STUDY ON THE EFFECTS OF PET BOTTLE FIBRE IN CONCRETE

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Abstract

Plastics and plastic bottles are versatile for common use, but its excessive usage has adverse impact on health and environment. Conversely, with increasing focus on development, numerous constructions are taking place around the globe, challenging the construction industry with raw materials. Concrete being one of the most popular construction materials, its higher demand in construction industry causes greater stress on environment. The extraction of natural fine aggregates as well as coarse aggregate exploits environment and disturbs aquatic life. Therefore, using one of the most common plastic products, PET bottles, in concrete is one of the possible solutions to such problems. This paper presents the application of PET bottle fibre used as a partial replacement of fine aggregate in concrete in various proportions of 0.75%, 1% and 1.25% with the promising values of compressive and flexural strength for 1.25% replacement.

Keywords: *PET bottle fibre, compressive strength, split tensile strength, flexural strength, percentage replacement.*

Introduction

Plastics can be used for different purposes and has the capability to meet various user demands. However, temporary use of this material with long decomposition period causes the amassing of huge pile in landfills and water bodies, polluting the environment and deteriorating aesthetic value of place.

With the fast on-going infrastructure development, there is high demand for construction material such as concrete, which directly or indirectly causes significant negative impact on environment. As 60-75% of concrete volume is occupied by natural aggregates (Soloaga, 2014), higher demand for concrete causes greater exploitation of environment, exposing the land to erosion, silting and disturbance in aquatic life.

Therefore, this experiment aims at addressing the above-mentioned issues with incorporation of PET bottle fibre in concrete.

Literature Review

Phuentsholing Thromde generates about 24.76 tons of waste every day of which 59.26% is organic, 17.18% is paper and 9.6% is rubber and plastic (Zam et al., 2011). In short, rubber and plastic comprise 2.4 tons of waste every day. While Memalakha landfill in Thimphu receives 30 tons of garbage everyday where 12% of the total disposed waste is plastic (Gurung, 2010; Tshomo, 2014).

Yin et al. (2015) mentioned the importance of fibre reinforcement in concrete. Fibres keep concrete mass bound together and prevent plastic cracks and dry shrinkage cracks. Fibres mixed together with concrete can prevent brittle failure and enhances crack control and ductility. It also enhances the tensile strength and toughness of concrete. Number of micro-cracks can be observed during failure instead of a single major crack, which causes gradual failure and not the brittle failure.

Ramadevi and Manju (2012) partially replaced fine aggregate with PET bottle fibres in varying proportion of 0.5%, 1%, 2%, 4% and 6% and studied the effect on the strength of concrete. Compressive and split tensile strength were found to increase till 2% replacement and a gradual reduction in further replacement was observed while flexural strength increased with increasing percentage of PET bottle fibre replacement but remained the same for 4% and 6% replacement. Therefore, the authors conclude 2% replacement to be reasonable.

Materials used

1. **Cement:** Portland Pozzolana cement (PPC) was used to prepare controlled mix.
2. **Fine Aggregate:** Natural sand extracted from riverbank has been used. Sieve analysis was done and the fine aggregate was graded under zone III conforming to Table 4 of IS 383-1970.
3. **Coarse Aggregate:** According to IS: 383-1970, Table 2 and 5, aggregate is classified as 20mm size.

Table 1: Properties of coarse aggregate

Specific Gravity	2.98
Water absorption	0.6%

4. **Plastic Fibres:** Manually shredded PET bottle fibres with approximate thickness of 2mm and length 20mm.

Figure 1: Shredded PET bottle fibres

Preparation of fibre: PET bottles are significant materials of this research. Bottles were collected from students' residences and canteens and these PET bottles were rinsed with water to remove dirt and impurities. Bottles were manually cut into small fibre of approximate thickness of 2mm and 20 mm length.

Methodology

1. Mix Design

The mix was designed according to IS: 10262:2009 and the mix proportion is shown in the table below. The mix was designed for various percentage replacement of fine aggregate with PET bottle fibre.

Table 2: Materials required as per the mix design

Material	Weight (kg)
Cement	413.33
Fine aggregate	662.68
Coarse aggregate	1309.8

2. Casting and Curing of samples:

Three different samples: beam, cube and cylinder were casted for the comparative analysis of flexural strength, compressive strength and the split tensile strength between the conventional concrete and the plastic fibre replaced concrete respectively.

A cube of 150x150x150 mm, beam of 100x100x500 mm and cylinder of 75 mm diameter and 150 mm height were casted to evaluate the compressive strength, flexural strength and split tensile strength of concrete respectively.

Nine samples each for compression test, flexural and split tensile test were prepared with water cement ratio of 0.45 for 0.5%, 1% and 1.25% replacement of fine aggregate by PET bottle fibre and nine control samples were also casted for comparative study of the strength for curing period of 7, 14 and 28 days.

3. Sample Test

Samples were de-moulded after 24 hours of casting and cured for 7, 14 and 28 days before subjecting to compression, split tensile and flexural test. The test set up is shown in the figure below:

Figure 2: Compression Test Setup

Figure 3: Split Tensile Test Setup

Figure 4: Flexural Test Setup

Result and Discussions

a. Compression Test:

Compressive strength of concrete cube is given in the following formula:

$$f_c = P/A \ N/mm2$$

Where, P=Load at failure in newton
A=Cross sectional area of a cube in mm2

Results obtained are shown in the graphs below:

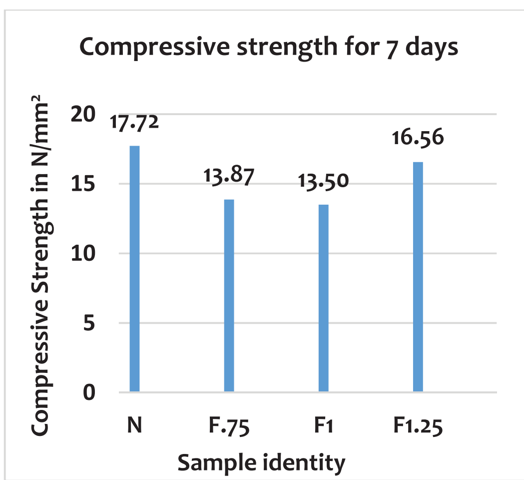

Figure 5: Compressive strength at 7 days vs. percentage replacement of PET fibre.

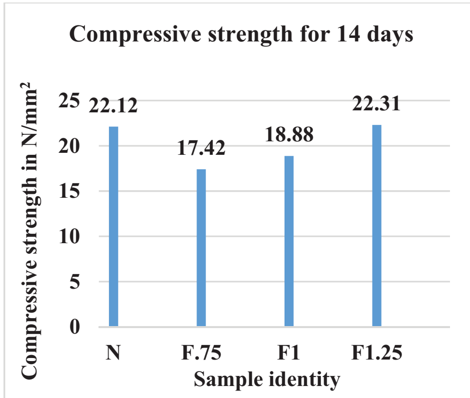

Figure 6: Compressive strength at 14 days vs. percentage replacement of PET fibre.

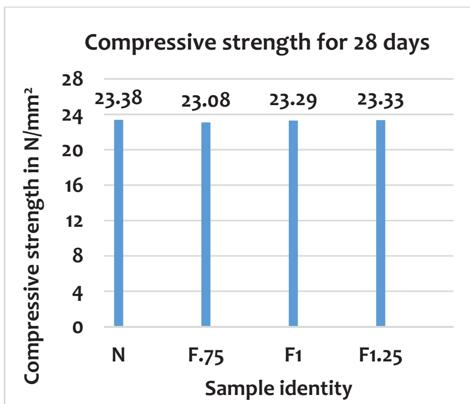

Figure 7: Compressive strength at 28 days vs. percentage replacement of PET fibre.

Compressive strength of concrete is found to increase with increasing percentage of fibre replacement and is maximized at 1.25% replacement of fine aggregate. The reduction in compressive strength of concrete with 1.25% replacement from that of control sample is negligible.

b. Split Tensile Test:

Split tensile strength of concrete cylinder is given by the formula:

$$f_c = P/A \ N/mm^2$$

Where, P= load at failure in newton
L=Length of specimen in mm
d= diameter of the specimen in mm

Results obtained are shown in the graphs below:

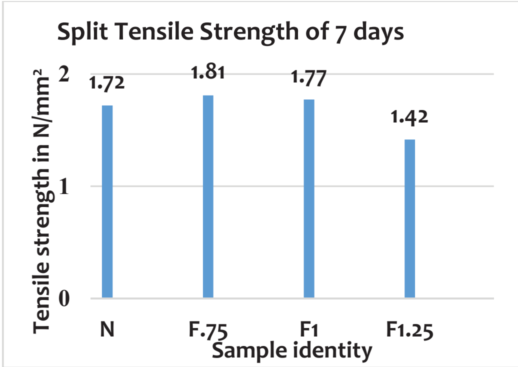

Figure 8: Split Tensile Strength at 7 days vs percentage replacement of PET fibre.

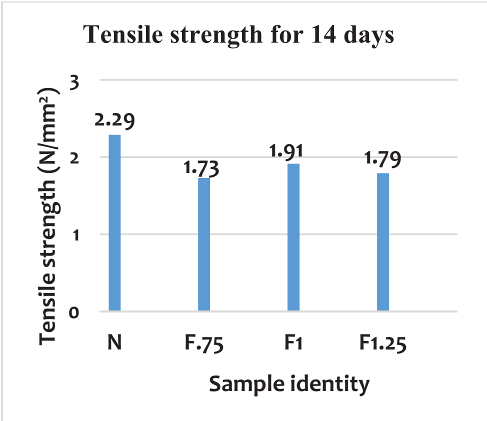

Figure 9: Split Tensile Strength at 7 days vs percentage replacement of PET fibre.

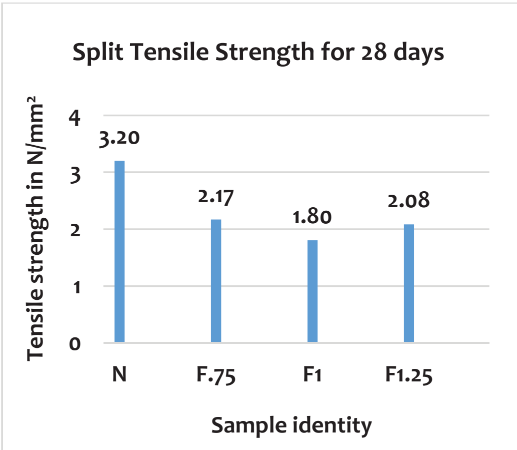

Figure 10: Split Tensile Strength at 14 days vs. percentage replacement of PET fibre.

Split tensile strength was found to be maximum for 0.75% replacement of fine aggregate with PET bottle fibres for 7 and 28 days. However, 1% replacement dominated for 14 days. A reduction of 32% was observed in split tensile strength of concrete with 0.75% of PET fibre replacement at 28 days.

c. Flexural strength test

Flexural strength of concrete is given by the formula:

$$f_b = 3Pa/(2\ bd^2)$$

Where P= Load at failure in N/mm2
a= distance of crack from nearer support in mm
b= width of specimen in mm
d= depth of specimen in mm

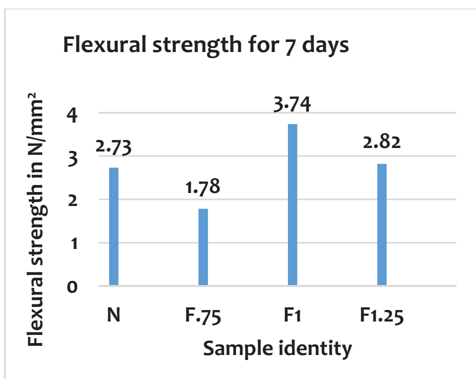

Figure 11: Flexural Strength at 7 days vs. percentage replacement of PET fibre.

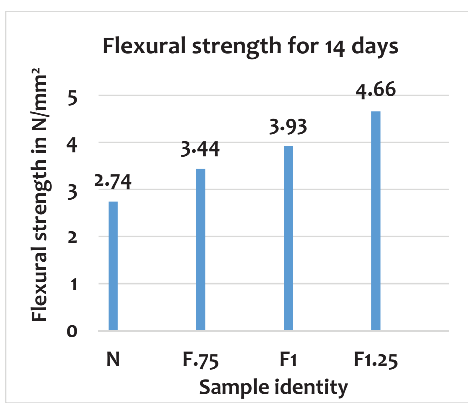

Figure 12: Flexural Strength at 14 days vs. percentage replacement of PET fibre.

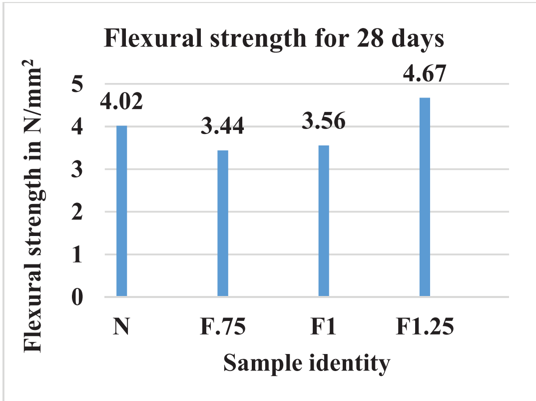

Figure 13: Flexural Strength at 28 days vs. percentage replacement of PET fibre.

Flexural strength of concrete was found to increase with increasing percentage of fibre replacement and exceeded that of control sample. Therefore, 1.25% replacement was found reasonable for flexural strength of concrete. An increment of 16% was observed in 1.25% replacement at 28 days.

Conclusion

1. Compressive strength of concrete is found to increase with increasing percentage of fibre replacement and is the maximum for 1.25% replacement of fine aggregate. The reduction in compressive strength of concrete with 1.25% replacement from that of control sample is negligible.

2. Split tensile strength of concrete is found to decrease when fine aggregate is replaced by plastic fibre and reduction of 32% was observed at 28 days with 0.75% replacement.

3. Flexural strength of concrete was found to increase with increasing percentage of fibre replacement and was found more than that of control sample. Therefore, 1.25% replacement was found reasonable for flexural strength of concrete.

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Rest of the authors are final year students, who are pursuing Bachelors of Civil Engineering at the College of Science and Technology, Phuentsholing.