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Hot Mix Asphalt Using Light Weight Aggregate Concrete

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Abstract: Hot mix asphalt concrete is produced by properly blending asphalt, coarse and fine aggregates in addition to filler at temperatures ranging from 80 to 165°C. This research is directed to study the effect of replacing the conventional aggregates by the recycled Light Weight Aggregate Concrete (LWAC) on the properties of the produced asphalt mix. The research studied the optimum asphalt content and the effect of some parameters on the properties of the recycled LWAC. The research included studying thirty-six Marshal Specimens lie in four main groups. Each group was made from crushed LWAC in addition to a comparison group used the pumice instead of the crushed LWAC. The LWAC mixes contained (0, 10, 15 and 20%) of silica powder content. The density, stability, flow, percentages of the air Voids in the Compacted Mixture (VTM), compacted mineral aggregate (VMA) and the Voids Filled by Asphalt (VFA) were investigated for all the studied specimens. The main conclusions drawn from the current research implies that the optimum percent of asphalt was 7.5% for the different percentages of silica powder ratios. The presence of voids in the light weight aggregates and the porosity of the obtained concrete affected largely the behavior of the obtained mix.

Key words: Asphalt, concrete, roads

INTRODUCTION

Lots of money is spent on the construction and maintenance of hot asphalt pavement roads. Aggregates constitute more than 90% of the weight of the HMA mixes. So, it is of great importance to search for other alternatives of using the conventional aggregates. This research is directed to study the effect of using light-weight aggregates in hot mix asphalt as a replacement for the conventional aggregates. The light-weight aggregates are used in two forms: Natural (pumice) aggregates and artificial (crushed light weight aggregates concrete).

Despite the fact that the decrease in the unit weight of aggregates is accompanied by a decrease in mechanical strength of the conventional aggregate, the HMA can be used in construction roads subjected moderate axle loads.

A number of works were found in literature to study the effect of using light weight aggregates on the properties of the produced LWAC. Among those, Rjoub and Awwad (2005) studied the effect of using silica powder on the properties of LWAC (in which the pumice was used as a concrete aggregates). Different percentages of silica powder ranged from zero to twenty percent were used. The results showed that both the compressive strength and the unit weight of the obtained LWAC increased as the percentage of the added silica increase up to the optimum percentage that was found 15% of the cement weight.

The demolition of concrete structures leaves large amounts of crushed concrete that in role may cause environmental problems. This research presents an attempt to substitute the aggregates that is used in the HMA by a crushed LWAC. So, the present study is conducted to cover a two fold objectives. The first is to obtain the optimum proportion of the LWAC mixes and the second is to study the different properties of the obtained mixes as a paving material.

Hence, the crushed LWAC resulting from the works of Rjoub and Awwad (2005) was crushed and reused as aggregates in a HMA and the properties of the obtained mixes were compared with those of mixes containing pumice as a HMA aggregates.

MATERIALS AND METHODS

An experimental program is conducted in the labs of Civil Engineering Department at Al-Balqa Applied University in the year 2006. The program consisted of testing the properties of the crushed pumice and Light Weight Aggregate Concrete (LWAC) used as an aggregate. The stability, flow, density and the other parameters of Marshal's tests are studied for two types of asphalt hot mixes. The first used the crushed pumice as a mix aggregate while the crushed LWAC substituted the pumice in the second one.

The LWAC that was used Rjoub and Awwad (2005) was crushed (recycled), sieved and used as an aggregate in the Hot Mix Asphalt (HMA).

Table 1: Absorption and specific gravity of crushed coarse aggregates made of LWAC

Silica (%)[1]	Absorption[2]	Bulk specific gravity[3]
0	12.4	1.72
10	12.1	1.74
15	12.1	1.73
20	12.2	1.71

Absorption and specific gravity of crushed fine aggregates made of LWAC

Silica (%)	Absorption (%)	Bulk specific gravity
0	32.05	2.14
10	31.46	2.14
15	31.76	2.15
20	31.79	2.15

[1]Silica (%): Weight of silica as a percentage of the cement content. [2]Absorption: The ratio of the weight of water in a saturated dry surface condition to the dried aggregate weight. [3]Bulk specific gravity: The ratio of the dried aggregate to the weight of the same volume of water

The LWAC mix (Rjoub and Awwad, 2005) was prepared using type I Portland cement and volcanic aggregates (pumice) with maximum aggregate size of 19 mm. The mechanical resistance of pumice was tested by the Los Angeles abrasion machine and lead to 32.2% abrasion. The absorption, specific gravity (saturated surface dry) and the unit weight of the aggregate were tested according to the ASTM (1986) C127, C128 and C29 and found equal 0.32%, 1.69 and 1330 kg cm^{-3}, respectively. The proportions per one cubic meter of concrete mix were: 300 kg cement, 92 kg sand, 275 kg fine pumice, 728 kg coarse pumice, mixed with 195 L of waters. The mix was prepared using water to cement ratio of 0.65.

In the current research, the crushed LWAC was sieved and classified to fine and coarse aggregates. The properties of this aggregate were studied and the results are summarized in the Table 1.

RESULTS AND DISCUSSION

The acceptance tests on the aggregates and asphalt cement of HMA should pass the procedure included in the ASTM D1559, Resistance to Plastic Flow of Bituminous Mixtures Using the Marshal Apparatus. The Marshal Criteria includes minimum amount of Voids in the Mineral Aggregates (VMA), a range of acceptable air void contents, a minimum stability and a range or flow value. And in sometimes the percent of Voids Filled with Asphalt (VFA) should be within a specified range. In addition to the field density requirements that can be achieved by increased compaction, increased asphalt content, increased filler content or any method that reduces the voids (Roberts *et al*., 1991). So the Marshal tests of this study included studying the density, stability, flow, the Voids in Total Mix (VTM), Voids in the Mineral Aggregates (VMA) and the voids filled with asphalt (VFA) for the prepared specimens.

Marshal tests on crushed LWAC

Density: Figure 1a shows the density of a HMA of crushed LWAC containing different values of silica content with different percentages of asphalt content ranging from 7 to 8%. The concrete mixes containing silica powder content ranging from 0 to 20%.

The Fig. 1a shows that increasing the silica content decreases the mixture density. The optimum unit weight was attained for mixtures that have a binder content of 7.5% whether the mix contain or have no silica.

Mix stability: The Fig. 1b shows that increasing the silica content, leads to slight increase in the mixture stability up to the optimum asphalt content (where the stability starts to decrease. The Fig. 1b shows similar trend for all the silica content mixes accept for zero percent mix that maybe attributed to the accuracy of result of specimens corresponding to 7.5% AC.

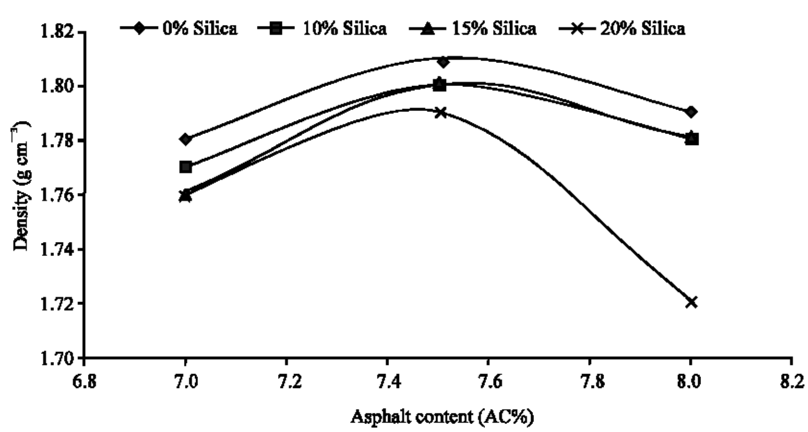

Fig. 1a: Silica density vs asphalt content (AC%)

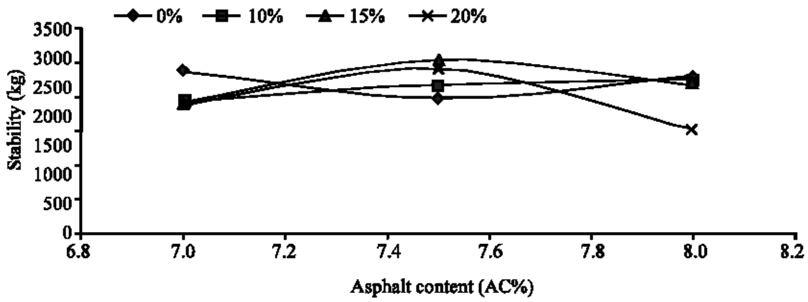

Fig. 1b: Stability vs asphalt content

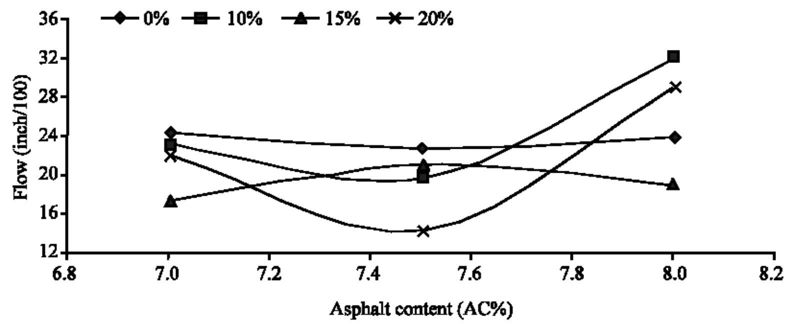

Fig. 1c: Flow vs asphalt content (1 inch = 25.5 mm)

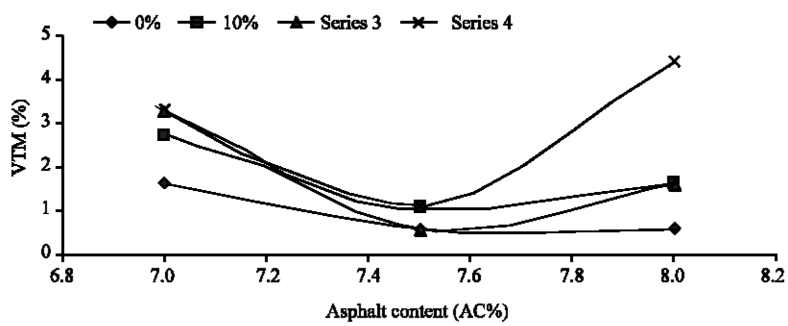

Fig. 1d: VTM vs AC%

Mix flow: The mix flow of the crushed LWAC is tested for the same mixes and plotted in Fig. 1c. The plot shows that adding silica powder to the concrete mix at the optimum binder content (7.5%) decreases the flow of the mixtures. As the Silica contents increase the flow decreases.

The voids in total mix (VTM): The total mix (VTM) versus the AC% for the LWAC are plotted in Fig. 1d.

The plots show that adding the Silica to the mixture lead to increases the VTM. At the optimum binder content of 7.5% and when adding Silica by 20%, the VTM of the mixtures increased by 0.5% at Binder content of 8% and when adding 20% of Silica, the VTM increased by 4% compared with mixtures with no Silica. In general, as the Silica contents increase the VTM increases.

The VMA and VFA: The Voids in the Mineral Aggregates (VMA) and the Voids Filled with Asphalt (VFA) vs AC% for different percentages of silica powder are plotted in Fig. 1e and f.

Figure 1e shows that adding the silica to the mixture lead also to increasing the VMA. At the optimum binder content of 7.5% and when adding Silica by 20%, the VMA of the mixtures increased by 1%. At Binder content of 8% and when adding 20% of Silica, the VTM increased by 4%

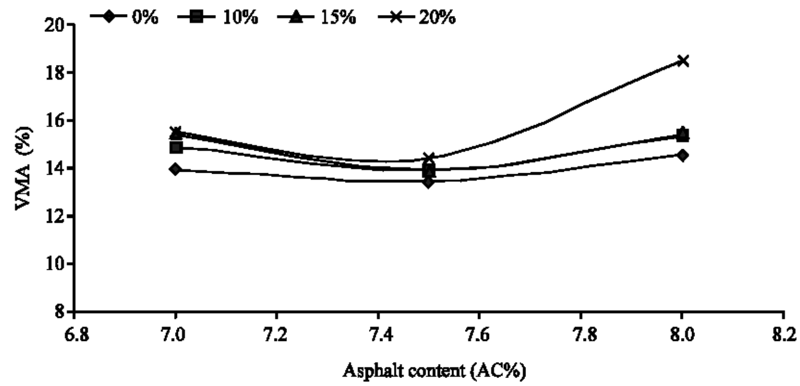

Fig. 1e: VMA vs AC%

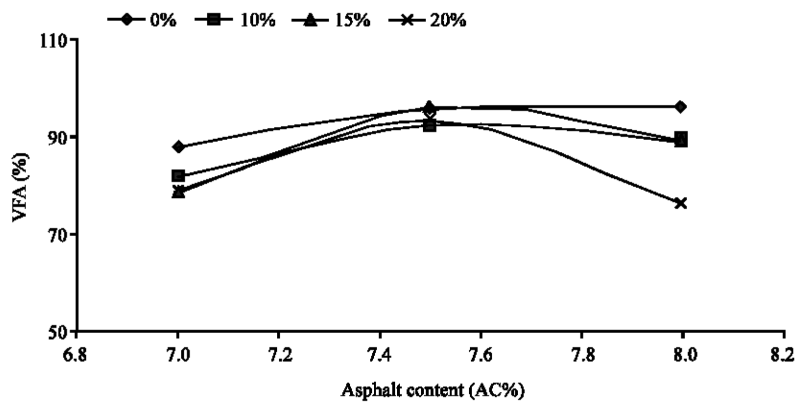

Fig. 1f: VFA vs AC%

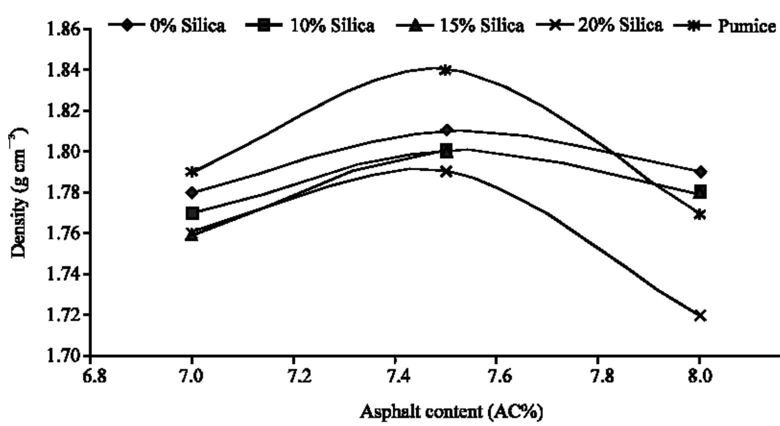

Fig. 2a: Mix density vs AC%

compared with mixtures with no Silica. In general, as the Silica contents increase the VMA increases.

On the other hand, Fig. 1f shows that the presence of silica powder in the concrete mix lead also to decreasing the VFA. At the optimum binder content of 7.5% and when adding Silica by 20%, the VFA of the mixtures decreased by 2%. At Binder content of 8% and when adding 20% of Silica, the VFA decreased by 20% compared with mixtures with no Silica. In general, as the Silica contents increase the VFA decreases.

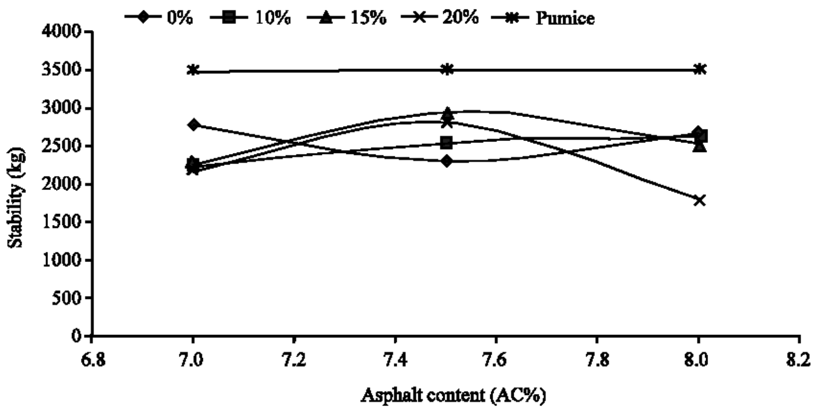

Fig. 2b: Mix density vs AC (%)

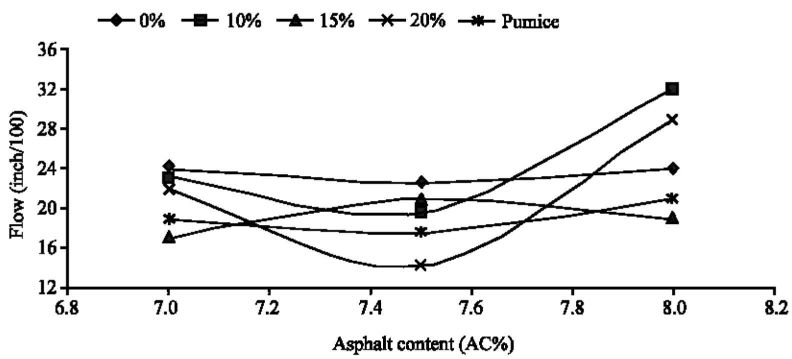

Fig. 2c: Mix flow vs AC% (1 inch = 25.5 mm)

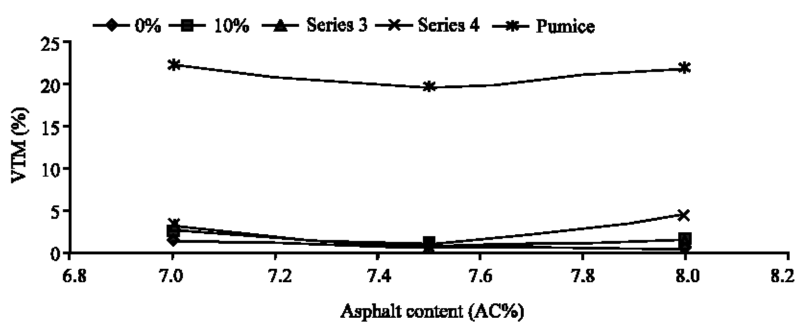

Fig. 2d: VTM vs AC% of the mix

Comparison of HMA with pumice aggregate instead of the crushed LWAC: The following plots compare the density, flow, VTM, VMA and VFA for hot asphalt mixes containing pumice aggregate instead of using crushed LWAC.

- The Fig. 2a-f show similar trend of what it was found in the mixes of crushed LWAC. The optimum AC% is about 7.5%.
- Using pumice instead of LWAC leads to greater density for the various Silica content.
- The maximum stability for mixes of crushed LWAC with various silica contents are less than those prepared with pumice.
- The plots show that as the silica contents increase the flow decreases. Mixtures prepared with Pumice shows lower values of flow compared with those of LWAC.

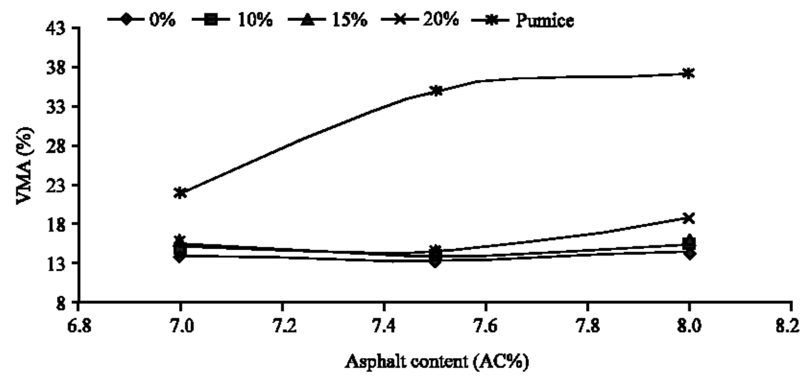

Fig. 2e: VMA vs AC% of the mix

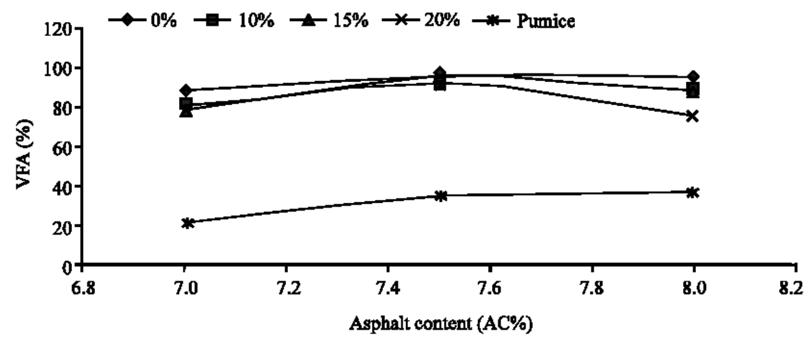

Fig. 2f: VFA vs AC%

- A large increase in the VMA is obtained for Pumice mixes compared with the LWAC mixes. On the contrary, a large reduction in the VFA is found for the pumice mixes compared with the LWAC mixes.

Marshal stability: The Marshal stability, which represents a measure of a mass viscosity of the aggregate-asphalt cement mixture, is defined as the maximum load carried by a compacted specimen tested at 60°C at loading rate of 50 mm min^{-1}. It is affected generally by the angle of internal friction of the aggregate and the viscosity of the asphalt cement at 60°C.

CONCLUSIONS

The following conclusions can be drawn from this research work

- The optimum asphalt content was 7.5% for all the studied HAM, whether the used aggregates were of pumice or crushed LWAC.
- The increase in the silica content in the crushed LWAC mixes leads to the following changes in the obtained mix properties: Decreases the mix density, flow and VFA. While it increases the VTM, VMA and slightly the stability.
- Compared with the crushed LWAC, using the pumice as a mix aggregates leads to increasing the VMA and the VTM in addition to the stability and a decrease in the flow and the VFA.
- The results showed that the crushed LWAC can substitute the aggregates in HMA with acceptable properties.

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