International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Investigations into the Flexural Performance of Reinforced Geopolymer Concrete Utilizing River Sand

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ABSTRACT:

An experimental study was conducted to establish the correlation between compressive strength, splitting tensile strength, and modulus of elasticity in Geopolymer Concrete. The investigation aimed to scrutinize the widely accepted 0.5 power relationship existing in traditional cement concrete between compressive strength (CS), splitting tensile strength (STS), and modulus of elasticity. The study explored the applicability of this relationship to Geopolymer concretes. The results revealed that Geopolymer Concrete (GPC) made with both sand and M-Sand exhibited superior structural integrity. Consequently, there is considerable potential for the production of high-quality GPC utilizing sand and M-Sand. Furthermore, the research delved into the flexural behavior of Reinforced Geopolymer Concrete sections using River sand and M-sand. The findings established the structural applications of such concrete, positioning it as a viable alternative to Reinforced Concrete made with Ordinary Portland Cement in the foreseeable future.

Keywords: Keywords are important word in paper **Example** Weather Prediction, forecast accuracy

Introduction:

Concrete is the most frequently used material in construction. In the production of concrete, ordinary Portland cement (OPC) is traditionally employed as the principal binder. Energy-intensive Portland cement production contributes significantly to the emission of greenhouse gases into the atmosphere.

Following China, India is the second-largest producer of cement in the world. The nation's cement manufacturing capacity amounted to 300 million tonnes in 2010, and the Cement Manufacturers Association projects that by 2020, that number will nearly double, reaching nearly 550 million tonnes (CMA). Conversely, as a result of climatic changes, global warming has emerged as a crucial issue. Global warming is the consequence of greenhouse gas emissions leading to an increase in the average surface temperature of the Earth. Regarding greenhouse gases, carbon dioxide (CO2) accounts for approximately 65 percent of the overall warming phenomenon. As a result, endeavours are being made to advance the development of alternative cementitious materials for the fabrication of concrete. One such substance is geopolymer concrete, which is manufactured using activated fly ash as a binder, thereby eliminating the need for Portland cement. Alkaline solution is used to activate the base material, such as fly ash, in order to produce the binder, which is abundant in aluminium and silica (Si) (Al).

The emission of approximately one tonne of carbon dioxide into the atmosphere is attributable to the production of one tonne of Portland cement; therefore, the cement industry bears a greater degree of responsibility for CO2 emissions. To mitigate the effects of global warming, numerous initiatives are presently underway to decrease the consumption of Portland cement in concrete. These encompass the implementation of additional cementitious substances, such as fly ash, granulated blast furnace slag, silica fume, metakaolin, and rice-husk ash, as well as the research and development of substitute binders for Portland cement.

Methodology:

MATERIALSUSED

Fly Ash

Fly ash is a cementitious material that is extracted through the high-temperature combustion of coal. Two varieties of fly ash exist, including ASTM class F.

Fine Aggregate(M-Sand)

In lieu of river sand, M-sand is composed of crushed fine aggregates extracted from hard granite stone that have been graded and washed to a consistent consistency, cubic in shape, and featuring ground edges. M-Sand is manufactured sand of exceptional quality that adheres to global standards. The manufactured sand possessed specific gravity and fineness modules with values of 2.8 and 2.9, correspondingly.

Fine Aggregate (Sand)

Sand serves the primary purpose of imparting consistency and workability to the mixture. Availability of clean, dry river sand in the area was utilised. Sand that had been sieved through an IS 4.75mm mesh was utilised in the casting process for every specimen. Additionally, the fine aggregate aids the cement paste in suspending the coarse aggregate particles. The present study utilised sand classified as Zone III and conducted the subsequent tests in accordance with IS: 2386– 1968 part III. The corresponding values for the Specific Gravity and Fineness modules of river sand were 2.7 and 2.6.

Coarse Aggregate

The current study utilised locally sourced crushed granite stone aggregate with a 20mm particle size that was retained in a 10mm IS sieve. The experimental procedures followed the guidelines outlined in IS:2386-1968 part III. The coarse aggregate specific gravity and fineness modules yielded values of 2.63 and 2.8, correspondingly.

Sodium Hydroxide

Sodium hydroxides are commonly encountered in solid form, specifically in the form of pellets and flakes. Primarily, the cost of sodium hydroxide fluctuates in accordance with the substance's purity. In this investigation, sodium hydroxide is utilised to activate the homogeneous Geopolymer concrete. Therefore, sodium hydroxide is advisable due to its cost-effectiveness and high purity. The pellets of sodium hydroxide utilised in this study were those whose physical and chemical properties are detailed in Tables 3.2 and 3.3 by the manufacturer.

Sodium Silicate

Sodium silicate is a liquid (gel) substance that is alternatively referred to as water glass or liquid glass. The current study employs sodium silicate 2.0 (a sodium to silicon dioxide ratio of 1:2). As bonding agents, silicates were supplied to the detergent and textile industries by the manufacturer. Similar sodium silicate is utilised in the production of geopolymer concrete. The manufacturer provides the chemical and physical properties of the silicates, which are detailed in Table 3.4.

Alkaline liquid

In general, alkaline solutions are produced by combining solutions of sodium hydroxide and sodium silicate at ambient temperature. When the solutions are combined, they undergo a chemical reaction, specifically polymerization, which generates significant heat. Therefore, it is advised to allow the mixture to sit for approximately 24 hours, during which time the alkaline liquid becomes suitable for use as a binding agent.

Compressive Strength of Concrete

An IS 516-1959-compliant test was conducted on a cube measuring 150mm x 150mm x 150mm in order to ascertain the compressive strength of geopolymer concrete. Utilizing a standard Compression Testing Machine with a 2000kN capacity, the examination depicted in Figure 3.5 was performed. The mean strength of three specimens is represented by the test results for the specimens in Tables 3.8 and 3.9. Figure 3.6 and 3.7 illustrate a comparison of the compressive strength of sand and M-sand in relation to the mix ratio.

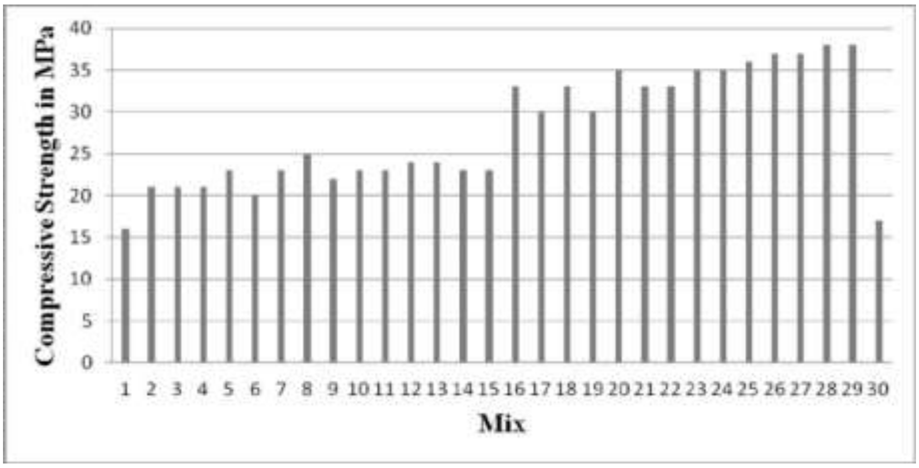

Figure 3.6 Comparison of Compressive strength of GPC mixes cast with Sand

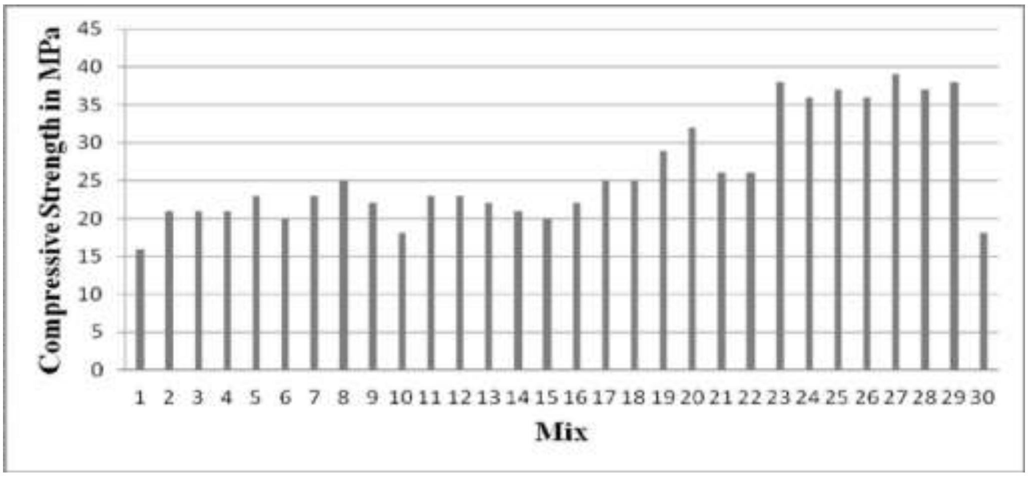

Figure 3.7 Comparison of Compressive strength of GPC mixes cast with M-Sand

Split Tensile Strength

A 100 x 200 mm cylinder was utilised in the test to determine the split tensile strength of GPC in accordance with IS: 516-1959. Figure 3.8 illustrates the tensile failure of concrete reinforced with M-sand and sand. The experiment was carried out usisented in Tables 3.10 and 3.11, represent the mean strength of three different specimens. The split tensile strength comparison between sand and M-sand for various mix ratios is illustrated in Figure 3.9 and 3.10. In Figure 3.11, the tensile failure of concrete made with M Sand and sand is illustrated.

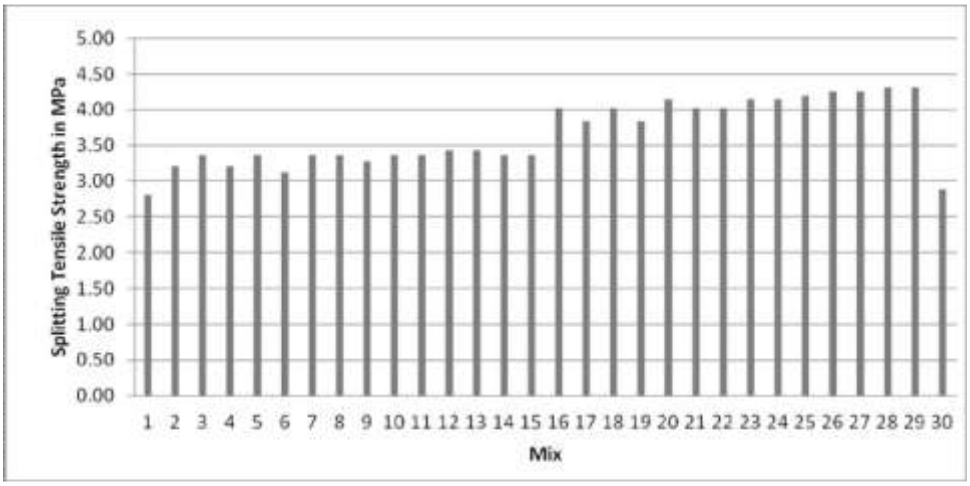

Figure3.9 Comparison of Split Tensile strength of GPC mixes cast withSand

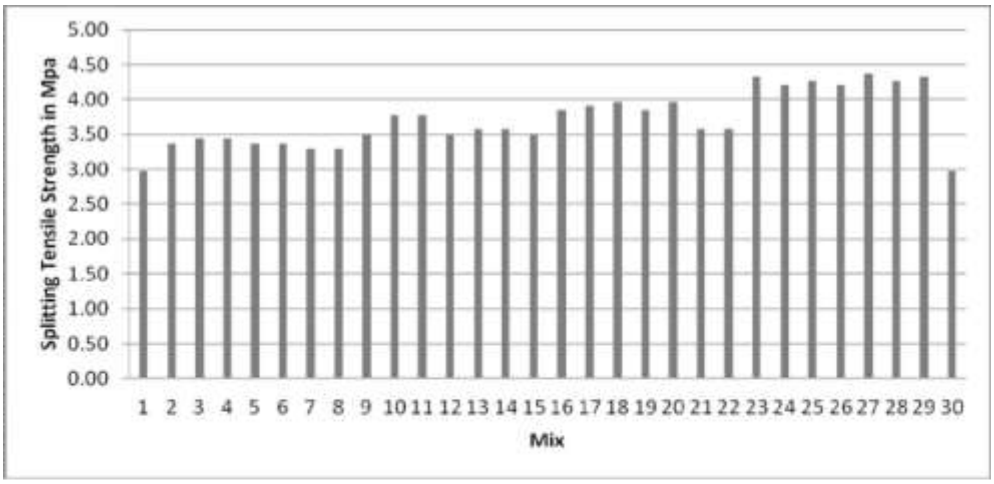

Figure3.10 Comparison of Split Tensile strength of GPC mixes castwithM-Sand

CONCLUSIONS

A rigorous trial-and-error approach was utilised to determine the fundamental properties of geopolymer concrete, including compressive strength, split tensile strength, flexural strength, and static modulus of elasticity, for both sand and M-sand.

- It is suggested that the mix ratios for various grades of geopolymer concrete be determined through trial and error. A novel design procedure was developed to address the requirements of the Indian standard for geopolymer concrete.
- Utilizing geopolymer concrete, the suitability of current mix designs was evaluated. This study examined two types of systems: those in which 100 percent of the cement was replaced with ASTM class F flyash, and those in which 100 percent of the sand was replaced with M-sand. Based on the test results, it was determined that the mix design of the Indian standard can be modified to apply to geopolymer concrete.
- Experimental investigations of the flexural behaviour of reinforced GPC concrete made with M-sand and sand for various curing processes validate the developed theory.
- Twenty-four reinforced GPC with a 100mm by 100mm cross section
- A beam measuring 200mm × 2000mm was examined for both sand and M-sand during ambient curing. Additionally, twenty-four beams were examined for heat curing with varying reinforcement ratios.
- A comprehensive analysis is provided of the experimental results, including the ultimate load, maximum deflection, first crack load, moment curvature, and ductility parameters including displacement ductility, curvature ductility, and others.
- The ultimate loads of the tested beams are computed and contrasted with the theoretical loads computed in accordance with the flexural strength theory designed specifically for geopolymer concrete beams with reinforcement.
- For both the curing process and GPC employing sand and M-sand reinforced beams, design charts were created so that they could be easily implemented in the design application.
- The tested specimen underwent numerical analysis utilising ANSYS 13.0 software. During this analysis, the critical load, deflection, and mode of failure were examined and compared to the results obtained experimentally.

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