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EVALUATION OF MECHANICAL PROPERTIES OF HOT MIX ASPHALT BY REPLACING THE COMBINATION OF MARBLE DUST AND SILICA FUME AS A FILLER

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ABSTRACT

Flexible pavement consists of admissible proportion of minerals fillers in the upper layer, which is the ongoing development in the asphalt concrete design. The filler used, contributes the mix cohesion, enhance serviceability and resistance to rutting. The role of mineral filler's importance is well acknowledging in the properties of hot mix asphalt mixtures. The effects of fillers on the properties of hot mix asphalt is decisive to proper mix design of better performance of hot mix asphalt mixtures. This research presents a laboratory investigation into the effects of different fillers on some properties of (HMA) mixtures. Two filler types (silica fume, marble dust) were used to investigate the effect of filler / asphalt ratio on the characteristics of (HMA) mixtures. In this research two different percentages of marble dust and silica fume in combination were used and compared their properties with the conventional asphalt.

KEYWORDS: Machanical Properties, Hot Mix Asphalts (HMA), Silica Fume, Marble Dust, Filler,

INTRODUCTION:

Marble dust and silica fume both are the byproducts in large amount in factories. These byproducts produced in the factories are stored outside or dumped in the open environment or with road side. It has a very bad effect on the environment. If these waste products are utilized in hot mixed asphalt (HMA) in suitable proportion, it not only enhances the desired properties of HMA but is also economic and environmental friendly.
As the high strength required for today's traffic density which is not affordable by normal paved surfaces There is an exaggeration in the pressure of truck tires, vehicle axel load and traffic densities, have seen in most of the countries. Increase in the pressure of truck tires, vehicle axel load describes that the exposure of upper most pavement road surface has higher stresses. These higher stresses are caused by heavy traffic volumes, overloaded vehicles, changes in daily and seasonal environmental temperature which mostly cause pavement road failures like undulation, bleeding, rutting etc. By using different of materials like different fillers in percentages showed increase in the life of wearing course depending upon various proportion used.
We are also concerned with some environmental problems these days like air pollution respiratory diseases, skin and eye issues due to marble dust produced in marble factory. These dusts or marble slurry flows through the water into a river or sea which is also harmful for aquatic life.

FILLER:

It is that component of bituminous concrete which fills the voids or open spaces among the aggregates and binder in a pavement. It helps in the densification of the bituminous concrete. It modifies the quality of conventional asphalt. Nowadays it has become a very useful and environment friendly component of the hot mixed asphalt (HMA). Normally used filler is stone dusts.
There are many types of mineral wastes (Filler) including granite dusts, stone dusts, fly ash, marble dusts, silica fume or micro silica etc. But we are interested here in using silica fume and marble dusts both in combination as a filler.

SILICA FUME AND MARBLE DUST:

Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive Pozzolan. Concrete containing silica fume can have very high strength. It is a component of lime stone and produced as a byproduct in marble cutting units during sawing and cutting the marble.

LITERATURE REVIEW

In stone industry there are granite and marble dust are easily available as a waste and fly ash obtained from thermal power plants in high amount of quantities. Researchers are now looking to increase the fatigue life, so for that purpose they are working on various materials like Marble dust and Fly Ash etc. Marble dust is byproduct and waste material, which aid to the severe environmental problem. Fillers are used to modify the properties of hot mix asphalt (HMA). Inclusion of modifiers to asphalt could increase the viscosity of the binder, and reduce its thermal susceptibility of the binder, and increase the cohesion of the asphalt cement [1].

Mix with marble dusts have almost 40% more life in rutting than conventional bituminous concrete where stone dust is used as filler.
The fatigue life of a mix with marble dust is 50-70% higher than that of a mix with conventional stone dust
[2] The important commercial materials such as Silica fumes is used to enhance the overall properties of asphalts cements and asphalt mixtures. The use of Silica fume as a material is very easy and it can easily mix with asphalt cement because of its too fine properties and also have good effect to reduce the temperature of asphalt cement. The Silica fume have minor effect to decrease the stiffness modulus [3].
On the other side, the Silica fume have minor effect to decrease the stiffness modulus [4].
It the asphalt content of 4.4%, enhancement in the fatigue life can be observe by using Silica fume by 50% to that of conventional mix. Under the fatigue of long term aging the fatigue life had increased by 96% for modified asphalt concrete with silica fume to that conventional mix [5].

Among the three industrial wastes (Marble dust, Granite, fly Ash), Marble dust is the most promising filler and will prove to be very economical also, as mixes with marble dust have the lowest optimum binder content.
(OBC). DOI: 10.1061/ (ASCE) MT.1943-5553.0000730. ©2013 American Society of Civil Engineers [6].

OBJECTIVES

To study the strength evaluation of flexible pavements by using the combination of two different types of mineral wastes as filler in hot mix asphalt (HMA) which are not used in combination as filler till now.
By doing this we should be capable of obtaining higher stability and durability of flexible pavements which are desirable in modern era. Fatigue life and aging can be extended and also rutting can be reduced through use of these fillers in HMA.

METHODOLOGY:

SPECIMENS PREPARATION

Marshall mix design is used to prepare different specimens. Marshall method is one of the conventional techniques for the design of asphalt mixes and adopted world widely. The proportion of mineral aggregate and bitumen is found by following the procedure AASHTO T-245. Specimens are prepared by mixing the materials followed the mentioned procedure and then compacted the mix by giving 75 blows on either side. Following is the marshal mix design procedure which is sequent shown in the figures below and followed through all over the research work.

Figure: 1 placing of aggregate for 1hr at 160^{o}C

Figure: 2 weighing of required material for single mould

Figure: 3 extractions of mould after preparation and cooled at room temperature

Figure: 4 moulds are kept at 60^{o}C for 1 hr.

Figure: 5 moulds are tested to find flow & stability

MATERIALS

The materials used in this research work are bitumen, aggregates, fillers (marble dust, silica fume).

BITUMEN

Bitumen is a black or dark colored viscous cementitious substance consists chiefly of high molecular weight hydrocarbons derived from distillation of petroleum or natural asphalt. Bituminous materials are extensively used for roadway construction because of: Excellent binding characteristics, Water proofing properties, Relatively low cost.

AGGREGATE AND FILLER

Aggregates constitute a major portion of HMA towards load bearing as compared to other mixture materials. Aggregates are present in mixture 91-96% in respect to mass and 76-86% with respect to area. In bituminous mixes combination of filler is basically used as filler to complement other components present in mix. Filler is that portion which passes on sieve # 200. The fillers used in this research work are, marble dust and silica fumes

Figure: 6 Coarse aggregates samples (Margala)

Figure 7 silica fume as a filler

Figure 8 marble dust as a filler

RESULTS:

TESTS ON MATERIALS:

TEST ON BITUMEN

1. **PENETRATION TEST**

Table 1: observed penetration values

S.No	Test 1	Test 2	Test 3	Mean
Penetration value	66	64	68	66

This test was performed according to the AASHTO T-49 Penetration Value = 66, Grade = 60-70

2. **SOFTENING POINT OF BITUMEN**

Table 2: observed temperature

S.No.	Ball 1	Ball2	Average
Temperature at which the balls touch the bottom	40^{o}C	42^{o}C	41^{o}C

This test was performed according to AASHTO T-53 Softening point of the bituminous material is 41^{o}C

TESTS ON AGGREGATES

1. **COATING AND STRIPPING TEST**

This test was performed according to the procedure described by AASHTO T-182
Description of sample of Asphalt wearing course, Size of aggregate sample 3/8" to ¼", Bitumen Penetration Grade: 60-70, Curing period at 25 ^{0}C for 24 hrs.

Table 3: observation for coating and stripping value

Weight of material	= 100 gm
Bitumen content	= 5.5 gm
Water immersion at 25^{o}C	= 18 hrs.
Visual inspection coated area	= 100%
Specification	= Estimated coated Area (Above 97%)

2. LOS-ANGELES ABRASION TEST

This test was performed according to procedure by AASHTO T-96
Material: coarse aggregate for asphalt
No. of cycles: 500, No. of balls: 11

Table 4: Los-Angeles abrasion observations

Passing of sieve size	Retained Sieve Size	Weight (Grams)
1;1/2	1	
1	¾	2500
¾	½	2500
½	3/8	
Initial weight (Kgs) A	5000	5000
Wt. retained after test on No.12 ASTM sieve (Kgs) B	3789	3745
% of wear by weight passing No.12 Sieve (A-B)/A*100	24.2%	25.1%

Figure:9 Los-Angeles abrasion drum

3. GRADATION OF AGGREGATES

The aggregates used to make the bituminous concrete sample should be selected in accordance with the specified gradation.

Table 5: Gradation of aggregates

SIEVE SIZES(mm)	CUMMULATIVE %AGE PASSING	LOWER LIMITS	UPPER LIMITS	LOWER LIMITS (jmf)	UPPER LIMITS (jmf)
19.4	100	100	100	100	100
12.5	83.3	75	90	76	90
9.5	71	60	80	63.3	77.3
4.75	50	40	60	45	53
2.36	30.2	20	40	28	36
1.18	11	5	15	6.7	14.7
0.075	4.7	3	8	3.6	5.6

Figure: 10, Sieve analysis of coarse aggregates

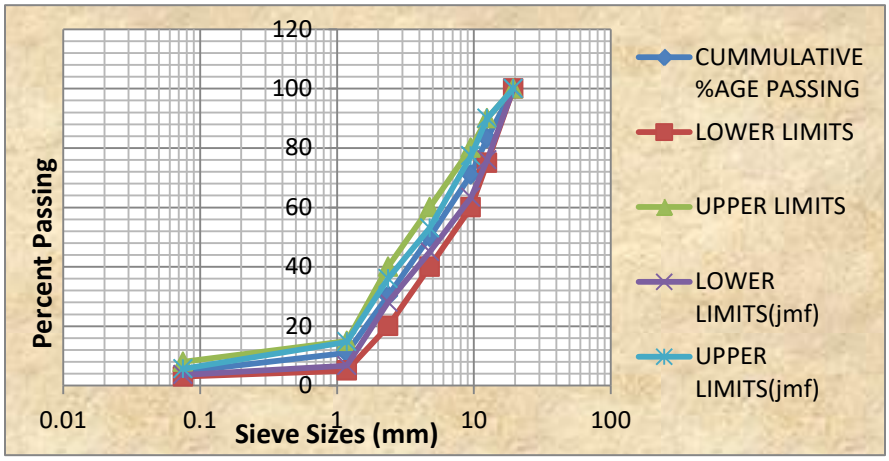

Figure: 11, Job mix formula curves

The moulds of different percentages of filler in combination are used, results are obtained which all are shown in their respective tables. Following are the filler percentages used in the research work

1. **50% marble dust and 50% silica fume**
2. **70% marble dust and 30% silica fume**

1. 50% MARBLE DUST AND 50% SILICA FUME USED IN COMBINATION

Specimens are prepared by using the mentioned percentages of the filler followed the procedure used for preparing conventional asphalt. Different properties, specification and results are shown in the table 6.

Table 6: 50% marble dust & 50% silica fume

Bulk specific gravity Marshal Stability and Flow test of compacted bituminous mixture CRD C-649								
Location:	Peshawar			**Material:**		Silica fume / Marble dust		
Type:	Wearing Course			**Mix %**		50 / 50		
Compacted specimen	Specimen No.	1	2	3	**Average (Gmb)**			
	Mass of Dry specimen in Air(gm)	1347.5	1228.1	1196.8				
	Mass of specimen in water(gm)	770.5	704.8	689.5				
	Mass of S.S.D specimen (gm)	1352.4	1240.6	1202.4				
	Volume Cubic Centimeter	581.9	535.8	512.9	**2.314**			
	Bulk Sp. Gr. (Gmb)	2.316	2.292	2.333				
	Asphalt % by WT of Mix (Pb)	**4.20**			%age of Agg(Ps) 95.8		Bulk Sp.gravity of Agg (Gsb)	2.670
	Effective Sp. Gr. Of Agg. (Gse)	2.6					Correction Ratio	Volume Cm^3
	Max. theoretical sp. Gr (Gmm)	2.483			**Specification**		1.25	444-456
Voids	V.M.A=100-(Gmb x Ps)/Gsb	17			Min : 12.0		1.19	457-470
	Air Voids= 100x(Gmm-Gmb)Gmm	**6.8**			4-7		1.14	471-482
	V.F.A=100(VMA-Va)/VMA	60			65-75		1.09	483-495
Stability (Kg)	**STABILITY AFTER**	**30 MINUTES**					1.04	496-508
	Dial Reading	780	850	890			1.00	509-522
	Ring Factor	**2.440**					0.96	523-535
	Volume Correction Factor	0.83	0.96	1.00			0.93	536-546
	Adjusted Stability Kg	1579.7	1991.0	2171.0			0.89	547-559
	Adjusted Stability Kg	**1914.1**					0.96	560-573
Flow	Flow(mm) / Average	**13.5**			7-11 mm		0.83	574-585

2. 70% MARBLE DUST AND 30% SILICA FUME USED IN COMBINATION

Following the above procedure here using the mentioned percentages. All results are shown in the table 7
.

Table 7: 30% marble dust & 70% silica fume

Bulk specific gravity Marshal Stability and Flow test of compacted bituminous mixture CRD C-649							
Location:	Peshawar			**Material:**		Silica fume / Marble dust	
Type:	Wearing Course			**Mix %**		70 / 30	
Compacted specimen	Specimen No.	1	2	3			
	Mass of Dry specimen in Air(gm)	1208.0	1234.6	1188.2	**Average (Gmb)**		
	Mass of specimen in water(gm)	690.0	700.2	670.2			
	Mass of S.S.D specimen (gm)	1215.8	1248.7	1199.3	**2.265**		
	Volume Cubic Centimeter	525.8	548.5	529.1			
	Bulk Sp. Gr. (Gmb)	2.297	2.251	2.246			
	Asphalt % by WT of Mix (Pb)	**4.20**	%age og Agg(		%age of Agg(Ps) 95.8	Bulk Sp.gravity of Agg(Gsb)	2.670
	Effective Sp. Gr. Of Agg. (Gse)	2.7				Correction Ratio	Volume Cm^3
	Max. theoretical sp. Gr (Gmm)	2.487			**Specification**	1.25	444-456
Voids %	V.M.A=100-(Gmb x Ps)/Gsb	19			Min: 12.0	1.19	457-470
	Air voids= 100x(Gmm-Gmb)Gmm	**8.9**			4-7	1.14	471-482
	V.F.A=100(VMA-Va)/VMA	52			65-75	1.09	483-495
Stability (Kg)	**STABILITY AFTER**	**30 MINUTES**				1.04	496-508
	Dial Reading	410	310	490		1.00	509-522 523-535
	Ring Factor (Average)	**2.440**				0.96	
	Volume Correction Factor	0.96	0.89	0.96		0.93	536-546
	Adjusted Stability Kg	960.4	673.2	1147.8		0.89	547-559
	Adjusted Stability Kg	927.1				0.86	560-573
Flow	Flow (mm) / Average	**8.9**			7-11 mm	0.83	574-585

STABILITY, FLOW RATE AND PERCENT AIR VOIDS RESULTS

Results obtained from using different percentages have no sufficient effects on the hot mix asphalt (HMA) except the mix design with 50% marble dust and 50% silica fume which has a greater stability and %voids are somewhat at the verge of the limits, but high flow. The following graphs show the comparison of different properties among the different percentages used in the HMA.

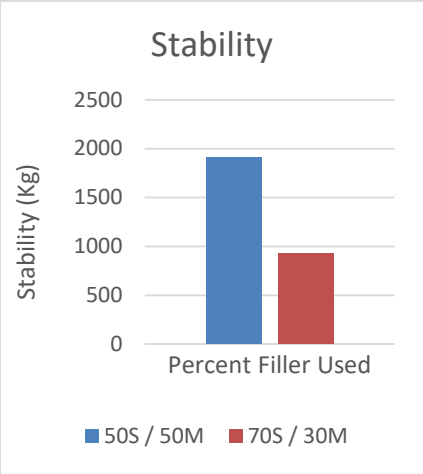

Figure: 12 Comparison of stability results Figure: 13 Comparison of flow values Figure: 14 Comparison of percent air voids

The figure 12 described that by using 50% Silica fume and 50% Marble dust as a filler, the stability value is 1914.1 Kg while by using 70% Silica fume and 30% Marble dust as a filler, the stability value is 927.1 Kg. The figure 13 shows that by using 50% Silica fume and 50% Marble dust as a filler, the Flow rate is 13.5 mm while by using 70% Silica fume and 30% Marble dust as a filler, the Flow rate is 8.9 mm. The figure 14 shows that by using 50% Silica fume and 50% Marble dust as a filler, the percent Air voids is 6.8% while by using 70% Silica fume and 30% Marble dust as a filler, the percent Air voids is 8.9%.

CONCLUSIONS

As the mix with 50% silica fume and 50% marble dust has greater stability than all the other percentages used in a marshal mix. It has also voids 6.8 which is in range i.e. range is 4~7. All other air voids results are out of range. All other percentages have lower stability and voids which are out of range as shown in the graph. Mix having 50% silica & 50% marble dust has only flow of 13.5mm which is greater than all other percentages which is not good and max. allowable flow is 11mm.

RECOMMENDATIONS

Stability of the mix with 50% marble dust and 50% silica fume is greater than all other mixes and conventional asphalt also. So this combination shows the greater engineering properties than all others. It will not be bad to use this percentage for future research work. The flow value of the mix having 50% silica and 50% marble dust is greater than all the other mixes and also greater the limited value. So, this is not the big issue and flow can be controlled if polymer modified bitumen is used instead of conventional bitumen.

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References

[1] SARSAM, S. I., & IBRAHIM, S. W. (2008). Contribution of liquid asphalt in shear strength and rebound consolidation behaviour of gypseous soil. Engineering and Technology Journal, 26(4), 484-495.
[2] Rajan Choudhary, Satish Chandra "GRANITE AND MARBLE DUSTS AS FILLER IN ASPHALT CONCRETE" Department of Civil Engineering Indian Institute of Technology Roorkee
[3] Sarsam, S. I., & AL-Zubaidi, I. (2014). Resistance to deformation under repeated loading of aged and recycled sustainable pavement. American Journal of Civil and Structural Engineering, 1(2), 34-39.
[4] Sarsam, S. (2013). Improving Asphalt Cement Properties by Digestion with Nano Materials. Research and Application of Material Journal,(RAM), 1(6), 61-64.
[5] Sarsam, S. I., & AL-Lamy, A. K. (2015). Fatigue life assessment of modified asphalt concrete. International Journal of Scientific Research in Knowledge, 3(2), 30.
[6] Strategic Highway Research Program. (1992). "FATIGUE LIFE OF BITUMINOUS MIXES" National Research Council, Washington ,DC
[7] Sarsam, S. I., & Al-Zubaidi, I. L. (2014). Assessing tensile and shear properties of aged and recycled sustainable pavement. International Journal of Scientific Research in Knowledge, 2(9), 444.