International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169
Volume: 6 Issue: 4 63 - 67

Experimental Study On Plastic Waste As A Course Aggregate For Structural Concrete

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***Abstract*—**Theuse of plastic is increasing day by day, although steps were taken to reduce its consumption. This creates substantial garbage every day which is much unhealthy. The suitability of recycled plastics as coarse aggregate in concrete and its advantages are discussed here. In this project, Plastic Coarse Aggregates (PCA) and steel fibers were used as replacement of Natural Coarse aggregate by different percentage of plastic aggregate for making concrete of M-25 grade, with w/c ratio 0.48. The study involves replacement of natural coarse aggregates by 0, 15 and 30 percentage of PCA. The steel fibers are used 1 to 3 percent by weight of cement. OPC-53 grade cement was used for making concrete. The waste plastic of HDPE (High density poly Ethylene) is collected from Agriculture waste, E-waste. The study also involves casting cube, beam and cylinder by using M-25 concrete with varying percentage of PCA and then testing compressive strength, flexural strength and Split tensile strength respectively. Also, from this study Optimum percentage replacement of natural aggregate by PCA was found out and that can be used in structural concrete.

Keywords: - *Plastic Aggregates, Compressive strength, flexural strength, w/c ratio, Split Tensile strength, Plastic Course Aggregate (PCA), High Density Poly Ethylene (HDPE).*

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I. INTRODUCTION

Concrete is the most widely used man made construction material in the world, and its second only to water as the most utilized substance in the planet. Seeking aggregates for concrete and to dispose of the waste from various commodities is the present concern. Today sustainability has got top priority in construction industry. In the present study the recycled plastics were used to prepare the coarse aggregates thereby providing a sustainable option to deal with the plastic waste.

There are many recycling plants across the world, but as plastics are recycled they lose their strength with the number of recycling. So, these plastics will end up as earth fill. In this circumstance instead of recycling it repeatedly, if it is utilized to prepare aggregates for concrete, it will be a boon to the construction industry. Most of the failures in concrete structures occur due to the failure of concrete by crushing of aggregates.

PCA which have low crushing values will not be crushed as easily as the stone aggregates. These aggregates are also lighter in weight compared to stone aggregates. Since a complete substitution for NCA was not found feasible, a partial substitution with various percentage of PCA was done. Both volumetric and grade substitution was employed in this investigation Generation of plastic waste is one of the fastest growing areas. The project aims at use of waste plastic in concrete as a partial replacement of Coarse aggregate. The maximum percentage of aggregate replaced by shredded plastic as been determined based on detailed experimental study. The waste plastic of HDPE (High density poly Ethylene) is collected from Agriculture waste, E-waste with OPC and sand in varying proportions (0, 15,and30 percent). The compressive strength, flexural strength, Split Tensile strength for each variant is determined in laboratory.

II. LITERATURE REVIEW

A. General

This chapter presents a review of relevant literature to bring out the background of the study undertaken in this seminar. The research contributions which have a direct relevance are treated in greater detail. Some of the historical works which have contributed greatly to the understanding

of the loading on PCA concrete are also described. First, a brief review of the historical background is presented. The concepts of PCA materials, steel fibers, their necessary advantages and applications, related to work carried out in this thesis, are then discussed. The amount of the literature on the subject has increased rapidly in recent years; particularly to FRPC. Several of this is available in the proceedings of the conferences which are very helpful to understand the recent developments in concrete engineering.

1. Zainab Z. Ismail, et.al [1] concluded that, the adhesive strength between the surface of the waste plastic and cement paste decreases which causes the strength of the plastic concrete to decrease. In addition, waste plastic is hydrophobic material which may restrict the hydration of cement. The slump values of waste plastic concrete mixtures showed a tendency to decrease below the slump of the reference concrete mixture. Despite this decline in the slump of those mixtures, those mixtures are easy to work based on the consideration that workability has a broad range from very low to high workability for different applications .

2. RaghatateAtul M [2] observed that, Compressive strength of concrete is affected by addition of plastic pieces and it goes on decreasing as the percentage of plastic increases addition of 1 percent of plastic in concrete causes about 20 percent reduction in strength after 28 days curing. The splitting tensile strength observation shows the improvement of tensile strength of concrete. Up to 0.8 percent of plastic improvement of strength recorded after that addition of strength of concrete decrease with addition of plastic. It was established that it is, in fact possible the use plastic can be used to increase the tensile strength of concrete.

3. Nibudey. R.N, et.al [3] observed that, workability is reduced in PFRC. It was due to resistance by the fibers to the movement of aggregates. The dry density is also reduced in PFRC but it is beneficial to reduce dead weight of concrete. The relationship between cube and cylinder compressive strength is linear. The ratio of PFRC cube compressive strength to cylindrical compressive strength is nearly same as for reference concrete but no certain trend is observed. This preliminary study has thus shown that the relationships between compressive strength, as used in European standard for plain concrete, can be applied to concrete containing PET-fibers. It was observed during experimentations that normal concrete specimens were suddenly broken into two pieces either cubes or cylinders but PFRC specimens did not suddenly break and failure was ductile.

4. Promod S. Patil, et.al [4] observed that his modified concrete mix, with addition of plastic aggregate replacing conventional aggregate up to certain 20 precent gives strength with in permissible limit. Modified concrete casted using plastic aggregate as a partial replacement to coarse aggregate shows 10 percent it could be satisfying as per IS codes. Density of concrete is reducing after 20 percent replacement of coarse aggregates in a concrete.

5. T. Subramani, et.al [5] observed that, plastic waste can be disposed by using them as construction materials. Since the plastic waste is not suitable to replace fine aggregate it is used to replace the coarse aggregate. The compressive strength and split tensile strength of concrete containing plastic aggregate is retained in comparison with controlled concrete specimens. However, strength noticeably decreased when the plastic content was more than 20 precent. Has been concluded 20 percent of plastic waste aggregate can be incorporated as coarse aggregate replacement in concrete without any long term detrimental effects and with acceptable strength development properties.

B. Concluding Remark

From the above literature review it is concluded that the PCA can easily and ecofriendly used in concrete. When percentage of PCA increased strength get reduced. For increase strength we had used steel fibers.

III. EXPERIMENTAL PROCEDURE

C. Test material and material properties

Ordinary Portland cement of 53 grade was used having fineness modulus of 3%, Specific Gravity 3.15and crushed aggregate of maximum size 20mm, Specific gravity of 2.84 were used. The grade of concrete is M25 with mix proportion of 1:1.77:3.16 by weight with water cement ratio of 0.48 was kept constant for all specimen. Steel fibers had an tensile strength of 875 MPa, Modulus of Elasticity of 200 GPa, Modulus of Elasticity Length of fiber = 50mm, thickness 1 mm, and a Specific gravity 7.8 (M and J International, Mira road, Mumbai),

Agriculture plastic waste HDPE (High Density Poly Ethylene) was used for formation of plastic course aggregate. PCA having density 439.62 kg/m³and heat resistant min - 90^{o} C&Max - 160^{o} C. PCA used in concrete with varying proportion (0%, 15% & 30%).

D. Specimen Preparation

The moulds were prepared cube, beam and cylinder 150mm*150mm*150mm, 500*100*100 and 300*150 Φ resp.

Size by placing aluminium trovel to get required corner

radius varying from 0mm to 40mm.. The moulds were prepared from 25mm standard material. Then specimens

were casted and cured for 28 days with concrete of grade M25.

Table 1

	Water	Cement	Fine aggregates	Coarse aggregates
By weight (kg)	186kg/m³	387.5 kg/m³	685.91 kg/m³	1224.56 kg/m³
By volume	0.48	1	1.77	3.16

There were total 27specimens casted.A total of 9 cubes and 9 cylinders and 9 beams were prepared for testing.

.Table 2

Sr. no.	Specimens	Dimensions (mm)	PCA %	Steel fibers %	No.of specimens
1	CUBE	150*150*150	0	0	3
			15	3	3
			30	3	3
2	CYLINDER	500*100*100	0	0	3
			15	3	3
			30	3	3
3	BEAM	300*150 Φ	0	0	3
			15	3	3
			30	3	3

E. Testing Procedure

The 2000kN CTM machine was applied to give compressive & Split tensile strength load on cubes and cylinder respectively.

For calculation of Compressive strength

$$f_{cu} = P_c / A$$

For calculation of Split tensile strength

$$f_t = 2P / \pi LD$$

The 2000kN UTM machine was applied to give flexural strength load on beam. Axial load acted on center of beam for flexural strength.

For calculation of Flexural strength

If a=distance between the line of fracture and the nearer support, measured on the centre line of tensile side of specimen,

$$Fb = \frac{Pl}{bd^2}$$

When a > 200 mm for 150 mm specimen or a > 133 mm for 100 mm specimen. or

$$Fb = \frac{3pa}{bd^2}$$

When 170 mm < a < 200 mm for 150 mm specimen or 110 mm < a < 133 mm for 100 mm specimen.

F. Results

Table 3

% of PCA added	Weight (Kg)			Compressive strength (MPa)		
	Days			Days		
	7	14	28	7	14	28
0	8.77	8.62	8.58	22.40	22.40	26.81
15	8.45	8.44	8.44	19.51	21.27	24.87
30	8.44	7.99	7.93	18.04	17.53	14.82

Graph 1

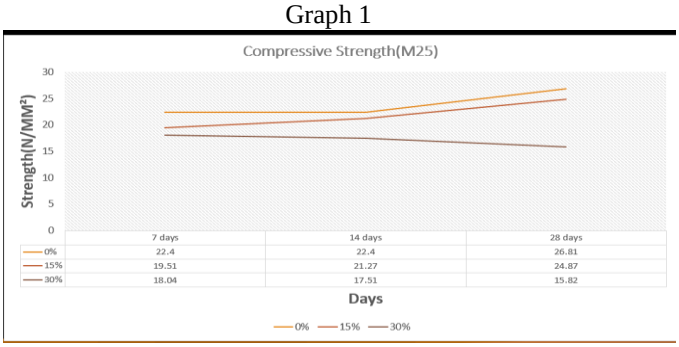

Table 4

% of PCA added	Weight (Kg)			Split tensile strength (MPa)		
	Days			Days		
	7	14	28	7	14	28
0	14.18	14.38	14.42	2.45	3.58	4.036
15	13.25	13.26	13.16	1.97	2.92	3.52
30	12.66	12.63	12.60	1.63	1.90	2.19

Graph 2

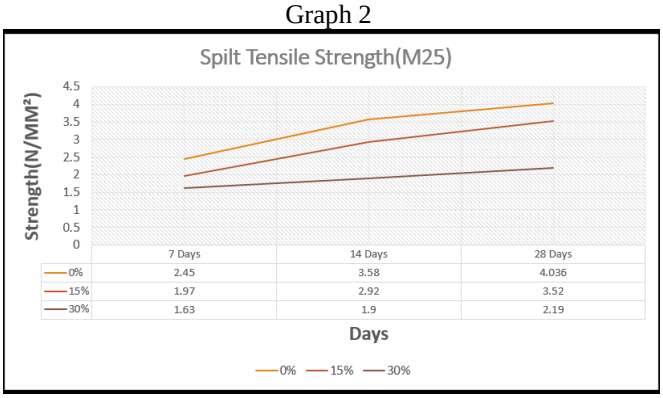

Table 5

% of PCA added	Flexural strength (MPa)		
	Days		
	7	14	28
0	3.58	5.54	7.34
15	2.42	4.11	5.46
30	1.19	2.95	3.84

Graph 3

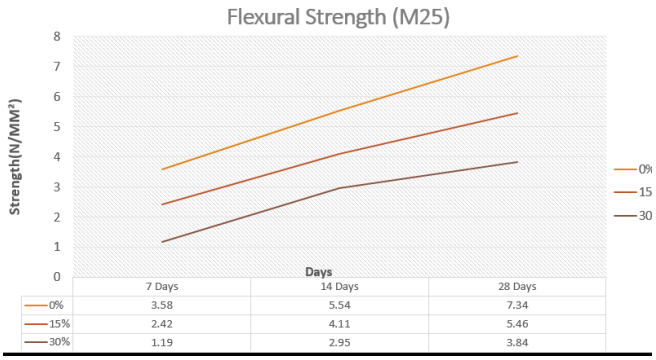

Table 6

% plastic replaced(by vol.)	Mass of concrete per cu. m (kg)	% reduction in mass of concrete
O	2700	7.4
5	2500	

Conclusion

1. Compressive strength for concrete with 15% PCA concrete by adding steel fiber so result approximate equal to normal concrete.
2. Split tensile strength for concrete with 15% PCA concrete by adding steel fiber so result approximate equal to normal concrete.
3. Flexural strength for concrete with 15% PCA concrete by adding steel fiber so result approximate equal to normal concrete.
4. Compressive strength, split tensile strength & flexural strength of concrete with more than 15% show reduction in strength even steel fiber are added.
5. A better workability is achieved for plastic concrete in comparison to the conventional one.
6. Considerable reduction in the weight results in the formation of light weight concrete.
7. Strength achieved for the plastic replaced concrete is slightly less than the conventional concrete is improved by the use of steel fiber.
8. . Recycled plastic in the construction purpose can set a benchmark by utilizing the non-bio-degradable waste and eventually minimizing the environmental pollution.

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II. ACKNOWLEDGMENT

Words are inadequate to express my deep sense of gratitude to Prof. M. N. Gaikwad, my guide, for his consistent guidance and inspiration throughout the project work, which I am sure, will go a long way in my life.

I owe sincere thanks to Prof. M. N. Gaikwad, for her encouragement and guidance throughout the project work.

I also owe sincere thanks to Prof D. S. Bhoite, Head of Civil Engineering Department and Dr. M. K. Phadatare, Principal, PES's College of Engineering Phaltan, for their guidance throughout the project work.

I express my sincere thanks to my family, friends and all those who have helped me directly or indirectly in completing this project.

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