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"EXPERIMENTAL INVESTIGATION ON USE OF PLASTIC WASTE IN BITUMINOUS ROAD."

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Abstract: With a total length of 5.89 million kilometers. India has the second-largest road network in the world (kms), this road network moves 64.5 percent of all commodities in India. Plastic is a non-biodegradable material and researchers are found that the material can remain on earth for 4500 years without degradation. It is possible to improve the performance of bituminous mixed used in the surfacing course of roads. The field tests and proved that plastic wastes used after proper processing as an additive would enhance the life of the roads and also solve environmental problems.

The rising amount of commercial vehicles, overloading of trucks further than double its capacity, change in daily and cyclic temperature and environmental factors have been responsible for decreasing the life of the pavement. As per the Research Scheme R-55 of MORTH, the use of E-Waste and Plastic waste in bituminous road construction of Central Road Research Institute (CRRI) indicates that the wearing course of e-waste and plastic waste bituminous mixes have longer lives. Indian Road Congress (IRC) has formulated IRC codes for the use of waste plastic and e-waste in road construction.

I. INTRODUCTION

As one of the most important components of the transportation infrastructure, roads are very important and important. The development of automobiles in the late 19th and early 20th centuries further drove the need for better roads. Governments around the world began investing in infrastructure to accommodate the growing number of vehicles on the roads. This led to the construction of highways, bridges, and tunnels, revolutionizing transportation and connecting distant regions.

In this project we are going to use plastic in road construction. Plastic is sometimes added to bituminous roads as a modifier to improve the performance and durability of the pavement. Here are some reasons why plastic is used in bituminous roads:

1. Enhanced durability: Adding plastic to bituminous mixtures can improve the durability and longevity of the road surface. Plastic polymers can help reduce rutting, cracking, and deformation caused by traffic loads and environmental factors, such as temperature variations and moisture.

2. Improved strength and flexibility: Plastic modifiers can enhance the strength and flexibility of the asphalt mix, making the pavement more resistant to fatigue, thermal stresses, and deformation. This can result in a longer service life for the road and reduced maintenance costs over time.
3. Better resistance to aging and oxidation: Plastic additives can help protect the asphalt binder from aging and oxidation, which can degrade the pavement over time. By improving the binder's resistance to environmental factors, such as UV radiation and oxygen exposure, plastic can help maintain the road's properties and performance.
4. Reduced moisture susceptibility: Plastic modifiers can enhance the moisture resistance of bituminous mixtures, reducing the risk of moisture damage, such as stripping and rutting. This can improve the overall quality and durability of the pavement, especially in regions with high rainfall or freeze-thaw cycles.
5. Environmental benefits: Incorporating recycled plastic materials into bituminous roads can help reduce plastic waste and promote sustainability in road construction. Using plastic waste as a modifier in asphalt mixtures can provide an environmentally friendly solution for managing plastic disposal while improving road performance.

Overall, adding plastic to bituminous roads can offer several benefits, including enhanced durability, improved strength, better resistance to aging, reduced moisture susceptibility, and environmental sustainability. However, it is essential to carefully design and test asphalt mixtures with plastic modifiers to ensure that they meet performance requirements and provide long-term benefits for road infrastructure.

II. OBJECTIVES

- To reduce plastic waste.
- To create awareness in people.
- To find effectiveness of roads constructed using plastic.
- To find effect of plastic on bitumen.
- Case study on roads constructed using plastic.

III. RESEARCH & DEVELOPEMENT

3.1 To Reduce Plastic

1. In our research we have found that we can replace 15% of bitumen by plastic.
2. In India on an average 11 Ton to 12 ton bitumen is used in national highway construction.
3. So as per calculation we can say that we can use 1.8 of plastic for 1 km highway construction.
4. Which will reduce majority of plastic waste.

3.2 To Find Effectiveness of Roads Constructed Using Plastic.

Plastic roads are a relatively new technology that have been developed to address some of the challenges associated with traditional asphalt roads. Here are some potential benefits and drawbacks of plastic roads in terms of their effectiveness:

Benefits:

1. Durability: Plastic roads are reported to be more durable than traditional asphalt roads, as they are less susceptible to damage from heavy traffic, extreme weather conditions, and chemical corrosion.

2. Sustainability: Plastic roads can help reduce the amount of plastic waste that ends up in landfills or oceans by incorporating recycled plastic materials into road construction.

3. Cost-effective: Plastic roads can be more cost-effective in the long run, as they require less maintenance and repair compared to traditional roads.

Overall, the effectiveness of plastic roads depends on various factors such as the quality of materials used, construction techniques, and maintenance practices. Further research and monitoring are needed to better understand the long-term performance and environmental impact of plastic roads.

Construction process-

Waste plastic is made into powder and varying percent plastic is mixed with bitumen. Plastic increase the melting point of the bitumen and makes the road flexible during winters resulting in its long life. By mixing plastic with bitumen the brittleness is overcome and its elasticity enhances. The plastic waste is melted and mixed with bitumen in a particular ratio. There are two important processes used for bitumen mix flexible pavement. (i) Dry Process (ii) Wet Process.

Dry Process:

For the flexible pavement, hot stone aggregate (170°C) is mixed with hot bitumen (160°C) and the mix is used for road laying. The aggregate is chosen on the basis of its strength, porosity and moisture absorption capacity as per IS code. The bitumen is chosen on the basis of its binding property, penetration value and viscous-elastic property. The aggregate, when coated with plastics improve its quality with respect to voids, moisture absorption and soundness.

In this process the shredded plastics are poured over the heated aggregates, thus forming plastic coated aggregates which are then mixed with hot bitumen to form plastic coated aggregate bitumen mixture for laying roads. The coating of plastic decreases the porosity and helps to improve the quality of the aggregate and its performance in the flexible pavement.

Wet Process:

In this method the waste polymer is directly added with bitumen and heated up to temperature of 170°C so that proper blend is formed with proper dispersion of waste polymer into bitumen. Then the hot mix is cooled up to 120°C into another chamber, which is then added to the aggregate in paddling chamber. The mix is to be cooled because when hot mix is poured. on aggregate then there are chances to form air pocket into small gaps of aggregate, reducing the strength of roads and rutting of roads. After addition of modified bitumen at 110°C on aggregate, it is then laid on the road and then spreader material is compacted by 8 ton roller.

3.3 To find of effect of plastic on bitumen.

3.3.1. Flash and fire Point test.

The flash and fire point tests are commonly performed on bitumen because bitumen is a flammable substance that is commonly used in various applications, such as road construction, roofing, and waterproofing. Understanding the flash and fire points of bitumen is important for several reasons:

1. Safety
2. Regulatory Compliance
3. Quality Control
4. Emergency Response Planning

TABLE I

Amount of plastic	**0%**	**5%**	**10%**	**15%**	**20%**	**25%**
Flash Point	165 ℃	171 ℃	187 ℃	193 ℃	201 ℃	216 ℃
Fire Point	185 ℃	193 ℃	201 ℃	208 ℃	212 ℃	223 ℃

For above VG 30 bitumen used & IS.73.2013. is referred.

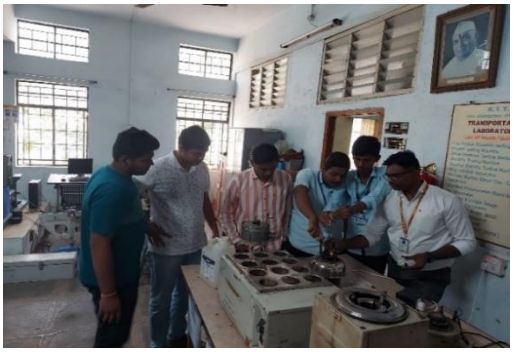

fig.1 – performing flash & fire point test

3.3.2. Ductility test.

The ductility test is performed on bitumen to measure its ability to deform without breaking under tensile stress. This test helps determine the flexibility and stretchability of bitumen, which are important properties for its performance in various applications, such as road construction, roofing, and waterproofing. Here are some reasons why the ductility test is performed on bitumen:

1. Performance Evaluation
2. Material Characterization
3. Quality Control
4. Specification Compliance
5. Research and Development

TABLE II

Amount of plastic	**0 %**	**5 %**	**10 %**	**15 %**	**20 %**	**25 %**
Ductility	40 mm	65 mm	62 mm	56 mm	42 mm	32 m

For above VG 30 bitumen used & IS.73.2013. is referred.

fig.2 – ductility test

3.3.3. Penetration test.

The penetration test is performed on bitumen to evaluate its consistency, hardness, and suitability for various applications. Here are some key reasons why the penetration test is conducted on bitumen:
1. Consistency Assessment
2. Hardness Determination
3. Quality Control
4. Specification Compliance
5. Research and Development

TABLE III

Amount of plastic	0 %	5 %	10 %	15 %	20 %	25 %
Penetration	45 mm	35 mm	28 mm	21 mm	18 mm	15 mm

For above VG 30 bitumen used & IS.73.2013. is referred.

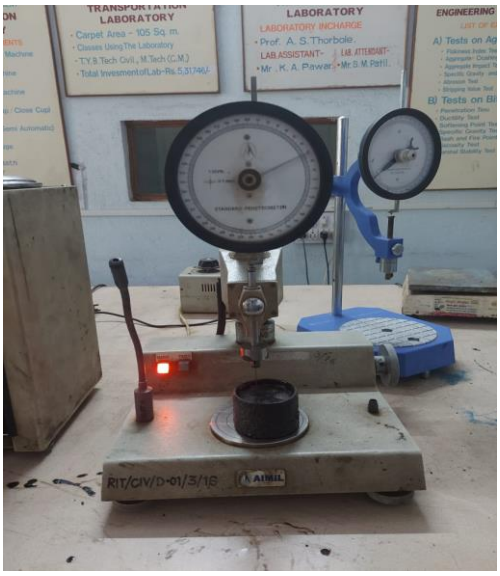

fig.3 – performing penetration test

3.3.4. Softening test.

The softening point test is conducted on bitumen to determine the temperature at which the material softens or becomes pliable. This test provides valuable information about the thermal properties and performance characteristics of bitumen, which are essential for various applications. Here are some key reasons why the softening point test is performed on bitumen:

1. Performance Evaluation
2. Material Selection
3. Quality Control
4. Compatibility Testing
5. Research and Development

TABLE IV

Amount of plastic	**0%**	**5%**	**10%**	**15%**	**20%**	**25%**
Softening point	47°C	55°C	60°C	62°C	65°C	70°C

For above VG 30 bitumen used & IS.73.2013. is referred.

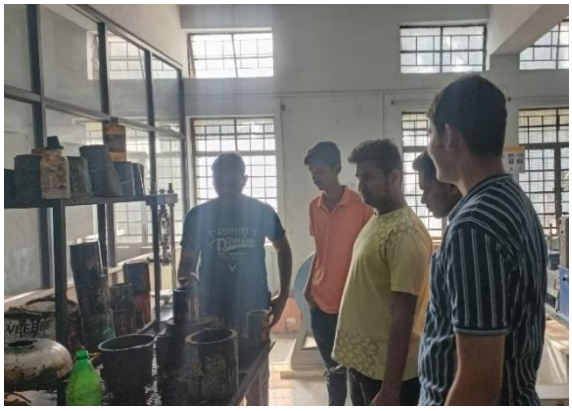

fig.4 – performing marshall stability test

3.3.5. Marshall stability test.

The Marshall stability test is performed on bitumen to determine the stability and strength of the bituminous mixture. This test helps to evaluate the ability of the bitumen to withstand deformation and resist rutting under traffic loads. It provides valuable information about the quality and performance of the bituminous material, which is crucial for designing durable and long-lasting road pavements. Additionally, the Marshall stability test helps in determining the optimum bitumen content for a specific mix design, ensuring that the pavement meets the required performance criteria.

TABLE IV

Amount of plastic	**0%**	**5%**	**10%**	**15%**	**20%**	**25%**
Marshall Stability (kN/mm)	5	6.7	6.9	7.1	7.8	8.1

For above VG 30 bitumen used & IS.73.2013. is referred.

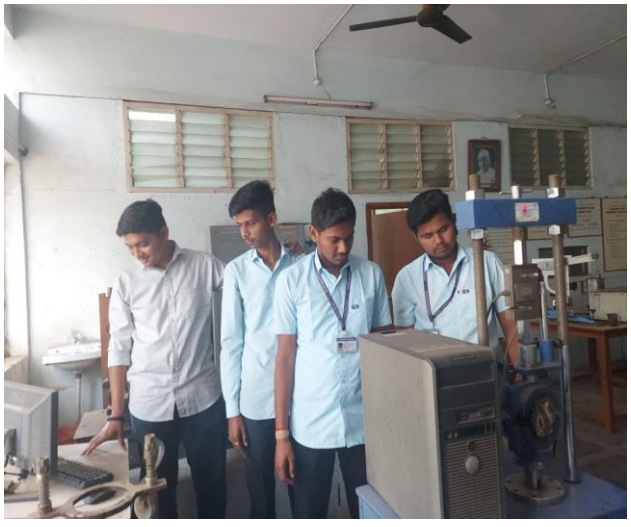

fig.4 – performing marshall stability test

3.4 Case study on roads constructed using plastic.

As per IRC.SP.098.2019 Government of India has given guidelines to use plastic waste in road construction. And it is necessary to use 5% plastic in road construction.

Chennai was among the first cities globally to adopt the technology in a big way when the municipality commissioned 1000 km of plastic roads in 2004. The first plastic road in Tamil Nadu was laid down in Kambainallur, a Panchayat Town of the Dharmapuri district as per the guidelines of then Chief Minister. Since then all major municipalities in India have experimented with the technology including Pune, Mumbai, Surat, Indore, Delhi, Lucknow, etc.

Chennai: While plastic roads may be a new concept in many parts of India, Chennai has been experimenting with them since 2011. Chennai has used nearly 1,600 tonnes of plastic waste to construct 1,035.23 kilometres length of roads in recent years, which include N.S.C Bose road, Halls road, Ethiraj Silai Street and Sardar Patel Street.

Pune: Using bitumen technology on waste plastic, the Pune Municipal Corporation constructed a 150-metre stretch of Bhagwat lane at Navi Peth near Vaikunth Crematorium in 2016. The other trial patches in Pune include Dattawadi Kaka Halwai Lane, Katraj Dairy, Magarpatta City HCMTR Road, Kavade Mala Road, Koregaon Park Lane No 3 and Yerawada Shadal Baba Darga Road from Chandrama Chowk.

Indore: Dating 2014, the Madhya Pradesh Rural Road Development Authority (MPRRDA) has constructed around 35 km of roads in 17 districts with plastic waste.

Surat: The idea of using plastic-bitumen mix was executed in January 2017. The problem of potholes significantly reduced as no cracks developed in areas where roads were layered with waste plastic.

The technology has penetrated deeply and has found application even in far flung areas such as Meghalaya, where a village converted 430 kg of plastic waste into a kilometer long road in 2018.

In December 2019, India built 21,000 miles of roads using plastic waste. Until now, the country has almost 33,700 km of plastic roadways that means every 1 km road uses one million plastic bags. As of 2021, only 703 kilometers of National Highways were constructed using plastic roads.

IV. CONCLUSION

From this project we can conclude that….

1. The project has been completed successfully.
2. Bitumen is showing very good results after mixing with plastic.
3. From above results we can determine that we can add plastic up to 15% in bitumen
4. The dry process of road construction is very effective and economical to use than wet process.
5. Due to plastic use in road construction, we can assure that plastic waste will be decreased effectively.
6. Due to government support and with the efforts of Indian scientist R. Vasudevan. Engineers Contractors are preferring this technology in road construction.
7. And after detailed investigation on different roads constructed using plastic waste, we can assure you about using plastic waste in road construction will be very effective and economical.

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