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A Result Paper on Impacts of Using Sisal Fiber with Mineral Filler on Dense Bound Macadam

Sahil Kumar[1], Ms. Shivani[2]

[1]M Tech Scholar, [2]Assistant Professor,
[1,2]Sat Priya Group of Institutions, Rohtak, Haryana, India

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*

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1. INTRODUCTION

The roadways including pavements are considered to be the backbone of the country on which the growth as well as upswing depends. Usually, all the countries consist of the sequence of the various programs for the construction of the new roads or the reconstruction of the existing roads, etc. Both the types of pavements i.e. rigid as well as flexible require the huge investment for their construction to attain the desired level of performance such as smoothness in quality and durability. In the developing countries like India, the Government considers the roadways as the prime assets for their income which results into the investment of huge capital for their maintenance and construction. To fulfill all the requirements along with its reliable performance, an engineered survey and study is done. There are two major factors for flexible pavement which are found to affect the performance of the pavement namely, design mix and design of pavement. This present study deals with the engineering characteristics and behavior of bitumen mixes which are formed by some non-conventional materials.

BITUMINOUS MIX DESIGN

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.

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. The main objective this design mix is to calculate the adequate ratio of bitumen and fractions of aggregate to form an effective mix which has to be essentially durable, economical and reliable.

2. REVIEW OF LITERATURE

A Research has been carried out by **Manimaran E and Mohan Kumar G (2017)** that higher concentration of bottom ash reduces the slump Value and to make the mix workable we need some extra amount of water. The characteristic strength of the pavement mix was observed to be 3% more than that was easily obtained by lowest molarity 8M of NaOH both in hot and ambient curing.

Patankar S.V (2018) studied the effect of various concentrations on the strengthj of bottom ash based concrete onj amount ofj sodium hydroxidej solutionj in terms of Molarity to bottomj ashj ratio 0.30, 0.35, 0.40 on workabilityj in terms ofj flow plastic state. This research showed that compressive strengthj increases in increases in amount of sodium hydroxide solj in terms of molarity. Theyj recommended 13M solution on the basis ofj workability and compressive strength.

Sudhakarreddy K (2020) reported that 6% of replacements of cement in fly bottom ash in the bituminous design mix yield the good results in flexure strength of the pavement.

3. RAW MATERIALS

A consistent mix formed by the aggregates having gradations form highest fraction to smallest fraction ranging from I.S. 25mm size to filler, smaller than I.S. 75 micron size with the bitumen binder, blended together to form a the bituminous mix. The mix is laid and compacted such as to attain the elastic body, hard and non-porous in nature. This present study is to calculate the most appropriate the ratio of aggregates, fillers, bitumen and some other additives if required.

The design of bituminous mix includes the process of calculating the ratio of bitumen, fine aggregates, coarse aggregates and filler. This design mix must be strong enough, durable, economical and workable. The basic materials which are used for the mix are listed below:

1. Bituminous Binder
2. Fly Ash
3. Aggregates
4. Slag
5. Additve

4. EXPERIMENTAL WORK

To ensure the required level of performance, the above defined gradation of aggregates is used for the following test:

1. Marshall Test for mixes for their volumetrical analysis
2. Splitting Tensile Strength Test / Static Indirect Test for tensile strength
3. Static Creep Test
4. Tensile Strengthj Ratio Test (Resistance to Moisture Damage)
5. Retained Stability Test

DESIGN MIX

According to specifications from the Marshall procedure defined in ASTM-D-6927 (2015), all the constituents of the mixes like filler, fine aggregates, coarse aggregates, fiber and VG – 30 bitumen are mixed thoroughly as per the specifications. Before the preparations of the specimens, the coating of fibers is done with emulsion SS – 1 and kept at controlled temperature conditions of around 1100° C for 24 hours. This condition mainly helps the fibers to sustain a proper coating around it and the extra amount of the bitumen to be drained out. The different specified lengths of fibers for the test are kept as 20 mm, 15 mm, 10 mm and 5 mm respectively. The heating of aggregates and bitumen takes place in the temperature range of about 1550° - 1600° C. It is interesting to note that the temperature of the aggregates should be around 100° C above the temperature of the binders. The desired amount of the VG – 30 bitumen and fibers having emulsion layer are added to pre-heated aggregates and completely mixed

5. RESULTS

Table : Analysis of Marshall Characteristics

Fiberj content, %	Fiberj 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
Fiberj content, %	**Fiberj length, mm**	**OBC, %**	**Optimum stability, kN**	**Flow value, mm**	**VA, %**	**VMA, %**	**VFB, %**	**Gmb**
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
Fiberj 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
Fiberj content, %	**Fiberj length, mm**	**OBC, %**	**Optimum stability, kN**	**Flow value, mm**	**VA, %**	**VMA, %**	**VFB, %**	**Gmb**
1	0	5.60	11.40	3.15	2.40	15.30	84.00	2.33
	5	5.93	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 STRNGTH TEST

For this test, the cylindrical shaped Marshall specimen is subjected to load in compression at rate of 5.1 cm per minute such that the loading planes are parallel along the perpendicular diametrical planes by the use of curved strips of stainless steel. The radius of curvature is quite similar to the radius of curvature of sample. Initially, the specimen is kept in the water bath to maintain at some specified temperature for 30 minutes before testing. It should be noted that the same temperature has to be maintained during testing. The applied configuration of external load generates a comparative uniform stress in tension normal to the direction of load applied and along the diametric planes also. Interestingly, the failure of specimen is done by the splitting action along the vertical plane of the diameter.

$$\text{Indirect / Splitting Tensile Strength} = \frac{2 \text{ X } P}{N \text{ X } D \text{ X } T}$$

Where, P = Maximum Value of Load Applied (in KN),
T = Height ofj Specimen just before test (in mm),
D = Diameter of Specimen (in mm)

The testing temperature varies in the range of 5° to 40° C with constant increase of 5°C temperature. The final result of tensile strength is taken as the average value taken from the three testing results of the specimens.

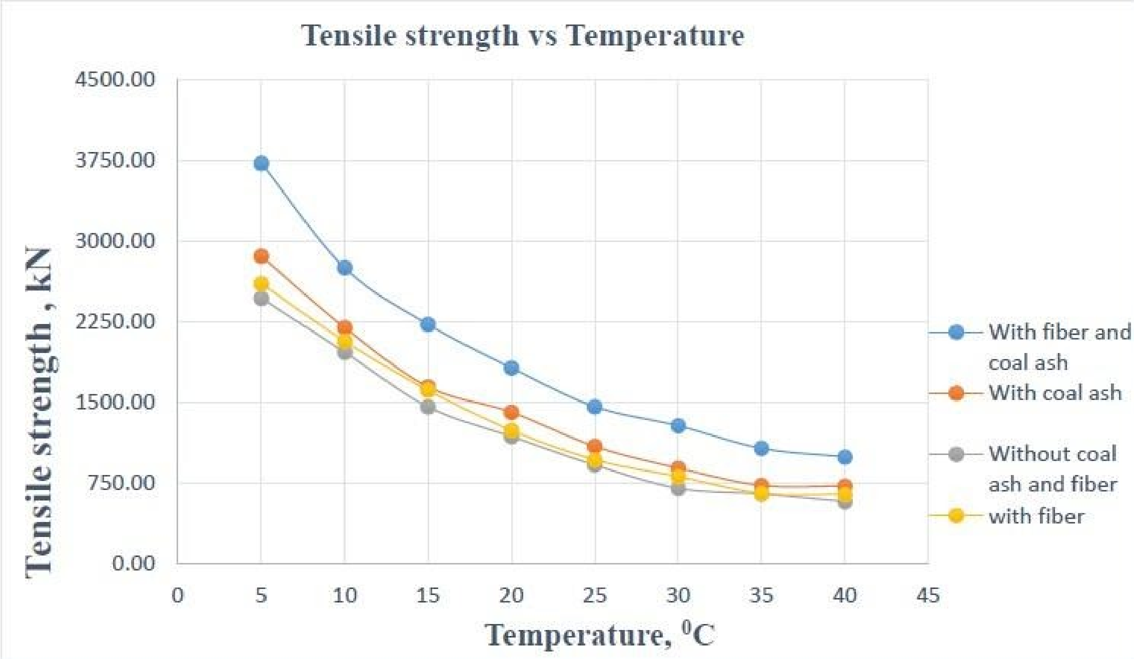

Fig. : Variation of Tensile Strength with respect to Temperature

This test is conducted on four types of specimens as given below:
1. Specimen with coal ash only
2. Specimen with fiber only
3. Specimen without coal ash and fiber
4. Specimen with coal ash and fiber both

The graphical figure 5.32 shows that the indirect strength in tension gets reduced with rise of temperature but this strength gets increased with coated fibers along with the coal ash are used for the preparation of DBM specimen. It may be due to texture of fibers used. It is also interesting to note that the contribution of coal ash helps to enhance the marginal rise in tensile strength when compared to the traditional design mix.

RATIO OF TENSILE STRENGTH (TSR)

Table shows that values of ratio of tensile strength of two various kinds of mix i.e. one is modified in nature while the other unmodified in nature. It is noted that when the coal ash and sisal fibers are used together, the resistance against the damage due to moisture of the DBM designed mix gets increased. It might be possible due to the fact that modified mix of BM consists of lesser air voids as compared to that of unmodified mix. When the design mix is prepared any of the content between coal ash or sisal fiber, a certain amount of resistance to damage susceptibility due to moisture is attained.

Table : Ratio of Tensile Strength

Ratio of Tensile Strength			Design Considerations
Mix Types	DBM containing coal ash	DBM Without coal ash	At least 80% (refer to MORTH specification)
DBM With Sisal fiber	83.00%	81.09%	
DBM Without Sisal fiber	83.12%	79.98%	

STATIC CREEP TEST

This test is a tool to measure the permanent deformations subjected to the consistent loading for large time interval. Fig. 5.33 shows the graphical variations between deformations and time such that minimum deformations for the DBM specimens are observed with 10 mm length of fiber, 0.5 % content of fiber, 14 % coal ash and optimum content of binder is 5.7 % by weight of the mix.

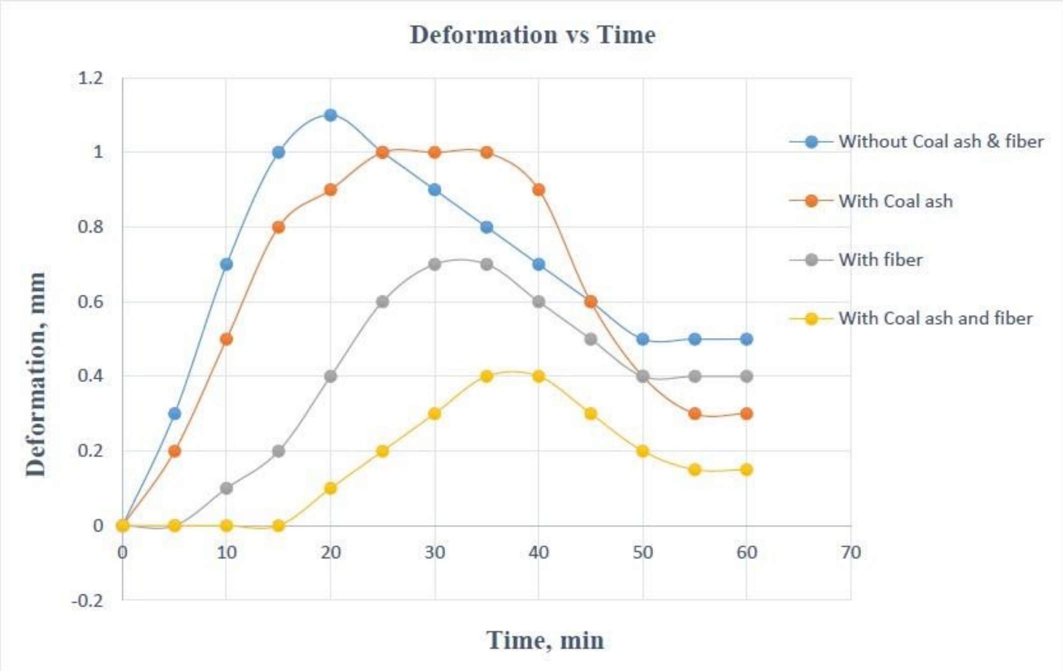

Fig: Deviations of Deformation for DBM specimens with time at temp.

6. CONCLUSION

The experimental approach to the present research work draws the following conclusions:

1. The Marshall tests concludes that Dense Bituminous Macadam designed mixes are formed by the addition of fly ash particles passing through 0.075 microns and bottom ash particles that lies in the range of 0.075 mm to 300 mm. These mixes are found to be the best design mixes that fulfills the criteria as per the Marshall tests such that the bituminous concentration, length of fibers ad their concentration used are 5.7%, 10 mm and 0.51% respectively.
2. It is interesting to note that the flow values and values of Marshall Stability obtained falls under the acceptable range of criteria provided that the content of coal ash remains within 15 % range.
3. It is noted that the flow value of the mixes gets reduced drastically with rise in the length of fiber and its content along with the concentration of air voids. In contrast to this, the increase in the value of Marshall Quotient takes place which results into the increase in stability value of the mixes.
4. It is also concluded that the requirements for the optimum content of bitumen and emulsions to be used for the fiber coating increases with rise of length of fibers and its content.
5. The various tests that are used to measure the various tensile strength values of concrete indicates that the strength of concrete in tension of the specimen increases by the adding coal ashes and the fibers having emulsions coating. It results into very wide improvements to the engineering properties for DBM specimens against cracking due to thermal changes.
6. The utilization of coal ash, fibers having emulsion coating or both to the Dense Bound Macadam design mixes imparts the higher resistance against the damage by the moisture in the form of ratio of tensile strength of the mixes along with the stability values.

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