

Recycling of Demolished Concrete and E-waste

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Abstract: Concrete is the most widely used construction material all over the world in view of its compressive strength, high mouldability, structural stability and economic considerations. It reduces the demand of new resources and cuts down the cost and effort of transport and production. Recycling is defined as the process of collecting and preparing recyclable materials and reusing them in their original form. Recycling is the act of processing the used material for use in creating new product. The processing of electronic waste in developing countries causes serious health and pollution problems due to the fact that electronic equipment contains some very serious contaminants such as lead, cadmium, and beryllium and brominates flame retardants. A few potential reuses of recovered non-metallic Printed Circuit Board have been reviewed. Many previous applications have used the recovered non-metallic materials as filler or for concrete and various framing materials. The main object of this project is to determine the compressive strength, tensile strength, flexural strength and bond strength by using fresh concrete material (FCM), waste concrete material (WCM), and E-waste material. Various mixes were prepared for carrying out the research by varying the proportions of cement, sand and aggregates. All mixes were designed for characteristic strength (f_{ck}) of M25. The compressive strength, tensile strength, Flexural strength and bond strength of concrete was tested in laboratory after 7 and 28 days. The specimens used for testing include cubes, cylinders and beams. In this project comparison between fresh concrete materials, waste concrete material, and E-waste concrete material for compressive strength, tensile strength, flexural strength and bond strength. The main aim of this study recommends the recycling of waste concrete as an aggregate and sand material in the production of new concrete.

Keywords: Waste material, Concrete, Recycled aggregates, Compressive strength, Tensile strength, Flexural strength, and Bond strength

1. Introduction

Recycled demolished concrete are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris. These materials are generally from buildings, roads, bridges. With the sharp development of construction and increase of people's awareness of environmental protection, waste control and management becomes one of the great challenges of modern society for the mission of sustainable development. Construction and demolition (C&D) waste constitutes one major portion of total solid waste produced in the world, including demolished concrete, bricks, and masonry, limestone, ceramic and other materials. Structures include buildings of all types, both residential and non-residential, as well as roads and bridges. Components of C&D debris typically include concrete, asphalt, E-waste, wood, metals, gypsum wallboard and roofing". Main components of CDW are generally brick, concrete, wood, and ceramic tile. Except for soil and fine aggregates, the predominant materials, especially in buildings from the last century, are brick and cement block. Concrete and masonry waste can be recycled by sorting, crushing and sieving into recycled aggregate. This recycled concrete can be used to make concrete for road construction and building material. E-Waste for short or Waste Electrical and Electronic Equipment (WEEE) is the term used to describe old, end-of-life or discarded appliances using electricity. It includes computers, consumer electronics, fridges etc. which have been disposed of by their original users. The processing of electronic waste in developing countries causes serious health and pollution problems due to the fact that electronic equipment contains some very serious contaminants such as lead, cadmium, beryllium and brominates flame retardants. Even in developed countries recycling and disposal of e-waste involves significant risk. In its simplest form, concrete is a mixture of paste and aggregates. Various materials are added such as fly ash, rice husk, PCB board, Glass fibre

admixture to obtain concrete of desired property. The character of the concrete is determined by quality of the paste. The key to achieving a strong, durable concrete rests in the careful proportioning, mixing and compacting of the ingredients. According to statistical data released by the National Bureau of Statistics of China, about 20 million electronic household appliances (including televisions, washing machines, refrigerators, air conditioners, and personal computers) and 70 million cell phones have come to their end-of-life every year since 2001. As a key component in electronic equipment, large amounts of waste printed circuit boards (PCBs) are generated by all this consumption of electronic appliances. PCBs form about 3% by weight of the total amount of electronic scrap Printed circuit boards (PCB) are platforms on which integrated circuits and other electronic devices and connections are installed. In general, waste PCBs contains approximately 30% metals and 70% non-metals (Guo et al., 2008, Goosy and Kellner, 2002). The material presents in PCB can be further categorized in three groups that are organic, metals, and ceramics.

2. Materials

A. Cement

The cement used in all mixtures was commercially available "Ultratech 53 grade Ordinary Portland Cement conforming to IS 12269-1987 was used in this study. The specific gravity of cement was 3.15. The initial and final setting time were found as 36 minutes and 395 minutes respectively.

B. Fine aggregate

Locally available river sand passed through 4.75mm IS sieve is used as fine aggregate. The specific gravity of sand is 2.82 and fineness modulus of 2.5.

C. Coarse aggregate

The Coarse aggregate are obtained from a local quarry is used. The coarse aggregate with a maximum size 20mm having a specific gravity 2.91 and fineness modulus of 3.06.

D. Demolished waste

The Demolished wastes are obtained from a laboratory crushed specimen. The specimens were crushed manually using a hammer. The aggregates passing through IS sieve 20mm and retained on 12.5mm are taken. The specific gravity of aggregates is 2.85 and fineness modulus of 3.10.

E. E-waste

The E-wastes like printed circuit board are used. The PCB was crushed by using Jaw crusher. The aggregates passing through IS sieve 2.36mm. The specific gravity of aggregates is 2.85 and fineness modulus of 3.10.

3. Experimental Program

The mix design is produced for maximum size of aggregate is 20mm conventional aggregate and crushed recycled aggregate. The variation of strength of hardened concrete using solid wastes as partial replacement of conventional aggregate is studied by casting cubes and cylinders until 20%. The concrete was prepared in the laboratory using mixer. The cement, fine aggregate and coarse aggregate and solid wastes are mixed in dry state and then the desired water quantity is added and the whole concrete is mixed for 5 minutes, the concrete is poured in the moulds which are screwed tightly. The concrete is poured into the moulds in 3 layers by poking with tamping rod for cubes of 150×150×150 mm Size, cylinders of 100×200 mm size and beams of 500×100×100 mm size was tested for compression and split tensile strengths. The cast specimens are removed after 24 hours and these are immersed in a water tank. After a curing period of 7 and 28 days the specimens are removed and these are tested for compression and split strengths and the results are compared with conventional concrete.

4. Mix Proportions

Different mixes including one control mix were used to examine the influence of adding CD (Crushed demolished) coarse aggregates and CE (Crushed E-waste) fine aggregates on the properties of concrete. Details of the mixes are given in Table-1. The control mix (CM) had a proportion of 1 (Cement): 1.93 (Fine aggregate): 3.25 (Coarse aggregate) for a targeted strength of 25MPa and did not contain recycled aggregates. The water cement ratio for all the mixes was 0.5. In mixes CD5, CD10, CC15 and CC20, the natural coarse aggregates were replaced with 5%, 10%, 15% and 20% (by weight) crushed concrete aggregates respectively. In mixes CE5, CE10, CE15 and CE20, the natural fine aggregates were replaced with 5%, 10%, 15% and 20%, (by weight) crushed PCB fine aggregates, respectively.

Table 1: Details of mix proportions

Mix ID	Cement	N.F.A	N.C.A	R.A (CD / CE)	Water
CM	387.42	747.12	1257.8	0	174.34
CD5	387.42	747.12	1194.9	62.89	174.34
CD10	387.42	747.12	1132.0	125.7	174.34
CD15	387.42	747.12	1069.1	188.6	174.34
CD20	387.42	747.12	1006.3	251.5	174.34
CE5	387.42	709.76	1257.8	37.35	174.34
CE10	387.42	672.41	1257.8	74.71	174.34
CE15	387.42	635.06	1257.8	112.0	174.34
CE20	387.42	597.70	1257.8	149.4	174.34

5. Results and Discussions

I] Compressive strength of fresh, demolished concrete & E-waste concrete for specimen cube N/mm²

Table 2: Test results

Sr. no.	% Replacement Recycled aggregate	28 Days compressive strength N/mm ²	
		Demolished concrete	E-waste concrete
1.	0%	34.23	34.23
2.	5%	33.16	37.47
3.	10%	32.00	39.00
4.	15%	30.21	35.10
5.	20%	27.32	32.02

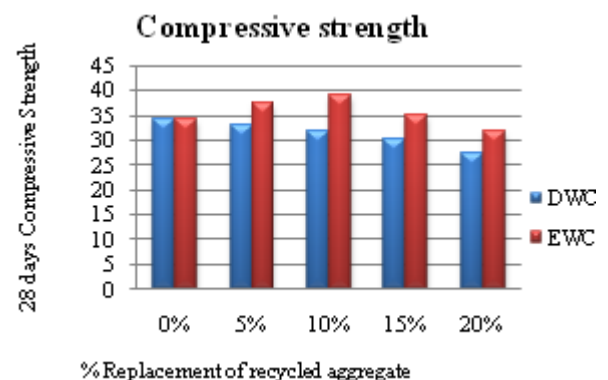


Figure 1: Compressive strength (MPa)

II] Split tensile strength of fresh, demolished concrete & E-waste concrete for specimen cylinder N/mm²

Table 3: Test results

Sr. no.	% Replacement Recycled aggregate	28 Days compressive strength N/mm ²	
		Demolished concrete	E-waste concrete
1.	0%	3.25	3.25
2.	5%	3.22	3.93
3.	10%	3.18	4.01
4.	15%	3.11	3.45
5.	20%	3.07	3.23

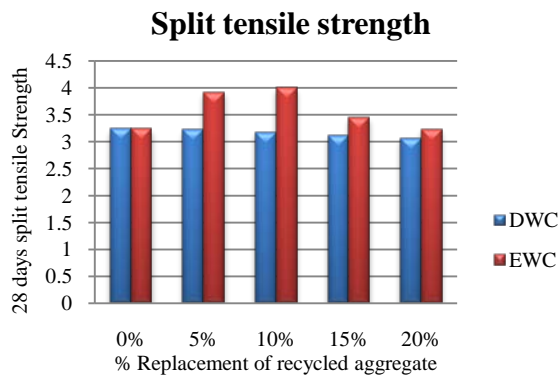


Figure 2: Split tensile strength (MPa)

III] Flexural strength of fresh, demolished concrete & E-waste concrete for specimen beam N/mm^2

Table 4: Test results

Sr. no	% Of Recycled aggregate	28 Days Flexural strength N/mm^2	
		DWC	EWC
1.	0%	6.9	6.9
2.	5%	6.81	7.35
3.	10%	6.70	7.00
4.	15%	5.57	6.00
5.	20%	4.98	5.12

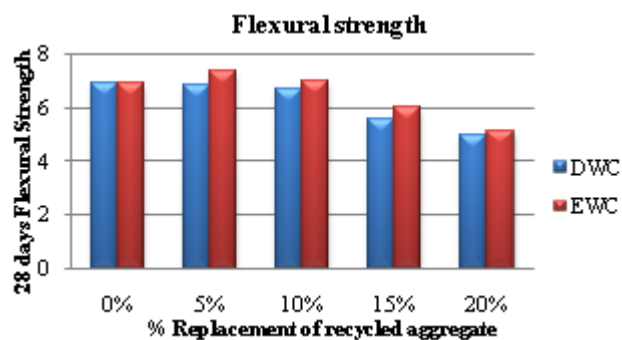


Figure 3: Flexural strength (MPa)

IV] Bond strength of fresh, demolished concrete & E-waste concrete for specimen cube N/mm^2

Table 5: Test results

Sr. no	% of Recycled aggregate	28 Days Bond strength N/mm^2	
		DWC	EWC
1.	0%	5.16	5.16
2.	5%	5.12	6.00
3.	10%	4.96	5.17
4.	15%	4.00	4.60
5.	20%	3.75	4.00

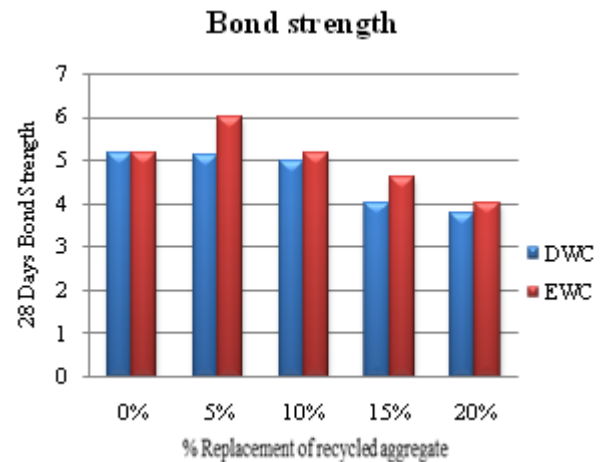


Figure 4: Bond strength (MPa)

6. Conclusions

Demolished waste and E-waste are the main problem of country and from demolition buildings. The aim of this work was the waste collected from laboratory waste specimens and E-waste collected from electronics store. The following are the conclusions obtained after performing the above experiments

- 1) Increasing the recycled coarse aggregate percentage then decreases the strength of concrete.
- 2) In printed circuit board chemical composition is silica 63.55% and copper 36.44%, due to this reason it increases the strength.
- 3) Concrete with PCB waste can be developed successfully with appropriate strength characteristics. The compressive strength increases with the increase in the percentage of pulverized PCB up to replacement (10%) of sand in concrete.
- 4) The workability of the concrete with waste did not show appreciable changes as compared to the control mix.
- 5) The maximum 28 days split tensile strength was obtained with 10% replacement of crushed PCB is greater than conventional concrete and the strength was obtained with replacement of demolished waste and demolished with admixture is near about same in conventional concrete.
- 6) Concrete with PCB waste can be developed successfully with appropriate strength characteristics. The flexural strength increases with the increase in the percentage of pulverized PCB up to replacement (5%) of sand in concrete.
- 7) The maximum 28 days bond strength was obtained with 5 % replacement of fine aggregate is greater than conventional concrete.
- 8) The PCB waste and demolished waste can be utilized in concrete making and hence solve a potential disposal problem and it saves natural aggregate.
- 9) Although recycled aggregate can be applied in the high strength structure, but one issue must not be neglected as recycled aggregate with reduce water content would have low workability. Whenever recycled aggregate is applied, water content in the concrete mix has to be monitored carefully due to the water absorption capacity varying quantity of recycled aggregate.

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