International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 5 Issue 5, July-August 2021 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

# A Review on Impacts of Using Sisal Fiber with Mineral Filler on Dense Bound Macadam

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**ABSTRACT**

In order to prepare the bitumen mix, the most commonly fillers in the form of fractions, fine aggregates and coarse aggregates are primarily used. In some part of the country, it is not possible that the various size fractions of aggregates are available easily. Hence, these will be transported by covering large distance which indirectly enhances the cost of the project. To fulfill the power requirements, large numbers of thermal power plants (around forty) have been installed throughout the countries which are reported to produce ashes of around 125Million Ton per year. Such huge amount of coal ashes possesses the challenging problems for their disposal in the forms of health hazards, dangers to environment, etc. A proper care is to be required for its disposal for the safety of environment, wildlife as well as human life too. As a result, to minimize the impacts of these materials, this research study is required to use it in a productive way which will fulfill all the needs of the society.

***KEYWORDS:*** *Coal Ash, DBM, Bitumen*

***How to cite this paper:*** Sahil Kumar | Ms. Shivani "A Review on Impacts of Using Sisal Fiber with Mineral Filler on Dense Bound Macadam" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-5 | Issue-5, August 2021, pp.1327-1331, URL: www.ijtsrd.com/papers/ijtsrd45087.pdf

IJTSRD45087





## INTRODUCTION

From the past studies related to pavement, it has been observed and very well concluded that the introduction to technique of bituminous pavement was done on rural roads in 20th century. Formally, the first mix design method was introduced by Habbard and named it as Habbard Field Method of mix design. Originally, this method was based on sand bitumen mixture. However, the major limitation of this technique is was the incompatibility to handle large sized aggregates. After some time span, the Farncis Hveem, Project Engineer from California Department of Highways, designed the instrument named as Hveem Stabilometer. It is used to calculate the expected stability of the bitumen mixture. Initially, Haveem had no expertise to predict the optimum quantity of bitumen which might be appropriate for the design mix. He considered the concept of calculation of surface area to be used to concrete design mix, to determine the amount of bitumen essentially required for the mix. Meanwhile, other equipment was also designed by Bruce Marshall during 1930's, to determine the deflection of the mix along with its stability.

## BITUMINOUS MIX DESIGN

The bituminous design mix is the combination of stone chips having gradations between the nominal highest size of aggregates and finer fractions lesser than 75 microns along with some quantity of bitumen. It should be mixed and produced such that it might be compacted sufficiently with smaller size of voids and constitute to produce its destructive and elastic characteristics.

## CLASSIFICATION OF BITUMINOUS DESIGN MIX

The bituminous mixes are classified as:

### Dense Graded Mix

This bituminous mixed concrete consists of a fair proportion of its constituents. This mix has comparatively higher strength in compression and tensile strength upto some extent.

**Gap Graded Mix**

This bituminous mixed concrete consists of proportion of aggregates such that some specific sizes of aggregates are missing. This mix has comparatively higher strength in fatigue and tension both.

**Open Graded Mix**

This bituminous mixed concrete consists of proportion of aggregates such that the fillers and finer aggregates are missing. This mixed concrete is highly porous. It has lower strength value and consists of considerable friction.

**Hot Mix Asphalt Concrete**

This hot mixed asphalt concrete is formed such that the asphalt in the form of binder is heated to such extent that its viscosity gets reduced and aggregates are dried of to eliminate its moisture content before its mixing. Mixing is usually performed along with the aggregates at temperature of around of 150° C to 160° C for the virgin asphalt.

**Warm Mix Asphalt**

This type of asphalt mix is formed by the addition of waxes of Zeolite, emulsions of asphalts, and sometimes, water also to the binder of asphalt before its mixing. The temperature should be maintained in the range of 100° - 135° C. It permits lower level of mixing which results into decrease in fossil fuel consumption and hence, lower level of $CO_2$, vapours and aerosols.

**Cold Mix Asphalt**

This cold mixed asphalt (CMA) is the product of emulsification of asphalt to the water before mixing with aggregates. It results into lower viscosity asphalt. This mix is quite workable and compact in nature. This emulsion mix gets dissociated when the water present gets evaporated.

**Cut-Back Asphalt Concrete**

This asphalt concrete is the product formed by the dissolution of the binders to the kerosene that acts as a solvent. The solvent may be any other lighter fraction obtained from the petroleum which may result into formation of asphalt concrete having low viscosity. This mix is extremely workable and compact in nature. The lighter fraction gets evaporated when the mixed asphalt is laid. However, the use of VOC as lighter fraction, results into higher pollution and hence, asphalt mixed emulsions has replaced it.

**Mastic Asphalt Concrete**

This mastic asphalt is the product of hard grade blown oxidized bitumen when heated in the green mixer/cooker such that the formation highly viscous liquid takes place prior to the mixing with aggregates. This process is followed by maturing or cooking of bituminous aggregate mix for the time duration between 6 to 8 hours. When this process gets completed, the mixer/cooker is taken to the site and is laid down to thickness of 20mm to 30mm (around 0.75-0.82 inches) for the roadway application and footpaths and about 10mm or 0.375 inch thick for roofing or floor applications.

## BACKGROUND STUDY ABOUT SISAL FIBERS, FLY ASH AND BOTTOM ASH IN VARIOUS BITUMINOUS DESIGN MIXES

As per the laboratory study conducted by **Shuler (1976)** on total six specimen of bottom ash collected from the various states of India. This study helps the material to characterize physically. This study included numerous tests like unit weight test, oil ratio test, Specific Gravity, Florida Bearing Test, Dry and Wet Sieve Analysis and Degradation Analysis. The performance of the various mixes is determined and obtained by the Florida Bearing Test in which the fine aggregates – ash mixtures are used. Stability test of Marshall is conducted on samples in soaked and dry conditions. It was concluded that the bituminous mixes having ash content imparts the higher results for retained stability value in water sensitivity test as compared to that of mixes without any ash content.

**R. E. Long and R.W. Floyd (2013)** performed the analysis in Texas on the shortage of aggregates and rise of transportation expenditure due to increament in the rate of construction items as the locality does not have any source of natural aggregates. Some of the naturally occurring aggregates were not even able to meet the desired standard as there were some chances of stripping, pavement distresses, rutting, and some other visual symbols. Due to rise in cost of construction, there had been observed some need to replace the naturally occurring aggregates with the bottom ash in the hot mix designed asphaltic concrete.

It was concluded that higher concentration of asphalt will be required for blending if bottom ash has to be used. It also resulted into formation low compacted density of the mixes, higher internal friction exhibited by the mix without any lateral displacement of the mix at the time of compaction, faster cooling rate, and need of sufficient amount of sheep footed rollers that worked closely over the laying operation. It was also observed that the above said mix maintained the permissible skid value after fourteen months of traffic. However, the overall cost of this mix blended with bottom ash was slightly more due to requirement of additional amount of asphalt.

**David Q. Hunsucker (1992)** analysed the experimental approach towards the overlay of bituminous surface, placed on October, 1987 in

Lwarence County, Kentucky. The laboratory experiment used the limestone, bottom ash and natural sand in the form of fine aggregates.

The conclusion made by this study represents that around 50% higher bituminous content is necessary for the mixture due to its absorptive properties of bottom ash used as aggregates. However, the increase in the quantity of bituminous content would definitely rise to the overall unit price of the material. Moreover, if limestone and natural sand is used with the bottom ash seems to improvise the basic performance of the surface mixture along with its characteristics of skid resistance.

A bi-annual demonstration project was started by **Musselman et al. (1994)** in which around 50% of aggregates were replaced by their substitute as bottom ash in the flexible pavement. This project included the considerable experiments of expected experimental influences along with the performance of the pavements in laboratory and fields both. The field performance of the roadways had been monitored by using the remote sensing in terms of resistance to strains, temperature probes along with the on-site pavement analysis.

This study concluded that the bottom ash used as the partial substitute for the traditional aggregates in the pavements appears to be some proper ash utilization skillful technique. If the fraction of bottom ash is less than half, it would suggest going for future testing. It was also noted that the Gyratory method of testing was found to be highly accurate and successful to determine the performance of the pavement at lower value of asphalt concentration when compared to the Marshall Test method.

Another research study was conducted by **Khaled Ksaibati et al. (1999)** on the expected use of integrated bottom ash in the bituminous mix designs. To evaluate this project in the field, a testing section of pavement had been constructed having bituminous mix and controlled amount of bottom ash. It was tested in the laboratory by the use of Thermal Stress Restrained Specimen Tester and Georgia Loaded Wheel Tester.

The evaluation presented the results such that there were observed to be huge difference in higher temperature rutting and lower temperature cracking. The analysis from the Georgia Loaded Wheel Tester indicated that the asphalt based mixes showed the considerable different characteristics related to higher temperature rutting while the analysis from Thermal Stress Restrained Specimen Tester indicated the wonderful results for low temperature based characteristics of cracking.

**Shuler et al. (2012)** considered the intermediate course of a flexible pavement and the practicality of the bottom ash used in the mix was studied. The conclusion made from this study indicates the better performance of mix was observed when the content of bottom ash used was 15% as the replacement of sand. It was also concluded that the wearing resistance observed increases with rise in the asphaltic content. The test represented that no deterioration was observed in the physical characteristics of the design mix having bottom ash while these were observed in the conventional mixes.

As per **Gunalaan Vasudevan (2013),** the performance evaluation of hot mix asphalt having bottom ash as content was tested in the laboratory. The scope of this study was to promote the use of bottom ash in the form of aggregate in wearing course, base course and sub-base course. This study was inspired by three way objectives to evaluate the design mix stability which includes the determination mechanical properties of bituminous mix having bottom ash content, evaluation of stability of the mixes using Marshall Test Method and evaluation of engineering parameters of Marshall Cube in the form of appearance and texture. The major conclusions drawn from the study indicates that the specimen having bottom ash is of extremely superior quality in terms of strength, flow, hardness and stiffness. As a result, the higher strength will be imparted to the pavement and may able to resist the heavily loaded traffic. The major limitation for the use of bottom ash in the bituminous designed mixes is the increase in the content of air voids that may leads to the decrease in the density of the mixture.

The investigation for the practicability to use the fly ash as the extender to asphalt is done by **Tons et al. (2019).** It also included determining the impact of various parameters such as particles size, etc on process of replacement. It was concluded that it was highly reasonable to replace the volume asphalt having medium fly ash by 40% if used in dry climatic regions while 30% when used in the moist climatic regions.

**Ali, N., et al. (2020)** experimentally analyzed the results of bottom ash on physical characteristics of the bituminous pavement mix. It was also considered to analyze the impacts of use of bottom ash for the improvement of performance parameters of the pavement distress. Total four samples having variable content of bottom ash was considered. At various temperature conditions, the various properties like creep, fatigue, resilient modulus and permanent deformation are also considered. The performance of the mix was ascertained by the use of VESYS model.

The conclusions represented in the favour of bottom ash to be used as a filler to improve the resistance to stripping and characteristics of resilient modulus. The bottom ash had no impact on rut depth and serviceability conditions but with rise of temperature, surface cracks to the pavements get increased.

**Boyes and Anthony J. (2011)** considered the fly ash as mineral fillers to investigate the anti-stripping impact of dust as waste products obtained from the cement kiln and the use of some product of amine as an additive. It was concluded that the class B fly ash may be used in the form of anti-stripping chemical in bituminous mix but it leads to increase the overall cost as compared to the product of amines or lime.

**Kumar P. and Chandra S. et al. (2007)** conducted the research to study the overall performance of the mix modified by the crumb rubber binder and jute fibers having coating with low viscosity binder. The performance of the stone mix asphalt was studied by various tests like test for durability, moisture susceptibility, rutting, fatigue life, etc. All the test results are compared between mix modified by the crumb rubber binder and jute fibers having coating with low viscosity binder.

The test concluded that amount of fibers added was around 0.3% by weight of mix which increased the drain-down characteristics of mix. The moisture susceptibility and rutting tests gave satisfactory results as per the standard conditions. The results from fatigue tests indicated the better results than that of conventional mix.

As per **Kar and Debashish (2012),** the sisal fibers were used as additive for bituminous concrete mix and as stabilizing agent for stone mastic asphalt mix. The content of fiber varied from 0 to 4 % by weight of mix and content of binder varied from 5 to 8 %. The fly ash was used as the mineral filler and gave the highly satisfactory results at initial stage.

The Marshall Test results observed that the indirect strength in tension and Marshall Stability improved due to addition of fibers which ultimately decreased the drain down value also. From the tests, the optimum content of binder for bituminous concrete and stone mastic asphalt were 4 % and 5.3 % respectively whereas optimum content of fiber were 0.35 %.

## CONCLUSION

1. From the above background study, it is observed that various bitumen mixes containing bottom ash has given highly satisfactory results in the form of their performance parameters. However, there have been observed drawbacks in the form of reduction of density of mixture and increase in the higher air voids in Marshall Characteristics.
2. Apart from this, the uses of fly ash and bottom ash collectively in the bituminous mixes have not been observed so far and that's why it is the prime motivation for this current research work.

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