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Light Weight Concrete Using Plastic Aggregate

Ankush Agrawal[1], Mahesh Ram Patel[2]
[1]*M.Tech. Scholar, Department of Civil Engineering, Shri Shankaracharya Technical Campus, Bhilai, India*
[2]*Assistant Professor, Department of Civil Engineering, Shri Shankaracharya Technical Campus, Bhilai, India*

***Abstract*: The use of recycled plastics in concrete is relatively a new development in the world of concrete technology and lot of research must go in before this material is actively used in concrete construction. In this study the various properties of light weight concrete which made by using plastic aggregate is done like Density, W/C Ratio, Compressive strength, Tensile strength etc.**

***Keywords*: Density, W/C Ratio, Compressive strength, Tensile strength.**

1. Introduction

Plastic waste is silent threat to the environment and their disposal is a serious issue for waste management. Nowadays society does not have any alternative to plastic products like plastic bags, plastic bottles, and plastic sheets etc. In spite of all efforts made to limit its use but unfortunately its utility is increasing day by day. To circumvent this, issue many efforts were made in the past to reuse the plastic waste but no significant results were achieved. On contrary concrete being the widely used construction material is facing problem due to unavailability of construction material (Cement, sand and coarse aggregate). Various attempts were made through experimentation to check the feasibility of plastic waste to be use partially in concrete with respect to enhance various properties of strength, workability, durability and ductility of concrete. Moreover, this research will draw our focus toward the impingement on the various properties of concrete when partially replacing with waste plastic.

Used Plastic bags, pieces of plastic sheets and bottles of diverse sizes, colors and textures are found flying around freely, scattered in the streets, swimming in the gutters, posing a serious environmental threat. These keep the environment dirty and cause blockages to our sewer system. Several attempts were made to discourage plastic bags and other plastic products but yield no result due to its versatility in daily use. Being cheap and easily available now it look like that we have to live up with it.

Recycling is the practice of recovering used materials from the waste stream and then incorporating those same materials into the manufacturing process. Recycling is one of the prominent issues in this environmentally conscious era. There are three main arguments for recycling: first, it preserves the precious natural resources; secondly, it minimizes the transportation and its associated costs; and thirdly, it avoids the environmental load caused by waster material, i.e. space requirement. The great strides have been made to increase recycling rates worldwide in recent years. The major consideration to support recycling all over the world is the expansion of infrastructure for recycling. The need to recycle plastics is clear. Over 22 million tons of plastics are discarded each year in the trash. While plastics account for only 9.2% (in 2000) of the trash Americans generate each year, plastic products do not decompose in landfills and are difficult to reduce in size.

There are a few technological and economic constraints that currently limit the full and efficient recycling of plastic wastes into useful products. The quantity of plastics consumed

Table 1
Types of recycled plastics

Plastic ID code	Name of Plastic	Description	Range of Products	Uses for Plastic made from Recycled Waste Plastic
1	Polyethylene terephthalate	Clear tough plastic	Soft drink & mineral water bottles	Soft drink bottles; detergent Bottles; clear packaging film; fleecy jackets; carpet fibers.
2	High density polyethylene (HDPE)	Usually white or colored. Very common plastic	Milk, cream, shampoo and cleaner bottles; milk crates; freezer bags.	Compost bins; Mobile garbage bins; agricultural pipes.
3	Un-plasticized polyvinylchloride (UPVC) Plasticized polyvinylchloride (PPVC)	Hard rigid plastic may be clear. Flexible clear elastic plastic.	Clear cordial & juice bottles: plumbing fittings, Garden hoses, shoe soles.	Detergent bottles; hoses; tiles; plumbing pipes & fittings.
4	Low density polyethylene (LDPE)	Soft, flexible plastic.	Garbage bags, black plastic sheet; ice- cream container lids.	Film & bags for building and packaging.
5	Polypropylene (PP)	Hard flexible plastic	Ice-cream containers, drinking straws, potato crisp bags.	Compost bins; recycling crates.
6	Polystyrene (PS) Expanded polystyrene (UPS)	Rigid, brittle plastic. May clear glassy.	Yoghurt containers; plastic cutlery. Hot drink cups; meat trays; packaging.	Clothes pegs, coat hangers, video & CD boxes.

annually all over the world has been growing phenomenally. Its exceptionally user-friendly characteristics/features, unique flexibility, Fabricate-ability and process-ability coupled with immense cost-effectiveness and longevity are the main reasons for such astronomical growth. Besides its wide use in packaging, automotive and industrial applications, plastics are also extensively used in medical delivery systems, artificial implants and other healthcare applications, water desalination and bacteria removal, preservation and distribution of food, housing appliances, communication and the electronics industry, etc. the uses of plastics and recycled plastics. The types of recycled plastics are shown in tabular form in Table 1.

2. Methodology

The aim of the experimental program is to compare the properties of concrete made with plastic aggregates and ordinary Portland cement. The mechanical properties tests carried out on materials used for casting concrete samples, mix deign and curing procedure adopted. At the end, the various tests conducted on the specimens are discussed.

A. Materials used

1) Cement

Cement is a binder material. It is mixed with water and materials such as sand, gravel, and crushed stone to make concrete. The cement and water form adhesive that binds the other materials together as the matrix hardens.

2) Fine aggregates

The sand used for the experimental program was locally procured and conformed to Indian Standard Specifications IS: 383-1970. The sand was first sieved through 4.75 mm sieve and then was washed to remove the dust. Properties of the fine aggregate used in the experimental work are tabulated in Table 2.

3) Coarse aggregates

Locally available coarse aggregate having the maximum size of 20 mm was used in our work. The aggregates were washed to remove dust and dirt and were dried to surface dry condition. The aggregates were tested per Indian Standard Specifications IS: 383-1970. The results of various tests conducted on coarse aggregate are given in Table 3.

Table 2
Properties of fine aggregates

S. No.	Characteristics	Value
1.	Type	Uncrushed (natural)
2.	Specific gravity	2.65
3.	Total water absorption	1.05 %
4.	Fineness modulus	2.58
5.	Grading zone	II

Table 3
Properties of Coarse aggregates

S. No.	Characteristics	Value
1.	Type	Crushed
2.	Maximum size	20 mm
3.	Specific gravity (20 mm)	2.83
4.	Total water absorption (20 mm)	3.65 %
5..	Fineness modulus (20 mm)	7.65

4) Plastics Aggregates

Plastic waste aggregate was used to replace natural coarse aggregates for making concrete cubes. These aggregates were available in three different sizes as shown in Fig. 1. The sieve analysis of these aggregates were carried out separately and is presented in Table 4, 5 and 6.

Fig. 1. Three types of plastic aggregates
(smaller, medium and coarser size)

Table 4
Coarse aggregate (Plastic aggregate Big - PAB)

S.No.	Sieve Size	Mass Retained (gms)	% Retained	% Passing	Cumulative % Retained
1.	20mm	0	0.00	100	0.00
2.	12.5mm	292.0	21.32	78.68	21.32
3.	10mm	398.50	29.09	70.91	50.41
4.	5.6mm	509.0	37.16	62.84	87.57
5.	Pan	170.00	12.41	87.59	99.98

Fineness Modulus of plastic aggregate big = ΣC+500/100 = 7.60

Table 5
Coarse aggregate (Plastics aggregates Medium - PAM)

S. No.	Sieve Size.	Mass Retained (gms)	percentage Retained	Percentage Passing	Cumulative % retained
1.	4.75 mm	6	1.2	98.8	1.2
2.	2.36 mm	486	97.2	2.8	98.4
3.	1.18 mm	8	1.6	98.4	100
4.	600 μm	0	0	0	100
5.	300 μm	0	0	0	100
6.	150 μm	0	0	0	100
7.	Pan	0	0	0	

Fineness Modulus of plastic aggregate medium = ΣC+500/100 = 9.97

Table 6
Coarse aggregate (Plastics aggregates small - PAS)

S. No.	Sieve No.	Mass Retained (gms)	percentage Retained	percentage Passing	Cumulative % Retained
1.	4.75 mm	4	0.8	99.2	0.8
2.	2.36 mm	89	17.8	82.2	18.6
3.	1.18 mm	407	81.4	18.6	100
4.	600 μm	0	0	0	100
5.	300 μm	0	0	0	100
6.	150 μm	0	0	0	100
7.	Pan	0	0	-	

Fineness Modulus of plastic aggregate small = ΣC+500/100 =9.20

5) Mixture proportioning

The tests are carried out on a wide range of water-cement

Table 7
Mix proportions for per meter cube of various water cement ratios

S.No	W/C Ratio	Water Kg/m^3	Cement Kg/m^3	Fine Agg. Kg/m^3	Coarse Agg. Kg/m^3	Plastics Kg/m^3	Mix Proportions
MC1	0.40	194.4	485.9	510.20	1117.6	-	1:1.05:2.30
MC2	0.42	194.4	462.8	513.70	1133.9	-	1:1.11:2.45
MC3	0.44	194.4	441.8	525.80	1144.3	-	1:1.19:2.59
MC4	0.46	194.4	422.5	549.30	1119.60	-	1:1.30:2.65
MC5	0.48	194.4	405.0	558.9	1138.0	-	1:1.38:2.81
MC6	0.50	194.4	388.7	571.40	1150.6	-	1:1.47:2.96
MC7	0.52	194.4	374.0	572.20	1114.50	-	1:1.53:2.98
MP1	0.40	194.4	485.9	510.20	-	471.3	1:1.05:0.97
MP2	0.42	194.4	462.8	513.70	-	486.0	1:1.11:1.05
MP3	0.44	194.4	441.8	525.80	-	472.7	1:1.19:1.07
MP4	0.46	194.4	422.5	549.30	-	485.9	1:1.30:1.15
MP5	0.48	194.4	405.0	558.9	-	486.0	1:1.38:1.20
MP6	0.50	194.4	388.7	571.40	-	478.10	1:1.47:1.23
MP7	0.52	194.37	374.0	572.20	-	478.80	1:1.53:1.28

ratios, ranging from 0.4 to 0.52. The control mix is designed with the Indian Standard Code guidelines IS 10262:2009. For making the mixes containing plastics, the amount of plastics is calculated by using the specific gravity of plastics, in place of the specific gravity of coarse aggregates. The resultant mix proportions of all the mixes are tabulated in Table 7.

3. Results

A. Workability

The workability of concrete is assessed by compaction factor test.

Table 8
Compaction factor for the controlled mix

S. No.	W/C ratio	Compaction factor
1.	0.40	0.878
2.	0.42	0.879
3.	0.44	0.891
4.	0.46	0.893
5.	0.48	0.895
6.	0.50	0.896
7.	0.52	0.898

Table 9
Compaction factor for the mix with plastics

S.No.	W/C ratio	Compaction factor
1.	0.40	0.817
2.	0.42	0.853
3.	0.44	0.862
4.	0.46	0.875
5.	0.48	0.885
6.	0.50	0.890
7.	0.52	0.894

B. Dry density

The dry density is measured for the cubes taken from the curing tank, just prior to compressive strength test.

Table 10
Dry densities of control concrete and plastic added concrete

w/c Ratio	Unit weight control concrete	of (Kg/m^3) plastic concrete
0.4	2316	1557
0.42	2314	1560
0.44	2335	1535
0.46	2347	1526
0.48	2337	1560
0.5	2329	1548
0.52	2325	1575

C. Compressive strength

The compressive strength for different water cement ratios of plastic added concrete and control concrete were tested at the end of 28 days using compressive strength testing machine. The water cement ratios were taken as 0.4, 0.42, 0.44, 0.46, 0.48, 0.50, and 0.52.

Table 11
Compressive strength of control and plastic added concrete

W/C Ratio	Compressive strength (MPa)	
	control concrete	plastic concrete
0.40	39.69	13.11
0.42	38.66	11.42
0.44	38.51	10.69
0.46	37.71	10.18
0.48	35.42	10.02
0.50	32.15	9.51
0.52	27.71	10.10

Fig. 2. (a) Control concrete cube failure, (b) Plastic concrete cube failure

D. Split tensile strength

The split tensile strength for different water cement ratios of plastic added concrete and control concrete is obtained tested at the end of 28 days. The water cement ratios were taken as 0.4, 0.42, 0.44, 0.46, 0.48, 0.50, and 0.52.

Table 12
Split tensile strength of control concrete and plastic concrete

w/c Ratio	Tensile strength (MPa)	
	Control concrete	Plastic concrete
0.40	3.96	1.15
0.42	3.93	1.10
0.44	3.90	1.0
0.46	3.74	0.77
0.48	3.68	0.74
0.50	3.25	0.72
0.52	3.01	0.71

4. Conclusion

Following are the conclusions can be made based upon the studies made by various researchers:

- Plastics can be used to replace some amount of the aggregates in a concrete mixture. This will lead to reducing the unit weight of the concrete. This is useful in manufacturing of lightweight concrete and application such as concrete panels used in facades.
- For a given water-cement ratio, the use of plastics in the mix lowers the density of the mix, compressive strength and split tensile strength of the concrete.
- The plastic aggregates reduce the bond strength of concrete. Therefore, the failure of concrete occurs due to failure of bond between the cement paste and plastic aggregates.
- Plastic aggregates in concrete make concrete ductile, hence increasing the ductility of concrete to significantly buckle before failure. This characteristic makes the matrix useful in situations where it will be subjected to severe weather such as expansion and contraction, or freeze and thaw.

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