USE OF BIOMEDICAL PLASTIC WASTE IN BITUMINOUS ROAD CONSTRUCTION

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Abstract
The amount of plastic in solid waste is increasing due to increase in population, urbanization and changes in life style which is leading to widespread littering on the landscape. The disposal of waste plastics has thus become a serious problem globally due to their non-biodegradability. The deteriorating quality of roads is another area of concern as the present roads are not able to withstand the increasing traffic and also are less resistant to adverse weather conditions. The present work deals with the use of autoclaved medical plastic waste (like glucose bottles, syringes etc.) in road construction. The study investigates performance of the bituminous mix modified with bio – medical plastic waste and compare it with the normal bituminous mix. Marshall method of mix design is adopted.

Keywords: Stone Mastic Asphalt (SMA), Biomedical Plastic Waste, Optimum Bitumen Content, Optimum Plastic Content

1. INTRODUCTION

Today, every vital sector of the economy starting from agriculture to packaging, automobile, building construction, communication or InfoTech has been virtually revolutionized by the applications of plastics. One of the major plastic waste generators are hospitals, and the waste generated by them are called biomedical waste. Biomedical waste means any waste, which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biological and including categories mentioned in schedule of the biomedical waste management handling rules, 1998. Proper management of these wastes is all the more important because of their infectious and hazardous characteristics. Use of plastic along with the bitumen in construction of roads not only increases its life and smoothness but also makes it economically sound and environment friendly. Plastic waste is used as additive to improve the properties of bituminous mix. Roads that are constructed using plastic waste are known as Plastic Roads and are found to perform better compared to those constructed with conventional bitumen. The experimentation at several institutes indicated that the waste plastic, when added to hot aggregate will form a fine coat of plastic over the aggregate and such aggregate, when mixed with the binder is found to give higher strength, higher resistance to water and better performance over a period of time. Plastic increases the melting point of bitumen and hence missing can be done in better and easier way.

This paper envisages the use of biomedical plastic waste in different proportion (6% to 12% by weight of bitumen) to prepare job mix formulae for S.M.A. An attempt is also made in this study to assess the properties of bituminous mixes when biomedical plastic wastes are incorporated into them.

1. OBJECTIVES

The objectives of the study are:

- To investigate the performance of bituminous mix modified with bio-medical plastic waste
- To compare the Marshall parameters of plastic modified mix with the normal mix.
- To compare normal aggregates with plastic coated aggregates

2. LITERATURE REVIEW

Swami and Abhijieet (2012) investigated the Use of waste plastic in the construction of bituminous

Road. They concluded that plastic waste consisting of carry bags, cups and other utilized plastic could be used as a coating over aggregates and this coated stone could be used for road construction. Their results showed that polymer bitumen blend is a better binder compared to plain bitumen. The blend increased softening point and decreased penetration value with a suitable ductility.

Sultana and Prasad (2012) investigated the utilization of waste plastic as a strength modifier in surface course of flexible and rigid pavements. They concluded that the potential use of waste plastic as a modifier for asphalt concrete and cement concrete pavement. By increasing the percentages of plastic, the stability values were increased and required quantities of binder contents were decreased.

Gawande, Zamare and Renge (2010) reviewed techniques to use plastic waste for construction purpose of roads and flexible pavements. Waste plastic modified bitumen mix showed better binding property, stability, density and more resistance to water.

Vasudevan and Velkennedy (2012) stated that polymer bitumen blend was a better binder compared to plain bitumen. The blend increased the softening point and decreased penetration value with sufficient ductility.it could withstand high temperature and load when used for road construction.

Bindu and Beena (2012) investigated the benefits of stabilising the stone mastic asphalt (SMA) mix in flexible pavement with shredded waste plastic. Conventional and stabilised SMA Mix was subjected to performance tests. Plastic content of 10% by weight of bitumen was recommended for the improvement of the performance of SMA Mix.

3. METHODOLOGY

In this study VG30 viscosity grade Bitumen is used. The properties of aggregates and bitumen were tested as per IS standard tests. The test results are summarized in Table 1 and 2 respectively. The proportioning of aggregates was done according to the specification of Ministry of Road Transport and Highways (MoRTH) for SMA. The aggregate proportioning of SMA mix is shown in Table 3.

Table 1: Bitumen test results

Sl No	Property	Test Results	Specification
1	Softeningpoint(^{O}C)	54	Min 47
2	Ductility(cm)	93	Min 75
3	Specific Gravity	1.05	Min 0.99
4	Standard Penetration	66.67	50-70
5	Viscosity(Sec)		14-45

Table 2: Aggregate test results

Sl No	Property	Test Results	Specifications
1	Aggregate Impact Value(%)	28.76	Max30
2	Aggregate Crushing Value(%)	26.67	Max30
3	Los Angeles Abrasion	31.14	Max35
4	Flakiness Index(%)	13.2	Max15
5	Elongation Index(%)	11.67	Max15
6	Combined Index(%)	24.76	Max30
7	Specific Gravity	2.7	2.6-2.8

Table 3: Aggregate proportioning of SMA mix

Sieve size (mm)	Weight Required(g)
16	0
13.2	60
9.5	390
4.75	462
2.36	48
1.18	36
0.6	24
0.075	60
FILLER	120
TOTAL	1200

To study the effect of biomedical plastic waste in bituminous mixes the following methodology was adopted.12 Normal mix specimens were prepared with bitumen contents of 4 percent, 5 percent, 6 percent and 7 percent. The Optimum Bitumen Content (OBC) was found out using Marshall test. The shredded biomedical plastic waste to size passing through 4.75 mm sieve and retained in 2.36 mm sieve was mixed with the hot aggregates. Plastic modified mix specimens with plastic contents of 6%,8%,10%, and 12%, by weight of bitumen were prepared through dry process by adding plastic to heated aggregates. Marshall test were conducted on plastic modified mix specimens to study different parameters. After finding out the optimum plastic content, the aggregates were then coated with this Optimum Plastic Content and aggregates, tests were conducted for comparing its properties with normal aggregate

Marshall Method of Mix Design

In this method, the resistance to plastic deformation of a compacted cylindrical specimen of bituminous mixture is measured when the specimen is loaded diametrically at a deformation rate of 50mm per minute. The Marshall stability of the mix is defined as the maximum load carried by the specimen at a standard test temperature of 60°C. The flow value is the deformation that the test specimen undergoes during loading up to the maximum load. Flow is measured in 0.25 mm units. The Marshall parameters are stability value, flow value, air voids and voids fill bitumen (VFB%) and optimum binder content.

1. RESULTS AND DISCUSSIONS

The Marshall specimen were prepared in various bitumen content (4%. 5 %, 6 % and 7 %). The Marshall parameter obtained are summarized in table 4, the variation of stability, flow value, air voids and voids fill bitumen (VFB%) is shown in fig 4 to 5.

Table 4: Marshall Mix Parameters for various Bitumen content

Bitumen Conten	Stability (kN)	Flow value (mm)	VMA (%)	Air Voids Vv	VFB (%)
4	12.13	4.33	12.55	3.75	70.11
5	19.69	3.33	13.52	2.53	81.28
6	16.01	7.33	14.79	1.71	88.43
7	10.28	9.33	16.39	1.29	92.13

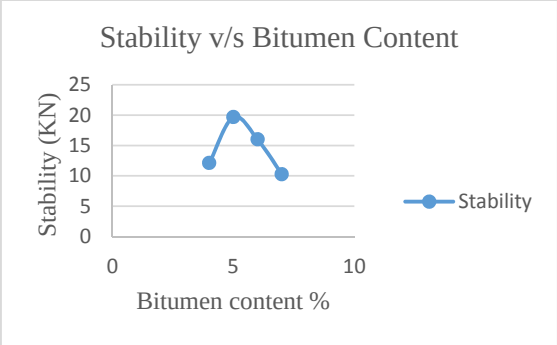

Fig 1: Stability v/s Bitumen Content

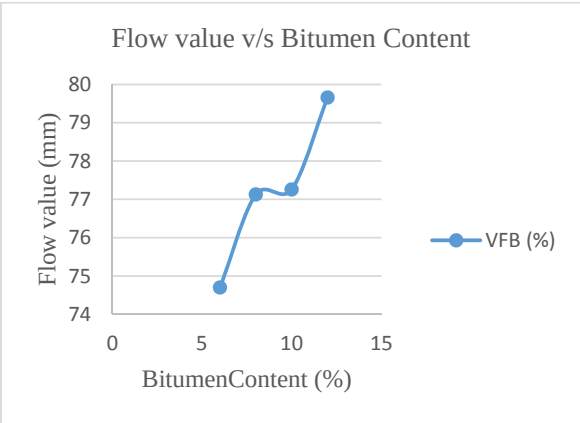

Fig 2: Flow value v/s Bitumen Content

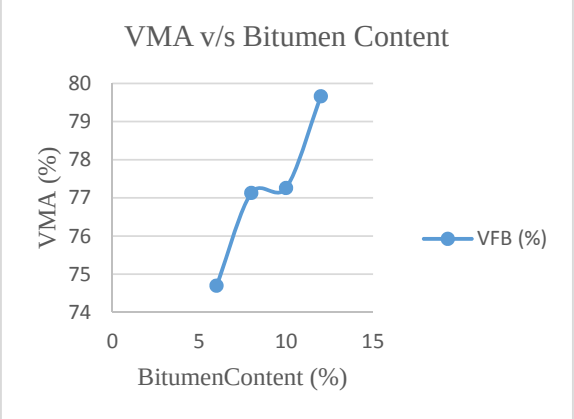

Fig 3: VMA v/s Bitumen Content

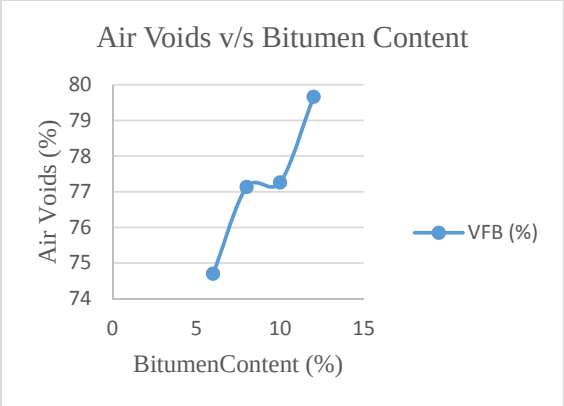

Fig 4: Air Voids v/s Bitumen Content

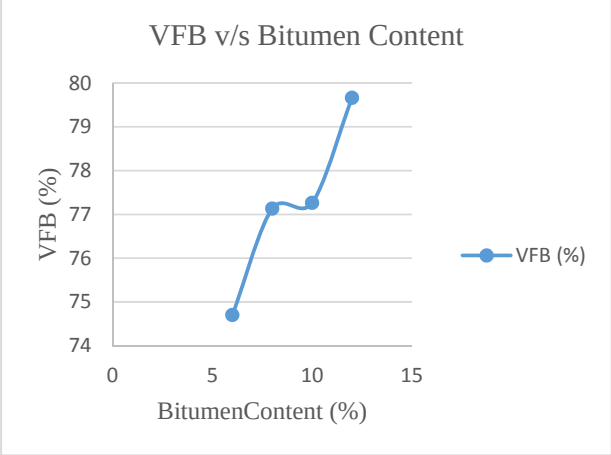

Fig 5: VFB v/s Bitumen Content

Optimum bitumen content is selected as the average binder content for maximum density, maximum stability and minimum flow value in the total mix. It is clear that optimum bitumen content was obtained as 5 percent.

Optimum plastic content

12 plastic modified mix specimens were prepared with varying plastic content of 6%,8%,10% and 12% (by weight of bitumen for optimum bitumen content), The Marshall parameter obtained are summarized in table 2, the variation of stability, flow value, air voids and voids fill bitumen (VFB%) and the optimum plastic content for the mix is determined. Table7.6 gives the various parameters obtained and is required for plotting these graphs.

Table 5: Marshall Mix Parameters for various plastic content

Plasticcontent (%)	Stability (kN)	Flowvalue (mm)	VMA (%)	AirVoids Vv	VFB (%)
6	20.75	3	10.04	2.54	74.7
8	22.18	1.6	9.27	2.12	77.13
10	24.77	2	5.63	1.28	77.26
12	23.90	3.2	5.31	1.08	79.66

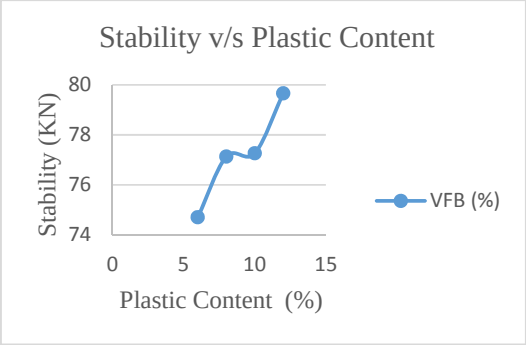

Fig 6: Stability v/s Plastic Content

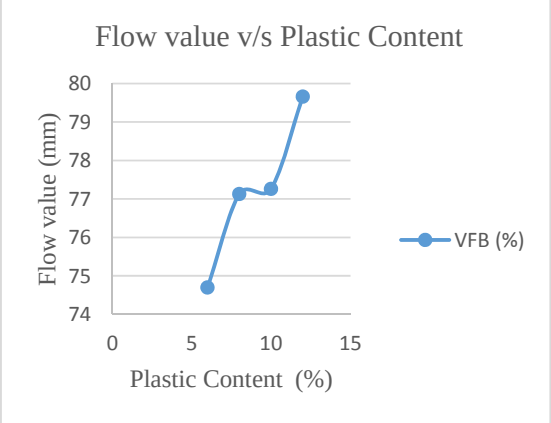

Fig 7: Flow value v/s Plastic Content

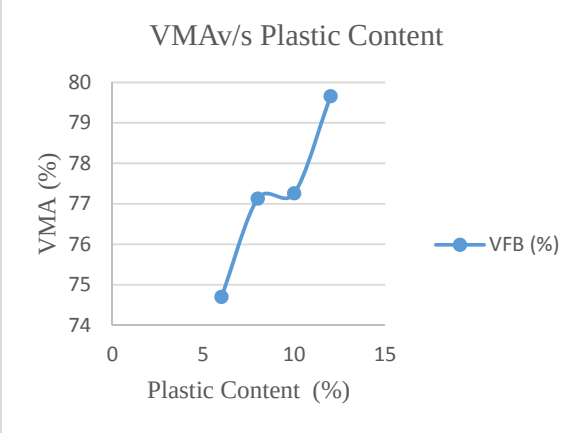

Fig 8: VMA v/s Plastic Content

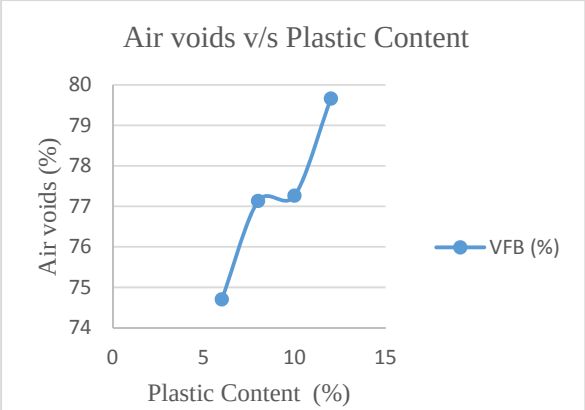

Fig 9: Air Voids v/s Plastic Content

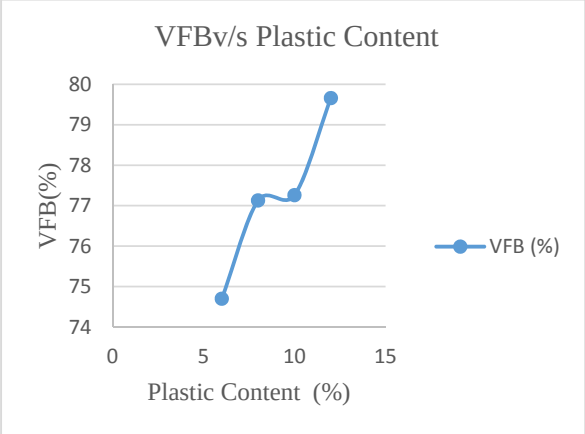

Fig 10: VFB v/s Plastic Content

Optimum Plastic Content is selected as the average plastic content for maximum density, maximum stability and minimum flow value by using optimum bitumen content. From the figures, it is clear that optimum plastic content was obtained as 9.33percent.

Comparison of plastic coated and normal aggregates

Aggregates coated with 9.33 percent plastic were tested for various properties. Comparison in properties of normal and plastic coated aggregates are shown in Table

Table 6: Comparison of Normal and Plastic Coated Aggregates

Sl No.	Property	Normal aggregates	Plastic coated aggregates
1	Aggregate impact value(%)	28.76	16.2
2	Aggregate crushing value(%)	26.67	15.4
3	Los Angeles Abrasion value(%)	31.14	18
4	Specific Gravity	2.7	2.75

All the properties of aggregates were found to satisfy the specified limits. It is seen that the aggregate crushing value and impact value were reduced on coating the aggregates with plastic. Los Angeles abrasion value of plastic coated aggregates was also found to be reduced. It can be seen from the test results that the properties of aggregates were desirably improved by coating them with biomedical plastic waste.

While comparing the Marshall parameters of normal mix and plastic modified mix, it can be seen that the plastic modified mix showed improved values. From table 4, maximum stability value obtained for the mix with 5 % bitumen content is 19.69 kN. The stability value increased when the mix was coated with plastic. It is clear from table 5. We can also see that with improved stability value flow value also decreased. Thus it can be interpreting that on coating the bituminous mix with plastic, the mix showed improvement in its properties, giving long lasting pavements.

CONCLUSIONS

In this paper an attempt was made to assess the properties of bituminous mixes when biomedical plastic wastes are incorporated into them. The Marshall test was conducted to check the various parameters such as stability value, flow value, voids filled with bitumen and arrive to the conclusion of optimum bitumen content as 5 %. The test was also conducted on plastic modified mix and the Optimum Plastic Content was obtained as 9.33%. The Marshall stability value of plastic modified mix was found to be more than that for the normal mix which indicates an increase in load carrying capacity. The aggregates were then coated with this Optimum Plastic Content (9.33%) and aggregate IS Standard tests were repeated for comparing its properties with normal aggregates. All the properties of aggregates were found to satisfy the specified limits. It can be seen from the test results that the properties of aggregates were desirably improved by coating them with plastic.

On the basis of the experimental results obtained, it is found that mixes prepared with biomedical plastic waste has shown better properties compared to the conventional bituminous mixes. Hence, the biomedical plastic waste can be disposed of judiciously by incorporating it in bituminous mixes.

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