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Properties of Concrete on Partial Addition of E-Waste and Metakaolin

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***Abstract*—Electronic waste is an emerging issue posing serious pollution problems to the people and the environment. Reuse of e-waste is a partial solution to environmental and ecological problems. In this work printed circuit board (PCB) is used as e-waste material. This work aims to reduce the ill effects of e-waste. Concrete cubes and beams with different percentages of e-waste and a constant percentage of Metakaolin were cast. The work was conducted on M20 grade mix .The replacement of coarse aggregate with E-waste was in the range of 0%,5%,10%,15%,20%.Finally the compressive strength, flexural strength of the concrete mix specimens obtained from the addition of these materials are compared with control concrete mix. The reuse of E-waste results in waste reduction and resources conservation**

Keywords— E-waste, compressive strength , Metakaolin.

I. INTRODUCTION

Concrete is one of the oldest and widely used construction materials and it possesses many inherent properties. Concrete can be manufactured to inexhaustible range of specifications to suit all applications .This is possible by using different proportions of the natural ingredients. Among all the ingredient, aggregates form the major part. The consumption of the primary aggregate was 110 million tons in the year 1960 and reached nearly 275 million tons by 2006.Use of natural aggregates in such a rate leads to a question about the preservation of natural aggregate sources. In addition operation associated with aggregates extraction and processing is the principal cause of environmental concern. In the light of this, in the contemporary civil engineering construction, using alternative materials in place of natural aggregate in concrete production makes concrete sustainable and environmentally friendly construction material. E-waste is one of the alternatives that we can use.

E-waste describes loosely discarded surplus, obsolete, broken electrical and electronic waste. The processing of electronic waste in developing countries causes serious health and pollution problems due to the fact that electronic equipment contains serious contaminants such as lead, cadmium, Beryllium etc. The utilization of e-waste materials is a partial solution to environmental and ecological problems. The use of E-waste will reduce the aggregate cost and provide good strength for the structures and roads. It will reduce the landfill cost and it is energy saving. In this work M20 mix is used with partial replacement of coarse aggregate by various percentages of e-waste ranging from 0-20% with constant percentage of Metakaolin.

II. OBJECTIVES

- To find the optimum percentage of e-waste with a constant percentage of metakaolin.
- To find the compressive strength of mixes.
- To compare the properties of control mix, e-waste - metakaolin mix

III. MATERIALS

The materials used in this experiment were locally available and these were Ordinary Portland Cement (O.P.C), M- sand as fine aggregate, crushed granite, metakaolin and e-waste. Potable water was used for mixing and curing

A. Cement

Ordinary Portland cement 53 grade was used conforming to IS 8112 – 1989 and physical property was given below*:*

TABLE 1 .PHYSICAL PROPERTIES OF CEMENT

SL.NO	PROPERTIES	RESULTS
1	Specific gravity	3.16
2	Consistency (%)	29
3	Fineness (%)	1.33

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B. *Fine Aggregate*

M-Sand was used as the fine aggregate

TABLE 2 .PHYSICAL PROPERTIES OF FINE AGGREGATE

SL.NO	PROPERTIES	RESULTS
1	SPECIFIC GRAVITY	2.37

C. *Coarse Aggregates*

Crushed granite was used as coarse aggregate of size 20 mm

TABLE 3 . PHYSICAL PROPERTIES OF COARSE AGGREGATE

SL.NO	PROPERTIES	RESULTS
1	Specific gravity	2.68
2	Water absorption (%)	0.75
3	Bulk density(kg/m^3)	1510

D. *E-Waste*

The E-Wastes like printed circuit board are used. The PCB was crushed and considered as partial coarse aggregate substitute retaining the mix ratio as the same. The divided particle size of E-Waste is 20mm

Fig. 1. E-waste coarse aggregate

TABLE 4. PHYSICAL PROPERTIES OF E-WASTE

SL.NO	PROPERTIES	RESULTS
1	Specific gravity	1.89
2	Water absorption (%)	0.5

E. *Metakaolin*

Metakaolin is a thermally activated aluminosilicate material obtained by calcining kaolin clay within the temperature range 650-800 °C. It contains typically 50-55% Si02 and 40-45% A1203 and is highly reactive. Metakaolin generally has particle size finer than cement. Thus, metakaolin can be produced with a controlled process to achieve the desired properties. It is very fine and reactive. It reacts with calcium hydroxide byproducts to form additional cementitious compounds and thereby the durability of concrete can be enhanced by the addition.

Fig. 2. Metakaolin

TABLE 5.PHYSICAL PROPERTIES OF METAKAOLIN

SL.NO	PROPERTIES	RESULTS
1	Specific gravity	2.53

IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

A. *Test on fresh concrete*

Fresh concrete or plastic concrete is freshly mixed material, which can be moulded into any shape. The relative quantities of cement, coarse aggregate, fine aggregate and water mixed together, control the concrete properties in the fresh state. Workability is defined as the ease with which concrete can be compacted. It is the property of concrete which determines the amount of useful internal work necessary to produce full compaction.

Compaction factor test is one of the most efficient tests for measuring the workability of concrete. This test works on the principle of determining the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height.

Slump test is the most commonly used method for measuring workability of concrete which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete. It is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch. The slump values and compaction values are given in the table.6

TABLE 6. SLUMP AND COMPACTION FACTOR OF DIFFERENT MIXES

E –waste (%)	Slump value (mm)	Compaction factor
0%	81	0.91
5%	78	0.88
10%	76	0.85
15%	70	0.82
20%	65	0.75

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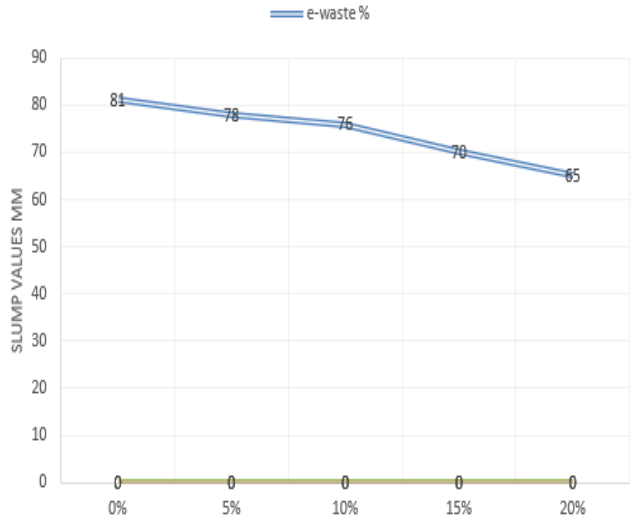

Fig. 3. Slump values of various e-waste mixes

Upto 15% of e-waste replacement the mixes were good workable. The 20% e-waste mix is less workable.

B. Compressive strength test

Compressive strength is the most important and useful property of concrete. In most structural applications concrete are primary to resist compressive stresses. The compressive strength is usally used as a measure of this property. Concrete cube of size 150x150x150mm were cast with various metakaolin percentages is given in table.7

TABLE.7 COMPRESSIVE STRENGTH OF CONCRETE HAVING VARIOUS PERCENTAGE OF METAKAOLIN

Metakaolin (%)	Compressive strength (N/mm^2)
	28th day
5%	25.3
10%	27.1
15%	24.9

The metakaolin replaced by 10% of cement shows maximum compressive strength. This percentage is constant throughout the test.

The cube compressive strength of concrete having various percentages of e-waste and constant percentages of metakaolin after 7th, 14th and 28th days are given in the table.8

TABLE.8 COMPRESSIVE STRENGTH TEST RESULTS OF CONCRETE HAVING VARIOUS E-WASTE PERCENTAGES.

E- waste(%)	Metakaolin (%)	Compressive strength (N/mm^2)		
		7th	14th	28th
0	0	20.3	21.8	25.25
5	10	19.1	21.5	23.56
10	10	18.3	19.8	21.73
15	10	14.7	15.2	17.78
20	10	12.1	14.7	15.22

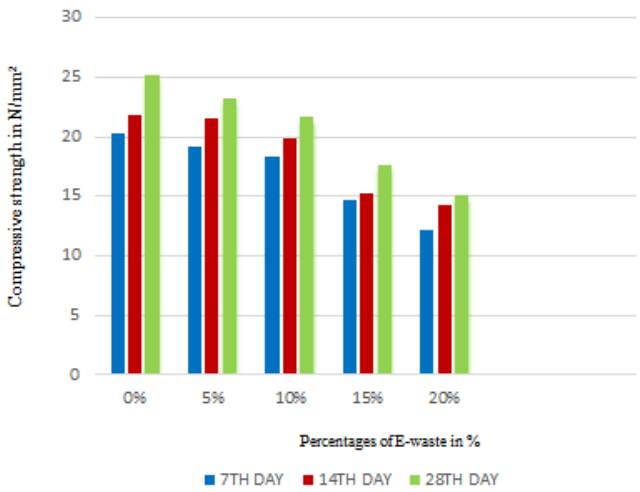

Fig.4. Compressive strength of concrete having various percentages of e-waste.

From the results it is observed that upto 10% e-waste replacement is possible without much reduction in strength.. Beyond 10% replacement strength reduces noticeably.

C. Flexural strength test

Universal testing machine was used for this test. Beam samples measuring 500×100×100mm were moulded and stored in water for 28days before test for flexural strength. Three similar samples were prepared for each mix proportion. The casting was made by filling each mould with freshly mixed concrete in three layers. Each layer was compacted manually using a 25mm diameter steel tamping rod to give 150 strokes on a layer. The hardened beam was placed on the universal testing machine simply supported over a span 3times the beam depth on a pair of supporting rollers. Two additional loading rollers were placed on top the beam. The load was applied without shock. The flexural strength was then calculated using the formula given below:

$f_c = Pl/d_1d_2^2$

Where, P = breaking load (in N) (1)

d_1 and d_2 = lateral dimensions of the cross sections (in mm);

l = distance between the supporting rollers (in mm);

The flexural strength of concrete having various percentage of e-waste is given in table.9

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TABLE.8 FLEXURAL STRENGTH OF CONCRETE HAVING VARIOUS PRECENTAGES OF E-WASTE

10% Metakaolin + E- waste of	Flexural strength(N/mm^2)
0%	6
5%	5.2
10%	4.4
15%	3.2
20%	2.8

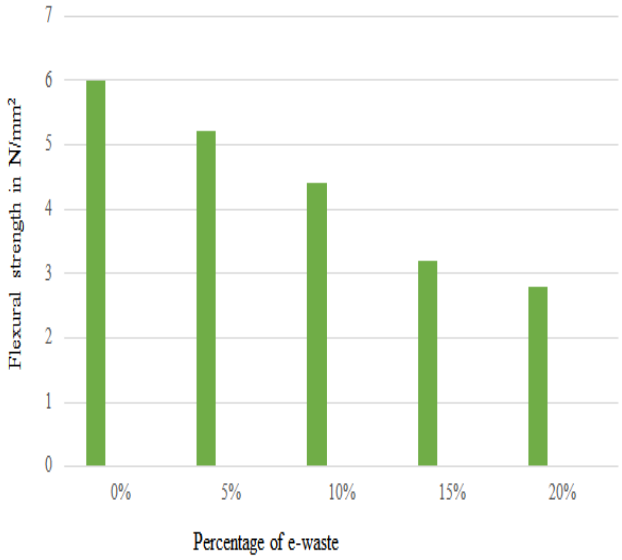

Fig.5. Flexural strength of concrete having various percentages of e-waste.

V. CONCLUSIONS

- From this study it is concluded that use of E-Waste in concrete by replacing coarse aggregate is possible.
- Hence it solves a potential disposal problem and it saves natural aggregate.
- Thus the environmental effects from industrial waste can be significantly reduced
- The workability decreases with increase in e-waste percentage.
- E-waste make the concrete more economical
- The compressive strength and flexural strength decreases with increasing e-waste percentages .Upto 10% we can safely use in concrete structures.

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