EXPERIMENTAL INVESTIGATION OF STONE MATRIX ASPHALT ADMIXTURES TO BE USED IN FLEXIBLE PAVEMENT(USING BAMBOO & COIR FIBER)

Submitted in partial fulfillment of the requirements

of the degree of

MASTER OF TECHNOLOGY

in

CIVIL ENGINEERING

by

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2016

DECLARATION

I,Himanshu Dwivedi (11211602), hereby declare that this thesis report entitled **"Experimental investigation of stone matrix asphalt admixtures to be used in flexible pavement(using bamboo & coir fiber)"**submitted in the partial fulfilment of the requirements for the award of degree of Master of Civil Engineering, in the School of Civil Engineering, Lovely Professional University, Phagwara, is my own work. This matter embodied in this report has not been submitted in part or full to any other university or institute for the award of any degree.

Date: 3/12/2016 **Himanshu Dwivedi**

Place:

CERTIFICATE

Certified that this project report entitled " Experimental investigation of stone matrix asphalt admixtures to be used in flexible pavement(using bamboo and coir fiber)" submitted individually by student of School of Civil Engineering, Lovely Professional University, Phagwara , carried out the work under my supervision for the Award of Degree. This report has not been submitted to any other university or institution for the award of any degree.

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ABSTRACT

Stone Matrix Asphalt (SMA) is a gap graded mix, characterized by high coarse aggregates, high asphalt contents and polymer or fiber additives as stabilizers. High concentration of coarse aggregate maximizes stone-to-contact and interlocking in the mix which provides strength, and the rich mortar binder provides durability. The stabilizing additives used are bamboo fiber and coir fiber are added to SMA mixtures to prevent drain down from the mix. In the present study, an attempt has been made to study the engineering properties of mixtures of stone matrix asphalt made with binder of grade 60-70 with a non-conventional natural fiber, namely coir and bamboo fiber. The binders and fibers in different proportions are used for preparation of mixes with a selected aggregate grading. The role of a particular binder and fiber with respect to their concentrations in the mix is studied for various engineering properties. For this, various Marshall samples of SMA mixtures with and without fibers with varying binder type and its concentration are prepared.

Key Words: stone matrix asphalt, coir fiber, bamboo fiber.

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LIST OF SYMBOLS

%	percentage
Min	minutes
Mm	milimetre
cm	centimeter
m	metre
sec	second
MPa	mega Pascal
^{o}C	degree Celsius
SMA	Stone Matrix Asphalt
MORTH	Ministry of Road Transport and Highways

Chapter 1

INTRODUCTION

1.1.GENERAL

In India flexible pavement is always preferred over rigid pavement due to low initial cost, better strength and are more durable. Since these properties are there in Stone matrix asphalt(SMA) so it is used in the design of pavement. These properties can be proved in the laboratory by determining optimum binder content. SMA was first of all developed in 1960 in Germany by Zichner.SMA found its use in Australia, Europe and US. Composition of Stone matrix asphalt 70-80% coarse aggregates,4-7% binder,8-12% filler,0.3-0.5% stabilizer. Coarse aggregates provides rutt- free surface, filler helps to fill the gap between aggregates to avoid deterioration, binderhelps to bind the material together. Fiberwhich is used as stabilizing agent provides stability and prevents drain down. In this research work aggregates are taken as per IRC SP-79-2008 specification and aggregates are taken by gradation. Bitumen of grade 60-70 is used as it is most suited for Indian traffic condition. Hydrated lime is used as filler. Fiber used are bamboo and coir fiber.

1.2. CONVENTIONAL BITUMINUOS MIXES

The bituminous mixes which were previously used was not effective as SMA. 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. 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. BAMBOO FIBER

Bamboo grows in the tropical, subtropical and temperate regions of all continents except Europe. Bamboo fiber is a natural fiber which can be obtained frombamboo stem. It is smooth and soft, temperature adaptability and anti-bacterial properties. It finds its application in clothing, fabrics and textiles. It has high strength in fiber direction, greater tensile, flexural and impact strength with light weight. Bamboo fiber is also very cost effective.

Fig. 1.1Bamboo fiber

1.4.COIR FIBER

Coir fiber is obtained from husk of coconut fruit which is naturally available. Also known as golden fiber because of its color. These fibers are made of small threads having length less than 1.3mm and diameter in between 10-20 micrometer. These fibers are water proof and only fiber to resist sea water.

Fig.1.2 Coir fiber

Table 1.1 Physical properties of coconut fiber

Property	Unit	Value
Width	Micron	16
Breaking Elongation	percentage	30
Air Filled Porosity	percentage	70
pH	-	5.8-6.4
Electrical Conductivity	mS/cm	1.5
Swelling in Water	percentage	5
Single Fiber Length	Inches	6-8

Table 1.2 Chemical properties (Composition) of coconut fiber

Property	Unit	Value
Ash	percentage	2.22
Cellulose	percentage	43.4
Water Soluble	percentage	5.2
Hemi-cellulose	percentage	0.25
Lignin	percentage	45.8
Pectin	percentage	3.3

1.5. SCOPE

In this work the aggregates used is stone aggregates. Hydrated lime is used as a filler material. Bitumen of grade 60-70 has been used by varying the percentage of bitumen content. Two types of stabilizers are used which are bamboo fiber and coir fiber. Comparison of both natural fiber will be done. Results of SMA without fiber and with fiber has been compared.

1.6. OBJECTIVE

-To find out optimum binder content by changing %of bitumen.

-To determine stability, flow value, VA and VMA of SMA mixture using

bamboo and coir fiber with stone aggregates.

-To find the suitability of bamboo and coir fiber in SMA.

-To compare results of SMA with and without fiber.

-To find out which natural fiber is better.

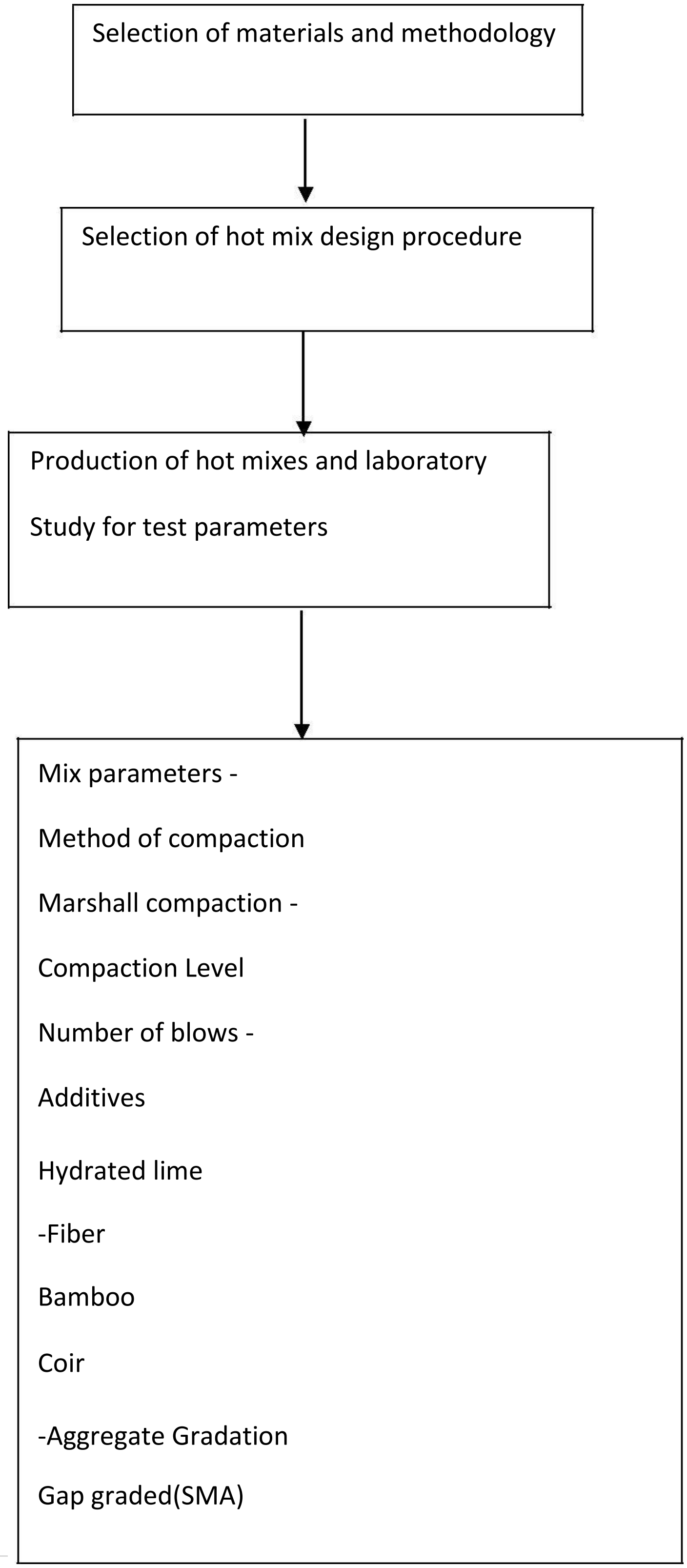
1.7. NEED

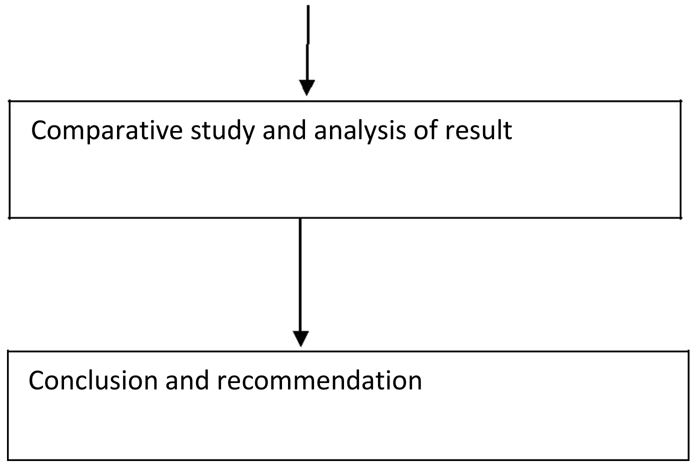
-It is relatively cheap method for construction of pavement.

-Use of natural fiber like bamboo and coir fiber is environment-friendly.

-It is mainly used in the design of low volume roads.

Overall frame work of present study is shown in the block diagram





1.8. THESIS LAYOUT

-Chapter 1 deals with general introduction, objectives of the work. The scope ofthe work as well as thesis layout is also included in this chapter.

-Chapter 2 deals with literature review carried out by the researchers previously and it includes brief summary on various study in SMA with varying fiber and bitumen content.

-Chapter 3 includes experimental work for the thesis. It includes all the tests that are to be performed.

-Chapter 4 includes experimental results which are analyzed after performing tests. Comparison with the help of graph and analysis are done.

-Chapter 5 deals with conclusion drawn from experiment. Also includes future scope and references.

Chapter 2

LITERATURE REVIEW

There has been many works going ahead at once and many effectively completed which can't be seen unless the proper literature survey is done. It is the most essential part to begin with, examines or any creative doing to in any event have the fundamental information on the research topic. It gives the information of past works, consequences of it in order to empower on the subject. Here in this theme the review works is primarily carried on the Stone Matrix Asphalt, properties, materials and its utilization. Also, the fiber which I used is Bamboo Fiber and Coir Fiber which helped in finding different properties, attributes from the prior studies on the subject.

1.[Ebenezer Akin Oluwasola etal,2015]

The main aim of this research is reuse of waste products from industries as it degrades our environment. Various waste products like coal ash, slag and silica fumes are used for the road construction. By using the combination of CMT and EAF as an aggregates the author wants to reduce the construction cost of pavement. Type of binder used are PG76-22 and penetration grade 80/100.Four type of mixtures were prepared with total of 344 samples.Mix1-100%granite,Mix2-80%granite and20%CMT,Mix3-80%CMT and 20% EAF,Mix4-40%granite+40%EAF+20%CMT.Indirect tensile strength test was done as per ASTM 2011 specification. Moisture susceptibility test done as per AASHTO 2007.Dynamic creep test as per ASTM 2003 and rutting test as per AASTHO 2008.The aggregates fulfilled the specifications and standards but with the exception of water absorption test,Mix3 was less prone to rutting as compared to other mixes. So it can contribute to green technology.

2.[Ganapathi Malarvizhi etal,2012]

The main purpose of present research is to reduce the environmental pollution due to vehicle tyres and polythene as they are not easily biodegrable.Here SMA properties are improved by using the combination of crumed rubber(15%) and low density polythene(30%).Dry process was used with binder of grade 60-70 was used. No fiber was used. Tests performed were Marshall test, drain down test, unconfined compression test and indirect tensile strength ratio test. Compressive strength value was improved by using C.R and LDPE.SMA mixes showed better stone-stone contact. Optimum dosage of additives was 30%.Based upon the results CR+LDPE can be used as an additives without any change in SMA design.

3.[OP Mittal et al,2016]

The present study makes use of rice husk ash, plastic bottles and tubes tyres which are no longer in use with DBM of grade1 as a partial substitute of bitumen content. Study is also made on CRMB and PMB in DBM GRADE 1.The researcher uses DBM as it can sustain heavy commercial traffic and large variation in gradation is possible. For DBM design Marshall Mix design method was adopted. Various test for bitumen and aggregates were done. The results depicts that stability value increases by 13.3% with 6%of rice husk ash but the stability value decreases with the increase in percentage of rice husk content and flow value is satisfied if bitumen is changed by 8% of plastic waste. In the end the researcher concludes that the rice husk showed the highest stability value as compared to other two materials.

4.[S.S Awanti et al,2013]

This paper depicts the outline and investigation of natural fiber in SMA by using coconut fiber which is present in abundant quantity. Another fiber used is cellulose fiber. Here the comparison is made between PMB-70 with coir fiber as stabilizers with VG 30 grade bitumen with coir and cellulose fibers as stabilizers. Design were done as per IRC-SP-79-2008.Various test were done to determine the physical properties of aggregates, mineral filler and bitumen. Other test includes static indirect tensile strength test, permanent deformation test, drain down test for fiber and indirect tensile fatigue test.The results obtained for

PMB-70 with coir fiber is 0.3% higher than SMA with VG-30 with coir fiber as stabilizers. From the outcomes it was discovered that PMB-70 with coir fiber showed higher fatigue life and higher rut resistance as compared to the mixtures of VG-30.

5.[Edwin Fabián Garcia-Aristizabal et al,2016]

The main objective of this research is to built houses for low income families. For this the materials used is soil which is present in abundant quantity in nature. In this research soil-cement block is used with sisal fiber and mineral wool fiber. Various samples were prepared by varying the ratios of soil with sisal and mineral wool fiber at different temperature conditions until the formation of soil block by using hydraulic press. Various tests were done to determine the physical and mechanical properties like bending strength, accelerated erosion, compression resistance test.The result obtained shows a large variation in chemical and geometrical properties of soil-cement block by using sisal and mineral wool fiber as it lead to decrease its density and small increase in abrasion resistance. By addition of 1% of mineral wool waste compression resistance value increased by 29% as compared to normal sample. In the end the researcher concludes that the use of soil-cement block is useful for developing countries.

6.[Metin Guru et al,2016]

This paper depicts outline and investigation of molasses which is waste product of sugarcane and MBOC which is molasses based boron oxide. MBOC is prepared in laboratory by using molasses and sulphuric acid as a catalyst. Binder used is of grade 50-70.The sample was prepared by using molasses and MBOC as an additive between 1% to 10% by weight of base bitumen. The tests performed were penetration, softening point, ductility, dynamic shear rheometer, Nicholson stripping test and Marshall test. A relative study has been made between molasses and MBOC, the results obtained were the increase in penetration by using 5% molasses and also decrease in softening point and viscosity. With the increase in concentration of MBOC results in the increase of viscosity and softening point and decrease in penetration. By using molasses ductility increases whereas it decreases with the use of MBOC. It was watched that Stability value was unchanged by using molasses whereas by using MBOC stripping resistance and Marshall Stability value improved significantly.

7.[Swayam Siddha Dash et al,2013]

This work is done on the use of cold mix especially in hilly, heavy rainfall areas and forest areas as there is difficulty in using hot mix technique. As the hot mix technique is widely used in our country but its excessive usage degrades the environment and also increase the cost of construction of pavement. In cold mix technology first water is added to the aggregates then emulsion is added at room temperature. Additives used were fly ash, lime and cement. Filler materials used were stone dust. MORTH(2001) specifications for dense gradation and for gap gradation IRC SP-79 specifications were used. Physical property of binder(CMS) and coarse aggregates were determined. Method of compaction were Marshall and gyratory. The results obtained were as the compaction level is increased the level of its field application also increases. Stability value increases with the increase in number of gyration. Additives improved the stability values. In the end it was seen that the dense graded cold mixes showed better stability values as it showed higher deformation and lesser indirect tensile strength test as compared to SMA.

8.[Ravada Surendra Dikshith et al,2012]

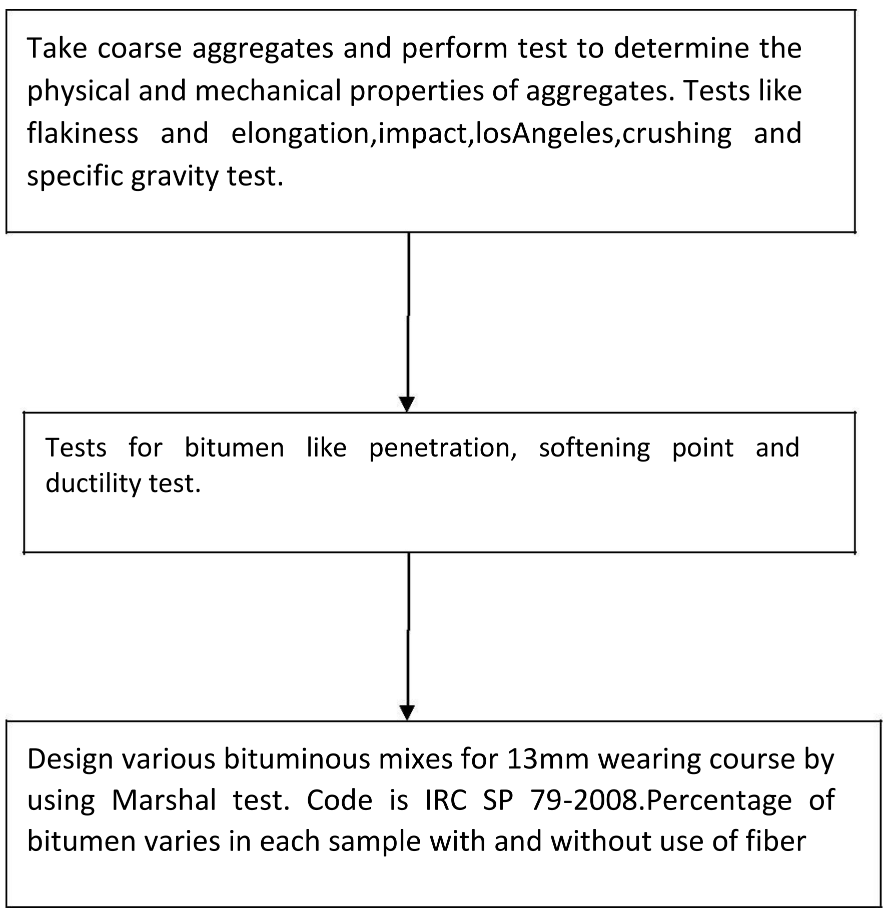
A review is given regarding the use of natural occurring fiber i.e. banana fiber as a stabilizing agent in SMA mixtures and also check various engineering properties with and without the use of fiber. The aggregates were taken as per MORTH specifications. Cement is used as filler and bitumen of grade 60-70 were used. .Various test for determining the physical property of aggregates and bitumen were performed. SMA methodology was followed by drain down test and static indirect tensile test. The results obtained were the flow value was higher by the use of fiber and it also showed higher stability value .Higher VMA value by using 6% binder content with fiber was obtained. No drain down was found by using fiber. Higher is the temperature lower is the indirect tensile test value of SMA. In the end the researcher concludes that the banana fiber can be used for pavements carrying heavy volume of traffic.

Chapter 3

METHODOLOGY

3.1. INTRODUCTION

In this study materials used are coarse aggregates, Fine aggregates, Filler, Binder and Stabilizer. Here coarse aggregates used is stone aggregates. Bitumen of grade 60-70 is used as a binder material which is most suited for Indian roads. Hydrated lime is used as a filler material. Two types of natural stabilizers are used namely Bamboo fiber and Coir fiber whose results are compared. Methodology is divided into following three sections-Test for aggregates, test for bitumen, Marshall test of SMA with and without additives.



IMPACT TEST

This test is done to determine the toughness of aggregates which may break down due to repeated traffic wheel load. This test is standardized by Bureau of Indian Standards (BIS).The aggregates passing through 12.5mm sieve and retained on 10mm sieve. Then aggregates are dried in an oven for4hrs at 100-110^{o}C. Aggregates are filled in a measure by one third and are given 25 blows by tampering rod. Procedure is repeated by filling remaining two-third aggregates. Now the test sample is placed in impact testing machine. Hammer of weight 13.5-14kg is made to free fall from 380mm height on the sample. Sample is subjected 15 such blows. Then aggregates are passed through 2.36mm sieve.

Fig.3.1 Impact test

Aggregates Impact Value(AIV)= 100 W_2/W_1

W_1=oven dry weight of aggregates.

W_2=weight of aggregates passing through 2.36mm sieve.

Table 3.1 Results of Impact Test

S.NO	A	B	B/A	B/A*100	Impact value
1	400	40	40/400	10	10
2	400	35	35/400	8.75	8.75

Average impact value=9.375%.It indicates that aggregates are exceptionally tough.

AGGREGATES CRUSHING VALUE TEST

In construction of road coarse aggregates are normally used so the aggregates should be strong enough to resist heavy traffic wheel load. This test is done as per IS:2386(iv)-1963.Aggregates which passes through 12.5mm sieve and retained on 10mm sieve are dried in an oven for 4 hours at 100-110^{o}C. The cylindrical apparatus are filled in three layers with 25 blows in each layer. Now it is weight.(X)The aggregates are then placed in compression testing machine load is applied@40 tons in 10 minutes. Now it is sieve in 2.36mm sieve(Y)

Fig.3.2 Crushing test

Aggregates crushing value(ACV)=100Y/X

Y=weight passing through 2.36mm sieve.

X=weight of aggregates in grams.

Table 3.2 Results of Crushing Test

Observation	X	Y	(Y/X)*100	ACV
1	3000	540	(540/3000)*100	18
2	3000	538	(538/3000)*100	17.93

Average Aggregates crushing value=17.965%

LOS ANGELES TEST

This test is done to determine abrasion action between aggregates and steel ball used as a abrasive charge.This test is done as per IS 2386(part iv)-1963. Take 5 kg of oven dried aggregates for category A,B,C,D and 10kg for category E,F and G. Put in the machine and rotate machine at speed 30-33 revolutions per minute. Stop the machine and sieve it through 1.7mm sieve. Take weight retained on this sieve.

Fig. 3.3 los Angeles

Los Angeles Abrasion Value[(W_2-W_1)/W_1]*100

W_1=original weight of aggregates in gram

W_2=Weight retained on 1.7mm sieve.

Table 3.3 Results of Abrasion Test

W1	W2	W1-W2	Abrasion value
5000	4199	801	16.02%

SPECIFIC GRAVITY TEST

Specific gravity is defined as the ratio mass of given volume of sample to the mass of equal amount of water.This test is done as per BIS 2386-3(1963). Take 3kg of coarse aggregates and immerse in water for one day. Now the sample in weighted in water and buoyant weight is determined. Aggregates are dried in an oven at 100-110degree centigrade and weighed.

Fig. 3.4 Specific Gravity

Specific Gravity=$W_4/[W_3-(W_1-W_2)]$

Water Absorption=(W3-W4/W4)*100

W_1=wt of sample+wirebucket+water=3350gm

W_2=mass of bucket suspended in water=2732gm

W_3=wt of saturated surface dry sample=994gm

W_4=oven dry weight=980gm

Specific gravity=2.606

Water absorption=1.428%

COMBINED FLAKINESS AND ELONGATION TEST

This test is done to determine the flaky and elongated particles as these particles have less strength and durability.This test is done as per MORTH.Take the sample and sieve it from 63-6.3mm IS sieve.Weight flaky material passing through the gauge. Weight the elongated material that are retained on length gauge.

Fig.3.5Flakiness and elongation test

Total weight=2.579kg

Flakiness Index=(X1+X2+X3+..Xn)*100/Total weight

=(0+0+157+158+204.5+92+1.5)*100/2579

=23.78%

Elongation Index=(Y1+Y2+Y3+…Yn)*100/Total weight

=(0+0+107.5+0+587+252.5+24)*100/2579

=38.3%

Since the combined flakiness and elongation value(62.08%) which exceeds the maximum permissible value(30%),it means this aggregate is not good.

PENETRATION TEST

The main aim of this test is to classify the bitumen into various grades. This test is done as per IS:1203-1978.Penetration is defined as depth in tenths of mm that a needle of standard size would penetrate into the bitumen sample.Instrument used is pentameter. Firstly the bitumen is soften by heating it in between 75-100^{o}C. Then the sample is properly stirred to remove air bubbles. Now keep the bitumen sample at room temperature for 90 minutes. Transfer the sample into water bath for another 90 minutes. After that keep the sample in the apparatus and adjust the needle and set the dial gauge to zero. Record the reading by realizing the needle for five seconds. Take the average of three readings.

Fig.3.6.Penetration test

Table 3.4 Results of penetration test

S.NO	Initial reading of dial guage	Final reading of dial guage	Dial guage reading	Penetration value
1	193	254	61	61/10 =6.1
2	255	323	69	69/10 =6.9
3	295	365	70	70/10 =7.0

The mean value of three readings are taken.
Penetration value(mm)=67

SOFTENING POINT TEST

The main of this test is to determine the softening point of bitumen at a specified temperature. This test is done as per IS:1205-1978.First the bitumen is heated between 75-100degree centigrade. Prepare ring-ball apparatus by filling the material in the ring. Arrange the sample with thermometer and distilled water at 5degree centigrade per minute. Continue heating until the material softens and allow the ball to pass through the ring. Note the temperature at which the bitumen softens.

Fig.3.7.Softening point

Temperature at which bitumen softens=47degree centigrade.So it is VG-

DUCTILITY TEST

Ductility is defined as distance in cm to which a bitumen will stretch before rupture when it is pulled apart at a specified temperature and speed. This test is done as per IS:1208-1978.Firstly heat the sample at 75-100⁰C.Apply the mould on brass plate and pour the material. Allow it to cool for half hours at room temperature and another 30 minutes. Place the brass plate and briquette specimen in water bath at 27 ⁰C for 85-95 minutes. Place the specimen in testing machine and a pull at specified speed until the briquette breaks. Note that distance in cm.

Fig3.8.Ductility test

Table 3.5 Results of ductility test

NO	Ductility
1	50.5
2	40.5
3	50.5

Average ductility=47.16mm
So as per BIS it is V.G30.

MARSHALL TEST

Marshall test is done to find out the stability and flow value. For this test code followed is IRC SP-79 -2008.and gradation is done according to that. Size of aggregates is 13mm used for wearing course of the pavement. The aggregate aredried and then graded as per IRC:SP-79 code. Weighed taken is about 1200 gram. Height of 63.5 + 1.3 mm is given when compacted in the mould. The aggregate is heated upto a temperature of 150-160 °C not higher than above the binder temperature for 60 minutes. Bitumen of required quantity is weighted and heated individually at the temperature of 170-190 °C .After that the aggregate are heated in mixing bowl and binder of required percentage is mixed properly by manual method. The mixing temperature is kept within the limit that is set for the binder temperature. Mould of 101.6 mm diameter and 76.2 mm height is used with base plate and an extension collar. For pouring thewhole mix a filter paper is placed at the bottom. Now place the mould in the compactionpedestal and give 75 blows without fiber and 50 blows with fiber by a 4.86kg standard hammer falling at a height of 450mm.Then same treatment is given by reversing the mould on the other side. The specimen is removed from the mould and kept at a room temperature of one day. Now many samples are prepared by varying the percentage of bitumen content. The mould is kept in hot water bath at 60degree centigrade for 30 minutes. Finally check the stability and flow value by using Marshall Stability apparatus.

Fig3.9.Marshall test

Chapter-4

EXPERMENTATION

4.1Sieve Analysis-Sieve analysis is done as per IRC:SP-79 and aggregates are arranged according to their respective sizes so as to obtain 1200gm of sample.Here the gradation table is made with and without fiber.

Table 4.1Gradation chart for 13mm mix as per IRC:SP-79

IS sieve	Cumulative% of aggregates passing	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

Fig4.1Sieve analysis

Table 4.2 Gradation table with fiber

Sieve size (mm)	% retained	4%	5%	5.5%	6%	7%
13.2	5	57.42	56.82	56.62	56.22	55.62
9.5	33	378	375.012	373.032	371.052	376.092
4.75	29.5	338.778	335.238	333.468	331.698	328.158
2.36	8	91.872	90.912	90.432	89.952	88.992
1.18	3.5	40.194	39.774	39.564	39.354	38.93
0.6	2.5	28.71	28.41	28.56	28.11	27.81
0.3	2.5	28.71	28.41	28.56	28.11	27.81
0.15	4	45.396	45.456	45.216	44.976	44.496
0.075	1.5	17.226	17.046	16.956	16.88	16.686
Filler	10.5	120.586	119.322	118.692	118.062	116.802
Binder		48	60	66	72	84
Fiber		3.6	3.6	3.6	3.6	3.6

Table 4.3 Gradation table without fiber

Sieve size (mm)	% retained	4%	5%	5.5%	6%	7%
13.2	5	57.6	57	56.7	56.4	55.8
9.5	33	380.16	376.2	374.22	372.24	368.28
4.75	29.5	339.84	336.3	332.53	332.76	329.22
2.36	8	92.16	91.2	90.72	90.24	89.28
1.18	3.5	40.32	39.9	39.69	39.44	39.06
0.6	2.5	28.8	28.5	28.35	28.2	27.9
0.3	2.5	28.8	28.5	28.35	28.2	27.9
0.15	4	46.08	45.6	45.36	45.12	44.64
0.075	1.5	17.28	17.1	17.01	16.92	16.74
Filler	10.5	120.96	119.7	119.07	118.4	117.18
Binder		48	60	66	72	84

4.2 Sample Preparation

The following steps are discussed below:

Sample weight

Here 5 samples are made by using binder content 4%,5%,5.5%,6% and 7%.So weight the sample as per gradation table..Fiber of 0.3% of weight is taken for making 3 samples of each binder content.

Heating of sample

Once the sample of 1200gm is made by gradation the sample is kept in an oven at 130 degree centigrade for one day.Care must be taken for fiber so that it may not get burnt.

Bitumen Heating

Bitumen of grade 60-70 is heated to very high temperature so that it mixes properly with fiber,filler and aggregates.

Fig4.2.Bitumen heating

Mixing

Here all the components are mixed properly to make homogeneous mix sample.

Mould

Now the sample is kept in a mould of radius 50mm for sample preparation.Mould is pre-heated so as to make proper sample.

Fig4.3.Mould

Compaction

Compaction is done with the help of cylindrical hammer of weight 4.8kg.Normally 50 blows is given on each side of sample with fiber and 75 blows is given on each side without fiber.

Fig.4.4.Hammer

Sample finalization

After compaction sample is named is named according to binder content for reconization.

4.3Experiments performed

Here the marshall test is performed on the sample.This test is done as per ASTMD-6927-06.This test is done to determine stability and flow value of the specimen.Firstly the dry weight of the sample is noted and then weight of sample in water is also recorded.Before placing the sample in water wax(heated wax) is applied on it so that the water may not enter into the sample. Weight of waxed sample is noted. Now the sample can be placed in water bath @600 C for half hours.Now the sample is ready for testing.

Fig4.5.Marshall testing machine

Marshall test on specimen

The sample is placed in marshall testing machine and load is applied @50.8mm/min until it is broken.For stability 25KN dial guage is used.Stability is defined as the total maximum load obtained on a dial guage.Correction factor is also applied when the average thickness is not 63.5mm or volume is not in the range 509-522cm^3.It is find out by maximum load in kg*correction factor gives the corrected value of Marshall Stability.Flow value is the vertical deformation of the test specimen corresponding to the maximum load,expressed in 0.25mm units is recorded as the flow value.The parameters to be calculated includes VA,VMA,Gmm,Gmb,Gsb by using their specific gravity and weight in and outside the water.

Fig4.6.Specimen after loading

Table 4.4Correction factors

Volume of specimen (cm^3)	Average thickness of specimen,mm	Correction factors
444-456	55.6	1.25
457-470	57.2	1.19
471-482	58.7	1.14
483-495	60.3	1.09
496-508	61.9	1.04
509-522	63.5	1.00
523-535	65.1	0.96
536-546	66.7	0.93
574-559	68.3	0.89
560-573	69.8	0.86

4.4 Experimentation result

Table 4.5 Stone aggregates without fiber

Sample Nos	Bitumen Content (%)	Temp	Wt before paraffin coating (gm)	Wt after paraffin coating (gm)	Wt in water (gm)	Ht (mm)	Wt of Aggregate Mix(gm)	Flow (mm)	Load Taken (KN)
4.1	4	160	1193	1211	708	64	1162	3.2	295
4.2	4	160	1184	1198	698	64.5	1162	2.5	255
4.3	4	160	1186	1201	702	65	1162	3.1	285
5.1	5	160	1180	1198	708	62.5	1140	4	350
5.2	5	160	1195	1199	700	63.1	1140	4.7	320
5.3	5	160	1182	1208	718	63.15	1140	3.7	290
5.5.1	5.5	160	1182	1191	748	56	1140	3.8	220
5.5.2	5.5	160	1178	1185	755	57	1140	4.2	280
5.5.3	5.5	160	1180	1188	756	62	1140	4.9	330
6.1	6	160	1202	1206	742	58.5	1128	4.6	270
6.2	6	160	1192	1202	755	57	1128	4.4	325
6.3	6	160	1186	1196	752	58.5	1128	5.4	250
7.1	7	160	1182	1211	708	61	1116	5.5	450
7.2	7	160	1184	1214	711	60	1116	5.6	475
7.3	7	160	1187	1213	712	60	1116	4.8	480

Table 4.6 Stone aggregate with bamboo fiber

Sample Nos	Bitumen Content (%)	Temp	Wt before Paraffin coating (gm)	Wt after paraffin coating (gm)	Wt in water (gm)	Height (mm)	Wt of Aggregate Mix (gm)	Flow (mm)	Load Taken (KN)
4.1	4	160	1184	1194	709	65	1162	3.6	355
4.2	4	160	1180	1185	704	63	1162	4.1	370
4.3	4	160	1179	1188	705	62	1162	3.1	430
5.1	5	160	1200	1207	719	57	1140	4.9	405
5.2	5	160	1194	1202	712	58	1140	5.2	330
5.3	5	160	1186	1195	710	57.5	1140	3.8	390
5.5.1	5.5	160	1174	1185	745	57.5	1140	4.5	475
5.5.2	5.5	160	1178	1188	746	57	1140	4.3	480
5.5.3	5.3	160	1194	1202	750	57.5	1140	5.2	415
6.1	6	160	1193	1203	757	59	1128	4.1	410
6.2	6	160	1202	1211	743	58	1128	5.5	390
6.3	6	160	1203	1214	748	60	1128	4.4	335
7.1	7	160	1182	1191	751	57.5	1116	5.1	375
7.2	7	160	1180	1187	753	57	1116	4.9	365
7.3	7	160	1179	1185	748	63.5	1116	5.7	325

Table 4.7 Stone aggregate with coir fiber

Sample Nos	Bitumen Content (%)	Temp	Wt before paraffin coating (gm)	Wt after paraffin coating (gm)	Wt in water (gm)	Height (mm)	Wt of aggregate mix (gm)	Flow (mm)	Load Taken (KN)
4.1	4	160	1145	1175	680	56	1162	2.9	265
4.2	4	160	1186	1216	681	57	1162	2.8	255
4.3	4	160	1150	1180	682	56	1162	2.7	270
5.1	5	160	1180	1197	671	57	1140	3.1	270
5.2	5	160	1185	1205	685	58	1140	3.2	255
5.3	5	160	1190	1208	687	57	1140	3.3	250
5.5.1	5.5	160	1202	1215	685	57	1140	3.6	280
5.5.2	5.5	160	1181	1192	691	56	1140	3.8	305
5.5.3	5.5	160	1185	1194	690	57	1140	3.7	300
6.1	6	160	1193	1202	692	58	1128	4.1	235
6.2	6	160	1185	1194	693	57	1128	4.3	230
6.3	6	160	1187	1197	694	58	1128	4.4	240
7.1	7	160	1171	1206	670	58	1116	4.5	205
7.2	7	160	1190	1198	680	56	1116	4.6	210
7.3	7	160	1185	1196	678	58	1116	4.7	215

Chapter 5

ANALYSIS

5.1 INTRODUCTION

In this section analyzation is done from the results obtained from the test.The results are compared with one another in order to determine the meaningful relationship.The results are shown either in tabular form or in a graphical form.Here all the parameters are find out and the value of Gsb,VA,VMA are used to plot the graph.

5.2 CALCULATIONS

Theoretical Maximum Specific Gravity of the mix(Gmm)

Gmm=Wt of mix/Volume of the (mix air voids)

Bulk specific gravity of the mix(Gmb)

Gmb=Wt of mix/Bulk volume of the sample

Percentage of the aggregate present(Ps)

Ps=Wt of aggregate/Wt of mix

Air voids(VA)

VA=[(Wt of mix/Gmb-Wt of mix/Gmm)/(Wt of mix/Gmb)]*100

Bulk specific gravity of aggregate(Gsb)

Gsb=Wt of aggregate/Vol of(aggregate mass+air void in aggregate+absorbed bitumen)

Voids in mineral aggregates(VMA)

VMA=[(Wt of mix/Gmb-Wt of mix*Ps/Gsb)/(Wt of mix/Gmb)]

Table 5.1 Analysis for Stone aggregate without fiber

Sample Nos	Bitumen Content (%)	Bulk volume of sample	Gmb	Ps	Gmm	VA (%)	Gsb	VMA (%)	Stability (KN)
4.1	4	502	2.407	0.96	2.61	7.8	2.71	14.8	5.82
4.2	4	500	2.396	0.97	2.61	8.2	2.71	14.3	5.80
4.3	4	500	2.406	0.96	2.61	7.82	2.71	14.7	5.72
5.1	5	490	2.444	0.95	2.57	5.0	2.74	15.3	7.20
5.2	5	499	2.402	0.95	2.57	6.53	2.74	11.3	6.31
5.3	5	490	2.465	0.94	2.57	4.1	2.74	10	6.91
5.5.1	5.5	443	2.688	0.95	2.94	8.5	3.6	28.5	8.23
5.5.2	5.5	430	2.755	0.96	2.94	6.3	3.6	26.3	7.24
5.5.3	5.5	432	2.750	0.95	2.94	6.4	3.6	26.7	7.38
6.1	6	464	2.590	0.93	2.88	10.1	3.22	25	6.74
6.2	6	447	2.680	0.94	2.88	7.0	3.22	21.8	7.2
6.3	6	444	2.693	0.94	2.88	6.6	3.22	21.5	7.3
7.1	7	503	2.407	0.93	2.54	5.3	2.77	19.2	5.49
7.2	7	503	2.413	0.92	2.54	5.0	2.77	19.9	6.20
7.3	7	501	2.421	0.92	2.54	4.7	2.77	19.6	5.70

Table 5.2 Analysis for Stone aggregates with bamboo fiber

Sample Nos	Bitumen Content (%)	Bulk Volume Of sample	Gmb	Ps	Gmm	VA (%)	Gsb	VMA (%)	Stability (KN)
4.1	4	485	2.461	0.97	2.98	17.42	3.16	24.4	5.82
4.2	4	481	2.463	0.98	2.98	17.35	3.16	23.6	6.05
4.3	4	483	2.459	0.98	2.98	17.48	3.16	23.7	6.02
5.1	5	488	2.473	0.94	2.94	15.9	3.19	27	8.406
5.2	5	490	2.453	0.95	2.94	16.5	3.19	26	8.432
5.3	5	485	2.463	0.95	2.94	16.5	3.19	26.9	8.12
5.5.1	5.5	440	2.693	0.96	2.94	8.4	3.19	18.8	8.24
5.5.2	5.5	442	2.687	0.95	2.94	8.6	3.19	19.2	7.98
5.5.3	5.5	452	2.659	0.94	2.94	9.5	3.19	20.9	9.0
6.1	6	446	2.697	0.94	2.94	8.3	3.25	22	8.56
6.2	6	468	2.587	0.93	2.94	12	3.25	26	7.21
6.3	6	466	2.605	0.93	2.94	12	3.25	26	7.86
7.1	7	440	2.706	0.94	2.88	6.04	3.22	21	7.35
7.2	7	434	2.735	0.94	2.88	5.03	3.22	20.15	6.50
7.3	7	430	2.755	0.94	2.88	4.35	3.22	19.58	6.97

Table 5.3 Analysis for Stone aggregate with coir fiber

Sample Nos	Bitumen Content (%)	Bulk volume of sample	Gmb	Ps	Gmm	VA (%)	Gsb	VMA (%)	Stability (KN)
4.1	4	495	2.373	0.98	2.99	20.6	3.18	26.8	8.2
4.2	4	535	2.272	0.95	2.99	24.0	3.18	32.0	7.5
4.3	4	498	2.369	0.98	2.99	20.7	3.18	27.0	7.7
5.1	5	526	2.275	0.95	2.57	11.4	2.74	16.9	8.2
5.2	5	520	2.317	0.94	2.57	9.8	2.74	20.5	7.5
5.3	5	521	2.318	0.94	2.57	9.8	2.74	20.4	7.8
5.5.1	5.5	530	2.292	0.93	2.93	21.77	3.24	33.64	8.2
5.5.2	5.5	501	2.379	0.95	2.93	18.8	3.24	29.80	8.6
5.5.3	5.5	504	2.369	0.95	2.93	19.14	3.24	30.20	8.5
6.1	6	510	2.356	0.93	2.94	19.80	3.25	32.0	7.5
6.2	6	501	2.383	0.94	2.94	19.86	3.25	31.85	7.6
6.3	6	503	2.379	0.94	2.94	19.08	3.25	31.20	7.4
7.1	7	536	2.25	0.92	2.88	21.80	3.21	29.0	6.7
7.2	7	518	2.312	0.93	2.88	19.72	3.21	33.0	6.8
7.3	7	518	2.308	0.93	2.88	19.86	3.21	33.10	6.6

Chapter 6

RESULTS&DISCUSSIONS

6.1RESULTS

Table 6.1 Stability vs Binder content

Binder (%)	Avg stability without fiber (KN)	Avg stability with bamboo fiber (KN)	Avg stability with coir fiber (KN)
4	5.78	5.96	7.80
5	6.80	8.31	7.83
5.5	7.61	8.40	8.43
6	7.08	7.87	7.50
7	5.79	6.94	6.70

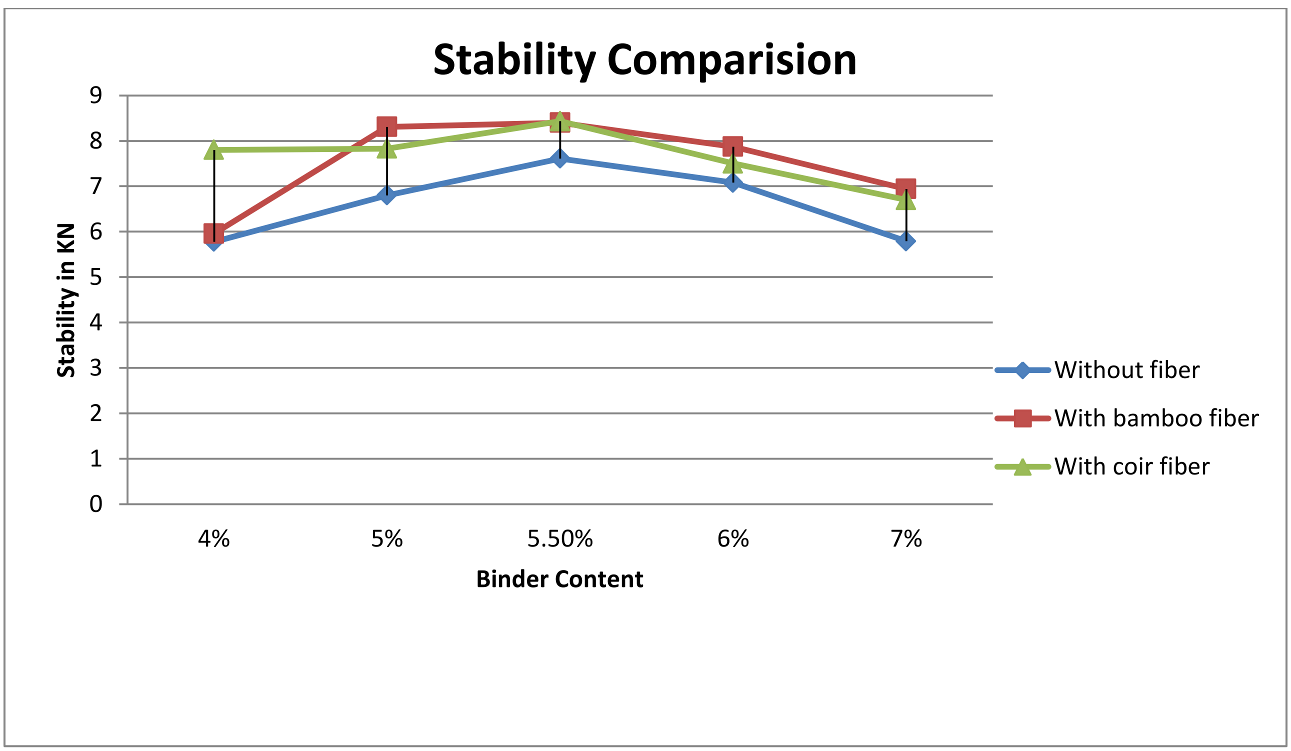


Table 6.2 Flow vs Binder content

Binder content (%)	Avg flow value without fiber (mm)	Avg flow value with bamboo fiber (mm)	Avg flow value with coir fiber (mm)
4	2.93	3.60	2.80
5	4.13	4.63	3.20
5.5	4.30	4.66	3.70
6	4.80	4.60	4.26
7	5.30	5.23	4.60

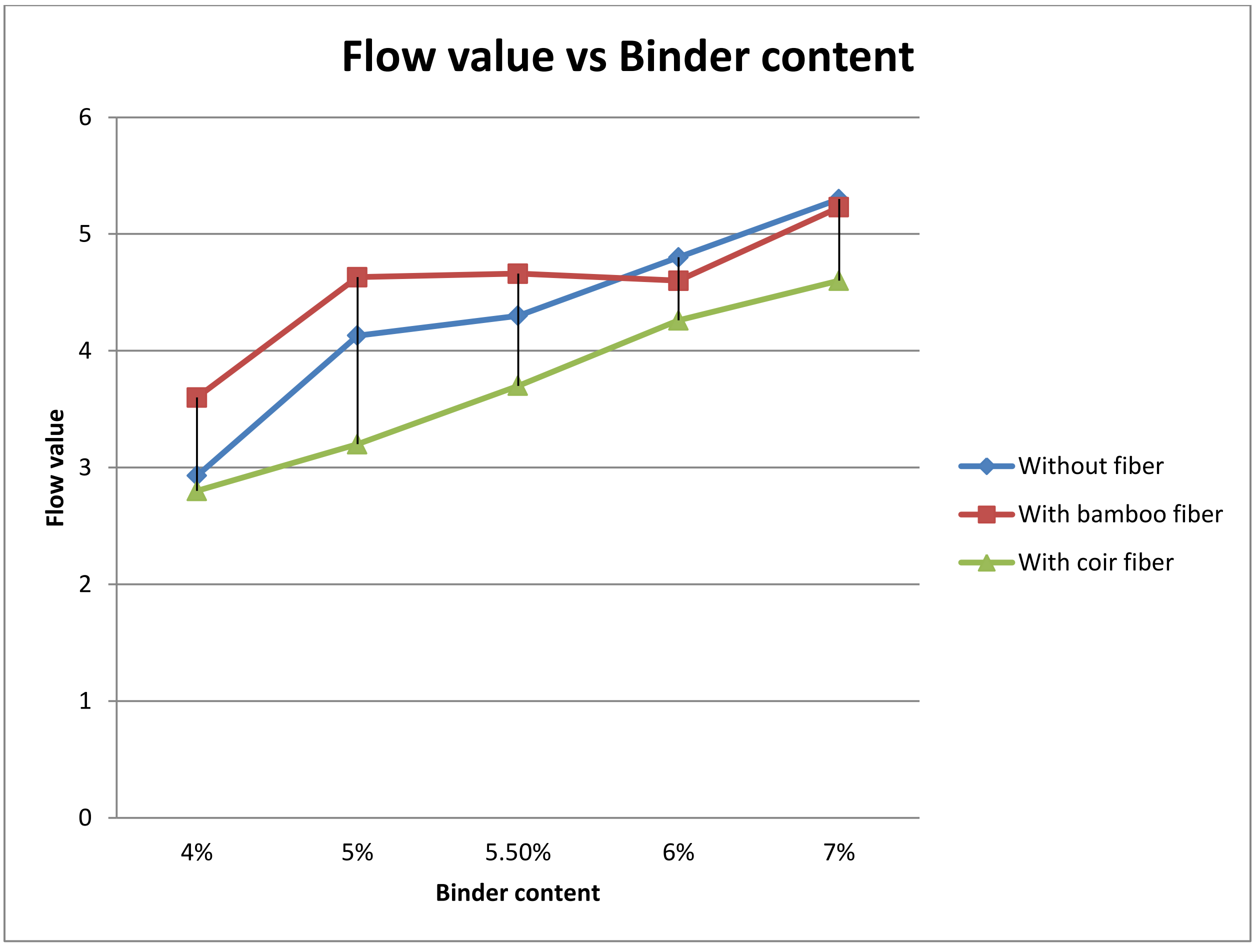


Table 6.3 VA vs Binder content

Binder content (%)	Avg VA without fiber (%)	Avg VA value with bamboo fiber (%)	Avg VA value with coir fiber (%)
4	7.94	17.42	21.76
5	5.22	16.30	10.33
5.5	7.06	8.83	19.90
6	7.90	10.76	19.58
7	5.00	5.14	20.46

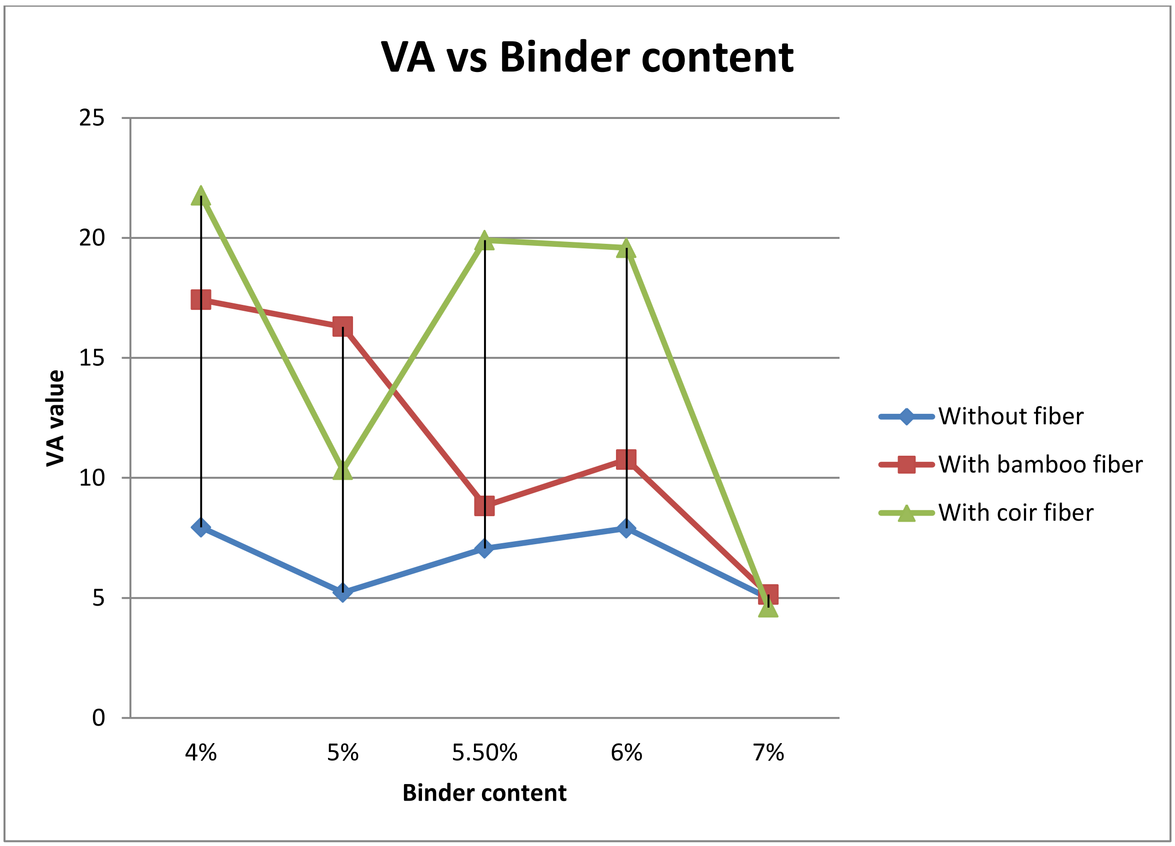
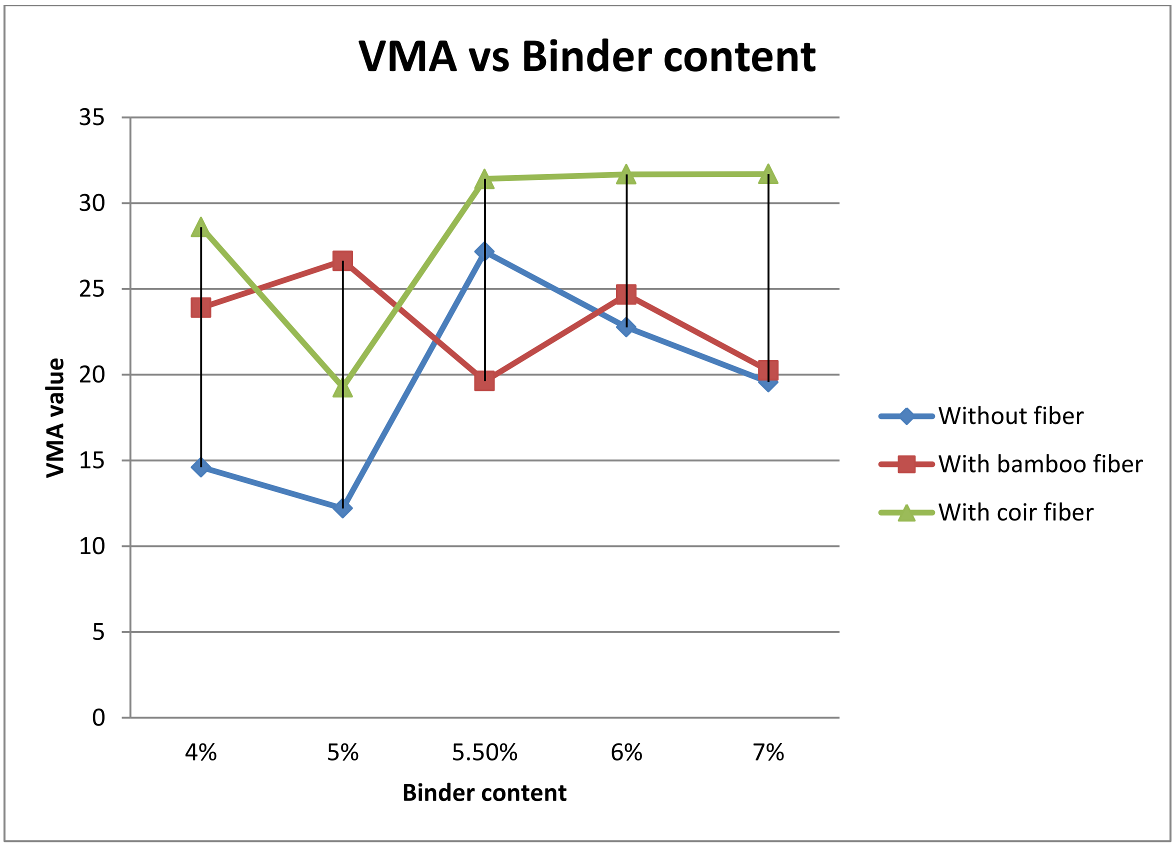


Table 6.4 VMA vs Binder content

Binder content (%)	Avg VMA without fiber (%)	Avg VMA value with bamboo fiber (%)	Avg VMA value with coir fiber (%)
4	14.60	23.90	28.60
5	12.20	26.63	19.26
5.5	27.16	19.63	31.41
6	22.76	24.66	31.68
7	19.56	20.24	31.70



6.2 Dicussions

The coir fiber has given quite better results followed by SMA design with bamboo fiber and without any fiber.Coir fiber with stone aggregates has given best stability value than bamboo fiber.Maximum flow value was given SMA mix without any fiber followed by bamboo and coir fiber.So the use of coir fiber as a stabilizer over bamboo fiber will be much effective in consideration of stability and flow value.

Chapter 7

CONCLUSION&FUTURE SCOPE

7.1Conclusion

-Stability value first increases with increase in binder content then at a certain point it decreases gradually.Firstly it increases because bond between binder and aggregates becomes stronger and it decreases because applied load is transmitted as hydrostatic pressure making fractions across contant point immobolized.This makes the mixture weak against plastic deformation and stability falls.From the graph the average stability value of coir fiber is highest(8.43KN) followed by bamboo fiber(8.40KN)and without fiber SMA mix(7.61KN).

-Flow value increases with the increase in binder content because at lower binder content the mixes provides more stability as its homogenity is not much disturbed but it is lost when binder content is increased.From the graph coir fiber has the least flow value(2.80mm) followed by bamboo fiber and mix without fiber mix.

-OBC is found to be 5.5%.It is found where maximum stability occurs.

-VA decreases with the increase in binder content because air voids is filled progressively.At 7% binder content the VA value of coir fiber is much more than bamboo and without fiber mix due to improper mixing.

-VMA at 6% binder content with coir fiber gives quite expected results(more values) than bamboo and without fiber.

-The use of coir fiber provides better stability as compared to bamboo fiber.

7.2Future Scope

-Natural fiber used here is coir and bamboo fiber has shown stasisfactory results used by varying the binder content.Other natural fibers can be used like sisal, banana,jute etc.

-Here binder used is VG30 so these natural fibers can be used by varying the binder like VG10,VG20 etc.

-The different fillers can be tried like cement,flyash etc.and different tests can be performed on it.

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