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Construction of Bituminous Road Using Plastic Waste

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ABSTRACT: The waste plastic and its disposal is a major problem to the environment, which results in pollution and global warming. The utilization of plastic waste in bituminous mixes enhances its properties and also its strength, durability, life. It will also be a best solution for plastic waste disposal & various defects in pavement i.e., pot holes on roads, corrugation etc. the types of waste plastic used are poly-ethylene, polypropylene. The waste plastic is shredded & coated over aggregate & mixed with hot bitumen and resulted plastic-bitumen mix is used for pavement construction. This will not only strengthen the pavement and also increases its durability & strength, life of the pavement/road. This new technology will be beneficial for Indian hot-humid climate. It's economical and eco-friendly. In this paper, we have discussed about the soil properties to be considered in design of flexible bituminous pavement, pavement design, and process of construction flexible. The plastic wastes could be used in road construction and the field tests reduce the stress and proved that the plastic wastes used after proper processing as an additive would enhance the life of the roads and find out solution on environmental problems. After addition of plastic, then melting point of bitumen will increase.

KEYWORDS: Plastic waste, aggregate, flexible bituminous pavement, strength.

I. INTRODUCTION

Plastic waste is commonly seen around the country and has started causing several problems to the environment. Plastic waste bags clog drains causing floods. It chokes animals who eat plastic bags, etc. Plastics found in fields blocks germination and prevent rainwater absorption & creates problem for draining rainwater.

According to recent studies, plastics can stay unchanged for as long as 5000 years on earth with increase in the global population and the rising demand for food and other needs, there has been a rise in the amount of waste being generated daily by each household. Plastic in different forms is found to be almost 5% in municipal solid waste, which is hazardous in nature. It is a appearing frequently in both urban and rural areas to find empty plastic bags and other type of plastic packing material trashing the roads as well as drains. Due to its biodegradability, it creates clog of water and associated hygiene problems.

By the turn of the century, light was thrown on to reduce the use of plastic and control the waste it was generating. At the same time, one evening, Prof. Vasudevan saw a doctor on a TV program. They said that plastic 'dissolved' in water bodies caused pollution.

A Government order in November 2015 has made it compulsory for all road developers in the country to use waste plastic, along with bituminous mixes, for road construction. This is to help reduce the growing problem of plastic waste disposal in India. The technology for this was developed by, Prof Rajagopalan Vasudevan, Professor of Chemistry at Thiagarajar College of Engineering, Madurai. Who was known as 'Plastic Man of India'.

Plastic roads consist of 8-10 per cent plastic, while 90-92 per cent is bitumen. Union minister Nitin Gadkari had declared the usage of plastic waste in road construction in 2016. Since then, plastic waste has been used in constructing one lakh kilometre of road in 11 states in India.

The plastic waste material is first shredded & cut into to a particular size using a shredding machine. The plastic waste coated aggregate is mixed with hot bitumen and the resulting mix is used for road construction. The road laying temperature is between 120°c to 130°c.It is important to monitor the temperature during heating. The pulverised plastic waste is then added to the aggregate. It gets coated uniformly over the

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aggregate within 30 to 60 seconds, giving an oily look & appearance. The plastic waste coated aggregate is mixed with hot bitumen and the resulting mix is used for road construction. The roller used has a capacity of 8 tons.

As the roads wear and tear down the years, the plastic waste particles break down into micro-plastics and get mixed with the soil and water, polluting them. Only polypropylene (PP), polystyrene (PS) and polyethylene (PE) polymers are suggested to use for road construction.

II. LITERATURE REVIEW

Athira R Prasad et. al. (2015) According to author, the bitumen which is conventional material used in the road construction can be partially replaced by the waste plastic and rubber. They added rubber and PET in 3%, 4.5%, 6%, 7.5% and 8% in bitumen and found that the optimum content was obtained at 6%. Thus, accordingto their study, the use of plastic in 6% by weight of bitumen improves the pavement stability and he found that the use of PET bottle is best. Therefore, the disposal of rubber and PET is best in the road construction.

Sasane Neha B. et. al. (2015) Author investigated that the addition of plastic is the innovative technology which strengthen the road construction and also increases the life of road. According to marshal stability test the optimum use of plastic is up to 10%.

S. Rajasekaran et. al. (2013) Author explains that, by coating the aggregate with the polymer has many advantages and which ultimately helps in improving the flexible pavement quality not only it improves the pavement quality but also improve the aggregate quality. This technology also helps in the disposal of waste plastic obtained from the domestic and industrial packing materials. The dry process is more valuable as it disposes the 80 % of waste polymer in eco-friendly way. And use of polymer reduces the equivalent bitumen quantity and therefore reducing the construction costof road.

Amit Gawandeet al. (2018) Summarized an overview on waste plastic utilization in asphalting of roads. They reviewed techniques to use plastic waste for construction purpose of roads and flexible pavements.

Vikas R. Agarwal et. al. (2016) Author stated that by proper usage of waste plastic in hot bitumen mix improves pavement performance. Here Bitumen modifier is found to be less affinity towards water and less stripping. It is concluded that use of higher percentage of plastic reduces Bitumen percentage by 10 and also improves strength.

Sultana et. al. (2012) Investigated the utilization of waste plastic as a strength modifier in surface course of flexible and rigid pavements and concluded that the optimum use of waste plastic as a modifier in pavement gives good strength.

III. METHODOLOGY

Waste plastic bags were collected from roads, garbage trucks, dumpsites and compost plants, waste-buyers at Rs.5-6 per kg. Household plastic was also collected for the project work, like empty milk bags, used plastic bags etc. The collected Plastic waste was sorted as per the required thickness. Generally, polyethylene of 60 micron or below is used for the further process. Less micron plastic is easily mixable in the bitumen at higher temperature (160°c-170°c). It is clean by de-dusting or washing if required. Collected Plastic was cut into fine pieces as far as possible. The plastic pieces were sieved through 4.75mm sieve and retaining at 2.36mm sieve was collected. Firstly, Bitumen was heated up to the temperature about 160°c-170°c which is its melting temp. Pieces were added slowly to the hot bitumen of temperature around 160-170°c. The mixture was stirred manually for about 20-30 minutes. In that time period, temperature was kept constant about 160-170°c. Polymer bitumen mixtures of different compositions were prepared and used for carrying out tests.

TESTING OF MATERIALS:

1. **Tests to be performed on Aggregate:**

a) Aggregate impact value test
b) Los Angeles abrasion test
c) Water absorption test
d) Flakiness Index and Elongation Index test
e) Crushing value test

2. Tests to be performed on Bitumen:

a) Penetration value test
b) Ductility test
c) Flash & fire point test
d) Softening point test

3. Marshall Stability Test

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IV. RESULTS AND DISCUSSION

1. Tests on Aggregate (Table No. 1)

Stone Aggregate	Plastic Content (%)	Aggregate Impact Value	Los Angeles Abrasion Test	Water Absorption Test	Flakiness Index Test	Elongation Index Test	Crushing Value Test
Without Plastic	0	23.12%	29.21%	1.1%	10.18%	9.33%	24.32%
With Plastic	3	22.49%	27.63%	1.09%	10.19%	9.38%	22.26%
	5	22.26%	26.01%	1.2%	10.04%	9.35%	21.86%
	7	21.88%	25.84%	1.1%	9.95%	9.45%	21.64%
	9	21.78%	25.98%	1.2%	`10.19%	9,51%	21.47%

2. Tests on Bitumen (Table No. 2)

Bitumen + Aggregate + Plastic	Plastic Content (%)	Penetration Value Test	Ductility Test	Flash and Fire Point Test	Softening Point Test
Without Plastic	0	37.33 mm	65.33 cm	243 °C	56.67 °C
With Plastic	3	37.67 mm	69.33 cm	254 °C	58.33 °C
	5	35.33 mm	72.47 cm	261 °C	58.67 °C
	7	34.67 mm	74.93 cm	269 °C	60 °C
	9	32.67 mm	75 cm	272 °C	62.67 C

3. Marshall Stability Test (Table No. 3)

Bitumen + Aggregate + Plastic	Plastic Content (%)	Marshall Stability (kg)
Without Plastic	0	1146.93
With Plastic	3	1195.21
	5	1237
	7	1274
	9	1306.57

4. Marshall Stability in Kg and % variation (Fig. 1)

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1. The aggregate impact value of plastic-coated aggregates was reduced than the normal aggregates. As the impact value decreases, toughness of aggregate increases. (Table No. 1)
2. The crushing value of reduces from 24.32% to 21.47% for normal and plastic-coated aggregates. Lower the aggregate crushing value higher the strength of the aggregate. (Table No. 1)
3. The abrasion value for plastic coated aggregates is less than the normal aggregates. This indicates that the plastic-coated aggregates are harder than normal aggregates. (Table No. 1)
4. In Penetration Test, it was observed that there was no difference in Penetration behaviour upto 5%, beyond 5% the penetration value decreases by 3-6% with increase of plastic by 2%. The Penetration value of bitumen is higher than the modified bitumen. (Table No. 2)
5. In Softening Point Test, it was observed that there was no difference in softening point behaviour upto 3%, beyond 3% the softening point increases by 2%-5% with increase of plastic by 2%. The bitumen softens more when replaced with plastic. (Table No. 2)
6. In Ductility Test, it was observed that there was no difference in ductility behaviour upto 3%, beyond 3% the ductility value increases by 2%-7% with increase of plastic by 2%. The polymer modified bitumen is more ductile than the normal bitumen. (Table No. 2)
7. Flash point and fire point gives a measure of the critical temperatures beyond which the bitumen should not be e xposed to. Thus, these critical temperatures help in preventing a hazardous situation. Flash and Fire point of plastic-coated bitumen increases as the increase in plastic %. (Table No. 2)

V. CASE STUDIES IN INDIA

In Tamil Nadu, length of streets around 1000 m in different stretches were developed utilizing waste plastic as an added substance in bituminous blend under the plan "1000 km Plastic Road", and tracked down that, the presentation of all the street extends are acceptable.

The presentation of the street extends developed utilizing waste plastic in Bangalore (Karnataka) are additionally discovered to be good. In excess of 2000 km have been laid up until this point.

In Delhi various test segments around 50 km were laid and the vast majority of them are performing great.

The plastic bitumen blend street built in Pune on Golibar Maidan is a solitary path street costing about Rs. 350/m^2.

VI. BENEFITS OF LAYING PLASTIC BITUMEN MIX ROADS

1. **Rural Roads-** 24.5 lakhs KM, if these roads are constructed as plastic tar roads, We need 24.5 lakhs tons of waste plastics. We forestall almost 75 lakh huge loads of Carbon Dioxide entering our atmosphere by consuming waste plastics. We save 24.5 lakhs huge loads of bitumen.
2. We save almost Rs. 12250 Crore worth of bitumen
3. No upkeep cost for a very long time.
4. Absolute waste plastics utilized for pressing material in India is around 20 lakhs tons as it were.
5. In a nut shell the Government provides not only good roads but also uses all the waste plastics and reduces carbon dioxide – bitumen usage.

VII. CONCLUSION

1. This innovation turns into a shelter to the climate as we are utilizing a great deal of trash which used to be unloaded or consumed prompting air, land and water contamination. This innovation without influencing the style customs and types of gear necessity serves a superior street for individuals nearby.
2. The hardware prerequisite of this street is like that of the normal street and henceforth no further expenses are consolidated. Accordingly, to develop the street no further preparing of the works for the treatment of new item is required.
3. The task shows the imaginative vision towards the foundation improvement of the country and thus makes certain to be generally acknowledged soon. Being in the trial stage it has shown superb outcomes and subsequently is should be acknowledged for the future tasks as well.
4. Accordingly, here we reason that the street will serve the residency of its development for the advancement of individuals living nearby the street. Furthermore, serve a decent property estimation for the future ventures proposed by the development offices sharing the course.

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