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Influence of Fillers on Paving Grade Bitumen

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ABSTRACT. This study is about the effect of fillers on paving grade bitumen under various conditions. The basis of the thesis is to find out change in the physical properties of the bitumen by modifying it with different fillers. The types of fillers used in project are Cement, Fly ash and Stone dust. Fillers help in filling the voids and change the physical and chemical properties. Fillers modify the properties, increase the performance of, and provide improved Durability to various construction materials (Such as concrete and asphalt). The effects of fillers are therefore of vital importance. When bitumen is combined with filler, mastic is formed. This mastic can be viewed as the component of the asphalt mixture that binds the aggregates together and also the component of the asphalt that undergoes deformation when the pavement is stressed under traffic loading. The characteristics of the filler can significantly influence the properties of the mastic, and thus the filler properties can have significant effects on asphalt mixture performance. Different percentage of fillers is used to modify the bitumen. Various physical tests were conducted on Virgin and Modified Bitumen to evaluate its physical properties. Marshall Test was conducted on bituminous mix prepared using modified and Virgin Bitumen and the results were analysed and compared. The study indicated that use of fillers improves the physical properties of Bitumen. Further it also indicated that use of fillers improves Marshall Stability and Flow in the bituminous mix

KEYWORDS: Mastic, Deformation, Marshall Test, Stability, virgin, modified.

I. INTRODUCTION

Pavement is a durable coating laid in the targeted area to support vehicles or pedestrians. In the past, widespread use of cobblestones and granite was made, but now these surfaces are mostly replaced by asphalt or concrete. Road surfaces are regularly marked to guide vehicular traffic. Fillers modify the properties, accelerate the performance, and offer greater durability to composites, polymers, rubber, adhesives, coatings and building materials (such as concrete and asphalt). Fillers are used to reduce the cost of materials, increase the stiffness and provide special features to a material (such as colour or fireproof). The effects of fillers are therefore crucial

Typical fillers are fine powders having particle size less than 75µm. Fillers can be naturally occurring like calcium carbonate, manufactured or derived from industrial waste such as fly ash from power plant. Other conventional fillers include silica, kaolin, mica, and silica materials. Fillers modify the system in two ways. Firstly, the manner in which shape, particle size and the size distribution of the particles of the filler affect the system by filling the liquid with solid particles. Secondly, the way that the interactions between the solid and liquid phase of the mixture meets the material. Second interactions may vary by strong chemical bonds or physical interactions leading reinforced materials strength. Asphalt is a vital building material. Most of the roads are built or paved with asphalt. In 2003, about 300 million tons of asphalt was produced in Europe and 500 million tons in the United States (EAPA, 2004). The effect of repeated stress manifests itself in two ways, permanent deformation, commonly known as "rutting" and "cracking", due to fatigue of asphalt.

The asphalt is composed of three major components; aggregates, binder and fillers. The relationship between these different components leads to a family of asphalt mixtures with different properties. HMA typically includes a proportion of air, which is often regarded as the fourth component. Minimizing the amount of air through the proper design and a proper compaction is essential to ensure a durable product. Furthermore, very little air, caused by overfilling aggregate structure can lead to rutting. The most commonly used filler in asphalt is limestone (Kavussi and Hicks (1997)), which is derived from microorganisms during the formation of the crust. Limestone is the general term for the rocks in which the form of calcite is predominant mineral. Limestone may also contain a proportion of

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magnesium carbonate, silica, clays, iron oxides and organic matter. Basically, gaps/voids are measured in the air and do not take into account the interactions between bitumen and filler. Charge interactions in the different types of bitumen can lead to changes in different ways. The filler may cause variations in the viscosity of the liquid phase as a result of the restructuring, changes or other physical effects.

II. RELATED WORK

M. Jovanovich, A. Mujkanovic and A. Seper (2011) in their study devolved samples of bituminous aggregate mixtures having fly ash, cement and lime as a filler with varying percentage of bitumen. After preparing various samples, laboratory investigation was done. The following results were observed:

Fly ash as a filler can be used in asphalt mixtures successfully.

With the addition of filler, optimum bitumen content was observed to be lower in mixtures

For flexible pavements, lower proportion of optimum moisture content is considered better. It leads to fewer voids in sub grade. Thus with the usage of pavement, there will be less settlement.

Konstantin Sobolev, Ismael Flores and Justin David Bohler (2013) determined the feasibility of fillers in asphalt concrete was determined. Two different binders were used. These binders were fully blended with filler materials i.e. fly ash, lime and cement .The study result demonstrated that:

Rheological properties of the asphalt were greatly improved with the addition of these fillers.

Fly ash also appears in improving the aging resistance of mastics

With the addition of fillers, compatibility of mixtures was not affected .

III. RESEARCH METHODOLOGY

This research consists of three stages: characterizing the material, designing mixtures for the three different fillers and suitability of fillers in the bituminous mixtures. In the first step, properties of bitumen, fillers and aggregates were established while in second step, optimum bitumen content for each of these mixtures was determined according to Marshall Mix design method, and in the third level, suitability of different fillers was evaluated.

Conventional bitumen grade VG 30 is used in the present laboratory work. For the preparation of bituminous mixes, aggregate gradation is done according to the MORT&H specifications. Gradation should be within the limits as per MORT&H. The sieves are arranged with one another according to the size. About 2.5 to 3kg of aggregates are then sieved through various sizes. The percent passing through each sieve is observed. When tested, the combined grading of coarse and fine aggregates and for the specific mixture shall be within the limits

Asphalt binder: Asphalt used in the study is of penetration grade 60/70, since it is used to a great extent and is good enough to temperature condition. It was purchased from the local distributor. Several tests have been conducted in laboratory to evaluate the physical properties of Asphalt Binder.

Fillers: Three different types of fillers were selected in this study. These are stone dust, cement and fly ash. Cement was bought from the local distributor of the ACC plant, Phagwara. Lime and fly ash was brought from various local sources. The filler material is screened by No. 200 sieve. Specific Gravity of the stone dust, lime and fly ash was calculated and noted down.

Aggregates: In combination to the binder, and mineral fillers used in Marshall Technique, crushed stone will be used in the preparation of bituminous mixture samples. Aggregate having desirable properties such as strength, hardness, toughness, specific gravity and shape is selected. The determination of physical properties of aggregates is done by performing various tests. The coarse aggregates and fine aggregates are isolated into different screen sizes. Aggregates are sieved, examined and recombined in laboratory to meet the specific gradation

Marshall Mix Designs: Marshall Stability test is performed to determine the optimum bitumen content and the test samples shall be prepared by combining varying percentages of bitumen ranging from 4.5% by the weight of aggregates to 6.5% with an increase of 0.5 % for each type of fillers. The Specimen preparation, compaction and

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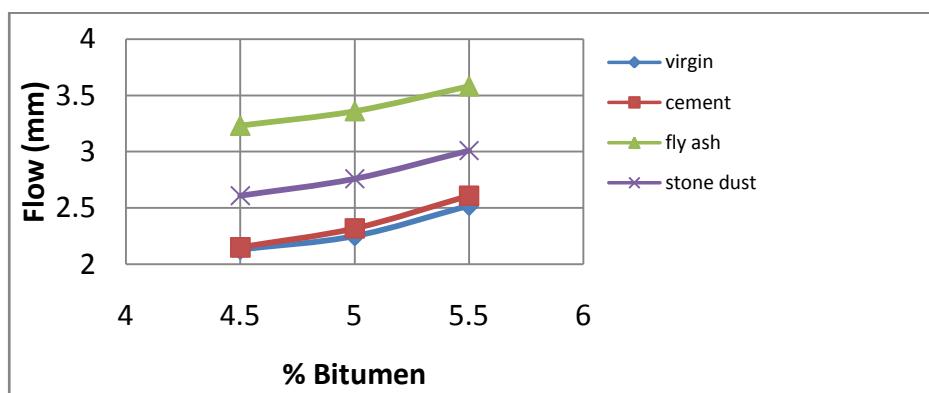
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testing will take place according to Marshall Mix Design Method. Marshall Stability and Flow Tests are conducted on each sample. The bulk specific gravity, density, and percent air voids will be determined for each sample

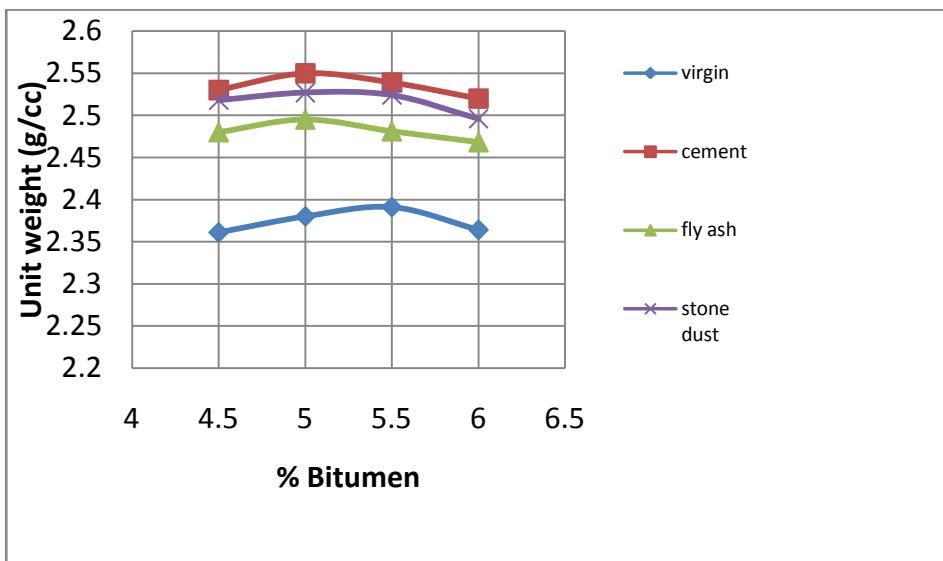
IV. EXPERIMENTAL RESULTS

Observations evaluated from Marshall Test : Fillers used were limited to 3 percent in each mix where as Bitumen was varied from 4.5 percent to 6 percent with an increment of 0.5 percent.

Flow Value: It is observed that flow value increases with increases in binder content. For Dense Bituminous Macadam (DBM), flow value should be within 2 to 4 mm . As we can conclude from the diagram, that with the use of fly ash , maximum flow value was observed.



Unit weight: It is observed that unit weight increases with increase in binder content up to certain binder content and after that it decreases. With the addition of cement, maximum unit weight was observed.

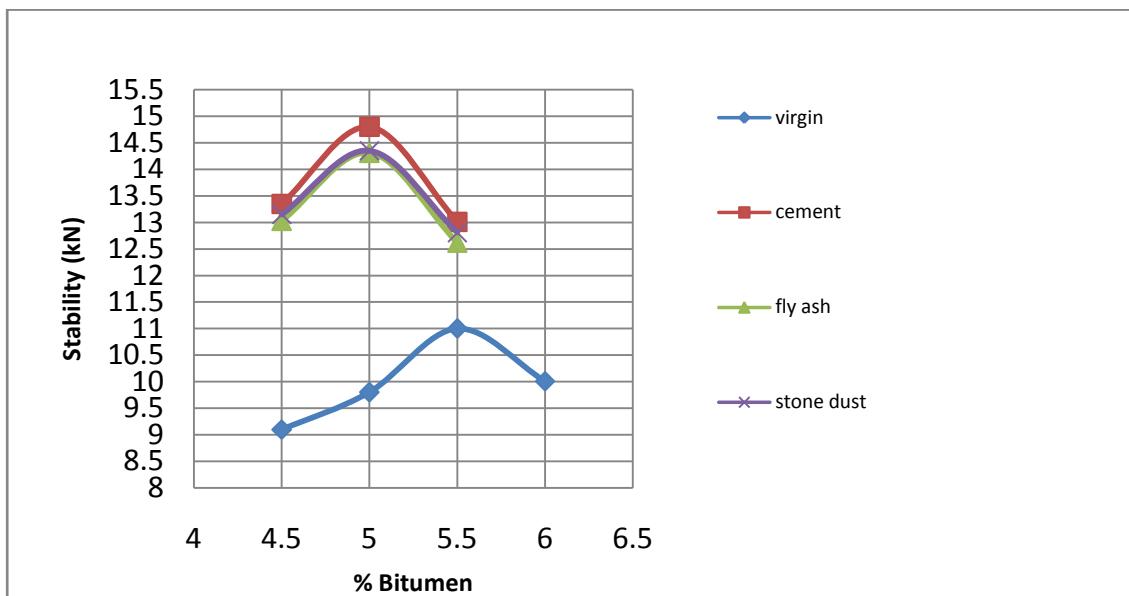


Stability: It is observed that stability value increases with increase in binder content up to certain binder content and after that it starts decreasing. Maximum Stability was observed with the use of cement as it fills the fine gaps and helps in making bitumen mixes as a compact mass with its strength

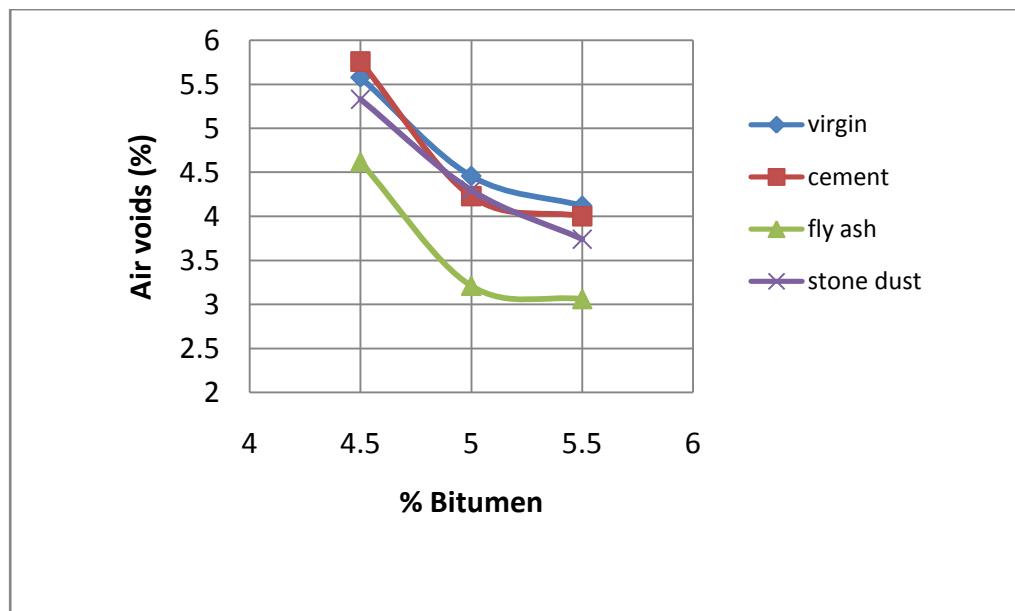
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Air voids: It is observed that with increase in binder content, air voids decreases. With the use of fly ash , minimum air voids were observed. Virgin bitumen and modified bitumen with cement as filler show almost same percentage of air voids. Thus air voids goes on decreasing with the use of fly ash as filler



V .CONCLUSION

Based on the results of the experimental investigations conducted on Virgin and modified bitumen using fillers, the following summaries have been drawn:

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- Modified bitumen by using different fillers show less penetration value, thus low grade bitumen can be modified to withstand higher loads.
- The ductility value decreased with the use of fillers as these fillers cause the bitumen to become stiffer.
- From Marshall Stability test, the stability values were found to be increased with the use of fillers. With the use of cement as filler, maximum stability was found followed by fillers fly ash and stone dust. These fillers tend to fill more voids between aggregate grains. Thus mix will continue to gain strength, leading to increased stability of bituminous mix
- The Marshall Flow value also increases with the use of fillers being maximum with the use of fly ash followed by stone dust and cement respectively. This indicates improvements in the resistance to permanent deformation of bituminous mixes with addition of these fillers.
- The density of bituminous mixes prepared with using modified binder increases up to certain limits and then decreases.

From the above results, it is observed that fly ash being a waste product can be effectively used as a filler to improve the properties of bituminous mix. Fly ash also being cost effective as compared to cement and lime.

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