Analysis of Bituminous Mix Concrete in Civil Construction

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Abstract— 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.

Keywords: Bituminous Concrete (BC), Stone Matrix Asphalt (SMA), Sisal Fibre, Marshall Properties, Static Indirect Tensile Strength, Static Creep

I. INTRODUCTION

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 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 concrete mix design and the direction of current research.

Fig. 1: flexible pavement Lab Samples

II. OBJECTIVE OF BITUMINOUS CONCRETE 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 concrete 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.

Fig. 1: Sisal fiber Mix Material

III. SELECTION OF BINDER

Different type of binder like convectional 60/70 or 80/100 penetration grade bitumen and many modified binder like Polymer Modified Bitumen (PMB), Crumb Rubber Modified Bitumen (CRMB), Natural Rubber Modified Bitumen (NRMB) is used by different researcher for their research work. Some researcher also used super pave performance grade binder like PG 76-22 with bituminous concrete mixture like Bituminous Concrete (BC) and Stone Matrix Asphalt (SMA). Here in this research a comparative study is done between BC and SMA with and without using fibre where 60/70 penetration grade bitumen is used as binder.

IV. 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:

A. Hot Mix Asphalt Concrete

The material is produced by heating the asphalt binder to decrease its viscosity, and drying the aggregate to remove moisture from it prior to mixing. Mixing is generally performed with the aggregate at about 300 °F (roughly 150 °C) for virgin asphalt and 330 °F (166 °C) for polymer modified asphalt, and the asphalt cement at 200 °F (95 °C). Paving and compaction must be performed while the asphalt is sufficiently hot. In many countries paving is restricted to summer months because in winter the compacted base will cool the asphalt too much before it is packed to the optimal air content. HMAC is the form of asphalt concrete most commonly used on highly trafficked pavements such as those on major highways, racetracks and airfields.

B. *Warm Mix Asphalt Concrete*

(commonly abbreviated as WMA) is produced by adding either zeo-lites waxes, asphalt emulsions, or sometimes even water to the asphalt binder prior to mixing. This allows significantly lower mixing and laying temperatures and results in lower consumption of fossil fuels, thus releasing less carbon dioxide, aerosols and vapors. Not only are working conditions improved, but the lower laying-temperature also leads to more rapid availability of the surface for use, which is important for construction sites with critical time schedules. The usage of these additives in hot mixed asphalt (above) may afford easier compaction and allow cold weather paving or longer hauls.

C. *Cold Mix Asphalt*

Concrete is produced by emulsifying the asphalt in water with (essentially) soap prior to mixing with the aggregate. While in its emulsified state the asphalt is less viscous and the mixture is easy to work and compact. The emulsion will break after enough water evaporates and the cold mix will, ideally, take on the properties of cold HMAC. Cold mix is commonly used as a patching material and on lesser trafficked service roads.

D. *Cut-back asphalt concrete*

is produced by dissolving the binder in kerosene or another lighter fraction of petroleum prior to mixing with the aggregate. While in its dissolved state the asphalt is less viscous and the mix is easy to work and compact. After the mix is laid down the lighter fraction evaporates. Because of concerns with pollution from the volatile organic compounds in the lighter fraction, cut-back asphalt has been largely replaced by asphalt emulsion.

E. *Mastic Asphalt Concrete*

or sheet asphalt is produced by heating hard grade blown bitumen (oxidation) in a green cooker (mixer) until it has become a viscous liquid after which the aggregate mix is then added. Then bitumen aggregate mixture is cooked (matured) for around 6- 8 hours and once it is ready the mastic asphalt mixer is transported to the work site where experienced layers empty the mixer and either machine or hand lay the mastic asphalt contents on to the road. Mastic asphalt concrete is generally laid to a thickness of around 3⁄4–1 3⁄16 inches (20-30 mm) for footpath and road applications and around 3⁄8 of an inch (10 mm) for flooring or roof applications. In addition to the asphalt and aggregate, additives, such as polymers, and antistripping agents may be added to improve the properties of the final product.

F. *Natural asphalt concrete*

can be produced from bituminous rock, found in some parts of world, where porous sedimentary rock near the surface has been impregnated with upwelling bitumen.

G. *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.

1) *Physical Properties of Coarse aggregate*

Property (%)	Test Method	Test Result
Aggregate Impact Value	IS: 2386 (P IV)	14.3
Aggregate Crushing Value	IS: 2386 (P IV)	13.02
Los Angeles Abrasion Value	IS: 2386 (P IV)	18
Flakiness Index	IS: 2386 (P I)	18.83
Elongation Index	IS: 2386 (P I)	21.5
Water Absorption	IS: 2386 (P III)	0.1

2) *Binder*

Here 60/70 penetration grade bitumen is used as binder for preparation of Mix, whose specific gravity was 1.01. It's important property is given in table 3.4

3) *Properties of Binder*

Property	Test Method	Value
Penetration at 25^0C (mm) IS :	1203-1978	67.7
Softening Point (^{0}C) IS :	1203-1978	48.5
Specific gravity IS :	1203-1978	1.03

V. MARSHALL TEST

Marshall Mix design is a standard laboratory method, which is adopted worldwide for determining and reporting the strength and flow characteristics of bituminous paving mixes. In India, it is a very popular method of characterization of bituminous concrete mixes. This test has also been used by many researchers to test bituminous concrete mixes. This test method is widely accepted because of its simplicity and low of cost. Considering various advantages of the Marshall method it was decided to use this method to determine the Optimum Binder Content (OBC) of the mixes and also study various Marshall Characteristics such as Marshall Stability, flow value, unit weight, air voids etc.

Fig. 2: Marshall Test in Progress

VI. Properties of Fine and Coarse Aggregate

Sand as fine aggregates are collected from locally available river and the sieve analysis of the samples are done. It is found that the sand collected is conforming to IS: 383-1970. For coarse aggregate, the parent concrete is crushed through mini jaw crusher. During crushing it is tried to maintain to produce the maximum size of aggregate in between 20mm to 4.75mm. The coarse aggregate particle size distribution curve is presented in Fig. 3.1. The physical properties of both fine aggregate and recycled coarse aggregate are evaluated as per IS: 2386-1963 and given below.

A. Properties of Coarse Aggregate and Fine Aggregate

Property	Coarse Aggregate	Fine Aggregate
Specific Gravity	2.72	2.65
Bulk Density (kg/L)	1.408	-
Loose Bulk Density (kg/L)	1.25	-
Water Absorption (%)	4.469	0.0651
Impact Value	26.910	-
Crushing Value	26.514	-
Fineness Modulus	3.38	2.84

VII. Marshall Stability

It is observed that stability value increases with increase binder content up to certain binder content; then stability value decreases. Also stability value increases with increase fibre content and further addition of fibre it decreases. Variation of Marshall Stability value with different binder content with different fibre.

VIII. Sisal Fiber Based Polymer Material

In this paintings, Sisal fiber based Polymer is Analysis as the binder, in place of Portland or every other hydraulic cement paste, to produce concrete. The fly ash-based totally Polymer paste binds the unfastened coarse aggregates, exceptional aggregates and other un-reacted materials collectively to shape the Polymer material, with or without the presence of admixtures. The manufacture of Polymer material is achieved using the standard concrete era methods. As within the OPC concrete, the aggregates occupy the biggest extent, i.e. approximately 75-80% through mass, in Polymer material. The silicon and the aluminum in the low calcium (ASTM Class F) fly ash are activated through a mixture of sodium hydroxide and sodium silicate solutions to shape the Polymer paste that binds the aggregates and other un-reacted substances.

A. Applications of Polymer Material

Si/Al	Application
1	Bricks, ceramics, fire protection
2	Low CO2 cements, concrete, radioactive & toxic waste Encapsulation
3	Heat resistance composites, foundry equipments, fibre glass Composites
>3	Sealants for industry
20<Si Al<35	Fire resistance and heat resistance fibre composites

IX. Conclusion

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.

1) From Indirect Tensile Strength it is concluded that Tensile Strength of SMA is more than BC.
2) 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.

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