Effects of Waste Bone, Fly Ash and GGBS as Modifier for Bitumen in Construction of Asphalt Pavement

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Abstract

Fly Ash, Ground Granulated Blast-furnace Slag (GGBS) and crushed bones are applied as a binder material in order to modify the physical properties of Bitumen. Marshall Test is performed to different mix ratios of cementing materials and observe the variation of several parameters with standard specifications with the aim of determining optimum contents of bitumen content. Outcome of this research, Air Void Value (for mixing ratio of 4% bitumen,10% bones,10% Fly Ash and 10% GGBS maximum air void is 4.929%) of almost all samples are lower than standard value which means it makes the roadway surface more impermeable. As the filler materials are increased, the value of VMA is decreased (for 5.5% bitumen, 10% bones, 10% Fly Ash and 10% GGBS minimum VMA value is 11.25%). The flow values (for 4.5% bitumen,5% bones,10% Fly Ash and 10% GGBS minimum flow value is 2.99) refers to the vertical deformation when the maximum load is reached and derived mainly from internal friction and cohesion.
Keywords: *Cementing, Additives, Waste bones, Fly Ash, GGBS etc*

1. Introduction

To ensure the upkeep of the announcement place to place, financial condition and socio-economic features, the network system plays a vital role that is roadway network. A flexible pavement has dissimilar parts such as wearing course, base, sub base, subgrade. Bitumen is used universally for this wearing surface because of its obligatory and waterproofing superiority. Bitumen is used in wearing surfaces with aggregates which is one of the most dangerous layers. As the wearing surface gets in direct interaction with the vehicle's axle, it must be vulnerable to surviving scratch, wear and tear due to heavy traffic load and also to prevent excessive entrance of water so that the layer beneath the surface is not highly spoiled.
Despite having such recompenses, it also has downsides. The most common problems are various cracking, rutting and formation of potholes etc. The possible solution is to create a maintainable road network. Various experiments are being conducted to modify bitumen to produce long-lasting, temperature acceptable, better waterproofing.
The effect of GGBS on bitumen. They had previously done some work related to this and those suggest that tallying cementing binder such as GGBS may enhance certain properties of bitumen suspension mixtures. The results of their experiments showed that the attachment of GGBS may enhance laboriousness and strength enlargement in high humidity conditions. The effects of GGBS with SBS on the strength properties of bitumen. Modified bitumen and asphalt mixtures are evaluated based on the penetration test, Marshall Stability. This test also showed that using three additives simultaneously has strengthened bitumen mixture properties such as Marshall Strength and uniaxial compression strength.

2. Objectives

To allocate a limited maintenance budget rationally, it is important to know the traffic carried by a particular roadway section in order to decide the importance of the road and fixing its relative priority. Depending on the load carrying capacity of roads, the bitumen mix design changes accordingly. By improving the roadway surface quality, the main objectives of this research are given

- To attain resistance against weathering effects as heat and cold;
- To generate impermeable roadway surface;
- To keep the roadway surface free from cracking or traveling for improving highway performances.

2.1 Materials

Enhance bitumen properties to apply filler like Fly Ash (F), Ground Granulated Blast-furnace Slag, GGBS (G) and crushed bones (B) which are fill voids, reducing optimum bitumen content. Meet aggregate gradation specifications Increase stability Improve the asphalt cement-aggregate bond.

a). Crashing Bone b). Fly Ash c). GGBS d). Mixing ingredients

Figure 1. Filler materials and mixture

Table 1. Penetration value of Bitumen

Bitumen	**Bones (%)**			**GGBS (%)**			**Fly Ash (%)**		
70	5	7.5	10	5	7.5	10	5	7.5	10
	67.35	**65.89**	**63.66**	**65.10**	**64.75**	**64.35**	**63.46**	**62.52**	**61.20**

3. Methodology

The Marshall Test method is conducted for the performance analysis of Bones, GGBS and Fly Ash mix by weight with the standard bituminous mix in the Transportation Lab of Ahsanullah University of Science and Technology. The Marshall Test procedures have been standardized by the American Society for Testing and Materials (ASTM) and published as ASTM D-1559. In this research, medium type design (50 blows per side of the specimen) is used to simulate medium traffic volume and compaction. In this research, there are four variables which are bitumen content, bones content, GGBS content and Fly Ash. All the variables are taken in four proportions to observe the performance within the range. For bitumen, chosen proportions are 4%, 4.5%, 5% and 5.5%. For each batch of bitumen there are three types of those ingredients where two types are always constant and the other one is varied with different percentages. There are 9 specimens built for each batch of bitumen and the total number of specimens are 36 for four batches.

a). Prepared specimens b) Specimens c). Hot water bath d). Marshall Test

Figure 2. Steps of Marshall test

4. Results and discussion

All the test samples are made for medium traffic (for sample compaction, 50 blows per face) specification for Marshall Test and are analyzed for medium traffic. After performing, all the data from the test and the Value of flow, stability are directly obtained from test and air void, Unit weight, VMA, VFB are computed by standard equation The Marshall parameters of the tested specimen are given below;

Table 2: Marshall Test Analysis data obtained from samples

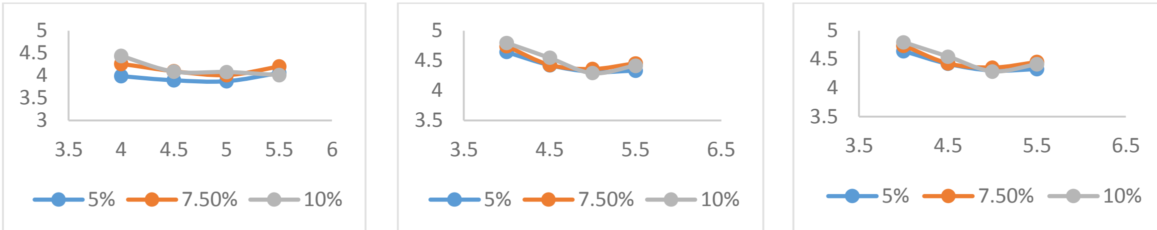
Samples No,	Bitumen Content (%)	Bones (%)	Fly Ash (%)	GGBS (%)	Air Void (%)	Unit Weight (pcf)	VMA (%)	VFB (%)	Stability (kN)	Flow (mm)
1		5			3.987	154.524	11.958	64.057	6.472	3.14
2		7.5	10	10	4.258	154.458	11.563	63.523	6.438	3.18
3		10			4.435	154.328	12.163	62.456	6.389	3.23
4			5		4.641	154.183	12.178	59.751	6.586	3.08
5	4.0	10	7.5	10	4.738	154.092	12.215	58.875	6.845	3.12
6			10		4.795	154.99	12.204	60.452	6.598	3.15
7				5	4.905	154.112	12.108	60.378	6.745	3.1
8		10	10	7.5	4.922	154.218	12.096	61.289	6.845	3.14
9				10	4.929	154.225	12.021	61.556	6.615	3.24
1		5			3.892	155.613	11.267	65.157	6.727	2.99
2		7.5	10	10	4.098	154.849	11.103	64.424	6.737	3.02
3		10			4.088	154.217	11.763	63.312	6.847	3.04
4			5		4.423	154.954	12.013	61.469	6.958	3.05
5	4.5	10	7.5	10	4.429	154.749	12.02	59.994	6.932	3.08
6			10		4.545	155.209	11.956	62.288	6.898	3.12
7				5	4.876	154.622	12.123	61.325	6.923	3.08
8		10	10	7.5	4.912	154.425	12.085	61.836	6.995	3.09
9				10	4.922	155.123	12.007	62.342	6.863	3.15
1		5			3.872	156.45	11.257	65.427	6.333	3.15
2		7.5	10	10	4.011	156.257	11.367	64.715	6.562	3.08
3		10			4.078	155.241	11.512	63.792	6.382	3.14
4			5		4.307	155.936	11.549	63.565	6.835	3.18
5	5.0	10	7.5	10	4.357	156.192	11.403	63.481	6.607	3.11
6			10		4.289	156.128	11.439	64.251	6.584	3.22
7				5	4.178	155.958	11.529	62.785	6.605	3.15
8		10	10	7.5	4.169	156.325	11.319	63.825	6.596	3.14
9				10	4.089	156.389	11.408	63.921	6.612	3.11
1		5			4.058	155.965	11.433	64.504	6.085	3.33
2		7.5	10	10	4.199	154.898	11.471	64.267	6.243	3.42
3	5.5	10			4.011	154.289	11.25	63.689	6.067	3.48
4		10	5		4.331	156.192	11.869	61.829	6.077	3.32
5			7.5	10	4.452	156.32	11.797	62.259	6.311	3.35

6		10		4.413	156.385	11.761	62.479	6.667	3.42
7			5	4.328	155.421	11.759	62.825	6.056	3.32
8	10	10	7.5	4.229	155.429	11.75	62.985	6.296	3.25
9			10	4.189	155.672	11.689	63.008	6.589	3.2

Comparing the maximum and minimum value of all segments which are obtained from this research with their respective standard values. This whole extensive analysis result can be summarized as below

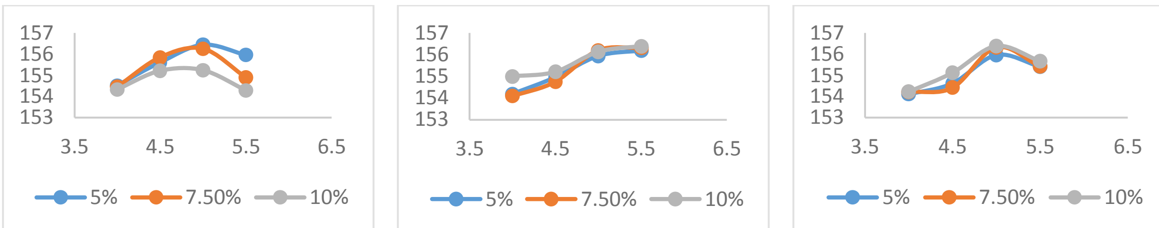
Parameter	Minimum	Maximum	Standard value
Air Void Value (%)	**3.872** 5% bitumen,5% bones,10% Fly Ash and 10% GGBS	**4.929** 4% bitumen,10% bones,10% Fly Ash and 10% GGBS	Maximum **5**
Comments	The Air Void Value of maximum samples are lower than standard value which means it makes the roadway surface more impermeable.		
Unit Weight Value (pcf)	**154.092** 4% bitumen,10% bones,7.5% Fly Ash and 10% GGBS	**156.45** 5% bitumen,5% bones,10% Fly Ash and 10% GGBS	-
Comments	The unit weight of all samples are greater than the unit weight of concrete.		
VMA Value (%)	**11.25** 5.5% bitumen,10% bones,10% Fly Ash and 10% GGBS	**12.215** 4% bitumen,10% bones,7.5% Fly Ash and 10% GGBS	Minimum **17**
Comments	As the filler materials are increased, the value of VMA is decreased.		
VFB Value (%)	**58.875** 4% bitumen,10% bones,7.5% Fly Ash and 10% GGBS	**65.427** 5% bitumen,5% bones,10% Fly Ash and 10% GGBS	Minimum **65**
Comments	The VFB value of maximum samples are close enough to standard one.		
Stability Value (kN)	**6.056** 5.5% bitumen,10% bones,10% Fly Ash and 5% GGBS	**6.995** 4.5% bitumen,10% bones,10% Fly Ash and 7.5% GGBS	Minimum **5.3**
Comments	The stability value is increased which means the resistance capacity of bituminous materials are increased against distortion, displacement, rutting and shearing stresses.		
Flow Value (mm)	**2.99** 4.5% bitumen,5% bones,10% Fly Ash and 10% GGBS	**3.48** 5.5% bitumen,10% bones,10% Fly Ash and 10% GGBS	Maximum **4**
Comments	The flow values refers to the vertical deformation when the maximum load is reached and derived mainly from internal friction and cohesion. Here this value is reduced for all samples.		

Total 18 graphs are plotted for samples using the data from Table 2. The individual parameters against the various percentages of bitumen content for different filler (B, F, G) ratios are plotted where one filler is variable, Others are constant. For the analysis of each sample, except for some points of the demonstrated graph the maximum points are similar to standard one. Six types of graphs are plotted below;



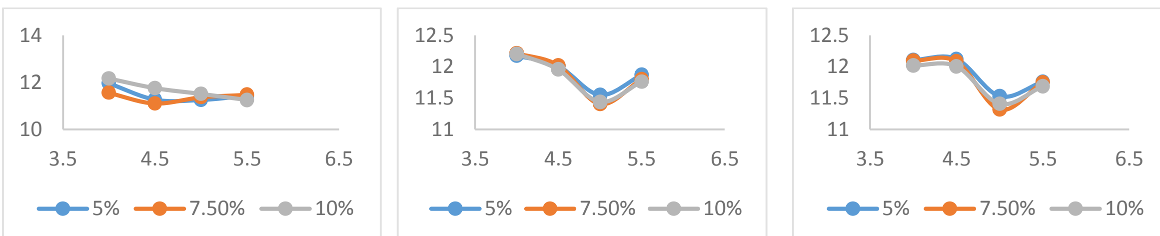
a). B 5%, 7.5%,10%; F, G 10% b). F 5%, 7.5%,10%; B, G 10% c). G 5%, 7.5%,10%; B, F 10%

Figure 3. Bitumen (%) vs Air void (%)



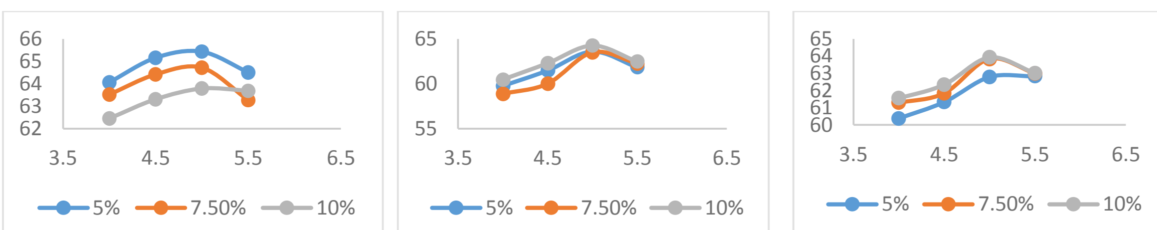
a). B 5%, 7.5%,10%; F, G 10% b). F 5%, 7.5%,10%; B, G 10% c). G 5%, 7.5%,10%; B, F 10%

Figure 4. Bitumen (%) vs Unit weight (pcf)



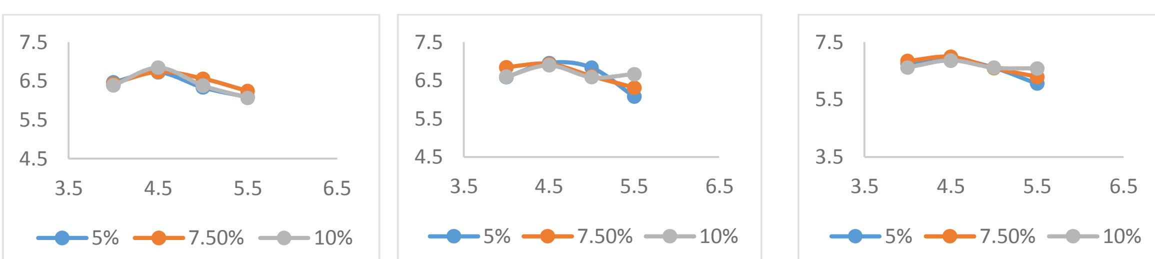
a).B 5%, 7.5%,10%; F, G 10% b).F 5%, 7.5%,10%; B, G 10% c). G 5%, 7.5%,10%; B, F 10%

Figure 5. Bitumen (%) vs Void in Mineral Aggregate (%)



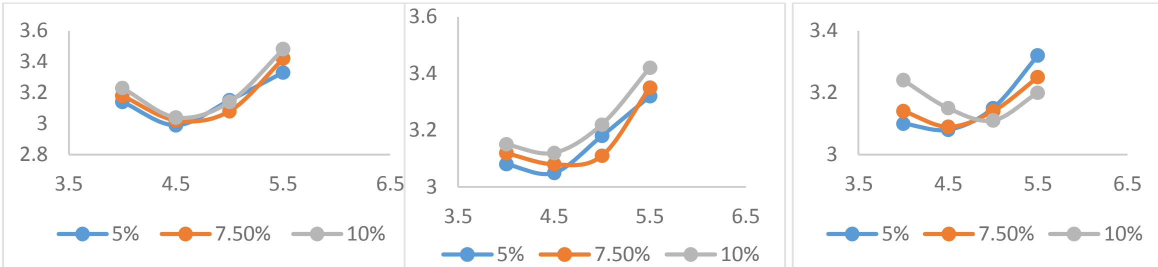
a). B 5%, 7.5%,10%; F, G 10% b). F 5%, 7.5%,10%; B, G 10% c). G 5%, 7.5%,10%; B, F 10%

Figure 6. Bitumen (%) vs Voids Filled with Bitumen (%)



a). B 5%, 7.5%,10%; F, G 10% b). F 5%, 7.5%,10%; B, G 10% c). G 5%, 7.5%,10%; B, F 10%

Figure 7. Bitumen (%) vs Stability (kN)



a). B 5%, 7.5%,10%; F, G 10% b).F 5%,7.5%,10%; B,G 10% c). G 5%, 7.5%,10%; B, F 10%

Figure 8. Bitumen (%) vs Flow value (mm)

5. Conclusion

As the flow value of experimental samples are reduced due to use of filler elements, respective stability values are increased which means the resistance capacity of bituminous materials are more susceptible to distortion, displacement, rutting and shearing stresses. Since filler materials are used, the air void content decreases. The lower air voids, the less permeable the mixer becomes where durability of an asphalt pavement is a function of that air void content.

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