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The Economic Value of Plastic Waste Used as Paving Aggregate

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Abstract: Solid waste, of which plastic waste is a significant part, is plentiful and often gets thrown away without being properly processed into a usable resource. Municipal plastic garbage disposal has increased dramatically, particularly in metropolitan areas, and this has a negative effect on the aesthetic quality of the environment. As a binding agent, plastic proved to be quite useful pliable asphalt mixtures made from bitumen. By limiting fracture formation and decreasing rainfall penetration, this effective strategy helps pavements tolerate greater temperatures, which would otherwise contribute to the development of potholes. Water seepage is decreased and crushing and abrasion parameters are increased in these pavements. Roads made of plastic would be a great solution to the problem of potholes caused by India's hot and humid environment, where temperatures often exceed 50°C and heavy rains cause havoc, leaving most roads in terrible condition.

Road paving, airport runways, parking garage floors, and other related construction applications often employ a composite material called bituminous concrete (BC). The final product is made by layering mineral aggregate with asphalt or bitumen (used as a binder), and then crushing the resulting mixture. The substantial distinction in daily and seasonal temperature, coupled with the ever-increasing volume of traffic comprised primarily of commercial vehicles, has put us in a precarious position that necessitates creative solutions for enhancing the characteristics and quality of the pavement through the implementation of some necessary modifications that must therefore satisfy the both strength and economic aspects.

When viewed from an environmental point of view, it is apparent that polythenes are a major contributor to air pollution. As it has been shown that polythenes are not biodegradable, finding a solution for waste polyethene has become an essential issue.

Keywords: Plastic Wastes, Bitumen, Aggregates, Plastic Roads, Plastic-Bitumen-Aggregate Mix.

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Introduction

The majority of the sub base and base of our paved roads are granular, although bituminous base and wearing courses are more common. Plastic may be used for a wide variety of purposes. Plastic, thanks to mass manufacturing made possible by the industrial revolution, seemed to be a practical and cost-effective raw material. Plastics are now used in almost every facet of modern life, including agriculture, packaging, automobiles, electronics, electricity, buildings, and communications. Plastic is not biodegradable, and scientists have calculated that it will still be here in 4,500 years. Many studies have shown the danger to human health from improperly discarded plastics. Polymers are a convenient material, but their usage has led to environmental problems.

Today's research is mostly focused on finding sustainable solutions for dealing with plastic and rubber wastes of various types. A total prohibition on waste plastic usage is unrealistic in the current lifestyle environment, despite waste plastic's reputation as a scourge to both the current and future generations [1-3]. Plastic roads outperform regular roads and the plastic waste that is seen as a pollution nuisance may be put to good use, hence the use of waste plastics in road building is gaining popularity. It was discovered that the performance qualities of the bituminous mix may be enhanced by covering the particles with waste plastic. Shredded polyethylene grocery bags are coated on aggregates of the mixture at a predetermined temperature. Using 60/70 bitumen and plastic coated aggregates/ordinary aggregates and cement as a filler, bituminous mixtures were made. When the percentage of plastic trash in the mix is more than 30 percent by weight, the abrasion and slide resistance of the pavement is much improved, and the values of the splitting tensile strength are within the allowed ranges[4]. All of these factors must be considered when plastic trash is used to create asphalt for roadways. India would benefit greatly from the plastic road. Long-lasting and environmentally friendly plastic roads are especially useful in places where summers are hot and humid. This will aid in the removal of all plastic trash from the planet. Several plastic items are discarded daily. Those with lower incomes tend to generate more plastic garbage because they are less concerned about environmental issues and have less experience in managing garbage [1]. Plastic waste should be recycled wherever possible. [2], [3]. There has been a recent trend away from using municipal water systems in favor of purchasing bottled water (often PET plastic) [4]. The increasing demand for bottled water has given rise to the concept of using recycled plastic water bottles in place of more costly cement in building projects [5]. The energy savings, decreased carbon dioxide emissions, and brick manufacturing would all result from this.

There is yet hope for recycling plastic trash into useful items. Home goods like plates, cups, and plastic cutlery might be made using plastics that aren't readily biodegradable or durable. These recycled plastic items have a duller hue and, after prolonged use, give off a foul odor. Incompatible color schemes and odors in the home reduce its desirability. As a result, the innovation of recycling plastic into useful items is a step forward in the fight against environmental degradation.

Recycled plastic may be utilized in place of or in addition to traditional building supplies. Use of plastic waste, asphalt, and aggregates in road building, for instance, may increase performance and strength while decreasing asphalt consumption, resulting in cost savings [6]. In addition, paving stones with greater strength may be made from PET plastic, quarry dust, and fly ash [7].

As mentioned in [8], the use of plastic trash is not restricted to the production of handcrafted goods; this is shown by the fact that plastic waste is used in the production of one of the construction components.

Although PET (Polyethylene Terephthalate) [9] plastic waste was utilized in prior experiments, HDPE (High Density Polyethylene) plastic trash is employed here. Thick, colorful bottles are a common source of HDPE plastic trash. The overall look is more durable

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than PET or PP materials. The visual contrast piques interest in testing it out for use in paving stones. have a high binding capacity for the product and may be used to make items that meet SNI quality criteria when they are made from HDPE type plastic waste? These factors serve as the basis for our investigation[10].After establishing that HDPE plastic scrap may be used in the production of paving stones,

According to SNI's criteria, type is the strongest. The goal of this research is to estimate how much plastic trash might be saved if this product were manufactured on a large scale. Manufacturers in the area are more likely to make and aggressively advertise a tried-and-true product because of the confidence that comes from doing so. Segregation initiatives beginning at the home level are projected to significantly minimize plastic trash that is discarded in nature if the public realizes that plastic garbage is still have economic worth. There is a serious ecological and monetary issue caused by all the plastic used to package things like betel nuts, chocolates, chips, handbags, and cold drink bottles. They have a significant impact on environmental degradation because to their high energy and resource demands. Plastic's low weight, cost efficiency, and strength make it an obvious choice for usage in manufacturing enterprises, construction sectors, and product delivery services. Banning plastic would lead to massive waste since other materials, such as paper and wood, would have to be used instead. It contains a wide variety of chemicals and is thus considered a very pestilent substance that does not readily dissolve in the natural environment after it has been used. Polyethylene, Polystyrene, and Polypropylene are the three main components of trash plastic. The melting temperature of these polymers is between 120 and 160 degrees Celsius [11-13]. They do not release any harmful gases when heated, but when sprayed over hot aggregate at 160 C, the melted plastic tends to create a lamination or coating. 14-15].

Literature Review

Yuetan Ma et.al 2021 Polymers are ubiquitous and employed in every facet of modern life. Without effective waste treatment methods, the excessive production of waste plastics will be the leading source of worldwide environmental problems. The widespread use of hot mix asphalt (HMA) in road building makes it a prime candidate for recycling unwanted polymers into useful products. This article examined the use of both wet and dry methods for recycling plastics from asphalt pavement. Improvements in rutting resistance, fatigue resistance, and moisture resistance were seen when waste plastics were added to asphalt mixes. The use of plastic modified asphalt still had issues with compatibility and low-temperature performance, however. Polymer additives, chemical additives, and nanomaterials are only some of the methods used to overcome the aforementioned restrictions. The effects of aging, pavement performance monitoring, polymer stability, and the financial and environmental implications of employing plastics in asphalt pavements are all areas that need further research.

P.O. Awoyera et.al.,(2021) Because of the massive amounts produced, plastic trash now poses a significant hazard to ecosystems and human populations. The marine ecosystem is particularly vulnerable to this threat. Flooding and poisoning of marine species are only two of the problems that arise when plastic trash from land fills makes its way to waterways. Fish that have absorbed marine debris, which includes plastics, pose health risks to humans. One

devastating condition that may develop is cancer. So, this research investigates several methods of recycling plastic wastes into new goods in an effort to identify an efficient means of managing these wastes and enhancing the sustainability of our ecosystem. Plastic wastes in the ocean are also emphasized as a major problem that needs to be addressed immediately. The potential and restrictions of reusing plastics in building projects are examined. This study concludes that recycling plastics may have a substantial impact on environmental sustainability while also providing a steady supply of building materials

Brian P. Grady et.al.,2020 Since there is so much plastic trash, one of the criteria for reply waste plastics applications is the ability to employ massive quantities of the material. Economic considerations are also important; recycling plastics should not cost too much. Filler in asphalt concrete is one of the few potential uses for comment waste plastics that might fulfill both criteria. Particularly, all of the plastic garbage being generated now might be used in this one application if the percentage of waste plastics in asphalt concrete were less than 10 weight percent. To that end, this article takes a look at the steps that have been taken so far to include waste plastics onto asphalt concrete and outlines the main obstacles that stand in the way of the widespread commercialization of this technology.

Patricia Nana Ama Asare et.al.,2019 The proper disposal of plastic trash is an important part of making the world a more aesthetically pleasing place. Incorporating plastic wastes into plastic roadways is only one of several possible options for managing plastic trash. This research determined how much plastic trash is produced in Ghana's Sunyani Municipality and what fraction of asphaltic materials may be created from plastic garbage for use in road building. We collected plastic trash from events, homes, and eateries; we spoke to influential people in the plastics sector; and we tried out a few different approaches to using plastic trash in road building. Just one business owner in the Municipality is actively engaged in plastic recycling, using the scraps to create new products like bags, dustbins, ropes, and many more. It was also calculated that each resident of the municipality produced 49.7 grams of plastic garbage each day, for a daily total of 6,725.64 kg. Moreover, multiple experiments shown that plastic wastes, in the form of plastic coated aggregates (PCA), may successfully replace roughly 10% of asphaltic road materials in order to fulfill the criteria set by the Ghana Highways Authority (GHA). The innovative result in this study is that replacing as little as 10 percent of Ghana's asphaltic road materials with plastic wastes might have significant financial benefits for the country's road building industry and its plastic wastes management system.

Process Methodology

Before being heated to 170 °C in the drum, the aggregate mix was made according to IRC specification. Polymer waste (ranging in size from 1.6 mm to 4.75 mm) was then added and the mixture puddled. Since the average temperature was at temperatures of 170 degrees Celsius, the polymer waste melted and quickly covered the aggregate, taking just 30 to 60 seconds. The puddling chamber was quickly updated with the addition and mixing of the hot bitumen 60/70 grade (160°C). Over the aggregate, bitumen was spread. Due to their similar

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liquid states, the polymer and bitumen combined well. The slurry was hauled to the road, where 8-ton rollers distributed and compacted it.

Process: II (using Central Mixing Plant)

Before adding bitumen, the polymer waste was mechanically mixed with the aggregate to ensure an even distribution. As a result of improved temperature regulation and material mixing at the Central Mixing Plant, a more consistent product may be produced for coating.

The temperature of the material retrieved from the tipper was consistent at about 140 degrees Celsius. Pavers and an 8-ton roller were used to lay this material at the site. Both the spreading and the laying went well. The components were blended throughout the procedure**.**

Collected polymer waste was separated from other trash and cleaned up. The purified polymer was shredded into particles ranging in size from 1.65 millimeters to 4.75 millimeters.

In order to meet the requirements of the International Road Congress (IRC), small hot plants heat the aggregates that will be used in the pavement to 170 degrees Celsius moved from the batch or central mixing plant to the mixing area. In order to recycle the leftover polymer, it was shredded and added to the heated aggregates. When the aggregate is heated, the polymer softens and coats it evenly. During 30-60 seconds, the coating will be applied.

just a few seconds of the polymer being mixed into the sizzling aggregate. The tiny hot mix facility heated the aggregate and bitumen mixture to 160 degrees Celsius. After some time, the mixture became uniform enough to be employed in the building of flexible pavement.

Figure 1 shows a process flow diagram for making polymer coated aggregate bituminous mix.

First, in Figure 2, we see the waste polymer cleaning process, followed by the waste polymer shredding process, the heating of the aggregates in the mini hot mix plant, the transfer of the aggregates to the mixing chamber, the addition of the waste polymers to the hot aggregates, and the application of the bitumen over the polymer coated aggregates.

Figure 3 compares polymer coated aggregates to plain aggregates, while Figure 7 depicts the transfer of shredded polymer from the hopper to the central hot mix facility.

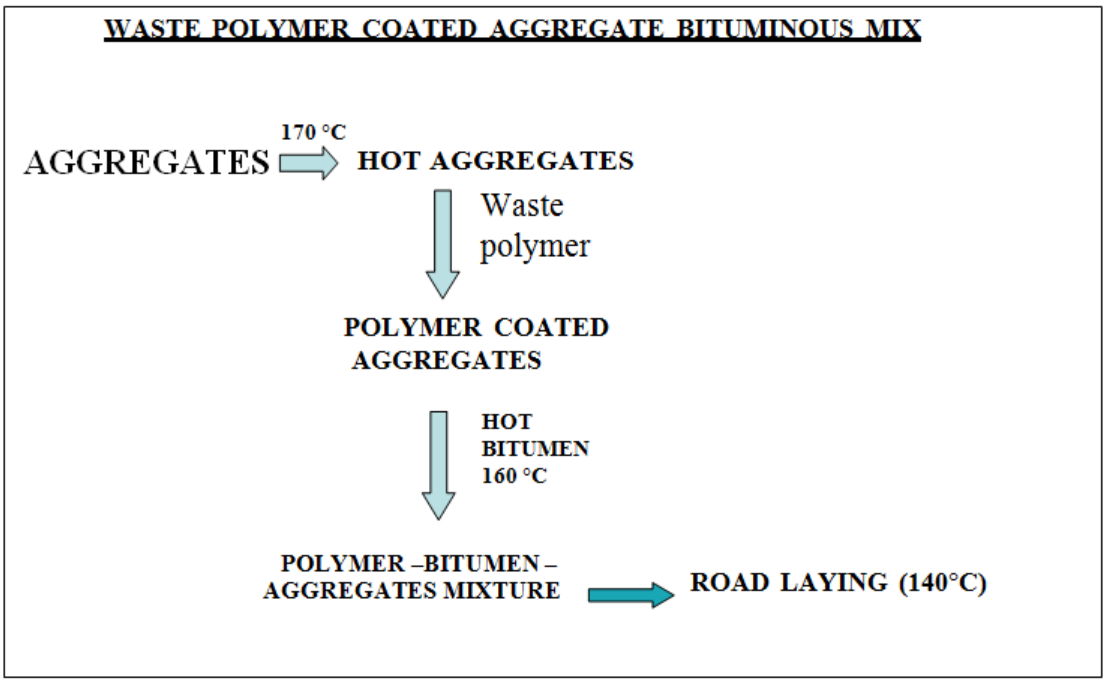

Fig. 1: Flow Chart Showing the Dry Process of PCA Bituminous Mix

Figure. 2: Cleaning Process

Figure. 3: Shredding Waste Polymers to 1.6mm to 4.75mm size

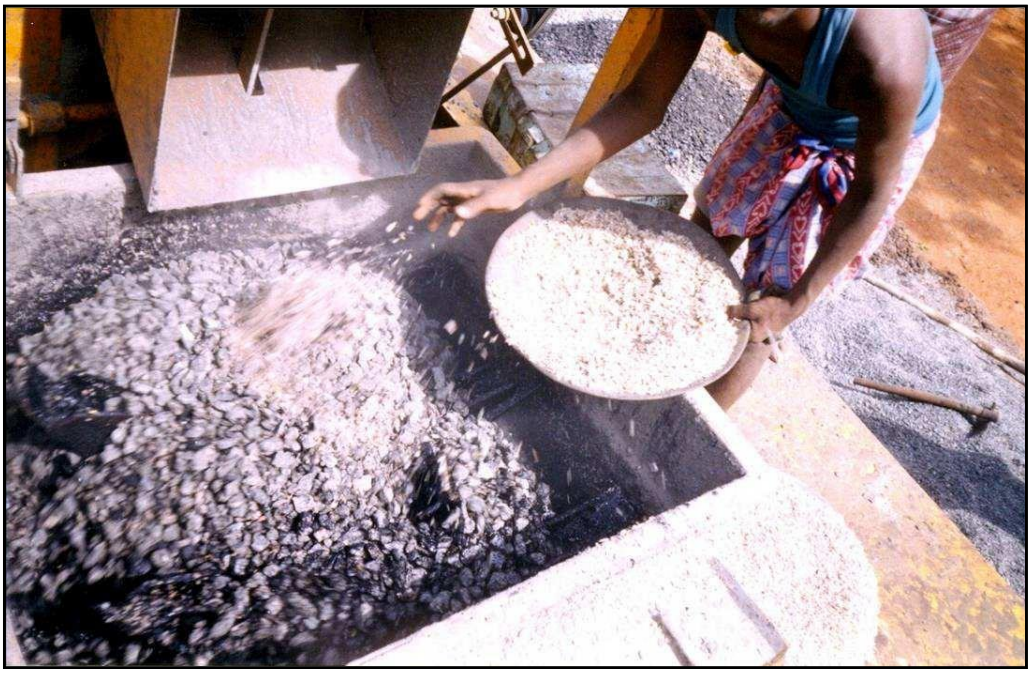

Figure. 4: Adding Waste Polymers to Hot Aggregates

1. TESTS ON AGGREGATE

Table-1: Results of tests on aggregate

Stone Aggregate	Plastic Content(%)	Aggregate Impact Value	Abrasion Value	Specific Gravity	Water Absorption	Stripping Value
Without Plastic	7	11.69%	13.85%	3	2.7%	Nil
With Plastic	11	9.87%	12.72%	2.99	1.89%	Nil
	17	9.94%	11.65%	2.82	1.22%	Nil

2. TESTS ON BITUMEN

Table-2: Results of tests on bitumen

Test	Result	Range
Ductility test	79.50 cm	Minimum 39cm
Penetration value	85 mm	78-92 mm
Softening point	47.25^{0}C	43-58^{0}C
Flash point test	282^{0}C	> 168^{0}C
Fire point test	310^{0}C	

Conclusion

Modifying bitumen with different additives to increase bitumen binding and road strength is one area of study aimed at bettering the quality of flexible pavement. Aggregate is coated with plastic in the dry process. Furthermore, making a fresh raw material modification for adaptable pavement. The method itself has also been patented. Polymer coating on aggregate offers various benefits, including but not limited to improved flexible pavement quality and the discovery of new scientific information gained from analysis of the coating process and performance studies of Plastic Tar Roads.

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