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Enhancing the Properties of Stone Mastic Asphalt Using Bagasse and Coir Fiber as Additives

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Abstract: Stone mastic asphalt is recognized for its remarkable durability, making it a crucial component for constructing pavements on aerital roads, which must withstand heavy traffic. When road authorities choose asphalt for main roads under these conditions, they often prefer stone mastic asphalt. The most crucial aspect of this type of asphalt is ensuring that SMA is implemented correctly, as it has excellent performance characteristics. However, improper implementation can lead to changes in performance. European countries favor SMA for its outstanding performance. There have been recent advancements in SMA methods, including computation and artificial intelligent systems such as artificial neural network and fuzzy logic (ANN and FL) in various engineering fields. It is vital to consider the resilient module when discussing fuzzy logic and SMA performance characteristics. Air voids, bulk density, and permeability coefficient are some of the critical SMA features that should be evaluated when applying fuzzy logic. In the initial stages, fuzzy logic utilizes weighted average operations to input data, and the output undergoes assessment by a mathematical model. Through experimental study, applying fuzzy logic can enhance the accuracy of evaluation.
Keywords: A Stone Mastic Ashphalt(SMA), Durability of Pavement, Aerital Roads etc.

I. INTRODUCTION

Infrastructure development in India has identified the construction of new roads and strengthening of bridges as a major focus area. To create a strong and sustainable wearing course for bridge construction, mastic asphalt is the preferred material due to its desirable properties. This material is made up of a mixture of coarse aggregate, sand, limestone fine aggregate, filler, and bitumen. It has a low void content and the binder content is adjusted to completely fill the voids. Mastic asphalt is pourable and requires no compaction on site, making it an ideal surfacing material for bridges. However, the high percentage of bitumen content can cause drain down during mixture and transportation.

Stone matrix asphalt (SMA), also known as stone mastic asphalt, is a type of high-quality asphalt that was originally developed in Europe to resist rutting and improve durability in heavy traffic road. SMA has a high content of coarse aggregate that interlocks to create a stone skeleton, providing deformation resistance. The skeleton is filled with a bitumen and filler mastic that includes fibers to stabilize the bitumen and prevent drainage during transport and placement. SMA consists of coarse aggregate, filler, binder, and fiber. Its design is largely determined by the selection of aggregate grading and the type and proportion of filler and binder. SMA has improved rut resistance, durability, and good fatigue and tensile strength. It is commonly used for surface courses on high volume roads due to its benefits of wet weather friction, lower tire noise, and less severe reflective cracking. Mineral fillers and additives are used to prevent asphalt binder drain-down during construction and increase mix durability.

A. Stone Mastic Asphalt

Stone mastic asphalt (SMA) is a type of asphalt mixture used for road construction and surfacing. It is a high-quality mix that consists of large stones, sand, filler, and bitumen binder. The large stones in the mix provide a high level of durability and resistance to wear and tear, while the sand and filler help to create a smooth, even surface. The use of SMA results in a pavement that is more resistant to deformation, cracking, and potholes compared to traditional asphalt mixes. It also has improved skid resistance and can reduce noise levels compared to conventional asphalt surfaces. SMA is typically used for high-traffic roads and motorways, where a durable and long-lasting surface is essential. It can also be used in more demanding applications, such as airport runways, industrial estates, and heavy-duty truck parks.

Advantages and Uses of Stone Mastic Asphalt:

Stone mastic asphalt is a type of asphalt mix that is commonly used in paving and construction projects. Some of the main uses and advantages of stone mastic asphalt include:

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1) *Road Paving:* Stone mastic asphalt is widely used in the construction of roads, highways, and other pavements. It provides a durable and long-lasting surface that can withstand heavy traffic and weather conditions.
2) *Improved Durability:* Stone mastic asphalt contains larger stones and a higher proportion of bitumen, which makes it more resistant to damage and wear. This makes it an ideal choice for high-traffic areas and areas exposed to harsh weather conditions.
3) *Better Skid Resistance:* The larger stones in stone mastic asphalt provide improved skid resistance, making it safer for drivers and pedestrians.
4) *Reduced Noise Levels:* Stone mastic asphalt is known for its noise-reducing properties. This makes it an ideal choice for residential and commercial areas that are close to busy roads.
5) *Easy Maintenance:* Stone mastic asphalt is easy to maintain and repair, making it a cost-effective choice for long-term projects.
6) *Cost-Effective:* Compared to other asphalt mixes, stone mastic asphalt is relatively affordable and can be used for a range of projects, making it a cost-effective option for many construction and paving projects.

As we know now the stone mastic asphalt is a versatile and durable paving material that provides a range of benefits, making it a popular choice for a variety of projects

B. Bagasse

Bagasse is the fibrous residue that remains after sugarcane or other plant materials have been crushed to extract their juice or sap. It is primarily composed of cellulose, hemicelluloses, and lignin and is used as a biofuel source for the production of energy, as well as for manufacturing paper, building materials, and animal feed.

In India, bagasse is a major agricultural waste generated by the sugarcane industry. According to the Ministry of New and Renewable Energy, the country produces about 27 million tonnes of bagasse every year. While some of it is used as a fuel in the sugar mills to generate electricity and steam, a significant portion of it remains unutilized and is either burned or disposed of in landfills, leading to environmental problems.

However, in recent years, there has been increasing interest in using bagasse for various purposes such as production of biofuels, animal feed, and paper pulp. Additionally, bagasse is being explored as a potential reinforcement material in composite materials, including in the construction of low-cost housing. The Indian government has also initiated various schemes and incentives to encourage the utilization of bagasse and other agricultural waste for renewable energy production and other applications.

Hence our aim is to use Bagasse as a reinforcing matial in SMA.

C. Coir Fiber

Coir fiber is a natural fiber extracted from the husk of coconut fruit. In Stone Matrix Asphalt (SMA), coir fibers are used as a reinforcement material to improve the mechanical properties and durability of the asphalt pavement. The addition of coir fibers to the SMA mix helps to increase the tensile strength, reduce the risk of cracking, and enhance the resistance to permanent deformation.

Coir fibers are particularly useful in hot and humid climates, as they have a high resistance to moisture absorption and are less likely to break down in such conditions. The use of coir fibers in SMA also has environmental benefits as it reduces the reliance on synthetic fibers, which can be harmful to the environment.

Overall, the addition of coir fibers to SMA has been found to result in improved pavement performance, particularly in terms of rutting resistance and cracking resistance, making it an attractive option for road construction and rehabilitation projects.

II. MATERIALS USED

The Following Materials were used:

- Cement: Ordinary Portland Cement

Basic Materials and There Properties

The materials used are as follows.

- Aggregates
- Bituminous Binder
- Mineral Filler
- Bamboo Fiber
- Coir Fiber

A. Aggregate

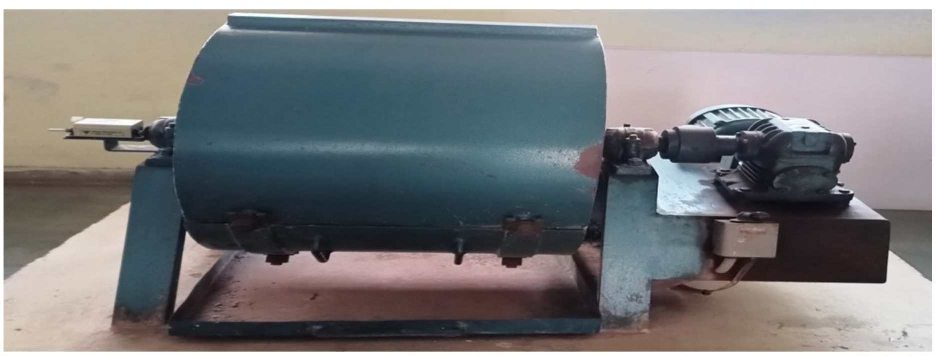
The granular component of bituminous concrete mixtures, known as aggregate, constitutes a significant portion of the mixture's weight, up to 90-95%, and contributes heavily to the load bearing and strength characteristics of the pavement. As a result, it is critical to monitor the quality and physical properties of the aggregates to ensure a well-functioning pavement. The necessary properties for suitable aggregates in pavement are outlined below:

1) Aggregates should exhibit minimal plasticity to avoid issues like swelling and bitumen adhesion caused by clay fines, which can lead to stripping problems. Clay lumps and friable particles must not exceed 1%.
2) The ability to resist weathering or durability should be evaluated through sulphate soundness testing.
3) The ratio of dust to asphalt cement, by mass, should be no more than 1.2 and no less than 0.6.
4) AASHTO T-209 is the recommended method for determining the maximum specific gravity of bituminous concrete mixes.
5) Aggregates are of 2 types. i.e.

a) Coarse Aggregate (CA)

For this study, the coarse aggregate used was naturally occurring and was retained on a 4.75mm IS sieve. To be suitable for use, coarse aggregate must be screened, crushed rock with an angular shape, free of dust particles, clay, vegetation, and organic matter. It should also possess the following characteristics:

- The Los Angeles Abrasion value should not exceed 25% (according to ASTM C131).
- The weighted average weight loss in the magnesium sulphate soundness test should not be higher than 18% (according to AASTHO T 104).
- The flakiness index should not exceed 25% (according to MS 30).
- The water absorption should not be more than 2% (according to MS30).
- The polished stone value should not be less than 40%



b) Fine Aggregate (FA)

For this study, naturally occurring fine aggregate (natural sand) that passes through a 4.75mm IS sieve was utilized. As for the fine aggregate, it must be sourced from clean, screened quarry dust that is free of clay, loam, vegetation, or organic matter. The fine aggregate should possess the following properties:

- The angularity must not be less than 45% as per ASTM C 1252.

- The methylene blue content should not exceed 10 mg/g according to the Ohio Department of Transportation Standard Test Method.
- The weighted average weight loss in the magnesium sulphate soundness test should not exceed 20% (AASTHO T 104).
- Water absorption should not be more than 2% (MS30).

Table:Physical Properties of Aggregates

Sl. No.	Physical Parameters	Results	Permissible Value
1.	Flakiness Index	13.63 %	Not to exceed 15%
2.	Elongation Index	12.71 %	Not to exceed 15%
3.	Los Angeles Abrasion Test	16.32 %	Not to exceed 30%
4.	Impact Value Test	15.55 %	Not to exceed 30%
5.	Specific Gravity	2.64	Range between 2.6 to 2.7

B. Bitumen

In this research, the type of asphalt binder used is VG30. The bitumen utilized must possess certain characteristics.

1) The selection of the bitumen grade for pavement construction must consider the prevailing weather conditions and past performance records.
2) It is advisable that the supplier's certification and testing results, along with the State project's verification samples, be used to determine the suitability of the bitumen. The acceptance procedures must provide prompt information on the physical properties of the bitumen.
3) The physical properties of the bitumen used in pavements are crucial and should be evaluated by the central laboratory or supplier tests. Each State must have specific requirements for each property, except for specific gravity.

Table: Physical Properties of Bitumen

Sl. No.	PROPERTY	RESULT	Permissible limit
1.	Specific Gravity(at 27^0C)	0.995	0.99-1.05
2.	Penetration Value(at 25^0C)	46.23 mm	60-70 mm
3.	Ductility(at 25^0C)	104.5 cm	Minimum 100 mm
4.	Softening Point	51ºC	45°C to 52°C
5.	Flash Point	267 ºC	not be less than 220°C
6.	Fire Point	345 ºC	not be less than 260°C

Table: gradation of aggregates

Sieve Size (in mm)	Wt. retained (grams)	% Wt. Retained	Cumulative % retained(by weight)	Cumulative % passing(by weight)
26.5	-	-	-	-
19	0	0	0	100
13.2	60	5	5	95
9.5	384	32	37	63
4.75	468	39	76	24
2.36	36	3	79	21
1.18	24	2	81	19
0.600	36	3	84	16
0.300	12	1	85	15
0.75	60	5	90	10
Pan	120	10	100	0

So the aggregates of different grades were sieved through different IS Sieves and they were kept in different containers with proper marking. The Naturally available Sand used is of Zone-II.

C. Mineral Filler

The fillers constitutes 8% to 12% of the mixture. In this study we have used 20% hydrated lime and 80% fine aggregates passing through 75µm for good binding properties.

Table: Specific Gravity of Filler Materials

Sl. No.	Filler	Specific Gravity
1.	Hydrated Lime	2.25
2.	Fine Aggregates	2.70

D. Coir Fibres and Bamboo

In this study two types of fibres were used Bamboo and Coir Fibre. 0.3% by weight of aggregate has been added to minimize the drain down effects.

Table: Specific Gravity of Fibres

Sl. No.	FIBRE	SPECIFIC GRAVITY
1.	Bamboo	0.685
2.	Coir	0.684

III. METHODOLOGY

Table: Amounts of raw materials

Polythene %	Wt. of Fibre(gm)	Wt. of Aggregate (gm)
MIX 1	3.6	1152
MIX 1	3.6	1152
MIX 1	3.6	1152
MIX 2	3.6	1140
MIX 2	3.6	1140
MIX 2	3.6	1140
MIX 3	3.6	1134
MIX 3	3.6	1134
MIX 3	3.6	1134
MIX 4	3.6	1128
MIX 4	3.6	1128
MIX 4	3.6	1128
MIX 5	3.6	1116
MIX 5	3.6	1116
MIX 5	3.6	1116

A. Void Analysis

The samples were weighed in air and also immersed in water so that water replaces the air present in the voids of specimens. But some amount of water will be absorbed by the aggregates which give flawed results. Therefore, the samples were coated with paraffin wax so that it seals the mix completely and checks the absorption of liquid into it.

B. Mix Volumetric

The volumetric parameters (refer Figure 4.5) are to be checked from the Marshall samples, prior to Marshall Test. The following are equations which would be used to determine volumetric parameters such as VMA, VA, VFB etc. and absorbed bitumen content (P_{ab}). The absorbed bitumen is a important parameter, which is ignored in bituminous mix design in many cases (Chakroborty & Das, 2005)

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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: Gradation table with Fibre

Sieve Size (mm)	% Retained	4%	5%	5.5%	6%	7%
13.2	5	57.42	56.82	56.52	56.22	55.62
9.5	32	367.49	363.65	361.72	359.80	355.97
4.75	39	447.88	443.196	440.86	438.52	433.84
2.36	4	45.94	45.45	45.22	44.98	44.50
1.18	3	34.45	34.09	33.91	33.73	33.37
0.6	2	22.97	22.72	22.60	22.49	22.25
0.3	0	0	0	0	0	0
0.75	5	57.42	56.82	56.52	56.22	55.62
Filler	10	114.84	113.64	113.04	112.44	111.24
Binder		48	60	66	72	84
Fibre		3.6	3.6	3.6	3.6	3.6

Table: Gradation table without Fibre

Sieve Size (mm)	% Retained	4%	5%	5.5%	6%	7%
13.2	5	57.6	57	56.7	56.40	55.8
9.5	32	368.64	364.80	362.88	360.96	357.12
4.75	39	449.28	444.60	442.26	439.92	435.24
2.36	4	46.08	45.60	45.36	45.12	44.64
1.18	3	34.56	34.20	34.02	33.84	33.48
0.6	2	23.04	22.80	22.68	22.56	22.32
0.3	0	0	0	0	0	0
0.75	5	57.6	57	56.7	56.40	55.80
Filler	10	115.20	114	113.40	112.80	111.60
Binder		48	60	66	72	84

Table: Correction Factors

Volume of Specimen (cm^3)	Average thickness of Specimen (mm)	Correction Factors
445-455	55.50	1.26
456-469	57.30	1.19
470-481	58.68	1.14
482-494	60.35	1.09
495-507	61.91	1.04
508-521	63.48	1
522-534	65.20	0.96
535-545	66.60	0.93
546-558	68.40	0.89
559-572	69.70	0.83

Table: Calculation of Parameters without fibres

Sample Nos	Bitumen Content (%)	Wt before paraffin coating (gm)	Wt after paraffin coating (gm)	Wt in water (gm)	Ht (mm)	Wt of Aggregate Mix(gm)	Flow (mm)	Load Tak-en (KN)
A-1	4	1194	1212	709	64.30	1152	3.22	296
A-2	4	1185	1197	697	64.55	1152	2.52	256
A-3	4	1187	1202	703	65.10	1152	3.11	287
B-1	5	1179	1197	707	62.57	1140	4.20	351
B-2	5	1196	1198	701	63.15	1140	4.68	322
B-3	5	1185	1207	716	63.18	1140	3.58	292
C-1	5.5	1181	1192	747	57.20	1134	3.84	221
C-2	5.5	1177	1186	756	57.12	1134	4.29	279
C-3	5.5	1182	1190	758	61.10	1134	4.89	329
D-1	6	1201	1204	740	58.42	1128	4.64	272
D-2	6	1193	1201	754	57.35	1128	4.47	328
D-3	6	1184	1192	750	58.49	1128	5.43	254
E-1	7	1180	1209	705	61.20	1116	5.52	448
E-2	7	1182	1211	707	60.23	1116	5.67	476
E-3	7	1188	1214	712	60.45	1116	4.78	482

Table: Calculation of Parameters with bamboo fibres

Sample Nos	Bitumen Content (%)	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)
A-1	4	1185	1195	710	65.30	1152	3.63	357
A-2	4	1182	1187	708	63.25	1152	4.15	374
A-3	4	1180	1187	704	62.50	1152	3.10	428
B-1	5	1198	1206	715	57.20	1140	4.89	402
B-2	5	1195	1204	711	58.30	1140	5.24	332
B-3	5	1188	1197	713	57.40	1140	3.88	394
C-1	5.5	1175	1186	746	57.40	1134	4.45	477
C-2	5.5	1175	1185	742	57.40	1134	4.35	482
C-3	5.5	1196	1206	755	57.60	1134	5.18	420
D-1	6	1195	1205	759	59.50	1128	4.18	413
D-2	6	1201	1210	741	58.40	1128	5.45	387
D-3	6	1204	1215	750	60.60	1128	4.48	337
E-1	7	1180	1190	750	57.45	1116	5.18	373
E-2	7	1182	1189	754	57.20	1116	4.94	368
E-3	7	1178	1184	746	63.40	1116	5.67	322

Table: Calculation of Parameters with Coir fibres

Sample Nos	Bitumen Content (%)	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)
A-1	4	1143	1173	678	56.50	1152	2.89	264
A-2	4	1188	1218	685	57.40	1152	2.85	258
A-3	4	1152	1182	684	56.30	1152	2.76	273
B-1	5	1182	1199	673	57.50	1140	3.16	272
B-2	5	1187	1207	687	58.40	1140	3.24	258
B-3	5	1192	1210	689	57.50	1140	3.35	254
C-1	5.5	1201	1214	684	57.40	1134	3.65	278
C-2	5.5	1180	1191	690	56.70	1134	3.84	303
C-3	5.5	1186	1195	691	57.50	1134	3.79	301
D-1	6	1195	1204	695	58.50	1128	4.15	239
D-2	6	1184	1193	691	57.40	1128	4.36	228
D-3	6	1188	1198	695	58.70	1128	4.65	242
E-1	7	1170	1205	668	58.40	1116	4.57	203
E-2	7	1191	1199	682	56.50	1116	4.62	209
E-3	7	1187	1198	680	58.50	1116	4.74	219

C. Marshall Testing

The Marshall test was done as procedure outlined in ASTM D6927 – 06.

1) *Marshall Stability Value:* It is defined as the maximum load at which the specimen fails under the application of the vertical load. It is the maximum load supported by the test specimen at a loading rate of 50.8 mm/minute (2 inches/minute). Generally, the load was increased until it reached the maximum & then when the load just began to reduce, the loading was stopped and the maximum load was recorded by the proving ring.
2) *Marshall Flow Value:* It is defined as the deformation undergone by the specimen at the maximum load where the failure occurs. During the loading, an attached dial gauge measures the specimen's plastic flow as a result of the loading. The flow value was recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load was recorded.

Two readings were taken from the dial gauge i.e. initial reading (I) & final reading (F) The Marshall Flow Value (f) is given by The Marshall Stability Values are shown in Table – 4.9, 4.10 and 4.11 The Marshall Flow Values

$$f = F - I$$

Table: Calculation of marshall design Parameters without fibres

Sample Nos	Bitumen Content (%)	Bulk volume of sample	Gmb	Ps	Gmm	VA (%)	Gsb	VMA (%)	Stability (KN)
A-1	4	504	2.404762	0.950495	2.62	8.215194	2.73	16.2742	8.791209
A-2	4	501	2.389222	0.962406	2.62	8.808338	2.73	15.77285	7.603208
A-3	4	501	2.399202	0.958403	2.62	8.42742	2.73	15.77285	8.523909
B-1	5	491	2.437882	0.952381	2.56	4.770239	2.74	15.26306	10.42471
B-2	5	500	2.396	0.951586	2.56	6.40625	2.74	16.78832	9.56341
B-3	5	491	2.458248	0.94449	2.56	3.974669	2.74	15.26306	8.672409
C-1	5.5	442	2.696833	0.951342	2.93	7.957932	3.59	28.53452	6.563707
C-2	5.5	431	2.75174	0.956155	2.93	6.083954	3.59	26.71057	8.286308
C-3	5.5	431	2.761021	0.952941	2.93	5.767205	3.59	26.71057	9.77131
D-1	6	466	2.583691	0.936877	2.89	10.59893	3.24	25.2901	8.078408
D-2	6	445	2.698876	0.939217	2.89	6.613273	3.24	21.76446	9.74161
D-3	6	446	2.672646	0.946309	2.89	7.520909	3.24	21.93988	7.543808
E-1	7	507	2.384615	0.923077	2.55	6.485671	2.79	21.10454	13.30561
E-2	7	507	2.38856	0.921552	2.55	6.330974	2.79	21.10454	14.13721
E-3	7	502	2.418327	0.919275	2.55	5.163659	2.79	20.31873	14.31541

Table: Calculation of marshall design Parameters with coir fibres

Sample Nos	Bitumen Content (%)	Bulk volume of sample	Gmb	Ps	Gmm	VA (%)	Gsb	VMA (%)	Stability (KN)
A-1	4	496	2.364919	0.982097	2.98	20.64029	3.16	26.50061	7.840808
A-2	4	534	2.280899	0.945813	2.98	23.45977	3.16	31.73091	7.662608
A-3	4	500	2.364	0.974619	2.98	20.67114	3.16	27.08861	8.108108
B-1	5	525	2.28381	0.950792	2.58	11.48025	2.75	21.03896	8.078408
B-2	5	521	2.316699	0.94449	2.58	10.20548	2.75	20.43273	7.662608
B-3	5	520	2.326923	0.942149	2.58	9.809183	2.75	20.27972	7.543808
C-1	5.5	531	2.286252	0.934102	2.92	21.70369	3.26	34.49101	8.256608
C-2	5.5	504	2.363095	0.952141	2.92	19.07208	3.26	30.9816	8.999109
C-3	5.5	503	2.375746	0.948954	2.92	18.63885	3.26	30.84438	8.939709
D-1	6	509	2.365422	0.936877	2.95	19.81619	3.24	31.60154	7.098307
D-2	6	502	2.376494	0.945516	2.95	19.44088	3.24	30.64778	6.771607
D-3	6	504	2.376984	0.941569	2.95	19.42427	3.24	30.92299	7.187407
E-1	7	535	2.252336	0.926141	2.87	21.52138	3.22	35.21797	6.029106
E-2	7	519	2.310212	0.930776	2.87	19.50481	3.22	33.22084	6.207306
E-3	7	517	2.317215	0.931553	2.87	19.26081	3.22	32.9625	6.504307

Table: Calculation of marshall design Parameters with bamboo fibres

Sample Nos	Bitumen Content (%)	Bulk Volume Of sample	Gmb	Ps	Gmm	VA (%)	Gsb	VMA (%)	Stability (KN)
A-1	4	486	2.458848	0.964017	2.97	17.21051	3.15	24.75015	10.60291
A-2	4	480	2.472917	0.970514	2.97	16.73681	3.15	23.80952	11.10781
A-3	4	484	2.452479	0.970514	2.97	17.42494	3.15	24.4392	12.71161
B-1	5	486	2.481481	0.945274	2.95	15.88198	3.20	26.69753	11.93941
B-2	5	491	2.452138	0.946844	2.95	16.87666	3.20	27.44399	9.86041
B-3	5	487	2.457906	0.952381	2.95	16.68117	3.20	26.84805	11.70181
C-1	5.5	441	2.689342	0.956155	2.94	8.525769	3.21	19.89319	14.16691
C-2	5.5	443	2.674944	0.956962	2.94	9.015525	3.21	20.25485	14.31541
C-3	5.5	454	2.656388	0.940299	2.94	9.646678	3.21	22.187	12.47401
D-1	6	445	2.707865	0.9361	2.93	7.581394	3.24	21.76446	12.26611
D-2	6	469	2.579957	0.932231	2.93	11.94685	3.24	25.76799	11.49391
D-3	6	467	2.601713	0.928395	2.93	11.20433	3.24	25.45008	10.00891
E-1	7	442	2.692308	0.937815	2.89	6.840564	3.23	21.83013	11.07811
E-2	7	435	2.733333	0.938604	2.89	5.420992	3.23	20.57222	10.92961
E-3	7	432	2.740741	0.942568	2.89	5.16468	3.23	20.02064	9.56341

IV. RESULTS AND DISCUSSION

Three samples had been tested for each percentage of the bamboo and coir fibre. The average of the three values had been taken for the analysis. All the average values have been mentioned below in the table:

Table: Stability Vs Binder Content

Binder (%)	Avg. stability without fiber (KN)	Avg. stability with coir fiber (KN)
4	8.306108	7.870508
5	9.55351	7.761608
5.5	8.207108	8.731809
6	8.454608	7.019107
7	13.91941	6.246906

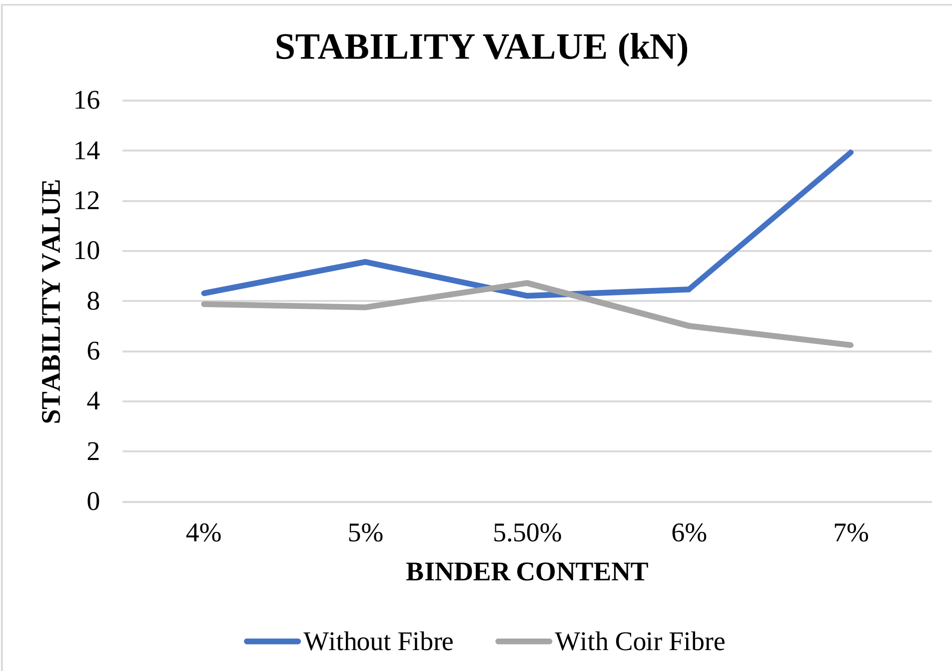

Fig: variation of stability value

Table: Flow Value Vs Binder Content :

Binder content (%)	Avg. flow value without fiber (mm)	Avg. flow value with coir fiber (mm)
4	2.95	2.833333
5	4.153333	3.25
5.5	4.34	3.76
6	4.846667	4.386667
7	5.323333	4.643333

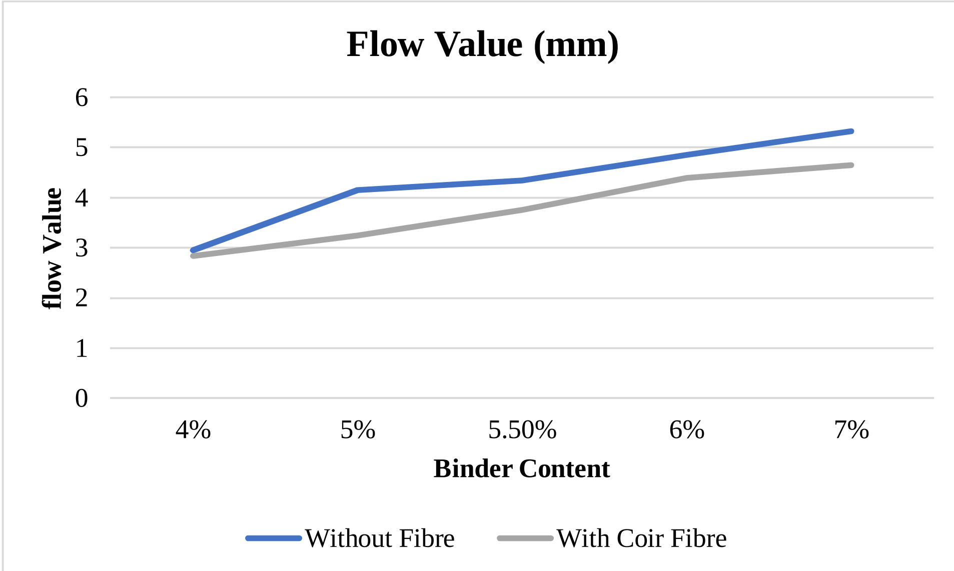

Fig: Variation of Flow value

Table: Air Void Analysis Vs Binder Content :

Binder content (%)	Avg. VA without fiber (%)	Avg. VA value with coir fiber (%)
4	8.483651	21.5904
5	5.050386	10.4983
5.5	6.603031	19.80487
6	8.24437	19.56045
7	5.993435	20.09567

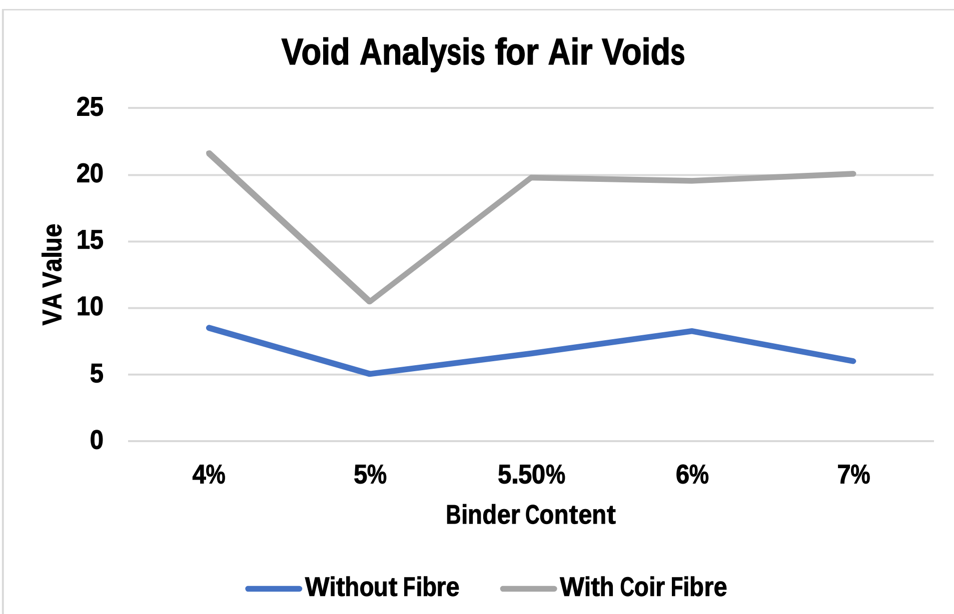

Fig: variation of VA Value

Table: Void in Mineral Aggregate (VMA) Vs Binder Content :

Binder content (%)	Avg. VMA without fiber (%)	Avg. VMA value with coir fiber (%)
4	15.93997	28.44004
5	15.77148	20.58381
5.5	27.31855	32.10566
6	22.99815	31.05744
7	20.8426	33.80044

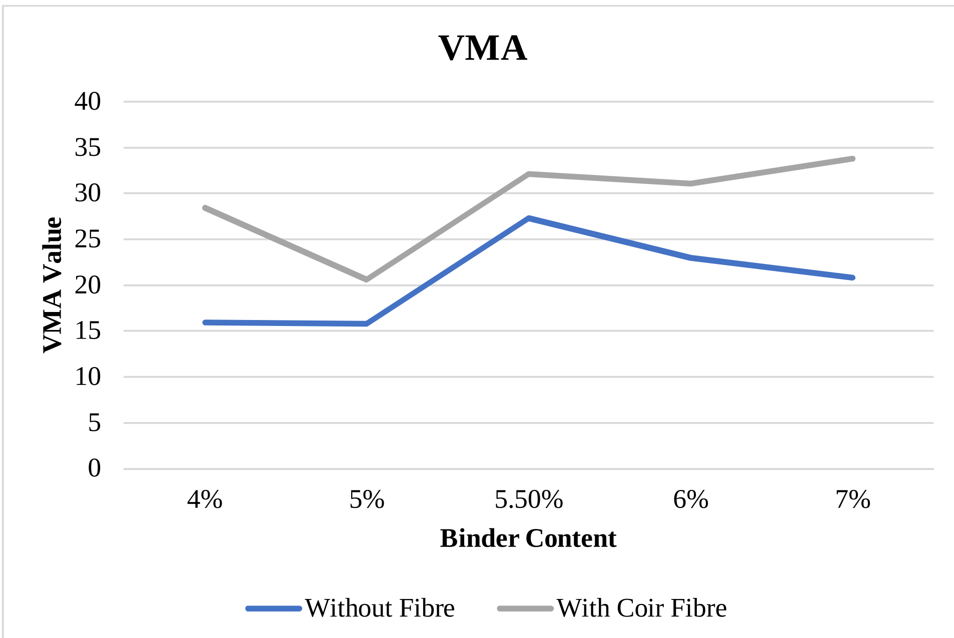

Fig: Variation of VMA Value

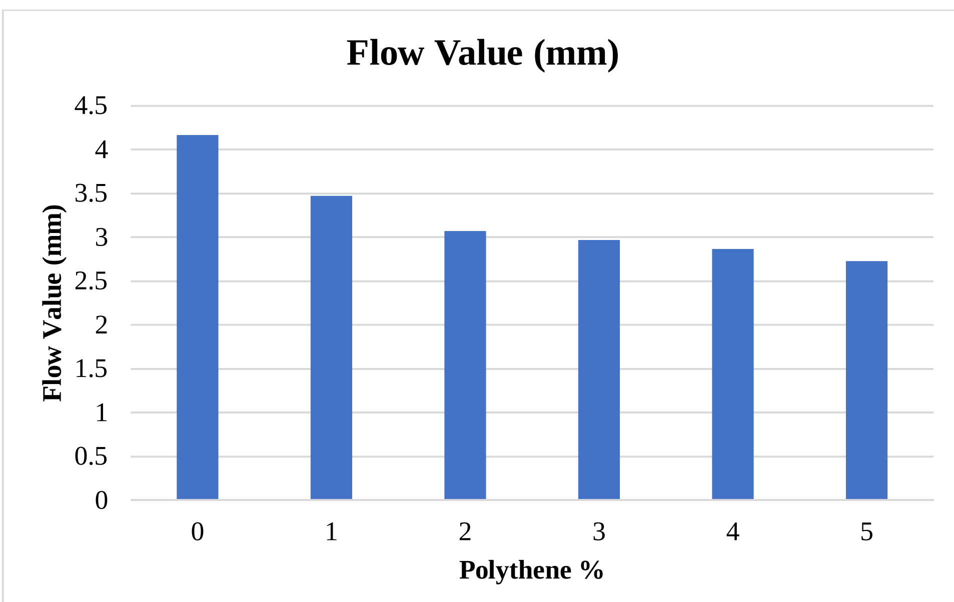

Fig: Flow value with different proportions of polythene

V. CONCLUSION

1) 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 hydro-static pressure making fractions across constant point immobilized. This makes the mixture weak against plastic deformation and stability falls. From the graph the average stability value of coir fiber is highest followed by bamboo fiber and without fiber SMA mix.
2) Flow value increases with the increase in binder content because at lower binder content the mixes provides more stability as its homogeneity 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.
3) OBC is found to be 5.5%.It is found where maximum stability occurs.
4) 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.

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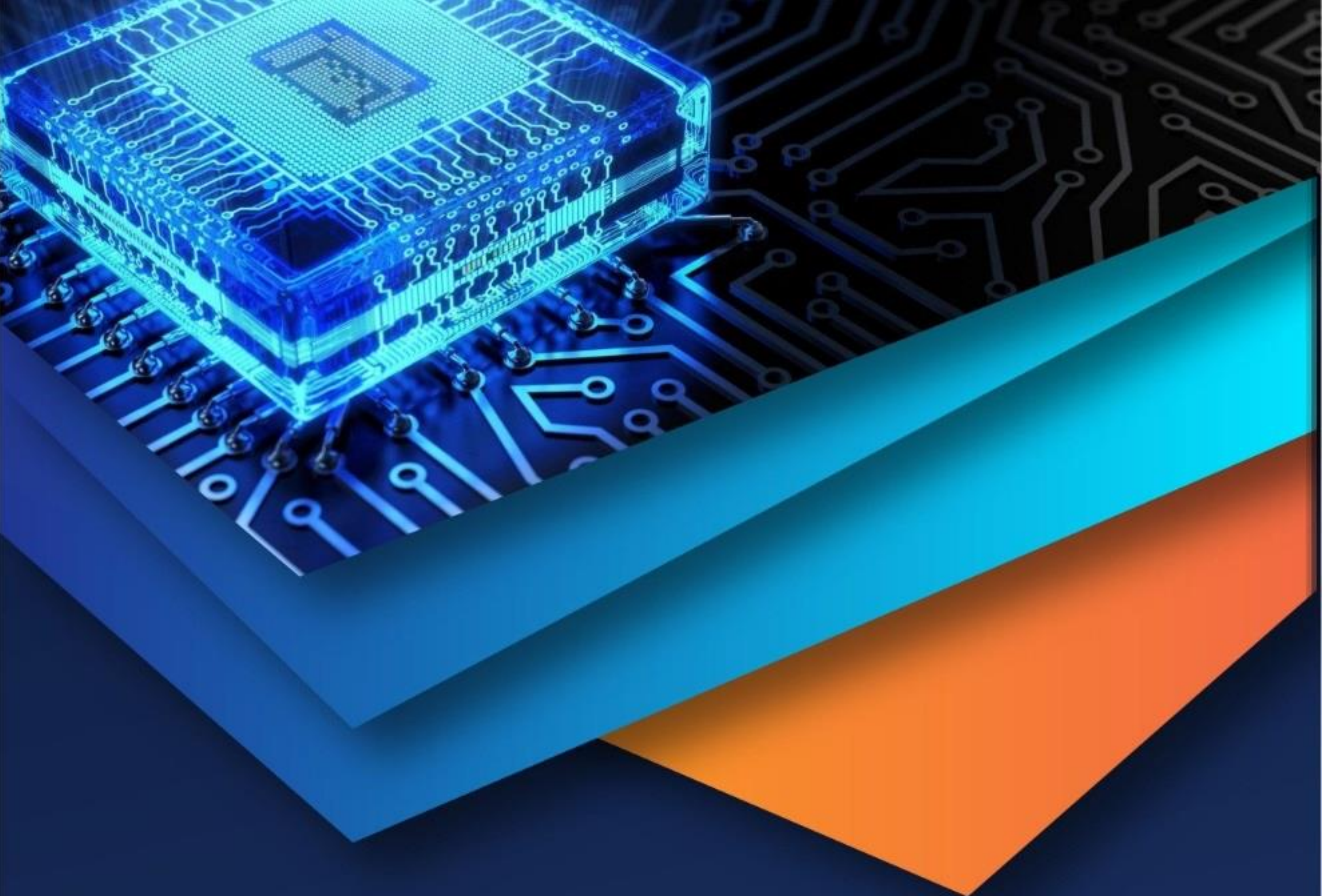

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