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EXPERIMENTAL STUDY OF BITUMINOUS MIXES USING NATURAL FIBRE

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Abstract - *Generally a bituminous mixture is a mixture of coarse aggregate, fine aggregate, filler and binder. A Hot Mix Asphalt is a bituminous mixture where all constituents are mixed, placed and compacted at high temperature. HMA can be Dense Graded mixes (DGM) known as Bituminous Concrete (BC) or gap graded known as Stone Matrix Asphalt (SMA). SMA requires stabilizing additives composed of cellulose fibbers, mineral fibres or polymers to prevent drain down of the mix. In the present study, an attempt has been made to study the effects of use of a naturally and locally available fibre called SISAL fibre is used as stabilizer in SMA and as an additive in BC. For preparation of the mixes aggregate gradation has been taken as per MORTH specification, binder content has been varied regularly from 4% to 7% and fibre content varied from 0% to maximum 0.5% of total mix. As a part of preliminary study, fly ash has been found to result satisfactory Marshall Properties and hence has been used for mixes in subsequent works. Using Marshall Procedure Optimum Fibre Content (OFC) for both BC and SMA mixes was found to be 0.3%. Similarly Optimum Binder Content (OBC) for BC and SMA were found to be 5% and 5.2% respectively. Then the BC and SMA mixes prepared at OBC and OFC are subjected to different performance tests like Drain down test, Static Indirect Tensile Strength Test and Static Creep Test to evaluate the effects of fibre addition on mix performance. It is concluded that addition of sisal fibre improve the mix properties like Marshall Stability, Drain down characteristics and indirect tensile strength in case of both BC and SMA mixes. Ii is observed that SMA is better than BC in respect of indirect tensile strength and creep characteristics.*

I. INTRODUCTION

Construction of highway involves huge outlay of investment. A precise engineering design may save considerable investment as well a reliable performance of the in-service highway can be achieved. Two things are of major considerations in flexible pavement engineering–pavement design and the mix design. The present study is related to the mix design considerations.A good design of bituminous mix is expected to result in a mix which is adequately (i) strong (ii) durable (iii) resistive to fatigue and permanent deformation (iv) environment friendly (v) economical and so on. A mix designer tries to achieve these requirements through a number of tests on the mix with varied proportions and finalizes with the best one. The present research work tries to identify some of the issues involved in this *art* of bituminous mix design and the direction of current research.

II. EVOLUATION OF MIX DESIGN

As per Das et al.(2004); During 1900's, the bituminous paving technique was first used on rural roads – so as to handle rapid removal of fine particles in the form of dust, from Water Bound Macadam, which was caused due to rapid growth of automobiles. At initial stage, heavy oils were used as dust palliative. An eye estimation process, called *pat test* was used to estimate the requisite quantity of the heavy oil in the mix. By this process, the mixture was patted like a pancake shape, and pressed against a brown paper. Depending on the extent of stain it made on the paper, the appropriateness of the quantity was adjudged. The first formal mix design method was Habbard field method, which was originally developed on sand-asphalt mixture. Mixes with large aggregates could not be handled in Hubbard field method. This was one of the limitations of this procedure. Francis Hveem, a project engineer of California Department of Highways, developed the Hveem stabilometer. Hveem did not have any prior experience on judging the *just right* mix from its colour, and therefore decided to measure various mix parameters to find out the optimum quantity of bitumen. Hveem used the surface area calculation concept (which already existed at that time for cement concrete mix design), to estimate the quantity of bitumen required. Moisture susceptibility and sand equivalent tests were added to the Hveem test in 1946 and 1954 respectively. Bruce Marshall developed the Marshall testing machine just before the World War-II. It was adopted in the US Army Corpes of Engineers in 1930's and subsequently modified in 1940's and 50's.

III.BITUMINOUS MIX DESIGN

Objective of Bituminous mix design:-Asphaltic/Bituminous concrete consists of a mixture of aggregates continuously graded from maximum size , typically less than 25 mm, through the fine filler that is smaller than 0.075 mm. Sufficient bitumen is added to the mix so that the compacted mix is effectively impervious and will have acceptable dissipative and elastic properties. The bituminous mix design aims to determine the proportion of bitumen, filler, fine aggregates, and coarse aggregates to produce a mix which is workable, strong, durable and economical. The objective of the mix design is to produce a bituminous mix by proportioning various components so as to have.

IV.OBJECTIVE OF PRESENT INVESTIGATION

A comparative study has been made in this investigation between Bituminous Concrete (BC) and Stone Matrix Asphalt (SMA) mixes with varying binder contents (4% - 7%) and Fibre contents (0.3% - 0.5%). In the present study 60/70 penetration grade bitumen is used as binder and Sisal fibre is used as stabilizing additive.

V.ASPHALT CONCRETE OR (BITUMINIOUS MIXTURE)

Asphalt concrete is a composite material commonly used in construction projects such as road surfaces, airports and parking lots. It consists of asphalt (used as a binder) and mineral aggregate mixed together, then are laid down in layers and compacted. Mixing of asphalt and aggregate is accomplished in one of several ways:
Hot mix asphalt concrete
Warm mix asphalt Concrete
Cold mix asphalt
Cut-back asphalt concrete
Mastic asphalt concrete
Natural asphalt concrete .

VI. CHARACTERISTICS OF MATERIAL USED IN BITUMINOUS MIX

Mineral Aggregate:
There are various types of mineral aggregates which can be used in bituminous mixes. The aggregates used to manufacture bituminous mixes can be obtained from different natural sources such as glacial deposits or mines. These are termed as natural aggregates and can be used with or without further processing. The aggregates can be further processed and finished to achieve good performance characteristics. Industrial by products such as steel slag, blast furnace slag etc. sometimes used as a component along with other aggregates to enhance the performance characteristics of the mix. Reclaimed bituminous pavement is also an important source of aggregate for bituminous mixes. Aggregates play a very important role in providing strength to asphalt mixtures as they contribute a greater part in the matrix. SMA contains 70-80 percent coarse aggregate of the total Stone content. The higher proportion of the coarse aggregate in the mixture forms a skeleton-type structure providing a better stone-on-stone contact between the coarse aggregate particles resulting in good shear strength and high resistance to rutting as compare to BC. According to WSDOT (2000) the Federal Highway Administration, McLean Virginia, has suggested the following characteristics for aggregates used in bituminous mixture.

VII. TESTS ON MATERIALS USED

Aggregates
For preparation of Bituminous mixes (BC, SMA) aggregates as per MORTH grading as given in Table, a particular type of binder and fibre in required quantities were mixes as per Marshall Procedure.

Adopted aggregate Gradation for BC (MORTH)

Sieve size (mm)	Percentage passing
26.5	100
19	95
9.5	70
4.75	50
2.36	35
0.30	12
0.075	5

Coarse Aggregates

Coarse aggregates consisted of stone chips collected from a local source, up to 4.75 mm IS sieve size. Its specific gravity was found as **2.75**. Standard tests were conducted to determine their physical properties.

Fine Aggregates

Fine aggregates, consisting of stone crusher dusts were collected from a local crusher with fractions passing 4.75 mm and retained on 0.075 mm IS sieve. Its specific gravity was found **2.6.**

Filler

Aggregate passing through 0.075 mm IS sieve is called as filler. Here cement, fly ash and Stone dust are used as filler whose specific gravity are 3.0, 2.2, 2.7 respectively. First a comparative study is done on BC where all these three types of fillers is used but later on only fly ash is used as filler where a comparative study is done on BC as well as SMA with or without using fibre.

Binder

Here 60/70 penetration grade bitumen is used as binder for preparation of Mix, whose specific gravity was 1.01.

Fibre

Here sisal fibre is used as additive whose length is about 900 mm. and diameter varied from 0.2 to 0.6 mm. The sisal fibres were cleaned and cut in to small pieces of 15-25 mm in length to ensure proper mixing with the aggregates and binder during the process of mixing.

Preparation of Mixes

The mixes were prepared according to the Marshall procedure specified in ASTM D1559. For BC and SMA the coarse aggregates, fine aggregates and filler were mixed according to the adopted gradation as given in Table 3.1. and Table 3.2 respectively. First a comparative study is done on BC by taking three different type of filler i.e. cement, fly ash, stone dust. Here Optimum Binder Content (OBC) was found by Marshall Test where binder content is very from 0% to 7%. Then Optimum Binder Content (OBC) and Optimum fibre Content (OFC) of both BC and SMA was found by Marshall Method where binder content is very from 0% to 7% and fibre content is vary from 0.3% to 0.5%. The sisal fibres after being cut in to small pieces (15-20 mm) were added directly to the aggregate sample in different proportions. The mineral aggregates with fibres and binders were heated separately to the prescribed mixing temperature. The temperature of the mineral aggregates was maintained at a temperature 10°C higher than the temperature of the binder. Required quantity of binder was added to the pre heated aggregate-fibre mixture and thorough mixing was done manually till the colour and consistency of the mixture appeared to be uniform. The mixing time was maintained within 2-5 minutes. The mixture was then poured in to pre-heated Marshall Moulds and the samples were prepared using a compactive effort of 75 blows on each side. The specimens were kept overnight for cooling to room temperature. Then the samples were extracted and tested at 60°C according to the standard testing procedure.

Tests on Mixes

Presented below are the different tests conducted on the bituminous mixes with variations of binder type and quantity, and fibre concentration in the mix.

Marshall Test
Drain down test
Indirect Tensile Strength Test
Static Indirect Tensile Test
Static Creep Test

Analysis of Test Results and Discussions

VIII. PARAMETERS USESD

Based on volume considered in evaluating specific gravity of an aggregate, some definitions of specific gravity are proposed. As per Das A. and Chakroborty P. (2010); the definitions and other formulae used in calculations hereafter are as follows:
Bulk Specific Gravity Of aggregate
Effective specific gravity of aggregate
Apparent Specific Gravity
Theoretical Maximum Specific Gravity of Mix
Bulk Specific Gravity of Mix
Air Voids
Voids in Mineral Aggregates
Voids Filled With Bitumen

IX. CONCLUSION

Based on the results and discussion of experimental investigation carried out on mixes i.e. SMA and BC following conclusion are drawn.

BC with different type of filler

1) As BC made of from all the three type filler satisfy above requirements we can use them as filler.
2) Although BC with cement as filler gives maximum stability, as it is costly we can also use fly ash and stone dust as filler material.
3) Use of fly ash is helpful in minimise industrial waste.

BC With different Fibre content

1) Here OBC is 5%, OFC is found as 0.3%
2) By addition of fibre up to 0.3% Marshall Stability value increases and further addition of fibre it decreases. But addition of fibre stability value not increased as high as SMA.

3) By addition of fibre flow value also decreases as compare to mix without fibre, but addition of 0.5% fibre again flow value increases.

SMA With different Fibre content

1) It is found that for SMA without fibre has binder requirement 5.8%, By addition of sisal fibre 0.3% to SMA this value is decreases to 5.2%. and further addition of fibre it increases up to 6 which leads to maximum drain down.
2) By addition of 0.3%fibre to SMA Stability value increases significantly and further addition to it, stability decreases.
3) By addition of 0.3%fibre to SMA flow value decreases and further addition of fibre flow value increases.
4) Main advantage of using fibre is that air void in mix decreases.
5) Drain down of binder decreases.

MIX at their OBC and OFC

1) Drain down of SMA is more than BC without fibre. At their OFC drain down of binder is decreases.
2) From Indirect Tensile Strength it is concluded that Tensile Strength of SMA is more than BC.
3) From Static Creep Test it is concluded that by addition of fibre to BC and SMA mixes deformation reduced. MORTH recommended that permanent deformation should not be more than 0.5 mm. SMA sample with fibre shows deformation about 0.45mm which is good.

X. CONCLUDING REMARKS

Here two type of mix i.e. SMA and BC is prepared where 60/70 penetration grade bitumen is used as binder. Also a naturally available fibre called sisal fibre is used with varying concentration (0 to 0.5%). OBC and OFC is found out by Marshall Method of mix design. Generally by adding 0.3% of fibre properties of Mix is improved. From different test like Drain down test, Indirect Tensile Strength and static creep test it is concluded that SMA with using sisal fibre gives very good result and can be used in flexible pavement.

XI. FUTURE SCOPE

Many properties of SMA and BC mixes such as Marshall properties, drain down characteristics, tensile strength characteristics have been studied in this investigation. Only 60/70 penetration grade bitumen and a modified natural fibre called sisal fibre have been tried in this investigation. However, some of the properties such as fatigue properties, moisture susceptibility characteristics, resistance to rutting and dynamic creep behaviour can further be investigated. Some other synthetic and natural fibres and other type of binder can also be tried in mixes and compared. Sisal fibre used in this study is a low cost material; therefore a cost-benefit analysis can be made to know its effect on cost of construction. Moreover, to ensure the success of this new material, experimental stretches may be constructed and periodic performances monitored.

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