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Experimental Investigation on the Effect Polypropylene Fibre and E-Waste Fibre Embedded in Concrete

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ABSTRACT- The main building material that can't be ignored even it's weak in tension and lead to various environmental problems during it's production is concrete. Properties of concrete can be enhanced using fibre in concrete. Using fibre from waste of plastic in concrete to some percentage increases strength as well as durability of concrete and solve disposal problems of plastic waste in environment. From electronic waste Polyvinyl chloride cables (PVC) are used as fibre and from polypropylene (PP) packing bag of cement are used as fibre in concrete. Both are used in 0%, 0.25%, 0.50%, 0.75% and 1% by weight of cement in concrete. Fresh and harden properties for both concrete with polypropylene fibre and with electronic waste fibre is determined and hybrid of optimum values calculated is used in a single mix and compressive strength is calculated. Results show that 0.75% and 0.50% is optimum value of concrete with electronic waste fibre and concrete with polypropylene fibre with 49% and 17.5% increase in concrete strength compared to normal concrete respectively and can be used in a single mixture. Concrete with hybrid of polypropylene fibre and electronic waste fibre shows enhancement of 56% in compressive strength. The hybrid of PPFRC and EFRC polypropylene fibre keep cracks small and e-waste fibre shows enhancement in mechanical properties.

KEYWORDS- Concrete; Cement Bag; Polyvinyl Chloride Fibre; Compressive Strength; Hybrid Fibre Reinforced Concrete

I. INTRODUCTION

Fibre in concrete is used from last 50 years and is used to change properties normal concrete according to requirement. With addition of fibre in concrete, some properties are enhance and while some reduces. In most cases slump value decreases. A decrease in slump value doesn't necessarily mean decrease in workability [1]. Different types of fibre are used in concrete like steel fibres [4], glass [5], fibres of natural origin [6], carbon fibres [16]; Hybrid fibres [3, 12]; as well as polymer fibres, i.e., polypropylene fibres [2, 17] made of poly alcohol vinyl [7]. Fibre-reinforced concretes (FRC) increase various properties of concrete, including: compressive strength more than ordinary concrete [5,3,7]; greater tensile strength [6,7,8] higher bending and splitting tensile strength and ductility [12]; greater flexural strength [5]; high impact loading resistance [9]; high dynamic resistance [17], improve unity of structure [11]; crack formation is delayed even after fresh state (post-cracking of concrete) [6,11]; elastic modulus, shrinkage control. The ability of fibre is to reduce cracks at maximum strain and increases its ductility also durability which reduces transport of corrosive material into concrete [2, 10]. When PP fibre is added, unit wt. of concrete is observed to reduce with rise in strength [2]. Wastes of different types can be used in concrete as fibre: polypropylene fibre made from post-consumer waste (food packaging) [8], recycled black polyethylene tubes [13]; E waste plastic (insulation wires) [14]. All wastes present on earth are cause of pollution and create some other environment problems. Municipal waste is observed to be less dangerous than e-waste. Use of e- waste in concrete shows positive effects on concrete properties and is thus used in concrete which is helpful for construction industry also solve disposal problems of toxic material [3]. Also enhances mechanical properties of concrete [3, 14]. Using more than one fibre in concrete mix increase's required properties of concrete also gives benefits of individual fibres. One of the applications of HFRC is in parts of reinforced concrete structures.

In this study two different fibre reinforced concrete are studied. Polyvinyl chloride cables from electronic waste and waste packing bags of cement collected from construction site used at 0%, 0.25%, 0.50%, 0.75% and 1% by weight of cement respectively. Hybrid of the optimum values of fibre from electronic waste added in concrete (EFRC) and fibre from polypropylene used in concrete (PPFRC) is studied. Wastes are utilized which solve the disposal problem of waste and is environmental friendly also.

II. MATERIAL USED

In this research cement in use is OPC-43. Fine, dry and lump free cement is used. Storage of cement is in humid free room. Physical properties of cement are shown in below table 1.

Fine aggregates used in the study is river sand that are retained at 150 micron and pass at 4.5mm sieve having S. gravity 2.31 and crushed stones that pass at 20mm

and retained at 10mm sieve with S. gravity 2.52 is coarse aggregate.

Table 1: Cement test results

Test	Results
Specific gravity	2.7
Initial setting time	50 minutes
Final setting time	490 minutes
Consistency	30%
Fineness	98%
Soundness	2.5mm

For casting and curing of concrete, Portable water free from impurities is used as per IS 456-2000.

A. E-waste fibre

Polyvinyl chloride (PVC) is a plastic material. PVC of cable shown in figure 1(a) is collected and its copper wire is taken out as shown in figure 1(b). Outer casing of PVC cable is cutted into 30mm to 35mm pieces as shown in figure 1(c). These 30mm to 35mm pieces are used as electronic waste fibre. Other properties of e-waste fibre are given in table 2. Practical application PVC is also in construction industry.

Table 2: Properties of E-waste fibre

Length of fibre (mm)	30-35
Diameter of fibre (mm)	1
Aspect ratio	30-35

(a)

(b)

(c)

Figure 1: (a) PVC cable; (b) copper extracted from PVC cables; (c) PVC fiber utilization

B. Polypropylene fibre

PP fibre has various applications and PP fibre is a synthetic fibre that is also known as polypropene changed from propylene. Cement packing bags of 30mm of length is used as polypropylene fibre. Figure 2(a) shows cement bags at construction site that are cleaned and cutted into 30mm to 35mm pieces as shown in figure 2(b). These cutted pieces of waste packing bags of cement are used as polypropylene fibre.

Table 3: Properties of Polypropylene fibre

Length of fibre (mm)	30-35
Width of fibre (mm)	1
Aspect ratio	30-35

(a)

(b)

Figure 2: (a) Cement bags at construction site; (b) Polypropylene fibre utilized in study

III. METHODOLOGY

Various specimens of different percentage of Polypropylene fibre and E-waste fibre are used. The mix design used is M20 as per IS 10262:2010. Specimens casted were cubes of 15cm x 15cm x15cm with 0%, 0.25%, 0.50%, 0.75% and 1% of PP fibre and 0%, 0.25%, 0.50%, 0.75% and 1% of e-waste fibre. Testing is done at 3 days, 14 days and 28 days. Physical and mechanical tests on samples prepared with PPFRC and EFRC are compared with specimens with fibre content 0%. Optimum value of fibre percentages are used in a single mix and hybrid fibre reinforced concrete mix is prepared and compressive strength is calculated.

A. Slump test

Workability is one of the physical parameters that influence strength and durability of concrete. For measuring the variations in workability of normal and fibre reinforced concrete, slump test is conducted on fresh concrete.

B. Compression test

Compression testing machine (CTM) is used for testing of specimens at 3 days, 7 days and 28 days of curing. Maximum load carrying capacity of CTM is 1000KN as per IS 516-1959. The loads at which cracks occur are noted and graph is plotted.

IV. RESULTS AND DISCUSSION

A. Slump value

i. Polypropylene fibre vs. E-waste fibre

Addition in fibre content leads to decrease in slump value. The decrease in slump with addition of 0.25% PP fibre and e-waste fibre is 6% and 7% respectively, at 0.50% of PP fibre and e-waste fibre decrease is 15% and 18% respectively, at 0.75% of PP fibre and e-waste fibre decrease is 17% and 21% respectively, at 1% of PP fibre and e-waste fibre decrease is 22% and 25% respectively. There is continuous decrease in slump value with respect to fibre content. This decrease doesn't indicate decrease in workability; decrease is because of increase in entrapped air voids due to fibre content. The decrease in slump value is 22% with addition of PP fibre and is 25% with addition of E-waste fibre as shown in fig. 3.

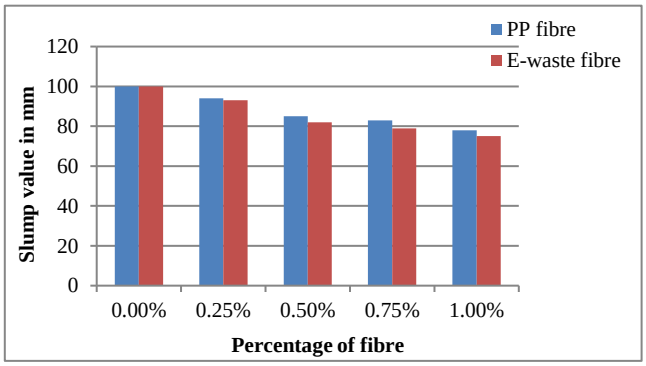

Figure 3: Effect of PP and E-waste fibre on workability

ii. Slump value vs. hybrid concrete

Mix of optimum values of PPFRC and EFRC i.e. 0.50% and 0.75% respectively is used in a single mix termed as hybrid concrete which shows maximum decrease of 40% slump value.

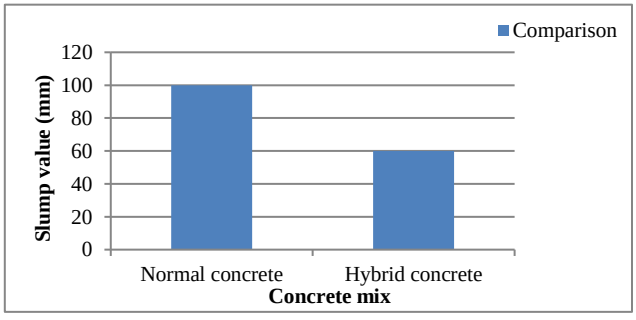

Figure 4: Comparison of effect of fibre with normal concrete

B. Compression test

i. Compressive strength vs. polypropylene fibre

C.S of concrete with PP from 0 to 1% is represented in fig. 8, 0% of PP fibre is taken as standard mix and results are compared with that. Compression strength of concrete cube increases with increase in fibre content. At 0.25 % fibre content compressive strength increases 5.2%, at 0.50% fibre content compressive strength increase 17.5% that is the optimum value of fibre content giving compressive strength of 29.77N/mm2.

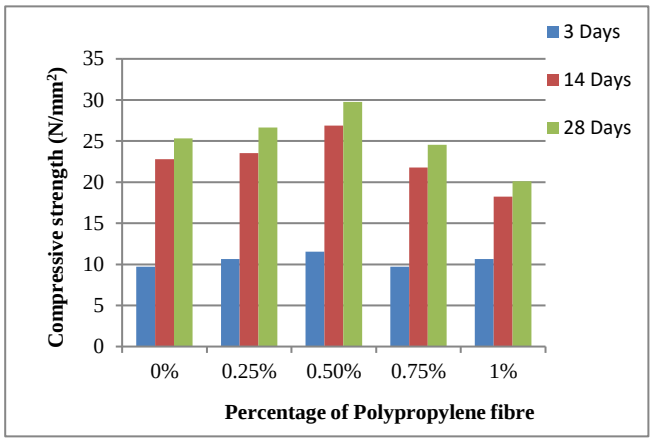

Figure 5: Compressive strength of PPFRC

ii. Compression strength vs. e-waste fibre

E-waste fibre added in a mix is reported in fig. 6, fibre added in 0%, 0.25%, 0.50%, 0.75% and 2% by wt. of cement, mix with 0% fibre content is considered as standard mix. Compression strength of concrete cube increases with increase in fibre content. At 0.25 % fibre content compressive strength increases 8.7%, at 0.50% fibre content compressive strength increases 40%, at 0.75% fibre content compressive strength increases 49% that is the optimum value of fibre content giving compressive strength of 37.77N/mm2.

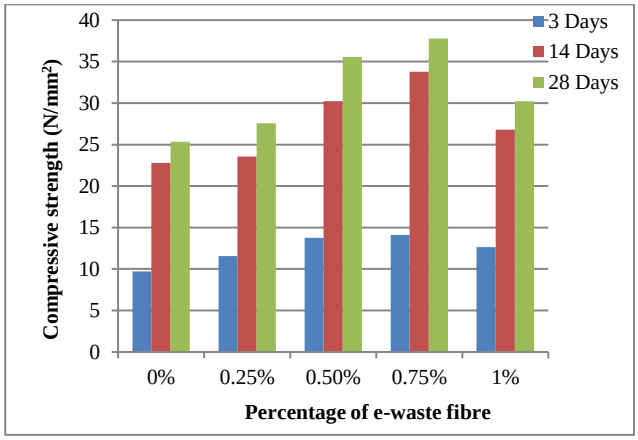

Figure 6: Compressive strength of EFRC

iii. Comparative graph of concrete mix reinforced with PP fibre and E-waste fibre.

The fig. 7 represents the comparative compressive strength of PPFRC and EFRC. PPFRC shows less increase compared to EFRC but the increase is more when compared to standard mix.

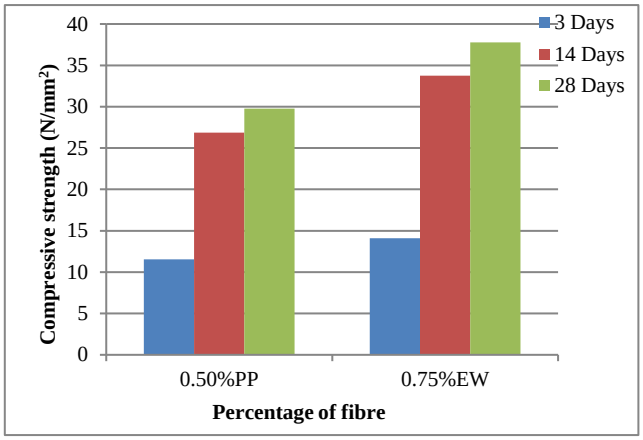

Figure 7: Comparison of compressive strength exhibited by HFRC with normal concrete

iv. Compressive strength vs. Hybrid fibre reinforced concrete

The optimum dosage for PPFRC and EFRC is 0.50% and 0.75% respectively. The hybrid concrete of optimum values of polypropylene fibre reinforced concrete and E-waste fibre reinforced concrete shows maximum increase in compressive strength as shown in fig. 8. The increase in C.S is 56% than standard mix. In HFRC, polypropylene fibre form bridge at cracks while mechanical properties are enhanced by PVC fibre.

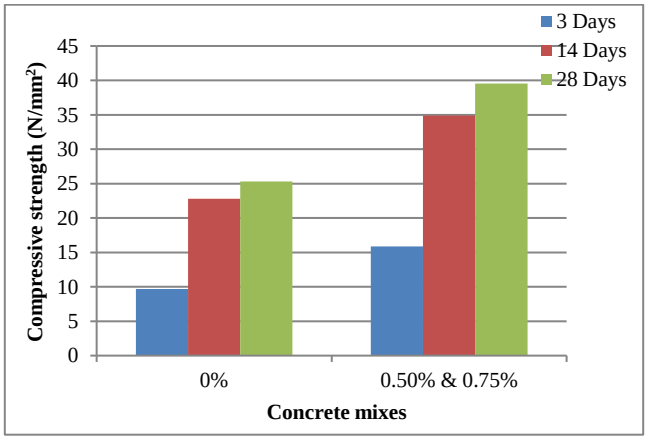

Figure 8: Comparison of compressive strength exhibited by PP fibre and E-waste fibre

V. CONCLUSION

Addition of fibre from waste to concrete is studied. Fibre added to concrete are cement packing bag from polypropylene fibre and polyvinyl chloride cable from e-waste fibre and are added in 0%, 0.25%, 0.50%, 0.75% and 1% with 0.5 water-cement ratio and compression test is conducted. The summarized points that the experimental study revealed after polypropylene fibre and e-waste fibre is added are:

- Addition of polypropylene fibre and e-waste fibre has positive effects on compression strength while effect on slump is reverse but in medium range of workability.
- PPFRC have shown maximum rise of 29.77N/mm2 in compression strength at 0.5% of polypropylene fibre that is 17.5% more that standard concrete mix.
- E-waste fibre reinforced concrete shows increase in compressive strength up to 49% at 0.75% fibre content, addition in fibre content decrease strength after 0.75%.
- Hybrid fibre reinforced concrete shows maximum increase in compressive strength with 39.55N/mm2 that's 56% increase than standard concrete mix, 5% increase than EFRC and 32% increase than PPFRC.
- Decrease in slump is up to 40% from 0% fibre to 1% fibre to hybrid of fibre's.
- Increase in compressive strength is due to crack bridging mechanism of fibres.
- With Hybrid fibre reinforced concrete it's possible to increase compressive strength of concrete and use of waste packing bags of cement and PVC cables can improve mechanical properties, make concrete durability by bridge formation at cracks and can be economical way for disposal of plastic waste also environmental friendly manner.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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