Assessment of suitability coconut shell as a Filler in stone Mastic asphalt

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ABSTRAC T

For reducing 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.

Keywords*: Mix, SMA,Coconut Shell Charcoal, Filler, Binder, Marshal Test.*

I. INTRODUCTION

Usually aggregates are mixed with bitumen are widely used all over the world for construction & maintenance of flexible pavements. Highway construction involves vast outlay of investment. Bitumen is used for covering surface in most of the Indian highways. SMA is a combination of coarse aggregate fine aggregates, mineral filler, and bitumen. Well graded aggregates and mineral filler resulting in maximum density when mixed with optimum quantity of bitumen result in a mix with very high stability.

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

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 fibre or stabilizer or additives. It provides a deformation resistant, tough surfacing material, suitable for heavily trafficked roads. SMA is used as a strong asphalt surfacing option for residential streets and highways. SMA forms an interlocks between coarse aggregate to form a stone skeleton which can maintain permanent deformation. The stone skeleton is fully filled with bitumen and filler along with fiber so that it can connect them properly so as to prevent drainage of binder and not to cause any problem while transportation and while placing.
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 make contact with, 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.

Fillers used: Mainly 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 decrease 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 is retained in 0.075mm sieve.

Portland cement
Cement can be used as 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 huge amount of carbon dioxide (CO2) to the atmosphere due to the use of Coconut shell Charcoal it binds the aggregates together.

Binder used
Different types of binder like convectional 60/70 or 80/100 penetration grade bitumen are used Now a days. 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.

II. MATERIALS USED

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

Materials details
Coarse aggregate
The coarse aggregate should be crushed Stone which should pass through 19mm sieve and retained in 4.75 mm sieve. The stone should be well graded, cubic shape and rough surface for good compaction. The hardness should be such that it can resist the traffic load.

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 passes through 0.075mm sieve is called filler. Mineral fillers have significant impact over the
properties of SMA mixes. s
It increases stiffness of asphalt& mortar matrix.
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.

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.
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 andSilicic acid), Plastics (Polymer Powder/Pellets)

Material testing
The materials should be tested with all standard tests for coarse aggregate, fine aggregate and bitumen. The test results should conform to IS Specifications and IRC recommendations.

III. EXPERIMENTAL PROCEDURE

Preparation of mixes

Samples of coarse and fine aggregate are carried out for 13mm SMA composition as specified by IRC: SP-79. Following table shows details of the same.

Table1:TheCompositionofSMAmixasperIRC: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

According to the composition, the total weight of each sample is 1200gm.
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 Stone as coarse aggregate and fine aggregate with different fillers are as follows:

- Stone dust
- Coconut Shell Charcoal
- Fly ash
- Cement

Sieving: The coarse and fine aggregates are properly cleaned and dry. After that 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.

Mixing: The aggregates are mixed carefully so that the gap between the aggregates reduces so as to provide better compaction. The sample is mix for 5 minutes. Then the sample is kept in the heating oven at 160oc for 1 hour. At that time the sample is mixed 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.

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.

Hot water bath: The sample is then kept in hot water bath at 60°c for 30 min. Care should be taken so that the specimen should not be heated more than 60°c or kept for more than 30 min. If such conditions occur, then the bitumen which is use for binding will be worthless and could not be used for the Marshall test because when the load will be applied it can be hold the pressure due the looseness of bitumen.

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

IV. EXPERIMENTAL WORK / ANALYSIS WORK

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.

V. COMPARISON OF RESULTS

Stability Value Comparison Using Different Fillers

TableNo.02AverageStabilityValueusingdifferentFillers

	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%	9.2	8.91	8.5
	6%	8.05	8.06	7.45
	7%	7.9	7.88	6.

Flow Value Comparison Using Different Fillers:

Table No.03 Average Flow Value using different Fillers

	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

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.

TableNo.04Airvoid(VA)usingdifferentfillers

	Bitumen content (%)	Stone dust as filler	Fly Ash as filler	Coconut shell Charcoal as fille
Stability (KN)				
	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

VI. CONCLUSION

The maximum stability obtained is 9.2 KN in case of Stone dust used as filler and the stability value obtained for coconut shell charcoal is 8.5 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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