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A STUDY ON ENHANCEMENT OF ENGINEERING PROPERTIES OF GRADE BITUMINOUS MIXES WITH COAL, ASH BY USING NATURAL FIBER

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ABSTRACT

Coal-based thermal power plants have been a key source of power generation in India. The prime waste product of a coal thermal power plant is fly ash and bottom ash. Heavy dumping of the waste products causes lathell environment pollution to air, water, and land, besides impairing human health. This research work is done to deliver the optimum use of ash, namely bottom ash as fine aggregate and fly ash as mineral filler with natural fiber (such as sisal and filament fiber) used to improvise the engineering properties of bituminous paving mixes. For national interest these waste products, which are available generally and abundantly can be used economically for bituminous paving are extremely strong purpose, which fundamentally helps in saving the natural aggregate resources of the nation.

In the present study, dense grade of bituminous mix specimens are prepared using natural aggregate as coarse aggregates, bottom ash as fine aggregates, fly ash as filler and sisal fiber as submission. 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 mix, slow setting emulsion (SS1) coated sisal fiber is added in meaning percentage of 0, 0.25%, 0.5%, 0.75%, and 1% by weight of the mix, with different length alternatives such as 5mm, 10 mm, 15 mm and 20 mm. At the initial stage of the research, specimens were prepared with the two types of paving bitumen i.e. VG30 and VG20, out of which the remaining trials resulting better Marshall characteristics with VG30 bit mastic and hence was conformed for subsequent read . Detailed study with Marshall test results were used to determine the marshall method characteristics, optimum binder content and also optimum fiber content including by the optimum length of fiber. Marshall stability as high as 15kN was obtained with optimum bitumen content of 5.57%, with optimum fiber content of 0.5% with optimum fiber span of 10 mm. Further, for delivering they accomplishment of the pavement, many performance tests were also conducted such as moisture susceptibility test, indirect tensile strength (ITS), creep test and water sensitivity test ratio of bitumen mixes. It is fallen observed then not only sufficient, but also much improved engineering properties result with coal ash as fine aggregate and filler, stabilized ,Utilization of non-conventional aggregate like coal ash and behavior fiber together thus may help to find a new way of bituminous reinforced construction. The coal ash dumping which is a serious concern about to everyone in respect of its waste disposal and environmental pollution, can find one way for its reuse in an economical way by substituting behaviors resources of sand and brick dust

INTRODUCTION

BACKGROUND OF THE STUDY

Pavements or highways or roads are regarded as country's backbone, upon which its upswing and progress depend on. All countries easilly have a series of functions for building a new road infrastructures or emerging the existing one. Construction of both flexible and rigid pavement include a gross amount of investment to reach better present by oriented and smooth quality of pavement that will endure for big time. In India, where highways are considered as the primary function of transportation, Government of India have been investing a huge amount of money for developing the pavement construction and maintenance. A detailed engineering study may retain significant amount of investment and pavement materials, which is turn achieve a reliable performance of the in-service highway. Regarding flexible pavement, two major facts are taken into considerations i.e. pavement design and mix design. The present research study is focused on engineering property of bituminous mixes prepared from alternate or nonconventional materials.

1.2. BITUMINOUS MIX DESIGN

1.2.1. OVERVIEW ON BITUMINOUS MIX DESIGN

From the review of Das et al. (2004); it is known that the bituminous paving technique was first introduced on rural roads during 1900's. The formal mix design method was first made possible by Habbard field method, which was originally developed for the sand-bituminous mixture. But one of the focal limitation of this technique was its incompatible of handling large aggregates. Later on, a project engineer Francis Hveem of California Department of Highways, developed an instrument called Hveem stabilometer to calculate the possible stability of the mixture. At the early stage, Hveem did not have any experience to estimate the amount of optimum bitumen that will just be right for mix design. He adopted the surface area calculation concept used for cement concrete mix design, to assess the quantity of bitumen vital for the mixture. On the other hand, Bruce Marshall developed equipment to test stability as well as deflection of the bituminous mixture. It was adopted by the US Army Corpse of Engineers in 1930's and successively adapted in 1940's and 50's.

1.2.2. BITUMINOUS MIX DESIGN

Bituminous pavement comprises of a mixture of stone chips, graded from nominal maximum aggregates size (NMAS), through the fine fraction smaller than 0.075 mm mixed with appropriate amount of bitumen that can be compacted adequately with smaller air voids and will have adequate dissipative and elastic properties. The aim of bituminous mix design is to determine the fair proportion of bitumen and aggregates fraction to yield a mixture that is effective, durable, reliable and economical.

1.2.3. TYPES OF BITUMINOUS MIXES

Bituminous mixes are combination of mineral aggregate and binder that are mixed with their optimum value to lay down and compacted in layers for building smooth road. Mixing of bitumen and mineral aggregates are done in several ways, which are listed below.

(A) HOT MIX ASPHALT

Commonly known as HMA, is prepared by heating bitumen binder and moisture dry aggregate to a mixing temperature of 150 ^{0}C to 160 ^{0}C (300 ^{0}F to 330 ^{0}F) which will provide a consistent mixture to work with. Due to high temperature of the mixture it is possible to compact the mixture to its optimum air content to give better stability than others. There as on being which HMA is widely used on highly trafficked roadways such as highways, airfields, and racetracks.

(B) WARM MIX ASPHALT

Frequently known as WMA, is prepared by mixing aggregate and

binder at a moderate temperature of 100 °C to 135 °C. The virgin binder is modified with foreign additives prior to mix, which will help bitumen binder to mix properly with mineral aggregate. Due to low temperature of mixing, consumption of fuel sand emission of harm gasses are comparatively lower than hot mix.

PROBLEM STATEMENT

For preparation of bituminous mixes, commonly aggregates, inform of coarse, fine and filler fractions are used. In many locations, the aggregates in different size fractions are not easily available, use of which needs procurement from long distances and hence increases the cost exorbitantly. On the other hand, a number of coal-based thermal power plants have been set up to somewhat cater to the power supply requirement. It is reported that around 120 Million Tons of ashes are producing from forty major thermal power plants per year in India. Most of the coal ash has likely to dispose of either dry or wet to open areas, which are available near the factory or by grounding into artificial lagoon or dumping yards. Such a vast quantity of these type of waste material does pose challenging problems, in the form of land usage, health hazards, and environmental dangers. Both in disposal as well as in utilization, utmost care has to be taken to safeguard the interest of human life, wildlife and environment. Hence to suppress the wretched effect of these materials, a detailed study is necessary to utilize them in a productive way that will satisfy the society need.

OBJECTIVES OF RESEARCH

This experimental study has done to enable the most appropriate use of coal ash as nonconventional aggregate along with natural fiber (Sisal fiber) as an additive by ensuring the adequate performance result in the field of fatigue, moisture susceptibility, and creep value. Again the possible effects of fiber on bitumen mixes are also taken into consideration, and comprehensive study was done to find the optimum fiber content and fiber length that will increase the engineering property of bituminous mix.

2. EXPERIMENTAL WORK

EXPERIMENTAL DESIGN

The adopted gradation for DBM sample has been considered as specified in MORTH (2013) and is given in Table-2.1. Throughout the experimental study the aggregate gradation given in Table4 was followed, and the following tests were performed. The aggregate gradation curve is shown in figure.2.1

TABLE 2.1 GRADATION OF AGGREGATE.

Sieve size (mm)	Adopted gradation (% Passing)	Specified limit (as per MORTH, 2013) (% Passing)	
37.5	100	100	Natural aggregate
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	Bottom ash
0.075	5	2-8	Fly ash

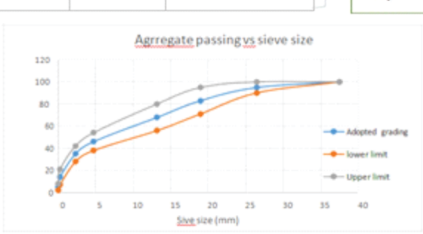

Fig 2.1 Aggregate gradation curve

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

- *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*

3. ANALYSIS OF RESULTS AND DISCUSSION MARSHALL STABILITY

It is seen from the figure 3.1 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.

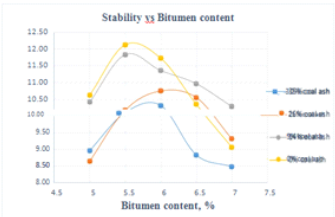

Fig 3.1 Variation of Stability value with bitumen content at different coal ash content

3.2 MARSHALL FLOW VALUE

It was seen from the flow value vs bitumen content graph shown in figure 3.2 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.

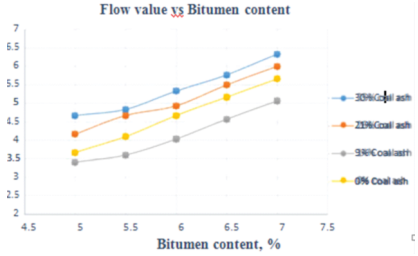

Fig. 3.2 Variation of value with bitumen content at different coal content

4. CONCLUDING REMARKS AND FUTURE SCOPE

4.1 Based on experimental study the following conclusions were drawn,

1. From the results of the Marshall tests it was observed that the DBM mixes prepared with bottom ash and fly ash used respectively in 300-75 micron sizes and passing 75 micron resulted best mixes satisfying the Marshall criteria when bitumen content, fiber content and fiber length were 5.6%, 0.5% and 10mm respectively.
2. It is also observed that Marshall stability and flow values are quite acceptable when the coal ash content is within 15%.
3. It is also observed that with increase in fiber content and fiber length, air-void and flow decreases and Marshall Quotient increases which in turn is due to higher stability value.
4. An increase in fiber content and fiber length resulted in higher requirement of optimum bitumen content and emulsion for coating of the fibers.
5. From the indirect tensile strength test it is perceived that the indirect tensile strength of sample increased due to the addition of emulsion coated fiber and coal ash, which gives an excellent engineering property for DBM sample to endure thermal cracking.
6. It is also observed the use of emulsion coated fiber, coal ash or both in DBM mix increases the resistance to moisture induced damages determined in terms of tensile strength ratio and retained stability values.

4.2 FUTURE SCOPE

1. As a natural fiber, sisal fiber has shown satisfactory results when used in bituminous mixes. Therefore to utilize the full

extent of fibers, other natural fibers such as jute, coconut fiber etc. are also taken in to consideration and their effects on DBM bituminous mix should be tested and studied.

2. In this study only SS-1 emulsion was considered as a coating medium for sisal fiber, therefore the effect of other types of emulsion such as rapid setting emulsion (RS) and medium setting (MS) emulsion are taken in to account and subsequent tests should be performed for future study.
3. Furthermore the effect of different mineral fillers such as cement and lime cannot be overlooked. Lime as an anti-stripping agent and cement as a stabilizing agent can be used as potential mineral filler for DBM mix, and subsequent tests may be performed as a part of future scope.

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