An experimental investigation of impact of polypropylene as a partial replacement in concrete

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Abstract

India is currently one of the world's developing nations. Concrete with exceptional strength and performance will be needed in the future to build projects. Fibrous concrete is a type of concrete that has fibrouss added to it to strengthen its structure. With different concrete fibrous materials, shapes, distributions, orientations, and densities, fibrous concrete takes on different characteristics. One synthetic fibrous that is lightweight is polypropylene. It gives the concrete construction strength and stops cracks from forming.
In this investigation, various percentages and values of polypropylene fibrouss—such as 0%, 0.5%, 1.0%, 1.5%, and 2.0% values—were added, and 1.0% of virgin polypropylene was substituted for cement in the concrete. Workability, split tensile strength, compressive strength, and flexural resistance tests were performed on specimen.

Concrete is used by people all over the world as a straightforward, long-lasting, and safe building material. One of the main ingredients in concrete construction is Portland cement. Concerns over the growing use of concrete in building, particularly in developing nations, have led to attempts to create cement alternatives using locally accessible virgin polypropylene.
This study's primary goal was to use virgin polypropylene at 0%, 0.5%, 1%, 1.5%, and 2% by weight to investigate the parameters of hardened (splitting tensile strength and compressive strength) and fresh (flowability) concrete. To achieve the goal strength of 28N/mm2, a total of 90 concrete samples—45 cubes and 45 cylinders—were made, cured, and tested on a UTM over the course of 7, 14, and 28 days.
For each proportion, a set of three concrete specimens were formed in the shapes of cubes and cylinders, respectively, and the average of the three concrete samples was used to determine the outcome. As the amount of polypropylene mixed into the concrete increases, the flowability of fresh concrete diminishes. The findings demonstrated that adding 1.0% polypropylene to the concrete specimens at the 28-day curing stage improved their compressive and tensile strengths by 11.8% and 7.31%, respectively. This study's primary goal was to look at the use of virgin polypropylene in cement composites mixed with concrete.

Keywords: Polypropylene, Compressive Strength, Workability, Split tensile strength

INTRODUCTION

Over human history, concrete has been utilized extensively and everywhere in the world [1]. Sand and crushed rock, or coarse aggregate, are mixed to create concrete using a hardened paste made of hydraulic cement and water [2]. The need for the resources used to make concrete—cement, sand, and gravel—will rise as its use increases. Due to the rapidly rising rate of high-rate concrete ingredients, an unconventional, easily presented, low-cost material that can provide concrete with a similar or higher strength is required [3].

One of the more expensive components of concrete is cement, whose manufacture generates significant emissions of carbon dioxide [4–8]. A tonne of cement requires 1.6 tonnes of natural resources to create, and the production of one tonne of cement emits approximately one tonne of CO_2 into the environment [9–11]. To lower costs, waste, and CO_2 emissions while these resources are readily available, many studies partially replace cement with agricultural and industrial waste, such as glass powder, sugar cane bagasse ash, rice husk ash (RHA), blast furnace slag, maize cob ash, millet husk ash, fly ash, etc. [9, 12]. RHA is an unwelcome byproduct of agricultural waste [13–15] that is primarily burnt by air [16, 17].

Nowadays, getting rid of industrial and agricultural waste is a big issue. Rice husk is one of these agricultural wastes. In paddy fields, approximately 120 million tonnes of rice husk are produced annually [17–19]. After rice is processed, the husk is either burned or disposed of. At a specific temperature, rice husk is burned in an environment. RHA has an 85% silica content, also referred to as non-crystalline silica, and it can be used as a material to partially replace cement [20–24]. RHA can be used to concrete as an extra material to lessen environmental problems because it is measured as a highly pozzolanic substance [25–29].

LITERATURE STUDY

In this investigation, concrete samples were mixed at a 1:2:4 ratio with a water-to-cement ratio of 0.45, 0.50, and 0.60. The samples were then cured and examined after 7, 14, and 28 days. The tensile and compressive strengths rose by 10.71% and 14.51%, respectively, at 0.45 water-cement ratio when 1.0% polypropylene was added to concrete and allowed to cure for 56 days, according to the data.

When compared to regular cement concrete, polypropylene helps lower the temperature of the concrete, according to authors in [29]. Researchers in [30] studied the hardened characteristics of concrete mixed with 5%, 10%, 15%, and 20% weight of cement and other polymeric substance. The concrete samples were cured for seven and twenty-eight days, with a target strength of 25N/mm^2. When 1.0% of polypropylene was added to concrete at 28 days, the crushing strength increased by 15.74% [28]. One of the most important components of cementitious materials is polypropylene [29]. Concrete's characteristics are enhanced by the shredded plastic particles' thicker size compared to OPC [30].

As the shreds of plastic are only about 55 microns in size, polypropylene can serve as an essential filler in cement [22]. Up to 2.0% of the weight of the concrete was combined with polypropylene in this experimental investigation.

RESEARCH METHODOLOGY

Concrete's fresh and hardened properties were studied using varying percentages of polypropylene (0%, 0.5%, 1.0%, 1.5%, and 2.0%) used as a cement substitute. To achieve the goal strength of 28N/mm2, a total of 90 concrete samples—45 cubes and 45 cylinders—were made and cured at 7, 14, and 28 days. Many trail mixes are made with different amounts of water, fine, coarse, and variable cement (binder) to achieve the best possible mix. To get the desired mix, polypropylene was substituted for cement to test the concrete specimens' features and strength. Afterward, the India Standard (BIS) code was followed when testing the concrete specimens on a UTM.

Concrete cylinders were produced for splitting tensile strength and cubes for compressive strength in this investigation. For each proportion, a set of three concrete examples were cast, and the final result was the average of the three specimens from the set of nine. The work was finished in the concrete laboratory of the IPS College of Technology, & Management, Gwalior Department of Civil Engineering.

MATERIALS USED

A. Cement

Ultratech PPC cement is easily and extensively available in the market; it was utilized during the trial job and it was collected from stack which was free from any moisture and the bag of cement does not carry any lumps.

B. Fine Aggregates

The fine aggregates of Zone-II, which passed through Sieve No. 4 (4.75mm) and satisfied the BIS code readings, were obtained from the Sindh River. Fine aggregates have a specific gravity of 2.60, a fineness modulus of 2.61, and water absorption of 1.8% and these values are obtained after carrying out various test.

C. COARSE AGGREGATES

The coarse aggregates used were 20mm in size and were available in the local market. The water absorption and the specific gravity of coarse aggregates were 1.4% and 2.73 respectively.

D. POLYPROPYLENE

After being removed from the plastic park situated at “Bilaua” and “Antri” region nearby to Gwalior city and, virgin polypropylene was allowed to air dry. For experimental reasons, colourless polypropylene was torn into little pieces to facilitate easy mixing with the liquid.

E. WATER

The potable water available in the institute was taken for experimental investigation and before using directly the TDS of water has been checked to make sure that it was free from any impurities.

RESULTS & DISCUSSION

The slump cone test was used to measure the flow of fresh concrete. It had three dimensions: a top diameter of 10 cm, a bottom diameter of 20 cm, and a height of 30 cm. It was filled with four layers of varied percentages of polypropylene addition in accordance with Indian standard, and it was rammed with 35 blows. The lowest value of workability was 25mm at 2.0% polypropylene by weight, while the maximum flow of fresh concrete was 65mm when utilizing 0% polypropylene as a substitute material for cement in the concrete. It was determined that when the amount of polypropylene added to concrete increases, the flow of fresh concrete reduces. Figure 1 displays the outcomes of the experiment.

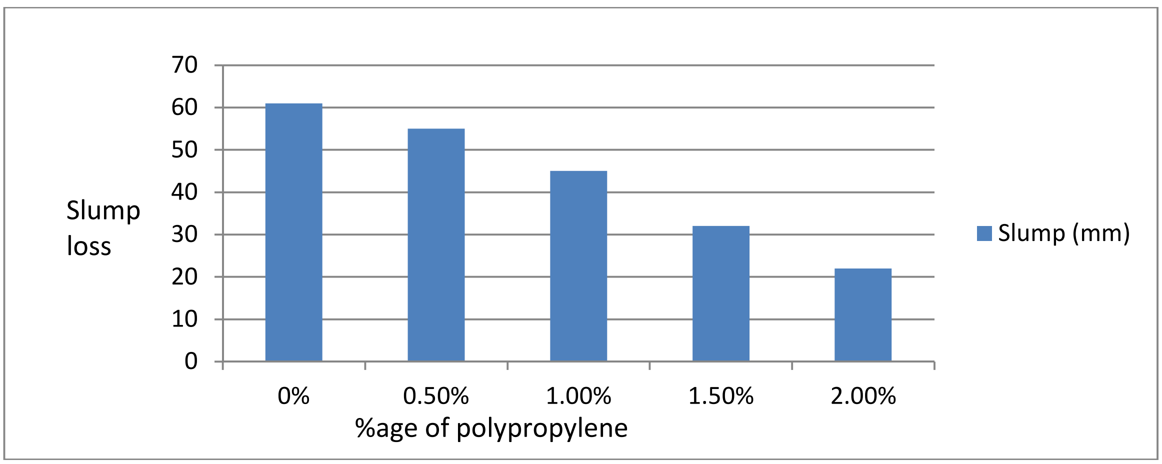

Figure 1: Impact of slump on the addition of polypropylene

COMPRESSIVE STRENGTH

Cubes measuring 150×150×150 mm^3 were subjected to compressive strength tests with varying percentages of polypropylene mixture. For every proportion, three concrete specimens were cast, and the final result was the average of these three concrete specimens. When virgin polypropylene is added to concrete as a cement substitute, the maximum compressive strength is reached at 1.0%, and the minimum is reached at 2.0% after 7, 14, and 28 days of curing. Figure 2 presents the findings.

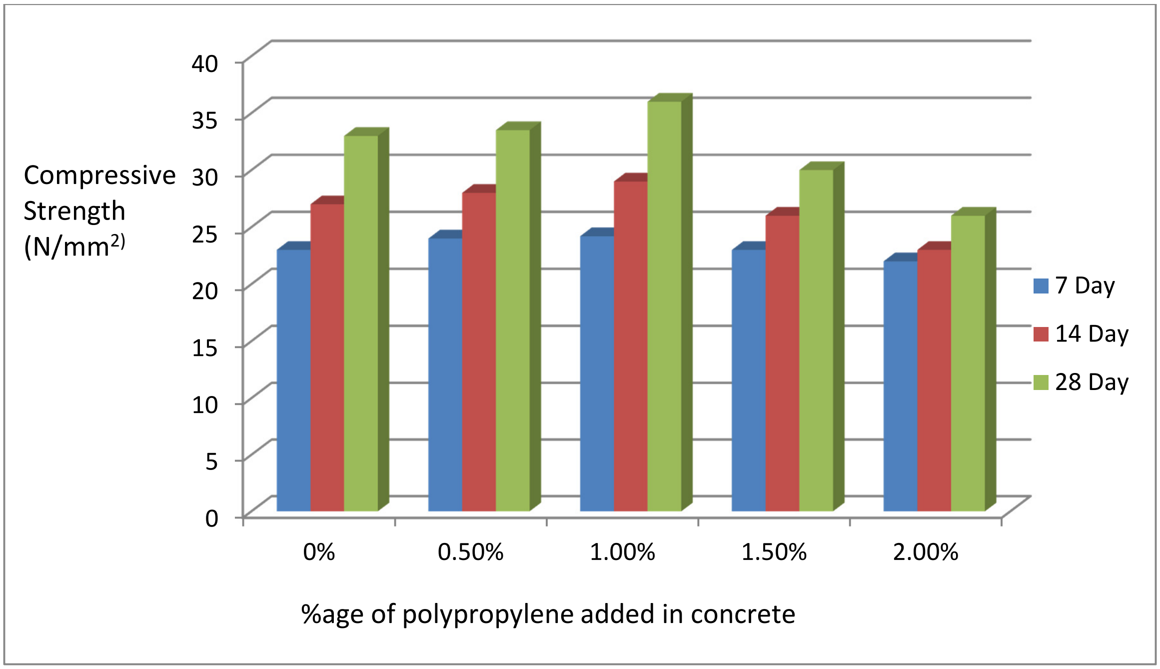

Figure 2: Variation of compressive strength after the addition of polypropylene

SPLITTING TENSILE STRENGTH

Testing for splitting tensile strength was done on 150 mm diameter by 300 mm height cylinders that had been combined with different amounts of virgin polypropylene and cured for 7, 14, and 28 days, respectively. For every proportion, three concrete samples were cast, and the average was determined as the outcome. Concrete's minimum splitting strength was reported at 2.0%, while its maximum splitting tensile strength was recorded at 1.0% for polypropylene specimens. A universal testing equipment with a 5kN capacity and a speed range of 0.5 to 500 mm/min was used to test the cylinders. Figure 3 displays the results of the experimental study.

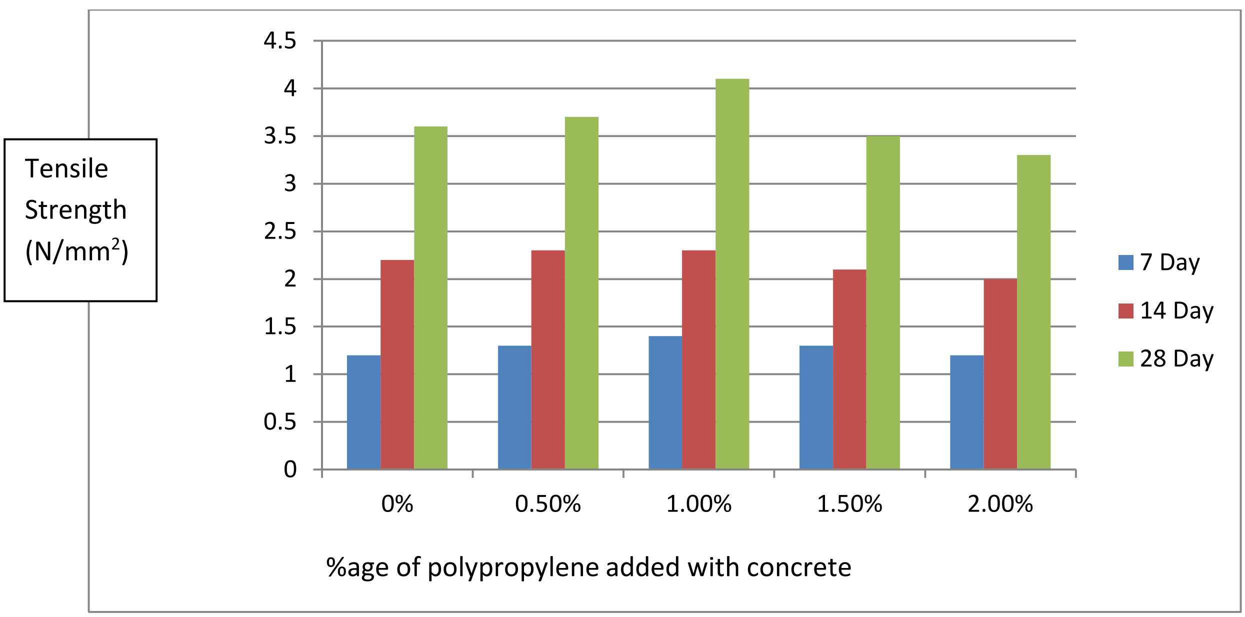

Figure 3: Variation of tensile strength after the addition of polypropylene

CONCLUSION

When utilizing zero percent polypropylene as a cement substitute material in concrete, the flow of fresh concrete was seen to be at its maximum. The lowest observed workability value was 2.0% when polypropylene was combined with concrete. It was determined that when polypropylene is added to concrete, the flow of fresh concrete diminishes. After 7, 14, and 28 days, the greatest compressive strength was achieved at 1.0% Polypropylene mixed with concrete, while the minimum was found at 2.0% Polypropylene mixed with concrete. At 7, 14, and 28 days, respectively, the minimum splitting strength was recorded at 2.0% Polypropylene added with concrete, while the maximum splitting tensile strength was detected at 1.0% Polypropylene added with concrete.

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