Comparative Study of Strength of FRC and RCC

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Abstract - *Concrete is a composite material made of small components of fine aggregates, cement as a binding agent, water and a number of additives. Concrete has been used for several decades because of its superior qualities hence creating the many uses of the material. However, there are some drawbacks to this material, for example, while concrete has some of the most outstanding features it does not do well when placed under tension stresses. As a result, improvements and subsequent research work have led to the development of fiber reinforced concrete (FRC). Fiber reinforced concrete (FRC) may be defined as the use of fibrous materials in the reinforcement of concrete.*

Key Words: RCC, FRC, compressive strength

1. INTRODUCTION

Typically, fibers are employed in concrete to regulate the occurrence of plastic contraction cracking and drying shrinkage cracking. Additionally, they decrease the permeability of concrete, resulting in a reduction of water bleeding (Bertelsen et al., 2020). Fiber enhances the several forms of strength in concrete and aids in fracture reduction. Short fibers in FRC are uniformly dispersed in random orientations. Multiple types of fibers can be utilized in concrete for building purposes. Several types of fibers include steel fibers, glass fibers, synthetic fibers, natural fibers, and others. Each of the fibers contributes to different qualities of the concrete. Geometries, fiber materials, orientation, distribution, and densities are among the several elements that influence the strength of fiber-reinforced concrete.

According to findings from recent research conducted on high-performance fiber-reinforced concrete, the incorporation of fibers resulted in the provision of residual strength and also reduced cracking. By incorporating steel fibers into the concrete mixture, a homogenous reinforcement is achieved (Gamage et al., 2024). This does not significantly enhance the mechanical qualities leading up to failure, but it does control the behavior after failure. Therefore, the brittle nature of ordinary concrete or RCC is transformed into the ductile behavior of steel fiber-reinforced concrete. Once the matrix begins to break, the stresses are taken in by the bridging fibers, and the bending moments are redistributed. When the matrix of the concrete element is broken, it does not fail on its own. Instead, it absorbs the deformation energy and becomes pseudo-ductile. The use of fiber reinforcement enhances the material's toughness, impact resistance, and fatigue resistance in concrete. Additionally, it improves the material's capacity to withstand cracking, water infiltration, and chloride intrusion, resulting in a substantial increase in the longevity of concrete buildings.

Today, the importance of fiber reinforced concrete is increasing gradually. Thus, it has been established that the incorporation of fiber as reinforcement in concrete can improve some or all of the engineering properties of the concrete. This paper focuses on the comparison of fiber reinforced concrete (FRC) to the properties of reinforced cement concrete (RCC). The findings of this experimental investigation will give the comparison of normal concrete with fiber reinforced normal concrete. The following conclusions will have important implications toward improving the performance of concrete structures.

1.1 Problem Statement

The construction industry consistently explores novel materials and ways to improve structural performance, longevity, and sustainability. It is crucial to do a thorough comparison analysis of reinforced cement concrete (RCC) and fiber reinforced concrete (FRC) in order to assess their individual benefits, drawbacks, and appropriateness for different structural uses.

1.2 objective of this study

The objective of this study is to comprehensively assess the mechanical, physical, and durability characteristics of both conventional concrete and fiber-reinforced concrete.

2. Literature Review

According to Norouzi et al. (2021), building process efficiency remains central to boosting competitiveness and development of the construction industry. As a result, a lot of research has been promoted globally to solve the limitations and failings of the concrete materials and their uses in the improvement of building materials, methods, practices, and systems. Ferreira et al. (2021) found out that due to the environmental and natural aging, the structures go through a number of chemical and physical changes and as a consequence a low rate but prolonged degradation occurred to the structural integrity and the concrete material properties. Typically, regular concrete is susceptible to several issues, such as plastic shrinkage, drying shrinkage, high permeability, spalling, brittleness, and low durability. Concrete is widely recognized for its significantly higher brittleness compared to other building materials like steel and aluminum. This brittleness makes concrete prone to cracking, which in turn leads to several crucial problems, such as, discoloration, steel corrosion, and the freeze-thaw effect. Fiber-reinforced concrete (FRC) has the potential to streamline processes and enhance the industrial building, particularly when used in conjunction with self-compacting concrete. Nevertheless, the absence of comprehensive design principles for FRC, particularly concerning the stress-crack opening connection, has impeded its extensive use.

Atmakuri et al. (2020) observed that synthetic fibers may be categorized into two types, namely organic and inorganic fibers, depending on their chemical composition. Natural fibers are obtained from three primary sources: animals, plants, and geological formations. Examples of fiber sources from plants or vegetables include foliage and timber. Natural Fiber becomes more cost-effective when its mechanical qualities, such as shear strength, tensile strength, and toughness, are improved. This is due to the fact that natural fibers are readily available through agricultural activities, simple to handle, and more flexible compared to industrial fibers. In addition, Atmakuri et al. asserted that natural fiber is lightweight, flexible, and hence easy to manipulate. It requires fewer chemical procedures before reuse and is readily accessible in several places, unlike industrial Fiber and Synthetic Fiber.

Fiber-reinforced concrete (FRC) is widely used to increase the toughness, strength, and elasticity of concrete and structures that incorporate concrete. Fiber reinforced concrete has become popular in civil engineering and construction due to possessing properties that improve the impact strength, static strength and dynamic tensile strength, flexural strength, strain capacity, and lesser formation of cracks. According to Khan et al. (2023), an appropriate way of improving the mechanical characteristics of concrete is by adding fibers into it. Fibers improve some technical properties of mortar and concrete, such as impact strength and durability, to a significant extent. Similarly, tensile strength, flexural strength, failure strength, and the spalling resistance are enhanced. Fibers also help to improve the uniformity and directional distribution of the concrete.

According to Ahmad & Zhou (2022), usage of natural, industrial, or synthetic fibers in concrete enhances mechanical aspects and control of cracks in FRC. According to their findings, fibers have a role of reinforcement in a similar manner to the steel bars in concrete to counter factors such as crack formation and failure at the flexural level. In their study, Ahmad and Zhou explored the various properties such as mechanical properties, technology, and applications of fiber reinforced composites (FRC). The conducted study supported the fact that a distinctive feature of FRC is its remarkable performance in terms of cracks' non-proliferation. Because of this crack arresting behavior, fiber composites demonstrate greater extensibility, as well as higher initial and ultimate tensile strengths when compared to plain concrete, particularly in flexure. Also, the fibers have the ability to prevent the degradation of the matrix even where extensive cracking is present. The net effect of these features is to endow the fiber composite with gross level of post-cracking ductility while the conventional concrete does not possess this feature. Therefore, based on this study, the transition from a fragile to a malleable material will greatly enhance the energy absorption properties of the fiber composite and its capacity to endure repeated, sudden, or forceful loads.

Currently, FRC is widely used in construction for many purposes, such as precast goods, offshore structures, footings, crash barriers, hydraulic structures, slabs, seismic-resistant structures, and architectural panels. This use enhances the performance of concrete. This demonstrates that the full use of fiber reinforced concrete (FRC) in construction has the potential to effectively manage cracking caused by plastic shrinkage and drying shrinkage. Additionally, it can minimize the bleeding impact and lower the permeability of fresh concrete. In addition, the use of fiber in concrete enhances its ductility, energy absorption capacity, and stress distribution under loading. The fiber is capable of filling the empty spaces in concrete, thus reducing the proportion of voids in the concrete. Adding fiber to concrete often enhances its mechanical qualities. Regarding the drawbacks of fiber, some fibers, often natural fibers, diminish the compressive strength of concrete.

All research is aimed at determining the strength of concrete with fiber, and they have demonstrated that the strength increases or decreases with time based on the amount of fiber, its length, and the kind of fiber. According to observations, research on the combination of industrial and natural fibers is still insufficient, and a comparative study between the two fibers is also restricted. This creates an information gap on the strength of FRC in relation to conventional concrete.

3. METHODOLOGY

This paper utilized a literature review research methodology. To collect data used in the study, comprehensive desk reviews of literature reviews were conducted following a thorough search of the aim of this study. The materials to be used were searched on the internet using sites such as Google Scholar. A purposive sampling methodology was used to select literature materials, analyze the selected materials, and collect data related to the subject of the research.

Search Strategy

A comprehensive search strategy was developed to identify relevant studies published in peer-reviewed journals. Google Scholar was used to search for a combination of keywords and controlled vocabulary terms related to FRC and RCC. The search was limited to studies published in English between January 2018 and December 2024 to ensure relevance to the recent developments in the construction industry. Studies were included in the review if they met the following criteria: discussed matters related to FRC and RCC, the studies included experimental data conducted by the researchers, and the research highlighted the methodology and the experimental steps used. A total of N= 10 records were identified after the search, where seven studies met the criteria, with seven articles selected for the final review. These reports comprehensively provided deep insights into the research subject.

Data Analysis

The data collected from the study was analyzed using the thematic data analysis technique. A thematic synthesis approach was employed with literature materials to analyze and interpret the findings by identifying common themes and patterns in the data. The synthesized findings were organized and presented in narrative form, supplemented by a table to illustrate key findings.

4. RESULTS AND DISCUSSION

Table -1: COMPARISION OF RESULTS

RESULTS			
Sr. No.	**Quality**	**FRC**	**RCC**
1	Compressive strength	Comparatively equal strength compared to RCC.	Comparatively equal strength to FRC.
2	Tensile strength	Higher tensile strength.	Weaker strength is better compared to FRC but better compared to conventional concrete.
3	Flexural strength	Improved strength.	Weaker strength.
	Durability and strength resistance	Superior strength compared to RCC.	Inferior strength compared to FRC.
	Fatigue resistance	Better than RCC.	Comparatively better compared to basic concrete.

One of the key factors in evaluating concrete materials is their compressive strength. The results in the compressive strength for FRC are comparable to those of plain concrete, although slight improvements may be achieved depending on the kind of fiber and its volume fraction. Thus, the fibers in FRC do not clearly affect compressive strength, but they have a bearing on other characteristics. However, the fitted compressive strength of RCC depends on the concrete mix design only because the reinforcement bar does not contribute to the compressive strength of RCC.

In terms of tensile strength, FRC has a specific advantage because of the fibers it contains as compared to plain concrete. These fibers span across the cracks and thus they slow the crack progression leading to improved tensile strength. RCC however in contrast has good tensile strength through the use of re-bars which aids it in handling tensile forces and does not fail when stretched.

The flexural strength, which is an important parameter when it comes to concrete bending, is substantially enhanced in FRC than in plain concrete. FRC fibers make load bearing more uniform and eliminate quick failure through crack bridging. In RCC, concrete is reinforced by the rebar which gives the required tensile strength when the concrete is bent.

The optimization of durability and crack resistance are paramount to the extent of use of concrete structures. FRC shows better performance in crack control because the fibers can stop the propagating of micro-cracks and hence, do not progress to big cracks. This increased toughness of FRC makes it ideal to be used in areas that are exposed to unfavorable working conditions. RCC also has fair crack control owing to the presence of rebar. However, if the cracks develop on the concrete and unveil the reinforced bars to moisture and oxygen, then corrosion is likely to happen, which may cause problems pertaining to the durability.

Fatigue strength is the other consideration especially for structures under cyclic loads. FRC has even greater fatigue resistance due to fibers ability of loading and unloading energy over a large volume of space thus being capable of withstanding fatigue. RCC depends on the rebar to deal with cyclic loads adequately, thus offering adequate fatigue strength for most structural purposes.

5. CONCLUSION

The aim of this study was to compare and analyze the performance of fiber reinforced concrete to that of ordinary concrete. These findings justify the fact that fiber-reinforced concrete could be a convenient, efficient, and economical solution to manage micro-cracks and similar issues. However, the studies reveal that both fiber-reinforced concrete (FRC) and reinforced cement concrete (RCC) have their different strengths that ensure they are useful in different settings. For instance, FRC offers enhanced mechanical properties such as crack resistance, durability and fatigue resistance, which qualifies structures that would require such properties. On the other hand, RCC is more important for many structural elements as it has high tensile strength and load carrying capacity. Therefore, when deciding between FRC and RCC in constructions, it would be wise to select a method that is best-suited for certain project load conditions, the environment and expected lifespan of construction. In conclusion, this comparative study reveals how important it is to choose the right material and for how concrete structures can be made to perform to the best of their abilities.

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