International Journal of Scientific Research & Engineering Trends
Volume 5, Issue 3, May-Jun-2019, ISSN (Online): 2395-566X

Stone Matrix Asphalt Based Flexible Pavement

Asst. Prof. Shriram P Marathe ram.nmamit@gmail.com
Sakshar S Huddar saksharh.sh@gmail.com com
Dept. of Civil Enggineering
NMAM Institute of Technology
Karkala, Karnataka, India

***Abstract*- stone matrix asphalt (sma) was originally developed in europe as an impervious/highly durable wearing surface for bridge decks. based on its performance history, split matrix asphalt began to be used as a surface layer for roadways carrying heavy truck traffic throughout Germany and other european countries. today, it is the pavement surface of choice where long-term performance and durability is needed. in this study various research works on sma have been reviewed, out of which, sma study using crmb-55 as *binder*, major influence of fibers on sma, the sma using different filler, properties of sma, use of carbon fiber and glass fiber, study of sma using coir fiber and pineapple fiber are investigated.**

***Keywords* -sma, filler, mix, marshall, strength.**

I.INTRODUCTION

SMA is a tough, stable, rut resistant mixture that relies on stone-to-stone contract for its strength and a rich mortar binder for its durability (NAPA 1999). SMA was first developed in Europe to combat rutting caused by the use of studded tires. In the 1980's federal and state highway officials in the United States recognized the need to design stiffer, more rut resistant pavements. As a result, American professionals participated in the European Asphalt Study Tour in 1990, where SMA pavements were investigated. This was the first concerted effort to figure out how to use SMA in the United States.

In 1994 the Federal Highway Administration awarded a contract to the National Center for Asphalt Technology (NCAT) to determine the performance of SMA pavements. Results from this study showed a significant reduction of rutting with SMA pavements (Brown et al. 1997).A number of states have had experience with SMA pavements, some with more success than others. SMA pavement projects and studies were conducted in Maryland, Virginia, Wisconsin, Georgia, and Washington to name a few. Many states have adopted SMA pavement as their standard mix for their high traffic highways.

Washington State has constructed four projects; one in Western Washington, two in Eastern Washington and one in Central Washington. The first project experienced many of the expected problems associated with a new product. The second project in Eastern Washington failed and had to be replaced with conventional hot mix asphalt (HMA) the following year. The last two projects experienced fewer problems and have performed well to date.

1. Advantages of Sma

- SMA provides a textured, durable, and rut resistant wearing course.
- The surface texture characteristics of SMA are similar to Open graded asphalt (OGA) so that the noise generated by traffic is lower than that on DGA but equal to or slightly higher than OGA.
- SMA can be produced and compacted with the same plant and equipment available for normal hot mix, using the above procedure modifications.
- SMA may be used at intersections and other high traffic stress situations where OGA is unsuitable.
- SMA surfacing may provide reduced reflection cracking from underlying cracked pavements due to the flexible mastic.
- The durability of SMA should be equal, or greater than, DGA and significantly greater than OGA.

II. LITERATURE REVIEW

Ashish, T. and Vaishakhi, T. [2014]: In this paper study of stone matrix asphalt (SMA) was carried out, double crushed tough premium aggregate of definite size, soundness ,shape etc. are used. Mineral filler like granite, basalt etc. can be used. The cellulose fiber polymer artificial siliceous materials are the additives which are used in this. And using grounded limestone as a filler material, mix design was prepared using appropriate job mix formula by carrying out Marshall stability test and drain down test, addition of CRMB-55 & modified aggregate decreased the drain down value, Marshall specimen are prepared at 135/145±5°C and by giving 50 blows on each side of the specimen, Marshall analysis was done and hence the stabilizer additives can be avoided the addition of CRMB-55 and modified aggregates improves the volumetric properties of SMA. From the investigation it was found that the OBC of the SMA mixes with CRMB-55 and modified aggregates were 6.2% and 6% using Marshall and SGC respectively, we can conclude that with help of proper additives we can improve the SMA Mix.

Bindu, C.S.andBeena, K.S. [2015]: In this paper influence of natural fiber on the compressive strength of stone matrix asphalt mixtures is studied, natural fiber like coir fiber, sisal fiber and banana fiber are used for the study. Aggregate of size 20mm, 10 mm and stone dust are used from local quarry and cement of 3.12 specific gravity, bitumen of 60/70 penetration grade obtained from Kochi refinaries are used. Mix is prepared using all the materials collected and strength was checked for each specimen with different additives.

From the investigation it was found that the compressive strength of SMA sample with coir fiber, sisal fiber and banana fiber were 5.96, 5.80, and 5.76 respectively at 0.3% at 25°C and at 60°C values were 5.87, 5.67, and 5.57 respectively. This SMA Mix enhanced the stone contact of aggregates all these gave rise to a stiffer and tougher mix with considerable importance in compressive strengthCompressive strength (MPa) of fiberstabilized SMA samples at 25˚C and 60˚C.

Table 1 Compressive strength results

Fiber (%)	Compressive strength of SMA samples with					
	Coir fiber		Sisal fiber		Banana fiber	
	25˚C	60˚ C	25˚ C	60˚ C	25˚ C	60˚ C
0	5.10	4.13	5.10	4.13	5.10	4.13
0.1	5.19	4.25	5.16	4.22	5.15	4.20
0.2	5.71	5.22	5.58	5.15	5.54	5.01
0.3	5.96	5.87	5.80	5.67	5.76	5.57

From the results we can conclude that presence of fibers in SMA Mix enhance the stone to stone contact of aggregate.

Akash, Ka P., et.al.[2016]: In this paper the study of SMA mix with design using different filler material is done. The mixture consists of 70-80% course aggregate of total mass, 6-7% of binder, 8-12% of filler and 0.3 to 0.5% of fiber or modifier in this study PMB-40 used as a binder material. For gradation 20 mm, 10 mm, 6 mm aggregates are used for the SMA Mix design. Brisk dust and lime powder is used as filler material with specific gravity of 2.675 and 1.923 respectively, for the analysis Marshall Stability test was conducted on the prepared specimen with varying the binder content in the range of 5% to 7%.

From the investigation it is found that highest stability value for brick dust and lime powder were 16.8 KN and 12.3 KN respectively.for lime powder. The aim was to find out alternative filler material to achieve similar or higher strength for SMA Mix design over existing fillers used mixes it was observed that bitumen content increases the flow value for both type of mixes.

Table 2 Results from the tests

Filler type	Bitumen content (%)	G_t	G_m	V_v	V_b	VMA	VFB	Stability (KN)	Flow (mm)
Brick dust	5	2.58	2.45	5.03	11.35	16.38	69.28	12.3	2.4
	5.5	2.57	2.46	4.40	12.46	16.86	73.90	16.8	2.6
	6	2.55	2.44	4.30	13.44	17.74	75.75	16	2.9
	6.5	2.53	2.43	4.0	14.42	18.42	78.31	11.8	3.1
	7	2.51	2.42	3.72	15.38	19.10	80.53	13	3.4
Lime powder	5	2.47	2.33	5.60	10.80	16.40	65.85	9.2	2.6
	5.5	2.45	2.34	4.33	11.89	16.22	73.30	12.9	2.9
	6	2.44	2.33	4.32	12.85	17.17	74.85	12.2	3.1
	6.5	2.42	2.32	4.11	13.78	17.88	77.04	7.7	3.4
	7	2.41	2.31	3.95	14.73	18.68	78.86	7.8	3.9

Karunakar, K., et.al. [2018]: In this paper study on SMA is done prepared using carbon fiber and glass fiber as additives, the aggregate gradations influence in the present study is compared between the MORTH, 2009 and the Chinese airfield gradation specifications. The MORTH gradation i.e. The Indian gradation having the nominal max size of 19 mm has been used, nominal maximum carbon fiber used in the percentage range of 0.2 to 0.4 and glass fiber in the range of 0.2 to 0.4, optimum fiber content in Carbon fiber is obtained at about 0.3% and for glass fiber at 0.3%, filler material used in this case is fly ash, the binder VG-30 is used.

The binder content is varied from 5.5% to 7.0%using these materials mix was prepared and test were under taken, from the investigation it was found that the carbon fiber is better than glass fiber. Optimum binder was evaluated to be 6.605% and 6.55% for Carbon and Glass fiber respectively with 5.5% as minimum binder content to prevent fat spots. The binder content required was more in Carbon fiber, from the above comparison we can conclude that use of carbon.

Table 3 Results from the tests

Property	Type of Fiber	
	Carbon	Glass
Bulk density (gm/cc)	2.3479	2.37
Voids in Mineral Aggregate VMA (%)	25.1007	24.3935
Void filled with bitumen VFB (%)	83.42	83.84
Marshall stability (Kgs)	1156.076	1021.68
Flow Value (mm)	3.1693	3.3088
Marshall Quotient (Kgs/mm)	366.1289	309.8179

III. PROPERTIES OF SMA MIXES AT OPTIMUM BINDER CONTENT

K jaswanth, et.al. [2016]: In this paper study on stone matrix asphalt using polymers is done. Aggregates of specific gradation are used. Filler martial passing through 0.075 mm sieve is used for example rock Dust, Port land cement is used and bitumen of VG30 grade is used as binder The Polymers Polyvinyl Chloride (PVC), Polyethylene (PE) and Styrene Butadiene Rubber (SBR) are used as filler material. Poly Ethylene was used of specific gravity 0.94% and Polyvinyl Chloride of 1.25.

Marshall Stability test was conducted on prepared specimen, The Marshall Stability value is found maximum of 16.03 kN at 0.4% (PVC) content which is more than SBR and PE. The Bulk density is found maximum having 2.420 g/cc for (PE) at 5.5% bitumen content. Drain down test was conducted and from the Drain down test results we see that bitumen drainage gets reduced at 0.4% (PVC, PE) and 2% (SBR). From the investigation it was found that the optimum bitumen content obtained at 4% Air Voids are 6.27% (PE), 6.24% (SBR) and 6.11% (PVC), it is observed that air voids decreased, which is required for better strength.

Satyavathi, M.,et.al. [2016]: In this paper study on SMA is done prepared using coir fiber and pineapple fiber as additives and the size of aggregates varying from 19mm to 75micron was used. Qualities of aggregates were check through various tests. Bitumen of VG-30 grade was acquired from HPCL (Visakhapatnam) is used for preparation of specimens. Coir fiber is acquired from local market in Srikakulam. Pineapple fiber was acquired from Lakshmi enterprises, Guntur mixtures.

The filler materials used are quarry dust and lime. Of the 10% (passing 0.075mm IS sieve) filler used, 8% is stone dust and 2% is lime. Marshall Stability test was conducted with varying the bitumen content from 5.5% to 7%. From the investigation it was found that Optimum bitumen content for coir fiber and pineapple fiber were 6.25% and 5.75%. Optimum coir Fiber and Optimum Pineapple fiber contents obtained from test results for both Grade-I and grade-II mixes was 0.3% and 0.1% respectively. From the test results, it was concluded that coir fiber and pineapple fiber reduces the drain down and increases the stability of the sample.

Table 4 Results from the tests

Property	Bitumen content by weight of mix			
	5.5	6.0	6.5	7.0
Gradation I (16mm)				
Bulk density	2.311	2.315	2.318	2.316
Volume of voids, Vv (%)	5.47	4.85	4.10	3.58
Voids in Mineral Aggregate, VMA (%)	17.96	18.46	18.86	19.47
Voids filled with Bitumen, VFB (%)	69.54	73.76	78.29	81.63
Marshall stability (KN)	13.87	14.53	16.04	15.18
Flow (mm)	2.86	3.97	4.44	7.02
Optimum Bitumen content, OBC (%)	*6.60*			

Yanping, S.,et.al.[2017]:In this paper the effect of fiber on mixture design of stone Matrix asphalt is carried out a modified asphalt binder, i.e., styrene-butadiene-styrene (SBS). In this study the diabase gravel and the limestone sand were chosen as coarse aggregate and fine aggregate, the mineral filler used is limestone. Four different fibers were selected for the analysis, i.e., flocculent lignin fiber, mineral fiber, polyester fiber, and blended fiber, and mix was prepared using these. The Marshall stability and flow tests were conducted on the prepared specimen to evaluate the resistance of asphalt mixtures to distortion, displacement, rutting, and shearing stresses. From the investigation it was found that Marshall Stability values were between 7 and 14 KN Marshall Stability of SMA mixtures with polyester fiber and flocculent lignin fiber increased with the fiber content increasing from 0.1% to 0.3%.

The Marshall Stability then maintained slight increase with the fiber content from 0.3% to 0.5%, and 0.4% to 0.6% for the blended fiber and the mineral fiber. From the investigation it was found that optimum fiber content is to be larger than 0.3% for flocculent lignin fiber, blended fiber, and polyester fiber, and larger than 0.4% for mineral fiber. Therefore, SMA mixtures with mineral fiber and polyester fiber will be better in heavy traffic sections or hot areas with larger high-temperature stability

Abhishek, M.,et.al [2015]: This paper Studies on Stone Matrix Asphalt with Warm Mix Technology using Sasobit and Zychotherm as Additives, Aggregates used are mainly divided into coarse and fine aggregate based on their size. In this study Polymer Modified Bitumen

(PMB-40) used as the binder. Sasobit and zychotherm are the additives used. Sasobit is a warm mix additive and it is manufactured from coal gasification Sasol wax. Zychotherm is a warm mix additive manufactured by Zydex industries Gujrat India. Fibers are used as stabilizer in SMA mixture. It helps to increase the strength and stability also decrease the drain down in SMA Mix. In the present study, the fiber used is ARBOCEL Marshall Test has been carried out on the conventional SMA Mix. Binder content were varied from (5.8%,6%,6.2%,6.4% and 6. 6%).the fiber content is varied with different percentages form (0.3%,0.35%,0.4% and 0.45%) to find out Marshall properties.

From the investigation it was found that the optimum binder content obtained for conventional SMA Mix was 6.2%, with a Maximum stability of 10.84 KN Marshall Stability test conducted on SMA Mix with addition of warm mix additives. Sasobit was added in percentages of (1%, 2% and 3%) out of these percentages 2% Sasobit was found to optimum considering the Marshall properties with a maximum stability of 12.33 KN. Zychotherm was added in percentages of (0.05%, 0.1% and 0.15%) out of these percentages 0.1% Zychotherm was found to optimum considering Marshall properties with a maximum stability of 13.93 KN.

Gholamali, S.,et.al.[2015]: In this paper there is a Study on Creep behavior of Stone Matrix Asphalt is done by Using of Nano Al_2O^3 The aggregates used in this study were graded using the Recommended type for stone asphalt mixtures of the AASHTO standard, Bitumen of 60-70 penetration grade is used, In this study Marshall test, the static creep test, the dynamic creep test, repeated axial load test (RLA), and the wheel-tracking test are used to determine the outcomes, The results obtained by the dynamic creep tests for samples show that 0.9% Nano Al_2O^3 as modifier of bitumen is an optimal content in SMA mixtures. The results obtained by this research show that the best replacement for reducing final strain and permanent deformation of SMA samples is the replacement of 0.9% bitumen with Al_2O^3.

Piyush Prakash., et.al.[2017]: In this paper we study of utilization of bamboo fiber in improving the properties of stone matrix asphalt mixes Materials taken for the SMA mix for the sample and for experiments and to compare the project work are filler stabilizer, coarse aggregate and fine aggregate, Coarse aggregate are taken are Stone aggregate and Slag aggregate obtained from steel slag. Stone dust is taken as fine aggregate. Stabilizers taken are Bamboo fiber. The Bitumen of grade 60-70 is taken as binder as it is most favorable in Indian environment. The mix was prepared and Marshall Specimens were prepared and Marshall Test was undertaken to find the stability. The stability was checked by varying bitumen content from 3 to 7% it was found that for 3% the stability was 5.84 and for 7% it was 6.94 the max stability was obtained at 5% that was 9.01. The Optimum Binder content for the SMA samples for all the cases except where the stone is used as coarse aggregate with the cane fiber is found to be 5% from the investigation we can say that ,The use of cane fiber is appropriate in attaining better stability, SMA Mix without using Fiber. Without adding stabilizers have shown results which are far poorer to the results obtained after mixing those similar ingredients with any stabilizer

Bindu, C.S. and Beena, K.S. [2015]: In this paper we study the influence of additives on the drain down characteristics of stone matrix asphalt mixtures Aggregate of sizes 20mm, 10mm and stone dust procured from a local quarry at Kochi, Kerala is used in the present investigation and the physical properties of aggregates like Aggregate impact value, Los Angeles Abrasion Value ,Combined Flakiness and Elongation Index Stripping Value Water Absorption, Specific gravity are checked physical properties like specific gravity is checked and was obtained as 3.12%.

Three natural fibers namely coir, sisal and banana fiber, a polymer, polypropylene and waste plastics in shredded form are used as stabilizing additives for the present study, polymer stabilizer like Polypropylene, manufactured by Reliance Petrochemicals is used for the present study. One more stabilizer that is waste plastic is used, the plastic used were the disposed carry bags, films, cups etc., with a maximum thickness of 60 microns made out of polyethylene, polypropylene and polystyrene. For the proposed design mix gradation, four specimens are prepared for each bitumen content within the range of 5.5 – 7.5% at increments of 0.5 percent, The stability and flow value of each test specimen shall then be determined in accordance with ASTM D 1559 after this drain down test was carried out and result obtained are shown in below table

Table 5 Results from the drain down test

% Fibre	Drain down (%)		
	Coir	Sisal	Banana
0	6.497	6.497	6.497
0.1	1.887	2.347	2.584
0.2	0.083	0.114	0.116
0.3	0	0.012	0.014
0.4	0	0	0.003

From the drain down study of the SMA mixtures, it can be concluded that all the five additives used in the stone matrix asphalt for the present investigation act as effective stabilizing agents.

GouthamSarang et.al.[2014]: in this paper we study use of chemicals in stone matrix asphalt, The primary objective of this investigation was to prepare SMA mixtures without any additional stabilizing material, by modifying the Aggregates and bitumen with suitable chemicals Modification of aggregates was done by treating them with a chemical named Terrasil and bitumen modification was achieved by the addition of another chemical called Zycosoil.

Table 6 Results from the Marshall tests:

Property	Modified Bitumen	Treated Aggregates
OBC (%)	6.295	6.255
G_{MM} (g/cc)	2.429	2.433
G_{MB} (g/cc)	2.332	2.335
VMA (%)	17.83	19.37
VFB (%)	77.54	79.32
Marshall stability (kN)	15.18	15.86
Flow value (mm)	3.18	3.18
Marshall Quotient (kN/mm)	4.76	4.99
VCA_{MIX}	34.59	34.64
VCA_{MIX} / VCA_{DRC}	0.868	0.869

Here two types of mixtures, one with modified bitumen and the other with treated aggregates, were prepared in SGC, For preparing SMA mixtures, VG – 30 bitumen and crushed granite aggregates from nearby Quarry were used. Quarry dust and lime were used as mineral filler and were used 8% and 2% respectively, by weight of total aggregates The aggregate gradation adopted for this study is as per Indian Roads Congress (IRC SP – 79) and SMA mixtures were prepared according to Marshall method of mix design for bitumen contents 5.0, 5.5, 6.0, 6.5 and 7 % by weight of aggregates, Drain down test was conducted as per ASTM D 6390,. Drain down was observed to be about 0.380% for SMA without any modifier whereas it was 0.240% and 0.192% for mix with modified bitumen and treated aggregates respectively.

Properties of SMA mixtures with modified bitumen and treated aggregatesTreated aggregate–SMA mixtures showed better volumetric and Marshall Properties. OBC was reduced from 6.295% in the case of modified bitumen-mix to 6.255% for treated aggregate-mixture

K. Shravanet.al[2017]: in this paper we study the performance of stone matrix asphalt with cellulose and coir fiber, the materials used are aggregates, nominal maximum aggregate size of 19mm is being used, additive like cellulose fiber and coir fiber is being used, coir fiber is chosen as a stabilizer because of its natural abundance in India and the cellulose fiber is the very commonly included fiber in SMA mixtures, This organic fiber which is completely harmless is generally acquired from plants and is profusely found in the nature, for 0.3% fiber content, bitumen content is varied from 5.5% to 7% and optimum binder content was found to be 6.23% for coir fiber and 6.43% for cellulose fiber the result are obtained. Stability value at OBC and 0.3 % fiber content was 1135.00Kgs and 1026.643Kgs for the Coir and Cellulose respectively almost 9.55% increase in stability as compared to Cellulose. Hence we conclude by saying that coir fiber is better additive compared to cellulose fiber.

Table 7 Results from the tests.

Property	Modified Bitumen	Treated Aggregates
OBC (%)	6.295	6.255
G_{MM} (g/cc)	2.429	2.433
G_{MB} (g/cc)	2.332	2.335
VMA (%)	17.83	19.37
VFB (%)	77.54	79.32
Marshall stability (kN)	15.18	15.86
Flow value (mm)	3.18	3.18
Marshall Quotient (kN/mm)	4.76	4.99
VCA_{MIX}	34.59	34.64
VCA_{MIX} / VCA_{DRC}	0.868	0.869

Vivek B. Ret.al[2015]: In this paper comparison is made between stone matrix asphalt mixes with varying binder contents and with different types of waste plastic mainly polyethylene packets, materials used are aggregates, binder and additives and filler. Binder of VG-30 grade is being used or the study which satisfies all the properties required for the binder, aggregates of proper specification are used for the mix, filler like stone dust is being used and additive used is coconut fiber, waste plastic is used in the mix as stabilizer.

The properties of any bituminous mix like stability, bulk density, air voids, are mainly dependent on thegradation of aggregates, binder content and its type, the type of compaction and compaction temperature. The Marshall Test specimens were prepared by adding 5.5, 6.0, and 6.5 per cent of bitumen by weight of mix. With varying percentage of shredded waste plastic (4%, 6%, 8% and 10%) by weight of the 60/70 grade of bitumen and 0.1%, 0.2% and 0.3% of coconut fiber by weight of total aggregate**.** and test was carried and Stability value of stabilized SMA with 0.3% coconut fiber is found to be 16.35 kN, which is lesser than the stability value of SMA with 8% shredded waste plastic from this result we can say that, stability value increases with increase in shredded waste plastic content up to certain value and then the stability value decreases.

GouthamSarang.et.al[2015]: This paper compares SMA mixtures prepared in Marshall Compaction and gyratory compactor, for this study, crushed granite aggregates from

nearby local quarry and VG–30 bitumen were used. Hydrated lime was used as the mineral filler and a chemical named Zycosoil (manufactured by Zydex Industries, Gujarat) was used to stabilize the mix. Bitumen content was varied from 5% to 7% and two types of samples are prepared for Marshall and gyratory compactor, 50 blows were given on either sides of the specimen using Marshall hammer, whereas for compacting in SGC, 100 gyrations were provided for each sample and results are obtained stability was found to be 14.51 for SGC and 12.09 for MC hence from this we can say that SMA samples compacted in SGC are showing better results than samples prepared by MC.

Mithanthaya I.Ret.al[2018]: In this paper we study the effect of gradation and waste plastic on performance of SMA, materials used are bitumen of VG-10 grade with specific gravity of 1.00 was used in the present study. The coarse aggregates consisting of crushed rock retained on 2.36 mm, and fine aggregates (2.36mm down size sieve and retained 75 microns IS sieve) consisting of 100 per cent stone-crushed aggregates from local plant from crushing operations were used.

The aggregates were properly washed, hard, clean, fairly cubical, durable, and free from the presence of any type of organic or other possible deleterious substances stone crushed dust and limes were used as mineral filler materials in the present investigation, In the present study, the Marshall's method of mix design was adopted, The test specimens were prepared at varied percentage of bituminous binder starting from 5.0% till 7.0% by weight of aggregates (with 0.5% variation) and drain down test and rutting have been carried out and result are obtained from the investigation it was found that the optimum bitumen content at 4% air voids was found to be 6%, 5.75%,5.70% as the waste plastic content increases, OBC value decreases for both for the Chinese and Indian gradation, the waste plastic content increases, OBC value decreases for both for the Chinese and Indian gradation

Poonam Singh et.al[2017]: in this paper study aimed at the use of wheat straw fiber as stabilizing additive in Stone matrix asphalt for surface course, for this study materials like Coarse and fine aggregate, Cement as filler,VG30 Bitumen as binder and Wheat straw fiber as stabilizer have been used and tests like abrasion test, impact value test, aggregate crushing test, flakiness and elongation test ,water absorption test were conducted on coarse aggregates, specific gravity test on both fine and coarse aggregate ,penetration test and softening test were conducted on VG-30 bitumen and the results are obtained and mix samples were prepared according to the Marshall procedure Binder concentrations were varied from 4% to 6% while fiber concentrations were selected as 0.3% . Stability was obtained and results are as follows.

We can conclude by the result that Stone matrix asphalt with wheat straw fiber gives better result in terms of flow, stability etc. as compared to stone matrix asphalt without fiber.

Table 8 Result between stone Matrix

Stability (kN)	Flow (mm)	VMA	Vv	VFB
7.98	4.5	14.8%	4%	70.2%

Imran Hafeez et.al[2012]: In this paper we study the effect of aggregate on rutting potential of stone mastic asphalt, materials used for the study are aggregate of specified grade bitumen and filler materials and fibers are used as additives, Rutting potential of four stone mastic asphalt concrete mixtures prepared with four nominal maximum sizes of aggregates i.e. 9.5 mm, 12 mm, 19mm & 25.4 mm and tested using Wheel Tracker at 25, 40 and 60^{o}C has been investigated and results were obtained and they are as follows

Table 9 Rut Depth in SMA Mixtures

NMS Size (mm)	Rut Depth of Mixtures (mm)		
	25^{o}C	40^{o}C	60^{o}C
25.4	2.14	4.67	6.6
19	2.50	6.95	9.03
12	2.71	9.97	12.17
9.5	3.13	12.7	15.14

From the results we can conclude that with increase in the size of aggregate, rut value decreases and also that Temperature has significant influence on the rut depth of SMA

Mohammad et.al.:[2014]: In this paper we study the performance of SMA and hot mix asphalt mixtures containing recycled concrete aggregate , materials used in this study are Granite aggregates, 80/100 penetration grade bitumen, hydrated limestone powder, oil palm fiber, and recycled concrete aggregates (RCA), crushed granite aggregates were provided from Kajang rock quarry (located near Kuala Lumpur, capital of Malaysia) and SMA and HMA mixtures were compacted by using roller compactor and the required specimens were cored out of the compacted slabs to evaluate the performance tests. 20%, 40%, 60%, and 80%, Marshall Mix design method was used to measure the optimum asphalt content (OAC) of SMA and HMA mixtures and results are obtained.

Table 10 Marshall Result.

Marshall Result		
Tests	SS	MS
Stability	151.35	12.612

Stability results are obtained as above. This paper has presented some of the experimental results obtained from the influence of recycled concrete aggregate from this we can conclude that attached excessive cements to the surface of the RCA could increase the bitumen absorption in the asphalt mixtures and reduce the adhesion between RCA and binder.

Esmaeil Ahmadinia.et.al [2015] :in this paper we study about the use of waste plastic bottles in the SMA mix is done. We have used several plastic materials as an additive to the SMA mix but they are not economical. In this research the use of waste plastic bottles, which are a type of polymer (Polyethylene terephthalate), as an additive for SMA, was investigated, Polyethylene terephthalate (PET) is a thermoplastic polymer resin, which belongs to the polyester family. The main purpose of this research was to determine the effects of incorporating waste PET on the engineering properties of SMAmixture with and without the chopped PET, tests are carried out and results are analyzed with respect to mix without PET. From the results we can conclude that use of PET can be economical and give necessary strength required for the mix.

III. CONCLUSION

We conclude that there are different filler materials that can be used in the mix and make the mix economical and standarduse for construction, in the investigation of SMA Marshall test is most commonly used which gives the stability and flow results of SMA from which we can know whether to use the mix or not. Suitable chemicals be used to modify the conventional bitumen and to treat the normal aggregates in SMA, can control drain down of the mixture without any additional stabilizer material. In a comparative study of SMA mixtures with modified bitumen and treated aggregates, it is observed that mix with treated aggregates is performing better than the other.

REFERENCES

[1] Ashish Talati, VaishakhiTalati, **"**Study of stone matrix asphaltfor the flexible pavement" International Journal of Modern Engineering Research 2014 IJEDR, Volume 2, Issue 1 | ISSN: 2321-9939

[2] Bindu C.S, Beena K.S**, "**Influence of natural fibers on the compressive strength of Stone Matrix iAsphalt mixtures" Volume-1, Issue-6, September 2015 ISSN: 2395-3470

[3] K. Jaswanth, B.P.R.V.S. Priyatham, K.S.B. Prasad**, "**Experimental Study on Stone Matrix Asphalt Using Polymers" International Journal of Modern Engineering Research (IJMER), ISSN: 2249–6645

[4] K. Karunakar, Dr.P.Sravana,K.GovindGoud, T.Sowjanya**, "**Properties of Stone Matrix Asphalt Using Carbon Fiber and Glass Fiber" International Journal of Engineering Science Invention (IJESI) ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726

[5] M.Satyavathi, B.Someswara Rao, G.Venkata Rao, **"**Experimental study of stone matrix asphalt with coir fiber and pineapple fiber" ISSN: 2277-9655 DOI: 10.5281/zenodo.167081

[6] AkashKa. Patel, Prof. SiddharthGupte, Prof. N. B. Parmar**, "**Stone Matrix Asphalt (SMA) Mix Design Using Different Filler" 2016 IJSRSET | Volume 2 | Issue 3 | Print ISSN: 2395-1990 Online ISSN: 2394-4099

[7] Yanping Sheng, Haibin Li, Ping Guo, Guijuan Zhao, Huaxin Chen and RuiXiong**, "**Effect of Fibers on Mixture Design of Stone Matrix Asphalt" Received: 28 December 2016; Accepted: 10 March 2017; Published: 18 March 2017

[8] Abhishek Mendigeri, Dr. H S Jagadeesh**, "**Studies on Stone Matrix Asphalt with Warm Mix Technology using Sasobit and Zychotherm as Additives" International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064

[9] GholamaliShafabakhsh, MostafaSadeghnejad, AsadollahChelovian**, "**Experimental Study on Creep behavior of Stone Mastic Asphalt by Using of Nano Al2O3" International Journal of Scientific & Engineering Research, Volume 6, Issue 10, October-2015 903 ISSN 2229-5

[10] Piyush Prakash,rajatpalya, "utilization of bamboo fiber in improving the properties of stone matrix asphalt mixes" International Journal of Mechanical and Production Engineering, ISSN: 2320-2092 Volume- 5, Issue-11, Nov.-2017

[11] Bindu, C.S. and Beena, K.S, "influence of additives on the drain down characteristics of stone matrix asphalt mixtures" International Journal of Research in Engineering and Technology eISSN: 2319-1163 | ISSN: 2321-7308: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | ISSN: 2321-7308

[12] Goutham Sarang, lekha b m, a u ravi Shankar, "Comparison of Stone Matrix Asphalt Mixtures Prepared in Marshall Compaction and Gyratory Compactor" IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X PP 14-20

[13] K. Shravan, k.b.r. prasadreddy, "performance of stone matrix asphalt with cellulose and coir fiber" Vol-3 Issue-6 2017 IJARIIE-ISSN (O)-2395-4396

[14] Vivek B. R , Dr. Sowmya N. J, "Utilization of Fibre as a Strength Modifier in Stone Matrix Asphalt" International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 3, special Issue-11, june 2015 ICvalue 13.98 ISSN:2321-9653

[15] GouthamSarangLekha B M, A U Ravi Shankar, "Aggregate and Bitumen Modified with Chemicals for Stone Matrix Asphalt Mixtures" International Journal of Civil Engineering Research.ISSN 2278-3652 Volume 5, Number 3 (2014), pp. 233-240.

[16] Mithanthaya I.R, ravishankar A.U and shriram p marathe, "Effect of gradation and waste plastic on performance of stone matrix asphalt(SMA)"International Journal of Civil Engineering and Technology (IJCIET) Volume 9, Issue 9, September 2018, pp. 1645–1656, Article ID: IJCIET_09_09_158

[17] Poonam Singh MohitTakhalate, Pranav Thepe, DrSubrat Roy, "Use of Wheat Straw Fibre as Stabilizing Additive in Stone Matrix Asphalt Mix" ISSN (Online): 2319-8753 ISSN (Print): 2347-6710

[18] Imran Hafeez, Mumtaz Ahmed Kamal, Muhammad WaseemMirza, &AyazAziz,"Investigating the Effects of Maximum Size of Aggregate on Rutting Potential of Stone Mastic Asphalt"
Pak. J. Engg. & Appl. Sci. Vol. 10, Jan., 2012, pg.89-96

[19] Mohammad Pourtahmasb and Mohamed Rehan Karim, "Performance Evaluation of Stone Mastic Asphalt and Hot Mix Asphalt Mixtures Containing Recycled Concrete Aggregate" Hindawi Publishing Corporation Advances in Materials Science and Engineering Volume 2014,ArticleID-863148 http://dx.doi.org/10.1155/2014/863148

[20] EsmaeilAhmadinia, Majid Zargar, Mohamed Rehan Karim, MahrezAbdelaziz, PayamShafigh, "Using waste plastic bottles as additive for stone mastic asphalt"