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EXPERIMENTAL INVESTIGATION ON PARTIAL REPLACEMENT OF WASTE PLASTIC IN CONCRETE

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ABSTRACT

The use of plastic is increasing day by day, although steps were taken to reduce its consumption. This creates substantial garbage every day which is much unhealthy. A healthy and sustainable reuse of plastics offers a host of advantages. The suitability of recycled plastics as fine aggregate in concrete and its advantages are discussed here. The initial questions arising of the bond strength and the heat of hydration regarding plastic aggregate were solved. Tests were conducted to determine the properties of plastic aggregate such as density and specific gravity. As 100% replacement of natural fine aggregate with plastic fine aggregate is not feasible, partial replacement at various percentage were examined. The percentage substitution that gave higher compressive strength was used for determining the other properties such as modulus of elasticity, split tensile strength and flexural strength. Higher compressive strength was found with 10% natural fine aggregate replaced concrete.

KEYWORDS: Waste plastic fibers, workability, compressive strength, split tensile strength.

INTRODUCTION

Concrete is the most widely used man made construction material in the world. Seeking aggregates for concrete and to dispose of the waste from various commodities is the present concern. Today sustainability has got top priority in construction industry. In this study the recycled plastics were used to prepare the fine aggregates thereby providing a sustainable option to deal with the plastic waste. There are many recycling plants across the world, but as plastics are recycled they lose their strength with the number of recycling. So these plastics will end up as earth fill. In this circumstance instead of recycling it repeatedly, if it is utilized to prepare aggregates for concrete, it will be a boon to the construction industry.

The productive use of waste material represents a means of alleviating some of the problems of solid waste management .The recycle of wastes is important from different points of view. It helps to save and sustain natural resources that are not replenished, it decreases the pollution of the. Wastes and industrial by-products should be considered as potentially valuable resources merely awaiting appropriate treatment and application. Plastic wastes are among these wastes; their disposal has harmful effects on the environment due to their long biodegradation period, and therefore one of the logical methods for reduction of their negative effects is the application of these materials in other industries. Concrete plays an important role in the beneficial use of these materials in construction. Although some of these materials can be beneficially incorporated in concrete, both as part of the cementations binder phase or as aggregates, it is important to realize that not all waste materials are suitable for such use. The strength properties and modulus of elasticity of concrete containing various types of plastic aggregate are always lower than those of a reference concrete containing normal density natural aggregate only, and they further decrease with increasing plastic aggregate content in concrete. Concrete containing plastic aggregate can stop or divert the propagation of micro cracks and improve concrete toughness, which is of great practical significance.

The use of plastic waste as a natural aggregate substitute in concrete is a relatively recent concept. One of the first significant reviews on the use of waste plastic in concrete focused on the advantages and financial benefits of such use, besides their physical and mechanical properties. And more over use of plastic as aggregate gives a solution to the problems encountered with the quarrying of natural aggregate. The main objective of this investigation is to study strength properties after partially replacing fine aggregate with plastic .In this project we made M30 grade concrete with w/c of 0.40. Workability, dry density properties, compressive strength, tensile strength, flexural strength were studied.

LITERATURE REVIEW

Simiha Akcozoglu (2009) had made investigation by using PET plastic, concluded that use of shredded PET granules due to its low unit weight reduces the unit weight of concrete which results in reduction in dead weight of building will help to reduce the seismic risk of building the earth quake forces linearly dependent on dead weight .

Mariaenrica Frigione (2010) had conducted an investigation on using recycled PET bottles as fine aggregate in concrete and concluded the workability, compressive strength, split tensile strength is slightly lower than referenceconcrete and moderately higher ductility.

Semiha Akcaozoglu (2011) had conducted an investigation on mortars by using PET as aggregate and studied the effect of Granulated Blast Furnace Slag , Fly ash on light weight mortars and concluded that the use of fly ash has decreased compressive strength ,flexural strength , tensile strength when compared to cement specimens .Both Granulated Blast Furnace Slag and fly ash increased carbonation depths of specimens .For this reason carbonation reducing measures must be taken when using these mineral admixtures .

R.V.Silva (2012) had conducted an investigation on concrete containing paste waste as aggregate and influence of curing conditions on the durability related performance of concrete. He concluded that workability decreases with increasing amount of coarser ,flakier and irregular shaped plastic aggregates. The gap between these values widened as all concrete specimens wore cured in progressively drier environments with reductions varying between 11.1%,28.3% of coarser plastic aggregate specimens cured .

Brahim Safi (2013) had conducted an investigation by using plastic waste a fine aggregate in self compacting mortars. Concluded that this plastic waste type can be used successfully as fine aggregate in self compacting mortars (or concrete). Fluidity is significantly improved by the presence of these waste. Reduction in Compressive strength was between 15 % and 33% for mortar containing 20 % to 50% plastic waste.

B.Harini and K.V.Ramana (2015) had conducted experiments on strength properties of M30 grade concrete are studied with different plastic percentage proportions. The various plastic proportions are5 %,6%,8%,10%,15%,20% by volume There is decrease in compressive strength when the ratio of plastic to aggregate was increased . For which compressive strength was least and to that mix have partially replaced cement with silica fume of 5%,10%,15% by weight. The strength properties were again studied, It was noticed that when cement was partially replaced by 10%, 15% of silica fume was higher than reference mix.

DESCRIPTION OF PLASTIC

The majority of worlds PET (polyethylene Terephthalate) production is for synthetic fibers (in excess of 60%), with bottle production accounting for about 30% global demand. PET consists of polymerized unit of the monomer ethylene Terephthalate, with repeating ($C_{10}H_8O_4$) units. Depending on its processing and thermal history, polyethylene Terephthalate may exist both as an amorphous (transparent) and as a semi crystalline polymer.

OBJECTIVES

The primary objective of this study is to evaluate the possibility of using plastic aggregate as coarse aggregate in concrete. Specific objectives of this work include:

To prepare plastic aggregate of 20mm size.

To determine the properties of plastic aggregate.

To conduct a comparative study of plastic aggregate and natural aggregate.

To study the effect of replacing natural aggregate with plastic aggregate on workability, compressive strength, splitting tensile strength and flexural strength of concrete.

To study the effect of replacing natural aggregate with plastic aggregate on weight of concrete.

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To find the optimum replacement of natural aggregate using plastic aggregate.

METHODOLOGY

The successive steps that were followed to complete the study were as follows:
Preparation of recycled plastic aggregate.
Various tests were conducted on cement, fine aggregate and coarse aggregate to determine its physical properties
a.Test on Cement: Specific gravity, standard consistency, initial and final setting time,
compressive strength of mortar cube.
b.Test on aggregates: Specific gravity, sieve analysis.
Mix design of M20 grade concrete.
Cubes, cylinders and beams were casted with control mix using natural aggregate. Cubes, cylinders and beams were casted for varying percentage replacement (5, 10, 15 and 20%) of natural aggregate by plastic aggregate.
Workability, compressive strength, splitting tensile strength and flexural strength tests of concrete were conducted.
Optimum percentage of plastic aggregate that can be replaced in concrete was determined.

MATERIALS AND THEIR PROPERTIES

The materials used in this investigation are
1. OPC 53 grade cement confirming IS 12269:1987
2.. Silica Fume confirming ASTM C1240 and IS 15388:2003
3. Natural river sand
4. Recycled PET Plastic
5. Coarse aggregate
6. Water

Cement

The fineness of cement is 3%, specific gravity of cement is 3.13, standard consistency of cement is 31%, Initial setting time is 60 minutes and final setting time is 250 minutes.

Fig. 1. Cement

Plastic

Plastic used in this investigation is PET (polyethylene Terephthalate) .The water absorption capacity is 0.12%, specific gravity is 1.32, size is below 4.75 mm,

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Table1. Properties of PET Bottle

Properties	PET Bottle
Chemical formula	$C_8H_{10}O_4$
Specific gravity	1.45
Melting point	250^0C- 260^0C
Water absorption	0.10%
Density (g/ cm^3)	0.95

Fig.2:Waste PET bottle

Natural river sand

Uncrushed natural river sand is used as fine aggregate in this investigation .As per IS 383:1970 fine aggregate properties were tested and concluded that the fine aggregate in this investigation falls in zone-II .The water absorption capacity is 1%, fineness modulus is 2.60, specific gravity is 2.65.

Fig. 3: Sand

Coarse Aggregate

As per IS 383:1970 the nominal size is 20 mm is used. The shape of coarse aggregate is angular, water absorption capacity is 0.5%, fineness modulus is 4.60. The Specific gravity is 2.73.

Experimental Results

Mix proportion The mix design was made confirming IS 10262:2009 .Ten mixes were made in this investigation including reference mix other than the reference mix ,the mixes were made by partially replacing plastic to fine aggregate of percentage 5%,10%,15%,20%. .The w/c ratio is 0.50.

Table 2. Mix design

Mix name	Weight of cement	Weight of sand	Weight of coarse aggregate	Weight of plastic
A (5%)	18.65	26.55	55.95	1.40
B (10%)	18.65	25.14	55.95	2.79
C (15%)	18.65	23.75	55.95	4.19
D (20%)	18.65	22.35	55.95	5.59

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Fig. 4. Casting

RESULT AND DISCUSION

WORKABILITY

In this investigation workability was measured in terms of slump. The slump results are shown in table 3.From the result it is observed that Slums increases when workability increases.

Table3. Workability of the concrete

Percentage replacement	Slump(mm)
5	26
10	21
15	17
20	13

COMPRESSIVE STRENGTH TEST

After curing the cubes for 28 days period, they were uncovered in readiness for compression test. The cube were then placed with the cast faces in contact with the platens of the testing machine that is the position of the cube when testing should be at right angle to that of casting. The load was then gradually applied until failure occurred, that is the cube crashed. It is seen from the Tables that the compressive strength is increased by 26% of 10% replacement. It is well established that addition of glass waste fibres contributes up to 10% replacement and do not contribute much to improvements in the compressive strength beyond 15% replacement of concrete. The results of the present study also indicate the same.

Table 4. Compressive strength of the concrete

Percentage replacement	Compressive strength(Mpa)
5	29.3
10	26.2
15	18.67
20	13.33

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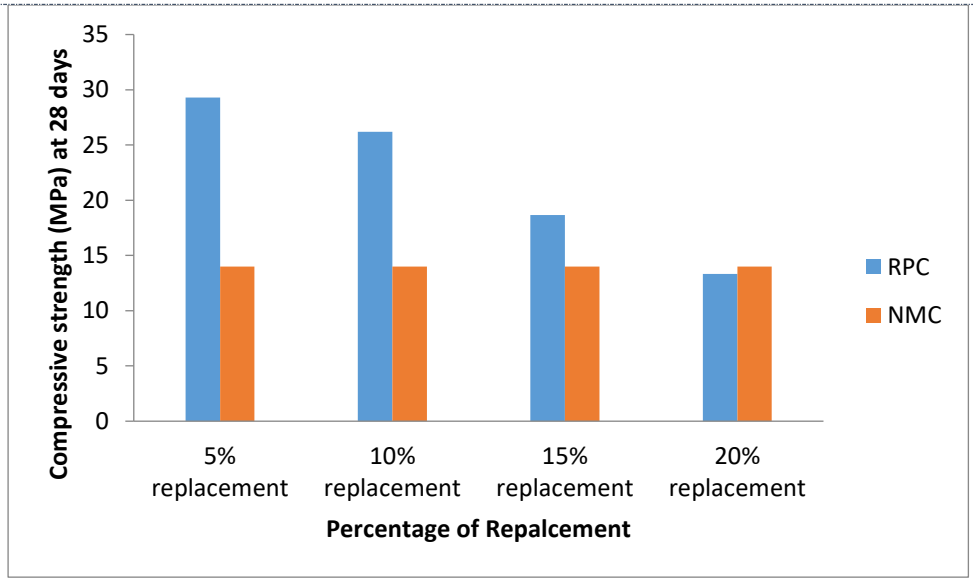

Fig. 5:Compressive strength on Concrete cubes

TENSILE STRENGTH

To understand the influence of the replacement percentage of fine aggregate with plastic aggregate at 28 days on tensile behavior of concrete, the concrete specimens were tested under split tensile test, the experimental results are presented in table 5. The graphical representation of compressive and split tensile strength is shown in Figure 5 and Figure 6. Split tensile strength of waste plastic fiber concrete specimen is 6% more than plain concrete of 5% replacement. Generally, it should be borne in mind that the flexural strengths are increased to the tune of 20-25% with the addition of steel fibers. However, the present fibers, being obtained from domestic waste do not exhibit appreciable improvements in the flexural strength of concrete as in the case of steel fibers.

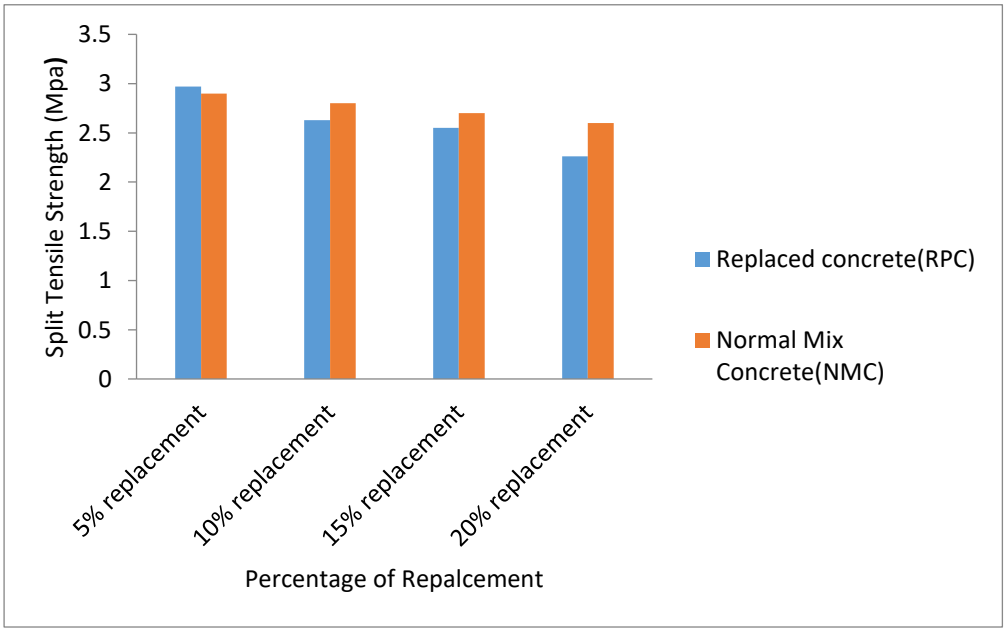

Fig. 6: split tensile strength on Concrete cubes

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Table5. Tensile strength of the concrete

Percentage replacement	Tensile strength
5	2.97
10	2.63
15	2.55
20	2.26

CONCLUSION

[1] As percentage of plastic increases workability also increases because the plastic which is used as aggregate is smooth .As well as water absorption capacity of plastic is also low.
[2] The modified concrete mix, with addition of plastic aggregate replacing conventional aggregate up to certain 10% gives strength with in permissible limit.
[3] The flexural strength at each curing age is prone to decrease with the increase of the waste plastic and aggregate ratio. This trend can be attributed to the decrease in adhesive strength between the surface of waste plastic particles and the cement paste .
[4] The density of concrete decreased when plastic content increased.
[5] Because plastic has more water tightness capacity when compared to natural aggregate this can help in arresting micro cracks.
[6] By using recycled waste plastic in concrete can reduce the land fill and environmental issues.
[7] This type of aggregate replacement is useful where aggregates are in crisis .By this we can conserve natural resources.

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