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Study of Effective Utilization of Waste Plastic in Flexible Pavement

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ABSTRACT: Today, plastic waste is a widespread issue worldwide. Used plastics that have undergone the necessary processing may be recycled and put to good use in highway building. Plastic is a harmful and everlasting substance. The non-biodegradable and extremely damage to human health nature of waste plastic, along with the fact that it is not disposed of correctly, has made its disposal a worldwide threat and significant concern. There is a serious ecological and economic issue with all the plastic used to package things like betel nuts, chocolate, chips, handbags, and cold drink bottles. They have a major impact on the environment because of the amount of energy and other resources they use. A ban on plastic would have unintended consequences, including the increased use of nonrenewable resources like paper and wood. There are many different chemical components in it, and it's generally regarded as a very pestilent substance that won't break down easily in the wild after it's used. Polystyrene, polyethylene, and polypropylene are the three primary components of waste plastics. Marshall stability values in the range of 18-20KN were observed in the sample, and the load bearing capacity of the road was found to be increased by 100%. The PCA-Bitumen mixtures used to pave roads since 2002 have held up well. An in-depth analysis of the roads' effectiveness reveals that the PCA Bitumen mix used in their construction is paying off. This method is not only cheap, but also good for the environment. Using this method, 10,000 plastic grocery bags may be used to strengthen a road by 100% and eliminate all potholes from a section that is 1 kilometer long and 3.375 meters wide. The strength of the aggregate mix coated with polymer has been shown to be increased. In order to conduct a comprehensive analysis of various plastics, we used LDPE, Polypropylene, HDPE, and Polystyrene. The process involves subjecting waste plastic to heat and melting it, after which a mixture of 3 to 4% plastic is combined with bitumen. Plastic garbage may be reused in road building by using this mixture. My project's overarching goal is to examine and investigate the feasibility of using recycled plastic as a binder material in the production of flexible pavement, with the aim of eventually substituting its bitumen component.

I. INTRODUCTION

Plastic is a substance that has one or more organic polymers with a high molecular weight, is solid at room temperature, and can be molded by flowing during the manufacture or processing into the final products. The chemical connections that make plastics so long-lasting also make them resistant to breakdown by the elements. Thermosets and thermoplastics are the two primary types of plastics. When heated, a thermo set solidifies or "sets" in an irreversible manner. They find primary use in automotive and building contexts due to their durability and strength. Among these synthetic materials are PET (polyethylene terephthalate), PTFE (polytetrafluoroethylene), PE (polyethylene), and PP (polypropylene). When heated, thermoplastics soften but harden again when cooled to room temperature. The uses of plastics have essentially altered almost every essential industry in the modern economy, beginning with agricultural and progressing through the packaging, vehicle, electronic, electrical, building construction, and communication industries. Plastic is a substance that non biodegradable, and experts have shown that the material may exist on earth for 4,500 years without degrading. The risk to human health from improperly discarded plastic has been demonstrated by a number of studies. Today's study is motivated by the need to determine how to responsibly dispose of various types of plastic and rubber trash. Considering the future of our current way of life, it would be impossible to completely ban plastic use. However, recycling plastic waste for use in road building is gaining popularity as an environmentally friendly alternative to conventional road building. It was discovered that the performance qualities of a bituminous mix might be enhanced by covering the aggregate with waste plastic.

One of the most promising materials for flexible pavements is polymer modified bitumen. There are a number of reasons why it is becoming more common to employ plastic waste in the creation of flexible pavement. Since most plastic waste is made up of polymers, using it in the polymer-modified bitumen process might help alleviate pollution. The polymer-modified bitumen demonstrates improved qualities for road building. It is believed that there are more

than 33 million kilometers of road in India. Roughly 90% of all transportation is carried by road, including passengers and 70% of all freight. It has been found via research conducted in India and elsewhere that specific additions or blends of additives may enhance the qualities of bitumen and bituminous mixtures, making them more suitable for use as a pavement material.

1.1 Significant use of plastic

Polymers contain a variety of important qualities that, when combined with one another, constitute a considerable and ever-increasing contribution to the requirements of the construction sector.

- Durable and corrosion resistant
- Good insulation for cold, heat and sound saving energy and reducing noise pollution.
- It is economical and has a longer life.
- Maintenance free
- Hygienic and problems
- Ease of processing
- Light weight

1.2 Flexible pavement

Roads, parking lots, railway lines, port runways, and airport runways are all examples of places that often use conventional flexible pavement. It is possible for it to be made up of several layers, such as the surface layer, the underlying base, the sub-base courses, and the sub-grade layer (Figure 1), but this will depend on the purpose and the required level of strength. The surface layer is composed of aggregates and asphalt, which is also known as bitumen. Bitumen is a sticky, black, very viscous liquid or semi-solid form of petroleum that is capable of severe plastic deformation due to its viscous nature [1]. The majority of asphalt surfaces are constructed on top of a gravel foundation, although there are other surfaces that are constructed entirely straight on the sub-grade.



Figure 1. Cross section of the layer of flexible pavement

Asphalt may be divided into three distinct types, depending on the temperature at which it is spread: hot mix asphalt, warm mix asphalt, and cold mix asphalt. When applying hot mix asphalt, however, the use of recycled plastics in place of some of the bitumen may be seen as a reasonable compromise. The surface layer is the one that takes the brunt of the stress and transfers it to the sub-grade [2]. This layer also has an interaction with the elements of the environment that surrounds it, such as the rain, the heat from the sun, and other things that are a direct result of the actions of humans. As a result, paying careful attention to this surface is necessary since its failure and durability are primarily dependent on it. Although each layer plays a unique part in the production of high-quality pavement, the primary emphasis of this analysis is on the top layer, which is where the recycled plastics are used [3].

II. REVIEW OF LITERATURE

Chavanet al., (2012) [4] suggested that nowadays, plastic waste is a widespread issue. Used plastics that have undergone the necessary processing may be recycled and put to good use in highway building. Plastic is a harmful substance that lasts forever. Waste plastics are a huge worldwide concern since they are non biodegradable, hazardous to human health, and difficult to dispose of properly, leading to increased levels of ground and water contamination. The environmental and economic damage caused by single-use plastics such as those used to package betel nuts, chocolate, chips, bags, and cold drink bottles is substantial. The melting point of these plastics is between 120 and 160 degrees Celsius. They don't release any dangerous gases when heated, but spraying them over hot aggregate at 160 degrees Celsius causes the plastic to soften and create a lamination or coating. An in-depth analysis of the roads'

functionality reveals that the PCA Bitumen mix used in their construction has been effective. Both money and the environment benefit from this method. By using this method, the strength of a road can be increased by 100% and no potholes can be discovered throughout its length of 1 km and breadth of 3.375m.

Gawandeet et al., (2014) [5] stated that pollution and climate change are two of the many negative outcomes of the present method for dealing with plastic waste. Recycled plastic improves the characteristics and durability of bituminous mixtures. Plastic waste disposal and pavement flaws including holes, divots, and ruts will also be addressed. It was discovered that plastic may be used as a binding agent for both porous and impermeable pavements. Plastic roads would be a blessing in India's hot and humid climate, where temperatures often top 50°C and frequent rains wreak havoc, leaving most roads with big potholes. Bitumen is utilized as a binding agent in the standard method of constructing roads. In order to minimize the bitumen content, Waste plastic in bituminous mix was experimentally investigated in this research for both rigid and flexible pavements at varying percentages of plastic waste. The bituminous mix and concrete mix have undergone testing in the lab in accordance with Indian Standards for road building. We can't focus on the field implementation right now. The purpose of this research is to determine whether or not recycled plastic can be used in place of bitumen and cement in the paving industry. This report examines the many aggregate, bitumen, and plastic-waste-utilization laboratory tests that have been conducted.

Russo et al., (2022) [6] analyzed that the goal of this study is to explore the possible effects on the environment as well as the mechanical benefits of recycling two distinct forms of waste, namely jet grouting waste (JGW) and plastic waste (PW), in order to produce hot asphalt mastics that are composed of bitumen and filler are as follows: The JGW is formed from the soil consolidation activities that take place during the building of pavements, and the PW is a combination of high-density polyethylene, low-density polyethylene, polypropylene, and poly The findings of the LCA showed that the process with the least impact on the environment was the PWM method. It returned, on average, 34% and 19% lower indicators than LM and JGWM, respectively, which reflected the fact that it caused the least amount of impact to human health, ecosystems, and the availability of resources. On the other hand, the results showed that LM had the worst environmental performance.

Ma et al., (2022) [7] studied that the potential environmental and economic advantages of recycling plastic waste into asphalt have led to its continued application. However, the majority of studies on the benefits of plastic in road building have reached conflicting findings. In preparation for a large-scale pavement experiment utilizing recycled plastics in the Regional Municipality of Durham, Ontario, this report describes and analyzes test results on plastic-modified binders and mixtures. Results showed that high-temperature binder grades fared better than low-temperature binder grades. Therefore, to reduce the potential for early and severe surface cracking, only the binder course layers should be altered. The results of 50°C Hamburg wheel tracking experiments on mixes were quite unremarkable. However, the ductile failure strain tolerance of changed mixtures was drastically reduced. It is suggested that the asphalt foundation be modified to a softer grade in order to tolerate substantial volumes of plastic and achieve overall increased performance. This makes it possible to increase the amount of additives used to make a rut-resistant mixture without reducing the mix's flexibility.

Ogada et al., (2023) [8] examined that one of the most pressing new sources of environmental contamination is plastic trash. The goal of this study was to examine the literature on the topic of using plastic and oil scraps as partial replacements for bitumen in road construction, and the Marshall Stability test was performed on both unmodified bituminous mixes and mixes that had been altered by the addition of plastic scraps and oil scraps. The clean samples showed that a bitumen concentration of 6% was optimal. The adjusted mix was then sampled at 10%, 20%, 30%, and 40% plastic by mass relative to the bitumen. Samples were made using 18% plastic waste and 10%, 20%, 30%, and 40% waste engine oil as replacements, respectively. The adoption of cutting-edge technology will not only enhance the quality of road building, but also the longevity of roads and the surrounding ecosystem.

Dawodu. et al., (2023) [9] examined that concrete pavements, interlocking stones, and many other components of construction continue to rely heavily on Portland cement as a binder. This dependency on a scarce and costly product highlights the need to investigate potential substitutes. This study examines the feasibility of replacing Portland cement with recycled plastics in the manufacturing of paving stones. This research looked at three different scenarios, each with its own study and control groups. The controls were created using Portland cement and the samples were made with recycled plastic; the mix ratios for cases 1 and 2 were 1:1:1 and 1:1:1.5, while the mix ratio for case 3 was 1:1.5:2.5. Compressive strength and water absorption resistance measurements were used to evaluate the sample and set of controls. The results showed that Portland cement paving stones have higher compressive strength than the

samples; the controls had the highest compressive strength at 45N/mm², while the sample only had 25N/mm². However, the study sample showed the highest water absorption resistance percentage at 5%, while the controls had as little as 0.8%. Because of this, roads built with paving stones manufactured from melted waste plastics are not as ideal for places with a high water table or areas prone to floods as those built with Portland cement, but they are acceptable for roads intended to bear less traffic. All of the samples used in this study were produced locally, and were restricted to the aforementioned three proportions. Additional studies employing a mechanical way to make the samples are possible, as is investigating whether or not partially replacing the cement with waste plastic might increase the strength of the paving stone.

III. PROBLEM STATEMENT

In today's lifestyle, plastic may be found almost everywhere. There has been a dramatic increase in the use of non-biodegradable plastic garbage, and scientists have discovered that it may persist on Earth unaltered for 4500 years. The rapid growth of urbanization and development has resulted in an increase in the amount of waste produced from plastic. Field testing demonstrated that the plastic trash could withstand stress, demonstrating that, if treated in preparation, it might assist achieve road stability and lengthen the life of pavement at a reduced cost of bitumen. The primary challenge is figuring out what to do with all of the wasted plastic. Disposing of plastic trash in landfills is hazardous because harmful chemicals may seep into the ground and groundwater, contaminating bodies of water. The elimination and disposal of waste plastic has recently emerged as one of the most critical problems facing waste management around the globe. This risk associated with the disposal of plastic will not be eliminated on its own; rather, certain practical steps will need to be performed at the ground level. On the other hand, as the volume of traffic on roads is expected to continue expanding over time, there is an increasing need for increased load bearing capacity of roadways. Because of people's tendencies to litter and an inadequate waste management program, the disposal of plastic waste has become an important problem for the local authorities, particularly in the urban regions. As a result, for the purpose of this current inquiry, preparations have been made to discover the possible applications of waste plastic in civil engineering endeavors.

IV. REASEARCH METHODOLOGY

The modern way of life features widespread use of plastic, which presents a significant disposal challenge. Because it is a product that does not biodegrade, the use of these materials may lead to environmental contamination and health issues such as breast cancer, difficulties with reproduction in both humans and animals, and genital anomalies. Plastic has been used in flexible pavements for a significant amount of time now in order to improve the stability and longevity of roads, as well as to minimize the cost of constructing roads by exchanging a certain proportion of bitumen for that of waste plastic. This practice has been ongoing for a number of years. Garbage is produced as a result of human activities; nevertheless, the management, storage, collection, and disposal of this garbage may provide potential dangers to both the environment and to the health of the general population. Research efforts have been concentrated on finding ways to consume garbage on a vast scale that are both environmentally benign and efficient. This is in response to the widespread problem posed by waste plastic and waste metal. When opposed to the disposal of waste plastic, recycling plastic waste is a good and environmentally beneficial alternative

4.1 Materials used and the tests conducted

The following is a list of the resources that were used over the duration of this study; Aggregates, Bitumen, and Plastic waste. The overall procedure of methodology is depicted in figure 2.

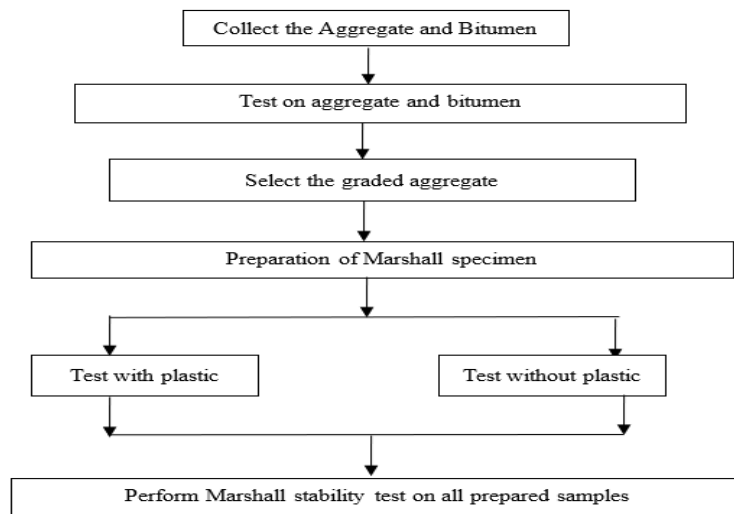


Figure 2. Process of methodology

4.1.1 Aggregate

When it comes to the creation of flexible pavement, aggregate is one of the most significant materials employed. Hot mix asphalt pavements are formed by combining bitumen with aggregate that has been carefully chosen and graded before being mixed together. The primary components of hot mix asphalt pavements that are responsible for sustaining loads are aggregates. They are classified as coarse aggregate if they remain on a sieve with a size of 2.36 millimeters, fine aggregate if they pass through a sieve with a size of 2.36 millimeters but still remain on a sieve with a size of 0.075 millimeters, and mineral filler if they pass through a sieve with a size of 0.075 millimeters. Figure 3 depicts the aggregate as shown below.



Figure 3. Aggregate

Test conducted on Aggregate

Test Conducted on Aggregate

- AGGREGATE IMPACT VALUE TEST
- Loss angeles abrasion test
- Water absorption test
- Specific gravity test
- Stripping value test

4.1.2 Bitumen

It is common knowledge that bitumen functions as the asphalt building material known as the binders as shown in Figure 4. It is one of the most essential components used in the building of highways. It is the significant binding feature of bitumen, which becomes softened when heated, which has made bitumen a popular choice as a material for binding. This is exactly has made bitumen so popular.



Figure 4. Bitumen

Test conducted on bitumen

- Penetration value test
- Ductility test
- Softening point test

4.1.3 Waste plastic

The bottled water market is expanding at an unprecedented rate and waste plastic is shown in figure 5. Over the last decade, rummage sales of bottled water have surged by 500 percent, and annually, 1.5 million tons of plastic are used to bottle water, as reported by the International Bottled Water Association (IBWA). Since the sales of virgin resin polyethylene terephthalate (PET) have skyrocketed and plastic bottle recycling has lagged behind, the third prong of the ecological triad—recycle—has risen to the center. High Density Polyethylene (HDPE) and Low-Density Polyethylene (LDPE) are the two types of plastic used to make empty water bottles and cans. Plastic bottles were pulverized and shredded to make room for the many lab tests. The polymer backbone and side chain chemical structure is often used to categorize plastics. Acrylics, polyesters, silicone, and halogenated polymers are only a few examples of the types of materials covered by these categories. Packing plastics have several uses. Plastic is a material made from a wide variety of synthetic or semi-synthetic organic compounds that are both malleable and resistant to breakage during the molding process. Plastics are typically high molecular mass organic polymers, however they may also include other materials. Although many are generated from nonrenewable resources like polylactic acid from cotton linters, they are mainly synthetic and obtained from petrochemicals.



Figure 5. Waste plastic

Preparation of samples: There will be a total of four marshall stability samples created, three of which will include plastic waste in varied percentages, such as 5%, 10%, and 15%, while the last sample will not contain any plastic waste.

Performing marshall stability test: Marshall stability test will be performed on all the samples prepared.

V. RESEARCH OBJECTIVE

- To obtain the optimum content of plastic that should be used in flexible pavement construction.
- To reduce the cost of construction by reducing the amount of bitumen binder used.
- To create a plastic-bitumen aggregate mix and design an asphalt pavement.

VI. SCOPE OF THE STUDY

- To eradicate potholes
- To minimize the global warming, greenhouse gases and pollution.
- The lifespan of the roads can be increased.
- Eco-friendly in nature.

VII. EXPECTED OUTCOME

The characteristics of aggregate and bitumen can be improved together with an increase in the amount of waste plastic included in bitumen. The application of a polymer coating to the surface of the aggregate may result in a number of benefits, all of which will contribute to an improvement in the quality of flexible pavement.

REFERENCES

- [1]. Appiah, Johnson Kwabena, Victor Nana Berko-Boateng, and Trinity AmaTagbor. "Use of waste plastic materials for road construction in Ghana." *Case studies in construction materials* 6 (2017): 1-7.
- [2]. Eze, Wilson Uzochukwu, Reginald Umunakwe, Henry ChineduObasi, Michael IfeanyichukwuUgbaja, Cosmas ChineduUche, and Innocent ChimezieMadufor. "Plastics waste management: A review of pyrolysis technology." *Clean Technol. Recycl* 1, no. 1 (2021): 50-69.
- [3]. Hira, Anil, Henrique Pacini, KwekuAttafuah-Wadee, David Vivas-Eugui, Michael Saltzberg, and Tze Ni Yeoh. "Plastic Waste Mitigation Strategies: A Review of Lessons from Developing Countries." *Journal of Developing Societies* 38, no. 3 (2022): 336-359.
- [4]. Pramukh, N., R. L. Prajwal, B. M. Darshan, S. Sunilkumar, and C. L. Santhosh. "Study On Utilization of Plastic Waste in the Construction of Flexible Pavement." *International Journal of Research in Engineering, Science and Management* 3, no. 7 (2020): 257-260.



- [5]. Gade, VenkataSarvani, and B. Manoj. "Use Of Plastic Waste In Rigid And Flexible Pavements." *Turkish Online Journal of Qualitative Inquiry* 12, no. 4 (2021).
- [6]. Russo, Francesca, Cristina Oreto, and Rosa Veropalumbo. "Promoting resource conservation in road flexible pavement using jet grouting and plastic waste as filler." *Resources, Conservation and Recycling* 187 (2022): 106633.
- [7]. Ma, Jianmin, Hanwalle MC Nawarathna, and Simon AM Hesp. "On the sustainable use of recycled plastics in flexible asphalt pavements." *Journal of Cleaner Production* 359 (2022): 132081.
- [8]. Ogada, Joyce Susan Liavuli, SixtusKinyuaMwea, and George Matheri. "Performance of Plastic Waste and Waste Engine Oil as Partial Replacements of Bituminous Asphalt Concrete in Flexible Pavement." *East African Journal of Engineering* 6, no. 1 (2023): 48-65.
- [9]. Dawodu, Praise Onimisi, A. C. Apata, U. U. Imoh, and Femi Akintunde. "Comparative Study of Cement Replacement with Waste Plastic in Interlocking Paving Stone for Highway Construction in Nigeria." *Journal of Engineering Research and Reports* 24, no. 1 (2023): 20-29



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