

Behavior of Flexible Pavements by the Addition of Plastic Waste

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ABSTRACT- Plastic trash production and disposal pose a serious threat to the environment, causing pollution and global warming. The characteristics and strength of plastic trash used in bituminous roads and pavements are improved. Also, it will be beneficial for India as a way to handle plastic waste disposal and numerous road/pavement flaws including ruts, potholes, corrugation, etc. Polythene, polystyrene, and polypropylene are the types of plastic trash that are used. The waste plastic is crushed, covered with gravel, and combined with hot bitumen to create a mixture that is used to build roads and pavement. The pavement will be strengthened and become more durable as a result. Its ground-breaking technology will also work in India's hot, humid climate. Both environmentally sustainable and cost-effective.

KEYWORDS- Plastic Waste, Aggregates, Bitumen

I. INTRODUCTION

Modern life is filled with plastic, and getting rid of it is a big issue. Regrettably, that doesn't imply that they are trustworthy or accountable. Our ability to reduce the toxic impact of plastic will increase as we gain a better understanding of negative consequences. But with this approach, we can lessen its negative environmental effects and intensify the use of plastic. Although they have many environmentally beneficial qualities, plastics are not inherently bad. In fact, a lot of the methods we employ in our designs specifically make use of plastic items.

Table 1: Year and Consumption (tonnes)

S.No	Year	Consumption (tonnes)
1.	2001	400000
2.	2011	13500000
3.	2021	21000000

We've come to the conclusion that plastic coating on aggregates is used for better road performance. This facilitates better bitumen and plastic binding. The polymer coating minimises voids and shields surfaces from moisture infiltration. As a result, there is less rutting and ravelling and no pothole formation. The roads are more durable and can endure heavy traffic [1]. "researched usage of biomedical waste in construction of bituminous roads." They explained

that the waste to be added is 2%, 3%, 5%, and 7%, and their analysis of the material's properties—including aggregate crushing value, optimal bitumen, impact value, etc.—shows good results [2]. In conclusion, HDPE coating of aggregates increases aggregate abrasion and impact resistance, enhancing the coated aggregates' strength and wear resistance qualities. Furthermore, polymer coating lowers its water affinity and increases stripping susceptibility [3]. Compared the environmental and economic situations when conducting a study on recycling plastic trash and combining it with bitumen to create roads in India. They have researched materials that are more robust than conventional road materials and are significantly less expensive. With their research, they demonstrated that plastic will raise bitumen's melting point. They claimed that this cutting-edge technology not only reinforced the construction of roads but also lengthened their useful lives [4]. carried out an experimental examination to look at how bitumen replacement with plastic waste (6%, 8%, or 10%) affected the physical characteristics of pavements. To ascertain the effect on bitumen and aggregate physically, experiments have been conducted. According to the findings, mechanical characteristics continuously improve as plastic waste content increases [5].

II. MATERIALS

A. Aggregates

The granular component of bituminous concrete mixtures, or aggregate, makes up up to 90–95% of the combination weight and accounts for the majority of the mixture's load-bearing and strength qualities. In order to create a decent pavement, the quality and physical characteristics of the aggregates should be managed. The primary materials used to produce pavement are aggregates, which make up the majority of the pavement's structure. Wheel loads on the surface course and the pavement cause stresses in the aggregates that must be supported. They must also withstand damage brought on by the abrasive action of traffic. They are employed in the construction of pavements made of cement concrete, bituminous concrete, and other types of bituminous constructions, as well as granular base courses that sit beneath the more advanced pavement layers. The aggregates' characteristics are therefore very important to the highway engineer. These aggregates are wanted for their strength, durability, toughness, hardness, and other qualities.

B. Bitumen

Asphalt and other bituminous materials are widely utilised in the construction of roads, largely because to their outstanding adhesive and waterproofing qualities and affordable price. Bitumen is a solid or viscous substance that is black or dark in colour, has adhesive qualities, and is soluble in carbon disulfide. It is made of high molecular weight hydrocarbons that are extracted from petroleum or natural asphalt. Tars are more temperature sensitive than bitumen and are by products of the damaging distillation of organic materials including coal, wood, and petroleum. In contrast to tar, bitumen will dissolve in petroleum oils.

C. Different Forms of Bitumen

Various Grades of bitumen used for pavements purpose: Grade 30/40, Grade 60/70, Grade 80/100 Bituminous primers: Mixing of penetration bitumen with petroleum distillate. Modified Bitumen: Blend of bitumen with plastic waste and or crumb rubber.

D. Plastic Waste

Waste plastic is shredded form of size 4.75mmthick such as:

E. Polypropylene

Low density polyethylene, or LDPE, is a plastic trash that is typically seen in supermarkets as carry bags. These plastic bags are incredibly thin and are also very accessible. HDPE (High Density Poly-Ethylene): High density poly-ethylene kind of plastic waste is typically offered in the market in the shape of carry bags.

F. Polyethylene

This plastic may be offered as solid plastic or carry bags. It comes in the form of mat sheets, plastic bottles, and other things.



Figure 1: Waste plastic

The discarded polypropylene plastic was dried and then cut into pieces no larger than 4.75mm. This is due to the need to guarantee adequate mixing when adding polypropylene along with bitumen and gravel. The likelihood of effective mixing and rapid heating increases with decreasing polypropylene size.

G. Construction Process Using Plastic Waste

There are two important processes namely dry process and wet process used for bitumen mix flexible pavement

H. Dry Process

Hot stone aggregate (170°C) and hot bitumen (160°C) are combined to create flexible pavement, and the resulting mixture is utilised to lay roads. According to IS code, the aggregate is chosen based on its strength, porosity, and ability to absorb moisture. When bitumen is coated with plastics, its quality in terms of voids, moisture absorption, and soundness is increased. Bitumen is chosen based on its binding property, penetration value, and viscous-elastic property on aggregate. The plastic coating reduces porosity and aids in enhancing the aggregate's quality and performance in my flexible pavement. It should be noted that the standard only permits stones with less than 2% porosity.

I. Wet Process

Waste plastic is powdered after being ground. The bitumen is blended with 2.5 to 12.5% plastic. The use of plastic lengthens the bitumen's melting point and helps the road maintain its flexibility over the winter.

Using shred plastic waste as a powerful binding agent prolongs the life of bitumen. Bitumen's capacity to endure high temperatures is increased by combining it with plastic. Bitumen is melted and then combined in a certain ratio with the discarded plastic. Normal blending occurs when the temperature reaches 45.5 C, however when plastic is blended, the mixture remains stable even at 55 0C.

III. METHODOLOGY

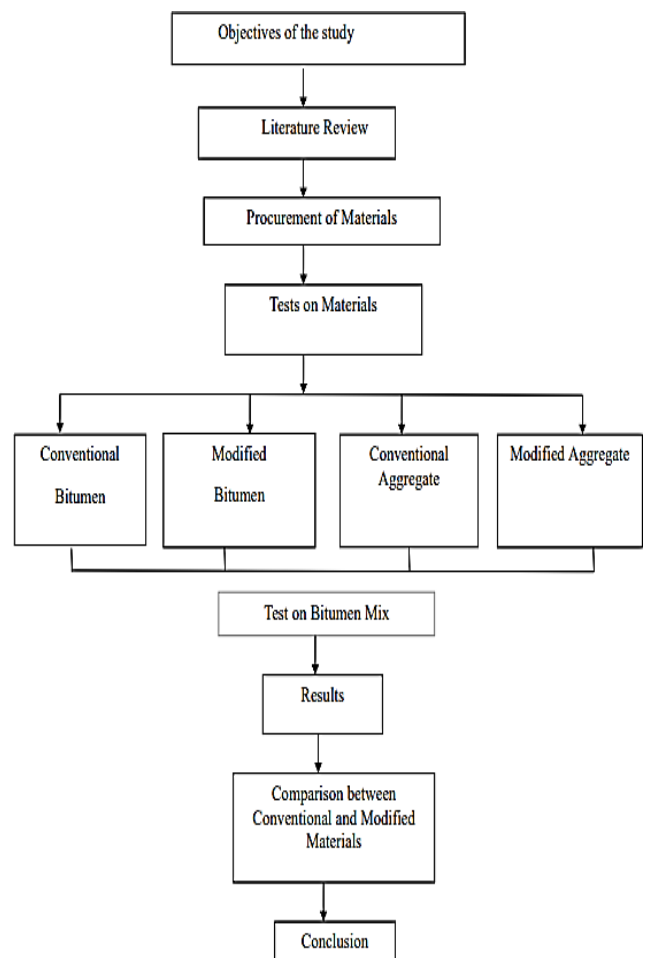


Figure 2: Flow chart of our study

IV. RESULT AND DISCUSSION

The results indicate that incorporating plastic waste into flexible pavements influences their behavior positively. The addition of plastic waste enhances pavement flexibility, resulting in reduced cracking and improved resistance to deformation. Plastic-modified bitumen exhibits increased tensile strength and ductility, leading to enhanced pavement performance under cyclic loading (show in table 2, and figure 3).

Table 2: Results of the tests conducted on aggregates coated with different percentage of plastic

S.No.	% of Plastic	Aggregate Impact	
value (%)	Los Angeles Abrasion value (%)		
1.	2	10.92	25.92
2.	4	10.84	25.68
3.	6	10.76	25.56

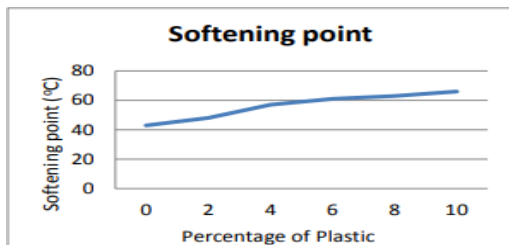


Figure 3: Aggregate impact value

The improved binding properties of plastic-modified bitumen also contribute to better cohesion and adhesion within the pavement layers. This study highlights the potential of plastic waste as a beneficial additive for enhancing the mechanical properties and overall durability of flexible pavements, offering a sustainable approach to pavement construction. (show in table 3, and figure 4 and 5).

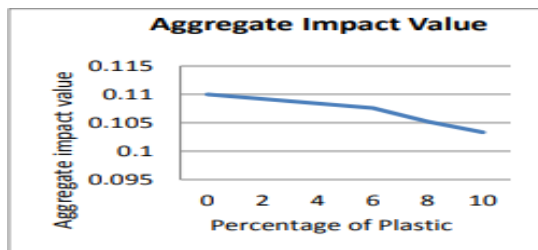


Figure 4: Los Angeles abrasion value

Table 3: Results of the tests conducted on bitumen modified with different percentages of plastic

S.No	%age of bitumen	%age of plastic	Softening point (°C)	Penetration (mm)	Ductility (mm)
01	100	0	43	73	63
02	98	2	48	58	58
03	96	4	57	55	54
04	94	6	61	53	50
05	92	8	63	50	47
06	90	10	66	46	44

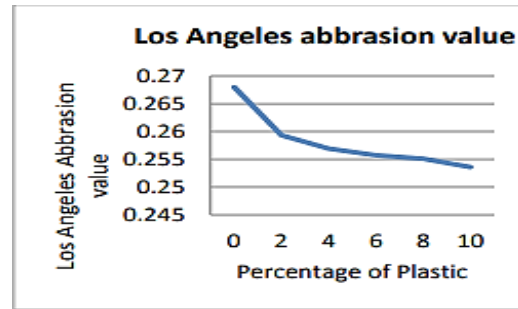


Figure 5: Softening point

V. CONCLUSION

We may infer from the experimental findings that were done using plastic waste, aggregate, and bitumen that the optimum value of plastic waste added is by weight, 9 to 10%. The characteristics of bitumen and aggregate were improved by adding plastic garbage to them. Reduces the weight of the bitumen by 9–10% and lowers the cost of building flexible pavement. We may lessen our influence on the environment by using plastic garbage to create flexible pavement.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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