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Article Title: **Comparative Study on Bitumen Road and Plastic Bitumen Road by the Utilization of Plastic Waste in Flexible Pavements**

Comparative Study on Bitumen Road and Plastic Bitumen Road by the Utilization of Plastic Waste in Flexible Pavements

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ABSTRACT

Plastic waste generation and disposal significantly contribute to pollution and global warming. Plastics are not eco-friendly as they are non-biodegradable. The properties and strength of bituminous mixtures are enhanced by the inclusion of plastic waste. Moreover, it will be a solution for many other pavement issues like potholes, corrugation and so on. The waste plastic is crushed, coated with gravel, and joint with hot bitumen to produce a mix which is used to construct the roadway. Additionally one of the major advantages of using plastic in road construction which gives the high quality and provide longer lifespan for the pavement. In this paper, plastic wastes are used successfully in bituminous mixes to create flexible pavements as well as comparing the bituminous road with plastic bituminous road are evaluated in this work. There are two ways to include waste plastic into bituminous mixes: the Dry Method (DM) and the Wet Method (WM) are used in this work. The results indicate that waste modified bitumen mix gives good binding property, stability, density and more resistant to water.

Keywords: Plastic road, bituminous road, Dry process, Wet process.

1 Introduction

Road transportation has been the most popular option out of all the available modes of transportation because of its adaptability, door to door service, dependability, and quickness [1]. The biggest issue with highways is the presence of potholes and corrugation in all over the world [2]. To overcome this issues, plastic pavement is used in this work. Waste plastic integration into the building sector is such a method of recycling plastic. Additionally, it has been discovered that shredded plastic trash can be successfully included into a variety of concrete and bituminous mixes are use in the construction of roads. Because plastic roads work superior to conventional roads, the usage of plastic in pavement is becoming more and more important today. These method improves the infrastructure and are socially very relevant. The hot as well as extremely humid climate of India, where temperatures regularly exceed 50°C and torrential rains cause havoc and leave the majority of the roads with large potholes, would benefit greatly from plastic roads with marble chips [3-6]. Pavement damage is a widespread problem in India but the roads made of plastic are said to be more durable than conventional roads that can slow down the rate of deterioration [7]. Additionally, it is anticipated that the waste plastic bitumen mix creates superior pavement material because it exhibits a greater Marshall Stability value as well as a sufficient Marshall Coefficient [8]. In comparison to

cement-made paver blocks, plastic paver blocks have higher tensile strength, better water absorption, greater corrosion resistance, and better heat absorption [9]. The dry process is the most often employed method for building roads because the waste material utilised for construction has a low raw material cost [10].Waste polythene and PET bottle would be the main subjects of the inquiry. Eventually, field tests would be conducted to evaluate whether the waste-blended bituminous road performed in the real world.

2 Recent works

Santos et al. [2021] [11] offered an ecological perspective on the techniques which turn waste plastics into recycled plastic pellets which can be added to asphalt mixtures as an additive or utilized in place of natural aggregate (dry method). For a relative life cycle evaluation analysis, statistics from recycling facilities in Victoria, Australia, were gathered and used as the basis. The results indicates that recycled plastics have the potential to be more environmentally friendly than their virgin counterparts, namely virgin polymers or natural quarry aggregates.

Hema Latha et al. 2019 [12] have suggested the contrast between bitumen and plastic bitumen roads. The amount of plastic garbage in municipal solid waste is rising as a result as a rapidly expanding population and construction activities, which is causing widespread landscape littering. Using plastic materials not decompose biologically and are typically thrown out after usage. As a result, the trash is either burned or dumped. Currently, asphalt, which is made of bitumen and aggregate combined at a certain temperature, is used to pave the majority of Indian roadways. Different techniques for using plastic waste in the creation of flexible pavements and roadways have been analysed.

Filippo G. Pratico et al. [2020] [13] have proposed the recycled and low temperature materials are efficient ways to decrease the environmental burden caused by hot mix asphalts. A standard case involving the usage of conventional paving materials is used to evaluate and compare various pavement production, construction and maintenance conditions. To determine those stages and processes which have the biggest effects, an influence of each life-cycle phase on the total impacts is evaluated for every scenario under evaluation. According to the results, all the effect categories which were examined at, material production contributes between 60 and 70 percent. Additionally, less energy is consumed when warm mix asphalts and recycled materials are used in bituminous mixtures.

Luzana Brasileiro et al. [2019] [14] have suggested the increased usage of polymer modified binders in asphalt mixtures is a result of their better rutting or fatigue resistance as well as their decreased thermal susceptibility. However, its high price restricts their utilisation, thus making the utilization of recovered polymers an exciting alternative for lowering costs and increasing the useful life of pavements. Although further work is required to produce bitumen which is stable across the whole temperature range, chemicals like maleic anhydride are frequently used to increase the binder's stability and improve its features.

Ajay Dwivedi et al. [2017] [15] have proposed the rate of waste production has significantly increased over the past several decades in practically every region of the world. There are significant disposal issues as a result of the growing quantities of this waste. The rate of waste production has significantly increased as a result of population growth, industrialisation, consumerism and technological advancement. Additionally, each year, industries generate around 150 million tonnes of high volume, low hazard wastes, almost majority of which is dumped on exposed, low-lying ground. The basic techniques of waste disposal are found to be hilarious in this case.

3 Methodology

3.1 Plastic road

Plastic waste is blended into an asphalt mixture to create plastic highways. The use of plastic in roads produces a new occasion for post-consumer plastic recycling. Using waste plastic, 703 km of national highways in India have been construct. Specifications for the mandatory use of waste plastic in hot mix regular renewal or restoration road coatings on national highways. The Ministry of Road Transport and Highways has released land within 50 kilometres of urban centres having a population of more than 5 lakh. Utilizing waste plastic in road construction defends the environment from the damaging effects of plastic waste.

3.2 Procedure

Waste plastic is crumpled into a powder and combined in variable percentages with bitumen. The use of plastic extends the life of the road by raising the bitumen's melting point and making it flexible during winter. Brittleness is overcome as well as elastic nature is improved by mixing plastic with bitumen. Two important procedures are employed to create flexible bitumen mix pavement.

- Dry process
- Wet process

3.2.1 Dry process

Hot stone aggregate (170°C) and hot bitumen (160°C) are blended to form flexible roadways and the blend solution is utilised to lay roads. According to IS code, gravel is selected based on its strength, porosity and moisture absorption ability. The binding, penetration as well as viscous elastic properties of a bitumen are chosen on the basis of its binding property. The aggregate's quality in terms of voids, moisture absorption and soundness was increased by the application of plastic coating. Figure 1 illustrated the flow chart of dry process.

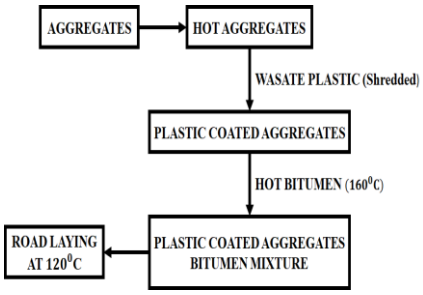

Figure 1: *Flow chart of dry process*

3.2.2 Wet process

These are the procedures used to create modified bitumen based on polymers. Waste polymer is combined effectively with bitumen and heated to a temperature of 1700°C to ensure proper mixture formation as well as waste polymer dispersion. After the hot mix has been formed, it is then cooled to a temperature of 1200°C and added to the aggregate in the paddling chamber. The mixture needs to cool down due to pouring hot mix over aggregate may cause gas bubbles to form in small aggregate gaps, which can damage rods and cause rutting in roadways. Movable material is compacted by an 8 tonne roller after modified bitumen has been added to aggregate at a temperature of 1100°C. Figure 2 depicts the flow chart of wet process.

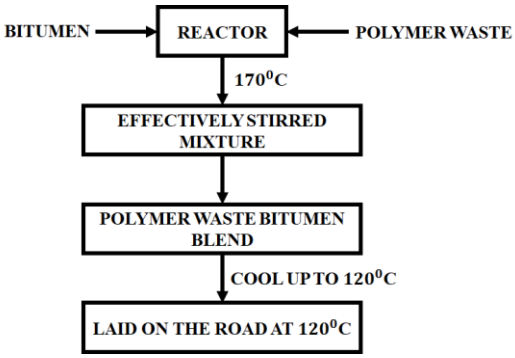

Figure 2: *Flow chart of wet process*

3.3 Bituminous road

The disposal of discarded plastic is a major ecological problem. The problems mentioned above will be better solution with plastic roadways. When a substance is solid in its completed state and comprises one or more organic polymers with a high molecular weight, it is referred to be plastic and can be shaped by using its flow. Plastic is high durable and degrades over time at a relatively slow rate. Plastic has a high level of degradation resistance as represented in Figure 3. The two primary categories of plastic are thermoplastics and thermoses. Thermosets are ideal for use in construction since they offer outstanding strength and durability due to their irreversible solidification when it heated. Plastic is a non-biodegradable trash which contributes

to the greenhouse effect and global warming. The effectiveness of recycling discarded plastic has been the focus of numerous studies.

Figure 3: *Plastic-bitumen road*

4 Result and discussion

Waste plastic are used in road construction to enhance its durability and flexibility. Several tests are made to calculate the strength of plastic coated aggregate and bitumen coated aggregate as illustrated in Table 1. As a results were compared and shown in the below table for the following process like dry & wet respectively.

Table 1: *Dry Process*

Type of Test	General Aggregate	Plastic Coated Aggregates	Bitumen Coated Aggregates
Abrasion Test	33.6%	27.2%	15%
Attrition Test	28%	8%	6%
Crushing Test	26.19%	20.63%	16%
Impact Test	22.104%	10.584%	5.6%
Specific Gravity Test	2.77	2.27	2
Water absorption test	1.8%	1.5%	0.8%

Table 2: *Wet Process*

Percentage of plastic	Ductility test	Penetration test	Softening point	Flash point	Fire point
0	103.5	68	50	290	340
2	62.8	56	51	294	340
4	39.6	45	56	313	346
6	31.6	31	63	329	350
8	20.5	20	69	327	342
10	9.1	18	70	295	310

4.1 Marshall Stability

The Marshall Stability values for the specimens are given below,

Table 3: *% of Plastic Content*

Content (%)	% of plastic content					
	0	2	4	6	8	10
4	1056	1371	1732	1862	1641	1104
4.5	1018	1524	1910	1961	1746	1614
5	1479	1797	1839	2024	2260	1944
5.5	1970	2050	2210	2350	2401	2325
6	1820	1535	1910	2087	1908	2186

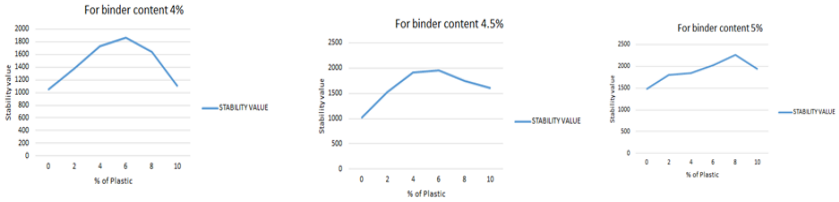

Figure 4: *For binder content 4%, 4.5%, 5%*

On observing Figure 4 and 5 it is noted that the maximum marshal stability value is achieved at 5.5 % of binder content during 8 percentage of plastic used. Thereby, it is confirmed that 8% of plastic is required to achieve the marshal stability value.

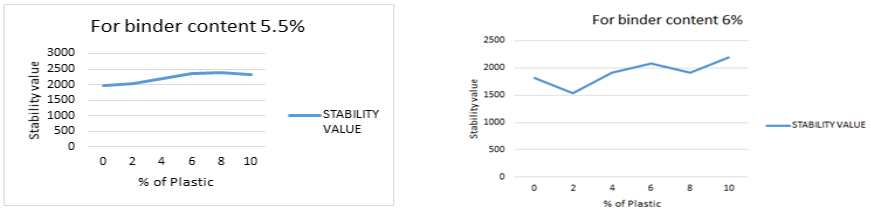

Figure 5: *For binder content 5.5%, 6%*

4.2 Flow Values

The flow values for Marshall Mix design are represented below,

Table 4: *% of Plastic Content*

Binder Content (%)	% of plastic content					
	0	2	4	6	8	10
4	142.90	140.9	138.9	137.0	138.2	138.3
4.5	143.52	143.0	140.2	138.7	139.5	139.5
5	144.14	144.6	142.5	141.2	140.9	140.4

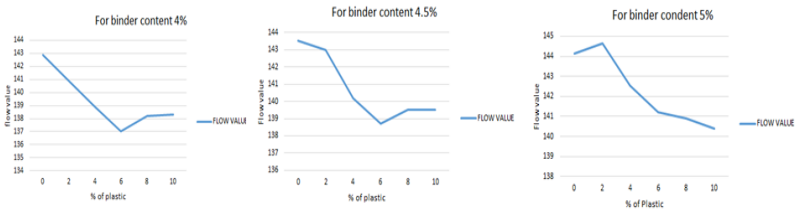

Figure 6: *For binder content 4%, 4.5%, 5%*

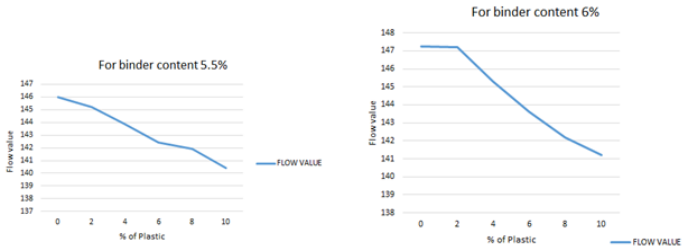

Figure 7: *For binder content 5.5%, 6%*

From the Figure 6 and 7 it specifies that the maximum flow value of Marshall Mix design is achieved at 6 % of binder content during 0 percentage of plastic used.

5 Conclusion

In this paper, the use of plastic waste in the construction of flexible pavements and roads has been investigated. When related to roads with asphalt generated from regular mix, the durability of roads made of shred plastic waste is expressively higher. There is a significant cost increase due to the requirement for mix bitumen and shreds of plastic trash, but this is compensated by the enormous volume of the whole mix, which results in a need for less bitumen. The majority of the plastic-coated aggregates' characteristics continue to enhance even with a 7% plastic waste level. After that, as the amount of plastic waste in the ecosystem continues to rise, the values begin to slightly become negative. Waste plastic is around 30% less expensive per unit than pure bitumen. Therefore, using waste plastic and bitumen to build and maintain roads may be financially feasible.

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