International Journal of Research in Engineering, Science and Management
Volume 4, Issue 6, June 2021
https://www.ijresm.com | ISSN (Online): 2581-5792

A Study On Use of Cement, Lime and Stone Dust as a Filler in Bituminous Concrete Mix

Tabiya Niyaz[1*], Kamal Preet Kaur[2], Neeraj Kumar[3]
[1]*M.Tech. Scholar, Department of Civil Engineering, SRIMET, Affiliated to Kurukshetra University, Kohra Bhhura, India*
[2,3]*Assistant Professor, Department of Civil Engineering, SRIMET, Affiliated to Kurukshetra University, Kohra Bhhura, India*

***Abstract*: Pavement constructed with bitumen, aggregate and filler is known as flexible pavements. Bitumen is used as a binder material; aggregates provide appropriate strength and filler is used to fill the bituminous layer void. Mainly we use cement as filler nowadays, as it is essential for better environmental conditions to utilize the waste materials as filler but it is also mandatory that material also fulfils the desired design characteristics. In this study we used of materials as filler to give better outcomes with the help of concern laboratory examination. The filler used in this study are cement, lime and stone dust. The test conducted were Ductility, Penetration test, Viscosity, Softening Point, Flash Point test and Marshall Test. From Marshall test optimum binder content (OBC) was determined. The test result obtained showed that stability value for lime and cement was maximum at 5.5% of bitumen.**

***Keywords*: pavements, bitumen, engine oil, cooking oil, addition percentage, highway industry.**

1. Introduction

Construction of highway involves huge outlay of investment. A precise engineering design may save considerable investment, as well as enhance the performance of highway in service. Two things are major considerations in this regard: Pavement design and mix design. Flexible concrete pavement is the paving system most widely adopted all over the world. It has been recognized that there are many different types of the factors affecting the performance and durability of a concrete pavement, including the service conditions, such as: the variation of temperature from mild to extremes and the repeated excessive axle loading as well as the inadequate quality of the raw materials. All of these when combined together are going to accelerate the occurrence of distresses in flexible pavement such as permanent deformation and fatigue cracking. As the result, there has an urgent need to enhance the ability of a concrete mixture to resist distresses happened in pavement. Use of additives is one of the techniques adopted to improve pavement properties. 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 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. Cement and granite powder are expensive and used for other purposes more effectively. Fine sand, ash, waste concrete dust and brick dust finer than 0.075 mm sieve size appear to be suitable as filler material. The use of waste powder as filler in asphalt mixture has been the focus of several research efforts over the past few years. Phosphate waste filler, Jordanian oil shale fly ash, bag house fines, recycled waste lime, municipal solid waste incineration ash and waste ceramic materials have been investigated as filler. It was proved that these types of recycled filler could be used in asphalt mixture and gave improved performance. So, the present study has been taken in order to investigate the behavior of bituminous mixes with different types of filler materials locally available. If filler is mixed with less bitumen than it is required to fill its voids, a stiff dry product is obtained which is practically not workable. Overfilling with bitumen, on the contrary, imparts a fluid character to the mixture. 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 cement to change the properties of the mastic. Elastic modulus of asphalt concrete mixture can increase by the addition of mineral filler. But excessive amount of filler may weaken the mixture by increasing the amount of asphalt needed to cover the aggregates. The fillers used in this investigation are likely to partly solve the solid waste disposal of the environment

2. Literature Review

Various researches have been conducted by various scholars on the effect of fillers in bitumen and different results were obtained. Some of the literature reviews are as under:

Panda, and Mazumdar, (1999) [1] this paper studied the engineering properties and reports the procedure for modification of 80/100 penetration-grade bitumen using ethylene vinyl acetate copolymer for paving mixes. Some of the basic physical properties of the bitumen and the modified

*Corresponding author: khurshidirtiza@gmail.com

binder are presented. The mechanical properties of the mixes containing such binder have been studied and compared with neat bitumen. They observed that the penetration, ductility, and specific gravity of the modified binders decrease as compared with unmodified bitumen while the softening point temperature, temperature susceptibility and viscosity increase. It was found that 5% EVA concentration in modified binder by weight is adequate in terms of the enhanced properties studied.

Murphy, et al., (2001) [2] research study aims to examine the possibility of incorporating waste polymer into bitumen as a modifier, evaluated the performance of recycled modified bitumen and compare their properties with those of standard bitumen and polymer modified bitumen. Tests included viscosity, penetration, softening point, aging, and rheology. They concluded polypropylenes are not useful in improving the properties of bitumen and displayed practical difficulties during mixing and testing, suggesting poor cohesion with bitumen. The blend with 3% low density polyethylene substituted for 1% styrene butadiene styrene had similar properties to that of Polyflex 75, although it had lower stiffness. The most impressive was a combination of low density polyethylene, bitumen, and ethyl vinyl acetate.

Wegan, and Nielsen, (2001) [3] studied microstructure of polymer modified binders in bituminous mixtures by preparing thin sections of the specimen and analyzing that thin section by Infrared Fourier Transform Spectrometer. When thin sections were illuminated with the UV-light, the polymer phase emits yellow light, fine and coarse aggregates often appear green, the bitumen phase is black and air voids or cracks appear with a yellow-green colour.

Justo, et al., (2002) [4] at the Centre for Transportation Engineering, of Bangalore University used processed plastic bags as an additive in asphalt concrete mixes. The properties of this modified bitumen were compared to that of ordinary bitumen. It was noted that penetration and ductility values, of modified bitumen was decreasing with the increase in proportion of the plastic additive, up to 12 % by weight.

Airey, et al., (2004) [5] studied Linear Rheological behaviour of bituminous paving materials. They concluded that the rheological behaviour of asphalt mixtures incorporating a range of unmodified and modified binders showed similarities to the rheological characteristics of the constituent RTFOT aged binders and the stiffening effect of the DBM asphalt mixture for both the unmodified and SBS modified binders was found to be approximately 100 times greater at high complex modulus values and approximately 6,000 times greater at low complex modulus values.

Recasens, et al., (2005) [6] used different fillers including lime in bitumen to study the effect of fillers on bituminous mixes. First properties of materials were determined then the optimum asphalt content for each mixture was determined according to the Marshall Mix Design Method and at last tests were conducted. The tests included Marshall Stability and Flow tests. Also bulk specific gravity, density and percent air voids were conducted. Lime was added in different percentage 0.5, 1, 1.3 and 1.5 and the mixture develops the maximum energy at the same concentration as the critical concentration (C_v/C_s=1.0) and at this point air voids content was 26.4% and density was 1.834 g/cm^3.

Mohammad T. Awwad, et al., (2007) [7] polyethylene as one sort of polymers is used to investigate the potential prospects to enhance asphalt mixture properties. The objectives also include determining the best type of polyethylene to be used and its proportion. Two types of polyethylene were added to coat the aggregate High Density Polyethylene (HDPE) and Low Density Polyethylene (LDPE). The results indicated that grinded HDPE polyethylene modifier provides better engineering properties. The recommended proportion of the modifier is 12% by the weight of bitumen content. It is found to increase the stability, reduce the density and slightly increase the air voids 1and the voids of mineral aggregate.

Casey, et al., (2008) [8] studied the development of a recycled polymer modified binder for use in stone mastic asphalt. From their study it was found that the addition of 4% recycled HDPE into a pen grade binder produced the most promising results, and results obtained from wheel track and fatigue tests show that although the binder does not deliver equivalent performance means dose not perform to the same high levels as a proprietary polymer modified binder, it does out-perform traditional binders used in stone mastic asphalt.

Fernandes, et al., (2008) [9] studied Rheological evaluation of polymer modified asphalt binders by using thermoplastic elastomer styrene butadiene styrene (SBS) and they compared the properties of Modified binder by addition of both oil shale and aromatic oil to improve their compatibly. The rheological characteristics of the SBS PMBs were analyzed in a dynamic shear rheometer (DSR) and the morphology accessed by fluorescence optical microscopy. The results indicated that the aromatic and shale oils have similar effects on the microstructure, storage stability and viscoelastic behavior of the PMBs. Thus, shale oil could be successfully used as a compatibilizer agent without loss of properties or could even replace the aromatic oil.

Al-Hadidy, and Yi-qiu, (2009) [10] investigated the potential use of pyrolysis a low density polyethylene (LDPE) as a modifier for asphalt paving materials. Their research results indicate that modified binders show higher softening point, keeping the values of ductility at minimum range of specification of (100+ cm), and cause a reduction in percentage loss of weight due to heat and air (i.e. increase durability of original asphalt).

3. Materials Used in Present Study

All the materials which are used in this study were properly tested and selected on the basis of permissible values. In addition to conventional materials of hot mix asphalt, we used waste plastic (LDPE) for partial replacement of bitumen in order to gain required properties of polymer modified bitumen.

a) Aggregates
b) Cement, Lime and stone dust as filler
c) Bitumen

A. Aggregates

An aggregate which has good and sufficient strength, hardness, toughness and soundness have to be chosen. Crushed aggregates produce higher stability. 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.

Table 1
Specific gravity of aggregates

S. No.	Types of aggregates	Specific gravity
1	Coarse	2.71
2	Fine	2.58
3	Filler (cement)	2.93
4	Filler (lime)	2.6
5	Filler (stone dust)	2.63

Table 2
Physical properties of coarse aggregates

S. No.	Property	Test method	Test result
1	Aggregate Impact Value (%)	IS: 2386 (P IV)	19
2	Aggregate Crushing Value (%)	IS: 2386 (P IV)	21
3	Los Angeles Abrasion Value (%)	IS: 2386 (P IV)	24
4	Flakiness Index (%)	IS: 2386 (P I)	25.58
5	Elongation Index (%)	IS: 2386 (P I)	23.4
6	Water Absorption (%)	IS: 2386 (P III)	1

B. Filler

Here in this experimental study cement, lime and stone dust used as Filler material. Cement is collected from Gupta cement store, Naraingarh, Ambala. lime is collected from Jagadhari, Yamunangar. Stone dust is collected from SS associate Naraingarh, Ambala.

Table 3
Chemical composition of Cement in percentage

S. No.	Constituents	Percentage of Constituents
1	CaO	64
2	SiO2	22
3	Al2O3	5.6
4	Fe2O3	3.36
5	MgO	2.06
6	SO3	2.14
7	Loss of ignition	0.65

Table 4
Chemical composition of Lime in percentage

S. No.	Constituents	Percentage of Composition
1	Al2O3 (aluminum oxide)	0.01
2	Fe2O3 (Iron Oxide)	0.11
3	CaO (Calcium Oxide)	65.25
4	MgO (Magnesium Oxide)	0.50
5	K2O (Potassium Oxide)	0.01
6	Na2O (Sodium Oxide)	0.01
7	S (Sulphur)	0.13
8	C (Carbon)	4.50
9	Loss on ignition	33.25

Table 5
Chemical composition of Stone dust in percentage

S. No.	Constituents	Percentage of Composition
1	Al2O3 (aluminum oxide)	8.24
2	Fe2O3 (Iron Oxide)	1.41
3	CaO (Calcium Oxide)	2.81
4	MgO (Magnesium Oxide)	1.48
5	K2O (Potassium Oxide)	1.52
6	Na2O (Sodium Oxide)	1.62

C. Bitumen

One conventional commonly used bituminous binder, namely VG 10 bitumen was used in this investigation to prepare the samples. Conventional tests were performed to determine the physical properties of these binders. The physical properties thus obtained are summarized in Table.

Table 6
Test results of VG 40 grade bitumen

S. No.	Characteristic	Unit	Result	Test Method
1	Ductility at 25° C	Cm	>100	IS 1208 : 1978
2	Penetration at 25° C	1/10mm	100	IS 1203 : 1978
3	Absolute Viscosity at 60° C	Poise	835.2	IS 1206 : 1978
4	Softening Point	°C	41.2	IS 1205:1978
5	Flash Point Test	°C	220	IS 1209 : 1978

Table 8
Different percentage of bitumen selected for finding OBC

S. No	% of Bitumen, (Pb)	% of Aggregates, [Ps=(100-Pb)]
1	5.00	95.00
2	5.50	94.50
3	6.00	94.00

Tests on Marshall Samples:

Marshall Method for designing hot asphalt mixtures is used to determine the optimum bitumen content to be added to specific aggregate blend resulting a mix where the desired properties of strength and durability are met. According to standard 75-blow Marshal design method designated as (ASTM D 1559-89) a number of 9 samples each of 1200 gm in weight were prepared using three different bitumen contents (5%, 5.5% & 6%). Three samples were used to prepare asphalt mixture with optimum bitumen content to have an average value of

Table 7
Percentage & Weight of aggregates for BC layer as per Specified Gradation

Sieve	Percentage	Percentage	Percentage	Percentage	Weight	Cumulative
19	100	100	0	0	0	0
13.2	79-100	91.25	8.75	8.75	105	105
9.5	70-88	76.25	23.75	15	180	285
4.75	53-71	53.7	43.3	19.55	234.6	519.6
2.36	42-58	45.35	54.65	11.35	136.2	655.8
1.18	34-48	37.14	62.86	8.21	98.4	754.2
0.6	26-38	29.04	70.96	8.10	97.2	851.4
0.3	18-28	21.8	78.20	7.24	86.88	938.28
0.15	12-20	13.66	86.34	8.14	97.68	1035.96
0.075	4-10	4.42	95.58	9.24	110.88	1146.84
Pan	0	0	100	4.42	53.04	1200

Table 9

S. No.	Specimen	%age of Bitumen content	%age of aggregate	%age of filler (cement)	%age of filler (lime)	%age of filler (stone dust)
1	A1					
2	A2	5	93	2	-	-
3	A3					
4	B					
5	B	5.5	92.5	2	-	-
6	B					
7	C					
8	C	6	92	2	-	-
9	C					
10	D					
11	D	5	93	-	2	-
12	D					
13	E					
14	E	5.5	92.5	-	2	-
15	E					
16	F					
17	F	6	92	-	2	-
18	F					
19	G					
20	G	5	93	-	-	2
21	G					
22	H					
23	H	5.5	92.5	-	-	2
24	H					
25	I					
26	I	6	92	-	-	2
27	I					

Marshal Stability, bulk density and flow. Marshall Properties of the asphalt mix such as stability, flow, density, air voids in total mix, and voids filled with bitumen percentage are obtained for various bitumen contents.

Optimum Binder Content:

The amount of binder to be added to a bituminous mixture cannot be too excessive or too little. The principle of designing the optimum amount of binder content is to include sufficient amount of binder so that the aggregates are fully coated with bitumen and the voids within the bituminous material are sealed up. As such, the durability of the bituminous pavement can be enhanced by the impermeability achieved. Moreover, a minimum amount of binder is essential to prevent the aggregates from being pulled out by the abrasive actions of moving vehicles on the carriageway. However, the binder content cannot be too high because it would result in the instability of the bituminous pavement. In essence, the resistance to deformation of bituminous pavement under traffic load is reduced by the inclusion of excessive binder content.

A number of 27 samples each of 1200 gm (approx) in weight were prepared using three different bitumen contents (from 5 - 6% with 0.5 % incremental) in order to obtain the optimum bitumen content (OBC). Testing is done on prepared Marshall Samples and the calculation work carried out to find out the desired parameters:

(a) ρA Bulk Density
(b) Va% Air voids content
(c) Vb% Percent volume of bitumen
(d) VMA% Percent voids in Mineral Aggregates
(e) VFB% Percent Voids Filled with Bitumen

Table 10

S. No.	Specimen	Wt. in Air gm (W_a)	Wt. in Water gm	SSD Wt. gm (W_{ssd})	Bulk Volume	Bulk Sp. Gr. (G_{mb})	Avg. Sp. Gr. (G_{mb})
			(W_w)		*(BV)*		
1	A1	1236.6	705.2	1237.4	532.2	Vs`	
2	A2	1235.5	700.1	1236.4	536.3	2.30	2.31
3	A3	1239.8	704.8	1240	535.2	2.32	
4	B	1236.4	708.5	1237.5	529	2.34	
5	B	1243.8	707.1	1242.6	535.5	2.32	2.33
6	B	1247.1	707.5	1245.3	537.8	2.32	
7	C	1241.3	713.4	1242	528.6	2.35	
8	C	1235.5	711.7	1237.2	525.5	2.35	2.35
9	C	1236.2	712.7	1239.7	527	2.35	
10	D	1236.9	704.9	1237.6	532.7	2.32	
11	D	1235.8	699.8	1236.6	536.8	2.30	2.32
12	D	1240.1	704.5	1240.2	535.7	2.31	
13	E	1236.7	708.2	1237.7	529.5	2.34	
14	E	1244.1	706.8	1242.8	536	2.32	2.35
15	E	1247.4	707.2	1245.5	538.3	2.32	
16	F	1241.6	713.1	1242.2	529.1	2.35	
17	F	1235.8	711.4	1237.4	526	2.35	2.31
18	F	1236.5	712.4	1239.9	527.5	2.34	
19	G	1236.8	705	1237.6	532.6	2.32	
20	G	1235.7	699.9	1236.6	536.7	2.30	2.32
21	G	1240	704.6	1240.2	535.6	2.32	
22	H	1236.6	708.3	1237.7	529.4	2.34	
23	H	1244	706.9	1242.8	535.9	2.32	2.35
24	H	1247.3	707.3	1245.5	538.2	2.32	
25	I	1241.5	713.2	1242.2	529	2.35	
26	I	1235.7	711.5	1237.4	525.9	2.35	2.31
27	I	1236.4	712.5	1239.9	527.4	2.34	

Table 11

S. No.	Specimen	Theoretical Sp. Gr. (Gmm)	Avg. Theoretical Sp. Gr. (Gmm)	Voids in Mineral Agg. (VMA)	Voids in total Mix (VTM)
1	A1	2.53	2.72	16.5	7.2
2	A2	2.51			
3	A3	2.52			
4	B	2.54	2.73	15.9	5.0
5	B	2.52			
6	B	2.52			
7	C	2.55	2.75	15.1	3.69
8	C	2.55			
9	C	2.55			
10	D	2.52	2.71	15.4	6.5
11	D	2.50			
12	D	2.52			
13	E	2.54	2.72	14.2	5.1
14	E	2.52			
15	E	2.51			
16	F	2.55	2.75	13.5	4.6
17	F	2.55			
18	F	2.55			
19	G	2.52	2.71	19.3	9.81
20	G	2.50			
21	G	2.52			
22	H	2.54	2.72	18.2	5.92
23	H	2.52			
24	H	2.51			
25	I	2.55	2.75	17.8	4.54
26	I	2.55			
27	I	2.55			

Table 12

S. No.	Specimen	Stability (KN)	Avg. Stability (KN)	Flow Value (mm)	Avg. Flow Value (mm)
1	A1	9.23	9.32	2.4	2.44
2	A2	9.21		2.41	
3	A3	9.51		2.52	
4	B	10.81	10.86	2.53	2.54
5	B	10.82		2.54	
6	B	10.96		2.54	
7	C	10.91	10.92	2.64	2.65
8	C	10.93		2.65	
9	C	10.92		2.65	
10	D	8.73	8.82	2.2	2.24
11	D	8.71		2.21	
12	D	9.01		2.32	
13	E	10.31	10.36	2.33	2.34
14	E	10.32		2.34	
15	E	10.46		2.34	
16	F	10.41	10.42	2.44	2.45
17	F	10.43		2.45	
18	F	10.42		2.45	
19	G	6.6	6.5	1.82	1.84
20	G	6.4		1.86	
21	G	6.5		1.84	
22	H	7.2	7.3	2.1	2.2
23	H	7.3		2.2	
24	H	7.4		2.3	
25	I	7.8	7.9	2.5	2.5
26	I	7.9		2.6	
27	I	8		2.4	

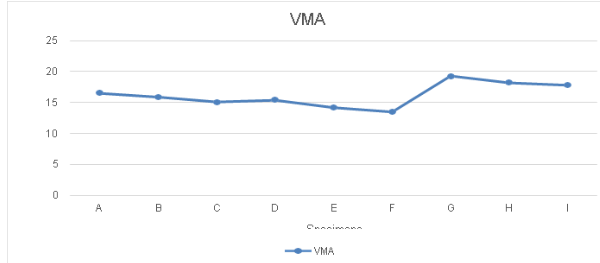

Fig. 1. Graphical representation of Specimen v/s VMA

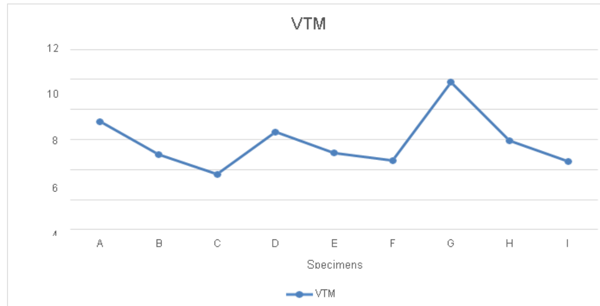

Fig. 2. Graphical representation of Specimen v/s VTM

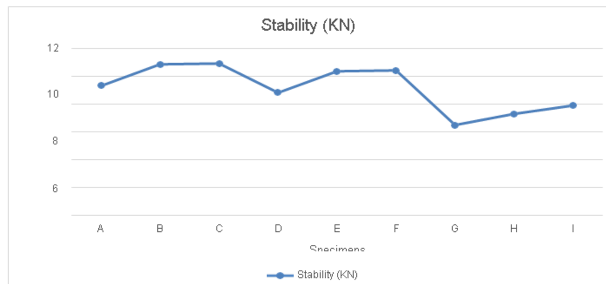

Fig. 3. Graphical representation of Specimen v/s Stability

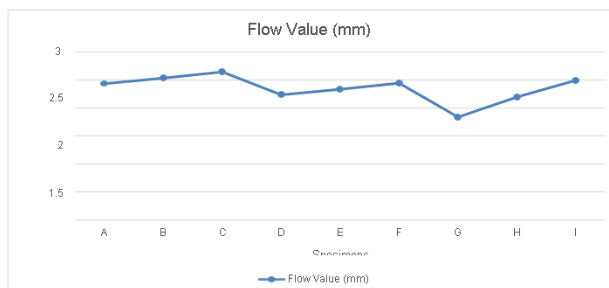

Fig. 4. Graphical representation of Specimen v/s Flow Value

4. Conclusions and Scope for Further Work

Following conclusions are found with same outcomes:

- According to graphical representation it is clear that with all three fillers namely, cement, lime and stone dust the flow value is increases as increase percentage of bitumen content.
- Stability value is different for all fillers it is maximum as maximum the percentage of bitumen content in stone dust case but, for cement and lime it is maximum with 5.5 percent of bitumen.
- VMA is minimum in lime after that cement and last high in stone dust as compare to these.
- VTM value is minimum in cement filler.
- As per experimental work we recommend the lime

for filler with its low cast and less bitumen content.

Scope for Further Work:

We have studied the effect of fillers namely Cement, Lime and Stone Dust on Bitumen and the results were encouraging. Various tests related to Bitumen were conducted and the results showed very improvement. In future all the aspects can be studied in great detail and that would prove to be a great success for road pavements.

Studies that can be undertaken:

- To study the improvement techniques for better bitumen usage.
- To study the effect of waste material on road pavements

References

[1] Panda M. and Mazumdar M. (1999), "Engineering Properties of EVA-Modified Bitumen Binder for Paving Mixes", journal of materials in civil engineering, Volume 11, Issue 2, pp. 131-135.

[2] Murphy M., O'Mahony M., Lycett C. and Jamieson I. (2001), "Recycled polymers for use as bitumen modifiers", Journal of materials in civil engineering, Volume 13, pp. 306-314.

[3] Wegan V., Nielsen C. B. (2001), "Microstructure of polymer modified binders in bituminous mixtures", pp. 1-19.

[4] Justo C.E.G. and Veeraragavan A "Utilization of Waste Plastic Bags in Bituminous Mix for Improved Performance of Roads", Centre for Transportation Engineering, Bangalore University, Bangalore, India, 2002.

[5] Airey G. D., Rahimzadeh B. and Collop A. C. (2004), "Linear rheological behavior of bituminous paving materials", Journal of materials in civil engineering, Volume 16, pp. 212-220.

[6] Miro Recasens, Martinez, Perez Jimenez, Bianchetto, "Effect of Filler on the Aging Potential of Asphalt Mixtures" in Transportation Research Record Journal of the Transportation Research Board. 2005.

[7] Awwad M. T. and Shbeeb L (2007), "The use of polyethylene in hot asphalt mixtures", American Journal of Applied Sciences, volume 4, pp. 390-396.

[8] Casey D., McNally C., Gibney A. and Gilchrist M. D. (2008), "Development of a recycled polymer modified binder for use in stone mastic asphalt", Journal of Resources, Conservation and Recycling, Volume 52, pp. 1167–1174.

[9] Fernandes M. R. S., Forte M. M. C. and Leite L. F. M. (2008), "Rheological evaluation of polymer-modified asphalt binders", Journal of Materials Research,

[10] Al-Hadidy A.I. and Yi-qiu T. (2009), "Effect of polyethylene on life of flexible pavements", Journal of Construction and Building Materials, volume 23, pp. 1456–1464.

[11] Bindu C.S., Beena K.S. (2010), "Waste plastic as a stabilizing additive in SMA", International Journal of Engineering and Technology, Volume 2, pp. 379-387.

[12] Sadq Abd Tayh and Aqeel Raheem Jabr, "The Effect of Filler Type on the Hot Mix Asphalt behavior" in Engg., & Tech Journal, Vol. 29, No. 9., 2011.

[13] Afifa Rahman, Syed Ashik Ali, Sajal Kumar Adhikary and Quazi Sazzad Hossain, "Effect of Fillers On Bituminous Paving Mixes," in Journal of Engineering Science 03(1),121-127, 2012.

[14] Saeid Hesami, Hossein Roshani, Gholam Hossein Hamedi, Alireza Azarhoosh, "Evaluate the mechanism of the effect of hydrated lime on moisture damage of warm mix asphalt," in 2013.

[15] V.Mouillet, D. Séjourné, V. Delmotte, H.-J. Ritter, D. Lesueur, "Method of quantification of hydrated lime in asphalt mixtures" in 2014.

[16] Dipu Sutradhar, Mintu Miah, Golam Jilany Chowdhury, Mohd. Abdus Sobhan, "Effect of Using Waste Material as Filler in Bituminous Mix Design". American Journal of Civil Engineering. Vol. 3, No. 3, 2015, pp. 88-94.

[17] Somnath Singh, and A. K. Mishra, "Utilization of Copper Slag and Stone Dust in Bituminous Pavement with Hydrated Lime as Filler Material" in International Journal of Advance Research and Engineering, Vol. 5, no. 6, April 2016.

[18] Niraj Bohara, Gautam Bir Singh Tamrakar, "A Study of Effect of Filler Contents and Filler Types in Marshall Stability and Flow Value in Asphalt Concrete" Vol: 5, ISSN:2350- 8914, 2017.

[19] Praveen kumar P, "Quarry Dust as a filler material in bituminous concrete", IOP Conf. Ser.: Mater. Sci. Eng., 2018.

[20] Ayush Kant Gupta,Neeraj Kumar, "Experimental Study on Use of Waste Polyethylene in Bituminous Paving Mixes" in International Journal in Applied Science& Technology, vol. 7, Issue 3, March 2019.

[21] "Standard test method for Marshall stability and flow of bituminous mixtures". Technical report, ASTM-D6927,2006.

[22] "Standard practice for preparation of bituminous specimens using Marshall Apparatus". Technical report, ASTM-D6926, 2010.

[23] ASTM D 1559, "Test method for resistance of plastic flow of bituminous mixtures using Marshall Apparatus", American society for testing and materials.

[24] ASTM D 792-08, "Standard test methods for density and specific gravity of plastic by displacement", American society for testing and materials.

[25] ASTM D882–12, "Standard test method for tensile properties of thin plastic sheet", American society for testing and materials.

[26] IS: 1203 (1978), "Methods for testing tar and bituminous materials: determination of penetration", Bureau of Indian Standards, New Delhi.

[27] IS: 1205 (1978), "Methods for testing tar and bituminous materials: determination of softening point", Bureau of Indian Standards, New Delhi.

[28] IS: 2386 (1963), "Methods of test for aggregates for concrete (P-I): Particle size and shape", Bureau of Indian Standards, New Delhi.

[29] IS: 2386 (1963), "Methods of test for aggregates for concrete (P-III): Specific Gravity, Density, Voids, Absorption, Bulking", Bureau of Indian Standards, New Delhi.

[30] Khanna S K, Justo C E G and Veeraragavan A (2000). "Highway Material and Pavement Testing (Labouratory Manual)", Nemchand and Bros, Roorkee 2000.

[31] Ministry of Road Transport and Highways (2001). "Specifications for road and bridge works" Fourth Revision, Published by Indian Road Congress on behalf of the Government of India.

[32] IS: 1203 (1978), "Methods for testing tar and bituminous materials: determination of penetration", Bureau of Indian Standards, New Delhi.

[33] IS: 1205 (1978), "Methods for testing tar and bituminous materials: determination of softening point", Bureau of Indian Standards, New Delhi.

[34] IS: 2386 (1963), "Methods of test for aggregates for concrete (P - I): Particle size and shape", Bureau of Indian Standards, New Delhi.

[35] IS: 2386 (1963), "Methods of test for aggregates for concrete (P-III): Specific Gravity, Density, Voids, Absorption, Bulking", Bureau of Indian Standards, New Delhi.

[36] Khanna S K, Justo C E G and Veeraragavan A (2000). "Highway Material and Pavement Testing (Labouratory Manual)", Nemchand and Bros, Roorkee 2000.

[37] Ministry of Road Transport and Highways (2001). "Specifications for road and bridge works" Fourth Revision, Published by Indian Road Congress on behalf of the Government of India.