ASSESSMENT OF THE SUITABILITY OF COCONUT SHELL CHARCOAL AS FILLER IN STONE MATRIX ASPHALT

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CERTIFICATE

This is to certify that the Project Report entitled "**ASSESSMENT OF THE SUITABILITY OF COCONUT SHELL CHARCOAL AS FILLER IN STONE MATRIX ASPHALT**" submitted by **Mr. SUSANTA DUNG DUNG** in partial fulfillment of the requirements for the award of Bachelor Of Technology Degree in Civil Engineering at National Institute Of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the results obtained in the thesis have not been submitted to any other University/ Institute for the award of any degree or diploma.

DATE : 12 May,2014

PLACE: ROURKELA

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Chapter – 01

Introduction

ABSTRACT:

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: SMA Mix, Coconut shell charcoal, Filler, Binder, Marshall Test.

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.

SMA was first carried out in Germany in year -1960 by Zichner of Straubag -Bau AG central laboratory, to resist the damage being caused by studded tires. As
SMA showed excellent rut-resistance and resistance to deformation caused by heavy traffic at high temperatures, its use became popular even after the ban of studded tires.

SMA is gap graded mixture consisting of 70-80% coarse aggregate of total mass, 6-7% of binder, 8-12% of filler, and about 0.3-0.5% of fiber or stabilizer or additives. It provides a deformation resistant, durable surfacing material, suitable for heavily trafficked roads. SMA is used as a durable asphalt surfacing option for residential streets and highways. SMA forms an interlocks between coarse aggregate to form a stone skeleton which can sustain permanent deformation. The stone skeleton is fully filled with bitumen and filler along with fiber so that it can bind them properly so as to prevent drainage of binder and not to cause any problem while transportation and while placing.
As the Coarse aggregate content is high in SMA Mix, it forms a skeleton- type structure which provide good resistance for rutting. Brown & Manglorkar (1993) reported that traffic loads for SMA are mainly carried by the coarse aggregate instead of the fine aggregate asphalt-mortar. The higher content of binder makes the mix durable. The fibers or stabilizer holds the binder in the mix even at a high temperature; this helps prevent factors like drainage during operations such as production, transportation and laying.

SMA is more cost efficient than dense graded mixes for the roads with high volume. Brown (1992) observed a number of influencing factors for the performance of SMA mixes, such as

- change in binder source & grade
- type of aggregates
- environment condition
- Production & construction method.

Therefore, SMA is defined as a gap-graded Hot Mix Asphalt designed to maximize deformation (rutting) resistance & durability by using stone-on-stone contact Structure. As aggregate are all in contact, rut resistance depends on aggregates property rather than asphalt binder property. Since the aggregate do not deform much as asphalt binders, the stone-on-stone contact significantly reduces the rutting under loading. [2]

FIG 1: SMA Sample

ADVANTAGE OF SMA MIX OVER OTHER CONVENTIONAL MIXES:

- Better Rut Resisting Capacity caused by slow and heavy traffic.
- It Provide better resistance to Skid and also resists permanent deformation at high temperature.
- The surface texture Properties is similar to Open graded asphalt (OGA) due to which the the noise produces between the tires and the surface of roads reduces.
- It has greater Strength, higher longevity, reduced moisture permeability over other conventional mixes.
- Due to rough texture, it provides good frictional property after surface film-coating of binder are removed by the traffic.
- Production and laying Cost is slightly higher than Dense graded mix because due to greater longevity of the pavement.

PROPERTIRES	SMA MIX	BC MIX
Sample Figure		
Definition	SMA is gap graded mix consists of very high percentage of coarse aggregate firmly bonded together by strong asphalt matrix.	BC consists of well graded coarse and fine aggregate, filler and bitumen.
Mass of Coarse Agg. Content (%)	70-80	50-60
Mass of Fine Agg. Content (%)	20-30	40-50
Mass of Filler Content (%)	<5	>5
Binder Type	60/70,PMB 40	60/70, 80/100 or Other modified Binder
Minimum Binder Content by Wt. of the mix (%)	3.5-4	5-6
Stabilizing Additive by Wt. of the mix	0.3-0.5	
Air Void (%)	5-10	3-6
Thickness(mm)	25-75	30-60

Table 1:Main difference between SMA mix & Bituminous mix (Bose et al., 2006)

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. The Fly Ash that is used in the project Work is obtained from Adhunik.

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.

Stone dust

Portland cement

Fly Ash

Coconut shell Charcoal

FIG 2: Types of Filler

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 and then product is incinerated in furnace at 800° C for 6 hrs then only we can obtain Coconut shell charcoal.

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.

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.

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.
- To find out optimum binder Content using Marshall Method.

Chapter – 02

Literature Review

LITERATURE REVIEW:

A basic definition of sustainability is the capacity to maintain a process or state of being into perpetuity, without exhausting the resource upon on which it depends nor degrading the environment in which it operates. In the context of human activity, sustainability has been described as activity or development "that meets the needs of the present without compromising the ability of future generations to meet their own needs"

Concrete pavements suffer from a perception that they contribute a considerable amount of carbon dioxide (CO2) to the atmosphere due to the use of Portland cement that binds the aggregates together. Although Portland cement manufacturing is an energy intensive process and does result in significant CO2 emissions, partly due to the pyro processing required and partly due to the calcination of limestone, advances in cement production have greatly decreased these impacts relative to even a few years ago. Future innovations will ensure additional improvements in reducing the carbon footprint and energy use over the next decade. When all aspects of sustainability are considered, especially when accounting for the pavement's life cycle, properly designed and constructed concrete pavements are clearly part of a sustainable transportation system.

Generally Pavement are 2 types:

- Flexible Pavement.
- Rigid Pavement.

Basically Flexible pavement is considered all over the world because the pavement deflects of flexes during loading which is very useful while driving. Flexible Pavement receive different load for different layers.

Its Structure Consists of:

- Surface Coarse
- Base Coarse
- Sub- base Coarse.

Hot Mix Asphalt (HMA): It is a mixture of Coarse and fine aggregates with addition of specific amount of binder for better performance. It is produced by heating the asphalt binder to decrease viscosity, and then drying the aggregates to remove moisture from it prior to mixing. Mixing is generally done with aggregates at around 300 °F (150 °C) for virgin asphalt and 330 °F (166 °C) for polymerize modified asphalts, and the asphalt cement at 200 °F (95 °C). Several different types of HMA mixes are present. These include

- Conventional Dense Graded Mixes (DGM)
- Stone Matrix asphalt (SMA)
- Open graded HMA.

PROPERTIES OF BITUMINOUS MIXTURE:

The bituminous mixture should possess following properties:

- It Shows resistance to Permanent Deformation
- It Shows resistance to fatigue & Reflective Cracking
- It Shows resistance to Cracking
- Durability.
- It Shows resistance to Stripping.
- Workability.
- Skid Resistance.

But in this research Project work, the mix that is used is STONE MIX ASPHALT (SMA) to improve the quality and longevity of the roads. It consists of gap-graded mix comprising of aggregate continuously graded from maximum size , typically less than 19 mm, through the fine filler that is smaller than 0.075 mm. The STONE MIX ASPHALT design aims to determine the proportion of bitumen, filler, fine aggregates, and coarse aggregates to produce a mix which is workable, strong, durable and economical.

Mineral filler play an important role in determining the properties of SMA mixes in terms of air voids (VA) and for determining optimum binder content in the mix for which different fillers are used.

Gradation with high amount of fines (either naturally occurring or caused by excessive abrasion) may cause distortion in mixtures as the large amount of fine particles tend to push the larger particles apart and act as lubricating ball-bearings between these larger particles, and this in turns problem in deformation resistance of mixtures under traffic loading [24].

Mineral fillers are added to asphalt paving mixtures to fill voids in the aggregate and reduce the voids in the mixture. However, addition of mineral fillers has dual purpose when added to asphalt mixtures. A portion of the mineral filler that is finer than the asphalt film thickness mixed with asphalt binder forms a mortar or mastic and contributes to improved stiffening of mix. This modification to the binder that may take place due to addition of mineral fillers could affect asphalt mixture properties such as rutting and cracking. The other portion of fillers larger than the asphalt film thickness behave as a mineral aggregate and serves to fill the voids between aggregate particles, thereby increasing the density and strength of the compacted mixture. In general, filler have various purposes among which, they fill voids and hence reduce optimum asphalt content and increase stability, meet specifications for aggregate gradation, and improve bond between asphalt cement and aggregate [25].

Ramzi et al. have evaluated the use of cement bypass dust (CBPD) as filler in asphalt mixtures. They have both investigated the effect of adding either lime or CBPD in different proportion on binder and Marshal Properties. From their test data, they have made the following conclusions:

• For any filler type (lime or CBPD), penetration and ductility of the filler-binder mortar generally decreased as filler content was increased. However, such decrease was steeper and

more pronounced when lime rather than CBPD was used as filler. On the other hand, softening point increased with the filler content where more significant increment was observed when lime rather than CBPD.

• When considering the Marshal properties, the substitution of 5% CBPD for lime as a filler would be the optimum value used in asphalt concrete mixtures. Any percentages higher than 5% CBPD would require more asphalt binder and thus produce an uneconomical mix. [26]

Brown and Mallick (1994) studied the properties of SMA related to mix design by using Marshall Mix design method. A compactive effort of 50 blows of the mechanical fixed base Marshall Hammer was given to the mix for preparing the mix and proper compaction. They showed an increase in the density of the mix prepared, if higher compactive effort was used, but this may result in crushing of the coarse aggregate due to which stone to stone contact may be lost. Hence they recommended that SMA mixtures be designed with 50 blows rather than blows as high as 75 and they suggested that drain-down of binder in the mix gets significantly affected by the types of fillers used. Presence of higher percentage of filler in the mix lowers the drain-down of the binder.

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 drain down of the mastic, rutting, low temperature cracking, workability, and moisture susceptibility

Brown and Haddock (1997) has remarked that, due to the fact that the strength of SMA relies mostly on the stone-on- stone aggregate skeleton, steps should be taken as to design the mix and place it with a strong coarse aggregate skeleton that would provide the desired strength and stability to the mix.

Punith V.S., Sridhar R., Bose Sunil, Kumar K.K., Veera ragavan A (2004) adopted Marshall mix design at 60̊ 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.

Putman et al. (2004) followed a Super-pave mix design guide-lines to design the SMA mixes using PG 76-22 binder and stabilizers like waste fibers such as waste tires as additives. They were compacted the specimen with the 50 gyrations of Super-pave Gyratory Compactor as per SC DOT procedures.

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.[27]

Yongjie Xue, Shaopeng Wu, Haobo Houa, 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.

Mustafa Karasahin et al. (2006) used waste marble dust obtained from shaping process of marble blocks and lime stone as filler and optimum binder content was determined by Marshall Test and showed good result.

Kumar et al. (2007) used 60/70 penetration grade bitumen and Crumb Rubber Modified Binder- CRMB without any stabilizing additives to study the performance and results on SMA mixes. They concluded that the use of CRMB without fibers in SMA mixes has a performance similar to or better than the conventional SMA.

Xue et al. (2008) utilized solid waste incinerator fly ash as a partial replacement of fine aggregate or mineral filler in SMA mixes. They made a comparative study on the performance of the design mixes using Super-pave and Marshall mix design procedures. These mixes were evaluated for dynamic stability, water -sensitivity and fatigue life. Theyconcluded that nearly 8-16% of the incinerated fly ash substitution in replacement for aggregates and filler meets the SMA specifications.

Yongjie 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.

Ravi Shankar et al. (2009) used stone dust as well as cement as the filler material for SMA mixes. They used a filler content of 10% by dividing it into 8% stone dust and 2% cement and for their studies used conventional 80/100 penetration bitumen in their performance study of SMA mixtures using waste plastics as modifier.

Perviz Ahmedzade, Burak Sengoz(2009) Conducted the Evaluation of steel slag as coarse aggregate in SMA along with polypropylene and found that According to the results obtained from Marshall stability and flow tests, it should be noted that the mixtures with steel slag have better results than mixtures with stone with increased stability and decreased flow values.

Bindu C.S. et. al.(2010),Plastic coated graded aggregates were used for the SMA mix and the Marshall Stability value of stabilized SMA mix was found to be higher than the prescribed value along with the values of retained stability. Excessive drain-down too was

reduced by a great factor.

Jony Hassan et al. (2010) studied effect of using waste glass power as mineral filler on Marshall property of SMA by comparing with SMA where lime stone, ordinary Portland cement was taken as filler with varying content (4-7%).

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.

Chapter – 03

Experimental Investigation

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%)

MATERIALS DETAILS:

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.

BINDER:

Bitumen acts as binding agent to the Coarse and fine aggregates and stabilizers in SMA mixtures. SMA mixes are very rich in mortar binder which increases the aging of the mix. Properties of bitumen depend on temperature. Bitumen shows viscous as well as elastic property. Bitumen used for the experiment is of 60/70 penetration grade.

Standard Properties of bitumen are:

Test Description	Standard Values
Penetration at 25℃	50-90
Softening Point ℃	>45
Specific Gravity	>60
Ductility (cm)	>1

Table 2: Properties of Binder

STABILIZERS:

Stabilizers are used to reduce the air void present between the aggregates and also to bind them together so that no bleeding of bitumen can occur. Due to which Compaction increases and drain down of bitumen decreases. Cellulose fiber is used as stabilizer in the experiment. Cellulose fiber is obtained from chemical farm and then cleaned properly. It is then cut into pieces of 10-15mm for proper mixing with aggregates.

The important stabilizing additives used in the SMA mixes can be classified into four different groups:

- Fiber (Cellulose Fiber, Chemical Fiber and Mineral Fiber)
- Polymer
- Powder and flour like materials (Special Filler and Silicic acid)
- Plastics (Polymer Powder/Pellets)

FIG 3: Topcel Cellulose Fiber

As per MoRTH specification usually 0.3%-0.5% fiber is used in SMA mixtures.

The Properties of Fiber are:

PROPERTY	VALUE
Density gm / cm^3	1.5
Elongation (%)	2-3
Cellulose (%)	65-80
Lignin (%)	10-15
Moisture Content (%)	10.5-22.5
Ph	10-15
Tensile Strength(Mpa)	500-1000
Young Modulus(Mpa)	2.5-9.5

Table 3: Properties of the Fiber

EXPERIMENTAL PROCEDURE:

- **PREPARATION OF MIXES:**

  Samples of coarse and fine aggregate are carried out for 13mm STONE MATRIX ASPHALT composition as specified by **IRC: SP-79**.

IS SIEVE	Cummulative %	mean	% retained	4%	5%	5.5%	6%	7%
19	100	100	0	0	0	0	0	0
13.2	90-100	95	5	57.6	57	56.6	56	55.8
9.5	50-75	67.5	32.5	374	370.5	373	369.4	362.8
4.75	20-28	24	38.5	443	438.9	436.5	435.1	434.1
2.36	16-24	70	4	45.8	45.6	45.4	45.1	45.12
1.18	13-21	17	3	34.5	34.2	34	33.7	33.5
0.6	12-18	15	2	23	22.8	22.5	22.2	22.3
0.3	10-12	15	3	34.5	34.2	34.0	33.7	33.5
0.075	8-12	10	2	23	22.8	22.5	22.4	22.3
Total				1152	1140	1134	1128	1116
Binder used				48	60	66	72	84

Table 4: The Composition of SMA mix as per **IRC: SP-79**.

According to the composition, the total weight of each sample is 1200gm.

2 samples each of 4%, 5%, 5.5%, 6% and 7% bitumen were prepared respectively and Marshall test was carried out to calculate their Stability, flow and VA respectively.

The Samples prepared using slag as coarse aggregate and stone as fine aggregate with different fillers are as follows:

1. Stone dust
2. Coconut Shell Charcoal
3. Fly ash

The Samples prepared using Stone as coarse aggregate and fine aggregate with different fillers are as follows:

1. Portland Cement
2. Stone dust

SIEVING:

The coarse and fine aggregates are properly cleaned and dried. Then by Sieving the aggregates are separated according to the Standard Composition of SMA mix. The aggregates are sieved through 19mm to 0.075mm and kept separately.

FIG 4: Sieving

MIXING:

The aggregates are mixed thoroughly so that the gap between the aggregates reduces so as to provide better compaction. The sample is mixed for 5 minutes. Then the sample is kept in the heating oven at 160̊C for 1 hour. Then the sample is mixed with bitumen according to the requirement.

FIG 5: Mixing aggregates with Bitumen

MOULDING:

The sample mixed with bitumen is then compacted by using Marshall Compaction Moulds. The compaction is done using a hammer of 4.54 kg which is allowed to fall from a height of 40cm. The sample is compacted with 50 blows on each side. The sample is allowed to dry for 24 hours. The sample is taken out from mould with a help of Sample Ejector.

FIG 6: Marshall Mould

FIG 7: Hand Hammer Compaction

FIG 8: Sample Moulding

WEIGHING:

The sample Weight, Radius and Height is measured. Then the sample is Coated with Paraffin/Wax and again measured. The sample weight in water is measured.

FIG 9: Sample Before & After Coating

HOT WATER BATH:

The sample is then kept in hot water bath at 60̊ C for 30mins. Care should be taken so that the specimen should not be heated more than 60̊ C or kept for more than 30mins. If such condition occurs, then the bitumen which is used for binding will be worthless and could not be used for Marshall Test. Because when the load will be applied it can hold the pressure due to looseness of bitumen.

FIG 10: Hot Water Bath

MARSHALL TEST:

Marshall Mix design is generally used worldwide for conducting different test regarding Stability and flow Characteristics of the mix sample. It is also available at low cost.

The sample is taken out of Hot water bath and placed in the Marshall Stability testing machine and loading is done at a constant rate of 5 mm per minute of deformation until failure.

- The total maximum load (kN) taken by the Specimen where failure occurs is taken as Marshall Stability. The stability value obtained is corrected by using correlation ratio table.
- The total amount of deformation which occur at maximum load is recorded as Flow Value whose unit is 0.25mm.

FIG 11: Marshall Test Machine

Chapter – 04

Analysis Of Result

ANALYSIS OF RESULT :

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.

RESULTS:

DIFFERENT RESULTS OF SLAG AS COARSE AGGREGATE AND STONE AS FINE AGGREGATE WITH CELLULOSE FIBER AS STABILIZER.

1. 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 5: Results using Stone dust as filler

2. 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 6: Results using Fly ash as filler

3. 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

Table 7: Results using Coconut shell charcoal as filler

COMPARISON OF RESULTS:

1. STABILITY VALUE COMPARISON USING DIFFERENT FILLERS:

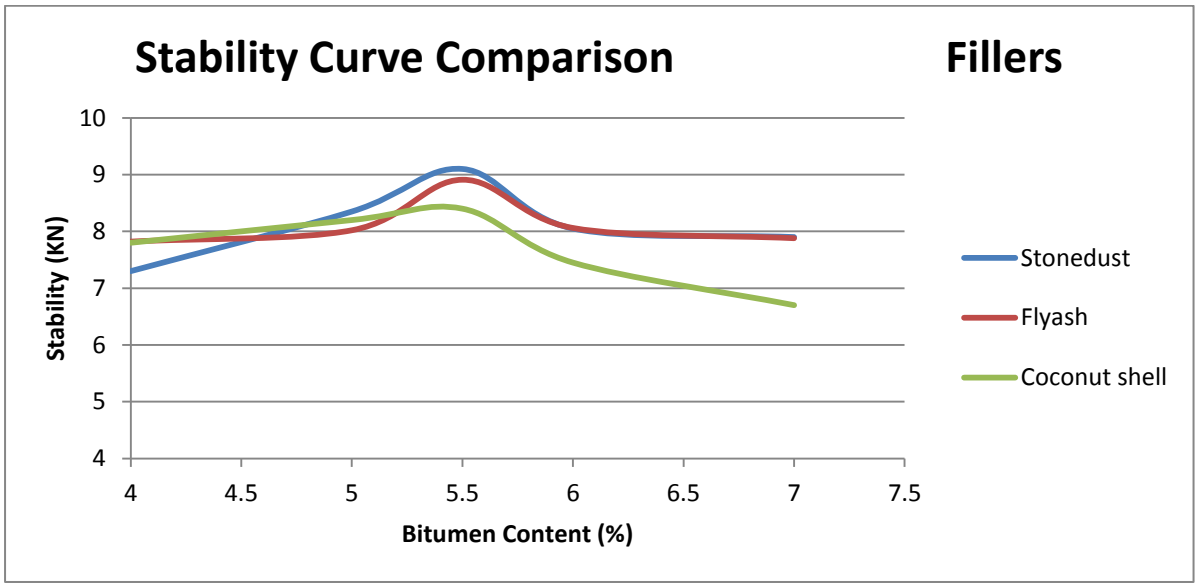

FIG 12: Average Stability Value Comparison Graph with different Bitumen Content

	Bitumen content (%)	Stone dust as filler	Fly Ash as filler	Coconut shell Charcoal as filler
STABILITY (KN)	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%	7.9	7.88	6.7

Table 8: Average Stability Value using different Fillers

2. FLOW VALUE COMPARISON USING DIFFERENT FILLERS:

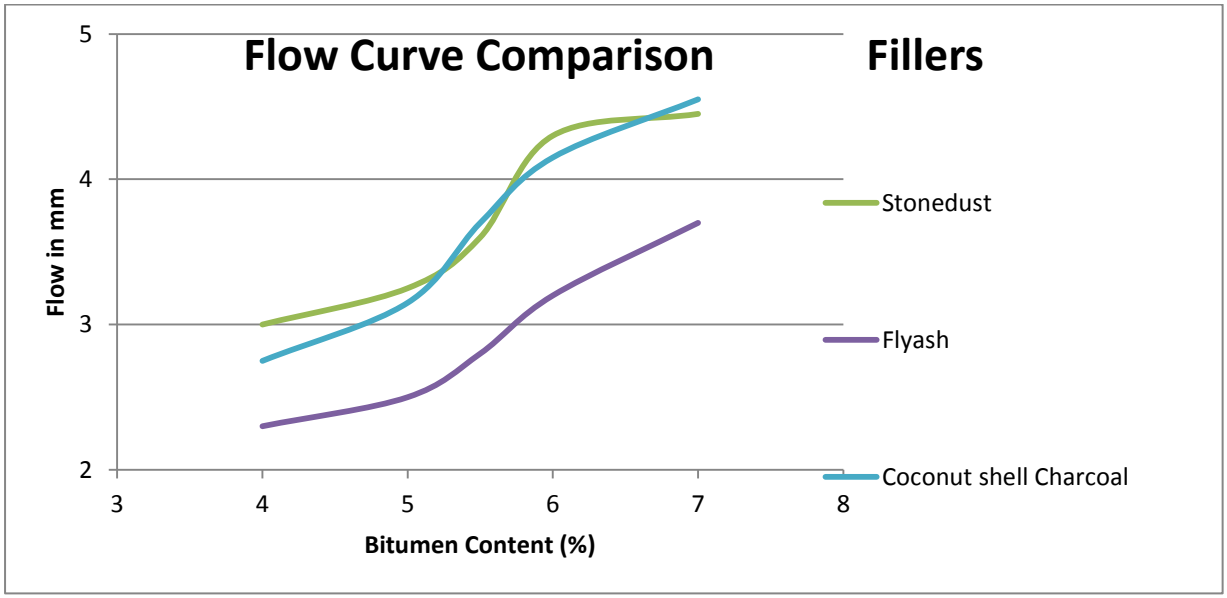

FIG 13: Average Flow value comparison Graph with different Bitumen Content

	Bitumen content (%)	Stone dust as filler	Fly Ash as filler	Coconut shell Charcoal as filler
FLOW VALUE (mm)	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

Table 9: Average Flow Value using different Fillers

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.

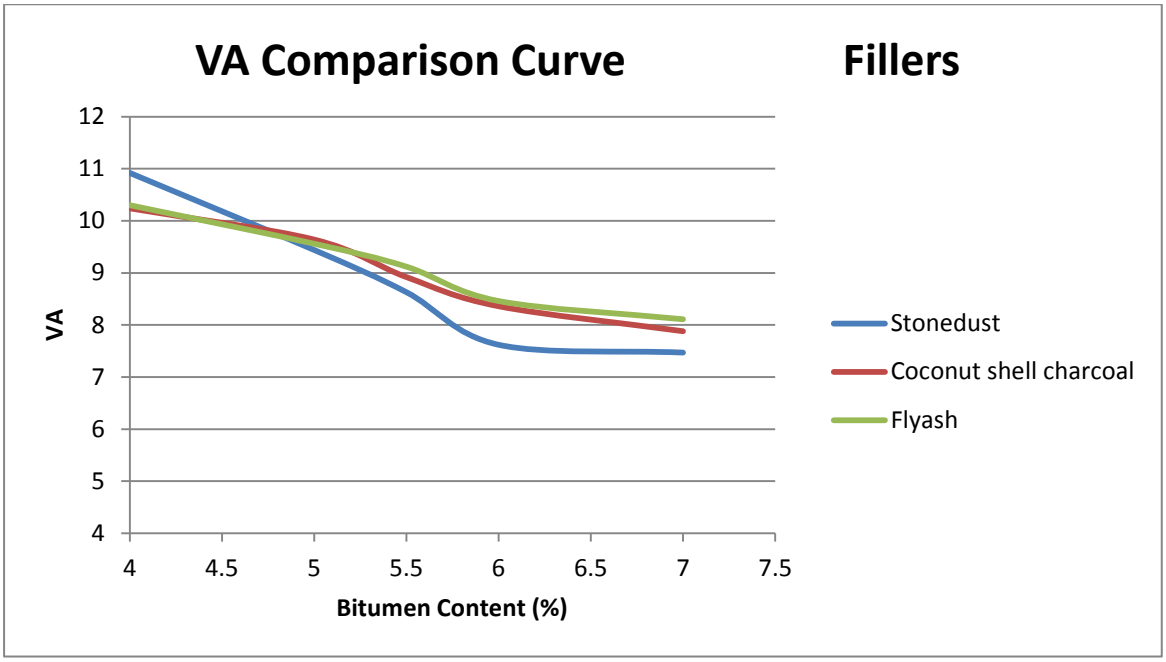

FIG 14: VA Comparison Graph with different bitumen Content

	Bitumen content (%)	Stone dust as filler	Fly Ash as filler	Coconut shell Charcoal as filler
STABILITY (KN)	4%	10.9	10.37.94	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

Table 10: Air void (VA) using different fillers

Chapter – 05

Conclusion & Discussion

CONCLUSION AND DISCUSSIONS:

MARSHALL STABILITY:

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.

Therefore it is proved that with increase in bitumen content, the Stability Value also increase but up to certain point i.e 5.5% of bitumen content. After that the stability Value decreases due to excess use of bitumen which decreases the strength of the Mix.

FLOW VALUE:

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

The results obtained from the experiment is :

- 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.

Chapter – 06

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