CHARACTERIZATION OF BITUMINOUS CONCRETE USING FLYASH AS FILLER

Sudeepta Prasanna Nayak, *Asst. Professor* **Minati Mohanty**

Department of Civil (Transportation) Engineering, Centurion University of Technology & Management, Odisha, India

**To whom correspondence should be addressed email: minati.mohanty@cutm.ac.in*

ABSTRACT

A bituminous concrete used in pavements is a mixture of fine aggregate, coarse aggregate, filler material and bitumen as binder mixed in required amount to obtain a durable and strong mix to safely take load of traffic on it. Generally, crushed stone dust and cement are used as filler. Study has been conducted to understand and analyze the use of fly ash, a by-product of thermal power plants in paving mix of bitumen. For the purpose of comparison, control mix with stone dust is also considered. Marshall test is considered as a means for the design of the mix and evaluating the paving mixes. It is found that the mix with fly ash as filler have inferior characteristics as compared to control mixes, but satisfies the desired criteria by higher margin. Therefore, it may be recommended to utilize fly ash wherever available which will result not only in reduction of execution cost, but also solve partly the disposal problems of such by-products.

Keywords: *bituminous concrete, fly-ash, optimum bitumen content, Marshall properties, Marshall stability, optimum filler content*

INTRODUCTION

Bitumen as a binder over the aggregates are conventionally used throughout the world in the construction of surface/wearing course of a flexible pavement. Surface course comprises of coarse aggregate, fine aggregate, filler heated to a suitable temperature, then mixed thoroughly to the bitumen heated as required after which the mix is compacted. Bituminous concrete (BC) is a well graded mixture of 50-60% coarse aggregate, 35-45% fine aggregate, 5-10% filler , 5-7% bitumen of a total mix. A major point of concern in such mix is the proportion of filler material to be used which affect the performance of the mix. Number of studies have been done to study the properties of the filler; material passing 0.075 mm IS sieve in order to evaluate the effect on paved mix in terms of Marshall stability, consistency, indirect strength and void filling.

REVIEW OF LITERATURE

Some studies carried out on use of different type of filler and its results have been briefed below.

1. (Zulkati et al., 2011): It is known that filler has a significant effect on the characteristics of asphalt concrete mixes although particles of filler are of very small size. From his study he found that well packed coarse aggregates , fine aggregates and filler form the backbone of the mixture.

2.(Kandhal et al., 1998): In this study he found that High filler concentration gives better cohesive and internal stability to the pavement. However filler in excess weaken the mixture by increasing the asphalt requirement for coating the aggregates .

3.(Brown and Mallick, 1994): Generally the type of filler, amount of filler not only affect the optimum bitumen content (OBC), but also affect the Marshall stability, tensile strength of the mix. OBC of dense graded mix is less than stone matrix asphalt.

4. (Karasahin and Terzi, 2007): Waste marble dust from shaping of marble blocks and lime stone as filler in hot mix asphalt showed good results in determination of optimum bitumen content by Marshall test.

5. (Muniandy and Aburkaba, 2011): Four types of industrial by-products as limestone as filler, ceramic waste dust, coal fly ash and steel slag increases the stiffness and fatigue life of Stone Mastic Asphalt (SMA) mixtures.

6.(Mistry et al., 2016): The effect of using fly ash as filler replacing the common filler in asphalt mixture indicated higher stability value with lower optimum bitumen content in comparison to control mixes which satisfies the standard specification.

From the above literature it can be found that limited study has been conducted on dense grade mixes with use of fly ash as filler. Fly ash is a major waste by-product of thermal power plants. At such areas, it is abundantly available but finds very little use for which it creates a serious disposal problem. Hence, an attempt has been made to explore and understand the use of fly ash, which is mostly passing through 0.075 mm IS sieve and has been considered as a filler in bituminous concrete mixes by studying the fundamental engineering properties.

MATERIALS AND METHODOLOGY

Materials used

1. Aggregates

The grading of aggregates was adopted as per MORT&H (2013) for bituminous concrete as given below (Table-1) for the preparation of Dense graded bituminous concrete mixture. Coarse aggregate consists of stone chips up to 4.75 mm IS sieve collected from local source. Its specific gravity was found to be 2.76 in the laboratory. Other properties are given below (Table-2).

Table-1. Adopted aggregate gradation

Sieve size (mm)	**Cumulative percentage passing by weight** (Range)	**Percentage passing by weight** (Adopted)
19	100	100
13.2	90-100	95
9.5	70-88	79

4.75	53-71	62
2.36	42-58	50
1.18	34-48	41
0.6	26-38	32
0.3	18-28	23
0.15	12-20	16
0.075	04-10	07

Table-2. Physical properties of aggregate

Property	Test method	Test result
Aggregate impact value (%)	IS:2386 (Part IV)	11.8
Aggregate crushing value (%)	IS:2386 (Part IV)	23.6
Los Angeles abrasion value (%)	IS:2386 (Part IV)	27.2
Flakiness index (%)	IS:2386 (Part I)	14
Elongation index (%)	IS:2386 (Part I)	18.3
Water absorption (%)	IS:2386 (Part III)	1.25

Fine aggregates comprises of stone crusher dusts with fractions passing through 4.75 mm and retained on 0.075 mm IS sieve collected from a local crusher. Its specific gravity was found to be 2.67.

The part of aggregates passing through 0.075 mm IS sieves are filler. Generally cement and stone dust are used as filler. To explore the use of fly ash from thermal power station in bituminous mix, the same was collected from local source and used. For comparison point of view, stone dust from local source has also been used. The specific gravities of stone dust and fly ash were found to be 2.6 and 2.2 respectively.

2. Bitumen

For the preparation of bituminous mixture, VG 30 grade bitumen has been used. The important physical properties are as given in Table-3

Table-3. Physical properties of VG 30 bitumen

Property	Test method	Test result
Penetration at 25^oC (0.1mm)	IS:73-2006	50.3
Softening point (^oC)	IS:73-2006	48.7
Specific gravity	IS:73-2006	45.6
Ductility at 25^o C (cm)	IS:73-2006	1.02

Marshall Method of Bituminous Mix Design

Marshall test method is widely practiced in construction to select and proportion aggregates and asphalt materials for pavement construction. This test has been used fundamentally to evaluate the various mixture at different bitumen contents. The parameters considered for evaluation are stability, flow value, unit weight, air voids, voids in mineral aggregates, voids filled with bitumen. The optimum bitumen content was selected having maximum stability, maximum unit weight and allowable limit of percentage air voids. Average of these three parameters is selected as the optimum bitumen content (OBC). All Marshall criteria at OBC are checked with respect to the same as given in MORT&H (2013).

Preparation of specimens

Bituminous concrete mixture samples were prepared as per ASTM D1559 with different bitumen contents against each filler. The mixtures with crusher stone dust as filler were considered to be control specimens. Optimum bitumen content for each type of filler in the mix was considered as per normal specified procedure. Using the optimum bitumen content, the test mix was prepared by replacing crusher dust with fly ash fully and partially i.e. 100%, 75%, 50%, 25%, 15%, 13%, 11%, 9%, 7%, 5%, 3% by the weight of filler. Three samples were prepared for each percentage of fly ash. Marshall Test was conducted on these prepared specimens and the fly ash content at which all the properties such as stability, flow, air voids, voids filled with bitumen (VFB) satisfy the standard limit was selected as the optimum fly ash content (OFC).

The Results of the Marshall test of specimens is Tabulated below:

Table 4 - Marshall Test result of Bituminous concrete with variation of fly ash as filler

Sl. No	Fly ash (%)	Crusher Dust (%)	Stability at 60^{O}c(in KN)	Flow value (in mm)	Density (in g/cc)	Air Void (%)	VFB (%)	Remarks
			>9	2 – 4		3 - 5	65-75	
(As per the MORT&H Specification)								
1.	0	100	11.3	2.21	2.44	3.85	75	Satisfied
2.	3	97	9.70	2.0	2.41	4.0	74.98	Satisfied
3.	5	95	13.01	2.03	2.42	4.17	74	Accepted
4.	7	93	11.29	2.1	2.41	4.25	75.5	Satisfied
5.	9	91	10.66	2.3	2.40	4.4	73	Satisfied
6.	11	89	9.94	2.45	2.39	4.49	72.58	Satisfied
7.	13	87	10.43	2.58	2.41	4.03	74.78	Satisfied
8.	15	85	10.82	2.5	2.43	4.23	73.78	Satisfied
9.	25	75	10.96	2.45	2.45	2.54	82.7	VA and VFB not satisfied
10.	50	50	11.53	2.0	2.454	2.39	83.56	VA and VFB not satisfied
11.	75	25	11.69	1.95	2.46	2.13	85.1	Flow, VA and VFB not satisfied

RESULTS AND DISCUSSIONS

This section deals with analysis of Marshall test results of BC mix with the fly ash as filler to find Optimum fly ash content i.e. optimum filler content (OFC) and the indirect tensile strength result to study the water sensitivity of bituminous concrete mix. Stability of mix is directly related to the density and flexibility of the mix. That is if the stability of the mix is more, then either the density of the mix should be more or flexibility of the mix should be more or both should be more. Stability also increases with the excess quantity of filler but the mix becomes brittle and is prone to sudden cracking. Stability decreases in case of deficient filler but the mix is soft.

The Marshall test results has been presented in figures 1 to15, in which variation of Marshall properties with respect to bitumen content and the same with respect to filler content are shown. OBC is found to be 5.5% considering all the parameters. At 5% Fly ash and 95% Crusher dust, the stability, flow, density, voids filled with bitumen (VFB) and air voids of the mix satisfy the requirements of bituminous concrete. Hence, the combination is recommended.

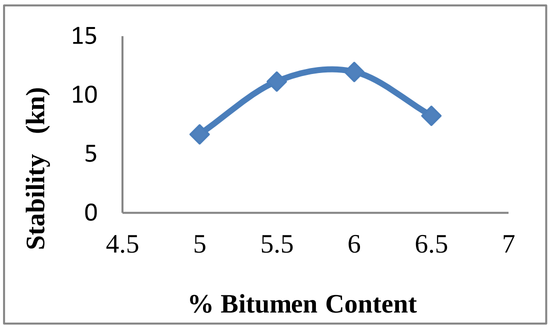


Fig 1. Stability variation with bitumen content

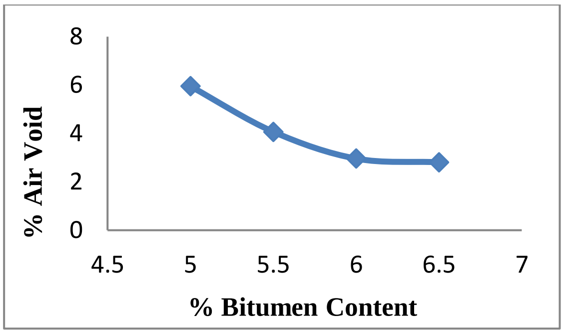


Fig 2. Air voids variation with bitumen content

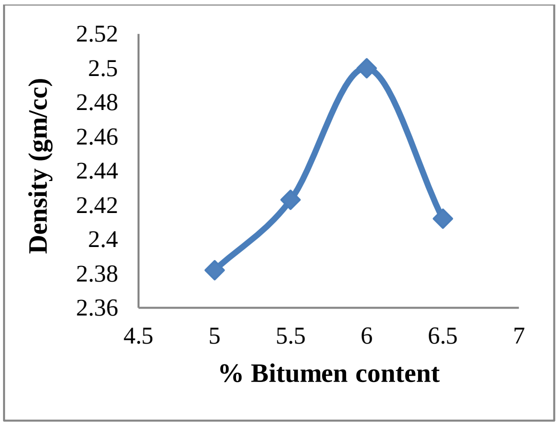


Fig 3. Density variation with bitumen content

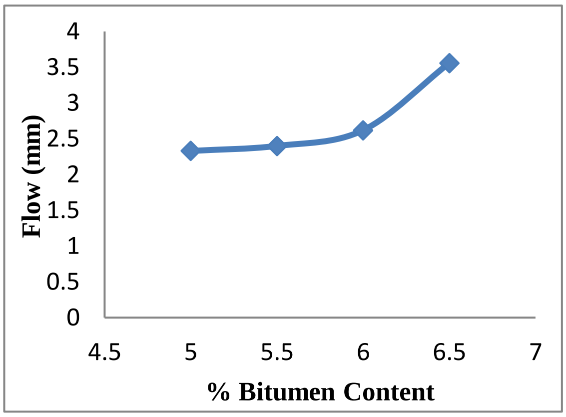


Fig 4. Flow value variation with bitumen content

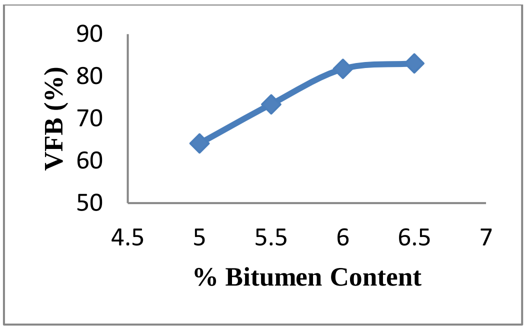
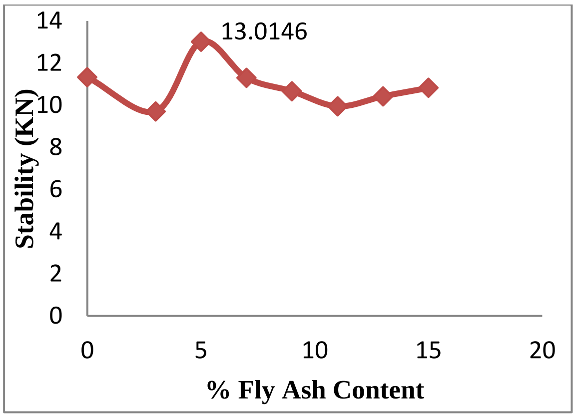


Fig 5. Variation of VFB with bitumen content



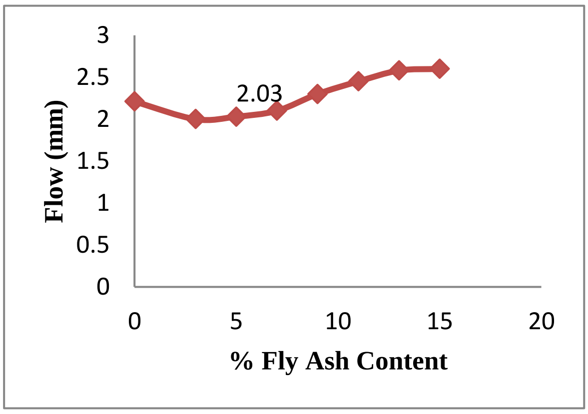
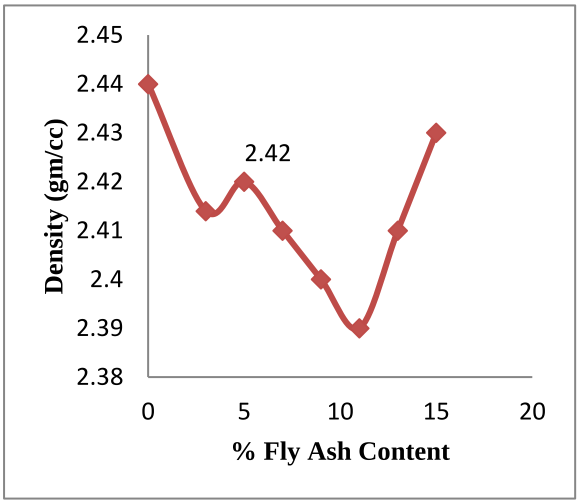


Fig.6 Variation of stability with fly ash content Fig.7 Variation of flow value with fly ash content



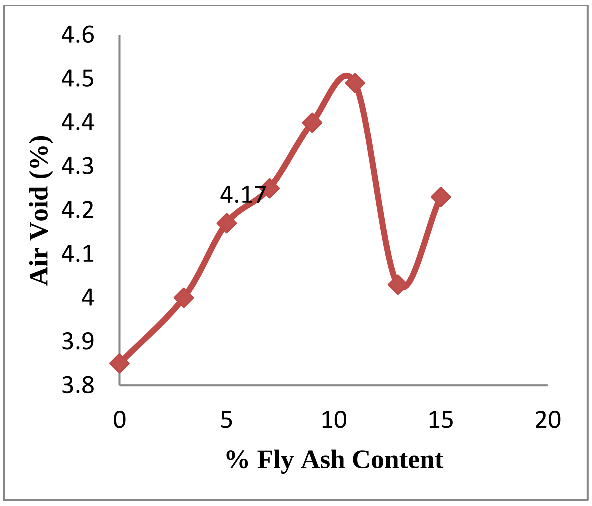


Fig. 8 Variation of density with fly ash content Fig.9 Variation of % air voids with fly ash content

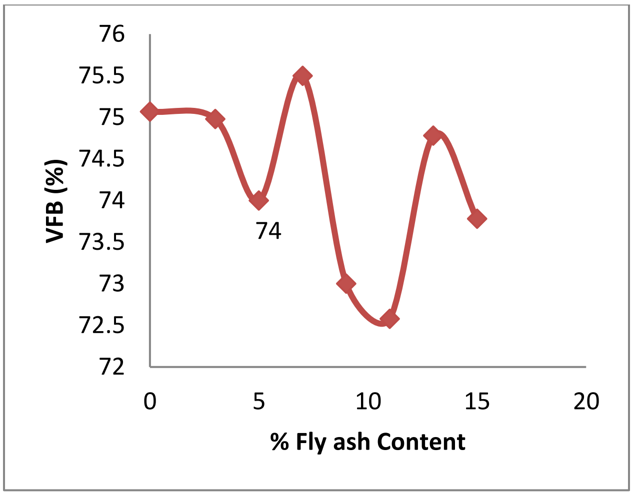


Fig.10 Variation of VFB with fly ash content

CONCLUSION

As the Fly Ash Content increases beyond 50% filler, the mix becomes gradually more and more brittle and prone to sudden cracking. At 5% Fly Ash and 95% Crusher Dust, the stability, flow, density, Voids Filled with Bitumen(VFB) and air voids of the mix satisfy the requirements of Bituminous Concrete. It also satisfies the Marshall Quotient requirements (2-5).Hence, this combination is recommended. Maximum Marshall stability value is found for crusher Stone dust as filler. However the variation as compared to fly ash as filler is nominal and at optimum bitumen content the mixes satisfy all Marshall criteria.

Considering the abundant availability of fly ash near thermal power plants, use of fly ash shall be economical as compared to other fillers. Hence, in general it is concluded that fly ash can be used efficiently as a filler material replacing conventional fillers. The use of fly ash give a solution for disposal problems and provide a means to have a clean environment.

REFERENCES

1.ASTM D 1559.. Test method for resistance of plastic flow of Bituminous mixes using Marshall apparatus. (American Society for Testing and Materials, Philadelphia, USA), 1989.

2.Brown E. Ray and Mallick Rajib B, “Stone matrix asphalt properties related to mixture design, NCAT report”, Albama, USA.,1994.

3.IS:73-2006. “Paving bitumen specification (Second revision)”, Bureau of Indian Standards, New Delhi, India.

4.IS:1203,. “Method of testing tar and bituminous materials: Determination of penetration, Bureau of Indian Standards”, New Delhi, India,1978.

5.IS:1205-1978, “Method of tar and bituminous materials: Determination of softening point, Bureau of Indian Standards”, New Delhi, India.

6.IS: 2386 (Part I, III, IV).” Methods of test for aggregates for concrete, Bureau of Indian Standards”, New Delhi, India.

7.Karasahin & Terzi,.” Evaluation of marble waste dust in the mixture of asphaltic concrete, Construction and building materials, Elsevier”. 21:616-620, 2007.

8.Kandhal P. and Parker F.,” Characterization tests for mineral fillers related to performance of asphalt paving mixes. Journal of Transportation Research Board”, 1638(1): 101-110,1998.

9.Ministry of Road Transport and Highways (MORTH.,”Specification for Road and Bridge works, Section 500”, Indian Roads Congress, New Delhi, India.,2013.

10.Muniandy R and Aburkaba E “The effect of type and particle size of industrial waste fillers on stiffness and fatigue performance of Stone Mastic Asphalt Mixtures, Australian Journal of Basic and Applied Sciences”. 5.11, pp. 297-308,2011.

11.Zulkati A, Diew W. Y. and Delai D.S.. “Effects of fillers on properties of Asphalt concrete mixture. Journal of Transportation Engineering”, ASCE. 138(7): 902-910,2011.