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EXPERIMENTAL STUDYING THE EFFECT OF ADDING STYRENE BUTADIENE STYRENE POLYMER (SBS) ON THE MECHANICAL PROPERTIES OF HOT MIXTURE ASPHALT

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Abstract: The objective of this research is to study the effect of adding Styrene Butadiene Styrene polymer SBS as a modifier on the mechanical properties of asphalt binder and hot mixtures asphalt (HMA) and to compare between the properties of the modified and unmodified asphalt binder and hot mixture asphalt (HMA) which is used in the rehabilitation of Baghdad province and Al-Basra province highway by paving the surface course of highway for areas suffers from problems such as rutting and cracks. There are two stages were used in the laboratory tests on asphalt binder and hot mixture asphalt (HMA). The first stage is used laboratory tests without using SBS polymer with asphalt and the second stage is used SBS Polymer with asphalt as an additive material. The results of asphalt binder tests show that the using of SBS Polymer with asphalt binder lead to improve the mechanical properties of asphalt binder. According to penetration test, the grade of asphalt is decreased from 61 and 62 to 39. The flash point, the ductility, and viscosity are increased and the solubility is decreased. The results of hot mixture asphalt test show that the adding of SBS polymer lead to improve the mechanical properties of modified hot mixture asphalt. Therefore, the Marshall stability for modified hot mixtures asphalt is increased for all samples. Therefore, the resistance to plastic flow and the load carrying capacity is improved by approximate more than 60%. The others Marshall properties such as Marshall flow, Marshall density, and Marshal air voids are improved. Therefore, the recommendation of this study is to use the modified hot mixture asphalt that is using Styrene Butadiene Styrene polymer SBS in the paving of new flexible pavement layers and in rehabilitation of the surface course of the old flexible pavement.

Keywords, *Hot Mixture Asphalt, Penetration, Ductility, Marshall Test, SBS Polymer, Modified.*

دراسة عملية لتأثير إضافة بوليمر (SBS) على الخصائص الميكانيكية للخلطة الإسفلتية الحارة

الخلاصة: الهدف من هذا البحث هو دراسة تأثير إضافة بوليمر (SBS) على الخواص الميكانيكية لمادة الإسفلت والخلطات الإسفلتية الحارة والمقارنة مابين خواص المادة الإسفلتية والخلطات الإسفلتية الحارة المعدلة والغير معدلة التي تستخدم في تأهيل طريق المرور السريع الرابط مابين محافظة بغداد ومحافظة البصرة في العراق بواسطة أكساء الطبقة السطحية للطريق في المناطق التي تعاني من المشاكل كالتخدد والتشققات. توجد هنالك مرحلتين استخدمت في إجراء الفحوصات المختبرية على المواد الإسفلتية والخلطات الإسفلتية الحارة. المرحلة الأولى استخدمت الفحوصات المختبرية بدون بوليمر (SBS) مع الإسفلت،أما في المرحلة الثانية استخدمت مادة بوليمر(SBS) مع الإسفلت. نتائج الفحوصات المختبرية على مادة الإسفلت أظهرت نتائج جيده جدا وان استخدام بوليمر (SBS) مع الإسفلت أدت إلى تحسين خواص الإسفلت. وفقا لاختبار الاختراق، درجة اختراق الإسفلت انخفضت من 61 و 62 إلى 39 .نقطة الوميض و الليونة و اللزوجة ازدادت بنسبة جيده أما الذوبان فقد قل. نتائج فحص مارشال على الخلطات الإسفلتية الحارة أظهرت إن إضافة بوليمر (SBS) يؤدي إلى تحسين الخواص الميكانيكية للخلطات الإسفلتية الحارة المعدلة. لذلك قوة ثبات مارشال للخلطات الإسفلتية الحارة المعدلة ازدادت زيادة جدا ملحوظة و بنسبة كبيره لذلك مقاومة الزحف اللدن وقابلية تحمل الأحمال قد تحسنت بمقدار أكثر من 60% تقريبا ولجميع النماذج. خواص مارشال الأخرى كالزحف والكثافة ونسبة الفراغات الهوائية أيضا قد تحسنت. إن توصية هذه الدراسة هي استخدام الخلطات الإسفلتية الحارة المعدلة باستخدام بوليمر (SBS) في إنشاء التبليط الإسفلتي المرن الجديد وفي إعادة تأهيل الطبقة السطحية للتبليط المرن القديم.

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1. Introduction

Pavement is an important in the construction of highway, runways, cars parking, and driveways. Pavement is the most widely used mode of transportation in the world, and the developments of countries are often measured in terms of its total paved road mileage [1] .

For highway engineering, pavement is a structure consists of strong layers. These layers are located above the natural soil (sub-grade). The main function of these layers is to distribute the applied vehicle loads to the natural soil. The structure of pavement should be able to give a suitable surface of acceptable riding quality, adequate skid resistance, favorable light reflecting characteristics, and low noise. According to the structural performance, the structure of pavements can be classified into two types. The first type is flexible pavements and the second type is rigid pavements. Generally, the flexible pavement layers can be divided into a surface layer (surface course and binder course), base layer, and sub-base layer. The surface layer and base layer are typically different in composition of materials and they are placed in separate construction operations. The wheel loads on flexible pavements are transferred by grain-to-grain contact of the aggregate through the granular structure. The flexible pavement, having less flexural strength, acts like a flexible sheet. For rigid pavement, the surface layer is constructed by using concrete slabs (reinforced or non-reinforced). The load carrying capacity can be produced according to the rigidity and high modulus of elasticity of the concrete slab structure [2, 3, 4, 5].

Hot mixture asphalt (HMA) is used in the construction of flexible pavement, and it can be produced by mixing many different percents of aggregates and asphalt binder in an asphalt plant at elevated temperatures ranged between 300 and 350ºF. According to the function of the aggregate gradation used in the mixture, HMA can be divided into three mixtures types. These types are dense-graded, open-graded, and gap-graded [5, 6].

The hot mixture asphalt pavement structural performance depends on the properties of asphalt binder, and external factors such as the volume of traffic and the environment conditions. The main factors will produce the destroyed of the pavement are the higher traffic volume will create the more tension into the layer of surface course [7].

The early failures of flexible pavement have many reasons. Some of these reasons are due to high traffic loads and the others related to environmental conditions such as high temperature and moisture. These failures can be classified as durability failure or stability failure. Generally, these environmental conditions have harmful effects on the structural performance of pavement. Therefore, the improvement or modifying of hot mixture asphalt (HMA) is an important to increase the structural performance of asphalt layer (surface layer) of pavement to resists the traffic loads and environmental conditions and to reduce the probability of different types of pavement failures. Therefore, any improvements or modifications attempt to extend the service life of flexible pavements, and then they will give a great economical advantage and improve the performance of asphalt pavements [8, 9].

For highway construction, asphalt polymer modification is a field widely covered by academic property and it is the incorporation of polymers in asphalt material by mechanical mixing or chemical reaction. There are many types of polymers that are used in the process of modified of asphalt material then improving the hot mixture asphalt. These polymers can be classified as two types. The first type is plastomers such as polyethylene (PE), polypropylene (PP), ethylene-vinyl acetate (EVA), and ethylene-butyl acrylate (EBA). The second types are thermoplastic elastomers such as styrene-butadiene-styrene (SBS), styrene-isoprene-styrene (SIS), and styreneethylene/butylene-styrene (SEBS) [10].

The objective of this research is to study the effect of adding Styrene Butadiene Styrene polymer SBS as a modifier on the mechanical properties of asphalt binder and hot mixture asphalt (HMA) and to compare between the properties of the modified and unmodified asphalt binder and hot mixture asphalt (HMA) which is used in the paving of surface course of Baghdad province and Al-Basra province highway in Iraq.

2. Related Studies

In the last 50 years, there are many researchers studied the using of different types of polymers and additive materials to modify the asphalt binder and hot mixture asphalt that was used in the construction of flexible pavement due to the failures in the pavement layer because of increasing in the traffic loads and environmental conditions. In this study, some related studies will be explained .

Vonk, W., et al., and Mahmoud, (1995) studied the using of SBS polymer to improve the properties of asphalt binder. They found that when the SBS and asphalt was mixed together, the polystyrene block's regions once more becomes hard and creates cross connections among the rubber blocks and forms a powerful 3d net after being cold the modified asphalt. Finally, they concluded that the using of SBS polymer in asphalt mixture will lead to reduce the deformation of asphalt and it will produce the fatigue resistance and also will give better connection between the asphalt and aggregates [11, 12].

Vonk, W., and Hartemink, R., (2004) used SBS polymer to modify asphalt binder that was used in the flexible pavement in hot area. They explained that SBS polymers are not particularly increasing the stiffness of asphalt binder, and they are not to be the optimum modifiers in hot climates. It is demonstrated that SBS-modified binders can be formulated over a wide temperature. Also they found that when the percentage of SBS is equal to 3% in appropriate asphalt, the deformation resistance (performance) is twice as good as that of a 60 penetration for unmodified asphalt at 50ºC. If the content of SBS increase to 5%, the deformation resistance will be increased to an equivalent level of asphalt has grade 20-30 penetration at 60ºC [13].

Baha,V., and Necati, K., (2007) studied the effects of different penetration grade asphalt binder with SBS polymer on the mechanical properties of hot mixture asphalt. They used 5% SBS polymer by weight of asphalt binder. They found that the mixes prepared with asphalt binder modified with %5 SBS have the highest stiffness modulus, the creep stiffness values were regularly increased with incising the hardness of asphalt binders, improving the adhesive properties of mixes, and increasing the resistance to moisture damage. [14]

Klaus. S., et al (2007) investigated the effect of SBS polymer on the characteristics of asphalt binder. They used two types of asphalt binder. The first type is plain asphalt binder, and the second types is modified asphalt binder by using SBS polymer produced with the plain asphalt binder as base material were characterized in terms of chemical composition, microstructure, micromechanical properties, and thermo-analytical behavior. The results of analysis show that the using of SBS polymer leads to improve the properties of asphalt binder. [15]

Amjad, H., and Hussein, K., 2011 explained the influence of modified asphalt binder on the mechanical properties of hot mixture asphalt. They using asphalt binder of penetration grade 40-50 and styrene butadiene rubber (SBR) as modifier in their study. Five different modification levels of SBR are used. The percentages of SBR wear equal to 0%, 1%, 3%, 5% and 7% by weight of asphalt binder. The results of experimental tests show that the mixes modified with SBR polymer lead to improve the elastic properties, fatigue and deformation resistance. [16]

Hayder, A., (2015) evaluated the effect of using SBS polymer as modifier on the moisture sensitivity of hot mixture asphalt. The percentage content of SBS polymer was equal to 0.5, 1.0, 1.5, 2.0, 2.5, 3.0.3.5, 4.0 by the weight of asphalt binder. He applied three performance tests. These tests include, indirect tensile strength ratio test, Marshall test and the index of retained strength test. The results of tests show that the hot asphalt mixtures modified by using SBS polymer lead to improve the Marshall properties, and to increase the moisture damage resistance. [17]

3. Material Used

3.1. Asphalt Binder

In this study, there are two types of asphalt binder. The first type of asphalt is selected from Al-Nasiriyah oil refinery and the second type is selected from Al-Dora oil refinery. The results of asphalt binder tests will be compared with Iraqi specification for Roads and Bridge (R9, 2003).

3.2. Aggregates

According to Iraqi standard specification for road and bridges, aggregates shall be uniform quality, crushed to size and shall be composted of sand, tough, durable particles, and mineral filler. Aggregates shall be clean, free from clay balls and clay coated particles. Coarse aggregates are the part of combined aggregates retained on the 4.75mm sieve (No.4). Fine aggregates are the part of combined aggregates passing the sieve No.4 (4.75mm) [18]. The aggregate was got from Karbala quarries. The aggregate was sieved and recombined to meet the requirements of base course and surface course gradation according to Iraqi specification for Roads and Bridge (R9, 2003).

3.3. Mineral Filler

Mineral fillers must be contained on limestone or other stone dust, Portland cement, and hydrated lime. Mineral fillers shall be dry and free from lumps or aggregates of fine particles. They represent mineral particles that pass sieve (No.200). Portland cement (Karbala) is used as filler in hot mixture asphalt.

3.4. Styrene-Butadiene-Styrene Polymer (SBS)

Styrene Butadiene Styrene polymer (SBS) is a thermoplastic polymer that is used to improve mechanical properties of hot mixture asphalt then recovering the overall performance of asphalt pavement by reducing potential rutting in summer and cracking in winter, and leading to increase the stability, elasticity, and stiffness of asphalt binders.

Under high temperature, SBS polymer is soft; therefore, it can be easily added and mixed with asphalt binder. The SBS polymer was produced by Kraton performance Polymer Company. Fig.1 shows the SBS material. [19]

(a) **(b)**

Figure 1. SBS material: (a) Kraton Performance Polymers company covers (KPP), (b) SBS appearance

4. Laboratory Tests on Asphalt Material and Hot Mixture Asphalt

In this study, there are two stages in the application of laboratory tests. The first stage is applied laboratory tests on asphalt binder and hot mixture asphalt without any additive materials (modifier materials).

The second stage uses additive materials with asphalt binder and hot mixture asphalt during laboratory tests. In these two stages, the laboratory tests on asphalt binder include penetration, flash point, ductility, solubility, and viscosity. For hot mixture asphalt, Marshal test will be applied.

4.1. Laboratory Tests on Unmodified Asphalt Binder

For asphalt binder, five tests will be applied for two types of asphalt to evaluate the mechanical properties of asphalt binder without modified materials. The first type of asphalt is selected from Al-Nasiriyah oil refinery and the second type is selected from

Al-Dora oil refinery. These tests include penetration, flash point, ductility, solubility, and viscosity.

Laboratory tests are performed in Karbala construction laboratory and Al-Mussaib Technical College construction laboratory. Table 1 lists the results of asphalt binder tests for Al-Nasiriyah asphalt and A-Dora asphalt binder. From these results it can be illustrated that the grade of asphalt is 60-70 and two types of asphalts gives same results of flash point and ductility.

For viscosity, Al-Dora asphalt has higher value than Al-Nasiriyah asphalt that is equal to 420cSt, but Al-Nasiriyah asphalt appeared more solubility in Trichloroethylene that is equal to 99.7%.

Table 1. Results of Al-Nasiriyah and Al-Dora asphalt tests without SBS polymer

Test Name	Average Value of Al-Nasiriyah asphalt	Average Value of Al-Dora asphalt	Standard Limit of Iraqi Specifications for Roads and Bridges 2003[18]
Penetration (1/100mm) 25C^o, 100gm, 5sec	61	62	60-70
Flash point, C^o	>232	>232	>232
Ductility, cm, 25 C^o, 5cm/min	>100	>100	>100
Solubility %	99.7	99.6	>99
Kinematic viscosity (cSt)	410	420	>300

4.2. Marshal Test for Unmodified Hot Mixture Asphalt

Marshall test is applied for unmodified hot mixture asphalt to evaluate the mechanical properties of mixture such as stability, flow, bulk density, and air voids percentage. The average optimum asphalt contents of unmodified hot mixture asphalt are calculated by using Marshall test. In this study, eight samples with average optimum asphalt content are used to construct the rural road in Al-Mussaib City within Babylon Province.

Al-Dora asphalt binder is mixed with aggregates from Karbala quarries to product hot mixtures asphalt. Table 2 lists the sieve analysis of aggregates according to Iraqi specification for road and bridges (2003). Table 3 gives the results of Marshall test.

Table 2. Results of sieve analysis of aggregates for base course.

Sieve No.(mm)	Standard Limit [18]	% passing							
		Sample No.							
		1	2	3	4	5	6	7	8
37	100	100	100	100	100	100	100	100	100
25	90-100	90	92.7	91.3	92	90.8	100	100	100
19	76-90	79.3	80.6	77.6	81.2	79.6	92.2	88.7	90.7
12.5	56-80	62.5	59.1	58.9	61.7	53.5	76.3	73.8	76.3
9.5	48-74	49.2	46.5	46.7	54	45.8	60.4	65.6	63.9
4.75	29-59	37	38.5	38	45.9	37.7	51.6	53.7	44.1
2.36	19-45	32.8	33.2	33.8	33.7	34.3	35.8	36.3	32.
0.3	5-17	15.7	15.2	14.4	17.1	13.6	12.1	9.6	17.2
0.075	2-8	3.5	4.1	3.3	6	2.5	4.7	6.6	4.8
Asphalt content %	3-5.5	3.73	3.63	3.81	4.06	4.13	4.68	4.53	5

Table 3. Results of Marshall test of unmodified hot mixture asphalt (Al-Dora asphalt) for base course

Property	Sample Number								Standard Limit of Iraqi Specifications for Roads and Bridges 2003[18]
	1	2	3	4	5	6	7	8	
Average Optimum asphalt content %	3.73	3.63	3.81	4.06	4.13	4.68	4.53	5	3-5.5
Marshall stability (kN)	5.53	5.97	5.70	5.20	5.47	8.37	8.50	7.77	≥ 5
Marshall flow (mm)	2.70	2.60	2.60	2.50	2.23	2.87	2.87	2.60	2-4
Bulk density (gm/cm^3)	2.289	2.298	2.307	2.292	2.289	2.284	2.279	2.281	-
Air Voids %	4.75	4.65	5	4.5	4.75	4.15	4.25	4.35	3-6

4.3. Laboratory Tests on Modified Asphalt Material

In Iraq, the flexible pavement layer suffers from many problems such as rutting and different types of cracks of surface due to high traffic volume, thermal stresses (temperature degrees ranged between winter and summer are 0 C^o to 48 C^o) [20], and using uncontrolled hot mixture asphalt. Therefore, there need to improve the mechanical properties of asphalt binder and hot mixture asphalt to resist the higher traffic loads and weather conditions, then the service life of pavement will be longer. In this study, Styrene Butadiene Styrene polymer (SBS) are used to modify the asphalt binder that is used to product hot mixture asphalt for paving the highway surface course between Baghdad province and Basra province. This study will compare between the properties of asphalt binder and hot mixture asphalt before and after the addition of SBS.

SBS is mixed with asphalt binder before mixing process of aggregate and asphalt to get on hot mixture asphalt in factory. Fig.2 shows the mixing machine of SBS with asphalt binder in hot mixture asphalt plant in site of project.

The mixing of asphalt with SBS is tested by using five laboratory tests. The laboratory tests consist of penetration, flash point, ductility, solubility, and viscosity. Table 4 lists the results of laboratory tests of modified asphalt.

The optimum percentage of SBS in the mixing is 5% by weight. This table shows that the mixing grade is 30-40, the flash point is more than 330, the ductility is 167cm, the solubility in Trichloroethylene is 99.3%, and the viscosity is 455cSt. The results of tests meet the standard limit of Iraqi Specifications for Roads and Bridges 2003[18].

(a) (b)

Figure 2. Mixing machine of SBS with asphalt within hot mixture asphalt plant in site of project

4.4. Marshal Test for Modified Hot Mixture Asphalt

Table 5 lists the values of sieve analysis of aggregates that is used in surface course paved. The results of Marshall test of samples modified hot mixture asphalt samples that includes the mixing of asphalt with SBS and suitable aggregates can be shown in Table 6. In this test, eight samples are selected from rehabilitation of Baghdad-Basra highway project to compare with unmodified hot mixture asphalt.

Table 4. Results of modified asphalt tests (Al-Dora Asphalt)

Test Name	Average Value	Standard Limit of Iraqi Specifications for Roads and Bridges 2003[18]
Penetration (1/100mm) 25C^o, 100gm, 5sec	39	40-50
Flash point, C^o	330	>232
Ductility, cm, 25 C^o, 5cm/min	167	>100
Solubility %	99.3	>99
Kinematic viscosity (cSt)	455	>400

Table 5. Results of sieve analysis of aggregates for surface course

Sieve No.(mm)	Standard Limit [18]	% passing							
		Sample No.							
		1	2	3	4	5	6	7	8
19	100	100	100	100	100	100	100	100	100
12.5	90-100	91	91	91	94	94	92	94	91
9.5	76-90	76	75	76	80	80	78	82	76
4.75	44-74	52	54	55	53	57	56	57	55
2.26	28-58	41	39	44	41	45	44	44	44
0.3	5-21	19	17	21	19	21	21	21	21
0.075	4-10	9.8	9.3	10.2	9.5	11.8	10.6	10.9	10.2
Asphalt content%	4-6	4.80	4.90	5	5.10	5.11	5.14	5.15	5.17

Table 6. Properties of hot mixture asphalt with SBS polymer for surface course (Al-Dora asphalt)

Property	Sample Number								Standard Limit of Iraqi Specifications for Roads and Bridges 2003[18]
	1	2	3	4	5	6	7	8	
Average Optimum asphalt content %	4.80	4.90	5	5.10	5.11	5.14	5.15	5.17	4-6
Marshall stability (kN)	15.60	17.90	19.6	19.6	19.90	19.80	19.60	20	≥8
Marshall flow (mm)	4.10	4.10	4.5	4.10	4.30	4.40	3.80	4.90	2-4
Bulk density (gm/cm^3)	2.356	2.351	2.370	2.395	2.369	2.370	2.339	2.384	
Air Voids %	3.60	3.35	3	3.20	3.65	3.30	3.50	3.70	3-5

5. Comparison of Results

Table 7 gives the comparison of results for the modified and unmodified asphalt binder. According to this table, the properties of asphalt binder are improved in good state and the tests shown excellent results. The grade of asphalt is decreased from 61 and 62 to 39, the flash point, the ductility, and viscosity are increased and solubility is decreased. Therefore, the modified asphalt can be used it and improved the mechanical properties of hot mixture asphalt.

5.1. Asphalt Binder Properties

Table 7 gives the comparison of results for the modified and unmodified asphalt binder. According to this table, the properties of asphalt binder are improved in good state and the tests shown excellent results. The grade of asphalt is decreased from 61 and 62 to 39, the flash point, the ductility, and viscosity are increased and solubility is decreased. Therefore, the modified asphalt can be used it and improved the mechanical properties of hot mixture asphalt.

Table 7. Comparison of results for the modified and unmodified asphalt

Test Name	Modified Asphalt (Al-Dora)	Unmodified Asphalt (Al-Nasiriyah)	**Unmodified Asphalt (Al-Dora)**
Penetration (1/100mm) 25C^o, 100gm, 5sec	39	61	62
Flash point, C^o	>330	>232	>232
Ductility, cm, 25 C^o, 5cm/min	167	>100	>100
Solubility %	99.3	99.7	99.6
Kinematic viscosity (cSt)	455	410	420

5.2. Hot Mixture Asphalt (HMA)

Fig. 3 through Fig. 6 shows the mechanical properties of modified and unmodified hot mixture asphalt. From Fig. 3 it can be explained that the Marshall stability for modified HMA is increased for all samples. Therefore, the resistance to plastic flow and the load carrying capacity is improved by approximate 60%, indicating that the using of SBS polymer is useful to improve the stability of hot mixture asphalt .

Fig. 4 shows the Marshall flow of modified and unmodified hot mixture asphalt. The total deformation (elastic and plastic) of modified hot mixture asphalt is more than unmodified hot mixture asphalt because of the modified optimum asphalt content is high. Fig. 5 and Fig. 6 appears the Marshall density and air voids of modified hot mixture asphalt are higher than unmodified hot mixture asphalt .

Finally, this study recommends to use the modified hot mixture asphalt in the paving of new flexible pavement and in the paving the surface course of the old flexible pavement because of SBS polymer is effective to improve the mechanical properties of hot mixture asphalt in unsuitable environmental condition such as hot weather.

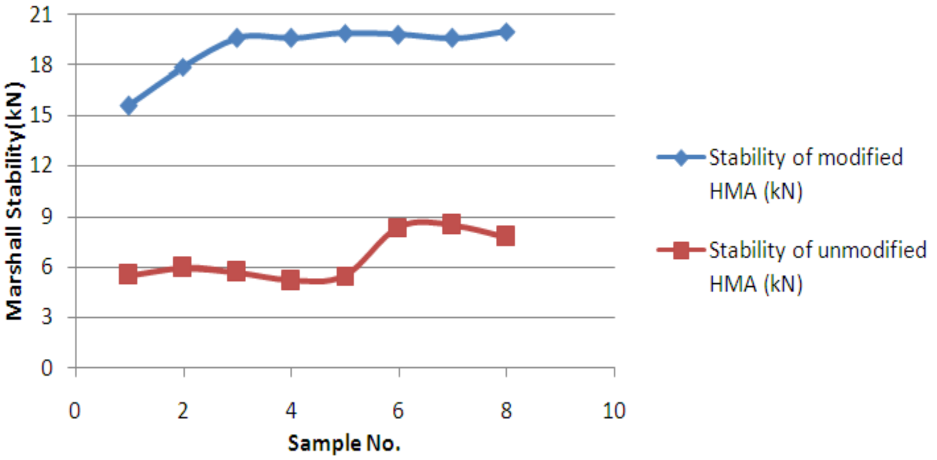

Figure 3. Marshall Stability of modified and unmodified HMA

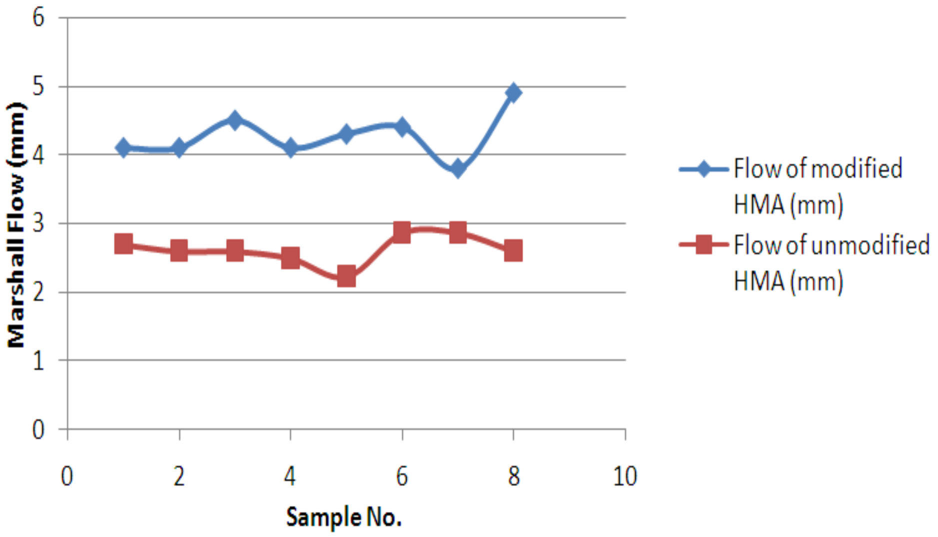

Figure 4. Marshall Flow of modified and unmodified HMA

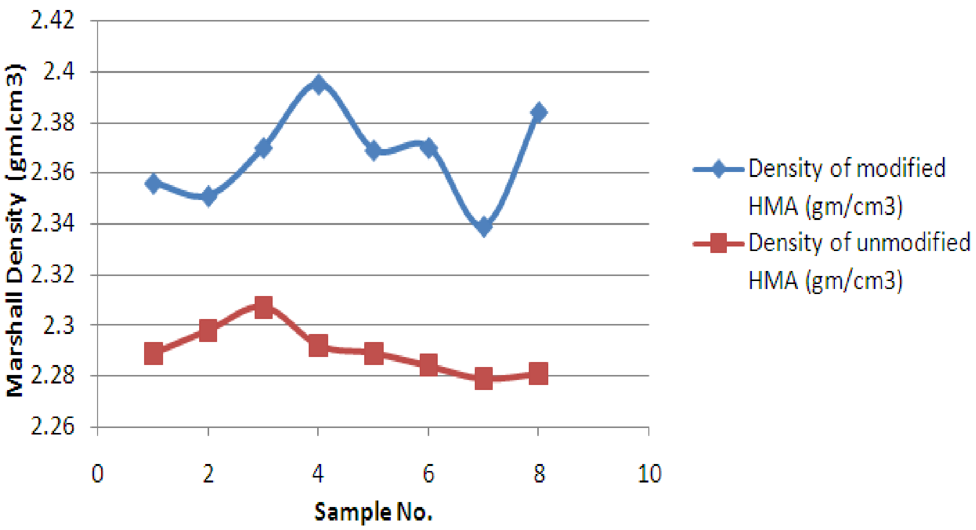

Figure 5. Marshall Density of modified and unmodified HMA

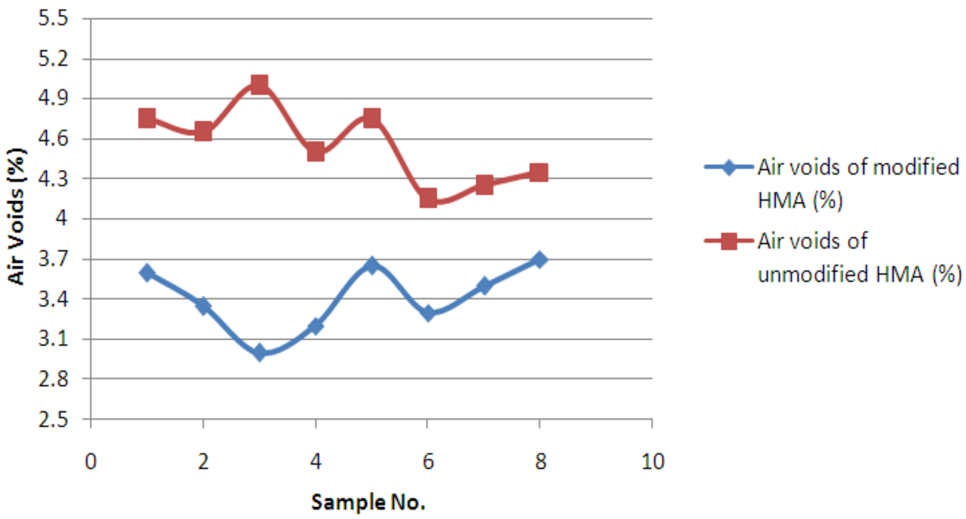

Figure 6. Marshall Air voids of modified and unmodified HMA

6. Application of Modified Hot Mixture Asphalt in Field

The modified hot mixture asphalt with SBS polymer is using in the rehabilitation of surface course of the highway between Baghdad province and Basra province. This way has significant effect on the transportation system in Iraq. It is connecting Baghdad province with Gulf countries by Basra province in the south of Iraq and also connecting Baghdad province with Jordon country and Syria country in the west of Iraq. The total length of way is 1200km and it has width equal to 31m. Each side has 15.5m width with 3.75m for each lane. This highway has been damaged in recent years as a result of the wars. Therefore, there is need to reconstruction of surface course of damaged sections of highway.

In this study, the part of highway between Al-Dywaniya province and Babylon Province (section 5, 73km) is selected to apply the modified hot mixture asphalt in the rehabilitation of damaged surface course. The pavement layer of damaged sections suffers from some damages such as cracks and rutting because of the high traffic loads and thermal stresses.

The Lebanese Strako Company (LSC) was selected to implement a rehabilitation project of section 5 of highway. The company is installed the asphalt plant to produce hot mixtures asphalt at the work site with asphalt testing laboratory and it equipped with all laboratory equipments for all tests. Additional parts of the plant were added to blend the SBS polymer with the asphalt before mixing with the aggregate and fillers. The thickness of surface course is 4cm. Fig. 7 shows the using of modified hot mixture asphalt in the paving of highway surface course.

Figure 7. Using of modified hot mixture asphalt in the paving of highway surface course

7. Conclusions

From this study it can be concluded that the using of Styrene Butadiene Styrene polymer (SBS) to improve the mechanical properties of asphalt binder are effective and it will lead to improve the mechanical properties of hot mixture asphalt. Two stages were used in the laboratory tests on asphalt binder and hot mixture asphalt.

The first stage involves conducting laboratory tests without the use of SBS polymer in the mixing with asphalt binder, and the second stage was used SBS polymer in the mixing with asphalt binder. The results of asphalt binder tests show that the using of SBS Polymer with asphalt binder lead to improve the mechanical properties of asphalt binder. According to penetration test, the grade of asphalt is decreased from 61 and 62 to 39.

The flash point, the ductility, and viscosity are increased and the solubility is decreased. The results of hot mixture asphalt test show that the adding of SBS polymer lead to improve the mechanical properties of modified hot mixture asphalt.

Therefore, the Marshall stability for modified hot mixtures asphalt is increased for all samples. Therefore, the resistance to plastic flow and the load carrying capacity is improved by approximate more than 60%. The others Marshall properties such as Marshall flow, Marshall density, and Marshal air voids are improved. Therefore, the recommendation of this study is to use the modified hot mixture asphalt that is using Styrene Butadiene Styrene polymer SBS in the paving of new flexible pavement layers and in rehabilitation of the surface course of the old flexible pavement because of Styrene Butadiene Styrene polymer SBS is effective to improve the mechanical properties of hot mixture asphalt in unsuitable environmental condition such as hot weather.

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