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Effect of Soft Clay on the Volumetric and Mechanical Properties of Hot Mix Asphalt

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ABSTRACT

Abstract. To define the behaviour of asphalt mixture including various penetration grade bitumen has been a major subject of paving engineering. This search investigated the volumetric and mechanical properties of a hot-mix asphalt (HMA) mixture with the Superpave mix design. The mixture was added with powdered soft clay at five different percentages based on the bitumen weight (0%, 2%, 4%, 6%, and 8%). Performance tests were then conducted to determine the resilient modulus and volumetric properties of the mixture. Results show that bulk specific gravity increased after adding soft clay to the asphalt mixture. The amount of air and mineral aggregate voids also decreased with increasing SC contents. Furthermore, the addition of 4% SC improved mixture stiffness, as determined through indirect resilient modulus test under aging conditions. Therefore, soft clay can be added to asphalt mixtures to improve their volumetric and mechanical properties, such as strength and durability.

Keywords:

Volumatic Properties.

Superpave Mix Design.

Stiffness Soft Clay.

Aging Method.

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1 INTRODUCTION

Through the last decades by growing number of vehicles and weights on roads, road pavement has been subjected to greater damages which in numerous cases happened even prior expecting pavement service life. Moreover, the pavements should be maintained under adequate structural, geometric, and signaling conditions to prevent accidents and ensure safe transportation [1]. Approaches for developing pavement designs gradually shift from traditional pavement designs to mechanistic designs. A successful mechanistic approach can be obtained by elucidating the behavior of material properties [2].

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The gyratory compactor devised in the Strategic Highway Research Program (SHRP), known as SGC, has been increasingly used for asphalt mixture design in several countries. The feasibility of using SGC in Malaysia is currently being evaluated [3]. In the other way, the mix design and analysis system of Superior Performance Asphalt Pavement (Superpave), SGCs are applied to simulate the field compaction of hot-mix asphalt mixtures [4]. According to Jitsangiam and Nikraz found that, SHRP has developed the Superpave mix design, which considerably shifts from the empiricism of the Marshall Mix design to provide reliable and responsive solutions to actual pavement conditions [5]. The Superpave mix design by SHRP is generally preferred than the Marshall mix design, considering the empirical nature and limitations of the latter[6].

Road failures are caused by many factors. Previous study showed that more than 30% of rural roads in the Batu Pahat district undergo road deterioration because of different factors, [7], As such, in Batu Pahat district, an open-channel system is adopted and built on BPSC. Malaysian local and federal authorities, who are accountable for road construction, are faced with undulating impacts when roads meet bridges and constructed on soft soils, such as peat and soft clay [8].

On the other hand of study, the service life of HMA mixtures ends when they lose their impedance after an assured period of time because of the following factors: mechanical stresses caused by traffic and physical stresses caused by changes in temperature. Karakas *et al,* found that, the stresses caused by traffic result in plastic deformation and deteriorations, such as fatigue cracks [9]. The engineering properties of the hot mix asphalt layer confer resistance to permanent deformation, fatigue, and thermal cracking. The modulus of HMA mixtures is defined as the relationship between the applied stress and the resulting strain. For a constant level of the applied stress, high modulus indicates low resulting strain [10]. Upon constructing HMA pavements, mixture composition is first determined based on the judgment and experience of the contractor or the proprietary mix designs used [11]. The need for durable pavement with excellent mechanical properties has motivated researchers to determine different alternatives for the HMA mixture [12]. According to the founding of Kok and Kuloglu found that, hot mix asphalt is applied as superficies layers in a pavement structure to distribute stresses caused by loading and save the underlying unbound layers from the influence of water [13].

Numerous studies modified asphalt to enhance the showing of asphalt mixtures [14]. Heating of asphalt through production and construction induces the volatilization and oxidation of binders in the mixture. These processes can degrade asphalt pavements by rising the hardness of the binder, thereby increasing susceptibility to cracking and negatively assuming the functional and structural performance of the pavement [15]. Aging of asphalt pavements typically occurs through the oxidation of asphalt and the evaporation of light maltenes from the binder. The aging process causes stiffening of the pavement, resulting in the cracking of its structure[16]. In this regard, modified binders have been used in Superpave mixture designs to enhance resistance to cracking and rutting [17].

2 MATERIALS AND MIX DESIGN

2.1 Additive

Soft clay particles were added to the asphalt mixture by wet method, and were modified with various ratios of SC (0, 2, 4, 6, and 8% by weight of binder). The binder was heated in a draft oven to 150°C for 1h and mixed with specific percentages of SC particles at 150 °C for an hour, and was modified by subjecting to a high-shear mixer at 3000 rpm.

2.2 Aging Method

The properties and performance of hot mix asphalt could be accurately predicted applying aged test specimen. As such, in this study, all specimens underwent mixture conditioning. Mixture conditioning was applied to the laboratory-prepared loose mixture only for the volumetric mixture design procedure. The aggregate was placed in a forced draft oven for 2–4 h to equilibrate at specific temperature. Asphalt was heated to the desired temperature at 155 °C for 2 h. After that, both the mixture and pan were then placed in the draft oven for 2 h ± 5 min at 135 °C for the non-aged condition and compaction temperature. Moreover, the described of short-term aging procedure was designed to simulate aging during mixing and construction. When the long-term aging procedure was applied to laboratory and loose mixture specimens, the samples were placed in the compacted test samples on a rack in the aging oven for 5 d at 85 ± 1 °C.

2.3 Soft Clay

Soft clay was introduced as small particles with size ranges from 10 µm to 14 µm and those particles are very desirable for application in asphalt binder because of their dimension and particle shape. It can also create a good enhanced mechanical behavior, and it has a high surface area of interaction which makes the intensive interaction with the asphalt binder. Likewise, in order to produce soft clay some of the procedures were done in various steps, which include getting soft clay by excavating within 4 m down the ground. Then, the soft clay was dried by forced-draft oven at temperature of 155°C to get rid of the moisture. After that, the clay was compacted and sieved using 0.075 mm. Finally, SC was used as filler at different ratios (2, 4, 6, and 8%) to determine the Optimum Binder Content (OBC). Figure 1 shows the equipment for producing SC.

Figure 2. Equipment for producing SC

3 CONE-PENETRATION TEST OF SOFT CLAY

In the past decades, several studies have been conducted on fall cone penetration test to determine Atterberg Limits of cohesive soils as shown in Figure 2. Hence, the aim of this test is to display the plastic and liquid limits of pure soft clay minerals. Then, the pure soft clay should be very beneficial in interpreting data for natural material. In the same way, the plastic index is the variation among the liquid and the plastic. The procedures of cone-penetration test were explained according to ASTM D 5778-07.

Figure 2. Cone-penetration equipment

3.1 The plastic index and plastic limit of SC

These tests were defined as the water contents in soft clay soil. Therefore, in order to determine the plastic and liquid limits for soft clay, the tests were carried out in UTHM Laboratory where the fraction of soft clay passes sieve size number 0.075 mm. The procedures of this test were conducted according to ASTM D 4318.

4 MECHANICAL TESTING

4.1 Superpave Volumetric Properties

The theoretical maximum density was calculated by CoreLok method via the loose mixture with 1200 g of NMAS 19 mm, thus; the CoreLok test was conducted by the water-displacement method using loose mixture samples as exhibited in Figure 3. Moreover, the following steps can be applied as an alternate to rice method test according to standers of AASHTO T209 and ASTM D2041 by using the loose asphalt mixtures method. Therefore, the other requirements that must be satisfied comprise the following Superpave criteria as showed in Table 1: voids in total mineral, voids in mineral aggregate, and voids filled with asphalt, $Gmm\ @\ Nini$, Gmm @ Ndes, $Gmm\ @\ Nmax$ and dust ratio.

Table 1. Superpave Mix Design Criteria

	Varying Asphalt Data Table					Specification
SC Contents (%)	**0.0**	**2.0**	**4.0**	**6.0**	**8.0**	
OBC (%)	6.0	5.8	5.6	5.4	5.3	
$\boldsymbol{Gmm\ @\ Nini}$:	87.852	88.461	88.586	88.850	88.901	≤ 89.0
$\boldsymbol{Gmm}$ **@ Ndes:**	94.497	94.597	94.660	94.225	94.581	96
$\boldsymbol{Gmm\ @\ Nmax}$:	96.117	97.030	97.782	97.846	97.910	≤ 98.0
%Air Void	4.0	4.0	4.0	4.0	4.0	3-5%
VMA:	17.8	17.7	16.7	17.1	17.0	13.0 Min
D/A Ratio: #200	1.12	1.13	1.14	1.15	1.15	0.6 - 1.2

Figure 3. CoreLok for loose mixture samples

4.2 Air Voids (VA)

Air voids (AV) represent the total volume of small air pockets among the coated aggregate molecules during the compacted mixture. AV is expressed as a proportion of the overall volume of the compacted paving mixture and calculated as the next equation:

$$P_a = 100\left(\frac{G_{mm} - G_{mb}}{G_{mm}}\right) \quad (1)$$

Where:

P_a is considering as the AV in the compacted mixture.

G_{mm} is the maximum specific gravity of the paving mixture.

G_{mb} is the bulk specific gravity of the compacted mixture.

4.3 Voids Filled with Aggregates

The purpose of VFA is to avoid less durable hot mix asphalt mixture caused by the formation of thin films of the asphalt binder on the aggregate molecules beneath light traffic situations [18]. VFA represents the proportion of the intergranular void space among the aggregate molecules filled with asphalt [19]. VFA is determined by the formula:

$$\mathrm{VFA} = \left(1 - \frac{\mathrm{AV}}{\mathrm{VMA}}\right) \mathrm{X}\ 100 \quad (2)$$

Where:

VFA is expressed as the percentage of VMA.

AV refers to the AV in the compacted mixture.

4.4 Plastic and liquid limit results of SC

The tests results for moisture contents of SC can be calculated by penetration reading from wet and dry weightings. Therefore, every of penetration (mm) is plotted as ordinate versus the corresponding moisture content (%) as shown in Figure 4. From the diagram, it can summarize that the moisture content identical to a cone penetration of 20 mm is read off to the nearest 0.1%.

Table 2 shows the results calculation of plastic and liquid limit test. Hence, the plastic and liquid limits of soft clay would probably range from less than 30 to 45 per cent, and with plastic index value of 0.66%.

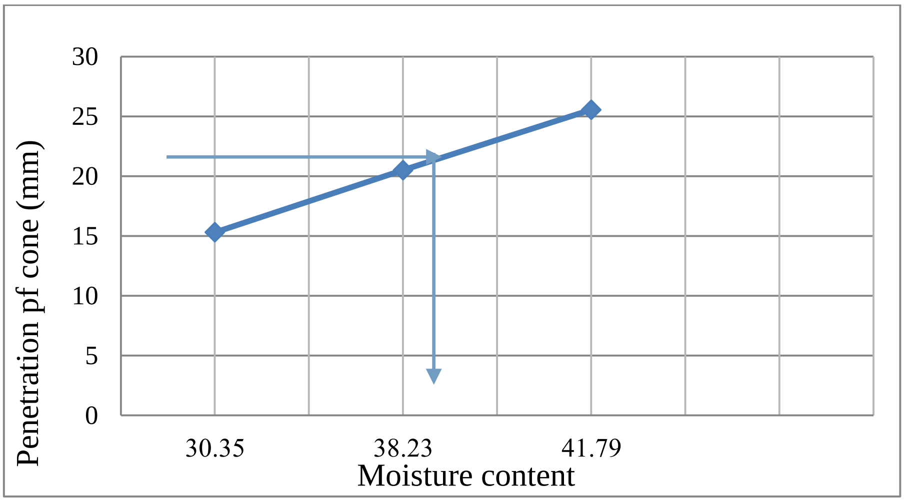

Figure 4. Plot result semi-log graph and determine the liquid limit

Table 2. Results of liquid and liquid limit of SC.

Test Number	Units	1	2	3
Dial Gauge Reading (Start)	mm	0	0	0
Dial Gauge Reading (End)	mm	152	205	255
Cone Penetration	mm	15.20	20.50	25.50
Can Number	Units	1	2	3
Mass of can + moist clay (Mcws)	gram	50	45	67

Mass of can + dry clay (Mcs)	gram	40.41	35.32	50.30
Mass of can (Mc)	gram	9	11	10
Mass of dry clay (Ms)	gram	31.41	25032	40.20
Mass of water (Mw)	gram	9.59	9.68	16.80
Water content	gram	30.35	38.23	41.79
Average				36.79

Plastic limit (PL) = 36.79%

Liquid limit (LL) = 37.45%

Plasticity index (PI) = liquid limit- Plastic limit = 37.45-36.79=0.66%

Plastic Index (PI) = 0.66%

4.5 Resilient Modulus Test

According to Nejad, F. M, *et al,* they found that, the test is a common form of stress–strain mensuration applied to evaluate elastic properties [20]. The resilient modulus is not often used to present HMA stiffness because the dynamic modulus is generally applied. According to Ref. [21], the indirect tensile modulus is non-destructive in determining the effects of temperature and loading rate. In this study, the durability modulus of the asphalt reduced with increasing temperature.

5 Results and Discussion

5.1 Bulk Specific Gravity ($\boldsymbol{G_{mb}}$)

Results displayed that $\boldsymbol{G_{mb}}$ of the asphalt mixture increase initially with increasing of soft clay contents, as shown in Figure 5, by adding amount of SC to the asphalt mixture, then SC particles fill the pores between the aggregate particles which results in higher bulk specific gravity and would share in higher sample volume and lower bulk specific gravity. As it could be seen in Figure 6, air void decreased with increasing soft clay contents, thus; the values of AV decreased by 4.2, 4.08, 3.38, 3.34, and 3.32% after adding soft clay ratios, respectively. Meanwhile, Figures 7 and 8 presents the relationship between VMA and SC contents, as well as between voids filled with asphalt VFA and SC content, respectively. VMA decreased with increasing SC content, whereas VFA increased by 75% when the SC content was increased from 0% to 8%.

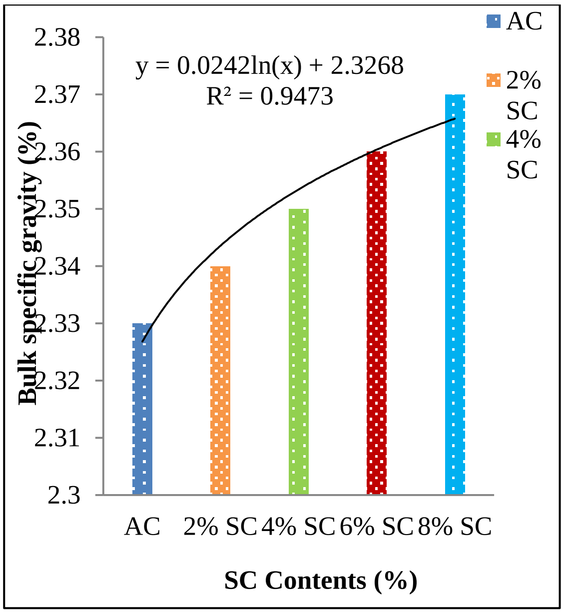

Figure 5. Relationship between SC% and Gmb

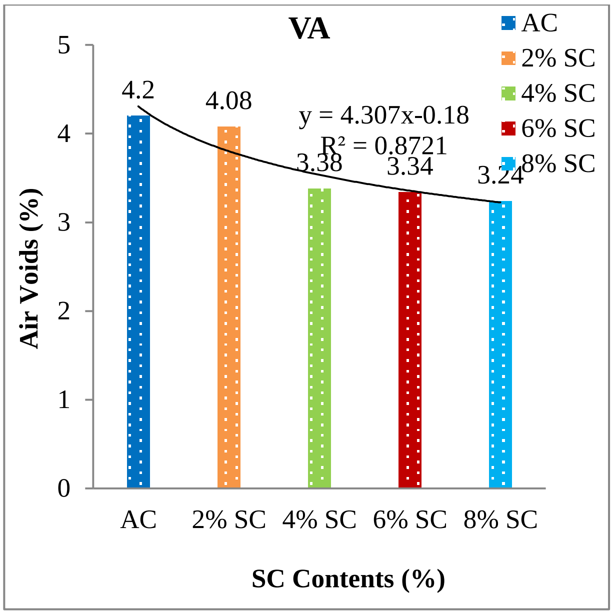

Figure 6. Relationships between AV and SC content

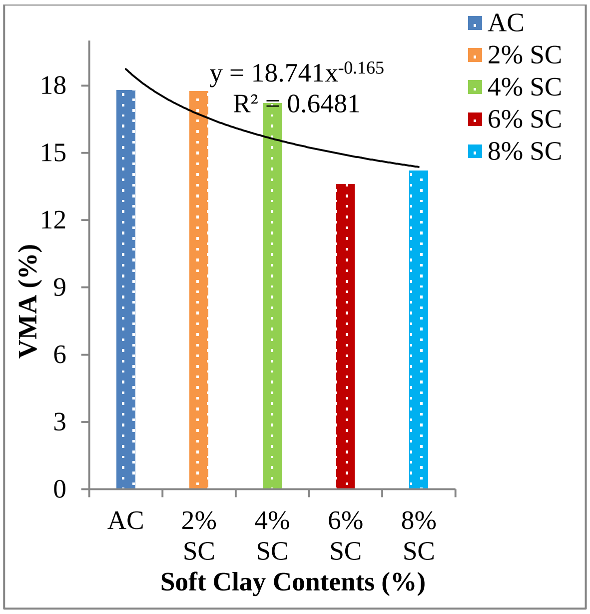

Figure 7. Relationship between VMA and SC contents

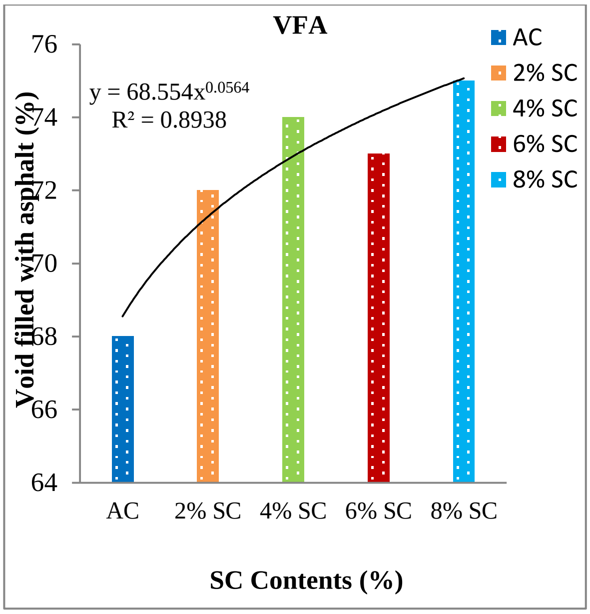

Figure 8. Relationship between VFA and SC content

5.2 Dust /asphalt ratio

Figure 9 shows that all the values of dust ratios were meeting the Superpave mix design criteria among 0.6 and 1.2. In general, all soft clay particles percentages have greater values than 0.6 and lower of 1.2 respectively. More importantly, it can be found that, an increase of SC concentrations results in an increase of D/A ratio regardless of binder and aggregate source. More importantly, soft clay contents don't have effect by dust ratios of all mixtures [22].

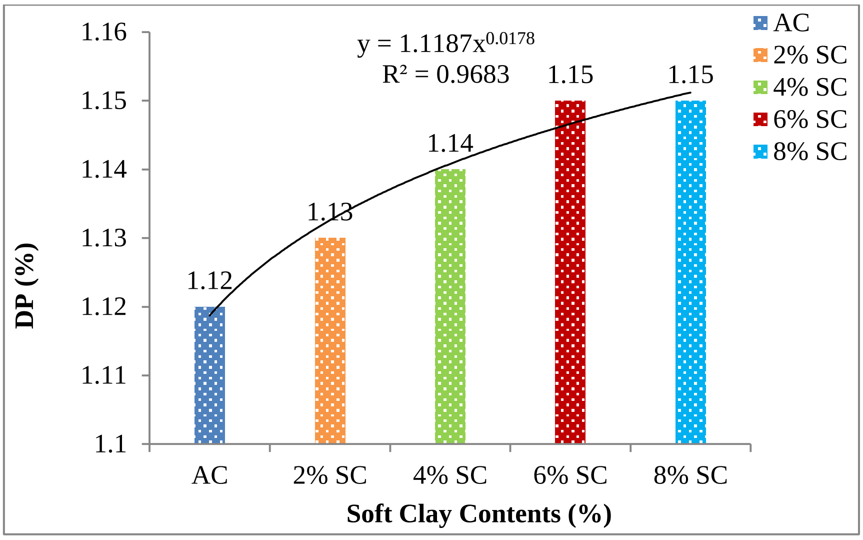

Figure 9. Dust ratio against soft clay contents

5.3 Stiffness

According to the results of the resilient modulus tests for three ageing conditions are presented in Figure. 10 and 11 respectively., for long-term ageing, 4% SC displays the least susceptibility to fatigue deformation with the highest value of 5231MPa, followed by 2% SC which given 4912MPa, 6% has been given 4975MPa, while 8% SC given 5365MPa, compared to the control sample that presented 5231MPa. Similar trends may be observed for the specimens that were exposed to unaged and short-term ageing. This study shows that the addition of SC would enhance impedance to fatigue deformation at intermediate temperatures, both for unaged and short-term specimens, according to the unmodified specimen [23-24].

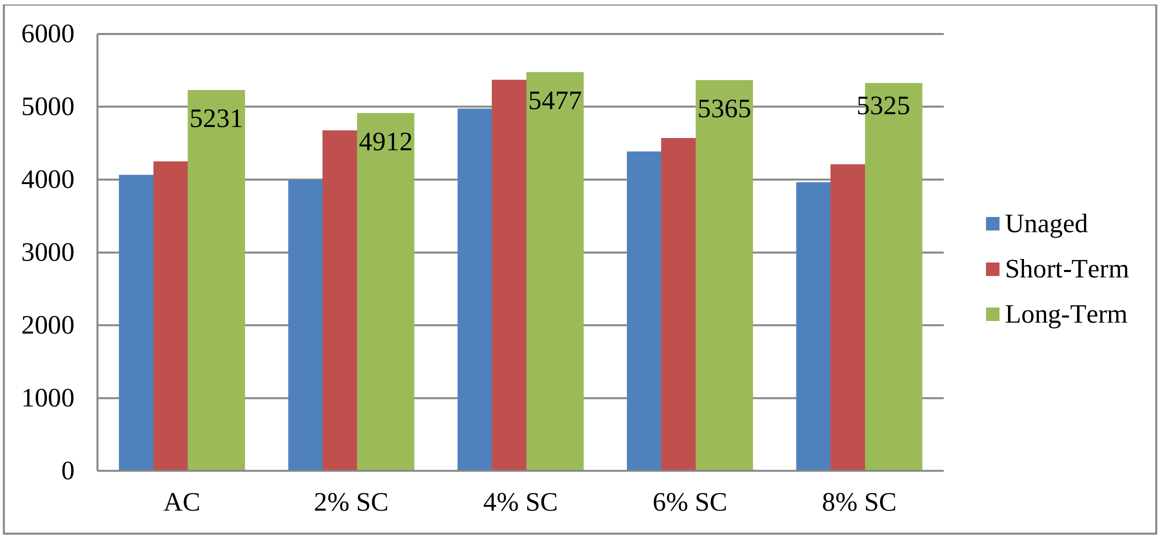

Figure 10. Resilient modulus stiffness test for 25C

Table 3 show summaries of further analysis using Tukey post-hoc multiple comparisons between modified mixtures with the control mixture. In general, it was found that there were statistically significant differences between the modified and unmodified asphalt mixture ($p < 0.05$) when tested at 25°C for all pulse repetition period 1000ms.

Table 3. Post Hoc Multiple Comparisons between Base and SC-Modified-Asphalt Mixture at 25°C (1000ms)

Dependent Variable	Asphalt (I)	Sample (J)	Mean Difference (I-J)	Std. Error	Sig.
Unaged	Asphalt Mixture	2.00	-374.80000	175.67071	.245
		4.00	-1324.80000*	175.67071	.000
		6.00	-1973.00000*	175.67071	.000
		8.00	-613.80000*	175.67071	.017
Short-Term ST	Asphalt Mixture	2.00	-813.00000*	145.14415	.000
		4.00	-1411.80000*	145.14415	.000
		6.00	-890.60000*	145.14415	.000

Dependent	**Asphalt**	**Sample**	**Mean**	**Std. Error**	**Sig.**
		8.00	-856.60000*	145.14415	.000
Long-Term LT	Asphalt Mixture	2.00	-515.60000	179.27246	.063
		4.00	-801.80000*	179.27246	.002
		6.00	-292.20000	179.27246	.497
		8.00	-261.80000	179.27246	.598

As the temperature was increased to 40 °C, addition of 4% SC yielded the highest resilient modulus compared with the control sample (Figure 8). Different values of resilient modulus at high temperatures indicate that 8% SC is the least susceptible to rutting compared with the control mix and considered the optimum concentration. This SC percentage also produced the highest resilient modulus of 809 MPa, followed by 2% SC and other SC ratios, compared with the control sample.

The Tukey post-hoc multiple comparisons between unmodified and SC-modified asphalt mixture as shown in Table 4. It can note that all modified asphalts were significantly when it compared with base asphalt cement ($p < 0.05$).

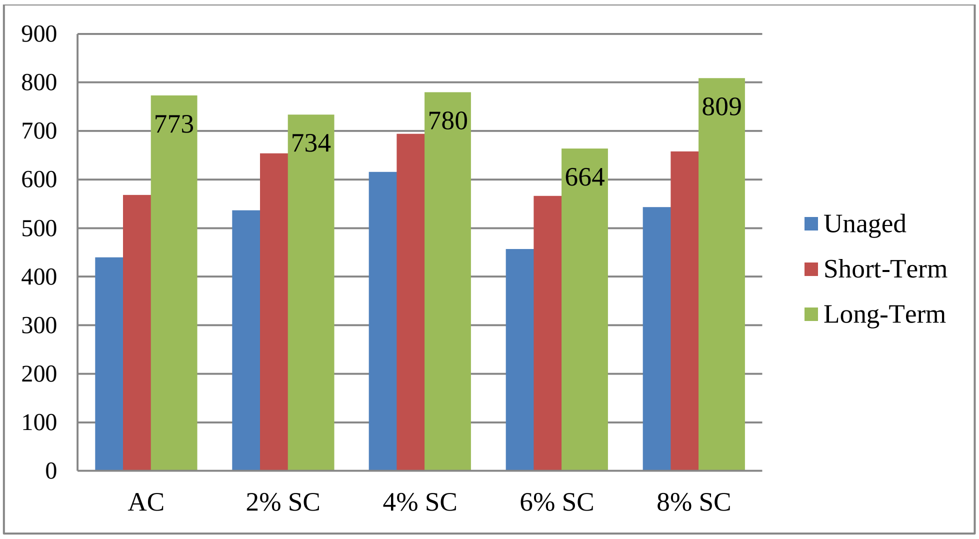

Figure 11. Resilient modulus stiffness test for 40C

Table 4. Post Hoc Multiple Comparisons between unmodified and SC-Modified-Asphalt Mixture at 40°C (1000ms)

Dependent	**Asphalt**	**Sampl**	**Mean**

Variable	(I)	e (J)	Difference (I-J)	Std. Error	Sig.
Unaged	Asphalt Mixture	2.00	-46.00000	38.23381	.750
		4.00	-111.00000	38.23381	.030
		6.00	5.40000	38.23381	.050
		8.00	-84.80000	38.23381	.014
S-T	Asphalt Mixture	2.00	25.40000	23.10117	.805
		4.00	-268.80000*	23.10117	.000
		6.00	-53.80000	23.10117	.077
		8.00	-104.00000*	23.10117	.002
L-T	Asphalt Mixture	2.00	-106.60000	57.96109	.380
		4.00	-272.80000*	57.96109	.001
		6.00	-9.20000	57.96109	1.000
		8.00	-210.20000*	57.96109	.013

Table 5 displays the ageing index that perform the variation between unaged and aged specimens at 25 and 40°C, where the ageing index was calculated by dividing the aged value with unaged of resilient modulus. It could be found that the short- term aged specimens have a higher stiffness than unaged samples. Therefore, the highest value was at 4% SC for short-term ageing. The ageing index values reported in this table show that the susceptibility to oxidative ageing is significantly decrease with an increase in the proportions of SC, especially in the case of short-term ageing.

Table 5. Ageing Index of Resilient Modulus Test at 25°C and 40°C

Samples	Tem	Ageing Index		
		Unaged	Short-Term	Long-Term
Control		1.00	1.04	1.28
2% SC		1.00	1.17	1.23
4% SC	25°C	1.00	1.07	1.10

6% SC		1.00	1.04	1.22
8% SC		1.00	1.06	1.34
Control		1.00	1.29	1.75
2% SC		1.00	1.22	1.37
4% SC	40°C	1.00	1.13	1.27
6% SC		1.00	1.24	1.45
8% SC		1.00	1.22	1.49

6 CONCLUSIONS

Based on the limited laboratory work which done in this study, it can be concluded that the addition of 4% SC is the optimum content to enhance the performance characteristics of the hot mix asphalt mixture with resilient modulus test. Moreover, the resilient modulus of mixtures which has been prepared with modified BPSC bitumen is higher than the control mixture; stiffness was significantly increased in 25°C while decrease at 40°C, while for volumetric properties of Superpave mix design, the AV and VMA decrease, while bulk specific gravity increases after adding SC

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REFERENCES

[1] Araujo, V. M., Bessa, I. S., & Branco, V. T. C. (2015). Measuring skid resistance of hot mix asphalt using the aggregate image measurement system (AIMS). Construction and Building Materials, 98, 476-481.

[2] Banerji, P. (2007), Laboratory evaluation of hot mix asphalt (HMA) in Delaware. University of Delaware

[3] Pérez-Jiménez, F., Martínez, A. H., Miró, R., Hernández-Barrera, D., & Araya-Zamorano, L. (2014), Effect of compaction temperature and procedure on the design of asphalt mixtures using Marshall and gyratory compactors. Construction and Building Materials, 65, 264-269.

[4] Buchanan, M., & Brown, E. (2001), Effect of superpave gyratory compactor type on compacted hot-mix asphalt density. Transportation Research Record: Journal of the Transportation Research Board, (1761), 50-60.

[5] Jitsangiam, P., Chindaprasirt, P., & Nikraz, H. (2013). An evaluation of the suitability of SUPERPAVE and Marshall Asphalt mix designs as they relate to Thailand’s climatic conditions. Construction and Building Materials, 40, 961-970.

[6] Asi, I. M. (2007). Performance evaluation of SUPERPAVE and Marshall Asphalt mix designs to suite Jordan climatic and traffic conditions. Construction and Building Materials, 21(8), 1732-1740.

[7] Masirin, M. I. B. M. (2006), Performance evaluation of encapsulated road pavement on difficult ground condition.

[8] Mohd, H. M. I. B. H., & Zain, R. B. M. (2013). Overview and Preliminary Study of Approach-Slab Design Concept for Bridges, Procedia Engineering, 54, 774-784.

[9] Karakas, A. S., Kuloglu, N., Kok, B. V., & Yilmaz, M. (2015). The evaluation of the field performance of the neat and SBS modified hot mixture asphalt. Construction and Building Materials, 98, 678-684.

[10] Sebaaly, P. E. (2007). Comparison of lime and liquid additives on the moisture damage of hot mix asphalt mixtures. Arlington (Virginia, USA): National Lime Association.

[11] National Cooperative Highway Research Program, American Association of State Highway, Transportation Officials, & Advanced Asphalt Technologies, LLC, (2011), A Manual for Design of Hot Mix Asphalt with Commentary (Vol. 673), Transportation Research Board.

[12] Burguete, L. M. F. Extending the study of the behaviour of bituminous mixtures incorporating nanomaterials.

[13] Kok, B. V., & Kuloglu, N. (2007). The effects of different binders on mechanical properties of hot mix asphalt, International Journal of science & technology, 2(1), 41-48.

[14] XuI, S., Zhou, Z., Qianl, P., & Derne, I. R. (2004), Use of Premium SBS Modified Bitumen to Combat Severe Rotting in Asphalt Pavement.

[15] Lolly, R. (2013), Evaluation of Short-Term Aging Effect of Hot Mix Asphalt Due to Elevated (Doctoral dissertation, Arizona State University).

[16]. Reed, J. (2010), Evaluation of the effects of aging on asphalt rubber pavements (Doctoral dissertation, Arizona State University).

[17] Sirin, O., Kim, H. J., Tia, M., & Choubane, B. (2008), Comparison of rutting resistance of unmodified and SBS-modified Superpave mixtures by accelerated pavement testing. Construction and Building Materials, 22(3), 286-294.

[18]. Daniel, J., & Lachance, A. (2005), Mechanistic and volumetric properties of asphalt mixtures with recycled asphalt pavement. Transportation Research Record: Journal of the Transportation Research Board, (1929), 28-36.

[19] Chen, H., Xu, Q., Chen, S., & Zhang, Z. (2009), Evaluation and design of fiber-reinforced asphalt mixtures, Materials & Design, 30(7), 2595-2603.

[20] Nejad, F. M., Azarhoosh, A. R., Hamedi, G. H., & Azarhoosh, M. J. (2012). Influence of using nonmaterial to reduce the moisture susceptibility of hot mix asphalt. Construction and Building Materials, 31, 384-388.

[21] Alataş, T., & Yilmaz, M. (2013), Effects of different polymers on mechanical properties of bituminous binders and hot mixtures. Construction and Building Materials, 42, 161-167.

[22] A. S. B. Ali, M. I. B. M. Masirin, and A. M. Al, “Evaluation of volumetric properties of asphalt mixture by using Batu Pahat Soft Clay as fillers.

[23] M. I. M. Masirin, A. M. Al Allam, and A. S. B. Ali, “Effect of Batu Pahat Soft Clay (BPSC) concentrations on the physical and rheological properties of asphalt binder,” Pertanika J. Sci. Technol., vol. 25, no. S5, pp. 101–108, 2017.

[24] A. M. Al Allam, M. I. M. Masirin, M. E. Abdullah, and A. S. Bader, “Evaluation of the Permanent Deformations and Aging Conditions of Batu Pahat Soft Clay-Modified Asphalt Mixture by Using a Dynamic Creep Test,” in MATEC Web of Conferences, 2016, vol. 47

تأثير الطين الناعم على الخواص الحجمية والميكانيكية للخلطة الاسفلتية الساخنة

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الملخص

لتحديد سلوك الخلطة الاسفلتية بما في ذالك الاسفلت بدرجة الاختراق بنسب مختلفة كان موضوعا رئيسيا لهندسة الطرق. لذالك، درس هذا البحث الخصائص الحجمية والميكانيكية للخلطة الاسفلتية مع إضافة الطين الناعم وبنسب مختلفة بناء على وزن الاسفلت (8٪،6٪،4٪،2٪،0٪). في حين تم تصميم الخلطة الاسفلتية باستخدام نظام السوبر بيف بعد ذالك، أجريت اختبارات الأداء لتحديد معامل المرونة والخصائص الحجمية للخليط. أظهرت النتائج أن الكثافة النوعية السائبة زادت بعد إضافة الطين الناعم الى الخلطة الاسفلتية. علاوة على ذالك، أدت إضافة 4٪ الى تحسين صلابة الاسفلت في الخلطة الاسفلتية وأيضا انخفضت كمية الهواء والفراغات الكلية مع زيادة نسب الطين الناعم. كما هو محدد من خلال اختبار معامل المرونة غير المباشر في ظل حالة التطاير للإسفلت. لذالك، بالإمكان إضافة الطين الناعم الى الخلطة الاسفلتية لتحسين خواصها الحجمية والميكانيكية مثل القوة والمتانة.

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الكلمات الدالة:

الخواص الحجمية.

الطين الناعم.

المتانة وطريقة التطاير.

تصميم بنظام السوبربيف.