

ANALYZING THE WASTE POLYETHYLENE IN BITUMINOUS MIXES WITH VARIATION IN DIFFERENT MIXED ELEMENTS UNDER SEVERAL STRENGTH TESTING CONDITIONS**K.NAGAMANI**

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Markapur, Prakasm(Dt).**Abstract:**

The quantum of plastic waste in is increasing due to increase in population, urbanization, development activities and changes in life style which leading widespread littering on the landscape. Thus disposal of waste plastic is a menace and become a serious problem globally due to their non biodegradability and unaesthetic view. As per the study, saw dust is suitable as a partial replacement of filler in asphalt concrete. The recommended content of Saw Dust Ash (SDA) is 2.74% of the total aggregate weight. Polyethylene Terephthalate (PET) fibres of 3cm length and a content of 2% by total aggregate weight is recommended. Asphalt waste can be successfully reused, without reducing the quality of the mix. Even, the reclaimed polyethylene originally made of LDPE has been observed to modify bitumen. In the present study, an attempt has been made to use reclaimed polyethylene which has been obtained from plastic packets used in packaging of a very popular brand of milk named OMFED, in dry form with the aggregates like a fibre in a bituminous mix. Thus, this technology contributes to give new life to cross-linked polyethylene plastic waste. Such bitumen can be modified with waste plastic pieces and bitumen mix is made which can be used as a top layer coat of flexible pavement. This waste plastic modified bitumen mix show better binding property, stability, density and more resistant to water to utilize them in a productive way which will satisfy the needs of the society. This particular work is an attempt to utilize these waste materials to some extent by replacing the filler and some fractions of fine aggregates in bituminous paving mixes

Key Words: Bituminous concrete (BC), Stone mix asphalt (SMA), Dense bound macadam (DBM).

INTRODUCTION

Bituminous mixes are most commonly used all over the world in flexible pavement construction. It consists of asphalt or bitumen (used as a binder) and mineral aggregate which are mixed together, laid down in layers and then compacted. Under normal circumstances, conventional bituminous pavements if

designed and executed properly perform quite satisfactorily but the performance of bituminous mixes is very poor under various situations. Today's asphaltic concrete pavements are expected to perform better as they are experiencing increased volume of traffic, increased loads and increased variations in daily or seasonal temperature over what has been experienced in the past. In addition, the performance of bituminous pavements is found to be very poor in moisture induced situations. Considering this a lot of work has been done on use of additives in bituminous mixtures and as well as on modification of bitumen. Research has indicated that the addition of polymers to asphalt binders helps to increase the interfacial cohesiveness of the bond between the aggregate and the binder which can enhance many properties of the asphalt pavements to help meet these increased demands. However, the additive that is to be used for modification of mix or binder should satisfy both the strength requirements as well as economic aspects.

Objectives of research

The present study aimed at preparation of bitumen modified with waste plastic fibers and to find the variation of conventional properties. The major objectives of the study are as follows. To study the physical properties of neat bitumen and modified with plastic fibers obtained from waste plastic bags To find out the optimum percentage of waste plastic bag fibers. To perform tests on bituminous mixes prepared using the optimum fibers content calculated

Scope of the study

- The significant scope of this study is to use coal ash as a fine material in HMA mix design and thus producing a good quality and smooth surface road which may be commercially acclaimed and can with stand in any possible environment condition.

- Again Utilization of non-conventional materials like coal ash and natural fibers together thus may help to find a new way of bituminous pavement construction. The coal ash dumping which is a serious concern to everyone in respect of its disposal and environmental pollution, can find one way for its reuse in an economical way by substituting natural resources of sand and stone dust.

In this research work a comparative study has been done on Dense graded bituminous macadam (DBM) by focusing on the following highlight

LITERATURE REVIEW

Boyes, Anthony John. (2011) studied the possible effect of fly ash as a mineral filler in asphalt mixes can aid in reinforcing and reducing bituminous moisture induce damage. The anti-stripping effect of two waste product cement kiln dust (CKD) and fly ash was investigated by compared them with hydrated lime and an amine-based chemical additive The observation shown that class C fly ash can be used as an anti-stripping additive in asphalt mix; however it is expensive than amine chemicals or lime. Also, test performed with dynamic shear remoter show that fly ash additives have a effect to stiffen the asphalt binder. Overall, 5% class C fly ash and 1.5% hydrated lime treated specimens demonstrated the greatest overall resistance to moisture damage. Combinations of 5% and 7% class C fly ash and 1.5% and 2% lime where determined to have significantly higher conditioned compressive strengths than control.

Partl, Manfred, K. Sokolov, and H. Kim. (2008) conducted Laboratory study on a special type of carbon fiber grid which was placed at different depth in

asphalt pavements. The purpose of the study was to obtain the design information about the position of the grid which will give optimum result. Two different types of asphalt pavements were examined (a) asphalt concrete and (b) mastic asphalt. This study reveals that with addition of carbon grid stiffness, failure strain and stress, and resistance against low temperature cracking increased. However, during rutting tests with Model Mobile traffic Load Simulator (MMLS) it was found that the grid was not able to improve resistance against flow value in the mastic asphalt layer.

Hadiwardoyo, SigitPranowo (2013) studied that the failure at the surface layers of road is due to the change in temperature and the load of the traffic. Structural. He performed an experiment on Short coconut fibres in bitumen mix. He execute the experiment with various percentage of coconut fibres ranging from 0.5% to 1.50% with the increment of 0.25%. The fiber size was also varied with 5mm, 7.5mm, 10mm, and 12.5 mm.

Putman, Bradley J., and Serji N. Amirkhanian (2004) studied the use of waste fiber in stone mastic asphalt mixture (SMA). He used waste tire and carpet fibers as an additive to stabilizing the excessive drain-down due to relatively high air void in SMA. He also studied the performance characteristics of SMA mixtures prepared with waste tire and carpet fibers. A comparative study has been done between SMA modified with tire and carpet fibers and with other mixes prepared with cellulose and polyester.

From the observation he found that the sample containing carpet and tire fibers, were effective in stopping unnecessary drain-down of the SMA mix. The toughness of the SMA mixes increases when added with tire and carpet fibers as compared to other cellulose fibers.

METHODOLOGY

In order to achieve the objectives of the study, a thorough review is done to have

knowledge of the works available in literature. First of all collection of plastic waste can be done. After that shredding or cutting of plastic into small pieces can be done After that ordinary tests can be performed on aggregate and bitumen. After that using plastic waste coating of aggregate can be done and tests will be performed. After that plastic is mixed with bitumen and laboratory tests can be performed. At last comparison of both test results with and without plastic waste can be done.

Table: Properties of Polymer Modified Bitumen

% of Plastics	Ductility (cm)	Penetration (mm)	Softening Point (°C)
1%	66	93	56
2%	56	89	51
3%	23	80	50
5%	16	60	78

The polymer bitumen blend is a better binder compared to plain bitumen. The blend has increased Softening Point and decreased Penetration Value with a suitable ductility. When used for road construction it can withstand higher temperature. Hence it is suitable for tropical regions. It has decreased Penetration Value. Hence its load carrying capacity is increased. The blend with aggregate has no Stripping Value. So it can resist the effect of water. The Marshall Stability Value is high. The bitumen required can be reduced depending upon the % of polymer added. It is a good saving too. No toxic gas is produced. Disposal of waste plastic will no longer be a problem. The binding properties of polymer also improve the strength of mastic flooring. The use of waste plastics on the road has helps to provide better place for burying the plastic waste without causing disposal problem. At the same time, a better road is also constructed. It also helps to avoid the general disposal technique of waste plastics namely landfilling and the incineration, which have certain burden on ecology.

Materials used in study

In this study following materials are taken in to consideration to prepare the bituminous mix.

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



Figure: fly ash, bottom ash, stone ash

Property	Code specification	Test Result	
		Natural Aggregate	Bottom ash
Aggregate impact value, %	IS 2386 part-IV	14	-
Aggregate crushing value, %	IS 2386 part-IV	13.5	-
Los Angeles Abrasion test, %	IS 2386 part-IV	18	-
Soundness test (five cycle in sodium sulphate), %	IS 2386 part-V	3	8.2
Flakiness index, %	IS 2386 part-I	11.9	-
Elongation index, %	IS 2386 part-I	12.5	-
Water absorption, %	IS 2386 part-III	0.14	10.75
Specific gravity	IS 2386 part-III	2.7	2

Bitumen used the 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 study the Marshall characteristics of mixes with the materials considered. These initial trials resulted better Marshall characteristics, especially the Marshall stability in respect of mixes made up of bottom ash, fly ash and emulsion coated fiber with VG-30 bitumen as binder. The physical characteristics of VG-30 bitumen tested as per IS standards are given in Table

**EXPERIMENTAL WORK
 EXPERIMENTAL DESIGN**

The adopted gradation for DBM sample has been considered as specified in MORTH and is given in Table-4.1.

Throughout the experimental study the aggregate gradation given in Table 4 was followed, and the following tests were performed. The aggregate gradation curve is shown in figure.4.1.

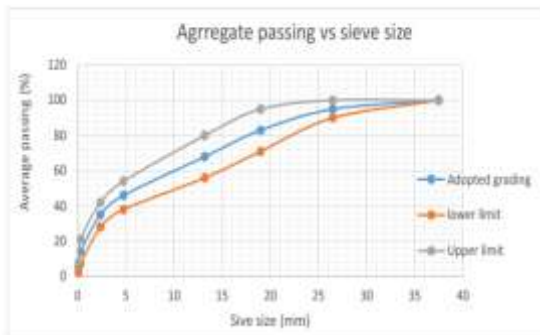
Table 4.1 Gradation of aggregate

Sieve size (mm)	Adopted gradation (% Passing)	Specified limit (as per MORTH, 2013) (% Passing)
37.5	100	100
26.5	95	90-100
19	83	71-95
13.2	68	56-80
4.75	46	38-54
2.36	35	28-42
0.3	14	7-21
0.075	5	2-8

Natural aggregate

Bottom ash

Fly ash



Aggregate gradation curve

After adopting the above aggregate gradation the subsequent test were made to ensure the performance characteristics.

Design mix

The DBM mixtures were prepared in accordance with the 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 specified procedure. The aggregates and bitumen were heated separately to the mixing temperature of 1550C to 160 0C. The temperature of the aggregates was maintained 100C higher than that of the binder. Required quantities of bitumen VG-30 and coated emulsion fiber pieces were added to the pre-heated aggregates and thoroughly mixed as shown in Figure



Cutting of coated fiber



Pouring of mixture in mould, (b) Compaction of mixture in progress, (c) DBM samples, (d) Marshall test in progress

The quantity of binder to be added was calculated from subtracting the weight of emulsion coated fiber from weight of design binder. Proper mixing was done manually till the colour and consistency of the mixture appeared to be uniform. The mixing time and temperature was maintained within 2-5 minutes and 1500C-1600C respectively. The mixture was then poured in to a pre-heated Marshall mould and compacted using Humboldt Automatic Marshall Compact with 75 compaction blows on each side. The specimens were kept 24 hours for cooling to a temperature of 25+ 1 0C (as shown in Figure 4.6 (a), (b), (c) respectively).

In this experiment, the resistance to deformation of a Marshall cylindrical specimen of DBM mixture is measured. The specimen is loaded diametrically at a deformation rate of 50 mm/min as shown in Figure 4.6(d). Here are two major

features of the Marshall method of mix design are given below.

1. Stability and flow values
2. Voids analysis

The Marshall stability for bituminous mix is defined as the maximum resistance carried by specimen at a standard temperature of 60°C. The flow value is recorded when the specimen deformed under maximum. The Marshall voids analysis were done before the Marshall stability test. In this voids analysis bulk specific gravity (G_{mb}), air voids (VA), voids in mineral aggregate (VMA), voids filled with bitumen (VFB), and Marshall Quotient were determined, that are discuss in next chapter.

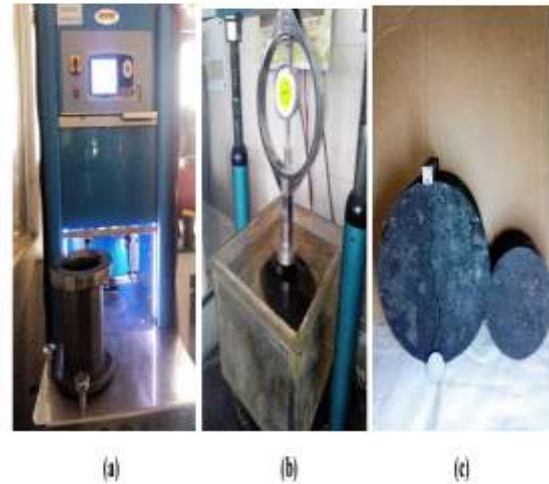
Static indirect tensile test

Static indirect tensile test of bituminous mixes was performed in accordance to ASTM D 6931 (2007) to assess the resistance to thermal cracking for a Marshall cylindrical specimen that is loaded in vertical diametrical plane as shown in figure 4.7. This tests were carried out on DBM specimen which were prepared at their optimum binder content, optimum fiber content and optimum fiber length as calculated from Marshall properties analysis. The effect of temperature on the Indirect Tensile Strength (ITS) of mixes with and without fiber was also studied. The load at which tensile crack were develop in the specimen were noted down from the dial gauge of the proving ring and was calculated.



One subset was partially saturate to be moisture conditioned with distilled water at room temperature using a vacuum chamber by applying a partial vacuum of 70 kPa or 525 mm Hg (20 in. Hg) for a short time such as five min. after that the

partially saturated samples are cured to be moisture conditioned in distilled water at 60+ 1.0°C for 24 hour.



(a) Sample Prepared in gyratory compactor, (b) Moisture susceptibility test in progress, (c) Failure cracks in DBM sample

Retained stability test

The loss of stability in bituminous mixes due to penetration of moisture are measure in the form of Retained stability test. This test also shows the sign of percentage striping of bitumen from aggregate

Static creep test

This test method is used to determine the resistance to permanent deformation of bituminous mixtures at specific temperatures. Then 125 lb. (556 N) load was applied for one hour followed by 1 min initial loading rest. This allows the loading platens to achieve more uniform contact with the specimen. The deformation was registered in each 5 min intervals starting from 0 min to 60 min by using a dial gauge graduated in units of 0.002 mm. After then the load was removed and its recovery was registered up to next 5 min at 1 min intervals. A graph has been plot between time and deformation.

RESULTS AND DISCUSSION

This chapter is divided into three sections. In first section the parameter and the equation used for Marshall Properties analysis are given below. Second section deals with calculation and comparison of

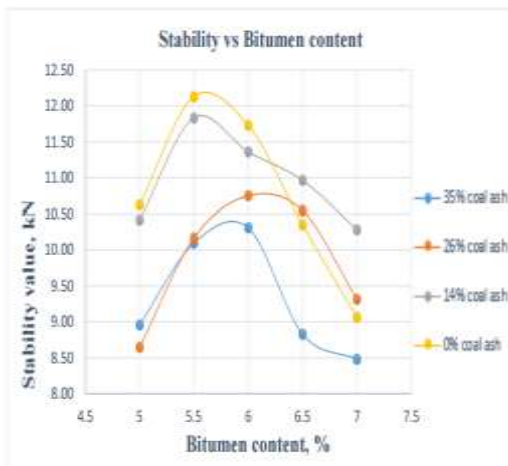
optimum binder content, optimum fiber content and optimum fiber length of DBM mixes with and without coal ash used as fine aggregate and filler. Third section deals with analysis made from the experiment such done in previous chapter static indirect tensile, static creep test at 400C, moisture susceptibility test (Tensile strength ratio), and retained stability test.

Parameters used in the study

Effect of coal ash (Bottom ash and Fly ash) on DBM mix At the initial stage of experiment bottom ash and fly ash was used as fine replacement in DBM mix. In this experiment the total coal ash content is taken as 35% by weight of the total mix, from which the percentage of fly ash as mineral filler is fixed, i.e. 5% of weight of the mix. The bottom ash content is varied according to the DBM gradation specified in MORTH (2013), which is given in chapter.

Marshall stability

It is seen from the figure 5.1 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 11.83 kN was achieved when 14% of coal ash by weight of the mix was mixed for preparing DBM samples

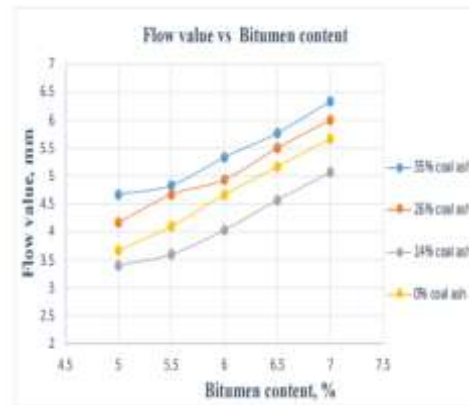


Variation of Stability value with bitumen content at different coal ash content

Marshall flow value

It was seen from the flow value vs bitumen content graph shown in figure 5.2 that with increase in bitumen content and Coal ash

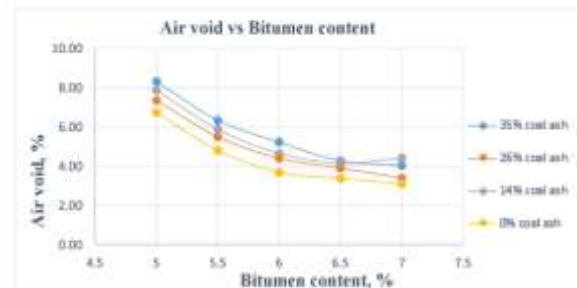
content the flow value increase. But with 14% coal ash content by weight of mix the flow value decrease as compare to the conventional mix.



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

Air void

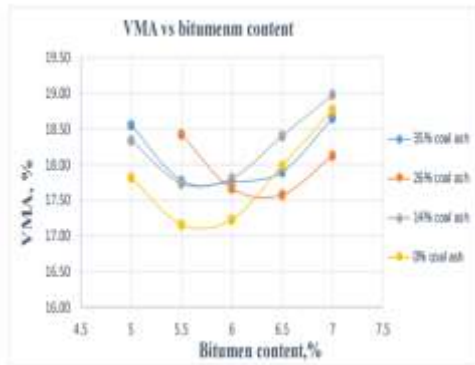
It is observed from the graph shown in figure 5.3 that with increase in coal ash the air void increases. By taking 14% coal ash by weight of the mix, the air void is fairly near to the conventional mix, which means coal ash can be used with some modification to achieve optimum properties than conventional mix.



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

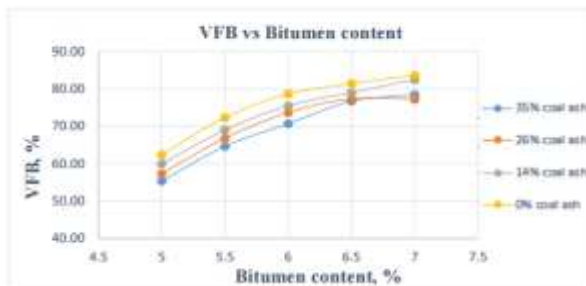
Voids in Mineral Aggregate (VMA)

From the observation of VMA vs bitumen content graph in Figure, it is clear that with increase in bitumen content voids in mineral aggregate decrease rapidly first and then increases steadily.



Variation of VMA value with bitumen content at different coal ash content
Voids Filled with Bitumen (VFB)

It is observe from the VFB and bitumen content graph shown in Figure 5.6 that VFB increase rapidly with increase in bitumen and coal ash content.



Variation of VFB value with bitumen content at different coal ash content

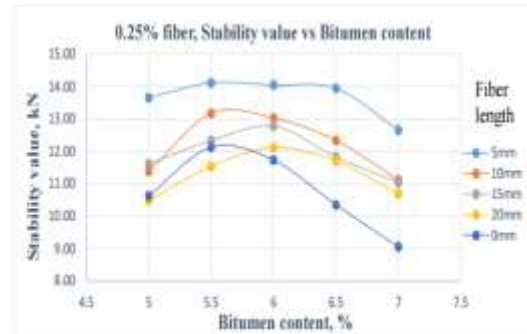
Effect of Sisal fiber and Coal ash (Bottom ash and Fly ash) on DBM mix

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 sisal fiber as an additive. The percentage of coal ash is taken as 14% as it shown better result than other coal ash content. The fiber content varied from 0% to 1% with 0.5% increment, along with fiber length ranging from 5mm, 10mm, 15mm, and 20mm.

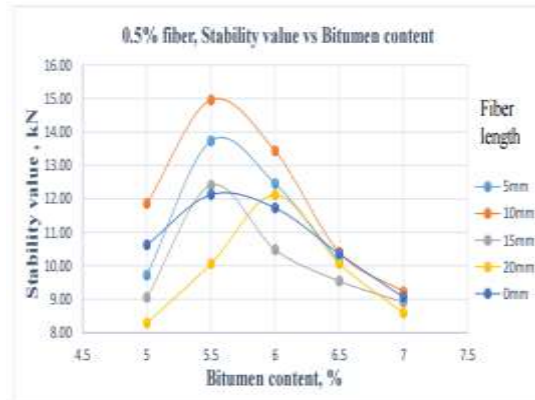
Marshall stability

From the optimum binder content analysis it is found That the maximum stability of 15kn was achieved at an optimum binder

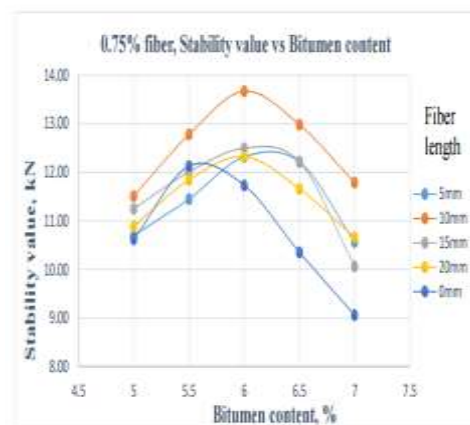
content of 5.57% with optimum fiber content of 0.5% by weight of mixture along with fiber length of 10mm which was duly coated with SS-1 emulsion and cured for 24hours at 110+ 1 °C.



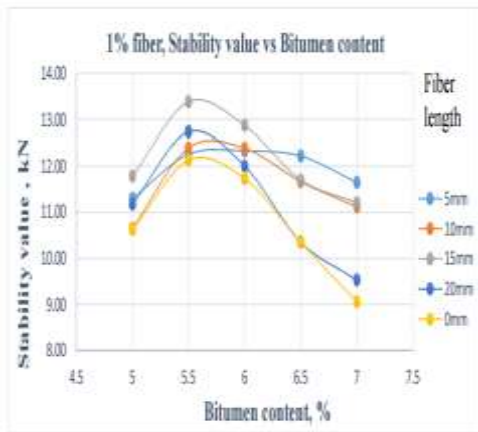
Variation of Stability value with bitumen content in 0.25% fiber content at different fiber length



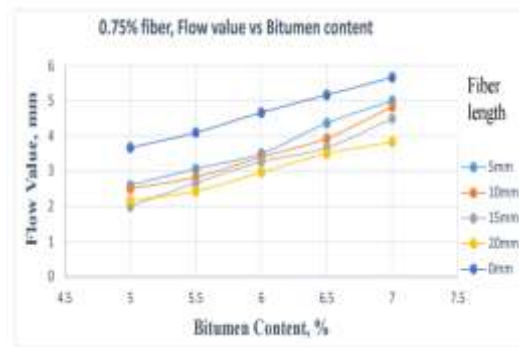
Variation of Stability value with bitumen content in 0.5% fiber content at different fiber length



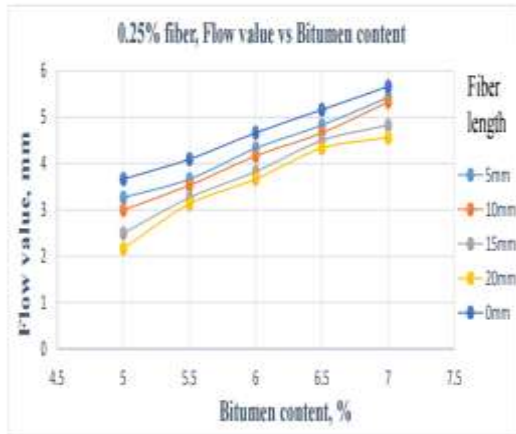
Variation of Stability value with bitumen content in 0.75% fiber content at different fiber length



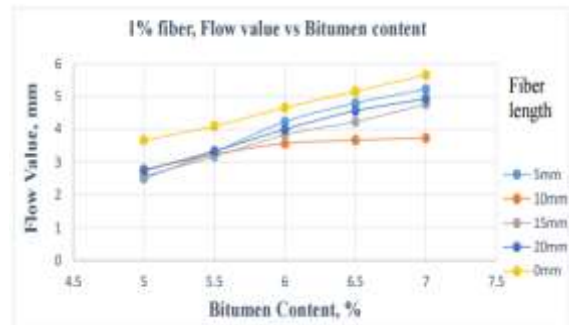
Variation of Stability value with bitumen content in 1% fiber content at different fiber length



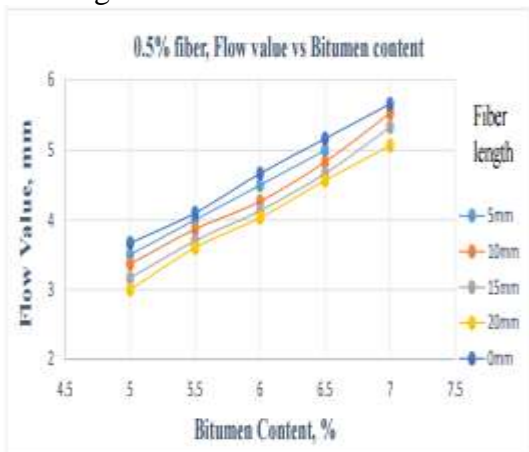
Variation of Flow value with bitumen content in 0.75% fiber content at different fiber length



Variation of Flow value with bitumen content in 0.25% fiber content at different fiber length



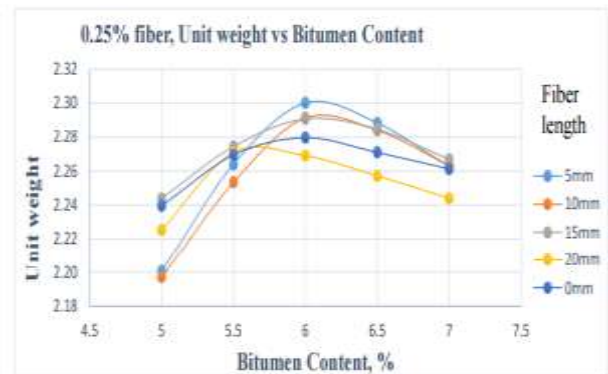
Variation of Flow value with bitumen content in 1% fiber content at different fiber length



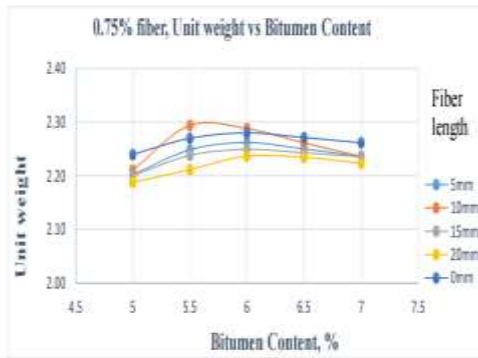
Variation of Flow value with bitumen content in 0.5% fiber content at different fiber length

Unit weight

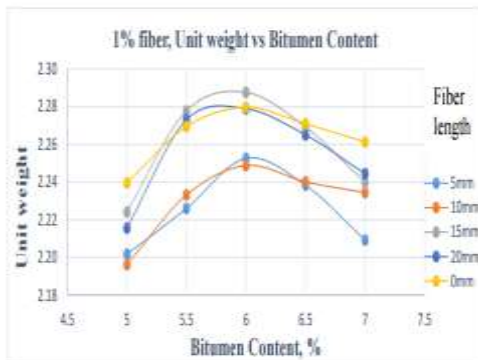
From the graph shown in figure 5.15 to figure 5.18 it is clear that with addition of fiber the unit weight decrease as compare to the conventional mix. It was also observe that not only addition of fiber but also coal ash reduced the unit weight too. This is because of both fiber and coal ash are lighter material than bitumen. The fiber content and fiber length has a significant effect on minimizing the unit weight.



Variation of Unit weight value with bitumen content in 0.25% fiber content at different fiber length



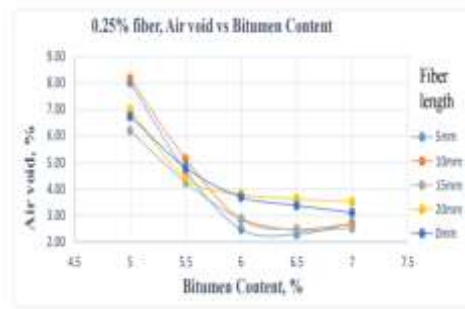
Variation of Unit weight value with bitumen content in 0.75% fiber content at different fiber length



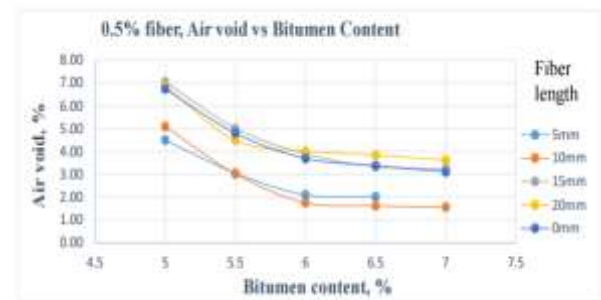
Variation of Unit weight value with bitumen content in 1% fiber content at different fiber length

Air voids

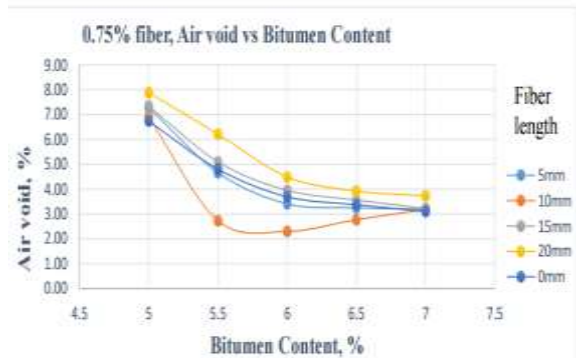
Generally DBM have HMA due to well graded aggregates. But at the initial stage of the study, the DBM sample prepared with coal ash have higher air voids in compare to conventional mix. Due to this reason sisal fiber is added to somewhat minimize the air voids. And as a result from the graphs shown in figure 5.19 to figure 5.22 it is clear that with increase in fiber content and fiber length the air void in the mixture decreases as compare to normal DBM mix. It has also observe that the air void was 14% less as compared to conventional DBM mix, when prepare with optimum coal ash content and optimum sisal fiber property.



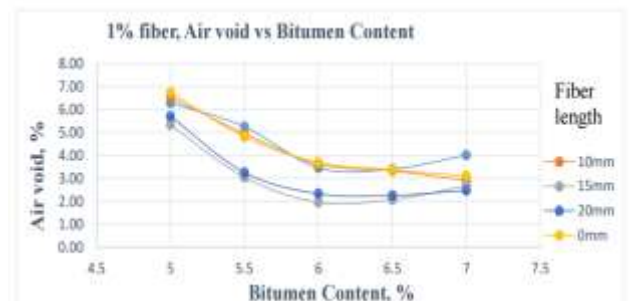
Variation of Air void value with bitumen content in 0.25% fiber content at different fiber length



Variation of Air void value with bitumen content in 0.5% fiber content at different fiber length



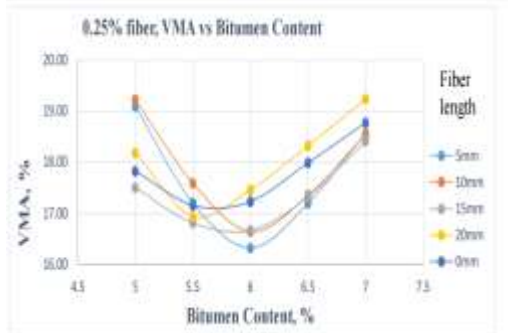
Variation of Air void value with bitumen content in 0.75% fiber content at different fiber length



Variation of Air void value with bitumen content in 1% fiber content at different fiber length

Voids in mineral aggregate (VMA)

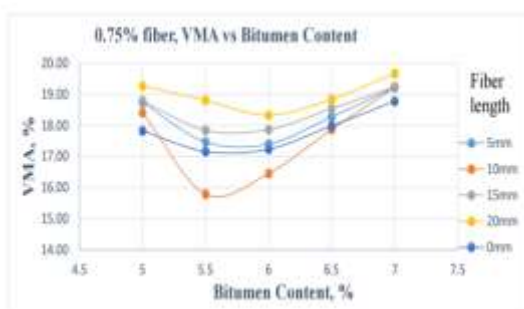
It is observed from VMA and bitumen content graph, shown in figure 5.23 to figure 5.26 that with increase in fiber length VMA value increases. Sample prepared with fiber and coal ash has shown satisfactory result with respect to design specification for DBM mixture.



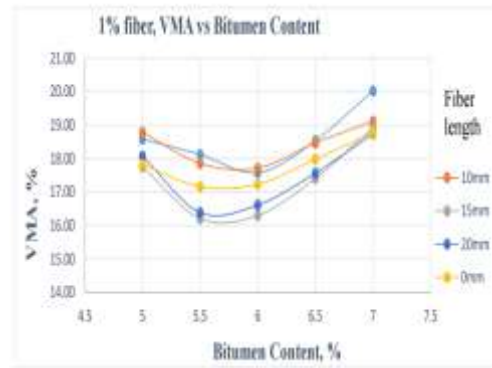
Variation of VMA value with bitumen content in 0.25% fiber content at different fiber length



Variation of VMA value with bitumen content in 0.5% fiber content at different fiber length



Variation of VMA value with bitumen content in 0.75% fiber content at different fiber length



Variation of VMA value with bitumen content in 1% fiber content at different fiber length

Marshall properties analysis

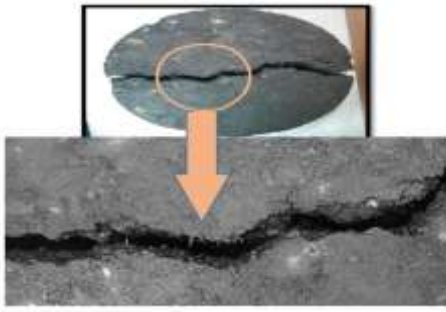
Fiber content, %	Fiber length, mm	OBC, %	Optimum stability, kN	Flow value, mm	VA, %	VMA, %	VFB, %	Gmb
0.25	0	5.60	11.40	3.15	2.40	15.30	84.00	2.33
	5	5.70	14.20	4.00	3.60	16.70	79.00	2.28
	10	5.78	13.20	3.50	3.60	17.00	76.00	2.28
	15	5.87	12.80	3.80	3.10	16.60	80.00	2.27
	20	5.73	11.90	3.80	4.00	17.00	77.00	2.27
0.5	0	5.60	11.40	3.15	2.40	15.30	84.00	2.33
	5	5.57	13.80	3.85	2.90	17.10	75.00	2.26
	10	5.60	15.00	3.50	2.80	15.80	82.00	2.30
	15	5.80	11.50	3.60	4.30	17.60	76.00	2.25
	20	6.13	12.00	4.90	4.00	17.90	78.00	2.24

Fiber content, %	Fiber length, mm	OBC, %	Optimum stability, kN	Flow value, mm	VA, %	VMA, %	VFB, %	Gmb
0.75	0	5.60	11.40	3.15	2.40	15.30	84.00	2.33
	5	5.90	12.20	3.70	3.60	17.30	80.00	2.26
	10	5.77	13.30	3.10	2.20	15.90	86.00	2.30
	15	6.00	12.50	3.40	4.00	17.90	78.00	2.25
	20	6.13	12.30	3.50	4.30	18.35	77.00	2.24
1	0	5.60	11.40	3.15	2.40	15.30	84.00	2.33
	5	5.95	12.30	4.20	3.70	17.60	80.00	2.24
	10	5.77	12.50	3.40	4.40	17.65	76.00	2.24
	15	5.55	13.40	3.20	2.90	16.10	82.00	2.28
	20	5.63	12.65	3.8	2.40	16.20	83.00	2.28

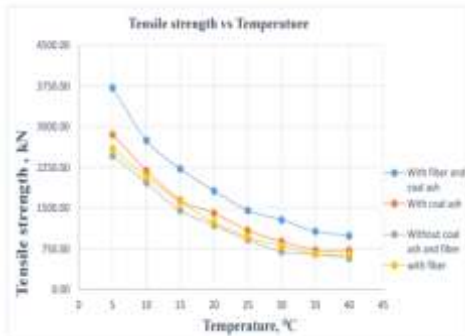
Static indirect tensile test

The static indirect tensile test was carried out on four types of samples given below.

- Sample with fiber and coal ash
- Sample with coal ash
- Sample without fiber and coal ash
- Sample with fiber



Criss-cross pattern of sisal fiber at tensile failure crack



Graph between Tensile strength vs Temperature.

Resistance to moisture damage (Tensile Strength Ratio (TSR))

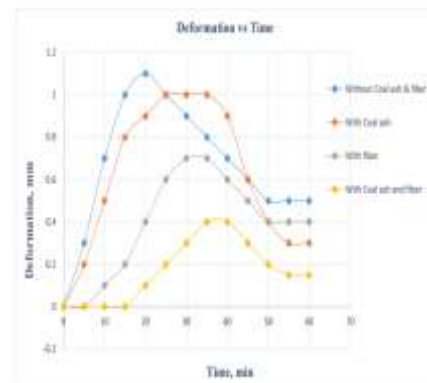
The results of tensile strength ratio (TSR) in respect of two different types mixes, one modified and other unmodified are presented in Table 5.2. It was observed that with addition of both fiber and coal ash together, resistance to moisture induced damage was increased as compared to the conventional DBM mixture. This may be due to the lesser amount of air voids in modified DBM mixture than unmodified mixture, when prepared with emulsion coated sisal fiber. Similarly from the table 5.1, it is observed that a minimal value of resistance to moisture damage is achieved when the mix was prepared with either fiber or coal ash.

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

Type of mixes	Tensile strength ratio		Design requirement
	DBM With coal ash	DBM Without coal ash	
DBM With fiber	84.77%	82.04%	Minimum 80% (as per MORTH specification)
DBM Without fiber	82.35%	80.26%	

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

Type of mixture	Retained stability			Design requirement
	Avg. stability after half an hour in water at 60 °c (kN)	Avg. stability after 24 hours in water at 60 °c (kN)	Avg. retained stability (%)	
DBM with fiber and Coal ash	14.78	13.21	89.37	Minimum 75% (as per MORTH specification)
DBM with Coal ash	13.88	10.17	73.21	
DBM with fiber	12.63	10.10	79.94	
DBM without fiber and Coal ash	13.56	10.45	77.03	



Variation of Deformation value at 400C for DBM sample with respect to time

CONCLUSIONS

In this manner the utilization of higher rate of waste polythene is not ideal While conversing with ecological contamination because of these no biodegradable plastics squander where transfer of such materials has turned into a difficult issue, its utilization in development of adaptable asphalt will give a superior place for their covering and subsequently taking care of the issue of their transfer on one hand and giving a superior adaptable asphalt with enhanced execution on other hand.

The following conclusions are drawn based on the results obtained in the present study

- The properties of bitumen such as penetration softening point improved with the addition of the waste fiber. There is a significant decrease in penetration values for modified blends, indicating the improvement in their temperature susceptibility resistant characteristics.
- The softening point increase with increase in percentage of fibre and this is so because the bitumen becomes increasingly viscous. The results show that bitumen modified with lower percentage of fibres can be used in road construction satisfactorily, but higher percentage of fibers i.e. more than 0.7 % may be used as a roofing material.
- The ductility value decreases with increase in percentage of modifier, but the rate of decrease is less when fiber is added beyond 0.5 percent. The ductility value less than 50cm should not be used in road constructions, but may be used as crack and joint filler materials.

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