International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 06 | June-2016 www.irjet.net p-ISSN: 2395-0072

Experimental Study onUse of Waste Plastic in Bituminous Concrete Mix

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Abstract-*Solid waste management is a key field nowadays. An enormous amount of plastic is generated every year around the globe. The problem with this kind of waste material is that it is accumulating because it does not decay and therefore is increasing in volume on the other hand the rapid increase in traffic intensity, effect of temperature change on pavement and effect of heavy rain on pavement have put us in a situation to think about some alternate ways for the improvement of pavement quality and characteristics by using a material which satisfies both the aspects , strength and economical. Utilization of waste plastic as an alternate material in pavement construction have been studied and tested in many countries. When waste plastic is added to hot aggregate it will form a fine coat of plastic over the aggregate and when such aggregates are mixed with the binder is found to give higher resistance to water, higher strength and better performance. In this paper, the application of plastic waste by the dry process in bituminous concrete pavement is studied. Marshall Method of mix design is adopted and a comparison is made between conventional mix and plastic coated aggregate mix with different plastic contents.*

Keywords: Marshall Method, Plastic Coated Aggregates (PCA), Bituminous concrete.

1. INTRODUCTION

Use of plastic in daily life is increasing. It comes mostly in the form of plastic bottles, carrying bags, packaging, syringes, containers, furniture and much more. In 2008 global plastic consumption has been estimated about 261 million tons and it were expected to reach about 298 million tons by 2016. This waste cannot biodegrade in nature and cause environmental pollution and hygienic problems. Disposal of waste plastic waste has become a major problem and when this waste plastic is burnt for disposal they cause environmental pollution. This problem of waste plastic will not solve itself and certain stepsshould be taken to ensure the proper disposal of this waste. Utilization of plastic waste with the bitumen in the construction of pavement will not only increases its smoothness and life but also makes it environment-friendly and economical. Roads which are constructed by using plastic waste are called plastic roads and performed better as compared to those constructed with conventional bitumen.

In this paper, the experimental study on the bituminous concrete mix is carried out by using well-graded aggregates of a nominal size of 13mm and cement as filler, the binder used is VG 30 grade. In the dry process, Plastic is shredded in size between 2mm to 8mm and is coated on the aggregates. Method adopted for mix design Marshall Method to find the optimum binder content of the mix and plastic content of 0.5% to 2% is used to compare the marshal properties of conventional mix and aggregate coated with plastic.

2. METHODOLOGY

In this experimental study, the Bituminous concrete mix has been designed for 13.2 mm aggregates nominal size and crushed aggregates from the quarry is used in this study and VG30 60/70 grade of Bitumen is used as a binder. Laboratory testing has been carried out to find the physical properties of Aggregate by conducting tests like Flakiness and elongation Index, Aggregate Impact value, Abrasion Test, Crushing value test, Water absorption, Specific Gravity etc. And sieve analysis is done to find the Gradation of Aggregate which satisfied the required Gradation for 13.2 mm nominal size of aggregate for BC design as per MORTH specifications. The various tests on bitumen are done for VG30 including Ductility test , Penetration test, Specific Gravity, Softening Point test etc which satisfied the requirement of IS:73-2006. Samples are prepared for Marshall Mix design and Optimum bitumen content for VG30 is determined by using differentbinder content. After the determination of OBC for

conventional mix samples at a different percentage like 0.5%, 1%, 1.5% and 2% of waste plastic are prepared with the change in binder content at given plastic content and based on this optimum bitumen content and plastic content is determined.

3. MATERIAL AND METHOD

3.1 Aggregates

Aggregates using sufficient strength, toughness, hardness, shape and specific gravity are used and various tests on aggregates are performed. The gradation 2 is selected for bituminous concrete as per IRC 111-2009. The aggregates used are of nominal size 13.2mm with the mix of both coarse aggregate which is retaining on 2.36 mm sieve and fine aggregate passing 2.36 mm and retained on 0.075mm sieve is used. Aggregates of size 13mm, 6mm, stone dust are used and mixed as per specified gradation.

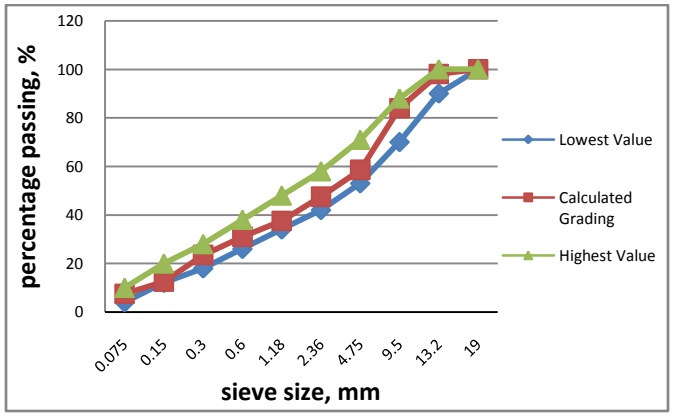

Chart-1: Gradation Curve for Bitumen.

3.2 Filler

The filler used in the study is bangur cement as per given requirement in IRC 111-2009. The quantity of cement used is 2%.

Table-1: Grading requirement of Mineral filler.

IS Sieve (mm)	Cumulative % passing by weight of aggregate
0.6	100
0.3	95-100
0.075	85-100

3.3 Bitumen

The grade of bitumen which is used in the experiment is of grade VG 30 and as per Indian standard specification. Various tests are performed on bitumen to find its properties like Ductility test, Penetration test, Specific Gravity, Softening Point test etc.

Table-2: Various Tests on Bitumen.

Properties Tested	Test Result	Specification IS:73-2006	BIS Code for Testing
Penetration	63	50-70	IS:1203
Ductility	82	Min 40	IS:1208
Specific gravity	1.03	Min 0.99	IS:1202
Softening point	51	Min 47	IS:1205
Grade of Bitumen		60/70	

3.4 Waste Plastic

The waste plastic used is LPDE and is in the shredded form of size 2mm-8mm.Properties like specific gravity, softening point finds out by performing the various tests. The specific gravity of the plastic is found out to be 0.905

3.5 Marshall Mix Design

Bituminous concrete is one of the widely used and costliest types of flexible pavement layer used in the surface course. Properties of a good bituminous mix are skid resistance, stability, durability etc. The mix Design should aim at economical blends, with the proper gradation of aggregate, an adequate proportion of bitumen and proper gradation of aggregate so as to fulfill the desired properties of the mix. Marshall Stability test carried out to find the flow

value, air voids, stability, density, voids fill with bitumen and finally finding the optimum binder content of the mix.

3.6 MarshallStability test

Marshall Stability test is conducted on compacted cylindrical moulds of bituminous mix to determine the optimum binder content. The various properties like stability, flow value, air voids, and voids filled with bitumen and voids in mineral aggregates are found out by this test.

Table-3: Requirement of Bituminous Mix

Properties	Viscosity Grade Bitumen		Test Method
Minimum Stability(KN at 60^{0}c)	9		AASHTO 245
Marshall Flow(mm)	2-4		AASHTO 245
Marshall Quotient (stability/flow)	2-5		
% Air Voids	3-5		MS-2 And ASTM D2041
% Voids Filled With Bitumen	65-75		MS-2
Compaction Level (no. of blows)	75 blows on each face		
% Voids in Mineral Aggregate VMA			
Nominal Maximum Particle Size (mm)	Min. % VMA related to designed % air voids		
	3	4	5
9.5	14	15	16
13.2	13	14	15
19	12	13	14
26.5	11	12	13
37.5	10	11	12

3.7 Bulk Density of mix

It is the ratio of weight in air of the specimen to the difference in weight of thespecimen in air and water and is denoted by Gm. The bulk density of the mix is increasing with increase in bindercontent up to a certain binder content which is OBC and then its starts decreasing. The values of bulk density are decreasing with increase in waste plastic content.

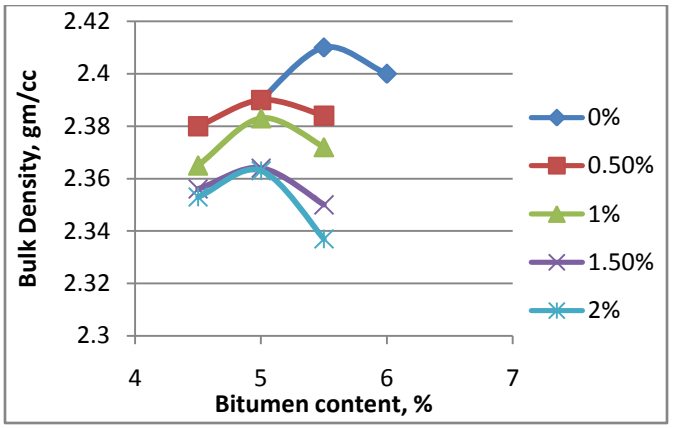

Chart-2: Variation of Bulk Density of BC with different Binder and Plastic Content.

3.7 Stability

The 'Marshall Stability' of the bituminous mix is defined as maximum load carried (kg) at the standard test temperature of 60^{0}c.Its value is increasing with the addition of plastic content.

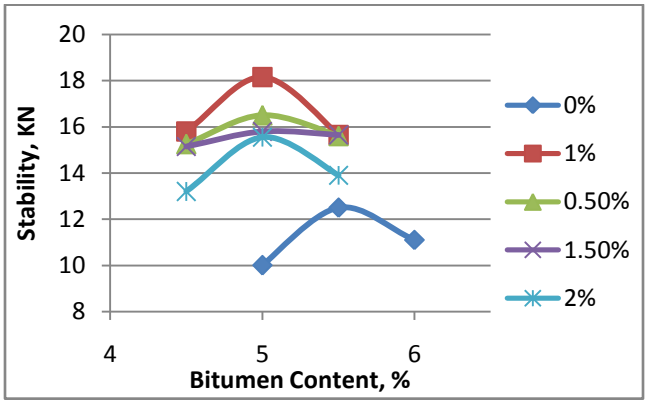

Chart-3: Variation of Stability of BC with different Binder and Plastic Content.

3.8 Flow value

Flow is the total amount of deformation which occurs at maximum load. Flow value increases as an increase in binder content but with the addition of plastic waste, its values are less than that of conventional values.

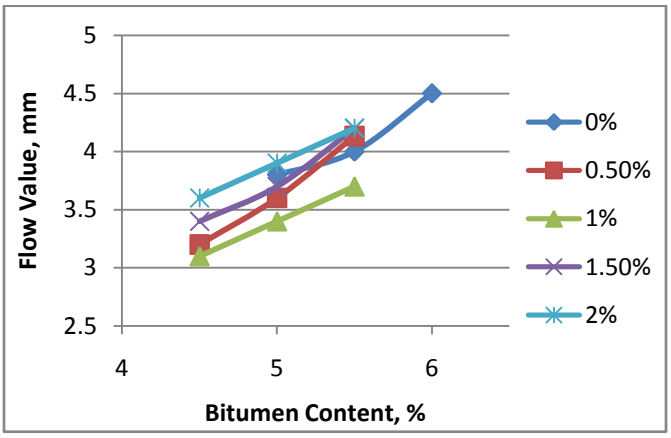

Chart-4: Variation of Flow Value of BC with different Binder and Plastic Content.

3.9 Air Voids

It is the total volume of small pockets of air between coated aggregate particles throughout a compacted paving mixture, expressed as the percentage of the total volume of the compacted paving mixture. WithIncrease in binder content air, voids are decreasing but the value decreases with increase in plastic waste content.

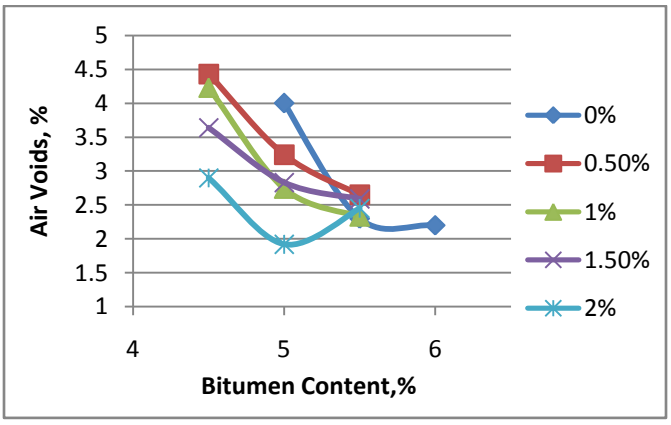

Chart-5: Variation of Bulk Air Voids of BC with different Binder and Plastic Content.

3.10 Voids in Mineral Aggregate

It is the volume of intergranular void space between the uncoated aggregate particles of a compacted paving mixture that includes the air voids and effective bitumen content. VMA is expressed as the percentage of the total volume of the compacted paving mixture. With an increase in binder content, VMA is also increasing. With Addition of plastic VMA values are increasing to that of convention mix.

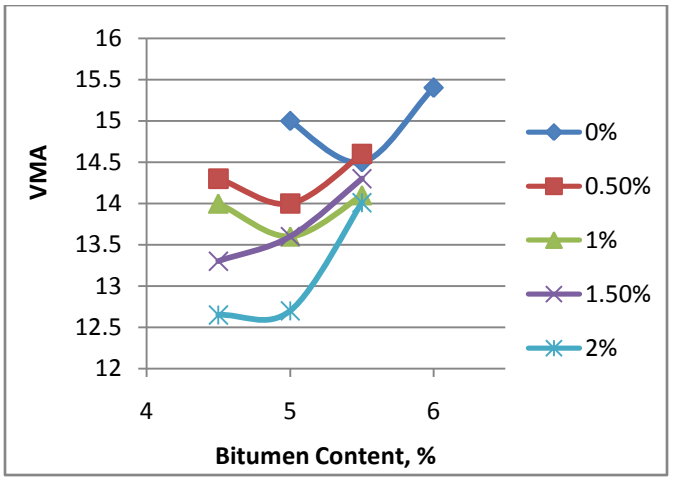

Chart-6: Variation of VMA of BC with different Binder and Plastic Content.

3.11 Voids Filled with Bitumen

It is the percentage of VMA that is occupied by the effective bitumen. Withan increase in binder content, VFB value is increasing also with the addition of plastic increase the VFB value as compared to that of the conventional mix.

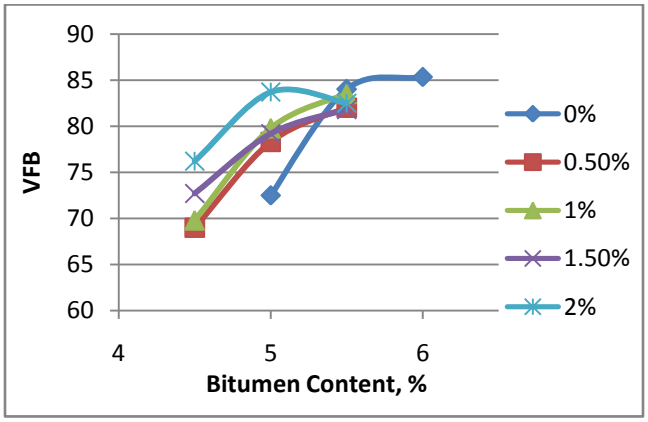

Chart-7: Variation of VFB of BC with different Binder and Plastic Content.

3.12 Optimum binder content

The optimum bitumen content (OBC) is found to be 5.33% which is calculated by taking the average of the followingthree values.

Table-4: Optimum Binder Content.

Sr. No	Description	Bitumen (%)
1	Bitumen content at highest stability value	5.5%
2	Bitumen content at highest value of bulk density	5.5%
3	Bitumen content at 4% air voids value	5%
	Average	5.33%

3.13 Optimum Waste Plastic Content

The highest value of stability is seen in the plastic content of 1% and optimum binder content is found to be 4.833 against the optimum plastic content of 1%.

Table-5: Optimum Plastic and Binder Content.

Type of mix	Optimum Plastic Content	Optimum Binder Content
BC without plastic	0%	5.33%
BC with plastic	1%	4.83%

4. CONCLUSION

Based on the results and discussions the following conclusions are made:

1. From the results obtained from the test, it is found that the value of optimum binder content is 5.33% by weight of the aggregates for the conventional mixes.
2. Using the results from the test using plastic coated aggregates, the optimum plastic content is found to be 1% by weight of the aggregates and optimum binder content is 4.83% by weight of aggregates when 1% of waste plastic by weight of aggregates is added in the mix.
3. From using the results of this study it is concluded that the value of Marshall Stability has increased from 12.5KN to 18.15KN by adding 1% of the waste plastic content.
4. Properties of BC can be further improved by use of waste plastic.
5. It has been observed that1% use of waste plastic in BC mix gives optimum results of Marshall Properties.
6. Use of the innovative technology not only strengthened the road construction but also increase the road life.
7. The study shows that the use of waste plastic will reduce the binder content from 5.33% to 4.83 % in the BC mix hence, it will save the overall cost of the pavement construction.
8. The problem of the effect of India's hot and extremely humid climate condition on pavement can be solved by using plastic waste.
9. This study will help to reduce the disposal problem of waste plastic and also in developing an eco-friendly technique.

ACKNOWLEDGEMENT

The authors would like to express their appreciation to the Department of Civil Engineering, Madhav Institute of Technology & Science, Gwalior for the facilities and support for this research work.

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