MECHANICAL AND DURABILITY PERFORMANCE OF POLYPROPYLENE FIBER ON HIGH PERFORMANCE GEO POLYMER CONCRETE

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ABSTRACT

In the construction sector, concrete takes a vital role as an inevitable construction material. The most crucial component in making concrete is cement. The main ingredient used to make regular Portland cement is limestone. Almost one ton of CO_2 is discharged into the atmosphere during the manufacturing of one ton of cement, endangering the environment. Additionally, while the concrete is inferior in tension, it is relatively satisfactory in compression. The geo polymer concrete is researched using polypropylene fiber to solve the afore mentioned issue. In this article, the impact of polypropylene fiber on geopolymer concrete in various quantities is presented. The geo polymer concrete samples were made and tested at various ages, including 3, 7, 14, and 60 days, to achieve this goal. To investigate the impact of polypropylene fiber over the properties (strength and durability) of

geopolymer concrete, an experimental test was conducted. The findings showed that, as compared to nominal geopolymer concrete, the split and flexural tensile capacity of geopolymer concrete with polypropylene fiber was significantly increased in the maximum range of 34–40%. Further, the water absorption and sorptivity of geo polymer concrete with polypropylene fiber was lower by 15-26% when compared to traditional geopolymer concrete.

Keywords: Geo polymer · Polypropylene fiber · Sorptivity · Tensile strength · Durability · Mechanical properties

1 Introduction

Globally 'construction' is the rapidly developing sector. Almost every year 260, 00, 00,000 tons of cement required. In the next 10 years, an increase of 25% in cement consumption is expected. Limestone is one of the foremost sources to produce ordinary Portland cement, becomes a critical shortfall after 25 to 50 years. Also, In the production of cement roughly the same quantity of carbon di oxide is produced as much as cement is produced and released in to the open atmosphere, which leads to polluted environment [1,2]. Geo polymer concrete does not use any amount of cement.

Concrete is the broadly used and is subsequently the most important material after water on earth. However, the concrete has certain characteristics such as a great amount of compressive strength and better durability under any sort of environmental acquaintance. On the other side, the concrete comes with demerits like weaker in tension capacity and brittle in nature. Thereby, the concrete gets some limitation in its application. Further, the occurrence of cracks is the basic cause of diffuseness of concrete. When the concrete is cast, because of improper mix design or inferior materials, the cracks start to appear before attaining the appropriate strength. The cracks tend to be a key reason for failure of any reinforced concrete structures, further leads to progressive damage results in minimizing the life span and its durability.

As mentioned above, the concrete which is brittle in nature, executes good compressive stress and poor in tensile stress. Therefore, to enhance the tensile strength of the concrete the fibers must be introduced into the concrete. This addition of fibers, improves the tension carrying ability and resist the cracks that is inexorable in any reinforced concrete. Keeping crack control in mind, the latest technology in concrete developments includes fibers as reinforcement, prominently polypropylene fibers [3-6]. The idea of reinforcement brittle materials with fiber is aged since 1960's, using polypropylene fiber in concrete in random distribution manner to increases some properties of concrete such as ductility, toughness of concrete and impact resistance of concrete [7-10].

2. Investigational program

2.1 Materials

For developing geopolymer concrete, constituents like fly ash, ground granulated blast furnace slag (GGBFS) and silica in the form of fume can be used. Specific gravity of cumulated fine aggregate is found to be 2.6. Based on IS: 383-1987 [11], the fine aggregate shall conform to zone II. Coarse aggregate has a cumulative specific gravity of 2.7, the maximum size of coarse aggregate is 20 mm which is conforming to IS: 383-1987 [11]. Water conforming to IS: 456-2000 [12] was used as a solvent. The alkaline liquid will be a mixture of sodium hydroxide (NaOH) solution and sodium silicate solution (Na_2SiO_3). This blended solution must be prepared 24 hours prior to testing. The sodium silicate solution is available commercial market in different grades. using sodium hydroxide with 97-98 percentage of purity in pellet form is advisable. This pellet must be dissolved in normal water with pH of 7 to make a solution with the desired concentration.

2.2 Polypropylene fiber (PP Fiber)

The fiber was used in the present study was fine polypropylene monofilaments as shown in Fig. 1. The Reliance Industry is marketing this fiber under the name of "RECRON - 3s". This can be available

in 6mm,12mm and 24mm in sizes. The fiber length is 6mm were used in the present study. The melting point of polypropylene is 165 ºC and 100 ºC is a withstanding temperature for short periods of time before softening. The polypropylene is chemically inert in nature.

Fig. 1 Polypropylene fiber.

2.3 Concrete mixture proportions

The particulars of various elemental proportions of geopolymer concrete are listed in Table 1. The polypropylene fiber was added to the concrete with 0.2%, 0.4% and 0.6% of the volume of concrete.

Table 1. Concrete mix details.

Constituent materials	**(kg/m^3)**
GGBFS	292
Fly ash	175
Silica fume	117
Sodium silicate	188
Sodium hydroxide	42
Coarse aggregate (20 mm)	718
Coarse aggregate (12.5 mm)	307
Sand	807
Water	33
Super plasticizer	5

2.4 Specimen preparation and curing

A steel mould was utilised throughout the investigation to cast the specimens. The sodium hydroxide was mixed with water for diluting. Meanwhile, sodium silicate solution is also added with water. The concrete is prepared by using mechanical rotatory mixer machine. The concrete was filled in the mould. The concrete samples were demoulded after 24 hours. Then the concrete samples were placed in the atmosphere temperature for curing.

2.5 Specimen testing

2.5.1 Compressive strength

This test was conducted as per IS: 516-1959 [13] with 150 mm cube specimen. For each age of testing, three samples were used. Autonomous compression testing machine of 3000 kN capacity was involved in testing. The load applied till the specimen brakes, and the failure point load was recorded.

2.5.2 Split tensile Test

According to IS: 5816-1999 [14], a split tensile test was conducted. A 200 mm high by 100 mm wide cylindrical specimen was employed. Using the aforementioned compression testing machine, the samples' split tensile strength was evaluated. Three duplicate test specimens were used, and the average split tensile strength values were reported.

2.5.3 Flexural strength test

According to IS: 516-1959 [13], a flexural test was conducted. Beam samples measuring 100mm, 100mm, and 500mm were used. The specimen was tested by three-point loading system. On three identical test specimens, the average flexural strength values were calculated.

2.5.4 Water absorption test

In accordance with ASTM C 642-1997 [15], the tests were performed on cube specimens of 100 mm. The specimens were oven dried for 48 hours at a temperature of 100 ºC following the precise curing period. The specimens' original weight was recorded. The specimen was then submerged in water for seven days and final weight was recorded. The difference between the specimens' original and final weights was recorded as a result of water absorption.

2.5.5 Sorptivity

In accordance with ASTM C1585-2013]16], the tests were performed on cube specimens of 100 mm. The specimens were oven dried for 48 hours at a temperature of 100 ºC following the precise curing period. The specimens' original weight was recorded. The specimen (One of the face) was then submerged in water for seven days and final weight was recorded. The difference between the specimens' original and final weights was recorded.

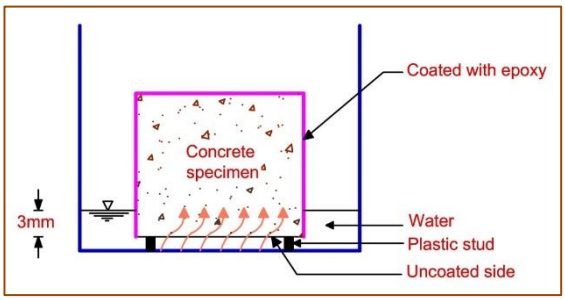

Fig. 2 Layout of sorptivity test.

3 Results and Discussion

3.1 Compressive strength

The compressive strength results of geo polymer concrete with various percentage of polypropylene fiber were displayed in Fig. 3. The results revealed that the compressive strength of geo polymer concrete with polypropylene fiber was marginally increased in all the adding of percentage of fiber.

The improvement was in the range of 3-9% and the improvement was increased with increase of polypropylene fiber percentage.

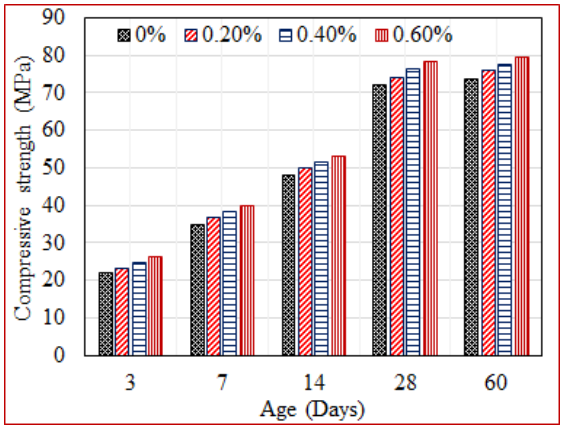

Fig. 3. Compressive strength.

3.2 Split tensile strength

The split tensile strength results of geo polymer concrete with various percentage of polypropylene fiber were displayed in Fig. 4. The results indicated that the split tensile strength of geo polymer concrete with polypropylene fiber was significantly increased in all the adding of percentage of fiber. The improvement was in the range of 12-40% and the improvement was increased with increase of polypropylene fiber percentage.

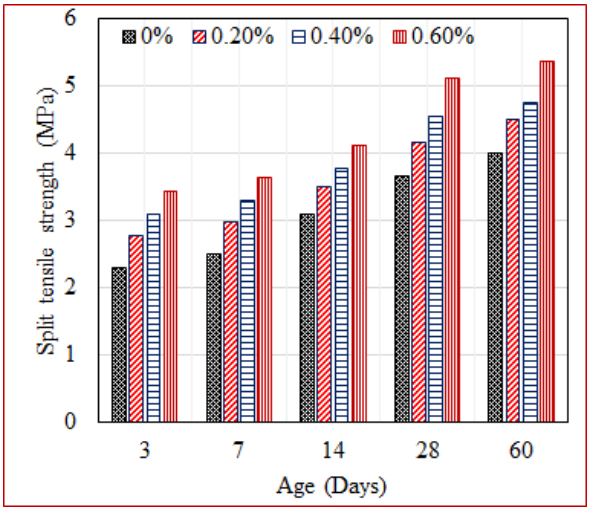

Fig. 4. Split tensile strength.

3.3 Flexural strength

The flexural tensile strength results of geo polymer concrete with various percentage of polypropylene fiber were displayed in Fig. 5. The results revealed that the flexural tensile strength of geo polymer concrete with polypropylene fiber was significantly increased in all the adding of percentage of fiber. The improvement was in the range of 12-35% and the improvement was increased with increase of polypropylene fiber percentage.

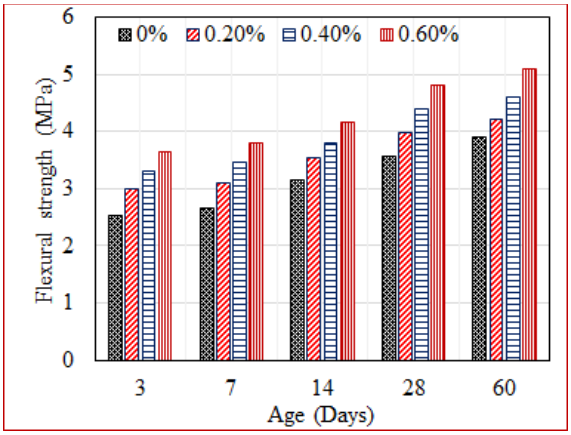

Fig. 5. Flexural strength.

3.4 Water absorption

The water absorption test results of geo polymer concrete with various percentage of polypropylene fiber were shown in Fig. 6. The results indicated that the water absorption of geo polymer concrete with polypropylene fiber was marginally decreased in all the adding of percentage of fiber. The decrease of water absorption was in the range of 8-24% when compared to conventional geo polymer concrete.

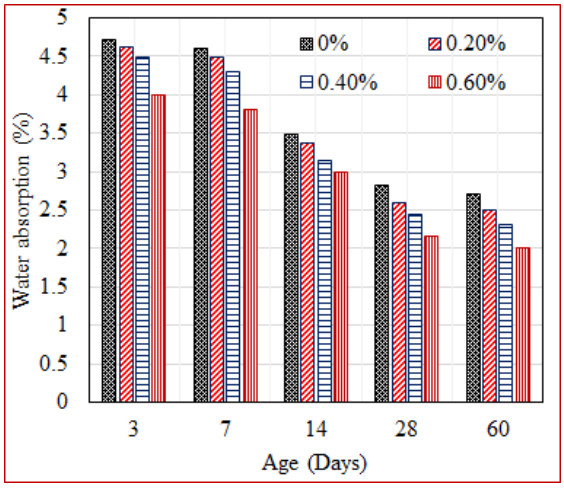

Fig. 6. Water absorption.

3.5 Sorptivity

The sorptivity test results of geo polymer concrete with various percentage of polypropylene fiber were shown in Fig. 7. The results indicated that the sorptivity of geo polymer concrete with polypropylene fiber was marginally decreased in all the adding of percentage of fiber. The decrease of sorptivity was in the range of 3-16% when compared to conventional geo polymer concrete.

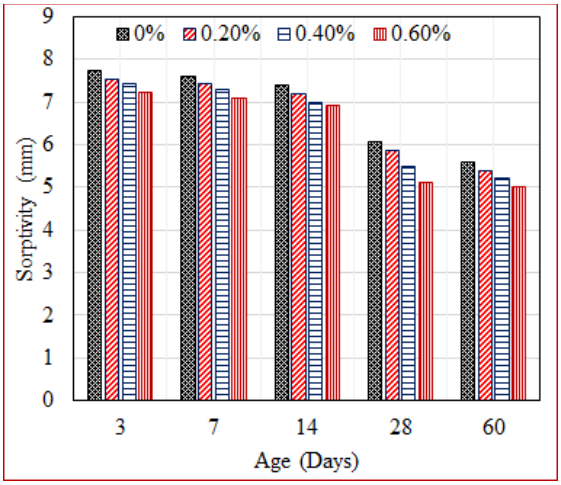

Fig. 7. Sorptivity.

4 Conclusions

The following conclusions were obtained based on the current experimental investigation:

(1) The compressive strength of geo polymer concrete with polypropylene fiber was marginally increased when compared to conventional geo polymer concrete. The improvement was in the range of 3-9%.

(2) The split tensile strength of geo polymer concrete with polypropylene fiber was significantly increased when compared to conventional geo polymer concrete. The improvement was in the range of 12-40%.

(3) The flexural tensile strength of geo polymer concrete with polypropylene fiber was significantly increased when compared to conventional geo polymer concrete. The improvement was in the range of 12-35%.

(4) The sorptivity value of geo polymer concrete with polypropylene fiber was marginally reduced when compared to conventional geo polymer concrete. The decrease of sorptivity was in the range of 3-16%.

(5) The water absorption values of geo polymer concrete with polypropylene fiber was marginally reduced when compared to conventional geo polymer concrete. This effect may be convey that the polypropylene fiber not absorb water. The decrease of water abssorption was in the range of 8-24%.

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