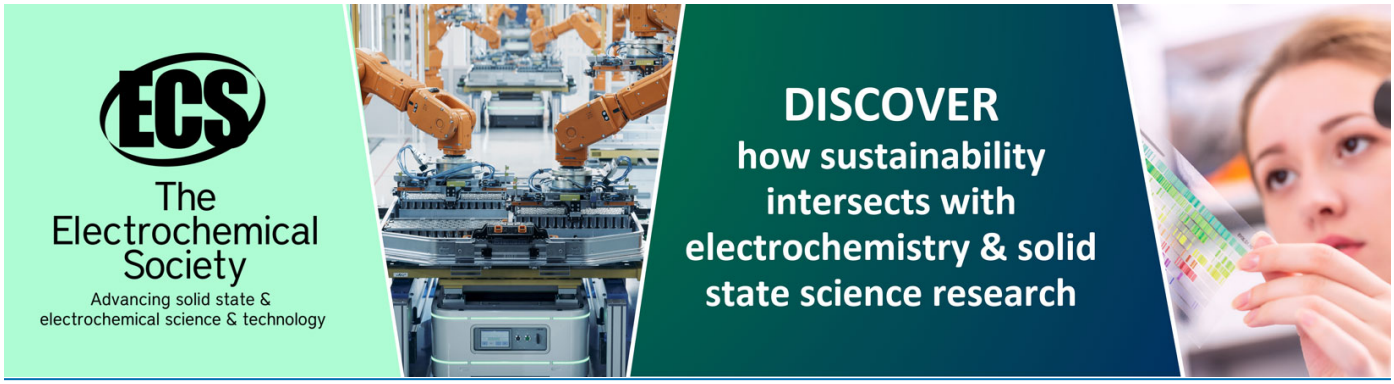
Study on Mechanical Properties of Concrete Using Plastic Waste as an Aggregate



Study on Mechanical Properties of Concrete Using Plastic Waste as an Aggregate

B Jaivignesh* and A Sofi

School of Civil and Chemical Engineering, VIT University, Vellore-632014. India.

*Email: jai_vignesh@yahoo.com

Abstract. Disposal of large quantity of plastic causes land, water and air pollution etc.., so a study is conducted to recycle the plastic in concrete. This work investigates about the replacement of natural aggregate with non-biodegradable plastic aggregate made up of mixed plastic waste in concrete. Several tests are conducted such as compressive strength of cube, split tensile strength of cylinder, flexural strength test of prism to identify the properties and behavior of concrete using plastic aggregate. Replacement of fine aggregate weight by 10%, 15%, 20% with Plastic fine (PF) aggregate and for each replacement of fine aggregate 15%, 20%, 25% of coarse aggregate replacement also conducted with Plastic Coarse(PC) aggregate. In literatures reported that the addition of plastic aggregate in concrete causes the reduction of strength in concrete due to poor bonding between concrete and plastic aggregate, so addition of 0.3% of steel fiber by weight of cement in concrete is done to improve the concrete strength. Totally 60 cubes, 60 cylinders and 40 prisms are casted to identify the compressive strength, split tensile strength and flexural strength respectively. Casted specimens are tested at 7 and 28 days. The identified results from concrete using plastic aggregate are compared with conventional concrete. Result shows that reduction in mechanical properties of plastic aggregate added concrete. This reduction in strength is mainly due to poor bond strength between cement and plastic aggregate.

Keywords: *Plastic aggregate, Bond strength, Concrete, Mechanical properties.*

1. Introduction

In civil engineering construction use of shredded plastics has increased drastically as a partial replacement of aggregates. As it is an added advantage in terms of environmental and potential economic consideration incorporation of waste in concrete increases[1-4]. Plastic can be incinerated with energy recovery, if material recycling is not feasible. Air pollution may cause and results in acid rain because of waste incineration[6,9]. Past investigations suggest that partial replacement of aggregate of concrete with waste plastic can improve properties such as abrasion resistance, impact resistance, ductility, shock absorption and thermal conductivity[10]. It also shows that addition of plastic to concrete causes some reduction in mechanical properties such as compressive strength, split tensile strength, flexural strength[5,7,8]. Literature reviews suggest that addition of steel fiber in normal concrete improves these mechanical properties. Taking the advantages of this, steel fiber is added to plastic waste aggregate concrete to make steel fiber reinforced waste plastic mix concrete. [12,13]This paper reports the strength characteristics of plastic waste aggregate mix concrete with the

addition of steel fiber for specimens of strength 30 MPa. Tests were performed for cube and cylinder and prisms for compressive strength, split tensile strength and flexural strength respectively.

2. Material Properties

2.1. Cement

Cement used as a binder material in concrete. The main characteristics of cement in the concrete mix design are developing the compressive strength within period. In this study 53 grade of ordinary Portland cement properties are confirming to code IS:12269-1987. The specific gravity of cement found in the laboratory is 3.13.

2.2. Aggregate

Fine aggregate passing through 4.75 mm IS sieve conforming to grading zone II of IS 383:1970 and having specific gravity of 2.6 was used in this study. Crushed aggregate available from local sources with maximum size of 20 mm and conforming to IS2386:1963 (part I, II and III) was used as coarse aggregate in this study. Specific gravity of coarse aggregate is found out as 2.7.

2.3. Water

Potable water was used in the experimental work for both mixing and curing purposes

2.4. Plastic waste

Waste plastic represents the discarded waste from plastic containers that were collected from plastic manufacturing plants located in Vellore. After collection of waste plastic, Plastic aggregate is obtained by crushing the plastic waste [11].

3. Mix Design

The M25 grade concrete mix proportions were arrived as per the Indian Standard IS: 10262-2009. Replacement of fine aggregate weight by 10%, 15%, 20% with Plastic Fine (PF) aggregate and for each replacement of fine aggregate 15%, 20%, 25% of coarse aggregate replacement also conducted with Plastic Coarse (PC) aggregate.0.3% of steel fiber is added by weight of cement.

4. Mix Proportion and Quantities

M-25 grade of concrete

Cement	:	395 kg/m^3
Fine aggregate	:	706kg/ m^3
Coarse aggregate	:	1151 kg/ m^3
Water	:	197kg/ m^3
Mix ratio	:	1:1.79:2.92:0.45

5. Experimental Work

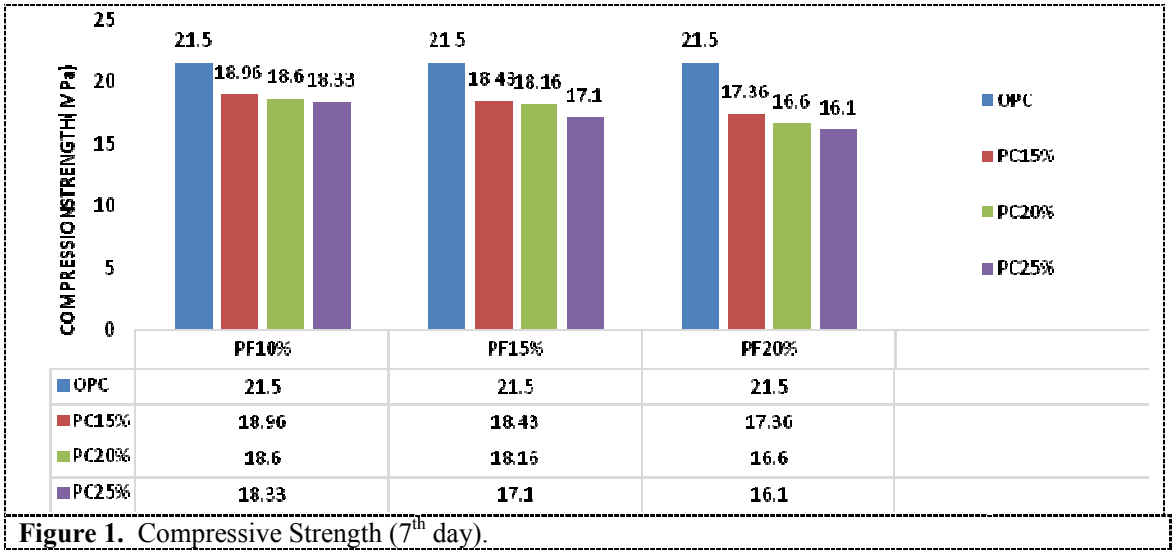
The experimental work is carried out in order to find out the mechanical properties of the concrete. The cubes of size 100mm × 100mm × 100mm are casted for all the mixes to find out the compressive strength. The cylinders of 100mm Ø× 200mm deep are casted to measure the split tensile strength. The prisms of size 500×100×100 are casted to measure flexural strength. The specimens are casted, cured and tested as per IS:516-1987. Testing was done for the same samples after 7 and 28 days of curing. The Universal Testing Machine (UTM) was used for testing.

6. Test Results and Discussion

6.1 Compressive Strength

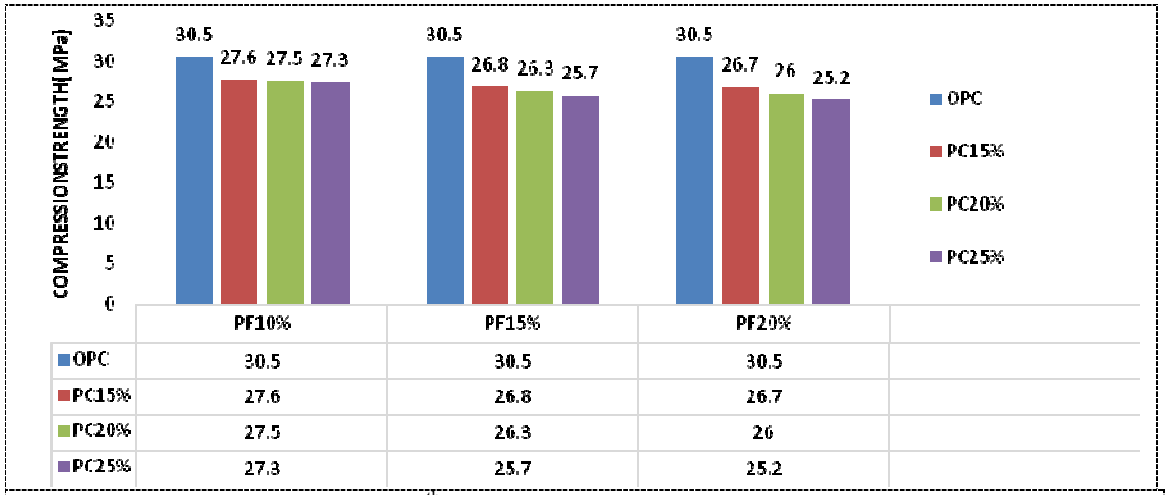
Concrete specimens are taken out from the curing tank and specimens are allowed to dry the surface moisture and kept in the compression testing machine. The load applied on the specimen until the specimen were failed and found the ultimate load of each specimen. The compressive strength of

concrete was calculated and the average of three specimen compressive strength was estimated at different curing age of all the concrete mixtures. By using the result plotted the graph and shown in Figure 1 and Figure 2.



	PF10%	PF15%	PF20%	
OPC	21.5	21.5	21.5	
PC15%	18.96	18.43	17.36	
PC20%	18.6	18.16	16.6	
PC25%	18.33	17.1	16.1	

Figure 1. Compressive Strength (7th day).



	PF10%	PF15%	PF20%	
OPC	30.5	30.5	30.5	
PC15%	27.6	26.8	26.7	
PC20%	27.5	26.3	26	
PC25%	27.3	25.7	25.2	

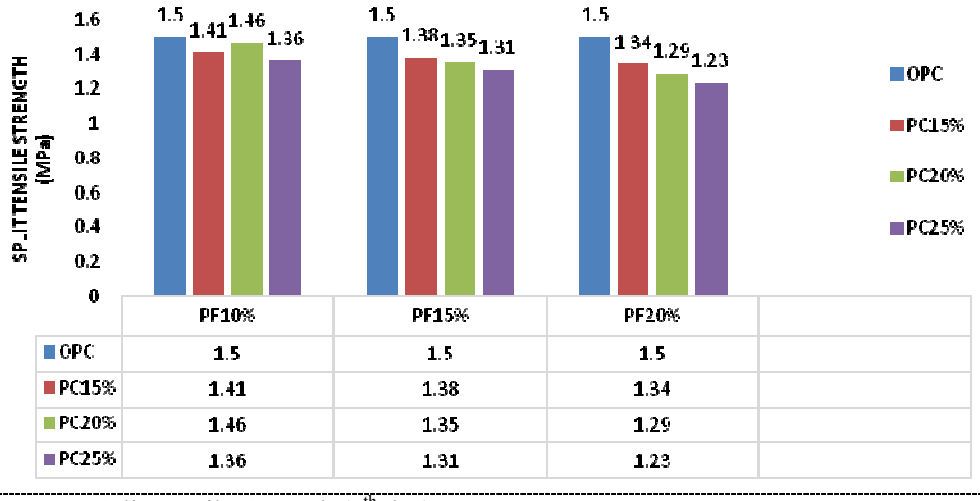
Figure 2. Compressive Strength (28th day).

6.1.1 Discussion on compressive strength test results. The compressive strength of waste plastic used concrete was lowered by the addition of plastic. The reduction is being in the range of 9 to 17 %. This loss may be attributed to the poor bond strength between plastic particles and concrete.

6.2 Split tensile Strength

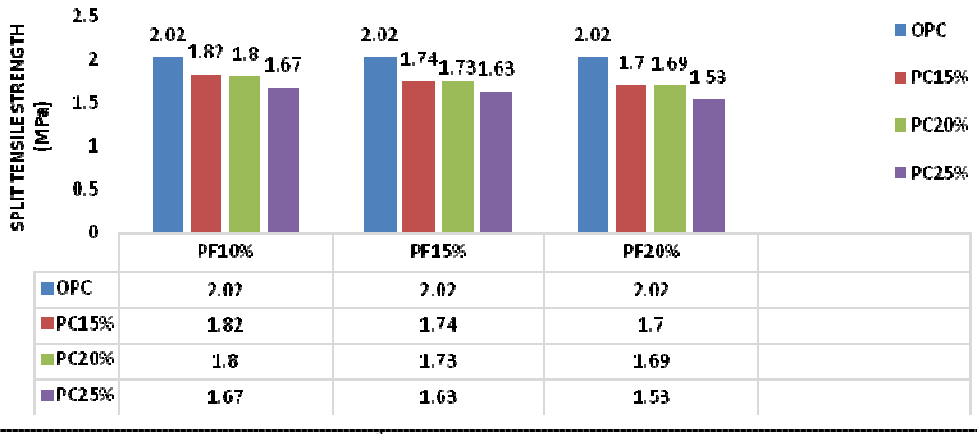
The concrete is weak in tension. There is no direct method to find out the splitting tensile strength of concrete. So the cylinder of 100mm Ø and 200mm depth were casted and cured into portable water for 7 days and 28 days. The specimens are allowed to dry the surface moisture and kept longitudinally in the compression testing machine. Load is applied at the longitudinal surface of the specimen and the

ultimate load is found at which the specimen may crack. From the results obtained graph has been plotted as shown in Figure 3 and Figure 4.



	PF10%	PF15%	PF20%	
OPC	1.5	1.5	1.5	
PC15%	1.41	1.38	1.34	
PC20%	1.46	1.35	1.29	
PC25%	1.36	1.31	1.23	

Figure 3. Split Tensile Strength (7th day).



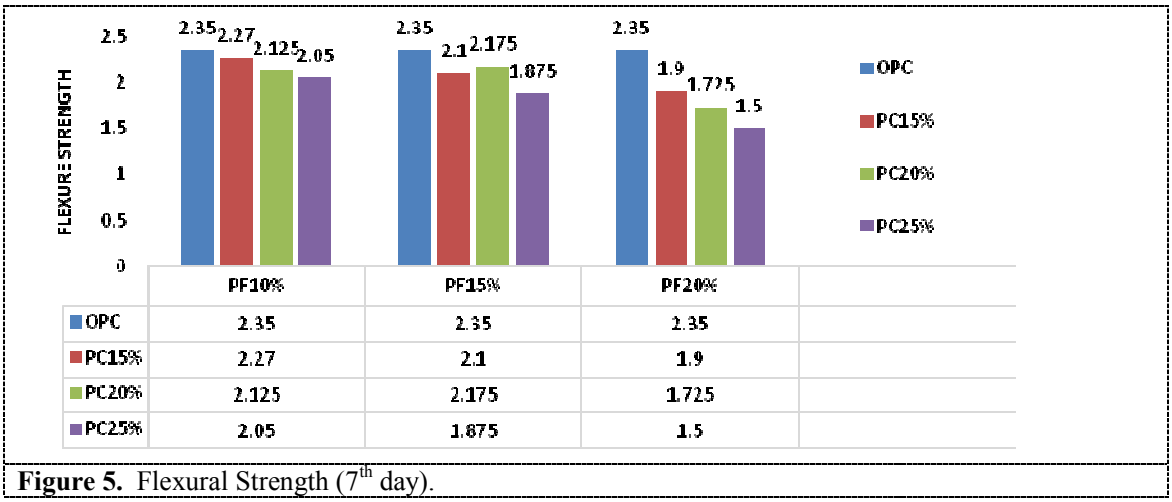
	PF10%	PF15%	PF20%	
OPC	2.02	2.02	2.02	
PC15%	1.82	1.74	1.7	
PC20%	1.8	1.73	1.69	
PC25%	1.67	1.63	1.53	

Figure 4. Split Tensile Strength (28th day).

6.2.1 Discussion on split tensile strength test results. The split tensile strength of waste plastic used concrete was lowered by the addition of plastic. The reduction is being in the range of 10 to 24 %.

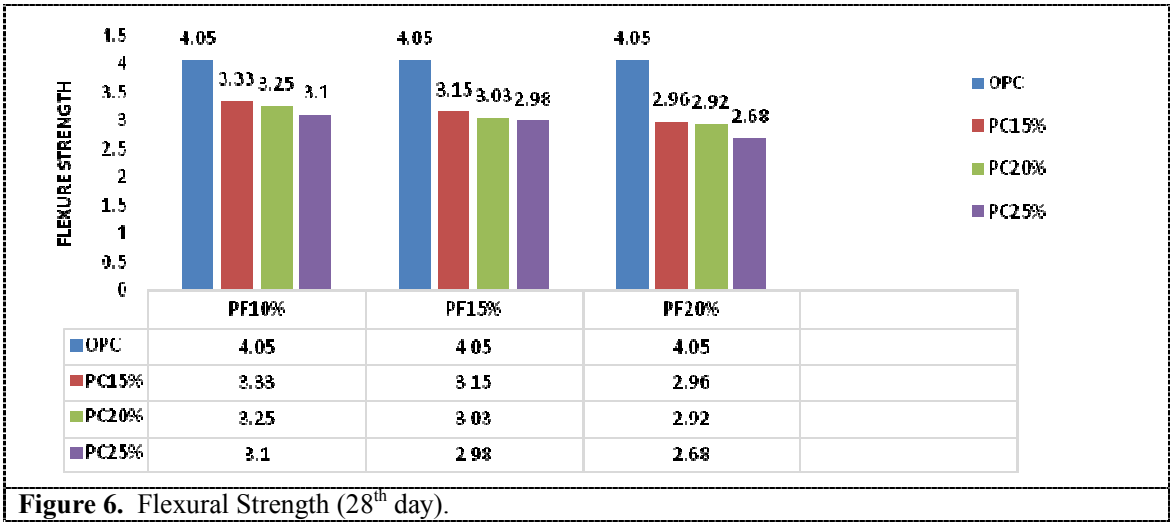
6.3 Flexural strength

The flexural strength was conducted on prisms of size 100 × 100 × 500 mm at the age of 7 days and 28 days to find out the behavior of beams. The specimen was mounted on the universal testing machine and two point loading was applied hydraulically which was increased until failure. From the results obtained graph has been plotted as shown in Figure 5 and Figure 6.



	PF10%	PF15%	PF20%
OPC	2.35	2.35	2.35
PC15%	2.27	2.1	1.9
PC20%	2.125	2.175	1.725
PC25%	2.05	1.875	1.5

Figure 5. Flexural Strength (7th day).



	PF10%	PF15%	PF20%
OPC	4.05	4.05	4.05
PC15%	3.33	3.15	2.96
PC20%	3.25	3.03	2.92
PC25%	3.1	2.98	2.68

Figure 6. Flexural Strength (28th day).

6.3.1 Discussion on flexure strength test results. The flexure strength of waste plastic used concrete was lowered by the addition of plastic. The reduction is being in the range of 20 to 30 %.

7. Conclusion

At all curing ages the compressive strength decreases when compared to control concrete. The decrease is mainly due to adhesive strength between the surface of the waste plastic and cement paste. The hydration of cement is also restricted by means of using waste plastic which it is a hydrophobic material. In addition waste plastic is hydrophobic material which may restrict the hydration of cement. Due to presence of plastic aggregate the reduction in split tensile strength and flexural strength were relatively less when compared with compressive strength. The use of waste plastic aggregate can be effectively used as aconservation point of view, cost-effective and energy-conserving benefits.

Acknowledgements

We would like to express our sincere thanks for VIT University Management for providing facilities in the laboratory for performing experiments.

References

[1] Osei D Y 2014 Experimental Investigation on Recycled Plastics as Aggregate in Concrete. *Int. J. Struct. Civ. Eng. Res.* **3**(2) 168-74.
[2] Praveen Mathew, Shibi Varghese, Thomas paul and Eldho Varghese 2013 Recycled Plastic as Coarse Aggregate for Structural Concrete. *Int. J. Innovat. Res. Sci. Eng. Technol.* **2**(3), 687-90.
[3] Liu F, Yan Y and Lan C 2015 Performance of Recycled Plastic-Based Concrete. *J. Mater. Civ. Eng.* **27**(2)
[4] Zainab Z. Ismail, Enas A. AL Hashmi, October 2007,"Use of waste plastic in concrete mixture as aggregate replacement", *Departmentof Environmental Engineering, college of Engineering, University of Baghdad, Iraq.*
[5] Rebeiz K S, Rosett J W and Craft A P 1996 Strength Properties of Polyester Mortar using PET and Fly Ash Wastes. *J. Energ. Eng.* **122**(1) 11052.
[6] Bhogayata A, Shah K D, Vyas B A and Arora N K 2012 Performance of concrete by using Non-Recyclable plastic wastes as concrete constituent. *Int. J. Eng. Res. Technol.* **1**(4) 1-3.
[7] Elzafraney M, Soroushian P and Deru M 2005 Development of energy Efficient Concrete Buildings Using Recycled Plastic Aggregate. *J. Archit. Eng.* **11**(4) 122-30.
[8] Patil P S, Mali J R, Tapkire G V and Kumavat H R 2014 Innovative Techniques of Waste Plastic Used in Concrete Mixture. Int. J. Res. Eng. Technol. **3**(9) 29-32.
[9] Sofi A 2016 Sustainable concrete with waste tyre rubber - An overview. *J. Chem. Pharmaceut. Sci.* **9**(2) 848-53.
[10] Sofi A and Phanikumar B R 2015 Effect of pond ash and steel fibre on engineering properties of concrete. *Ain Shams Eng. J.* **7**(1) 89-99.
[11] Sofi A and Phanikumar B R 2015 An experimental investigation on flexural behaviour of fibre-reinforced pond ash-modified concrete. *Ain Shams Eng. J.* **6**(4) 1133-42.
[12] Sofi A and Phanikumar B R 2015 Durability properties of fibre-reinforced pond ash-modified concrete. *J. Eng. Sci. Technol.* **11**(10) 1385-402.