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Utilization of Saw Dust Ash as Mineral Filler in Hot Mix Bituminous Concrete

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ABSTRACT: In the study, it was found that the use of saw dust ash (SDA) in the bituminous mixture as a filler. Various tests such as sieve analysis, specific gravity test, chemical analysis and plasticity index test were performed to evaluate the suitability of saw dust ash as filler in hot mix bituminous concrete. For this purpose ordinary Portland cement was replaced with saw dust ash (SDA) as a filler to make asphalt briquettes. The samples were prepared by replacing the OPC with SDA at 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100%. A number of samples were prepared with OPC and SDA in different proportion. In all samples Marshall test was conducted to study the effect of SDA in the bulk density, voids in mineral aggregates and total voids in the bituminous mixture. The flow value and stability also evaluated in the test. After the Marshall test was conducted on the samples and their results were evaluated, it was found that the cement can be partially replaced with 10% SDA at 5.5% bitumen content.

KEYWORDS: Bituminous Concrete, Marshall Method, Saw dust ash, Filler, OPC.

I. INTRODUCTION

The aim of this research work is to evaluate the effect of saw dust ash (SDA) as mineral filler in hot mix bituminous concrete. Continuous generation of industrial wastes such as volcanic ash, blast furnace slag, and fly ash has a negative impact on the environment. In India construction industry is identified as a bigger sector for generation of industrial waste. Many research papers suggest the use of industrial waste in the production of concrete. Proper utilization of such waste materials has both ecological and economic benefits. The environmental hazards associated with industrial waste can be reduced by changing these waste materials into new products by recycling process and it also reduces the emission of greenhouse gases.

II. LITERATURE SURVEY

The SDA produced from burning of sawdust is suitable for use in concrete making proposed by Mageswari et al. [1]. As high as 30% by weight of OPC can be replaced with reburnt rice husk ash without any adverse effect on strength and permeability properties is suggested by Ganesan et al. [2]. CCA and SDA up to 10% replacement of Ordinary Portland cement in concrete would be acceptable to enjoy maximum benefit of strength gain was proposed by Adesanya et al. [3].

Slag and rice husk ash can effectively be used as filler in paving mixes in place of most commonly used filler such as stone dust was suggested by Rocksana et al. [5]. It is well known that on adding filler to asphalt mixture made it hard and stiff, and hence it prevents the stripping of bitumen. Limestone powder and ordinary Portland cement are some of the common materials which are available easily can be used as filler in asphalt mixture. Addition of 2% polyethylene for SMA and DBM mixes and 1.5% polyethylene for BC mixes results in optimum Marshall Properties where stone dust is used as filler was proposed by Mohanty [10].

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The aim of this research work is to assess the suitability of saw dust ash (SDA) as mineral filler in asphalt mixture. Partial replacement of saw dust ash (SDA) with cement or limestone powder will surely make it economical to produce asphalt mixture. Also it will reduce the environmental pollution caused by saw dust ash (SDA). In the study the suitability of saw dust ash (SDA) as filler in asphalt mixture is checked as per IRC and chemical constituents of SDA are determined. The samples are tested with Marshall Apparatus and the test results are compared with the given standards. The asphalt mixture mainly composed of aggregates and bitumen. All categories of aggregates such as coarse, fine and fillers are used in the mixture. The fines are the fillers; fine aggregates are of sand sizes and coarse aggregates ranges from 10 mm to 14 mm.

III. MATERIALS

2.1. Bitumen-Bitumen was sourced from Indian Institute Of Petroleum, Dehradun, Uttarakhand.

Bitumen of grade 60/70 is used in this research work. The following tests carried out on bitumen

2.1.1. Penetration test-Penetration test is carried out to determine the grade of the bitumen.

The average penetration value of the bitumen is **62.3**

2.1.2. Ductility test- The average ductility value of the samples was measured as 103 cm.

2.1.3. Specific Gravity test-The specific gravity of bitumen is calculated as **1.08**

2.2. Coarse Aggregates: Coarse aggregates of 10mm and 12 mm sizes are used. Following test were done on the coarse aggregates

2.2.1. Sieve Analysis

Table 3- Sieve analysis of 12 mm aggregates

Sieve size in mm	Mass retained in gm.	Percentage retained (%)	Percentage passing
25	0	0	100
12.5	270	54	46
10	223	44.6	55.4
4.75	7	1.4	98.6
Pan	0	0	0
Total	500	100	

The sieve analysis of 12 mm size aggregate is as shown in above table. The percentage retained in sieve size 25 mm, 12.5 mm, 10 mm and 4.75 mm are 0, 54, 44 and 1.4 % respectively. It shows the uniformity of the particle size.

Table 4- Sieve analysis of 10 mm aggregates

Sieve Sizes (mm)	Mass Retained (g)	Percentage Retained (%)	Percentage Passing (%)
25	0	0	0
12.5	18	2.85	97.15
10	155	24.6	75.4
4.75	280	44.45	55.55
2.36	177	28.10	71.9
Pan	0	0	0
Total	630	100	

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The sieve analysis of 10 mm size aggregate is as shown in above table. The percentage retained in sieve size 25 mm, 12.5 mm, 10 mm, 4.75 mm and 2.36 mm are 0, 2.85, 24.6, 44.45 and 28.10 % respectively. It shows the uniformity of the particle size.

2.2.2. Aggregate Impact Value Test

Average aggregate Impact Value of 12 mm aggregates is calculated as **19.51** and average aggregate Impact Value of 10 mm aggregates is calculated as **24.17**. This value lies within the permissible limit of aggregate impact value.

2.2.3. Aggregate Crushing Value Test

Average aggregate Crushing Value of 12 mm aggregates is calculated as **21.97** and average aggregate Crushing Value of 10 mm aggregates is calculated as **23.99**. This value lies within the permissible limit of aggregate crushing value.

2.2.4. Specific Gravity

Specific Gravity of 12 mm coarse aggregates using pycnometer = **2.63**

Specific Gravity of 10 mm coarse aggregates using pycnometer = **2.67**

2.3. Fine Aggregates

Fine aggregates ranges from 4.75 mm to 75 micron

Table 9- Sieve analysis of fine aggregates

Sieve Size	Mass Retained (gm)	Percentage Retained (%)	Percentage Passing (%)
4.75 mm	0	0	100
2.36 mm	137	13.7	86.3
2.0mm	358	35.8	64.2
600μ	129	12.9	87.1
300	155	15.5	84.5
150μ	94	9.4	90.6
75μ	43	4.3	95.7
Pan	84	8.4	0
TOTAL	1000	100%	

The sieve analysis of fine aggregates as shown in above table show a well graded distribution ranging from 4.75 mm sieve size to 75 micron sieve size. The mass retained is maximum for 2 mm sieve size while minimum in 4.75 mm sieve.

2.4. OPC

This is a common material used as filler in asphalt concrete.

2.5. Saw Dust Ash

The sample was collected carefully to avoid mixture of any other material. In a metal container the saw dust was burnt into ashes. Proper grinding is made on saw dust ash to make it finer.

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2.5.1. Sieve test on SDA

Table 10- Sieve analysis of SDA

Sieve Size in mm	Mass Retained in gm.	Percentage Retained (%)	Percentage Passing (%)
150 μ	0	0	100
75 μ	18	18	82
Pan	82	82	0
TOTAL	100g	100%	

The sieve analysis of saw dust ash as shown in above table show a uniform distribution as more percentage of particles are below 75 micron size. The particle of saw dust is not retained on 150 micron sieve, so all particles are above the 150 micron size.

2.5.2. Physical properties of mineral filler

Table 11- Physical properties of mineral filler

Property	Saw dust ash	OPC
Plasticity index	3.5	0
Specific gravity	2.15	3.20
% passing through 75 micro meter sieve	79.7	70.4

2.5.3. Specific Gravity test

Specific gravity of saw dust ash is calculated as **2.72**.

IV. BITUMINOUS CONCRETE MIX DESIGN

The purpose of mix design is to determine the best proportion of bitumen, filler, fine and coarse aggregates. The optimum bitumen content is obtained by Marshall Mix design method. In Marshall mix design method following major steps are adopted

- i) Aggregates are mixed in suitable proportion with given specification
- ii) For surface course with 12.5 mm aggregates, for determination of optimum bitumen content the briquettes were made at 5%, 5.5%, 6%, 6.5% and 7% asphalt.
- iii) Briquettes were cured at 55 $^{\circ}$ C - 60 $^{\circ}$ C temperature.
- iv) In Marshall Apparatus stability and flow values are obtained.

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V. EXPERIMENTAL RESULTS

Graph shows the results of test performed on samples of bituminous concrete with cement control as well as SDA as filler.

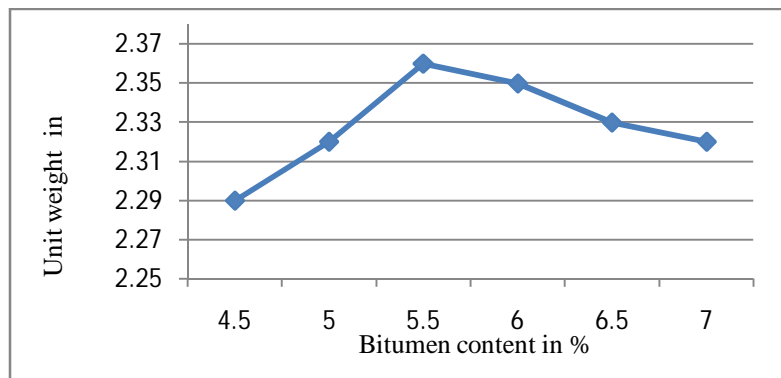


Fig 1 Relationship of Unit weight (gm. /cm³) to bitumen content (%) with cement mix

The above test result show relationship between Unit weight (gm. /cm³) to bitumen content (%) with cement mix. The unit weight increases initially as bitumen content increases but after reaching a maximum value it decreases gradually as shown in fig. 1

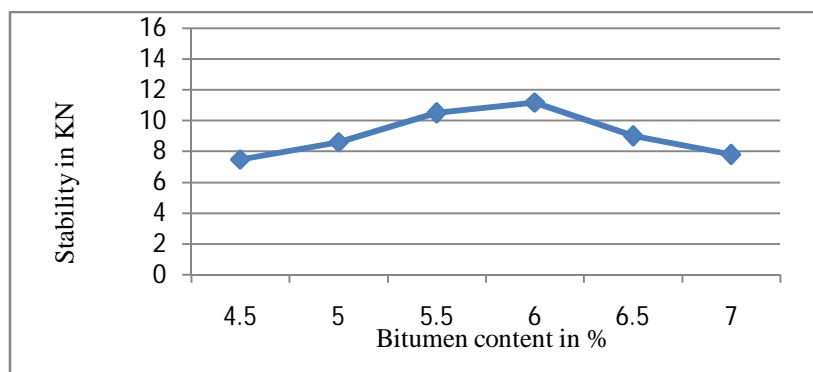


Fig 2 Relationship of stability (KN) to bitumen content (%) with cement mix

The above test result show relationship between stability (KN) to bitumen content (%) with cement mix. The stability value increases initially as bitumen content increases but after reaching a maximum value it decreases gradually as shown in fig. 2

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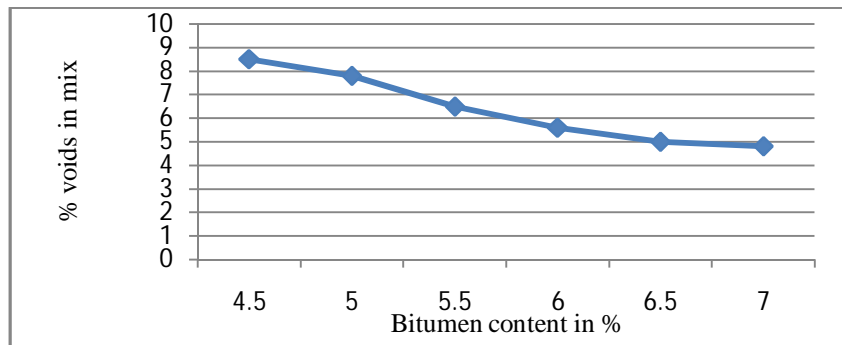


Fig 3 Relationship of % voids in mix to bitumen content (%) with cement mix

The above test result show relationship between % voids in mix to bitumen content (%) with cement mix. The % voids in mix decreases as bitumen content increases but after a certain point it becomes constant as shown in the figure no. 3 above.

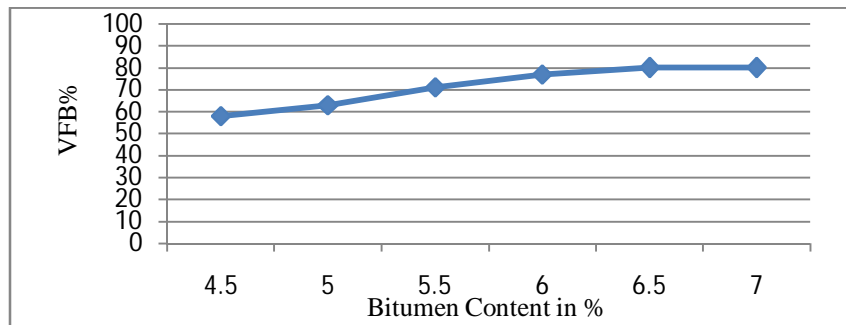


Fig 4 Relationship of VFB % to bitumen content (%) with cement mix

The above test result show relationship between VFB % to bitumen content (%) with cement mix. The VFB % gradually increases as bitumen content increases but after a certain point it becomes constant as shown in the figure no. 4 above.

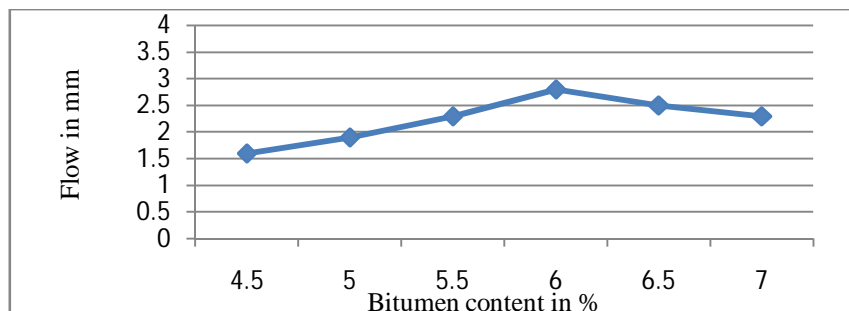


Fig 5 Relationship of flow in mm to bitumen content (%) with cement mix

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The above test result show relationship between flow in mm to bitumen content (%) with cement mix. The flow value gradually increases initially as bitumen content increases but after reaching a maximum value it decreases as shown in the figure no. 5 above.

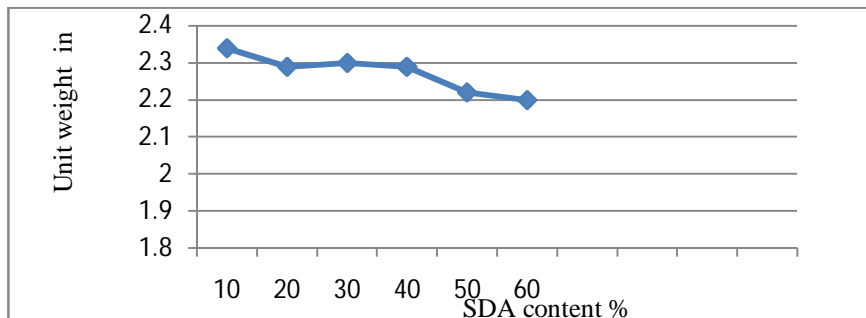


Fig 6 Relationship of Unit weight (gm. /cm³) to SDA (%)

The above test result show relationship between Unit weight (gm. /cm³) to Saw Dust Ash (%). The Unit weight (gm. /cm³) value decreases with increase in saw dust ash percentage and reaching a minimum value at 60 % SDA content as shown in the figure no. 6 above.

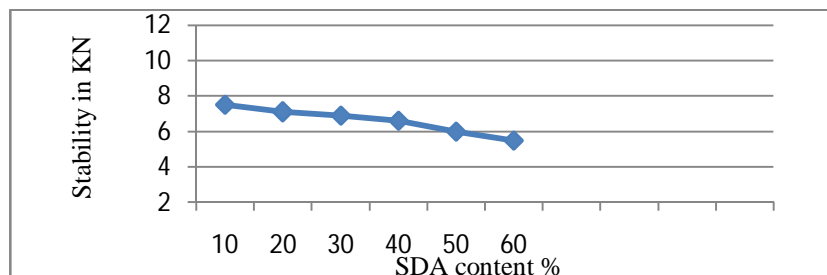


Fig 7 Relationship of Bulk density (gm. /cm³) to SDA (%)

The above test result show relationship between Bulk density (gm. /cm³) to Saw Dust Ash (%). The Bulk density (gm. /cm³) value decreases gradually with increase in saw dust ash percentage and reaching a minimum value at 60 % SDA content as shown in the figure no. 7 above.

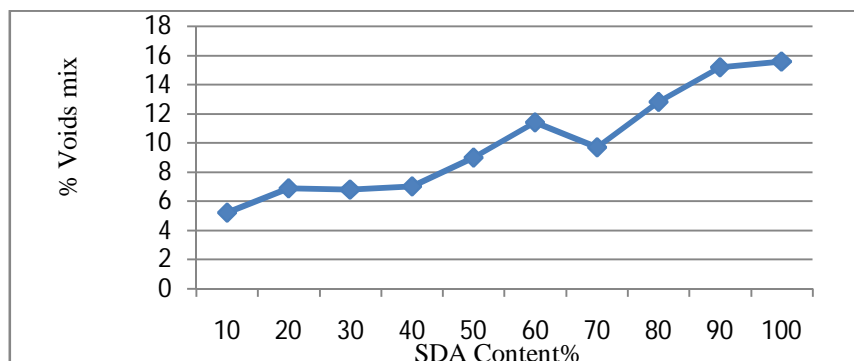


Fig 8 Relationship % voids mix to SDA (%)

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The above test result show relationship between % voids mixto Saw Dust Ash (%). The % voids mix value increases initially then becomes nearly constant but after a certain point at 60 % SDA content it decreases up to 70 % SDA then increases gradually as shown in the figure no. 8 above.

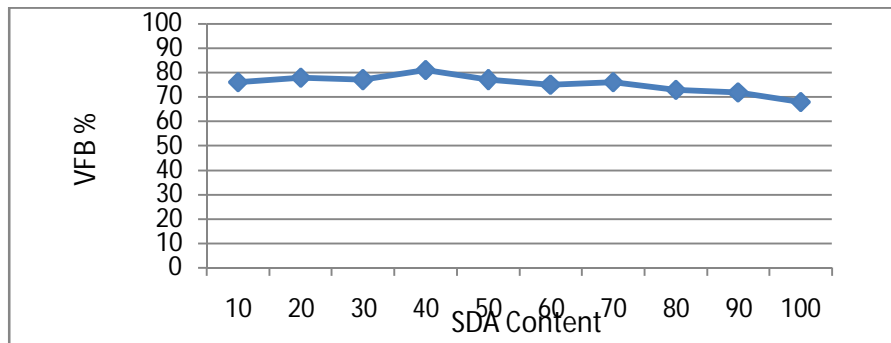


Fig 9 Relationship of VFB % to SDA content (%)

The above test result show relationship between VFB percentto Saw Dust Ash (%). The VFB % slightly increases at up to40 % SDA content but after that this value show a decline with increase in SDA content as shown in the figure no. 9 above.

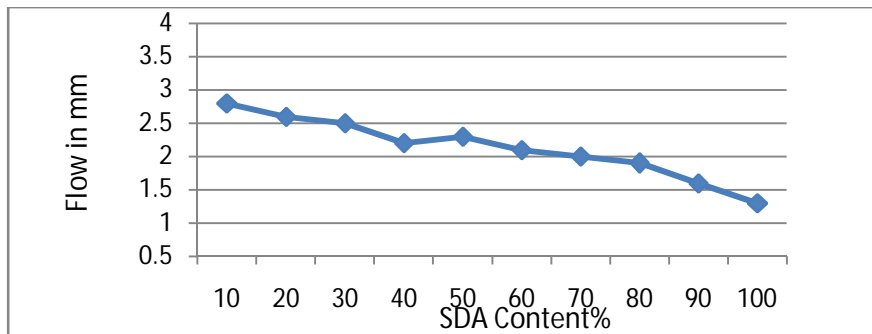


Fig 10 Relationship of Flow in mm to SDA content (%)

The above test result show relationship between Flow in mm to Saw Dust Ash (%). The Flow in mm valuedecreases with increase in SDA content except at 50 % SDA content where it shows a slight increase in flow value as shown in the figure no. 10 above.

The test results carried out on saw dust ash to check its suitability as mineral filler in bituminous concrete has a specific gravity of 2.72 with passing through 150 μ sieve completely. A number of samples were prepared using 100% Ordinary cement as control. Then saw dust ash was replaced with ordinary cement at 0% to 100% with an interval of 10% by weight of cement. With the use of cement 5.5% optimum bitumen content was obtained. Maximum stability, maximum Unit weight , Flow value, % voids in total mix, % of voids filled with bitumen was obtained as 11.2KN, 2.36g/cm³, 2.3 mm , 6.5 % , 61% respectively. At the variation of percentages of ordinary cement and saw dust ash at optimum bitumen content, as the % of saw dust ash increases, the value of bulk density of the mix also decreases. At 0% replacement of cement with saw dust ash the stability value was 11.2 KN, At 10% replacement of saw dust ash the stability value obtained was 7.5 KN which satisfy the specifications. At 10 % replacement of saw dust ash, flow value obtained was 2.8 mm. % voids in total mix increases from 6.5% at 100% ordinary cement to 15.6% at 100% saw dust

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ash. % voids filled with bitumen increases from 71 % at 100 % ordinary cement to 68 % at 100 % saw dust ash. It was found that saw dust ash can perform satisfactory as mineral filler in the mix at 10% saw dust ash.

VI. CONCLUSION

It was found from the experiment that the maximum stability at 10 % replacement of cement with saw dust ash was 7.5 KN which satisfy the minimum stability requirement (3.4 KN). The flow value at 10 % SDA was found to be 2.8mm which lies within the specified value (2 mm to 4 mm). The % voids in total mix obtained was 5.1 % which found satisfactory under specified value (3% to 5 %). Voids filled with bitumen were found to be 76 %, which also satisfy the specified limit (75 to 85 %). So the saw dust ash with 10 % replacement with cement can be used in bituminous concrete design as filler.

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