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RESEARCH ARTICLE

Effect of Waste Low Density Polyethylene on Mechanical Properties of Concrete

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Abstract

Concrete is a versatile material for civil engineering construction. Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Presently construction industry is in need of finding cost-effective materials for increasing the strength of concrete structures. This study mainly focused on the use of waste plastic bags (Low Density Polyethylene (LDPE)) in concrete. Waste plastic (LDPE) mix in concrete with or without superplasticizer. Cubes and cylinders are casted with 0%, 0.4%, 0.6%, 0.8% and 1% (by weight) with plastic waste. Samples were tested for the compressive strength and split tensile strength of concrete with plastic waste as aggregate and observed a good strength gain. All specimens were tested after curing age of 7 and 28 d.

Keywords: Concrete, coarse aggregate, low density polyethylene, compressive strength, split tensile strength.

Introduction

Concrete plays a vital role in the development of infrastructure viz. buildings, bridges and highways etc. leading to utilization of large quantity of concrete. In the last 60 years, plastic has become a useful and versatile material with a wide range of applications. Its uses are likely to increase with ongoing developments in the plastic industry. In future, plastic could help to address some of the world's most pressing problems, such as climate change and food shortages. As demand for materials with certain qualities increases, the plastics industry will aim to supply them. Now, increasing plastic production and use in emerging economies looks set to continue and waste management infrastructure will have to develop consequently. Development of concrete with non-conventional aggregate such as plastic bags, PET Bottles and waste LDPE were used in concrete to improve the properties of the concrete and reduce cost. By using these plastic wastes in concrete will lead to sustain the concrete design and protect the environment.
The properties of plastic that make it so precious also make its disposal challenging, such as its durability, light weight and low cost. In many cases, plastics are thrown away after one use, especially packaging and sheeting, but they are durable and persist in the environment. Soroushian *et al*. (1995) stated that polypropylene can be used as synthetic fibers to increase the toughness of concrete. Choi *et al.* (2005) investigated the effects of waste PET bottles aggregate on the properties of concrete. According to Gupta *et al*. (2006), the value of segregation index increases with the increase in the amount of marble powder as a replacement of fly ash. Marzouk *et al*. (2007) reported that the plastic bottles shredded into small (PET) particles may be used successfully as sand-substitution aggregates in cementious concrete composites which appear to offer an attractive low-cost material with consistent properties. Batayneh *et al*. (2007) found that glass containing concrete composites was the most consistent composite than fiber glass within the selected range of 5 and 20% aggregate substitutes. Plastic is still a relatively new material, which means the problem of plastic waste has only recently been realized and has knowledge about its environmental persistence (Barnes *et al.,* 2009). Ismail and Al-Hashmi (2011) observed that the mixture of iron filings and plastic waste materials could be used successfully as partial substitutes for sand in concrete composites. Kandasamy and Murugesan (2011) added 0.5% by volume of polythene (domestic waste polythene bags) fibre to concrete and the cube compressive strength, increased by 5.12%,3.84% and 1.63% respectively. Keeping the above facts in view, this study was aimed with the following objectives:

1. To study the compressive, split tensile and flexural strength of concrete with partial mixing of LDPE.
2. To examine the structural performance with partial mixing of LDPE.
3. To determine the percentage of plastic LDPE which gives more strength when compared to conventional concrete.

Materials and methods

Cement: Portland Pozzolana Cement (PPC) is kind of blended cement which is produced by either intergrinding of OPC clinker along with gypsum and pozzolanic materials in certain proportions of grinding the OPC clinker, gypsum and pozzolanic materials separately and thoroughly blending them in certain proportions. The portland cement contains mainly two basic ingredient namely argillceous and calcareous.

Table 1. Properties of cement.

Properties	Experimental	Codal requirement[IS 1489 (Pt-1)-1991]
Normal consistency %	31.5%	-
Initial setting time	185 min	(Not less than 30 min)
Final setting time	265 min	(Not more than 600 min)
Soundness of cement (Le chatelier expansion)	0.75 mm	(Not more than 10 mm)
Fineness of cement (% retained on 90 µ IS sieve)	3.77%	10%
Specific gravity of cement	2.67	3.15
Compressive strength		
7 d testing	33.0	22 N/mm^2(min)
28 d testing	41.7	33 N/mm^2(min)

Table 2. Sieve analysis for fine aggregate.

Sieve size	Weight retained (g)	Cumulative weight retained	Cumulative % weight retained	Passing %	Standard % weight passing for zone II
10 mm	-	-	-	100	100
4.75 mm	6	6	1.2	98.8	100
2.36 mm	32	38	7.6	92.4	75-100
1.18 mm	68	106	21.2	78.8	55-90
600 µm	106	212	42.4	57.6	35-59
300 µm	190	402	80.4	19.2	8-30
150 µm	94	496	99.2	0.8	0-10
Pan	04	500	-	-	-
Total = 252			Fineness modulas = 252/100 = 2.52		

PPC was used in this experimentation conforming to IS: 1489-1991 (Part I) (Table 1). The fine aggregate consist of natural sand or subject to approval, other inert materials with similar characteristics, or combinations having hard, strong, durable particles. The fine aggregate was locally available river sand which was passed through 4.75 mm sieve. The specific gravity of fine aggregate is 2.64 and fineness modulus of fine aggregate is 2.52. Natural river sand was used as fine aggregate. The properties of sand were determined by conducting tests as per IS: 2386 (Part- I). Result of sieve analysis is given in Table 2.

Coarse aggregate: Coarse aggregate shall consist of naturally occurring materials such as gravel or resulting from the crushing of parent rock, to include natural rock, slags, expanded clays and shales (lightweight aggregates) and other approved inert materials with similar characteristics, having hard, strong, durable particles, conforming to the specific requirements of this section. The coarse aggregate was locally available quarry having two different sizes; one fraction is passing through 20 mm sieve and another fraction passing through 10 mm sieve. Specific gravity of coarse aggregate is 2.66 for both fractions. Properties of aggregate were determined by conducting test as per IS: 2386 (Part III). Proportion of 20 and 10 mm aggregate was taken as 60% and 40%. The grading of coarse aggregate of 10 and 20 mm size are given in Table 3, 4 and sieve analysis of plastic is given in Table 5. Potable water is used for mixing and curing. Water free from impurities and salt used for casting and curing the concrete blocks as per IS: 456-2000.

Superplasticizer: Superplasticizers, also known as high range water reducers, are chemical admixtures used where well-dispersed particle suspension is required. In this experimental program, superplasticizer SIKO Brand was used to increase the workability of concrete. In the laboratory, the entire model of mix proportion measured by the slump cone test. Concrete of M25 grade were considered for a W/C ratio of 0.46 with the targeted slump of 4±1 inch (100±25 mm).

Waste plastic: **"**Plastics are non-biodegradable, synthetic polymers derived primarily from petro-fossil feedstock and made-up of long chain hydrocarbons with additives and can be moulded into finished products". Plastic is a relatively cheap, durable and versatile material. Plastic products have brought benefits to society in terms of economic activity, jobs and quality of life.

1. To collect the polyethylene bags need for research.
2. To procure equipment needs.
3. Shredded plastic waste into pieces.
4. Granulated the pieces to tiny size like as sand.
5. Sample is casted and cured for the determination of strength.

Concrete mixes: The design mix proportion of 1:1.65:3 and W/C ratio of 0.46 is used for a control mix of slump 4±1 inch (100±25 mm) M25 grade of concrete and the quantity of cement is 380 kg/m^3 by using IS:10262-2009 method of mix design.

Compressive strength: Compressive strength is a measure of a material's ability to withstand compressive forces, where it is squeezed laterally.

Table 3. Sieve analysis for coarse aggregate of 10 mm size.

Sieve size	Weight retained (g)	Cumulative weight retained	Cumulative % weight retained	Passing %
20 mm	0.018	0.018	0.36	99.64
10 mm	3.490	3.508	70.16	29.84
4.75 mm	1.456	4.963	99.26	0.74
2.36 mm	0.026	4.989	99.78	0.22
1.18 mm	0.011	5.000	100	-
600 µm	-	-	100	-
300 µm	-	-	100	-
150 µm	-	-	100	-
Fineness modulus = 669.56/100=6.69				

Table 4. Sieve analysis for coarse aggregate of 20 mm size.

Sieve size	Weight retained (g)	Cumulative weight retained	Cumulative % weight retained	Passing %
40 mm	-	-	-	100
20 mm	4.444	4.444	44.44	55.55
10 mm	5.531	9.975	99.75	0.25
4.75 mm	0.025	10.00	100	-
2.36 mm	-	-	100	-
1.18 mm	-	-	100	-
600 µm	-	-	100	-
300 µm	-	-	100	-
150 µm	-	-	100	-
Fineness modulus = 744.19/100=7.44				

Table 5. Sieve analysis of plastic material.

Sieve size	Weight retained (g)	Cumulative weight retained	Cumulative % weight retained	Passing %
2.36 mm	0.057	0.057	2.85	97.15
1.7 mm	0.042	0.099	4.95	95.05
1 mm	1.743	1.842	92.1	7.9
600 µm	0.069	1.911	95.55	4.45
425 µm	0.052	1.963	98.15	1.85
300 µm	0.028	1.991	99.55	0.45
212 µm	0.006	1.997	99.85	0.15
150 µm	0.0026	1.9996	99.98	0.02
75 µm	0.0004	2.0	-	-
F.M=592.98/100=5.92, Specific gravity of plastic material =0.93				

Compressive strength test were carried out on 100 mm X 100 mm X 100 mm specimen for that three cube were prepared for each mix. Test was carried out as per IS: 14858:2000. Specimen shall be tested after 7 and 28 d respectively.

Split tensile strength: A test for tensile strength in which a cylindrical specimen is loaded to failure in diametral compression applied along the entire length, method of determining the tensile strength of concrete using a cylinder which splits across the vertical diameter. Split tensile strength test were carried out on a cylindrical specimen 150 mm in dia and 150 mm long for three cylinders were prepared for each mix. Specimen shall be tested after 7 and 28 d respectively.

Results and discussion

Compressive strength: The result of compressive strength of 7 and 28 d were presented in Table 6. The average reduction in compressive strength of plastic concrete is 1%. This reduction in compressive strength is attributed to the decrease in adhesive strength between the plastic aggregate and the cement paste. At 0% mixing of LDPE, compressive strength is 21.8 N/mm^2, 0.4% compressive strength is 22 N/mm^2, 0.6% compressive strength is 22.4 N/mm^2 and 0.8% compressive strength is 23.6 N/mm^2 in 7 d. At 0% mixing of LDPE, compressive strength is 26.67 N/mm^2, 0.4% compressive strength is 32.67 N/mm^2, 0.6% compressive strength is 35.86 N/mm^2 and 0.8% compressive strength is 36.06 N/mm^2 in 28 d.

Table 6. Compressive strength of specimen with waste LDPE.

Cube designation	Average compressive strength (N/mm^2)		% of Plastic
	7 d	28 d	
A1	21.8	26.67	0
A2	22.0	32.67	0.4
A3	22.4	35.86	0.6
A4	23.6	36.07	0.8
A5	22.34	23.47	1

Fig. 1. Compressive strength of specimen with waste LDPE.

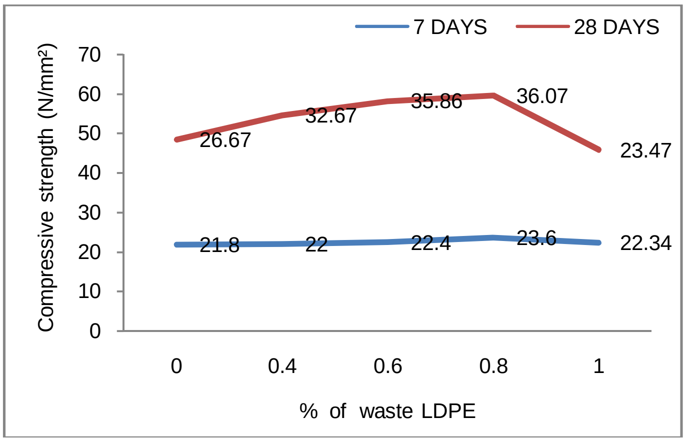
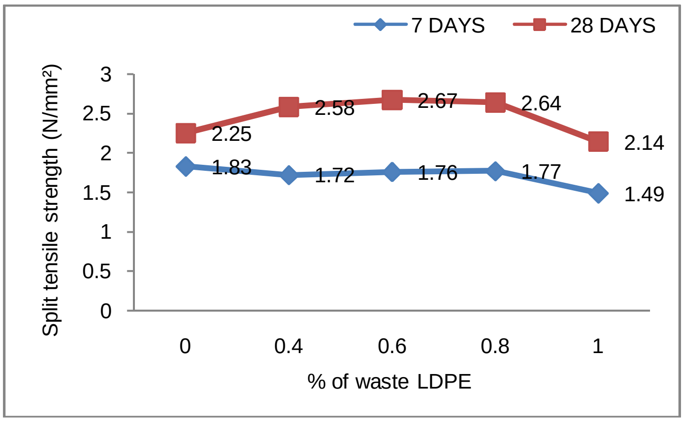


Table 7. Split tensile strength of specimen with waste LDPE.

Cylinder designation	Average compressive strength (N/mm^2)		% of Plastic
	7 d	28 d	
B1	1.83	2.25	0
B2	1.72	2.58	0.4
B3	1.76	2.67	0.6
B4	1.77	2.64	0.8
B5	1.49	2.14	1

Fig. 8. Split tensile strength of specimen with waste LDPE.



Split tensile strength: The result of tensile strength of 7 and 28 d are presented in Table 7. The average reduction in split tensile strength of plastic concrete is 1%. At 0% mixing of LDPE, tensile strength is 1.83 N/mm^2, 0.4% tensile strength is 1.72 N/mm^2, 0.6% tensile strength is 1.76 N/mm^2 and 0.8% split tensile strength is 1.77 N/mm^2 in 7 d. At 0% mixing of LDPE, tensile strength is 2.25 N/mm^2, 0.4% tensile strength is 2.58 N/mm^2, 0.6% tensile strength is 2.67 N/mm^2 and 0.8% split tensile strength is 2.64 N/mm^2 in 28 d.

Conclusion

The following are the conclusive points derived at the end of the study:

1. The compressive, split and flexural strength of concrete containing the waste plastic LDPE shows increasing indication.
2. When we mixed waste plastic LDPE with concrete in shredded form it reduces the level of pollution of the surrounding environment.
3. It can be used as light weight aggregate.

References

1. Barnes, D.K.A., Galgani, F., Thompson, R.C. and Barlaz, M. 2009. Accumulation and fragmentation of plastic debris in global environments. *Philosoph. Trans. Royal Soc. B*. 364: 1985-1998.
2. Gupta *et al.* 2006. Study of the use of plastic from municipal solid waste in concrete as a disposal technique," in QIP Short Term Training Program on " Emerging Technology For Environmental Management", Department of Civil Engineering, New Delhi, India.
3. IS: 1489:1991. Portland-Pozzolana Cement-Specification-Part 1: Fly Ash Based, Bureau of Indian standard institution, New Delhi.
4. IS: 10262:1982. Recommended guidelines for concrete mix design, Bureau of Indian standards, New Delhi.
5. IS: 2386-1963. Indian standards code of practice for methods of test for Aggregate for concrete, Bureau of Indian standard Institution, New Delhi.
6. IS: 383-1970. Specification for coarse and fine aggregates from natural sources for concrete" (Second revision).
7. IS: 456-2000. Specifications for plain and reinforced concrete.
8. IS: 516-1959. Method of test for strength of concrete Bureau of Indian standards. New Delhi, India.
9. IS: 5816-1999. Method of test for splitting tensile strength of concrete. BIS New Delhi, India.
10. Batayneh, M., Marie, I. and Asi, I. 2007. Use of selected waste materials in concrete mixes. *Waste Manage*. 27(12): 1870-1876.
11. Marzouk, O.Y., Dheilly, R.M. and Queneudec, M. 2007. Valorization of post-consumer waste plastic in cementitious concrete composites. *Waste Manage*. 27: 310-318.
12. Kandasamy, R. and Murugesan, R. 2011. Fibre reinforced concrete using domestic waste plastics as fibres. *ARPN J. Engg. Appl. Sci*. 6: 3.
13. Soroushian, P., Mirza, F. and Alhozaimy, A. 1995. Permeability characteristics of polypropylene fiber reinforced concrete. *ACI Mater. J.* 92: 291-295.
14. Choi, Y.W., Moon, D.J., Chung, J.S. and Cho, S.K. 2005. Effects of waste PET bottles aggregate on the properties of concrete. *Cement Concre. Res*. 35(4): 776-781.
15. Ismail, Z. and Al-Hashmi, E. 2011. Validation of using mixed iron and plastic wastes in concrete, Second Int. Conf. on Sustainable Construction Materials and technologies, ISBN 978-1-4507-1490-7.