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Suitability of Partial Replacement of Pulverized Plastic as Fine Aggegate in Cement Concrete

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Abstract

Objectives: Disposal of plastic was a major problem in the present era, as the usage of plastics was growing day by day and it takes hundreds of year for plastic material to degrade. The effective ways to recycle and reuse of plastics are being formulated. Methods: Low Density Polyethylene (LDPE) Bags was taken into consideration as it was easily available and had low density than other type. The used plastic bags were collected, ground in to smaller components. Melted and pulverized in order to get granules of plastic of about 1 mm size. The density of the pulverized was found to be 920 Kg/m^3 and its specific gravity was 0.89. Seive analysis were carried out and about 95% of the plastic bags were found to be in the range of 1-1.15 mm. 45 Nos of 100 × 100 × 100 mm cement concrete cubes of M20 mix were cast for 0%, 5%, 10%, 15% and 20% fine aggregate being replaced with pulverized plastic material. Volumetric proportioning was adopted instead of design mix since the low density of plastic bags material was too low. Workability test, mechanical properties were determined. Findings: The test results revealed that the compression strength of concrete at 28th days of conventional concrete is 23.56 N/mm^2. By partial replacement of 5% of Burned LDPE bags in concrete the 28th days increased by about 0.36 N/mm^2 when compared to conventional concrete. By partial replacement of 10% of burned LDPE bags in concrete the 28th days increased by about 1.02 N/mm^2 when compared to conventional concrete. By partial replacement of 15% of burned LDPE bags in concrete at 28th day increased by about 2.27 N/mm^2 for when compared to conventional concrete. By partial replacement of 20% of Burned LDPE bags in concrete the 28th days increased by about 1.16 N/mm^2 when compared to conventional concrete. Thus it is inferred that partial replacement of Burned LDPE bags up to 15% can be adopted. Novelty/Improvement: It is thereby suggested that utilization of this Low Density Polyethylene (LDPE) bags in concrete will reduce the requirement for convectional fine aggregate thereby resulting in conservation of natural resources.

Keywords: Low Density Polyethylene (LDPE), Fresh Concrete, Mechanical Properties Pulverized Plastic Concrete, Replacement of Fine aggregate

1. Introduction

Plastic have become an integral part of our daily lives. Plastic consumption and generation of plastic wastes continue to pose environmental concerns globally[1]. Its increased usage could be attributed to its low density, strength, long life, and low cost. Other reasons include its resistance to rusting, flexibility of shape, heat conservation[2,3]. Various uses of plastic include packaging, automotive and industrial application[4]. With such varying applications, the amount of plastic consumption and resulting wastes generated in the developed countries had witnessed sporadic growth in the last two decades. Plastics consumption in the United Kingdom (UK) in 2003 amounted to 4.7 million tonnes, out of which 3.0 million tonnes ended up as wastes[5]. While in India, demand for plastic between 2005 and 2006 was approximately 20 trillion[6].

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Recycling of plastic wastes is difficult owing to its commingled nature and difficulty in difficulty in identification, separation and classification[7,8]. The common practice of land filling is becoming unattractive owing to the inert nature and poor biodegradability of plastic wastes[7].

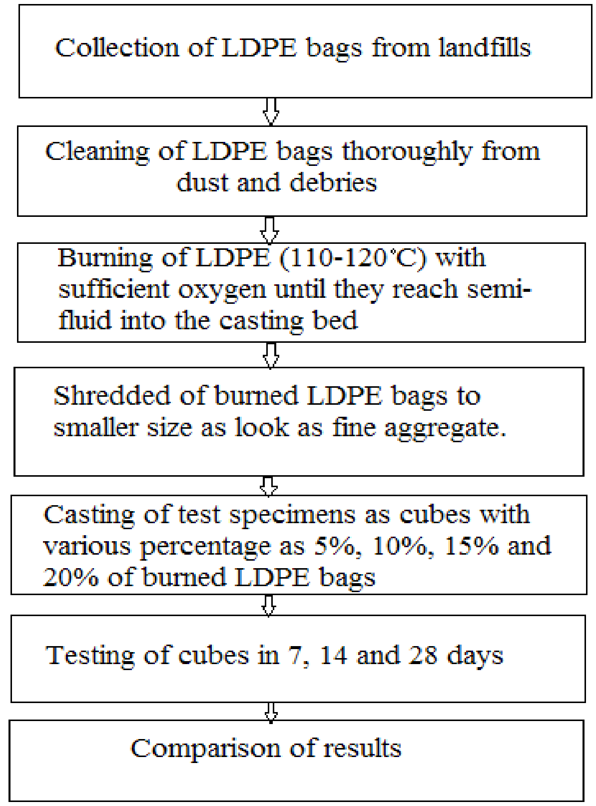
The Polyethylene bags are utilized by humans for their needs and wants, but there is no proper disposal of polythene bags into the garbage. This one creates major problems in environmental, ecological issues[9,10]. Actually LDPE bags are recyclable but proper steps are not taken to recycle, reuse etc. 80% of LDPE bags are filled in the surface of the landfills, and 19% are reused, and 0.5% littered, 0% recycled. According to this increase of waste disposal of LDPE bags the environment can be affected by many serious issues[11,12].

So, the landfill LDPE bags are collected, cleaned, burned, crushed, and used as a partial replacement of sand in concrete[13,14]. The purpose of this project is to evaluate the possibility (or) suitability to determine the high strength by using burned LDPE bags to partially substitute for the fine aggregate in concrete.

1.1 Objectives of Study

- Classify the pulverized LDPE into the appropriate classification.
- Evaluate the use of pulverized LDPE plastic wastes in concrete as an alternative solid waste management option viz a viz results obtained for normal compressive strength.
- Investigate the properties of fresh concrete.
- Investigate the structural behaviour of such partial replacement of pulverized LDPE as fine aggregate.
- To investigate the mechanical properties of the addition of LDPE.
- To determine the optimum percentage of burned LDEP.

1.2 Methodology



Flowchart 1. Methodology of the project.

2. Materials and Methods

The materials used in this study include cement, fine aggregate, coarse aggregate, water and LDPE in various proportions used to replace fine aggregate.

- Cement

Ordinary Portland Cement (OPC) of 43-grade was used as it satisfied the requirements of IS: 269-1969 and results have been tabulated in Table 1.

Table 1. Properties of OPC 43 grade cement

Characteristics	Values obtained	Standard value (IS 8112- : 2013)
Normal consistency	34%	-
Initial setting time(min)	48min	Not less than 50 min
Final setting time(min)	240min	Not greater than 600 min
Fineness (%)	3.5%	<10
Specific gravity	3.15	-

- Aggregate (Fine and Coarse Aggregates)

Various properties of aggregates can influence the performance of concrete; therefore various considerations have to be kept in mind while selecting the materials. Aggregates used in present study, were tested for their specific gravity and other properties and results have been tabulated in Table 2.

Table 2. Properties of fine aggregate

Characteristics	Fine Aggregate	Coarse Aggregate
Type	Crushed	Uncrushed
Specific gravity	2.7	2.68
Moisture content	0.8%	0.16%
Fineness modulus	2.54	0.5%

- Pulverized LDPE Plastic Wastes

LDPE bags are collected from surface of landfills and cleaned thoroughly without dust and debris, and melting process has been takes place until they reach semi fluid into the mould. During melting process of LDPE bags, high temperature (110^{o}C-120^{o}C) must be providing to attain the semi-fluid, because low temperature can produce gases like carbon-monoxide (CO) and carbon-dioxide ($C0_2$) and water (H_2O). Complete combustion of LDPE bags can give only carbon-dioxide (CO_2) and water (H_2O). Waste water sachets (type of low density polyethylene) were collected and cleaned. They were cut into pieces. The plastics were put on fire until they got melted. This caused the plastics long chain polymer chains to break apart. The plastics in the liquid form were poured on roofing sheets and were allowed to solidify. With the aid of metallic mortar and pestle, the solidified plastics were ground into small particles then are grinded (or) shredded (or) pulverized into 1mm-2mm test sieve is within the upper size limits of 4.75 mm. Figures 1, 2 and 3 showed the LDPE Bags, Burned LDPE Bags, and particle size distribution for pulverized LDPE fine aggregate and results have been tabulated in Table 3.

- Water

Water used for mixing and curing was clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that are deleterious to concrete or steel.

Table 3. Properties of burned LDPE bags

Characteristics	Value
Type	Crushed
Specific gravity	0.89
High & Low temperature	80^{o}C & 50^{o}C
Fineness modulus	5.4
Water absorption	Slightly

Figure 1. LDPE bags.

Figure 2. Burned LDPE bags.

Figure 3. Pulverized burned LDPE fine aggregate.

2.1 Methods

The laboratory tests carried out on the pulverized LDPE plastic wastes, Fine aggregate, Coarse aggregate, cement and concrete in accordance with respective standards.

2.2 Mix Design

Mix design was performed as per IS: 10262- 2009 to obtain M20 mix were calculated and given in Table 4. For making a mix with plastic aggregate, the amount of plastic was calculated using the specific gravity of plastic.

Table 4. Materials required as per IS method of mix design

Burned LDPE bags %	5%	10%	15%	20%
Water (Kg/m³)	186	186	186	186
Cement (Kg/m³)	383.2	383.2	383.2	383.2
Fine aggregate (Kg/m³)	745.7	689.0	667.8	646.6
Coarse,aggregate (Kg/m³)	1005.5	1005.5	1005.5	1005.5

3. Results and Discussion

3.1 Grading Analyses

The results of the physical properties for pulverized LDPE plastic waste are presented in Table 5, Figure 4. Showed the particle size distribution for pulverized LDPE plastic waste.

In line with Table 5, Figure 4 showed that the maximum size of the LDPE granules was approximately 1.15 mm while.

Table 5. Sieve analysis of burned LDPE bags

Sieve size (mm)	Weight of LDPE retained (Kg)	% of weight retained	Cumulative % retained	% finer
4.75mm	-	-	-	-
2.36mm	0.353	70.6	70.6	29.4
1.18mm	0.064	12.8	83.4	16.6
0.600µm	0.058	11.6	95.0	5.0
0.300µm	0.012	2.4	97.4	2.6
0.150µm	0.008	1.6	99.0	0.8
0.075µm	0.004	0.8	99.8	0.2

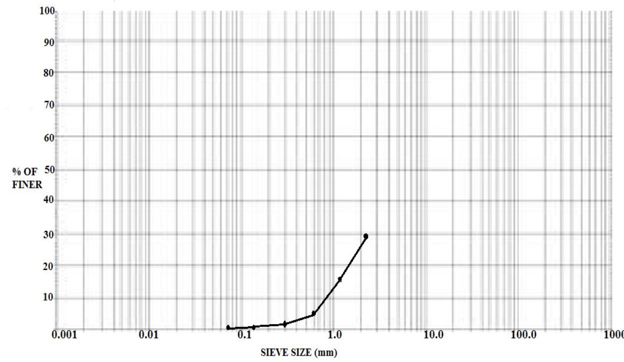


Figure 4. Particle size distribution for pulverized LDPE plastic waste.

3.2 Compression Strength Test

The result of compressive strength of 7, 14 and 28 days were presented in Figure 5. From the result 15% replacement of LDPE gives better compressive strength increased 2.27 N/mm² than conventional concrete.

3.3 Spilt Tensile Strength

The results of spilt tensile strength of 28 days were presented in Figure 6. From the result 15% of replacement of LDPE gives better tensile strength increased 0.96 N/mm² than conventional concrete

3.4 Flexural Strength Test

The results of flexural strength of 28 days were presented in Figure 7. From the result 15% of replacement of LDPE gives better flexural strength increased 0.26 N/mm² than conventional concrete

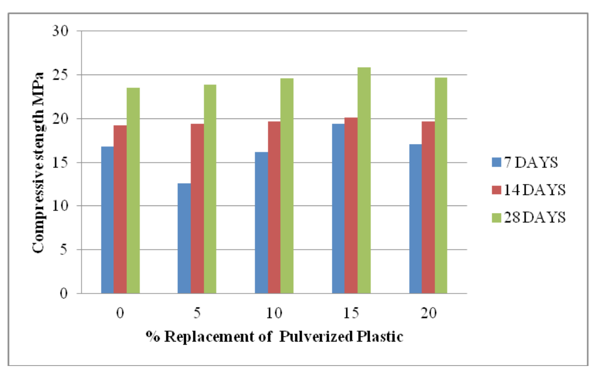


Figure 5. Compressive strength vs % replacement of pulverized plastic.

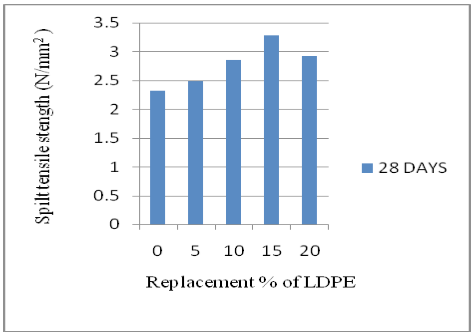


Figure 6. Spilt Tensile strength of specimen.

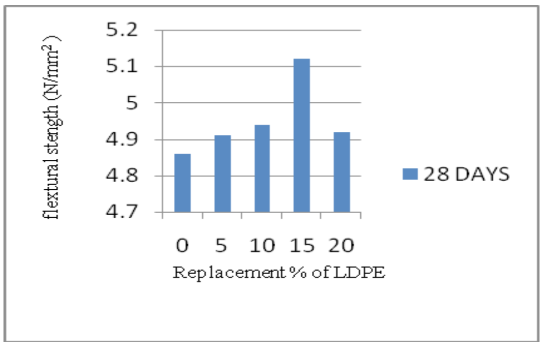


Figure 7. Flexural Strength of specimen.

4. Conclusion

There is a gradual increase in compressive strength, split tensile strength and flexural strength for partial replacement of burned LDPE bags in concrete from 0%,10% and 15% replacement of LDPE and slightly decreased in 20% replacement. Plastic aggregate was a light weight material with specific gravity 0.89. In the present investigation it was found that optimum up to 15% replacing of waste plastics there is a slight deviation of compressive strength. From the test results it was observed that the compressive strength value of the concrete mix decreased with the addition of waste plastics more than 15% of waste plastic. By using 15% of burned LDPE bags in concrete instead of sand gives more compressive strength, tensile and flexural strength compare to the conventional concrete specimens. It is economical and reduces the environmental pollution that occurs in the landfills. The concept of mixing of plastic wastes in concrete could be a very environment friendly method of disposal of solid waste in the landfills.

4.1 Recommendations

- Further research continues to investigate the percentage replacement of sand to obtain structural light weight concrete.
- Recycling of LDPE plastic wastes in concrete is environmentally friendly and should be encouraged.

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