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Use of Biomedical Plastic Waste in Bituminous Road Construction

Bhageerathy K. P, Anu P. Alex, Manju V. S, Raji A. K

Abstract*— The quantum of plastic in solid waste is increasing due to increase in population, urbanization, development activities and changes in life style which is leading to widespread littering on the landscape. The disposal of waste plastic 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. Research is being carried out to develop suitable alternatives to the conventional road construction materials. In this work, the use of autoclaved medical plastic waste in the form of shredded syringes in road construction is tested. The main objective of the study was to investigate the performance of the bituminous mix modified with bio-medical plastic waste and to compare it with the normal mix. Medical plastic waste was collected from IMAGE (Indian Medical Association Goes Eco-friendly), Palakkad, Kerala, India. As part of the study, the properties of Plastic Coated Aggregates (PCA) were determined. The results showed improved properties for PCA when compared to normal aggregates. The properties of both the mixes were tested by conducting creep test and indirect tensile stiffness modulus test.

Index Terms*— Autoclaved medical plastic, Plastic Coated Aggregates, Creep test, Indirect tensile stiffness modulus test.

I. INTRODUCTION

Any nation's progress is directly dependent on infrastructure. India is on the threshold of a major forward thrust in the field of transportation infrastructure. Over the past two decades, traffic volumes have increased, demanding from pavement engineers, stronger and long lasting pavements. New methods of pavement design are being developed to improve the performance of roads. New materials are being used to replace the old ones to improve the durability, strength, aesthetics and economy. One of the promising ways is to use plastics in bituminous road construction industry. Today, the availability of the waste plastics is enormous, as the plastic materials have become part and parcel of daily life. If not recycled, their present disposal is either by land filling or by incineration. Both these processes have certain impact on the environment. Under this circumstance, an alternate use for the waste plastics is the need of the hour. An attempt is made in this study to assess the properties of bituminous mixes when biomedical plastic wastes are incorporated into them.

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Disposal of biomedical plastic wastes like plastic syringes and glucose bottles have always been a matter of concern because of the various health hazards and pollution caused by them. Their use in flexible pavements would open up a solution for the disposal issues regarding biomedical plastic wastes. Many research works have been done in the area of use of plastic waste in road construction. Swami et al. [1] suggested 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. Sultana and Prasad [2] investigated the potential use of waste plastic as a modifier for asphalt concrete and cement concrete pavement. Gawande et al. [3] reviewed techniques to use plastic waste for construction purpose of roads and flexible pavements. Vasudevan et al. [4] stated that the polymer bitumen blend was a better binder compared to plain bitumen. Bindu and Beena [5] investigated the benefits of stabilizing the Stone Mastic Asphalt (SMA) mixture in flexible pavement with shredded waste plastic. Raji et al. [6, 7, 8] stated that mixes prepared with biomedical syringe and glucose plastic waste had better Marshall stability than the conventional bituminous mixes. It is seen from the review that only a few experiments are reported on the use of biomedical plastic waste. This proves the significance of a study to be conducted when biomedical plastic wastes are used as additives on bituminous pavements. Hence in this study, the properties of bituminous mix when modified with shredded syringe plastic waste were investigated. The scope of the study is limited to the use of syringe plastic waste only. The work is carried out by mixing shredded autoclaved plastic syringes with heated aggregates by dry process.

II. METHODOLOGY

The bio-medical syringe plastic waste needed for the work was collected from a private organization, IMAGE (Indian Medical Association Goes Eco-friendly), Kanjikode, Palakkad. The following tests on aggregates were done:

- Aggregate crushing value test
- Aggregate impact value test
- Specific gravity test
- Water absorption test
- Los Angeles abrasion test

Normal mix specimens were prepared with bitumen contents of 4.5 percent, 5 percent and 5.5 percent. The Optimum Bitumen Content (OBC) was found out using Marshall test. Plastic modified mix specimens with plastic contents of 2 percent, 3 percent, 5 percent and 7 percent by weight of bitumen were prepared through dry process by adding plastic to heated aggregates.

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Marshall test was conducted on plastic modified mix specimens to find out the Optimum Plastic Content. The aggregates were then coated with this optimum plastic content and aggregate tests were repeated for comparing its properties with normal aggregates. Creep test and Indirect tensile stiffness modulus tests were conducted on both normal mix and plastic modified mix.

III. ANALYSIS AND RESULTS

A. Normal Mix

Marshall test was conducted on three normal mix specimens prepared with bitumen contents of 4.5 percent, 5 percent and 5.5 percent respectively. Various Marshall parameters computed are shown in Table I and Fig. 1 to Fig. 6.

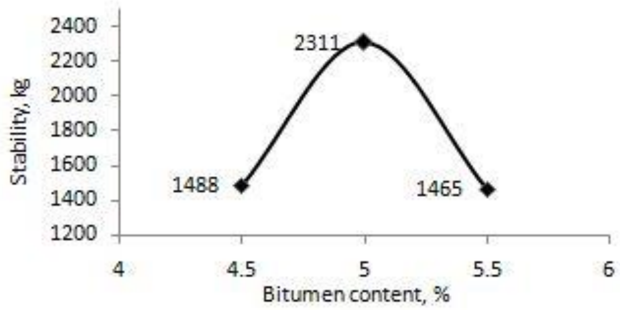

Fig. 1 Variation of Stability with Bitumen Content

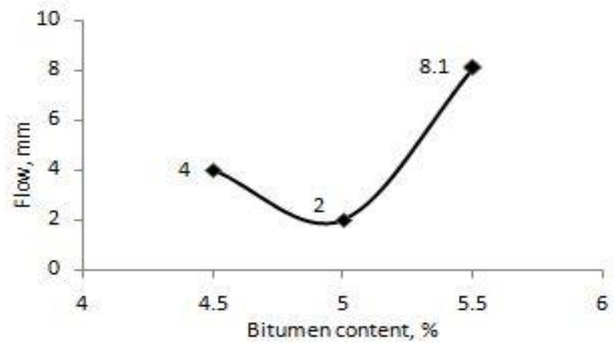

Fig. 2 Variation of Flow with Bitumen Content

Table I Marshall Parameters for Normal Mix Specimens

Bitumen Content (%)	Stability (kg)	Flow (mm)	Unit weight (g/cc)	Air voids (%)	VMA (%)	VFB (%)
4.5	1488	4	2.334	4.966	15.47	67.901
5	2311	2	2.343	3.433	15.149	77.338
5.5	1465	8.1	2.341	2.371	15.244	84.446

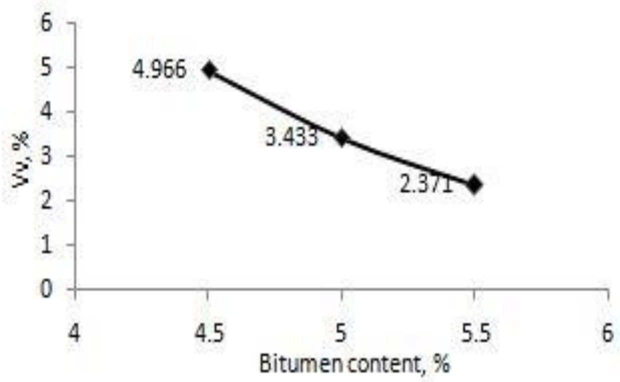

Fig. 3 Variation of Air Voids with Bitumen Content

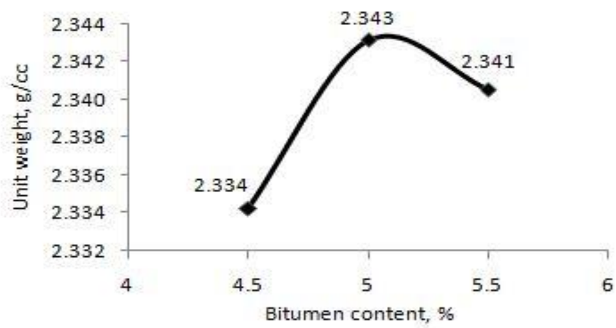

Fig. 4 Variation of Unit Weight with Bitumen Content

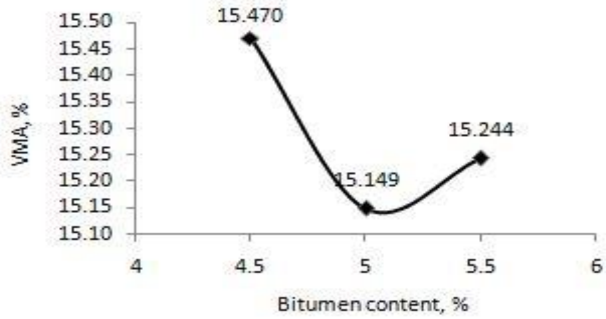

Fig. 5 Variation of VMA with Bitumen Content

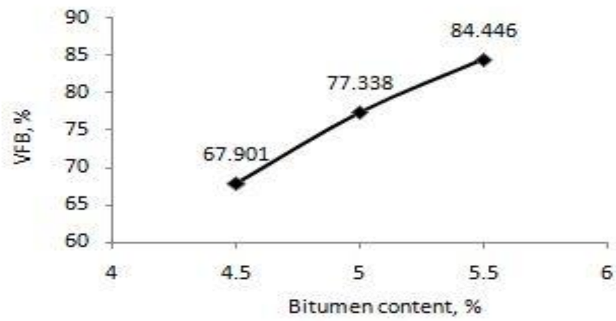

Fig. 6 Variation of VFB with Bitumen Content

From the figures, the optimum bitumen content was obtained as 5 percent.

B. Plastic Modified Mix

Marshall test was conducted on four plastic modified mix specimens prepared with varying plastic contents of 2 percent, 3 percent, 5 percent and 7 percent respectively. Various Marshall parameters computed for plastic modified mix are shown in Table II and Fig. 7 to Fig. 12.

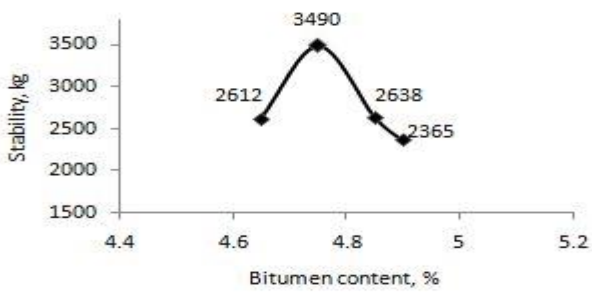

Fig. 7. Variation of stability with bitumen content (Plastic modified)

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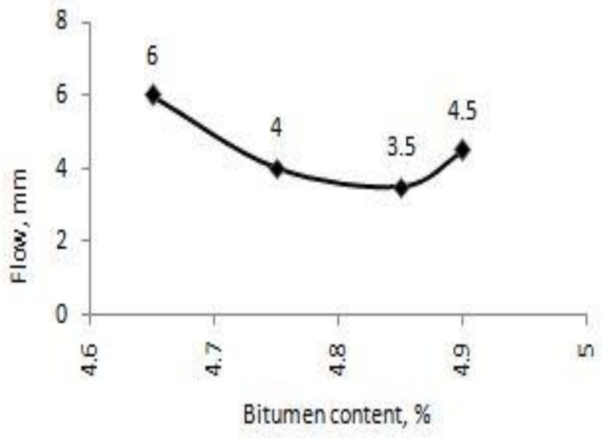

Fig. 8 Variation of Flow with Bitumen Content (Plastic Modified)

Table II Marshall Parameters for Plastic Modified Mix Specimens

Plastic Content (%)	Stability (kg)	Flow (mm)	Unit weight (g/cc)	Air voids (%)	VMA (%)	VFB (%)
2	2365	4.5	2.303	3.755	16.602	67.971
3	2638	3.5	2.305	4.078	16.530	67.631
5	3490	4.0	2.309	5.212	16.385	66.938
7	2612	6.0	2.303	6.220	16.602	64.503

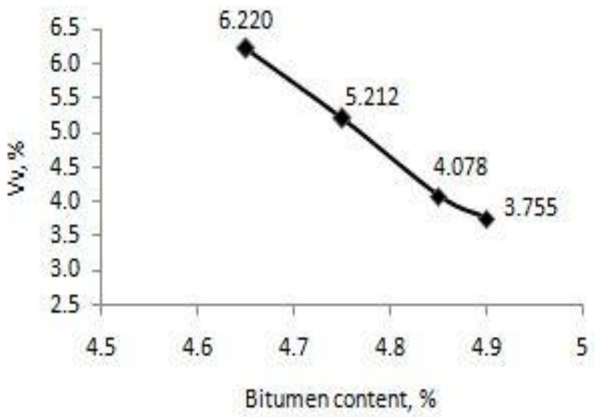

Fig. 9 Variation of Air Voids with Bitumen Content (Plastic Modified)

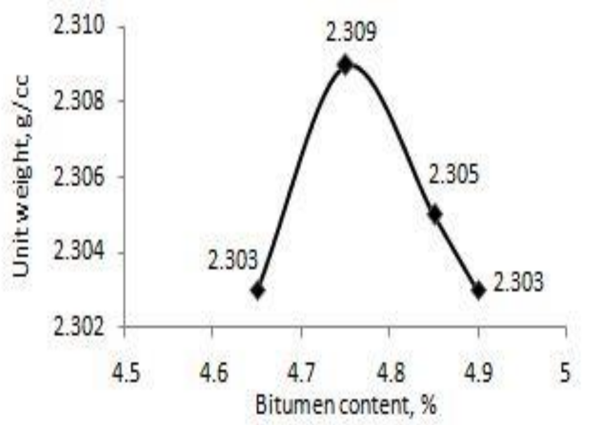

Fig. 10 Variation of Unit Weight with Bitumen Content (Plastic Modified)

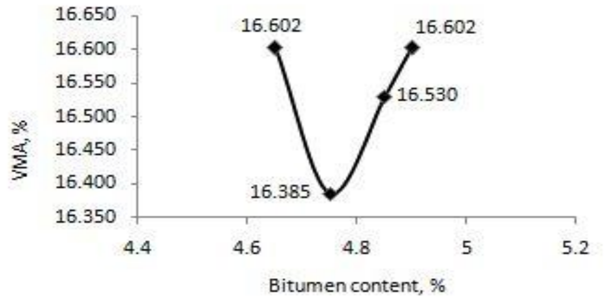

Fig. 11 Variation of VMA with Bitumen Content (Plastic Modified)

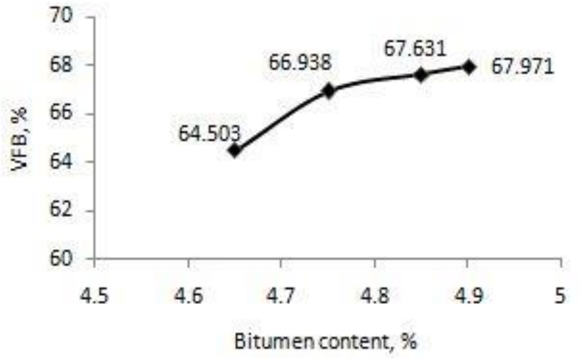

Fig. 12 Variation of VFB with Bitumen Content (Plastic Modified)

From the figures, the optimum plastic content was obtained as 5 percent. Static creep test and Indirect tensile stiffness modulus test was conducted on normal mix and plastic modified mix specimens. The results of creep test are shown in Fig. 13.

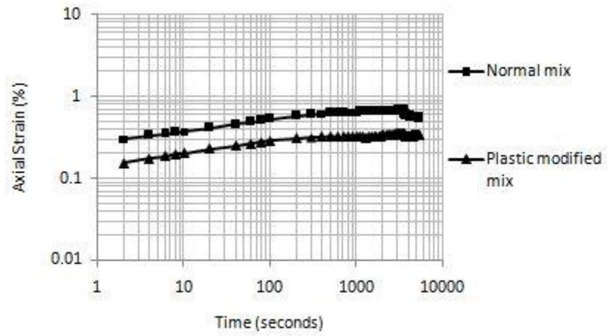

Fig. 13 Axial Strain of Normal and Plastic Modified Mix

The percentage permanent strain obtained for normal and plastic modified mix specimens are 0.54 and 0.33 respectively. The results of Indirect Tensile Stiffness Modulus (ITSM) test are tabulated in Table III.

Table III Indirect Tensile Stiffness Modulus of the Specimens

Type of mix	Tensile Stiffness Modulus (MPa)	
	Along Diameter 1	Along Diameter 2
Normal	1209	338
Plastic modified	1375	912

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It is observed that the plastic modified mix has higher tensile stiffness modulus value than the normal mix.

C. Plastic Coated Aggregates (PCA)

Aggregates coated with 5 percent plastic were tested for various properties and are shown in Table IV.

Table IV Properties of Aggregates

Property	Without Plastic	Plastic Coated	IRC Specification
Aggregate crushing value (%)	23.30	17.00	< 30
Aggregate impact value (%)	20.00	16.00	< 30
Los Angeles abrasion value (%)	25.00	23.00	< 35
Specific gravity – 19mm aggregate	2.76	2.76	2.5-3.0
Specific gravity – 13mm aggregate	2.77	2.77	2.5-3.0
Specific gravity – 9.5mm aggregate	2.83	2.83	2.5-3.0
Water absorption – 19mm aggregate (%)	0.60	0.00	< 2
Water absorption – 13mm aggregate (%)	0.40	0.00	< 2
Water absorption – 9.5mm aggregate (%)	0.50	0.00	< 2

All the properties of aggregates were found to satisfy the specified limits. It is seen that the aggregate crushing value was reduced by 27 percent on coating the aggregates with plastic. The aggregate impact value showed a percentage reduction of 17.7 on coating. Los Angeles abrasion value of plastic coated aggregates was found to reduce by 8 percent. Water absorption of plastic coated aggregates is 0 percent. It can be seen from the test results that the properties of aggregates were desirably improved by coating them with plastic.

IV. CONCLUSIONS

The following conclusions are drawn from the study:

- Optimum plastic content was obtained as 5 percent by weight of bitumen.
- The Marshall stability value of plastic modified mix was found to be 51 percent more than that for the normal mix which indicates an increase in load carrying capacity.
- It was observed that the aggregate crushing value was reduced by 27 percent on coating the aggregates with plastic. This implies that the crushed fraction will be lower when the plastic coated aggregates are subjected to loads.
- The aggregate impact value showed a percentage reduction of 17.7 on coating. This means that the plastic coated aggregates have better impact resistance.
- Los Angeles abrasion value of plastic coated aggregates was found to reduce by 8 percent indicating that these aggregates have superior abrasion resistance compared to normal aggregates.
- The permanent strain was reduced by 0.21 percent for plastic modified mix.
- The average tensile stiffness modulus value of plastic modified mix is found to increase by 47.8 percent than the normal mix which indicates an increase in the tensile strength.

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 off judiciously by incorporating it in bituminous mixes.

REFERENCES

[1] Vidula Swami, J. Abhijeet, and P. Karan, "Use of waste plastic in the construction of bituminous road", *International Journal of Engineering Science and Technology*, vol. 4, Issue 5, 2012, pp. 1-5.

[2] S. K. Sultana and K. S. B. Prasad, "Utilization of waste plastic as a strength modifier in surface course of flexible and rigid pavements", *International Journal of Engineering Research and Applications*, vol. 2, Issue 4, 2012, pp. 1185-1191.

[3] A. Gawande, G. Zamare and V. C. Renge, "An overview on waste plastic utilization in asphalting of roads", *Journal of Engineering Research and Studies*, vol. 3, Issue 2, 2012, pp. 1-5.

[4] R. Vasudevan, A. Ramalinga Chandra Sekar, Sundarakannan, and R. Velkennedy, "A technique to dispose waste plastics in an eco friendly way - Application in construction of flexible pavements", *Construction and Building Materials Journal*, vol. 28, Issue 7, 2011, pp. 311-320.

[5] C. S. Bindu and K. S. Beena, "Waste plastic as a stabilizing additive in stone mastic asphalt", *International Journal of Engineering and Technology*, vol. 2, Issue 6, 2010, pp. 379-387.

[6] K. K. Babu and A. K. Raji, "Utilization of marginal materials as an ingredient in bituminous mixes", *Highway Research Record No. 36, Indian Roads Congress*, 2007, pp. 42-43.

[7] A. K. Raji, K. K. Babu and G. Sreekala, "Use of certain industrial solid wastes in Flexible pavement construction", *Proc. XXI Kerala Science Congress, Kollam*, 2009, pp. 276-278.

[8] A. K. Raji, K. K. Babu and G. Sreekala, "Utilisation of medical plastic wastes in bituminous pavement", *Proc. XXI Kerala Science Congress, Kollam, 2009*, pp. 325-327.

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