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Use of Plastic in Bitumen Road Construction

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ABSTRACT: Plastic waste has become a significant environmental concern worldwide due to its non-biodegradable nature and adverse effects on ecosystems. The disposal of plastic waste poses a significant challenge, and its accumulation in landfills and water bodies has raised serious environmental and health concerns. As a result, researchers and engineers have been exploring innovative ways to recycle and reuse plastic waste to minimize its environmental impact. This research paper aims to provide a comprehensive review of the use of plastic in bitumen road construction as an effective and sustainable solution. The study investigates various techniques and methodologies employed in incorporating plastic waste into bitumen mixtures and evaluates their impact on road performance. The review encompasses an analysis of existing literature, research studies, and practical case studies conducted on the subject. It discusses the advantages and challenges associated with using plastic-modified bitumen, highlighting its potential benefits in terms of improved road durability, reduced rutting, increased fatigue life, and enhanced resistance to moisture-induced damage. Furthermore, the environmental advantages of incorporating plastic waste in road construction, such as reduced plastic landfill waste, lower energy consumption, and decreased greenhouse gas emissions. The paper also addresses potential concerns and limitations related to the use of plastic-modified bitumen, including the need for proper quality control, the selection of appropriate plastic types, and the long-term performance and maintenance requirements of plastic-infused roads. Additionally, the economic feasibility and scalability of plastic-modified bitumen technologies are discussed, with an emphasis on the potential cost savings associated with using recycled plastic materials.

KEYWORDS: plastic waste, bitumen road construction, plastic-modified bitumen, environmental sustainability, road performance, recycling, waste management.

I. INTRODUCTION

1.1 General Introduction

The construction and maintenance of roads are crucial for transportation infrastructure, facilitating the movement of goods and people. Over the years, road engineers and researchers have been continuously exploring innovative techniques and materials to enhance road durability, performance, and sustainability. One such development is the utilization of plastic in bitumen road construction. Bitumen, a sticky and viscous black liquid derived from crude oil, is commonly used as a binder in road construction. It acts as a glue that holds the aggregates together, providing strength and durability to the road surface. However, conventional bitumen roads are susceptible to various issues, including cracking, rutting, and aging, due to factors like traffic loads, climate conditions, and environmental degradation. To address these challenges, researchers have experimented with incorporating plastic waste into the bitumen mix. Plastic waste, such as polyethylene (PE) and polypropylene (PP), can be obtained from various sources like recycled bottles, bags, and packaging materials. By adding shredded or granulated plastic waste to bitumen, several beneficial properties can be achieved. One of the key advantages of using plastic in bitumen roads is improved road durability. The plastic particles in the mix act as a reinforcement and help reduce cracking and rutting caused by heavy traffic loads. The plastic also enhances the resistance to deformation and increases the overall strength of the road surface. Another significant benefit is the reduced environmental impact. By incorporating plastic waste into roads, the amount of plastic sent to landfills or incineration facilities is reduced, mitigating the environmental hazards associated with plastic disposal. Additionally, the use of plastic in roads can contribute to lower energy consumption and greenhouse gas emissions during road construction. Furthermore, the inclusion of plastic waste in bitumen can enhance the waterproofing properties of roads, reducing the permeability.

1.2 Scope of The Project

- Research and Development
Investigate the optimal plastic content and particle size for achieving desired road properties. Explore the compatibility of plastic-modified bitumen with traditional construction practices and materials.
- Material Testing and Characterization

Assess the performance of plastic-modified bitumen in terms of rutting resistance, fatigue life, moisture susceptibility, and temperature sensitivity. Analyse the impact of plastic modification on the workability and compaction of asphalt mixtures.

- Field Trials and Performance Evaluation

Identify suitable test sections or pilot projects for constructing plastic-modified bitumen roads.

Monitor and assess the performance of plastic-modified roads in terms of pavement distress, roughness, skid resistance, and durability.

- Environmental and Economic Analysis

Conduct a life cycle assessment (LCA) to evaluate the environmental impact of plastic-modified bitumen roads, considering factors such as carbon footprint and energy consumption. Perform a cost-benefit analysis to assess the economic feasibility and long-term savings associated with plastic-modified roads.

1.2.1 Advantages

- Improved durability
- Enhanced flexibility
- Better resistance to water damage
- Better resistance to water damage
- Cost-effective

1.2.2 Disadvantages

- Quality and Performance Issues
- Environmental Concerns
- Limited Compatibility
- Recycling Challenges
- Increased Cost
- Lack of Standardization.

II. LITERATURE REVIEW

The concept of using plastic in flexible pavement has been done since several years ago in India. The concept of utilization of waste plastic in construction of flexible road pavement has been done since 2000 in India. The properties of this modified bitumen were compared to that of ordinary bitumen. It was noted that penetration and ductility values of modified bitumen were decreasing with the increase in proportion of the plastic additive, up to 12 % by Weight. Dr. R. Vasudevan states that the polymer bitumen blend is a better binder compared to plain bitumen. Blend has increased softening point and decreased Penetration value with a suitable ductility. The coating of plastics reduces the porosity, absorption of moisture and improves soundness. Use of plastic bags in road help in many ways like Easy disposal of waste, better road and prevention of pollution and so on. The results indicated that there was an improvement in strength properties when compared to a conventional mix. Therefore, the life of pavement surfacing using the waste plastic is expected to increase substantially in comparison to the use of conventional bituminous mix. Hence the use of waste plastics for flexible pavement is one of the best methods for easy disposal of waste plastics. This technology not only strengthened the road construction but also increased the road life.

Plastic roads are such as a new idea, creation processes may vary. roads are made from the mix of plastic and bitumen. Roads are developed from recycled plastics, and the first step in constructing them into collect and manage plastic material.

(Dr. S. L. Hake 2022) :- According to him the optimum bitumen content of the semi dense bituminous concrete mixes showed 10% higher when compared with modified semi dense bituminous concrete mixes with waste plastic.

(Shweta N. Rokdey) :- According to her This innovative technology not only strengthened the road construction but also increased the road life. And Rokdey were using of dry mix process. they could achieve durability of the roads laid out with shredded plastic waste is much more compared with roads with asphalt with the ordinary mix

(Mohd Ezree Abdullah) :- says using of binding techniques and mixing of waste plastic and bitumen mix at temperature 170 °C to 175 °C and mixer at 1200-1500 rpm for 1 hour. Moreover, plastic waste improves the performance of bitumen when it was added into bitumen. The higher plastic waste percentage give the higher strength.

(P Priya) :- et. al. presented that in the world plastic waste is the threat to the environment in current scenario. As the plastic is not eco-friendly as they are not bio-degradable. They presented that partial replacement of bitumen by polymer (plastic) waste in bituminous mix with marble chips as aggregate and comparative study is done. They used different percentage of plastic proportion of 5, 10 and 15% plastic and determine various aspects such as stability and void contents. Plastic road would be boon for India's hot and extremely humid climate, where temperature frequently cross 50°C. The comparative study is done by them with different percentage of plastic and marble chips usage. Finally, they concluded that the in flexible pavement with polymer bitumen in various proportion the stability of marble chips in plastic pavement gives considerably good results than conventional plastic pavement up to 10%. After that plastic pavement gives better stability than marble aggregate plastic pavement.

Sunil J. Kulkarni (2015) - Minimization of waste material is important aspect of the modern growth and development initiatives . Plastic is used in various domestic and industrial applications. Use of plastic bags and bottles is very common. The disposal of plastic waste is major problem due to non-biodegradable nature of plastic. The plastic can be used as feedstock for ethanol like products. It can be used for road construction and other construction related activities. The current review summarizes the research on use of waste plastic

Rishi Singh Chhabra (2014) - In the highway infrastructure, a large number of originates materials and technologies have been invented to determine their suitability for the design, construction and maintenance of these pavements. Plastics and rubbers are one of them. Also considering the environmental approach, due to excessive use of polythene in day to day business, the pollution to the environment is enormous. The use of plastic materials such as carry bags, cups, etc. is constantly increasing day by day¹⁰. Since the polythene are not biodegradable, the need of the current hour is to use the waste polythene in some beneficial purposes. The use of these materials as a road construction proves eco-friendly, economical and use of plastic gives strength in the sub-base course of the pavement.

2.2 Aim

- The Reuse of waste plastic, without burning or without producing carbon dioxide.
- Use near about 20 to 25% of plastic in bituminous road.
- Reduce soil pollution by using plastic in road construction
- Reduce air pollution by using plastic in road construction instead of burnig or disposal
- Reduce percentage of potholes by using plastic in road
- Construct economical road than tradition method
- Improve wearing surface of road so improve runoff speed of rain water

2.3 Objectives

- Environmental Sustainability: Reduce plastic waste and its impact on the environment by utilizing it in road construction.
- Enhanced Road Performance: Improve the quality and durability of roads by incorporating plastic in bitumen.
- Cost Reduction: Explore the potential for cost savings by using plastic-modified bitumen.
- Waste Management: Address plastic waste management challenges by finding an alternative use for plastic materials that would otherwise end up in landfills or the environment.

III. METHODOLOGY

- **Segregation:** Plastic waste collected from various sources is separated from other wastes.
- **Cleaning Process:**
- **Shredding Process:**
- **Collection Process:** The plastic waste retaining on 2.36 mm IS sieve is collected.

Test on aggregates

- i. Aggregate crushing test
- ii. Los Angeles abrasion test



iii. Impact test

Test on bitumen

- i. Penetration test
- ii. Softening point test
- iii. Marshall Stability test.

3.2 RESULT

3.2.1 TEST ON AGGREGATE

Table: - Results of tests on aggregate

Aggregate	Plastic Content(%)	Aggregate Impact Value	Los Angeles Abrasion Value	Specific Gravity	Water Absorption
Without Plastic	0	10.50%	12.90%	2.6	3.5%
With Plastic	20	9.30%	12.50%	2.87	3%
	25	8.80%	11.60%	2.90	1.2%

(Table no – 2)

3.5.2 TEST ON BITUMEN

Table: -2 Results of tests on bitumen

Test	Result	Range
Ductility test	60.50 cm	Min 40 cm
Penetration test	85 mm	80-100 mm
Softening point test	49.20 ⁰ C	45-60 ⁰ C

(Table no – 3)

3.2.2 MARSHALL STABILITY TEST

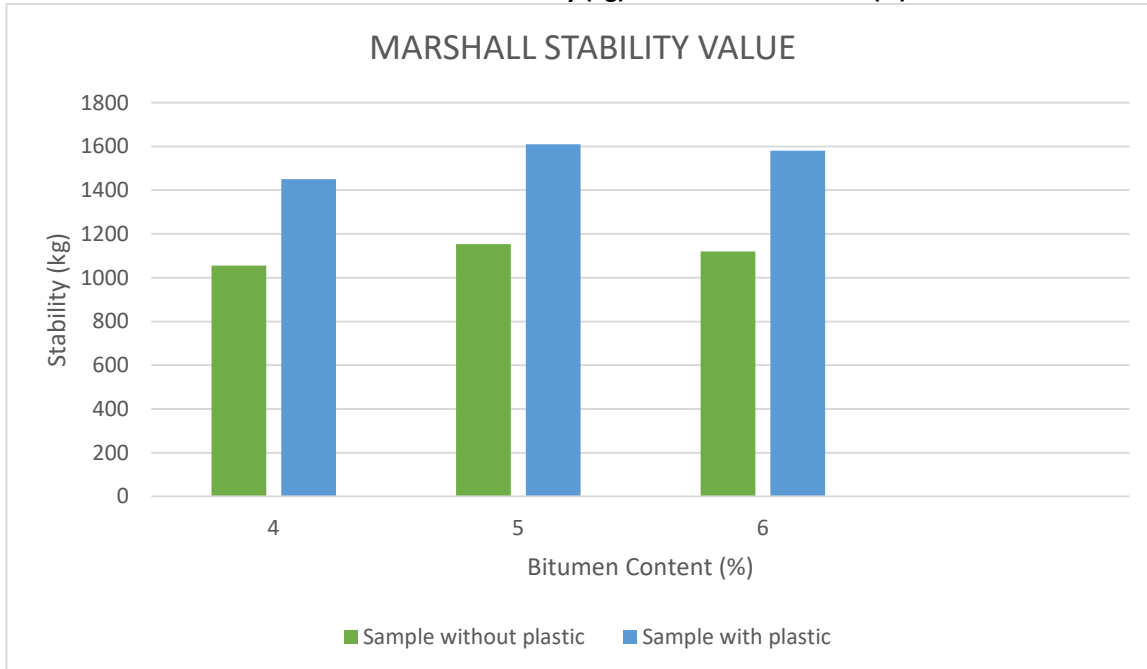
Table: - Marshall stability and flow value

Sample No.	Bitumen content (%)	Plastic content (% by weight)	Marshall stability (kg)	Flow value (mm)
1	4	0	1055	3.2
2	5	0	1154	3.6
3	6	0	1120	3.8
4	5	20	1450	4.6
5	6	25	1610	5.5
6	6	30	1580	5.4

(Table no – 4)

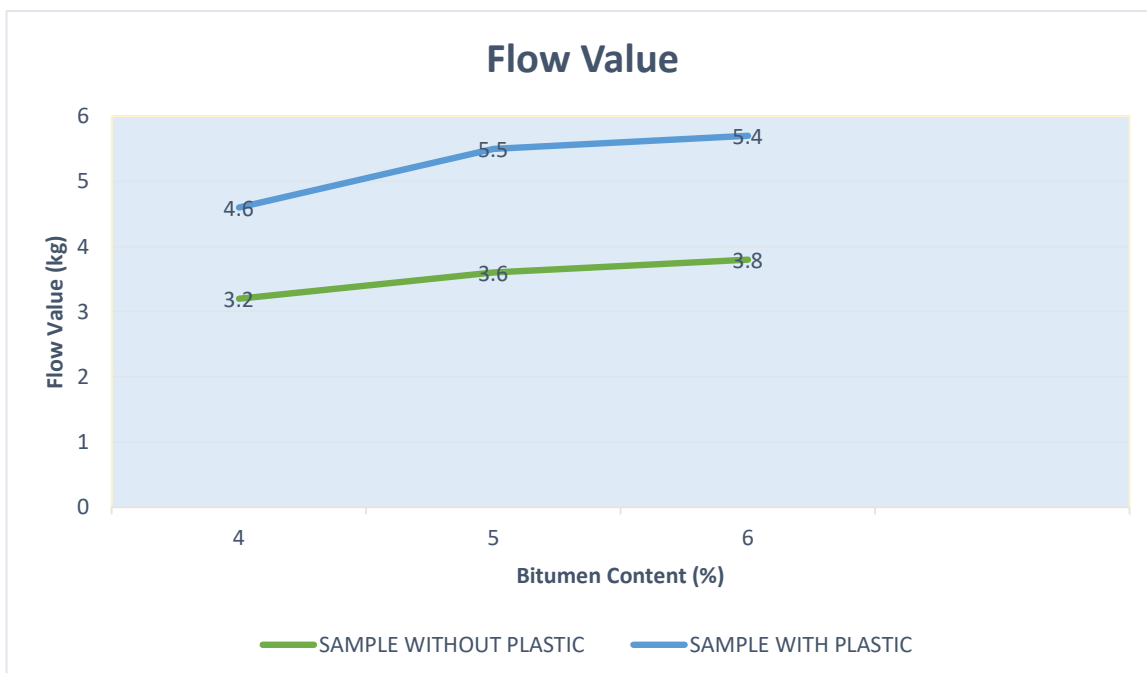


Chart-1 : Stability (kg) and bitumen content (%)



(Table no – 5)

Chart-2: Flow Value (mm) and bitumen content (%)



(Table no – 6)

IV. CONCLUSION

After the analysis of the above result it will be observe that plastic improve the Marshall stability of the sample. Also increase the melting point of bitumen from above result it is conclude that 25% of plastic content in road is economical. By adding 25% plastic in mix design it Gain more strength as per IRC (INDIAN ROAD CONGRESS) recommendation. By adding 25% plastic we can make 10-15% road cheaper than traditional method. From above result it is observe that more than 25% use of plastic form lumps in mix design and also affect the stability value of road. The plastic mixed with bitumen and aggregates is used for the better performance of the roads. The polymer coated on aggregates reduces the voids and moisture absorption. This results in the reduction of ruts and there is no pothole formation. The plastic pavement can withstand heavy traffic and are durable than flexible pavement. The use of plastic mix will reduce the bitumen content by 10% and increases the strength and performance of the road. This new technology is eco-friendly. The use of smoke absorbent material (titanium di-oxide) by 10% of polymer content can reduce the vehicular pollution. The use of plastic in bitumen road construction offers several benefits. The incorporation of plastic waste in road construction helps address the growing environmental concerns related to plastic pollution. By utilizing plastic waste in road infrastructure, we can reduce the amount of plastic ending up in landfills or polluting water bodies. The addition of plastic waste to bitumen improves the properties of the road material, enhancing its durability, flexibility, and resistance to wear and tear. The plastic content acts as a binding agent, improving the overall strength of the road and reducing the formation of cracks and potholes. This, in turn, leads to longer-lasting roads and reduces the need for frequent repairs and maintenance. The use of plastic in bitumen road construction promotes sustainable development by conserving natural resources. By substituting a portion of bitumen with plastic waste, we can reduce the demand for virgin bitumen, which is derived from petroleum. This helps in conserving fossil fuel reserves and reducing greenhouse gas emissions associated with bitumen extraction and production. Incorporating plastic waste into road construction can contribute to the circular economy by providing an effective way to recycle and reuse plastic materials.

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