EFFECT OF GLASS POWDER AND LIME AS FILLER IN BITUMINOUS MIX: AN EXPERIMENTAL STUDY

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***Abstract*: The use of waste materials in road construction can reduce the difficulties in disposal of wastes. In current study, the feasibility of improving the properties of bituminous concrete (BC) mix with waste glass as filler in place of conventional costly fillers like lime and cement was studied. BC mixes were prepared at OBC with two different fillers namely lime and glass powder at four different dosages (10%, 20% 30%, & 40%). The marshall and volumetric properties of these samples were investigated and compared. BC mixes with glass powder displayed nearly same properties as those of BC mixes with conventional fillers. Also, at the optimum dosage of 5.5% glass modified BC mixes displayed higher stability density and lower flow values as compared to normal BC mixes with quarry dust alone as filler thus glass powder waste from industries Can be safely disposed by using as an alternative for conventional fillers to produce more stable and durable bituminous paving mixes.**

Index Terms: BC mix, Glass waste, Marshall Mix design, OBC, Optimum dosage.

I. 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. Various materials such as cement, lime, granite powder, stone dust, glass powder and fines sand are normally used as filler in bituminous mixes. Cement, lime and granite powder are expensive and used for other purposes more effectively. Fine sand, ash, waste concrete dust glass powder brick dust finer than 0.075mm sieve size appears 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 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 asphalt cement to change the properties of the mastic. 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 effects of these fillers are also dependent on gradations.

BITUMEN (VG 30 GRADES):

Viscosity Grade Bitumen (Asphalt) is a standard grade Bitumen usually used as a Paving Grade Bitumen suitable for road construction and for the production of asphalt pavements with superior properties. This grade of Bitumen is mainly used in the manufacture of hot mix asphalt for bases and wearing courses and possesses characteristics and qualities unique sand quite different from other agents. They achieve very flexible and tenacious connections with other materials due mainly to viscoelastic response of bitumen, which behavior depends on how fast charges are applied.

II. OBJECTIVES OF THE PRESENT STUDY:

- To determine the properties of aggregate and assess the test results as per MORT&H specification.
- To determine the properties of viscosity grade bitumen [VG 30] and assess the test result as per IRC SP: 53-2010 requirements.
- To determine the optimum bitumen content of Bituminous Concrete Mix prepared using Glass powder (10%, 20%, 30% and 40%) and lime (2%) as fillers by Marshall Method of mix design.
- To determine the Marshall Properties of Bituminous Concrete Mix prepared using Glass powder (10%, 20%, 30% and 40%) and Lime (2%) as fillers at optimum bitumen content.

III. LITERATURE REVIEW

EFFECT OF USING WASTE CEMENT DUST AS MINERAL FILLERON THE MECHANICAL PROPERTIES OF HOT MIX ASPHALT: In this study, by pass cement dust is proposed within this research as an alternative to traditional limestone mineral filler in hot mix asphalt (HMA). The effect of using waste cement dust as mineral filler on the mechanical properties of hot mix

asphalt was investigated. The optimum cement dust content was determined. The studied mechanical properties include Marshall Properties, indirect tensile strength, and unconfined compressive strength. Five asphalt concrete mixtures with various cement dust contents, namely: 0%, 25%, 50%, 75% and 100% by weight ofthe limestone mineral filler were studied. Laboratory testing has revealed an enhancement is Marshall and mechanical properties of asphalt concrete mixtures when cement dust was used. Marshall testing results have indicated an increase in the stability, unit weight and a decrease inthe flow, voids ratio and voids in mineral aggregates when the percentage of cement dust content increases. The indirect tensile strength and unconfined compressive strength have also increased as the ratio of cement dust increased. The optimum cement dust ratio was found to be 100% of theused mineral filler. Hence, cement dust can totally replace lime stone mineral filler in asphalt paying mixtures.

EFFECT OF MINERAL FILLER TYPE AND CONTENT ON PROPERTIES OF ASPHALT CONCRETE MIXES: In the present study, some of the newly constructed highway pavements in Iraq have shown premature failures with consequential negative impacts on both roadway safety and economy Major types of these failures are permanent deformation (rutting) and cracking. Fillers were suspected to be a major contributor to these failures. The objective of this study is to evaluate the influence of new different fillers extracted from different local sources on the performance of asphalt mixtures. The effect of filler type and content on the failures potential of asphalt concrete as well as other mixes properties was investigated. A detailed laboratory study is carried out by preparing asphalt mixtures specimens using aggregate from Al-Taji quarry, (40 - 50) grade asphalt from dourah refinery and three different types of fillers (Portland cement, Silica fume, and Fly ash) were tested in the laboratory. Marshal Mix design was made using all types of fillers and different ratios to evaluate the performance of different types and filler quantities in the asphalt mixture. The mechanical properties of mixes were studied using indirect tensile strength, creep and marshal tests. Three different tests temperature (15, 30, 45℃) were employed in the indirect tensile test to investigate the susceptibility of these mixes to change in temperature.

INFLUENCE OF FLY-ASH AS A FILLER IN BITUMINOUS MIXES: In the present investigation, it is described about that a bituminous paving mixture is a mixture of coarse aggregate, fine aggregate and bitumen mixed in suitable proportion to result strong and durable mix to withstand traffic load. In this paving mix, normally cement and stone dust are used as filler material. A study has been carried out in this study to explore the use of fly ash, a byproduct of a coal based thermal power plant in bituminous paving mixes. For comparison, control mixes with cement and stone dust have also been considered. Marshall Test has been considered for the purpose of mix design as well as evaluation of paving mixes. Other performance tests such as indirect tensile strength and retained stability have also been carried out.

It is observed that the mixes with fly ash as filler exhibit marginally inferior properties compared to control mixes and satisfy desired criteria specified by a much higher margin. Hence, it has recommended to utilize fly ash wherever available, not only reducing the cost of execution, but also partly solve the fly ash utilization and disposal problems.

INFLUENCE OF MINERAL FILLERS ON THE PROPERTIES OF HOT MIX ASPHALT:

While considering the dynamic creep properties for 1.5% addition of hydrated lime by the total weight of the mix, the stiffness modulus value increased by 41.5% when compared with the base mix, while by the addition of phosphor gypasum and fly ash by the same amount increased by 5.2% and 4.7% respectively. For the Indirect Tensile Stiffness Modulus test, when compared with the base mix, for 1.5% hydrated lime addition by the total weight of the mix, the indirect stiffness modulus value increased by 103.6%, while by the addition of phosphor gypsum and fly ash in the same amount increased the indirect stiffness values by 16.9% and 11.4% respectively. The dynamic modulus value, when compared with the base mix, for 1.5% hydrated lime addition by the total weight of the mix, the dynamic modulus value increased by 35% , while by the addition of phosphor gypsum and fly ash in the same amount increased the dynamic modulus values by 8.2% and 4.3% respectively. The most advantageous filler among the three investigated fillers is hydrated lime, and the optimum content of hydrated lime is 1.5% by the total weight of the mix.

IV. EXPERIMENTAL INVESTIGATION

1. AGGREGATES: The coarse aggregates shall consist of clean, hard, durable, crushed rock free of disintegratedpieces, organic and other deleterious matter. Aggregate mainly consisting of both coarse andfine aggregates. The coarse aggregate is the fraction of the aggregate components retained on a 2.36mm test sieve. Fine aggregate is the fraction of the aggregate components passing the 2.36mm test sieve and retained on 0.075mm test sieve. Basic engineering tests are conducted on aggregates used in this study and the properties of aggregates are given in

Table 1.1

Particulars of tests	**Test result**	**Requirement as per table 500-17 of MORT&H (Ⅳ revision) specifications**
Aggregate impact value (%)	22.8%	Max 24%
Los Angeles abrasion value (%)	24.02%	Max 30%
Flakiness and elongation index (combined)(%)	19.76%	Max 30%
Water absorption (%)	0.4%	Max 2%
Aggregate specific gravity		
Material A	2.6	Min 2.5
Material B	2.65	Min 2.5
Material C	2.67	Min 2.5
Material D	2.68	Min 2.5

2. BINDER: Bitumen acts as a binding agent to the aggregates, fines and stabilizers in bituminous mixtures. Binder provides durability to the mix. The characteristics of bitumen which affects the bituminousmixture behavior are temperature susceptibility. Visco-elasticity and aging. The behavior of bitumen depends on temperature as well as on the time of loading. It exhibits both viscous as well as elastic properties at the normal pavement temperature. Though at low temperature it behaves like an elastic material and at high temperatures its behavior is like a viscous fluid. In this study Viscosity grade 30 bitumen (VG 30) is used as binder. The test results satisfy the requirements as per IRC SP: 53-2010. The test results are presented in

Table 1.2

Particular of tests	**Test results**	**Requirement as per IRC-53-2010**
Penetration at 25℃, 100gm, 5 seconds, 0.1mm	67	50-80
Softening point (ring & ball), ℃	63	Min 55
Flash point, ℃	248	Min 220
Fire point, ℃	280	Min 220
Ductility @27℃, cm	100	Min 75
Specific gravity	1.01	Min 0.99

3. FILLER: Mineral filler consists of very fine, inert mineral matter that is added to the bituminous mix, to increase the density and enhance strength of the mixture. These fillers should pass through75 microns IS Sieve. The filler material used in the study is glass powder and lime. It is taken as 1 and 2% by weight of aggregate. The specific gravity test was conducted in the lab and results are presented in

Table 1.3

Filler	**Specific gravity**
Glass powder	2.58
Lime	2.32

4. GRADATION

The aggregate gradation (grading 2) was adopted for bituminous concrete mixes as per MORT&H(Ⅳ Revision) specifications.

Table 1.4

Sieve size(mm)	Material A	Material B	Material C	Material D	Obtained Gradation	Desired gradation asper MoRT&H
19	100	100	100	100	100	100
13.2	63.45	100	100	100	96.7	90-100
9.5	19.25	51.83	100	100	86.4	70-88
4.75	0.75	0.17	25.35	100	59.42	53-71
2.36	0	0.16	1.0	90.9	48.44	42-58
1.18	0	0	0.23	72.1	38.27	34-48
0.6	0	0	0	53.9	28.56	26-38
0.3	0	0	0	38.1	20.19	18-28
0.15	0	0	0	30	15.9	12-20
0.075	0	0	0	9	4.77	4-10

Aggregate gradation for bituminous concrete mix

Table 1.5

Material A (20mm down)	10%
Material B (12.5mm down)	15%
Material C (6mm down)	25%
Material D (4.75mm down)	48%
Material E (filler)	2%

5. MARSHALL METHOD OF MIX DESIGN:

Marshall Stability test of a mix is defined as maximum load carried by a compacted specimen at a standard test temperature at 60 degrees Celsius. The flow value is the deformation the Marshall Test specimen under goes during the loading up to the maximum load in 0,01mm units. The Marshall Stability test is applicable for hot mix design using bitumen and aggregates with maximum size of 25mm. In this method, the resistance to plastic deformation of cylindrical specimen of bituminous mixture is measurement when the same is loaded

There are two major features of Marshall Stability method of designing mixes are
Density voids analysis.
Stability flow test.

Preparation of sample:

- The aggregates were proportioned and mixed as given in table 3.4. (Aggregates and filler contribute to 1200 gm.). The aggregate were heated to a temperature of 160 to 185 ℃.
- Required quantity of Viscosity grade 30 bitumen (VG 30) i.e.5, 5.5, 6.0 and 6.5 percent by weight of aggregate. The heated bitumen was added to the heated aggregates and thoroughly mixed at a desirable temperature 150℃ - 160℃.
- The mix was placed in a pre-heated mould of 10.16 cm diameter and 6.35 cm with base plate and collar.
- After leveling the top surface, the mix was compacted by means of rammer of weight 4.54 kg and with a height of fall 45.7 cm with 75 blows on either side at a temperature of 130℃ - 140℃.
- The compacted specimens were removed from the mould after 24 hours using the specimen Extractor.
- The diameter, mean height, weight in air, weight in water of the specimen was noted and bulk density is calculated.

ANALYSIS OF DATA:

Tests were carried out on bituminous concrete mix (Grading 11) prepared using Viscosity grade30 bitumen (VG 30). The optimum bitumen content was determined by Marshall Method of mix design. Bituminous concrete mix samples are prepared by using different fillers (Glass powder 10% 20% 30% & 40% and lime 2%). Marshall Stability-flow test was performed on prepared bituminous sample**.**

BINDER OPTIMIZATION BY MARSHALL METHOD*:*

In order to determine the optimum binder content for this type of mixture four different percentages of bitumen content are used such as 5.0, 5.5, 6.0, 6.5% respectively by weight of aggregate. The optimum binder content is determined by the ability of a mix to satisfy the mechanical properties and volumetric properties. The data obtained from Marshall Stability-flow test are used to plot the Marshall properties versus Bitumen content, from these plots optimum bitumen contents are determined corresponding to Maximum stability, Maximum Bulk density and air voids in total mix. The optimum bitumen content of the mix is the numerical average of the three values for bitumen contents determined as above.
Marshall Test were conducted on bituminous concrete mix with glass powder (10%, 20%, 30%, 40%) and lime 2% filler to determine optimum bitumen content, Marshall Stability, Flow, bulk density, total air voids, voids in mineral aggregates and voids filled with bitumen. Test results are presented in

Marshall Properties of bituminous concrete mix prepared Using Bitumen (VG 30), Glass powder and lime to find out the optimumbitumen content.

Table 1.6

Bitumen Content (%)	Density(gm/cc)	Stability(kg)	Flow(mm)	Vv (%)	VMA(%)	VFB(%)
5.0	2.34	1224.42	2.57	5.40	16.35	67.00
5.5	2.36	1266.53	3.30	4.09	16.16	74.99
6.0	2.35	1206.52	4.06	4.02	17.05	76.51
6.5	2.34	1020.74	5.16	3.65	17.65	79.40

The graphs are plotted for Marshall Properties of prepared specimen using glass powder and limes are shown below

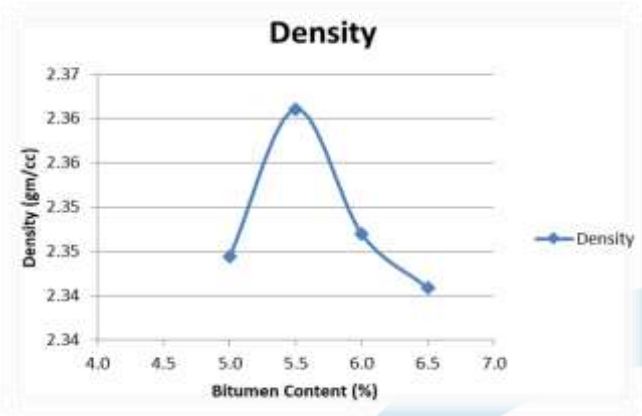

Fig 1.1 Density v/s Bitumen content

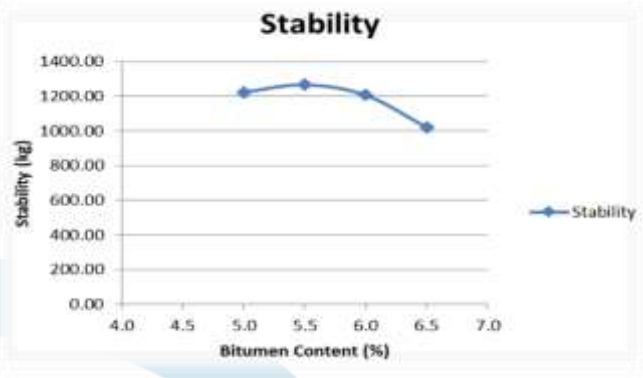

Fig 1.2 Stability v/s Bitumen content

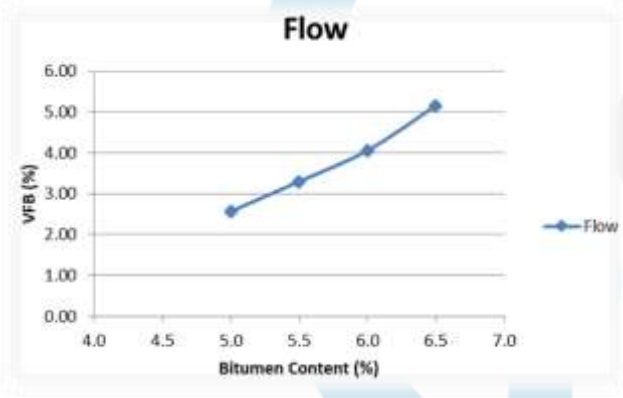

Fig 1.3 Flow v/s Bitumen content

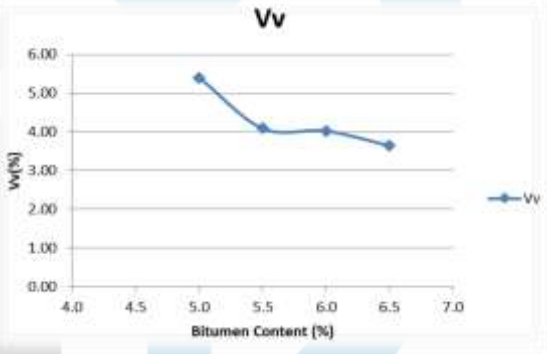

Fig 1.4 Air Voids v/s Bitumen content

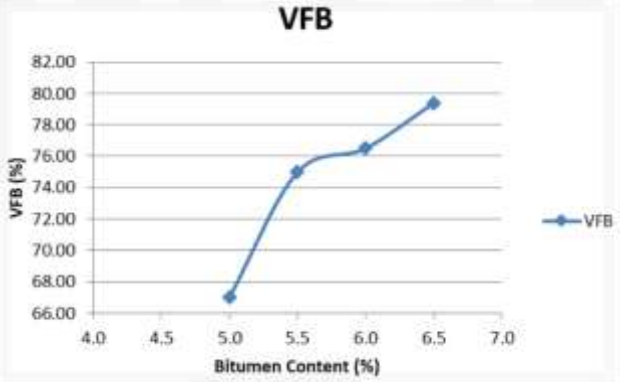

Fig 1.5 Voids filled with Bitumen v/s Bitumen content

OPTIMUM BITUMEN CONTENT = (5.5+5.5+5.5+5.4)/4 =5.5%

Marshall Properties of Bituminous Concrete mix prepared using Bitumen (VG 30), Glass Powder (10%, 20%, 30%&40%) and lime 2% at optimum bitumen content (5.5%):

Table 1.7

% Dosages	Density(gm/cc)	Stability (kg)	Vv (%)	Vb(%)	VMA (%)	VFB (%)	Flow(mm)
0 @OBC 5.5%	2.36	1266.53	4.09	12.07	16.16	74.99	3.3
10 @OBC 5.5%	2.34	995.16	4.76	11.96	16.73	71.54	9.25
20 @OBC 5.5%	2.40	1768.75	2.10	12.28	14.38	85.37	7.87
30 @OBC 5.5%	2.31	1401.43	5.66	11.81	17.48	67.61	6.83
40 @OBC 5.5%	2.26	1293.86	7.67	11.54	19.21	60.45	6.16
Specifications asper MORT&H	-	900kg(min)	3-5%	-	-	65-75	3.5

The graphs are plotted for Marshall Properties of prepared specimen usingBitumen (VG 30), glass powder, and lime at optimum bitumen content (5.5%):

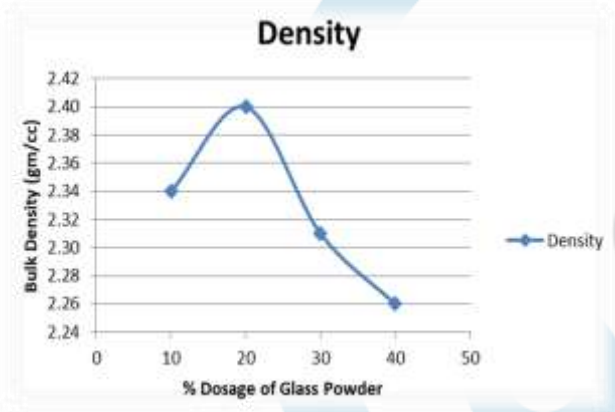

Figure 4.21 Density v/s %Dosage of glass powder

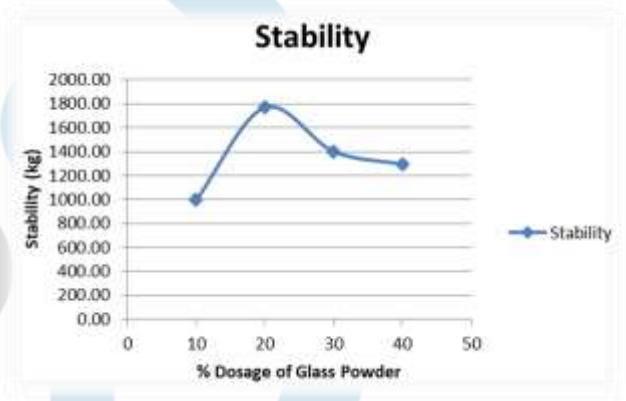

Figure 4.22 Stability v/s %Dosage of glass powder

CONCLUSION:

1. The test results of aggregates are satisfying the requirements as per table 500-8 of MORT&H (IV Revision) specifications.
2. The test results of viscosity grade 30 are satisfying the requirements as per IRC SP-53 2010.
3. Substantial increase in Marshall Stability value of bituminous concrete mix prepared using Glass powder used and lime as filler.
4. Substantial decrease in flow value of bituminous concrete mix prepared using Glass powder and lime.
5. Substantial reduction in the percent air voids value for the specimen prepared using Glass powder and lime.
6. Marginal reduction in VMA value of bituminous concrete mix prepared using Glass powder and lime.
7. Marginal increase in VFB value for the specimen prepared using Glass powder and lime.
8. The bulk density value for bituminous mix at optimum bitumen content with Glass powder and lime is almost same for both cases.
9. Based on experimental work and analysis carried out it can be concluded that the behaviour of bituminous concrete mix prepared using Glass powder and lime is found to be good, hence it can used as filler material in bituminous concrete mix to improve the marshal properties.
10. The above investigation we have found that 20% of replacement of fine aggregate with glass powder is found to be optimum and idealistic.
11. Therefore replacing 20% of glass powder for fine aggregate in any bituminous mixes is suggested.
12. Replacement of glass powder in fine aggregate conserve the resources and availability of natural sand is diminishing glass powder is preferred.

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