EFFECT OF ASPHALT MIXTURE COMPACTION ON STABILITY AND VOLUMETRIC PROPERTIES OF ACW14

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Abstract

This paper investigates the influence of Marshall Compaction (50 and 70 blows) on the Stability and Volumetric Properties of ACW14 asphaltic concrete mixes. The samples were prepared according Marshall Mix design method. The properties studied were resilient modulus, air voids, bulk density and stability. The results of this study indicate that 75 compaction yield the highest Marshall Stability value and lower bitumen content. The study concluded that mixtures subjected to 75 compaction blows show better performance than the mixtures subjected to 50 blows.

Key Words: Asphaltic Concrete, Marshal Compaction, Stability,

1 Introduction

The performance of asphaltic concrete after construction is influenced by volumetric properties resulting from mixing and compacting at high temperature. Compaction provides adequate lubrication for aggregates to stick each other, therefore high quality (Blades et al. 2004). The stiffness of asphaltic is improved due to higher degree of compaction and hence improves the ability of the material to distribute traffic loads more effectively over lower pavement layers and the soil foundation (Powel and, Lister, 1978). Research into the effect of compaction influence air voids on the performances of dense graded asphalt concrete pavements surface has also been undertaken. Decker (2006) explained the importance of compaction by optimizing all desirable mix properties through a good density. The desirable mix properties include high strength, durable, resistance to deformation, resistance to moisture damage, impermeable, and high skid resistance. A Hot Mix Asphalt mixture produced in laboratory may have all the desired mix properties but the same mix may perform poorly under subjected traffic loading if the mix is not compacted to the proper level of density on the roadway (Scherocman, J.A., 2006). Marshall Stability and flow test was used although the test is considered as an index test and empirical in nature, it gained popularity over the other more fundamental methods Roberts et al. (1991) and it has been the most widely used mix design method in Malaysia. According Asphalt Institute (1979), 50 numbers of blows is used for medium traffic and 75 numbers of blows is used for heavy traffic.

2 Methods and Materials

2.1 Materials

The materials used in this study were: crushed granite with a maximum size of 20 mm and ordinary portland cement (OPC) as filler with relative density of 3.018. The selected aggregate gradation was in accordance with the Malaysia Ministry of Public Works (PWD)-recommended gradation as shown in Figure 1. Conventional 80/100-pen grade (0.1mm at 25°C 100g and 5 sec), sofeting point of 42°C and relative density of 1.02 and ductility of > 100 cm. Cariphalte PG 76 was also used as a modified bitumen in this study were supplied by Shell Ltd. The compacted mixes were then subjected to physical and mechanical tests to determine the optimum bitumen content. The physical tests conducted in this study include measurement of density. The compacted specimen was weighed in air and water and then bulk density was simply determined based on equation. The calculations of volumetric properties parameters were started, firstly calculating the maximum theoretical density TMD and then expressing the difference between it and the actual bulk density as a percentage of total volume determined the percentage of air voids in the mix (VTM), subsequently voids in the mineral aggregates (VMA).The results were compared with the requirements outlined in Table 1, to check for conformity

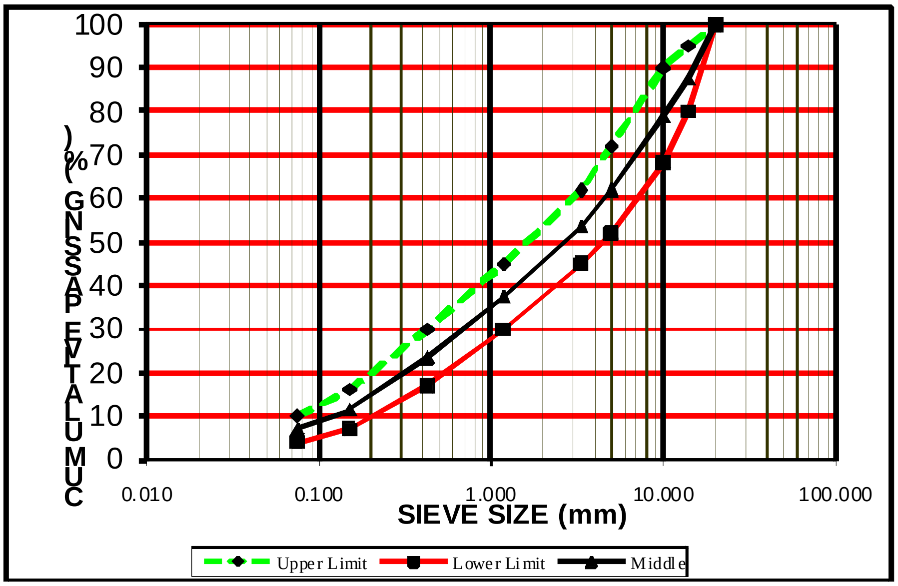

Figure 1: ACW14 Aggregate Gradation Used in this Study
(Source: PWD, 1988).

Table 1: Mixture Design Evaluation Parameters

PARAMETER	WEARING COURSE	REFERNCE
Stability	> 500 kg	(JKR/SPJ/1988)
Flow	> 2.0 mm	
Air Voids in the Mix (%)	3.0 - 5.0	
Voids in Aggregate Filled with Bitumen (%)	75 - 85	

2.2 Resilient Modulus Test

Resilient modulus test was carried out in accordance with ASTM D 4123 (ASTM, 1999). Prior to actual test specimens were conditioned in the UTM-5P machine at 25^{o}C, for at least two hours. A direct compressive load was then applied through 12 mm wide loading strips along the vertical diameter of the specimens. Linear variable differential transducers (LVDTs) monitored the resultant indirect tensile stress and strain along the horizontal diameter. The UTM software can replicate varying road conditions through increases in frequency and force of axial loads. The test conditions as described Table 2.

Table 2: Resilient Modulus Parameters Used for This Study

PARAMETER	DURATION
Condition Pulse Period (ms)	2000
Test Temperature	25°C
Test Pulse Period (ms)	3000
Pulse with (ms)	50
Poison's Ratio	0.35

2.3 Marshall Mix Design

The Marshall method ASTM D1559 (ASTM, 1999) was used to determine the optimal bitumen content for conventional and modified asphalt mixtures. The aggregate specimens were blended and mixed with various percentages of bitumen. A Marshall compaction value of 75 and 50 blows per side, was used. A water bath was prepared at a temperature of 60°C and all specimens were immersed for 30 to 40 min in the water. After compacting samples were placed in a water bath at 60°C. After 30 minutes of immersion in the water bath. The Marshall Stability testing machine was cleaned and set up to begin the test. After the specimens had been conditioned, a load was then applied to the specimen at a constant rate (50mm/min) until failure, observing the flow and stability while loading. When the stability gauge reading reached its maximum and began to drop, the Marshall Stability value (in kN) was noted as the deformation at the point of failure.

3 RESULT AND DATA ANALYSIS

Air voids are a physical property of asphalt concrete which is often correlated to in-field rutting performance of asphalt pavements. VMA is defined as the sum of the volumes of the air voids and the unabsorbed binder in the compacted specimen. It is widely accepted that these volumetric properties are useful in predicting hot-mix asphalt pavement performance. Results in Figure indicated that 75 blows has lower VMA values compared to 50 blows. From Figure 2, the VMA results pattern for specimen using base bitumen with 50-blows compaction has lower VMA values compared to specimen that uses SBS polymer modified bitumen. This indicates that VMA values are higher with the presence of polymer modifier.

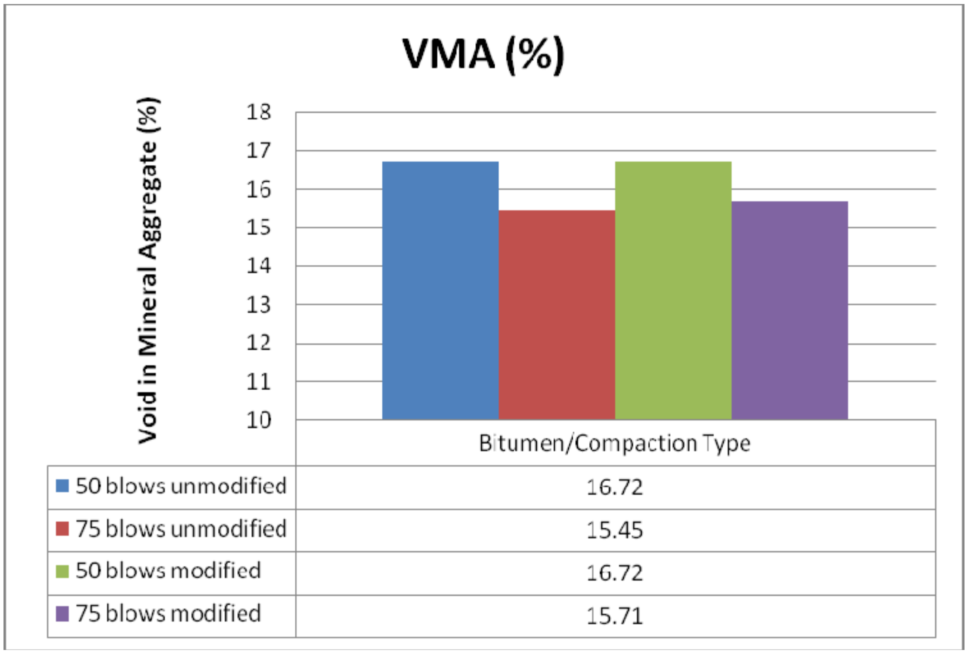

Figure 2: VMA comparison at Optimum Bitumen Content

Figure 3 show the comparison of VFA in specimen at Optimum Bitumen Content illustrates the comparison of VFA versus bitumen content for each type of specimen. Based on Figure 3, difference of VFA properties due to compaction effort can be seen as the specimen with 75 numbers of blows applied has lower VFA compared to specimen compacted with 50 numbers of blows, the effect of SBS polymer modifier can be seen as specimen using base bitumen has higher and steeper VFA line compared to specimen using modified bitumen at 75 blows. Therefore, it should be noted that specimen prepared with higher compaction together with the present of polymer modified bitumen give the most stable mixture. However, all mixture still meets the JKR specification of 75% ~85% of VFA value. Higher compaction effort lead to lower VFA values of the mixture. Based on the Marshall Method, VFA percentage is dependent on VMA and

VTM values. Therefore increase of air voids in the mixture reduces the VFA percentage. The effect of Polymer modifier can only be clearly seen on 75-blows compaction effort as the VFA is relatively lower compared to specimen using 80/100 Grade bitumen.

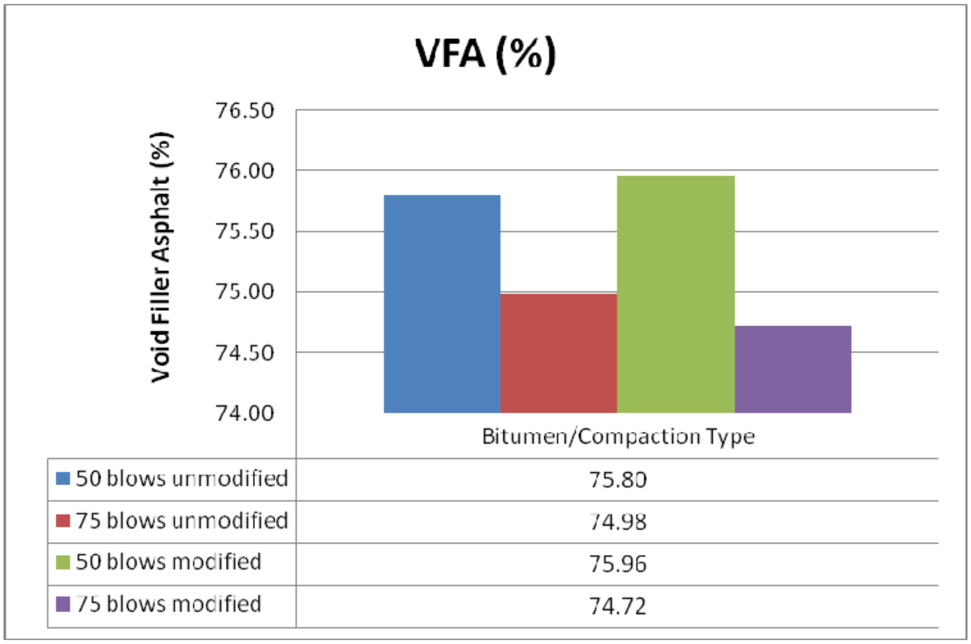

Figure 3: VFA comparison at Optimum Bitumen Content.

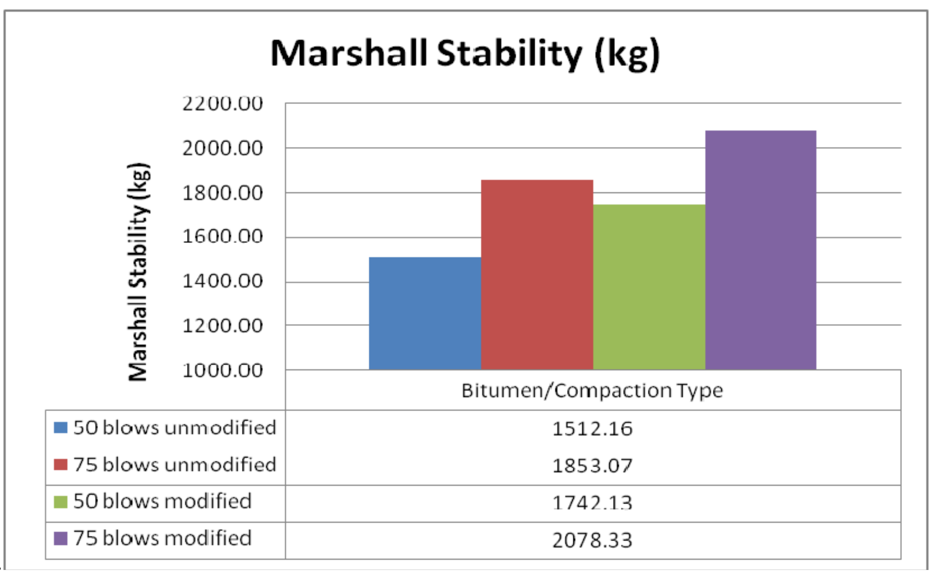

Figure 4: Marshall Stability comparison at Optimum Bitumen Content.

The results indicated that the mixture containing SBS modifier and compacted with 75 blows gives the highest result of stability while mixture containing base bitumen and compacted with 50 blows resulted the lowest. Both figures show that higher compaction resulted in higher stability values and the stability is improved with the presence of SBS polymer modified bitumen. However, both types of compaction and bitumen used satisfy the JKR requirement. These results are consistent with the previous study done by Salifu, A. et al (2009) at which affirmed that higher stability values are observed at 75-blows compaction compared to 50-blows compaction. These imply that the degree of impact of compaction causing mix to perform better as the increase of density allows the mix to carry higher ultimate load. The effect of Polymer Modified Bitumen used in the mixture clearly can be seen in Figure 4. Specimen with 75-blows containing SBS modifier has the highest stability of 2078.33kg while specimen using base bitumen only has 1853.07kg of stability value although the optimum bitumen content for SBS is higher.

3.1 Indirect Tension Test Results

Table 3 summarize the results of the test. Based on Table 3, the results shown that samples with 50 blows compaction effort using 80/100 penetration grade bitumen has the lowest modulus of resilient while samples compacted with 75 blows compaction effort using SBS modified bitumen has the highest modulus of resilient. The difference between resilient of modulus can be seen between two modes of compaction used where 75 blows compaction effort yield higher resilient modulus compared to 50 blows compaction effort. This is probably due to difference of the thickness of asphalt film produced by the two different compaction effort and bitumen content. Another difference can be noted is that SBS modified bitumen used in mixture increase the modulus of resilient of the HMA. The reduction of thickness of asphalt film leads to the increase of resilient of modulus. Therefore, higher degree of compaction will caused pavement to have higher stiffness and more resistance to permanent deformation. The results also show that the polymer modification of the bitumen increases the modulus of resilient of the HMA. This is likely because of the improved viscoelastic properties of the binder following the polymer modification of the bitumen causing increased of stiffness and viscosity (Airey, G. 2003).

Table 3: Resilient Modulus Results

Bitumen Type	Compaction	Resilient Modulus (Mpa)	Recoverable Horizontal Deformation (µm)	Peak Loading Force (kN)
Grade 80/100	50	**1349**	6.56	973
	75	**1837**	4.81	979
Cariphalte PG 76	50	**1555**	5.4	939
	75	**2000**	4.31	938

Conclusion

The objective of this study was to investigate the influence of Marshall Compaction (50 and 70 blows) on the Stability and Volumetric Properties of ACW14 asphaltic concrete mixes. Two levels of compaction of 50-blows and 75-blows were conducted on the mixes. Conventional 80/100 penetration grade bitumen and the SBS polymer modified bitumen were used. Based on the analysis of results, the main findings of the study concluded that mixtures subjected to 75 compaction blows show better performance than the mixtures subjected to 50 blows.

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