iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** I **Month of publication:** January 2018

DOI: http://doi.org/10.22214/ijraset.2018.1173

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887
Volume 6 Issue I, January 2018- Available at www.ijraset.com

Performance of Bituminous Mix using E-waste and Fly-ash for the Flexible pavement

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Abstract: Marshall Stability Test is a very important test for the bituminous mixes in flexible pavement. Electronic waste and fly-ash are disposed very casually, which may cause serious health and pollution problems. The disposal of electronic waste is difficult because of non-degradable plastic contents and metals like lithium, copper and aluminum, which may lead to adverse effects on the environment. To deal with this problem, here to study the use of electronic waste and fly-ash as an alternative to conventional material in a BC (Bituminous Concrete) layer of flexible pavement. In Literatures, there are various tests which have been carried out by replacing coarse aggregates using electronic waste and fine aggregates with fly-ash. The results obtained by laboratory investigation indicate major gain in strength with substantial saving in cost.
Keywords: Marshall Stability Test, Flow value Analysis, Partial Replacement, Electronic waste, Fly-ash.

I. INTRODUCTION

In India, due to new techniques, the electronic equipments are gathering more attention across the globe, due to modern upgraded version is available in the market and the older becomes scrap. Most of electronic waste materials are recyclable, but some are not recyclable. Higher transportation cost for processing of worthless pieces which may be higher than its scrap value. Electronic waste consists of discarded old computers, televisions, radios, refrigerators etc. In short electronics appliance that has reached its end of life. E-waste may involve significant risk as leaking of materials and unsafe exposure during recycling and disposal operations like landfills and burning. The use of these materials as an alternative to conventional material for the construction industry which may not only helps in decreasing the manufacturing cost of a particular item but also helps in saving the environment from pollution and other harmful effects which causes problems, reduce landfill cost and also helps in saving our natural resources.

The use of customized asphalt concrete mixes in surface layers creates a demand for evaluation of the performance of those customized mixtures. Asphalt modification is done by adding additives in mixture of bitumen and aggregate during mixing process. The importance of using waste materials (here e-waste and fly ash) in the modification of asphalt aggregate mixture is one of the imperative area of research. The use of e- waste and fly ash in asphalt–aggregate mixture behaves in beneficial way.

In developed countries and developing countries like India, huge amount of e-waste and fly ash is produced every year. This huge amount of waste creates major problems with respect to handling and storage, which are important, both from the economic as well as environmental point of view. Nations were forced to search for more suitable ways to recycle these waste materials. This study aims to provide a suitable means for the utilization of e-waste and fly ash in bituminous concrete.

Figure 1.Electronic waste

Figure 2: Fly-ash

II. OBJECTIVES

A. To study the Partial Replacement of e- waste and fly ash with Various Percentage with coarse and fine aggregates in bituminous mix.

B. Find suitable alternative conventional materials with cost reduction and improvement in strength and other parameters like V_v, VMB and VFB etc. in flexible pavements.

III. NEED OF STUDY

A. Most of the electronic waste is recyclable or repairable, but number of worthless electronic pieces causes higher transportation cost for their processing which may be higher than its scrap value.

B. The disposal of electronic waste is difficult because of non-degradable plastic contents which may lead to adverse effects on the environment.

C. Fly Ash is a mineral by-product of coal combustion in thermal power plants. It is a waste material and dumped on the land adjoining thermal power plants and townships.

D. To deal with the problem, here an attempt is made to study the use of electronic waste and fly-ash as an alternative to conventional material like aggregate in flexible pavement.

IV. SCOPE OF WORK

A trial section of a pavement, with BC (Bituminous Concrete) Grade 1 layer, can be prepared and investigated by using the optimum percentage replacement values of various additives obtained in the work. This trial section can be evaluated for the performance characteristics both in terms of structural evaluation as well as functional evaluation of the pavement.

V. METHODOLOGY

The current study evaluates the performance evaluation of e-waste in flexible pavement. The Marshall Test procedure as per MORTH is used to conduct the test.

A. Selection Of Material

1) Bitumen: In this study 60/70-penetration grade bitumen was used as binder as it is generally used in Testing. The physical properties of bitumen are shown in table-1.

2) Aggregate: The aggregates conforming to IS: 383-1978, was chosen and possessed physical Properties within range decided by MORH. Physical properties of aggregate are shown in table.

B. Proportioning of Aggregates

The mix design was decided on the basis of sieve analysis and the required amount ofaggregates should be oven dried for 4 hrs at about 102 to 110ºC temperature so that free moisture of

Aggregate if present is removed. The oven-dried aggregates are then weighed as per blending percentageand transferred to mixing pan.

Table 1: Physical properties of bitumen

Sr. no.	Name of test	IS Standard	Permissible Value	Results Obtained
1	Ductility	IS: 1208:1978	75 cm minimum	80.16 cm
2	Softening Point	IS: 0334:1982	40 ºc to 55 ºc	50 ºc
3	Penetration	IS: 1203:1978	60/70	66 mm
4	Viscosity	IS: 1206 (Part I) - 1978	1057	1000±200

Table 2: Physical properties of aggregate

Sr. no.	Name of test	IS Standard	Permissible Value	Results Obtained
1	Impact Value	IS : 2386-Part IV:1963	24% maximum	10.52 %
2	Water Absorption	IS : 2386-Part III:1963	2% maximum	0.50 %
3	Specific Gravity	IS : 2386-Part III:1963	2 - 3	2.82
4	Los Abrasion value	IS : 2386-Part IV :1963	Maximum 35	28

C. *Preparation of Specimen*

Approximately 1200g aggregates are required for a specimen. The aggregates are taken as per mix design and required percent of aggregates are replaced by e-waste by total weight. Bitumen is added to the aggregate by percent of total weight and mix thoroughly at 170-180ºc temperature. After mixing thoroughly the mix is fill in to Marshall Mould and compacted by giving 75 blows on either side in Marshall Compactor. After compaction the mould is cooled for 10 to 12 hrs at atmospheric temperature. The specimen is removed from Marshall Mould after cooling.

D. *Curing Specimen in Water Bath*

The sample specimen, after cooling at room temperature is extracted from mould. The sample is then weighed and placed in water bath for 30minutes at 60ºC. Constant temperature should be maintained for entire duration of 30 min as the weakest condition for bitumen is achieved by keeping and maintaining 60ºC temperatures in water bath.

E. *Testing in Marshall Apparatus*

The sample is then placed in Marshall testing machine. The stability is measured in terms of strength and resistance to plastic deformation of cylindrical specimen is measured in mm on dial gauge when it is loaded at rate of 5 cm per min.

F. *Marshall Method's Various Parameters*

The properties that are of interest include the theoretical specific gravity Gt, the bulk specific gravityof the mix Gm, percent air voids Vv, percent volume of bitumen Vb, percent void in mixed aggregate VMA and percent voids filled with bitumen VFB. These calculations are discussed in table-3.

Table 3: Stability of normal mix sample prepared with different percentage of bitumen

Bitumen Content	Correlation Ratio	Corrected Stability (KN)	Flow (mm)	G_t	G_m	V_v%	V_b %	VMA %	VFB %
4.5 %	1	14.41	4.68	2.6447	2.4487	7.41	10.04	17.45	57.53
5 %	0.96	14.94	4.71	2.6257	2.4491	6.72	11.10	17.83	62.29
5.5 %	1	15.83	5.49	2.6072	2.4596	5.66	12.21	17.87	68.32
6 %	1	12.45	5.93	2.5890	2.5080	3.12	13.52	16.64	81.22

1) *Optimum Binder Content*

a) Max stability = 5.5 percent bitumen content.
b) Max G_m = 6 percent bitumen content.
c) Maximum air void = 4.5 percent bitumen content.
d) The optimum bitumen extent is the average of above = 5.33 percent.

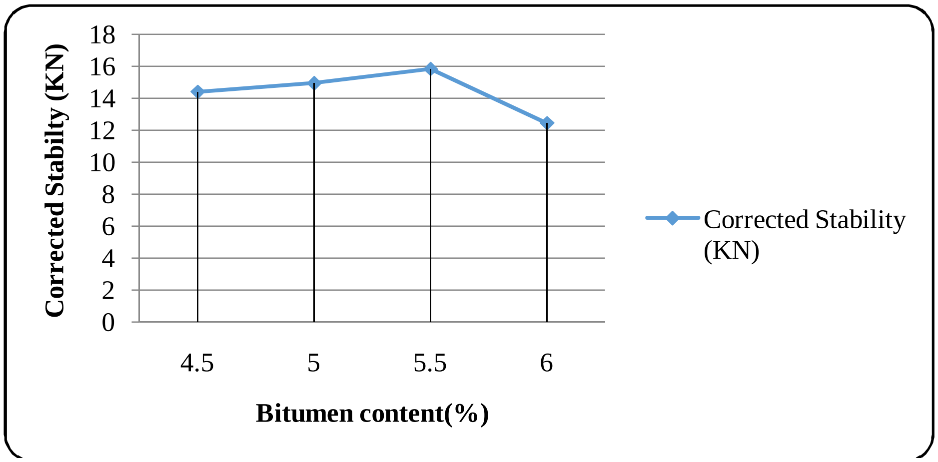

Figure 3 Variation of Stability Value to the Variation in Bitumen Content

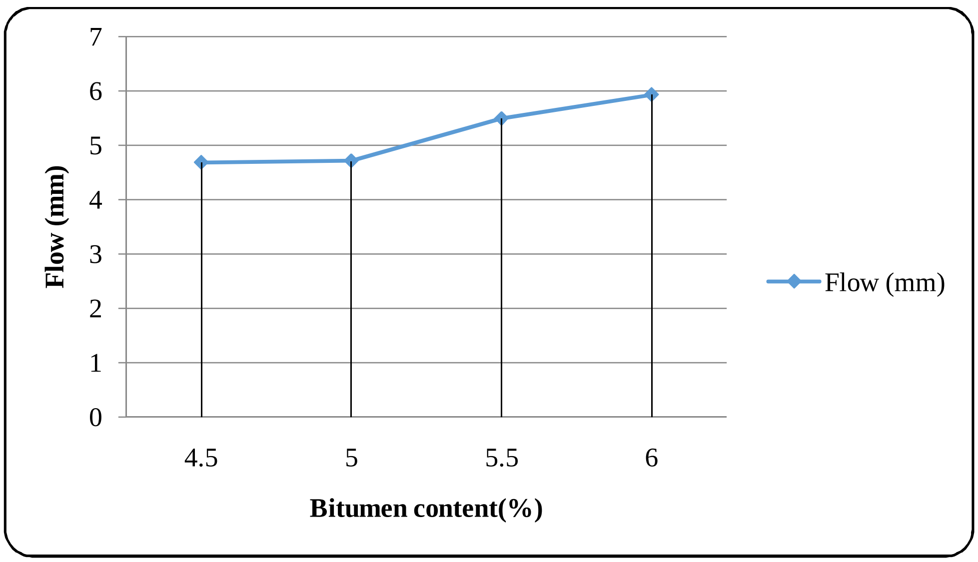

Figure 4 Variation of Flow Value to the Variation in Bitumen Content

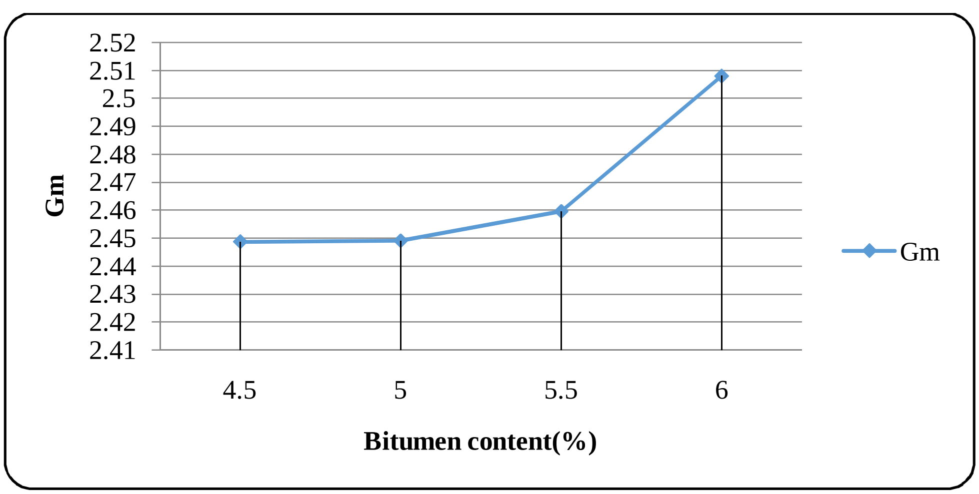

Figure 5 Variation of specific gravity to the Variation in Bitumen Content

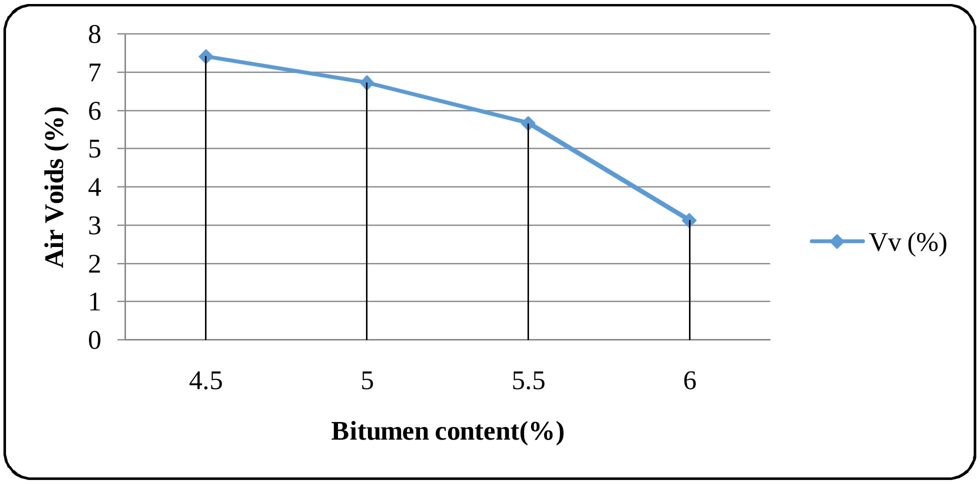

Figure 6 Variation of Air voids to the Variation in Bitumen Content

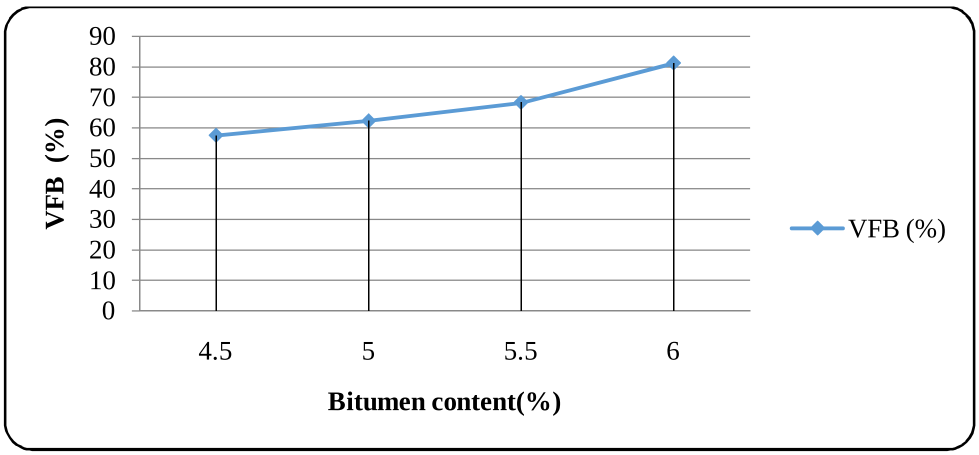

Figure 7 Variation of VFB to the Variation in Bitumen content

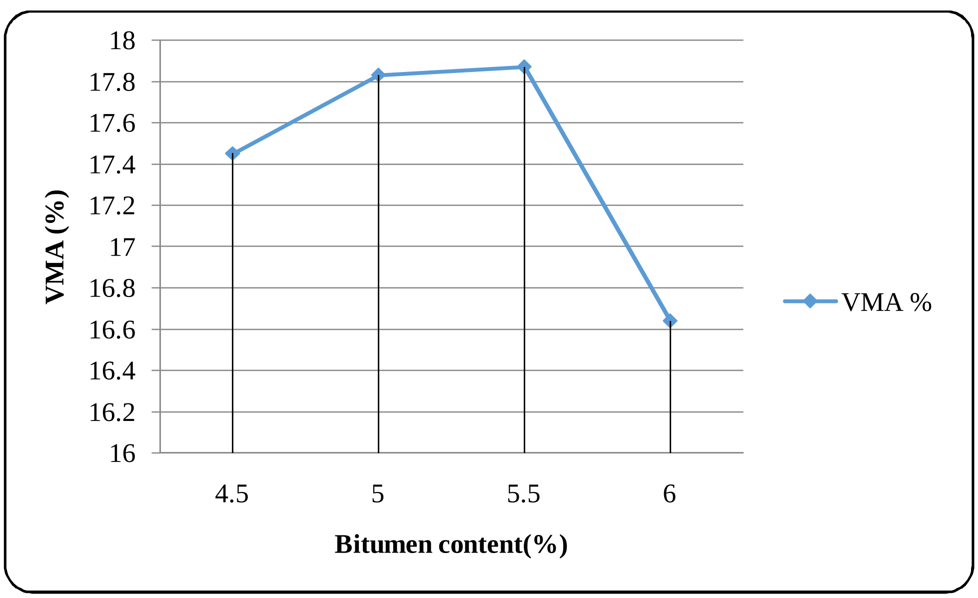

Figure 8 Variation of VMA to the Variation in Bitumen content

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G. Mix Design Results of Bituminous Concrete Grade-1 with E-waste

The electronic waste were used in the bituminous mixes of BC Grade-1 and stability flow characteristics of the mix was carried out using Marshall Method of bituminous mix design. The optimum binder content (OBC) of 4.5%, 5 %, 5.5%, 6% were replaced with 5%, 10% and 15% of e-waste to determine the Stability and Flow characteristics of the modified mix. The outputs are shown in following Table and Figures.

Table 4 Corrected stability of different sample prepared with different percentage of bitumen and 5 % E-waste

Bitumen Content	Correlation Ratio	Corrected Stability (KN)	Flow (mm)
4.5 %	0.96	12.80	5.61
5 %	0.89	14.88	6.76
5.5 %	0.89	17.53	7.17
6 %	0.89	15.45	8.43

Table 5 Corrected stability of different sample prepared with different percentage of bitumen and 10 % E-waste

Bitumen Content	Correlation Ratio	Corrected Stability (KN)	Flow (mm)
4.5 %	0.78	14.43	6.34
5 %	0.78	16.93	6.73
5.5 %	0.78	18.25	7.3
6 %	0.76	15.87	9.15

Table 6 Corrected stability of different sample prepared with different percentage of bitumen and 15 % E-waste

Bitumen Content	Correlation Ratio	Corrected Stability (KN)	Flow (mm)
4.5 %	0.76	12.30	7.64
5 %	0.93	15.53	8.14
5.5 %	0.96	15	8.95
6 %	0.83	13.89	9.86

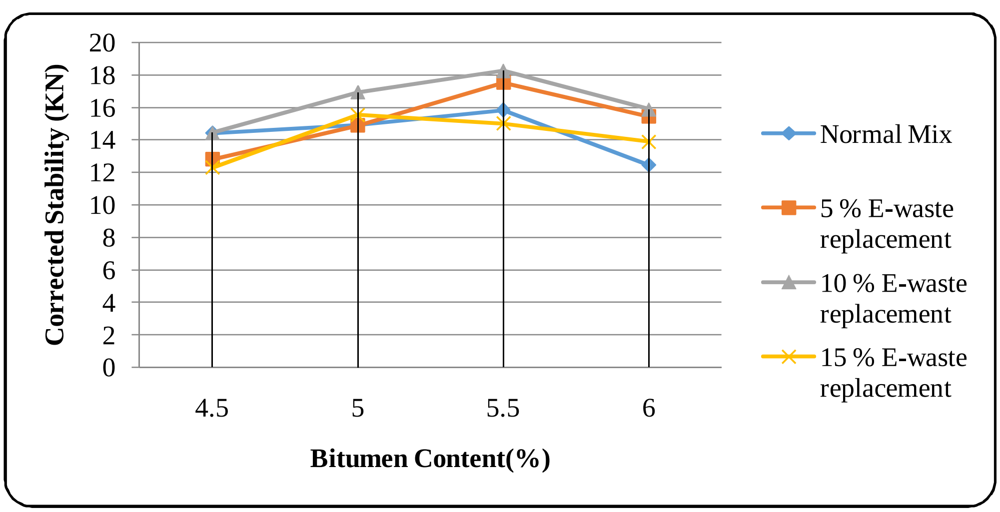

Figure 9 Variations in Stability Value of Normal and E-waste replacement bituminous mix

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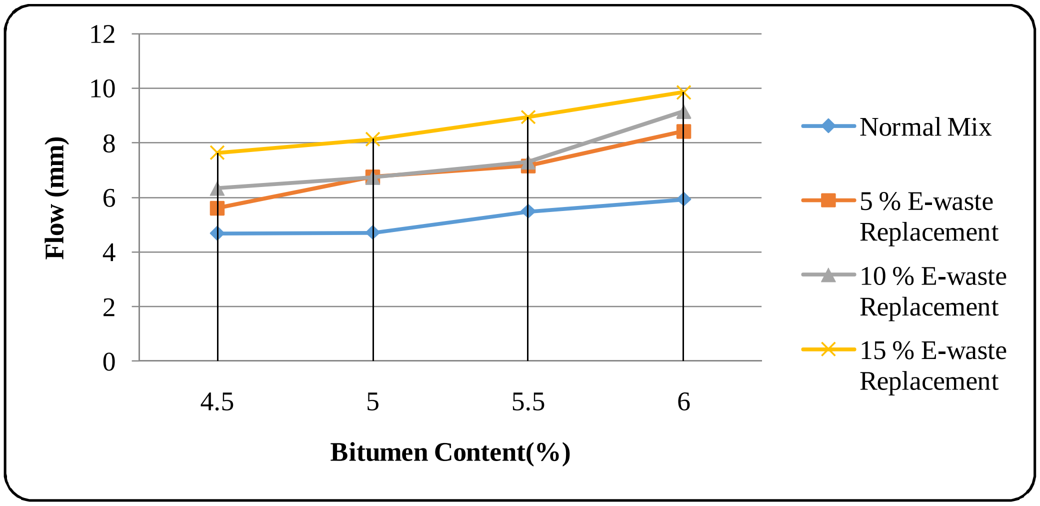

Figure 10 Variations in Flow of Normal and E-waste replacement bituminous mix

H. Mix Design Results of Bituminous Concrete Grade-1 with Fly-ash

The Fly-ash was used in the bituminous mixes of BC Grade-1 and stability flow characteristics of the mix was carried out using Marshall Method of bituminous mix design. The optimum binder content (OBC) of 4.5%, 5 %, 5.5%, 6% were replaced with 4%, 8% and 12% of fly-ash to determine the Stability and Flow characteristics of the modified mix. The outputs are shown in following Table and Figures.

Table 7 Corrected stability of different sample prepared with different percentage of bitumen and 4 % Fly-ash

Bitumen Content	Correlation Ratio	Corrected Stability (KN)	Flow (mm)
4.5 %	0.93	16.1076	5.4
5 %	0.83	14.9068	5.78
5.5 %	0.96	20.0256	6.12
6 %	0.93	15.5589	6.29

Table 8 Corrected stability of different sample prepared with different percentage of bitumen and 8 % Fly-ash

Bitumen Content	Correlation Ratio	Corrected Stability (KN)	Flow (mm)
4.5 %	0.76	13.0188	6.31
5 %	0.76	12.5476	6.73
5.5 %	0.78	14.6406	6.95
6 %	0.83	12.5081	7.09

Table 9 Corrected stability of different sample prepared with different percentage of bitumen and 12 % Fly-ash

Bitumen Content	Correlation Ratio	Corrected Stability (KN)	Flow (mm)
4.5 %	0.83	12.4749	7.63
5 %	0.76	12.0536	7.92
5.5 %	0.89	14.2133	8.09
6 %	0.78	11.6142	8.21

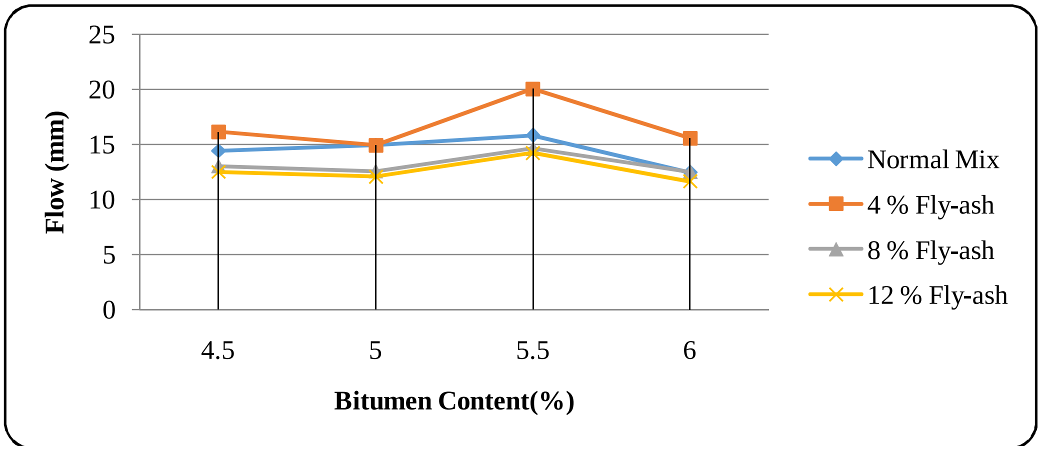

Figure 11 Variations in Stability of Normal and Fly-ash replacement bituminous mix

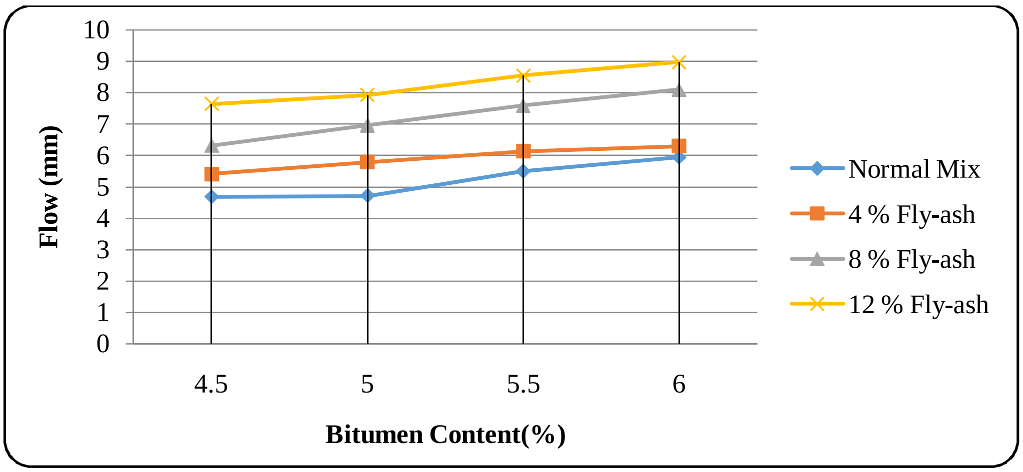

Figure 12 Variations in Flow of Normal and Fly-ash replacement bituminous mix

VI. CONCLUSIONS

A. Table-4, 5, 6 and Figure-9 and 10 shows the variation of stability and flow of bituminous concrete mix with partial replacement of coarse aggregates by 5%, 10% and 15% e-waste. The stability value increased by 5.5% bitumen and 10% e-waste replacement and decreased by 15% e-waste replacement.

B. From the experimental study, it is observed that the 10 % of coarse aggregate can be volumetrically replaced by e-waste in BC layer having 5.5 % optimum bitumen content gives the best stability value.

C. As, the e-waste percentage goes on increasing beyond 10% decrease in stability is observed clearly indicating negative results from excess use of e-waste.

D. Table-7, 8, 9 and Figure- 11 and 12 shows the variation of stability and flow of bituminous concrete mix with partial replacement of fine aggregates by 4%, 8% and 12% Fly-ash.

E. In this experimental work, it is observed that the 4 % of stone dust can be volumetrically replaced by Fly-ash in BC layer having 5.5 % optimum bitumen content gives the best stability value.

F. The stability decreased by 8% and 12% fly-ash replacement. When the Fly-ash percentage goes on increasing beyond 4% decrease in stability is observed clearly indicating negative results from excess use of fly-ash.

G. The outcomes from the laboratory investigation proves the suitability of electronic waste and fly-ash in road construction with substantial cost saving. So, disposal of hazardous electronic waste and fly-ash in the pavement can prove to be one of the alternatives to make the earth greener and pavements more durable.

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