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Effect of Fillers on Stability Properties of Stone Matrix Asphalt

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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 composed of cellulose fibers, mineral fibers or polymers are added to SMA mixtures to prevent draindown from the mix. In comparison to dense graded mixtures SMA has higher proportion of coarse aggregate, lower proportion of middle size aggregate and higher proportion of mineral filler. It resists permanent deformation and has the potential for long term performance and durability. Harm in adaptable asphalts happen because of the development of overwhelming vehicles and change in climatic conditions. For improvement of pavement of road, the use of asphalt material and its mixture are used so that their durability and performance can be enhanced. For which the suitable mixture that is been adopted is SMA Mix (Stone mastic asphalt or Stone matrix asphalt) which is better than bituminous Concrete or dense graded mix (DGM). It was first implemented in European Countries and North America. The Stone Mix asphalt is gap- graded mixture Consisting of Stone or Slag as Coarse aggregate, different binders are used (natural or artificial) as stabilizers and high bitumen Content. For Minimizing the Cost and increasing the efficiency of roads, many different alternative are used for improvement by using different waste materials as fillers among them Coconut shell charcoal is one of them. In the Research work, the main objective is to compare the results obtained by using fillers like Stone dust, Portland cement, Fly ash with Coconut Shell charcoal . The Properties that Coconut shell Charcoal possesses are resistance to crushing, absorption, surface moisture, grading, resistance to freezing, light weight, heating and synthetic resin glues which is most important for pavement of roads. Therefore its Stability and flow parameters and Air Void ratio are obtained so that it can be compared with different types of Fillers. From that we can establish a perfect combination so that it can be useful as a substitute as a filler for improving the quality and durability of pavement of roads. Therefore aggregate gradation taken as per IRC-SP-79 specification for SMA mix. The Binder Content are varied as 4%, 5%, 5.5%, 6%, 7% by weight of aggregates. 0.3% by weight of aggregate is used as Optimum Binder Content. Binder of 60/70 penetration grade bitumen is used. For carrying out the experiment, Marshall test method is used for obtaining better results.

KEYWORDS: Stone Matrix Asphalt (SMA), Filler, Stability, Durability, Stabilizers, Bituminous, Coconut Shell

I. INTRODUCTION

Generally aggregates are mixed with bitumen are widely used all over the world for construction & maintenance of flexible pavements. The close and well-uniform , or dense graded aggregates mixed with normal bitumen generally perform very well in heavily trafficked roads therefore they are very common in paving industries. Basically to form dense graded aggregate, it is very difficult to arrange aggregates of different size which are found in sites. In such a situation, bituminous mix known as stone matrix asphalt (SMA) consisting of gap graded aggregates can be used.

Stone Matrix Asphalt (SMA) is a gap-graded mixture, have a better stone to stone contact which gives better strength to the mixture. In this research work aggregate used as per the MORTH specification was taken from a same lot. The samples are made with aggregate with different gradation, filler (cement) and binder (bitumen 80/100). Fibers are used as stabilizer. Fibers are used to decrease the drain down and to increase the strength and stability of the SMA Mix. The test of the SMA Mix samples are done in Marshall Apparatus. Here the comparison of SMA Mix with and without fiber was done. All the research work done before by using cellulose fiber, synthetic fiber, polypropylene fiber and polyester fibers. Cellulose fibers are extensively used in SMA in Europe and USA. These fibers are patented. The fires improve the service properties of the mix by forming micromesh in the asphalt mix to prevent the drain down of the asphalt so as to increase the stability and durability of the mix. Here we have tried to use sisal fiber which is more economic than cellulose fibers, doing same work as cellulose fiber. Cement Kiln Dust (CKD) is a fine-grained strong material created as the essential by-result of the generation of concrete. CKD comprises basically of calcium carbonate and silicon dioxide which is like the concrete furnace crude food or cement kiln raw feed, however the measure of soluble bases, chloride and sulphate is normally impressively higher in the dust.Aggregates bound with bitumen are conventionally used all over the world in construction and maintenance of flexible pavements. The close, well, uniform, or dense graded aggregates bound with normal bitumen normally perform well in heavily trafficked roads if designed and executed properly and hence very common in paving industry. However, it is not always possible to arrange dense graded aggregates available at the site. In such situations a bituminous mix called stone matrix asphalt (SMA) which basically consists of gap graded aggregates, can be attempted.

Stone Matrix Asphalt-

SMA was developed in Germany in the 1960s by Zichner of the Straubag-Bau AG central laboratory, to resist the damage caused by studded tires. As SMA showed excellent resistance to deformation by heavy traffic at high temperatures, its use continued even after the ban of studded tires. SMA is a gap graded mixture containing 70-80% coarse aggregate of total aggregate mass, 6-7% of binder, 8-12% of filler, and about 0.3-0.5% of fiber or modifier. The high amount of coarse aggregate in the mixture forms a skeleton-type structure providing a better stone-on-stone contact between the coarse aggregate particles, which offers high resistance to rutting. Aggregate to aggregate contact is also there in dense graded mixtures but it occurs within the fine aggregate particles as the coarse aggregate floats in the fine aggregate matrix, which don't give the same shear resistance as the coarse aggregate skeleton. Brown and Manglorkar (1993) reported that the traffic loads for SMA are carried by the coarse aggregate particles instead of the fine aggregate asphalt-mortar. The higher binder content makes the mix durable. The fibers or modifier hold the binder in the mixture at high temperature; prevent drainage during production, transportation and laying.

[Fig.1.1: Stone Matrix Asphalt]

Advantages over Conventional Bituminous Mixes-

Conventional bituminous pavements lack the strength, durability and longevity of SMA. There are several factors for which SMA is better than the conventional mixes. As mentioned by Bose et al. (2006) SMA provides better resistance to rutting due to slow, heavy and high volume traffic, resistance to deformation at high pavement temperatures, improved skid resistance, noise reduction over conventional alternative pavement surfaces, improved resistance to fatigue effects and cracking at low temperatures, increased durability, reduced permeability and sensitivity to moisture. According to Brown and Manglorkar (1993) SMA has also shown good resistance to plastic deformation under heavy traffic loads with high tyre pressures as well as good low temperature properties. Further, SMA has a rough texture which provides good friction properties after surface film of the binder is removed by the traffic. Kamaraj et al. (2004) have reported that SMA has an extended life as compared to conventional dense graded mixes. They have also reported that the cost of SMA has been estimated to be about 20-25 percent more than conventional dense graded mixtures, but this can be justified by the increased life of pavement. In view of these advantages SMA has been proved to be superior over HMA mixes.

OBJECTIVE OF THE PROJECT:

- The main Objective is to check the suitability of Coconut shell charcoal as filler in SMA mix and then comparing its properties obtained with different types of fillers and then study its effect on different properties of SMA mix.
- Study of different Marshall Properties using different fillers (Stone dust, Portland cement, Fly ash etc.) and then comparing the results with Coconut shell charcoal as filler.

II. LITERATURE REVIEW

A detailed review of literatures made on works related to SMA mixes is described in the following paragraphs. Majority of the roads all over the world are made up of flexible pavements. Flexible pavements consist of a bituminous layer on the surface course and sometimes in base course followed by granular layers in base and sub base courses over the subgrade. Asphalt Concrete Pavement or Hot Mix Asphalt pavement are the bound layers of a flexible pavement structure at the surface course. The most common type of flexible pavement surfacing used in India is a premix bituminous material, commonly called outside as Hot Mix Asphalt (HMA). HMA is a mixture of coarse and fine aggregates and asphalt binder. HMA, as the name suggests, is mixed, placed and compacted at higher temperature. HMA is typically applied in layers, with the lower layers supporting the top layer, which is known as surface course or friction course. The aggregates used in the lower layer are to prevent rutting and the aggregates which are used in the top layer are generally selected on the basis of their friction properties and durability. There are several types of HMA mixes. These include conventional Dense Graded Mixes (DGM), Stone Matrix asphalt (SMA) and various Open graded HMA. The HMA mixes differ from each other mainly in maximum aggregate size, aggregate gradation and binder content or type of binder used.

Mineral fillers have a significant impact on the properties of SMA mixtures. Mineral fillers increase the stiffness of the asphalt mortar matrix. According to Mogawer and Stuart (1996) mineral fillers also affect workability, moisture resistance, and aging characteristics of HMA mixtures. Mineral fillers also help to reduce the draindown in the mix during construction, which improves the durability of the mix by maintaining the amount of asphalt initially used in the mix. It also helps to maintain adequate amount of voids in the mix. Different types of mineral fillers are used in the SMA mixes such as stone dust, ordinary Portland cement (OPC), slag cement, fly Ash, hydrated lime etc.

Brown and Mallick (1994) reported that draindown of binder in the mix is significantly affected by the type of filler used. Higher percentage of filler in the mix lowers the draindown of the binder.

Brown et al. (1996) evaluated the SMA mortars in terms of Superpave binder tests and studied the influence of each of the mortar components in the mix on the overall mortar performance. They used two types of mineral fillers, limestone dust and baghouse fines from a HMA plant to prepare SMA mixes. They concluded that most of the stiffening effect of the mortar comes from mineral fillers. They reported that Portland cement can also be used as a filler material in SMA mixes.

Mogawer and Stuart (1996) studied the effect of mineral fillers on properties of SMA mixtures. They chose eight mineral fillers on the basis of their performance, gradation etc. They evaluated the properties of SMA mixtures in terms of draindown of the mastic, rutting, low temperature cracking, workability, and moisture susceptibility.

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Ravi Shankar et al. (2009) used stone dust and cement as the filler material in SMA mixture. They used filler content of 10% by dividing it to 8 percent stone dust and 2 percent cement.

Xue et al. (2008) utilized municipal solid waste incinerator (MSWI) fly ash as a partial replacement of fine aggregate or mineral filler in stone matrix asphalt mixtures. They made a comparative study of the performance of the design mixes using Superpave and Marshall mix design procedures. The mixes were evaluated in terms of dynamic stability, water sensitivity and fatigue life. They concluded that nearly 8-16% of MSWI ash substitution for aggregates and filler is guaranteed to meet the requirement of SMA mixtures through Marshall and Superpave mix design procedure.

Brown et al. (1996) investigated the SMA mortars using Superpave system binder tests and concluded that some of the Superpave binder test equipment like BBR and DSR can be used for testing SMA mortars with slight modifications. Putman et al. (2004) followed Superpave mix design guide lines to design SMA mixtures using PG 76-22 binder and waste fibers such as waste tire and carpet fibers as additives. They compacted the specimen with 50 gyrations of Superpave Gyratory Compactor per SC DOT procedures. Neubauer and Partl (2004) investigated the behaviour of SMA mixtures with different filler/ binder combination in order to do a comparative study between Marshall and Gyratory Methods. They observed that the optimum binder content value determined using Marshall compactor were distinctively higher than those using the Gyratory compactor. They also concluded from the values of air voids, voids of mineral aggregate, and volume of voids filled with binder for all the mixes that SMA is more efficiently compacted with the Gyratory compactor than with the Marshall compactor. Xue et al. (2008) also made a comparative study of use of Marshall mix design and Superpave mix design methods in SMA mixtures with MSWI. They concluded that Superpave mixtures showed superior performance over Marshall mixtures in almost all pavement performance, such as dynamic stability, water sensitivity and fatigue life.

Punith V.S., Sridhar R., Bose Sunil, Kumar K.K., Veeraragavan A (2004) ad M m g C, using 50 blows of compaction per side and did a comparative study of SMA with asphalt concrete mix utilizing reclaimed polythene in the form of LDPE carry bags as stabilizing agent (3 mm size and 0.4%) .The test results indicated that the mix properties of both SMA and AC mixture are getting enhanced by the addition of reclaimed polythene as stabilizer showing better rut resistance, resistance to moisture damage, rutting, creep, aging and better drain-down properties as well.

Neubauer and Partl (2004) investigated the nature of SMA mixes with different filler/binder combination to do a comparative study in between Marshall and Gyratory Methods. They found out and observed that the optimum binder content (OBC) value determined using Marshall compactor were bit higher than those found using the Gyratory compactor. They also used two different binders, one of penetration grade bitumen 50/70 and another was the polymer modified bitumen with SBS modifiers. And from the experiments they observed that the polymer modified bitumen gives better performance in terms of deformation and stability than the other unmodified bitumen.

Karasahin and Terzi (2004) conducted an investigation on marble waste as filler material in asphalt mixtures. Samples were prepared having marble dust and limestone dust filler. The optimum binder content was then determined by Marshall Test procedure. They have also carried out dynamic plastic deformation tests on both mixes using marble waste and limestone dust. The study indicated that both Marshal and plastic deformation test results for mixes using both limestone and marble waste are almost the same. Hence, conclusion was made that those marble wastes which are in dust form can be considered as an alternative filler material to other materials. However, some care should be taken into account for mixes with marble dust since they have higher values of plastic deformation and hence, they should be used on low volume roads.

YongjieXue, Shaopeng Wu, HaoboHoua, Jin Zha (2006) Conducted Experimental investigation of basic oxygen furnace slag used as aggregate in asphalt mixture. By testing and analyzing, BOF steel slag was found to be able to be used as asphalt mixture aggregate in expressway construction.

Behnood, M. Ameri (2012) conducted Experimental investigation of stone matrix asphalt mixtures containing steel slag. According to the results obtained from Marshall stability it was found that mixtures with steel slag have shown encouraging results in comparison with those containing stone. Also, replacing the coarse portion of stone aggregate with steel slag leads to some better results in comparison with mixtures that contain steel slag as the fine portion. Steel slag used as the coarse portion in SMA mixtures increased Marshall Stability and decreased the flow values.

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III. PROPOSEED METHODOLOGY

FILLERS USED: Basically Filler are the fine particles which when passed through 2.36mm sieve and retained in 0.075mm sieve. Generally the Filler that we have used are waste materials that are produced from industries or from any natural products to reduce the cost and increase its workability and durability. As filler are used to reduces the gaps i.e Voids so that the compaction between Coarse and Fine aggregate increases to provide better Stability to the pavement.

The fillers that are used in experimental process are as follows:

- **Stone dust:** Stone are the cheapest material. It is basically obtained by crushing the stones such that the size of the stone particles are retained in 0.075mm sieve.
- **Portland Cement:** Cement can be used as a filler due to its lump property due to which it can bind the particles properly.
- **Fly Ash:** Fly Ash are the waste materials produced from the industries which can used as a replacement for fillers and also the cost is very low.
- **Coconut Shell Charcoal:** Concrete pavements suffer from a perception that they contribute a considerable amount of carbon dioxide (CO2) to the atmosphere due to the use of Coconut shell Charcoal it binds the aggregates together.

[Fig.3.1: Types of Fillers]

PROPERTIES OF COCONUT SHELL CHARCOAL:

- High Strength property than other fillers due to its hardness and low specific weight.
- It shows high modulus Property.

- High lignin Content as it has high resistance to different weather and therefore suitable material for construction of road.
- It shows good durability and abrasion resistance Characteristics.
- It has low Cellulose Content.

EXTRACTION OF COCONUT SHELL CHARCOAL:

The Process used for extraction of Coconut shell charcoal are as follows:

- Cutting: First the Coconut is cut down from the tree and dried for somedays.
- Ripping: Then the Cover is ripped out such that the shell can be visible properly.
- Burning: The coconut shell is burnt in open air for around 3-4 hrs then product is incinerated in furnace at 800 ^{0}C for 6 hrs then only we can obtain coconut shell charcoal.

Experimental Investigation:

MATERIALS USED:

• Slag – Coarse aggregate
• Stone – Fine aggregate
• Mineral filler – stone dust, Portland cement, fly ash and Coconut shell charcoal.
• Binder – bitumen of penetration grade 60/70
• Stabilizer – Cellulose fibre (0.3% - 0.5%)

CELLULOSE FIBER:

Cellulose fiber is used as a stabilizer in the present project. It is mixed with SMA mix so that it can bind the bitumen with the aggregate properly. It also provides better strength to the sample. It generally spread throughout the sample when heat is applied to it. The amount of Fiber that is used during experiment is about 0.3% - 0.5% of the total weight.

BINDER USED:

Different types of binder like convectional 60/70 or 80/100 penetration grade bitumen are used nowadays. Also many modified binder which are used by different researchers for their work are:

- Polymer Modified Bitumen (PMB),
- Crumb Rubber Modified Bitumen (CRMB),
- Natural Rubber Modified Bitumen (NRMB).

In this research project work 60/70 penetration grade bitumen is used in SMA mix and different results are obtained.

COARSE AGGREGATE:

The coarse aggregate should be crushed rocks which should pass through 19mm sieve and retained in 4.75 mm sieve. The rocks should be well graded, cubic shape and rough surface for good compaction. The hardness should be such that it can resist the traffic load. Generally Stone Chips are used as Coarse aggregate but in this research project work Slag is used for comparing the results.

FINE AGGREGATE:

Fine aggregates are generally stone crusher dusts with fractions passing through 4.75 mm and retained on 0.075 mm IS sieve. The fine aggregate should consist of 100% fine crushed stone dust which should be clean, hard to resist pressure, durable for long period, cubic shape and free from soft pieces.

MINERAL FILLER:

Aggregate which pass through 0.075mm sieve are called filler. Mineral fillers have significant impact over the properties of SMA mixes.

- It increases stiffness of asphalt & mortar matrix.
- It affects workability, aging characteristics and moisture resistance.
- It helps to reduce drain-down in the mix which improves the longevity of the mix by using required amount of asphalt in the mix.
- It maintains adequate amount of void in the mix.

Different types of mineral fillers that are used in the SMA mixes such as:

- Stone dust,
- Slag Cement or dust
- Ordinary Portland cement (OPC),
- Hydrated lime
- Fly Ash
- Coconut shell Charcoal etc.

Main Objective of the experiment is that by using different filler with SMA mix and comparing the results obtained by which we can find out the most suitable filler for SMA mix.

IV. RESULTS AND DISCUSSIONS

MARSHALL STABILITY: The stability of the specimen is derived by the load taken by it and then multiplying with the correlation ratio which is obtained from thickness/height or volume of the sample. Theoretically with increase in Bitumen content, the stability also increases up to a certain point and then gradually decreases. This is due to with increase in bitumen content, the bond between the aggregate and the bitumen increases but with further increase, the strength between them decreases as the contact point between the aggregates become immobilize. Due to which mix become weak against plastic deformation. Simultaneously the stability Values also decreases.

FLOW VALUE: Flow Value is defined as deformation caused when maximum load is applied where usually failure occurs. The flow value increases with increase in bitumen content. But the flow is gradually slow where stabilizers are not used. The flow increases very slowly initially but with increase in bitumen content, the flow value increases theoretically.

AIR VOIDS: The air void is the gap present between the aggregates. The void decreases with increase in bitumen. Bitumen fills the gap present and increases the compatibility. Theoretically the air voids decreases slowly initially and with increase in bitumen percentage the air voids decreases very quickly. With addition of stabilizers, it also helps to fill the void along with bitumen.

Table 4.1: Results using Stone dust as filler

Sample No.	Bitumen Content (%)	Wt. before Coating (gm)	Wt. after Coating (gm)	Wt. in water (gm)	Height (cm)	Flow (mm)	Load Taken (KN)	Stability (KN)
1	4%	1188	1201	747	5.6	2.9	240	7.4
2	4%	1186	1200	744	5.5	3.1	260	7.2
3	5%	1195	1204	750	5.4	3.1	280	8.5
4	5%	1180	1193	751	5.8	3.4	260	8.2
5	5.5%	1185	1192	734	5.8	3.2	300	9.1
6	5.5%	1186	1193	736	5.6	3.4	280	8.5
7	6%	1192	1198	771	5.4	4.2	230	7.9
8	6%	1188	1194	767	5.2	4.4	250	8.2
9	7%	1195	1196	738	5.2	4.3	260	8.3
10	7%	1183	1197	735	5.2	4.6	240	7.6

Table 4.2: Results using Fly ash as filler

Sample No.	Bitumen Content (%)	Wt. before Coating (gm)	Wt. after Coating (gm)	Wt. in water (gm)	Height (cm)	Flow (mm)	Load Taken (KN)	Stability (KN)
1	4%	1185	1201	736	5.8	2.3	320	7.92
2	4%	1188	1205	741	5.7	2.4	260	7.6
3	5%	1184	1204	742	5.6	2.5	350	8.48
4	5%	1183	1192	744	5.8	2.7	260	7.64
5	5.5%	1185	1200	744	5.8	3.0	390	8.91
6	5.5%	1184	1198	736	5.6	2.9	360	8.7
7	6%	1181	1198	756	5.4	3.1	340	8.44
8	6%	1182	1191	748	5.6	3.3	305	7.92
9	7%	1187	1205	761	5.6	3.9	320	8.1
10	7%	1185	1197	758	5.6	3.8	260	7.6

Table 4.3: Results using Coconut shell charcoal as filler

Sample No.	Bitumen Content (%)	Wt. before Coating (gm)	Wt. after Coating (gm)	Wt. in water (gm)	Height (cm)	Flow (mm)	Load Taken (KN)	Stability (KN)
1	4%	1144	1174	681	5.7	2.8	270	8.1
2	4%	1187	1215	682	5.6	2.7	250	7.6
3	5%	1181	1198	672	5.6	3.1	270	8.1
4	5%	1186	1206	684	5.7	3.2	250	7.6
5	5.5%	1201	1214	686	5.7	3.6	280	8.2
6	5.5%	1182	1193	690	5.6	3.8	305	8.6
7	6%	1194	1201	693	5.6	4.1	230	7.4
8	6%	1184	1180	692	5.7	4.2	238	7.5
9	7%	1170	1207	669	5.8	4.6	210	6.8
10	7%	1190	1197	680	5.6	4.5	205	6.6

COMPARISON OF RESULTS:

1. STABILITY VALUE COMPARISON USING DIFFERENT FILLERS:

Table 4.4: Average Stability Value using different Fillers

Bitumen content (%)	Stone dust as filler	Fly Ash as filler	Coconut shell Charcoal as filler
4%	7.3	7.82	7.8
5%	8.35	8.02	8.2
5.5%	9.1	8.91	8.4
6%	8.05	8.06	7.45
7%	7.09	7.88	6.7

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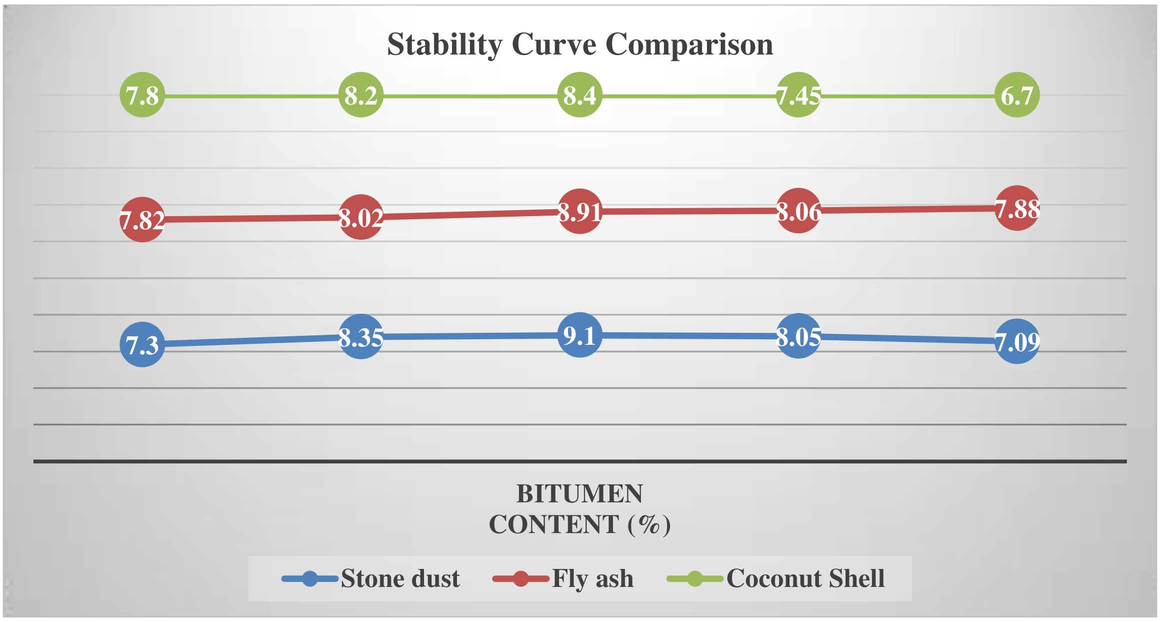
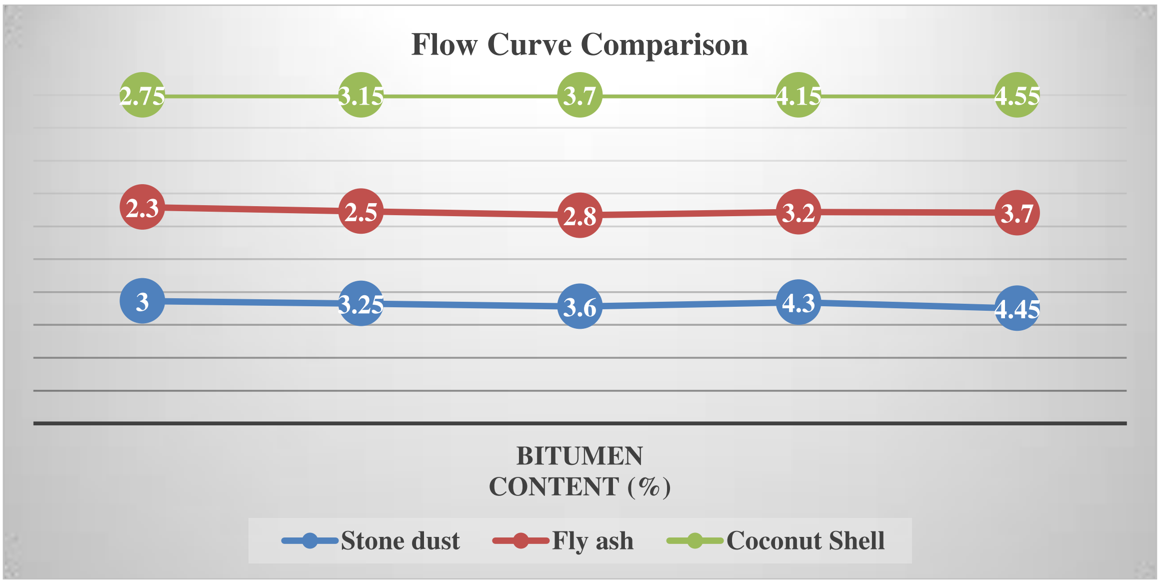


[Fig.4.1: Average Stability Value Comparison Graph with different Bitumen Content]

2. FLOW VALUE COMPARISON USING DIFFERENT FILLERS:

Table 4.5: Average Flow Value using different Fillers

Bitumen content (%)	Stone dust as filler	Fly Ash as filler	Coconut shell Charcoal as filler
4%	3.0	2.3	2.75
5%	3.25	2.5	3.15
5.5%	3.6	2.8	3.7
6%	4.3	3.2	4.15
7%	4.45	3.7	4.55



[Fig.4.2: Average Flow value comparison Graph with different Bitumen Content]

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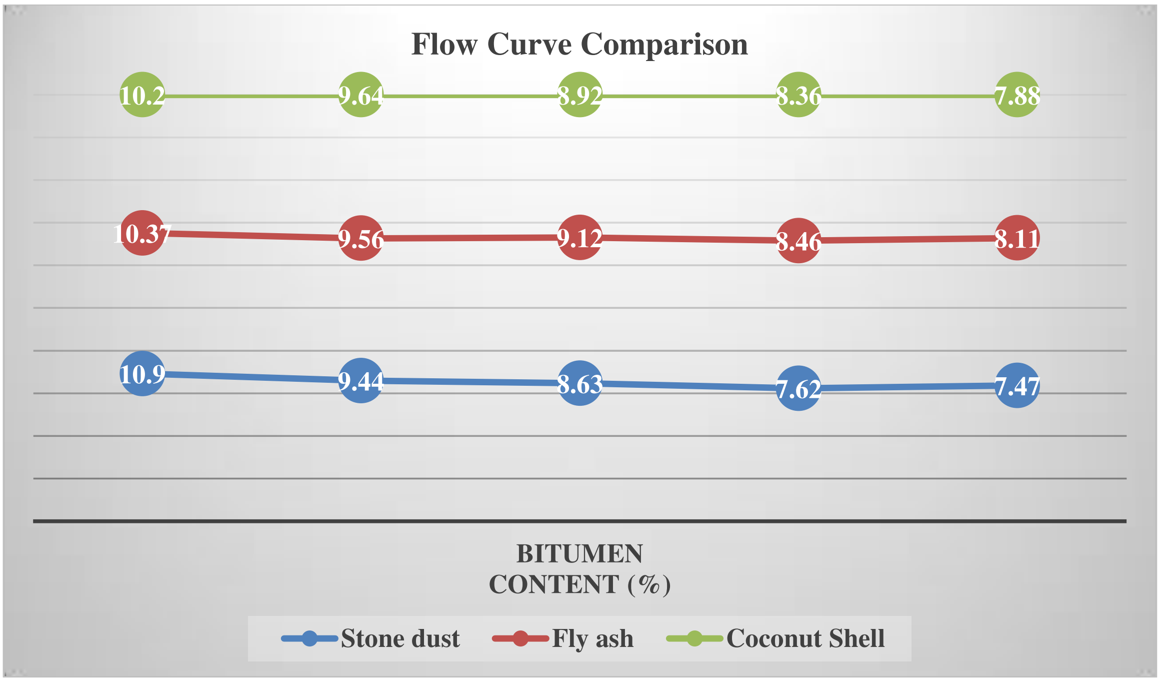
3. AIR VOID (VA) COMPARISON USING DIFFERENT FILLERS:

VA= [1 - Gmb/Gmm] *100
Gmb = Bulk Specific Gravity Of the mix
= Mmix / Bulk Vol.of mix.
Gmm = Theoretical max. specific Gravity of Mix
= Mmix / Vol. of (mix – air voids)
By using the formula, the air void (VA) is found out.

Table 4.6: Air void (VA) using different fillers

Bitumen content (%)	Stone dust as filler	Fly Ash as filler	Coconut shell Charcoal as filler
4%	10.9	10.37	10.2
5%	9.44	9.56	9.64
5.5%	8.63	9.12	8.92
6%	7.62	8.46	8.36
7%	7.47	8.11	7.88



[Fig.4.3: VA Comparison Graph with different bitumen Content]

V. CONCLUSION

By using different bitumen content of 4%, 5%, 5.5%, 6% & 7%, the Optimum Stability of the SMA Mix is found out. It is observed from the graph that the Stability value increases with increase in bitumen content and the decreases gradually which helps us to find out the performance of different fillers used in SMA mix at corresponding bitumen content (%).

From the graph, it is found that

- The maximum Stability Value obtained is 9.1 KN by using Stone dust as Filler at Optimum binder of 5.5% seconded by fly ash filler with stability value of 8.91 kN.
- Using Coconut Shell charcoal as filler, an average Stability is obtained which is 8.4 KN.
- As the difference in Stability value is less which is 9.68% therefore Coconut shell charcoal can be used as a substitute as filler.

FLOW VALUE:

Theoretically it is found that with increase in bitumen content, the Flow Value increases for different types of fillers.

- The Flow value increases with increase in bitumen percentage as the maximum increase is shown by Coconut shell charcoal as filler.
- The Flow Value is least in case of fly ash fillers .
- From the graph it is found that Flow Value increases very slowly at first but with increase in Bitumen content it increases very quickly because as % of bitumen increases, the sample mould loses its uniformity, strength and also stability decreases as a result deformation increases when load is applies on the sample specimen.

AIR VOIDS (VA):

Theoretically we know that the Voids that are present between the aggregate due to irregular shape decreases the strength of the mix. So to avoid this, Bitumen along with fillers and stabilisers is added to it so that voids gets filled up and also it acts as a sticky material so that the aggregates are closely packed among themselves. So, with increase in bitumen content the air voids decreases.

- From the graph, it is observed that the VA decreases very slowly initially but with increases in bitumen content, the VA decreases very quickly.
- The maximum decrease in the VA is obtained when Stone dust is used as filler.
- The decrease is steady in case of Coconut shell charcoal as filler.

OPTIMUM BITUMEN CONTENT (OBC):

The Optimum bitumen content is obtained where the maximum Stability occurs.

- According to the graph, at 5.5% bitumen content, the maximum stability is obtained which is 9.1 KN for stone dust filler sample.
- Optimum bitumen content does not depend in filler type as the size of the fine particles is 0.075mm.

CONCLUDING REMARK:

- The maximum stability obtained is 9.1 KN in case of Stone dust used as filler and the stability value obtained for coconut shell charcoal is 8.4 KN.
- As the Stability value is more than 8 KN in case of coconut shell charcoal as filler, it can be used as filler in SMA mix for pavement of roads.
- Flow increases with increase in bitumen content in case of all fillers used in the sample.
- Air voids decreases with increase in bitumen content for all the fillers used in the sample.
- From the experiment, it can be concluded that coconut shell charcoal can be used as a substitute for filler as it satisfies all the criteria to be used as a filler.

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