Use of Baghouse Fines from Hot Mix Plant in Asphaltic Concrete

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Abstract— This study is done to determine the effects of "Baghouse Fines" in the asphaltic concrete mixes. The analysis includes carrying out Marshall Tests on asphaltic mixes having various filler/baghouse fines ratios. Sieve analysis and hydrometer analysis were used to produce gradations for aggregate mixtures with baghouse fines. Chemical properties of baghouse fines were determined using X-ray fluorescence machine. The results of the study indicate that indicate that baghouse fines can greatly affect the properties of the design mix, such as the stability values, the flow values and the optimum asphalt content. The chemical properties of baghouse fines indicate the absence of any harmful heavy metal in the baghouse fines. It is anticipated that the results of this study will be of great help in the improvement of local mix properties.

Key words: Use of Baghouse Fines, Hot Mix Plant in Asphaltic Concrete

I. INTRODUCTION

India has a second largest road network in the world consisting of 33 lakh kilometers. As of October 2014, India has completed and placed in use over 23,000 kilometers of recently built 4 or 6-lane highways connecting many of its major manufacturing, commercial and cultural centers. Subsequently, a large expansion in the asphalt industry has begun. Asphalt plants are more abundant now than ever. Along with this, pollution potential for the dust emitted from hot-aggregate elevators, plant screens, bins, hoppers, and pugmills of these plants is becoming more eminent. This dust has already caused major problems in farms located near asphalt plants. An asphalt plant operating at a rate of 100-200 ton/hour will generate about 3,000 lbs of dust/hour or 50 lb/min.

One variable aspect of asphalt concrete production is the collection and use of fine particulate matter carried in plant exhaust gases. Asphalt plants use large drums and hot air to dry aggregate before mixing. This air carries away a fraction of the smallest aggregate particles. These particles pose environmental and health problems if released into the atmosphere. Currently collection systems are used to remove the fine material before the exhaust gas is released into the air. One of these collection systems is the baghouse. It consists of filters that trap the airborne fines and collect the fines, which are known as baghouse fines. These fines can then be wasted or recycled back into the mix. A majority of asphalt plants reintroduce baghouse fines, although there are many methods for reintroduction. Many plants do not meter these fines and intermittently purge them back into the mix, which leads to concentrations of baghouse fines in the mix.

Many transportation materials designers and agencies have noted that the use of baghouse fines accelerates pavement deterioration and moisture damage.[12] For this reason some agencies require disposal of the waste of all baghouse fines while others intend to use a controlled amount of the fines. Many studies have been performed on the contribution of baghouse fines to the performance of asphalt binder and asphalt concrete. Variability in the properties of the baghouse fines makes it difficult to judge its suitability.

In view of the above, an experimental study is planned to determine the use of baghouse fines in asphalt design mixture.

II. LITERATURE REVIEW

Hamad [5] in his study found that replacing a part of filler with baghouse fines affects the Marshall properties of the design mix. He observed a slight drop in Marshall Stability with addition of baghouse fines.

He also observed that by replacing the fines with baghouse fines decreased the specific gravity of the mix. However the effect of increasing the percentage did not decrease the specific gravity appreciably. He concluded the same for the variation of percent of voids filled with asphalt.

He also observed that the inclusion of baghouse fines affected the optimum asphalt content, which increased from 5.21 when ratio of fines to baghouse fines (F/BH) is 100/0 up to a maximum value of 5.93 percent when ratio of fines to baghouse fines (F/BH) is 50/50. Beyond this ratio, the optimum asphalt content starts to drop slightly. He concluded that this increase in optimum asphalt content was due to the existence of carbon in the baghouse fines.

Anderson and Tarris [1] performed a study on the behavior of the asphalt-filler mastic using the penetration, softening point and ductility. He used five filler/asphalt (F/A) ratios and five different types of filler. These F/A ratios are calculated by volume of material to allow for comparison between filler types. He found that the penetration decreases with an increase in the F/A ratio. He also found the softening point and viscosities increased with an increasing F/A ratio. His results showed a large increase in the viscosity at an F/A ratio of 0.4. This F/A ratio is lower than those found in many HMA mixtures. The much higher viscosity can affect the compatibility of the HMA and require more compactive effort or higher compaction temperatures.

Birdsall [2] performed a study using three different aggregates and three different additives as well as a control set without additives. His results showed significant increases in the tensile strength and the tensile strength ratio (TSR) values with the use of lime, amine, and ester. Another test showed an increase of tensile strength as the fraction of baghouse fines increased. The fines were sampled from an asphalt plant using lime to treat the aggregate. A portion of the lime escapes in the exhaust gas and is retained in the baghouse fines, which are reintroduced into the mix. The addition of lime as an antistrip additive in the baghouse fines outweighs the detrimental effects of baghouse fines on moisture susceptibility.

Eick and Shook [3] found out that five different plants provided baghouse fines samples with widely scattered gradations. Since the gradation of fines for different plants is inconsistent, job mix- formulas (JMF) will be unique for each plant. His results show a correlation between viscosity ratio and fineness of the baghouse fines. He performed viscosity tests on mastics as well as neat asphalt with no filler. The two values were used to find a viscosity ratio for each F/A ratio. The results showed increasing viscosity ratios as the F/A ratio increased. The results also showed a correlation between the fineness of the baghouse fines and the viscosity ratio. As the percent of baghouse fines material passing the 75 micron sieve increased, the viscosity ratio also increased.

Hanson and Cooley [6] performed TSR testing on thirty different sets with different fine types, asphalt types, and F/A ratios. Using the NCDOT requirement of 85 percent, none of the sets passed.

Kandhal [7] suggested that there is a relation between bulk volume of fines in the mix and resistance to compaction. This relation is straightforward since as bulk volume increases, free binder decreases, decreasing the flow. Using the Ridgen voids test, the bulk volume of fines is determined. If the value is below 50 percent, the HMA mixture is acceptable. If, however, the bulk volume is greater than 50 percent, a softening point test is used to determine the suitability of the HMA mixture.

Tayebali, Natu, and Waller [8] conducted DSR testing on asphalt mastics containing baghouse fines. Samples of neat PG 64-22 asphalt as well as mastics containing 50 percent baghouse fines or mineral filler were tested. The results showed an increase in stiffness and rut resistance of the mastics over the asphalt binder. An increase in stiffness was also observed in one of the baghouse fines mastics over the regular mineral filler.

Fischer [4] showed that mineral fillers can increase the stiffness of both the asphalt cement as well as the asphalt pavement. Baghouse fines, a constituent of the mineral filler, also affects both the asphalt cement and the HMA performances, depending on the particle size distribution. Baghouse fines interact with the asphalt cement as an extender as well as a stiffener. In asphalt concrete the fines fill the spaces between the larger aggregates producing a stiffer mix, which can lead to compaction problems.

III. Methodology

1) Collection of baghouse fines-: Baghouse fines are to be collected from a Hot Mix Plant where there a collection system is properly installed.
2) Characterization of baghouse fines-:
   - Determination of physical properties i.e. gradation of baghouse fines, optimum moisture content, liquid limit, etc.
   - Determination of chemical composition of baghouse fines and check for presence of heavy metals using X Ray Fluorescence (XRF) testing machine.
3) Characterization of aggregates and asphalt to be used for asphaltic mix design.
4) Mix Design- To investigate the effect of fillers and baghouse fines on asphaltic mix design, the Marshall method is to be used. Firstly gradation of aggregates is to be done for asphaltic concrete from 3 sources namely Aggregate I, II and III. Baghouse fines passing through 75 micron sieve are then to be mixed with fillers passing thorough 75 micron sieve at different ratios, namely, Filler/Baghouse Fines (F/BH) = 100/0, 80/20, 65/35, 50/50 and 0/100.
5) Asphalt is to be added to each ratio at different percentages i.e. 5.2, 5.6, 6.0, 6.4 and 6.8 of the total weight of aggregates and there effects are to be compared.
6) Finding out a feasible and optimum percentage of Baghouse fines which can be reintroduced in the design mix.

IV. Experimental Work

Figure shows the flowchart according to which the experiments were performed.

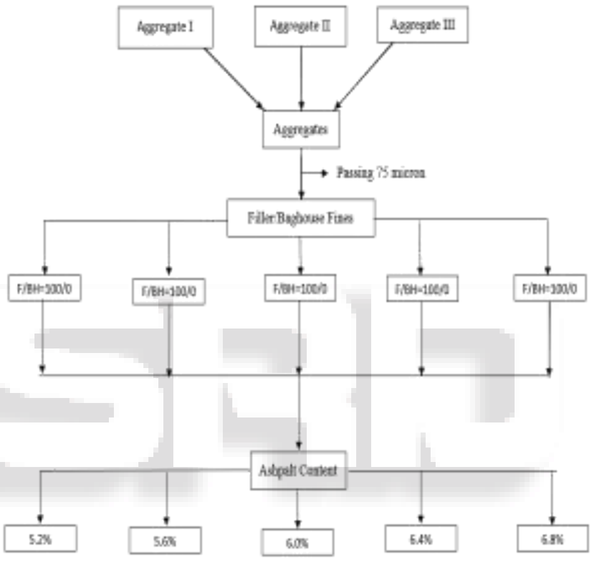

Fig. 1: Flowchart of Experimental Process

Three different sources were used to make the marshal mix design which was done by Rothfosh method. According to which 15% of Aggregate I, 20% of Aggregate II and 60% of Aggregate III were used. Table 1 shows the gradation of the aggregates done

Dia. (mm)	Req. %	Agg. I	Agg. II	Agg. III	Total
19	100	100	100	100	100
13.2	79-100	35.50	100	89.70	79.14
9.5	70-88	5.50	100	79.87	68.74
4.75	53-71	3.10	97	65.16	58.96
2.36	42-58	1.0	77	47.25	43.9
1.18	34-48	-	59.35	35.98	33.45
0.6	26-38	-	47.10	28.52	26.53
0.3	18-28	-	34.2	20.77	19.30
0.15	12-20	-	28.90	17.56	16.31
0.075	4-10	-	11.35	6.87	6.39

Table 1 Gradation of Aggregates

A. Case 1 When Ratio F/BH=100/0

Table 2 shows the 24 hour Marshall values for the mix when the ratio of F/BH is 100/0.The total weight of aggregates is

1200 gm. The weight of fillers introduced is 76.68 gm and the weight of baghouse fines introduced is 0 gm.

Asp. %	M.St. (kg)	M.Fl. (mm)	Unit.Wt (g/cc)	$\%V_t$	%Va
5.20%	1334.5	2.36	2.33	5.28	78.21
5.60%	1632.4	2.7	2.45	4.5	83.29
6.00%	1828.3	2.95	2.55	3.91	89.45
6.40%	1520.2	3.45	2.47	3.43	92.3
6.80%	1475.2	3.62	2.4	3.03	96.09

Table 2 Marshall Values for F/BH=100/0

B. Case 2 When Ratio F/BH=80/20

Table 3 shows the 24 hour Marshall values for the mix when the ratio of F/BH is 100/0. The total weight of aggregates is 1200 gm. The weight of fillers introduced is 61.34 gm and the weight of baghouse fines introduced is 15.33 gm.

Asp. %	M.St. (kg)	M.Fl. (mm)	Unit.Wt (g/cc)	$\%V_t$	%Va
5.20%	1412.6	2.4	2.29	5.12	77.9
5.60%	1544.9	2.76	2.38	4.26	82.1
6.00%	1711.2	3.16	2.44	3.62	86.5
6.40%	1735.6	3.46	2.45	3.21	92.6
6.80%	1610.2	3.64	2.38	2.85	95.2

Table 3 Marshall Values for F/BH=80/20

C. Case 3 When Ratio F/BH=65/35

Table 4 shows the 24 hour Marshall values for the mix when the ratio of F/BH is 100/0. The total weight of aggregates is 1200 gm. The weight of fillers introduced is 49.84 gm and the weight of baghouse fines introduced is 26.83 gm.

D. Case 4 When Ratio F/BH=50/50

Table 5 shows the 24 hour Marshall values for the mix when the ratio of F/BH is 100/0. The total weight of aggregates is 1200 gm. The weight of fillers introduced is 38.34 gm and the weight of baghouse fines introduced is 38.34 gm.

E. Case 4 When Ratio F/BH=0/100

Table 6 shows the 24 hour Marshall values for the mix when the ratio of F/BH is 0/100. The total weight of aggregates is 1200 gm. The weight of fillers introduced is 0 gm and the weight of baghouse fines introduced is 76.68 gm.

Asp. %	M.St. (kg)	M.Fl. (mm)	Unit.Wt (g/cc)	$\%V_t$	%Va
5.20%	1469.2	2.36	2.29	5.28	75.8
5.60%	1586.3	2.66	2.34	4.5	80.1
6.00%	1725.2	3.12	2.42	3.91	86.5
6.40%	1769.8	3.45	2.45	3.43	91.7
6.80%	1503.5	3.62	2.4	3.03	96.1

Table 4 Marshall Values for F/BH=65/35

Asp. %	M.St. (kg)	M.Fl. (mm)	Unit.Wt (g/cc)	$\%V_t$	%Va
5.20%	1490.6	2.48	2.31	5.28	77.84
5.60%	1632.4	2.84	2.39	4.78	81.24
6.00%	1836.4	3.14	2.49	4.32	86.52
6.40%	1969.6	3.52	2.53	3.96	93.54
6.80%	1585.5	3.73	2.44	3.62	96.94

Table 5 Marshall Values for F/BH=50/50

Asp. %	M.St. (kg)	M.Fl. (mm)	Unit.Wt (g/cc)	$\%V_t$	%Va
5.20%	1384.25	2.26	2.24	5.16	78.21
5.60%	1526.25	2.52	2.39	4.65	83.29
6.00%	1656.24	3.12	2.44	3.95	89.45
6.40%	1724.32	3.45	2.43	3.42	92.3
6.80%	1498.96	3.62	2.4	2.98	96.09

Table 6 Marshall Values for F/BH=0/100

V. RESULTS AND DISCUSSION

A. Effect on Marshall Stability Values

The 24 hour Marshall Stability v/s Asphalt Content for different F/BH ratios are given in Figure 2. It can be seen that the overall value of Marshall Stability tends to decrease slightly on adding baghouse fines. However the Marshall Stability values increases with an increase in F/BH up to 50/50 after that it decreases slightly but the values are within acceptable limits (Min 900).

B. Effect on Marshall Flow Values

The 24 hour Marshall Flow Values v/s Asphalt Content for different F/BH ratios are given in Figure 3. It can be seen that the flow values are well within the acceptable limits (2-4).

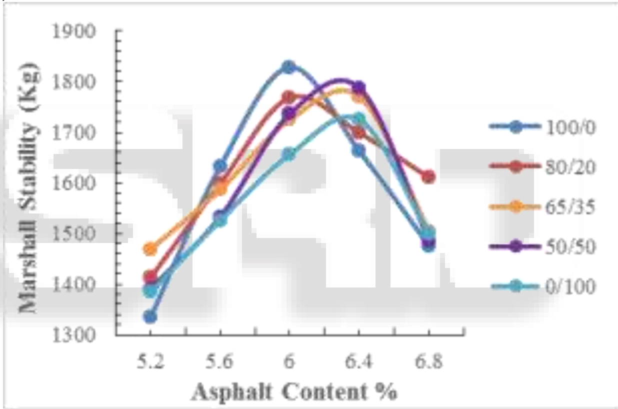

Fig. 2: Asphalt Content v/s Marshall Stability

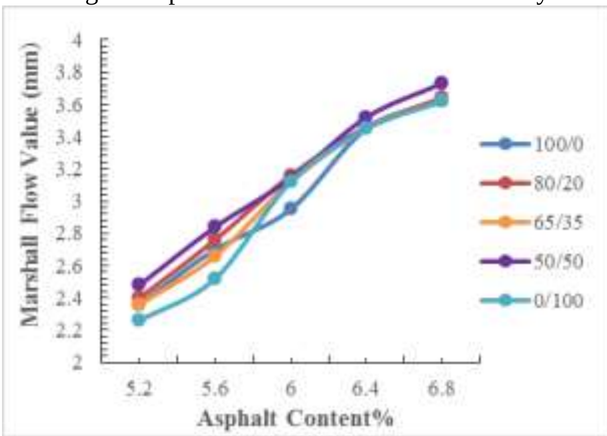

Fig. 3 Asphalt Content v/s Marshall Flow Values

C. Effect on Unit Weight

The 24 hour Unit Weight Values v/s Asphalt Content for different F/BH ratios are given in Figure 4. It can be seen that the unit weight decreases slightly on addition of F/BH at different ratios. However the unit weight increases with an increase in F/BH up to 50/50 then it decreases slightly but the values are within acceptable limits (2-3).

D. Effect on Percent Voids in Total Mix

The 24 hour Percent Voids in Total Mix v/s Asphalt Content for different F/BH ratios are given in Figure 5. The percentage of voids for each F/BH ratio was obtained and results are given in Table 5.4. It can be seen that the percentage of voids decreases on addition of F/BH and there is a slight decrease in percentage of voids with an increase of F/BH. However all the values of percent voids in total mix are within acceptable limits (3-6).

E. Effect on Percent Voids Filled with Asphalt

The 24 hour Percent voids filled with Asphalt v/s Asphalt Content for different F/BH ratios are given in Figure 6. It can be seen that there is a slight decrease in percent voids filled with Asphalt on addition of F/BH at different ratios. However some the values of percent voids filled with Asphalt are not within acceptable limits (75-85).

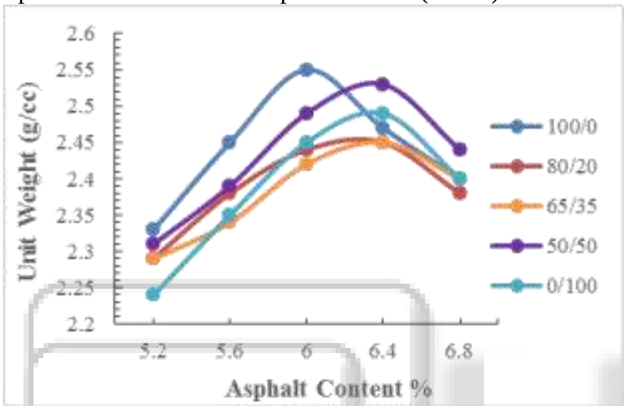

Fig. 4: Asphalt Content v/s Unit Weight

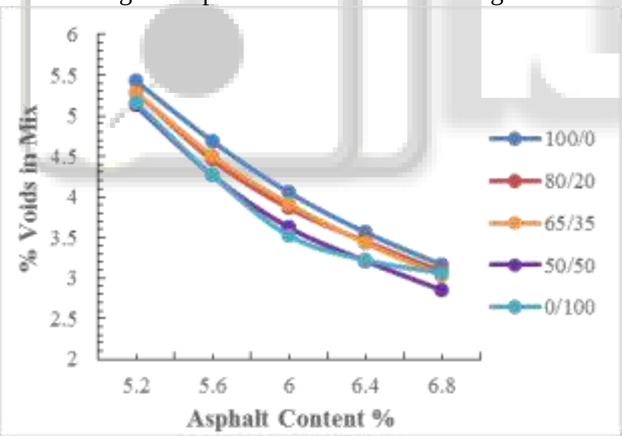

Fig. 5: Asphalt Content v/s Percent Voids in Total Mix

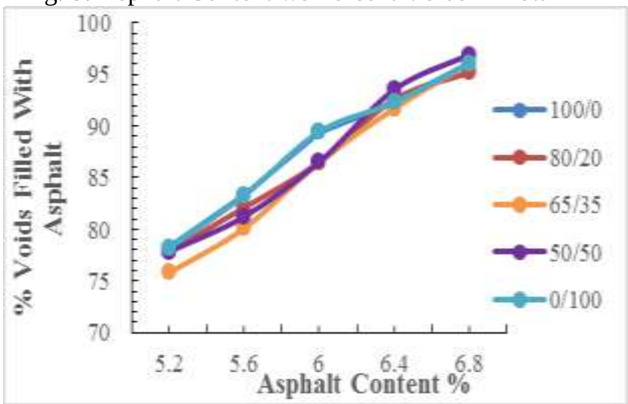

Fig. 6 Asphalt Content v/s Percent Voids Filled with Asphalt

F. Effect on Optimum Asphalt Content (OAC)

The 24 Optimum Asphalt Content for different F/BH ratios are given in Figure 7. The optimum asphalt content for each F/BH ratio was obtained and results are given in Table 7. It can be seen that optimum asphalt content increases with increase in F/BH ratio up to 65/35 and then it tends to decrease slightly.

F/BH	Optimum Asphalt Content
100/0	6
80/20	6.08
65/35	6.22
50/50	6.19
0/100	6.10

Table 7: OAC for Various F/BH Ratios

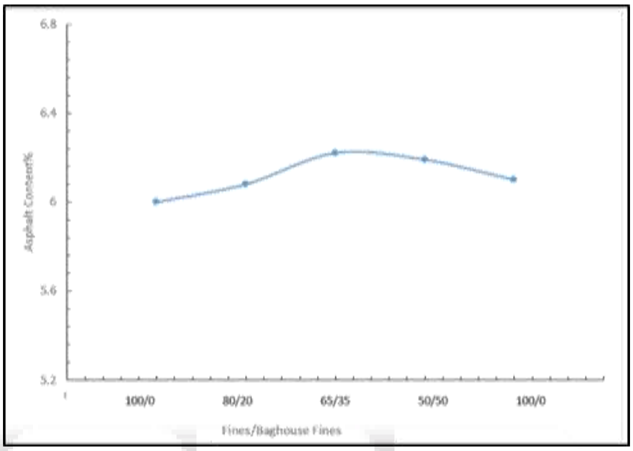

Fig. 7: Asphalt Content v/s F/BH Ratio

VI. CONCLUSIONS AND RECOMMENDATIONS

The conclusions of the results and discussions of the previous chapter can be summarized as follows:

1) Mixes which utilize approximately 50/50 ratio of fines to baghouse fines are optimum design mixes because of their satisfactory Marshall properties and are recommended to be used during the construction of asphaltic concrete layers in the roads.
2) Presence of large percentage of carbons i.e. 17.8% in baghouse fines will have a major effect on the performance of baghouse fines in the mix. The stability loss will decrease when the ratio of F/BH increases up to an optimum point.
3) Baghouse fines if properly blended with the filler affects the optimum asphalt content OAC of the design mix.
4) Due to the inclusion of baghouse fines in design mix the problem of pollution due to baghouse fines can be resolved and the cost of dumping of baghouse fines in landfills can also be reduced.

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