Strength Study On Concrete With Polyethylene Terephthalate Fibre

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ABSTRACT

Concrete, one of the major pollutants in the construction field to be made green is the need of the hour. Though concrete is largely used, its lifetime has become a huge concern due to the cracks produced in it as a result of shrinkage. The addition of fiber into the concrete has been found to improve several of its major properties like tensile strength, cracking resistance, impact, wear and tear, ductility etc as concrete is very much weak in tension which readily undergoes cracking. To resolve these problems and to make the concrete eco-friendly, waste plastic fiber can be employed in concrete in the name of Plastic Fiber Reinforced Concrete (PFRC). As far now, papers have been surveyed on concrete reinforced with plastic fiber such as polyethylene, polypropylene, polyvinylchloride, polyethylene terephthalate(PET). Regarding the domestic consumption of plastics these many years, PET stands first and therefore the use of concrete reinforced with recycled PET fiber as a construction material can be suggested. In future, we are going to propose and investigate the effect of the addition of various percentages of PET strips in the form of mesh in the plastic concrete.
Keywords: Concrete, PET, waste, Plastic,Fiber.

1. INTRODUCTION

1.1 General

Concrete is a versatile material in civil engineering construction. The properties of concrete are mainly affected by its ingredients. Concrete is strong in compression butweak in tension and a brittle one. The fiber act as micro crack arrester in cement composites. Many commercial fiber like steel, carbon, glass etc. are used as an addition or are placement in the concrete to increase the strength. But use of steel and carbon fiber in concrete may be quite expensive when used in a large scale. So, usage of any waste products in concrete will enhance to reduce the cost as well as the environmental degradation.

It is well known that the incorporation of low volume fractions (0.05 to 0.5%) of low-modulus synthetic fiber in concrete does not lead to increased strength, but it does enhance the cracking properties, fracture toughness and impact resistance of the material. Polyethylene terephthalate (PET)fiber, which are formulated and produced specifically for reinforced mortars and concrete, are the most popular because they are cost competitive and alkali resistant; moreover, at low volumes, no additional care is required in mix proportioning and the manufacturing technique. In addition, properties of polyethylene terephthalate (PET)-fiber-reinforced concrete can be significantly improved. Polyethylene terephthalate (PET) fiber in concrete can be used to reduce spalling and to enhance the residual strength of heated concretes. Mixtures containing between 0.2 to 0.5 vol.% polyethylene terephthalate (PET)fiber were generally characterized by an increase in compressive strength, whereas with 0.5 vol.% fiber, the compressive strength of fibrous specimens at the age of 91 days increased by 15% compared with those of the reference sample. Industrial processes generate many residues and by-products, such as the waste obtained from recycled bottles composed of polyethylene terephthalate (PET) strings. These PET strings are collected, selected, and used for PET fiber production. The remaining portion of the strings can be industrially cut to form short, multi-filament-type fiber (approximately 30μm in diameter) for use in concrete as a substitute for polyethylene terephthalate (PET) and asbestos fiber. This type of material contributes to the sustainable development of the construction industry through recycling and the production of lower cost materials. These fiber are used with the aim of increased fracture toughness after concrete hardening According to Johnston, the durability of polyester in Portland-cement-based material is doubtful and controversial. Balaguru and Slatum performed flexural toughness measurements of polyester-fiber-reinforced concrete and concluded that polyester fiber are not durable in the alkaline environment of concrete. Wang et al.and Houge tobserved that polyester fiber lose strength rapidly in the cement matrix due to their hydrolysis and dissolution in an alkaline environment. Silva concluded that recycled PET fiber interact with $Ca(OH)_2$and Lawrence solutions, their surface becomes rough and phases identified as alkaline terephthalates precipitate. In this work, the tested amount of PET fiber (0.4 and 0.8 vol.%) had no effect on the compressive, tensile or flexural strength of the mortars or their degradation inside the composite; however, the fracture toughness of the mortars in flexural tests increased when fiber were introduced. However, due to the degradation of the fiber inside the mortars, the toughness decreased with time.

In their recent study, won et alverified that recycled PET-fiber-reinforced cement composites exhibit a reduced compressive strength in alkaline and sulfuric acid environments. They concluded that when a recycled PET-fiber-reinforced cement composite was exposed to an alkaline environment, progressive deterioration was observed on the PET fiber surface as the aging time increased. If the recycled PET fiber is exposed to an alkaline environment, its performance can be expected to be poor; when recycled PET-fiber-reinforced cement composite was exposed to salt or sodium sulfate environments, very little deterioration of the PET fiber surface occurred, and this deterioration did not progress with aging time. The reduction in the observed mechanical properties yielded values similar to those of the reference concretes, not indicating, according to the authors, fiber deterioration.

The problem of fiber durability is complicated because polyesters are a large polymer family and not all of them appear to be subject to alkali attack. Moreover, studies of their stability in Portland cement matrix are scarce. The research reported herein focuses on the properties of recycled-bottle PET-fiber-reinforced concrete that are susceptible to the eventual long-term degradation of these fiber. These properties include impact resistance, flexural load-deflection behaviour and porosity. Scanning electron microscopy (SEM) observations were also performed. Other mechanical properties that are less affected by the PET fiber, such as the compressive and tensile strengths and the modulus of elasticity, are also discussed. Additional properties, such as specific gravity, water absorption, and natural carbonation depth, can be found elsewhere because they were not significantly affected by PET fiber addition nor did they provide evidence of PET fiber degradation in concretes.

1.2 Objective Of the Study

Specific objectives of this work include,

- To determine the properties of plastic fiber.
- To conduct a comparative study of plastic pet fiber and sand.
- To find the optimum percentage of replacement of sand using Plastic pet fiber.

1.3 Scope Of the Study

Disposal of solid waste has been a challenge for decades and one of the main pollutants is plastic. Though various measures are taken to avoid the usage of plastics, it cannot be controlled entirely. Hence, innovative ideas for replacing plastics are used to manage plastic waste disposal. Also, Sand is the most important material used in concrete. It is used as a filling material. But excessive usage of natural sand has resulted in depletion of natural resource. But in order to solve this issue plastic fiber is used as a partial replacement of sand. So, the usage of the waste materials serves a dual role by minimizing the usage of raw material of concrete and by using the waste materials that are affecting the environment. The other advantage of using these waste materials is that they are helping in improving the properties of concrete.

2. METHODOLOGY

Figure 1 shows the methodology of the study.

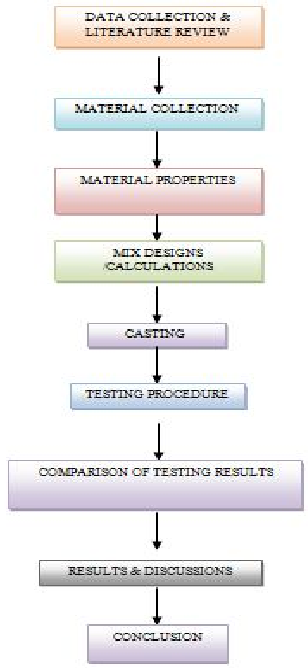

Figure 1 Methodology

3. MATERIALS COLLECTION

3.1 Cement

The cement used was ordinary Portland cement 53 (OPC 53).All properties of cement were determined by referring IS 12269 - 1987. The specific gravity of cement is 3.15. The initial and final setting times were found as 55 minutes and 258 minutes respectively. Standard consistency of cement was 30%. Cement is one of the binding materials in this project. Cement is the important building material in today's construction world. 53 grade Ordinary Portland Cement (OPC) conforming to IS: 8112-1989.

3.2 Coarse Aggregate

20mm size aggregates-The coarse aggregates with size of 20mm were tested and the specific gravity value of 2.78 and fineness modulus of 7 was found out. Aggregates were available from local sources. Locally available crushed blue granite stones conforming to graded aggregate of nominal size 20 mm as per IS: 383 – 1970.Crushed granite aggregate with specific gravity of 2.77 and passing through 4.75 mm sieve and will be used for casting all specimens. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

3.3 Fine Aggregate

The sand which was locally available and passing through 4.75mm IS sieve is used. The specific gravity of fine aggregate was 2.60. Locally available river sand conforming to Grading zone I of IS: 383 –1970.Clean and dry river sand available locally will be used. Sand passing through IS 4.75mm Sieve will be used for casting all the specimens.
Fine aggregate" is defined as material that will pass a No. 4 sieve and will, for the most part, be retained on a No. 200 sieve. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.

3.4 Water

Water: Generally, water that is suitable for drinking is satisfactory for use in concrete. Water from lakes and streams that contain marine life also usually is suitable. When water is obtained from sources mentioned above, no sampling is necessary. When it is suspected that water may contain sewage, mine water or waste from industrial plants or canneries, it should not be used in concrete unless tests indicate that it is satisfactory. Water from such sources should be avoided since the quality of the water could change due to low water or by intermittent discharge of harmful wastes into the stream. In the present experimental programme, potable tap water is used for casting It should be free from organic matter and the pH value should be between 6 to 7.

3.5 Polyethylene Terephthalate Fiber

Polyethylene terephthalate commonly abbreviated PET, PETE, or the obsolete PETP or PET-P, is the most common thermoplastic polymer resin of the polyester family and is used in fiber for clothing, containers for liquids and foods, and thermoforming for manufacturing, and in combination with glass fiber for engineering resins.
The majority of the world's PET production is for synthetic fiber (in excess of 60%), with bottle production accounting for about 30% of global demand. In the context of textile applications, PET is referred to by its common name, polyester, whereas the acronym *PET* is generally used in relation to packaging. Polyester makes up about 18% of world polymer production and is the fourth-most-produced polymer after polyethylene (PE), polyethylene terephthalate (PET) (PP) and polyvinyl chloride (PVC). Figure 2 shows the Fiber of PET.

Figure 2 Fiber of PET

4. MATERIALS PROPERTIES

4.1 Cement

Ordinary Portland cement (OPC) of 53 grade, satisfying the requirements of IS 12269-2013 has been used to produce control mix. The physical properties of the cement were measured as per BIS 4031- 1988 & 1999 and the results are summarized in Table 1.

Table 1: Properties of Cement

S.No	Description	Test Result
1	Specific gravity of cement	3.15
2	Fineness of cement	1.17
3	Standard consistency of cement	30%
4	Setting time Initial setting time Final setting time	33 min 310 min
5	Soundness of cement	2.2mm

4.2 Coarse Aggregate

Locally available hard granite broken stones of 20 mm maximum size coarse aggregate were used in the present work. The result shows that the characteristics of aggregates are in conformity with the requirements prescribed by BIS 383-1970 (reaffirmed 2011). Table 2 shows the test result of coarse aggregate.

Table 2:Test Result of Coarse Aggregate

S. No	Description	Test Result
1	Specific gravity	2.7
2	fineness modules	7.419
3	water absorption	0.8
4	Impact value	10.9
5	Crushing value	26.2
6	Abrasion value	35.24
7	Flakiness index Elongation index	11.84 16.92
8	Density of coarse aggregate Loose bulk density Rodded bulk density	 1413 kg/m^3 1450 kg/m^3

4.3 Fine Aggregate

Clean and dry river sand available locally will be used. Sand passing through IS 4.75mm Sieve will be used for casting all the specimens. Table 3 shows the properties of fine aggregate.

Table 3: Properties of Fine Aggregate

S.NO	Properties	Value
1	Specific Gravity	2.65
2	Fineness Modulus	2.25
3	Water absorption	0.5%

4.4 Properties Of PET

Itis a hard, stiff, strong, dimensionally stable material that absorbs very little water. It has good gas barrier properties and good chemical resistance except to alkalis. Its crystallinity varies from amorphous to fairly high crystalline. Polyethylene terephthalate can be highly transparent and colourless but thicker sections are usually opaque and off-white. The strain-hardening response is always associated with high performance fiber reinforced composites in which coarse aggregates are completely eliminated. It was found that concrete in the presence of PVA fiber attained strain-hardening response with a drop in the load up to 50% of the peak load and the strain capacity of about 2% under direct tension. The post-cracking relation based on single fiber pull-out test closely matches the results of direct tension test.

The mechanical properties of polystyrene are low elongation at break and heat resistance, good electrical insulating features, not suitable for high centrifugal forces. The maximum usage temperature of these glasses is 75-80^o C and its density ranges 1.05 gms/cm^3. These glasses are inflammable and the general chemical resistance are salt solutions, non-oxidizing acids as well as alkaline and alcohols, fuel, etheric oils, strong oxidizing agents and aromatic substances lead to the formation of cracks. The concrete reinforced with circular PET fiber and long strips are having more ductile behaviour and high concrete-PET adherence.

Disposal of polystyrene is a pure hydrocarbon compound and thus environmentally neutral during disposal. Incineration does not yield any harmful substances. It has Good mechanical characteristics, which make it suitable for structural uses such as concrete reinforcement with specific gravity of 0.000138 g/cm^2. A great benefit in the use of PET is given by its durability, which is one of the major concerns about concrete: the corrosion of steel bars (due to several reasons) is the main cause of concrete deterioration; therefore, PET may become fundamental to tackle with this problem and to increase the durability of reinforced concrete and structural elements in concrete.
Differences in the size, shape and texture of PET-aggregates affect the water to cement ratio as well as the slump of fresh concrete mixes, which ultimately change the mechanical behaviour. Accordingly, the fiber-reinforced specimens were found to be much more ductile than unreinforced specimens, which is highly desirable in many backfill applications. Table 4 shows the properties of PET fiber.

Table 4: Properties of PET Fibre

S.NO	Properties	Value
1	Length (mm)	30mm
2	Diameter (mm)	2mm
3	Aspect ratio	15
4	Specific gravity	1.38
5	Density (kN/m^3)	13.57
6	Water Absorption (%)	0.10%

5. MIX DESIGN

5.1 Mix Design for M_{30} Grade

Mix design for M30 grade concrete by Indian Standard recommended method of concrete mix design as per design code IS: 10262-2009.The details of mix proportions are given in Table 5.

Table 5: Mix Proportion of Materials

Cement	Fine aggregate	Coarse aggregate	Water
330	789.7	1206.9	150
1	2.4	3.65	0.45

Table 6 shows the fiber material required.

Table 6: Fibre material required

S. No	% Of Fiber	Weight in Kg/m^3
1	0%	0
2	2.5%	8.5
3	5%	16.5

6. TESTING PROCEDURE

6.1 Slump Test

Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete. It does not measure all factors contributing to workability of the concrete. Table 7 shows the slump test on concrete.

Table 7: Slump Test on Concrete

S.No.	Volume of PET fiber %	Slump, mm
1	0	100
2	2.5	155
3	5	70

Figure 3 shows the slump test on concrete.

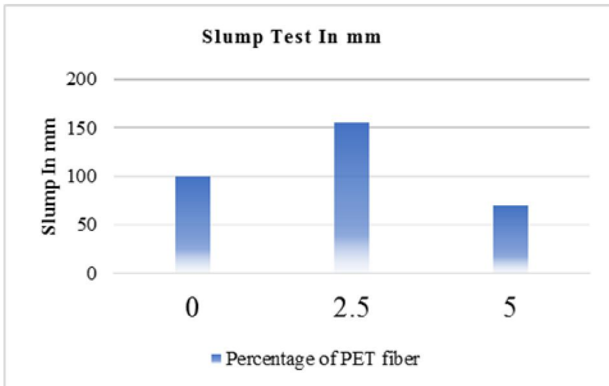

Figure 3 Slump test on concrete

7. CONCLUSION

From the investigations carried out, a number of conclusions may be deduced.

- The significant improvements in strengths were observed with inclusion of plastic fiber in concrete.
- It was found that normal concrete specimen was suddenly broken into two pieces at ultimate strength but PET fiber specimen did not suddenly break.
- The optimum strength was observed at 1% of fiber content for all type of strengths.
- From this experimental investigation, the composites would appear to be low-cost materials which would help to resolve some solid waste problems and preventing environment pollution.

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