A Study on Recycling of Crumb Rubber And Low Density Polyethylene Blend on Stone Matrix Asphalt

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Abstract- *Stone Matrix Asphalt (SMA) is gap graded hot mixture asphalt that is designed to maximize deformation resistance and durability by using a structural basis of stone – on-stone contact. To prevent pavement distresses there are various solutions such as adopting new mix designs or utilization of asphalt additives.To minimize the pollution from waste tires and to improve the properties of SMA, Recycled Crumb Rubber (CR) plus Low Density Polyethylene (LDPE) flakes were used as additive using dry process in this study. This project investigate the feasibility of using 16% and 20% CR+LDPE by weight of bitumen with 60/70 penetration grade bitumen for SMA. SMA mixture with varying bituminous mix of 6% and 6.5% of weight of aggregate has been applied to determine the properties of SMA with crumb rubber and low density polyethylene. Indirect tensile tests were carried out in the matrix No fiber was needed to prevent drain down when this rubber blend was used. The addition of CR+ LDPE using dry process could improve engineering properties of SMA mixtures, and the rubber content has a significant effect on long term performance.*

Keywords- Recycled crumb rubber, low density polyethylene flakes, dry process, SMA, mix design.

I. INTRODUCTION

Stone matrix asphalt (SMA) has found use in Europe, Australia and the United States as a durable asphalt surfacing option for residential streets and highways. SMA has a high coarse aggregate content that interlocks to form a stone skeleton that resist permanent deformation.The world generates about 1.5 billion waste tyres annually, 40 percent of them in emerging markets such as China, India, South Africa, South East Asia, South America and Eastern Europe. The huge number of waste tyres disposal has become an urgent problem of environment in India. The disposal of waste tyres in the world primarily has three ways to deal with such as landfill, burning and recycling. Recycled tire rubber applied to pavement may be the best way to reduce waste tyres in large quantities and, at the same time, improve some engineering properties of asphalt mixtures. The excellent performances of SMA include resistant to mechanical and temperature deformation, cracking, and particularly rutting, resistant to weathering actions such as aging and low temperature cracking.SMA provides a deformation resistant, durable, surfacing material, suitable for heavily trafficked roads.Typical SMA composition consists of 70−80% coarse aggregate, 8−12% filler, 6.0−7.0% binder, and 0.3 per cent fibre. Crumb rubber can be incorporate by a wet process or dry process. Wet process refers to modification of asphalt cement binder with 5-25 wt% of fine tyre rubber Crumb Modifier (CRM) at an elevated temperature. The dry process includes mixing the rubber particles with aggregates prior to addition to asphalt.In this project study, a dry processing of Crumb Rubber (CR) and Low Density Polyethylene (LDPE) blend were used as additive for SMA mixture. The main purpose of this research is to determine the effects of incorporating CR + LDPE waste on the engineering properties of SMA.

SIGNIFICANCE

The current project is able

- To provide a mixture that offered maximum resistance to studded tire wear.
- To prevent pavement distresses, new mix designs of asphalt additives is developed.
- To minimize the damage of pavement such as resistance to rutting and fatigue cracking, asphalt needs to be modified with polymer such as crumb rubber modifier (CRM) and low density poly ethylene (LDPE).
- To reduce the cost of rehabilitation.
- To develop a new material that improves the durability of the SMA mix.

APPLICATIONS:

Stone Mastic Asphalt has proved superior on heavily trafficked roads and industrial applications:

- With high lorry frequency

- Intense wheel tracking
- On highways
- On bridges
- In bus lanes
- In car parks
- In harbors

OBJECTIVES

1. To study the performance of SMA mixes with CRMB, LDPE and treated aggregates under repeated loads.
2. To determine the tensile strength ratio of SMA with 16% & 20% (Combined Combination with 30% CR and 70 % LDPE) by weight of the bitumen).
3. To determine the optimum dosage of the Additive to SMA mixture.

II. METHODOLOGY

The aim of the project is to improve the mechanical properties of SMA with additives.Aggregates play a very important role in providing strength to SMA mixtures.We have adopted 19 mm SMA which is used as Binder Course. The total weight of aggregate taken was 1100g. Particle size distribution is determined with aggregate gradation. Various tests were performed to determine the properties of SMA ingredients. Mix design is computed for SMA consisting modifier in two varying percentage such as 16% and 20% with 6% and 6.5% bitumen proportion in each modifier respectively.In dry process, the additives were blended with the aggregate before adding bitumen. The selected bitumen was heated to 160 ºC for about 1 h prior to blending with the aggregate. The Marshall compactor was used for the compaction stage of the process with 50 blows applied to both the faces of the sample at 150 ºC.The Optimum bitumen Content (OBC) was estimated at which the air voids (Va), and the minimum voids in mineral aggregates (VMA) are 4 and 17 percent respectively. Volumetric properties are determined and plotted in graphs. Indirect tensile strength of the SMA mix is determined and the OBC is estimated by comparison of volumetric properties of various mix.

Steps in Methodology

1. Allocation of raw materials like Aggregates, Crumb Rubber, LDPE flakes andBitumen.
2. Properties of materials is determined as per IS Code respectively.
3. Specimen is prepared with Marshall Compactor as per mix design.
4. Volumetric properties are determined and plotted in graph.
5. Indirect tensile strength determination.
6. OBC is identified from the comparison of volumetric properties.

III. MATERIALS

SMA Mix consists of coarse and fine aggregate, bitumen, crumb rubber and low density polyethylene. Well graded 19 mm coarse aggregate is used to add strength to the mix. Penetration grade bitumen such as 60/70 grade is utilized as a binding agent. A recycled rubber called crumb rubber and LDPE flakes of 16MA400 grade are the modifiers added to the mix.

IV. MIX DESIGN

The Marshall Mix design procedure as specified in ASTM D1559 was used in this study. The bitumen contents used in the mixture was varied at the rate of 6% and 6.5% by weight of aggregate. Two rubber contents were replaced instead of bitumen(16% and 20% by weight of bitumen), in crumb rubber and LDPE (30C+70L)) in dry process. In dry process, the additives were blended with the aggregate before adding bitumen.The weight of aggregate for each sample was 1200g.

A. *Mix Design*

Sample 1:
16% Modifier – 6% Bitumen

Weight of aggregate = 1200 g
Weight of bitumen:
Considering 16% modifier
Weight of bitumen = 60.48 g
16 % Crumb rubber + Low Density Polyethylene:
Weight of crumb rubber = 3.306 g
Weight of LDPE = 8.214 g

TABLE I MIX DESIGN

S. no	Description	Sample 1 (g)	Sample 2 (g)	Sample 3 (g)	Sample 4(g)
1	Weight of aggregate	1200	1200	1200	1200
2	Weight of bitumen	60.48	65.52	57.6	62.4
3	Weight of CR	3.306	3.74	4.32	4.68
4	Weight of LDPE	8.214	8.74	10.08	10.92

V. TESTS & RESULTS

For testing of the SMA Mix the test usually is of three types 1. Material Test 2. Marshall test 3.Indirect tensile test

A.MATERIAL TESTING

First the materials must be tested for its property, there are various test available for testing the materials. They are

1. *Gradation of coarse aggregate:*Gradation of the aggregate required for the mix is done according to IRC: SP: 79-2008. We have adopted 19 mm SMA which is used as Binder Course. The total weight of aggregate taken was 1200g.

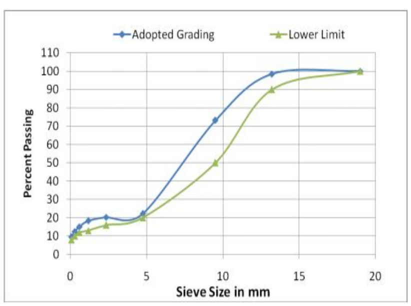

Fig. 1 Aggregate Gradation Curves

2. *Specific gravity of coarse aggregate:* The specific gravity of coarse aggregate is determined by using pycnometer and the result was found to be 2.85.
3.*Water absorption of coarse aggregate:*Water absorption of coarse aggregates is determined by following IS: 2386 (Part III) 1963,and found to be 1.7%
*4.Specific gravity of Bitumen:*The specific gravity of bitumen was found to be 1.018.
*5. Penetration test of Bitumen:*Penetration of a bituminous material at 25°C is 64.35.

*6. Softening Point Of Bitumen:*Softening point of bituminous material is 55°C.

B.MARSHALL TEST

The Marshall Mix design procedure as specified in ASTM D1559 was used in this study.The weight of aggregate for each sample was 1200g.The results are plotted below

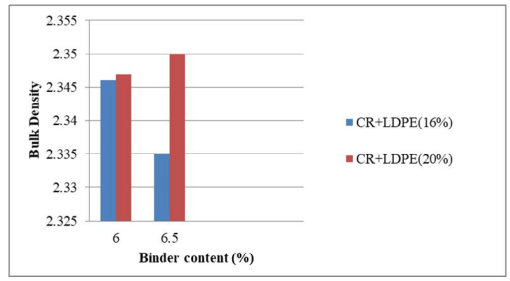

Fig2 Bulk Density for SMA with various contents

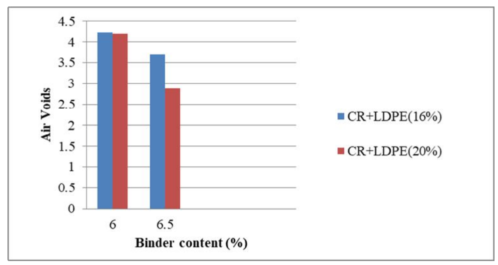

Fig 3 Air Voids for SMA with various contents

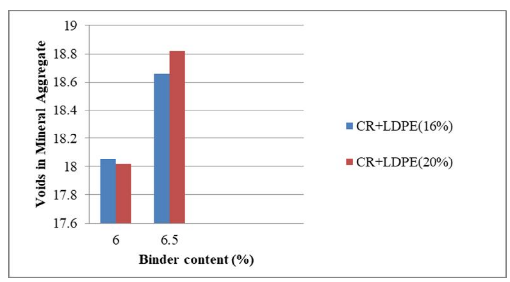

Fig 4 Voids in Mineral Aggregate

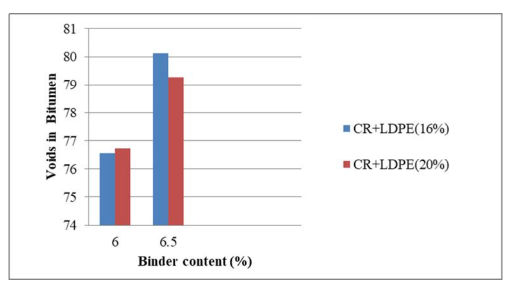

Fig 5 Voids in Bitumen

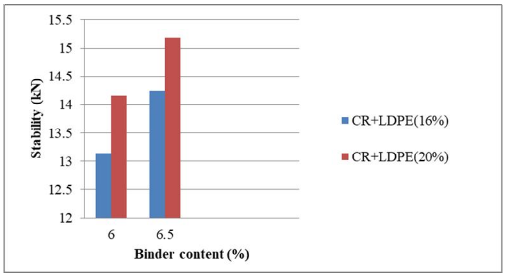

Fig 6 Marshall Stability

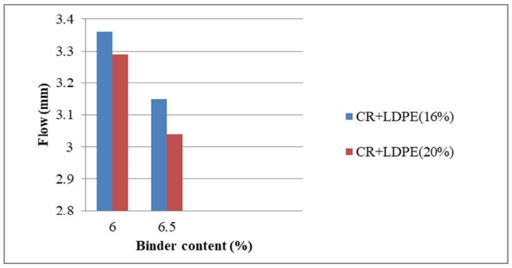

Fig 7 Flow value

C. INDIRECT TENSILE STRENGTH

The variation of Indirect Tensile Strength Ratio for Mix with different dosage of the Crumb Rubber and LDPE is determined by:

TSR (%) = (ITSwet/ ITSdry) X 100

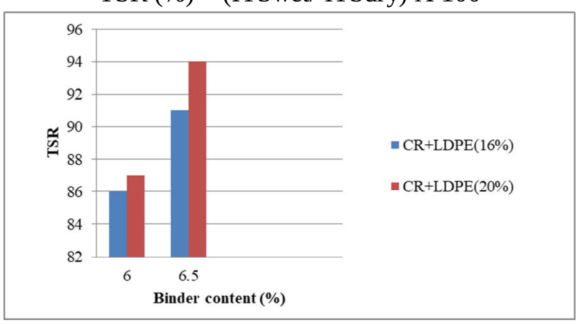

Fig 8 TSR for SMA mixes

D. PROPERTIES OF OPTIMUM BINDER CONTENT

OBC for SMA Mix has been estimated considering the Air Voids (Va), Minimum Voids in Mineral Aggregates (VMA) and Tensile Strength Ratio (TSR) respectively.

TABLE II Volumetric Properties of SMA Mixtures at OBC

Properties	Value obtained
Optimum Binder Content by Weight of Aggregate, %	6.5
Bulk Specific Gravity of Compacted Mixture, Gmb	2.35
Air Voids, %	2.89
VMA, %	18.82
VB, %	79.27
Stability, kN	15.18
Flow, mm	3.04
TSR, %	94

From the above tests, the optimum bitumen content is 6.5% mix of aggregate (20% (Crumb rubber + low density polyethylene)).

VI. CONCLUSION

From the experimental investigations the following conclusions are drawn.

- The Tensile strength Ratio values are found to be in the range 85 - 94 % which is more than 85 % as specified for a SMA mixture.
- The SMA mixes designed with available aggregates showed good stone on stone contact (VCA DRC< VCA MIX).
- The 17% Voids in Mineral aggregate and 3 - 5% air voids in the mix were fulfilled as SMA Mix design criteria.
- Based on the above performance, Combined Combination of Crumb Rubber and LDPE could be used as stabilizing additive in the form of dry processing showed without affecting the design criteria of SMA mixture.
- The optimum dosage of the Additive was found to be 20 % (Combined Combination with 30% Crumb Rubber and 70 % LDPE) by weight of the bitumen.
- The long-term performance of recycled CR+LDPE blend on SMA mixture using dry process will need to be further studied.

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