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Comparison of Volumetric Properties of Stone Matrix Asphalt by Using Different Fillers

D Manikanta[1], Dr. N C Anil[2], P M S Satish Kumar[3], P Sanyasi Naidu[4]

[1]*PG Student,* [2]*Vice Principal,* [3]*Head of the Department,* [4]*Assistant Professor,*
[1243]*Civil Engineering & Sanketika Institute of Technology and Management*

Abstract—Highway construction involves huge investment in men and material. There are many alternatives for improving the stability and efficiency of pavement structure. Asphalt material and mixture are used to improve the durability and performance of pavements. SMA requires stabilizing additives composed of cellulose fibres to prevent drain down of mix. SMA consists of 70-80% of coarse aggregates that interlocks to form a skeleton structure which resists permanent deformation. The main objective of this work is to compare the volumetric properties of SMA at 5-7% of bitumen content by using fillers like stone dust, coconut shell charcoal, concrete dust and coir as a fibre which possesses resistance to crushing, surface moisture, resistance to freezing, light weight, adsorption, synthetic resin glues which is most important for pavement of roads. Therefore its volumetric properties like stability, flow and air voids ratio which are obtained that are compared with properties of different types of fillers. From that we can establish a perfect combination of filler material for SMA, so that it can be useful as a substitute of filler in reducing cost, improving the quality and durability of pavement structure.

Keywords— SMA, Asphalt, Filler, Coconut Shell Charcoal, Coir Fibre

I. INTRODUCTION

A. *General*

Generally, people all over the world uses to depend on several modes of transportation. Especially in our country they are mainly depending upon the road ways, as it has second largest road network throughout the world. Basically there are two types of pavements flexible and rigid. Most of the roads in our country are flexible pavements due to its unique characteristics and the properties that it exhibits like stability, durability, strength. A specific engineering design of flexible pavements may save considerable investments as well as reliable performance of the working of highway pavement can be achieved. The materials that are used are very few in number and less in cost when compared to rigid pavements. There are several methods and designs for construction of flexible pavements based on the type of soil sub grade and the availability of locally constructional materials.

Among them SMA is a type of mix design in which it resists the deformation against loading. It forms a skeleton structure by stone on stone interlock and the voids that are forming are filled up by mastic a combination of bitumen filler and fiber. It can resists the max wheel load of vehicle, skid resistance and rutting action. The present research tries to identify properties involved with fillers and fibres in flexible pavements and to suggest other materials which replaces the present constructional materials and satisfies the desirable properties by that we can reduce the cost of construction.

B. *Pavements*

A highway pavement is a structure consisting of super imposed layers of processed materials above the natural soil sub-grade, whose primary function is to distribute the applied vehicle loads to the sub-grade. The pavements structure should be able to provide surface of acceptable riding quality, adequate skid resistance, favourable light reflecting characteristics and low noise pollution. The ultimate aim is to ensure that the transmitted stresses due to wheel loads are sufficiently reduced, so that they will not exceed wearing capacity of the sub grade. Two types of pavements are generally recognized as servicing this purpose, namely flexible pavements and rigid pavements. This chapter gives an overview of pavement types and layers. unacceptable design of pavements leads to early failure of pavement surfaces and affecting the riding quality. Pavements are generally classified into two categories. i. Rigid Pavements, ii. Flexible Pavements

C. Bituminous Mix Design

Asphaltic/bituminous concrete consists of mixture of aggregate continuously graded from maximum size, typically less than 25mm, through the fine filler that is smaller than 0.075mm. 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 proportional of bitumen, filler, fine aggregate, and course aggregates to produce the mix which is workable, strong, durable, and economical. The object of mix design is to produce a bituminous mix by proposing various components so has to have –

- Required amount of bitumen to ensure a durable pavement.
- Sufficient strength to resist shear deformation under traffic at higher temperature.
- Sufficient air voids is the compacted bitumen to allow for additional compaction by traffic.

- Sufficient workability to permit easy placement without segregation
- Sufficient resistance to avoid premature cracking due to repeated bending by traffic
- Sufficient resistance at low temperature to prevent shrinkage cracks

1. STABILITY

Stability is defined as the resistance to deformation of the pavement structure under traffic load. Stability of a pavement lies in thickness of pavement and the number or layers that it is laid. In flexible pavement we observe four layers that are filled with locally available materials.

2. DURABILITY

Durability is defined as the resistance offered by the pavement structure against weathering and abrasive actions. Weathering causes harden of pavement due to loss of volatiles in the bitumen and the durability of structure depends upon the quality and quantity of materials used.

3. FLEXIBILITY

Flexibility of a pavement is used to quantify the level of bending strength needed to counteract traffic load, retains to its position prevent cracking of surface and Fracture is the crakes form in the surface the main reason of shrinkage and brittleness of the binder. Shrinkage crakes are due to volume change in the binder due to aging brittleness id due to repeated bending of the surface due to traffic loads. Higher bitumen content will give better flexibility and fewer factors.

4. SKID RESISTANCE

It is the resistance of the finished payment against skidding which depends on the surface texture and bitumen content. It is an significant factor in high speed traffic. Normally and open graded coarse surface texture is desirable.

5. WORKABILITY

Workability is the case with which the mix can be laid, compacted and formed to the required condition and shade. This depends on the gradation on the aggregates, shape and texture, bitumen content and its type angular, flaky and elongated aggregates effect workability. On the other hand, rounded aggregates improved workability.

6. DESIRABLE PROPERTIES

The required properties of a bituminous mix can be summarized as follows:

- Stability to meet traffic demand
- Bitumen content to ensure proper binding and water proofing
- Voids to accommodate compaction due to traffic
- Flexibility to meet traffic volume, especially in winter season.
- Sufficient workability for construction

D. Constituents of Bituminous Mix

1. MINERAL AGGREGATES

There are several types of mineral aggregates that can be used in bituminous mixes. The aggregates used to manufacture bituminous mixes can be obtained from different natural sources such as glacial deposits of mines. These are termed as naturally occurring aggregates and can be used with or without further processing. The aggregates can be furtherlly processed and refined to achieve good performance characteristics

2. MINERAL FILLERS

Mineral fillers have a significant impact on the properties of SMA mixes mineral fillers increase the stiffness of the asphalt mortar matrix mineral fillers also helps in reduce the drain down in the mix during constructions, which improve the durability of the mix by maintaining the amount of asphalt initially used in the mix. It also helps in maintaining adequate amount of voids in the mix. Different types of mineral fillers are used in the SMA mixtures such as lime, stone dust, ordinary Portland cement(OPC),slag cement, fly ash, hydrated lime etc...,

3. BITUMEN

Bitumen acts as binding agent to the aggregates, fines and stabilizers in the SMA mixtures. SMA mixes are rich in high asphalt which provides durability to the mix. The characteristics of bitumen which affects the bituminous mixture behaviour are temperature susceptibility, viscous-elasticity and aging. The behaviour of bitumen depends on the temperature as well as on the time of loading. It is stiffer at lower temperature and under shorter loading period bitumen must be treated as viscous-elastic material as it exhibits both viscous as well as elastic properties at the normal pavement temperature. Though at low temperature it behaves like an elastic material and at high temperature it behaves like a viscous fluid

4. STABILIZING ADDITIVES

SMA is a gap graded mix, having maximum size of aggregates due to this voids in the mix increases. Therefore stabilizing additives are used in the mixture to prevent mortar drain down and to provide better binding. Initially SMA was developed using asbestos fibres. Though it was perfect from technical point of view its use was restricted for health reasons. Fibres commonly used now a day are polypropylene, polymer, polyester, mineral and cellulose. The main stabilizing additives used in SMA mixes can be classified into different groups.

- Fibres (cellulose Fibres, mineral fibres, chemical fibres)
- Polymers
- Powder and flour like materials (silica acid, special fillers)
- Plastics (polymer powder or pellets)

E. Stone MATRIX Asphalt:

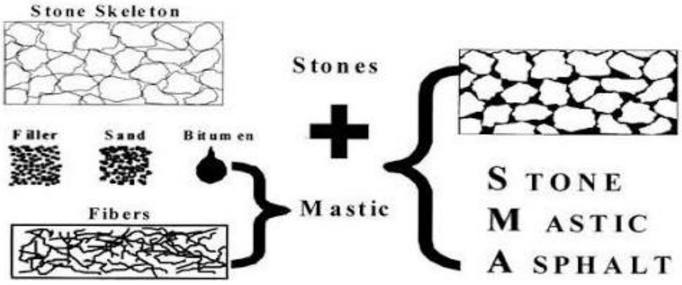


Fig. ***Error! No text of specified style in document.*** *Description of Stone MATRIX Asphalt*

Washington State Department of Transportation (WSDOT, 2000)has mentioned in the tech notes on SMA thus as per National Asphalt Paving Association (NAPA), SMA is a tough, stable, rut resistant of asphaltic mixture that forms aggregate to aggregate contact to provide strength and a rich mortar binder to provide durability.

F. Objective of the Present Study

The main objective of this analysis is

- To identify the optimum binder content (OBC) in case of unmodified mix.
- To identify volumetric properties of specimen using different fillers.
- To identify the Marshall properties.
- To identify the Binder drain down properties.

G. Scope of the Present Study

The scope of the present work involves the determination of various physical properties of the binder, aggregates and fillers used for SMA Mix. Samples are prepared by varying the binder content from 5% to 7.0% i.e., 5%,5.5%, 6.0%, 6.5% and 7.0% respectively to obtain optimum binder content, at the obtained OBC; drain down test was conducted to identify the OSA. At the obtained OSA modified samples using coir as fibre are prepared by varying the binder content from 5% to 7.0% i.e., 5.5%, 6.0% and 7.0% respectively to obtain optimum binder content. These specimens are analysed for density-voids and stability-flow.

II. LITERATURE REVIEW

1. SMA is a gap graded Hot Mixture Asphalt (HMA). It is developed in Germany during the mid-1960"s and it has been used in Europe for more than 30 years. In Europe SMA was first used as a mixture that would resist the wear of studded tires. Later they found the additional benefits of SMA that is durable and highly rut resistant. Because of the success of SMA, five state agencies of US constructed SMA pavement during 1991.
2. **Mohammad Altar Bhat, O.P.Mittal (2016)** researches about the effect of various fillers on bituminous mixes. Bitumen in combination with filler forms MATRIX this MATRIX can be seen as a constituent of mixture of asphalt that holds the aggregates together an important role is played by the fillers with increase in the amount of filler stability of these mixes increase directly.
3. **Sutradhar.D (2015)** in this study an attempt is made to find the effect of types of fillers on the behaviour of bituminous mixes according the properties of bituminous mixes container filler like waste concrete dust and brick dust is studied
4. **Susanta Dung (2014)** in research work, the main objective is to compare the results obtained by using fillers like stone dust, Portland cement, fly ash with coconut shell charcoal the properties that coconut shell charcoal possesses resistance to crushing, absorption, surface moisture, resistance to freezing, light weight synthetic resin which is most important for pavement of roads so that its properties are compared by using different fillers
5. **Salam ridha oleiwi, Sravana.(2013)** he made an attempt has been made to study the effect of aggregate gradations and filler types of properties of SMA four of different aggregates gradations with two types of filler such as hydrated lime and crushed stone dust have been tried for penetrations of mixes first three gradations
6. **Uma Devi R (2012)** examined performance of SMA with fly ash as filler and plastic waste and additive in the range of 2% to10% the optimum plastic content obtained from the result to 8% by weight of fly ash from laboratory test result it saw concluded that utilization of plastic waste increased the in directed tensile strength values also reused the rutting
7. **Bindu C.S(2010)**have conducted the performance test on SMA mixtures on conventional SMA mixtures and as well as SMA mix with waste plastics as an additive in the range of 5% -12% with an increment of 1% in SMA mix with a plastics that additions 10% waste plastics content result is improved stability split tensile strength and compressive strength it was also noticed that addition 10% waste plastic content also resultingdecrease in angle of shear resistance and drain down values compared to conventional mix
8. **Kumar(2007)** used 60/70 penetration grade bitumen and crumb rubber modified binder –CRMB without any stabilization additives to study the performance and result on SMA mixes they conclude that the use of CRMB without fibres in SMA mixes as a performance similarly to or better than the conventional SMA
9. **Mustfa Karashani et. Al. (2006)** used waste marble dust obtained from shaping process marble blocks and lime stone as filler and optimum binder content was determined by marshal test and showed good result
10. **Karasahin and teriz (2004)**conductedaninvestigation on marble waste as filler material in asphalt mixture samples were prepared having marble dust and lime stone dust filler. The optimum binder continent was then

detrained by Marshall test produced they have also carried out dynamic plastic deformation tests and both mixes using marble waste and lime stone dust however some care should be taken into an account for mixes with marble dust since they have higher values of plastics performances and hence, they should be used on low volume roads

III. MATERIALS AND METHODOLOGY

This chapter describes the materials used in preparation of SMA mixes using stone dust, coconut shell charcoal and concrete dust as a fillers by using coir fibre as stabilizer additives. An attempt is made to compare the Marshall properties for individual filler. The normal aggregate size is 13mm and the nominal layer thickness is 40-50mm. for the preparation and testing Marshall specimens the adopted gradation is IRC: SP:79-2008.

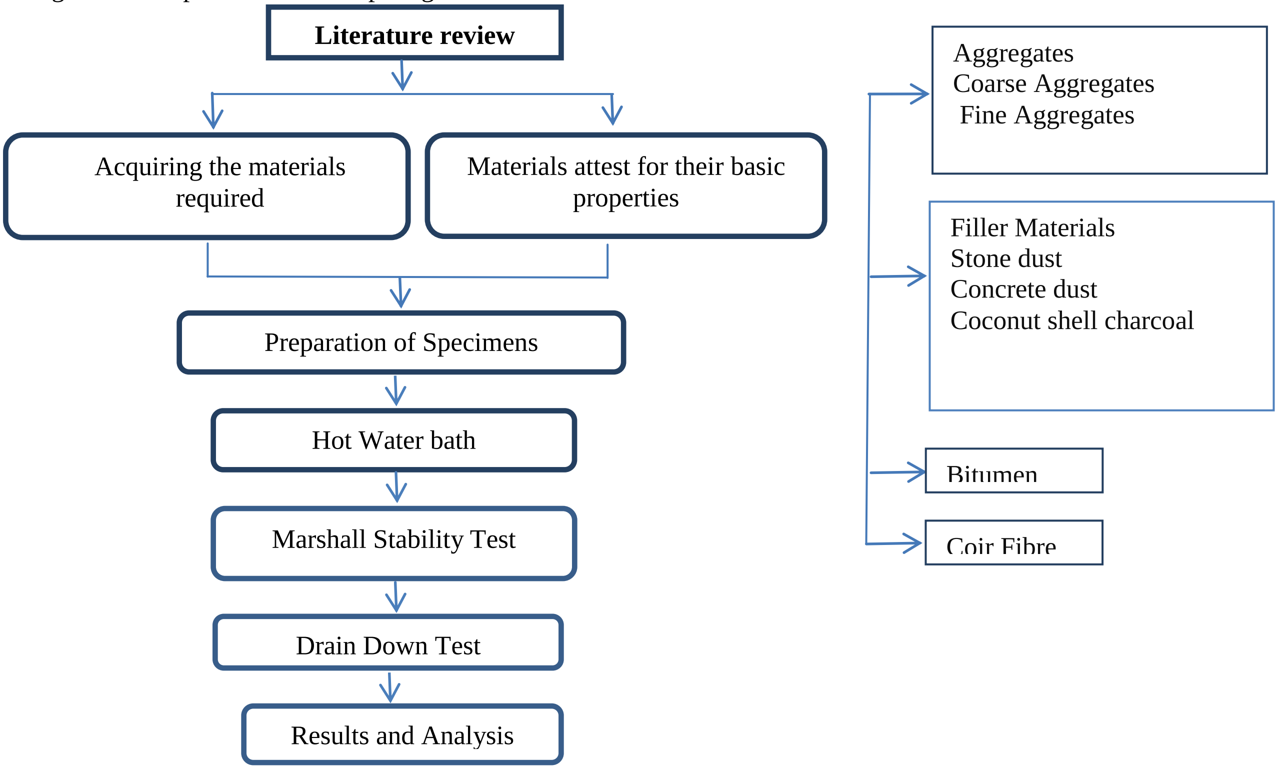


TABLE 1
TEST RESULTS OF AGGREGATES

S.No	Experiment	Test Method	Test Result	Morth Specification Limit
1	Abrasion value	IS:2386 Part 4	24.4%	Max 40%
2	Impact value	IS:2386 Part 4	13.21%	Max 24%
3	Crushing value	IS:2386 Part 3	16.31%	Max 30%
4	Specific gravity Coarse aggregate	IS:2386 Part 4	2.65	2.5-3.5
5	Specific gravity Fine aggregate	IS:2386 Part 4	2.50	2.5-3.0
6	Water absorption	IS:2386 Part 3	0.6%	Max 2%
7	Flakiness Index	IS:2386 Part 1	19.5%	Max 13%
8	Elongation Index	IS:2386 Part 1	13.2%	Max 15%

A. *Fillers*:

Fillers are micro particles which are finely divided and passed through 0.075mm sieve. In general lime is used as a filler known as anticipating agent. As the function of a filler is to reduces the gaps i.e. voids so that the compaction between coarse and fine aggregate increases the stability

TABLE 2
GRADING REQUIREMENTS OF MINERAL FILLER (IRC:SP: 79-2008)

IS Sieve (mm)	Cumulative % passing by weight of Total aggregate
0.6	100
0.3	95-100
0.075	85-100

B. *Stone Dust*

Stone dust also known as quarry dust, quarry screening, and decomposed granite, is one of the most commonly used stone by products. It has potential to be used in both flexible and rigid pavements as partial replacement of natural river sand in rigid pavement and as a mineral filler to fill the void gaps in rigid pavement.

C. Coconut Shell Charcoal

Coconut shell is an important raw material and is widely used for making charcoal in the world, particularly in developing countries like India, Malaysia etc..; In turn coconut shell charcoal can be used in many fields by the reason of its advantages and important features. However an experimental process has done by using coconut shell charcoal as filler in SMA as they contribute a considerable amount of carbon dioxide (CO2) to the atmosphere due to the use of coconut shell charcoal it binds the aggregate together.

D. *Concrete Dust*

When aggregates are mixed with dry Portland cement in the presence of water a hard solid substance is formed which is named as concrete. Concrete blocks from laboratories after testing are collected and smashed by using hammer, so that it separates and decreases its size and by sieving process the coarse aggregates are separated and the fine aggregates are ground to fine dust particles so that it can able to pass through 75microns size sieve. The powder that obtained is named as concrete dust.

E. *Tests on fillers*

TABLE 3
SPECIFIC GRAVITY AND WATER ABSORPTION TESTS

S.no	FILLER NAME	SPECIFIC GRAVITY	WATER ABSORPTION (%)
1	STONE DUST	2.7	1.43
2	CONCRETE DUST	2.5	1.23
3	COCONUT SHELL CHARCOAL	2.05	1.21

F. *Bitumen*:

A black viscous mixture of hydrocarbons obtained naturally or as a residue from petroleum distillation. It is of two types namely Tar and Bitumen depending upon the production. Asphalt is another type of bitumen which is a sticky, black and highly viscous liquid or semi-solid form of petroleum. The terms asphalt and bitumen are often used to mean both natural and manufactured forms of substance. The function of bitumen in SMA is to combine with mineral filler and fill the void space.

TABLE 4
TEST RESULTS OF BITUMEN

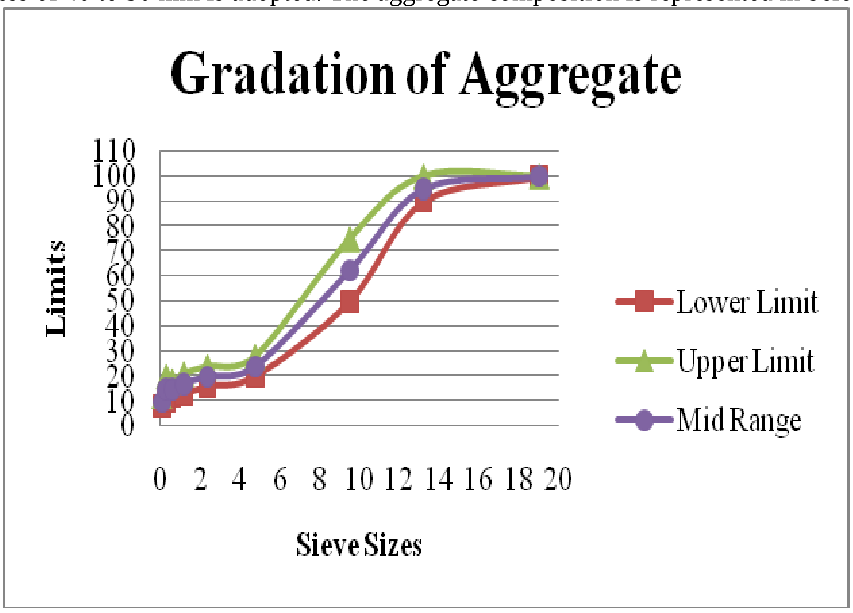
S.NO	EXPERIMENT	TEST METHOD	TEST RESULT	MORTH SPECIFICATION LIMIT
1	Penetration value	IS:1203	65	65-70
2	Ductility	IS:1208	78	>75
3	Softening point	IS:1205	48.65	40°C-55°C
4	Viscosity	IS:1206	500	Mini 300CST
5	Specific gravity	IS:1202	1.03	0.99 min

G. *Coir Fibre:*

Coir fibre is a natural fibre derived from the mesocarp tissue or husk to the coconut fruit. Brown coir fibres are stronger as they contain more lignin than cellulose, but they are less flexible. Coconut fibres are relatively water proof and the decomposition of these fibres are less when compare to the other fibres due to high lignin content.

H. *Stone Matrix Asphalt Gradation*

In the present investigation SMA samples are to be prepared by using 60/70 grade bitumen with filler replacement and addition of stabilizer additives were prepared and compared the properties. The wearing course with nominal layer thickness of 40 to 50 mm is adopted. The aggregate composition is represented in below table.



Graph 1. Gradation of Aggregate

TABLE 5
AGGREGATE GRADATION

SMA Designation	**13mm SMA**	
Course where used	Wearing course	
Nominal aggregate size	13 mm	
Layer thickness	40-50 mm	
Sieve Size (mm)	**Passing Weight by Percentage** (Specified range)	**Passing Weight by Percentage** (Adopted)
19	100	100
13.2	90-100	95
9.5	50-75	62.5
4.75	20-28	24
2.36	16-24	20
1.18	13-21	17
0.600	12-18	15
0.300	10-20	15
0.075	8-12	10

TABLE 6
CALCULATION OF QUANTITY OF AGGREGATES FOR PREPARING SPECIMENS

Sieve size (mm)	**% passing**		**% Retained**	**Material**	**Amount of aggregates taken in the preparation of moulds**				
	Range	**Mid-range**			1200	1200	1200	1200	1200
19	100	100	0	**Coarse aggregate**	0	0	0	0	0
13.2	90-100	95	5		60	60	60	60	60
9.5	50-75	62.5	32.5		380	380	380	380	380
4.75	20-28	24	38.5		462	462	462	462	462
2.36	16-24	20	4	**Fine aggregate**	48	48	48	48	48
1.18	13-21	17	3		36	36	36	36	36
600	12-18	15	2		24	24	24	24	24
300	10-20	15	0		0	0	0	0	0
75	8-12	10	5		60	60	60	60	60
Pan			10	**Filler**	120	120	120	120	120
Bitumen					5%	5.5%	6%	6.5%	7%
Fibre					0.3%	0.3%	0.3%	0.3%	0.3%
Bitumen in grams					60	66	72	78	84
Total weight of ingredients					1260	1266	1272	1278	1284

I. *Marshall Stability Test*

Stability of a specimen is depends upon the maximum load that it is bearing against deformation. Experimentally SMA is a gap graded which can resist the deformation of structure by it interlocking skeleton structure of aggregates. With increase in percent of bitumen stability increases up to a level and then decreases.

1. FLOW**:**

Flow value increases with increases in bitumen content. It is the vertical deformation maximum load acting on the specimen to produce failure. But the flow is gradually decreases when we add natural fibres which reduce the drain down parentage of mixture.

2. AIR VOIDS

Interlocking skeleton structure of gap graded aggregates form air voids which reduce the strength or structure those void spaces are filled with MATRIX mixture filler and bitumen and increases its durability and strength by increasing the percentage of bitumen voids decreases maximum percentage of bitumen leads to bleeding.

TABLE 7
REQUIRED PROPERTIES OF SMA

Design requirements of the mix:	
Marshall stability value, kg	820 kg.(min)
Flow value mm	2-4 mm
Air Voids in total mix Va %	3-5 %
Voids in mineral aggregates (VMA), %	>12 %
Voids filled with Bitumen (VFB), %	65-75 %

3. DRAIN DOWN TEST:

This test procedure determines the amount of drain down in an uncompacted asphalt mixture. When the sample is placed in oven at required temperatures comparable to those encountered during the production storage, transport and placement of the mixture. The test is particularly applicable to mixtures such as Open graded courses and Stone MATRIX Asphalt its value doesn't exceeds more than 0.3% by weight of mix

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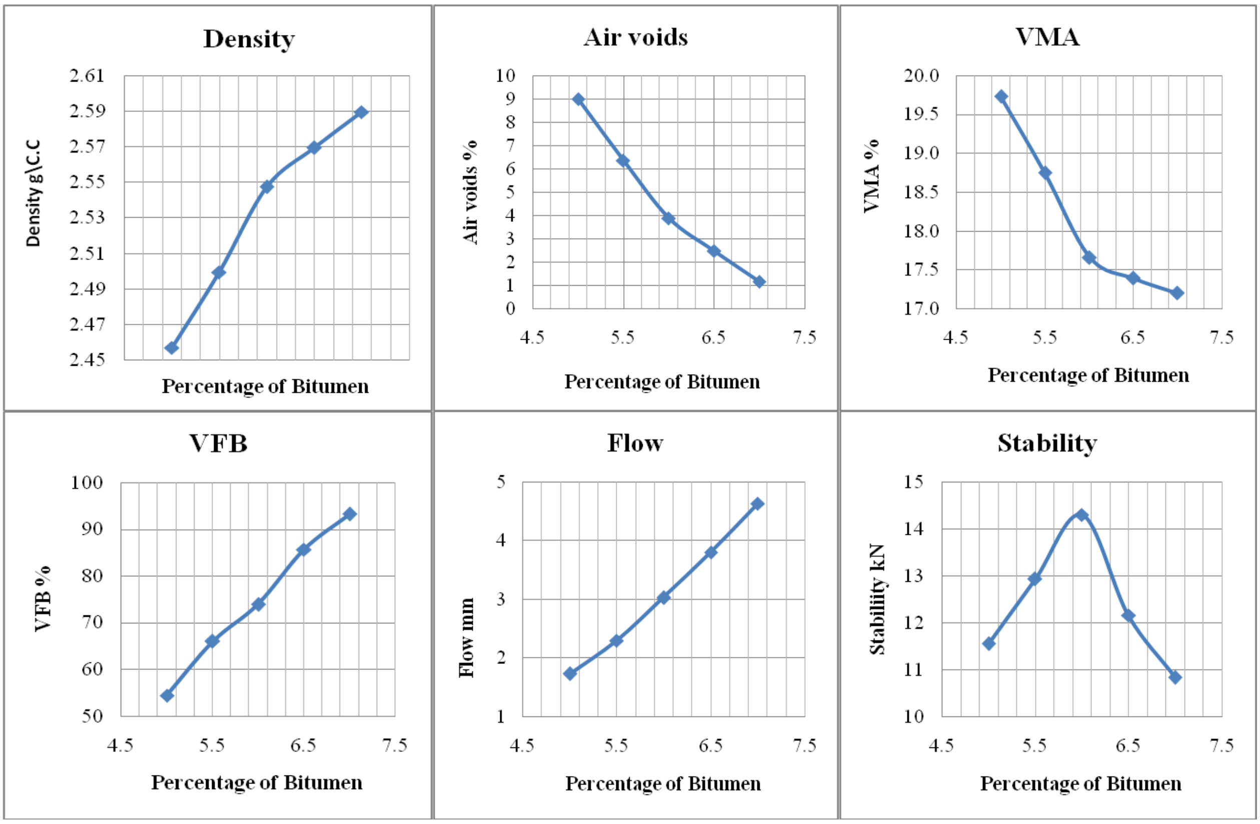
IV. RESULTS AND DISCUSSIONS

TABLE 8
VOLUMETRIC PROPERTIES OF SMA BY USING STONE DUST AS FILLER

		WEIGHT OF SPECIMEN												**Stability**		**Marshall Quotient**
S. No	**Asphalt Content**	**In Air**	**In Water**	**SSD in Air**	**Volume** e-d	**Gmb** c/f	**Gmm**	**VMA**	**Air Void**	**VFB**	**Flow**	**Dial Reading**	**Correction Factor**	**Measured**	**Corrected**	
A	B	C	D	E	F	G	H	I	J	k	L	m	N	o	p	q
1	5%	1236	733	1237.5	504.5	2.450					1.60	180	1.00	10.94	10.94	
2	5%	1236	736	1237	501	2.467					1.80	200	1.00	12.16	12.16	
3	5%	1237	735	1239	504	2.454					1.90	190	1.00	11.55	11.55	
					Avg	**2.457**	**2.700**	**19.73**	**9.00**	**54.38**	**1.73**			**11.55**	**11.55**	**6.67**
1	5.50%	1242	745	1244	499	2.489					2.20	190	1.00	11.55	11.55	
2	5.50%	1244	748	1246	498	2.498					2.30	200	1.00	12.16	12.16	
3	5.50%	1237	746	1238.5	492.5	2.512					2.40	230	1.04	14.5	15.08	
					Avg	**2.500**	**2.670**	**18.75**	**6.37**	**66.02**	**2.30**			**12.7**	**12.93**	**5.621**
1	6%	1251.5	761	1251.5	490.5	2.551					2.90	230	1.00	13.9	13.9	
2	6%	1251	762	1252.5	490.5	2.550					3.10	260	1.00	15.8	15.8	
3	6%	1255	764	1258	494	2.540					3.10	220	1.00	13.3	13.3	
					Avg	**2.547**	**2.650**	**17.66**	**3.88**	**73.93**	**3.03**			**14.3**	**14.3**	**4.71**
1	6.50%	1255	766	1256	490	2.561					4.00	200	1.00	12.16	12.16	
2	6.50%	1257	769	1257	488	2.576					3.90	190	1.00	11.55	11.55	
3	6.50%	1261	771	1261.5	490.5	2.571					3.80	210	1.00	12.77	12.77	
					Avg	**2.569**	**2.635**	**17.39**	**2.49**	**85.68**	**3.80**			**12.16**	**12.16**	**3.2**
1	7%	1262	774	1262	488	2.586					4.50	190	1.00	11.55	11.55	
2	7%	1260.5	773	1260.5	487.5	2.586					4.60	180	1.00	10.94	10.94	
3	7%	1262	776	1262	486	2.597					4.80	165	1.00	10.03	10.03	
					Avg	**2.589**	**2.610**	**17.20**	**1.17**	**93.19**	**4.63**			**10.84**	**10.84**	**2.34**
		Specification Limit						**>12 %**	**3-5%**	**65-75%**	**2-4mm**			**>9KN**		**2-5**

TABLE 9
AVERAGE VOLUMETRIC PROPERTIES OF SMA BY USING STONE DUST AS A FILLER

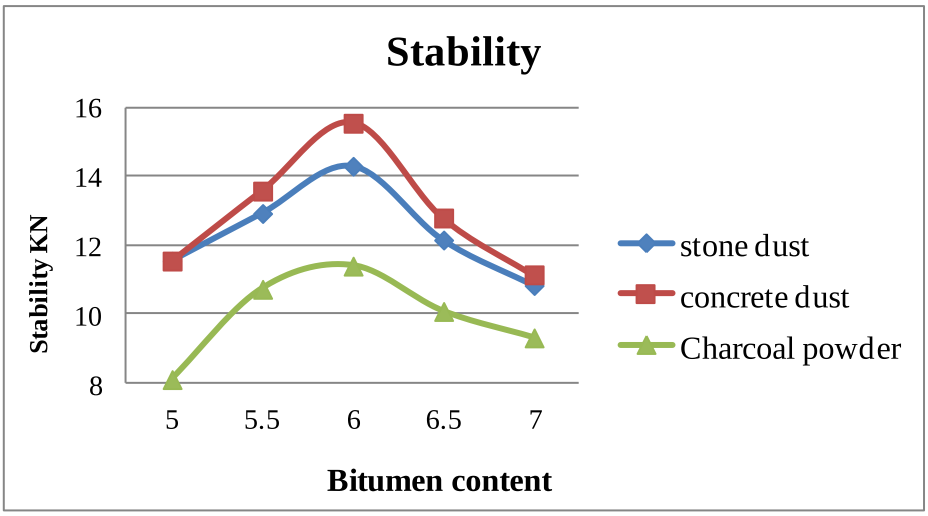
Bitumen (%)	Density (g/c.c)	Air voids (%)	VMA (%)	VFB (%)	Stability (kN)	Flow (mm)
5	2.457	9.00	19.73	54.38	11.55	1.73
5.5	2.500	6.37	18.75	66.02	12.93	2.30
6	2.547	3.88	17.66	73.93	14.3	3.03
6.5	2.569	2.49	17.39	85.68	12.16	3.80
7	2.589	1.17	17.20	93.19	10.84	4.63



Graph 2. Average Volumetric properties of SMA by using Stone Dust as a Filler

Same, We can also discuss about Volumetric properties of SMA By using Concrete dust & coconut shell charcoal as Filler Tabular form, Average Volumetric properties of SMA by using Concrete Dust & coconut shell charcoal as Filler, graphs of Average Volumetric properties of SMA by using Concrete Dust & coconut shell charcoal as Filler and discussions.

Comparision of volumetric properties for Different fillers



Graph 3. Comparison of Stability for different fillers

TABLE 10
COMPARISON OF STABILITY TEST RESULTS FOR DIFFERENT FILLERS

% Bitumen	STABILITY (kN)		
	Stone dust	Concrete dust	Charcoal powder
5	11.55	11.55	8.11
5.5	12.93	13.58	10.73
6	14.3	15.55	11.403
6.5	12.16	12.8	10.087
7	10.84	11.15	9.32

By comparing the stability values of these three curves, maximum stability obtained is 15kN for concrete dust at 6% of bitumen increase of stone dust it is 14kN and the max stability value obtained for coconut shell charcoal is 14kN. These values that are obtained for these fillers are within the standard specifications limits so they can be recommended for using as filler in stone MATRIX asphalt mix for pavement of roads.

Every individual filler is unique to fulfil its characteristics, as the concrete dust attains maximum stability because of a mixture of fine sand, stone dust and concrete powder but when compare to that values coconut shell charcoal doesn’t attain that much of stability but it have properties like resistance to crushing, absorption, light weight and synthetic resin glues which is most important for pavement of roads and for the durability of structure. Same we can also observe Flow, Air voids, VMA, VFB and Density Graphs & Tables for different fillers

DISCUSSIONS:

From the above results we noticed that with increase in binder content ranges from 5-7% . the stability attains maximum value at 6% i..e, 14.03 KN as the bitumen percentage increases the stability value decreases. So the optimum bitumen content is achieved at 6% by using Stone Dust as a filler.

It is clear that by increasing in the percentage of bitumen content Flow increases, flow value obtained at OBC is 3.03. as the coir fibre we are using helps in bind them together so that no bleeding can occur.

With increase in bitumen content formation of Air voids decreases so that it can able to accumulate maximum binder and filler content into the void spaces and helps in maintaining durability and stability of structure.

Here VMA (volume filled with mineral aggregates) value gradually increases with increasing in bitumen content as the bitumen percentage increases VMA value decreases.

By increaing in bitumen content percentage the VFB(volume filled with bitumen) increases.

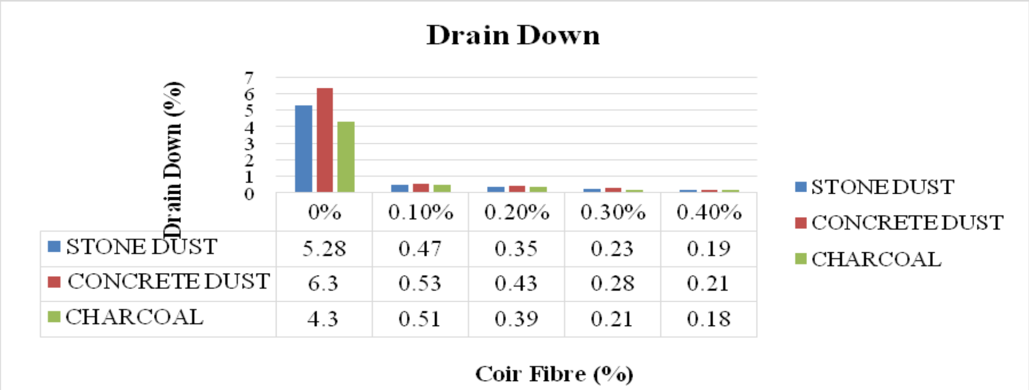
Influence of Natural fibre in SMA

Drain down Test for Optimum Fibre Content

The Drain down test was performed using the basket drainage test as per ASTM D 6390 (2005) for the obtained gradation mix with 6% bitumen content. It is conducted at a temperature of 1600c with fibre percentage starting from 0.1 to 0.4% and without fibre.

TABLE 11
DRAIN DOWN VALUES OF COIR FIBRE FOR DIFFERENT FILLERS

COIR FIBRE (%)	0%	0.1%	0.2%	0.3%	0.4%
STONE DUST	5.28	0.47	0.35	0.23	0.19
CONCRETE DUST	6.3	0.53	0.43	0.28	0.21
COCONUT SHELL CHARCOAL	4.3	0.51	0.39	0.21	0.18



*Graph **Error! No text of specified style in document.** Comparison of Drain down values of coir fibre for different fillers*

It is found that at 0.3% for both the filler materials has the optimum stabilizer additive content. The Drain down values obtained for the coir fibre by using concrete dust and coconut shell charcoal as a filler are 0.21 and 0.23 respectively. Hence it satisfies the Drain down should be less than 0.3 as per IRC: SP: 79-2008.

The Bar chart represents the drain down of SMA Mix with fibre fraction as the percentage of fibre increases leads to the decrease in drain down values. The reason may be attributed as due to the presence of fibres reduces the void space in bitumen mix, interlocking of fibre and aggregate helps in attaining the maximum stability. As the fibre percentage increases results in decrease of drain down. The value ranges from 0% of coir fibre to 0.4% and at last we can conclude that with increase in fibre percentage drain down decreases. The obtained drain down values for coir fibre when stone dust, concrete dust and coconut shell charcoal using as a filler is 0.23, 0.28 and 0.21 which are under specified limits. (AASTHO T305) not exceed 0.3% by total weight of mix.

V. CONCLUSIONS

A. *MARSHALL STABILITY:*

By using different bitumen content ranges from 5% to 7%, the optimum stability of the SMA Mix is found out. It is observed from the graph that the stability value increases with increase in bitumen content and then decreases gradually which helps us to find out the performance of different fillers like concrete dust and coconut shell charcoal.

- The maximum stability value obtained is 15kN by using coconut shell charcoal as a filler at optimum binder content of 6%.secondary by stone dust at 14 kN.
- Using Coconut Shell charcoal as a filler, an average stability is obtained which is 11KN. it doesn't attain stability values as much as other fillers but satisfies the Marshall mix design requirements and helps in durability of structure by possessing resistance to crushing, surface moisture, light weight and synthetic resin glues.

B. *FLOW:*

Generally, with increase in bitumen content, the flow value increases for different types of fillers.

- The flow value increases with increase in bitumen percentage as the maximum increase in flow value shown by Coconut Shell charcoal as filler.
- The flow value is least in case of stone dust as filler.
- From the graph it is found that flow value increases very slowly at first with increase in bitumen content and it increases rapidly as the percentage of bitumen increases, but the sample mould loses its uniformity, strength and also stability as a result deformation increases when load is applied on the sample specimen.

C. *AIR Voids:*

Theoretically we know that the voids that are present between the aggregate due to irregular shape decreases the strength of the mix. To avoid this, bitumen is added with fillers and stabilizers, so voids get filled up and also it acts as a sticky material. Moreover the aggregates are closely packed among themselves. Hence with increase in bitumen content there is a decrease in percentage of air voids.

- From the above graphs, it is observed that the VA decreases very slowly initially but with increase in bitumen content , the VA decreases very quickly
- The maximum decrease in the VA is obtained when stone dust and coconut shell charcoal is used as filler.
- The amount of decrease in air voids is steady in case of concrete dust as filler.

At last we concluded that by comparing the volumetric properties of SMA by using different fillers Concrete dust and Coconut Shell charcoal can be used as a substitute for the stone dust as filler in SMA. Over all the fillers Concrete dust which is available free of cost attains maximum stability of 15 KN as Coconut shell charcoal doesn't attain as much as other fillers but satisfies the specifications of SMA.

D. *Drain Down Test:*

In case of coir fibre using as a natural cellulose fibre the minimum drain down values are obtained at 0.3 % of fibre content and which holds the bitumen not to drain from the mixture at the time of transportation.

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