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Partial Replacement of Stone Dust with Coconut Shell Charcoal Powder in Flexible Pavement

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Abstract:
Waste materials are used as an alternative to mineral filler, for reducing cost and increasing the efficiency of roads. Some of the waste materials are coconut shell charcoal ash, iron steel slag, scrap tire, plastic waste and fly ash. Among those coconut shell charcoal powder is referred as study. Coconut shell contributes solid waste approximately 1.2 million tonnes in India, these coconut shells are generally disposed out and burnt, and these are locally available especially in southern India. In this paper composition of bituminous concrete, Grade 1 for surface course was implemented. Here coconut shell charcoal powder was partially replaced with stone dust at 2%, 4%, 6%, 8% and 10% by the weight of aggregates, the bitumen content varied as 4%, 4.5% and 5 %. The performance of stone dust and coconut shell charcoal powder in bituminous concrete mix (BC) was tested by Marshall Stability test. The optimum binder content obtained at 4.33%. From the results we have observed that coconut shell charcoal (CSC) powder can be used as a partial replacement of stone dust in surface course.

Keywords*: Marshall Stability Test, Optimum binder content, bituminous concrete, Coconut shell charcoal powder, Stone dust.*

I. INTRODUCTION

Bituminous paved roads are mostly preferred in developing countries like India, to increase the road network with fewer funds. In bituminous mix filler plays an important role in filling voids which increases toughness, stability and density of a conventional design mix. In past few years most of the countries experiencing increase in the truck pressure, traffic volumes and axle loads, if this may happen rigorously the upper layer of the pavement is exposed to higher stresses. These stresses are responsible for distress like ravelling, cracking, rutting, shoving etc. To counteract these problems Bituminous concrete mix is best to handle the high axle loads and traffic volumes and this mix is easy to refinish. In India flexible pavements are more when compared to rigid pavements. The things which comes into consideration while constructing these flexible pavements are construction cost, economical, less maintenance cost, less repair cost, sustainability. Using waste materials as a replacement of aggregate, bitumen and filler help to reduce the cost, increase the strength to some extent [1]. There are lots of waste materials producing due to increase in industries, population, urbanization, development activities and changes in lifestyle [2]. Some of the waste materials are coconut shell charcoal ash, fly ash, steel slag and plastic waste[3]. Coconut shell charcoal ash possess properties like resistance to crushing, absorption, surface moisture, heating etc. Concrete pavement suffers from the fact that they add a significant amount of Co2 to the environment because of the use

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of CSC powder which binds the aggregates [4]. These wastes contribute in low cost, low density, low pollution and high toughness properties. And also Coconut shell categorised as MMC (Metal matrix composites) which has properties like good weather resistance, precise modulus, strength and good damping capacity.

Coconut shell is considered as a waste by product, this CSC produces activated carbon, these can be seen in coal, rice hush ash etc. The coconut shell is burnt at 450°C for 5-10 min to obtain coconut shell charcoal. This type of charcoal is used in oil industry, fillers in pavement, refineries. The activated charcoal is appeared when charcoal is treated in presence of oxygen. The activated charcoal is used in bleaching process of edible oil preparation, water purification filters, air purification etc. Granulated activated charcoal is used in medical treatments, deodorizing, Gold refining etc.

II. MATERIALS USED

A. *Aggregate and Material Description*

The sizes of aggregates are taken based on the MORTH specifications for road and bridge works, 5th revision, bituminous concrete Grade- 1 [5]. Fillers used in this mix are stone dust, coconut shell charcoal powder and cement. Fillers fill the remaining voids which are left between coarse and fine aggregates. Generally, binder used is bitumen. Bitumen of 40/50 penetration grade is used.

B. *Coconut shell charcoal powder CSC)*

The size of CSC powder used is passing on 1.18mm sieve and retained on 0.075mm sieve. It can be produced after using coconut shells as fuels in industries, household purposes. Coconut shell charcoal powder which we have used is displayed in fig.1

Fig- 1 Coconut shell charcoal powder

III. EXPERIMENTAL PROCEDURE

1200 grams of aggregate sample is taken depending upon the gradation table and is heated upto temperature of 140 0 C - 150 0 C. Then bitumen is heated upto 100 0 C to 120 0 C. Aggregates and Bitumen need to be mixed thoroughly to get uniform grey colour. Now Marshall Mould is taken and sample is poured into it. Each face is compacted with no. of blows 75. Marshall Mould is picked out and kept at normal standard temperature for about 24 hrs. Then the samples are taken out and kept in water bath at a constant temperature of 60° C for about 30 minutes. After 30 mins samples are taken out and weighed. Those samples are kept in Marshall Stability testing machine for proving ring and dial gauge readings. Load is applied vertically downwards at the rate of 50mm per minute. Maximum load at which sample specimen fails gives stability value. Corresponding vertical strain gives flow value which indicates deformation value.

We have conducted penetration test as per IS: 1203-1978 [6], softening point test as per IS: 1205-1978 [7], ductility test as per IS: 1208-1978 [8] and Marshall Stability test as per IRC111:2009 [9].

For Marshall Stability test we have taken bituminous concrete Grade1 as per MORTH specifications as shown in Table-1.

Table-1 Composition of bituminous concrete pavement layers.

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Grading	1
Nominal Aggregate Size	19 mm
Layer thickness	50 mm
IS Sieve (mm)	Cumulative % by wt. of total aggregate passing
45	
37.5	90-100
26.5	59-79
19	52-72
13.2	35-55
9.5	52-72
4.75	35-55
2.36	28-44
1.18	20-34
0.6	15-27
0.3	10-20
015	5-13
0.075	2-8
Bitumen content % by mass of total mix	Min 5.2*

IV. METHODOLOGY AND TESTS CONDUCTED

A. Aggregate Tests

Aggregate Crushing Test, Impact Test, Flakiness Index, Elongation Index, Water Absorption Test, Los Angeles Abrasion Test. These tests are conducted based on IRC specifications

B. Bitumen Tests

Penetration Test, Softening point Test, Ductility test

METHODOLOGY

Based on the total weight of the aggregates the percentage of the CSC powder as filler is partially replaced with stone dust as following percentages (2%, 4%, 6%, 8% and 10%) in Bitumen percentages of 4%, 4.5% and 5%.

The schematic representation of the project. The below Fig-2 describes about workflow procedure of this project.

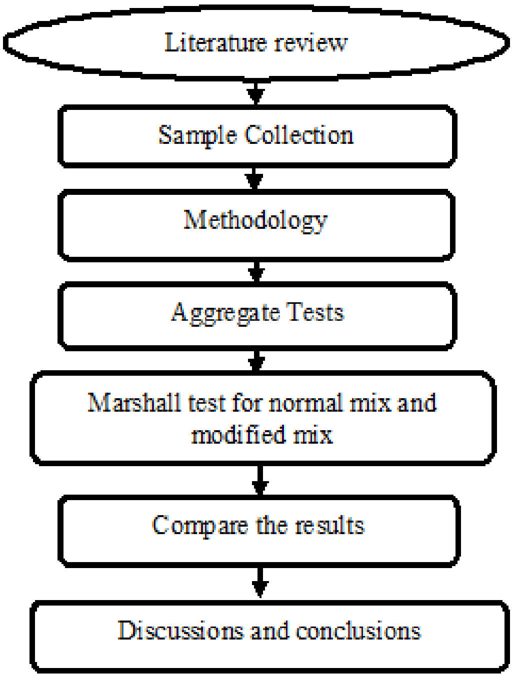

Fig-2 workflow procedure

V. RESULT AND ANALYSIS

The results depict that the optimum binder content (OBC) for the specimens of 4%, 4.5% and 5% was at 4.33%.%. Here VA, Volume filled by bitumen, VMA, Bulk Density of all specimens was determined. Marshall Stability values are highest at 4.5% bitumen content. The flow values for 4%, 4.5%, 5% bitumen mixes are within the limits. The bulk density attained is almost same of 2.33 g/cc, at 4.5% the value was at maximum and later on it decreased. The values of all results are shown in Table-2.

Table-2 Characteristic properties of bituminous mix

Bitumen Percentage	**Coconut shell charcoal**	**Air voids (%)**	**VMA (%)**	**VFB (%)**	**Stability (kg)**	**Flow value**	**Bulk Density (g/cc)**

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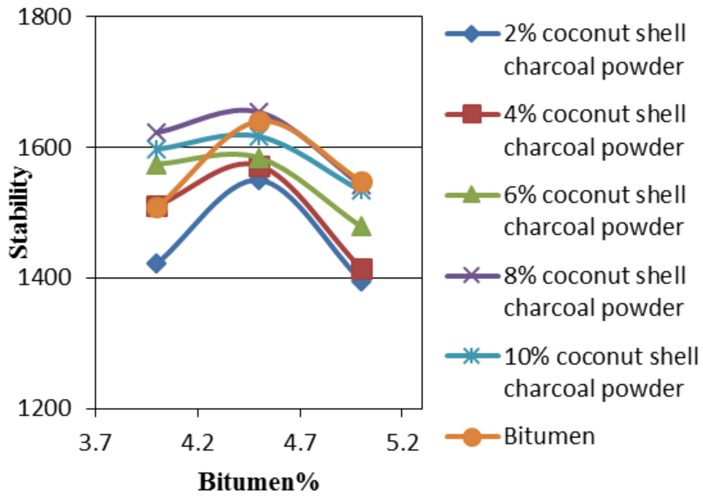
	powder (%)					(mm)	
4	0	4.03	13.38	69.91	1507.72	2.90	2.30
	2	4.75	14.04	66.15	1422.12	2.00	2.28
	4	4.54	13.85	67.21	1510.76	2.27	2.29
	6	4.20	13.54	68.97	1574.30	2.47	2.30
	8	4.14	13.50	69.37	1622.36	2.70	2.32
	10	3.94	13.30	70.39	1596.88	3.07	2.32
4.5	0	3.67	14.11	73.99	1639.73	3.10	2.36
	2	4.24	14.61	71.01	1549.70	2.13	2.31
	4	4.12	14.51	71.59	1571.99	2.53	2.32
	6	3.92	14.33	72.62	1584.00	2.77	2.33
	8	3.82	14.24	73.18	1653.63	2.80	2.34
	10	3.72	14.20	73.80	1616.57	3.20	2.35
5	0	3.61	15.07	76.07	1548.10	3.50	2.33
	2	4.00	15.42	74.05	1395.68	2.23	2.30
	4	3.92	15.35	74.47	1414.26	2.63	2.30
	6	3.83	15.27	74.94	1478.33	2.87	2.32
	8	3.76	15.21	75.25	1542.17	2.97	2.32
	10	3.59	15.06	76.16	1533.19	3.37	2.30

The graphs are plotted between stability vs Binder content, Density vs Bitumen content, Air void vs Bitumen content, VFB vs Bitumen content, Flow value vs Bitumen content were shown in following Graphs. From the Graphs it is observed that maximum stability value is obtained at 8 % of filler which is almost nearer to the conventional mix. The flow value, VFB and density are almost same when compared to the conventional mix.



Graph-1 Stability Vs Bitumen content

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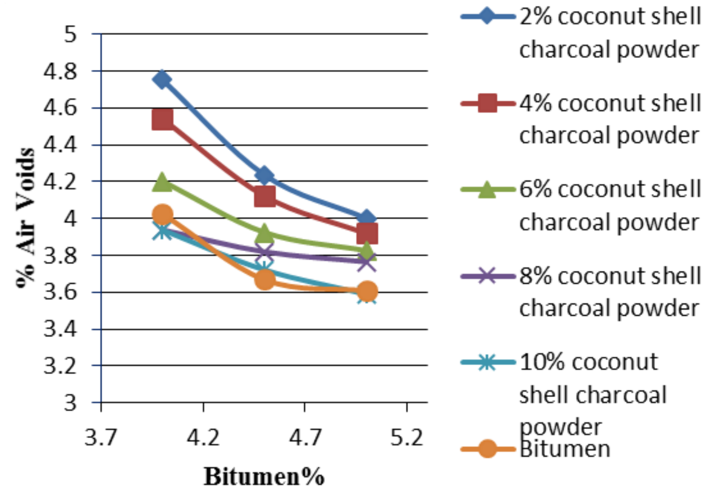
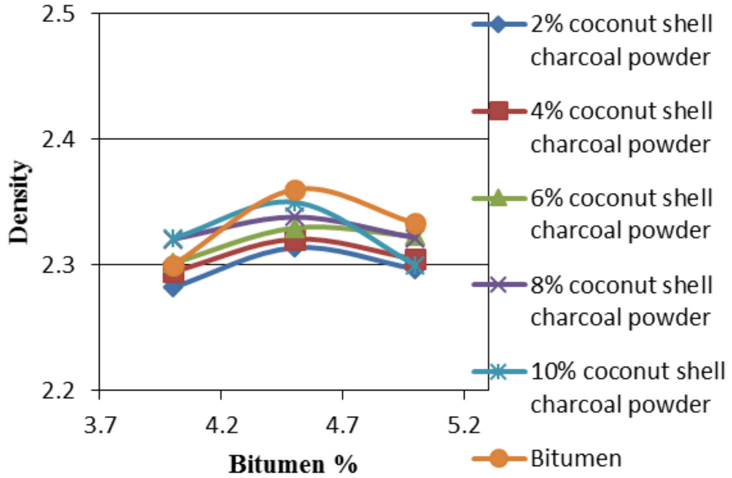
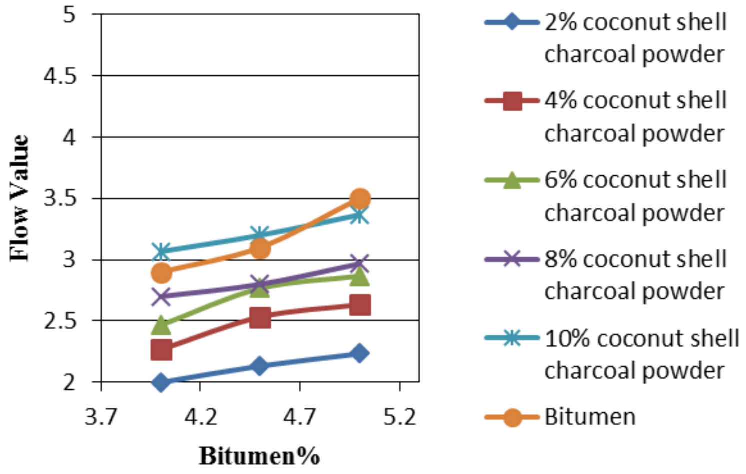


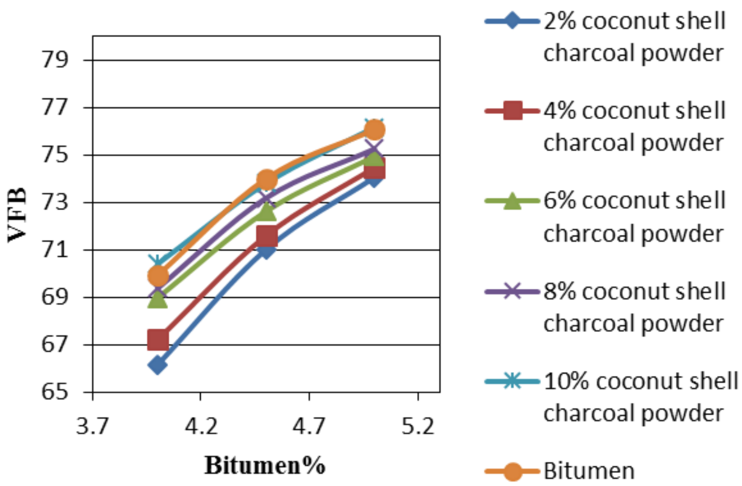
Graph-2 Air voids Vs Bitumen content



Graph-5 Density Vs Bitumen content



Graph-3 Flow value Vs Bitumen content



Graph-4 VFB Vs Bitumen content

VI. CONCLUSIONS

Coconut shell charcoal powder which passes through 1.18mm sieve is used. Maximum value of stability is obtained at 8% coconut shell charcoal powder and 4.5% binder content. Stability of 2%, 4%, 6%, 8% and 10% coconut shell charcoal powder are increased up to 4.5% binder content and gradually decreased up to 5% binder content. Percentage of air voids keeps on decreasing by increasing bitumen content. As the percentage of bitumen increase the flow value increases.

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