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The Influence Of Fly Ash On The Engineering Properties Of Asphalt And Hot Mix Asphalt

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Abstract

The objective of this paper is to study the effects of adding fly ash filler on the properties of asphalt and hot mix asphalt. Four percentages of hot mix asphalt were used, the first mixture is not adding any filler, second mixture by adding 7% filler limestone, the third and fourth mixture adding the fly ash filler at rates of 3% and 5%, respectively. Also the same mentioned percentages of filler were added to asphalt. The study also dealt with compared to the intensive laboratory test results between the four asphalt mixtures with each other and with the standard specifications for asphalt mixtures. The study also addressed the material cost estimate for the material fly ash filler compared to limestone filler. The results have shown that, the first mixture gave poor results due to the high percentage of air voids and low relative stability, the second mixture gave acceptable in terms of stability and Flow and air voids results, the third mixture has showed good characteristics except relatively high air voids and the best results were found in the fourth mixture according to the specifications.

Key Words: *fly ash, asphalt and limestone*

1. INTRODUCTION

Roads are considered the most construction projects important because they direct to affect economic, social, political, cultural and other side. Road construction projects are more expensive projects because of the high cost of materials used in the construction of the road and include all of the layers and heavy machinery operating in the transportation, distribution and compaction operations in addition to the surface layer, which is the most expensive of all the components of materials [1], and is considered the asphalt the most expensive element of the components the surface layer and the reason that the asphalt imported certain specifications and the cost of deportation also material a prominent role in the total cost [2].

The filler is a surface layer components play a major role in the quality of the surface layer, the main role of the filler is that they are with asphalt paste asphalt that work on linking the mixture components of asphalt throughout the lifespan, and thus whenever the Badra used good properties whenever they mix asphalt properties are good, and vice versa, Thus whenever the filler characteristics of a good used whenever they mix asphalt properties are good, and vice versa, local filler (limestone) are considered filler of not so good properties the plasticity index is relatively high, fine properties (passing sieve No. 200) large, these characteristics result in poor properties mix asphalt as a whole, so it was interesting research study another type of filler called fly ash which filler imported from China, which is already one of the additives and concrete admixtures this powdered material likeness with cement and now used in the Merowe Dam [3 - 5].

2. MATERIAL, TEST PROCEDURES AND RESULTS

This study based on the experimental method through the work of laboratory testing to study the effects of filler to asphalt and hot mix asphalt properties were four initial

mixes asphalt, the first mixture is not adding any filler, second mixture by adding 7% filler limestone, the third and fourth mixture adding the fly ash filler at rates of 3% and 5%, respectively, has also been added the same percentage of filler to asphalt, Were compared to the results obtained from the laboratory test Marshall for standard asphalt concrete results and these results include all of stability, Flow, density, air voids, percent voids in mineral aggregates (VMA) and Voids Filled with Asphalt (VFA). It was also added fly ash and limestone filler to asphalt in the same ratios participation in the asphalt mixture to see the effect of filler to asphalt properties, The following are the results of laboratory tests performed on the asphalt; penetration test and softening point test, final results have shown on the all asphalt mixtures, were analyzed by using Excel program software.

From the test results shown in Table 1 it is clear that when you add fly ash filler with the same ratios in the hot mix asphalt, the degree of penetration less than from (60-70) to (40-60) penetration unit and therefore fly ash filler considered one of the additives asphalt, which help reduce the degree of penetration, and the areas of high-temperature heat such as Sudan, the asphalt with a low degree of penetration favorite so these filler very favorite of Sudan because of the high temperature. And we also find that the limestone filler perform the same function, but by less than fly ash filler.

Table - 1: Test results of asphalt when filler used.

Type & percentage of filler	Penetration test (0.1 mm)	Softening point test (C°)
Without filler	(60 – 70), 53	53
Fly ash 5%	(40 – 60), 57	59
Lime stone 7%	(40 – 60) , 59	56

Also from the results shown in the Table 1 it is clear that when you add fly ash filler with the same ratios in the hot mix asphalt, the degree of softening point has increased from 53C° to 59 C° and therefore this fly ash filler is one of the improved material characteristics of asphalt raising the level of softening point, and in Sudan prefer to be the degree of high softening point because of the high temperature, And we also find that the addition of limestone filler raise the degree of softening point from 53C° to 56C°, a degree less than the degree of softening point when you add fly ash filler to asphalt.

2.1 Asphalt mix design without filler

Table 2 and Figures 1 to 5 are presented the test results of marshal hot mix asphalt without filler.

Table - 2: Results of marshal hot mix asphalt (without filler).

AC	STABILITY	FLOW	DENSITY	VA	VMA	VFB
4.0	1037.0	4.8	2.393	9.3	17.5	46.9
4.5	1109.0	4.9	2.406	8.1	17.5	53.6
5.0	1237.0	5.2	2.421	6.8	17.3	60.6
5.5	1197.0	5.4	2.410	6.7	18.2	63.3
6.0	1081.0	5.6	2.400	6.3	18.8	66.6

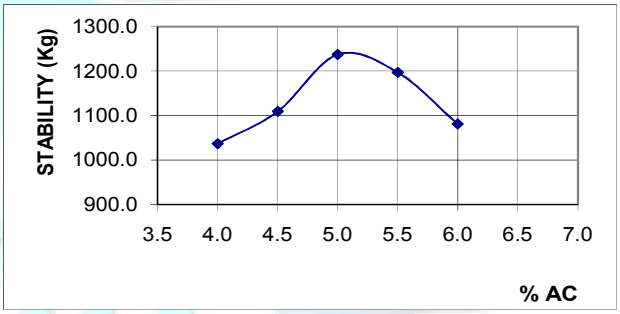

Fig – 1: Stability Curve (mix asphalt without filler)

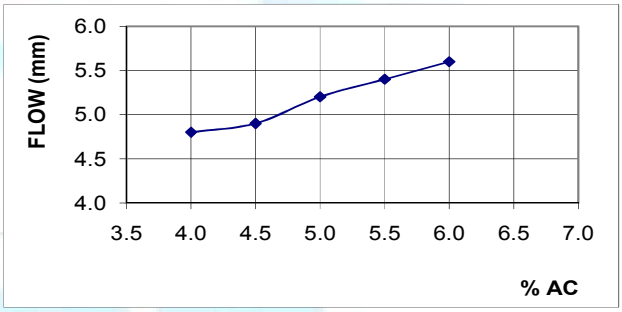

Fig – 2: Flow Curve (mix asphalt without filler)

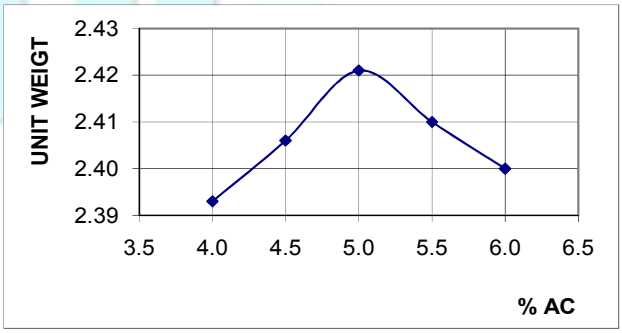

Fig -3: Unit weight Curve (mix asphalt without filler)

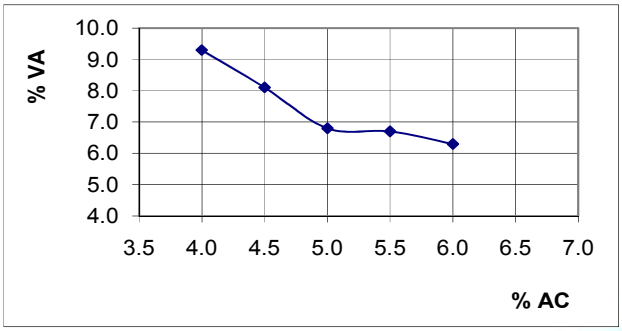

Fig – 4: Air voids Curve (mix asphalt without filler)

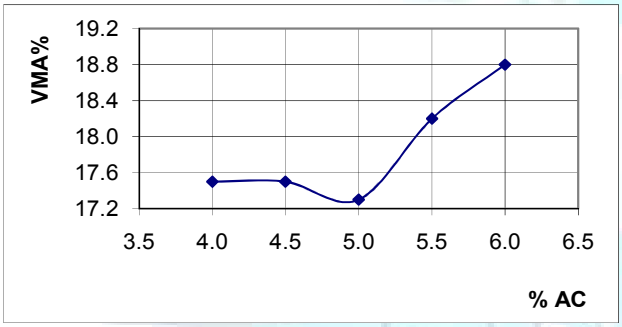

Fig – 5: VMA Curve (mix asphalt without filler)

2.2 Asphalt mix design in the case of using the limestone filler

Table 3 and Figures 6 to 10 are presented the test results of marshal hot mix asphalt with limestone filler 7%.

Table - 3: Results of marshal hot mix asphalt (limestone filler 7%).

AC	STABILITY	FLOW	DENSITY	VA	VMA	VFB
4.0	1080.0	2.8	2.385	8.1	16.2	50.0
4.5	1215.0	3.1	2.381	7.6	16.7	54.8
5.0	1270.0	3.5	2.384	6.9	17.0	60.0
5.5	1527.0	3.7	2.415	4.9	16.3	70.0
6.0	1225.0	3.9	2.400	4.8	17.2	72.3

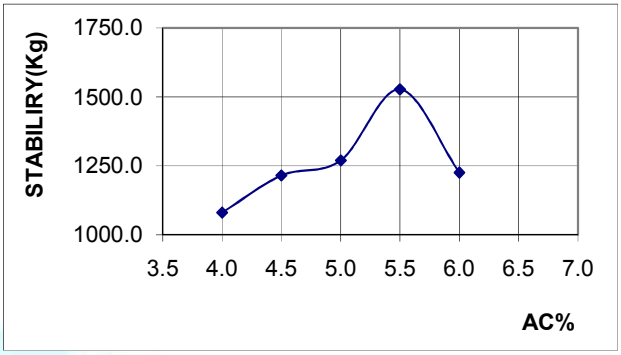

Fig – 6: Stability (hot mix asphalt limestone filler 7%).

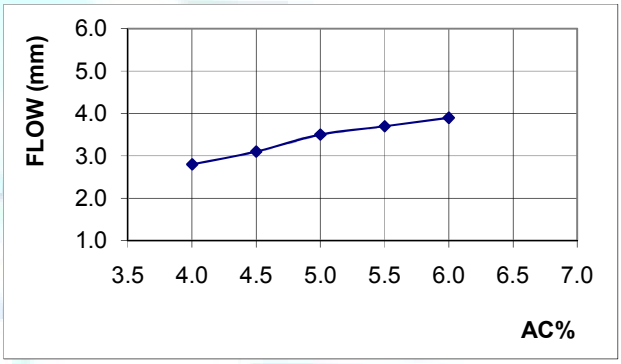

Fig -7: Flow (hot mix asphalt limestone filler 7%).

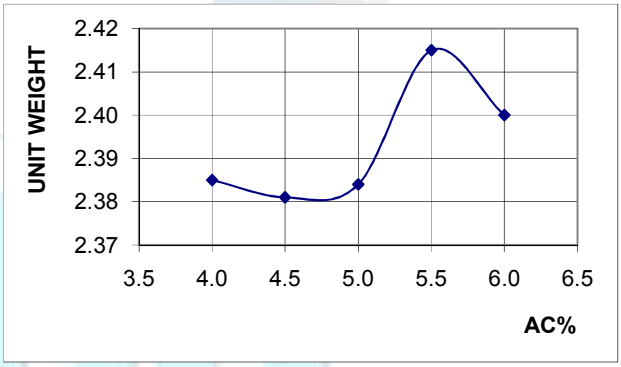

Fig – 8: Unit weight (hot mix asphalt limestone filler 7%).

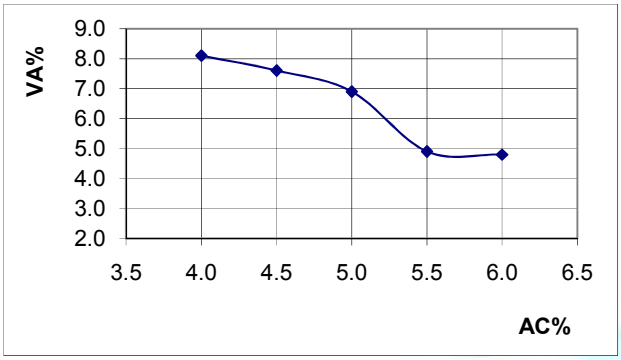

Fig – 9: Air voids (hot mix asphalt limestone filler 7%).

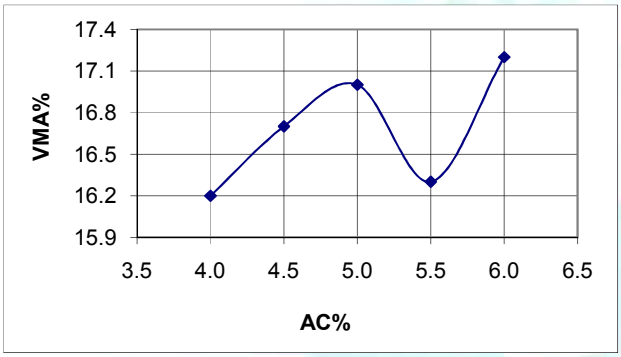

Fig – 10: VMA Curve (hot mix asphalt limestone filler 7%).

2.3 Asphalt mix design in the case of using the fly ash filler (3%)

Table 4 and Figures 11 to 15 are presented the test results of marshal hot mix asphalt with fly ash filler 3%.

Table - 4: Results of marshal hot mix asphalt (fly ash filler 3%).

AC	STABILITY	FLOW	DENSITY	VA	VMA	VFB
4.0	1266.0	2.3	2.400	8.5	16.6	49.2
4.5	1298.0	2.6	2.413	7.3	16.5	55.9
5.0	1343.0	3.0	2.428	6.3	16.7	62.1
5.5	1288.0	3.3	2.408	6.1	17.5	65.2
6.0	1269.0	3.7	2.407	5.5	18.0	69.2

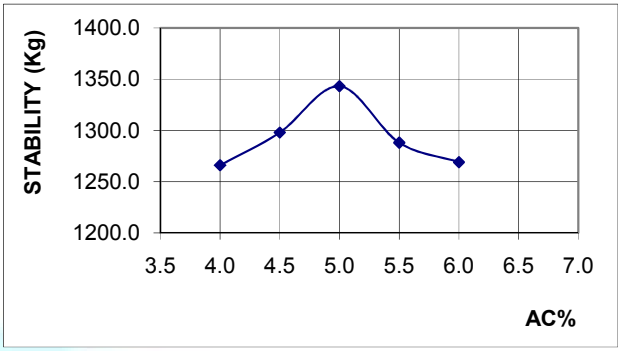

Fig – 11: Stability curve (hot mix asphalt fly ash filler 3%).

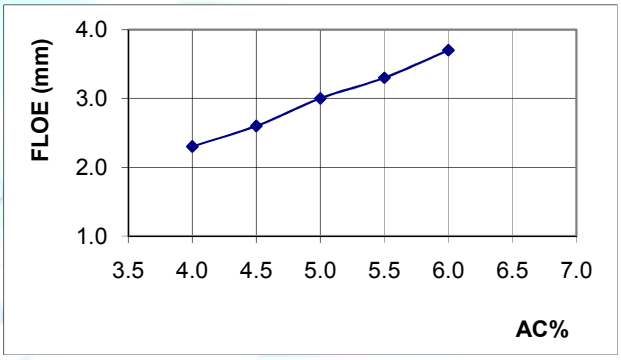

Fig – 12: Flow curve (hot mix asphalt fly ash filler 3%).

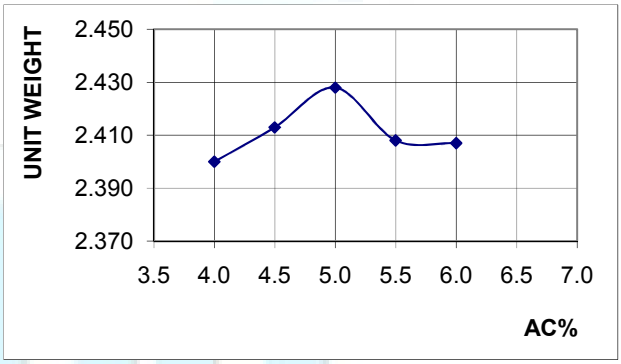

Fig – 13: Unit weight (hot mix asphalt fly ash filler 3%).

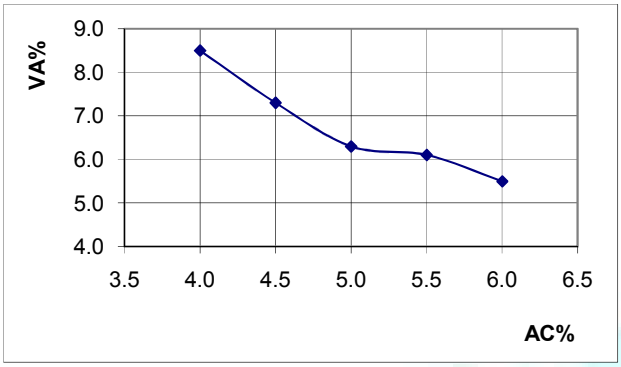

Fig – 14: Air voids (hot mix asphalt fly ash filler 3%).

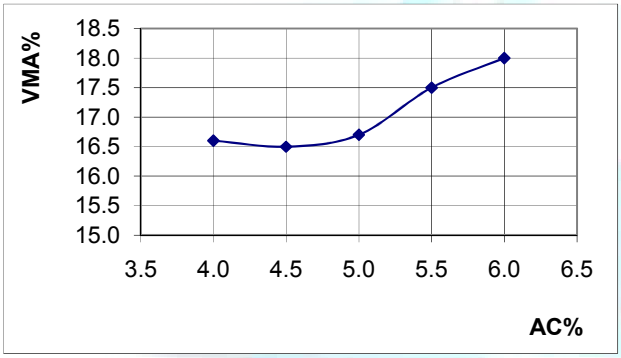

Fig – 15: VMA curve (hot mix asphalt fly ash filler 3%).

2.4 Asphalt mix design in the case of using the fly ash filler (5%)

Table 5 and Figures 16 to 20 are presented the test results of marshal hot mix asphalt with fly ash filler 5%.

Table 5: Results of marshal hot mix asphalt (fly ash filler 5%).

AC	STABILITY	FLOW	DENSITY	VA	VMA	VFB
4.0	1783.0	3.7	2.445	6.3	14.6	57.0
4.5	1561.0	4.0	2.465	5.0	14.5	65.2
5.0	1923.0	4.3	2.476	3.7	14.3	74.4
5.5	1244.0	4.5	2.457	3.7	15.3	75.8
6.0	1150.0	4.6	2.445	3.6	16.3	77.7

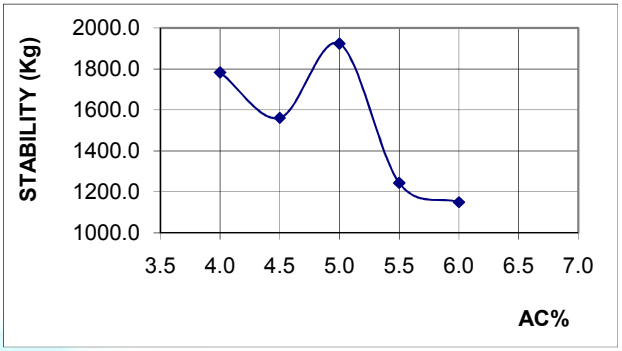

Fig – 16: Stability curve (hot mix asphalt fly ash filler 5%).

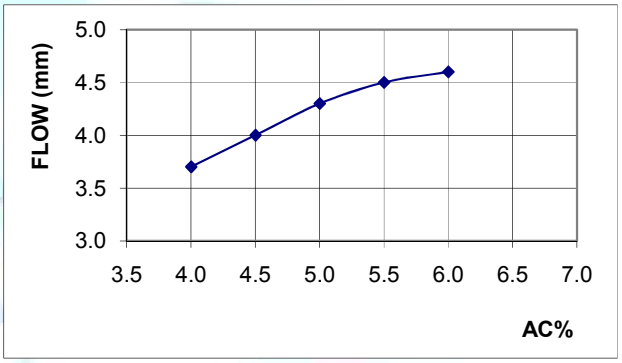

Fig – 17: Flow curve (hot mix asphalt fly ash filler 5%).

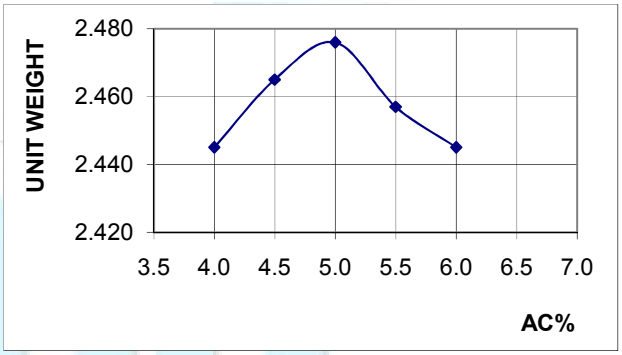

Fig – 18: Unit weight (hot mix asphalt fly ash filler 5%).

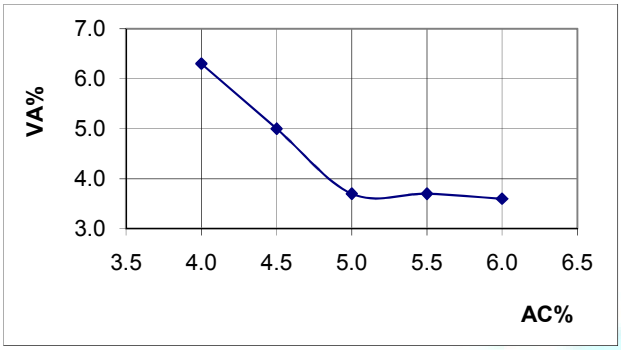

Fig – 19: Air voids (hot mix asphalt fly ash filler 5%).

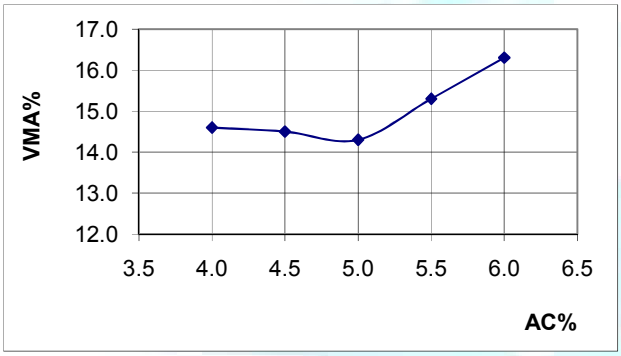

Fig – 20: VMA curve (hot mix asphalt fly ash filler 5%).

3. DISCUSSION OF THE RESULTS

And to simplify the process of analyzing the results were taken from all the properties of asphalt concrete mixtures of four each property alone and compared each property with the properties of standard asphalt mixes.

3.1 Discussion of the Stability

Stability curves of the four hot mix asphalt used fly ash filler 5% is the highest (1923 kg) as shown in Fig 21 and therefore this mix is the best in terms of reliability.

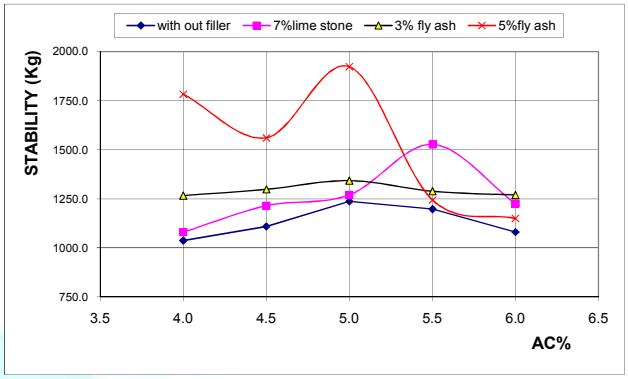

Fig – 21: General Stability Curves

3.2 Discussion of the Flow

Flow curve of the four hot mix asphalt used fly ash filler 5% is the best as shown in Fig 22 because the value of Flow is the average value. As the value of high-Flow cause the rutting and Depression, and the value of low-Flow causing stiffness on mix asphalt.

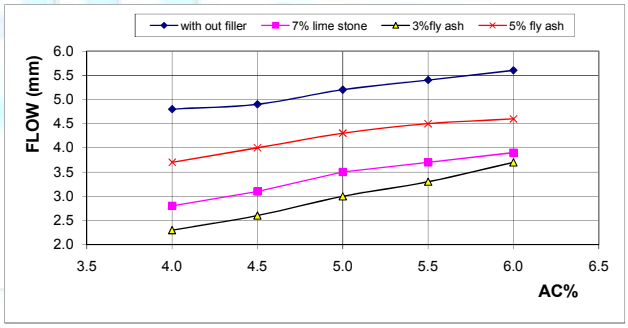

Fig – 22: General Flow Curves

3.3 Discussion of the Unit weight

Unit weight curves of the four hot mix asphalt used fly ash filler 5% gives the highest value of unit weight as shown in Fig 23. The unit weight is inversely proportional to the air voids and therefore this mixture is considered less mix in terms of the air voids and the reason for increasing the unit weight is included soft filler who helps it to fill in most of the voids.

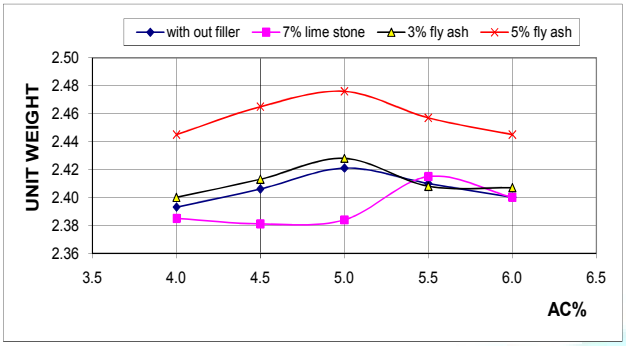

Fig – 23: General Unit weight Curves

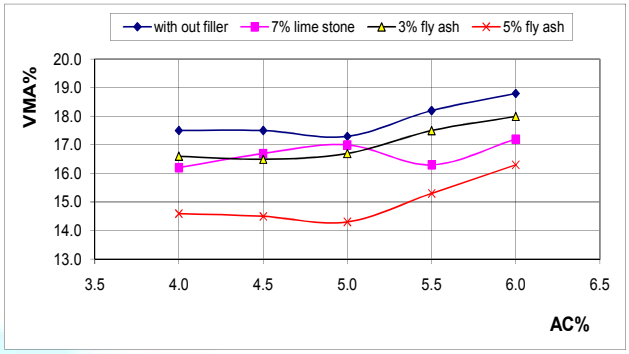

Fig – 25: General VMA Curves

3.4 Discussion of the Air voids (VA)

Air voids curves of the four hot mix asphalt used fly ash filler 5% is the lowest and best as shown in Fig 24. And the lack of air voids meant for the lack of permeability and thus guarantees no water and air entry into the pavement.

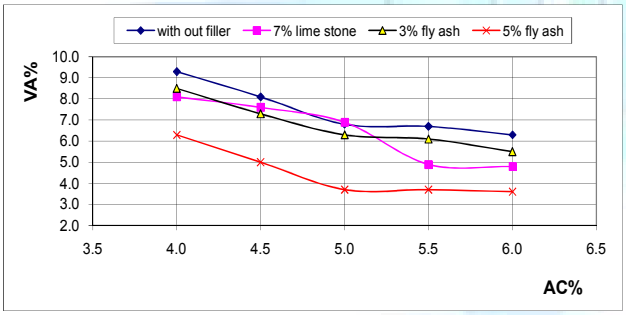

Fig – 24: General Air voids Curves

3.5 Discussion of the percent voids in mineral aggregates (VMA)

percent voids in mineral aggregates (VMA) curves of the four hot mix asphalt used fly ash filler 5% is the minimum and is better as shown in Fig 25, it is better that the percent voids in mineral aggregates is low because increase this percentage impact on the content of asphalt and asphalt will enter into aggregate instead of connecting the components of asphalt mixture.

4. CONCLUSIONS

Through the results of the study of the four hot mix asphalt and also by comparing the cost of the four mixtures is clear that the hot mix asphalt used fly ash filler 5% gave the best results in terms according to the specifications and at the same time, this mixture is considered the most expensive and the cost difference is not much compared to the high cost of the road, especially when taking into account the results obtained when using these filler.

The study concluded the following points:

1. Four hot mix asphalt mixtures were showed suitable stability of the patients (above the minimum 850 kg), and if you use the fly ash filler 5%, the stability was very high (1923.0 kg).
2. Flow in the four mixtures suitable (except for the mixture that did not use the filler).
3. Air voids in the second mixture (used limestone filler) is suitable and very suitable in the fourth mixture (used fly ash filler 5%), but in the first mixture (without filler) and third mixture (used fly ash filler 3%) the large air voids and non-conforming ratio.
4. Percent voids in mineral aggregates (VMA) in the four mixes are suitable and conform to the specifications.
5. Voids Filled with Asphalt (VFA) suitable if you use the lime stone In the case of the use of the fly ash 5%, but in case of non-use of filler and if you use the fly ash 3%, the Voids Filled with Asphalt (VFA) is unacceptable and nonconforming.
6. When the fly ash filler was added to Asphalt, it found decreased degree of penetration and increase the degree of softening point. The contribution of these results found that the fly ash

filler is working to improve the properties of the asphalt.

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