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A COMPREHENSIVE LABORATORY STUDY ON IMPROVING BITUMINOUS MIXES WITH NATURAL FIBRE REINFORCEMENT

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Abstract

A bituminous mixture is made up of coarse aggregate, fine aggregate, filler, and binder. A Hot Mix Asphalt is a bituminous mixture in which all elements are heated before being mixed, put, and compacted. HMA can be Dense Graded Mixes (DGM) also known as Bituminous Concrete (BC) or Gap Graded Asphalt (SMA). To keep the mix from draining, SMA requires stabilising additives made of cellulose fibres, mineral fibres, or polymers.

The current study attempted to investigate the effects of using a naturally and locally available fibre termed SISAL fibre as a stabiliser in SMA and as an additive in BC. The aggregate gradation was chosen according to MORTH specifications, the binder concentration was varied on a regular basis from 4% to 7%, and the fibre content was varied from 0% to a maximum of 0.5% of the overall mix. As part of the preliminary study, fly ash was discovered to have satisfactory Marshall Properties and was so employed for mixes in following works. The Optimum Fibre Content (OFC) for both BC and SMA blends was determined using the Marshall Procedure to be 0.3%. Likewise, the Optimum Binder Content (OBC) for BC and SMA was discovered to be 5% and 5.2%, respectively. The BC and SMA mixes prepared at OBC and OFC are then subjected to several performance tests such as the drain down test, the static indirect tensile strength test, and the static creep test to assess the effects of fibre addition on mix performance. The addition of sisal fibre improves the mix features such as Marshall Stability, Drain down characteristics, and indirect tensile strength in both cases BC and SMA mixes. Ii is observed that SMA is better than BC in respect of indirect tensile strength and creep characteristics.

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

1. INTRODUCTION

1.1 General

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.

1.3 Bituminous Mix Design

1.3.1 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-

1. Sufficient bitumen to ensure a durable pavement.
2. Sufficient strength to resist shear deformation under traffic at higher temperature.
3. Sufficient air voids in the compacted bitumen to allow for additional compaction by traffic.
4. Sufficient workability to permit easy placement without segregation.
5. Sufficient resistance to avoid premature cracking due to repeated bending by traffic.
6. Sufficient resistance at low temperature to prevent shrinkage cracks.

1.6 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.

The whole work is carried out in four different stages which are explained below.

- Study of Marshall Properties of BC mixes using three different types of fillers without fibre(fly-ash, cement, stone dust)

- Study of BC mixes with fly ash as filler and sisal fibre as stabilizer
- Study of SMA mixes with fly ash as filler and sisal fibre as stabilizer
- Evaluation of SMA and BC mixes using different test like Drain down test, Static Indirect tensile Strength test, Static Creep test

2. Review of Literature

2.1 General

Pavement consists of more than one layer of different material supported by a layer called sub grade. Generally pavement is two type flexible pavement and rigid pavement. Flexible pavements are so named because the total pavement structure deflects, or flexes, under loading. A flexible pavement structure is typically composed of several layers of material. Each layer receives the loads from the above layer, spreads them out then passes on these loads to the next layer below.

3. Experimental Investigations

3.2 Tests on Materials Used

3.2.1 Aggregates

For preparation of Bituminous mixes (BC, SMA) aggregates as per MORTH grading as given in Table 3.1 and Table 3.2 respectively, a particular type of binder and fibre in required quantities were mixes as per Marshall Procedure.

Table 3.1 Adopted Aggregate Gradations 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

Table 3.2 Adopted Aggregate Gradations for SMA (MORTH)

Sieve Size (Mm)	Percentage Passing
16	100
13.2	94
9.5	62
4.75	34
2.36	24
1.18	21
0.6	18
0.3	16
0.15	12
0.075	10

3.2.1.1 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 as summarized in Table 3.3

3.2.1.2 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 as **2.6.**

3.2.2. 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 is 3.0, 2.2, and 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.

Table 3.3 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

3.3 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-heat 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.

3.4.4 Static Creep Test

For Static Creep test sample were prepared at their OBC and OFC. The test consists of two stages. In first stage a vertical load of 6 KN is applied for 30 min. The deformation was registered during these 0, 10, 20, 30 min using a dial gauge graduated in units of 0.002 mm and it was able to register a maximum deflection of 5 mm. Secondly, the load was removed and its deformation had been registered during next 10 min interval of time i.e. 40, 50, 60 min. Here throughout the test temperature is maintained 40℃. A graph has been plot between time-deformation which shown next chapter.

Fig 3.9 Static Creep Test In Progress

4. Analysis of Tests Results And Discussions

4.1 Introduction

In this chapter Result and Observation of test carried out in previous chapter is presented, analyzed and discuss. This chapter is divided into five sections. First section is deals with parameter used for analysis. Second section deals with calculation of Optimum binder Content (OBC) of BC where cement, fly ash, stone dust is used as filler. Third section deals with calculation of Optimum binder Content (OBC) and Optimum Fibre content (OFC), Marshall Properties of BC with or without using fibre. Fourth section deals with calculation of Optimum binder Content (OBC) and Optimum Fibre content (OFC), Marshall Properties of SMA with or without using fibre. Fifth section deals with result of Drain down test and Static Indirect Tensile Stress and static Creep test.

5. Conclusions

5.1 General

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

5.2 BC with Different Type of Filler

1. As per MORTH Specification mix design requirements of bituminous mix is given intable 5.1

Table 5.1 MORTH Specification Mix Design Requirements of Bituminous Mix

Property	**Value**
Marshall stability (KN at 60°C)	>9 KN
Flow Value (mm)	2-4
Air Void (%)	3-6
VFB (%)	65-75
OBC (%)	5-6

2. As BC made of from all the three type filler satisfy above requirements we can usethem as filler.

3. 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.

4. Use of fly ash is helpful in minimize industrial waste.

5.3 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.

5.4 SMA With Different Fibre content

1. Requirements of SMA according to IRC SP-79-2008 IS given in table 5.2

Table 5.2 IRCSP79-2008 Specification Mix Design Requirements of SMA

Property	**Value**
Void (%)	4
Binder Requirement (%)	5.8 Min
Vma (%)	17
Ofc (%)	Should Not Exceed 0.3%

Here OBC is 5.2% and OFC is 0.3%.

2. 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.

3. By addition of 0.3%fibre to SMA Stability value increases significantly and further addition to it, stability decreases.

4. By addition of 0.3%fibre to SMA flow value decreases and further addition of fibre flow value increases.
5. Main advantage of using fibre is that air void in mix decreases.
6. Drain down of binder decreases.

5.5. MIX at Their OBC and OFC

Different test like Drain down test, Indirect Tensile Strength (ITS), Static creep test is done on MIX at their OBC, OFC and its conclusion is given below.

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.

5.6Concluding 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.

5.7 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.

References

1. ASTM D 1559 (1989), "Test Method for Resistance of Plastic Flow of Bituminous Mixtures Using Marshall Apparatus"

2. ASTM D 6931 (2007), "Indirect Tensile (IDT) Strength for Bituminous Mixtures"

3. Brown E.R. and Manglorkar H. (1993), "Evaluation of Laboratory Properties of SMA mixtures", NCAT Report No. 93-5, Auburn University, Alabama

4. Brown E.R. and Mallick R.B. (1994), "Stone Matrix Asphalt Properties Related to Mixture Design", NCAT Report 94-02

5. Bradley J. Putman and Serji N. Amirkhanian (2004), "Utilization of Waste Fibre in Stone Matrix Asphalt Mixtures", Resources, Conservation and Recycling, Volume 42, Issue 3, pp 265-274

6. Bose S., Kamaraj C. and Nanda P.K. (2006), "Stone Mastic Asphalt (SMA) – A Long Life Pavement Surface", International Seminar on Innovations in Construction and Maintenance of Flexible Pavements, Agra, 2-4 September, Technical Papers, Volume 1, pp 169-17

7. Chui-Te Chiu and Li-Cheng Lu (2007), "A Laboratory study on Stone Matrix Asphalt using Ground Tire Rubber", Construction and Building Materials, Volume 21, Issue 5, pp 1027-1033

8. C.S Bindu, Beena K.S.(2010),"Waste Plastic as a Stabilizing additive in SMA", International Journal of Engineering and Technology, Volume 2, Issue6, pp 379-387

9. Das A. and Chakroborty P. (2010), "Principles of Transportation Engineering", Prentice Hall of India, New Delhi, pp 294-299

10. Das A., Deol, M. S. Ohri S. and Pandey B. B.(2004). "Evolution of non-standard bituminous mix – a study on Indian specification", The International Journal of Pavement Engineering, Vol 5(1), pp. 39-46.

11. H. Jony Hassan, Y. Jahad Israa (2010), "The Effect of Using Glass Power filler on Hot Asphalt Concrete Mixture Properties", Engg and Technology journal, vol.29, Issue1, pp44-57

12. IS: 2386 (1963), "Methods of Test for Aggregates for Concrete (P - I): Particle Size and Shape", Bureau of

Indian Standards, New Delhi

13. IS: 2386 (1963), “Methods of Test for Aggregates for Concrete (P-III): Specific Gravity, Density, Voids, Absorption, Bulking”, Bureau of Indian Standards, New Delhi

14. IS: 2386 (1963), “Methods of Test for Aggregates for Concrete (P-IV): Mechanical Properties”, Bureau of Indian Standards, New Delhi

15. IS: 1203 (1978), “Methods for Testing Tar and Bituminous Materials: Determination of Penetration”, Bureau of Indian Standards, New Delhi

16. IS: 1205 (1978), “Methods for Testing Tar and Bituminous Materials: Determination of Softening Point”, Bureau of Indian Standards, New Delhi

17. IRC SP-79 (2008),” Specification for SMA”

18. Ibrahim M. Asi (2005), “Laboratory Comparison Study for the Use of Stone Matrix Asphalt in Hot Weather Climates”, Construction and Building Materials, Volume 20, Issue 10, pp 982-989

19. Karasahin Mustafa, Terzi Serdal (2007), “Evaluation of marbal waste dust in mixture of asphalt matrix”, Construction and Building Materials, Volume 21, Issue 5, pp 616-620

20. Kamraj C., Kumar G., Sharma G., Jain P.K. and Venkanna Babu P. (2004), “Laboratory Studies on the Behaviour of Stone Matrix Asphalt vis-à-vis Dense Graded Bituminous Mixes using Natural Rubber Powder (Wet Process)”, Highway Research Bulletin, No 71, IRC, New Delhi, pp39-60

21. Khanna S.K. and Justo C.E.G. (2001), “Highway Engineering”, Nem Chand and Bros,Roorkee, pp315-321

22. Kumar Pawan, Chandra Satish and Bose Sunil (2007), 'Laboratory Investigations on SMA mixes with Different Additives', International Journal of Pavement Engineering, Volume 8, Issue1, pp 11-18.

23. Mogawer W.S. and Stuart K.D. (1996), “Effect of Mineral Fillers on Properties of Stone Matrix Asphalt Mixtures”, TRR 1530, National Research Council, TRB, USA, pp 86 -94

24. Muniandy Ratnasamy and Huat Bujang B.K. (2006), “Laboratory Diameteral Fatigue Performance of Stone Matrix Asphalt with Cellulose Oil Palm Fibre”, American Journal of Applied Sciences 3 (9): 2005-2010.