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Strength of Geopolymer Concrete using Hybrid Fibers

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Abstract: Sustainable building methods have undergone a paradigm change with the introduction of geopolymer concrete, a ground-breaking substitute for conventional Portland cement-based concrete. Instead of using cement, which has a large carbon footprint in the process of making concrete, geopolymer concrete uses industrial byproducts like fly ash or slag, which improves material performance while having less of an adverse effect on the environment. Hybrid fibers such as steel, basalt propylene etc. are some of the fibers which are used for increasing the strength.

Literature Reviews: Crushed concrete, mortar, bricks, or asphalt that has been recovered from construction waste and used again in different building projects is called recycled aggregate. To recover the aggregate, it is obtained by crushing demolished debris. The quantity of construction and demolition waste has expanded dramatically over the last few decades, which has prompted the concrete industry to include it and lower aggregate costs. Utilizing waste in construction not only reduces carbon emissions but also makes it easier for the concrete sector to grow without negatively impacting the environment.

In order to optimize the size of the fiber, the content of fiber, and fly ash content in hybridpolypropylene-steel fiber concrete with low content of fiber, based on general mechanical qualities, **(Qian C. X. and Stroeven P. 2000)** conducted study. The study's findings indicated that in order to spread fibers uniformly, a specific amount of small particles, like fly ash, was required. At least to varying degrees, the various steel fiber sizes contributed to various mechanical qualities. The splitting tensile strength was onlymarginally impacted by the addition of a tiny fiber type, while the compressive strength was significantly influenced. Opposite mechanical effects were induced by a big fiber, and these effects were strengthened by optimizing the aspect ratio. A synergistic impact was observed in the hybrid fiber system. For the hybrid fiber concrete with good generalmechanical characteristics, more research may be done on the fracture and dynamic properties.

In their 2002 study, **Wu Yao et al.** investigated the compressive, splitting tensile, flexural, and the other mechanical characteristics of hybrid fiber-reinforced concrete that contained several hybrid fiber types at the same volume percent (0.50%). Three different kinds of hybrid composites were built with steel, carbon, and polypropylene fiber combinations. The study found that carbon fibers have a high tensile strength and modulus.

Polypropylene fibers had high elongation, less modulus, and tensile strength, whereas steel fibers had medium elongation and tensile strength, similar to carbon fibers. Becausethe modulus of both fibers and the interaction between two reinforcing bars wereidentical, the research recommended the best mix

In a brief review published in 2004, **Hardjito D. et al**. addressed the advancement of geopolymer concrete. Geopolymer concrete shown great promise as a material for the future. It had both short- and long-term durability and was environmentally beneficial. The authors claim that water was a major factor in the geopolymer concrete's workability. Workability was obtained, according to studies, by modifying the water content and maintaining a consistent H2O to Na2O ratio, which allowed geopolymer concrete to be handled without setting or losing its compressive strength for at least 120 minutes after mixing. The study verified that the curing temperature and duration had a substantial impact on the compressive strength of the concrete. The project's conclusion was a 60°Cmaximum curing temperature and a 48-hour maximum curing period.

Fly ash-based geopolymer concrete's manufacturing process and technical characteristicswere described by **Hardjito D. et al. (2005).** The study made it clear that low calcium dryfly ash, a solution of sodium hydroxide and sodium silicate, additional water, fine and coarse aggregates, and extra water were required to make fly ash based geopolymer concrete. The study demonstrated that aging has zero effect on the compressive strength of geopolymer concrete. The geopolymer concrete demonstrated outstanding defense against sulfate assault. The study found that slump value dropped with longer mixing times. Longer mixing times also resulted in greater density and compressive strength. Incomparison to specimens without a rest time, the report states that the compressive strength rose by 20–50% as the rest duration increased. The relationship between stress and strain was reported in the research, and it was found that the relationship was comparable to Portland cement concrete. The study came to the conclusion that fly ash- based geopolymer concrete structures can be designed by using the provisions of currentcodes and standards for concrete structures.

In **2012, Patodi S. C. and Kulkarni C. V.** conducted research on the hybrid fiber reinforced concrete matrix's performance evaluation. In this case, two or more distinct fiber types were logically mixed as hybrid fibers to create cementitious composites that showed a synergistic reaction and benefited from each unique fiber. Twelve different kinds of HFRC matrices were created in total for performance assessment. Comparing the mix to plain conventional concrete, it was found that the addition of 0.3% Recron and 0.7% steel fibers boosted the mix's compressive strength by 21.91%, split tensile strength by 69.00%, and flexural strength by 23.98%. In addition, ductile failure was seen when 0.7% of steelfibers and 0.3% of Recron hybridized.

The water to geopolymer binder ratio effect on workability in terms of compressive strength and flow were experimentally investigated by **Patankar S. V. et al. (2013)**. Afterheat curing for eight hours at 90 degrees Celsius in an oven, the specimens were evaluated. The flow of geopolymer concrete was shown to rise as the ratio of geopolymerbinder to water rose, while the compressive strength decreased. The flow table, slump cone, and compaction factor tests were used to determine how workable fresh concrete was. It was noted that delayed concrete subsidence and challenges with slump value measurement actually happened with viscous mixes. The slurry flowed from the bottom of the slump cone as the geopolymer concrete was being placed, which also affected thevalue of slump, for mix which is less viscous and flowable. The geopolymer concrete didnot flow smoothly through the hopper in the compaction factor test. The flow table test yielded good workability results.

Experimental research on the mechanical characteristics and microstructure of chopped basalt fiber reinforced concrete was conducted by **Chaohua Jiang et al. in 2014**. The studyemployed coarse aggregate consisting of calcareous crushed stone with a maximum size of 5 mm and fine aggregate with diameters ranging from 0 to 3 mm. The polypropylene fibers utilized in the mix had volume fractions of 0%, 0.05%, 0.1%, and 0.3% of the overall volume. Similarly, the same volume proportion of the mix's total volume was made up of chopped basalt fibers of two different types: one with a diameter of 20 µm and length of 22 mm. It has been noted that adding basalt fibers to concrete causes the workability of the material to diminish. Concrete reinforced with basalt fibers performed mechanically better than concrete reinforced with polypropylene fibers. Based on the outcomes of the experiment, the ideal proportion of basalt fibers in volume fraction was around 0.3%.

Research on the strength, bond and setting time of high calcium fly ash geopolymer concrete was conducted by **Pattanapong Topark Ngarm et al. (2015)**. The experiment employed high calcium fly ash from the Mac Moh power station in Northern Thailand, coupled with concentrations of NaOH (10M, 15M, and 20M). A ratio of 1 to 2 for Na2SiO3/NaOH was used. The ratio of alkaline solution to fly ash was taken into consideration, and two different curing techniques were employed curing at 60 +2^{o} C for 24 hours, and room temperature curing at 23 + 2^{o} C. The high calcium content of fly ashwas found to be the reason behind the quick setting time of 28 to 58 minutes for geopolymer concrete. For compressive strength, a concentration of 15 M NaOH was ideal, whereas a fly ash's ideal Na2O content was about 12%.

(2015) Patankar S. V. et al. conducted research on the fly ash-based geopolymer concretemix design process. Various factors were examined in order to choose the best geopolymer concrete components and get the desired strength and workability. The current study process addressed the selection of fly ash quantity based on fly ash fineness,fine to total aggregate ratio, water quantity, and fine aggregate grading. In the current study, the ratios of sodium silicate to sodium hydroxide (1.0), alkaline solution to fly ash(0.35) and water to geopolymer binder (0.35) were taken into consideration. To create geopolymer concrete, alkaline activators based on sodium were employed. Using a flow table instrument, the workability of newly mixed geopolymer concrete was examined. Inaddition, the compressive strength of concrete of the M30 grade was measured at 37.22 MPa at a concentration of 13 Molar NaOH after 7 days of testing.

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