International Research Journal of Engineering and Management Studies (IRJEMS)
Volume: 03 Issue: 04 | April -2019 ISSN: 1847-9790 || p-ISSN: 2395-0126

Laboratory Study on use of Waste materials as filler in Bituminous mixes

Emy Paulose[1], Arjun Vijayan[2], Mahin Sasikumar[3], Sapna Sebastian[4], Sreerag K. D[5]

[1]Assistant Professor
[2]Student,[3]Student,[4]Student,[5]Student
Department of Civil Engineering, Mar Athanasius College of Engineering, Kothamangalam

---***---

Abstract - *This paper summarizes the ongoing researches about the effect of various fillers on bituminous mixes. Many studies regarding bitumen fillers that have been carried out earlier were studied, and their effects on the bituminous paving mixes were also analyzed. In this study, the usage of Non-conventional materials like glass dust, brick dust, blast furnace slag and concrete dust are used as mineral filler in hot mix asphalt alternate to conventional filler materials were investigated. An important role is played by the fillers that pass through 0.075mm sieve. With the increase in the amount of filler, Marshall Stability of the bitumen mix increases directly. Use of 4-8% filler in asphalt concrete is recommended by the Asphalt Institute. Most of the industrial solid wastes can be used in highway constructions and road layers from top to sub grade By addition of fillers to bituminous mixes a considerable amount of increase in Marshall Properties can also be observed. Higher performance and environment friendly roads can be constructed by the use of by-products instead of traditional materials.*

***Key Words*: Filler, Brick, Glass, Slag, Concrete, Stability, Flow, Cement, Lime, VMA,VFB,Air-Voids,Density,Bitumen**

1.INTRODUCTION

Bituminous roads are defined as the roads in the construction of which bitumen is used as binder. It consists of an intimate mixture of aggregates, mineral filler and bitumen. The quality and durability of bituminous road is influenced by the type and amount of filler material is used. The filler tends to stiffen the asphaltic cement by getting finely dispersed in it. Growth in world population and industry brings up huge amount of natural resource necessity. Using waste or by-products instead of natural materials have great benefits such as economic and environmental. Energy consumption can be reduced by reuse of by-products instead of natural materials.

Mineral filler has two important roles in hot mix asphalt. The first one is to fill the voids between course and fine aggregates and thus denser and stiffer layers can be obtained. The second one is to provide more contact points between aggregates. Bitumen film cover filler's large surface area and more stiff contact points can be generated with the aggregates. Mostly crushed stone and brick dust has been utilised in hot mix asphalt as mineral filler. According to various studies, the properties of mineral fillers, especially the material passing 0.075 mm (No. 200) sieve, have an essential effect on the performance of asphalt paving mixture regarding deformation, Fatigue cracking, and moisture susceptibility.

In this study, the usage of glass dust as mineral filler in hot mix asphalt alternate to traditional crushed stone dust were investigated. Optimum bitumen content was determined by Marshall Mix Design Method by using different contents (5, 5.5 and 6%). With the optimum bitumen content different filler ratios (4 ,6 and 8%) were used to prepare asphalt mixtures as mineral filler alternate to crushed stone dust if the economic and environmental factors are in favor. The additives such as brick dust, concrete dust, glass dust and blast furnace slag or a combination of these materials are used to harden the mastic at high temperatures during production and placement, and to obtain even higher binder contents for increase in durability. Since effect of fillers on bituminous mixes is the focus of the present study, the literature related to that has been presented as a separate session later.

2. MATERIALS AND METHODOLOGY

2.1 MATERIALS

Several materials required for producing asphalt specimen includes:

2.1.1 Aggregate

Coarse aggregates of 12 mm down (Aggregate 1) and 6 mm down (Aggregate 2) and M-sand were used. The aggregates used in this investigation for BC mixes satisfied all the physical requirements specified by **MORTH (2009).**

2.1.2 Bitumen

In this study VG 30 grade bitumen was used. Same bitumen was used for all the mixes so the type and grade of binder would be constant.

2.1.3 Filler

Cement(OPC), lime, brick dust, concrete dust, glass dust and blast furnace slag finer than 0.075 mm size sieve were used as filler in the bituminous mixes for comparison and economical point of view.

International Research Journal of Engineering and Management Studies (IRJEMS)
Volume: 03 Issue: 04 | April -2019 ISSN: 1847-9790 || p-ISSN: 2395-0126

Fig -1: Cement

Fig -2: Lime

Fig -3: Brick Dust

Fig -4: Concrete Dust

Fig -5: Blast furnace slag

2.2 METHODOLOGY

2.2.1 Aggregate Proportioning by Trial and Error method:

The sieve analysis of Coarse aggregates 12 mm down (Aggregate 1), 6 mm down (Aggregate 2) and m sand was done. Aggregate mix proportioning was done using Trial and Error method. The mixes were then prepared in the obtained aggregate proportions.

2.2.2 Marshall Method of Mix Design

In this research work Marshall Stability testing setups was used. Tests were performed to determine the Marshall stability, flow value, optimum bitumen content and amount of bitumen required for mix types containing different filler. To investigate the Marshall stability of bituminous mixes with different fillers specimens of 101.6 mm diameter and approximately 63.5 mm thickness were prepared. It was observed from preliminary trails that about 1200 grams of aggregates were required to prepare one specimen of 101.6 mm (4 inch) diameter and 63.5 mm (2.5 inch) thick. Three specimens were prepared for each bitumen contents and 5 bitumen contents (4%, 6%) were used with an increment of 0.5% by weight of total mix. Preparation of specimen, compaction and testing were performed according ASTM D1559 (Marshall Mix Design Method). The aggregates and bitumen were rapidly mixed to yield a mixture having a uniform distribution of bitumen throughout. The bulk specific gravity and density, theoretical maximum specific gravity was determined. After determination of specific gravities of the compacted specimens were immersed in the thermostatically controlled water bath maintained at a temperature of 60ºC for 30 minutes. Marshall Stability and flow test were performed afterwards for each specimen by testing machine. Marshall testing machine is an electrically powered compression testing device. Load was applied to the test specimens through cylindrical segment testing heads at a constant rate of vertical strain of 51 mm (2inch) per minute until the maximum load was reached. The maximum load resistance and respectiveflow value were recorded and percent air voids were determined according to ASTM D3203.

Fig -6: Marshall mould

Fig -7: Marshall testing apparatus

2.2.3 Calculations

1)Determination of Theoretical Specific Gravity

The theoretical specific gravity of the test specimen is determined based on the known values of the specific gravity of aggregate and that of bitumen, without considering the air-voids, and is expressed as,

Gt = 100 / [((100 -Wb)/Ga)+ (Wb/Gb)]

where, Gt= theoretical specific gravity of test specimen (g/cm3); Wb= percentage by weight of bitumen content; Ga = average specific gravity of aggregates; and Gb= specific gravity of bitumen.

2) Determination of Bulk Density and Volumetric Properties

The bulk density of the compacted specimen is determined as per **AASHTO T 166(AASHTO, 2012)** by measuring the weight of the sample in air, weight in water and the saturated surface-dry weight. It is the actual specific gravity measured, considering the air voids, and is given by,

$$Gm = W_a / (W_{SSD} - W_w)$$

where, Gm= bulk density of test specimen (g/cm^3); W_a= weight of the sample in air (g); W_{SSD}= saturated surface-dry weight of the sample (g); W_w= weight of the sample in water (g).

The percentage of air voids (V_v) in the specimen is given as,

$$V_v = [(G_t - G_m) *100] / G_t$$

The percentage volume of bitumen (V_b) in the specimen is given as,

$$V_b = (W_b / G_b) *G_m$$

The percentage of voids in mineral aggregate (VMA)is calculated as,

$$VMA = V_v + V_b$$

The percentage of voids filled with bitumen (VFB) is given as,

$$VFB = (V_b / VMA) *100$$

3) Determination of Optimum bitumen content

Based on the Marshall tests performed above, and the values computed, the following graphs were plotted:

1. Corrected Marshall Stability versus Bitumen Content
2. Flow versus Bitumen Content
3. Unit Weight or Bulk Density (Gm) versus Bitumen Content
4. Percent Air Voids in the total mix (*Vv*) versus Bitumen Content
5. Bitumen Content versus Percentage of Voids Filled with Bitumen (VFB)

The optimum bitumen content (OBC) for the mix design is then found by taking the average of the following three:

1. Bitumen content corresponding to Maximum Stability.
2. Bitumen content corresponding to Maximum Bulk Density
3. Bitumen content corresponding to the median of the design limits of Percent Air Voids in the total mix (3.5%).

3. RESULT AND DISCUSSIONS

From the sieve analysis performed on aggregates 12mm, 6 mm and m sand and by doing trial and error method the mix proportions were obtained. The percentage of aggregates A, B and C in total mix were obtained as given below:

A= 24% B=32% C=44%

The aggregates were proportioned and mixed as given in Table 5.2. The gradation adopted was almost within the desired gradation for BC mix as specified in MoRTH (2009).

3.1 Test results on materials

3.1.1 Aggregate Physical Properties

To investigate the physical properties of the aggregates and their suitability in road construction, various tests were conducted, and the results are indicated in Table 1.

Table -1: Aggregate physical properties

PROPERTY		RESULT
CRUSHING VALUE		30.5%
IMPACT VALUE		27%
SPECIFIC GRAVITY	Aggregate 1	2.60
	Aggregate 2	2.5
	M Sand	2.45
WATER ABSORPTION	Aggregate 1	0.6%
	Aggregate 2	0.4%
	M sand	0%
FLAKINESS INDEX		10.2%

3.1.2 Asphalt Binder Properties

A series of tests, including penetration, specific gravity and softening point conducted for the fundamental characteristic properties of penetration grade asphalt. The test results are shown in Table 2,

Table -2: Asphalt Binder properties

PROPERTY	RESULT
SPECIFIC GRAVITY	1.02
SOFTENING POINT	$47^{0}C$
PENETRATION VALUE	62

3.2 Determination of Optimum Bitumen Content (OBC)

Graphs were plotted with Marshall Stability, density and percentage air voids against bitumen content. OBC was obtained by taking average of bitumen content corresponding to maximum Marshall Stability, maximum density and 3.5% air voids.

Table -3: Determination of OBC

Property	Bit. Content
Max Stability	5.5 %
Max Density	6 %
3.5% Air voids	5.5%
OBC	5.5%

The OBC for BC mix was found to be 5.5%. The construction waste modified mixes were prepared at this OBC.

3.3 Comparison of Marshall and Volumetric Properties of Normal and Other Filler Modified Bituminous Mix :

The modified BC mixes were prepared at OBC by adding 4% ,6% and 8% powdered waste materials by weight of aggregate. The volumetric and Marshall properties of normal and modified mixes were then compared. The comparison is given in Fig. 8, Fig.9, Fig. 10.

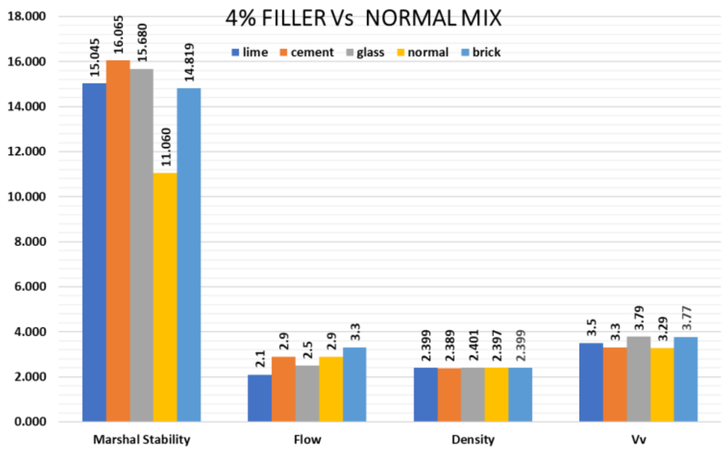

Chart -1: Comparison of Marshall properties- 4% Filler

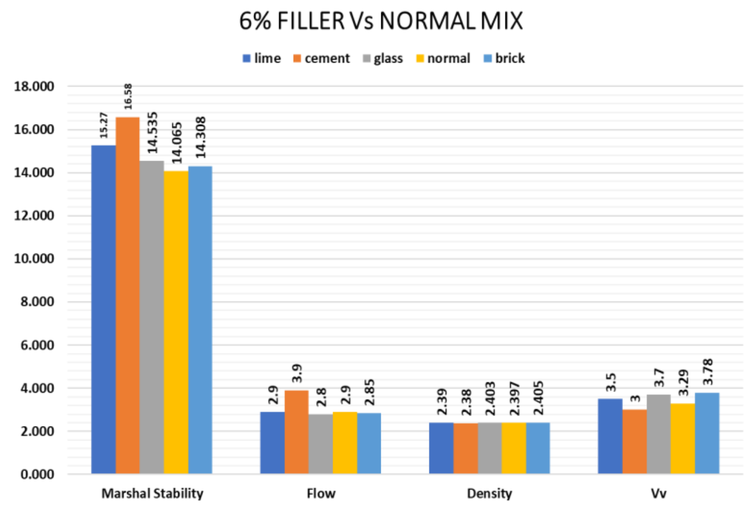

Chart -2: Comparison of Marshall properties- 6% Filler

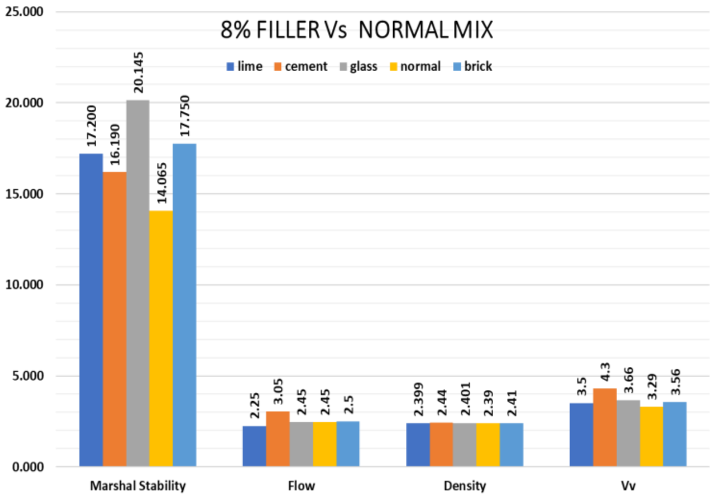

Chart -3: Comparison of Marshall properties- 8% Filler

3.4 Effect of Construction waste materials as a filler in Bituminous Mixes

Various powdered construction waste materials were added as a filler in normal BC mix at OBC as 4%, 6% and 8% by the weight of aggregate. Comparison of Marshall and volumetric properties are shown in the table 4 and table 5.

Table 4: Comparison of properties on various dosages of glass powder

%OF GLASS POWDER	STABILITY	FLOW	DENSITY	VV
4	15.680	2.5	2.401	3.79
6	14.535	2.8	2.403	3.7
8	20.145	2.45	2.401	3.66

Table -5: Comparison of properties on various dosages of brick powder

%OF GLASS POWDER	STABILITY	FLOW	DENSITY	VV
4	14.819	3.3	2.399	3.79
6	14.308	2.85	2.405	3.78
8	17.750	2.5	2.41	3.56

For selecting an optimum dosage of glass powder and brick powder , all the basic requirements of BC Mix should be satisfied. Basic requirements of BC Mix as per MORTH(2009) is shown in Table 4.6

Table-6: Basic Requirements of BC Mix

MIN.STABILITY (KN)	9
FLOW(MM)	2 --4
VV (%)	3--5
VFB (%)	65--75
MIN. VMA (%)	12

4. CONCLUSIONS

The use of waste materials as bitumen modifiers in road construction can reduce the difficulties in disposal of such wastes and also can improve the properties of bituminous mix. In the current study, construction wastes such as glass powder and brick powder was used as the bitumen modifier and the obtained results were compared with conventional fillers like cement and lime.

The glass modified bitumen was found to have lower penetration value and higher softening point compared to normal bitumen. The flow and Air void in the mixture value obtained indicate decreasing trend due to the addition of brick dust as filler in the mixture than mixture not blend with brick filler to obtain maximum marshal criteria values. The laboratory result for brick provides specific gravity and plastic index, satisfying the specification for using filler in the hot asphalt mix, so that brick can use as filler in hot asphalt mix design. It is found that bituminous mixes containing waste glass dust and brick dust as fillers have almost same or better Marshall Properties as those of conventional (cement and lime) fillers. Thus, with some modification in design mixes, can result in utilization of waste glass dust and brick dust as fillers in bituminous pavement, thus save considerable investment in construction and partially solving the disposal of wastes. Based on the results, in consequence of increased awareness of environmental issues and natural resources constraints, the studied waste materials can be advantageously utilized in road construction.

5. ACKNOWLEDGMENT

The authors wish to thank the Mar Athanasius College of Engineering, Kothamangalam for allowing this research project to proceed. This hard work could not be completed without the joint sponsorship program.

6. REFERENCE

[1] Dr. Hassan H. Jony , Mays F. Al-Rubaie & Israa Y. Jahad(2011): "The Effect of Using Glass Powder Filler on Hot Asphalt Concrete Mixtures Properties" *Eng. & Tech. Journal ,Vol.29, No.1, 2011.*

[2] Prof. Eng. Shafik Jendia,Khalil Nabil Dalloul(2013)"Study of the Effect of Crushed Waste Glass as Coarse Sand and Filler in the Asphalt Binder Course" *Master Thesis in Infrastructure Engineering,The Islamic University of Gaza,2013*

[3] V. Mouillet , D. Séjourné , V. Delmotte , H.-J. Ritter , D. Lesueur(2014) :"Method of quantification of hydrated lime in asphalt mixtures" Construction and Building Materials 68 (2014) 348–354

[4] Saltan , Mehmet,Öksüz , betüluz, volkan(2015) :" Use of glass waste as mineral filler in hot mix asphalt", Science and Engineering of Composite Materials,Issue 3.2015

[5] Prof. M.H. Lunagaria, Gatesi Jean De Dieu(2015):" Utilization of High Calcium Fly Ash as Filler Materials in Concrete Bituminous Mixes for Flexible Pavement", International Journal for Scientific Research & Development Vol. 2, Issue 11, 2015

[6] Mohammad Altaf Bhat, IIO.P Mittal: "Review Paper on Effect of Various Fillers on Bituminous Mixes" International Journal of Advanced Research in Education & Technology (IJARET)

[7] MORTH CODE

[8] IS 73:2013