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Utilization of Waste Plastic and Rubber for Commercial Purpose

Virendra K Paunikar, Pradeep E More, Dr. Ravi W Tapre
Chemical Engineering Department, Datta Meghe College of Engineering, Navi Mumbai, Maharashtra, India

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ABSTRACT

Plastics are non-biodegradable elements that pollute our environment. Plastic garbage has shown to be a health hazard due to its poisonous nature. In today's world, plastic garbage is a major annoyance. As a result, this plastic trash should be repurposed in order to eliminate the harm to the environment. One example is the creation of flexible pavements. Plastic-coated aggregates have been shown to be more resistant to abrasion and wear and tear. Furthermore, due of the increased surface area of interaction among plastic (i.e. polymers) and bitumen, the binding between these plastic coted aggregates and bitumen is particularly strong. These roads function better and have a longer life period.
Keywords : Plastic Waste, Aggregates, Bitumen

I. INTRODUCTION

Plastic goods are used in our daily lives. From greenhouses, coatings, and wires to packing, films, coverings, bags, and containers, we have it all. According to a 2009 UNEP report, the global manufacturing waste electrical and electronic equipment is around 40 million tonnes per year. Because of the various features of plastics, such as their light weight, durability, and strength, the global population and use of plastics has expanded dramatically from 1.5 million tonnes in 1950 to 299 million tonnes in 2013. Global plastic output might treble by 2050, according to estimates. Chemical recycling, also known as feedstock recycling or tertiary recycling, is an alternative technique. Which has lately sparked a lot of attention with the goal of transforming waste plastic into basic petrochemicals that may be utilised as chemical feedstock or fuels in a number of downstream processes. The cetane and octane values of polyethylene-derived gasoline are exceptionally high. [1] India is third in the world in terms of plastic garbage consumption. Bakelite and plastics can be utilised as an alternative for road and pavement building. This report also informs us about the general qualities and properties of waste plastics and Bakelite.

Plastic debris collected from garbage cans is shredded and mixed to bitumen as aggregate and blended material. To identify the key features and strength parameters of aggregates and bitumen, the relevant experiments were performed. They determined that plastic waste roads are more durable than flexible pavements and may be utilised in high traffic areas; TiO2 is added to minimise vehicle pollution by 10%.

Waste bakelite fine aggregate (WBFA) is used as a substitute material for natural fine aggregate in cement mortar in the following proportions: 0%, 20%, 40%, 60%, 80%, and 100%. Waste bakelite fine aggregate might be utilised in the mortar mix to replace some of the sand. [2]

Asphalt pavements are made of two fundamental components: gravel and asphalt binder. The quantities of these two main components (aggregate and asphalt) in HMA mixes are ideally blended to generate an affordable mix design.

Material evaluation is an important step in the performance and design of the both flexible and stiff pavements. The rut depth is proportional to the number of passes and the temperature. [5]

According to the experimental results, addition plastic waste with small particle size, thin thickness, and at 15% by weight of the total aggregate resulted in improved Marshall stability and resistance to water damage, as well as they can make a contribution to alleviating some of the environmental damage caused by traditional plastic methods of waste disposal. [7]

The use of plastic strengthens the pavement. Furthermore, a rise in the use of plastic may enhance the characteristics of aggregate up to a certain limit. Reusing waste materials such as plastic trash bottles (Polyethylene Terephthalate) with stone mastic asphalt at varied ratios ranging from 0% to 10% by weight of bitumen. The experiment results reveal that the ideal range is 4% to 6%. [8]

Plastics trash coated aggregate is combined with hot bitumen at temperatures ranging from 150oC to 165oC. The resulting temperature mixture of 130oC-140oC is employed in road construction. The temperature for road laying is between 110oC and 120oC. Using an 8ton (min.) capacity roller. Coating is simple, and the temperature required is the same as for road laying. Bitumen is linked to aggregate with the use of plastic, which acts as a binder. The plastic roadways include transition mats to help tyres go up to and down from the crossing. By dispersing the weight throughout the surface, these techniques help preserve wetland freight routes from rutting. According to the head of the Central Road Research Institute (CRRI), bitumen blended with plastic or rubber increases road quality and life. According to the CRRI's deputy director, polymers blended with bitumen raised construction costs by up to 6% while greatly increasing road lifetime. [9]

Plastic trash disposal has arisen as a significant environmental concern, and recycling is hampered by its non-biodegradable nature. Because plastic does not biodegrade, the amount of plastic garbage in our environment is continually rising. Plastic garbage is frequently the most unattractive type of litter and will remain visible in disposal sites for months without decomposing. [10]

Air blowing of asphalt reduces the penetration value of the asphalt binder, making the asphalt more brittle and prone to cracking during thermal cycling. The goal of this research is to increase the elasticity of blasted asphalt by combining it with 3percent, 5 percent and 7% by weight of thermoplastic waste EVA copolymer (WEVA). [13]

II. MATERIAL SELECTION

1. Aggregates

Fig.1 AGGREGATE[16]

Aggregates comprise the majority of the pavement structure and are the most commonly used materials in pavement construction. The strains induced by wheel loads on the pavement and surface course must be absorbed by the aggregates. They must also withstand the abrasive effect of traffic. These are used in the production of cement concrete, bituminous concrete, and other bituminous pavements, as well as granular base course beneath the superior pavement layers. As a result, the aggregate properties are critical to the roadway engineer. Aggregate qualities that are desired include strength, durability, toughness, and hardness. [20]

2. BITUMENS

Fig.2 BITUMENS [16]

Bitumen is a sticky, black, and viscous liquid/semi-solid. It is composed of extremely condensed polycyclic aromatic hydrocarbons with 95% carbon and hydrogen, 5% sulphur, 1% nitrogen, 1% oxygen, and 2000 ppm (parts per million) of metals. [2]

Bitumen is mostly utilized in exposed activities like road construction. It must deal with a variety of climatic circumstances, including rain. As a result, it should be insoluble in water and act as a waterproofing agent. Bitumen with a lesser water-resistance quality has a lower durability and strength. It also results in poor adhesion. As a result, bitumen should be highly water resistant.

3. Waste plastic

Fig.3 SHREDDED PLASTIC [16]

A plastic substance is any of a large variety of flexible synthetic or semi-synthetic organic solids. And they're frequently made of synthetic materials. Petrochemicals are the most typical source. Waste made of plastic (for ex. bags, cups, bottles) composed of PE, PP, and PS shrunk to a size of 2.36 millimeter to 4.75 millimeter using a shredding (cutting) machine [15]

Polyethylene glycols, also known as macro gels, are created by polymerizing ethylene oxide with water, mono ethylene glycol, or diethylene glycol as the raw material, with alkaline catalysis. After reaching the required molecular weight, the process is stopped by neutralizing the catalyst with acid. Normally, lactic acid is employed, however acetic acid as well as other acids can sometimes be found. [3]

4. Waste rubber

Truck or automotive's tyres are used to make crumb rubber. Whole truck tyres have 18% natural rubber, relative to 9% in automotive tyres and the discarded tyre is shredded into little bits using mechanical blades ranging in size from 1mm to 75m. [15]

III. METHODOLOGY

A) BASIC PROCESS

1. Segregation: Plastic garbage is gathered from a variety of places. In this process plastic and other waste material gets separated. Plastic must have a maximum thickness of 60 microns.
2. Cleaning Process: The plastic trash is cleaned to eliminate dust particles, and then dried to remove water particles.
3. Shredding process: Shredding is the process of plastic cutting into small pieces ranging from 2.36mm to 4.75mm using a plastic shredding equipment such as the agglometer or Scrap Grinder.
4. Collection process: Plastic particles with a diameter of 2.36-4.75 microns are collected and are used in road construction.

B) MAIN PROCESS

Many factors influence the modifier chosen for a project, including construction ability, availability, cost, and predicted performance. Modification is accomplished using two primary procedures: 1. Dry process, 2. wet method. The dry process includes direct incorporation of waste plastic, which is mixed with aggregate prior to actually adding bitumen to create a plastic modified bituminous concrete mix, whereas the wet process requires parallel blending of bitumen and waste plastic to develop a plastic modified bituminous concrete mix. [11]

Plastic waste is crushed into a powder, then blended in varying ratios with bitumen. Plastic raises the bitumen's melting point and makes the road more pliable during the winter, resulting in a longer life. Brittleness is eliminated and elastic nature is enhanced by combining plastic with bitumen. Plastic debris is melted and blended in a specific ratio with bitumen. [10]
There are two major procedures utilised for bitumen mixture flexible pavement, and they are as follows:

1. Dry Process:

Hot stone aggregate [i.e. 170°C] is combined with hot bitumen [i.e.160°C] for the pliable pavement, and the mixture is utilized for road laying. As per IS codes, the aggregate is selected depending on its durability, porosity, and water absorption capacity. The bitumen is selected based on its adhesion, penetrating, and high viscosity qualities. When the aggregate was coated with plastics, it improved in terms of voids, water absorbency, and durability. [10]

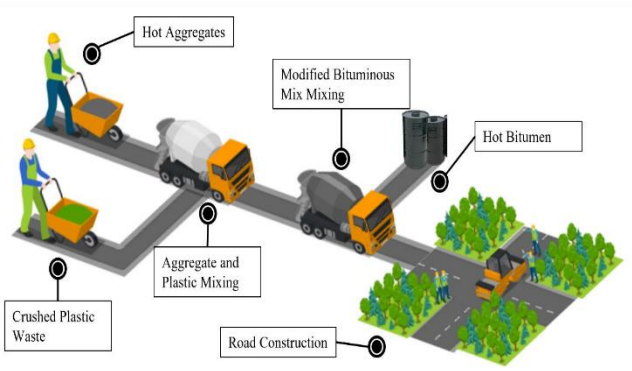

Fig.4 DRY PROCESS [19]

Chopped plastics are spread on heated aggregates to form plastic coated aggregates, which are then combined with hot bitumen to create a plastic coated aggregate- bitumen mixtures for road construction. The plastic covering reduces leakage of water and greatly improves aggregate performance and quality in flexible pavement.

Plastics waste is sprayed on top of aggregate in the modified method(i.e. dry process). Because of the improved bonding and area of contact among plastic and bitumen, this resulted in greater bitumen binding with both the plastic-waste coated aggregate. The polymer coating also helps to eliminate voids. This prevents trapped air from absorbing moisture and oxidising bitumen. This has led in less rutting and wear and tear, as well as no pothole development. [10]

In the dry process, plastics utilization mechanisms and connections between asphalt, aggregates, and plastics are all worth exploring. To

increase work ability throughout construction, the uniformity problem of covering between plastics and aggregates must be overcome. [4]

2. WET PROCESS:

1. The plastic is gathered in 60 micron or smaller pieces, which are desired for the next step. The reason for this is, that smaller plastic particles may easily combine with hot bitumen at temperatures ranging from 160 degree C to 170 degree C.

2. The bitumen is heated to the melting point of plastic, which itself is 160degree Celsius-170degree Celsius.

3. The tiny plastic bits were added to the hot bitumen at fixed temperature and the mixture was manually agitated for around 20-30 minutes. [17]

IV. TESTS

1. Aggregate Crushing Test

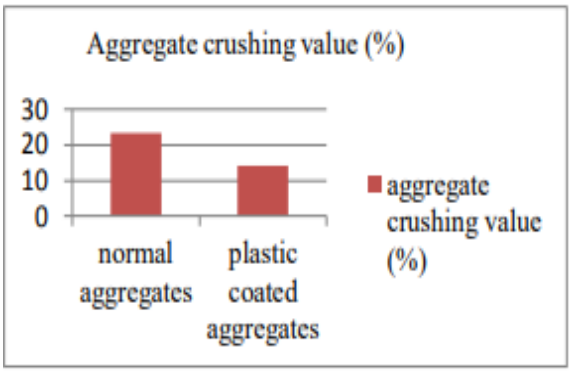

Fig.5 Aggregate Crushing Test [18]

The strength of coarse aggregate may be determined using aggregate crushing tests. The aggregate crushing value is indeed a relative concept of crushing resistance when compressive load is progressively applied. Aggregates with high crushing resistance or a low aggregate crushing value are preferred for good pavement quality. [18]

2. Los Angeles Abrasion Test

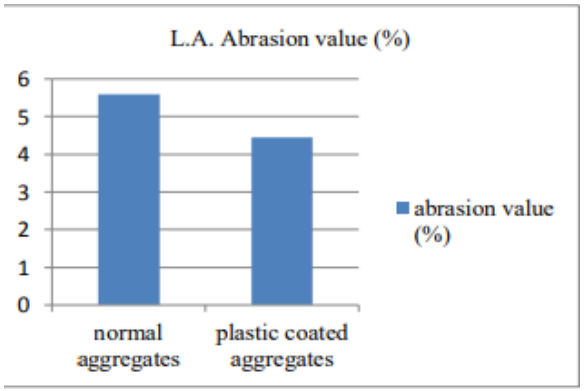

Fig.6 Los Angeles Abrasion Test [18]

The Los Angeles abrasion test is being used to calculate the percentage wear generated by the rubbing action of both the aggregate and steel balls used for the abrasive charge. During the test, these balls are pounded, and their resistance to wearing and impact is assessed. [18]

3. Impact Test

The impact test is created to assess the hardness of stone or aggregates' resistance to shatter under repeated impact. The aggregate impact test, which has been established by ISI, is often used to evaluate the impact resistance of aggregates. The aggregate impact value is a relative concept of aggregate to impact, each of which has a distinct effect from resistance to rising compressive stress. For aggregate to be utilized in the wearing course of pavements, the aggregate impact value should typically not exceed 30%. The maximum permitted value for bituminous macadam base course is 35 percent and 40 percent for water bound macadam base course. [18]

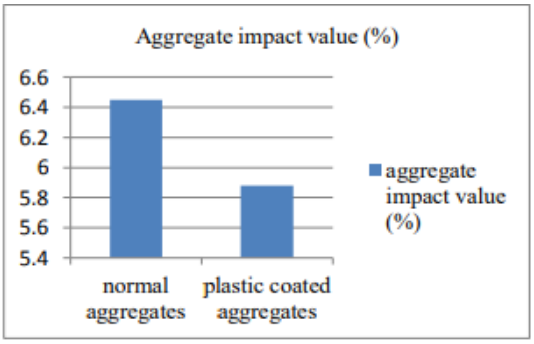

Fig.7 Aggregate Impact Test [18]

TABLE NO.1.MECHANICAL PROPERTIES OF AGGREGATE. [14]

Type of Test Tests	Method	Result	MORTH, 2013 Specification
Aggregate Impact Test	BS812: Part3	18.12%	<27%
Los Angeles Abrasion Test	ASTM: C131	26.7%	<35%
Aggregate Crushing Test	BS812: Part3	22.32%	<30%
Water Absorption Test	ASTM: C127	1.5%	<2%

V. COMPARISON

Plastic coated aggregates have been developed. no soundness, minimal water absorption and voids minimum aggregate impact, crushing value, and abrasion value than regular conventional aggregates.

By boosting the strength and performance of roads, the plastic waste mix will assist to reduce the requirement for bitumen by roughly 10%. [2]

When compared to improved semi dense bituminous concrete mixes including waste plastic, the clean semi dense bituminous concrete mixes had a 10% higher optimal bitumen concentration.2. The Marshall Stability of pristine semi dense bituminous concrete mixes at optimal bitumen % was 1.6 percent lower when comparison to modified semi dense bituminous concrete mixes containing waste plastic. When compared to modified semi dense bituminous concrete mixes containing waste plastic, the bulk density of plain semi dense bituminous concrete mixes with appropriate bitumen concentration was 0.43 percent higher. [9]

All binders were classified into three series: A, B, and C. Series A and B are binary mixes, i.e., Bitumen (B) + Plastic (P) and Bitumen (B) + Rubber (R), respectively, but Series C is a tertiary mix with changing proportions of plastic and rubber in bitumen.

TABLE NO. 2 [14]

Serial No.	Composition	Penetration (25 C, 100 g, 5 sec)	Ductility (25 C)	Softening Point Specific Gravity (27 C)
Test Method		ASTM: D5-97	ASTM: D113	ASTM: D3
Units		0.1 mm	cm	C
* CM	100% B	67	82	51.2
Series A				
BM1	96% B + 4% P	64.5	79	53.5
BM2	94% B + 6% P	63	74	54.5
BM3	92% B + 8% P	59.5	71	56
BM4	90% B + 10% P	56.5	69	59
Series B				
BM5	95% B + 5% R	61	73	55.8
BM6	90% B + 10% R	57	69	57
BM7	85% B + 15% R	49	59	

Plastic garbage is classified as waste because it is believed to have little to no value. As a result, using such materials for construction will eliminate the costs associated with traditional building materials, lowering the overall cost of construction. [12]

According to IRC 37:2012, a cost analysis of bituminous concrete mix was performed on a stretch of National Highway. The analysis findings are shown in the table.

The anticipated mix cost research revealed that the use of various waste additives in BC mix aids in road construction and makes it more cost effective than non-modified mix. [14]

VI. ADVANTAGES

1. Plastic garbage disposal will no longer be an issue.
2. When compared to regular roads, the expense of upgrading is lower.
3. The load with standing property rose as well.
4. The cost of road construction has also decreased.
5. The road's strength improves as well.
6. Plastic roadways could feature a hollow gap for wiring. Pipelines, for example.
7. Plastic roads absorb less moisture than conventional roads.
8. Improved resistance to rain and stagnation.
9. Increases the aggregate and bitumen's binding strength.
10. When compared to normal, the road's durability improves road.
11. On-site construction time has been reduced. [17]

VII. DISADVANTAGE

1. Cleaning procedure - Toxics present in co-mingled plastic debris begin to leach.
2. The presence of chlorine during the road laying process will undoubtedly result in the release of harmful gas.
3. Plastic heat treatment may result in the discharge of hazardous gases into the atmosphere. [6]

VIII. CONCLUSION

The production of discarded plastics is rising by the day. In their molten form, polymers exhibit adhesion properties. Bitumen's melting point will be raised as a result of the use of plastics.

As a result, using waste plastics for pavement is one of the finest options for easily disposing of waste plastics. Furthermore, plastic is not recyclable, thus employing it in road building will aid in the environmentally friendly disposal of such plastic garbage.

The introduction of modern technologies will not only boost road building but will also make it more cost effective and extend the life of roadways.

Plastic roads will be most practical in countries like India, where temperatures hover around 50oC and torrential monsoons wreak havoc on roadways, causing potholes and ruts.

It is hoped that in the near future, we will have sturdy, long-lasting, and environmentally friendly highways that will rid the world of all kinds of plastic waste.

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