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REPLACEMENT OF COARSE AGGREGATES WITH E-WASTE

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ABSTRACT

Due to the increase in the demand of raw of raw materials in the construction industry, there has been a serious depletion in the naturally available raw material in the construction industry. In this regards, the non-biodegradable environmentally hazardous electronic and electrical waste arising from various industrial and domestic appliances was considered as an alternative raw material for the present research. The current study not only offers a solution to the ongoing crisis in effective safe disposal of E-wastes, but also resolves the issue of dearth of raw materials. The present study targeted effective utilisation of E-waste Ceramic as a potential aggregate in BC Mix. The research subsequently investigated the probable changes in physical and strength properties of the mixes casted using Marshall Method of Mix design, And conclusions were later drawn depending on the comparative result analysis for the best percentage replacement of aggregate by E-waste ceramic as proposed for a roadway of width 3.75m for soil CBR of 4%. The study herewith hence postulated the best possible percentage replacement by weight of total mix asnd also conducted an approximate construction cost comparison.

I. INTRODUCTION

The development of technology is at amazing rate today the development in the field of electronics is huge and notable in spite of its notability there is a huge dangerous and controversial thing behind their usage due to the use of large electronic components in day-to-day life, its waste also increases. so, we the engineers and technologists are in need of new arena to find best system for e-waste management.

One such system is “an effective management of e-waste as a part of construction materials” which is surely going to be the biggest revolution in the management of e-waste. Our proposed system deals with the management of e-waste as a part of construction materials.

The overall idea is mixing the e-waste in the construction practice as Replacement for coarse aggregate and thereby reducing the waste in a greater way now we have started implementing this idea the work progress is at the initial stage. Once it becomes successful it is going to be greatest boon in the management of e-waste.

The production of electric and electronic equipment is one of the fastest growing manufacturing activities. The development has result in an increase of waste electric and electronic equipments. rapid economic growth, coupled with urbanization growing demand of consumer goods, has increased both the consumption of Electronic Wastes which can be the sources of the hazardous wastes that pose a risk to the environment and to sustainable economic growth.

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II. OBJECTIVE

- To study the physical properties of coarse aggregates.
- To study the physical properties of Bitumen and E-waste.
- To design the mix by partial Replacement of E-waste as a coarse aggregate.
- To Evaluate the strength criteria for the design mix by Marshall stability test.
- To Arrive at the optimum percentage replacement of E-waste in the design mix.

III. TESTS ON AGGREGATES

The coarse aggregate used was a normal weight aggregate with a maximum size of 9.5 mm. Stone dust was used as the fine aggregate. Salient properties of the aggregates as determined by standard tests are given in Table 1

Table 1: Test Results of Coarse Aggregates

Sl. no	Description of tests	Test result	Requirements as per Table 500-14 of MoRT&H Vth Revision Specifications	IS codes
1	Aggregate crushing value (%)	23.99		IS 2386 PartIV1963
2	Aggregate impact value (%)	23.20	Max 27%	IS 2386 PartIV1963
3	Los Angeles Abrasion Value (%)	28.00	Max35%	IS 2386 PartIV1963
4	Flakiness and Elongation Index (Combined) (%)	14.35	Max 30%	IS 2386 Part I 1963
6	Aggregate specific Gravity 1.Coarse aggregate 2.Fine aggregates	2.61 2.78	2.5-3	IS 2386 Part III 1963
7	Filler specific Gravity Cement Dust	3.08 2.85		

IV. TESTS ON BITUMEN

VG30 grade of bitumen is used as the binder and its properties as determined by standard test procedures are tabulated in Table 2

TABLE 2: Test Results of Neat Bitumen (VG 30 GRADE) Bitumen

Sl No.	Test conducted	Test results	Requirements as per IS: 73-2002	IS codes
1	Penetration at 25^0 C ($1/10^{th}$ of mm)	66.33	60-70	IS: 1203 –1978
2	Softening point, ^{0} C	57.25	45-55	IS: 1205 – 1978
3	Ductility,cm	75+	75 min	IS: 1208 – 1978
4	Specific Gravity	1.00	0.99	IS :1202 -1978
5	Flash point,^{0}C	235	175 min	IS:1209- 1978

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V. TESTS ON E-WASTES

For the investigations on E-wastes bituminous mixes, we used E-wastes as it is easily available and it does not vary much in properties when compared to other wastes like ceramic etc. These wastes was obtained in enormous amount and then cut to the required size.

Table 3: Properties of E-Wastes as Obtained From Literatures

Tests	Value
Crushing test	30.0%
Impact test	28.5%
Specific Gravity	0.99

VI. PROPORTIONING FOR BC GRADE II

On proportioning the aggregates for Bituminous Concrete mix as per MoRTH specifications, the following mix proportion was obtained.

The gradation of the above mix proportion is given in Table 4

Table 4: Gradation Of Proportioned Bituminous Mix

IS Sieve (mm)	Average value of % passing	Average value % retained	Weight (gms)	Cumulative weight (gms)
26.5	100	0	0	0
19	95	5	60	60
9.5	68	27	324	384
4.75	50	18	216	600
2.36	36	14	168	768
0.300	12	24	288	1056
0.075	5	7	84	1140
Cement			24	1158
Stone dust			36	1200
Total weight of aggregates in Marshall specimen (gms)				1200

TABLE 5: Gradation of 10% E-Waste Replace Mix

Sieve size in mm	Total weight of aggregates	Aggregate	E-waste Replaced
26.5-19	60	60	-
19-9.5	324	324	-
9.5-4.75	216	194.4	21.6
4.75-2.36	168	151.2	16.8
2.36-0.3	288	259.2	28.8
0.3-0.075	84	84	-
Cement	24	24	-
Dust	36	36	-

Table 6: Gradation of 20% E-Waste Replace Mix

Sieve size in mm	Total weight of aggregates	Aggregate	E-waste Replaced
26.5-19	60	60	-
19-9.5	324	324	-
9.5-4.75	216	172.8	43.2
4.75-2.36	168	134.4	33.6
2.36-0.3	288	230.4	57.6
0.3-0.075	84	84	-
Cement	24	24	-
Dust	36	36	-

Table 7: Gradation of 30% E-Waste Replace Mix

Sieve size in mm	Total weight of aggregates	Aggregate	E-waste Replaced
26.5-19	60	60	-
19-9.5	324	324	-
9.5-4.75	216	151.2	64.8
4.75-2.36	168	117.6	50.4
2.36-0.3	288	201.6	86.4
0.3-0.075	84	84	-
Cement	24	24	-
Dust	36	36	-

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VII. DESIGN OF BITUMINOUS CONCRETE MIXES

The main objective of the mix design is to produce a bituminous mix by proportioning various components so as to have:

- Sufficient bitumen to ensure a durable pavement.
- Sufficient strength to resist shear deformation under traffic at higher temperature.
- Sufficient air voids in the compacted bitumen to allow for additional compaction by traffic.
- Sufficient workability to permit easy placement without segregation.
- Sufficient flexibility to avoid premature cracking due to repeated bending by traffic.
- Not very high stiffness at low temperature to prevent shrinkage cracks.

The bituminous mix was designed by using Marshall Method of mix design. The Marshall test was used to obtain the optimum bitumen content based on ASTM D-1559-96 the procedure of testing is given below.

Table 8: Marshall Test Results for Mix With Neat Bitumen

	Bitumen	Marshall Stability	Flow	Bulk density	Total air voids	Voids filled	Voids in mineral aggregates
Sl. No	Content	in	In	Gb in grm/cc	Vv	By bitumen	
	(%)	Kgs	Mm		(%)		
1	4.5	1384	2.75	2.378	5.62	63.01	15.90
2	5.0	1499	2.82	2.389	4.70	69.63	15.98
3	5.5	1553	3.16	2.398	4.20	74.82	16.14
4	6.0	1448	3.52	2.394	2.70	76.49	16.78

Table 9: Marshall Stability Test With 10% of E-Waste

	Bitumen	Marshall Stability	Flow	Bulk density	Total air voids	Voids filled	Voids in mineral aggregates
Sl. No	Content	In	In	Gb in grm/cc	Vv	By bitumen	
	(%)	Kgs	mm		(%)		
1	4.5	643	2.90	2.372	5.83	63.84	16.09
2	5.0	700	2.97	2.384	4.71	70.92	16.17
3	5.5	796	3.31	2.392	3.68	77.52	16.33
4	6.0	743	3.67	2.388	3.19	81.22	16.97

Table 10: Marshall Stability Test With 20% of E-Waste

	Bitumen	Marshall Stability	Flow	Bulk density	Total air voids	Voids filled	Voids in mineral aggregates
Sl. No	Content	In	In	Gb in grm/cc	Vv	By bitumen	
	(%)	Kgs	mm		(%)		
1	4.5	731	2.80	2.370	5.93	63.41	16.18
2	5.0	789	3.10	2.369	5.27	68.37	16.66
3	5.5	884	3.55	2.390	3.79	76.97	16.42
4	6.0	834	3.65	2.381	3.47	79.89	17.21

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Table 11: Marshall Stability Test With 30% of E-Waste

Sl. No	Bitumen Content (%)	Marshall Stability In Kgs	Flow In mm	Bulk density Gb in grm/cc	Total air voids Vv (%)	Voids filled By bitumen	Voids in mineral aggregates
1	4.5	702	3.04	2.364	6.14	62.55	16.37
2	5.0	759	3.34	2.364	5.48	67.49	16.84
3	5.5	855	3.79	2.373	3.56	73.79	17.01
4	6.0	804	4.08	2.367	3.26	77.16	17.70

Table 12: Optimum Binder Content for Neat Bitumen Mix and E-Waste Replaced Mix (Obtained By Graphs)

PERCENTAGE OF E-WASTE	OPTIMUM BITUMEN CONTENT, %
0	(5.55+5.61+5.50)/3= **5.55**
10	(5.50+5.30+5.50)/3= **5.43**
20	(5.50+5.42+5.50)/3=**5.47**
30	(5.51+5.38+5.50)/3=**5.46**

TABLE 13: table 500-24. Requirements of bituminous concrete mix

sl. no.	Description	Requirments	0% Replacement	10% Replacement	20% Replacement	30% Replacement
1	Marshall stability (ASTM Designation: D-1559) determined on Marshall specimens compacted by 75 compaction blows on each end	820 kg (1800 lb) minimum	1560	785	845	810
2	Marshall flow (mm)	2-4	3.25	3.20	3.70	3.45
3	Per cent air voids in mix	3-5	4.30	3.60	3.50	3.70
4	Per cent voids in mineral aggregate (VMA)	Minimum 11-13 per cent	12.30	160	11.60	16.20
5	Per cent voids in mineral aggregates filled by bitumen (VFB)	65-75	73.50	76.00	73.00	76.40
6	Binder content, per cent by weight of total mix	Minimum 4.5	5.55	5.43	5.47	5.46

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VIII. RESULTS AND CONCLUSIONS

- The physical properties of binder and coarse aggregates used for the study was tested and were aggregates satisfying the MORT&H vth revision requirements
- The Marshall test results for neat bitumen mix satisfies the requirement of MORT&H vth revision Table 500-24.
- The optimum binder content of E-waste replace mix will show increase in the content of binder.
- It is observed from the test results that there will be appreciable decrease in the bulk density of E-waste replaced mixes when compared to the neat bitumen mix.
- It is evident from test results that E-waste replace mix shows increase in the flow compared to normal mixes or neat bitumen mix.

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