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DESIGN OF STONE MATRIX ASPHALT PAVEMENT USING CHROME SAVINGS

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Abstract: Stone Matrix Asphalt (SMA) is a gap graded mix which is characterized by high coarse aggregates, asphalt contents and fibre additives. Due to high amount of coarse aggregate and binder content in SMA, there is a possibility of drain down during mixing, transportation and compaction. To avoid this problem, the chrome bearing waste called Chrome Shaving (CS) contains Cr(III) generated during the levelling of tanned skins/hides is used. Another solid waste namely spent lime is generated during the beam house operation. It is predominant in the nature of Calcium Sulphate (CaSo4) after neutralizing by sulphuric acid. These wastes are dumped in the open ground which causes environmental pollution. Therefore, a study has been taken to evaluate the performance of CS as stabilizing additives and spent lime as filler in SMA mixture to determine the optimum dosage at which the drain down study give less than 0.3% by weight of mix.

Keywords: Stone Matrix Asphalt (SMA), chrome shaving, spent lime and stabilizing additives

1. Introduction

1.1 General

A highway pavement is a structure consisting of superimposed layers of processed materials above the natural soil sub-grade, whose primary function is to distribute the applied vehicle loads to the sub-grade. Stone matrix asphalt (SMA) is a gap-graded mix with a skeletal stone-to-stone arrangement that requires a higher viscosity asphalt binder to keep the interlocked aggregates bound and intact. The interlocking nature of the mix is expected to increase the stability and to minimize the lateral displacement of the aggregates that tend to reduce permanent deformation or rutting of the mix. The concept was first developed in Germany in the early sixties. It was further developed in the United States in the early 1990s.There are certain differences between the conventional hot mix and stone matrix asphalt which is shown in Figure 1.1

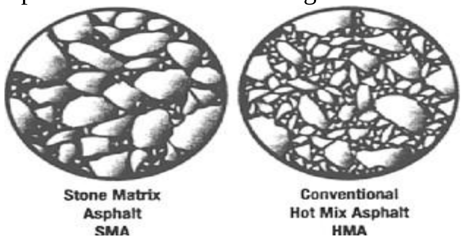


Fig 1.1 Stone Matrix Asphalt and Conventional Hot Mix

Whenever a conventional dense graded aggregate gradation is altered to a gap graded matrix, the voids in mineral aggregates (VMA) increases considerably. Such a void content must be filled with mastic that has excellent shear properties so as to hold the gap graded coarse aggregate matrix over a long period of time. To minimize this problem fibre were normally used.

1.2 Need for the Study

The need for SMA is important because of

- Increased Traffic
- Slow moving vehicles
- Over loading in combination
- Insufficient degree of maintenance
- Extreme climatic - caused frequent deterioration of flexible pavements particularly in urban areas.

During the process of conversion of hides and skins into leather, large amounts of wastes are produced. Treatment of solid wastes is not a cost effective and poses economic burden to the tanners. Such wastes are highly toxic due to chemicals added and also the disposal of such waste will cause environmental pollution. Instead of disposal of waste into open space, an alternative measures should be taken care by using it as alternate material. Hence in this study, the use of leather fibre as an additive in SMA is studied. Stone Matrix Asphalt (SMA) is a gap-graded mixture, have a better stone to stone contact which gives better strength to the mixture as shown in Figure 1.2.

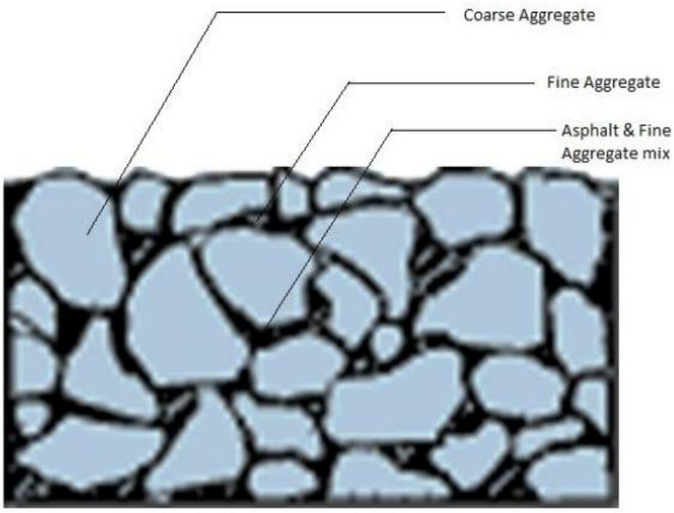


Fig 1.2 Section view of SMA

1.3 Objectives

The Objective of this study is

- To study the effect of fibres in Stone Matrix Asphalt mix.
- To study the effect of different dosage of leather waste in SMA as stabilizing additives.
- To determine the optimum dosage of fibre for maximum benefit in terms of drain down, tensile strength ratio and aging.

1.4 Review of Literature

- The mix properties of SMA mixture are getting enhanced by the addition of reclaimed polythene as stabilizer showing better rut resistance, resistance to moisture damage, rutting, creep and aging.
- The Cellulose Oil Palm Fibre (COPF) was found to improve the fatigue performance of SMA deign mix. The fatigue life increased to a maximum at a fibre content of about 0.6%, whilst the tensile stress and stiffness also showed a similar trend in performance. The initial strains of the mix were lowest at a fibre content of 0.6%.
- Reinforcing the paving mixture with fibre improves the performance of the pavement structure, thereby reducing the frequency of future rehabilitation costs and resulting in more economical pavement.
- The addition of fibres to bituminous mixes requires a slight increase in the optimum binder content.
- Fibres have the potential to increase the structural resistance to distress occurring in the road pavement due to traffic roads.
- Effective use of wastes from leather industry will help in reducing the pollutant content such that it will formulate the pollution free environment in future.
- The incorporation of 0.3% of leather sawdust increased the engineering properties of asphalt mixtures and minimized the cracking of pavement surface layer due to the fibre incorporation in the asphalt micro-surface.

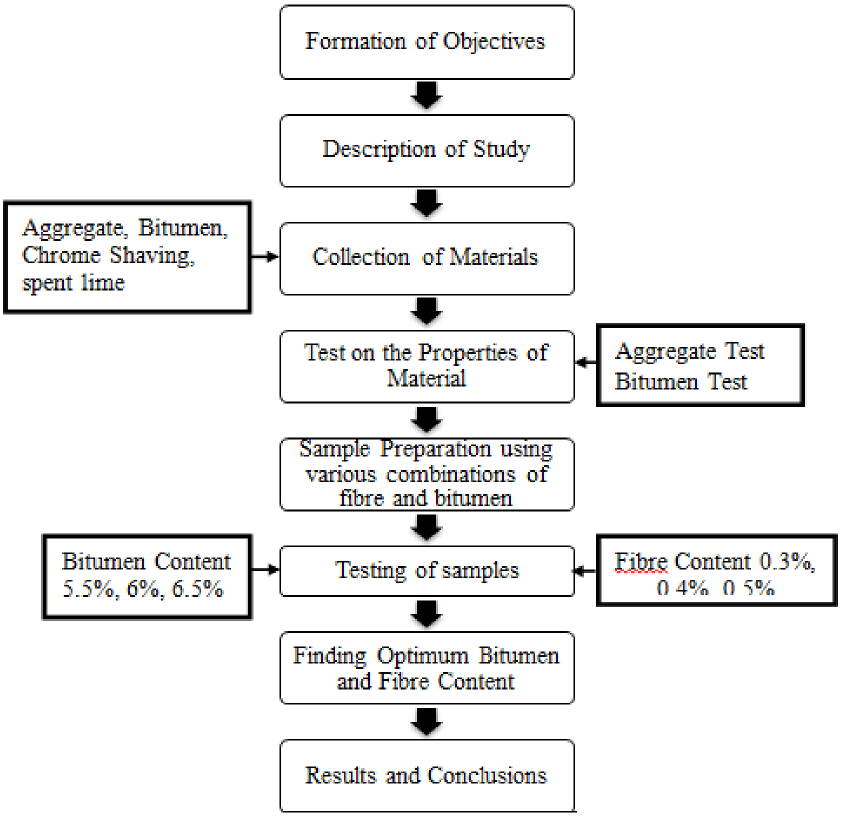
It was found out that with the use of fibres no drain down was obtained.

2. Methodology

2.1 General

The Methodology chart is shown in the Figure 2.1

Fig 2.1 Methodology Chart



2.2 Design Requirements for Sma

The SMA design mix should meet the requirements given in Table 2.1

Table 2.1 Basic Requirements for SMA Mix

Mixdesignparameters	Requirement
Airvoidcontent, percent	4.0
Bitumencontent,percent	5.8min.
Celluloidfibres	0.3%minimumbyweightoftotalmix
VoidsinMineralAggregate(VMA),percent	17min.
VCAmix,percent	LessthanVCA (dryrodded)
Asphaltdraindown	0.3max.
TensileStrength Ratio(TSR),percent	85min.

2.3 Characteristics of Material Used In SMA

2.3.1 Coarse and Fine Aggregate

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. The adopted aggregate must possess –

- A highly cubic shape and rough texture to resist rutting and movements,
- A hardness which can resist fracturing under heavy traffic loads,
- A high resistance to polishing, and abrasion

Required and adopted aggregate gradation as per MoRTH specifications are mentioned in Table 2.2 and 2.3 respectively and the Figure 2.2 shows graph for aggregate gradations.

Table 2.2 Gradation of Aggregate as per MoRTH

Sieve Size	% of Passing
19	100
13.2	90-100
9.5	50-75
4.75	20-28
2.36	16-24
1.18	13-21
0.6	12-18
0.3	10-20
0.075	8-12

Table 2.3 Adopted Gradation of Aggregate as per MoRTH

Sieve Size	Lower Limit (L.L)	Upper Limit (U.L)	Adopted Gradations	
19	100	100	100	100
13.2	90	100	94	98
9.5	50	75	60	70
4.75	20	28	22	24
2.36	16	24	18	20
1.18	13	21	16	18
0.6	12	18	15	16
0.3	10	20	14	15
0.075	8	12	10	11

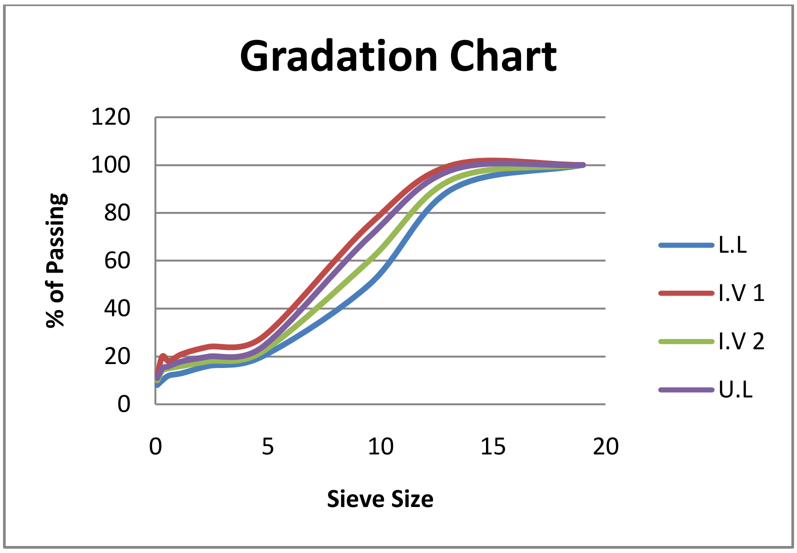


Fig 2.2 Gradation of Aggregates

2.3.2 Mineral filler

Mineral fillers affect workability, moisture resistance, and aging characteristics of HMA mixtures. Generally filler plays an important role in properties of bituminous mixture particularly in terms of air voids, voids in mineral aggregate. Different types of mineral fillers are used in the SMA mixes such as stone dust, Ordinary Portland Cement (OPC), slag cement, fly Ash, hydrated lime etc. Here in this project mineral filler is taken as Leather Lime of 3-6% of total weight of the sample.

2.3.3 Binder

Bitumen along with different additives (fibers, polymers etc.) is act as a stabilizer for bituminous Mix. Different types of bitumen have been used by various researchers to the mixture properties. In this study Bitumen grade of 60/70 is carried out as 5.5%, 6%, and 6.5% of total weight of sample for SMA mixtures.

2.3.4 Stabilizing Additives

The main stabilizing additives used in mixes can be classified in to different groups;

- Fibres (Cellulose Fibres, Mineral Fibres, Chemical Fibres)
- Polymer, Powder and flour like materials (Silicic acid, Special Filler)
- Plastics (Polymer Powders or Pellets)

The Stabilizing additives used here are chrome shaving (Leather Fibre) of 0.3% of total weight of sample. The Physical and Chemical characteristics of chrome shaving by elemental analysis per gram of sample is mentioned below in Table 2.4 and 2.5

Table 2.4 Physical Characteristics of Chrome Shaving

PROPERTIES	UNIT	VALUES
Specific Gravity	-	1.5
Bulk Density	gm/cc	1600
Moisture Content	%	15-40
Air Content	%	13
pH value	-	3.0-4.1
Temperature Resistant	^oC	Less than 200^oC

Table 2.5 Chemical Characteristics of Chrome Shaving

Chemicals Present	Amount in %
Nitrogen	15.6
Carbon	37.3
Hydrogen	6.54
Sulphur	14.53
Oxygen	26.10

3. Tests on Materials

3.1 Tests on Aggregate

The aggregates were tested as per Marshall Requirements and gradation of aggregates results shows that the aggregate falls within the allowable limits as per IRC section 500 (MoRTH) and it can be used for the sample preparation. The results of tested aggregates are given in the Table 3.1

Table 3.1 Properties of Aggregates

S.No	Test	Test Method	Test Results	Permissible Values
1	Specific Gravity of Aggregates	IS: 2386	2.73	2.5 – 3.0
2	Aggregate Impact Value	IS: 2386	17%	<20%
3	Flakiness and Elongation Index	IS: 2386	24%	<30%
4	Water Absorption	IS: 2386	0.92%	0.1 – 2%

3.2 Tests on Binder

The Physical Properties of Bitumen obtained from laboratory tests as per relevant IS codes with necessary recommendations are given in the Table 3.2

Table 3.2 Properties of Bitumen

S.No	Test	Test Method	Test Results	Permissible Values
1	Specific Gravity (gm/cc)	IS:1202	1.044	-
2	Penetration(100gm, 5sec, 25^oC, 1/10mm)	IS:1203	68.6	60 – 70
3	Softening Point- Ring and Ball method ^oC	IS:1205	44	40 - 55
4	Ductility test	IS:1208	78	>75

4. Sample Preparation

4.1 Mixing of components

Aggregate, bitumen, spent lime and chrome shavings are mixed together to make a homogeneous SMA sample by heating up-to a temperature of 160^0C.

4.2 Putting in mould

For preparation of samples the mixture prepared was put in moulds. A standard mould is a cylindrical mould made of iron having a diameter of 100 mm.

4.3 Compaction

After putting in mould hammering was performed. For hammering a mould, Marshall Compactor was used. Usually hammering was done by giving 50 or 75 blows to each side of specimen.

Fig 4.1 Sample of Chrome savings, mixing process SMA mix.

4.4 Finalizing the sample

After hammering the sample was taken out of mould. Later on the sample was left in open to cool down to room temperature. The Figure 4.1 shows the sample of Chrome savings, mixing process SMA mix.

5. Tests on Specimen and Analysis

The tests carried out whether it meets basic recommendations. Table 5.3 indicates that the SMA Mix meets the Basic recommendations with optimum dosage of leather fibre as 0.3% by weight of mix.

Table 5.1 SMA meets the Basic Recommendations

Properties	Requirements*	SMA
Bitumen content, %	5.8 min	6.0
Stabilizing additive, %	Min 0.3%,	0.3%
Air void content, %	4	>4
Void in mineral aggregate, %	17min	>17
Compactive effort, No of blows	50	50
Drain down, %	<0.3%	0.12
Voids in Coarse aggregate, %	Less than VCA (Dry rodded)	31.5
VCA by dry rodded method, %	Min 45%	46.4
VCA Ratio	<1	0.
Tensile Strength, Ratio	85% min	88.5

6. Results and Discussions

From the experimental investigations the following conclusions are drawn.

- The SMA mixes designed with available aggregates showed good stone on stone contact. The **17% Voids in Mineral aggregate** and **4% air voids** in the mix were fulfilled as SMA Mix design criteria. The Drain Down values was in the range of **0.12-0.22%** by weight of mix.
- The value of Creep Modulus is high so leather fibre is **higher** resistance to permanent deformation. The Tensile Strength Ratio is more so, it indicating improving the adhesion property of binder to hold the aggregate in mix and it exhibit superior water resistance property of mix and it is used in heavy rain fall area.

- Based on the above performance, leather fibre can be used as a **stabilizing additive** without affecting the design criteria of SMA Mixtures.
- The Optimum dosage of Binder content is found to be 6% by total weight of mix for 60/70 grade of Bitumen. The Optimum dosage of leather fibre is found to be 0.3% by weight of the mix. It is recommended that the design mix may be taken as 6% penetration grade 60/70 bitumen with 0.3% leather fibre fulfilled the design criteria as per IRC SP 79:2008.

References

[1]. Aravind and Animesh Das (2009) 'Industrial Waste in Highway Construction', *J.Conservation and Recycling*, No. 35, 2002, pp. 117–129.

[2]. Bradely J. Putman, Serji N Amir Khanian (2004), 'Utilisation of Waste Fibres in Stone Matrix Asphalt Mixtures Resources, *J.Conservation and Recycling*', Vol 42, Issue 3, pp. 265-274.

[3]. Gangopadhyay S and Kamaraj C (2012), 'A Technological Approach to Utilize Tannery Solid Waste in Road Construction',accessed on 3 September 2012, <http://www.sciencedirect.com>.

[4]. IS 2386: Part I: 1963 (Reaffirmed 2002), Methods of Test for Aggregates for Concrete: Particle Size and Shape.

[5]. Kamaraj.C, Kumar.G, Sharma.G, Jain P.K. and Babu K.V (2004), 'Laboratory Studies on the Behaviour of Stone Matrix Asphalt Vis-Vis Dense Graded Bituminous Mixes using Natural Rubber Powder (Wet Process)', *Highway Research Bulletin*, December, pp. 39-60.

[6]. KarineKrummenauer, Jairo Jose, Oliveira Andrade (2009), 'Incorporation of Chromium-tanned Leather Residue to Asphalt Micro-surface Layer', *J.Construction and Building Materials* 23, pp.574–581.

[7]. Kumar, PawanChaturvedi, Verma A (2011), 'Jute and Cotton Fibre Reinforce Paper Laminates and their Characterization', *J.International Congress of Environmental Research*, India.

[8]. Muniandy R, Huat B.B.K (2005), *J. Applied Sciences*, Vol-III, and Issue-9.

[9]. Narayan Panda (2010) 'Laboratory Investigations on Stone Matrix Asphalt using Sisal Fibre for Indian Roads' , National Institute of Technology, Rourkela.

[10]. Punith V S, Sridhar R, Sunil Bose, Kumar K.K, and Veeraragavan A (2004), 'Comparative studies on the Behaviour of Stone Matrix Asphalt and Asphalt Concrete Mixtures Utilizing Reclaimed Polyethylene', *Highway Research Bulletin*, December, pp. 61-76.

[11]. Ravichandran K, Natchimuthu N (2002), 'Polímeros (Leather)', International Seminar on Advancement in Polymer Technology, India accessed on 7 September 2012, <http://www.polimeros.in>.

[12]. Surendhar G (2012), 'Laboratory Evaluation of Sisal Fibre Reinforced Bituminous Mixes in Thick Layer', Unpublished M.E (Urban Engineering) Thesis, CEG, AU, Chennai.

[13]. Vilvakumar (2011), 'Laboratory Evaluation of Sugarcane Fibre Reinforced Bituminous Mixes in Thick Layer', Unpublished M.E (Urban Engineering) Thesis, CEG, AU, Chennai.