Experimental Study on Strength of Concrete by Partial Replacement of E-Waste

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***Abstract*- E-waste management is the major threat around the globe, with increasing modernization, tremendous growth of technology and mainly due to upgradation of electrical and electronic goods. Disposal and recycling of these wastes are becoming more harmful and deadly without proper procedures. On the other hand our natural resources are being depleted at enormous amount. So they are completely or partially replaced according to the needs. Cement is partially replaced by various other agents and Fine aggregate is replaced by M-sand. Eventually coarse aggregate should need a replacement, various materials are used as partial replacement of coarse aggregate, in this study coarse aggregate is partially replaced by e-plastic waste at specific percentages and strength of concrete is tested accordingly. On the strength criteria of M35 grade e-waste is partially replaced by 0%, 4%, 8%,12%,16%, of coarse aggregate, water cement ratio is kept as 0.45 for all proportions. Printed circuit boards are used as partial replacement for coarse aggregate. OPC 53 grade cement is used. The mechanical properties compression, split tensile and flexural strength are determined for 7days, 14days and 28days.**

***Index terms*- E-waste, Coarse aggregate, Partial replacement, high performance concrete**

INTRODUCTION

If a concrete structure is compared with human body. Reinforcements play the role of nerves, concrete plays the role of tissue and blood which is the most important organ for the existence of the body. Accordingly it is simple and the most inevitable source of the structure. Strength and durability of the concrete should be increased in various ways. Replacement of concrete materials for this purpose have been in use, for long now. This study deals with partial replacement of coarse aggregate with e-waste. Electronic or electrical waste is referred to as e-waste. Used electronic and electrical devices which can reused, recycled and disposed. They are categorized as, household appliances large and small, IT electronic and electrical, Lamps, Toys, Instruments, Medical equipment, Monitoring and control devices and Automatic dispensers. E-waste is considered as the mass emerging waste stream in the world. An estimated 50 million tons of e-waste are produced each year around the globe. The Environmental Protection group estimates that only 15-20% of e-waste is recycled, the rest of these go directly into landfills and incinerators polluting the land mass at adverse rate. India is the fifth largest electronic waste producer in the world. According to an industrial body India will generate 5.2 million tonnes of e-waste in 2020. E-waste recycling is a main source of income for many people around the country more than 95% of India's e-waste is recycled by improper methods causing various threat to human life and environment. In Indian top five cities producing e-waste are Mumbai, Delhi, Bengaluru, Chennai, and Kolkata. To control this one of the effective methods is to use e-waste in the construction industry because we don't have vast lands for landfills and steps should be taken soon to avoid further damage to the environment. Thus, e-waste is taken as partial replacement of coarse aggregate in this experiment and certain properties are tested.

METHODOLOGY

For this experimental study OPC grade 53 is used, m-sand is taken as fine aggregate, naturally crushed aggregate is used as coarse aggregate and crushed plastic waste, passed through 20mm sieve and retained on 4.75mm sieve is used in this experiment. As per IS 10262:2009 concrete mix design is done. Three sets of cubes were prepared for testing on 7th, 14th, and 28th day. After completing the design mix,

150*150*150mm cubes were casted. Then specific tests were conducted to determine the strength of the concrete.

MATERIALS USED

CEMENT

OPC 53 Grade is stronger and also it is more durable. It is conformed to IS 12269-1987 with a designed strength of 53 MPa or 530 kg/sqcm for 28 days. For high performance 53 grade is used. Table 1 below displays the properties of cement.

WATER

Water is one of the important component in construction. Quality of water for concrete mix was conformed from IS 456-2000.

M-SAND

Manufactured sand is referred as M-sand. It is manufactured by crushing the hard granite stone. It is a replacement for normal sand. The size of m-sand is less than 4.75mm. It is conformed to IS 383-1930. Table 2 below shows the properties of sand.

COARSE AGGREGATE

Coarse aggregate sizes are larger than 4.75mm, size varying from 1Omm to 20mm is used. It is conformed to IS 383-1970. Table 3 below shows the properties of coarse aggregate.

E-WASTE

Printed Circuit Boards (PCB) is used as e-waste here. Size of the aggregate is between 1.20mm to 2.30mm. All the metals were removed from PCB. Table 4 below shows the properties of e-waste.

S.NO	PROPERTIES	EXPERIMENTAL VALUE
1	Specific gravity	3.15
2	Initial setting time	30mins
3	Final setting time	600mins
4	Soundness of cement	0.8%
5	Fineness of cement	225

TABLE 1. PROPERTIES OF CEMENT

S.NO	PROPERTIES	EXPERIMENTAL VALUE
1	Specific gravity	3.61
2	Water Absorption	0.86%
3	Fineness modulus	3.01

TABLE 2. PROPERTIES OF M-SAND

TABLE 3. PROPERTIES OF COARSE AGGREGATE

S.NO	PROPERTIES	EXPERIMENTALVALUE
1	Specific gravity	2.71
2	Water Absorption	0.30%
3	Crushing Value	18.22%
4	Impact Value	12.9%
5	Fineness modulus	6.56

TABLE 4. . PROPERTIES OF E-WASTE

S.NO	PROPERTIES	EXPERIMENTALVALUE
1	Specific gravity	1.20
2	Water Absorption	0.04%
3	Crushing Value	2.35%
4	Impact Value	1.95%
5	Fineness modulus	2.50

EXPERIMENTAL INVESTIGATION

S.NO¤	CUBE DESIGNATION¤	% OF E-WASTE¤	COMPRESSIVE STRENTH (MPa)¤		
			7 DAYS¤	14 DAYS	28 DAYS
1¤	CUBE 1¤	0¤	36.91¤	45.46¤	49.89¤
2¤	CUBE 2¤	4¤	37.71¤	46.05¤	48.0¤
3¤	CUBE 3¤	8¤	38.67¤	47.78¤	48.56¤
4¤	CUBE 4¤	12¤	37.07¤	45.36¤	47.17¤
5¤	CUBE 5¤	16¤	35.72¤	42.74¤	45.64¤

TABLE 5. SLUMP VALUE

% OF E- PLASTIC IN MIX	SLUMP IN mm
0	100
4	110
8	125
12	112
16	90

Table6. COMPRESSIVE STRENGTH OF CONCRETE

WORKABILITY

Workability is the property of freshly prepared concrete, it is used to determine the workable property and compaction of concrete without any segregation. It is measured using concrete slump test. Concrete is poured into the slump cone after tampering cone is removed. The shape and size of the concrete after the removal of cone is used to identify the workability. Table 5 below shows the slump

value for various % of e-waste added with the concrete.

COMPRESSIVE STRENGTH

Mechanical test which is used to measure the maximum amount of compressive load acting on a structure before developing a crack. Sample is compressed between the platens by a compression-testing machine by gradually applying load. By the above procedure we get the compressive strength of the concrete. In this study compressive strength is taken for 7, 14, 28, days after casting the moulds. E-plastic waste are added as a partial replacement of coarse aggregate at 4%, 8%, 12% and 16% and compressive strength is tested accordingly. Design mix M25 is used and OPC 53grade is used. Table 6 below shows the compressive strength of the concrete.

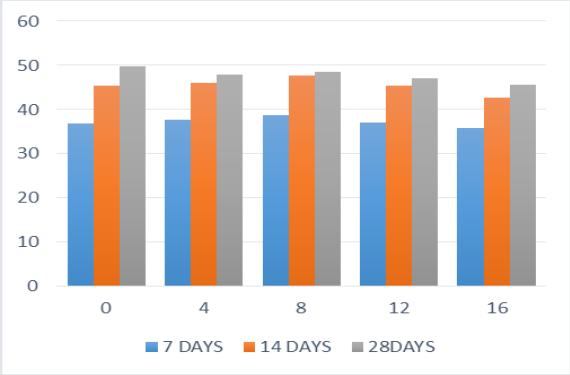

FIGURE 1. GRAPH REPRESENTS TENSILE STRENGTH OF CONCRETE

SPLIT TENSILE STRENGTH

Tensile strength, it is the maximum amount of tensile stress taken by the structure before failure. Method of determining tensile strength of concrete is by using a cylinder which splits across the vertical dia. Table 7 below shows the split tensile strength of the concrete.

Table 7. SPLIT TENSILE STRENGTH OF CONCRETE

S.NO	CUBE DESIGNATION	% OF E-WASTE	SPLIT TENSILE STRENGTH (MPa)		
			7 DAYS	14 DAYS	28 DAYS
1	CUBE 1	0	4.2	4.5	4.9
2	CUBE 2	4	4.1	4.9	4.8
3	CUBE 3	8	3.14	5.0	5.5
4	CUBE 4	12	2.2	3.0	3.8
5	CUBE 5	16	2.0	2.9	3.2

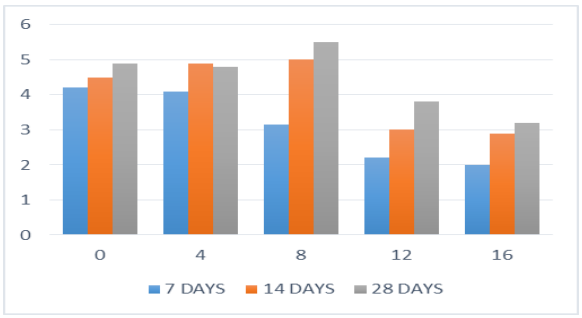

FIGURE 2. GRAPH REPRESENTS TENSILE STRENGTH OF CONCRETE

FLEXURAL STRENGTH

Flexural strength is known as modulus of rupture and bend strength which is a material property, it is the stress in the material before it starts yielding. It is tested using three point flexural test technique. Table 8 below shows the flexural strength of the concrete.

S.NO	CUBE DESIGNATION	% OF E-WASTE	FLEXURAL STRENGTH (MPa)		
			7 DAYS	14 DAYS	28 DAYS
1	CUBE 1	0	1.9	3.0	4.21
2	CUBE 2	4	1.5	2.6	4.1
3	CUBE 3	8	1.0	2.0	4.0
4	CUBE 4	12	0.75	1.25	2.5
5	CUBE 5	16	0.5	1.0	2.0

Table 8. FLEXURAL STRENGTH OF CONCRETE

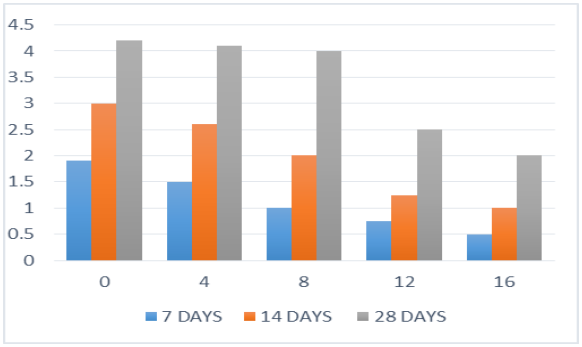

FIGURE 3. GRAPH REPRESENTS FLEXURALSTRENGTH OF CONCRETE

CONCLUSION

E-waste can be used as partial replacement of concrete. Thus by reducing landfilling and incineration and also protecting the environment from depletion.

Compressive strength of concrete increases with increase in percentage of coarse aggregate up to 8%.

Further increase on percentage of e-plastic waste, it reduces the strength of concrete according to the above study.

Tensile strength of concrete also increases with increase in percentage of coarse aggregate up to 8%. Flexural strength of concrete is also studied and the results are founded to be decreasing with increase in percentage of e-waste.

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