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# STUDY ON THE EFFECT OF REPLACEMENT OF FINE AGGREGATE WITH PLASTIC GRANULES ALONG WITH STEEL AND POLYPROPYLENE FIBERS

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***Abstract*— Concrete is an ancient material of construction, first used during Roman Empire. Concrete is the second most consumed substance in the world after water. Plastic is a common material which finds its application in day today life. Lack of proper disposal methods for plastic waste is one of the main hazards faced by present the world. Plastic is of manmade material and is a stable polymer which is light in weight. The reduction of waste plastic is essential as it creates various environmental problems. This paper deals with the partial replacement of fine aggregate with plastic granules and using a fixed proportion of steel and polypropylene fibers. Experimental program includes two stages. In the first stage fine aggregate is replaced with 4%,8%,12% plastic granules in an M30 grade of concrete and its percentage was optimized and in the second stage, the residual strength of the above mixes were found out by heating the specimens to$200^0$c,$300^0$c and $400^0$c for one hour duration. Strength parameters studied includes compressive strength, flexural strength, split tensile strength, residual strength.***

***Keywords*— compressive strength, split tensile strength, plastic granules, steel fiber, polypropylene fiber***

## I. INTRODUCTION

Concrete is the second most consumed substance in the world after water. Although wide varieties of construction materials are available in the market, concrete has able to fix one of the top positions in the category of construction materials. Concrete today is a sophisticated material to which exotic constituents can be added. As per standard definition concrete is a mixture of portland cement or any other hydraulic cement, fine aggregate, coarse aggregate and water, with or without admixtures. The ability of concrete to mould into any desired shapes makes it as the most common construction material in the industry.

Fiber reinforced concrete is one which contains fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibres include steel fibers, glass fibers, synthetic fibers and natural fibers. Fibers are usually used in concrete to control cracking due to plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater impact, abrasion and shatter resistance in concrete. Concrete containing two or more fibers are known as hybrid fiber reinforced concrete. Combination of low and high modulus fibres can arrest cracks at micro level as well as macro level. The use of two or more types of fibres in a suitable combination potentially improves the overall properties of concrete and also results in performance of concrete. The most commonly observed one is that made with steel and polypropylene fibers.

## II. PLASTIC REINFORCED CONCRETE

Plastic is a common material which finds its application in day today life. Lack of proper disposal methods for plastic waste is one of the main hazards faced by present the world. It affects the ecological system very badly as plastic is a non-biodegradable material. Various researches are ongoing in the world to make use of plastic waste in concrete. Plastic is of manmade material and is a stable polymer which is light in weight. The reduction of waste plastic is essential as it creates various environmental problems. If we make utilize the waste plastic as substitution of fine aggregate in concrete it will be greatly reducing the pollution caused by them. Thus the concrete can be made more eco-friendly.


 

## III.EXPERIMENTAL PROGRAM

### A. MATERIALS AND PROPERTIES

Different materials used for this experimental study includes OPC 53 grade cement, natural coarse aggregate, manufactured fine aggregate, super plasticizer and plastic.

*3.1) Cement*: Ordinary Portland cement 53 grade was used for the entire work and it was purchased from St. Mary's hollow bricks company, Kothamangalam and it conforms to IS specifications. Properties of the cement are listed below.

TABLE 1 PHYSICAL PROPERTIES OF CEMENT

| NAME OF TEST | RESULT |
|---|---|
| SPECIFIC GRAVITY | 3.14 |
| STANDARD CONSISTENCY | 32% |
| INITIAL SETTING TIME | 40 MINUTES |

*3.2) Fine aggregate*: It should pass through IS sieve 4.75mm. Fine aggregate used for the study was M sand. Fine aggregate selected was free from clay, silt, and chloride contamination. Specific gravity was found to be 2.62

*3.3) Natural coarse aggregate*: It is the strongest component of concrete. Angular aggregates are preferred. Flaky and elongated aggregates should be avoided as far as possible. Both 20 mm and 12 mm aggregates were used. Aggregate crushing value was obtained as 30 % and specific gravity as 2.67

*3.4) Plastic granules*: Recycled plastic granules of size 1-2mm were used for the work.

*Fig 1 Plastic granules*

*3.5 Steel and Polypropylene fibers*: Steel fiber used was of length 30mm and diameter 0.5mm. Polypropylene fiber was of monofilament type.

*Fig 2 Steel fibers*

### B. EXPERIMENTAL WORK

The mix design was done as per IS: 10262(1982). M30 Grade was adopted for the work. Fine aggregate selected for the study conforms to zone II. Water cement ratio was fixed at 0.43. The mix proportion was carried out to get a slump of 150 mm. The quantity of materials required per $m^3$ of concrete is listed in table 2.

TABLE 2 MATERIALS FOR 1M$^3$

| MATERIAL | QUANTITY |
|---|---|
| CEMENT (KG) | 388 |
| FINE AGGREGATE (KG) | 670 |
| COARSE AGGREGATE(KG) | 1200 |
| WATER(L) | 167 |
| SUPER PLASTICIZER(L/) | 1.373 |

## IV. TESTS AND RESULTS

### A. COMPRESSIVE STRENGTH

150mm cubes were casted. Both 7 and 28 day compressive strength tests were done. The results are shown in table 3.

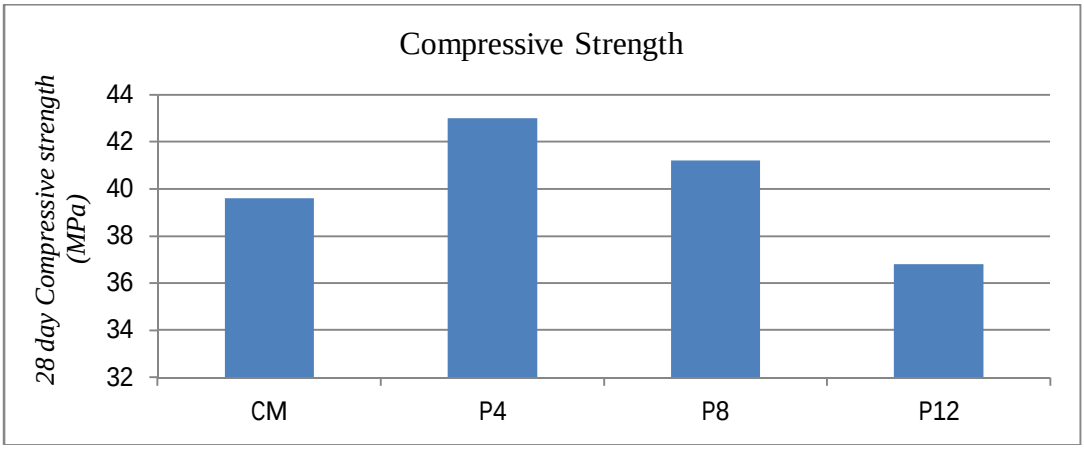


*Fig 3 Compressive Strength at 28 Day*

TABLE 3 COMPRESSIVE STRENGTH

| MIX | 7 DAY COMPRESSIVE STRENGTH (MPA) | 28 DAY COMPRESSIVE STRENGTH (MPA) |
|---|---|---|
| S0.75P0.25 (CM) | 27.6 | 38.6 |
| P4 | 28.6 | 42.8 |
| P8 | 26.4 | 40.8 |
| P12 | 24.8 | 37.13 |

### B. Split tensile strength

Cylinders of size 150mm x 300 mm were casted .both 7 and 28 days split tensile strength were tested. The results are shown in Table 4.

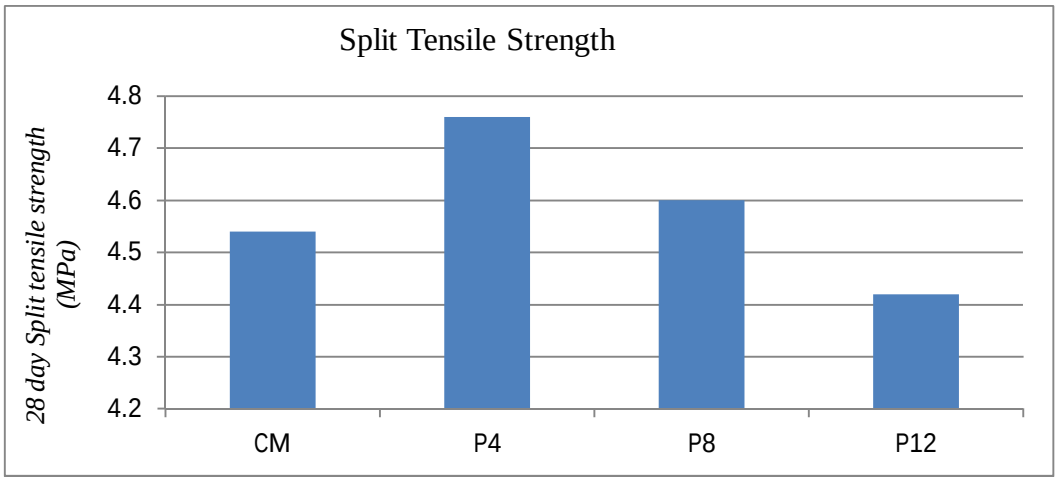


*Fig 4 Split Tensile Strength at 28 Day*

TABLE 4 SPLIT TENSILE STRENGTH

| MIX | 7 DAY TENSILE STRENGTH (MPA) | 28 DAY TENSILE STRENGTH (MPA) |
|---|---|---|
| S0.75P0.25 (CM) | 3.5 | 4.6 |
| P4 | 3.64 | 4.8 |
| P8 | 3.52 | 4.68 |
| P12 | 3.46 | 4.62 |

### C. FLEXURAL STRENGTH

Beams of size 100mm x 100mm x 500 mm were casted. Both 7 and 28 day flexural strength test were done. Results are shown in table 5

TABLE 5 FLEXURAL STRENGTH

| MIX | 7 DAY FLEXURAL STRENGTH (MPA) | 28 DAY FLEXURAL STRENGTH (MPA) |
|---|---|---|
| S0.75P0.25 | 4.12 | 5.46 |
| P4 | 3.78 | 5.64 |
| P8 | 3.54 | 5.58 |
| P12 | 3.32 | 5.21 |

From the above results 4 % of plastic granules shows max strength in compression, flexure and in tensile strength.

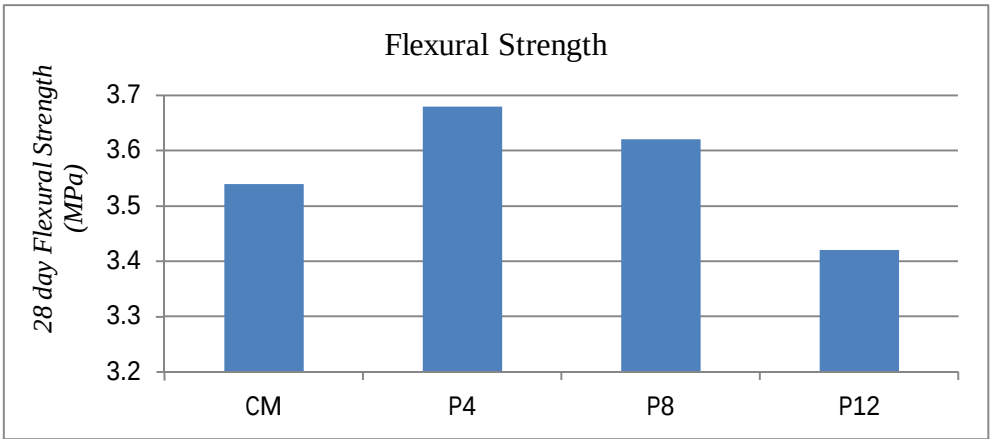


*Fig 5 Flexural Strength at 28 Day*

### D. THERMAL RESULTS

The strength of the specimens gets decreased with increase in temperature. The residual strength of the plastic reinforced mixes was determined at 28days of curing and heating to the required temperature. The residual strength obtained is shown in table 6.

TABLE 6 RESIDUAL COMPRESSIVE STRENGTH

| MIX | RESIDUAL COMPRESSIVE STRENGTH AT $200^0$C (MPA) | RESIDUAL COMPRESSIVE STRENGTH AT $300^0$C (MPA) | RESIDUAL COMPRESSIVE STRENGTH AT $400^0$C (MPA) |
|---|---|---|---|
| S0.75P0.25 (CM) | 36.9 | 35.6 | 34.2 |
| P4 | 40.2 | 38.6 | 34.8 |
| P8 | 39.6 | 37.4 | 32.2 |
| P12 | 35.2 | 32.6 | 28.4 |

From the test results of compressive strength, tensile strength and flexural strength, it can be seen that, up to 8 % of replacement of fine aggregate by plastic granules is possible.

## V. CONCLUSION

These are the main findings of this works and are listed below

- *The compressive strength is slightly increased with addition of plastic granules. A maximum increase in compressive strength of 10.88% was observed in P4 mix when compared with control mix. P8 mix has obtained a better strength than the control mix.*
- *The split tensile strength also observed to be maximum for P4 mix and it possess 4.35% higher strength compared to control mix.*
- *The flexural strength also found to be higher for P4 mix.*
- *It can be concluded that up to 8% replacement of fine aggregate can be done successfully.*
- *From thermal results, it can be seen that all the plastic mixes P4, P8 and P12 have retained about 75% of their original strength when heated to $400^0$c.*

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