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# RESEARCH ON ENGINEERING PERFORMANCE OF DENSE GRADED BITUMEN COMBINED WITH NATURAL FIBER AND COAL ASH MIXTURE

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**ABSTRACT**: Coal-based thermal power plants are a key source of power generation in India. The prime waste of a coal thermal power station are ash and bottom ash. Heavy dumping of those waste products causes fatal environment pollution to air, water, and land, besides impairing human health. This research work is completed to deliver the optimum use of ash, namely bottom ash as fine aggregate and ash as mineral filler with natural fibre (like sisal fiber) want to improvise the engineering properties of bituminous paving mix. For national interest these waste products, which are available easily and abundantly are often used economically for bituminous paving purpose, which ultimately helps in saving the fine aggregate and stone dust.

In the present study, dense graded bituminous mix specimens are prepared using bottom ash as fine aggregates, ash as filler and sisal fiber as additive. Proportion of aggregate for dense graded bituminous macadam (DBM) grading has been considered as per MORTH (2013) having nominal maximum aggregates size (NMAS) 26.5 mm. To strengthen the mixture, slow setting emulsion (SS1) coated sisal fiber is added in varying percentage of 0, 0.25%, 0.5%, 0.75%, and 1% by weight of the mixture, with different length variations like 5mm, 10 mm, 15 mm and 20 mm. At the initial stage of the research, specimens were prepared with two kinds of paving bitumen i.e. VG30 and VG10, out of which the initial trials resulted better Marshall characteristics with VG30 bitumen and hence was considered for subsequent study. Detailed study with Marshall test results were used to determine the marshal characteristics, optimum binder content and also optimum fiber content including the optimum length of fiber. Marshall stability as high as 15kN was obtained with optimum bitumen content of 4.50%, with optimum fiber content of 0.5% with optimum fiber length of 10 mm. Further, for delivering the performances of the pavement, various performance tests were also conducted like moisture susceptibility test, indirect tensile strength (ITS), creep test and tensile strength ratio of bitumen mixes. it's finally observed that not only satisfactory, but also much improved engineering properties result with coal ash as fine aggregate and filler, stabilized with natural sisal fiber duly coated with SS-1 emulsion beforehand.

Utilization of non-conventional aggregate like coal ash and natural fibre together thus may help to hunt out a replacement way of bituminous pavement construction. The coal ash dumping which may be a big concern to everyone in respect of its disposal and environmental pollution, can find how for its reuse during an inexpensive way by substituting fine aggregate and stone dust.

**Key word:** Bottom ash, Fly ash, Sisal fiber, Emulsion, Indirect tensile strength, Static creep test, Tensile strength ratio.

## INTRODUCTION:

For the preparation of bitumen mixtures (usually aggregates), coarse, fine and filler fractions should be used. In many places, it is not easy to obtain aggregates of different size scores. The use of these aggregates requires remote procurement, which greatly increases the cost. On the other hand, many coal-based thermal power plants have been established to meet power demand to some extent. According to reports, India has 40 large thermal power plants producing approximately 120 million tons of ash each year. Most fly ash may dispose of dry or wet powder to open spaces, which can be obtained near the factory, or by grounding it to an artificial lagoon or dump. Such a large amount of such waste does pose challenging problems in the form of land use, health hazards and environmental hazards.Whether it is disposal or utilization, extreme care must be taken to safeguard the

interests of human life, wildlife and the environment. Therefore, in order to suppress the painful effects of these materials, it is necessary to conduct detailed research to use them in a productive way that meets the needs of society.

**Objectives of research**

This experimental study ensures that it has sufficient performance in the areas of fatigue, moisture sensitivity and creep value, so that coal ash can be used as unconventional aggregate and natural fiber (sisal fiber) as an additive. The possible influence of fiber on the bitumen mixture was considered again, and a comprehensive study was conducted to find the best fiber content and fiber length to increase the engineering performance of the bituminous mixture.

- It can be clearly seen from the literature research that the bituminous mixture prepared with bottom ash has achieved satisfactory results in terms of performance characteristics, and in the Marshall characteristic analysis, it shows the shortcomings of high porosity and reduced density. mixture.
- In addition, there is no research on using bottom ash and fly ash (coal ash) together in asphalt mixtures. This is the main motivation of this research.
- Similarly, due to its higher air gap content, the use of fibers is limited to SMA and BC. Therefore, in many research work, fibers are used as additives or stabilizers in SMA or BC.

**Materials used in study**

In this study, the following materials were considered to prepare the asphalt mixture.

- Stone chips (coarse aggregate)
- Bottom ash (fine aggregate)
- Fly ash (as a mineral filler)
- VG-30 (as an asphalt binder)
- Sisal fiber (as an additive)
- SS-1 emulsion (as a fiber coating agent)

**Bitumen**

Paving bitumen grade VG-30 (VG viscosity grade) was used in this experimental study. Initially, two bitumen grades (such as VG-30 and VG-10) were used to investigate the Marshall characteristics of the material. These preliminary tests produced better Marshall properties, especially the Marshall stability in a mixture of bottom ash, fly ash, and emulsion-coated fibers with VG-30 pitch as the binder.

**Additives (SisalFiber)**

The sisal fiber, a normally and locally accessible item has been utilized as a modifier for improving the designing properties of ordinary DBM combinations. In this test work sisal strands were covered with moderate setting emulsion (SS-1) and put away at 110oC in hot air broiler for 24hrs. Emulsion covering was considered thinking about the natural idea of the material. Sisal fiber is a cellulose fiber having delicate yellowish tone.

**Emulsion(SS-1)**

SS-1 is an anionic based lethargic setting bitumen emulsion, which is widely utilized for prime coat, mist seal, dust control, and in fine reviewed blend. Moderate setting emulsions are the steadiest emulsions, which generally can be weakened with water and blended in with totals and mineral fillers and for all clearing employments. To permit the emulsion to completely fix, the asphalt temperatures at development ought to be adequately high [12]. The rate buildup content in SS-1 emulsion is discovered to be 71.48% in 100ml of emulsion by buildup vanishing technique referenced in IS 8887 (2004)

Figure 1 Sisal fiber used.

After adopting the above aggregate grades, follow-up tests are performed to ensure performance characteristics.

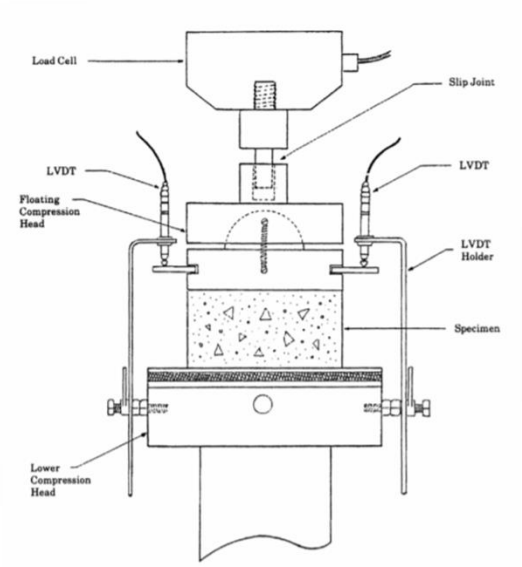
Marshall mixture test to evaluate volume analysis

Static indirect tensile test

Moisture resistance (tensile strength ratio)

Retained stability test

Static creep test




**Schematic Diagram of the Static Creep Setup**

**RESULTS:-**

**Marshall stability**

It can be seen from Figure 5.1& Table 5.1(a) that compared with the traditional mixture, the stability value of using coal ash in the DBM mixture is not satisfactory. When mixing 14% coal ash by weight of the mixture to prepare DBM samples, the maximum stability value of 11.80kN can be reached.

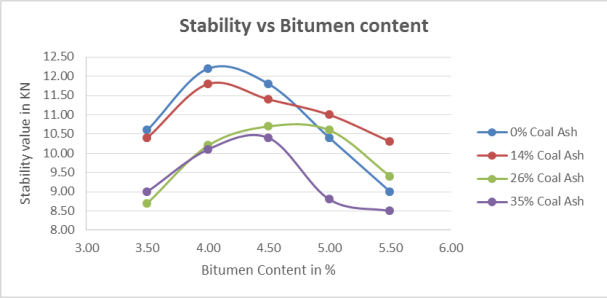



**Figure 5.1 Variation of Stability value with bitumen content at different coal ash content**

**Marshall flowvalue**

It can be seen from the flow value and asphalt content graph that as the asphalt content and coal ash content increase, the flow value also increases. But when the coal ash content is 14% of the weight of the mixture, the flow rate is reduced compared with the conventional mixture.

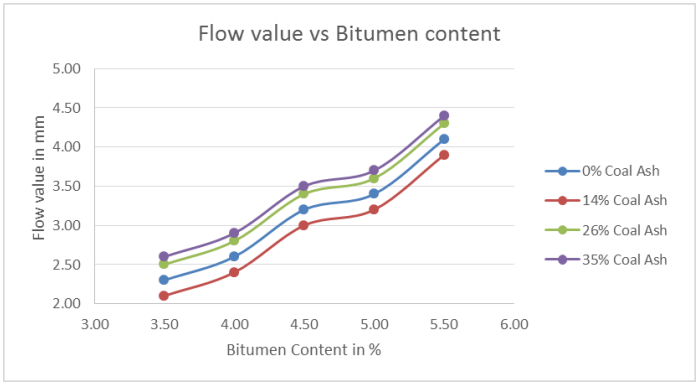



Figure 5.2 Variation of Flow value with bitumen content at different coal ash content

**Air void**

It can be seen from the graph& table shown in Figure 5.3& Table 5.3(a) that as the coal ash increases, the air voids also increase. By taking 14% coal ash based on the weight of the mixture, the air voids are very close to the conventional mixture, which means that some modifications can be made to the coal ash to achieve better performance than the conventional mixture.

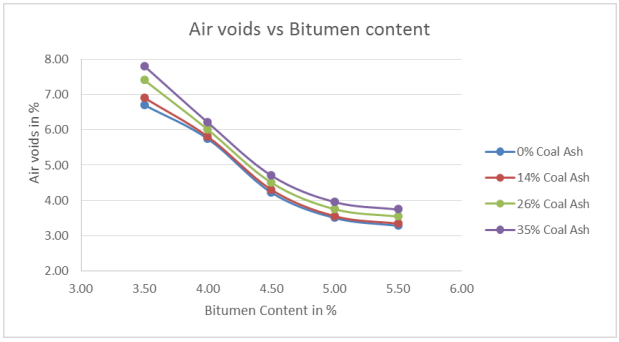



**Figure 5.3 Variation of Air void value with bitumen content at different coal ash content**

**Static creep test**

Static creep test is a measure of permanent deformation caused by long-term constant load. From the deformation it can be seen that the prepared with 0.5% fiber content, 10mm fiber length, 14% coal ash (9% bottom ash and 5% fly ash) weight ratio Compared with other modified and unmodified DBM mixtures, the deformation value of the DBM sample shows that the optimal binder content of the mixture is reduced, and the optimal binder content of the mixture is 5.6% (by weight). It can also be seen that compared with conventional mixtures, when coal ash or

fiber is added to the mixture, the deformation value is reduced.

**Retained stability test**

Held strength was assessed for DBM test which were set up with fiber, coal .It was seen that the example containing both emulsion covered fiber and coal debris has given higher outcome than regular DBM test. Be that as it may, the example arranged uniquely with coal debris and ordinary total has shown less protection from dampness and henceforth given decreased soundness than plan prerequisite.

**CONCLUSION:-**

According to experimental research, the following conclusions are drawn:

1. From the results of the Marshall test, it can be seen that the DBM mixture prepared with bottom ash and fly ash with a size of 300-75 microns, after passing 75 microns, when the asphalt content, fiber content and fiber content reach the Marshall standard, mix The best effect length is 4.5%, 0.5% and 10mm respectively.
2. It is also observed that when the coal ash content is within 14%, the Marshall stability and flow rate values are acceptable.
3. It is also observed that with the increase of fiber content and fiber length, the pores and flow decrease, and the Marshall quotient increases, which is due to the higher stability value at 14% coal ash.
4. The increase in fiber content and fiber length leads to higher requirements for the optimal pitch content and emulsion for coating the fibers.
5. It can be seen from the indirect tensile strength test that the indirect tensile strength of the sample is increased due to the addition of emulsion-coated fiber and fly ash, which provides the DBM sample with excellent engineering properties to withstand thermal cracking.
6. It has also been observed that the use of emulsion-coated fibers, fly ash or a mixture of both in the DBM mixture can improve the ability to resist damage caused by moisture, depending on the tensile strength ratio and the retained stability value.

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