Scientific Journal of Impact Factor (SJIF): 4.72

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 4, Issue 2, February -2017

A Review on 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 has 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, Replacement, Electronic waste, Fly-ash.*

In India, due to modernization and advancement in new techniques, the electronic equipments are gathering more attention across the world, due to which modern and most upgraded version is available in the market and the older becomes scrap. Most of electronic waste materials are repairable and recyclable, but higher transportation cost for processing of worthless pieces which may be higher than its scrap value. Electronic waste, In short e-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 incineration. 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.

Figure 1. Electronic waste

Figure 2: Fly-ash

I. FUNCTIONS OF DIFFERENT HIGHWAY MATERIALS

Coarse Aggregates

The coarse aggregate gradation is generally as described in MORTH, except that the aggregates which will satisfy the physical requirements is prescribed in the table-I where brayed gravel is proposed for use as aggregate and it is maximum 95 percent by weight of the crushed material and retained on the 4.75 mm sieve should have minimum two fractured faces.

TABLE I

PHYSICAL REQUIREMNTS OF COARSE AGGREGATE FOR BITUMINOUS CONCRETE AS PER IS 2386 (1993)

Properties	Specification
Impact Value	24% maximum
Los Angles Abrasion Value	30% maximum
Specific Gravity of Coarse aggregates	2 – 3
Water Absorption	2% maximum

Fine Aggregates
Fine aggregates shall consist of naturally or occurring mineral passing through the 2.36 mm sieve and retained on the 75 micron sieve. These should be properly dry, clean and free from dust. Natural sand shall not be allowed for the binder courses. The fine aggregate shall have a sand equivalent value of minimum 50 as per IS: 2720 (1985).

Bitumen
Bitumen is the a black viscous graded paving material mix of hydrocarbons obtained naturally or as a residue from petroleum distillation obeying with IS Specifications for paving bitumen, specified in the IS:73 (2013). The type and grade of bitumen used depends on the climatic conditions and traffic volume.

TABLE II

SPECIFICATIONS FOR BITUMEN SPECIFY BY IS:73 (2013)

Properties	Specification as per IS IS:73 (2013)
Softening Point Test temp. 0C	40˚C to 55˚C
Penetration Test (mm)	60-70
Ductility Test (mm)	75 cm minimum
Viscosity Test	2400-3600

II. BITUMINOUS MIX DESIGN

The objective of this design is to establish an economical mix through various trial mixes. The Gradation and Binder content would be such that the resultant mix can compensate the following conditions.

1. Enough binder is used to make the pavement durable by providing a layer of water proof covering material on the aggregate particles and binding them mutually under compaction.
2. Enough strength so that it can offer the resistance against deformation due to sustained or repeated loads.
3. The binder in the mix develops interlocking and creates a strong bond between the aggregate particles which provides resistance to deformation.
4. Enough flexibility to avoid early cracking because of repeated deformation by the traffic loads and additionally to intercept shrinkage cracks at low temperatures. Proper quantity and grade of bitumen ensures the sufficient flexibility in the pavement.
5. Enough air voids in the compacted bitumen mix to compensate for the additional compaction by means of the moving traffic.
6. Should have enough workability for the smooth placement of the bituminous mix on the pavement, which avoids the segregation of the material.

Gradation of Aggregates
Gradation of aggregates is one of the most critical factor in the blending of bitumen mix. The gradations of aggregates used for the Bituminous Concrete (BC) layer is kept as per MORTH gradation (Grading-1) as specified in the Table III (MORTH: CLAUSE 507.2.5 in addition to mix design criteria for bitumen mix as given in Table IV.

TABLE III
COMPOSITION FOR BITUMINOUS CONCRETE PAVEMENT LAYERS AS PER MORTH: CLAUSE 507.2.5

Grading	**1**
Nominal aggregate size*	**19 mm**
Layer thickness	**50 mm**
IS Sieve (mm)	**Accumulative % by weight of total aggregate passing**
26.5	100
19	90-100
13.2	59-79
9.5	52-72
4.75	35-55
2.36	28-44
1.18	20-34
0.6	15-27
0.3	10-20
0.15	5-13
0.075	2-8
Bitumen content percentage by mass of total mix	Min 5.2*

TABLE IV
REQUIREMENTS OF BITUMINOUS CONCRETE (BM) AS PER MORTH: CLAUSE 507.3.1

Properties	**Viscosity Grade paving Bitumen**	**Modified Bitumen**		**Test Method**
		Hot Climate	**Cold Climate**	
Compaction level	75 blows on each face of the sample			
Minimum stability (KN at 600˚C	9	12	10	AASTO T245
Marshall flow (mm)	2-4	2.5-4	3.5-5	AASTO T245
Marshall Quotient (Stability/Flow)	2-5	2.5-5		MS-2 and ASTM D2041
% air voids	3-5			
% Voids Filled with Bitumen (VFB)	65-75			
Coating of aggregate	95 % minimum			IS:6241
Tensile Strength ratio	80 %minimum			AASHTO T 283
% Voids in Mineral Aggregate (VMA)	Minimum % voids in mineral aggregate (VMA) are set out in Table V			

TABLE V
MINIMUM PERCENT VOIDS IN MINERAL AGGREGATE (VMA) AS PER MORTH: CLAUSE 507.3.2

Nominal Maximum Particle Size (mm)	Minimum VMA Percent Concerned to Design Percentage Air Voids		
	3%	4%	5%
26.5	11.0	12.0	13.0
37.5	10.0	11.0	12.0

IV. LITERATURE REVIEWS

Kadam Digvijay et al. (2015) {9} in this study it was found that 7.5 % of aggregate was volumetrically replaced by Electronic waste in DBM layer with 5.5 % optimum bitumen content (OBC). As, the e-waste percentage was increased beyond 7.5% the stability was decreased which clearly indicates negative results due to excess use of e-waste. The outcomes from the laboratory investigation proved that the use of Electronic waste is suitable in the construction of flexible pavement which also helps in cost saving. Also the disposal of Hazardous electronic waste in the flexible pavement and it was proved that e-waste was one of the alternatives to make the earth greener and pavements more durable.

Nikhil H Pitale et al. (2014) {5} in this study it was found that the properties of Bituminous Concrete mix were enhanced by the use of plastic waste. Utilize of plastic waste 0.76 % by weight of aggregate and 3 % filler significantly enhanced the volumetric properties of bituminous mixes and shows good performance with plastic waste than the nominal control mix (without replacement of plastic waste). The problem occurs during this project was the shredding of plastic waste. Use of this innovatory technology not only increases the road life but strengthened the road construction and also helps to reform the environment. Plastic road was a benefited for India's hot and extremely humid weather which was relived the earth from all type of plastic waste. This small investigation was not only beneficial but enhances the pavement with good strength with increased design life of the pavement.

Jyoti Prakash Giri et al. (2014) {3} in this study it was found that the impact of fly ash, a waste by-product of coal based thermal power station used as filler in dense graded bituminous concrete (DBM) paving mixes. Maximum Marshall Stability and unit weight values were designed by filler stone dust and fly-ash. At particular temperature, susceptibility was improved with fly ash for the bituminous mix. The result shows that the fly ash was effectively used as filler in paving mixes as a replacement of stone dust as a filler.

N.G.Raval et al. (2014) {6} in this study it was found that Marshall Stability value, which was the strength parameter of bituminous mixes was increased about 25 % by the addition of fly-ash. It provides the better mix which is more stable for the flexible pavements. The values of other parameters like VFB, VMA and Vv in the case of fly-ash was found to be within required specifications as per IS standards. This study creates a positive impact on the environment as it reduces the volume of waste which is to be disposed of by deflagration and land filling.

M. S. Ranadive et al. (2012) {7} in this study it was found that replacement with e-waste can improve the Marshall stability of modified mix. It was also concluded that 5.5 % bitumen content and 10 % e-waste as replacement attained maximum strength, which was approximately 11% more than the nominal control mix. The use of e-waste was saved bitumen consumption by 5.33% and 10% aggregate by total volume. The bituminous concrete mix with 10% e-waste was found to be the optimal mix. The fly ash along with E-waste as filler replacement shows unsatisfactory results in which strength was not improved (strength decreases with addition of both materials) and it was found that about 14.78 % stability was decreased as compared with nominal control mix.

S. Krishna Rao et al. (2015) {1} in this study it was found that when the replacement of Fly Ash was 4%, Stability value was reached to maximum. Density decreased with fly ash content, at 4% voids are filled to maximum extent. For a desirable pavement, voids was minimum. At 4% fly ash, total voids were minimum. With increase of fly ash, requirement of bitumen was more Marshall Properties of 4 -12% of fly ash content was within desirable limits for 4.25% of bitumen content and 4% of fly ash content gave best results.

Dr Sowmya N J et al. (2015) {2} in this study it was found that the Marshall stability was higher for the stone dust as a filler material as compared to the fly ash mix. When the bitumen content was increased the flow value was

increased and volume of voids was lower when fly ash was used as the filler material. This was due to the fact that fly ash was very fine graded and had highest surface area filled the voids more effectively. When the bitumen content was increased, the voids in mineral aggregates (VMA) and void filled with bitumen (VFB) were increased.

Tapase Anand et al. (2015) {8} in this study it was concluded that 5.5% bitumen content in which 7.5% of bitumen replaced by waste plastic and 7.5% aggregate replaced by Electronic waste showed increased stability keeping all the other parameters within limits. From the experimental work, it was cleared that the properties of the designed bituminous mix for bituminous concrete were much more superior to those of the control mixes entirely composed of mineral aggregates and effectively used in practical applications.

Prof. M .H. Lunagaria et al.(2015) {4} in this study it was found that Maximum Unit weight value and Marshall Stability were observed by fly-ash as a filler. The results of the flow value show that high calcium fly ash was effectively used as filler. The use of high calcium fly ash in paving mixes is give good solution for high calcium fly ash utilisation and disposal problems.

CONCLUSION

The following conclusions are drawn regarding the use of e-waste and fly ash in bituminous concrete:

1. The laboratory investigation proved that suitability of electronic waste and fly-ash in road construction with cost saving and shows better strength.
2. Different Percentage of aggregate was volumetrically replaced by different percentage of electronic waste and fly-ash in BC layer.
3. 7.5 % of aggregate was volumetrically replaced by electronic waste in DBM layer with 5.5% optimum binder content have good Marshall Stability. It is concluded that at 5.5% bitumen content and 10 % e-waste as replacement attained maximum strength.
4. When the e-waste percentage is increase beyond 7.5 %, Stability is decrease.
5. Marshall Stability value was increase about 25% by addition of fly-ash material with replacement of aggregate.
6. Fly-ash replacement with stone dust is about 4-12% but replacement of fly-ash with 4% shows the maximum stability.

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