# Assessment of The Asphalt Produced in Some Factories of Asphalt in Al-Hilla City

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## Abstract

The purpose of this study is to present an evaluation of the properties and characteristics of asphalt concrete of several hot mix asphalt (HMA) from five factories in Al-Hilla city. The research is divided into two parts. The first part included the laboratory analysis of samples. The second part is evaluation of results according to standard specifications.

The test results included (Asphalt content percent, stability, creep compliance, voids ratio, density, flow, crushed aggregate percent, Loss Angless abrasion and $SO_3$ percent).The results of laboratorial tests indicated that all properties of asphalt mixes were susceptible and possible to be used in the asphaltic roads.

The mixes types prepared and tested according to Marshall method. The values of Marshall stability, creep and density are (9.4, 5.4, 9.8, 9, 8.6), (2.5, 2.7, 2.7, 2.6, 2.3) and (2.334, 2.336, 2.337, 2.333, 2.338) with asphalt content between (4.2 to 4.6) % for all asphalt mixes of different factories.

**Key words:** Asphalt concrete, Samples, Voids ratio, Crushed aggregate

## الخلاصة

الغرض من هذه الدراسة هو تقييم خواص وصفات عدة خلطات اسفلتية ساخنة مأخوذة من خمسة معامل لإنتاج الخرسانة الاسفلتية في مدينة الحلة.

قسم العمل الى جزئين، الجزء الاول تضمن اجراء التحاليل المختبرية للعينات، اما الجزء الثاني تضمن تقييم النتائج في ضوء المواصفات القياسية. خواص الخلطات المفحوصة هي (نسبة الاسفلت ، الثبات، الزحف، نسبة الفجوات، الكثافة، الانسياب، نسبة الركام المكسر، نسبة التآكل الميكانيكي ونسبة الكبريتات.

انواع الخلطات هيأت وفحصت بالاعتماد على طريقة مارشال، نتائج الفحوصات المختبرية اوضحت بان جميع خواص الخلطات المفحوصة كانت ملائمة مع امكانية استخدامها في اكساء الطرق. قيم ثبات مارشال، الزحف والكثافة هي (9.4، 5.4، 9.8، 9، 8.6) و(2.5، 3.1، 2.7، 2.6، 2.3) و(2.334، 2.336، 2.337، 2.333، 2.338)، ونسبة الاسفلت تراوحت بين 2.4 و4.6 للخلطات الاسفلتية للمعامل المختلفة.

**الكلمات المفتاحية :** خلطات اسفلتية، نماذج، نسبة الفجوات، الركام المكسر .

## Introduction

Bituminous mixes are used in the asphalt layer of road and airfield pavements. The mix is composed usually of aggregate and asphalt cements. The design of asphalt paving mix is largely a matter of selecting and proportioning constituent materials. The mix should contain sufficient asphalt cement to ensure an adequate film thickness around the aggregate particles (Harold and Attkins , 1990).

Penetration of grade (40-50) asphalt results give high resistance to cracking with less permanent deformation when we compare with the results obtained for penetration grades of (60-70) and (85-100). Using recommended kind of mixtures in south, mid and west of Iraq to protect the pavement from rutting and low temperature cracking (Abdul Majeed , 2000).

( Dorina, 2009 ), reported that the road structures have deteriorated more rapidly than expected due to increases in tire pressure, traffic volume, axle loading and insufficient degree of mainten. To improve durability and minimize the deterioration bitumen layers with regard to performance properties such as fatigue, wear and resistance to permanent deformation.

The properties of aggregate used in asphalt concretes are very important to performance of the pavements in which the asphalt concretes are used often pavement distress, such as stripping and rutting can be traced directly to the aggregate used (Yiping *et.al.*,1998).

(From laboratory studies Balgham ,1990), stated that when the aggregate was washed lead to improve the adhesion characteristics of asphaltic and concrete mixes.

In Iraq, usually, black rounded gravel of Sammara region is commonly used in most asphalt concrete mixes for road construction, most construction projects face constantly the problem of transportation of the material from the region to destination considerably.

The durability of a flexible road structure depends on the durability of the materials from which it is constructed, in particular the bitumen bound materials (Safar, 1992 ; Abdul *et.al.*, 2011).

The strength and stability of asphalt concrete is derived from the cohesive strength of the binder and the frictional resistance produced by aggregate interlock. Assuming the cohesion of the asphalt is strong, and the aggregates and asphalt are fully bonded, failure in the mix must occur either within the binder or through the aggregate (Kanitpong, 2004 ; Hussain *et.al.*, 2007).

(Hussain *et.al.*, 2008) reported that when designed and constructed any asphalt pavement continually undergo various types of stresses, that induce several defects of asphalt road, such as reduce the flexibility, cracking of the pavement surface and inducing fatigue failure.

(Abdullahi, 2007) studied, that asphalt concretes durability are greatly affected by the environmental changes (hot and cold) temperatures, which adversely effects of asphaltic concrete performance. Thus, low temperature flexibility and high temperature stiffness are important properties in asphalt mixtures to avert cracking and rutting.

Aggregate properties such roughness increases bond strength by providing more surface area to accommodate the asphalt-aggregate bond.

Asphalt fumes and vapors may be absorbed following in halation and dermal exposure. Because asphalt is a complex mixture, its pharmacokinetic behavior will vary depending upon the properties of individual constituents. Therefore, it is un appropriate to make generalizations regarding the extent of absorption, distribution and metabolism of asphalt. Since the compositions of asphalt fume and vapors vary depended on temperatures manufacturing process (Joann *et.al.*, 2005).

Aggregate impact and crushing values with suitable and unsuitable aggregate for bitumen macadam road base. When aggregate subjected to wetting and drying and/or freezing and thawing must be resistant to breakdown or disintegration. If the asphalt cement coating remains intact, these weathering cycles do not significantly affect the asphalt concrete mixture (Ballas and West ,1991 ; Yiping *et.al.*, 1998 ; D' Angelo and Anderson , 2003 ) .

## Methodology of the Work

The research methodology used in this study is illustrated and consists of the following tasks:

1- Assessment the asphalt produce in five different asphalt factories in Al-Hilla city.
2- Marshall method is used to standardize properties of asphalt mixes.
3- The parametric investigation focused on one layer pavement structure.
4-The study considered a uniform temperature change with depth in the asphalt concrete surface layer.
5 -The results of materials testing and data analysis to assess the implications and potential benefits of incorporating a mechanical and fracture energy test.

6 -The results of this analysis provided five mix designs, included the effects of different aggregate gradation of fine and coarse aggregate blends were used.
7 -This study involves the physical testing of the mixes, collection of the data, analysis of the data and comparison of results to examine any relationships that significantly affect mixture performance.

**Marshall Method of Mix Analysis ( Aashto, 1993; Astdm, 2006 )**

In this method, an attempt is made to obtain:

1- Aggregate grading.
2- Determination the proportion of each aggregate size.
3- Determination the mixes density.
4- Asphalt content.
5- Calculation the percentage of voids .
6- Bulk density.
7- Crushed aggregate % and (Loss Angles abrasion %).
8- Marshall stability.
9- Marshall creep.

## Results and Discussion

The quality of asphalt material and validity is determined through knowledge of several properties. Asphalt must be resistant to climatic conditions and remain flexible in order to stay acceptable as a binding material. One of the reasons for the loss of the fundamental properties of asphalt is (oxidation, evaporation, effect of light waves and the effect of the age of the asphalt) (Safar, M., 1992 ; SCRB, 2003 ).

Table (1) illustrated that the Aggregates grading of asphalt for the five factories of asphalt are within the limits of the binder course specification. This reason led to improve the properties of asphalt and survival within the ranges of the specification limit (air voids ratio, stability strength, Marshall density) were good interference between aggregate partial, because of the diversity and good gradient of aggregate size.

**Table (1): Sieve analysis of aggregate**

| Factory name | Al-Hejaz | Jawharat Babel | Alwifaq | Alwady algarby | Al-Hussain | Limits of (SORB/R6 ) (%) |
|---|---|---|---|---|---|---|
| Sieve size mm | Passing % | Passing % | Passing % | Passing % | Passing % | |
| 25 | 100 | 100 | 100 | 100 | 100 | 100 |
| 19 | 90 | 92 | 90 | 90 | 93 | 90-100 |
| 12.5 | 73 | 87 | 75 | 78 | 73 | 70-90 |
| 9.5 | 64 | 73 | 61 | 64 | 61 | 56-80 |
| 4.75 | 43 | 45 | 43 | 43 | 48 | 35-65 |
| 2.36 | 32 | 28 | 35 | 28 | 30 | 23-49 |
| 0.3 | 11 | 15 | 12 | 8 | 12 | 5-19 |
| 0.075 | 3.5 | 3.8 | 4 | 4.5 | 4.2 | 3-9 |

Table (2) shows the different values which were obtained for physical and chemical properties of various types of asphalt processed from five different randomly asphalt factories in Al-Hilla city.

**It can be seen from Table (2) and Figures (1 to 11) the following points:**

1- All types of asphalt (research topic) conform the specification limits of adhesive binder course as shown in Figure (2) and Figure (7), with the exception of a decrease in the strength of the stability of Marshall model for the second model (Jawharat Babel factory).

2-Asphalt ratio also was within the limits of the standard ranges of binder course. The presence of a sufficient amount of asphalt led to increase the plasticity of asphalt as shown in Figure (1)and Figure (9) which is important properties in order to property asphalt acts as the binder material and increase the stability of asphalt by increasing the ability of aggregate adhesion.

3-Marshall stability of the asphalt sample were (8.6 to 9.8)KN and this within binder course specification as shown in Figure (2), except for the Marshall stability of the second sample (Jawharat Babel factory) which was less than required values. The observed high Marshall stability of the samples was because of high density and low voids as shown in Figure (4) and Figure (5), which may be due to increase of filler and greater coherence and bond of coarse aggregate, while the reason for decrease of Marshall stability of asphalt attributed to the less of filler and an increase the asphalt materials used. The asphalt stability was used in the road depends on the ability of the adhesion between asphalt and aggregates with presence of water and reflected the phenomenon of separation between the asphalt and aggregates in certain cases, especially in the cold asphalt mixes and can improve the situation by wing additives against secession.

4-The expected trend of decreasing Marshall stability of (Jawharat Babel factory) with increasing voids is present in asphalt mix as shown in Figure (2) and Figure (4).

5-Increasing creep compliance and decreasing Marshall stability with increasing air voids is present as shown in Figure (2), Figure (3) and Figure (4) of (Jawharat Babel factory) resulted from relationship between creep and stability and with decreasing temperature in asphalt mix (David and Steven, 2008).

6-It can be seen from Figure (1), Figure (5) and Figure (6) that, decreasing asphalt percent and increasing crushed aggregate percent lead to increasing density for different asphalt factories mixes.

7-Fiure (1) which shows the sulphate ($SO_3$) percent value lie between (0.26 and 0.39) for all asphalt factories mixes. 8-It can be seen from Figure (8), Figure (9) and Figure (10) that, the increasing asphalt percent led to increasing creep, flow and voids ratio of different asphalt mixes.

**Table (2): Result of asphalt mixes properties**

| Properties | Factory name | | | | | Specification Limits (SORB/R9) |
|---|---|---|---|---|---|---|
| | Al-Hejaz | Jawharat Babel | Alwifaq | Alwady algarby | Al-Hussain | |
| Asphalt (%) | 4.2 | 4.6 | 4.5 | 4.2 | 4.3 | 4 to 6 |
| Marshall stability (KN) | 9.4 | 5.4 | 9.8 | 9 | 8.6 | ≥ 7 |
| Marshall creep (mm) | 2.5 | 3.1 | 2.7 | 2.6 | 2.3 | 2 to 4 |
| Marshall flow (mm) | 3.4 | 3.0 | 3.6 | 3.3 | 3.2 | 2 to 4 |
| Voids ratio (%) | 3.6 | 4.9 | 4.1 | 3.8 | 3.9 | 3 to 5 |
| Marshall density ($gm/cm^3$) | 2.334 | 2.336 | 2.337 | 2.333 | 2.338 | - |
| Crushed aggregate (%) | 91.5 | 91 | 91 | 91.5 | 90.5 | ≥ 90 |
| Loss Angles Abrasion (%) | 28 | 22 | 15 | 32 | 18 | ≤ 40 |
| $SO_3$ (%) | 0.358 | 0.261 | 0.390 | 0.311 | 0.276 | |

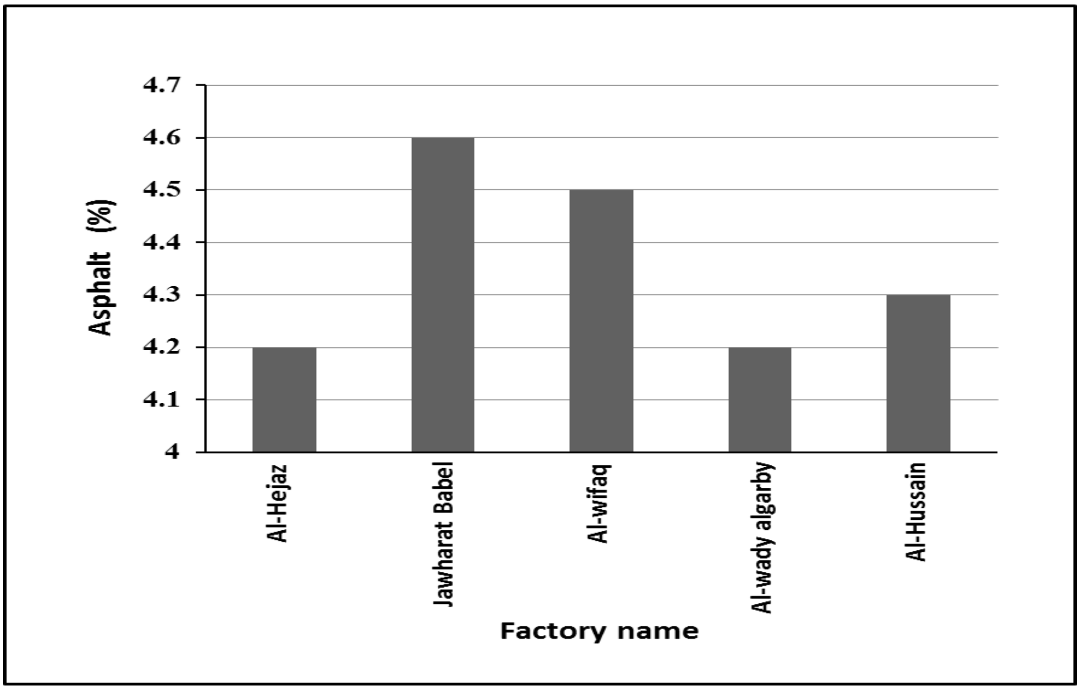


**Figure (1): Asphalt percent for different asphalt factories samples**

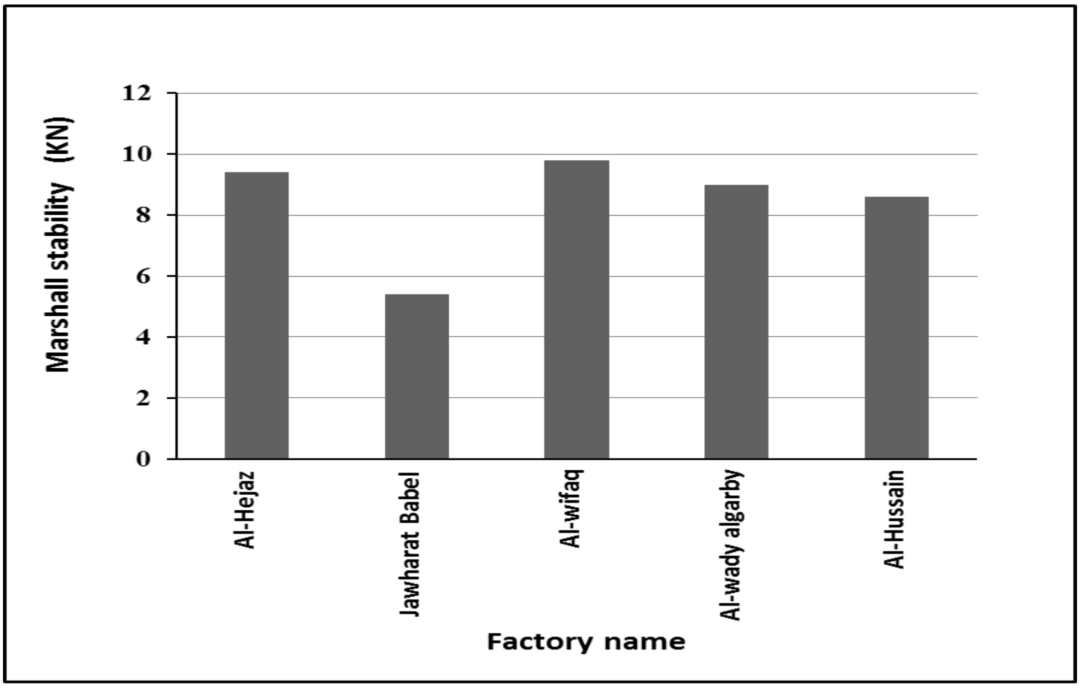


**Figure (2): Marshall stability for different asphalt factories samples**

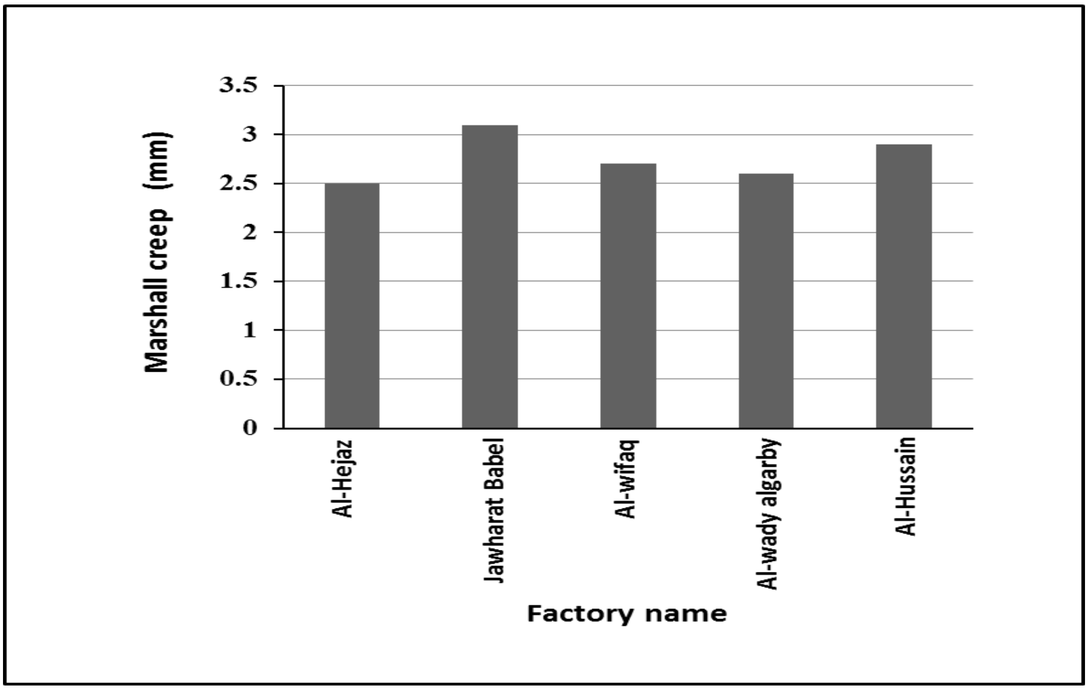


**Figure (3): Marshall creep for different asphalt factories samples**

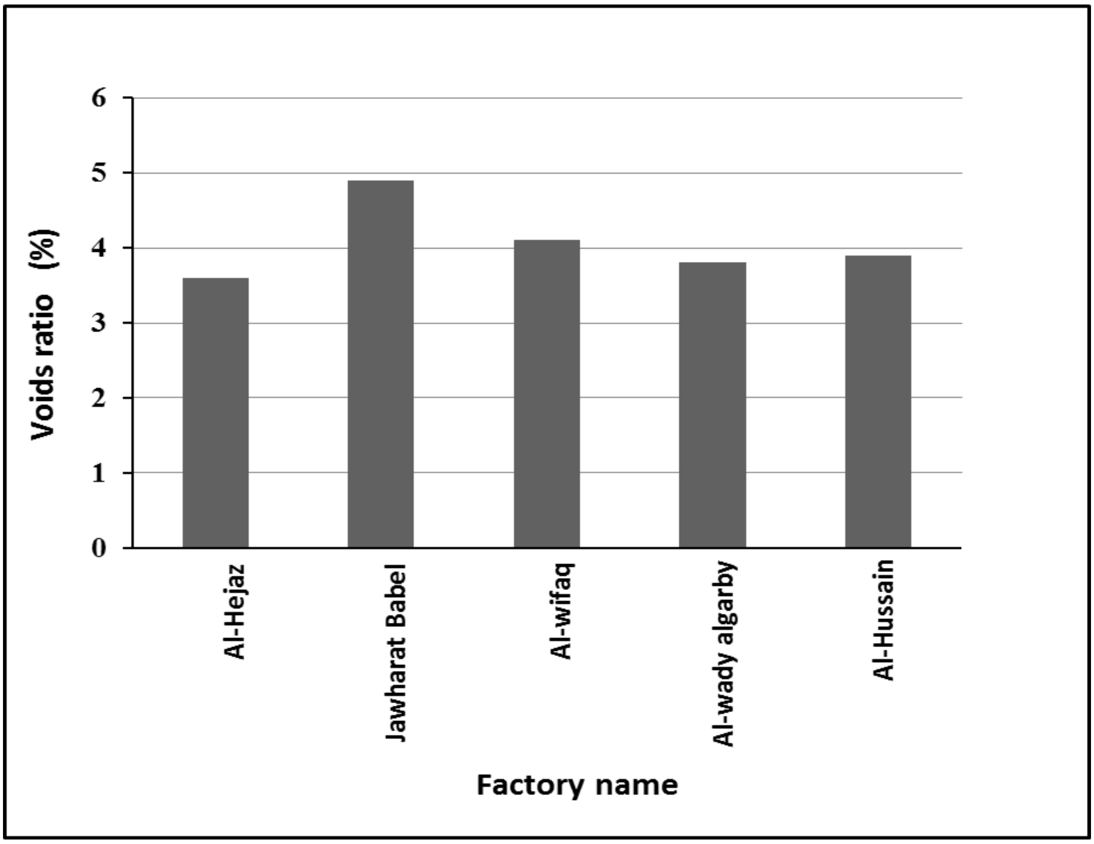


**Figure (4): Voids ratio for different asphalt factories samples**

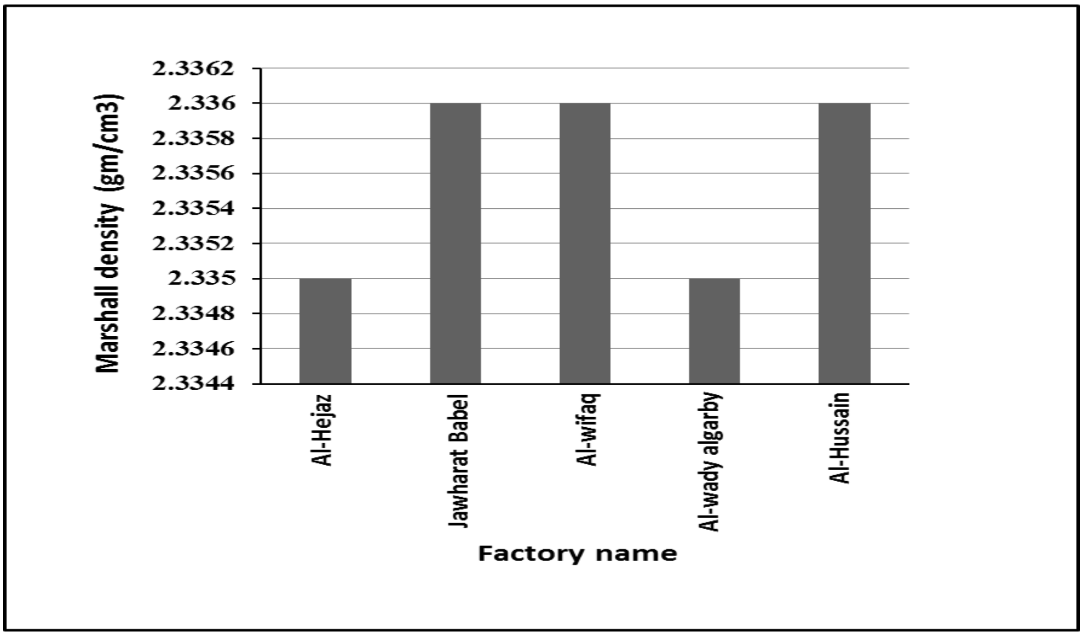


**Figure (5): Marshall density for different asphalt factories samples**

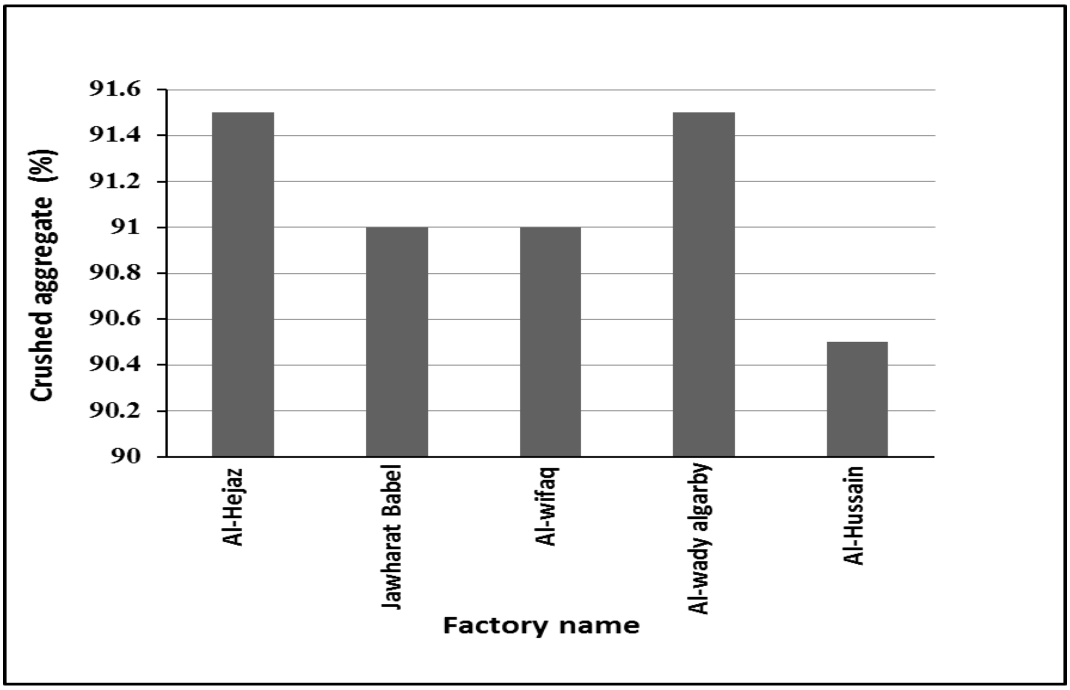


**Figure (6): Crushed aggregate for different asphalt factories samples**

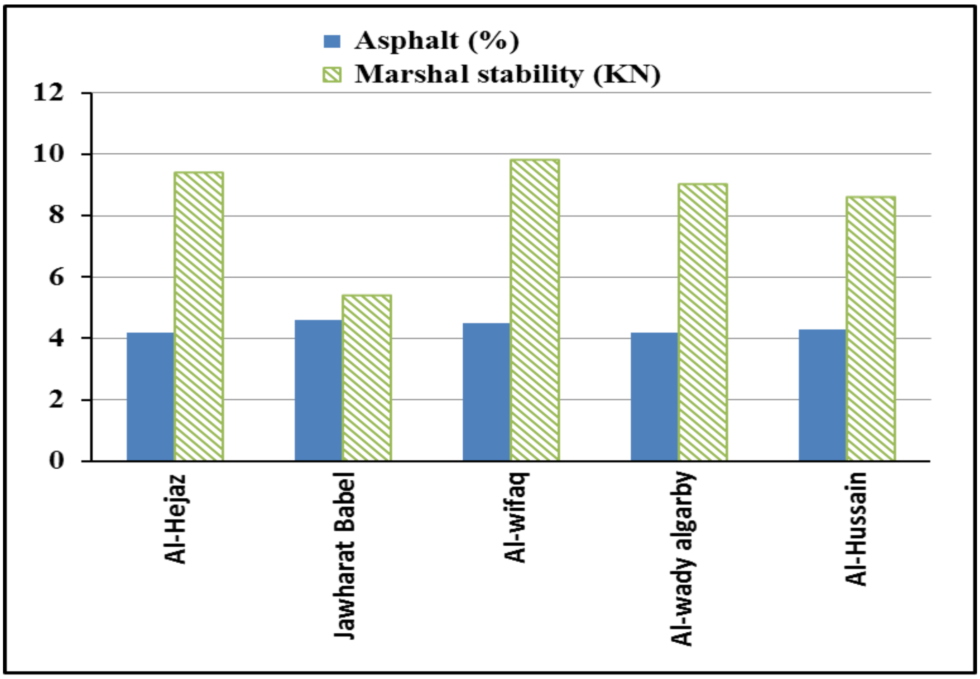


**Figure (7): Relationship between Asphalt (%) and Marshall stability (KN)**

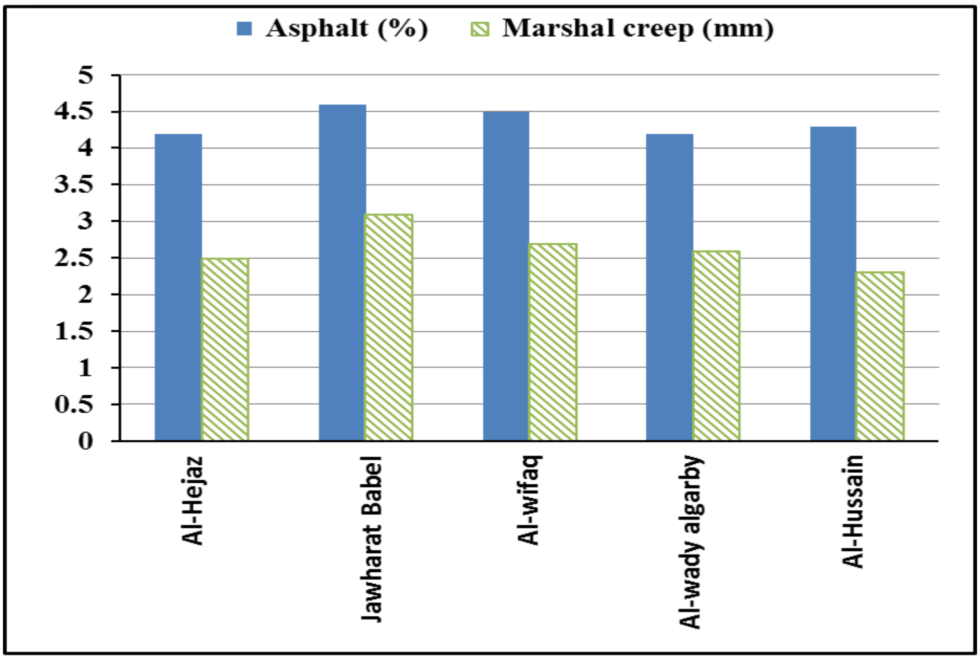


**Figure (8): Relationship between Asphalt (%) and Marshall creep (mm)**

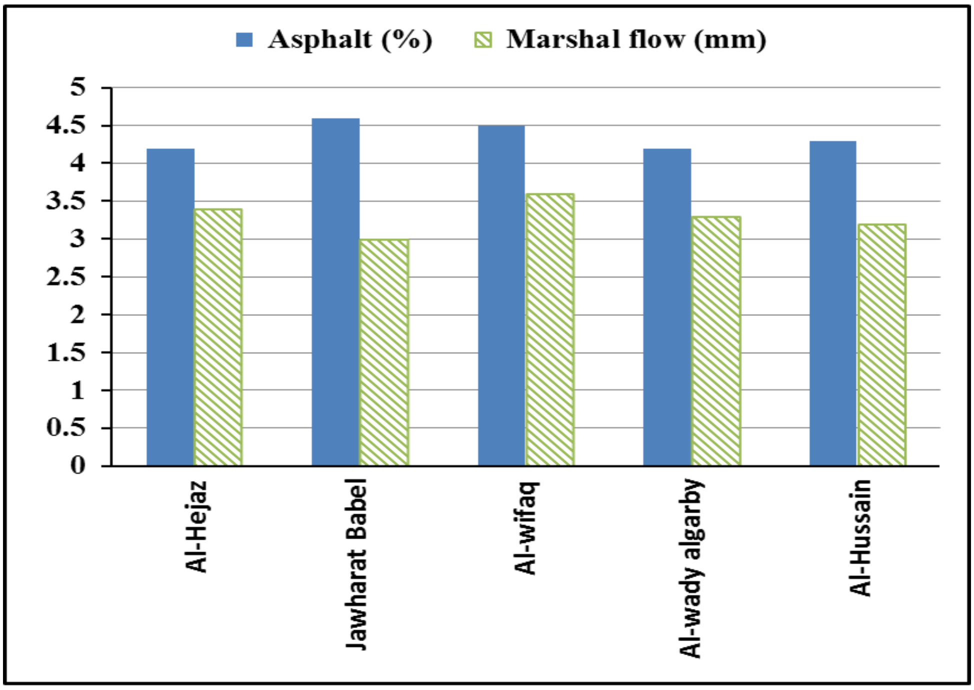


**Figure (9): Relationship between Asphalt (%) and Marshall flow (mm)**

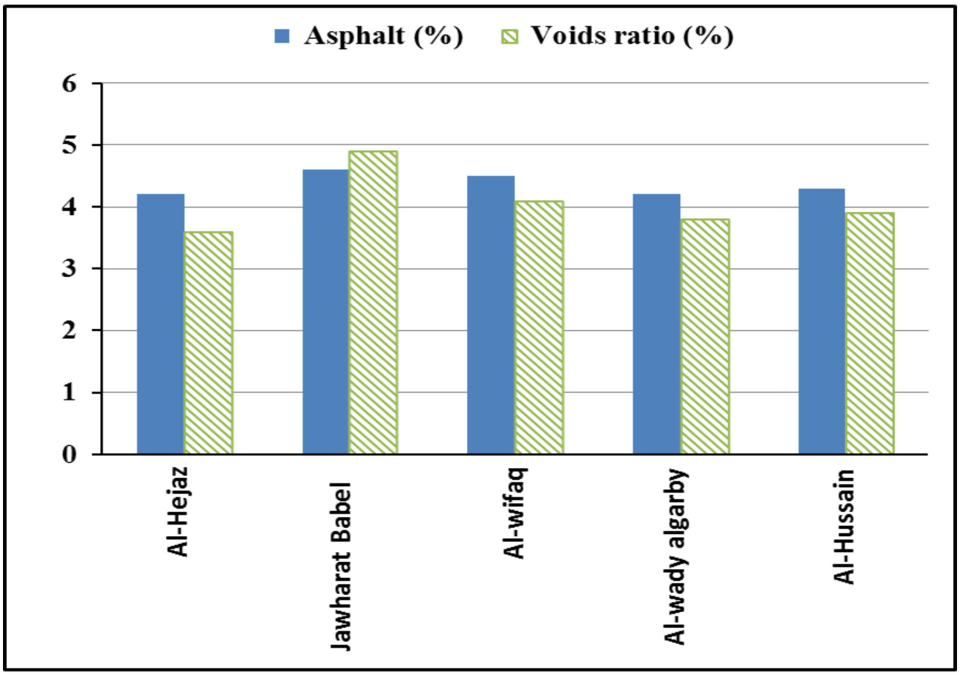


**Figure (10): Relationship between Asphalt (%) and Voids ratio (%)**

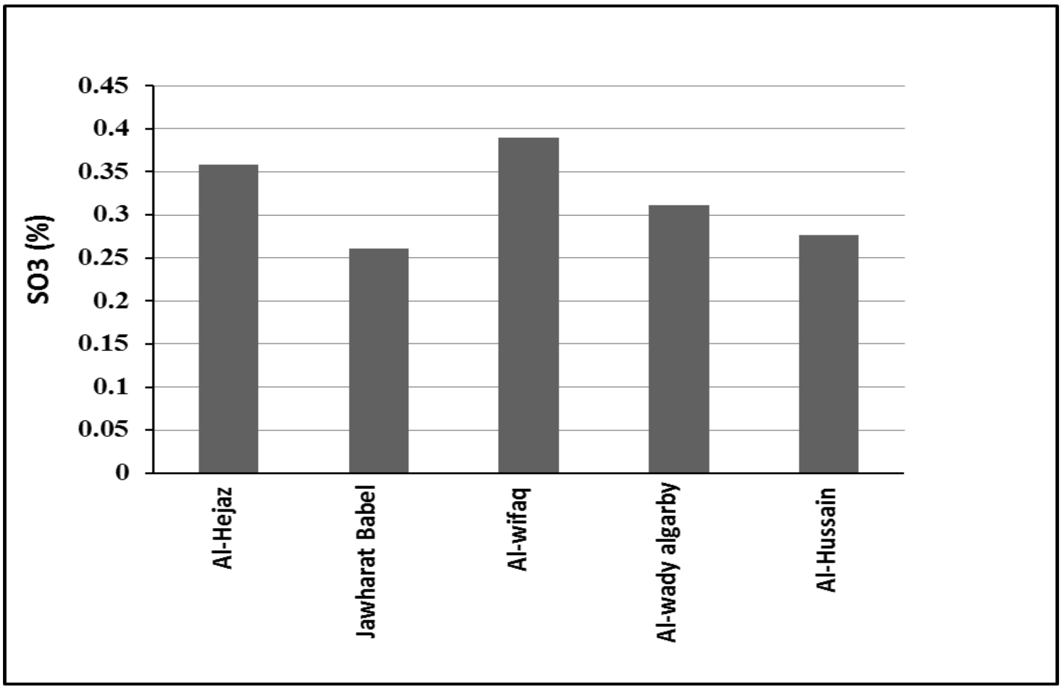


**Figure (11): SO3 percent for different asphalt factories samples**

## Conclusions

Based on the present research, the following conclusions can be drawn:

1- Increasing asphalt percent led to increasing flow, creep and voids ratio of asphalt mixes.

2- High density of asphalt mixes led to high Marshall stability.

3- All types of asphalt mixes conform to the Iraqi limits.

## Recommendations

The circumstances which help to reduce the effect of the properties of asphalt as a result of (oxidation, evaporation, effect of light waves, and the age of asphalt) will be through:

1- The use of the highest possible degree of asphalt liquidity.

2- Reducing the air voids percentage in the asphalt mixes to reduce internal oxidation (interaction between oxygen and asphalt), which increases the stiffness of asphalt and thus be more likely to break, and becomes brittle material less resistance to cracking and easy separation of the aggregate under the influence of traffic loads.

3- Using the least possible temperature when heating the asphalt in the hot mix asphalt concrete as the high temperature reduces the asphalt life because of the rearrangement of asphalt molecules in the asphalt mixes.

4- More work is needed to get better understanding of the effects of recycled materials on the binder mix properties as they relate to creep compliance and tensile strength.

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