Performance Evaluation of Waste Plastic and Bitumen Concrete mix in Flexible Pavements

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Abstract: Plastics are user friendly but not eco-friendly because they are non biodegradable and generally it is disposed by way of land filling or incineration of materials which are hazardous. The better way of disposal of waste plastic may be using it in molten state for bituminous road. From practical experiences of asphalt binder with polymer additives offer several benefits to enhance various engineering properties many modifiers such as styrene based polymers, polyethylene based polymers, poly chloroprene, Gilsonite and various oils have been used in asphalt. In the present work an attempt has been made to use waste cement bags which are made of Poly-Propylene (PP) using different percentage of Poly-Propylene (PP) in the CRMB-60 grade bitumen.

Keywords: BC Mix, CRMB, Marshall Stability, Polypropylene.

1. Introduction

In India the road transport carries close to 90% of passenger traffic and (70%) of freight transport. Investigations in India and abroad have revealed that properties of bitumen and bitumen mixes can be improved to meet out requirements with addition of certain additives called "Bitumen Modifiers'.

Modified bitumen is expected to give higher life of pavement. The different types of modifiers used are polymers, natural rubber and crumb rubber.

In present study waste Poly Propylene (PP) bags are used with CRMB-60 bitumen which are available in huge quantity as waste material. Different Projects having the Culverts & bridges has been used with percentage of (2%-12%) of Poly-Propylene (PP) waste cement bags with respect to bitumen for B.C. Mix. The strength and stability characteristics are analyzed by Marshall Stability Test. Previously Mr. R. Vasudevan et. al (2007)[0] in his paper studied on the polymer modified bitumen and crumb rubber modified bitumen.

Mohammed T. Awwadet et. al (2007)[0] in his study was determine the best type of polyethylene to be used, two types of polyethylene were added to coat aggregate (HDPE) high density polyethylene and LDPE low density polyethylene. The result shows that grained HDPE polyethylene modifier provides better engineering properties.

Shankar et al (2009), Crumb rubber modified bitumen (CRMB-55) was blended at specified temperatures. Marshall's mix design was carried out by changing the modified bitumen content at constant optimum rubber content. Another study was done by Sharma D.K. and others using 60/70 penetration grade bitumen. Here waste plastic/polymer was used as modifiers.

Another study was carried out by Shivangi Gupta and Veeraragvan they used (60/70) penetration grade bitumen and styrene butadiene styrene (SBS) modified binder.

Generally it is seen that previously nobody has studied on the waste cement bags i.e. PP bags with CRMB and by this study strength and economical aspects are analyzed.

2. Material Characterization

Study involves the use of materials like Bitumen, Aggregate and waste Polypropylene cement bags

a. Bitumen

Bitumen is a material which is a byproduct of petroleum refining process. It is a highly viscous at temperature above 100 degrees Celsius and is solid at room temperature. Basic Properties are show in Table-1.

b. Aggregates

An aggregate which has good and sufficient strength, hardness, toughness and soundness have to be chosen. Crushed aggregates produce higher stability.
Basic physical parameters of aggregates are sow in Table-2.

c. Plastic

Waste Polypropylene cement bags strips in small pieces between (2.36 -4.75mm).
Waste Polypropylene cement bags were shredded. The physical properties of waste plastic bags are show in Table-3.

3. Objectives

- To conduct the Standard tests for the properties of plain bitumen.
- To determine the optimum binder content for plain mixes CRMB, by Marshall Stability method.
- To use waste Polypropylene cement bags as additive with aggregate and blended with bitumen and test all the basic test parameters.

4. Methodology

a. In dry process shredded PP is added to hot aggregates and mixed thoroughly. Waste PP gets coated on the surface of aggregates uniformly. Then bitumen is added to the coated aggregates and mixed to get a uniform mix. This mix is placed in Marshall Moulds.

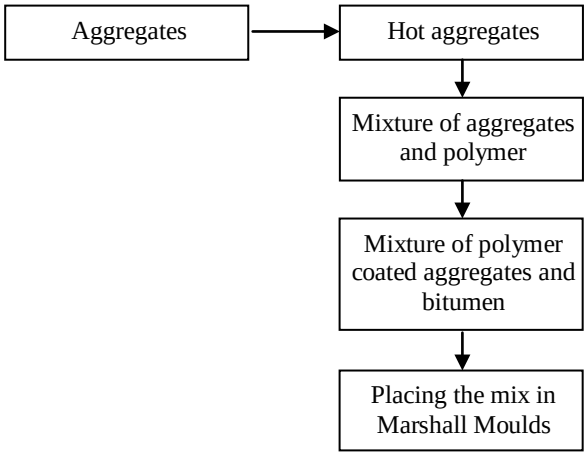

Fig 3.1: Waste PP Blended With Bitumen- Aggregate Mix- Process (Dry)

Marshal moulds were prepared for different percentages of modified bitumen by varying the bitumen percentage from 3.5% – 6.5% by in a interval of 0.5%. The specimens were kept for 24hrs and then were demoulded. Marshall Stability test was conducted and parameters such as flow value, bulk density, percentage air voids, voids filled with bitumen (VFB) and voids filled with mineral aggregates (VMA) were calculated. The optimum bitumen content, maximum bulk density and 4% volume of voids for bitumen grade CRMB-60 were calculated using the above properties.

Marshall Stability number also determined by adding waste Polypropylene cement bags of varying percentage from 0-12% for the known binder content of CRMB-60 grade bitumen.

b. Selection of Aggregate gradation

Selection of proper gradation for the mix is one of the most important parameter. Ministry of road transport [MoRTH] has given some of the grading specifications for all the bituminous and non-bituminous layers used in road construction. Bituminous concrete [BC] is considered as the wearing course or the surface course. Nominal aggregate size of 19mm and layer thickness of 50-60mm is selected. Grading specification for bituminous concrete course is given in Table 4.

Aggregates of size 25mm, 12mm, 6mm and dust which were procured from the crusher were taken and sieve analysis was

c. Test on bitumen:

Standard tests on bitumen such as penetration, softening point, ductility and flash and fire point were conducted by using appropriate method.

d. Tests on mixes:

Test on bituminous mixes for various properties such as stability, flow value, bulk density and optimum binder content were conducted by using Marshall Stability apparatus. The properties of bituminous mix mainly depends on aggregate gradation, binder content, method of compaction and method adopted for compaction and temperature during compaction.

5. Result and Discussion

Parameters used for calculation:

Percentage weight of bitumen by weight of aggregate, W4 = 3.5-6.5
Apparent specific gravity of all aggregate, Gsb = 2.739
Apparent specific gravity of all aggregate Gse = 2.816
Apparent specific gravity of bitumen, G4
Modified CRMB-60 grade bitumen, G4 = 1.025

Properties of bituminous mixes

The following properties were obtained from the laboratory studies on Bituminous Concrete-

Results of Optimum bitumen content for CRMB grade bitumen

Maximum stability = 1394 Kg at bitumen content = 5%
Maximum bulk density = 2.410 gm/cc, at bitumen content = 5%
Percent air voids = 4% at bitumen content = 4.9%
Optimum bitumen content of CRMB grade bitumen=5%

Properties of bituminous mix after adding waste plastic for CRMB- 60grade bitumen

(Table 6: Marshall Stability values Kg for BC Grade I for varying Waste PP %)

Optimum bitumen content for bituminous concrete (BC) mix

Optimum bitumen content obtained for bituminous concrete grade I mix for CRMB-60 grade bitumen was 5% as per the specification of MORT&H standards. The stability obtained for the respective OBC was 1394 Kg.

Addition of waste PP to bituminous concrete mix and same amount replace bitumen.

Waste shredded PP were added in the increasing percentage

carried out to obtain individual gradation of aggregates. Gradation and proportioning of aggregates are show in Table-5.

Effect of method of coating on the mix parameters of BC grade I mix

Addition of 2% to 12% waste shredded PP by the weight of bitumen to BC mix has resulted in following:

- The maximum stability was 1617 Kg at 8% waste PP by the weight of bitumen, 4.8mm flow at 8% waste PP and 74.238 VFB at 8% waste PP.
- Bulk density (Gb) was found to be maximum of 2.484gm/cc at 8% waste PP and then reduces to 2.438 gm/cc at 4% waste PP.
- Voids in the total mix Vv varies from 4% to 10% by varying the waste PP content from 2% - 12% and at 8% waste PP Vv was found to be 3.94%.

6. Conclusions

In the present study, the importance was to add the shredded waste PP to use bituminous concrete (BC) mix and to evaluate the various mix properties like Marshall Stability number, flow, bulk density, voids in the mix and voids field with bitumen (VFB) and 8% PP coated on aggregates which had yielded the highest marshal stability.

Construction and repairs work, bituminous work in India is cost too much amount every year and by using waste PP @ 8%. The cost can be reduced considerably, beside that modified CRMB surface reduced vehicle wear and tear.

- The optimum PP content for CRMB-60 grade bitumen was 8%.
- bitumen with PP content 8%, the maximum stability was achieved
- The use of waste PP on the road has helped to provide better place for burying the PP waste without causing disposal problem. At the same time a better road is also constructed at negligible cost of Waste Polypropylene Cement Bags.

of 0% - 12% to bituminous concrete mix.

Table 1: Properties of bitumen used in present study

Sl. No.	Properties	Grade	Test methods
		CRMB-60	
1	Penetration at 25^0 C	38.3	IS:1203-1978
2	Softening point (R&B) 0 C	65.7	IS:1205-1978
3	Elastic Recovery @15^0C, %	68	IS:1208-1979
4	Flash point, ^{0}C	285	IS:1209-1981
5	Specific gravity of bitumen	1.025	IS:1202-1980

Table 2: Properties of Aggregates used in present study

Sl. No.	Aggregate tests	Test results obtained	Requirements as per Table 500-14 of MORTH (IV revision) Specifications
1	Crushing value (%)	24.8	Max 24%
2	Impact value (%)	20.8	Max 24%
3	Los Angeles abrasion value (%)	32	Max 30%
4	Combined index (%)	29%	Max 2%
5	Water absorption (%)	0.25	
6	Specific gravity of 26.5-12 mm aggregates	Bulk SG-2.774, Apparent SG- 2.828	
7	Specific gravity of 12 – 6 mm aggregates	Bulk SG-2.74, Apparent SG- 2.814	
8	Specific gravity of Stone Dust	Bulk SG-2.715, Apparent SG- 2.810	
9	Specific gravity of filler (Bag House)	2.691	

Table 3: Properties of plastic used in present study

Properties	Results obtained
Specific gravity	1.03
Melting point ^{0}C	250-260
Sieve analysis	Passing 4.75 mm sieve retained on 2.36 mm sieve

[Source: pheonixtechnologies. net]

Table 4: Gradation and proportioning of aggregates

Sieve size	Obtained gradation				Desired gradation				Total	Middle Limits	Lower Limits	Upper Limits
	25	12	stone dust	filler	25	12	stone dust	filler				
					32%	24%	42%	2%				
26.5	100	100	100	100	32	24	42	2	100	100	100	100
19	63.46	100	100	100	20.31	24.00	42.00	2	88.31	89.5	79	100
13.2	7.86	100	100	100	2.52	24.00	42.00	2	70.52	69	59	79
9.50	1.06	77.81	100	100	0.34	18.67	42.00	2	63.01	62	52	72
4.75	0.00	8.04	99.03	100	0.00	1.93	41.59	2	45.52	45	35	55
2.36	0.00	3.47	80.96	100	0.00	0.83	34.00	2	36.84	27.	20	34
1.18	0.00	2.49	55.15	100	0.00	0.60	23.16	2	25.76	27	20	34
0.06	0.00	1.55	41.94	100	0.00	0.37	17.61	2	19.99	21	15	27
0.03	0.00	0.00	27.46	100	0.00	0.00	11.53	2	13.53	15	10	20
0.150	0.00	0.000	15.85	98.11	0.00	0.00	6.66	1.96	8.62	9	5	13
0.075	0.00	0.000	7.27	89.90	0.00	0.00	3.05	1.80	4.85	5	2	8

Table 5: Marshall Stability values Kg for BC Grade I for varying Waste Plastic %

Waste Plastic %	Gmm	Gb	Vv	VMA	VFB	Stability Value KN	Flow Value in 0.25mm
0	2.588	2.473	4.44	14.225	68.787	14.94	3.4
2	2.57	2.455	4.47	14.504	71.801	14.98	3.7
4	2.553	2.438	4.50	15.44	70.855	15.22	4.0
6	2.558	2.456	3.99	14.815	73.068	1561	4.5
8	2.586	2.484	3.94	13.845	74.238	16.17	4.8
10	2.547	2.467	3.14	14.430	75.549	15.74	4.2
12	2.513	2.451	2.47	14.990	81.387	15.14	4.0

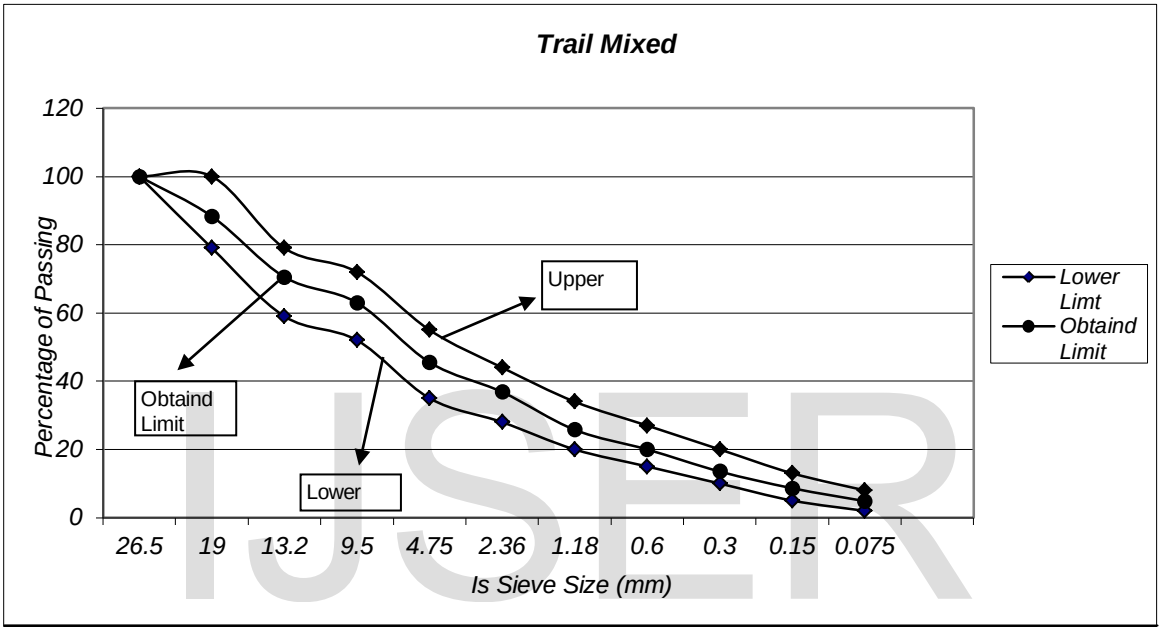

Fig 1: Curve of BC mix with the obtained gradation for grade I

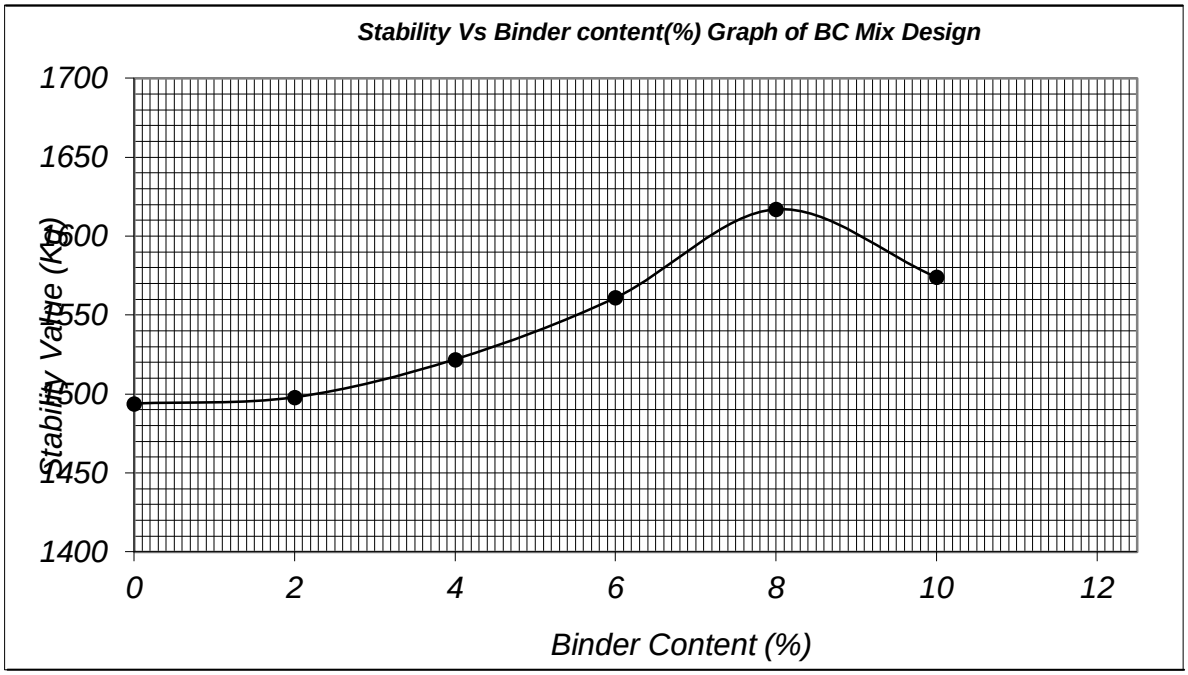

Fig 2: Relation between stability and binder content

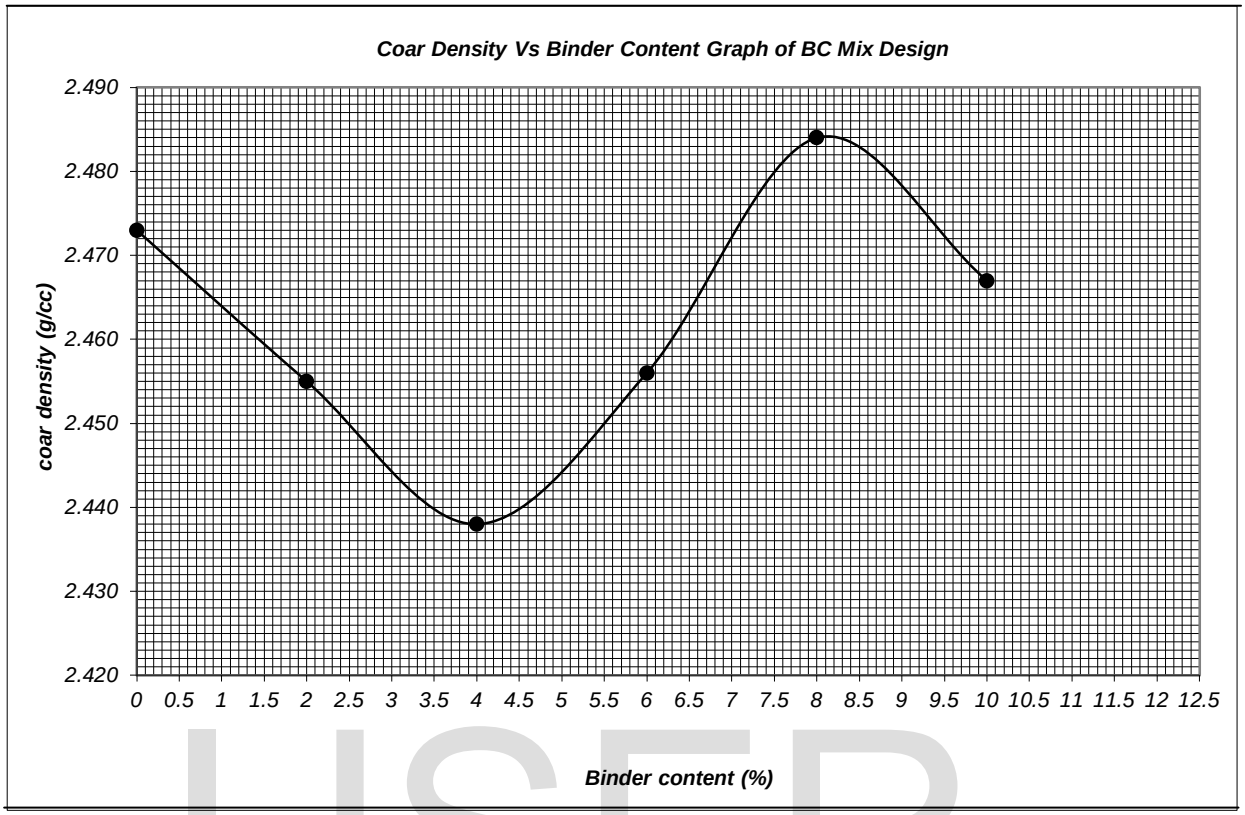

Fig 3: Relation between bulk density and bitumen content

Note: - Binder – Bitumen and Plastic waste@ (0% - 12%)

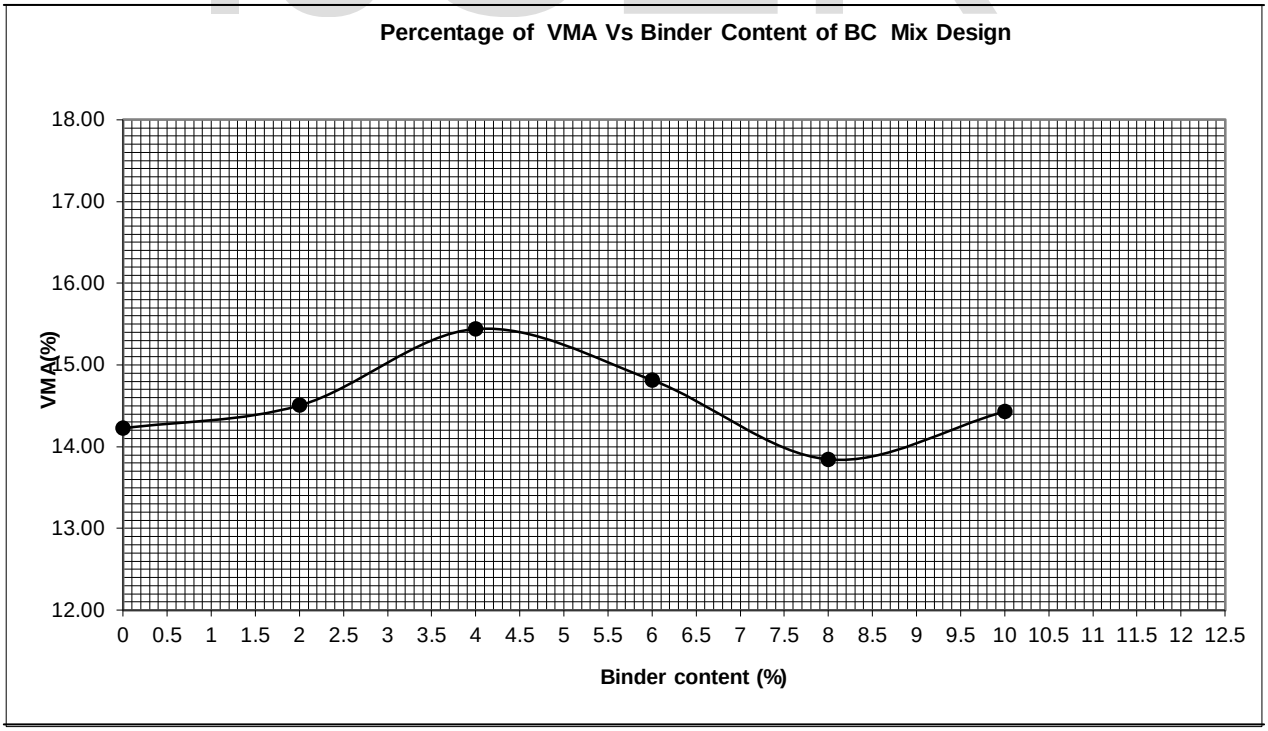

Fig 4: Relation between VMA and bitumen content

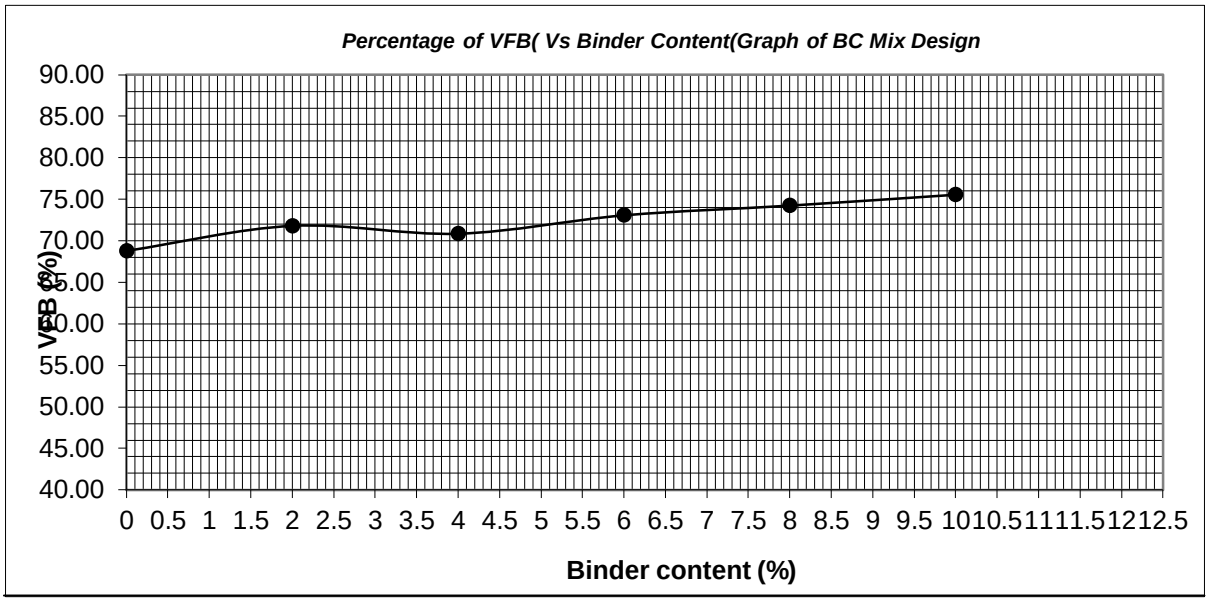

Fig 5: Relation between VFB and bitumen content

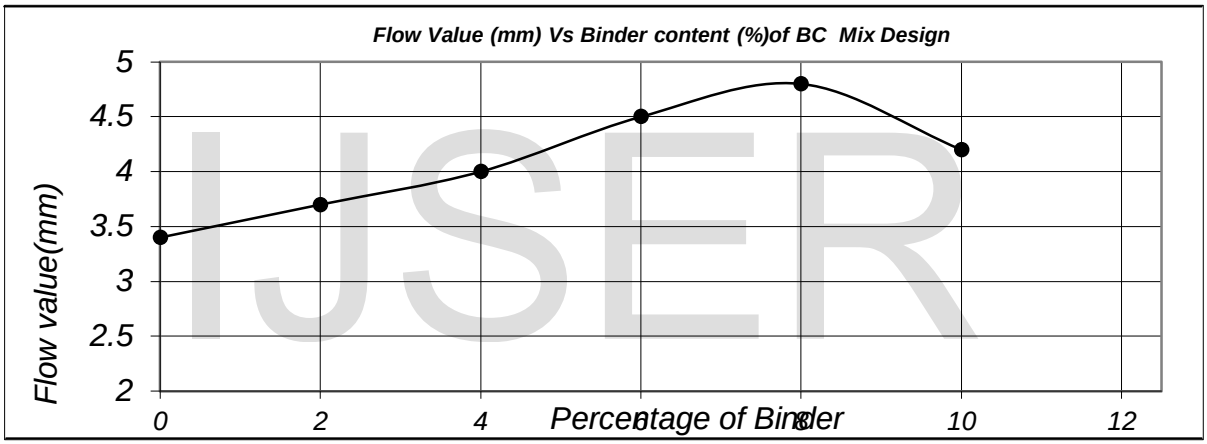

Fig 6: Relation between flow and bitumen content

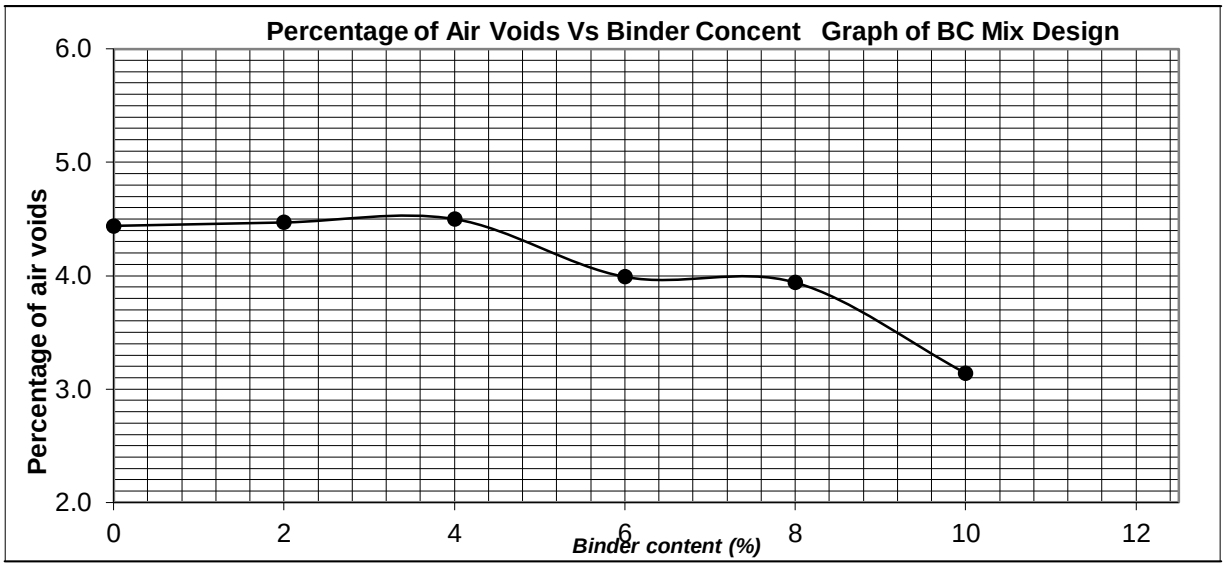

Fig 7: Relation between voids ratio (Vv) and bitumen content

Results:

Maximum stability = 1552 kg
Waste plastic = **8%** of weight of bitumen

7. References

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