International Journal of Innovative Research in Engineering and Management (IJIREM)
ISSN(Online): 2350-0557, Volume-11, Issue-3, June 2024
https://doi.org/10.55524/ijirem.2024.11.3.1
Article ID IJIR2533, Pages 1-4
www.ijirem.org

Plastic Road Construction a Recent Advancement in Waste Management

Mushtaq Hyder [1], and Er. Asif Altaf [2]

[1]M. Tech Scholar, Department of Civil Engineering, RIMT University, Mandi Gobindgarh, Punjab, India
[2]Assistant Professor, Department of Civil Engineering, RIMT University, Mandi Gobindgarh, Punjab, India

Correspondence should be addressed to Mushtaq Hyder; hydermushtaq300@gmail.com

Received: 12 April 2024 Revised: 26 April 2024 Accepted: 9 May 2024

ABSTRACT- The primary goal of this initiative is to use waste plastics in India as an addition for bituminous mixtures used in road surface. This strategy might aid in addressing the steadily increasing environmental contamination brought on the plastic products. Municipal solid waste (MSW) generation worldwide is currently estimated to be producing close to 1.3 billion tons annually; by 2025, that number is predicted to rise to2.3 billion tons annually. In the meantime, India has emerged as one of the worst pollutants of plastic. The eco systems and marine life may be impacted by the quantities of waste plastic debris that is dumped into the ocean. Our local context indicates that by2015, the amount of municipal solid waste (MSW) produced in India has increased to 6500–7500 tons.
Consequently, we have found a workable solution for the previously mentioned plastic waste problem. If we could get rid of the plastic garbage, we could build new roads with the leftover plastic, which would fix the problem immediately. Although the county's plastic problem won't be resolved by this new asphalt mix, it will help keep road building costs down.

KEYWORDS- Plastic Waste, Marshall Stability, Municipal Solid Waste, Recycled Plastic Waste

I. INTRODUCTION

The usage of plastic in road construction is not a recent development. Regarding the utilization of waste plastic in road construction, recent research in this area has given rise to some optimism. Use PET cups, throwaway cups, and plastic carry bags that are gathered at waste disposal yards mostly when traveling on plastic roads. The plastic melts when combined with heated bitumen to create an oily layer that covers the aggregate and is spread out over the road surface similarly to a typical tar road [1]. One major hazard to the environment is plastic. Research has shown that properly processed plastic wastes can extend the life of roads and provide solutions for environmental issues. Plastic trash can be used in road construction. Road construction uses recycled plastic from items like carry bags, water bottles, milk packets, glasses, cups, and other plastic debris [2]. The daily production of plastic trash in India amounts to 15 million tons, of which 40% is either neglected or not properly disposed of. Adding polymer to dried bitumen enhances its service characteristics. Currently just 9% of plastic is recycled globally. More than 8 million pieces of their bodies wash up in our seas every day. Ninety-two to ninety-four percent bitumen and six to eight percent plastic make up plastic roads. The nature benefits from this since plastic waste is used to build roads. enhancing the different characteristics of road materials [3]. Today, plastic trash is a number of days. In a molten state, the polymers polythene, polypropylene, and polystyrene exhibit the adhesion property. Plastic usage will rise the temperature at which bitumen melts. Therefore, one of the greatest ways to get rid of waste plastic rapidly is to use it for pavement. When compared to roads created with traditional bitumen, plastic roads also referred to as roads made from waste plastic perform better [4][7].

II. OBJECTIVES

- Determine the materials required for building the plastic road.
- Marshall's trial design Create a sample combination that is suitable by varying the amount of waste plastic in it.
- Testing the plastic bitumen mixture's strength and durability and contrasting it with the traditional mixture.
- After examining the test findings, determine the mixture's ideal waste plastic content.
- Examine the benefits and drawbacks of using waste plastic asphalt mixture in place of regular asphalt mixture for building new roads.

III. LITERATURE REVIEW

In the review section, bitumen properties measured using rheological and traditional physical tests are covered. Marshall Stability, the Softening Viscosity test, and Penetration are the tests that are the most frequently performed on bitumen.

Estabargh et al. [1] direct shear tests were conducted on the clayey soil reinforced with 0.4% polypropylene fibres by weight of the soil. The results showed that the fibre reinforced soil had a higher internal friction angle and cohesiveness than the native soil. The shear strength, effective stress, and friction angle of the reinforced soil rose with the increase in nylon fibre content.

Vasudevan et al. [2] bitumen can be modified using waste plastics that are gathered from various sources. When mixed with bitumen, they do not release any toxic gas, and their softening point is higher than 100 degrees Celsius. It is discovered that plastic is a superior raw material for paving when it is put over heated aggregate, coating the aggregate. After mixing bitumen with this raw material in a conventional manner, testing was conducted. This demonstrates a higher Marshall Stability than the actual asphalt aggregate mix. The sample has a high Marshall Stability value between 18 and 20 KN [2].

Flynn F [3] studies have previously shown that adding the right modifiers can improve the performance of the BC mixes used in the surface course of flexible pavements. These are waste plastics that have been shred; the majority of them are low-density polyethylene (LDPE), which can be utilized to make bitumen that has been changed with plastic. It has been demonstrated that the inclusion of low-density, recycled polyethylene carry bags on bituminous roadways has contributed to a decrease in bituminous surfacing rutting and cracking.

Zoorab and Suparma [4] used plastic which were comprising of polyethylene and low-density polyethylene (LDPE) in the BC mixes and produced improved stability and fatigue life. An increment of 20% and 30% in the Stability and indirect tensile strength (IDT) respectively was observed with BC mixes treated with plastic waste.

Sridhar et al [5] contrast to conventional BC mixes, modified BC mixes have a 200% longer fatigue life. Adding 5 to 10% recycled plastic to the binder significantly reduces the rutting actions of the BC mixes, and adding 8% recycled plastic to BC mixes increases stability by 65%. The addition of 8% plastic waste to BC mixes results in an increase in stability, tensile strength, and moisture resistance. The research program also included stiffens testing on bituminous mix samples prepared with various binders. While certain recycled modified bitumen was discovered to have stability issues, other cases proved to be successful.

Yadav and Tiwari [6] they studied on the potential application of crumb rubber in soft clay treated with cement were improved.

IV. METHODOLOGY

A. A Basic Mixture of Asphalt

Bitumen is a naturally occurring, oily, viscous substance that is produced when organic molecules break down. It is black in colour. around prehistory and around the world, bitumen, often referred to as asphalt or tar, was combined with various substances and used as a sealer, adhesive, building mortar, incense, and decorative coating for pottery, structures, or human skin. The substance was also helpful for waterproofing other watercraft, such as canoes. An appropriately designed bituminous mix should be (I) strong (ii) long-lasting (iii) resistant to wear and tear and permanent deformation (iv) environmentally friendly (v) reasonably priced, and so on.
Choosing the components of the mix

B. Binder

Generally, a few quick tests and additional site-specific specifications are used to choose binders. Depending on the type of binder penetration grade, cutback, emulsion, modified binder, etc. these tests may vary. The requirements prefix the test conditions for the majority of these tests. Temperature is a significant factor that influences both the binder's aging and modulus. According to Superpave specifications [Superpave 1997, 2001], these acceptance tests should be conducted at field temperatures rather than at a temperature defined in a laboratory.

C. Aggregate

To evaluate the characteristics of the aggregates, such as strength, hardness, toughness, durability, angularity, shape parameters, clay content, adhesion to binder, etc., a number of tests are advised in the specifications. Because aggregate interlock angularity offers sufficient shear strength and reducing flakiness assures the aggregates would not break during handling and compaction.

D. Types of Plastics

- PET, polyethylene terephthalate
- HDPE, high-density polyethylene
- LDPE, low-density polyethylene
- PP, polypropylene
- PS, polystyrene

E. Classification of Plastic Waste

- **Polyethylene**

➢ LDPE (Low Density Poly-Ethylene)
Low density poly-ethylene is a plastic waste that is typically seen in retailers as carry bags. These plastic bags are incredibly thin and accessible.

➢ HDPE (High Density Poly-Ethylene)
Generally speaking, carry bags made of high-density polyethylene trash are readily accessible in the market.

- **Polypropylene**

Depending on the needs and uses of the various industries, this plastic may be offered as solid plastic or as carry bags. It comes in various forms, such as mat sheets and plastic bottles.
➢ Basic processes

- **Wet process**

In this procedure, waste plastic is combined directly with 1600C hot bitumen and stirred with a mechanical stirrer. This combination needs to be well cooled and includes extra stabilizers. Because it requires more equipment, larger plants, and significant investments than the Dry Process, it is not as popular.

- **Dry Process**

Initially, the waste plastic is gathered, sorted, and stored. The reason for the segregation is that some plastics, such as flux sheets and polyvinyl chloride (PVC), cannot be utilized owing of safety issues. The plastic needs to be cleaned in the following step. This is required since the majority of the plastic garbage that is collected roughly 55% of it comes from India has been used for packaging. As a result, it is likely to contain leftover materials, like small food fragments, which need to be removed. Following this, the plastic undergoes shredding to bring it down to the proper thickness of 2-4 mm. After heating the aggregate to between 1600 and 1700 degrees Celsius, the plastic is applied, and a uniform coating is seen after 30 to 40 seconds. This covering makes it appear greasy. After that, bitumen is added, and the mixture is well combined before being laid. Between 1550°C and 1630°C is the temperature at which bitumen is added the precise control of this temperature ensures a robust binding.

F. Plastic Types Utilized in Plastic Roadways

In this technique, polyester, polypropylene, polyethylene, and polystyrene are the most often utilized plastics. Three processes can be used to create polyethylene. These three distinct processes produce polyethylene with various qualities. As a result, everyone is given a somewhat unique name. Plastic bags are typically made of low-density polyethylene. Plastic chairs, dustbins, bowls, and other items are made of high-density polyethylene. Plastic sheets and wraps are made from linear low-density polyethylene. Typically, polystyrene is used as insulation and in fast food boxes. The primary application of polyester (polyethylene terephthalate) is as a clothing fabric. Radio-controlled toy planes and apparel are both made of polypropylene.

V. RESULTS AND DISCUSSION

Additionally, we can determine the ideal bitumen concentration for waste plastic content that is 0.2%, 0.8%, 1%, and 2.5%. Ultimately, we may analyse, and choose the best mix proportion for the waste plastic mix design once we have determined the ideal bitumen content for each waste plastic percentage.

Table 1: For 0.8 % Plastic Content

Bitumen %	Air voids (Va) %	VMA (%)	VFB (%)	Load kN	Flow (*0.25mm)	Unit wt.
3.50	10.7	17.6	7.2	15.9	10.1	2.25
4.00	8.6	17	8.5	15.9	10.3	2.29
4.50	7.3	16.9	9.6	16.8	10.2	2.31
5.00	6.4	17.2	10.8	16.8	11.1	2.31
5.50	5.5	17.4	12	16.3	11.4	2.32

Additionally, we can determine the ideal bitumen concentration for waste plastic content that is 0.2%, 0.8%, 1%, and 2.5%. Ultimately, we may analyse, and choose the best mix proportion for the waste plastic mix design once we have determined the ideal bitumen content for each waste plastic percentage. There is 4.5% bitumen in the economical mix. The percentage of waste plastic that can be determined as most economical and effective is 0.2%.

Table 2: Final Results

	Normal Design	2.5% plastic	1% plastic	0.8% plastic	0.2% plastic
B.C %	4.5	4.5	4.5	4.5	4.5
VMA %	15.4	18.7	17.5	15.3	15.3
V a %	5.5	9.9	7.2	7.5	5.1
Stability KN	13.9	20.1	17.8	16.4	15.3

Table 3: Results for aggregate

Percentage Of Plastic	Moisture Absorption (%)	Aggregate Impact Value (%)	Aggregate Crushing Value (%)	Los Angeles Abrasion Value (%)	Specific Gravity	Stripping Value (%)
Control Specimen	1.7	5.45	18.9	13.40	2.44	8%
PP8	Nil	4.89	13.67	10.96	2.5	Nil
PP10	Nil	4.28	9.74	9.49	2.80	Nil

In the above table 1, 2 and 3 we determine following tests. Namely aggregate impact value, Los Angeles abrasion value, moisture absorption test, crushing value.

- Aggregate Impact Value-
  The findings of the experiment, which was done with 0%, 1%, 2%, and 3% of plastic, were determined to be 25.4%, 21.2%, 18.5%, and 17%, respectively. This implies that in the case of a strong force, the plastic prevents the combination from breaking.
- Los Angeles Abrasion Value:
  The experiment was carried out for 0%, 1%, 2%, and 3% of plastic, and it was discovered that 37%, 32%, 29%, and 26% of the mass passed through the sieve, correspondingly. According to this, the plastic coating greatly increases abrasion resistance and is necessary to lower it below the 30% in table 4.
- Moisture Absorption Test:
  For 0%, 1%, and 2% of additional plastic, the outcomes were 4%, 2%, and 1.1%. Very little water was absorbed in the case of 3% plastic. This shows that the plastic reduces the mixture's susceptibility to moisture.

The tests that were performed on the bitumen and aggregate yielded the following results. The standard ranges for each test are included after the tables.

Table 4: Result for bitumen

Test	Result	Ranges
Ductility Test	76.50cm	Min40
Penetration value	60mm	60-70mm
Viscosity value	51.1sec	-
Softening Point	45.25°c	45-600c
Flash Point Test	280c	>65-175C
Fire point test	302C	

- Crushing Value
  For PP8 and PP10, the crushing value decreases from 19.2%to 13.33% and 9.82%, respectively. Value decreased for PP8 by 30% and PP10 by 48%. since crushed fraction is small, a low aggregate crushing value suggests strong aggregate.

VI. CONCLUSION

Aggregate plastic coating is applied to improve road performance. Because of the enhanced bonding and area of contact between polymers and bitumen, this aids in improving bitumen binding with plastic waste coated aggregate. Additionally, the polymer coating lessens the voids. This stop trapped air from oxidizing bitumen and absorbing moisture. Ravelling and rutting have decreased as a result, and pothole creation has stopped. The roadways are more durable and able to tolerate high traffic. Some conclusions from the study are as follows:

- The control specimen's aggregate impact value was 5.45%. For PP8, it dropped to 4.89%, and for PP10, to 4.28%. Value reductions were 21% for PP10 and 10% for PP8. This demonstrates that the aggregate's toughness was raised to withstand the impacts.
- For PP8 and PP10, the Crushing Value was lowered from 18.9% to 13.67% and 9.75%, respectively. Value decreased for PP8 by 30% and PP10 by 48%. Since the

crushed fraction is small, a low aggregate crushing value suggests strong aggregates.

- Because of the plastic coating, the aggregate's specific gravity rises from 2.45 for the control specimen to 2.6 for PP8 and 2.78 for PP10.
- For PP8 and PP10, the Stripping Value was zero, down from 8% for the control specimen. This demonstrates that coated aggregates work better than plain aggregates in bituminous construction.
- The water absorption of PP8 and PP10 is also zero, compared to 1.7% for the control specimen.
- Los Angeles abrasion the control specimen's value was discovered to be 13.42%. For PP8, polymer coating over aggregate improved the abrasion value by 19.97%, and for PP10, it rose by 29.88%.

This shows how hard the aggregate is. In summary, incorporating plastic waste into mix will help reduce bitumen requirements by about 10%, improve road strength and performance, prevent the need for anti-stripping agents, prevent plastic waste from being disposed of through land filling and incinerator and eventually lead to the development of environmentally friendly technology. The lifespan of roads will be shortened by increased traffic. In the end, plastic roads will be the solution a preventative measure. It will lower the quantity of resources used for construction and save millions of dollars in the future.

The redesigned waste plastic mix design's strength, durability, and other characteristics were further validated by the Marshall Test findings, which fell between the RDA standard parameters.

Table 5: RDA standard parameters

	RDA Standard specification	Modified Waste plastic mixture
Stability Value	(10 – 81) kN	15.6 kN
Flow Value	8 - 16 Units	12.6 units
Air Voids	3 - 5 %	5.5%
VMA Value	>13%	15.4%

Based on the comparison in the above table 5, it can be concluded that the waste plastic mix design was more successful in achieving durability than the traditional mixture.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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