EXPLORING THE USE OF RECYCLED WASTE PLASTIC BOTTLES IN ASPHALTING ROAD

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Abstract : The problem of disposal of plastic waste has increased day by day due to lots of households, commercialization and industrialization. Plastic waste has toxic pollutants that damage environment and cause land, water and air pollution. Plastic waste generally consists of carry bags, PET bottles, and disposal cups. Plastic is good binder, durable and non-degradable showing properties related to bitumen, so plastic waste can be used as partial replacement for bitumen in asphalting road. Most of roads constructed are asphalting road because of easily available bitumen and its maintenance. The problems challenged by roads are bad riding, poor geometrics and inadequate pavement thickness. Traffic is another problem faced by roads because of rapid rise in ownership of vehicles and industrialization. Due to these lots of pot holes created on roads. The objective of this research paper is to use waste plastic bottles in shredded form as partial replacement for bitumen in asphalting road to increase its strength. Shredded waste plastic bottles of size 2-3 mm are mixed with hot aggregates at 160-1800 C to coat over aggregates effectively. Waste plastic bottles of 7.5% by weight of bitumen gives higher Marshall Stability value i.e. 18.02 KN than bitumen content. Plastic-coated aggregates are not only beneficial for environment but also cost saving construction materials.

Keywords **– Recycling, Plastic Bottles, Asphalting Road, Plastic-coated Aggregates.**

1. INTRODUCTION

The major problem faced in India is disposal of waste plastic bottles. In India, plastic waste generation is 25940 tonnes per day which is huge amount [1]. Out of 25940 tonnes, plastic waste generated in Mumbai is 408 tonnes per day which is 4th largest plastic generation city in India [1].

Plastic waste generally consists of carry bags, PET bottles, and disposal cups. In India now-a-days plastic wastes is very tremendous problem occur. Plastic waste has toxic pollutants that damage environment and cause land, water, and air pollution thousands of years. Plastic waste has toxic pollutants that damage environment and cause land, water, and air pollution thousands of years. Plastic is good binder, durable and non-degradable material causing lots of pollution in environment. Due rapidly growing population, land becomes more valuable, and it will become more difficult to find place for garbage. Plastic waste use in road construction is not new for people. When plastic added to hot aggregates it makes thin coat over aggregate and laid as normal tar road. So, solution of above is use of waste plastic in flexible road as partial replacement for bitumen. There are lots of experiments done on plastic waste for reuse. Various literature showed that when plastic added to hot aggregates its coated over aggregate and binds them together and shows good strength.

Many research works have been done on use of waste plastic in flexible pavement [2,3]. When waste plastic mixed with hot aggregates at high temperature, it makes thin coat over aggregates which are used as best construction materials [4,5]. Recycling of PET in asphalt concrete as replacement for aggregates in flexible pavement helps to reduce environmental problems and save energy [6] and also improves mechanical and volumetric properties of bituminous mixture [7]. When waste plastic used as stabilizing additive, it shows positive effects on stone mastic asphalt [8,9]. Waste plastic in municipal solid waste (MSW) is increasing due to increase in population, development activities and change in lifecycle therefore, author developed new techniques to use plastic waste for construction purpose of roads and flexible pavements [10].

Waste plastic such as carry bags, cups and PET bottles economically and eco-friendly way in asphalt pavement to reduce quantity of bitumen used which helps to reduce pot-holes, corrugation and ruts [11]. Disposal of waste plastic mainly bags, cups, foams and films are generally made up of poly-ethylene (PE), poly-propylene (PP) and poly-styrene (PS) when added in bituminous mix it increases strength of flexible pavement plastic mixed with hot aggregates it makes thin coat over aggregates which is best raw material for flexible pavement [12]. When bio-medical plastic waste (syringe) when added into bitumen, it gives better properties as compared to normal mix [13]. So many tests conducted on aggregates, bitumen, plastic coated aggregates and modified plastic bitumen as per standard codes [14-17].

2. PROBLEM STATEMENT

The major problem facing in world is environmental pollution. One of the reasons for environmental pollution is waste plastic. Plastic waste generation has been increased day by day. Plastics are durable which last long time on earth surface which needs lots of landfills. Due rapidly growing population, land becomes more valuable and it will become more difficult to find place for disposal of plastic waste. Plastic waste can take up more than 1000 years to decay completely. Plastic is good binder, non-degradable and shows properties related to bitumen, so waste plastic can be used as partial replacement for bitumen into asphalting road.

This research work proposes to identify effectiveness of waste plastic into asphalting road.

3. AIMS AND OBJECTIVES

The aim of this study is to check the probability of waste plastic bottles as partial replacement for bitumen in flexible pavement. The primary objective of this work is to evaluate effect of waste plastic modified bitumen on quality of road. To ensure

protection of environment through effective plastic waste management. To identify potential environmental impacts from generation of waste plastic. To spread awareness about reuse of plastic waste

4. MATERIALS

4.1Aggregates

Aggregates was obtained from a local Quarry at Kundewahal in Panvel. The physical properties of aggregates are given in Table 1 and Table 2 shows the recommended gradation limits for roads.

Table 1 Physical properties of aggregates

Sr. No.	Properties	IS Code	Limit	Results
1.	Impact Value (%)	IS:2386 (P-4)	Max.24%	13.60
2.	Flakiness and Elongation index (%)	IS:2386 (P-1)	Max.35%	18.55
3.	Specific gravity			
	16-6 mm	IS:2386 (P-3)	-	2.741
	6-3 mm	IS:2386 (P-3)	-	2.712
	3-0 mm	IS:2386 (P-3)	-	2.663
4.	Water Absorption (%)			
	16-6 mm	IS:2386 (P-3)	Max. 2%	1.697
	6-3 mm	IS:2386 (P-3)	Max. 2%	1.767
	3-0 mm	IS:2386 (P-3)	-	2.298
5.	Water Sensitivity Test (%)	ASHTO-T-283	Min.80%	90.91

Table 2 Gradation of aggregates

IS Sieve size (mm)	Cumulative % by weight of aggregate (combined) passing	Specified Limits
19.0	100	100
13.2	94.98	95.0
9.50	79.76	79.0
4.75	61.78	62.0
2.36	52.52	50.0
1.18	40.84	41.0
0.60	32.95	32.0
0.3	24.40	23.0
0.15	16.90	16.0
0.075	6.48	7.0

4.2 Bitumen

The bitumen VG 30 penetration grade was obtained from local Refineries near Panvel which is used in this study.

Table 3 Gradation of aggregates

Properties	Results
Viscosity Grade	VG 30
Specific Gravity	0.97
Penetration at 25^0 C (mm)	64
Softening Point (^{0}C)	49

4.3 Waste Plastic Bottles

Plastic bottles are generally made of high-density polyethylene, low density polyethylene and polyethylene terephthalate. In this research study, water bottles were used which are made of polyethylene terephthalate (PET). Bottles were kept into hot water for 1hr, cleaned, dried and then shredded into size 2-3 mm manually. Specific Gravity of Waste plastic bottles = 1.25

Figure 1. Waste Plastic Bottles in Shredded Form

4.4 Plastic-coated Aggregates

The aggregates heated at 170-1800C for 2h. Waste plastic bottles of size 2-3mm added into hot aggregates and mixed for 5 minutes. Waste plastic bottles of 7.5% by weight of bitumen were used. Following test carried out on normal aggregates and plastic-coated aggregates [15]:

1. Los Angeles Abrasion Test
2. Impact Test

5. RESULTS AND DISCUSSION

5.1 Marshall Stability Test

The Marshall test is carried out to determined stability measure of the asphaltic pavement under load. The Marshall test has been standardized and has been designated as per ASTM D 6927-15. In Marshall Test, the maximum load at which test specimen fails is termed as stability. Pavement should have higher Marshall stability and lower Marshall flow value. Flexibility of pavement depends on the quality of binder used.

Two methods i.e. dry and wet processes are used to added additive for prepare sample for Marshall stability test. In wet process, additive i.e. waste plastic bottles are mixed with bitumen and then added to aggregates. While in dry process, additive i.e. waste plastic bottles are mixed with aggregates and then bitumen is added to mixture. In this research paper dry process was used to prepare sample.

Following procedure are followed to prepare sample:

1. Weight of bitumen content into mixture 5.87% by weight of total mix i.e. around 70gm [16]. The bitumen was heated to 1400C for 1 h before adding into aggregates.
2. Weight approximately 1130 gm of Aggregates and take into pan. Heated weight aggregates at 150-1800C for period of 2 h.
3. Add waste plastic bottles into hot aggregates at 150-1800C for around 5 min. Percentage of waste plastic bottles varies from 2.5% to 15% (2.5%, 5%, 7.5%, 10%, 12.5%, 15%) by weight of bitumen.
4. Add bitumen into mixture and mixed at 1600C for 5 min for better binding.
5. Sample prepare by using Marshall compaction mould. Gives 75 blows from each side of sample using Marshall hammer.
6. Test the samples as per guidelines given into ASTM D-6927-15 [17].

Table 4 shows value of Marshall stability, Marshall flow and Marshall quotient versus plastic content respectively. 7.5% of waste plastic bottles content by weight of bitumen gives higher Marshall stability i.e. 18.02kN which is higher than normal bitumen content. As percentage of waste plastic bottles increase, Marshall flow decreases up to 7.5% then after increases gradually.

Table 4 Test Results of Marshall Stability Test

Sr No	Bitumen Content (%)	Plastic Content (%)	Marshall Stability (KN)	Marshall Flow (mm)	Marshall Quotient (KN/mm)
1	5.87	0	14.24	2.6	5.47
2	5.87	2.5	14.89	4.0	3.72
3	5.87	5	16.45	3.5	4.7
4	5.87	7.5	18.02	3	6.00
5	5.87	10	16.45	3.6	4.57
6	5.87	12.5	13.58	4.0	3.4
7	5.87	15	12.01	4.5	2.66

5.2 Los Angeles Abrasion Test

The principle of Los Angeles Abrasion test is to produced abrasion action by use of steel balls which when mixed with aggregates and rotate in drum for specific number of revolutions which causes impact on aggregates. This test has been standardized and has been performed as per AASHTO T 96-2001. Road aggregates must be hard enough to resist abrasion action. This test is carried out on both normal aggregates and plastic-coated aggregates. Aggregates having less value of abrasion test shows high strength. Fig.2 shows values of los angeles abrasion test of normal aggregates and plastic-coated aggregates. As per results plastic-coated aggregates are more strong than normal aggregates.

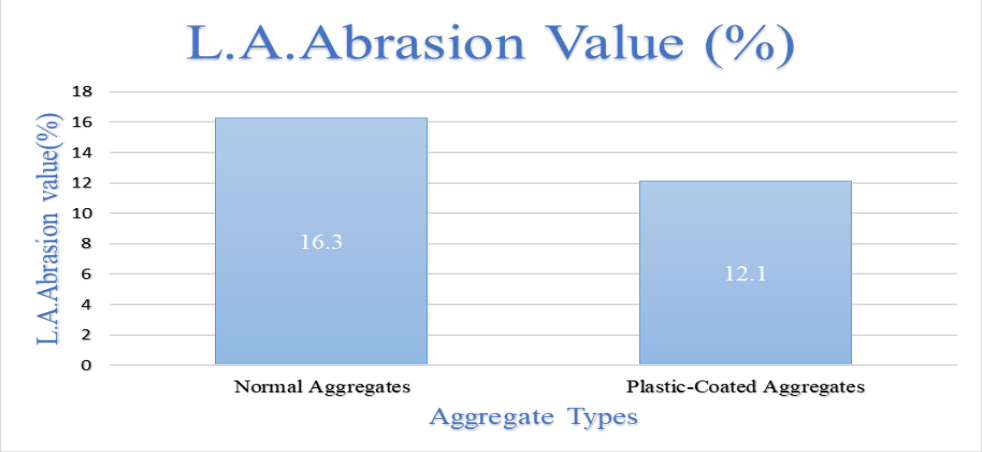

Figure. 2. Results of Los Angeles Abrasion Test

5.3 Impact Test

The Impact Test is to carried to measure resistance to sudden impact or shock, which may differ from its resistance to gradually applied compressive load. This test has been standardized and has been performed as per AASHTO T 96-2001. This test is carried out on both normal aggregates and plastic-coated aggregates. Lower the impact value higher is strength of aggregates. Fig.3 shows values of impact test of normal aggregates and plastic-coated aggregates. Plastic-coated aggregates resist impact better than normal aggregates.

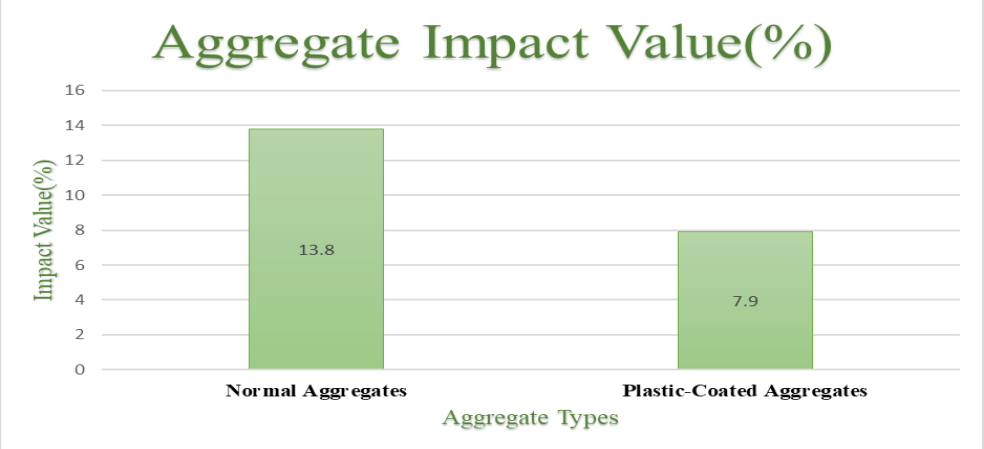

Figure 3. Results of Impact Test

6. Conclusion

The use of waste plastic bottles in flexible pavement helps to increase strength of pavement and reduces quantity of plastic wastes. Plastic-coated aggregates used as best construction materials which reduced waste plastic and saves bitumen up to 7.5%.

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