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Industrial Plastic Waste and High Density Polythlene (HDPE) Used In Light Weight Concrete Mixture as Aggregate Replacement

Er. Rohit Kumar*, Er. Prabhat Kumar Singh, Er. Prativa Manjari Barik**

*Department of Civil Engineering, Swami Vivekananda School of Engineering & Technology, Madanpur, Bhubaneswar, Odisha, India-752054
** Department of Civil Engineering, Swami Vivekananda School of Engineering & Technology, Madanpur, Bhubaneswar, Odisha, India-752054
***Department of Civil Engineering, Swami Vivekananda School of Engineering & Technology, Madanpur, Bhubaneswar, Odisha, India-752054

ABSTRACT

Rapid industrial development causes serious problem all over the world such as depletion of natural aggregates and creates enormous amount of waste material from construction and demolition activities. Quantities of polymer wastes also have been increased these recent years due to the boost in industrialization and the rapid improvement in the standard of living. Quantities of polymer wastes have been increased these recent years due to the boost in industrialization and the rapid improvement in the standard of living In Malaysia, most of polymer wastes is abandoned and not recycled. This situation causes serious problems such as wastage of natural resources and environmental pollution. Polymer products such as synthetic fibers, plastics and rubber belong to petrochemical compound and not easily biodegradable even after a long period. One of the ways to reduce this problem is to utilize waste materials in the production of concrete. . The aim of this experimental work is to study the properties and characterization of polymer HDPE concrete (M20) with partial replacement of coarse aggregate Utilization of waste materials and byproducts is a partial solution to environmental and ecological problems Use of these materials not only helps in getting them utilize in cement, sand, aggregate, concrete and other construction materials, it helps in reducing the cost of concrete manufacturing, but also has numerous indirect benefits such as reduction in land-fill cost, saving in energy and protecting the environment from possible pollution effects. An experimental research is made on the utilization of plastic waste, High Density Polyethylene (HDPE) as coarse aggregates in concrete with a percentage replacement of 10 %, 20 % and 30 %. The laboratory tests include slump test, compressive strength and water absorption were conducted in this research. The samples content 10 % of HDPE has better performance in term of strength

Keywords: Plastic Waste, Recycle Material in Concrete, High Density Polyethylene (HDPE) Compression test.

INTRODUCTION

Production of solid waste in Malaysia is 1 kg/person per day. In average, approximately 26 million people in the country produce 26 million kilos of solid waste every single day. Plastic waste is the most common solid waste that generate in the country accounting for 7-12 percent by weight and 18-30 percent by volume of the total residential waste generated [1]. Plastic is everywhere in today's life style .It is used for packaging, protecting, serving, and even disposing of all kinds of consumer goods. With the industrial revolution, mass production of goods started and plastic seemed to be cheaper and effective raw material .Today ,every vital sector of the economy starting from agriculture to packing ,automobile, building construction, communication or info tech has been virtually revolutionized by the applications of plastic Increasing amount of byproducts which are used by municipal and industrial processes has become a major problem for the future. Use of these non-biodegradable (according to recent studies, plastics can stay unchanged for as long as 4500 years on earth) product is growing rapidly and the problem is what to do with plastic-waste. Big attention is being focused on the environment and safeguarding of natural resources and recycling of wastes materials. Actually many industries are producing a significant number of products which incorporate scrap (residues). In the last 20 years, a lot of works concerning the use of several kinds of urban wastes in building materials industrials

process have been published. Many researchers have been extended to study new kinds of wastes to investigate deeply particular aspects The main aim of environmental protection agencies and governments is to find ways to minimize the problems of disposal and health hazards of these by-products. Plastic has become an inseparable and integral of our lives. Plastic have been used in packaging, automotive and industrial application, medical delivery systems, artificial implants and other uses. With so large and verifying application, plastic contributes to increasing of volume in the solid waste stream. The waste plastic collected from solid wastes is contaminated, assorted mixture of a variety of plastics. This make their identification, segregation and purification become very hard to do. Advantages of using waste or recycled plastics are it will help on reducing the municipal solid wastes being land filled and it became an alternative to pressure-treated lumber that leaches toxic chemical into water. There is many type of waste and recycled plastic that been used in concrete mix. The most common waste or recycled plastic is virgin polypropylene, recycled plastic (melted process), recycled plastic (automobile shredded residue) and recycle plastic (shredded) [2]The productive use of waste materials is one of the ways to alleviate some of the problems of solid waste management. There are several benefits of using waste materials. It helps people save and sustain industrial resources for which it is impossible to renew, as well as having an effect on decreasing the environmental pollution. Because of the environmental and economic reasons, currently there has been a growing trend for the use of the industrial wastes or the by-products as supplementary materials or as an admixture in the production of composite cement and concrete. Using industrial by-products in concrete will lead us to have sustainable concrete design and a greener environment.

A. Materials used in the present study

1) Cement: Ordinary Portland cement Zuari-53 grade conforming to IS: 12269-1987 [6] were used in concrete. The physical properties of the cement are listed in Table 1.

Table 1. Physical Properties of Zuari-53 Grade Cement

Sl no	1	2	3	4	5		
Properties	Specific gravity	Normal consistency	Initial setting time	Final setting time	Compressive strength (Mpa)		
Values	3.15	32%	60min	320min	3 days	7 days	28days
					29.4	44.8	56.5

2) Aggregates: A crushed granite rock with a maximum size of 20mm with specific gravity of 2.60 was used as a coarse aggregate. Natural sand from Swarnamukhi River in Srikalahasthi with specific gravity of 2.60 was used as fine aggregate conforming to zone-II of IS 383-1970 [7]. The individual aggregates were blended to get the desired combined grading.

3) Water: Potable water was used for mixing and curing of concrete cubes.

4) HDPE: HDPE was adopted to be the replacement material .This is because of easy availability of this material, its density and its
workability. Development of concrete with non-conventional aggregate such as polystyrene foam wastes, HDPE, PET and others plastic were used in concrete to improve the properties of the concrete and reduce cost. By using these plastic wastes in concrete its
will lead to sustain the concrete design and greener the environments.

Fig 1 HDPE

The sieve analysis is carried out for the hdpe to find out its fineness modulus. The results are listed in Table 2

Table 2 Sieve ananlysis of HDPE

SL no.	Sieve size	Mass Retained(gms)	%Retained	%passing	Cumulative %Retained
01	20mm	0	0	100	0
02	12.5mm	292.5	21.35	78.65	21.35
03	10mm	395	29.06	70.94	50.41
04	5.6mm	510	37.23	62.77	87.64
05	PAN	169	12.34	87.66	99.98

Fineness Modulus of bigger sized HDPE aggregate = 7.59

B. Mix Proportioning

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 M20grade controlled concrete and Different replacement levels of
HDPE plastic waste of all the mixes are tabulated in Table 3 & Table 4.

Table 3 Mix Proportion for M20 Concrete

Parameter	Different replacement levels of HDPE plastic waste				cement	Fine aggregate	Coarse aggregate	water
	Control Mix	5% (MIX 1)	10% (MIX 2)	15% (MIX 3)		20% (MIX 4)		
W/C Ratio	0.50	0.50	0.50	0.50		0.50		
Water Kg/m3	196.1	196.1	196.1	196.1		196.1		
Cement Kg/m3	382	383	383.0	383		383		
Fine Aggregates	664.04	664.04	664.04	664.04		664.04		

Kg/m3								
Coarse Aggregates Kg/m3	1090.74	1036.203	981.666	927.129				
Plastics Kg/m3 0	0	54.537	109.074	163.611				
Mix Proportions (C:FA:CA:P)	1 : 1.74:2.8:0	1 : 1.74: 2.66:0.14	1 : 1.74: 2.52:0.28	1 : 0.716 2.38:0.42				
Composition in Kg/m3					383	664.04	1090.74	196.1
Ratio in %					1	1.74	2.8	0.50

Table 4 Different replacement levels of HDPE plastic waste

II. RESULTS AND DISCUSSIONS

A. Dry Density

The dry density is measured for the cubes taken from the curing tank, just prior to compressive strength test. The value of dry densities obtained for the control mixes and for plastic concrete is shown in Table 5. It is found from the testing that the unit weight of there is considerable decrease in unit weight when compared with the control concrete without plastic replacement. Water cement ratio does not affect the unit weight that much but the quantity of plastic as aggregates can reduce the unit weight of concrete considerably. It is found that the plastics replaced with concrete reduces the unit weight of concrete and can be used as light weight concrete. For the accuracy of the results the minimum three samples of the control concrete and three samples of plastic replaced concrete were casted and tested and average of three are taken for the accuracy of results. The results of unit weight of control and plastic replaced concrete are shown in Table 5. In order to compare the effect of plastics with normal aggregates, the percentage reduction in the unit weight of concrete achieved by using plastics as aggregates is found and is presented in Table 5. It can be seen from the Table that with the use of plastics, the dry density is reduced for all mixes, at 0.50 water-cement ratio. The density is reduced for all the mixes.

B. Compressive Strength

The compressive strength test results for controlled concrete and different trial mixes were shown in Table 5. The tests were carried out as per IS: 516-1959.The150mm cubes of various concrete mixtures were cast to test compressive strength.The bar charts of compressive strength results for 7,21and 28 days are presented in Fig 2 also the dry density for various trial mixes are indicated in Fig 3.

Table 5. Compressive strength and Density test results of various Mix proportions

HDPE replacement levels	Compressive strength N/mm2			Density kg/m3
	7 DAYS	21 DAYS	28 DAYS	
Controlled Mix	16.4	18.47	21.66	2366
MIX 1	17.88	19.56	23.67	2342

MIX 2	17.49	18.98	22.12	2301
MIX 3	13.67	15.78	19.56	2296
MIX 4	10.54	14.1	17.78	2290

COMPRESSIVE STRENGTH, N/mm2

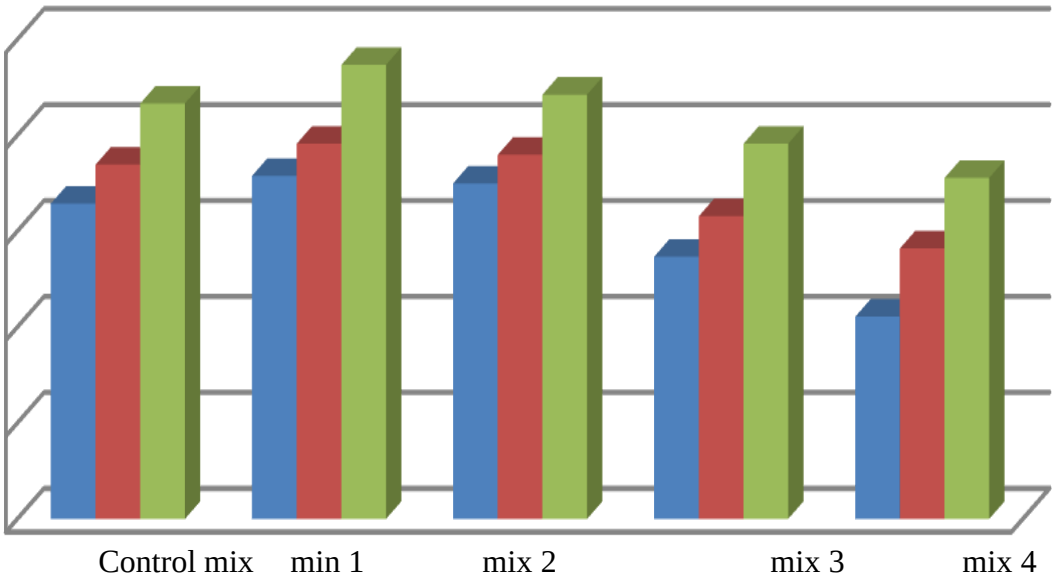

Fig 2 Variation of Compressive Strength at different Percentage replacements of HDPE

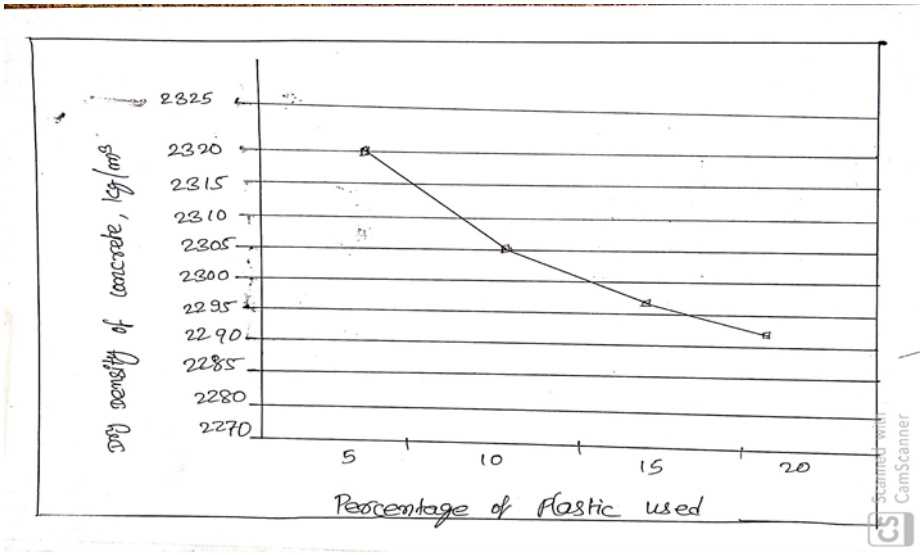

Fig 3 Percentage of Plastic used vs Dry Density (Kg/m3)

III. CONCLUSIONS

A. HDPE can be used to as partial replacement of coarse aggregate in developing concrete mixture. By making use of these
aggregates the overall unit weight of the concrete may be substantially reduced.
B. It is observed that there is increase in the compressive strength and density of concrete compared with the conventional
concrete at 5 % replacement. But with 10% to 20% HDPE plastic replacement there is gradual variation in the decreasing of
density and compressive strength.
C. So the experimental study reveals that 5 % of hdpe may be partially replaced with coarse aggregate in making concrete.
D. The lightweight concrete can be found suitable in applications requiring non-bearing lightweight concrete, such as concrete
panels.

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