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Performance Evaluation of E-plastic Waste as a Partial Replacement of Fine Aggregate

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ABSTRACT

Westernization and population increase has resulted in the gradual increase of e-plastic waste filling out the entire globe, which is a global concern. Green concrete production with the help of waste materials is one of the solutions. Efforts have to be made to undertakes a systematic study of M20 grade concrete with various proportions of E-plastic waste as fine aggregate in the concrete. This paper presents the results of an investigation to study the performance of concrete prepared with electronic plastic waste (E-plastic waste) as part of the fine aggregate. The initial trail mix proportions for choosing an effective and efficient certain percentage to replace the fine aggregate by 0% of E-plastic aggregate up to 25% replacement by volume of the fine aggregate. The test results showed that a substantial improvement in compressive, split tensile, and flexural strength was achieved in the E-plastic concrete compared to conventional concrete.

Key words *: Concrete, E-plastic waste, PPC, Beam, Flexural Strength*

Introduction

The devastating impact of the non-degradable material wastes and thermal power plant ashes are high and the hazardous content of these materials pose a threat to human health and environment, is not sustainable. For example, the estimation shows 20-50 million tons of e-waste discarded annually worldwide, Asian countries discard an estimated 12 million tons, this share will likely only increase with the rapidly developing economies of China and India, who will have 178 million and 80 million new computers, respectively, out of the global total of an estimated 716 million new computer users in 2020.

E-Waste

"Electronic waste" may be defined as discarded computers, office electronic equipment, entertainment device electronics, mobile phones, television sets and refrigerators. bE-waste describes loosely discarded, surplus, obsolete, broken, electronically or electronic devices. Rapid technology change, low initial costs have resulted in a fast growing surplus of electronic waste around the globe. The e-waste inventory based on obsolescence rate and installed base in India for the year 2005 had been estimated to be 146180.00 tones.

This was expected to exceed 8, 00,000 tons by 2012. Traditional landfill or stockpile method is not an environmental friendly solution and the disposal process is also very difficult to meet EPA regulations. In developed countries, previously, it was about 1% of total solid waste generation and currently it grows to 2% by 2010. In developing countries, it ranges 0.01% to 1% of the total municipal solid waste generation. Maharashtra ranks first fol-

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lowed by Tamil Nadu and Andhra Pradesh.

Cement

Cement is a finely ground material having adhesive and cohesive properties which provide a binding medium for the discrete ingredients it is obtained by burning together, in a definite proportion.

Fig. 1. Pozzolonic Portland cement

Fig. 2. Ordinary Portland cement

Source

The quantity of solid waste is expanding rapidly. It is estimated that the rate of expansion is doubled every 10 years. This is due to the rapid growth of the population as well as the industrial sector. The solid-waste crisis is important from an environmental and economic point of view. As landfill areas are rapidly depleting, the cost of solid-waste disposal is rapidly increasing, this represents about 7% by weight of the

Fig. 3. Crushed Electronic Waste

Table 1. International E-waste Resources

Country	Total E-waste Generated tones/year	Categories of Appliances counted in e-waste	Year
India (Chennai)	28,789	Domestic Appliances, Commercial usages, office, Manufacture waste.	2011
Switzerland	66,04	Office & Telecommunications Equipment, Consumer Entertainment Electronics, Large and Small Domestic	2003
Germany	1,100,000	Appliances, Refrigerators, Fractions	*Estimated in 2005
Taiwan	14,036	Computers, Home electronically appliances (TVs, Washing Machines, Air conditioners, Refrigerators)	2003
Thailand	60,000		2003
Canada	67,000	Computer Equipment (computers,printers etc) & Consumer Electronics (TVs)	*Estimated in 2005

total solid wastes. However, plastic wastes are very visible, since they constitute about 30% by volume of the total solid wastes. The various types of plastics in municipal wastes are Polyethylene terephthalate (PET), High density polyethylene (HDPE), Low density polyethylene (LDPE), Polypropylene (PP), Polystyrene (PS) etc.

Test results

Compressive strength

One of the important properties of concrete is its strength in compression. The strength in compression has a definite relationship with all the other properties of concrete. These properties are improved with the improvement in the compressive strength, hence the importance of the test.

Final Compersion of OPC and PPC

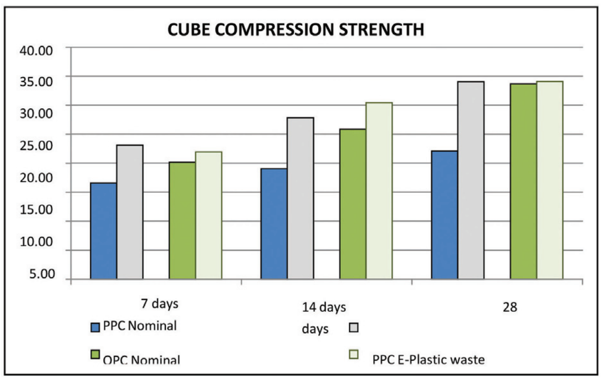

Fig. 4. Comparison of Cube Compression Strength

Split tensile strength

The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However,

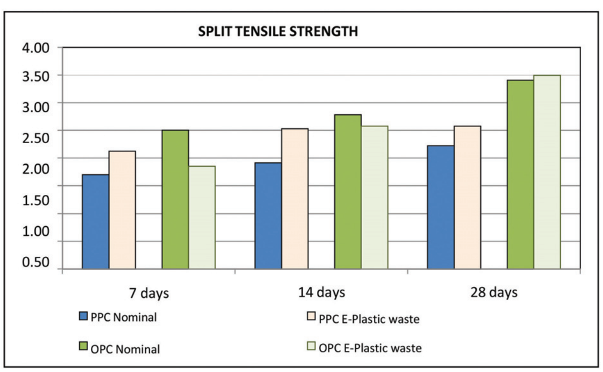

Fig. 5. Comparison of Split Tensile Strength of Concrete

the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack.

Modulus of Elasticity of Concrete

It is a measure of the stiffness or the resistance of the material to deformation. Concrete exhibits creep under sustained loading, within elastic limit. It is used in the analysis of reinforced concrete structures to determine the stress developed in simple elements and to determine the moments, stresses and deflections in more complicated structures.

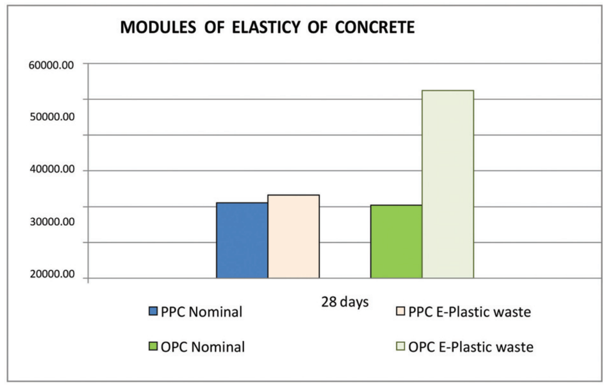

Fig. 6. Modules of Elasticity of Concrete Compaction

Flexural strength of non reinforced beam

Grade of concrete	=	M20
Type of Cement	=	OPC
Type of Mix**Size of the Specimen**	=	Nominal

Width of the specimen	"B"	=	100 mm
Depth of the specimen at the point of failure	"D"	=	100 mm
Length of the specimen	"l"	=	500 mm
The span on which the specimen was supported	"L"	=	400 mm

Flexural strength of reinforced beam

Reinforced concrete beams of size 100 x 150 x 1100 mm were cast using metal mould at the structural laboratory. Conventional beam with PPC Nominal, OPC E-Plastic sand and beams with PPC E-Plastic sand were cast and tested under two point loading. All beams were tested under two point loading at a load increment of 5 kN. The corresponding deflections were noted. Two point loading system is used at L/3 distance in order to get pure bending. Load and deflection values for Conventional beam with PPC Nominal, OPC E-Plastic sand and beams with PPC E-Plastic sand were discussed

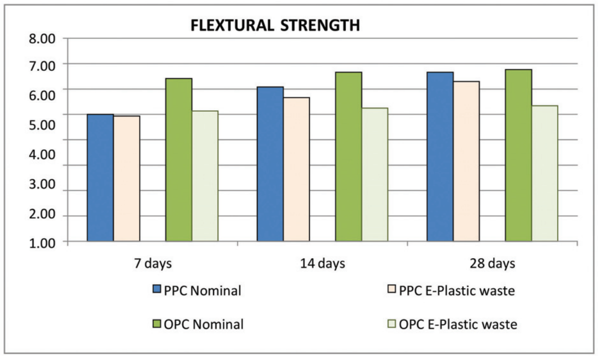

Fig. 7. Comparison of Flexural Strength of Concrete

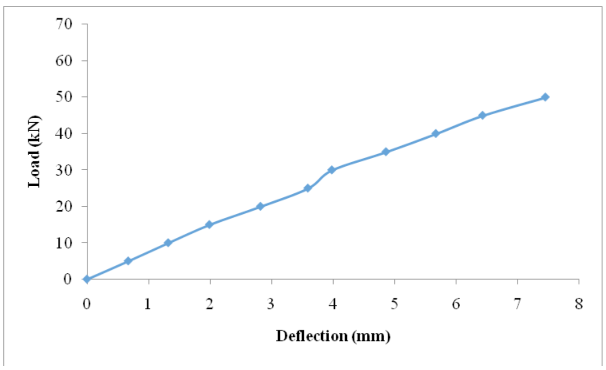

Fig. 8. Load vs Deflection plot for Conventional beam with PPC Nominal

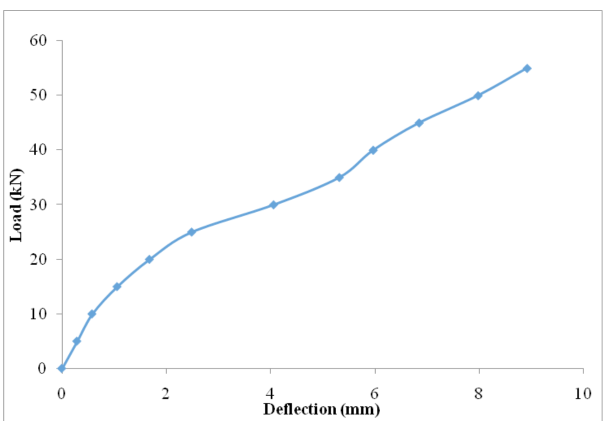

Fig. 9. Load vs Deflection plot for OPC E-Plastic beam

First crack load and Ultimate load

In conventional beam, initiation of crack take place at a load of 15 kN. For OPC E-Plastic and PPC E-Plastic beams, initiation of crack took place at a load of 20kN and 30 kN. This shows the ductile behavior of PPC E-Plastic beam.

All the beams were loaded upto their ultimate

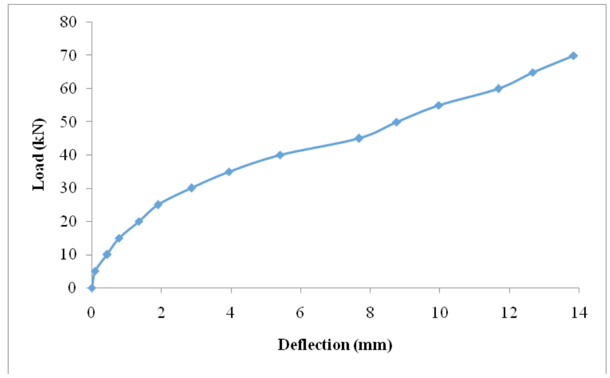

Fig. 10. Load vs Deflection plot for PPC E-Plastic beam

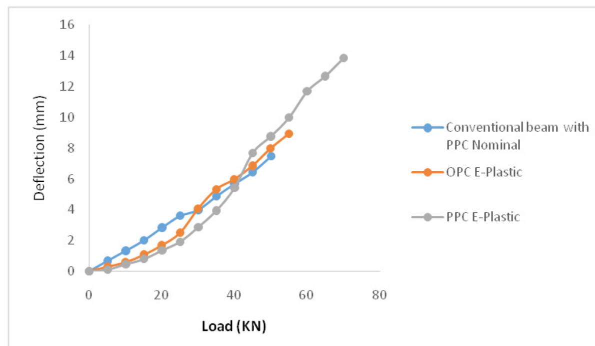

Fig. 11. Load vs Deflection plot for Conventional vs OPC E-Plastic vs PPC E-Plastic beam

load. It was noted that PPC E-Plastic beam has the higher load carrying capacity compared to the conventional beam and OPC E-Plastic beam. In conventional specimen, ultimate failure took place at a load of 50 kN whereas, in OPC E-Plastic and PPC E-Plastic beams it is 55kN and 70 kN. 40% increase in ultimate load was observed in PPC E-Plastic beam when compared with the conventional beam. Comparison chart for first crack and ultimate load was given in Fig. 12.

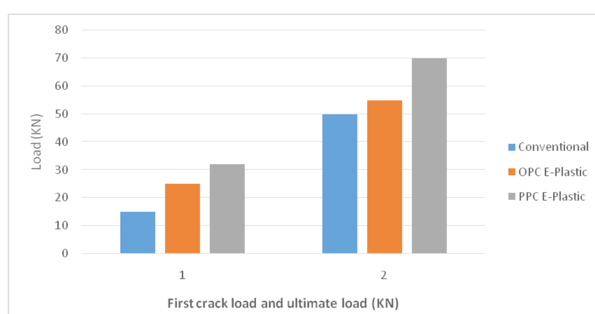

Fig. 12. First crack load and ultimate load

Table 2. Summary of Beam Flexural Results

S. No.	Name of the specimen	First Crack load (kN)	Ultimate load (kN)	Maximum midspan deflection (mm)	Stiffness (kN/mm)
1	Conventional	15	50	7.08	5.32
2	OPC E-Plastic	25	55	8.95	4.61
3	PPC E-Plastic	32	70	13.09	3.82

Stiffness

Stiffness may be defined as the amount of load required to cause a unit deflection. Stiffness calculation is done for ultimate load and its corresponding deflection value. Stiffness value for conventional, OPC E-Plastic and PPC E-Plastic beams are 7.08 kN/mm, 6.85 kN/mm and 4.92 kN/mm respectively are plotted in Fig. 13.

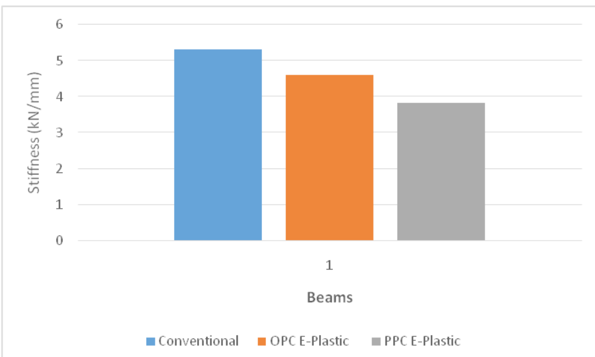

Fig. 13. Stiffness

Conclusion

The addition of E-plastic content above 18% significantly affects the compressive strength and split tensile strength. When comparing conventional concrete mix and E-plastic mix difference in strength characteristics is more. According to the scale of acceptable quality criteria, small deviations in 7 days and 14 days strength in PPC was observed and good in OPC. However 28 days results confirmed the quality criteria of E plastic concrete is good. The initial crack load and the ultimate load has been improved for OPC E-Plastic with 15% when compared with conventional concrete. An optimum percentage of PPC E-Plastic can be partially replaced for cement to overcome the environmental issues and reduce the usage of cement leading to sustainable environment.

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