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Improvising the Quality of Asphalt Mix Using Marle Dust and Banana Fiber

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ABSTRACT- Bituminous mix is a mixture of coarse aggregate, fine aggregate and filler. Hot Mix Asphalt (HMA) is a type of bituminous mix in which all particles are mixed and compacted at high degree of temperature. HMA is available in two forms namely dense graded and Stone Matrix Asphalt (SMA), formally is known as Bituminous Concrete (BC) and second one is known as gap graded. SMA needs additional fiber to minimize the drainage through the material. In this research, an effort has been made to enhance the stability of SMA by using banana fiber as a filler agent along with binder content (BC). The mixture has been prepared as per the MORTH specification. The grade of bitumen used in this research work is VG-30. The percentage of BC and fiber content is varied from 4.8 % to 6.4 % and from 0 % to 0.8 %. A number of tests have been performed on the marble dust to check its properties. As per the test analysis, Marble dust is used to find out Optimum Binder Content (OBC) and has been used for the mixture with an average value determined as 5.5 %. After adding 5.5 % of BC into the bitumen along with different percentage of banana fiber such as 0 %, 0.2 %, 0.4 %, 0.6 % and 0.8 %. The experiments has been performed on five different samples and tests values in terms of stability, flow value, Air Void (VA) and Void in Mineral Aggregate (VMA) have been measured. From the experiment it has been observed that banana fiber enhances the stability of the mixed sample.

KEYWORDS - Bituminous Mix, Banana Fiber, Marble Dust, Stone Matrix, Stability, Flow Value, VA, VMA.

I. INTRODUCTION

A. General

A highway pavement is a structure consisting of superimposed layers of processed materials above the natural sub-grade, whose primary function is to distribute the applied vehicle load to the sub-grade. Pavement is the actual travel surface especially made durable and serviceable to withstand the traffic load commuting upon it. Pavement grants friction for the vehicles thus providing comfort to the drivers and transfers the traffic load from the upper surface to the natural soil. Two types of pavements are generally recognized as serving this purpose, namely flexible pavements and rigid pavements. There are two factors that need to be considered while using flexible pavement as well as the mix design.[2]

These two factors are the main elements in engineering-paving design and mixing design. This research deals with mixed design of bitumen.

The main objective of bituminous mix design is to proportion various components for pavement construction to achieve the following objectives:

- To obtain a durable pavement, sufficient amount of bitumen is required to obtain adequate strength.
- Adequate strength must be provided to obtain resistance against the shear.
- Additional voids must be incorporated to facilitate the compaction performed by traffic.
- The placement must be performed with ease which will demand sufficient workability.
- The flexibility must be attained at smaller temperatures so that the shrinkage cracks can be avoided.
- The premature cracking in the bitumen pavement can be avoided by providing sufficient flexibility for the bitumen.

The aim of this research is to identify some difficulties that are implicated in the art of bitumen mixed designs and then determine the direction of the research.

B. Evolution of Mix Design

According to Das et al. (2009), at some stage in 1990s the bituminous paving technique was initially used on rural roads to control the fast removal of fine particles in terms of dust particles. Primarily, heavy oil was operated as dust calmative and the amount of heavy oil has been determined by the execution the tests earlier.[5] This process is whipped up like a mixed pancake form and underlying in a brown paper. Based on the degree of stain on the paper, the size of the coating has been decided. Initially the Hubbard Field method was commonly used that focused on the surfacing mixture, the sand-wearing course. Specimens were 2 inches in diameter and were compacted with a hand rammer due to which the mix with large amount of aggregates could not be handled.[4]

To overcome this drawback, in 1927, Francis Hveem became a resident engineer in California, and having no experience with oil mixes, used the information about gradation with the

paper stain test to evaluate asphalt content. He recognized this process was controlled by aggregate surface area and found the method to calculate surface area. This method was used during the cement concrete mixture to evaluate the amount of bitumen required. In 1946, Humidity sensitivity test and in 1954 sand equivalent test have been integrated to the Hveem test.[7]

Prior to the Second World War, Bruce Marshall of the Mississippi Department of highways developed Marshall Mix design in the late 1930s to early 1940s. Marshall Mix design is essentially an outgrowth of the Hubbard-Field method. The approach is similar although the practice was different. This test was acknowledged be the US Army Engineers' Institute in the year 1930s and accordingly changed in the 1940s.[9]

II. LITERATURE REVIEW

Chen and Lin (2005)[3] had examined the mechanism of reinforcement of bitumen mixed with different fiber. Different type of fiber such as cellulose, rock wool and polyester had been added to the bitumen. Various engineering properties like toughness, viscosity etc was done on bitumen-fiber mastics. After the testing was done the results point out that reinforcing effect increase with the increase in fiber content and the tensile strength also increase with the increase in fiber content. Due to the increasing tensile strength, it has good adhesion between fiber and bitumen. From this research it also concluded that the optimum fiber content (OFC) is dependent on the length, type and the diameter of the fiber.

Karaşahin and Terzi (2007)[6] had examined the performance of marble waste dust in the mixture of asphalt concrete. In this research work, researcher has used the marble dust that was obtained during shaping the marble block as filler in asphalt. The samples had been made by adding marble dust and limestone as filler and then the optimum fiber content (OFC) was obtained by using the Marshall procedure. Dynamic plastic deformation test was also carried out using the indirect tensile test apparatus. The results had demonstrated that the plastic deformation was between the upper and the lower limits of grounded marble. So, this research work showed that the marble dust can be used as a filler material in the asphalt concrete as it is easily available and also the cost of transportation is less compared to rest of the filler agents.

Xu et al. (2010)[11] had examined the performance of fiber reinforced asphalt concrete under environmental temperature and water effects. Four types of fiber had been used which were polyester, polyacrylonitrile, asbestos and lignin. Various tests were done on the fiber reinforced asphalt concrete to measure various behaviours like strain, fatigue and strength. Results showed that the fiber had considerably increased asphalt concrete rutting resistance, toughness and fatigue life. Many other properties such as flexural strength and ultimate flexural strain and split indirect tensile strength at low temperature had also increased. It has also show that the use of fiber in the freezing-thaw effect does not seem effective.

Chandra et al. [3] had examined the use of marble dust in road construction. In this research work, the researcher had evaluated the effectiveness of marble dust when used as filler. To evaluate the effectiveness of the result, two types of fillers were used namely marble dust and lime and various tests such as Marshall Stability test, unconfined compression test, fatigue test and indirect tensile test were performed. As per the results higher values for compressive strength, tensile strength and elasticity w obtained by using marble dust as filler compared to the lime.

Rahman et al. (2020)[8] had examined the use of cigarette butt fiber modified bitumen in stone mastic asphalt. Cigarette butts (CBs) contributed one-third of the world's littered waste and takes years to decompose due acetate-based fiber wrapped in paper alongside with many more toxic compounds like tobacco etc. After taking years to decompose CBs insert toxic chemicals into the environment. So, the research had been done to recycle cigarette butts in asphalt concrete and bitumen. Many tests such as Marshall stability and flow test of SMA were taken and compared with the sample that were prepared with the conventional virgin cellulose fiber modified bitumen. The results obtained from the test fulfilled the industrial standards and favoured the use of cigarette butt fiber modified bitumen into the construction of stone mastic asphalt instead of virgin cellulose fiber.

Okumu et al. (2021)[8] had examined the performance of waste marble dust as mineral filler in Hot-mix asphalt concrete. Due to the increase in the population, there was a need to develop best practices geared towards developing sustainable construction. Thus, there is a requirement to develop more efficient ways to consume asphalt. Hence, this research was carried by the researcher to use waste marble dust produced during shaping and polishing of the stone as filler in Hot-mix asphalt (HMA). Various tests were performed on the waste marble dust that were used and these tests were Marshall stability test, flow test, void characteristics, indirect tensile strength and tensile strength ratio text. From the test it was concluded that it is very beneficial to use waste marble dust as a filler in asphalt and can be very economical also as it is easily available.

Raza and khan (2021)[10] had examined the influence of marble dust filler on marshal properties of Hot-mix asphalt. As per this research filler plays an important role in altering the properties of asphalt concrete. Since large amount of waste marble dust is produced every year, the effort was made by researcher to assess the influence of marble dust on the strength properties and permanent deformation resistance of asphalt mix. In this research optimum binder content was calculated using lime as filler and then other optimum bitumen content was calculated using marble dust as filler. The results concluded that it was more useful to use marble dust as filler as it gave better results when used with Hot-mix asphalt.

III. SELECTION OF MATERIALS AND METHODOLOGY

A. Coarse Aggregates

Coarse aggregate consists of different sizes of interiors that are used in the construction of pavement. Coarse plays a major role to improve their power to composite material.

B. Fine Aggregates

Fine aggregates are basically any natural sand particles won through the mining process from the land. The size of fine aggregates is 4.75mm or lesser. Fine aggregates include things such as sand, silt and clay.

C. Filler (Marble Dust)

A large quantity of powder is generated during the cutting, shaping and polishing process of marble which is known as marble dust. In this research, marble dust is used as a filler agent in asphalt for road pavement. The marble that has an extreme purity is of bright white colour and is very useful. Marble is crushed to a powder and then processed to remove impurities as many as possible. The resulting product is known as whiting that is used as filler. Marble dust has a property to form a robust and non-porous surface. Marble dust is easily available in the nearby market. Marble dust is passed through a sieve of 0.075mm and then used as a filler material. It is finer than the cement hence used as a binding agent in bitumen. It increases the workability and durability of the product.

D. Binder

In this research to prepare bitumen mix, VG-30 bitumen is used in this research.

IV. TEST METHODS

- Aggregate Impact Test
- Los Angeles Abrasion Value
- Specific Gravity Test
- Water Absorption Test
- Penetration Test
- Softening Point Test
- Ductility Test
- Specific Gravity Test
- Marshall Stability Test

V. RESULTS

The sample prepared by mixing marble dust as a filler agent has fulfilled all the above criteria's and hence, we have used it as a filler material in this research. We could have used other filler but in other to reduce the cost we used marble dust as the filler agent. The test results are given below:

- Marble dust is the waste material obtained after cutting Mable pieces and hence in order to reduce the industrial waste it has been used.
- The OBC of 5.5 % and OFC of 0.4% have been obtained.
- The Marshall Stability value has been obtained maximum at a fiber content of 0.4% and after this percentage it starts reducing.
- The air voids start decreasing up to 0.4% of banana fiber content and after this percentage the value of air voids starts increasing again.
- Hence, we conclude that the optimum value of these parameters has been observed at the banana content of 0.4% in the bitumen mix sample design

VI. CONCLUSION

As per MORTH, the properties of mix design are:

- Marshall Stability value should be greater than 900kg
- Flow value should lie between 2mm to 4mm.
- Air void (VA) percentage should lie between 3% to 6%.
- Voids in mineral aggregate (VMA) must lie between 11% to 13%.
- Optimum bitumen content (OBC) value should lie between 5% to 6%.

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