International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

Study on effect of ceramic waste as a filler in bituminous concrete mix

ADABALA MAHESH KUMAR,
Email Id:adabalamahesh2009@gmail.com
K.SREEKAR CHAND, Email Id: chandu.sree225@gmail.com
A.M REDDY MEMORIAL COLLEGE OF ENGINEERING AND TECHNOLOGY

ABSTRACT:

The purpose of this project is to evaluate the suitability of ceramic waste as a filler material in Bituminous Concrete mix. A bituminous concrete mix with ceramic dust and cement were prepared as filler. The amount of optimum binder content was determined by Marshall Stability test for samples. The mechanical performance was determined for Marshall Stability, deformation behavior or flow, as well as for density and void characteristics base on prevailing Indian standards specifications. Results show that the stability values and other parameters of samples containing ceramic wastes are improved in comparison to conventional mineral filler. The benefits of using ceramic waste in bituminous concrete mixture as mineral filler (4% to 7%) are therefore recommended. The replacement of conventional filler like cement, lime and other mineral in bituminous concrete by ceramic wastes will have major environmental benefits.

Keywords: Marshall Stability, ceramic wastes, mineral filler, cement, lime, bituminous concrete.

I. INTRODUCTION

1.1 General

Bituminous roads are defined as the roads in 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. Various materials such as cement, lime, granite powder, stone dust and fine sand are normally used as filler in bituminous mixes. The filler has the ability to increase the resistance of particle to move within the mix matrix and/or works as an active material when it interacts with the asphalt cement to change the properties of the mastic. But excessive amount of filler may weaken the mixture by increasing the amount of asphalt needed to cover the aggregates. The effects of these fillers are also dependent on gradations.

Globally various researches had been conducted by Scientists and Engineers to understand the use of waste materials in road construction with the key objectives of effective disposal of these materials to save environment and also to reduce overall road construction cost without impacting construction quality. These studies try to match society's need for safe and economic disposal of waste materials with the highway industry's need for better and more cost-effective constructionmaterials

Some of the industrial wastes like fly ash, blast furnace slag and ceramic waste materials can be effectively utilized for road construction work. The proposed study is aimed to determine the applicability of ceramic waste material in bituminous mix for the flexible pavement design. The ceramic industries are established near Hyderabad city produce the waste (broken tiles) in large quantity and dumping the stacks surrounding the industry creating hazardous environment. Looking at this problem the proposed study can suggest the suitable application of ceramic waste in road construction which may result in improvement of environment.

1.2 MIX DESIGN

1.2.1 Objectives of Mix design

The bituminous mix design aims to estimate the proportions of bitumen, filler material, fine aggregates, coarse aggregates & polythene to produce a mix which should have

- Sufficient workability so that there is no segregation under load
- Enough strength to survive heavy wheel loads & tyre pressures.
- Sufficient durability
- Should be economical

1.2.2 Types of Mix

- Hot mix asphalt concrete
- Warm mix asphalt concrete
- Cold mix asphalt concrete
  Cut-back asphalt concrete
- Mastic asphalt concrete or sheet asphalt

1.3 CERAMIC WASTE

Ceramic waste is produced from ceramic bricks, roof and floor tiles and stoneware industries**.** Indian ceramic production is 100 million ton per year. In the ceramic industry, about 15%-30% waste material generated from the total production. The principle waste coming into the ceramic industry is the ceramic powder, specifically in the powder forms. Ceramic wastes are generated as a waste during the process of dressing and polishing. Ceramic waste powder is settled by sedimentation and then dumped away which results in environmental pollution.

II **MATERIALS AND EXPERIMENTS**

2.1 Materials Used

The materials used are as follows.

i. Aggregates

ii. Bituminous Binder

iii. Fillers (Cement, Stone dust, Ceramic waste)

2.1.1 Aggregates

Aggregate constitutes the granular part in bituminous concrete mixtures which contributes up to 90-95 % of the mixture weight and contributes to most of the loadbearing & strength characteristics of the mixture. Hence, the quality and physical properties of the aggregates should be controlled to ensure a good pavement.

Aggregates are of 2 types. i.e.

- Coarse Aggregate (CA)
- Fine Aggregate (FA)

Coarse Aggregate (CA)

The aggregates retained on 4.75 mm Sieve is called as coarse aggregates and the physical properties of aggregates had shown in the given below table.

Property	Method of Test	Specification	Test Result
Aggregate Impact Value (%)	IS: 2386 (Part-IV)	Max 24%	17.13 %
Aggregate Crushing Value (%)		Max 35%	18.80 %
Combined Flakiness and Elongation Indices (%)	IS: 2386 (Part-I)	Max 35%	16.18 %
Coating And Stripping of Bitumen Aggregate Mix	(IS:6241)	Minimum Retained Coating 95%	98%
Water Absorption (%)	(IS:2386 Part III)	Max 2%	0.15%

Fine Aggregate (FA)

Fine aggregate should be clean screened quarry dusts. It should be free from clay, loam, vegetation or organic matter. FA should have the specific gravity of 2.6 and water absorption 0.6%.

2.1.2 Bituminous Binder

Asphalt binder 80/100 are used in this research and the properties of the binder are tabulated as given below.

Property	Method of Test	Test Result
Specific gravity	IS : 1202-1978	1.01
Penetration at 25°C (mm)	IS : 1203-1978	83
Softening Point (°C)	IS : 1205-1978	52
Ductility (cm)	IS : 1208-1978	96
Flash Point (°C)	IS : 1209-1978	290
Fire Point (°C)	IS : 1209-1978	305

2.1.3 Filler

Mineral filler consists of, very fine, inert mineral matter that is added to the hot mix asphalt, to increase the density and enhance strength of the mixture. These fillers should pass through 75µm IS Sieve. The fillers used as cement, stone dust and ceramic waste.

2.1.3.1 Ceramic Filler

Ceramic waste was using as filler material in this research work with varying percentages are 4% to 7% whole weight of aggregates and the average specific gravity of ceramic dust is 2.5. The grades of aggregates and their quantities to be used for preparing Marshall samples were used according to the chart given in the MORTH specification.

2.2 Sample Preparation

2.2.1 Marshall sampling mould

The specifications of the sampling mould and hammer was taken as standard and the mixing of ingredients in the mould is done according to the following procedure (STP 204-8).

IS Sieve (mm)	Percent Passing	
	Specification Grading	Grading adopted
19	100	100
13.2	90-100	95
9.5	70-88	75
4.75	53-71	60
2.36	42-58	50
1.18	34-48	40
0.600	26-38	32
0.300	18-28	20
0.150	12-20	15
0.075	4-10	5
Binder Content % by weight	5-7	5.0 - 6.0

2.2.2 Mixing Procedure

The mixing of ingredients was done as per the following procedure (STP 204-8).

1. Required quantities of coarse aggregate, fine aggregate & mineral fillers were taken in an iron pan.
2. This was kept in an oven at temperature 160^0c for 10min. This is because the aggregate and bitumen are to be mixed in heated state so preheating is required.
3. The bitumen was also heated up to its melting point prior to the mixing.
4. The aggregates in the pan were heated on a controlled gas stove for a few minutes maintaining the above temperature.
5. For BC: Now bitumen (54, 60, 66, 72 gms), i.e. 4.5%, 5.0%, 5.5%, 6.0% was added to this mix and the whole mix was stirred uniformly and homogenously. This was continued for 15-20 minutes till they were properly mixed which was evident from the uniform colour throughout the mix.
6. Then the mix was transferred to a casting mould.
7. This mix was then compacted by the Marshall Hammer.

BC	Bitumen (%)	Mean Marshall Stability(KN)	Mean Flow (mm)
	4.5	9.2	7.2
	5.0	10.2	7
	5.5	9.7	6.2
	6.0	9.5	5.7

8. 75 no. Of blows were given per each side of the sample so subtotal of 150 no. of blows was given per sample.
9. Then these sample moulds were kept separately and marked.

2.2.3 Optimum Binder Content

Bitumen Contents for BC varies 4.5% ,5.0%, 5.5%, 6% in that we need find the optimum filler content for future research work on ceramic dust used as filler with 4% - 7%.

Table:2.2.3.1 Marshall Stability for control mix (Cement as filler)

BC	Bitumen (%)	Mean Marshall Stability (KN)	Mean Flow (mm)
	4.5	9.0	7.6
	5.0	9.8	7.2
	5.5	9.4	6.5
	6.0	9.2	5.9

Table:2.2.3.2 Marshall Stability for control mix (Stone dust as filler)

Based on the above two tables the optimum binder content is 5.0%. For future work carried out on 5.0% bitumen content.

2.2.4 Ceramic dust Using as filler in BC

The addition of ceramic dust to the bitumen with varying percentages i.e: 4%, 5%, 6% & 7% by the weight of aggregates. After addition of Ceramic dust to bitumen, to prepare the 3 samples for each proportion of the BC mixes for finding out the marshall properties. The amount raw materials requirement for BC (5.0%) is given in table below.

Filler (%)	Weight of bitumen (gm)	Weight of Aggregate (gm)	Weight of filler (ceramic) (gm)
4	60	1094.4	45.6
5		1083	57
6		1071.6	68.4
7		1060.2	79.8

2.3 MARSHALL TESTING

The Marshall test was done as procedure outlined in ASTM D6927 – 06.

<u>Marshall Stability Value :</u>

It is defined as the maximum load at which the specimen fails under the

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

application of the vertical load. It is the maximum load supported by the test specimen at a loading rate of 50.8 mm/minute (2 inches/minute).

Marshall Flow Value :

It is defined as the deformation undergone by the specimen at the maximum load where the failure occurs. The flow value was recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load was recorded.

The Marshall Stability and Flow Values for BC are shown in given below Table.

Filler (%)	Sample	Stability (KN)	Mean Stability (KN)	Flow (mm)	Mean Flow (mm)
4	1	9.35	9.346	6.4	6.2
	2	9.37		6.2	
	3	9.32		6.0	
5	1	9.51	9.543	5.8	5.53
	2	9.58		5.5	
	3	9.54		5.3	
6	1	9.7	9.76	4.5	4.36
	2	9.85		4.4	
	3	9.73		4.2	
7	1	9.61	9.56	3.8	3.56
	2	9.52		3.6	
	3	9.56		3.3	

III.RESULTS AND DISCUSSIONS

3.1 Optimum Bitumen Content

In this four curves were plotted, i.e: for

1) Cement: Marshall flow & Marshall stability
2) Stone dust: Marshall flow & Marshall stability

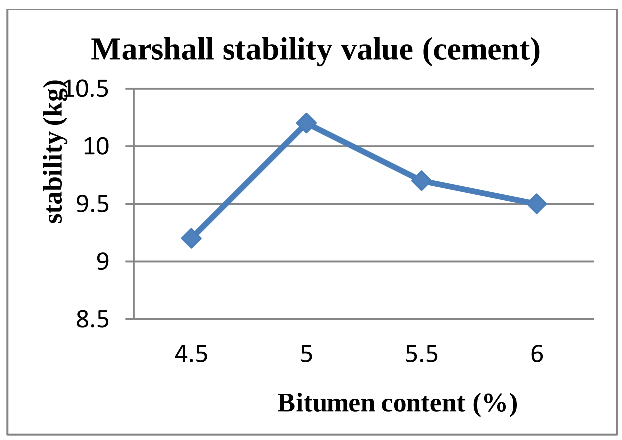

Figure 3.1.1 Marshall stability vs. Bitumen content

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

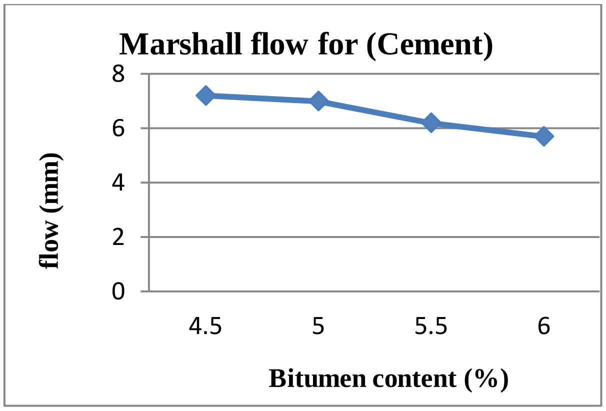

Figure 3..1.2 Marshall flow vs. Bitumen content

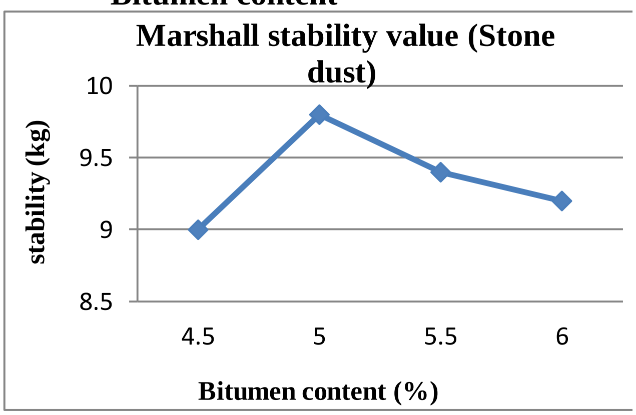

Figure 3.1.3 Marshall stability vs. Bitumen content

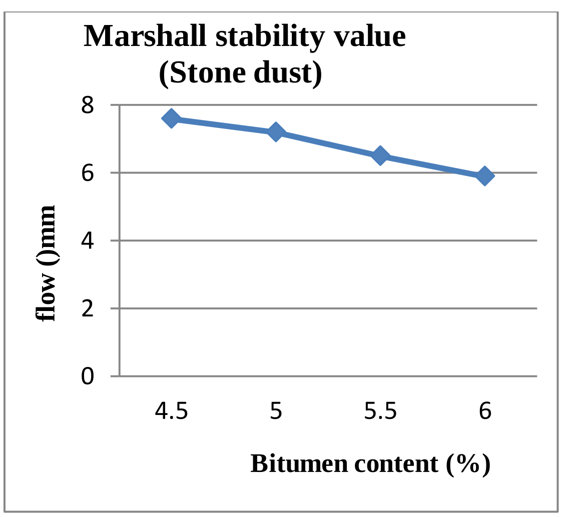

Figure 3.1.4 Marshall flow vs. Bitumen content

3.2 Optimum Ceramic dust filler Content

In these six curves were plotted. i.e.:

- ✓ Marshall Stability Value vs. filler Content
- ✓ Marshall Flow Value vs. filler Content
- ✓ VMA vs. filler Content
- ✓ VA vs. filler Content
- ✓ VFB vs. filler Content
- ✓ Bulk unit weight vs filler Content

And the data for the plotting curves can be tabulated as shown below

Table 3.2.1 Data for plotting curves

S. No	Filler (%)	Unit weight (G_{mb})	VA (%)	VMA (%)	VFB (%)	Mean Stability (Kg)	Mean Flow (mm)
1	4	2.304925	5.275	16.3666	67.769	9.346	6.2
2	5	2.293893	4.1525	16.7667	75.2336	9.543	5.53
3	6	2.275731	3.346	17.42578	80.7985	9.76	4.36
4	7	2.258427	2.727	18.05365	84.895021	9.56	3.56

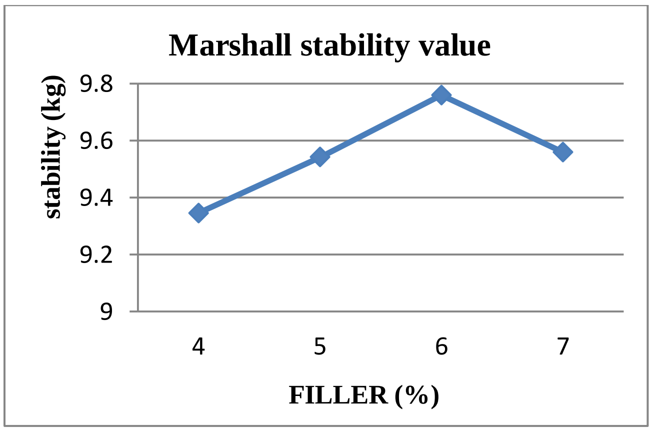

Figure 3.2.2Marshall Stability Value vs. Filler Content

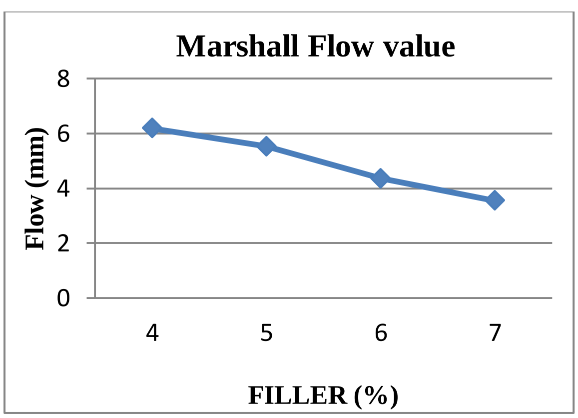

Figure 3.2.3 Marshall Flow Value vs. FillerContent

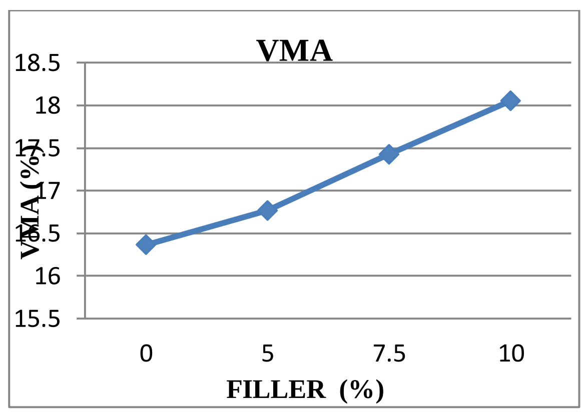

Figure 3.2.4 VMA vs. Filler Content

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

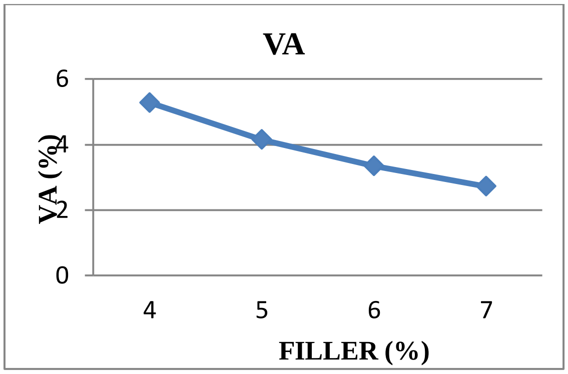

Figure 3.2.5 VA vs.Filler Content

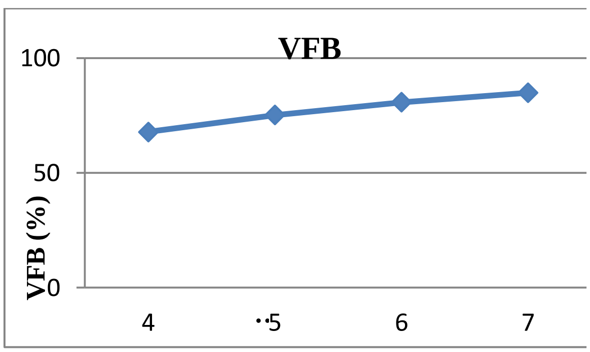

Figure 3.2.6 VFB Vs Filler Content

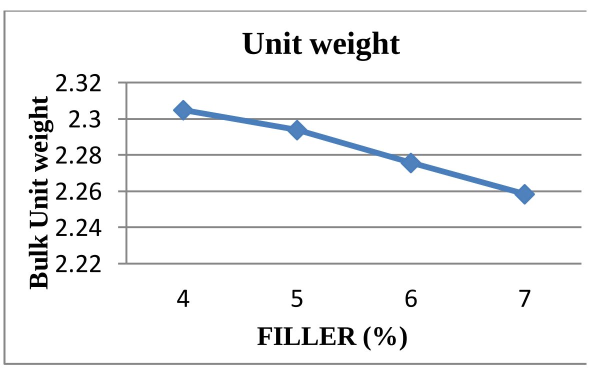

Figure 3.2.7 Bulk unit weight vs. Filler Content

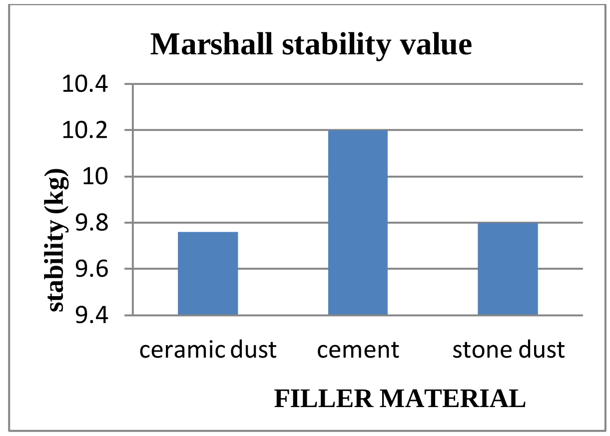

Figure 3.2.8 Comparative stability for 3 fillers

IV CONCLUSION

The higher order roads like National highway, State Highway and Major Urban Arterials and Sub Arterials possess the bituminous concrete at the top and need filler contents. Generally, lime, cement or fine dusts are used. As ceramic industries produce ceramic powder as waste in huge quantity, it necessitates the disposal of such materials. The alternate option is to use it in construction activities.

This study focuses on a laboratory evaluation of the mechanical performance of asphalt concrete mixes using Ceramic Waste as filler. A comparative study is carried out here for three different filler materials i.e. Cement, Stone dust and Ceramic powder. Initially we find optimum binder content by using cement and stone dust as filler materials with 5% of whole aggregate weight. By this we got 5% is the optimum binder content. Based on this 5% binder content we find out the optimum ceramic filler content. Based on the laboratory experiments and analysis, the following conclusions are drawn.

1. It is observed that with the increase in Ceramic Waste content from 4 to 6%, the

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal
www.ijarst.in
ISSN: 2457-0362

stability value increases.

2. On comparison between Ceramic Waste, Cement and Stone dust, it is found that Marshall Stability of Cement mix greater than that of stone dust mix and ceramic dust. But Ceramic mix stability value near to cement mix value.

3. Ceramic waste satisfies the entire minimum requirement for mineral filler specified in the MORTH bituminous concrete mixture. It was concluded that ceramic industrial waste can be utilized as a replacement for conventional mineral fillers in bituminous mixes. The utilization of ceramic waste in the Bituminous concrete mixes may solve the significant disposal problem to save the environment.

REFERENCES

[1] Kadeyali: Principles and practice of HighwayEngineering.3rdedition (1997).

[2] Katamine NM: Phosphate waste in mixtures to improve theirdeformation. J Transport Eng 2000; 126:382–9.

[3] Asi Ibrahim, Assa'ad Abdullah: Effect of Jordanian oil shalefly ash on asphalt mixes. J Mater CivEng 2005; 17:553–9.

[4] Lin Deng-Fong, Lin Jyh-Dong, Chen Shun-Hsing: Theapplication of baghouse fines in Taiwan. Resour ConservRecycle 2006; 46:281–301.

[5] Sung Do Hwang, Hee Mun Park, Suk keun Rhee: A study onengineering characteristics of asphalt concrete using filler withrecycled waste lime. Waste Manage 2008; 28:191–9.

[6] Xue Yongjie, Hou Haobo, Zhu Shujing, Zha Jin: Utilization ofmunicipal solid waste incineration ash in stone mastic asphaltmixture: pavement performance and environmental impact.Constr Build 2009; 23:989–96.

[7] Huang Baoshan, Dong Qiao, Burdette Edwin G: Laboratoryevaluation of incorporating waste ceramic materials intoPortland cement and asphaltic concrete. Constr Build Mater2009; 23:3451–6.

[8] Kalkattawi, H.R: Effect of Filler on the Engineering Propertiesof Asphalt Mixes, M.S. Thesis, King Abdul Aziz University,Jeddah, Saudi Arabia. (1993)

[9] Anderson, D. A.: Guidelines for use of dust in hot mix asphaltconcrete mixtures."Proc. Association of Asphalt PavingTechnologists, 56, Association of Asphalt PavingTechnologists, St. Paul, MN, 492–516, 1987

[10] Elliot, R.P., Ford, M.C., Ghanim, M., and Tu, Y.F. :Effect ofaggregate gradation variation on asphalt concrete mixproperties, Transportation Research Record, 1317, National Research Council, Washington, D.C., 1991

[11] Kandhal, P.S., Lynn, C.Y., and Parker, F.: Characterization testsfor mineral fillers related to performance of asphalt pavingmixtures, NCAT Rep. No. 98-2, 1998

[12] Bahia, H.U., Zhai, H., Bonnetti, K.,and Kose, S.: Non-linearvisco-elastic and fatigue properties of asphalt binders, Journalof Association of Asphalt Paving Technology, 68, 1-34,1999

[13] Geber, R. and Gomze, L.A.: Characterization of mineralmaterials as asphalt fillers, Material Science Forum,659,471-476, 2010

[14] Vavrik, W.R., Pine, W.J., Carpenter, S.H., and Bailey, R.:Bailey method for gradation

selection in hot-mixasphaltmixturedesign,TransportationResearchBoard,NationalResearchCouncil, Washington,D.C., USA., 2002

[15] Zulkati, A., Diew, W. Y. and Delai, D.S. :Effects of Fillers onproperties of Asphalt-Concrete Mixture, Journal ofTransportation Engineering, ASCE, Vol. 138, No. 7,902-910.,2012

[16] Taylor, R.: Surface interactions between bitumen and mineralfillers and their effects on the rheology of bitumen-fillermastics. Ph.D. thesis,

1.

Univ. of Nottingham, UK., 2007

[17] Lesueur, D.: The colloidal structure of bitumen: consequenceson the rheology and on the mechanisms of bitumenmodification. Adv.Colloid Interface Sci., 145(1–2), 42–82.,

2009

[18] Bahia, H. U., Faheem, A., Hintz, C., Al-Qadi, I., Reinke, G.,and Dukatz, E.: Test methods and specification criteria formineral filler used in HMA."NCHRP Research Results Digest,357, Transportation Research Board, Washington, DC., 2011