Analyzing Plastic Waste Used in Road Construction

Paresh Gamar[1], Jash Nimesh Kansara[2], Sivakumar K. Patel[3]

Student, M.tech Transportation Engineering, Sankalchand Patel College of Engineering, Visnagar, India[1]
Student, M.tech Transportation Engineering, Sankalchand Patel College of Engineering, Visnagar, India[2]
Assistant Professor, Civil Engineering, Sankalchand Patel College of Engineering, Visnagar, India[3]

gamarparesh934@gmail.com[1], jnkansaracivil_spce@spu.ac.in[2],skpatelcivil_spce@spu.ac.in[3]

Abstract: - The objective of this project is to utilize waste plastics as an additive in road surfacing in India, with the purpose of addressing environmental pollution resulting from plastic materials. India's municipal solid waste (MSW) had increased to a range of 6500-7000 tonnes per day by 2015. Dumping waste into the sea could have adverse effects on marine life and ecosystems. Disposing of plastic waste could serve as a straightforward remedy to this issue. The county is implementing a novel asphalt blend that effectively tackles plastic-related concerns while concurrently lowering road construction expenses, enhancing rainwater resistance, promoting better adhesion, and bolstering road durability. The objective of this study is to create an improved plastic asphalt mixture by incorporating shaded polythene materials into the bitumen blend. This will enhance the adhesive properties between the aggregate surfaces, resulting in increased strength, durability, and skid resistance of the asphalt pavement. This study investigates the utilization of waste plastics in the construction of roads, which is a commonly accepted method that has the potential to greatly influence the industry and support environmental sustainability.

Keywords: plastic, stability, waste management, air voids

I. INTRODUCTION

Building roads with plastic has been around for a while. There has been encouraging new research on recycling plastics for use in road building. When you're on plastic roads, use disposable cups, PET bottles, and plastic shopping bags that you find at trash disposal yards. The aggregate is coated with an oily layer made of melted plastic and heated bitumen; this mixture is then spread out over the road surface in the same way as a regular tar road. Plastic pollution is a big problem. A solution to environmental problems and an asset to the road's longevity can be found in the use of plastic waste in road construction, according to research. Every year, India receives around 500,000 MT of plastic and polythene. Out of this amount, 30% is sent overseas for export and 70% is utilized within the country. Out of that 70%, around 40% will be recycled and 60% will end up in the trash. Dumping this trash into the ocean threatens marine life and the ecosystems that support it.

A. Problem Statement

- Because plastic is lightweight, easy to handle, unbreakable, and has so many other benefits that make life easier, its use in human life is growing daily.
- While toys, bottles, and broken household items made of hard plastic can partially be recycled Products made of polythene, like lunch sheets, plastic bags, and shopping bags, cannot be recycled. These things clog drains, choke animals that eat waste food, and emit poisonous gases into the atmosphere when they burn.
- The management of the garbage dumping yards under their jurisdiction and the disposal of waste polythene have proven to be challenges for the local authorities.
- Thus, the goal of the research was to determine whether adding shredded polythene to asphalt concrete road surfacing would improve its qualities and lengthen its lifespan.

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B. Objectives of the research

- Determine the materials required to build the plastic road.
- Marshall's trial design Mix designs with varying waste plastic contents should beidentified, along with the suitable trial mixture.
- Testing the plastic bitumen mixture's strength and durability and contrasting it withthe traditional mixture.
- After examining the test results, determine the mixture's ideal waste plastic content.
- When building a road, weigh the benefits and drawbacks of waste plastic asphaltmixture against regular asphalt mixture.

II. LITERATURE REVIEW

[1]. According to research in 2013, the cost of normal asphalt roads and waste plastic roads in Indian currency, estimating the benefits of using an asphalt mixture. The cost of plastic waste is Rs. 5 per Kg, while the cost of bitumen per drum is Rs. 10000. For a 1 km road, 10 tons of bitumen are required, resulting in a total cost of Rs. 5,00,000 per Km. The optimal percentage of plastic used is around 10%, resulting in a total cost of Rs. 4,50,000 for 9 tons of bitumen and Rs. 5,000 for plastic waste.

[2]. The 2018 study explores the use of waste plastic in road construction, focusing on its effects on porosity, soundness, and moisture absorption. It reveals that plastic can increase the melting point of bitumen, making roads stronger and longer-lasting. This technology also contributes to the environment by improving bitumen properties, aiming to create strong, long-lasting, and environmentally friendly roads.

[3]. Azmat Shaikh examined that the addition of plastic waste to bituminous road pavements improves its Marshall Characteristics, increasing its stability and resistance to deformations under heavy wheel loads. This study not only utilizes non-degradable plastics but also provides a more stable and durable pavement with improved strength and longer life,reducing plastic waste disposal volume and developing eco-friendly technology.

[4]. In 2016, The increasing generation of waste plastics presents an eco-friendly solution for disposal. By using plastics in the pavement, they can increase the melting point of bitumen, making it easier to dispose of these non-recyclable wastes. This innovative technology strengthens road construction, making it more economical and extending the life span of roads. This is particularly feasible in countries like India.

[5]. This systematic review in 2023 examines the impact of plastic waste on asphalt mixture fatigue and rutting behavior. The findings suggest that plastic waste incorporation improves rutting performance,but further studies are needed to confirm its effects. Other additives like PET, HDPE, LDPE, and PP and PVC improve rutting and fatigue performance. The optimal amount of plastic added is around 1% of the mixture's weight. The study also found no evidence of theinfluence of asphalt mixture gradation and plastic shape on plastic effects. Dense-graded mixtures were the most studied.

III. METHODOLOGY

A. Preparation

- Specimen Quantity - Create specimens for every possible combination of aggregates and bitumen content.
- To prepare the aggregates, heat them at a temperature between 1500°C and 1100°C until they reach a constant weight. Then, use a sieve to separate the aggregates into the desired size fractions. The following size fractions are suggested:

25.0 to 19.0 mm

19.0 to 9.5 mm

9.5 to 4.75 mm

4.75 to 2.36 mm

Passing 2.36 mm

- Get the aggregates measured out into separate pans for each test specimen, making sure to include the amount of each size fraction. This will ensure that the final batch will produce a compacted specimen weighing around 1200 g. Heat the oven to a temperature of 1750 to 1900 degrees Celsius, being careful not to go higher than the pans themselves.

- Add the heated aggregate to the mixing bowl, then fully mix by hand. Create a crater in the dry blended aggregate and add the necessary quantity of heated bituminous material to the mixture by weighing it. Aggregate and bituminous material should be mixed quickly to ensure complete coating.

IV. RESULTS & ANALYSIS

We can find the OBC for 0.8 % of plastic &4.5% of bitumen.

First, we have to find the bulk specific gravity (Gm) of the sample.

$$Gm = \frac{total\,weight}{\dfrac{total\ volume}{density\ of\ water}}$$

$$Gm = (1269.7\ g/555.0\ cm^3)\ /\ 1\ (g/cm3)$$

$$Gm = 2.29.$$

Then the theoretical specific gravity (Gt) is calculated,

$$Gt = (Wf + Wb + Wca + Wfa)\ /\ \Sigma\ Wi\ /\ Gi$$

$$Gt = (33.2 + 484.5 + 263.4 + 316.6 + 106.0 + 47.8)\ /\ 455.25$$

$$Gt = 2.74$$

Then we have to find voids in mineral aggregate (VMA) to that we have to find (V a) and (Vb)

The volume of air voids (V a),

$$Va = (Gt - Gm)\ /\ Gm * 100\%$$

$$Va = (2.74 - 2.29)\ /\ 2.29 * 100\%$$

$$Va = 20.8\ \%$$

Volume of Bitumen (V b),

$$V\ b = (volume\ of bitumen\ /\ total\ volume) * 100\%$$
$$= (47.8\ /1.023\ /1267.7\ /2.29) * 100\%$$
$$= 8.4\ \%$$

Therefore, voids in mineral aggregates (VMA),

$$VMA = Va + Vb$$

$$= (20.8 + 8.4)\%$$

$$= 29.2\ \%$$

Void filled with bitumen (VFB),

$$VFB = (Vb\ /\ VMA) * 100\%$$
$$= (8.4 / 29.2) * 100$$
$$= 28.76\ \%$$

Following is the result sheet for 0.8% plastic content. Refer the annexes for the Marshall TestData Sheet.

TABLE I:
RESULT FOR 0.8 % PLASTIC CONTENT

Bitumen %	Air voids (V a)%	VMA (%)	VFB (%)	Load kN	Flow (*0.25mm)	Unit Weight
3.50	8.8	12.88	8.4	15.9	10.3	2.24
4.00	7.9	13.02	9.1	15.9	10.1	2.25
4.50	6.8	13.96	10.2	16.8	10.4	2.28
5.00	6.1	13.77	11.4	16.8	11.3	2.30
5.50	5.3	14.73	12.3	16.3	11.1	2.33

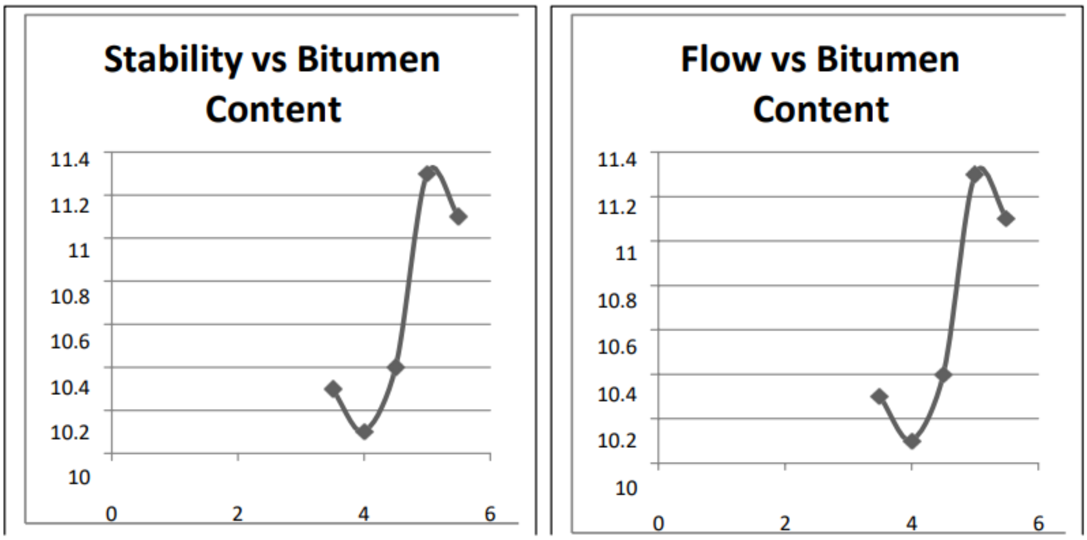

Fig. 2 Stability Vs Bitumen Content & Flow vs. bitumen Content

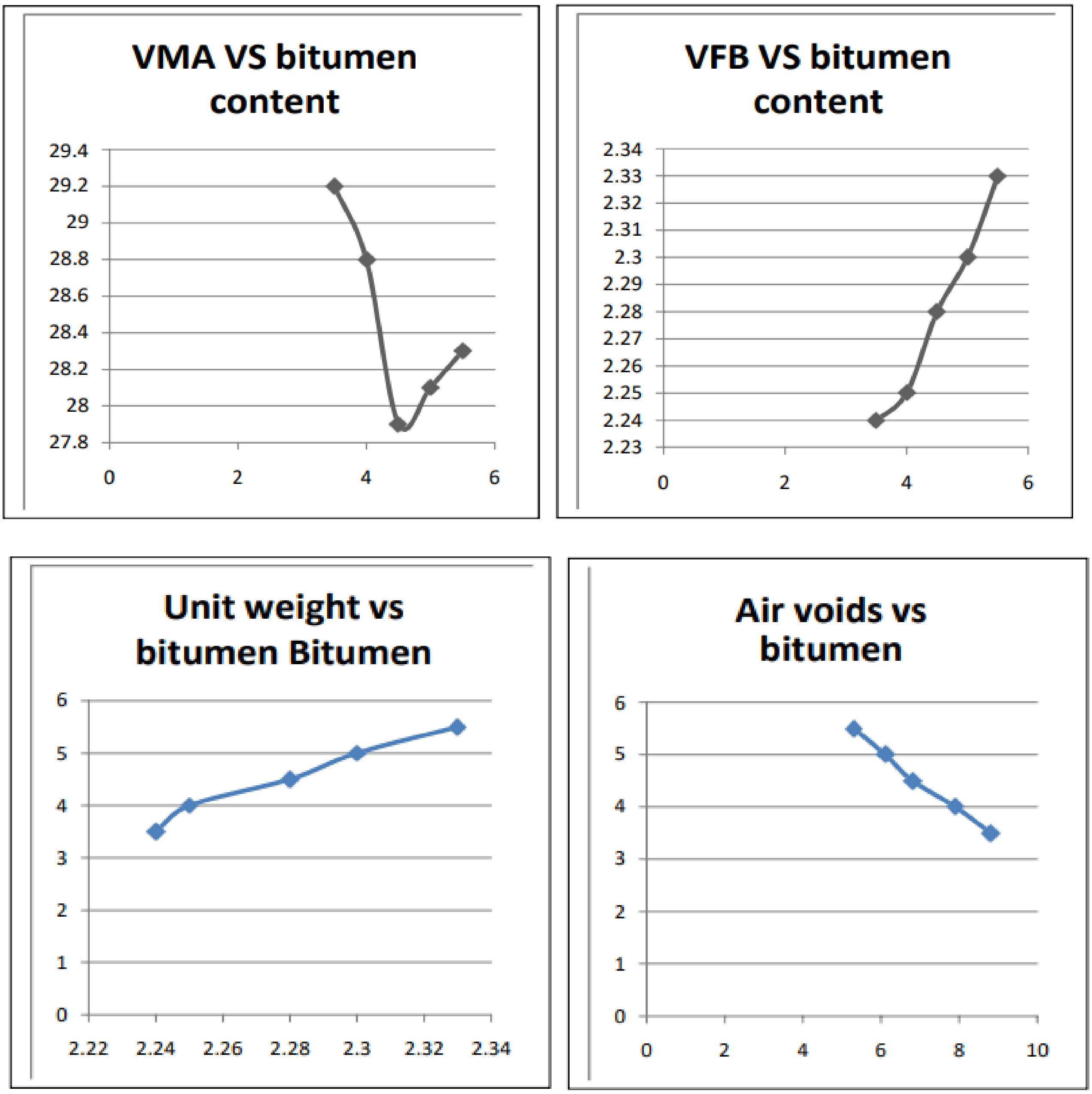

Fig. 3 VMA, VFB, Unit weight, Air voids Vs Bitumen

According to Road Development Authority standards the Standard specification for a B-Class road as follows,

- Value of Stability – 10 – 81 kN
- Value of Flow – 8 - 16 Units (0.25mm)

- Voids in Air – 3 - 5 %
- Value of VMA – > 13 %

TABLE II:
FINAL RESULTS

	Normal Design	**2.5%**	**1%**	**0.8%**	**0.2%**
B.C.%	4.5	4.5	4.5	4.5	4.5
VMA%	15.2	19.5	16.7	13.96	13.1
Va%	5.3	10.1	6.9	6.8	5.2
Stability (kN)	13.5	19.8	15.9	16.8	14.8
Flow (0.25mm)	12.2	10.7	9.8	10.4	12.6
Stability by Flow (kN/mm)	4.5	7.6	6.5	6.5	4.7
G (mm)	2.485	2.485	2.485	2.485	2.485

V. CONCLUSIONS

The waste plastic material used in this process was shaded polythene with particle sizes ranging from 6 to 14 mm. As a result, a significant quantity of plastic waste is needed for a short distance of road; otherwise, there will be less plastic waste lying around. The Marshall Test results verified that the modified waste plastic mix design's strength, durability, and other properties fall within the standard specifications for roads.

	Road standard specification	**Modified waste plastic mixture**
Value of Stability	(10 to 81) kN	14.8
Value of Flow	8 to 16 Units	12.6
Voids in Air	3 to 5 %	5.2
Value in VMA	Great than 13%	13.1

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