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Utilization of Plastic Waste and Fly Ash in Bituminous Road: A Review Paper

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ABSTRACT-

Disposal of waste materials including waste plastic bags and Fly Ash have become a serious problem and waste plastics are burnt for apparent disposal which cause environmental pollution. Utilization of waste plastic in bituminous mixes has proved that the properties of mix are improved and disposal problems are also solved to some extent. The cleaned Plastic waste is cut into a size such that it passes through 2.36 mm sieve using shredding machine. The aggregate mix is heated and the plastic is effectively coated over the aggregates. This plastic waste coated aggregates and fly ash are mixed with hot bitumen to prepare job mix formula. The use of the innovative technology will not only strengthen the road construction but also increase the road life as well as will help to reduce the environment pollution. The present study investigates the use of waste plastic and Fly Ash as a modifier for bituminous concrete. In this study the shredded plastic waste is mixed in hot aggregate and the plastic modified mix is prepared using different percentages of plastic by weight of bitumen and fly ash by weight of filler .it has been found that the Marshall stability value is maximum when 10% plastic waste is added to the mix. The other Marshall parameters are also improved with the addition of plastic waste into the bituminous mix.

Key Words: Plastic waste, Fly Ash, Plastic coated aggregate, Marshall Stability

1. INTRODUCTION

Plastic is a substance that comprises one or more organic polymers of significant molecular weight, is solid in its completed state, and can be moulded by its flow at some point during manufacture or processing into finished objects. Plastics are long-lasting and disintegrate slowly; the chemical connections that make plastic so strong also make it resistant to natural decomposition processes. Thermoses and thermoplastics are the two major kinds of plastics. When heated, a thermoset solidifies or "sets" irreversibly. They are widely employed in vehicles and construction applications because of their durability and strength. Polyethylene, polypropylene, polyamide, polyoxymethylene, polytetrafluorethylene, and polyethylene terephthalate are the plastics in question. When subjected to heat, a thermoplastic softens and returns to its original state at room temperature. Milk bottles, floor coverings, credit cards, and carpet fibers are all examples of thermoplastic items that may be easily molded and moulded. Phenolic, melamine, unsaturated polyester, epoxy resin, silicone, and polyurethane are some of the plastic varieties available.

According to recent studies, plastics can last for up to 4500 years on Earth. As the world population grows, so does the demand for food and other necessities, resulting in an increase in the amount of waste generated daily by each home. Plastic, in various forms, accounts for over 5% of municipal solid waste, which is harmful by nature. Empty plastic bags and other types of plastic packaging material polluting the roads and drains is a typical sight in both urban and rural locations. Because of its biodegradability, it causes water stagnation and associated hygienic issues. To address this issue, studies were conducted to see if this waste plastic might be utilized productively. Experiments at numerous institutes revealed that when waste plastic is added to heated aggregate, it forms a fine coat of plastic over the aggregate, and that this aggregate, when mixed with the binder, provides greater strength, water resistance, and long-term performance. Road surfacing can be done with waste plastic such as carry bags, disposable cups, and laminated pouches like chips, pan masala, aluminum foil, and packaging material used for biscuits, chocolates, milk, and supermarket items.

The use of plastic in conjunction with bitumen in road building not only extends the life and smoothness of the road, but also makes it more cost-effective and environmentally friendly. To improve some of the qualities of bitumen, plastic waste is utilized as a modifier. Plastic Roads are roads that are made out of plastic waste and have been found to perform better than roads made out of traditional bitumen. It was also discovered that when such roads came into contact with water, they were not stripped. A higher percentage of plastic is used.

Bitumen consumption is reduced by 10% as a result of waste. It also improves the road's strength and performance. Because plastic raises the melting point of bitumen, mixing becomes easier and more efficient. Plastic trash substitutes 10% to 15% of bitumen, according to Dr. R. Vasudevan, Dean ECA and Professor, Department of Chemistry, Thiagarajan College of Engineering, Madurai, saving roughly Rs.35000 to Rs.45000 every kilometer of road stretch. Incorporating plastic waste into road building prevents road surface plastic shrinkage cracking and lowers drying shrinkage to some extent.

2. REVIEW OF THE LITERATURE

The use of plastic waste in flexible pavements would provide a solution to the problem of plastic waste disposal. Many studies have been conducted on the use of plastic trash in the construction of bituminous roads. Bhageerathy et al. (2014) looked into the usage of biomedical plastic waste in the construction of bituminous roads. The Marshall stability value of the plastic modified mix was found to be 51% higher than that of the standard mix, indicating an increase in load carrying capability.Gawande et al. (2012) summarized an overview of the use of waste plastic in road asphalting. They looked at methods for repurposing plastic trash for road and flexible pavement construction. Sultana et al. (2012) explored the use of waste plastic as a strength modifier in flexible and rigid pavement surface courses. They came to the conclusion that waste plastic might be used as a modifier for asphalt concrete and cement concrete pavement. Dr. R. Vasudevan (2007) studied how coating plastics reduces porosity, moisture absorption, and increases soundness. Because the polymer coated aggregate bitumen mix has a greater Marshall Stability value and a sufficient Marshall Coefficient, it is a better material for flexible pavement construction. As a result, using waste plastics for flexible pavement is one of the greatest ways to dispose of waste plastics quickly. Plastic bags on the road aid in a variety of ways, including waste disposal, road improvement, and pollution control.According to Dr. R. Vasudevan and S. Rajasekar (2007), a polymer bitumen blend is a superior binder than plain bitumen. With a proper ductility, the blend has a higher Softening point and a lower Penetration value.Raji et al. (2007) looked into the "use of marginal materials as a component in bituminous mixtures." They came to the conclusion that plastic wastes can be employed as bituminous pavement additives. The qualities of bituminous mix when changed with shredded syringe plastic waste were studied in their study. The operation was done using a dry technique to combine shredded autoclaved plastic syringes with heated aggregates.

3. OBJECTIVES

The basic goal is to effectively use waste plastic in a constructive way that benefits society, however the current project's main goals are as follows:

- To coat the aggregates with the waste plastic materials.
- To examine the qualities of a specimen of bituminous mix.
- To compare the properties of bituminous mix specimens with the properties of coated aggregates due to the coating of waste plastic materials on bituminous mix specimens.
- To determine the best proportion of waste plastic and Fly Ash to add to the bitumen mix in order to get the desired strength.
- To compare the experimental results to traditional pavement details and conduct a cost-benefit analysis.

4. PROPOSED METHODOLOGY

1. Collect waste plastic bags first.
2. Collected plastic waste and categorized it according to thickness requirements.
3. Polyethylene 60 microns or less is usually utilized for the next step.
4. At higher temperatures, less micron plastic is more easily mixed into bitumen (160-170^{o}c)
5. As much as feasible, the collected plastic was cut into fine bits.
6. Then filter it through a 4.75mm sieve and collect it on a 2.36 mm sieve.
7. First, the bitumen is heated to a melting temperature of 160-170 degrees Celsius. Then more pieces were added to the mix.
8. Mixture was manually swirled for 20-30 minutes at a constant temperature.
9. Polymer bitumen mixtures of various compositions will be created and employed for various tests, including penetration, ductility, flash point, and fire point testing, stripping, ring and ball testing, and Marshall stability testing.

4.1 Plastic-Waste Coated Aggregate Preparation:

The aggregate was heated to roughly 170 C, and the plastic waste was shredded to sizes ranging from 2.36mm to 4.75mm. This shredded plastic garbage was mixed in with the hot aggregate to provide a consistent distribution. The plastic melted and adhered to the aggregate. Hot bitumen 60/70 or 80/100 grade was combined with hot plastic waste covered aggregate (160C).

4.2 Mini Hot Mix Plant Mixing:

Step I: Shredding machine is used to shred plastic waste comprised of PE, PP, and PS into sizes ranging from 2.36mm to 4.75mm.

Step II: To ensure good binding and avoid weak bonding, the bitumen should be heated to a maximum of 1600C. (It's critical to keep an eye on the temperature.)

Step III: Add the shredded plastic trash to the hot aggregate in the mixing chamber. Within 30 seconds, it coats the aggregate uniformly, giving it an oily appearance. It is possible to obtain plastic-coated aggregate.

Step IV: The plastic-coated aggregate is then coated with hot bitumen, and the resulting mix is used for road construction. The temperature for laying roads is between 1100 and 1200 degrees Celsius. The roller in question has an 8-ton capacity.

4.3 Central Mixing Plant (CMP) Mixing:

The dry process can also be done with a central mixing plant. Up the conveyor belt, the shredded plastic is mixed in with the aggregate. This is poured into the steaming cylinder. The bitumen is applied after the aggregate has been covered with plastic. After that, the mixer is placed into a dipper lorry and sent for road laying. CMP allows for greater temperature control and mixing of the material, resulting in a more uniform coating.

5. RESULTS AND DISCUSSIONS

5.1 Aggregate impact value

The test is used to determine the fracture resistance of the aggregate. It determines the road's ability to withstand impact or the road's toughness. Heavy trucks on the road are subjected to continual impact, which causes them to disintegrate. It often looks like crocodile skin at first before entirely breaking down. To determine this, a sample of the mixture is obtained and smashed 15 times using a 14 kg hammer. The amount of mass that becomes powdered should not be more than 30%. The mass passing through a 2.36mm sieve will be designated as the powdered mass. The findings of the experiment were determined to be 25.4 percent, 21.2 percent, 18.5 percent, and 17 percent for 0 percent, 1 percent, 2 percent, and 3 percent of plastic, respectively. This indicates that the plastic reduces the likelihood of the mixture splitting in the event of a large force.

5.2 Los Angeles abrasion value

The Los Angeles abrasion test was employed. This test determines how resistant the road's aggregate is to abrasion. As the vehicles move down the road, soil particles in the tyres and on the road cause abrasion of the road. This test determines whether or not the road aggregate is abrasion resistant. The mixture is rubbed with steel balls to determine this. This is accomplished by placing the mixture within a revolving drum on a 1.70mm sieve. Until 500 rotations had been completed, a predetermined number of steel balls rotated in a circular form at a velocity of 30-33 rpm. The mixture was placed at a specific spot on the perimeter so that each steel ball rubbed the mixture as it passed. The percentage of mass passing through the sieve should not exceed 30%. The experiment was carried out using 0%, 1%, 2%, and 3% plastic, and the percent mass flowing through the sieve was determined to be 37 percent, 32 percent, 29 percent, and 26 percent, respectively. This indicates that the plastic coating considerably enhances abrasion resistance and is required to bring it below the 30% threshold.

5.3 Binding test

The ability of a mixture to withstand deformation under a strong load is referred to as bending strength. The ability of a mixture to withstand being compressed or squeezed is referred to as compression strength. The hot mixture was crushed with a compacting machine before being compressed with a universal testing machine for this test. The test was carried out on mixes containing 10%, 20%, and 25% plastic, and it was repeated with different plastics. The findings show that the bigger the fraction of plastic, the better the bending strength and compression strength. For example, the bending strengths of polyethylene were 325kg, 340kg, and 350kg at 10%, 20%, and 25%, respectively, while the compression values were 250 tonnes, 270 tonnes, and 290 tonnes.

5.4 Moisture absorption test

The moisture absorption test is used to determine how much water the aggregate can absorb. In the event of any water logging, the road is prone to break down and form potholes if the water absorption is excessive. A fixed mass of the mixture was taken and immersed in water to assess how resistant the road is to water absorption. The mixture was withdrawn and reweighed after 24 hours. The water absorbed mass was the difference in mass. This was discovered at 0 percent, 1 percent, 2 percent, and 3 percent plastic concentrations. The amount of moisture absorbed has been expressed as a percentage of the mass of the added mixture. For 0 percent, 1 percent, and 2 percent of plastic added, the outcomes were 4%, 2%, and 1.1 percent, respectively. Only a small amount of water was absorbed by the 3% plastic. This shows that the plastic reduces the moisture susceptibility of the mixture.

5.5 Soundness test

This test assesses the mixture's resilience to weathering by subjecting it to accelerated weathering simulations. The salts dissolved in the water crystalize when water enters pores and gaps in the mixture, causing weathering. More crystal is generated when the water evaporates, and this crystal causes the mixture to split and break. The porous aggregate can disintegrate prematurely due to freezing and thawing. The test involves performing five accelerated weathering cycles and calculating the amount of mixture that was lost. When using sodium sulphate solution, the percent mass lost should not exceed 12%. Plastics of 0%, 1%, 2%, and 3% were employed in the same way that they were in the moisture test. The results showed that the percent lost for 0 percent plastic (plain aggregate) was 5 percent 1 percent, while no mass loss was detected for 1 percent, 2 percent, or 3 percent plastic. This indicates that the plastic in the combination improves the mixture's weathering resistance. This could be explained by the fact that as the percentage of plastic in the mixture grew, the percentage of voids in the mixture dropped. For 0 percent, 1 percent, and 2 percent plastic, the values were 4 percent, 2.2 percent, and 1 percent, respectively, whereas no voids were identified in 3 percent plastic.

5.6 Results of tests on aggregates

Percentage of Plastic	Moisture Absorption (%)	Aggregate Impact Value (%)	Aggregate Crushing Value (%)	Los Angeles Abrasion Value (%)	Specific Gravity	Stripping Value (%)
Control Specimen	1.7	5.43	19.2	13.42	2.45	8
PP8	Nil	4.91	13.75	10.45	2.3	Nil
PP10	Nil	4.36	9.38	9.17	2.64	Nil

5.7 Results of tests on bitumen

Test	Result	Ranges
Ductility Test	77.50 cm	Min 40
Penetration value	63 mm	60-70 mm
Viscosity value	50.1 sec	-
Softening Point	48.25˚c	45-600 ˚c
Flash Point Test	145˚c	65-175 ˚c
Fire point test	157˚c	65-175 ˚c

5.8 Plastic Road- Advantages and Disadvantages

Advantages:

1) Better binding properties, higher softening point; can endure high temperatures.
2) Lower penetration value; can handle more weight. No water permeability – Doesn't need to be stripped.
3) Increased road strength due to higher Marshall Stability. When compared to a bitumen road, it is less expensive.
4) Waste plastics should be disposed of more efficiently. In a one-kilometer route, there are ten lakhs or one ton of carry bags.
5) The gaps are reduced by the plastic coating. As a result, there is less rutting and reveling, and no potholes emerge. The road is more durable and can endure high traffic.

Disadvantages: Burning plastic waste pollutes the air and causes environmental issues.

6.CONCLUSION

The use of a plastic coating on aggregates improves the performance of roadways. Due to increased bonding and area of contact between polymers and bitumen, this aids in better bitumen binding with plastic waste coated aggregate. The spaces are also reduced by the polymer covering. This prevents entrapped air from absorbing moisture and oxidizing bitumen. This has resulted in less rutting, ravelling, and the production of potholes. The roads are more durable and can endure heavy traffic. The following are some of the study's key findings:

1. The control specimen's aggregate impact value was 5.43 percent. For PP8, it was 4.91 percent, while for PP10, it was 4.26 percent. The value of PP8 was reduced by 10%, while PP10 was reduced by 22%. This demonstrates that the aggregate's toughness was strengthened in order to withstand the impacts.
2. For PP8 and PP10, the crushing value was reduced from 19.2 percent to 13.33 percent and 9.82 percent, respectively. The value of PP8 has been cut by 30%, and the value of PP10 has been reduced by 48%. Because the crushed fraction is low, a low aggregate crushing value suggests strong aggregates.
3. Due to the plastic coating, the specific gravity of the aggregate increases from 2.45 for the control specimen to 2.7 for PP8 and 2.85 for PP10.
4. For PP8 and PP10, the stripping value was reduced from 8% for the control specimen to 0%. As a result, coated aggregates are better suited to bituminous construction than plain aggregates.
5. Water absorption for PP8 and PP10 is also reduced to nil, compared to 1.7 percent for the control specimen.
6. Abrasion in Los Angeles The control specimen was found to have a value of 13.42 percent. For PP8, polymer coating over aggregate increased abrasion value by 19.97%, and for PP10, it raised abrasion value by 29.88%. This shows the aggregate's hardness.
7.In conclusion, employing plastic waste in mix will assist reduce the demand for bitumen by roughly 10%, boost the strength and performance of the road, prevent the need of anti-stripping agents, avoid incineration and land filling of plastic waste, and ultimately produce an eco-friendly technology.
8. Roads' lifespan is being shortened as a result of increased traffic. Plastic roads are a preventative measure that will, in the end, be the cure. It will save millions of dollars and reduce the number of resources utilized in building in the future.

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