THE EFFECT OF BAMBOO FIBER ON THE PERFORMANCE OF STONE MATRIX ASPHALT USING SLAG AS AGGREGATE REPLACEMENT

By

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UNDER THE GUIDANCE

Of

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CERTIFICATE

This is to certify that the report on "**THE EFFECT OF BAMBOO FIBER ON THE PERFORMANCE OF STONE MATRIX ASPHALT USING SLAG AS AGGREGATE REPLACEMENT"** submitted by DURYODHAN MUNDA,109CE0051 in partial fulfilment for the Degree of Bachelor of Technology in Civil Engineering, NIT Rourkela is an authentic work carried out by him under my guidance and supervision.

To the best of my knowledge, the matters enclosed in this thesis have not been submitted to any other university or Institute for the award of any Degree or any Diploma.

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ABSTRACT

Stone matrix asphalt , was first of all developed in 1960 in Germany which now largely helps in providing a greater permanent deformation resistance, durability to surfacing materials, longer service life, improved ageing ,high resistance in cracking, fatigue, wear, better skid resistance and like in reducing noise. It is a gap graded mixture of aggregates which helps by maximising the asphalt-cement content and fractions of coarse aggregate . It is a stable, rut-resistant mixture and tough which relies on aggregate-aggregate contact for providing strength . Along with rich mortar binder it provides better durability. The SMA sample is prepared by mixing coarse aggregate, fine aggregate , filler as per the gradation chart given by the standard code when using stabilizer and without stabilizers.

. A fibre that is readily available in nature. less cost effective comparing to other non-conventional fibres has been used as stabilizer. It is Bamboo fibre, which is cellulose fibre extracted from naturally available Bamboo stem. It has high strength in fibre direction, greater tensile, flexural and impact strength. Thinness degree of fibre can easily be obtained from it. It is durable in nature, possesses tenacity and good stability value. An attempt has been made to find out its suitability in increasing the stability and flow value in the mixture of Stone Matrix Asphalt Mixes.

For this project, we have prepared SMA mixes using stone as coarse aggregate, slag in partial replacement of coarse aggregate and used different stabilizers and have tried to compare the results at a varying bitumen content of 4,5,5.5,6,7 % bitumen. The stabilizers were used at an optimum of 0.3% of the weight of sample.

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LIST OF ABBREVIATIONS

SMA: Stone Matrix Asphalt

OBC: Optimum Binder Content

VA: Air Voids

VMA: Voids in Mineral Aggregate

BVS: Bulk Volume Sample

VFB: Voids filled with Bitumen

Gmb: Bulk Specific Gravity of the Mix

Gsb : Bulk Specific Gravity of the Aggregate

Gse: Effective Specific Gravity

Gmm: Specific Gravity of the Mix

Ga: Apparent Specific Gravity

Gb: Specific Gravity of Bitumen

Mb: Mass of the Bitumen Used

Magg: Mass of the Aggregate

Mmix: Mass of the Bituminous Mix

Vagg: Volume of Aggregate

Ps: Percentage of the Aggregate present

CHAPTER 1

INTRODUCTION

1.1.GENERAL

In the designing of Road Pavement, Flexible Pavement Designing is preferred always over all other rigid pavements. It is mainly due to the better load carrying capacity, durability, resistance to tear and wear, greater strength to perform well during heavy loads. This Properties of the road is mainly achieved due to its surface bituminous pavement. It is the surface coating over the Stone Matrix Asphalt which is the gap graded mixture provides strength by stone to stone contact. And this properties of the SMA is determined initially in the laboratory testing so as to provide maximum stability, better flow value using Optimum binder Content.

Stone Matrix Asphalt basically consists of coarse aggregate of about 70-80% of total aggregate, binder is taken 4-7% , filler 8-12% and fibre as stabilizer between 0.3 to 0.5%. Coarse aggregate in the mixture provides stone-stone contact to resist rutting, filler helps in filling the voids between aggregate to prevent tearing and wearing, binder helps in binding all the materials together. Fibre provided act as stabilizer to increase the stability binding the mixture during high temperature and prevents drainage during production, laying and transportation.

1.2. CONVENTIONAL BITUMINOUS MIXES

The Bituminous Mixes which were been practiced in early days before SMA mix. It was not that as effective compared to Stone Matrix Asphalt (SMA) for which it is now completely overshadowed by the use of SMA. SMA evolved as better with respect to all. SMA provides better rutting resistance, resist high deformation in high temperature region, greater resistance to fatigue, increased durability. SMA has reduced sensitivity and resistance to moisture, resists crack at low temperature. It has shown better resistance in plastic deformation than that of conventional Bituminous Mixes. In view of all these SMA has been proven better compared to the conventional Bituminous Mixes to work on and pay more and more interest on.

1.3.OBJECTIVE

- To determine the Optimum Binder Content (OBC) for every SMA mix taking various readings with different %age of Bitumen content.
- To find out the stability, flow value, VA and VMA of SMA mix using bamboo fibre using stone aggregate and slag aggregate as coarse aggregate .
- To compare the results of different SMA mix without fibre and with different fibre as stabilizer.
- To obtain the suitability of Bamboo fibre over other conventional fibres as stabilizer in SMA mix over all other SMA mixes.

1.4.SCOPE OF THE WORK

In this work two different types of coarse aggregate are used which are Stone aggregate and Slag Aggregate keeping the stone aggregate as fine aggregate, Bitumen grade of 60-70 has been used throughout the study as Binder. And two types of stabilizer is used ,those of one fibre naturally available Bamboo Fibre whose results has been compared with SMA results without fibre for both the Coarse Aggregate and with the Topcel Cellulose as Stabilizer in Stone as coarse aggregate.

1.5. THESIS LAYOUT

The Project work is organized as:

- An introductory part describing the statement and then the objectives of the work. The scope of this work is properly stated in here this chapter and in the thesis layout also.
- Literature Review in the beginning extensively with introduction and brief summary comprises various study in SMA with different fibre and bitumen composition .
- It comprises of the method of sample preparation considering all required materials and apparatus for the Specimen preparation.
- Experimental Results obtained from the test conducted and its analysis for all the different tests separately. And by individual graphs plotted below for each result.
- Different graphical comparison to check and compare the suitability of all the specimen tested.
- Conclusions drawn from different analysis and comparison of the graphs.
- References which has been very useful throughout, for the completion for the research work.

CHAPTER 2

LITERATURE SURVEY

2.1.INTRODUCTION

There has always been many works going on at a time and many already finished up which cannot be noticed unless proper survey on the topic is carried out. It is one of the most important part to start with during the project works, researches or any innovative doing to at least have the basic knowledge on the topic of interest. It gives the knowledge of previous works, results of it so as to encourage on the topic. Here in this topic the survey works is mainly carried on the Stone Matrix Asphalt, mix preparation, properties, materials and its use. And the fibre which I introduced to work on Bamboo Fibre which helped in finding various properties, characteristics from the earlier studies on the topic.

2.2. STONE MATRIX ASPHALT

After the development of Stone Matrix Asphalt by **ZICHNER ,1960** STRAUBAG-BAU, AG central laboratory, Germany , it widely extended to Europe, US in very short time duration due to its characteristics like rutting resistance, durability, longer service life, better resistance to fatigue, cracking and wear, skid resistance. Later on many research works on it has been done to enhance the quality and strength of SMA among which **By E. Ray Brown, L. A. Cooley, 1997** evaluated various properties by using three major stabilizing additive. Those are by cellulose fibre, polymers and mineral fibre. It was **FREDERICK T. WALLENBERGER, 2002** who worked on finding out various properties of wood and natural fibre in polymer reinforcement. **SHAMIM ZAFAR**, **2005** a material specialist from NESPAK looked into possible utilization of penetration grade asphalt binder in SMA for heavy traffic roads and highways, studying various pavement failure. Again **L. Allen Cooley Jr., Graham C. Hurley, 2004** evaluated potentials of using SMA in MISSISIPPI, which designed successfully for rut resistant based on the laboratory tests and analyses. In recent past **KRZYSZTOF BAZEJOVSKI, 2010** has provided detailing of the material mixes of aggregates, filler, binder and stabilizers which has been used in practical examples.

2.3. STABILIZERS

Bamboo Fibre is introduced in here which is naturally obtained fibre , readily available in nature. It is less cost effective comparing to other conventional fibres. According to the study on mechanical behaviour of Bamboo and it's composite by **SEEMA JAIN, U.C.JINDAL AND RAKESH KUMAR,1992** it has high strength in fibre direction, greater tensile, flexural and impact strength. As per the study on properties of Bamboo fibre **BY DR. SUBRAT DAS, 2002** he has found that it has got good stability, durability and thinness degree of fibre which can be helpful as stabiliser in SMA mix. According to the test result provided on the data sheet after testing Topcel Cellulose has been interpreted in binding of SMA as high resistance base course.

CHAPTER 3

SMA METHODOLOGY

3.1. INTRODUCTION

Stone Matrix asphalt which is a gap graded mixture widely varies in its result according to the varying methods, procedures, apparatus and Materials to be used for the Mix preparation and so the result also is valid only to the particular region and conditions . In this topic it mainly includes the selection of material types which includes Coarse and Fine Aggregate, Filler, Binder and Stabilizer. Here two types of Coarse Aggregates are taken i.e Stone aggregate and Slag aggregate. Binder is Bitumen of grade 60-70 as it is the binder required and mostly preferred by the engineers due to its atmospheric condition of India. Bamboo fibre and Topcel Cellulose are used as stabilizer to check their varying results.

3.2.ESSENTIAL REQUIREMENTS

3.2.1.Materials used:

Materials Used for the SMA mix for the sample preparation and testing to obtain and compare the project work are mainly coarse aggregate, fine aggregate, filler and stabilizer. Coarse aggregate are taken here of two different types i.e Stone aggregate and Slag aggregate which is steel slag. Fine aggregate for the all the case is taken as stone dust. And Stabilizer taken are Bamboo fibre and Topcel Cellulose. The binder used is the Bitumen of grade 60-70 as it's the grade which is most favourable in Indian Condition.

Properties of the materials used are as given below:

Table1.

1.Physical properties of the Stone Aggregates

Test description	Coarse aggregates	Fine aggregates	Standard values
Combined flakiness & elongation index (%)	28	-	< 30
Specific gravity	2.76	2.64	2.6-2.9
Los Angeles abrasion value (%)	27	-	< 30
Impact value (%)	21.4	-	< 18
Aggregate Crushing value (%)	27	-	<30
Angularity number	10	-	0-11

Table2.

2. Physical properties of the Slag Aggregates

Properties of Slag Aggregates			
Properties	Value		
	Limestone	Iron slag	Steel slag
Coarse aggregate			
Bulk sp. gr. (gr/ cm3)	2.65	3.44	3.51
Apparent sp. gr. (gr/ cm3)	2.69	3.63	3.74
Water absorption (%)	0.7	1.7	1.6
L.A. abrasion (%)	25.4	20.7	19.5
Soundness<comma> Na2SO4 (%)	4.5	3.2	2.4
Fine Aggregates			
Bulk sp. gr. (gr/ cm3)	2.43	2.91	2.98
Apparent sp. gr. (gr/ cm3)	2.77	3.68	3.86
Plasticity index	Non-plastic	Non-plastic	Non-plastic

Table3.

3.Physical properties of Bitumen

Test description	Results	Standard values
Penetration at 25oC (1/10 mm)	65	50 to 89
Softening point oC	65.2	>48 oC
Ductility, cm	> 90	>50
Specific gravity	1.025	-

3.2.2.Apparatus Requirement

As per the code IRC:SP-79, the gradation of the materials are required. Hence the IS Sieve size of the same is required for the gradation which is done by sieving. After the Sieving is done, the sample is heated up to 155°C -160°C for which Oven is required. Then the sample is mixed in the sample mixing apparatus adding Bitumen as binder. The Moulds are needed where the casting is done using the hammer of specific weight and fixed falling. Then before testing hot water bath is used for water bath of the sample at 60°C for 30 minutes. Finally Marshall Testing Apparatus, where the testing is done and stability and flow value readings are taken.

Table4.

1.IRC:SP-79 gradation chart for 13mm Mix

IS Sieve	Cumulative %	Mean	% retained
26.5	-	-	-
19	100	100	0
13.2	90-100	95	5
9.5	50-75	67.5	32.5
4.75	20-28	24	38.5
2.36	16-24	70	4
1.18	13-21	17	3
0.6	12-18	15	2
0.3	10-20	15	3
0.75	8-12	10	2

Fig1. **1. Moulds**

Fig.2 **2. Hammer**

Fig3. **3. Water Bath**

Fig.4 **4. Marshall Testing Machine**

3.3.PREPARATION OF TEST SPECIMEN

3.3.1.Material Selection

In the SMA mix Bitumen is highly preferred by the engineers than other binders. It is due to the properties of Bitumen like Water proof, Durable, Resistant to strong acid and Good cementing properties. For the stabilizing material Bamboo fibre and Topcel cellulose whose suitability is to be determined in the terms of stability and flow value has been taken. Bamboo fibre has been considered mainly for the reasons like it's strong durability, good stability, degree of fineness is very thin, Tenacity and it's easy readily availability and less cost effective comparing to other conventional fibres available naturally.

Fig5. **1. Bamboo fibre**

Fig6. **2. Topcel Cellulose**

3.3.2. Aggregate gradation for 4,5,5.5,6 &7% with and without fibre as per IRC:SP-79

Table5.

Table **5**. gradation table for sample with fibre

Sieve size (mm)	%age retained	4%	4.50%	5.00%	5.50%	6.00%	7.00%
		0%	0%	0%	0%	0%	0%
		1148.4	1142.4	1136.4	1130.4	1124.4	1112.4
13.2	5%	57.42	57.12	56.82	56.62	56.22	55.62
9.5	33%	378.972	376.992	375.012	373.032	371.052	376.092
4.75	29.5%	338.778	337.008	335.238	333.468	331.698	328.158
2.36	8%	91.872	91.392	90.912	90.432	89.952	88.992
1.8	3.50%	40.194	39.984	39.774	39.564	39.354	38.934
0.6	2.50%	28.71	28.56	28.41	28.26	28.11	27.81
0.3	2.50%	28.71	28.56	28.41	28.26	28.11	27.81
0.15	4%	45.396	45.696	45.456	45,216	44.976	44.496
0.075	1.50%	17.226	17.136	17.046	16.956	16.866	16.686
Filler	10.50%	120.582	119.952	119.322	118.692	118.062	116.802
Binder		48	54	60	66	72	84
Fiber (gm)		3.6	3.6	3.6	3.6	3.6	3.6

Table 6. gradation table for sample without fibre

Sieve size (mm)	%age retained	4%	4.50%	5.00%	5.50%	6.60%	7.00%
		1152	1146	1140	1134	1128	1116
13.2	5%	57.6	57.3	57	56.7	56.4	55.8
9.5	33%	380.16	378.18	376.2	374.22	372.24	368.28
4.75	29.5%	339.84	338.07	336.3	332.53	332.76	329.22
2.36	8%	92.16	91.68	91.2	90.72	90.24	89.28
1.18	3.50%	40.32	40.11	39.9	39.69	39.48	39.06
0.6	2.50%	28.8	28.65	28.5	28.35	28.2	27.9
0.3	2.50%	28.8	28.65	28.5	28.35	28.2	27.9
0.15	4%	46.08	45.84	45.6	45.36	45.12	44.64
0.075	1.50%	17.28	17.19	17.1	17.01	16.92	16.74
Filler	10.50%	120.96	120.33	119.7	119.07	118.44	117.18
Binder		48	54	60	66	72	84

3.4. PREPARATION OF SAMPLE

The Methods followed during the preparation of SMA sample and all the other practice followed before taking it to the Marshall testing Machine for its test for Stability and flow values are :

- Sampling of coarse and fine aggregates is carried out for 13mm STONE MATRIX ASPHALT composition as specified by IRC:SP-79.
- The aggregate, graded according to IRC:SP-79 is dried and sufficient amount is weighed (about 1200 g) to give a height of 63.5 + 1.3 mm when compacted in the mould.
- The aggregate is then heated in the oven to a temperature up to 150-160 °C not higher than above the binder temperature for 1 hour.
- The required amount of bitumen is weighted and heated separately up to a temperature up to 170-190 °C .
- The aggregate contained is then brought out and heated in mixing bowl. The binder is then poured in it and manual mixing is carried out until aggregates are properly coated. The mixing temperature is kept within the limit that is set for the binder temperature.
- A properly cleaned mould of 101.6 mm diameter and 76.2 mm height is provided along with base plate and an extension collar.
- A piece of filter paper is fitted in the bottom of the mould and the whole mix is poured in it .
- The mould assembly is placed on the compaction pedestal and given 75 blows for no fibre and 50 blows for fibre by the 2500 g compacting hammer with falling height of 457.2 mm. The specimen is then reversed by reversing the mould and given the same treatment on the other side.
- The specimen is then carefully extruded from the mould, transferred to a smooth flat surface and allowed to cool to room temperature for 24 hours.

- Finally, the specimen is measured and weighed in air and water after paraffin wax coating is given (for volume determination). The specimen is then marked and stored for stability and flow measurements.
- Before conducting the Marshall test, each of the sample was kept in hot water bath for 30 min. at 60 °C temperature.

Fig7. **1. Mould setting**

Fig8. **2.Bitumen Addition**

Fig9 **3. Mixing of Sample**

Fig10. **4.Casting of sample**

Fig11 **5.Prepared sample**

Fig12 **6. Sample removed after 24 hour**

Fig13. **7. Sample After Paraffin wax Coating**

CHAPTER 4

EXPERIMENTATION

4.1.MARSHALL TEST ON SPECIMEN

- After keeping the prepared sample for 30 minutes in water bath maintained at 60oC the is placed in the marshal test apparatus.25 kN dial gauge is been used for dial gauge reading for stability. Marshall stability testing machine loaded is then allowed for loading at a constant rate of deformation of 5 mm per minute until failure.

- The total maximum load obtained in dial gauge is been noted as stability value, which is calculated again using the co-relation factor given for the standard 25kN dial gauge to obtain load in kN which causes the specimen to fail and is taken as Marshall Stability.

- The total amount of deformation in units of 0.25 mm is observed and noted which occurs when maximum load is applied is recorded as Flow Value.

- VA and VMA values are calculated using the sample characteristics of specific gravity, which is been calculated from the different weight of the sample taken in water and outside of water.

Fig14. **1. Marshall testing Apparatus Loaded with Specimen**

Fig15 **2. Sample after Marshall Tes**

Table6

1.Table to find the co-relation factor for stability

Volume of specimen,	Approximate thickness of specimen		Correlation ratio
cm^3	mm	in.	
200 to 213	25.4	1	5.56
214 to 225	27.0	1 1/16	5.00
226 to 237	28.6	1 1/8	4.55
238 to 250	30.2	1 3/16	4.17
251 to 264	31.8	1 1/4	3.85
265 to 276	33.3	1 5/16	3.57
277 to 289	34.9	1 3/8	3.33
290 to 301	36.5	1 7/16	3.03
302 to 316	38.1	1 1/2	2.78
317 to 328	39.7	1 9/16	2.50
329 to 340	41.3	1 5/8	2.27
341 to 353	42.9	1 11/16	2.08
354 to 367	44.4	1 3/4	1.92
368 to 379	46.0	1 13/16	1.79
380 to 392	47.6	1 7/8	1.67
393 to 405	49.2	1 15/16	1.56
406 to 420	50.8	2	1.47
421 to 431	52.4	2 1/16	1.39
432 to 443	54.0	2 1/8	1.32
444 to 456	55.6	2 3/16	1.25
457 to 470	57.2	2 1/4	1.19
471 to 482	58.7	2 5/16	1.14
483 to 495	60.3	2 3/8	1.09
496 to 508	61.9	2 7/16	1.04
509 to 522	63.5	2 1/2	1.00
523 to 535	64.0	2 9/16	0.96
536 to 546	65.1	2 5/8	0.93
547 to 559	66.7	2 11/16	0.89
560 to 573	68.3	2 3/4	0.86
574 to 585	71.4	2 13/16	0.83
586 to 598	73.0	2 7/8	0.81
599 to 610	74.6	2 15/16	0.78
611 to 625	76.2	3	0.76

4.2.EXPERIMENTAL RESULT

4.2.1.Using stone aggregate without fibre

Table7.

Sample No.	Bitumen content	Temp oC.	Wt. before paraff. Coating (gm)	Wt. aftr paraff coating (gm)	Wt in water (gm)	Heigh (mm)t	Radius (mm)	Wt. of aggr. Mix. (gm)	Flow (mm)	Load take (kN)
S-4-1	4%	160	1194	1210	709	64.5	50	1162	3.1	300
S-4-2	4%	160	1183	1199	699	65	50	1162	2.4	250
S-4-3	4%	160	1187	1202	703	65	50	1162	3.1	280
S-5-1	5%	160	1185	1197	709	63.2	50	1140	3.6	355
S-5-2	5%	160	1182	1196	701	63	50	1140	4.8	290
S-5-3	5%	160	1198	1209	719	62.5	50	1140	4	315
S-5.5-1	5.5%	160	1183	1192	750	57	50	1140	3.9	230
S-5.5-2	5.5%	160	1179	1186	755	56	50	1140	4.2	280
S-5.5-3	5.5%	160	1181	1189	754	61.7	50	1140	4.8	340
S-6-1	6%	160	1201	1208	740	59	50	1116	4.7	275
S-6-2	6%	160	1186	1194	757	56.25	50	1116	5.4	250
S-6-3	6%	160	1193	1201	753	59	50	1116	4.3	320
S-7-1	7%	160	1180	1210	707	60	50	1116	5.4	455
S-7-2	7%	160	1186	1215	712	61	50	1116	4.8	480
S-7-3	7%	160	1184	1212	710	60.5	50	1116	5.7	470

4.2.2.Using slag aggregate without fibre

Table8.

Sample No.	Bitumen content	Temp oC.	Wt. before paraff. Coating (gm)	Wt. aftr paraff coating (gm)	Wt in water (gm)	Heigh (mm)t	Radius (mm)	Wt. of aggr. Mix. (gm)	Flow (mm)	Load take (kN)
L-4-1	4%	160	1194	1204	758	57	50	1162	2.8	440
L-4-2	4%	160	1204	1215	742	60	50	1162	2.8	430
L-4-3	4%	160	1201	1211	749	61	50	1162	2.7	400
L-5-1	5%	160	1183	1192	750	57	50	1140	3.6	230
L-5-2	5%	160	1179	1186	755	56	50	1140	3.2	280
L-5-3	5%	160	1181	1189	754	61.7	50	1140	3.7	340
L-5.5-1	5.5%	160	1194	1204	758	57	50	1128	4	415
L-5.5-2	5.5%	160	1204	1215	742	60	50	1128	4.6	395
L-5.5-3	5.5%	160	1201	1211	749	61	50	1128	3.7	330
L-6-1	6%	160	1183	1192	750	57	50	1116	5.2	380
L-6-2	6%	160	1179	1186	755	58	50	1116	4.8	360
L-6-3	6%	160	1181	1189	754	63.5	50	1116	5.6	320
L-7-1	7%	160	1201	1208	740	59	50	1116	6.1	275
L-7-2	7%	160	1186	1194	757	56.25	50	1116	5.4	250
L-7-3	7%	160	1193	1201	753	59	50	1116	6.3	320

4.2.3.Using stone aggregate with Bamboo fibre

Table9.

Sample No.	Bitumen content	Temp oC.	Wt. before paraff. Coating (gm)	Wt. aftr paraff coating (gm)	Wt in water (gm)	Heigh (mm)t	Radius (mm)	Wt. of aggr. Mix. (gm)	Flow (mm)	Load take (kN)
B -4-1	4%	160	1183	1192	710	63	50	1162	3.7	360
B -4-2	4%	160	1179	1186	705	65	50	1162	4.2	375
B -4-3	4%	160	1181	1189	704	62	50	1162	2.9	435
B -5-1	5%	160	1201	1208	720	58.5	50	1140	4.8	410
B -5-2	5%	160	1186	1194	711	59.2	50	1140	5.1	325
B -5-3	5%	160	1193	1201	713	57.5	50	1140	3.9	390
B-5.5-1	5.5%	160	1175	1186	746	57	50	1140	4.6	480
B-5.5-2	5.5%	160	1178	1188	745	57	50	1140	4.2	475
B-5.5-3	5.5%	160	1193	1201	751	57.5	50	1140	5.2	415
B-6-1	6%	160	1194	1204	758	57	50	1128	4	415
B-6-2	6%	160	1204	1215	742	60	50	1128	5.6	395
B-6-3	6%	160	1201	1211	749	61	50	1128	4.5	330
B-7-1	7%	160	1183	1192	750	57	50	1116	5.2	380
B-7-2	7%	160	1179	1186	755	58	50	1116	4.8	360
B-7-3	7%	160	1181	1189	754	63.5	50	1116	5.6	320

4.2.4.Using slag aggregate with Bamboo fibre

Table10.

Sample No.	Bitumen content	Temp oC.	Wt. before paraff. Coating (gm)	Wt. aftr paraff coating (gm)	Wt in water (gm)	Heigh (mm)t	Radius (mm)	Wt. of aggr. Mix. (gm)	Flow (mm)	Load take (kN)
B -4-1	4%	160	1176	1185	730	60	50	1162	3	380
B -4-2	4%	160	1182	1191	742	58	50	1162	2.9	350
B -4-3	4%	160	1181	1189	739	59	50	1162	2.5	400
B -5-1	5%	160	1175	1186	746	57	50	1140	4.6	490
B -5-2	5%	160	1178	1188	745	57	50	1140	2.4	475
B -5-3	5%	160	1193	1201	751	57.5	50	1140	3.6	420
B-5.5-1	5.5%	160	1183	1192	750	57	50	1140	3.9	485
B-5.5-2	5.5%	160	1179	1186	755	56	50	1140	4.2	425
B-5.5-3	5.5%	160	1181	1189	754	60	50	1140	4.8	500
B-6-1	6%	160	1194	1204	758	57	50	1128	3.9	415
B-6-2	6%	160	1188	1197	749	60	50	1128	5	370
B-6-3	6%	160	1201	1211	761	59	50	1128	4.5	330
B-7-1	7%	160	1186	1191	752	58	50	1116	4.2	355
B-7-2	7%	160	1179	1186	750	58	50	1116	4.8	375
B-7-3	7%	160	1203	1211	767	59	50	1116	5.2	350

4.2.5.Using stone aggregate with topcel cellulose as stabilizer

Table11.

Sample No.	Bitumen content	Temp oC.	Wt. before paraff. Coating (gm)	Wt. aftr paraff coating (gm)	Wt in water (gm)	Heigh (mm)t	Radius (mm)	Wt. of aggr. Mix. (gm)	Flow (mm)	Load take (kN)
C-4-1	4%	160	1194	1204	758	57	50	1162	2.8	350
C-4-2	4%	160	1204	1215	742	60	50	1162	2.8	340
C-4-3	4%	160	1201	1211	749	61	50	1162	2.7	380
C-5-1	5%	160	1185	1197	709	59	50	1140	3.6	420
C-5-2	5%	160	1182	1196	701	58	50	1140	4.2	470
C-5-3	5%	160	1198	1209	719	57.5	50	1140	4	480
C-5.5-1	5.5%	160	1194	1204	758	56	50	1128	4	470
C-5.5-2	5.5%	160	1204	1215	742	60	50	1128	4.6	425
C-5.5-3	5.5%	160	1201	1211	749	61	50	1128	3.7	495
C-6-1	6%	160	1194	1204	758	58	50	1128	4.3	380
C-6-2	6%	160	1204	1215	742	61	50	1128	5.6	400
C-6-3	6%	160	1201	1211	749	60	50	1128	4.5	375
C-7-1	7%	160	1186	1191	752	58	50	1116	5.7	355
C-7-2	7%	160	1179	1186	750	58	50	1116	4.8	375
C-7-3	7%	160	1203	1211	767	59	50	1116	6.2	350

CHAPTER 5

ANALYSIS OF RESULTS

5.1.INTRODUCTION

The Test Result obtained from the laboratory tests conducted using various types of gradation according to the IS code for different SMA Mix are analysed in this section to get all the required results. The Results analysed are then compared with one another and finally all comparisons are made to find out the results properly in tabular as well as in graphical form to get the results more satisfactorily. Here Stabilised value is mainly calculated using the co-relation method and all the required values like bulk volume and Volume of sample, Gmb,Gmm,Ps value to calculate and find out GSB, VA and VMA value to plot in the graph.

5.2.CALCULATIONS

Gmb = Mmix/Bulk Volume of the Mix

Ps= Magg/Mmix

VA=

[(Mmix/Gmb-Mmix/Gmm)/(Mmix/Gmb)]*100

Gmb = Mmix/bulk volume of mix

Gmm = Mmix/Volume of the mix air voids

VMA=

[(Mmix/Gmb- Mmix Ps/Gsb)/ (Mmix/Gmb)]

Gsb =

Magg/Volume of (aggregate mass+ air void in aggregate+ absorbed bitumen)

5.3.RESULTS ANALYSIS

5.3.1.Using stone aggregate without fibre

Table12.

Sample No.	Bitumen content	Bulk volume sample (BVS)	Gmb	Volume (mm3)	ps	Gmm	VA (%)	GSB	VMA (%)	Stability (kN)
S-4-1	4%	502.78	2.41	506.58	0.97	2.62	8	2.72	15.2	5.84
S-4-2	4%	501.78	2.39	510.51	0.98	2.62	8.65	2.72	15.8	6.13
S-4-3	4%	500.67	2.4	510.51	0.98	2.62	8.22	2.72	15.4	5.74
S-5-1	5%	489.33	2.45	496.37	0.96	2.58	7.3	2.75	15.6	6.93
S-5-2	5%	496.56	2.41	494.8	0.96	2.58	6.75	2.75	16.9	7.84
S-5-3	5%	491.22	2.46	490.87	0.95	2.58	6.82	2.75	15.1	7.12
S-5.5-1	5.5%	443	2.69	443	2.57	2.95	5.96	3.2	20.12	8.157
S-5.5-2	5.5%	431.78	2.75	431.78	2.64	2.95	5.66	3.2	18.45	7.11
S-5.5-3	5.5%	435.89	2.73	435.89	2.62	2.95	7.46	3.2	19.02	7.48
S-6-1	6%	468.78	2.58	468.78	2.38	2.87	7.35	3.21	22.42	6.76
S-6-2	6%	437.89	2.73	437.89	2.55	2.87	4.91	3.21	21.09	7.3
S-6-3	6%	448.89	2.68	448.89	2.49	2.87	6.51	3.21	22.57	7.2
S-7-1	7%	506.33	2.39	471.24	0.95	2.53	5.4	2.76	22.5	5.52
S-7-2	7%	506.22	2.4	479.09	0.94	2.53	4.99	2.76	23.5	6.4
S-7-3	7%	505.11	2.4	475.17	0.94	2.53	5.01	2.76	24.8	5.8

5.3.2.Using slag aggregate without fibre

Table13.

Sample No.	Bitumen content	Bulk volume sample (BVS)	Gmb	Volume (mm3)	ps	Gmm	VA (%)	GSB	VMA (%)	Stability (kN)
L-4-1	4%	447.11	2.69	447.11	2.6	2.99	10.07	3.17	18.35	6.53
L-4-2	4%	474.22	2.56	474.22	2.45	2.99	14.44	3.17	22.32	5.86
L-4-3	4%	463.11	2.61	463.11	2.51	2.99	12.68	3.17	20.71	6.33
L-5-1	5%	443	2.69	443	2.57	2.95	8.72	3.2	20.12	8.157
L-5-2	5%	431.78	2.75	431.78	2.64	2.95	6.82	3.2	18.45	7.11
L-5-3	5%	435.89	2.73	435.89	2.62	2.95	7.46	3.2	19.02	6.48
L-5.5-1	5.5%	447.11	2.69	447.11	2.52	2.93	8.17	3.24	20.20	8.25
L-5.5-2	5.5%	474.22	2.56	474.22	2.38	2.93	6.63	3.24	24.08	7.22
L-5.5-3	5.5%	463.11	2.61	463.11	2.44	2.93	6.83	3.24	22.51	7.39
L-6-1	6%	443.00	2.69	443.00	2.52	2.87	6.17	3.21	23.12	7.378
L-6-2	6%	431.78	2.75	431.78	2.58	2.87	4.21	3.21	23.97	6.52
L-6-3	6%	435.89	2.73	435.89	2.56	2.87	4.88	3.21	24.01	6.94
L-7-1	7%	468.78	2.58	468.78	2.38	2.87	10.14	3.21	25.42	6.76
L-7-2	7%	437.89	2.73	437.89	2.55	2.87	4.91	3.21	23.01	6.36
L-7-3	7%	448.89	2.68	448.89	2.49	2.87	6.7	3.21	24.84	7.206

5.3.3.Using stone aggregate with Bamboo fibre

Table14.

Sample No.	Bitumen content	Bulk volume sample (BVS)	Gmb	Volume (mm3)	ps	Gmm	VA (%)	GSB	VMA (%)	Stability (kN)
B -4-1	4%	483.00	2.47	483.00	2.41	2.99	17.58	3.17	20.20	5.84
B -4-2	4%	481.78	2.46	481.78	2.41	2.99	17.79	3.17	22.08	6.055
B -4-3	4%	485.89	2.45	485.89	2.39	2.99	18.28	3.17	22.51	6.01
B -5-1	5%	488.78	2.47	488.78	2.33	2.95	16.16	3.20	19.62	8.409
B -5-2	5%	483.89	2.47	483.89	2.36	2.95	16.29	3.20	17.94	8.437
B -5-3	5%	488.89	2.46	488.89	2.33	2.95	15.60	3.20	18.51	8.11
B-5.5-1	5.5%	441.22	2.69	441.22	2.58	2.95	8.17	3.20	19.36	8.26
B-5.5-2	5.5%	444.11	2.68	444.11	2.57	2.95	12.63	3.20	19.75	7.99
B-5.5-3	5.5%	450.89	2.66	450.89	2.53	2.95	10.83	3.20	20.09	9.01
B-6-1	6%	447.11	2.69	447.11	2.52	2.93	8.81	3.24	25.17	8.58
B-6-2	6%	474.22	2.56	474.22	2.38	2.93	9.25	3.24	23.36	7.22
B-6-3	6%	463.11	2.61	463.11	2.44	2.93	9.64	3.24	25.80	7.85
B-7-1	7%	443.00	2.69	443.00	2.52	2.87	6.17	3.21	25.86	7.378
B-7-2	7%	431.78	2.75	431.78	2.58	2.87	4.21	3.21	25.97	6.52
B-7-3	7%	435.89	2.73	435.89	2.56	2.87	4.88	3.21	26.30	6.94

5.3.4.Using slag aggregate with Bamboo fibre

Table15.

Sample No.	Bitumen content	Bulk volume sample (BVS)	Gmb	Volume (mm3)	ps	Gmm	VA (%)	GSB	VMA (%)	Stability (kN)
B -4-1	4%	456.00	2.60	456.00	2.55	2.99	13.22	3.17	21.21	7.06
B -4-2	4%	450.00	2.65	450.00	2.58	2.99	11.62	3.17	19.75	6.67
B -4-3	4%	450.89	2.64	450.89	2.58	2.99	11.94	3.17	20.04	8.056
B -5-1	5%	441.22	2.69	441.22	2.58	2.95	8.81	3.20	19.36	8.51
B -5-2	5%	444.11	2.68	444.11	2.57	2.95	9.25	3.20	19.75	7.99
B -5-3	5%	450.89	2.66	450.89	2.53	2.95	9.64	3.20	20.09	9.21
B-5.5-1	5.5%	443	2.69	443	2.57	2.95	5.96	3.2	20.12	8.36
B-5.5-2	5.5%	431.78	2.75	431.78	2.64	2.95	5.66	3.2	18.45	9.375
B-5.5-3	5.5%	435.89	2.73	435.89	2.62	2.95	7.46	3.2	19.02	8.58
B-6-1	6%	447.11	2.69	447.11	2.52	2.93	8.17	3.24	20.20	8.58
B-6-2	6%	449.00	2.67	449.00	2.51	2.93	9.09	3.24	21.00	6.74
B-6-3	6%	451.11	2.68	451.11	2.50	2.93	8.46	3.24	20.45	8.62
B-7-1	7%	439.56	2.71	439.56	2.54	2.87	5.51	3.21	22.86	6.84
B-7-2	7%	436.78	2.72	436.78	2.56	2.87	5.31	3.21	23.88	7.56
B-7-3	7%	444.89	2.72	444.89	2.51	2.87	5.08	3.21	21.72	6.34

5.3.5.Using stone aggregate with topcel cellulose as stabilizer

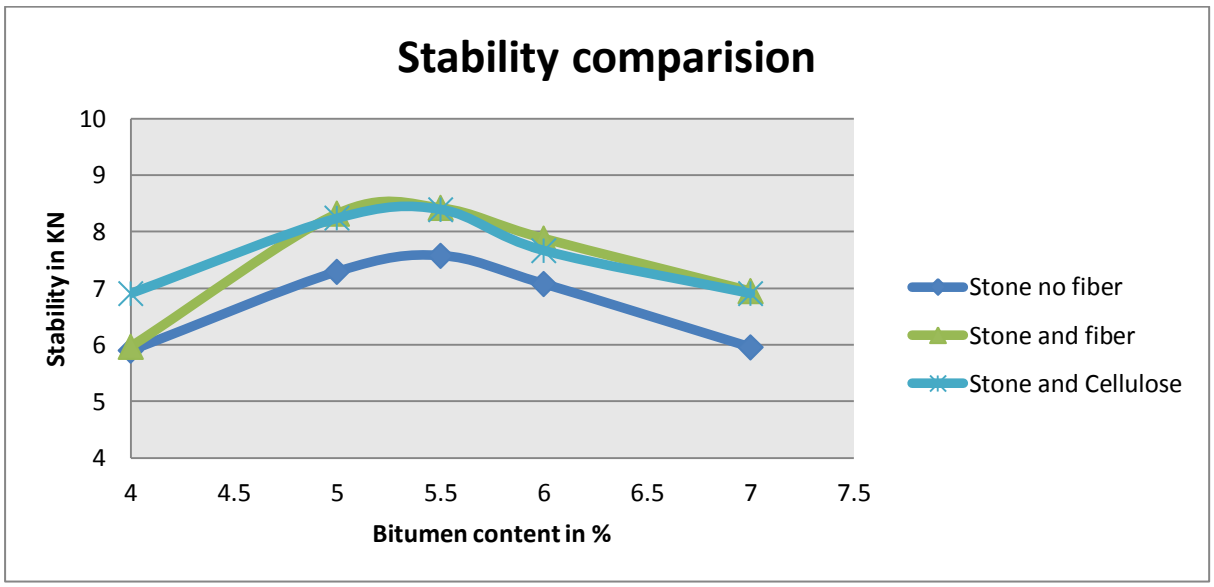
Table16.

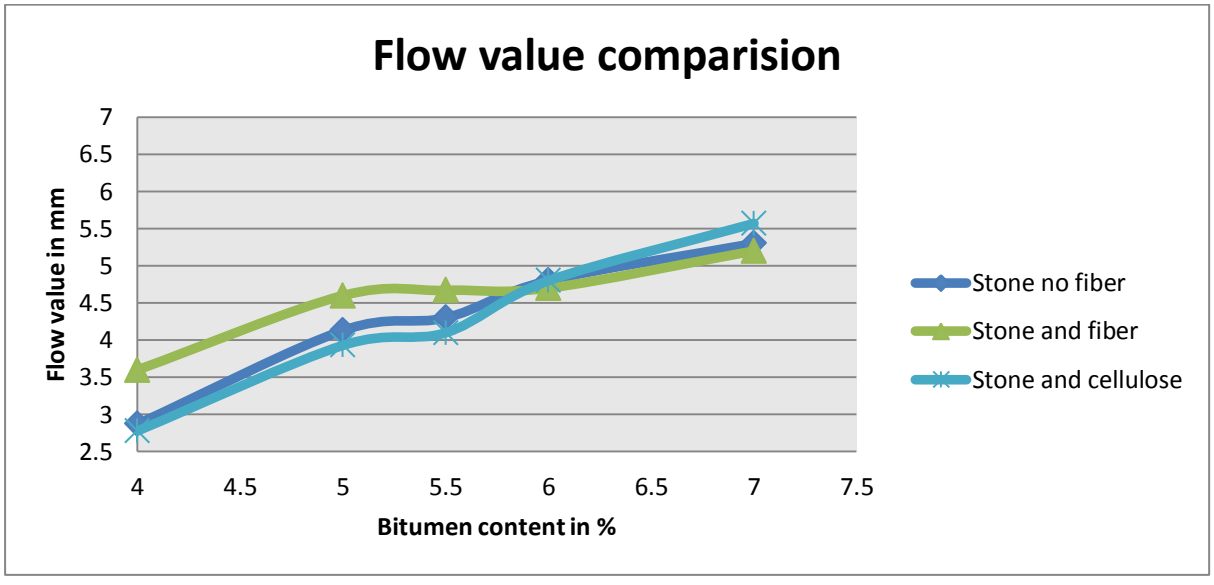
Sample No.	Bitumen content	Bulk volume sample (BVS)	Gmb	Volume (mm3)	ps	Gmm	VA (%)	GSB	VMA (%)	Stability (kN)
C-4-1	4%	447.11	2.69	447.11	2.6	2.99	10.07	3.17	18.35	6.87
C-4-2	4%	474.22	2.56	474.22	2.45	2.99	14.44	3.17	22.32	6.53
C-4-3	4%	463.11	2.61	463.11	2.51	2.99	12.68	3.17	20.71	7.33
C-5-1	5%	489.33	2.45	496.37	0.96	2.58	8.17	2.75	15.6	8.75
C-5-2	5%	496.56	2.41	494.8	0.96	2.58	12.63	2.75	16.9	7.81
C-5-3	5%	491.22	2.46	490.87	0.95	2.58	10.83	2.75	15.1	8.165
C-5.5-1	5.5%	447.11	2.69	447.11	2.52	2.93	8.17	3.24	20.20	8.697
C-5.5-2	5.5%	474.22	2.56	474.22	2.38	2.93	6.63	3.24	24.08	8.55
C-5.5-3	5.5%	463.11	2.61	463.11	2.44	2.93	6.83	3.24	22.51	7.94
C-6-1	6%	447.11	2.69	447.11	2.52	2.93	7.3	3.24	18.54	7.75
C-6-2	6%	474.22	2.56	474.22	2.38	2.93	6.75	3.24	23.36	8.052
C-6-3	6%	463.11	2.61	463.11	2.44	2.93	6.82	3.24	20.96	7.204
C-7-1	7%	439.56	2.71	439.56	2.54	2.87	5.51	3.21	22.86	6.84
C-7-2	7%	436.78	2.72	436.78	2.56	2.87	5.31	3.21	23.88	7.56
C-7-3	7%	444.89	2.72	444.89	2.51	2.87	5.08	3.21	21.72	6.34

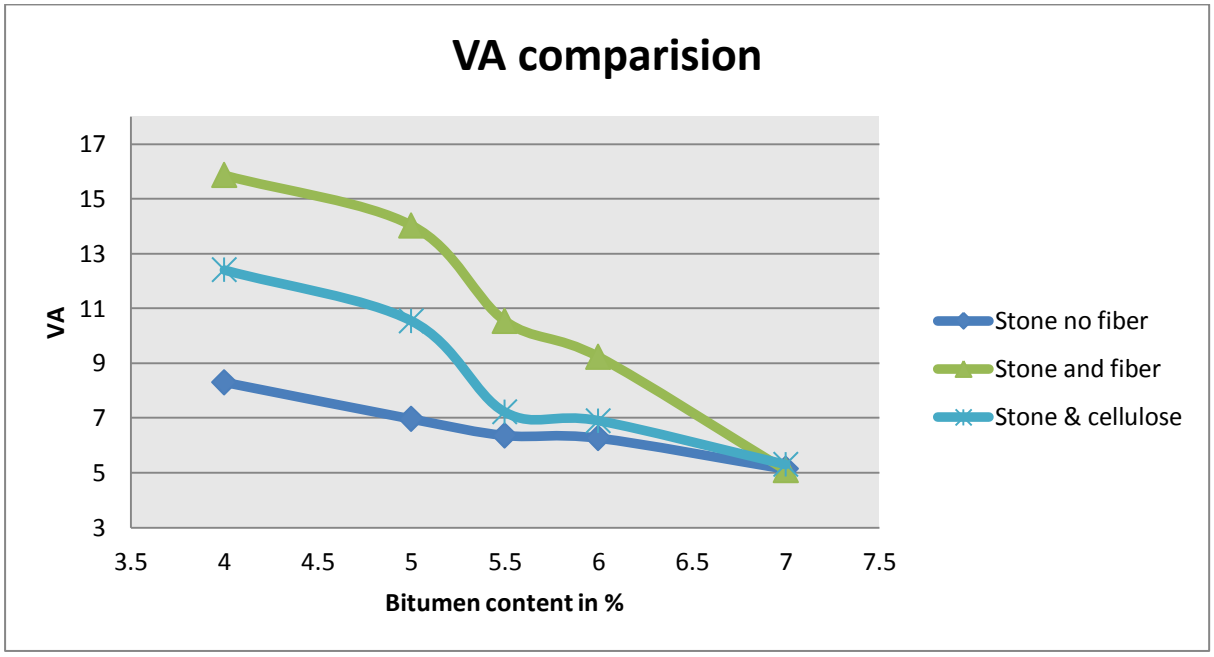
RESULTS AND DISCUSSION

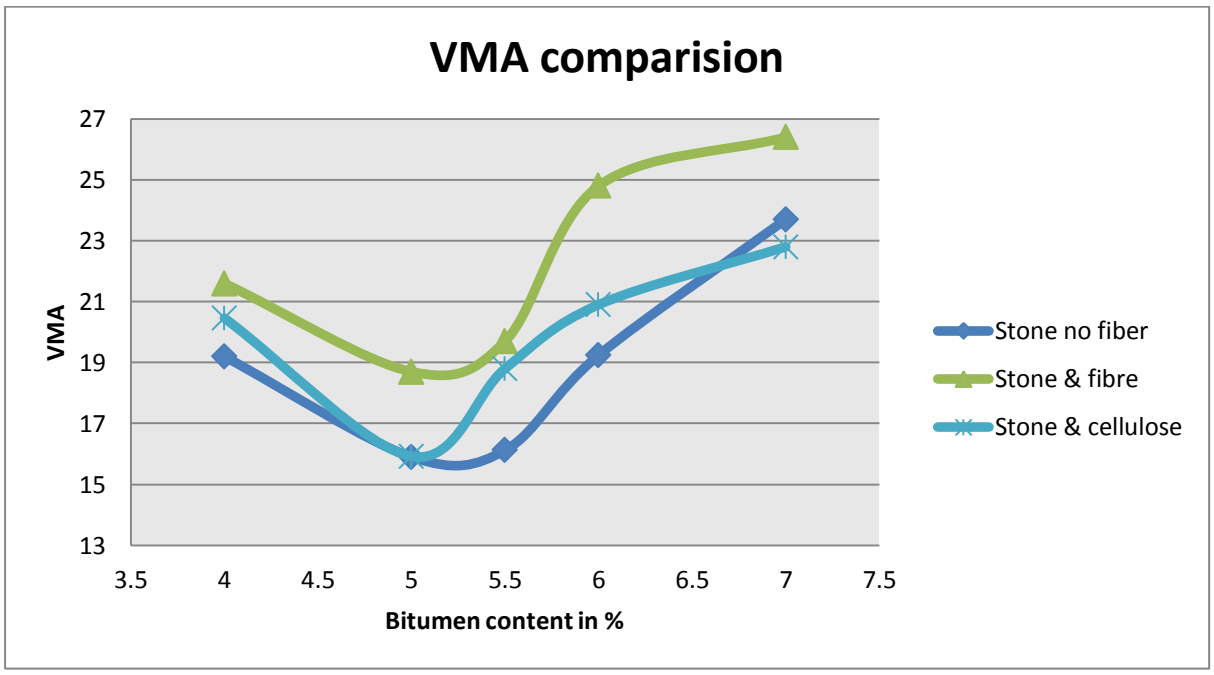
6.1.RESULTS

Graph1. 6.1.1.Stone aggregate Results



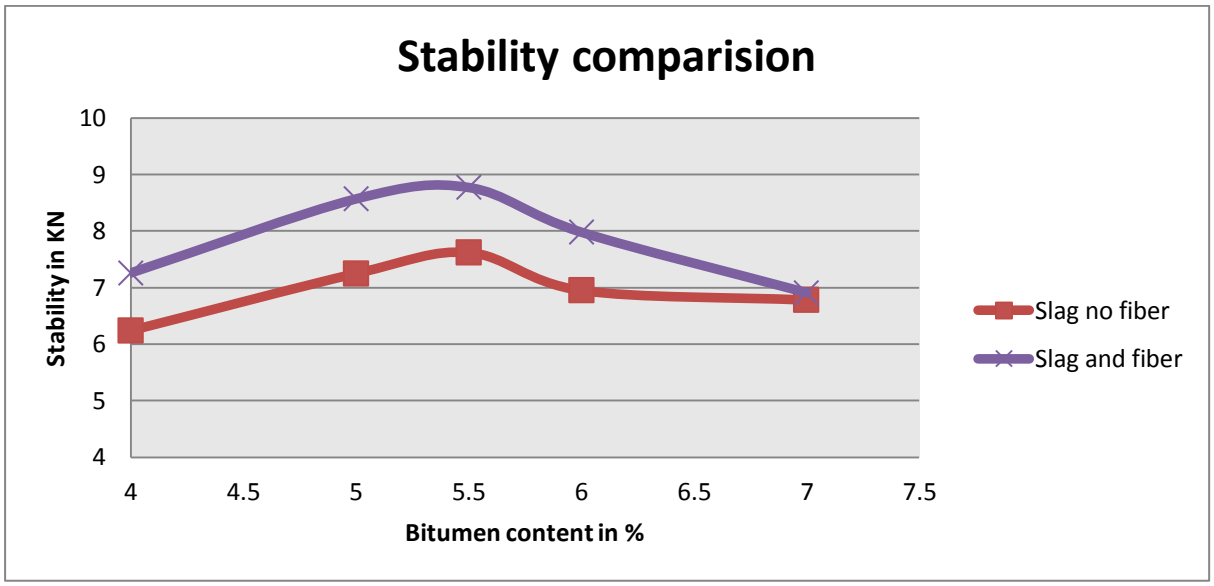


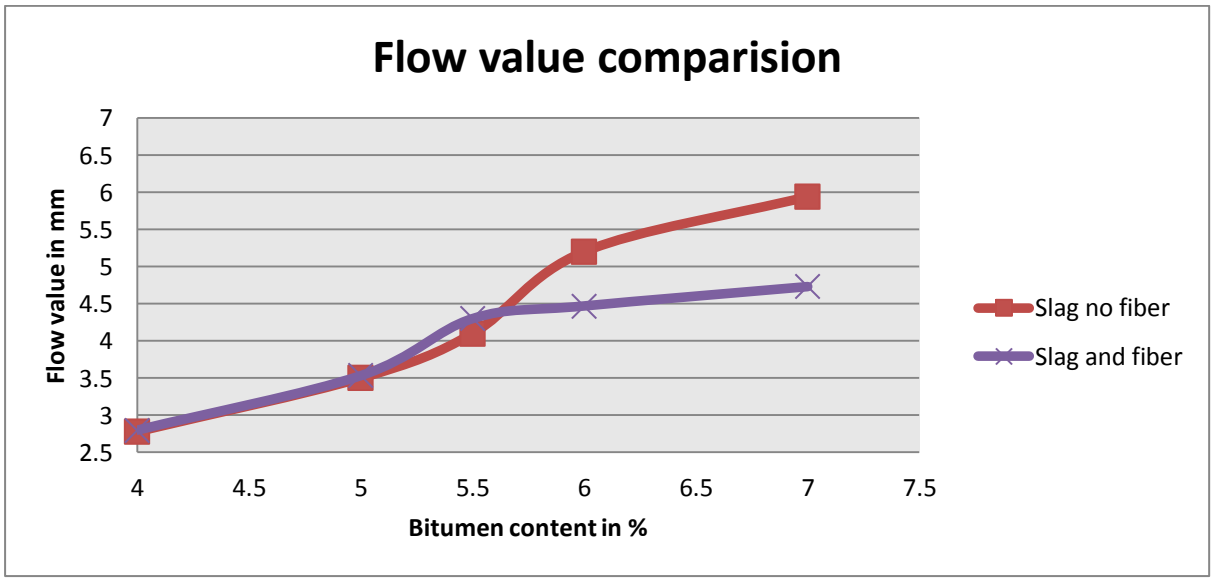


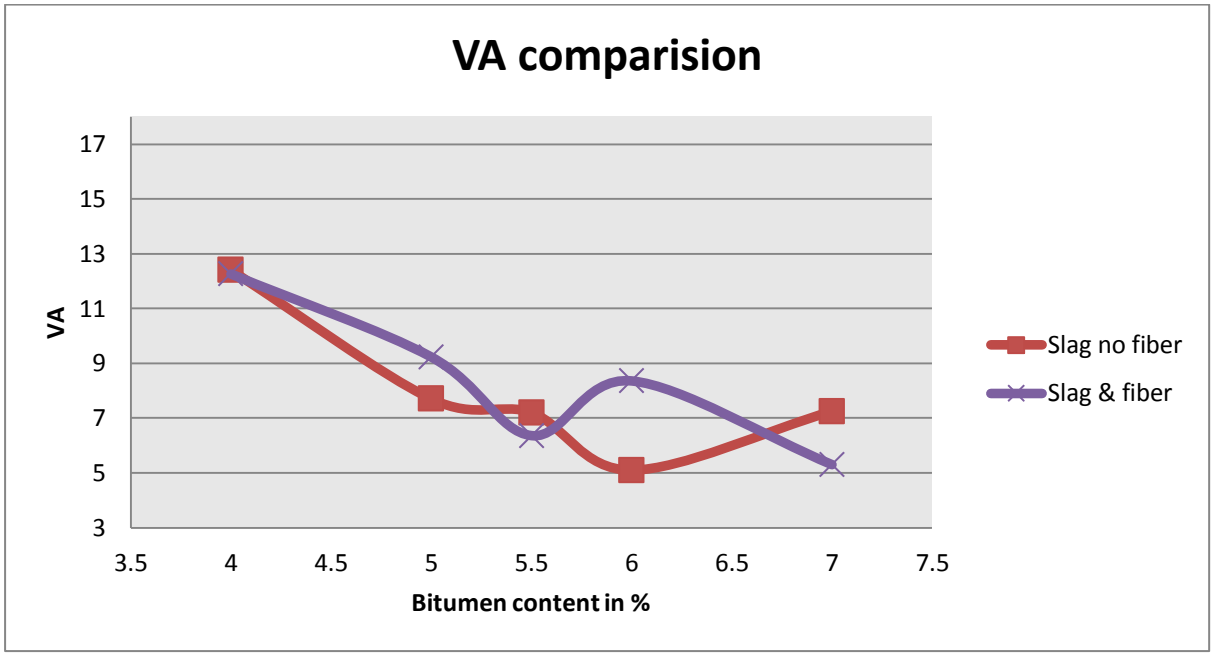


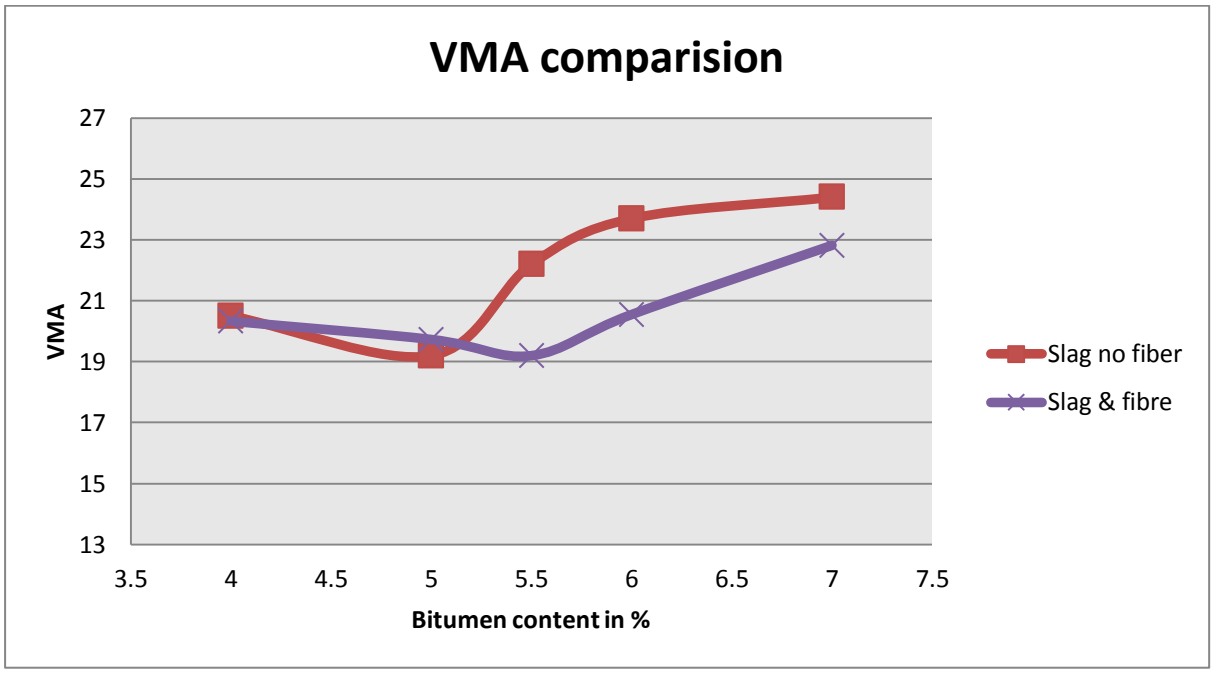
STONE AGGREGATE RESULT GRAPHS

6.1.2.Slag aggregate Results



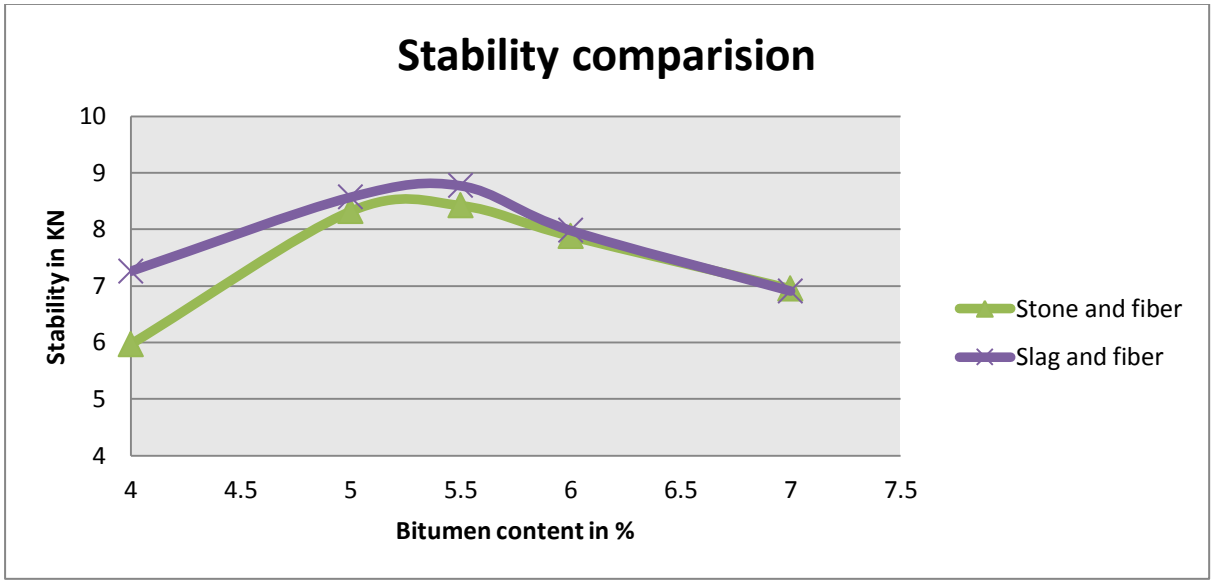


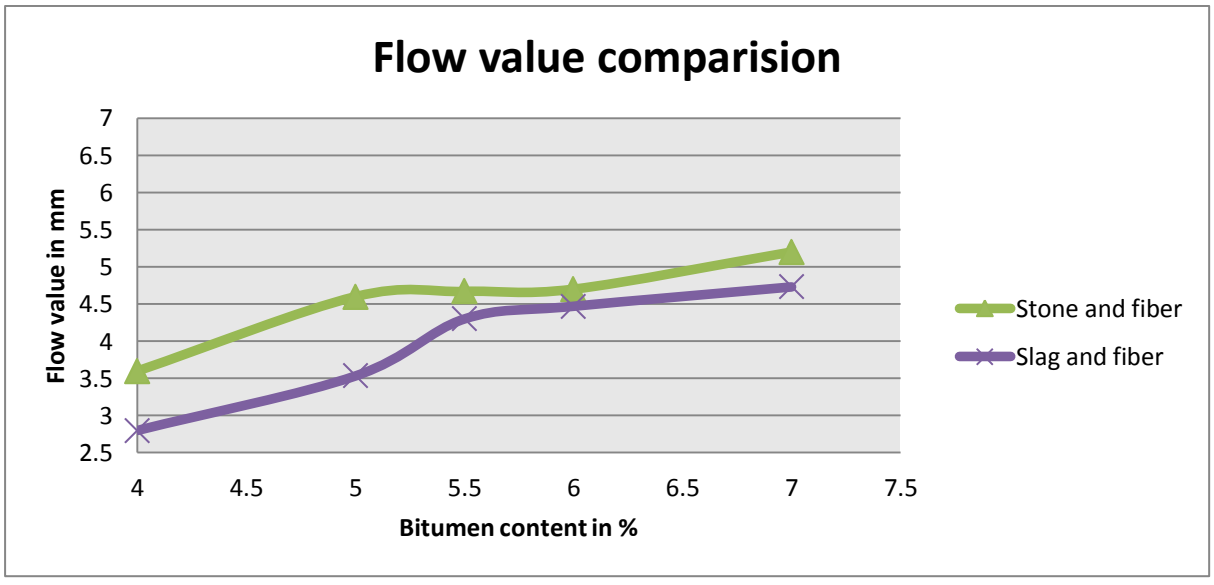


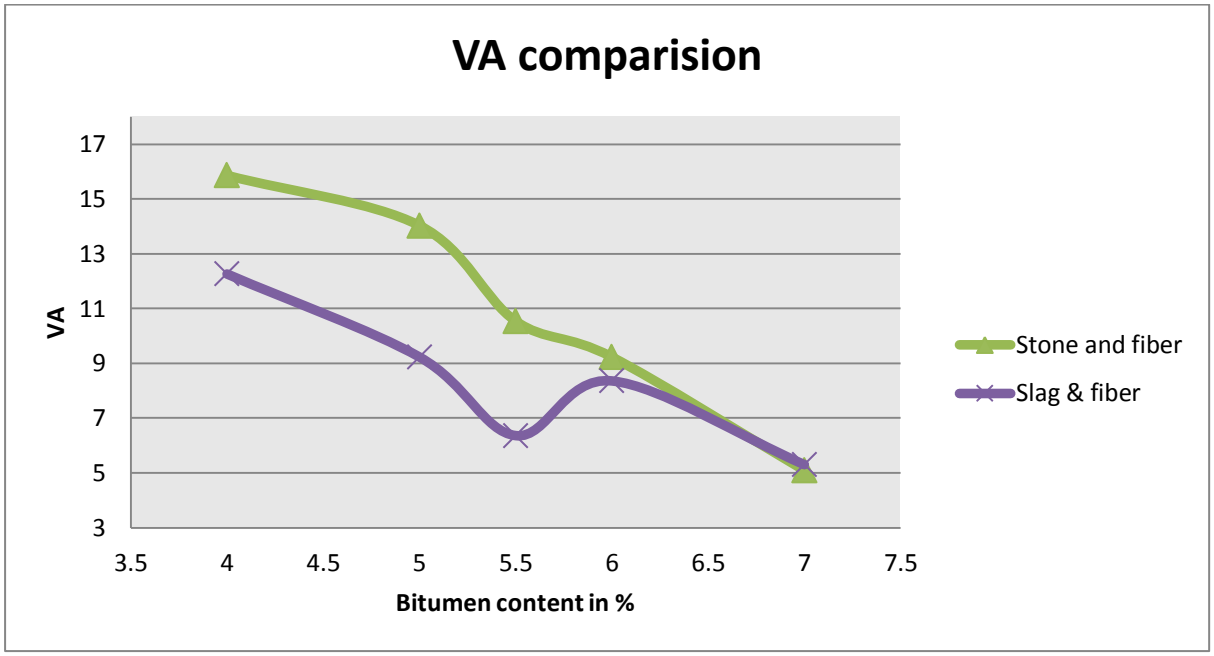


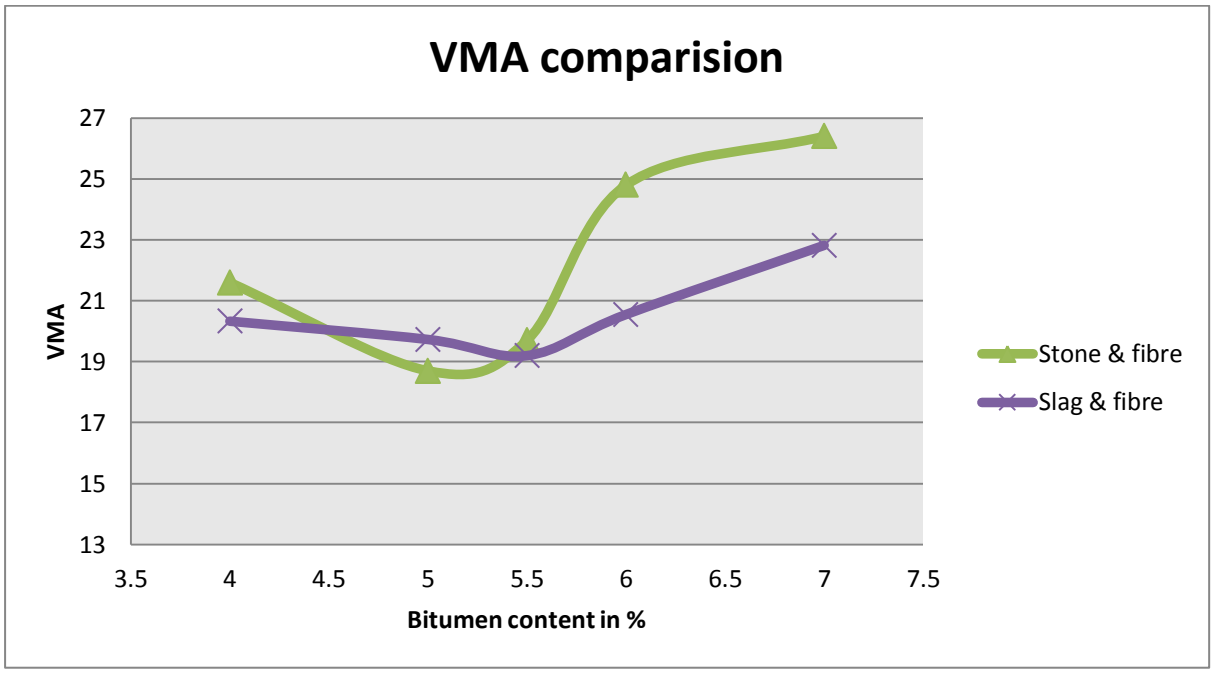
SLAG AGGREGATE RESULT GRAPHS

6.1.3.Bamboo Fibre Results





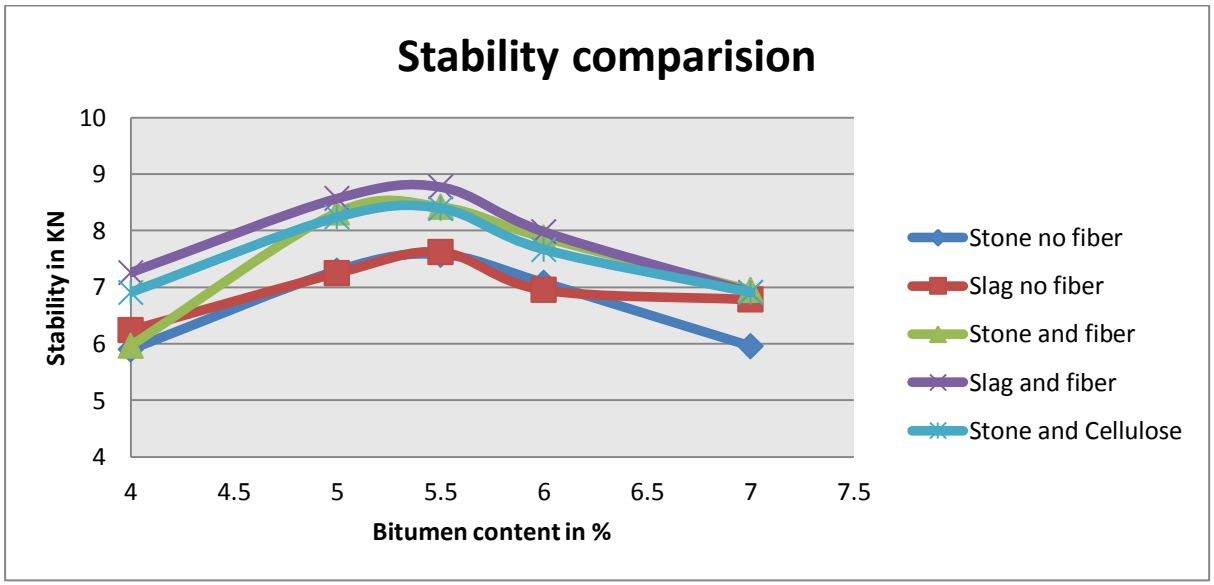




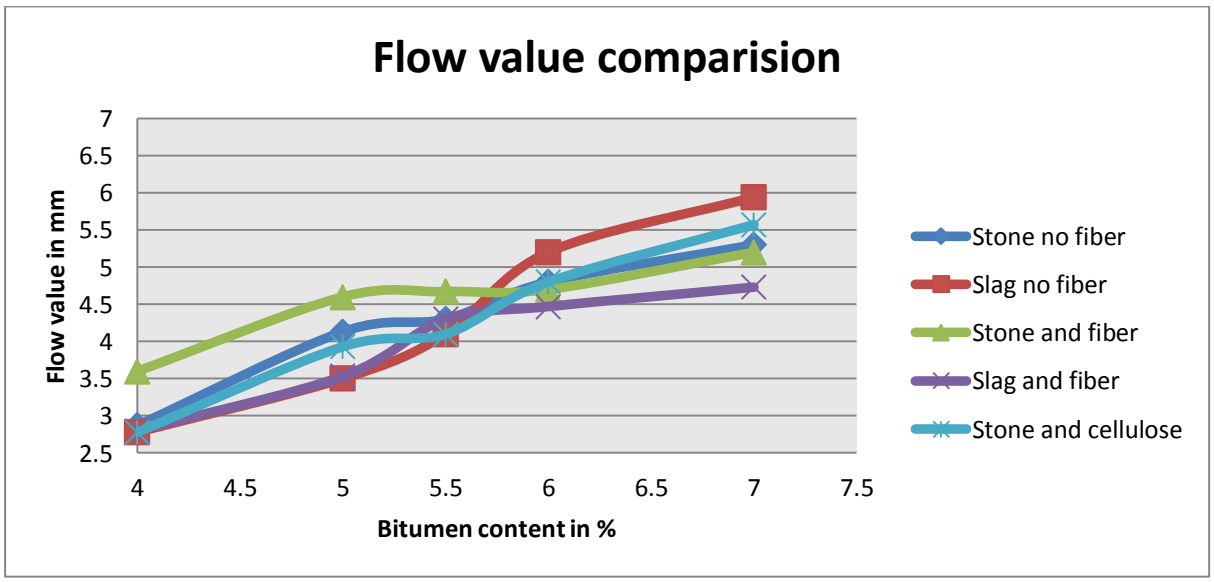
RESULT GRAPHS USING BAMBOO FIBRE

6.2.COMPARISON

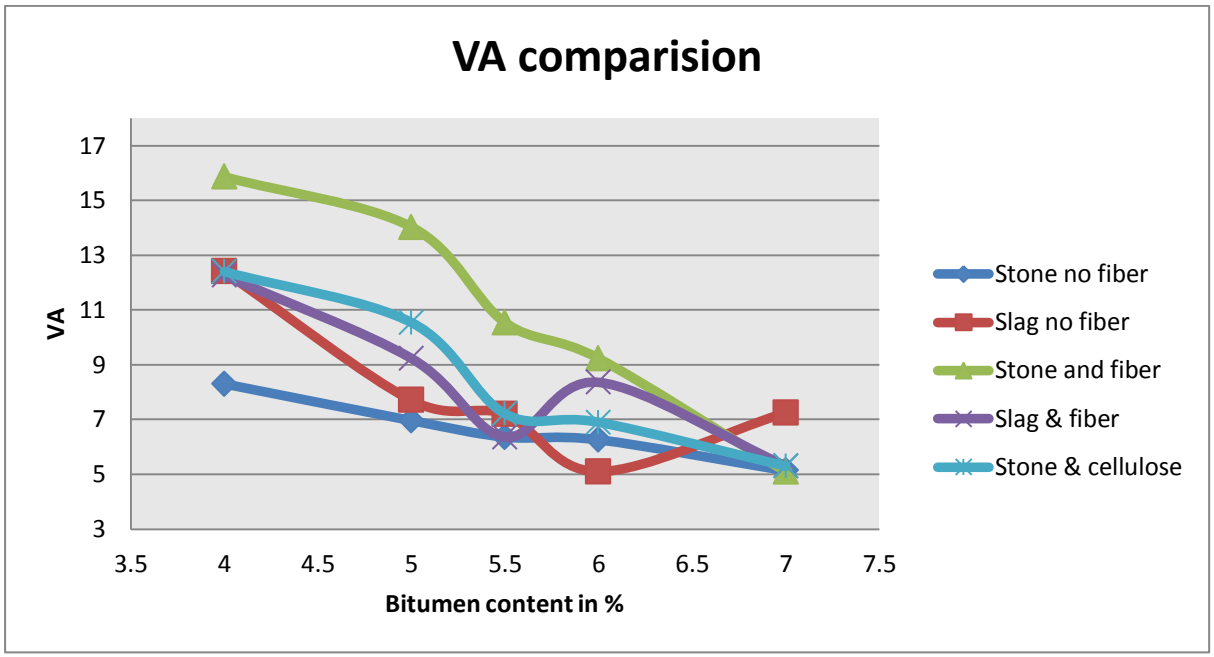
6.2.1.Stability



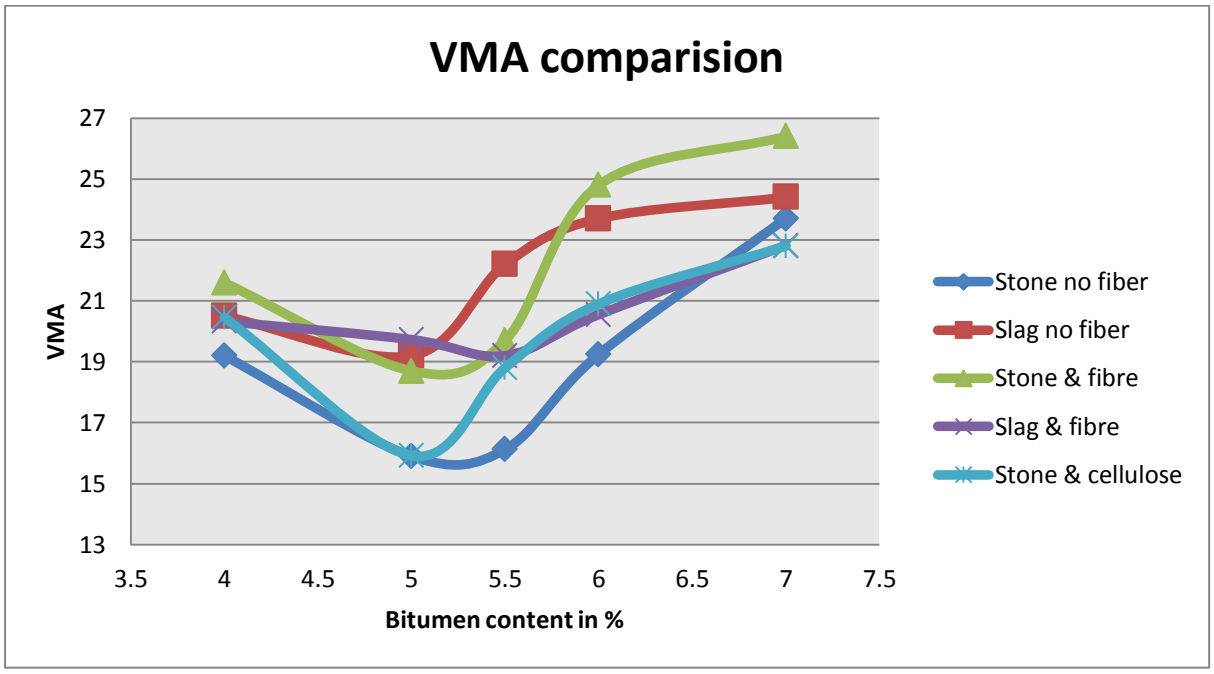
6.2.2.Flow value



6.2.3.VA



6.2.4.VMA



6.3.DISCUSSION

The SMA mix using Bamboo fibre has given quite expected results, which can be applied in the practical field. SMA mixes prepared without adding stabilizers have shown to give results that are far inferior to the results obtained while mixing those similar ingredients with any stabilizer. Slag as Coarse Aggregate using Bamboo Fibre has the best stability followed by Stone aggregate with Bamboo Fibre, which is followed by stone aggregate with Topcel Cellulose. So the use of Bamboo Fibre as stabilizer over Topcel Cellulose will be highly beneficial in consideration of stability and Flow Value.

CHAPTER 7

CONCLUSION

The study of all the results, graph and comparison of all the results each separately and wholly concluded that:

- The Optimum Binder content for the SMA samples for all the cases except in the case where stone is used as coarse aggregate with the bamboo fiber (where in the OBC is found to be 5%) is found to be 5.5%.
- Highest stability achieved, was by Slag aggregate using Bamboo fibre which is 4.16% higher to the stability obtained using Stone aggregate with Bamboo Fibre.
- The least flow value achieved was at 5.5% Bitumen content which is 4.1mm for Slag Aggregate without fibre and 12.2% lesser than that of Stone Aggregate Using Bamboo Fibre.
- The Slag as Coarse Aggregate with Bamboo Fibre is preferred for the SMA mix over all other Mixes.
- The Stone as Coarse Aggregate using Bamboo Fibre is preferred as it gives suitable value over SMA mix without using fibre and for Stone aggregate using Cellulose Fibre.
- The use of Bamboo fibre is suitable in achieving better stability than that of cellulose fibre and SMA mix without using Fibre.

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