EXPERIMENTAL STUDY ON COMPARATIVE ANALYSIS OF WASTE PLASTIC AS FINE AGGREGATE IN FIBER REINFORCED CONCRETE

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Abstract

Concrete is being widely used for the construction of most of the buildings, bridges etc. Cement, fine aggregate and coarse aggregate are the main ingredients of concrete. Aggregates are considered one of the main constituent of concrete. They occupy more than 70% of concrete mix. In many countries there is scarcity of natural aggregate that are suitable for construction due to the greater demand by the construction industry. In order to reduce dependence on natural aggregate, artificial aggregate generated from plastic waste provide an alternative for construction industry. The use of waste materials saves natural resources and dumping spaces, and helps to maintain a clean environment. Recycling of plastic waste to produce construction material like concrete appears as one of the best solutions for the disposal of plastic waste. The main objective of this study is to reduce the wastage of plastic and to improve the eco-friendly environment. Many investigations were taken for plastic so far, that has led to current research for using pulverized plastic which passes through 2.36 mm sieve and retained in 1.18 mm sieve in concreting material. The investigation was done and the mechanical properties of concrete were discussed in the present study. The experiment was done with M20 grade concrete for a curing of 28 days from which its compressive strength, tensile strength, flexural strength were taken and compared with the conventional concrete. This paper presents the results of study of comparative analysis of high density polyethylene and low density polyethylene as partial replacement of waste plastic as fine aggregates from 5% to 15% with 2.5% increment and polypropylene fibers as 2% replacement with cement . When both plastics are compared there is an increase in compressive strength, flexural strength and split tensile strength when 10% of plastic with 2% addition of polypropylene fiber.

Introduction

The consumption of aggregate of all types has been increasing in recent years. In most countries at a rate far exceeding that suggested by the growth of their economy of construction industry. The non-decaying waste materials cause a waste disposal crisis, thereby contributing to the environmental problems. Most of these materials are left as stockpiles, landfill material or illegally dumped in selected areas. Since waste plastic is a non-decomposable material and dumping of waste plastic disturbs the environment and ecology. Hence lot of innovations in recycling of waste plastics has been practiced in many countries in order to avoid environment pollution. Due to

the scarcity of river sand this current study motivated to substantiate river sand by using waste plastic as aggregate. The application of powdered plastic in building material helps the search for alternative materials in a way to reduce costs and encourage the use of fine aggregates that are environmentally less aggressive.

S. Sreenath and S. Harishankar introduces ground Low-Density Poly Propylene (LDPP) bags as a partial replacement of fine aggregate in concrete. Designed M25 mix was taken for the study. Different mixes were proportioned by replacing the fine aggregate with different fractions of LDPP aggregates. The replacement proportions were of 5%, 10%, 15% and 20% of fine aggregate Standard strength tests were conducted on specimens of each proportion and the results were compared with the strength properties of the control specimens made of M25 concrete with 0% of LDPP. The mix proportion with 10% of LDPP exhibited good strength in compression, tension and flexure than the conventional concrete.

Divya S Dharan, Aswathy Lal investigated that Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. The character of fiber-reinforced concrete changes with varying concretes fiber materials, geometries, distribution, orientation, and densities. Polypropylene fiber is a light weight synthetic fiber. It prevents crack formation and provides reinforcement to the concrete structure. In this project work polypropylene fibers (Blended type) of different percentage (0.5%, 1%, 1.5%, and 2%) added in concrete. Tests on workability, compressive strength, flexural resistance, split tensile strength and modulus of elasticity were conducted on specimens.

Renji Xavier C and Nidhin B Parappattu explained the partial replacement of fine aggregate with plastic granules and using a fixed proportion of steel and polypropylene fibers. Experimental program includes two stages. In the first stage fine aggregate is replaced with 4%,8%,12% plastic granules in an M30 grade of concrete and its percentage was optimized and in the second stage, the residual strength of the above mixes were found out by heating the specimens to2000c,3000c and 4000c for one hour duration. Strength parameters studied includes compressive strength, flexural strength, split tensile strength, residual strength.

Although there are many studies that have been reported by investigators on the use of waste plastic in cement concrete, not much research has been carried out in India concerning the comparative analysis of low density and high density plastic in fibre reinforced concrete. Therefore this paper presents the study of the comparison of low density and high density plastic as a partial replacement of fine aggregate in fibre reinforced concrete.

Materials

Cement

The cement used in this work was an ordinary Portland cement (OPC) of grade 43 with a specific gravity of 3.12.

Fine aggregate

In the present investigation, river sand taken from Vaigai river, which was available at Madurai, was used as fine aggregate. The specific gravity of fine aggregate was 2.57.

Coarse aggregate

Coarse aggregates used in this study were crushed blue granite stone aggregate of size 20mm. The specific gravity of coarse aggregate was 2.7.

Polyethylene

There are a number of different variants of polyethylene. Low and high density polyethylene (LDPE and HDPE respectively) are the two most common and the material properties vary across the different variants.

1. LDPE: LDPE is the plastic used for plastic bags in grocery stores.
2. HDPE: A stiff plastic used for more robust plastic packaging like laundry detergent containers as well as for construction applications or trash bins.

The specific gravity of HDPE is 1.58 and LDPE is 1.1. Water absorption was 0.2%.

Polypropylene fiber

Addition of Polypropylene fibers to the concrete increases the resistance against micro cracks due to shrinkage during curing. In this experimental work fibrillated fiber length is 12mm.

Mix proportions

M20 concrete was used in this study. The mix proportion chosen for this study is given table 4. The following mix proportion is adopted as per IS-10262-2009

Wate : Cement: Fine Aggregate: Coarse Aggregate

0.5 : 1 : 1.838 : 3.289

Compressive strength Test

To determine the compressive strength, cube moulds of size 150x150x150 mm should be used. 3 cubes for each percentage should be cast with different proportion of High density polyethylene ranging from 0% (control),5%, 7.5%, 10%, 12.5% and 15% with 2% of cement replaced by polypropylene fiber except control concrete. And for low density polypropylene 3 cubes for each percentage should be cast with different proportion of low density polyethylene ranging from 0% (control),5%, 7.5%, 10%, 12.5% and 15% with 2% of cement replaced by polypropylene fiber except control concrete. The specimens should be cleaned thoroughly using a waste cloth and then properly oiled along its faces. Concrete was then filled in mould and then compacted using a standard tamping rod of 60 cm length having a cross sectional area of 225mm^2

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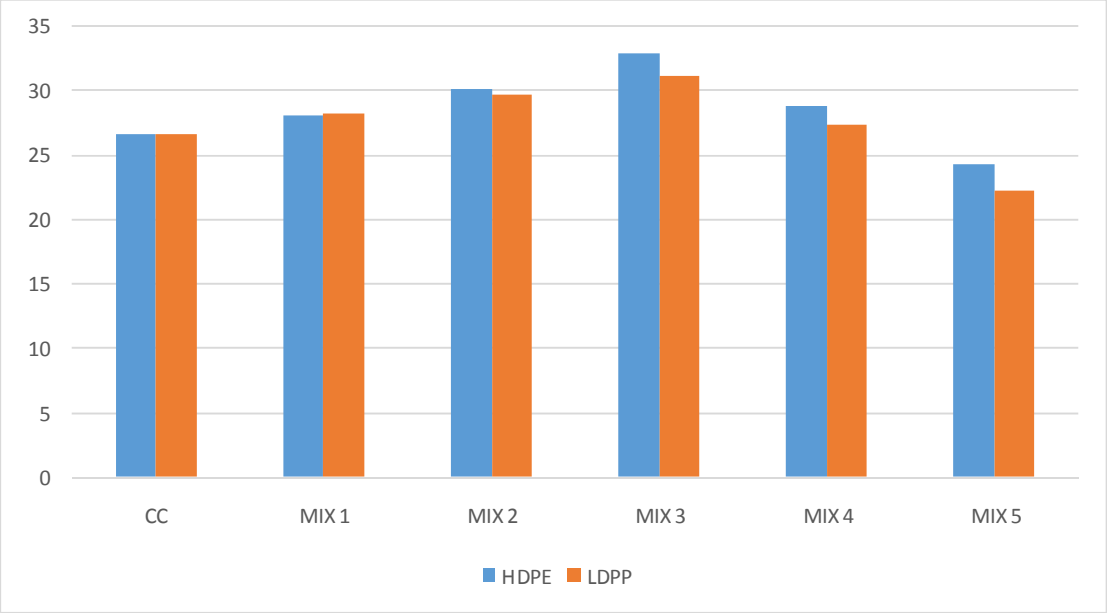
$$\text{Compressive strength (N/mm}^2\text{)} = \frac{\text{Ultimate compressive load (kn)}}{\text{Area of cross section of specimen (mm}^2\text{)}}$$

Mix details	Waste plastic	Polypropylene fiber	Average compressive strength in 28 days N/mm² HDPE	Increase in compressive strength (%)	Average compressive strength in 28 days N/mm² LDPP	Increase in compressive strength (%)
CC	0%	2%	26.7	-	26.7	-
MIX1	5%	2%	28.1	4.85	28.2	5.617
MIX2	7.5%	2%	30.2	10.82	29.7	11.23
MIX3	10%	2%	32.9	22.76	31.2	16.85
MIX4	12.5%	2%	28.8	4.104	27.4	2.62
MIX5	15%	2%	24.3	-9.578	22.3	-16.48



The compressive strength is increasing as the percentage of replacement of fine aggregate varies from 0% to 10% respectively. Then it is decreased as it reaches 15% replacement of fine aggregate with 2% of polypropylene fiber replacement with cement.

Split Tensile strength

To determine the split tensile strength, cylinder moulds of diameter 150mm and length 300mm were cast. 15 cylindrical specimens were cast with different proportions of high density polyethylene ranging from 0% (control) to 15% with 2% of cement replaced by polypropylene fiber. And for low density polypropylene15 cylindrical specimens were cast with different proportions of high density polyethylene ranging from 0% (control) to 15% with 2% of cement replaced by polypropylene fiber except control concrete. The crude oil was applied as seen earlier along the inner surfaces of the mould for the easy removal of casted cylinder from the mould. Concrete was poured throughout its length and compacted well.

The split tensile strength of concrete is calculated by using the following formula

$$F_{st} = 2P/\pi ld$$

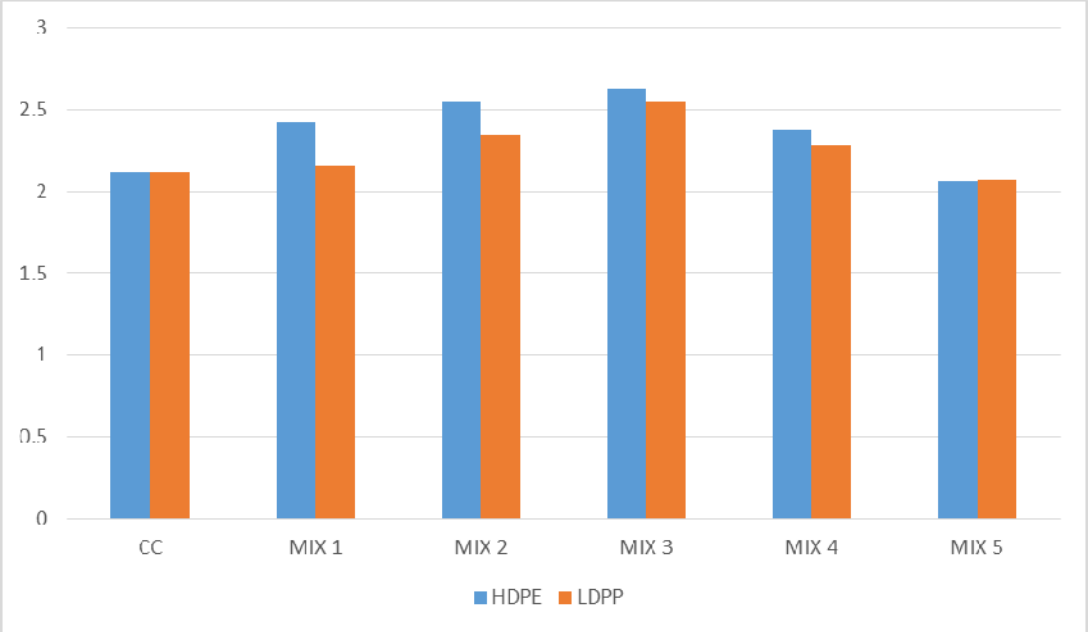
Where

P- maximum load at failure in kn

L-length of cylindrical specimen in mm

D-diameter of cylindrical specimen in mm.

Mix details	Waste plastic	Polypropylene fiber	Average compressive strength in 28 days N/mm² HDPE	Increase in compressive strength (%)	Average compressive strength in 28 days N/mm² LDPP	Increase in compressive strength (%)
CC	0%	2%	2.12	-	2.12	-
MIX1	5%	2%	2.42	14.15	2.156	1.698
MIX2	7.5%	2%	2.55	20.28	2.343	10.52
MIX3	10%	2%	2.63	24.06	2.55	20.28
MIX4	12.5%	2%	2.38	12.26	2.28	7.54
MIX5	15%	2%	2.06	-2.83	2.07	-2.36

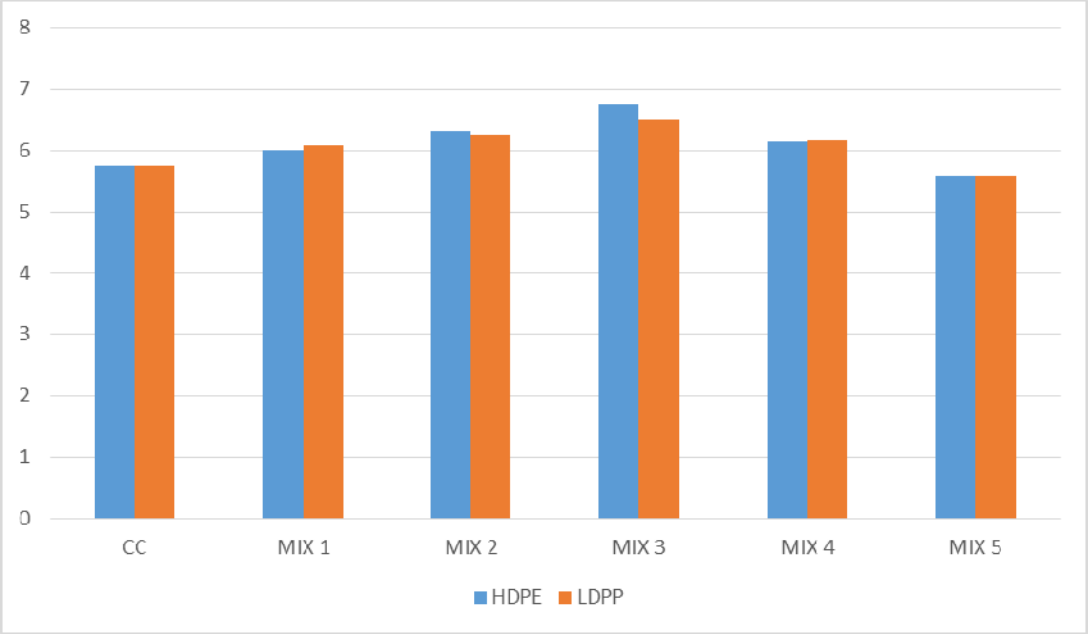


An increase in split tensile strength was observed as the percentage of replacement of fine aggregate varies from 0% to 10% respectively.

Flexural strength test

The size of beam specimens is 1500 x150 x150mm. This test method is used to determine the modulus of rupture of specimens prepared and cured. The strength determined will vary where there are differences in specimen size, preparation, moisture condition or curing. This test method covers the determination of the flexural strength of concrete specimens by the use of the sample beam with centre-point loading.

Mix details	Waste plastic	Polypropylene fiber	Average compressive strength in 28 days N/mm² HDPE	Increase in compressive strength (%)	Average compressive strength in 28 days N/mm² LDPP	Increase in compressive strength (%)
CC	0%	2%	5.75	-	5.75	-
MIX1	5%	2%	6	4.347	6.08	5.739
MIX2	7.5%	2%	6.33	10.08	6.25	8.695
MIX3	10%	2%	6.75	17.39	6.5	13.04
MIX4	12.5%	2%	6.15	6.956	6.16	7.13
MIX5	15%	2%	5.58	-2.956	5.58	-2.956



It was observed that the concrete with 10% of LDPP exhibits the maximum flexural strength. From 0% of replacement to 10% of replacement, the flexural strength was gradually increasing while from 10% to 15% it was gradually decreasing.

Conclusion

1. The compressive strength of concrete increases up to 10% as the percentage of plastic is increased in concrete as a replacement of fine aggregate.
2. A concrete mixture made of 15% plastic waste had lowest compressive strength at 28 days curing age that was below the value of the conventional concrete mixture.
3. Best compressive strength, split tensile strength and flexural strength is obtained at 10% fine aggregate replacement with plastic waste and using polypropylene fibre reinforcement.
4. As the strength of 10% replaced concrete is very close to the conventional cube strength hence it can be concluded that it is safe to use plastic as partial replacement of fine aggregate (10%) with 2% of polypropylene fibres in concrete.

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