Rubber Content

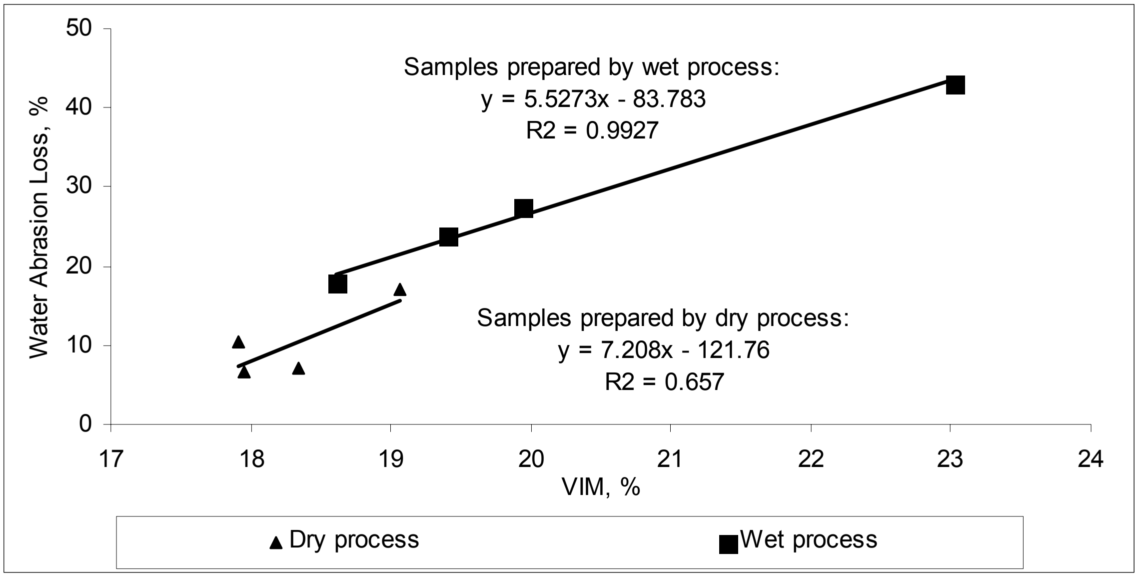

Figure 6. Water Abrasion Loss Results at 300 Revolutions for Different VIM Percentages

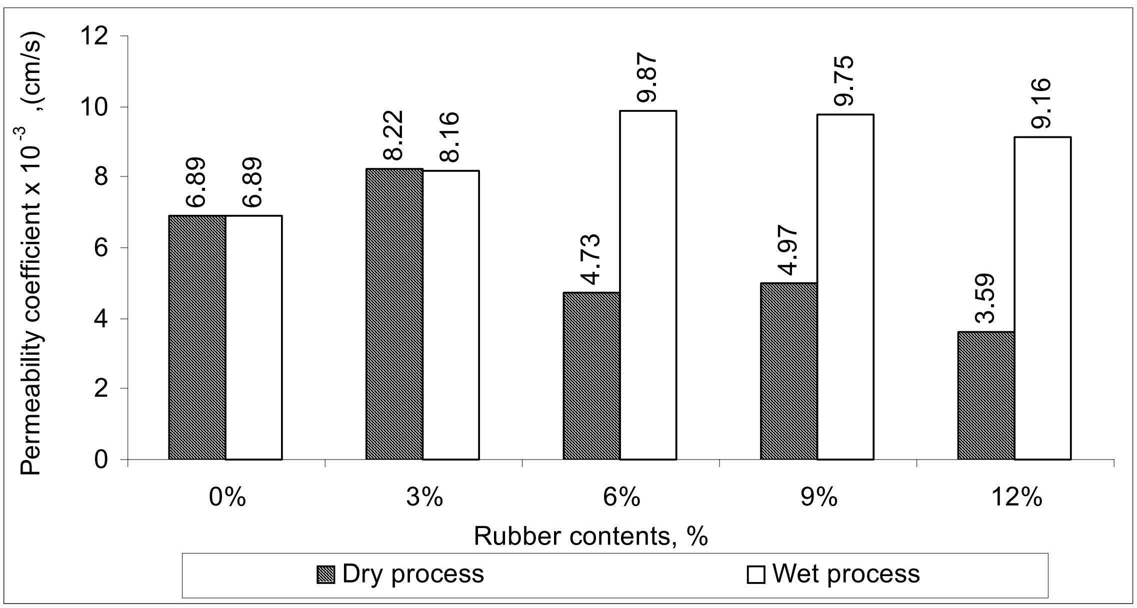

Figure 7. Permeability Coefficient Results for Different Rubber Content

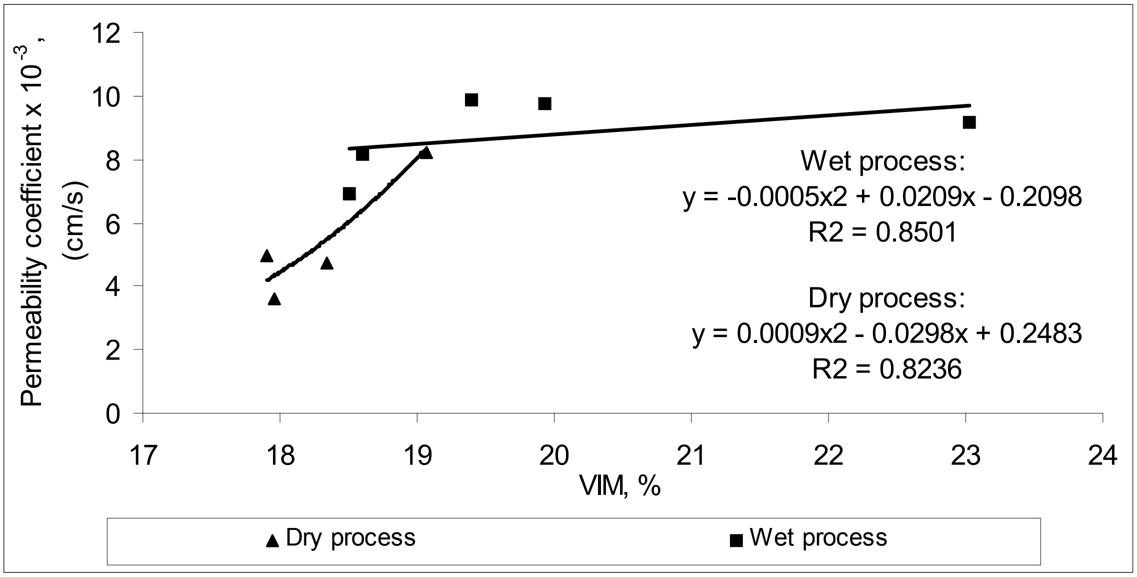

Figure 8. Permeability Coefficient Results for Different Voids Content

4. CONCLUSIONS AND FUTURE WORK

The study appear to indicate that the samples prepared using a dry process give better performance compared to samples prepared using a wet process. Samples prepared with dry process provide excellent resistance to raveling and resistance to stripping.

From the results obtained, the following future works can be considered:

1. Incorporation of rubber to bituminous mixes requires a slight increase in the optimum binder content. The investigation on the optimum binder contents is needed.
2. The amount of rubber contents is believed to be a factor in the performance of the mixes. Thus the optimum rubber content is needed to enhance the asphalt performance.
3. The potential of rubberized porous asphalt obtained from laboratory work must be followed by field studies to identify any potential problems.

REFERENCES

1. Rajib B.Mallick, Prithvi S.kandhal,L.Allen Cooley,Jr.,Donald E.Watson (2000) Design, Construction, And Performance of New Generation Open-Graded Friction Courses NCAT Report No.2000-01.
2. H.A. Khalid and C.M. Walsh, (1999) Design for Long term Performance of Porous Aspahlt, **Proc. 2nd European Symposium, Performance and Durability of Bituminous Materials and Hydraulic Stabilised Composites,** Leeds, pp 211 – 226.
3. ISABELLE G.R. SKVARKA (1996), A Rational for the Design of Open Graded Friction Course Asphalt, M.Sc. Thesis, Royal Melbourne Institute of Technology.

4. ASTM D 3203-91 Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
5. ASTM D 4123-82 (1987) Test Method for Indirect Tension Test for Resilient Modulus of Bituminous Mixtures
6. BS EN 12697-17:2004 Bituminous Mixtures. Test Methods for Hot Mix Asphalt. Particles Loss of Porous Asphalt Specimen.
7. B.C Punmia, (1975), Falling Head Permeability Test, **Soil Mechanics and Foundations,** Standard Book House, Delhi.