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A Study on Workability and Flow Characteristics of Graded Glass Fiber Reinforced Concrete Using Slump Test

Anil Gupta [a], Priya Iyer [b]

[a] *Department of Civil Engineering, Earth Span University, Darbhanga, India.*
[b] *Department of Civil Engineering, Earth Span University, Darbhanga, India.*

Abstract

The most common building material is concrete mixture. It is adaptable and has desirable engineering qualities that allow it to be produced using reasonably priced components and moulded into any shape. Sand carrying issues are a daily occurrence in developing nations like India. The demand for sand is growing daily, and it is currently made from crushed rock that has been properly graded for use as a fine aggregate. In this sense, construction companies face intense pressure to locate substitute natural sand. The current focus is on the potential substitution of equally viable resources, like marble dust and quarry dust, for fine aggregates. The current study falls under the heading of introducing the innovative idea of using comparable elements from industrial waste dumps to partially or possibly completely replace the traditional concrete ingredients. The mechanical and physical properties of marble dust and quarry dust were determined for different amounts from 20% to 80% replacement with sand in terms of workability, flexural strength, split tensile strength, and compressive strength in the first stage as a preliminary inquiry.

Keywords: Workability, Flexural Strength, Split Tensile Strength.

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Introduction

Concreate here's the good news: we can actually boost the tensile properties of concrete by adding fibers. Going back in history, Joseph Lambot had this innovative idea of using continuous fibers in a mesh format to create new building materials, which eventually led to the creation of Ferro-cement and reinforced concrete (Raj et al., 2014). The performance of FRC largely depends on the properties and dimensions of the fibers used. When you mix different types of fibers or combine fibers of varying lengths, that's what we call hybrid fiber reinforced concrete (HFRC). Using discontinuous fibers in brittle matrices, like a cementitious matrix, really shows its benefits once the matrix cracks. These fibers can help maintain the load-carrying capacity of the cracked composite by creating a mechanism to transfer loads across the crack, which leads to a pseudo-ductile response (Sharifi et al., 2015).

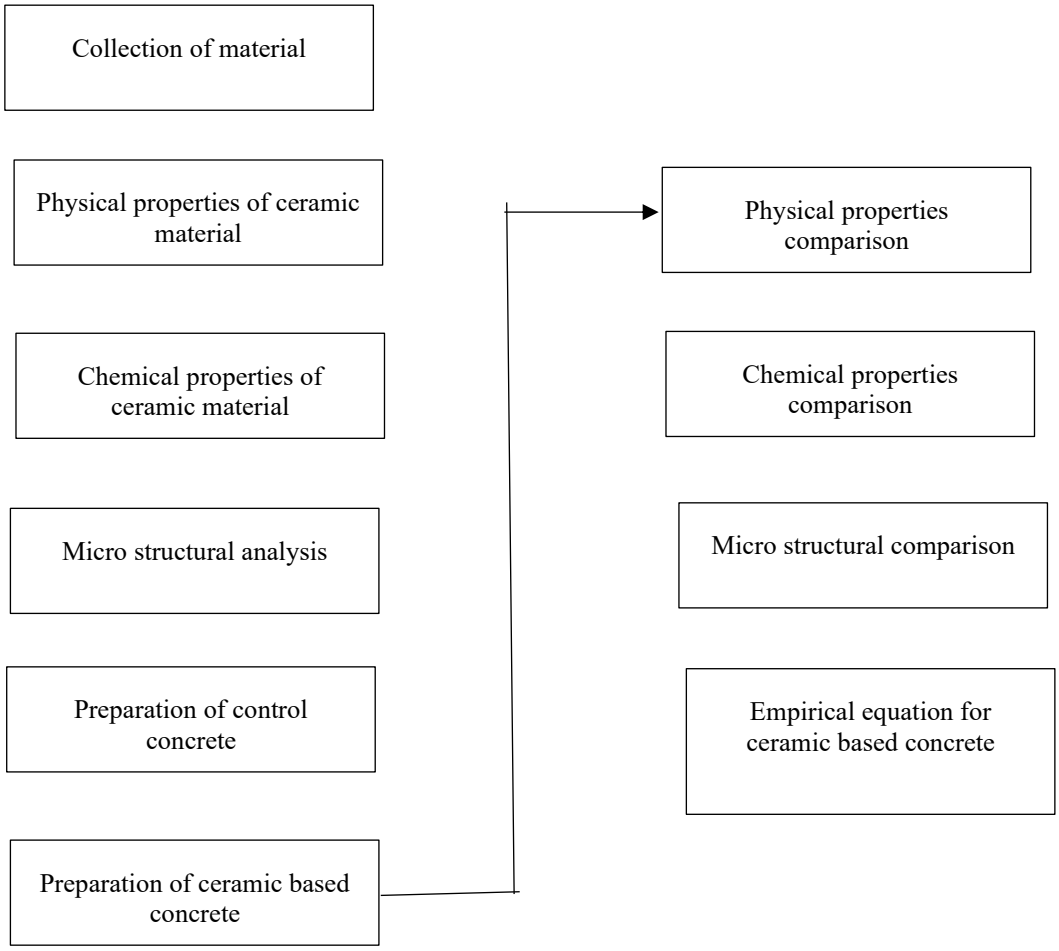

Fig. 1: Research Methodology

Materials

Cement

For this research, we used 53-grade Ordinary Portland cement, which is comparable to ASTM Type I, specifically from the Ultra Tech brand. We carried out tests to determine various properties following the guidelines of IS: 4031–1988, and the results were found to meet the standards set by IS: 12269–1987.

Fine Aggregate

We gathered fine aggregate from the riverbed to use as our experimental raw material. (Xu et al., 2022). The sand we used meets the zone-III specifications and was kept moisture-free in a room before we used it to cast our specimens.

We carefully assessed the properties of the crushed rock according to the IS-383:1970 standards.

Water

Water plays a crucial role in concrete, but it can also introduce some unwanted impurities like suspended solids, organic matter, and dissolved salts (Gencel et al., 2011). These impurities, often found in natural water sources, can negatively affect the concrete's properties, particularly during the setting and hardening phases. For cement to hydrate properly, clean water is essential. According to IS 456-2000, potable water is generally recommended for mixing concrete. However, using contaminated water can lead to drying shrinkage cracks and compromise the overall physical properties of the concrete.

Glass Fibers

The AR-glass fibers sourced from Chemzest Enterprises in Chennai, India, are illustrated in Fig. 4.2. In this study, the glass fibers have a tensile strength of 1700 MPa, a modulus of elasticity of 73 GPa, and a specific gravity of 2.6.

Results

The slump test is a widely used method for checking the consistency of concrete, whether in a lab or on-site. However, it’s not the best choice for extremely wet or dry concrete. This test is handy for quality control and helps indicate how uniform the concrete is from one batch to another (Mehdipour et al., 2013).



Fig. 2: Slump Test

The slump cone itself is fashioned like a cone's frustum and is composed of galvanized metal that is 1.6 mm thick. It is 300 mm tall with a base diameter of 200 mm and a top diameter of 100 mm. The mold's top and bottom are both open, parallel to one another, and perpendicular to the axis of the cone. The mold has grips for easy removal from the sample and a bottom piece on each side to keep it stable. The tamping rod is a circular, straight steel rod that is roughly 600 mm long and 16 mm in diameter. The tamping end is grounded into a 16 mm-diameter globe. (El Ouni et al., 2023).

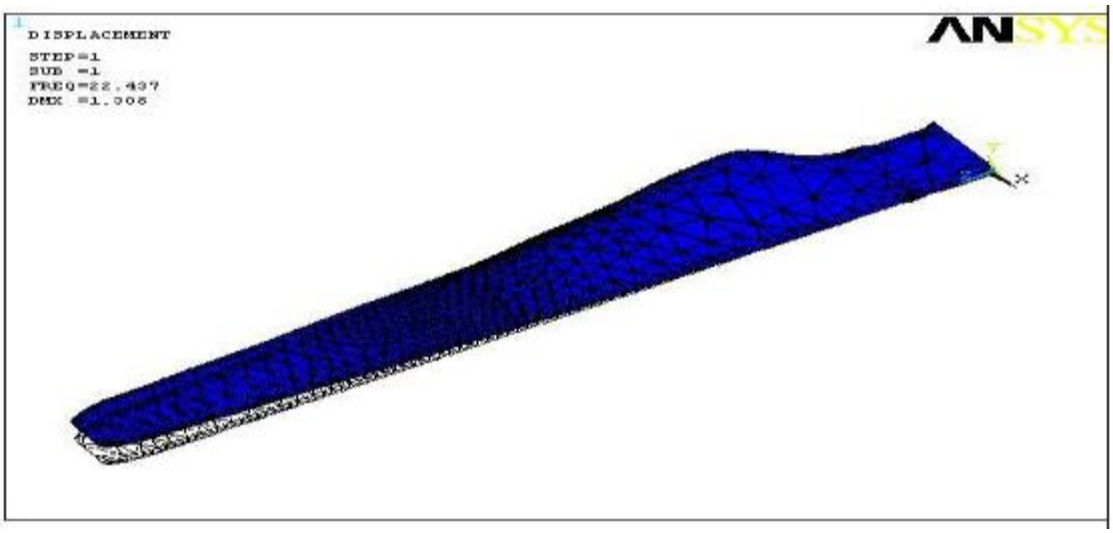

Fig. 3: ANSYS Result

To enhance the strength and deformation properties of the composite, we mix different lengths of fibers, which we refer to as Graded Fibers, based on the MGFRC results. Our experimental program aims to explore how these graded fibers impact concrete grades M30 and M50. In this study, we combine two or more fiber lengths to create these Graded Fibers.

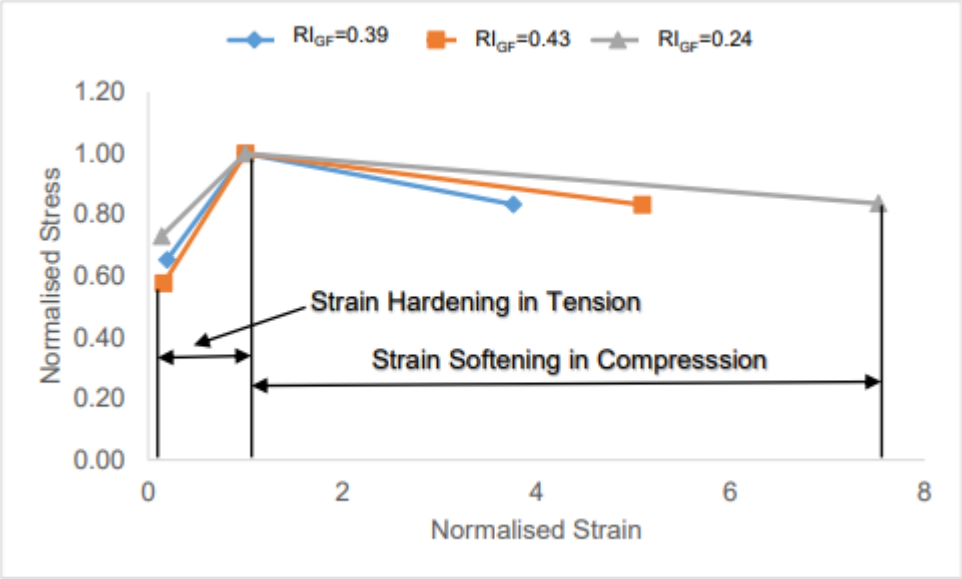

Fig. 4: Strain Analysis (M50-GGFRC)

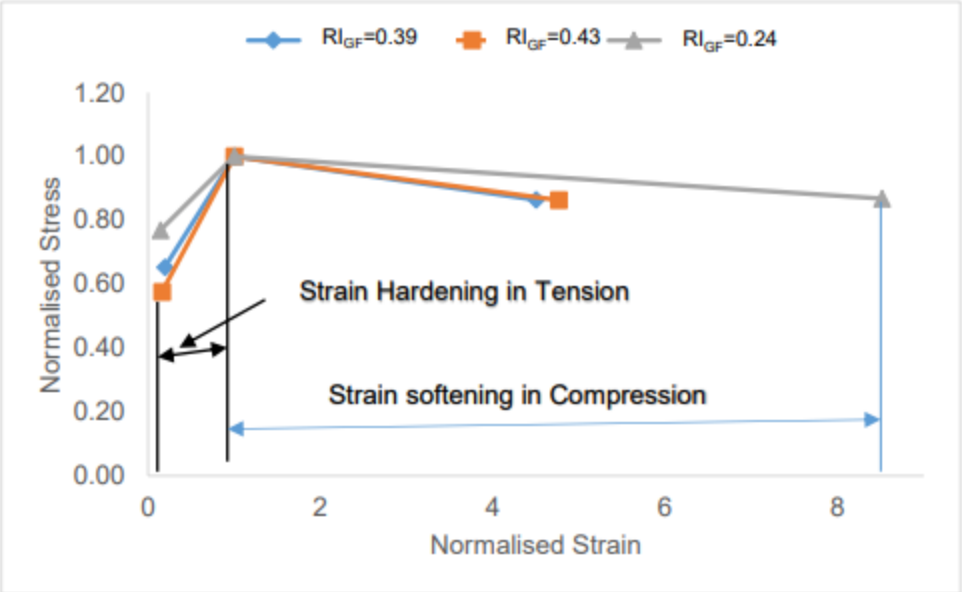

Fig. 5: Strain Analysis (M30-GGFRC)

To really grasp how specifically at a 0.3% volume fraction with RIGF values of 0.39, 0.43, and 0.24, as illustrated in Figures 4 and 5. The specimens that had a mix of graded fibers, meaning RIGF = 0.24, showed notable strain hardening when pulled in tension, along with a corresponding strain softening when compressed (Tibebu et al., 2022). This leads us to conclude that, for any given reinforcing index, as strain hardening in tension increases, the related strain softening also tends to rise.

Conclusion:

Hybrid fiber reinforced concrete is an exciting area of research where various types of fibers are blended together, allowing the best features of each to enhance the strength and flexibility of concrete. By mixing short and long fibers, we can reap the benefits of hybrid reinforced concrete. This combination is referred to as Graded fiber reinforced concrete. Previous studies have shown that short fibers mainly help control the spread of micro cracks and boost the overall strength, while long fibers work to stop macro cracks and enhance the concrete's performance after it reaches its peak. Therefore, using different combinations of short and long fibers can effectively tackle both micro and macro cracks, improving the concrete's performance both before and after it reaches its peak. While the synergy between short and long fiber hybridization is acknowledged, it hasn't been explored in depth yet.

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