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Utilization of E-Waste in Flexible Pavement: A Sustainable Solution to Waste Management

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Abstract— the E-waste generation has increased due to the rapid rate of modernization and technology development. The total amount of E-waste is estimated to be 65.3 million metric tons by 2025 globally. This rapid growth is making E-waste management a global issue. Electronic waste includes electronic devices, which reached their end-of-life such as computers, screens, televisions, smartphones, tablets, radios, air conditioners and refrigerators. The disposal of electronic waste is difficult because of highly toxic and non-degradable plastic contents and metals such as lead, lithium, copper and chromium, which can result in adverse effects on the environment. To deal with this issue, several studies have confirmed that electronic waste can be used in experimental works related to asphalt pavements, bitumen and bituminous mixes can be modified in order to improve the performance of bituminous concrete mixtures. According to the obtained results from previous and ongoing research efforts, the use of E- waste plastics in asphalt pavement materials have enhanced the asphalt pavement properties such as resistance to permanent deformation, high-temperature properties and asphalt stability. This paper affords an overview of the studies that have been conducted using E-waste in flexible pavement and The behavior of aggregate coating with e-waste. This review transacts through the applications of electronic-waste plastics within the asphalt modification in an environmentally friendly manner. Furthermore, the impact of E-waste on the durability, stability, viscosity, penetration, and low and high-temperature performance are discussed.

Keywords: E-Waste, Aggregate-coating, asphalt pavement, asphalt modification, asphalt performance.

INTRODUCTION

The rapid growth of the electronics industry has led to an exponential increase in the production of electronic waste, commonly referred to as E-waste. The disposal of E-waste has become a major environmental challenge worldwide. The improper disposal of E-waste can lead to soil and water pollution, causing serious health risks to humans andthe environment. According to a report by the United Nations University, the world generated 53.6 million metric tons of E-waste in 2019. The report also highlighted that only 17.4% of the generated E-waste was properly collected and recycled, while the rest was either landfilled, incinerated or dumped in the environment. Pavement construction is a significant contributor to carbon emissions, which has led to the development of eco-friendly materials to minimize environmental impact. The use of E-waste in pavement construction can provide a sustainable solution to the E-waste disposal problem while reducing the carbon footprint of pavement construction. The use of E-waste in pavement construction can also enhance the pavement's physical and mechanical properties and reduce construction costs.

E-waste is electronic waste which has become a major problem nowadays, it is essential to create awareness people regarding e-waste. e-waste is discarded, damaged electronic which are destined to repair, reuse, recycle, etc. E-waste has a hazardous effect on environment as during incineration hazardous gaseous are generated as it contains harmful chemicals, toxic substance. The e-waste is a non-biodegradable waste and pollutes area nearby dumping yard and creates chances of health hazard. In this project we are going replace the aggregates with nonhazardous e-waste in pavement layers. The objective of this study is to show that the replacement of e-waste filler material in pavement layer is both economically viable & sustainable. Electronic waste is hazardous to human health as well as to environment hence its disposal should be proper.

Primary focus of this project is to dispose the electronic waste with asphalt aggregate coating between surface course and base course. The segregated e-waste of a specified size and physical property is used for the mix design also, study effect on the strength of the flexible pavement. Pavement construction is a significant contributor to carbon emissions, which has led to the development of eco-friendly materials to minimize environmental impact. The use of E-waste in pavement construction can provide a sustainable solution to the E-waste disposal problem while reducing the carbon footprint of pavement construction. The use of E-waste in pavement construction can also enhance the pavement's physical and mechanical properties and reduce construction costs.

METHODOLOGY

This loading The study will investigate the effect of E-waste on the physical, mechanical and environmental properties of flexible pavement. The study will use a laboratory test to evaluate the properties of flexible pavement containing E-waste. The study will investigate the effect of different proportions of E- waste on the physical and mechanical properties of flexible pavement. The study will also evaluate the environmental impact of using E-waste in flexible pavement construction. The tests to be conducted include the Marshall Stability Test, the Indirect Tensile Strength Test, and the Environmental Impact Test.

- E-waste is collected from various sources, such as recycling centers, businesses, and households.
- The e-waste is sorted and cleaned.
- The e-waste is ground up into a fine powder.
- The e-waste powder is added to the asphalt mix.
- The asphalt mix is then heated and poured into a mold.
- The asphalt is allowed to cool and harden
- E-waste is collected from various sources, such as recycling centers, businesses, and households.
- Certainly E-waste, which refers to discarded electronic devices and electrical equipment, is collected from various sources, including recycling centers, businesses, and households.

- <u>Materials</u>
- Aggregate-fine angular of below 4.75mm
- Bitumen VG-70
- E-waste (PCB) Granular size 0.5 to 1 mm.
- Sorting: E-waste materials are sorted to separate different types of electronic devices and components.

<u>E-waste (PCB) preparation</u>

- Disassembly This disassembly step involves removing external casings, fasteners, and connectors to access the internal components of the electronic devices.
- Cleaning: Once disassembled, the individual components of e-waste undergo a cleaning process. The cleaning process aims to remove any dirt, dust, or contaminants that may have accumulated on the components
- Preparatory Stage: Prior to grinding, the e-waste materials may undergo preliminary preparation. This can include the removal of non-metallic components, such as plastics or glass, from the e-waste
- Shredding or Crushing: The e-waste is then subjected to shredding or crushing processes to break it down into smaller pieces shredding or crushing equipment, such as hammer mills or granulators, may be used for this purpose
- Grinding: The shredded or crushed e-waste is then subjected to grinding to further reduce the particle size. Grinding machines, such as ball mills, attractor mills, or pulverizes, are commonly used in this stage
- Sieving or Classifying: Once the grinding process is complete, the resulting fine powder may undergo sieving or classifying. Sieving involves passing the powder through a mesh or sieve to separate particles of different sizes.

<u>Preparations to make E-waste Modified Bitumen blend</u>

The studies on the behavior and binding property promoted a study on the preparation of E-waste-bitumen blend. Its bituminous properties are found. These properties are compared with Normal Bitumen. Then its suitability as a blend for road construction is investigated. Scrap E-waste may be incorporated into asphalt paving mixes using two different methods, which are referred to as the wet process and the dry process. In the wet process, E-waste acts as an asphalt cement modifier, while in the dry process, granulated E-waste is used as a portion of the fine aggregate.

E-waste byproduct is produced by the so-called wet process in which E-waste is added to hot bitumen of temperature around 150 -160-degree C and the mixture is agitated mechanically until there is a “reaction” between the bitumen and E-waste. The “reaction” is not a chemical process but rather a diffusion process that includes the physical absorption of aromatic oils from the bitumen into the polymer chain of the E-waste. The waste particles swell as they absorb oils.

Mixing of E-waste with Plain Bitumen

In preparing the modified binders, four samples each of about 500 gm of the bitumen will heated to a fluid condition. For the blending of E-waste with bitumen, it will heat to a temperature of 160 °C and then E-waste will add. For each mixture sample 0%, 5%, 10%, 15%, and 20% of E- waste by weight will add into the bitumen. The blend will mix manually for about 3-4 minutes. The mixture then heats to 160 °C and the whole mass will stir using a mechanical stirrer for about 50 minutes. Care will take to maintain the temperature between 160 °C to 170 °C. The contents gradually stir for about 55 minutes.

Problem Statement

“By studying The rapid growth of the electronics industry has resulted in the generation of large amounts of electronic waste (E-waste). Improper disposal of E- waste has adverse effects on the environment, leading to pollution of air, water, and soil. Therefore, there is an urgent need to find sustainable solutions for the management of E-waste. At the same time, the construction of flexible pavements for roads and highways requires a large amount of natural aggregates, which are becoming scarce and expensive.”

“The project aims to address these two issues by investigating the potential use of E-waste as an alternative material for the coating of flexible pavement aggregates. The proposed solution has the potential to reduce the amount of E-waste in landfills while providing a cost-effective and sustainable alternative to natural aggregates. However, the effectiveness and durability of such a coating need to be studied in detail to ensure that it meets the required standards for road construction.”

Aim

“The aim of the project "utilization of e-waste in flexible pavement: a sustainable solution to waste management in asphalt is to explore the potential of incorporating e-waste into asphalt mixtures as aggregate coating for the construction of flexible pavements”.

Objectives

- To reduce the environmental impact of road construction by using recycled materials.
- To develop a cost-effective method for using e-waste in asphalt pavement
- Analyze adoption of non-hazardous E-waste as an aspect of sustainable flexible pavement.
- Study effect of E-waste in Flexible pavement as replacement Modified bitumen with aggregate.
- Analyze the strength of flexible pavement with replacing e-waste.
- Identify that e-waste can be disposed by using them as construction material.
- To develop and improve the technology for e-waste management.

RESULT

Test on Aggregate Coated E-waste

- Crushing value of Sample is 32.5%. AS PER IRC IS -2386 PART-IV 1963 value below 35% is strong aggregate.
- Impact value of sample is 10.70%.AS PER IRC IS-2386 PART-IV 1963 value 10-20 is strong aggregate.
- Los Angeles abrasion value of sample is 48%.AS PER IRC IS 2386-PART-IV 1963 value WBM base course 50%.
- Water absorption of sample is 0.47%
- Specific gravity of sample is 2.7.

Test on Bitumen and Asphalt

- Penetration value of Sample 76. 67mm. AS PER IRC IS -1203–1978.
- Flash Point-342C^0 and Fire Point-364C^0 AS PER IRC IS 1209-1978.
- Ductility value of sample is 80cm. AS PER IRC IS 1203–1978.
- Marshall Stability value of Sample is 410 kg. AS PER IRC IS - ASTMD6927.

CONCLUSION

The cost difference between traditional road construction and road construction using e- waste in

Indian rupees can vary depending on a number of factors, including the type of road, the length of the road, and the cost of e-waste in the region. However, in general, road construction using e-waste is likely to be more cost-effective than traditional road construction. The use of e-waste in road construction can also have a number of environmental benefits. E-waste contains a number of hazardous materials, such as lead, mercury, and cadmium. When e-waste is disposed of in landfills, these hazardous materials can leach into the soil and groundwater, contaminating the environment. Using e-waste in road construction can help to prevent these hazardous materials from entering the environment. Overall, the use of e-waste in road construction is a promising solution that can help to reduce costs, improve durability, and protect the environment.

% of E-waste mix	cost for road(1km) (Rs)	Amountsa ved (Rs)
Pure Bitumen	2,76,000	0
5% of E-waste	2,69,000	7000
10% of E-waste	2,62,000	14000
15% of E-waste	2,55,000	21000

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