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Study of Geopolymer Concrete With Fly Ash Addition

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Abstract

Alternative binder materials for environmentally friendly building are being investigated in an effort to lessen the negative effects of the toxic emissions emitted during the manufacturing of Ordinary Portland Cement (OPC). Geopolymer Concrete (GPC), a potential invention that replaces cement with industrial waste, is one example. Numerous studies have determined that elements including fly ash, silica fume, ground granulated blast furnace slag (GGBS), and alcofines are useful ingredients for creating geopolymer concrete. When activated using alkaline solutions, GGBS, a byproduct of the steel industry, shows great promise as a single binder, producing a high-performance and long-lasting cement-free concrete. GGBS-based Geopolymer Concrete (GGC) reinforced with hybrid fibers—a blend of steel and polypropylene fibers—maintained at a total volume fraction of 1% of the binder is the major goal of the current investigation. The mechanical behavior of this Hybrid Fiber Reinforced Geopolymer Concrete (HFGGC) under flexure, tension, and compression was examined. The findings showed that polypropylene fibers improved the flexural performance while steel fibers greatly increased the split tensile strength. Improved strength, ductility, and durability resulted from the fibers' synergistic impact, proving that GGBS-based geopolymer concrete is a viable and sustainable substitute for OPC concrete.

Keywords: GGBS, Cement, binder, Strength Performance

1. Introduction

Cement's applications in the transportation, residential, and infrastructure sectors have greatly accelerated human civilization, economic growth, and personal development. However, some inert qualities of cement are still difficult to overcome due to the raw ingredients. There are primarily two significant drawbacks to sustainability. For every ton of cement, around 1.5 tons of raw materials are needed, and during the production process, about 1 ton of carbon dioxide (CO2) is released into the atmosphere. A few materials were suggested to replace the amount of cement in order to address the aforementioned problems. In concrete, silica and alumina-containing by-product components were utilized in place of some of the cement.

Examples of frequently used concrete substitute materials are fly ash, GGBS, RHA, and silica fumes. In essence, the binder material created by a pozzolanic reaction between hydration paste and concrete substitute elements has improved the qualities of conventional concrete. When two distinct types of materials with varied strength and elasticity qualities are combined, they adopt these traits such that the composite or concrete has better strength and stiffness as a result of the combination. To a certain extent, using a single type of fiber can improve the FRC characteristics. In any event, the concept of hybridization—the process of incorporating at least two different kinds of concrete fiber—can help to improve the appeal of building characteristics as the advantages of one fiber facilitate the efficient utilization of potential qualities of another fiber.

GGBS is a by-product of the steel making process, as is previously known. It is often sold as glass granules that may be processed into a fine powder. When alkali solutions like NaOH and Na2SiO3 react, finely ground slag (GGBS) is used to create geopolymer concrete. To create geopolymer concrete, 100% ground granule blast furnace slag (GGBS) is used as the source material and polymerized using an alkaline solution in place of cement. The fiber ratio utilized in hybrid fiber reinforced geopolymer concrete are as follows: 0% polypropylene fiber and 1% steel fiber 0.25% polypropylene fiber and 0.75% steel fiber 0.5% polypropylene fiber with 0.5% steel fiber 0.75% polypropylene and 0.25 percent steel fiber 1% polypropylene and 0% steel fiber.

2. Literature Review

The cement sector is currently under investigation due to its high CO2 emissions. In actuality, 5-7% of all anthropogenic CO2 emissions come from this industrial sector. According to the fly-ash-based geopolymer, chemistry can only take place when an alkaline aluminosilicate polymer gel is present. However, some research indicates that G.G.B.S. Alkalinity is the consequence of calcium dissolving in the C-S-H geopolymer gel, which also produces soluble calcium silicates. This makes G.P.C. more powerful.To create soluble silicates with enough mechanical strength, the majority of the calcium in blast furnace slag is either activated by SI or S, alkaline solutions utilizing high alkaline solutions, or both. The calcium in Class C fly ash is partially formed with silicon and alumina, and it can only be initiated in a high alkaline solution that contains soluble silicates. The durability studies and mechanical characteristics of G.G.B.S. concrete were investigated by Karri et al. (2015) [9]. G.G.B.S. was used to partially replace cement at 30%, 40%, and 50%. The qualities of concrete of grades M20 and M40 were examined. Moisture is studied with sulfuric and hydrochloric acids. For M20 and M40 grade concrete, the strength and efficiency of the concrete are boosted when GGBS is substituted with cement. When compared to conventional concrete, the compressive strength values of acid-induced concrete drop; nevertheless, the effect of the acid on the concrete reduces as the amount of GGBS increases, and the effect for HCLs is more than for HGSS concrete. The investigations demonstrated that extensive research has been conducted on geopolymer concrete to create a new concrete that uses fly ash and GGBS as by-products and less cement. Research is also conducted on concretes that use various kinds of natural and synthetic fibers.

3. Materials and Method

The following lists the materials needed to make GGC. GGBS Superplasticizer Water Alkaline liquid Fine aggregate Coarse aggregate. According to IS 12089-1987 requirements, GGBS was the sole and primary source material needed to create GGC. Sodium hydroxide and sodium silicate are the primary alkaline solutions used to create 100%GGBS-based geopolymers.The ratio of silicon dioxide and sodium oxide in the sodium silicate solution was 3.13, with 25.72% of the solution being silicon dioxide, 8.48% being sodium oxide, and 65.8% being water. The solution was purchased in large quantities from a neighboring industrial facility. NaOH and Na2SiO3 were the alkalis utilized to create the geopolymers for this investigation.There were 29.4% SiO, 14.7% Na2O, and 55.9% water in the Na2SiO3 solution that was bought at the neighborhood market. In the local market, a sodium silicate solution is offered in semisolid form. The following characteristics of the purchased solution were present: The modulus, or the ratio of silicon dioxide to sodium oxide, of the sodium silicate solution was 3.13, with 25.72% SiO2, 8.48% Na2O, and 65.8% water represented by proportion. The solution was purchased in large quantities from a neighboring industrial facility. GGBS Physical and chemical Properties are noted in Table 1. Fig. 1 Particle size distribution of fine aggregate in Fig.1.

Table 1. GGBS Physical and chemical Properties

Sr. No	Property	Result
1	Specific Gravity of GGBS	2.87
2	Blaine Fineness	4380 cm2/g
3	Silicon-di-Oxide	32.69
4	Calcium Oxide	34.20
5	Aluminum trioxide	15.78
6	Ferric Oxide	0.735
7	Sulphur Trioxide	1.62
8	Magnesium Oxide	7.21
9	ignition Loss	2.1

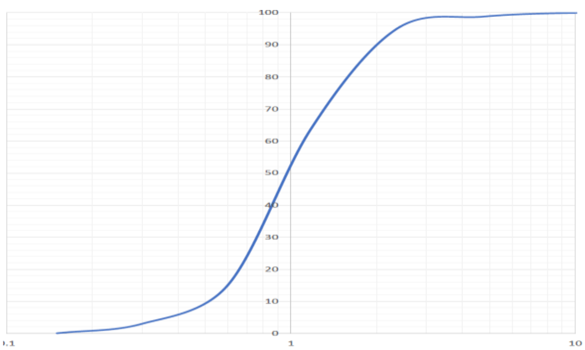

Fig. 1 Particle size distribution of fine aggreagate

4. Results

Fine aggregates that are restricted to zone-II and meet IS 383-1970 standards were taken into consideration for the mix in this investigation.For reinforced concrete constructions that need vibrators for compaction, the geopolymer concrete prepared with 100% GGBS (GGC) exhibited a compaction factor value of 0.89 for the mix with a 12 molar NaOH concentration, indicating that the mix falls within the medium workability range. The best workability was attained at mix S1P0, which indicates that geopolymer concrete built with 100% GGBS, which contained 1% steel fibers and 0% polypropylene fibers, had a compaction factor value of 0.91 for 12 molarity. The addition of fibers such as steel and PP fibers decreased workability. For mix ID S50P50 at 8Molarity, the strength in compression of HFGGC increased by almost 71% of the 28-day strength after 3 days of curing, whereas 7-day cubes demonstrated an 82% increase in the 28-day strength.

For mix ID S25P75 at 8Molarity, the strength in compression of HFGGC increased by almost 69% of the 28-day strength after 3 days of curing, whereas 7-day cubes demonstrated a 71% increase in the 28-day strength. In contrast to 7-day cubes, which demonstrated a gain of 76% of 28-day strength, the strength in compression of HFGGC for mix ID S0P1 at 8Molarity for a 3-day curing time increased roughly 68% of 28-day strength. Comparing the compressive strength results with a control mix is crucial for understanding how HFGGC behaves under compression. The control mix in this study is a simple geopolymer concrete that uses 100% GGBS (GGC) as the binder material. After 28 days, the GGC mix without fibers reached its maximum strength at 12 molar concentration, or 62.1 MPa. Additionally, the HFGGC had the highest compression strength at 12 molarity.

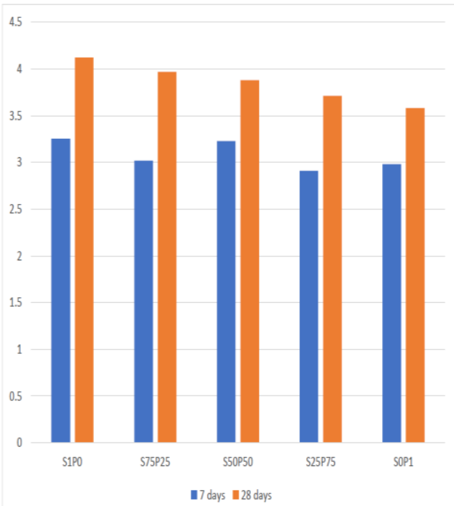

Fig.2 Split tensile results

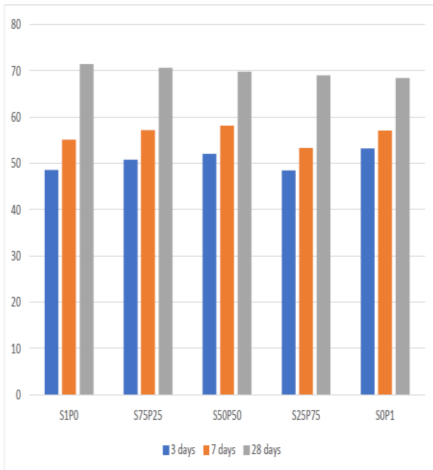

Fig. 3 Compressive strength Results

5. Conclusion

A When the molarity of the NaOH solution rose, the workability of the fiber-free geopolymer concrete increased. Because the fiber content varied, the cubes constructed with fiber reinforcement displayed a distinctive workability pattern. The highest workability was achieved by the HFGGC, which contained 1% polypropylene fiber. However, when steel fiber is substituted with polypropylene, workability appears to decline, albeit not significantly, as the presence of fibers in the mix generally reduces workability in comparison to GGC. When compared to different fiber proportions with varying steel and polypropylene contents, the mix with 1% steel fiber and 0% polypropylene exhibited the highest compressive strength for each molar concentration, which are 8, 10, and 12M, for HFGGC.

Declaration of Conflicting Interests

The authors declare no potential conflicts of interest with respect to the research, authorship and publication of this article.

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