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Study On Utilization of Plastic Waste in the Construction of Flexible Pavement

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***Abstract*: Plastic waste is a common problem nowadays. Plastic waste material which we can reuse by certain processing and use in road construction. Plastic is a toxic and perpetual material. Disposal of waste plastic is a menace and become a serious problem globally due to their non-biodegradable and very harmful to human health's since they are not disposed scientifically and then create a ground and water pollution. Wrappers of betel nuts, chocolate, chips, handbags, cold drink bottles and all other forms of plastic create significant environmental and economic problem Temperature varying among 120°C – 160°C gives the softening point of these plastic. They do not produce any toxic gases during heating but the softened plastics have inclination to form a lamination or coating over the aggregate, when it is sprayed over the hot aggregate at 160°C. A detailed study on the performance of these roads shows that the construction with PCA Bitumen mix is performing well. This process is eco-friendly and economical too. By this process a road of 1 Km length and 3.375M width of single lane can consumes 100000 carry bags and the road strength is improved by 100% and there found no any pot hole.**

***Keywords*: Waste plastics, Bitumen.**

1. Introduction

Most of the paved roads in our country have granular sub base and base and wearing course. Plastic is a very resourceful material. Due to the industrial revolution, and its large scale production plastic seemed to be an in expensive and nominal raw material. Today, every dynamic sector of the economic starting from agriculture to packaging, automobile, electronics, electrical, building construction, and communication sector has been practically reformed by the applications of plastics. Plastic is a non-biodegradable material and researchers found that the material can sustain on earth for 4500 years without degradation. Several studies have proven the health risk caused by unsuitable dumping of plastic waste. Disposal of a selection of plastic & rubber wastes in an eco-friendly way is the drive area of today's research. Looking forward the scenario of current lifestyle a whole prohibition on the use of plastic cannot be put, although the waste plastic in roads construction is gaining importance these days because plastic roads improve better than normal ones and the plastic waste considered to a pollution hazard, can find its use. The use of waste plastic for coating the aggregate of the bituminous mix found to improve its performance characteristics. Recycled polythene carry bags were shredded into small sizes (4.75mm & 2.36mm) and is coated on aggregates of the mix at a specified temperature. Bituminous mixes were prepared with VG-30 bitumen and plastic coated aggregates/ordinary aggregate with cement as a filler material. The use of plastic waste help in substantially improving the abrasion and slip resistance of flexible pavement and also permits to achieve values of splitting tensile strength fulfilled the specified the specific limits while plastic waste content is beyond 30% by weight of mix. This all should be occupied in awareness while mixing and laying of roads is to be done using plastic waste. The plastic road would be a benefit for India. In hot and extremely humid climate durable and eco-friendly plastic roads are of greater advantages. These will also relief in releasing the earth from all type of plastic waste.

A. Objectives of use of waste plastic

Today the availability of the waste plastics is enormous, as the plastic materials have become part and parcel of daily life. They either get mixed with Municipal Solid Waste and/or thrown over land area. If not recycled, their present disposal is either by land filling or by incineration. Both the processes have certain impact on the environment. Under this circumstance, an alternate use for the waste plastics is also the needed. Plastic waste when mixed with hot bitumen, plastics melt to form an oily coat over the aggregate and the mixture is laid on the road surface like a normal tar road.

In the construction of flexible pavements, bitumen plays the role of binding the aggregate. It also helps to improve the strength of the road. But its resistance towards water is poor. Anti-stripping agents are being used. A common method to improve the quality of bitumen is by modifying the rheological properties of bitumen by blending with organic synthetic polymers like rubber and plastics. Studies on this subject are going on both at national and international level. This Concept of Utilization of Waste Plastic in Bituminous Mixes for Road Construction has been done since 2000 in India, they can return to the earth as beneficial additives in bitumen roads.

2. Characterization of Materials and Methodology

A. *Characterization of aggregates*

Aggregates used in the study are collected from a quarry near Ramasandra, Bangalore.

B. *Characterization of bitumen*

VG-30 bitumen obtained from KTR Asphalt plant Ramasandra, Bangalore.

C. *Characterization of waste plastic*

The source of the Waste plastic is from Waste plastic recycling at Mathur, Tamilnadu. This Waste plastic is tested for its physical and chemical properties.

Table 3
Physical Properties of waste Plastic (PET)

Properties	Results obtained
Specific gravity	1.03
Melting point ℃	250-260
Sieve analysis	Passing 4.75 mm sieve retained on 2.36 mm sieve

3. Marshall Stability Test for Bitumen

The details are shown in table 4.

4. Results and Discussion

A. *Tests on bitumen with waste plastic replacement*

1) *Penetration Value*

Table 5
Bitumen Penetration Value

Penetration dial reading	0% plastic	5% plastic	10% plastic	15% plastic
Initial reading	0	0	0	0
final reading	50	62.1	57	48
Penetration Value (mm)	50	62.1	57	48

Recommended values:

IRC suggests bitumen grades 30/40, 60/70, 80/100. In warmer regions, lower penetration grades are preferred to avoid softening whereas higher penetration grades like 180/200 are used in colder regions to prevent the occurrence of excessive brittleness.

2) *Ductility Value*

Table 6
Bitumen ductility value

Ductility reading	0% plastic	5% plastic	10% plastic	15% plastic
Initial reading	0	0	0	0
final reading	80	92	75	61
Ductility Value (cm)	80	92	75	61

Recommended values:

Suitability of bitumen is judged depending on its type and proposed use. Bitumen with low ductility value may get cracked especially in cold weather. Minimum values of ductility specified by ISI for various grades are as follows.

Table 1
Physical Properties of Aggregates

S. no.	Test	Result	Specifications as per MORTH	Reference
1	Aggregate impact value test	23.80	Max 24%	IS:2386 Part 4
2	Aggregate Crushing value test	27.5	Max 30%	IS:2386 part 4
3	Los Angeles abrasion test	28.2	Max 30%	IS:2386 part 4
4	Water absorption	0.40	Max 2%	IS:2386 part 3
5	Specific gravity 20mm down 10mm down	 2.68 2.71	--------	IS:2386 part 3

Table 2
Physical Properties of Binder

S. No.	Properties	Result	Specifications	Reference
1	Penetration test (mm)	50mm	45(min)	IS 73-2006
2	Softening point (ºc)	54.35°	min 47º c	IS 73-2006
3	Ductility test (cm)	80cm	Min 75	IS 73-2006
4	Specific gravity at 25ºc	1.025	0.97 -1.02	IS 73-2006
5	Flash and Fire point test (°c)	272° c 300° c	Min 220º c Min 270º c	IS 73-2006

Table 4
Characteristic values at different Bitumen Content

Mould No.	Bitumen Content (%)	Stability (Kg)	Average Stability (kg)	Flow Value (mm)	Avg. Flow Value (mm)
1 2 3	4.25%	822 931.6 712.4	822	2.8 3 3	2.93
4 5 6	4.5%	822 1013.8 1013.8	949.87	4 2.4 3.1	3.26
7 8 9	4.75%	685 808.3 863.1	785.67	3.2 3.4 3.2	3.17

Table 7
Ductility recommended values

Source of paving bitumen and penetration grade		Min ductility value (cms)
Assam Petroleum	A25	5
	A35	10
	A45	12
A65, A90 & A200		15
Bitumen from sources other than Assam Petroleum S35		50
S45, S65 & S90		75

3) Softening Point Value

Table 8
Bitumen Softening point value

Softening Point reading	**0% plastic**	**5% plastic**	**10% plastic**	**15% plastic**
Temperature when the ball touches bottom (°C)	54.35	49	52	58

Recommended values:

Softening point indicates the temperature at which binders possess the same viscosity. Softening point has particular significance for materials to be used as joint and crack fillers. Higher softening point ensures that they will not flow during service. Higher the softening point, lesser the temperature susceptibility. Bitumen with higher softening point is preferred in warmer places.

B. Bitumen with waste plastic replacement test results comparison

Table 9
Bitumen test results comparison

Bitumen	**Plastic Content**	**Penetration Value**	**Ductility**	**Softening Point**
100	0%	50	80	54.35
95	5%	62.1	92	49
90	10%	57	75	52
85	15%	48	61	58

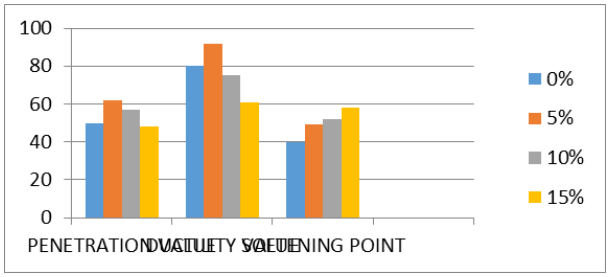

Fig. 1. Graphical representation of test results of bitumen after replacement of waste plastics

C. Marshall stability test for bitumen with replacement of waste plastic

Table 10
Characteristic values at different waste plastic replacement with bitumen content

Mould No.	**Bitumen Content (%)**	**Plastic Content (% by weight)**	**Marshal Stability (kg)**	**Flow Value (mm)**
1	4.50%	0	950	3.6
2		5	1635	3.9
3		10	1710	4.6
4		15	1753	4.85

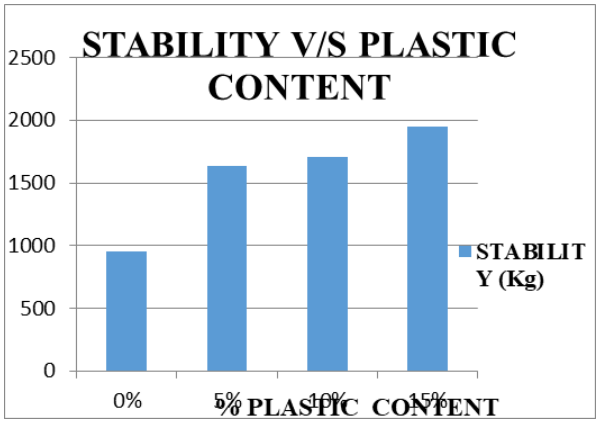

Fig. 2. %plastic in bitumen and stability (kg)

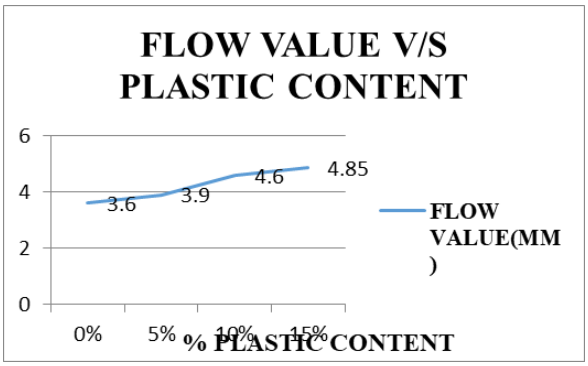

Fig. 3. %plastic in bitumen and Flow value (mm)

5. Conclusion

The aim of the study was to utilize the waste materials i.e. PET wastes for mass scale utilization such as in highway construction in an environmentally safe manner.

- Properties of Bitumen can be further improved by use of waste plastic.
- Use of waste plastic reduces the cost of the bitumen because of replacing the percentage of bitumen by waste plastic and we know that waste plastic disposal is a big problem in the world.
- Use of waste plastic 5% by weight of aggregate significantly improve the volumetric properties of bituminous mixes resulting better performance of BC with plastic waste than control mix (without plastic waste).
- Use of waste plastic 10% by weight of bitumen significantly increases the melting point of the bitumen.
- It is observed that the Marshal Stability value is maximum at 5% of bitumen for PET modified bitumen and It is observed that it gives good results at 8% and 10 % of PET modified bitumen for PET.

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