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IMPROVING BITUMINOUS MIX PERFORMANCE WITH E-WASTE AND POLYMER MODIFIED BITUMEN: A NOVEL APPROACH

Suresh Kumar Ramanathan
Department of Civil Engineering, Sri Venkateshwaraa College of Engineering and Technology, Puducherry, India

Abstract
With the rapid increase in urbanization, the generation of waste materials such as e-waste and plastic waste has become a significant problem, causing harm to the environment. The incorporation of these waste materials in road construction is an eco-friendly way to reduce the impact of these wastes. This paper presents a study on the performance of e-waste and polymer modified bituminous mix in flexible pavement. The aim of the study is to partially replace e-waste with coarse aggregate and plastic waste with bitumen using the wet-mix process in an economical way to construct roads. The research focuses on investigating the properties of the modified bituminous mix and comparing them with the conventional bituminous mix. The results of the experimental work indicate that the modified bituminous mix is superior to the conventional bituminous mix in terms of strength and stability. The incorporation of e-waste increases the strength of the mix, while plastic waste improves its flexibility and durability. However, beyond 15% addition of e-waste, the stability of the mix decreases. The study provides a framework for the use of e-waste and plastic waste in road construction in an environmentally friendly way. The modified bituminous mix can effectively reduce the harmful effects of e-waste and plastic waste in the environment, and there is scope for further work in this area.

Keywords: e-waste, plastic waste, bitumen, polymer, modified bituminous mix, wet-mix process, flexural strength, stability, sustainable development.

1.0 INTRODUCTION

In India, due to modernization and advancement in new techniques, electronic products are gathering more attention. Due to this, modern and upgraded versions of electronic products are available which are becoming scraps after some years. Most of the electronic waste materials are repairable and recyclable but since the processing cost is very high usually they are discarded. Electronic waste is commonly known as e-waste and it consists of discarded old computers, televisions, radios, refrigerators and so on. Due to the extreme rate of obsolescence, the electronic industry is producing a much higher volume of waste. This has been compounded by the change in the consumption pattern which has also contributed to the large volume of e-waste being generated in the country. This has happened due to population explosion and advancement in technology. The use of e-waste as an alternative to conventional material for the construction of roads will not only help in decreasing the manufacturing cost of an item but also helps in saving the environment from pollution. Plastic is a synthetic material made from a wide range of organic polymers such as polyethylene, polyvinyl chloride, nylon, etc. that can be molded into shape while soft and then set into a rigid or slightly elastic form. Plastics are durable and they degrade very slowly. Plastics can stay unchanged as long as 4500 years on earth. Due to the rapid rate of urbanization and development, plastic waste generation has increased. The major reasons for plastic generation are littering habits of people, inadequate waste management system and improper disposal of waste. Plastic waste can be used as a modifier for bitumen in road construction. Plastic can help in enhancing some of the properties of bitumen. The performance of plastic roads was found to be better than that of conventional bitumen.

In this project, we focused on incorporating the plastic and e-waste with bitumen and coarse aggregate in such a way that it could increase its strength, stability, and flexibility. This work offers an economical way to use such non-decaying materials as an alternative for road construction.

2.0 AIMS AND OBJECTIVES

To study the use of e-waste and plastic waste in road construction. To find an eco-friendly way for disposal of waste materials. To study the performance modified bituminous mix and compare its properties with the conventional bituminous mix.

3.0 MATERIAL AND METHODS Bitumen

In present work, the bitumen of 60/70 grade is used as a binder. This grade is suitable for highways where there is a substantial load.

Aggregate

Aggregate forms the skeleton of the pavement. It is tested for its suitability as a road construction material.

Plastic

Bitumen is partially replaced with waste plastic. The plastic helps in making the mix more flexible by increasing the melting point of bitumen.

E-waste

E-Waste is used as a partial replacement of coarse aggregate. Various tests are conducted on e-waste to find out its suitability for pavement construction.

Since there are two changes happening in the conventional bituminous mix hence, the methodology is divided into two. One change deals with the polymer-modified bitumen and the other with e-waste partially replaced by coarse aggregate.

For polymer modified bitumen, the wet process is implemented. In the wet process, waste plastic is shredded and then mixed with bitumen in specific proportions. The first step is collection of waste material which consists of LDPE and HDPE. The waste plastic is then cleaned and cut into a size between 2.36 mm and 4.75 mm. Then the bitumen is heated at about 160 degree Celsius. The shredded plastic is then mixed with the bitumen at an optimum temperature and it melts with bitumen.

For partial replacement of coarse aggregate with e-waste, the first step is the preparation of samples which consists of the selection of material i.e. bitumen and aggregate. Then the aggregates are proportioned based on the mix design. They are oven-dried for about 4 hours at about 102-110°C so that the free moisture of aggregate if present can be removed. The next step is preparation of specimen. The dried aggregates are now replaced by the e-waste by total volume as per the mix design. Bitumen is then added to the aggregate by percentage of total weight and mix thoroughly at about 170-180°C. The mix is then filled in the Marshall mould and compacted by giving 75 blows on either side. After the compaction process is over, the mould is cooled about 10-12 hours and then the specimens are removed.

The most common method to determine the strength of the specimen is the Marshall Stability test. The conventional bituminous mixes, as well as the modified bituminous mix with varying proportions, were tested. Here, the proportion of plastic waste was taken as 1% of the total bitumen and was kept constant. Whereas, the proportion of

E-waste was varied at 5%, 10%, 15% and 20% of the total coarse aggregates. The mix proportion of the materials in both conventional and modified bituminous mix is given below in **Table 1.**

Table 1: Mix proportion of bitumen, e-waste and plastic in conventional and modified bituminous mix

Mix specification	Control mix	A1	A2	A3	A4
Proportion of plastic	0%	1%	1%	1%	1%
Proportion of E-waste	0%	5%	10%	15%	20%
Bitumen content	5%	5%	4%	4%	4%

4.0 RESULTS AND DISCUSSION

The Marshall Stability test value for the conventional bituminous mix with 5% optimum bitumen content was found to be 1460 kg which is within the limits prescribed by MORTH which is 917.74 kg (min). The Marshall stability value at 1% plastic and 15% e-waste was found to be 1223.66 kg which was maximum. **Fig 1** shows a graph in which e-waste content values are plotted as x-axis and stability values as the y-axis.

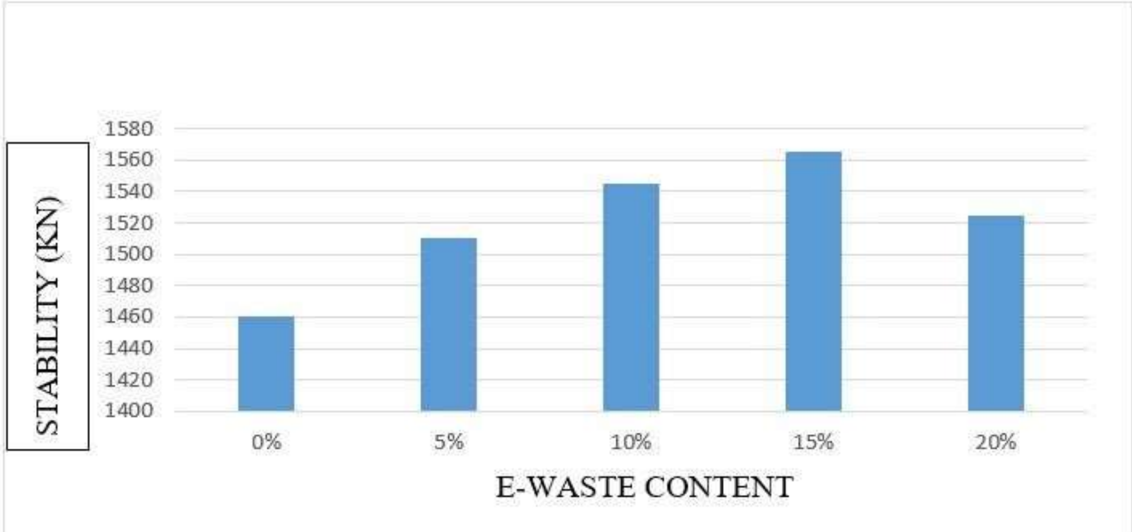

FIG 1: STABILITY VS E-WASTE

It is evident from the graph that, as the e-waste increases, stability also increases. But after the addition of 20% e-waste, the stability decreases.

The flow index value for conventional bituminous mix was found to be 3.47mm which is in accordance with MORTH. The MORTH value is between 2.5-4mm. The flow index value at

1% plastic and 15% e-waste was found to be 3.6mm which was the maximum. **Fig 2** shows graph in which e-waste content values are plotted as x-axis and flow index values are plotted as y-axis.

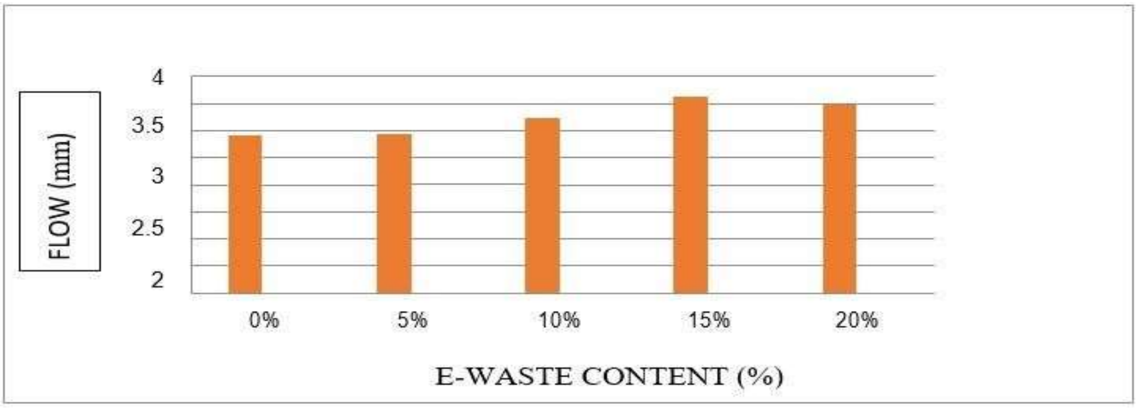

Fig 2: FLOW VALUE VS E-WASTE

It is evident from graph that, as the e-waste increases, flow value also increases. But after the addition of 20% e-waste, the stability decreases.

The density of the conventional bituminous mix was found to be 1397 kg/m^3. The density of the modified bituminous mixes showed significant decrease with the addition of e-waste. This is because density of e-waste is less than that of coarse aggregate. **Fig 3** shows a graph where e-waste values are plotted against x-axis and density values against y-axis.

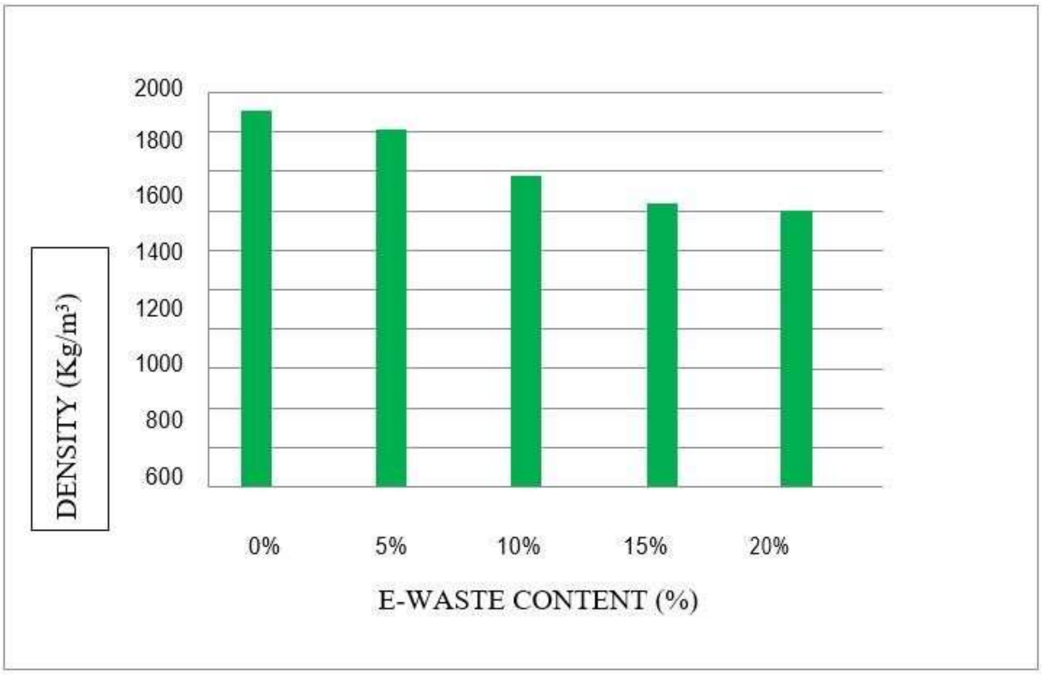

FIG 3: DENSITY VS E-WASTE

5.0 CONCLUSION

As seen from the above results it is concluded that at 5% optimum bitumen content in which 1% of bitumen is replaced by waste plastic and 15% of aggregate is replaced by e-waste shows the increase in the stability. E-waste increases the strength and plastic increases the flexibility and durability of the mix. Beyond 15% addition of e-waste, the stability drops gradually. The flow value increases up to 15% addition of e-waste and then drops. The density of the modified bituminous mix is minimum compared to conventional bituminous mix. This is due to the increase in content of the e-waste. From the experimental work, it is evident that the modified bituminous mix is much more superior to that of the conventional mix. It is clear that there is a difference in values of the mix when compared to conventional values. Hence, the modified bituminous mix can be used for practical applications thereby reducing the harmful effects of e-waste and plastic waste in the environment. There is further scope of work in this area as there can be more variations in the bitumen and waste content.

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