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An Experimental Study On Performance Of Bituminous Mix Using E-Waste For The Flexible Pavement

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Abstract

The paper carries a work for enhancing the performance characteristics of bituminous mix for flexible pavement. The electronic wastes are being disposed in the city which involves several risks such as leaking of materials and its careless exposure during recycling. Electronic wastes disposal maybe hazardous to the environment as it contains lithium, copper, aluminium and several components. And the transportation cost for the processing of e-waste may be higher compared to its scrap value. The main objective of this study is carried out by replacing various percentage of e-waste in bituminous mixes. Wastes from electrical products such as computers, televisions, printers etc are taken and is converted into small dimension pieces and melted. The bitumen of grade 60/70 is selected in the present work. The physical properties of bitumen are determined by tests with procedures as in Indian standards. The e-waste used in bituminous mix and stability flow characteristics of mix is determined using Marshall Method. The bitumen content 4.5%, 5%, 5.5%, 6% is replaced with 5%, 10%, 15% of e-waste. The mix which is found to be higher stability is selected for construction purposes. In this study, the high stability is obtained for bitumen content of 5.5% and E –waste 10% respectively. It results in efficient waste management of wastes and reduces the cost of construction.

Keywords: *E-waste, Marshall Stability, Bitumen, Grade, hazardous material.*

Introduction

In transportation engineering, the pavement generally bears the traffic of different vehicle loads. The pavement should be of adequate strength, quality in order to resist any type of loads. For this reason heaps of research has been done so as to improve the nature of the asphalt. The progressing of adaptable asphalt should be possible by supplanting or including different materials.

Bituminous mixes or asphalt mixtures are made from mixing aggregates of various grades, fillers with

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bitumen samples. The modified black-top blends have made an interest in the assessment of execution of the asphalt.

The utilization of any waste materials in the change of bitumen total blend is one of the indispensable significance in the field of research. For this situation, we are thinking about the electronic waste in bituminous blends for the better execution. In our nation, huge measure of e-waste is created each spending year. The primary issue experienced by every country is to reuse these waste items. In this examination, our essential point is better use of waste.

The electronic wastes are being thrown in the city which includes a few dangers, for example, spilling of materials and its imprudent presentation during reusing. Electronic waste removal possibly unsafe to the earth as it contains lithium, copper, aluminium and a few segments.[2] What's more, the transportation cost for the preparing of e-waste might be higher contrasted with its piece esteem. The use of such materials in development methods diminishes the assembling cost as well as recoveries the earth from hurtful contamination.[4]

One of main reason for excessive amount of e-waste in each passing year is the aggressive growth of technology and due to the short span of electronic devices; the people tend to change products every now and then. In many developing countries, many people earn their living by dismantling, refurbishing, repairing of such wastes without having any lack of knowledge and not using any safety measures, which may later results in spontaneous abortions, premature births, congenital malformations when directly inhaled or in close contact with waste products. The main objective of this study is carried out by replacing various percentage of e-waste in bituminous mixes. It results in efficient waste management of wastes and reduces the cost of construction. [3]

The problems faced by e-waste can be summed as

- Amongst top e-waste producing countries in the world, India is ranked fifth [1] after USA, China, Japan and Germany. Our country annually recycles less than 2% of total waste it produces.
- From 2018, more than 2 tones have been generated in our country annually and it imports large quantity of wastes from other countries.
- The significant assets of e-waste in India is from PC gear which is 70% of e-waste, 12% from media transmission hardware, 8% from electrical gear, 7% from clinical hardware, and remaining originates from family unit.
- In our country, nearly 80% of e-waste workers are suffering from respiratory difficulties due to lack of precaution measures. And most shocking thing is that nearly 500,000 children are been involved in collection of e-waste without proper protection.
- Even though strict laws have been enforced for the e-waste collection and disposal across the world, out of 66%, only 20% of e-waste is properly recycled globally every year. And remaining 40% of e-waste is unsuitably disposed by burning or illegally trading.
- By improper dumping of e-waste in certain landfills leads to delay of soil by increase in certain toxics and may become unsuitable for agricultural practices by the presence of poisonous mercury, cadmium, lead contents in it.
- Recycling of e-waste has been harmful to environment by causing air pollution, water pollution and soil pollution.
- The toxic materials in e-waste which is of no commercial value are usually dumped which in turn causes degrading quality of ground level water.
- E-waste may results in human hazards by affecting lungs, kidney to brain disorders.

Objectives

Following are the objectives of the current study:

- To study the physical properties of bitumen and coarse aggregates.
- To study the effect of performance of bituminous mix using different percentage of E- waste.

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- To examine the strength of design mix by Marshall Stability test.
- To find the alternative method of disposal of e-waste in eco friendly manner.

Materials and methodology

Bitumen sample: Bitumen also known as asphalt is extensively used in road construction. It is usually black in color, sticky in nature, viscous liquid or sometimes solid or semi solid. It is the petroleum product found in natural deposits. The various properties of bitumen are adhesion, resistance to water and ductility. The properties of bitumen changes with temperature such that it provides certain lubrication between aggregates at some range.

The bitumen sample for the following study is collected from Bharath road makers, Bagalur road, Bangalore.

Electronic waste (e-waste)
Discarded older or repaired electrical goods are termed as electronic waste. In other words, it is termed as electrical products which are nearing the end of their life. The electronic wastes are generally obtained from old computers, televisions, printers, mobiles etc. Some of the waste materials can be reused or recycled. There are numerous toxic materials present in e-waste namely lead, ferrous metals, non ferrous metals, mercury etc. [10]

In this area we shall discuss the experiments conducted for bitumen and bituminous mixes. The waste material used in the bituminous mix is e-waste which can be extensively found in all cities and disposed without any suitable measures. As people tend to change or replace electronic devices more often due to changing technology or when it is malfunctioning. By adding or replacing any e-waste materials in bituminous mixes, the cost of construction may get reduced and in turn helps in the safety and more eco friendly way of disposal of these waste materials. The laboratory experiments are conducted in order to estimate strength parameters and other characteristics of bitumen.

Testing program for basic characteristic [6]

- Penetration test on bitumen
- Softening point on bitumen
- Flash and fire test on bitumen
- Specific gravity test on bitumen
- Viscosity test on bitumen

Table 1: Bitumen test results

Tests	Results
Penetration test	65.33
Softening point test	44.28◦C
Flash and fire point test	190◦C and 220◦C
Specific gravity test	1.08
Viscosity test	16.68 seconds

Tests on aggregates

- Impact test on coarse aggregates
- Crushing value test on coarse aggregates
- Los Angeles abrasion test on coarse aggregates
- Specific gravity test on coarse aggregates

Table 2: Aggregate test results

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Tests	Results
Impact test	13.89%
Crushing value test	23.5%
Los angeles test	13.3%
Specific gravity test	2.55

Marshall Mix design[9]

A blend plan of bituminous blends contains coarse totals, fine totals, fillers and bituminous covers. The desirable properties of bituminous mixes are:

- It should be stable
- It should be flexible.
- It should resistant to permanent deformation.
- It should be resistant to low temperature cracking.
- It should be durable.
- It should posse's sufficient air voids to prevent bleeding.
- It should posse's adequate skid resistance.
- The mix should also posse's quality of workability.

Marshall Stability test[6]

The method is mostly recommended by MORTH. Marshall Stability of the blend is called as max load conveyed by example at standard temperature of 60◦C.

Apparatus required

- Breaking head
- Compaction pedestal and hammer
- Loading machine
- Sample extractor
- Mold assembly
- Flow meter
- Water bath
- Thermometers

The design steps are as follows

- Firstly gradation of aggregate is to be selected
- Select the aggregates proportion of each size required for the mix design
- Specific gravity of aggregates taken should be calculated
- For each specimen vary the bitumen content
- After preparation of specimen perform stability tests
- Now decide percent of voids and percent of voids loaded up with bitumen
- From the data, select the optimum binder content is taken into consideration, which is known as the amount of asphalt binder that balances various desirable mix properties for each of aggregate, its gradation, binder type combination.

Procedure

- Take 1200 grams of aggregates for each specimen. The totals ought to be proportioned to satisfy prerequisites.
- Heat the aggregate mixture at the temperature at 160◦ C ± 5◦C
- The bitumen content 4.5%, 5%, 5.5% and 6% is taken for the experiment purposes. For each percent of bitumen prepare three test specimens. Total 12 specimens are prepared and this is called as control mixes. By replacing with e-waste materials of percentage 5%, 10%, 15% prepare 36 specimens which is called as modified mixes.
- Before adding bitumen to the blend, heat the accompanying example at the temperature at 165◦C ± 5◦C. And afterward the blending of totals and bitumen is done.

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- Now adjust mould on pedestal and place filter paper on it. The mould should be thoroughly greased.
- Mixing temperature of both bitumen and aggregates should be 150◦C ± 5◦C. Now take the contents into the mould.
- Rammer should be oiled to the bottom surface of it.
- The mould is compacted on both sides by giving 75 blows.
- After compaction is completed, the mould is removed from pedestal.
- Keep aside the shape for 24 hours at room temperature
- After 24 hours, the center is separated from the shape and its weight is recognized by setting it in water.
- The water shower is changed in accordance with temperature of 60◦C.
- Presently the center example is embedded in water shower for 30 minutes.
- After 30 minutes length, take immersed surface dry load of center (SSD).
- Now put center in the breaking head.
- Adjust vertical of Marshall testing machine. Note down the perusing of applied burden and relocation.

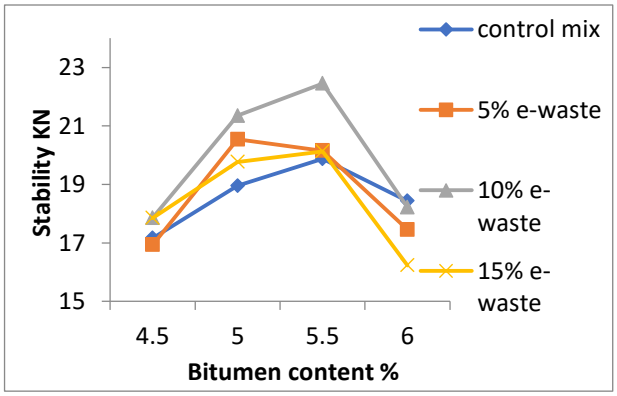
Results and discussion

Marshall Stability values:

Table 3: Marshall Stability values

	4.5% bitumen	**5% bitumen**	**5.5% bitumen**	**6% bitumen**
Control mix	17.18	18.95	19.87	18.46
5% e-waste	16.93	20.54	20.17	17.45
10% e-waste	17.86	21.35	22.45	18.22
15% e-waste	17.85	19.77	20.16	16.23

Fig 1: Stability vs. bitumen content



Flow values

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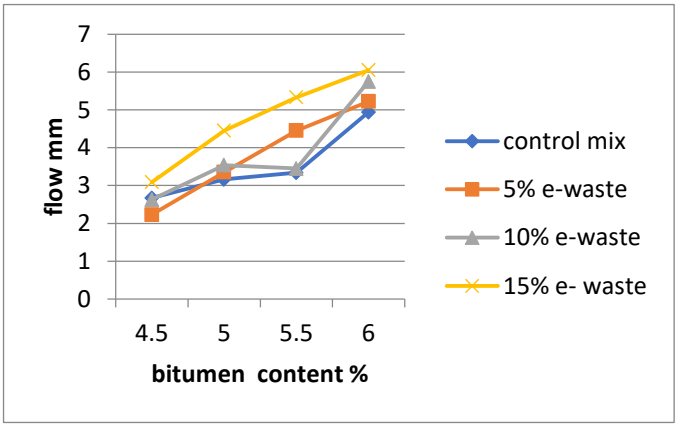
Table 4: flow values

	4.5% bitumen	**05% bitumen**	**5.5% bitumen**	**06% bitumen**
Control mix	2.67	3.16	3.34	4.94
5% e-waste	2.23	3.35	4.45	5.22
10% e-waste	2.63	3.54	3.45	5.75
15% e-waste	3.09	4.45	5.33	6.05

Fig 2: Flow vs. bitumen content



Bulk density

Bulk density of the specimen is given by

$Gbcm = \frac{Wa}{Wa - Ww}$

Here, Wa= weight of sample in air in grams

Ww= weight of sample in water in grams

Table 5: bulk density values

	4.5% bitumen	**05% bitumen**	**5.5% bitumen**	**06% bitumen**
Control mix	2.05	2.06	2.09	2.06
5% e-waste	2.1	2.14	2.13	2.135
10% e-waste	2.01	2.08	2.12	2.13
15% e-waste	2.02	2.05	2.09	2.07

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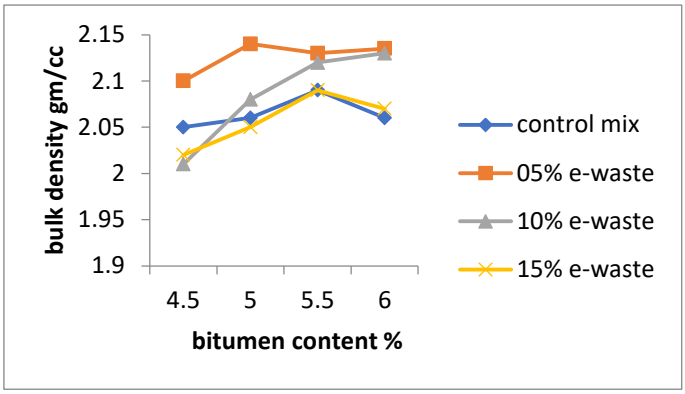
	4.5% bitumen	**05% bitumen**	**5.5% bitumen**	**06% bitumen**
Control mix	10.42	9.54	9.42	10.25
5% e-waste	9.53	7.80	7.05	6.25
10% e-waste	11.26	10.48	8.54	7.58
15% e-waste	11.28	10.47	9.47	8.03

Fig 3: Bulk density vs. bitumen content



Percent air voids

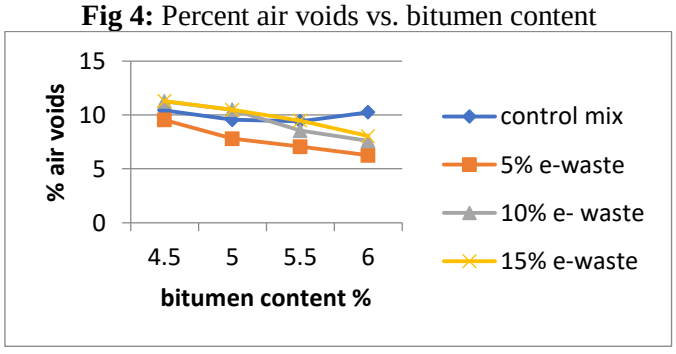
The percent air voids is given by

$$Pav = 100 * \frac{Gmp - Gbcm}{Gmp} \quad [10]$$

Here, Pav = percentage air voids in mixture
Gmp = max specific gravity of mixture
Gbcm = bulk specific gravity of mixture

Table 6: percent air voids values

Fig 4: Percent air voids vs. bitumen content



Voids in mineral aggregate (VMA)

It is given by the equation

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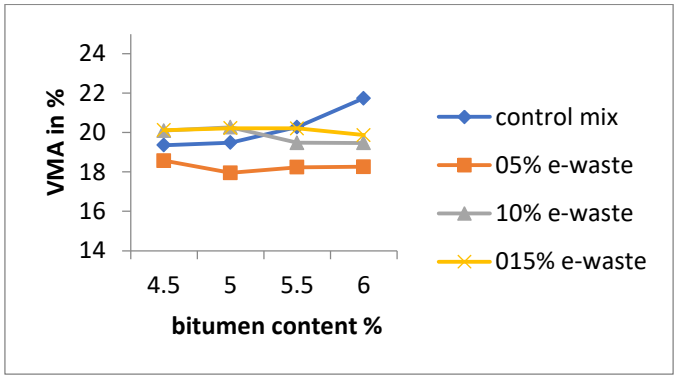
$$VMA = 100 - \frac{Gbcm \times Pta}{Gbam}$$

Here, VMA= percentage of voids in mineral aggregates sample
Gbcm = bulk specific gravity of specimen
Gbam = bulk specific gravity of aggregate
Pta = aggregate percent by weight of total mixture

	4.5% bitumen	**05% bitumen**	**5.5% bitumen**	**06% bitumen**
Control mix	19.36	19.49	20.28	21.74
5% e-waste	18.57	17.95	18.24	18.26
10% e-waste	20.1	20.27	19.48	19.47
15% e-waste	20.12	20.22	20.21	19.87

Table 7: voids in mineral aggregates values

Fig 5: VMA vs. bitumen content



Conclusion

- From the outcomes acquired it is discovered that the most extreme soundness is accomplished when bitumen content is 5.5% and e-waste content is 10%.
- The stability of the mix increases as there is increase in e-waste content and it decreases gradually.
- The flow values are increased when the bitumen content as well as e-waste percentage is increased.
- The modified mix has got higher flow values compared to control mixes because of increase in cohesive property of mix by the presence of e-waste content.
- The bulk density of control mixes for 5.5% bitumen is observed as 2.09 gm/cc. With the addition of e-waste is added the bulk density increases, with the observed value as 2.12 gm/cc at 05.5% bitumen and 010% e- waste content.
- The modified mix show 1% greater density compared to the control mixes.
- The addition of 10% e-waste to the bituminous mix is considered as the optimal mix, and can be effectively used in the application of roadway construction.
- By using e-waste in the construction purposes, nearly 10 percent of aggregates and 5.33 percent of bitumen can be used.
- By utilizing e-squander as the substitution material, it will lessen the expense of development of roadways and sparing development materials like totals and bitumen.

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- And most importantly the e-waste can be utilized in an eco friendly manner without causing any harm to mankind and surrounding atmosphere.

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