Journal of Academia and Industrial Research (JAIR)
Volume 3, Issue 3 August 2014

ISSN: 2278-5213

RESEARCH ARTICLE

Effect of Waste Polythene on Compressive Strength of Concrete

Ankit Kumar[1]*, Vikas Srivastava[2] and Rakesh Kumar[3]
[1,2]Dept. of Civil Engineering, SHIATS, Allahabad-211007, U.P, India
[3]Dept. of Civil Engineering, MNNIT Allahabad-211004, U.P, India
ankitengg2011@gmail.com*, vikas_mes@rediffmail.com, rkpat@mnnit.com; +91 9410047488

Abstract

Solid waste management systems across the world face a challenging issue of safe disposal of non-recyclable thin polythene bags. The first choice for construction in many countries is concrete, if plastic wastes can be mixed in the concrete mass in dry form, without significant change on its basic properties or slight compromise in strength, we can consume large quantities of plastic waste by mixing it in the concrete mass. This study presents a comparative study of compressive strength of concrete made using plastic bags as fibrous material and focuses the effect of polyethylene plastic bags on the workability and compressive strength of M25 concrete. The proportions of waste plastic added in concrete are 0.5%, 0.75% and 1.0% by weight of cement and compressive strength is determined at 7, 28 and 56 d of curing. It is observed that the workability is reduced with increase in dose of polythene and the compressive strength is increased on inclusion of waste polythene in concrete at all edges up to 0.75% and thereafter it starts decreasing.

Keywords: Concrete, waste polythene, compressive strength, workability, superplasticizer.

Introduction

Concrete is the most commonly used construction material in the world today. The concrete consumed by the construction industry in India is around 370 million cum per year and it is expected to increase 30 million cum every year (Bhogayata and Arora, 2011). Concrete is a highly versatile construction material, well suited for many applications. In its simplest form, three basic ingredients are required to make concrete–cement (the binder), aggregates (ranging in size from fine to coarse) and water. Cement reacts with water to form hardened silicate compounds that bind all of the individual aggregate components together into one homogenous material i.e. concrete. Concrete's constituent materials are available naturally in all parts of the world. Plastic industry is one of the fastest growing industries and around one trillion plastic bags are being used around the world per year, which is just one example of plastic products. Disposal of polythene wastes in environment is considered to be a huge problem as plastic is durable and non-biodegradable. The chemical bonds of polythene make it very durable and increase its resistance against the natural process of degradation. Plastic materials have become a part and parcel of our daily life which increases the availability of plastic wastes which either gets mixed with municipal wastes or is thrown over a land area. The only disposal of plastic waste is either by land filling or by incineration but these processes have significant impacts on the environment. If it is dumped into some places, it causes soil and ground water pollution and if it is incinerated, it causes air pollution.

Plastic wastes do adversely affect the living beings which includes habitants and many animals. It is seen that plastic waste (especially polythene bags) are major cause of death of many animals, due to suffocation encountered on eating them. One of the major disadvantages of the plastic waste is their non-recycling nature as being a petrochemical product, recycling process cause serious effect to the environment. Studies show that plastic waste being a non-biodegradable material can last for centuries. As such an alternate use of plastic waste is need of the time. Of late several studies carried out to explore the possibilities of use of these plastic wastes in construction industry besides its use in bituminous carpet in construction of floor. Kandasamy and Murugesan (2011) used polymer fibres in concrete by weight of cement and reported an increment in compressive strength of 0.68% at 7 d and 5.12% in 28 d. Bhogayata *et al.* (2012) added plastic waste in fibre form of 0% to 1.5% by volume of concrete along with variation of fly ash from 0% to 30% by volume of concrete. Different curing conditions were used to note the effect of chemical attack and corresponding changes in the compressive strength of concrete mix. In another study, Bhogayata *et al.* (2012) used ordinary plastic bags having thickness less than 20 µ in the form of plastic fibres in the range of 0% to 1.2% by volume of concrete and the compressive strength was compared for manually cut and shredded plastic. They concluded that the plastic bags could be used preferably in shredded form to avoid difficulty in workability of concrete.

Table 1. Properties of cement.

Properties	Experimental	Codal requirement[IS 1489 (Pt-1)-1991]
Normal consistency %	32.5	-
Initial setting time	145 min	(Not less than 30 min)
Final setting time	215min	(Not more than 600 min)
Soundness of cement (Le chatelier expansion)	0.70 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		
3 d testing		
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 %
10 mm	-	-	-	100
4.75 mm	6	6	1.2	98.8
2.36 mm	32	38	7.6	92.4
1.18 mm	68	106	21.2	78.8
600 µm	106	212	42.4	57.6
300 µm	190	402	80.4	19.2
150 µm	94	496	99.2	0.8
Pan	04	500	-	-
Total = 252			Fineness modulas = 252/100 = 2.52	

Rai *et al*. (2012) used plastic pallets as fine aggregate and studied the workability, compressive strength and flexural strength of waste plastic-mix concrete with and without using superplasticizer. Rebeiz (1996) investigated the strength properties of unreinforced polymer concrete using an unsaturated polyester resin based on recycled polythene terephthalate (PET). Marzuok *et al.* (2006) studied the use of consumed plastic bottle waste as sand-substitution aggregates within composite material for building application and showed the effects of PET waste on the density and compressive strength of concrete. Torgal *et al.* (2012) investigated the durability aspects of concrete added with rubber wastes and PET bottles fibre in different aspects ratio and form of rubber wastes. They observed that such materials can be used for non-load bearing structures. This study presents the workability and compressive strength of concrete made with waste plastic in fibrous form at different doses (0.5%, 0.75% and 1.0%) and results are compared with conventional concrete.

Materials and methods

Experimental design: To study the effect of waste polythene on the compressive strength of concrete, cubes (100 mm × 100 mm × 100 mm) are cast using a nominal mix of (1:1.68:3). Specimens are tested to determine compressive strength at the end of 7, 28 and 56 d of curing. Test set-up is shown in Fig. 1.

Cement: In this study, Portland Pozzolana Cement (PPC) of Prism brand obtained from single batches is used throughout the investigation.

Fig. 1. Set-up for the compressive strength test.

The Portland cement has mainly two basic ingredients namely argillaceous and calcareous. The physical properties of PPC as determined are given in Table 1. The cement satisfies the requirement of IS: 1489 (Pt-1)-:1991.

Fine aggregate: Aggregate most of which passes 4.75 mm IS sieves are called fine aggregate. Specific gravity of fine aggregate is 2.9; bulk density is 1.688 kg/L and fineness modulus is 2.52 of fine aggregate. The result of sieve analysis is given in Table 2.

Coarse aggregate: Uncrushed gravel or stone which is the result of natural disintegration and crushed gravel or stone are usually called the “Coarse Aggregates”. Coarse aggregates are the stones that are retained on 4.75 mm sieve.

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				

Fig. 2. Sample of waste polythene used.

The coarse aggregate is locally available quarry having two different sizes; one fraction is passing through 20 mm sieve and another fraction passing through 10 mm sieve. The specific gravity of coarse aggregate is 2.7 for both fractions and the grading of coarse aggregate of 10 mm and 20 mm size are given in Table 3 and 4 respectively. Proportion of 20 mm and 10 mm size aggregate was 60% and 40%.

Waste polythene: The waste material used in this study was polythene (Fig. 2). It is shredded in very fine random fibre form. The specific gravity of waste polythene is 0.41. In this study, the doses adopted for waste polythene are 0.5%, 0.75% and 1% by weight of cement.

Water: Potable water is used for mixing and curing. A water cement ratio (w/c) of 0.44 is adopted for concrete mix.

Superplasticizer: In this study, superplasticizer of Sica company is used in 0.4% dose of weight of cement for enhancing the workability and compressive strength of cement.

Concrete: Mix design for the concrete is done in accordance with IS 10262-2009. The cement content used in the mix design is taken as 380 kg/m^3 which satisfies minimum requirement of 300 kg/m^3 in order to avoid the balling affect.

Results and discussion

A comparative study of concrete mix is carried out to find the effect on workability and compressive strength of concrete by adding waste polythene to it. The compressive strength of concrete made with polythene waste at 7, 28 and 56 d is given in Table 5 and Fig. 3. It seems that the compressive strength at 28 d is not up to the required target mean strength of M25 grade concrete. This may be due to the use of superplasticizer which up to some extent acts as retarder. However strength at 56 d is satisfactory. The results of compressive strength test are shown graphically in Fig. 4 and 5 for comparative analysis. It is observed that, the compressive strength increases up to the optimum percentage of waste polythene i.e. 0.75% of weight of cement and after that, it tends to decrease at 1% of waste polythene mix concrete.

Table 5. Workability and compressive strength of concrete.

Dose of polythene (%)	Compressive strength (N/mm^2)			Slump value (mm)
	7 d	28 d	58 d	
0	21.8	27.89	35.06	118
0.5	22.46	28.28	36.03	83
0.75	22.66	29.06	41.06	64
1	22.86	26.23	38.50	27

Fig. 3. Slump of concrete mix with varying dose of waste polythene.

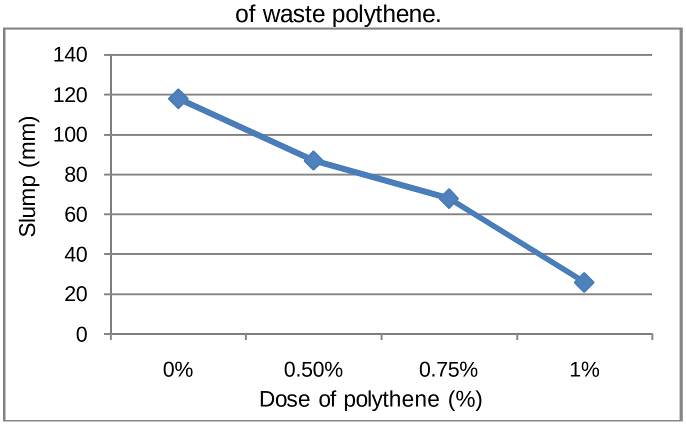


Fig. 4. Compressive strength of concrete with varying dose of waste polythene (line chart).

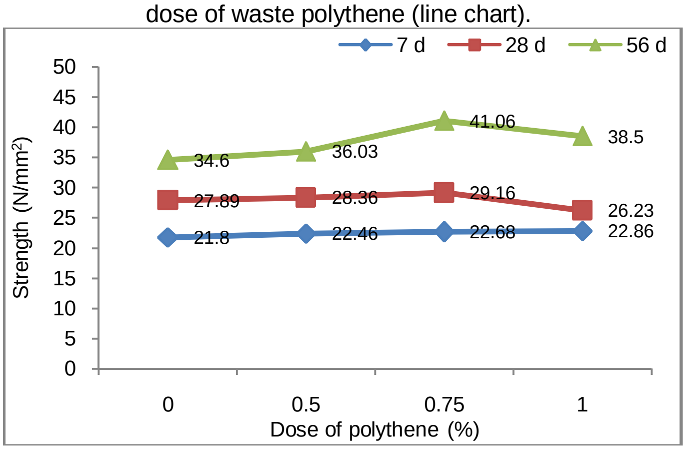
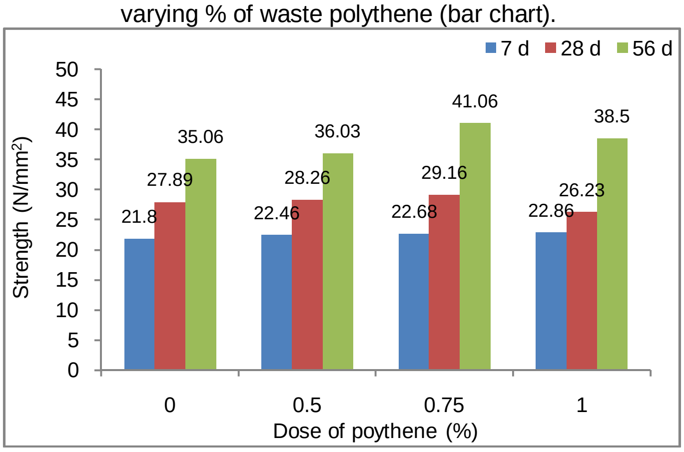


Fig. 5. Compressive strength of concrete with varying % of waste polythene (bar chart).



It is also observed that the slump decrease with increase in dose of waste polythene. However, in addition of waste polythene, resulting mix has substantial workability (Slump ranging 27-83 mm). Slump of fresh concrete at different dose of waste polythene is also shown in Table 5.

Conclusion

From the present study, following conclusions may be drawn:

- On addition of waste polythene, workability of concrete is reduced and slump loss increased with increase in dose of waste polythene.
- Compressive strength of concrete made using waste polythene is increased by 4.03%, 4.55% and 17.11% at 7, 28 and 56 d respectively at 0.75% dose of waste polythene.
- Compressive strength of concrete made using waste polythene is increased by 3.03%, 1.32% and 2.76% at 7, 28 and 56 d respectively at 0.5% dose of waste polythene.
- The increase in compressive strength of concrete on inclusion of waste polythene is observed up to 0.75% and thereafter compressive strength is reduced however, compressive strength at 1% waste polythene is more than the referral concrete.
- The concept of mixing of plastic wastes in concrete could be a very environment friendly method for disposal of solid waste in the country, this study has shown a potential towards this concept.

References

1. Bhogayata, A. and Arora, N.K. 2011. Green concrete from the post consumer plastic wastes: Indian scenario. *ICTSET proceedings*, ISBN: 978-81-906377-9-4, pp.437-440.
2. Bhogayata, A., Shah, K.D., Vyas, B.A. and Arora, N.K. 2012. Feasibility of wastes metallised polythene used as concrete constituent. *Int. J. Engg. Adv. Technol.* 1(5): 204-207.
3. 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. Engg. Adv. Technol.* 1(4): 1-3.
4. IS: 10262- 2009. Indian Standard "Recommended Guidelines for Concrete Mix Design-Code of practice. *Bureau of Indian Standards*, New Delhi.
5. Kandasamy, R. and Murugesan, R. 2011. Fibre reinforced concrete using domestic wastes plastics as fibres. *ARPN J. Engg. Appl. Sci.* 6(3): 405-410.
6. Marzouk, O.Y., Dheilly, R.M. and Queneudec, M. 2006. Valorisation of post consumer waste plastic in cementitious concrete composites, *Pub Med, U.S. National Library of Medicine, National Institute of Health.* 27(2), Issue-12, 310- May, 2006.
7. Rai, B., Rushad, S.T., Bhavesh, K. and Duggal, S.K. 2012. Study of wastes plastic mix concrete with plasticizer. *International Scholarly Research Network ISRN Civil Engineering* Volume 2012, Article ID 469272,doi:10.5402/2012/469272, pp.1-3.
8. Rebeiz, K.S. 1996. Precast use of polymer concrete using unsaturated polyester resin based on recycled PET waste. *Construct. Build. Mater.* 10(3): 215-220.
9. Torgal, F.P., Ding, Y. and Jalali, S. 2012. Properties and durability of concrete containing polymeric wastes (tyre rubber and polyethylene terephthalate bottles): An overview. *Construct. Building Mater.* 30: 714-724.