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

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Abstract:

To cut costs and improve road efficiency, waste materials are employed as a substitute to mineral filler. Some of the waste products are coconut shell charcoal, fly ash, iron steel slag, scrap tires, and plastic garbage. Coconut shell charcoal powder is one of those, according to the study. About 1.2 million tonnes of solid trash in India come from coconut shells, which are often burned after disposal and are widely available, especially in southern India. Grade 1 for the surface course was utilized in this bituminous concrete composition paper. Here, the bitumen percentage changed as 4%, 4.5%, and 5%, and the coconut shell charcoal powder was partially substituted with stone dust at 2%, 4%, 6%, 8%, and 10% by the weight of aggregates. Marshall Stability test results were used to evaluate how well stone dust and coconut shell charcoal powder performed in bituminous concrete mix (BC). The ideal binder concentration was attained at 4.33%. According to the findings, coconut shell charcoal (CSC) powder can be utilized in place of some of the stone dust in the surface course.

1. INTRODUCTION:

For developing nations like India to expand their road networks while spending less money, bituminous surfaced roads are typically favored. To strengthen the toughness, stability, and density of a typical design mix, filler plays a crucial function in bituminous mixes by filling up the gaps. The majority of countries have seen an increase in axle loads, truck pressure, and traffic volumes over the past few years; if this trend continues, the pavement's upper layer will be subjected to greater pressures. Distress symptoms like raveling, cracking, rutting, shoving, and other similar symptoms are caused by these pressures. For these issues to be resolved The finest concrete mix for handling heavy axle weights and traffic volumes is bituminous concrete since it can be easily refinished. When opposed to rigid pavements, flexible pavements are more prevalent in India. When building these flexible pavements, factors like cost, economy, ease of maintenance, affordability of repairs, and sustainability are taken into account. Utilizing waste products in place of aggregate, bitumen, and filler can assist save costs and, to some extent, boost strength. Due to growing industries, population growth, urbanization, development activities, and changes in lifestyle, a lot of trash is produced. Ash from coconut shell charcoal, fly ash, steel slag, and plastic garbage are a few of the waste products. Coconut shell charcoal ash possesses qualities including resistance to heating, absorbing moisture from the air, and crushing.These wastes offer low price, low density, low pollution, and excellent tensile strength qualities. Additionally, coconut shells are classified as MMCs (Metal Matrix Composites), which have strengths, exact moduli, strong damping capacities, and good weather resistance.

Activated carbon, which is found in coal, rice husk ash, and other materials, is produced by CSC using coconut shell, which is regarded as a waste byproduct. To make coconut shell charcoal, the coconut shell is burned at 450°C for 5–10 minutes. This kind of charcoal is utilized in refineries, fillers for paving, and the oil sector. When charcoal is handled with oxygen present, activated charcoal is produced. The bleaching process for preparing edible oils, water purification filters, and air filtration all employ activated charcoal Granules of activated charcoal are used for Uses for activated charcoal include air purification, water filtration, and whitening the manufacture of edible oils. Granulated activated charcoal is utilized for a variety of purposes, including gold refining and deodorizing

2. MATERIALS USED

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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. Fillers used in this mix are stone dust, coconut shellcharcoal 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. RYAN When combined with a binder (such as water, bitumen, Portland cement, lime, etc.) to create composite materials (such bituminous concrete and Portland cement concrete), mineral components including sand, gravel, and crushed stone are referred to as aggregate. Bituminous concrete and Portland cement concrete both contain between 92 and 96 percent by volume of aggregate, respectively. Additionally, base and sub-base courses for both flexible and rigid pavements are made of aggregate. Aggregates can be created artificially or naturally. Larger rock formations are typically mined for natural aggregates using an open excavation called a quarry. Usually, mechanical crushing is used to reduce extracted rock to sizes that may be used. Aggregate that has been manufactured is frequently a byproduct of other industrial sectors.

B. Coconut shell charcoal powder CSC :

The CSC powder used passes through a 1.18 mm sieve but is held by a 0.075 mm sieve. It can be made by burning coconut shells for domestic and industrial purposes. Charcoal is a thin, dark residue made of carbon and any leftover ash that is produced by stripping vegetation-based materials of their water and other volatile components. The typical method for producing charcoal is slow paralysis, which involves heating wood or other materials without oxygen. Peat, coal, wood, coconut shells, or petroleum can all be used to make common charcoal. Any carbonaceous material, including coal, lignite, wood, paddy husk, coir pith, coconut shells, etc., can be used to make activated carbon, which is a non-graphite type of carbon. Because of its narrow macro pore structure, which makes it more effective for the adsorption of gas and vapor as well as the removing of color and odor from substances, activated carbon produced from coconut shell is said to be superior to those obtained from other sources. The activated carbon is widely used in a variety of processes, including the bleaching and refinement of chemical and vegetable oils, the purification of water, the recovery of solvents and other vapors, the manufacture of gas masks for the protection against toxic gases, the manufacture of filters that offer adequate defense against war gases and nuclear fallout, etc.

Coconut shell charcoal powder which we have used is display.

Fig- 1 Coconut shell charcoal powder

3. EXPERIMENTAL PROCEDURE

Depending on the gradation table, 1200 grams of aggregate sample are taken and heated to a temperature of 140°C to 150°C. Following that, the bitumen is heated to between 100 and 120 °C. For a consistent gray color, aggregate and bitumen must be completely combined. The sample is currently poured into a Marshall Mould. A total of 75 blows are used to compress each face. For around 24 hours, Marshall Mould is selected and maintained at room temperature. The samples are then removed and stored in a water bath for roughly 30 minutes at a constant 60° C temperature. Samples are extracted and weighed after 30 minutes. For the purpose of demonstrating ring and dial gauge readings, those samples are preserved in the Marshall Stability testing apparatus. A vertical downward force of 50mm per minute is imparted to the load. Stability value is the maximum load at which the sample specimen fails. The flow value that corresponds to the vertical strain indicates the deformation value.
We performed penetration tests in accordance with IS: 1203-1978, softening point tests in accordance with IS: 1205-1978, ductility tests in accordance with IS: 1208-1978, and Marshall Stability tests in accordance with 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.

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

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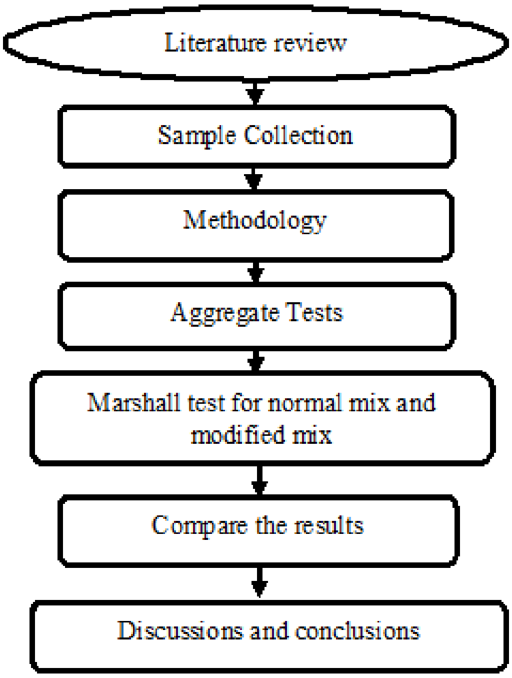
0.3	10-20
015	5-13
0.075	2-8
Bitumen content % by mass of total mix	Min 5.2*

In bitumen percentages of 4%, 4.5%, and 5%, (2%, 4%, 6%, 8%, and 10%).
Project depiction in schematic form. The workflow process for this project is shown in Fig. 2 below.



4. METHODOLOGY AND TESTS CONDUCTED

A. *Aggregate Tests*

Los Angeles Abrasion Test, Aggregate Crushing Test, Impact Test, Flakiness Index, Elongation Index, and Impact Test. According to IRC requirements, these tests are carried out.

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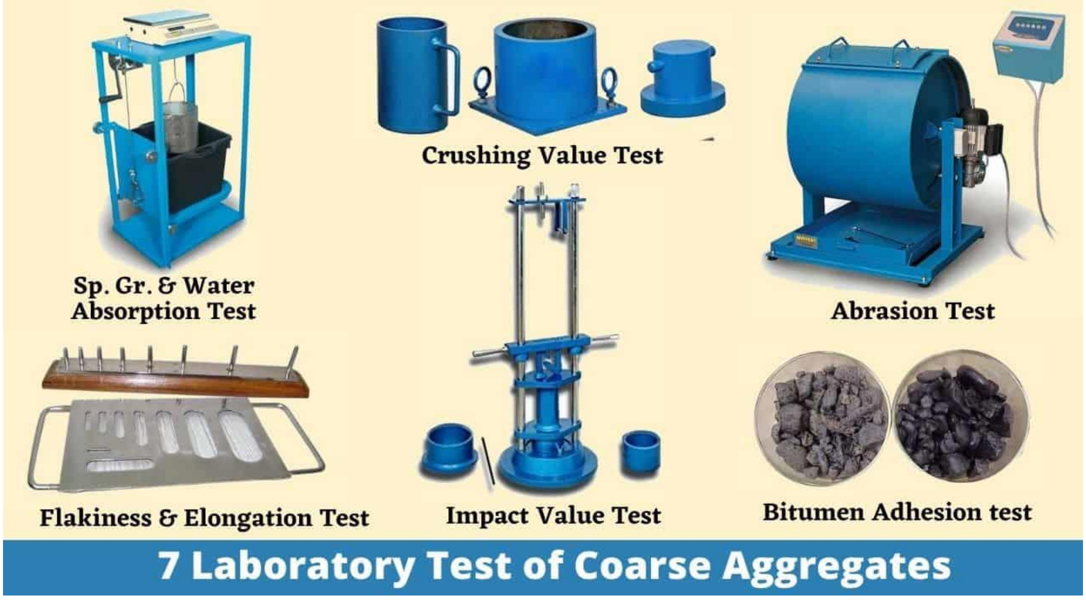
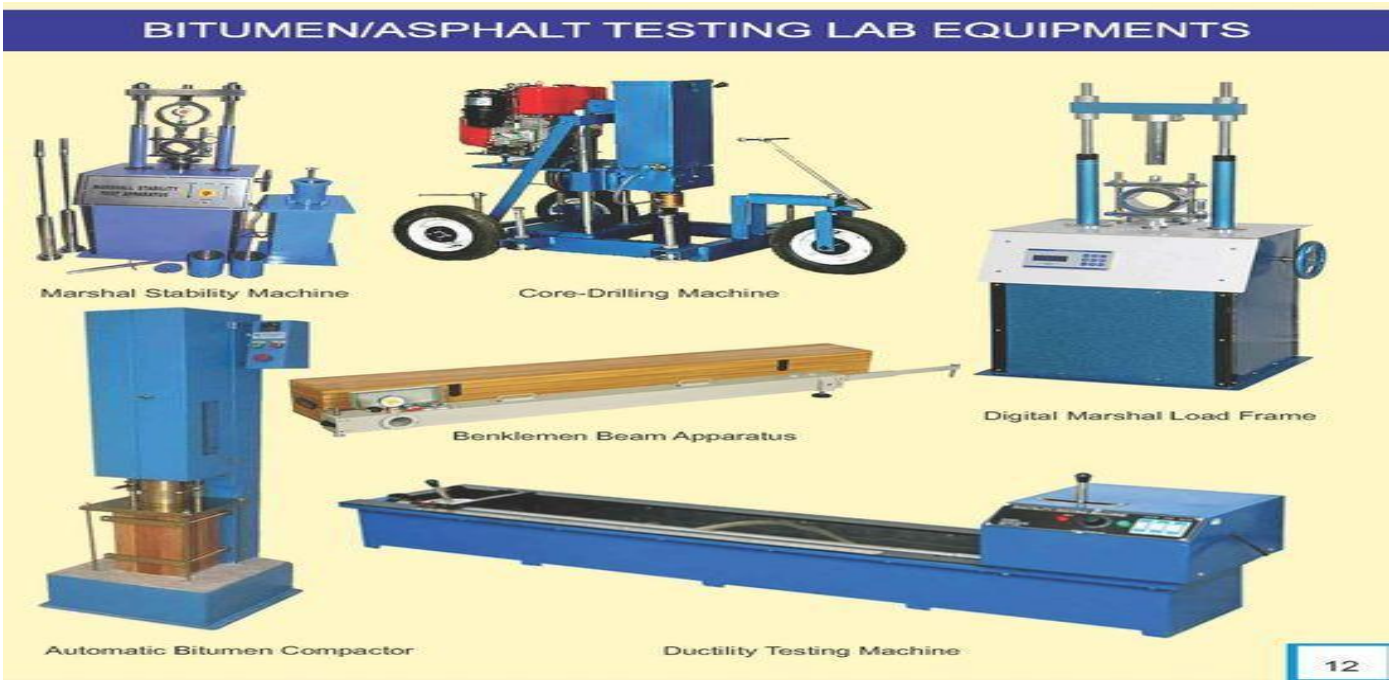


B. Bitumen Tests

Testing for penetration, softening points, and ductility test. The proportion of the CSC powder as filler is partially replaced with stone dust as f ollows percentages based on the overall weight of the aggregates. Table 2 lists the characteristics of bituminous mix.

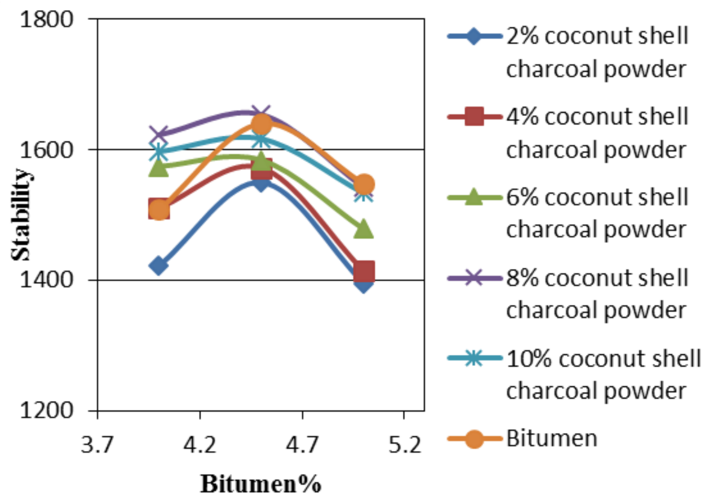


5. RESULT AND ANALYSIS

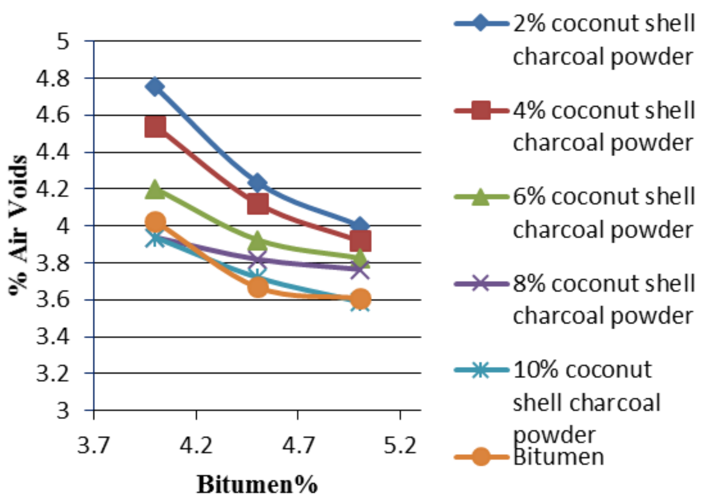
The results depict that the optimum binder content (OBC) for the specimens of 4%, 4.5% and 5% was at 4.33%.%. Here VA, Volume filled by bitumen, VMA, Bulk Density of all specimens was determined. Marshall Stability values are highest at 4.5% bitumen content. The flow values for 4%, 4.5%, 5% bitumen mixes 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.

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

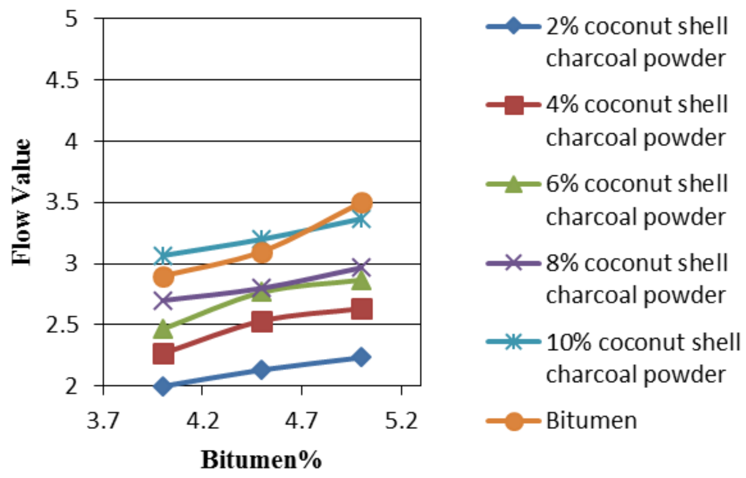
The graphs are plotted between stability vs Binder content, Density vs Bitumen content, Air void vs Bitumen content, VFB vs Bitumen content, Flowvalue vs Bitumen content were shown in following Graphs. From the Graphs it is observed that maximum stability value is obtained at 8 % of filler which is almost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



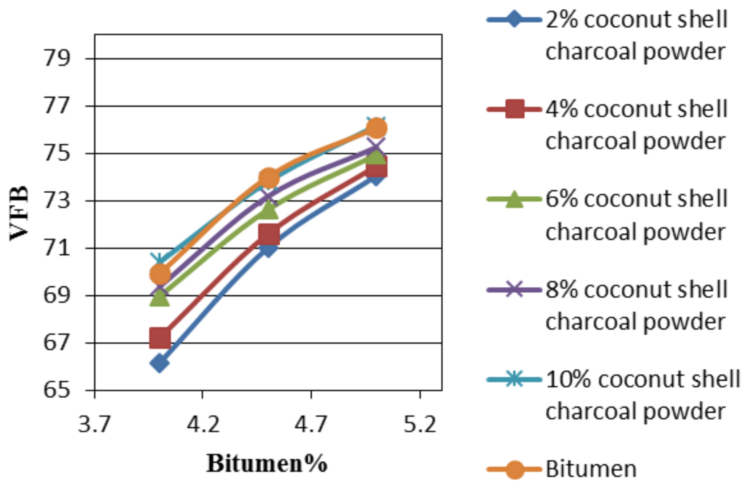
Graph-1 Stability Vs Bitumen content



Graph-2 Air voids Vs Bitumen content



Graph-3 Flow value Vs Bitumen content



Graph-4 VFB Vs Bitumen content

6. CONCLUSIONS

It is utilized coconut shell charcoal powder that has passed through a 1.18 mm filter. When 4.5% binder and 8% coconut shell charcoal powder are present, stability is at its highest. Coconut shell charcoal powders with a stability of 2%, 4%, 6%, 8%, and 10% have binder contents that are gradually increased to 4.5% and dropped to 5%. By enhancing the bitumen content, the percentage of air spaces continues to decline. The flow value rises as the bitumen percentage does.

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