

A Study on Use of Plastic Waste Aggregate as Partial Replacement of Natural Coarse Aggregate in Cement Concrete Mix

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ABSTRACT: Due to rapid population growth and their consistent necessity the use of plastic articles is increasing regularly. This creates a large quantity of garbage every day which is unhealthy and pollutes the environment. In present scenario solid waste management is a challenge in our country. The present topic covers the use of recycled plastics as partial replacement of natural coarse aggregate in cement concrete mix. Complete replacement of natural coarse aggregate by recycle plastic aggregate is not realistic so partial replacement in various percentages were incorporated. Intended percentages of recycled plastic aggregates were from 0% to 40% with a increment of 10. It was observed that higher compressive strength was obtained with replacement of 20% natural coarse aggregate by recycled plastic aggregate in concrete mix.

KEYWORDS: Recycled plastic aggregate, compressive strength, coarse aggregate, cement concrete.

I. INTRODUCTION

There is a acute problem of disposal of wastes and it has become expansive due to over loaded landfills in present scenario. The threat due to non-biodegradable materials like waste plastics, scrap tyres etc. may contaminate the soil and ground water. The problem of disposal can be solved to some extent by reusing these wastes after recycling and it will also give a solution to environmental pollution as well. Re-use of waste plastic after recycling is economical as it is available at lower cost for mixing with other variants like bitumen, concrete etc. In order to modify the properties of concrete with the use of waste plastic materials such as Low density polythene (LDPE), High density polythene (HDPE), polystyrene foam wastes, polythene terephthalate (PET) and other plastic materials have been investigated to be used in concrete in order to modify it and to improve the properties of it and reduce the cost. This will give a way for green construction and a eco- friendly environment.

In this research work recycled plastic aggregates were used as a partial replacement to natural coarse aggregate (NCA) of concrete. Intended percentages of recycled plastic coarse aggregates (RPCA) were in varying percentages from 0% to 40% with a increment of 10%. (0%, 10%, 20%,30% and 40%) . The compressive strength of each sample was determined and compared with conventional concrete mix.

Objectives: The objectives of this research work are listed below-

- To compare the various properties like compressive strength and density of modified concrete with partial replacement of natural coarse aggregates (NCA) by recycled plastic coarse aggregates (RPCA) used for modified concrete with Conventional concrete.
- To compare physical properties of natural coarse aggregate (NCA) with recycled plastic coarse aggregates.
- To produce lighter weight polymer concrete for its multidimensional use.

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II. MATERIALS AND METHODS

2.1. Materials Used: In this research work recycled plastic coarse aggregates (RPCA) of 20 mm nominal size were used as a partial replacement to natural coarse aggregate (NCA) to produce modified cement concrete. The following materials were used in this research work.

2.1.1. Cement: It is a important building material. Ordinary Portland cement(OPC) of 53 grade ,conforming to IS:8112-1986 was used. Details of its properties are given in table-1 below-

Table-1 Properties of cement

S. No.	Description of Tests	Results obtained	Specifications as per IS:8112-1986
1	Initial setting time	60 minutes	Min. 30 minutes
2	Final setting time	280 minutes	Max. 600 minutes
3	Fineness	4.8%	Less than 10%

The physical properties of cement are-

- Setting time
- Soundness
- Fineness
- Strength

2.1.2. Aggregates: Aggregates both coarse and fine were collected from nearby locality conforming to specifications of IS:383-1970 and tested. The test results of coarse aggregate is shown below in table -2 below-

Table-2 Test results of coarse aggregate

Description of Test	Conventional Aggregate	Specifications as per IS:383-1970 and IRC:111-2009
Aggregate Crushing strength value	16.27%	Max 30 %
Impact value	15.77%	Max 24%
Specific gravity value	2.68	2.5-3.0
Los Angeles Abrasion value	15.34%	Max 30%
Flakiness Index value	12.44%	Max 35 %
Elongation index value	12.3%	Max 35 %
Water absorption value	0.82%	Max 2%
Soundness value with Sodium sulphate	10%	Max 12 %

2.1.2. Water: It is a important ingredient which actively plays a part in the chemical reactions. It should be a potable water free from organic matter and pH value should be between 6 to 7.

2.1.3. Plastic Waste: Waste scrap bag plastics, articles of Low density polythene (LDPE), High density polythene (HDPE), polystyrene foam wastes, polythene terephthalate (PET) and other plastic materials were collected from landfills and other locations of nearby locality as shown in fig.-1 below. These were cleaned and dried. The waste plastics articles were shaped and cut to required size.

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Vol. 4, Issue 11, November 2015



Fig-1 Mixture of collected waste plastics

Modification of plastic aggregate was done by heat treatment at a temperature between 160°C to 200°C in Plastic Granule Recycling Machine (PGRM). Then aggregate was cooled at room temperature by removing it from the machine.



Fig-2 Waste plastics cut to required size

The aggregate thus obtained were a mixture of angular and round shape similar to that of crushed concrete aggregates. Obtained plastic granules were grinded in a grinding mill to a size 20 mm nominal as required for concrete as shown in fig-2 above.

Table-3 Physical properties of Plastic

Property	Detail
Plastic type	Grinded waste polythene plastic bags & High density polythene & other plastic articles
Plastic material	Low density Polyethylene (LDPE) & HDPE (High density polythene), PET
Size (mm)	20 mm nominal size
Density (g/cm ³)	0.95
Melting point (°C)	120-130

Physical properties of grinded plastic to 20 mm nominal size is shown in table no-3. The density of plastic material is 0.95 g/cm³ and melting point in the range of 120°C to 130°C.

2.2. Methods: Cement Concrete Mix M20 was chosen for analysis. The raw material were mixed in specified proportion of 1:1.5:3 (1 cement : 1.5 coarse sand : 3 stone aggregate of 20 mm nominal size) and suitable water with adopting water cement ratio as 0.50. The experiment were conducted replacing natural coarse aggregate (NCA) with recycled plastic coarse aggregate (RPCA) of 20 mm nominal size. The samples were prepared in various proportions. Details are shown in table no-4 as below-

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2015

Table-4 Samples of various proportions

Sample Series	Description of various Mix Proportions
C0	100 % Crushed stone aggregate of 20 mm nominal size
C10	(10% Recycled plastic aggregate + 90% Crushed stone) both of 20 mm nominal size
C20	(20% Recycled plastic aggregate + 80% Crushed stone) both of 20 mm nominal size
C30	(30% Recycled plastic aggregate + 70% Crushed stone) both of 20 mm nominal size
C40	(40% Recycled plastic aggregate + 60% Crushed stone) both of 20 mm nominal size

The mixing of various ingredients were done in a proper manner and a homogeneous mixture was obtained with proper coating of cement on the aggregates. Suitable numbers of cubes of concrete in suitable mould size (15cmx15cmx15cm) were made and cured for specified temperature and time. The compressive strength of various samples were tested by compression machine. Test results are tabulated below –

Table-5 Compressive strength of Cubes of different proportions

Sample Series	Compressive Strength (N/mm ²)		
	7 Days	14 days	28 Days
C0	17.95	27.82	32.84
C10	17.96	21.10	26.12
C20	19.93	23.12	28.14
C30	18.96	20.92	25.12
C40	9.10	14.86	20.76

The compressive strength of concrete cubes of various proportions cured for 7, 14 and 28 days are shown in table no-5.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2015

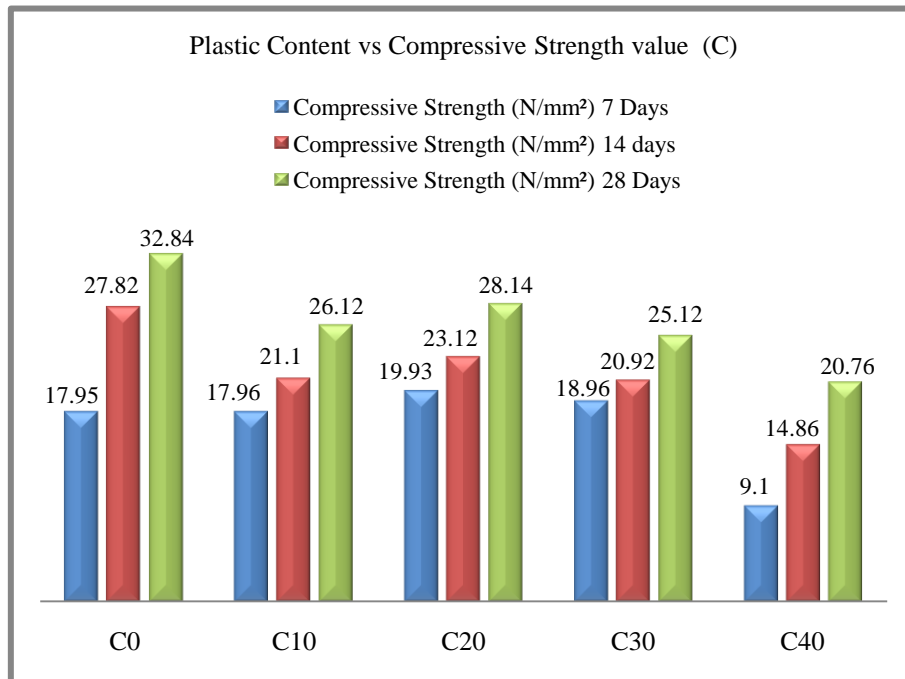


Fig- 3 Variation in Compressive strength of Various Sample series

The variations in compressive strength of concrete cubes of different proportions of mix of recycled plastic aggregates and natural conventional aggregates are plotted in the figure-3. The compressive strength of concrete is shown in N/mm².

Table-6 Dry densities of conventional and Plastic added concrete

Sample Series	Dry density (Kg/m³)		% Reduction in dry density
	Water cement ratio of 0.50		
C0	conventional	2325	-
C10	Plastic added	1610	30.75
C20	Plastic added	1580	32.04
C30	Plastic added	1570	32.47
C40	Plastic added	1555	33.12

The values of dry densities of concrete cubes of different proportions of mix of recycled plastic aggregates and natural conventional aggregates and their reduction as compared to conventional concrete are shown in table no-6.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 11, November 2015

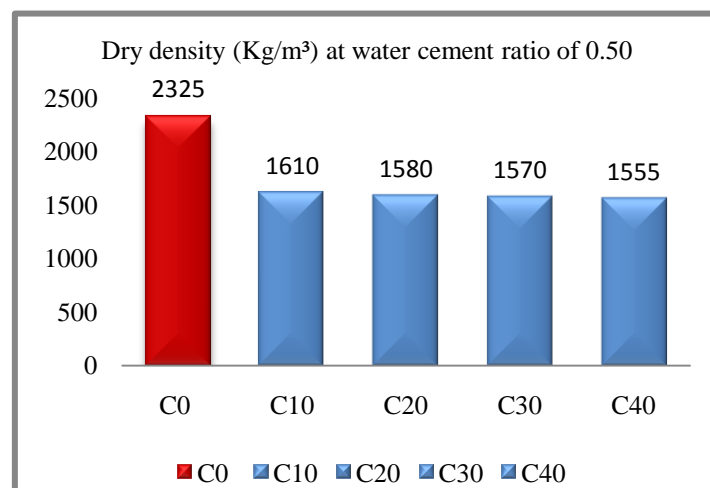


Fig- 4 Dry densities of conventional and Plastic added concrete

The variations in dry densities of concrete of different proportions of mix of recycled plastic aggregates and natural conventional aggregates are plotted in the fig-4 and their reduction as compared to conventional concrete are shown in table no-6. It shows that recycled plastic coarse aggregate (RPCA) up to 30% as a replacement for natural coarse aggregate (NCA) can be used in light weight concrete structure successfully.

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

The results of experimental investigations on use of recycled plastic aggregates as a partial replacement to natural coarse aggregate (NCA) in concrete were analyzed. Results as follows-

Use as Constructional Material: It was confirmed that plastic wastes can be disposed off by using it as constructional materials. It can be used as a coarse aggregate replacement in cement concrete.

Compressive Strength: The compressive strength of modified concrete with recycled plastic coarse aggregates (RPCA) was compared with conventional concrete and it was observed that the compressive strength in comparison to conventional concrete was achieved up to 79.54%, 85.69%, 76.49% and 63.22% for mix of waste plastic of 10%, 20%, 30% and 40% respectively. It shows that recycled plastic coarse aggregate (RPCA) up to 30% as a replacement for natural coarse aggregate (NCA) can be used in light weight concrete structure successfully. However higher percentage more than 30% is not acceptable as the compressive strength is considerably reduced.

Mechanical Properties: There was not any appreciable change observed in mechanical properties of recycled plastic coarse aggregate (RPCA) concrete as compared to conventional concrete up to 20% plastic content.

Dry density: The decrease of dry density of modified concrete is due to result of the low density of added plastic material. The density was reduced by 30.75%, 32.04%, 32.47% and 33.12% for added plastic aggregate percentage of 10, 20, 30 and 40 respectively.

Cost Economy: By producing light weight concrete with use of recycled plastic coarse aggregate (RPCA) there will be reduction in cost of raw materials and minimization of disposal of polymer waste.

Thermal conductivity: It was observed that thermal conductivity of concrete was reduced by use of plastic aggregates in concrete. This indicates that recycled plastics can be used for thermal insulation of buildings.

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IV. CONCLUSION

Based on study and results of experimental investigations on use of recycled plastic aggregates as a partial replacement to natural coarse aggregate (NCA) in concrete the following conclusion can be drawn-

- It can be utilized as constructional materials in cement concrete. It can be used as a coarse aggregate replacement in cement concrete also giving an eco-friendly solution for safe disposal of plastic waste.
- The compressive strength of modified concrete with recycled plastic coarse aggregates (RPCA) was compared with conventional concrete and it was observed that the compressive strength in comparison to conventional concrete was achieved up to 79.54% , 85.69%, 76.49% and 63.22% for mix of waste plastic of 10%, 20%, 30% and 40% respectively. It shows that recycled plastic coarse aggregate (RPCA) up to 30% as a replacement for natural coarse aggregate (NCA) can be used in light weight concrete structure successfully. However higher percentage more than 30% is not acceptable as the compressive strength is considerably reduced.
- There was not any appreciable change in mechanical properties of recycled plastic coarse aggregate (RPCA) concrete as compared to conventional concrete up to 20% plastic content. The decrease in dry density of modified concrete is due to the result of the low density of added plastic material and the average decrease was around 32%.
- By producing light weight concrete with use of recycled plastic coarse aggregate (RPCA) there will be reduction in cost of raw materials and minimization of disposal of polymer waste.
- Due to decrease in thermal conductivity of concrete by use of recycled plastic aggregate it can be used for thermal insulation work of buildings.

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