EFFECT ON BITUMINIOUS MIXES BY ADDING COAL ASH AND JUTE FIBRE IN FLEXIBLE PAVEMENTS

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ABSTRACT: Thermal power plants that fuel on coal are key source of power generation in India. These thermal power plants leave coal as waste product. This coal ash is not just harmful to human health but also causes serious threat to environment. This research work focuses on use of heavier part of coal ash that is "bottom ash" to replace certain range of fines, its lighter part that is fly ash as the filler and jute used in optimum quantities so as to enhance the properties of "DBM".
Experimental studies are carried out on dense grade bituminous mixes prepared by using coarse aggregates, "bottom ash" to replace certain size range of fines, "fly ash" as filler in place of stone dust and jute fiber as an additive to enhance properties of mix. "Gradation for dense graded bituminous macadam (DBM)" has been taken in accordance with recommendations put forth by MORTH using maximum aggregates size of 26.5 mm. since jute is biodegradable so it needs to be coated with slow setting emulsion (SS-1) which is then added in percentages varied by .25% from 0% to 0.75% by weight of the mix, lengths are varied from 0mm to 20mm with the increment of 5mm. For preparing the test samples VG30 was used as the paving bitumen. Determination of marshal characteristics, binder content, fiber content and length of jute fibre was done by using Marshall's test. Highest value of Marshall Stability obtained was 15kN, bitumen content of 5.6%, fiber content of 0.5% and length of 10 mm gave best results. Besides Marshall's characteristics various other performance characteristics including tensile strength, creep and susceptibility towards moisture were also determined. Summarizing this, overall boost in the properties of "DBM" was found when coal ash was used as fine aggregates and mineral filler, stabilized with SS-l coated jute fibre.
Coal ash and jute fibre together can pave a way for new methods of pavement construction. Use of coal ash in pavements is one of the solutions to reuse it in a best possible way by substituting costlier resources of sand and stone dust.

KEY WORDS: Jute fiber, coal ash, Voids in Mineral Aggregates (VMA), Marshall Stability value, Marshall flow value, asphalt

I INTRODUCTION

Pavements or highways or roads are regarded as country's backbone, upon which it's up swings and progress depend on. All countries normally have a series of programs for building a new road infrastructure or developing the existing one. Construction of both flexible and rigid pavement include a gross amount of investment to reach better performance oriented and smooth quality of pavement that will endure for long time. In India, where highways are considered as the primary system of transportation, Government of India has been investing a huge amount of money for the pavement construction and maintenance. A detailed engineering study may cost significant amount of investment and pavement materials, which in turn achieves a reliable performance of the in-service highway. In case of flexible pavement, two important factors are taken into considerations i.e. Mix design and pavement design. This study is centered on engineering property of bituminous mixes prepared from non-conventional or alternate materials.

II MATERIALS AND METHODOLOGY

Materials taken in to consideration to prepare the bituminous mix are Coarse aggregate, bottom ash (fine aggregate), fly ash (mineral filler), VG-30 (bitumen binder), Jute fiber (additives) and SS-1 emulsion (fiber coating agent)

Table 1 Physical properties of binder.

Physical Properties	IS Code	Test Result
Penetration at 25^{O}C/100gm/5second, 0.01mm	IS:1203-1978	46
Softening Point, ^{O}C	IS:1205-1978	46.5
Specific gravity, at 27^{O}C	IS:1203-1978	1.01
Absolute viscosity, Brookfield at 160^{O}C, Centi Poise	ASTM D 4402	200

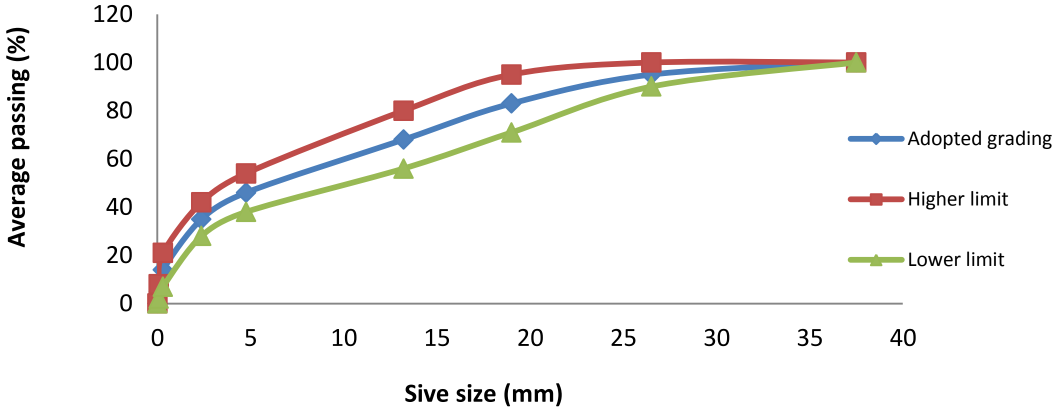
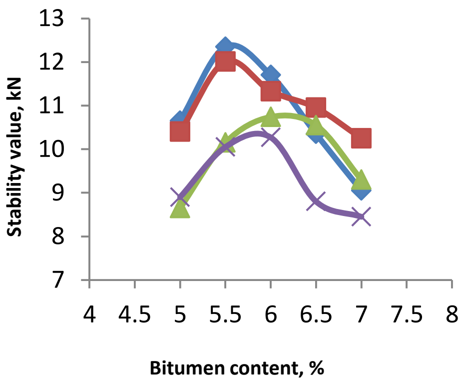


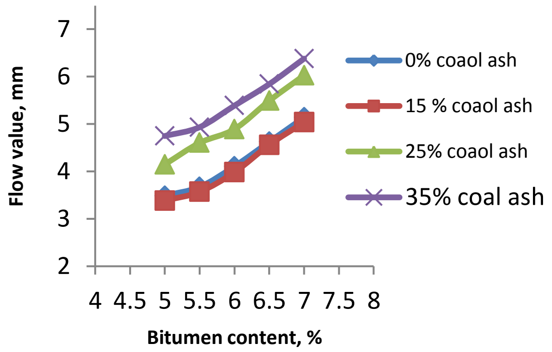
Figure 1 Aggregate gradation curves.

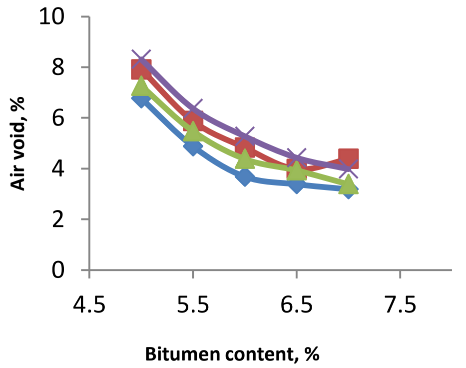
Some of the tests conduted were Marshall test of mixes to evaluate volumetric analysis, Static indirect tensile test, Resistance to moisture damage (Tensile strength ratio), Retained stability test, Static creep test

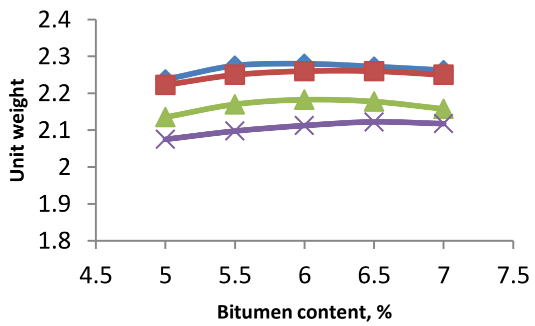
III MARSHALL MIX DESIGN

The DBM mixtures were prepared in according to Marshall Procedure specified in ASTM D6927-2015. All ingredients of mixture, such as coarse aggregates, fine aggregates, filler, fiber and VG-30 bitumen were mixed in a procedure as mentioned. Before preparing the samples, fibers were coated with SS-1 emulsion and stored in a hot air oven at 1100C as coated jute fibers are stored for 24 hours to ensure proper coating around each fiber and to drain down extra bitumen that may adhere to fiber, Then the fibers were cut into specified lengths of about 5mm, 10mm, 15mm and 20mm. The aggregates and bitumen were heated separately to the mixing temperature of 1550C to 1600C. The temperature of the aggregates was maintained 100°C higher than that of the binder. Required quantities of bitumen VG-30 and coated emulsion jute fibre pieces were added to the aggregates that are preheated and thoroughly mixed.the results obtained by varing coal ash percentage are









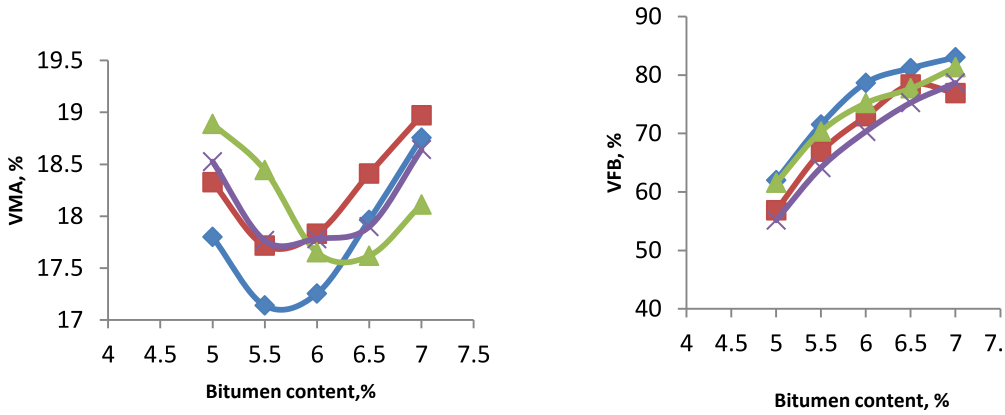
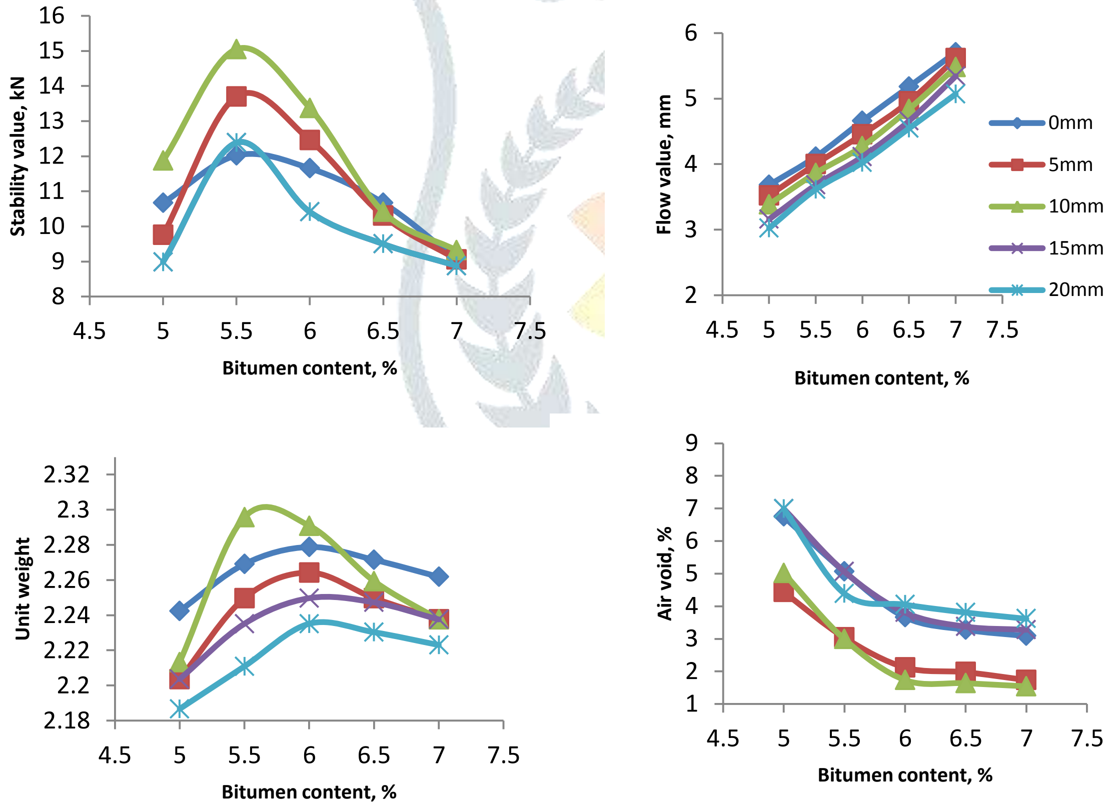


Figure-2 Marshalls properties with bitumen content at different coal ash content

It the can be concluded from the above graphs that using of coal ash in DBM mix is not satisfactory with respect to stability value, when compared with conventional mix. The maximum stability value of 12.01 kN was achieved when 15% of coal ash by weight of the mix was mixed for preparing DBM sample

From the above Marshall property of DBM mix that is prepared with coal ash, it is observed that, coal ash cannot deliver satisfactory result when used alone. The stability and flow values are not within the specification made for DBM mix. Also the volumetric analysis such as air void, unit weight, VMA and VFB, are lagging behind the conventional mix. Therefore the Marshall Properties study is done by using coal ash and jute fiber as an additive. The percentage of coal ash is taken as 15% as it shows better results than other coal ash content. The fiber content varied from 0% to .75% with 0.25% of increment, along with fiber length ranging from 5mm, 10mm, 15mm, and 20mm.results for 0.5 fiber content with various fiber lengths at 15 percent coal ash are given



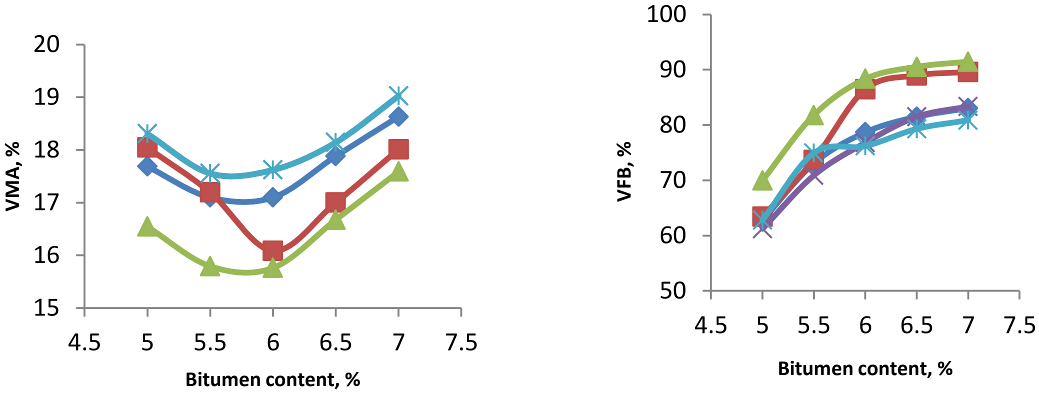


Figure 3 Variation of Marshall Properties with bitumen content in 0.5% fiber content at different`

It is observed from the stability and bitumen content graph, shown in figure 3 that with increase in bitumen content, fiber content and fiber length the stability values increased to certain limit and then decreased. From the optimum binder content analysis it is found that the maximum stability of 15.05 KN was achieved at an optimum binder content of 5.556% with optimum fiber content of 0.5% by weight of mixture along with fiber length of 10mm which was duly coated with SS-1 emulsion and cured for 24hours at 110±10°C

At the initial stage sample prepared with coal ash has shown increased flow value than the conventional DBM mix. But with the addition of jute fiber the flow value decreased as shown figure 3. The length of jute fiber has significant influence on flow value. It is seen that with increase in fiber length flow value decreased, which is because of the stiffness of the mixture caused by adding jute fiber.

From the graph shown in figure 3 it is also clear that with addition of fiber unit weight decreases as compared to the conventional mix. It was also observed that not only addition of fiber but also coal ash reduced the unit weight too. This is because of both fiber and coal ash is lighter material than bitumen. The fiber content and fiber length has a significant effect on minimizing the unit weight

At the initial stage of the study, the sample prepared only with coal ash has higher air voids in compare to conventional mix but jute fiber minimize the air voids of the mix. figure 3 depicts that increase in fiber content and fiber length decreases air void in the mixture as compared to normal DBM mix. It was also observed that the air voids were 13% less as compared to conventional DBM mix,

Figure 3 clearly show that VMA increases with increase in fiber length. fiber and coal ash together have shown satisfactory results on design specification for DBM mixture.

From the figure 3 it can be clearly seen that with increase in binder content VFB increase. As observed any of the fiber fractions and fiber lengths has given good VFB values when compared with conventional mix

The static indirect tensile test was carried out on samples with jute fiber and coal ash, sample with coal ash, sample without jute fiber and coal ash, sample with jute fiber,

From the graph given in Figure 4, usually with increase in temperature, the indirect tensile strength of any bituminous mix decreases but when coal ash along and emulsion coated fiber is added the indirect tensile strength of DBM sample is increased. This may be possible due to the interlocking pattern of fibers present in the mixture. Coal ash also contributes to a small increase in tensile strength, which can be used as advantage.

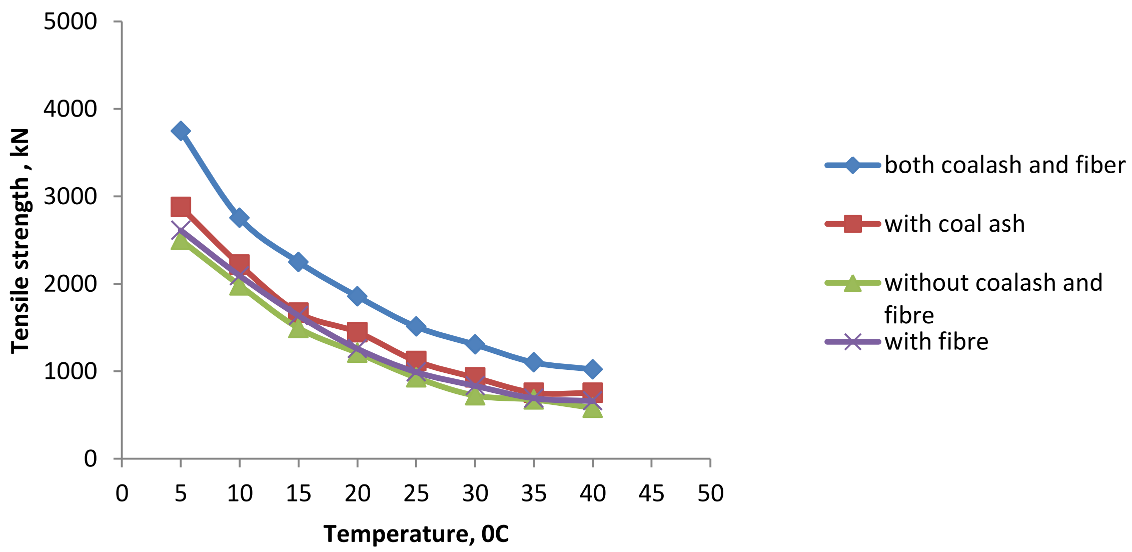


Figure 4. Graph between Tensile strength vs Temperature

The data from tensile strength ratio (TSR) test of four different types of mixes is presented in Table 2. It is observed when both fiber and coal ash together are present in the sample, resistance to moisture induced damage is maximum. Lesser air voids in modified DBM mixture could be the reason behind the increase, when made from coated jute fiber.

Table 2 TSR of DBM mixes with and without fiber and coal ash.

Tensile strength ratio			Design requirements
Type of mixes	DBM With coal ash	DBM Without coal ash	Minimum 80% (as per MORTH specification)
DBM With fiber	85.01%	81.78%	
DBM Without fiber	82.50%	80.3%	

DBM sample which were prepared with fiber, coal ash and conventional aggregates were subjected to Retained stability test results of which are given in table 3. The samples containing both coated fiber and coal ash has given better results. But the samples containing only coal ash have shown less resistance to moisture and reduced stability than required for design of mix.

Table 3 Retained stability of DBM mixes with and without fiber and coal ash

Retained stability				Design requirement
Type of mixture	Avg. stability after half an hour in water at 60 °c (kN)	Avg4.stability after 24 hours in water at 60°c (kN)	Avg. retained stability (%)	Minimum75% (as per MORTH specification)
DBM with fiber and Coal ash	14.95	13.42	89.76	
DBM with Coal ash	11.9	8.10	67.31	
DBM with fiber	13.50	11.10	82.22	
DBM without fiber and Coal ash	12.20	9.30	76.22	

Static creep test calculates resistance to permanent deformation under the constant loading with time, deformation vs. time graph is shown in figure 5 DBM sample made from 0.5% fiber content, 10mm fiber length, 15% coal ash (10% bottom ash and 5% fly ash) by weight of the mix and optimum binder content of 5.6% by weight of the mixture had lesser deformation values when compared with other DBM samples. By adding any of coal ash or fiber in the samples, the deformation also decreases when compared to conventional DBM samples.

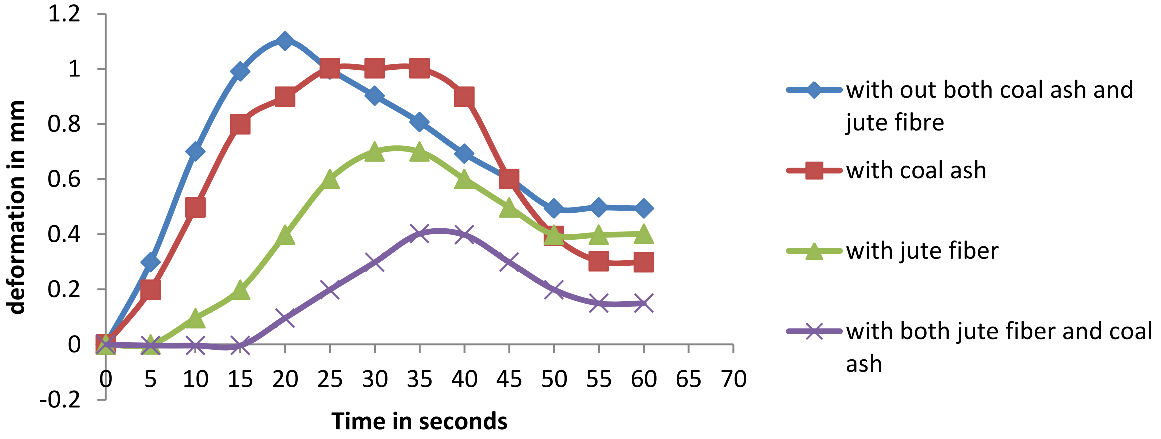


Figure 5 Variation of Deformation value at 40^{0}C for DBM sample with respect to time

IV CONCLUSION

1. DBM mixes prepared with bottom ash replacing fines of 300-75 microns and fly ash replacing filler resulted best mixes when coal ash content of 15%, bitumen content of 5.6 %, jute fiber percentage of 0.5% and fiber length of 10mm was taken. Marshall Stability and flow values are nearly similar to .
2. Tensile strength of sample increased when bitumen coated jute fiber and coal ash were added to DBM samples, which will make pavements resistant to thermal cracking.
3. Resistance to moisture susceptibility is increased when coal ash or jute fiber is added which is determined by tensile strength ratio and retained stability values.

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