Studies on Mechanical Properties of Plasti-Fibre Reinforced Concrete

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Abstract:

The most commonly used construction material across the world is concrete. The construction industries are looking for making it "greener" by reducing its ecological effects on environment and they are in need of finding cost effective materials for increasing the strength of concrete structures. On the other hand, the non-recyclable pollutants like plastics, rubber, tin, etc. come out from the industries results in an increasing environmental threat. So the use of non-recyclable materials for preparation of concrete can be an encouraging act. Utilization of waste materials and byproducts can be a partial solution to environmental and ecological problems. Use of these materials not only helps in getting them utilized in cement concrete and other construction materials, but also helps in reducing the cost of cement and concrete manufacturing. It has also numerous indirect benefits such as reduction in landfill cost, saving in energy, and protecting the environment from possible pollution effects. The use of plasti-fibre in cement concrete has not yet been investigated. This paper covers the mechanical properties of plasti-fibre reinforced concrete (PFRC) prepared from hand shredded plasti-fibres consisting Polyethylene plastic bags of 40 microns and PET bottles. The compressive strength and flexural strength of normal M20 grade PFRC were evaluated after 7days, 14days & 28days and compared with the conventional concrete i.e., normal M20 mix (1:1.5:3) by adding the plasti-fibre by 0.2% & 0.4% of total weight of concrete (30kgs) that has been the aim of this research work. The main findings of this investigation revealed that the plastic waste materials could be used successfully as an addition to concrete composites. Due to exceptionally low density, recycled polymer modified blocks and concrete can be used in non-load bearing structures, floating structures and where lightweight materials recommended.

Keywords- concrete, plasti- fiber concrete, fiber reinforced concrete, recycled material concrete

I. INTRODUCTION

Concrete is the most commonly used construction material. Its usage by the communities across the globe is second to water. Due to its durability, longevity, and versatility, concrete is well-suited for broad construction applications under diverse loading and exposure conditions. Unfortunately, it is a relatively brittle material and is inherently weak in tension.

On the other hand, plastic possess high tensile strength and durability.

Most of the plastic is non- biodegradable waste which leads to serious environmental threats.

Plastic pollution can unfavorably affect lands, waterways and oceans. Living organisms, particularly marine animals, can also be affected through entanglement direct ingestion of plastic waste, or through exposure tochemicals within plastics that cause interruptions in biological functions. Humans are also affected by plastic pollution, such as through the disruption of the thyroid hormone axis or hormone levels.

The rapid urbanization and industrialization all over the world has resulted in large deposition of waste polymer materials. The world's annual consumption of plastic materials has increased from around 5 million tons in the 1950s to nearly 100 million tons in 2001. The annual plastic consumption in the United States is more than 11 million tons and 80% of the post-consumer plastics are sent to landfills, 8 % is incinerated and only 7% is recycled while, in UK, the amount of plastic waste generated was about 3 million tons in 2001 of which, only 7 % was recycled. According to a recent survey the plastic consumed by India in the year 2013-2014 was found to be approximately 10.5-11 million metric tons. The plastic consumption is expected to be 20 million metric tons by 2020. Since the recycling cost of plastics is more than the manufacturing cost of virgin plastics, nearly 93% of total plastics manufactured are dumped on landfills.

Taking into account that concrete will continue to be the main construction material in the future, several research projects have showed that it was possible to use plastic waste in concrete. Thus it is highly efficient and sustainable to use plasti-fibres in concrete which in turn enhances the mechanical properties and shear capacity of concrete. In India, domestic waste plastics are causing considerable damage to the environment and hence an attempt has been made to understand whether they can be successfully used in concrete to improve some of the mechanical properties as in the case of the steel fibres.

II. PAST RESEARCH

Konin A [1] has studied the effect of plastic waste content on Physico-Mechanical properties of flexible pavement.

The author reports that the use of plastic waste enhances abrasion resistance and slip resistance up to 20% while reducing porosity which is less than 5% of for the pavements, along with it the relationship between content of plastic waste with that of splitting tensile strength and abrasion resistance is also presented.

Md. MostafizurRahman [2] has partially replaced aggregates for concrete with three types of recycled waste polymeric materials namely expanded polystyrene (EPS) based packaging waste, high density polyethylene (HDPE) and vehicle tire. The authors assess the mechanical, physical and morphological properties of the modified concrete and have reported that the inclusion of waste polymer materials decreases compressive strength, density, porosity and water sorption properties.

Lakshmi R [3] has observed gain in compressive strength, tensile strength and flexural strength of concrete with E plastic waste as coarse aggregates. On the contrary, A.A., Al-Manaseer [4] reports decrease in mechanical properties of concrete with increase in percentage of post consumed plastic waste as coarse aggregates.

The past literatures deal with plastic waste as a replacement for aggregates in concrete or a binder for flexible pavements. The type of plastic waste employed were from poly ethylene teraphthalite (PET) or E waste or granular plastic. The past research encourage that the recycled plastics can be use in concrete for improving its property. The use of plastics in fiber form has given better results than granule forms. The aim of this paper is to explore the possibility of using a waste material like used mineral water bottles in concrete and compare compressive strengths & flexural strengths. The current paper covers also the use of plastic covers of 40 micron as fibre in concrete.

III. EXPERIMENTAL INVESTIGATION

A. *Materials Used*

1) *Cements & aggregates:*

53 grade Ordinary Portland cement conforming to IS 12269:1987 with specific gravity 3.15 was used. River sand and the locally available blue granite crushed stone aggregates of size 20mm were used as fine aggregates and coarse aggregates respectively in the present investigation. Their physical properties (Table 1) like specific gravity, bulk density, percentage of water absorption and fineness modulus were tested in concurrence with IS: 2386:1963.

Type	Fine aggregate	Coarse aggregate
Specific gravity (SSD)	2.67	2.6
Fineness modulus	2.36	4.81
Water absorption (%)	0.5	1.21
Bulk density (SSD),kg/m^3	1628	1562

Table 1: Physical Properties of Aggregates

2) *Water*

Potable water was adopted as the liquid for mixing and curing of specimens throughout the experimentation.

3) *Plasti-Fibre:*

Plasti-fibres were prepared from Polyethylene (PE) bags of 40 microns and PET bottles. The plasti-fibres were hand shredded to a size of 10mm x 50mm which comprised of PE bags and PET bottles in the ratio of 1:4. The plasti-fibres were added to concrete at dosages of 0%, 0.2% and 0.4% by weight of concrete (30kgs) to form the plasti-fibre reinforced concrete (PFRC).

Figure 1: Polythene Bags of 40 Microns & PET Bottles

B. *Mix Design*

Based on the trial mixes the final design mix was prepared for M20 grade of concrete as per IS 10262:2009 [8] and IS: 456:2000 as shown in Table 2. The plasti-fibers were added into dry mix of concrete in the percentages of 0%, 0.2% & 0.4% by weight of concrete (30kg).

Specimen	OPC	FA	CA	Water
Control	1	1.79	2.92	0.5
PF 0.2%	1	1.79	2.92	0.5
PF 0.4%	1	1.79	2.92	0.5

Table 2: Mix Proportions

C. Preparation of Test Specimens

Standard steel moulds were used for casting cubes of size 150mm x 150mm x 150mm. and prisms of size 150mm x 150mm x 700mm. Total Nine cube specimens and three prism specimens were cast where for each mix consists of three cubes and each prism for each mix. The concrete mixes obtained by means of tilting type drum mixer & were placed uniformly in three layers and each layer was well compacted using ramming rod. The finishing of top surface was carried out with trowel. These specimens were demoulded 24 hours after casting and were cured under water until the age of testing.

D. Test for Mechanical Properties

The compression test, flexural test and split tensile tests were carried out as per IS516:1959 [8] and IS5816:1999 [9].

1) Compressive Strength

Compressive Strength test was performed in a universal testing machine of 2000 KN capacity at the age of 7, 14 and 28 days respectivelyas per IS516:1959 [9] and IS5816:1999 [10].

2) Flexural Strength

Flexural Strengthtest was performed by subjecting the prism to two point loading on a compression testing machine of 2000 KN capacity at the age of 28 days as per IS516:1959 [9] and IS5816:1999 [10].

IV. RESULTS & DISCUSSION

A. Compressive Strength:

Specimen	Compressive Strength (MPa)		
	7th day	14th day	28th day
Control	20.1	28.2	31.11
PF 0.2%	21.44	29.64	32.2
PF 0.4%	18.33	25.2	27.7

Table 3: Compressive Strength at Various Ages

PFRC cubes were found to show increase in compressive strength compared to control concrete. At the age of 7,14 and 28 days the compressive strength of control mix were found to be 20.1N/mm^2, 28.2N/mm^2& 31.11N/mm^{2}respectively whereas the compressive strength of PFRC with dosage of 0.2% and 0.4% of plasti-fibres were found to be 21.44N/mm^2, 29.64N/mm^2, 32.2N/mm^2 and 18.33N/mm^2, 25.2N/mm^2, 27.7N/mm^2 respectively. At the age of 7 days, 14 days and 28days the compressive strength of PFRC with 0.2%of plasti-fibres were found to increase by 6.25%, 4.86% and 3.4% respectively whereas the

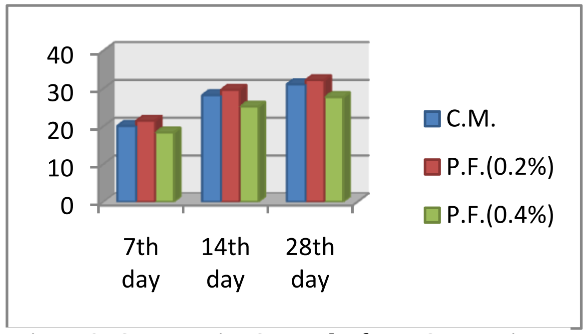

Figure 2: Compressive Strength of PFRC at Various Ages

compressive strength of PFRC at the age of 7days, 14days and 28days with 0.4% ofplasti-fibres were found to decrease by 8.8%, 10.64% and 10.96% respectively than the control concrete. Hence itis observed that the PFRC showed decrease in compressive strength with increase in dosage of plasti-fibres as observed by RaghatateAtul M [11]. This may be due to the lack of bonding between the plasti-fibres and concrete. Also the cracking pattern observed from Figure 10 shows that the fibres present in the cubes prevent shattering and spilling of concrete under compressive stress to a great extent.

C.M. (0.0% PF) 0.2% PF 0.4% PF

Figure 3 : PFRC Cubes After Compression Test

E. Flexural Strength:

The flexural strength values of the PFRC at the age of 28days with 0.0%, 0.2% and 0.4% are given in Table4 as 4.32 N/mm^2, 4.51 N/mm^2, and 3.48 N/mm^{2}respectively which has increased by 4.2% and decreased by 19.44% on addition of 0.2% & 0.4% of plasti-fibres respectively.In similar to results reported by Zainab Z. Ismail [12] who partially replaced fine aggregates with granulated plastic waste, flexural strength decreased with increase in dosage of plasti-

Specimen	Flexural Strength F_{cr}(MPa) at the age of 28th day
Control	4.32
PF 0.2%	4.51
PF 0.4%	3.48

Table 4: Flexural Strength at 28th day

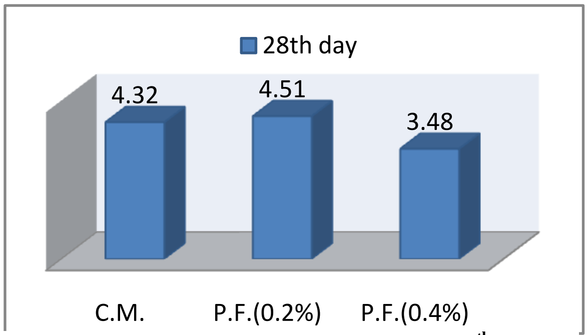

Figure 4: Flexural Strength of PFRC at 28th day

fibres which may be due to the lack of bonding between the concrete and plastic as the flexural strength was observed to follow the same trend of the compressive strength,. Also the theoretical flexural strength was calculated as per IS456:2000 [13] clause 6.2.2 and the theoreticalresults were found to be compatible with the experimental results.

V. CONCLUSION

1. The use of unmanaged or non-decomposable plastics in concrete mixtures as fibers has not only paved way for its safe disposal method but also it has enhanced the mechanical properties of concrete.

2. The compressive strength and flexural strength of M20 grade PFRC prepared from hand shredded plasti-fibres of size 10mm x 50mm consisting Polyethylene plastic bags of 40 microns and PET bottles in the ratio of 1:4 were evaluated and compared with the conventional concrete.

3. At the age of 7days, 14days and 28days the compressive strength of PFRC was found to increase by 6.25%, 4.86% & 3.4% and decrease by 8.8%, 10.64% & 10.96% on addition of 0.2% and 0.4% plasti-fibres by weight of concrete(30kgs) respectively.

4. At the age of 28days the flexural strength was found to increase by 4.2%, and decrease by 19.44%on addition of 0.2% and 0.4% plasti-fibres by weight of concrete (30kgs) respectively.

5. It was observed that increase in the dosage of plasti-fibre decreased the compressive strength and flexural strength of PFRC which was due to the lack of bonding between the concrete and plasti-fibres.

Hence, the use of non-decomposable plastics as plasti-fibres in concrete enables a march towards sustainability via efficiently and qualitatively improved concrete.

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